United States Department of the Interior

FISH AND WILDLIFE SERVICE

Western Washington Fish and Wildlife Office
510 Desmond Drive SE, Suite 102
Lacey, Washington 98503

Memorandum

MAY 1 6 2006

To: Assistant Regional Director, Ecological Services
Portland, Oregon
Attention: Larry Salata

From: Manager, Western Washington Fish and Wildlife Office
Lacey, Washington

Ken S. Berg

Subject: Biological Opinion for the Issuance of a Section 10(a)(1)(B) Incidental Take Permit to the State of Washington for the Forest Practices Habitat Conservation Plan
(FWS Reference: 1-3-06-FWI-0301)

This document transmits the U.S. Fish and Wildlife Service's Biological Opinion regarding the proposed issuance of an incidental take permit (PRT-TE121202-0) to the State of Washington for the implementation of the Washington Forest Practices Habitat Conservation Plan. Issuance of an incidental take permit is pursuant to Section 10(a)(1)(B) and Section 7(a)(2) of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*).

Your November 4, 2005, request for formal consultation was received on November 9, 2005.

The State of Washington is requesting 50-year coverage of incidental take for the federally threatened bull trout (*Salvelinus confluentus*) that may arise from forest practices activities they regulate across 9.3 million acres in Washington State. Forty-seven other unlisted species will also be included on the U.S. Fish and Wildlife Service's incidental take permit, including 40 fish and 7 amphibian species. The State of Washington is also making a similar request to the National Marine Fisheries Service.

Attachments

Endangered Species Act – Section 7 Formal Consultation

Biological Opinion

Washington Forest Practices Habitat Conservation Plan

(Service Reference Number: 1-3-06-FWI-0301)

Agency:

U.S. Fish and Wildlife Service
Region 1
Portland, Oregon

Consultation Conducted by:

U.S. Fish and Wildlife Service
Western Washington Fish and Wildlife Office
Lacey, Washington

May 16, 2006

Ken S. Berg

Ken S. Berg, Manager
Western Washington Fish and Wildlife Office

U.S. FISH and WILDLIFE SERVICE'S

BIOLOGICAL and CONFERENCE OPINION

for the

PROPOSED ISSUANCE

of a

SECTION 10(a)(1)(B) INCIDENTAL TAKE PERMIT

(PRT-TE-X121202-0)

to the

STATE OF WASHINGTON

for the

FOREST PRACTICES HABITAT CONSERVATION PLAN

May 2006

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Acronyms

BMP	(Best Management Practices)
CFR	(Code of Federal Regulations)
CMER	(Cooperative, Monitoring, Evaluation, and Research committee)
CMZ	(channel migration zone)
dbh	(diameter at breast height)
DFC	(Desired Future Condition)
DPS	(Distinct Population Segment)
ELZ	(Equipment Limitation Zone)
EPA	(Environmental Protection Agency)
ESA	(Endangered Species Act)
FEMAT	(Forest Ecosystem Management Assessment Team)
FMO	(Foraging, Migration, and Overwintering Habitat for bull trout)
FPHCP	(Forest Practices Habitat Conservation Plan)
FFR	(Forests and Fish Report)
FPA	(Forest Practices Application)
FWS	(U.S. Fish and Wildlife Service)
GIS	(Geographic Information Systems)
HCP	(Habitat Conservation Plan)
LWD	(large woody debris)
NMFS	(National Marine Fisheries Service)
PCE	(Primary Constituent Element)
RCW	(Revised Code of Washington)
RMAP	(Road Maintenance and Abandonment Plans)
RMZ	(Riparian Management Zone)
SEPA	(State Environmental Policy Act)
SOSEA	(Spotted Owl Special Emphasis Area)
TFW	(Timber, Fish, and Wildlife)
TMDL	(total maximum daily load)
USDA	(U.S. Department of Agriculture)
USDI	(U.S. Department of the Interior)
WAC	(Washington Administrative Code)
WDFW	(Washington Department of Fish and Wildlife)
WDNR	(Washington Department of Natural Resources)
WDOE	(Washington Department of Ecology)
WRIA	(Water Resource Inventory Area)

1. INTRODUCTION

This document constitutes the U.S. Fish and Wildlife Service's (FWS) Biological and Conference Opinion (Opinion) regarding the FWS's issuance of an incidental take permit (Permit) to the State of Washington (State) for the Forest Practices Habitat Conservation Plan (FPHCP) and its effect on the threatened bull trout (*Salvelinus confluentus*), threatened northern spotted owl (*Strix occidentalis caurina*), threatened marbled murrelet (*Brachyramphus marmoratus marmoratus*), threatened bald eagle (*Haliaeetus leucocephalus*), 47 unlisted aquatic species, and on critical habitat for the northern spotted owl, marbled murrelet, and bull trout. The 47 unlisted aquatic species are included because the State is seeking incidental take authorization for these species should they become listed during the term of the Permit. This document was prepared in accordance with section 7 of the Endangered Species Act (16 U.S.C. 1531 et seq.; ESA).

This Opinion is based primarily on information provided in the FPHCP (WDNR 2006), which is incorporated by reference, and the sources cited herein. A complete administrative record of this consultation is on file at the FWS's Western Washington Fish and Wildlife Office.

1.1 BACKGROUND

In 1999, the Washington State Legislature passed the Salmon Recovery Funding Act (Engrossed Substitute House Bill 5595) which identified forest practices as a critical component for salmon recovery. Through that act, the Legislature recognized a report known as the Forests and Fish Report (FFR) as being responsive to its policy directive for a collaborative, incentive-based approach to support salmon recovery; ESA coverage and regulatory certainty being key incentives of implementation of the FFR. The FFR was developed though a collaborative, multi-stakeholder process to create forest-practices prescriptions that would protect riparian and aquatic habitat for the conservation of listed salmonid species and other unlisted fish and stream-associated amphibian species.

The groups that contributed to the development of the FFR included groups representing all six caucuses of Timber, Fish, and Wildlife (TFW): State agencies, Federal agencies, Native American Tribes, industry, nonindustrial forest landowners, and environmental groups. At the conclusion of the discussions leading to the submittal of the FFR, the environmental caucus and some individual Tribes withdrew their support and chose to not be listed as authors of the report. Authors include State agencies: Washington Department of Natural Resources (WDNR), Washington Department of Fish and Wildlife (WDFW), Washington Department of Ecology (WDOE), Governor's Office; Federal agencies: FWS, National Marine Fisheries Service (NMFS), Environmental Protection Agency (EPA); the Colville Confederated Tribes, other Washington Tribes, the Northwest Indian Fisheries Commission; the Washington State Association of Counties; the Washington Forest Protection Association; and the Washington Farm Forestry Association.

Also in 1999, the Washington State Legislature passed the Forest Practices Salmon Recovery Act (Engrossed Substitute House Bill 2091) which directed the Washington Forest Practices Board to adopt new Washington Forest Practices Rules, encouraging the Forest Practices Board to follow the recommendations of the FFR. In its rulemaking procedures, the Forest Practices Board conducted an evaluation of the FFR, as well as alternatives to the FFR. This evaluation included an Environmental Impact Statement under the Washington State Environmental Policy Act (SEPA). The Final State Environmental Impact Statement, entitled *Alternatives for Forest Practices Rules for Aquatic and*

Riparian Resources, was published in April 2001. The Forest Practices Board adopted new permanent Washington Forest Practices Rules in 2001 based on the FFR. As directed by the Washington State Legislature, through the Forest Practices Salmon Recovery Act, (Revised Code of Washington (RCW), Chapter 77.85.190(3)), Governor Gary Locke designated the Commissioner of Public Lands, Doug Sutherland, to negotiate on behalf of the State with the relevant Federal agencies to satisfy Federal requirements under the ESA and the Federal Water Pollution Control Act (Clean Water Act) (33 U.S.C. 1251 *et seq*.).

Since 2001, the State has worked with the U.S. Fish and Wildlife Service and the National Marine Fisheries Service (together known as the Services) to develop a Habitat Conservation Plan (HCP) under Section 10(a)(1)(B) of the ESA based on the Washington Forest Practices Rules adopted in 2001. The Services formally initiated an environmental review of the project through publication of a Notice of Intent to prepare an Environmental Impact Statement in the Federal Register on March 17, 2003 (68 FR 12676). The State submitted a formal application to the Services for Permits from each agency on February 9, 2005. On February 11, 2005, (70 FR 7245 – 7247), a draft of the FPHCP was released for 90-day public comment period, along with a Draft Environmental Impact Statement as directed by the National Environmental Policy Act of 1969, as amended (42 U.S.C. 4321-4347) (NEPA). The comment period began on February 11, 2005, and closed on May 12, 2005.

The Services and the State prepared a Final Environmental Impact Statement, Response to Comments, and a final FPHCP. These documents were made available to the public on January 27, 2006, for a 30-day public review period.

1.2 CONSULTATION HISTORY

Informal consultation on the proposed action considered herein was initiated on February 9, 2005. A request for formal consultation on the proposed action was transmitted via memorandum from the FWS's Pacific Regional Office to the Western Washington Fish and Wildlife Office on November 4, 2005 The FWS analyzed the potential for effects to all listed, proposed, and candidate species that occur within the proposed action area for the FPHCP. The determinations, of effects to species, of "no effect" and "not likely to adversely affect" are documented in a FWS memorandum (USFWS "no effect and NLAA determinations memo" May 12, 2006). The remainder of this Opinion analyzes the effects to all other listed, proposed, candidate, and covered FPHCP species in the proposed action area.

The National Marine Fisheries Service is also conducting formal consultation on the proposed action on anadromous salmonids and a few other marine fish species that are under their jurisdiction.

On April 17, 2006, the FWS provided FFR stakeholders (e.g., representatives from State and Federal agencies, Tribes, private landowners, and environmental organizations) with the majority of our draft Biological Opinion for their review and comment. We considered these comments during the revisions to this final Biological Opinion. The comments we received from stakeholders are included in our administrative record for this Opinion.

2. BIOLOGICAL AND CONFERENCE OPINION

3. DESCRIPTION OF THE PROPOSED ACTION

The FWS proposes to issue a 50-year Permit under the authority of section 10(a)(1)(B) of the ESA to the State to cover the incidental take of the bull trout and 47 unlisted aquatic species (should they become listed). This Permit would address incidental take that may be caused by the State's implementation of the FPHCP. The State is requesting a Permit that would cover its actions as regulator and permitter of forest practices activities in Washington State. Such a Permit would cover the regulatory actions of the State, and, in turn, would be an umbrella for the forest practices of third-party operators and landowners regulated by the State.

3.1 LANDS COVERED BY THE FPHCP

The FPHCP covers approximately 9.3 million acres of forestland in Washington, about 6.1 million acres of which are located west of the crest of the Cascade Range, and approximately 3.2 million acres are in eastern Washington. Ownership patterns range from individuals and families who own small forest parcels to large holdings owned and/or managed by private corporations and public agencies.

Covered lands are forestlands within the State subject to the Washington Forest Practices Act, chapter 76.09 of the RCW. Forestland means "all land which is capable of supporting a merchantable stand of timber and is not being actively used for a use which is incompatible with timber growing" (WAC 222-16-010). For purposes of road maintenance and abandonment planning and implementation for small forest landowners, "forestland" excludes the following: residential home sites; crop-fields; orchards; vineyards; pastures; feedlots; fish pens; and land on which appurtenances necessary to the production, preparation, or sale of crops, fruits, dairy products, fish, and livestock exist (WAC 222-16-010).

Forestlands covered by existing federally approved HCPs are generally not considered part of FPHCP covered lands (Washington Administrative Code (WAC) 222-12-041). However, there are two exceptions. One is the 5-year Western Pacific Timberlands (*nee* Boise Cascade Corporation) single-species HCP (Boise Cascade Corporation 2001) that encompasses 620 acres and provides coverage for the northern spotted owl, but does not include coverage for aquatic species. The other exception is approximately 228,000 acres of managed land on the east side of the Cascade Crest that were included in the approximately 1.6 million acres addressed by the Washington State Department of Natural Resources HCP (WDNR) (WDNR 1997). The WDNR State Lands HCP provides coverage for some listed terrestrial species east of the Cascade Crest (e.g., wolves, spotted owls, and bald eagles), but does not include coverage for aquatic species. The forestland contained within these two areas is considered part of the covered lands under the FPHCP.

Covered lands may change over time as lands are bought and sold, or change land-use status. For instance, covered lands may increase if another existing HCP is terminated and those lands then become subject to the standard Washington Forest Practices Rules covered by the FPHCP. Lands may decrease if a new HCP is developed and those lands are no longer subject to the standard Washington Forest Practices Rules. Forest lands purchased and included as Federal lands would no longer be covered by the FPHCP. Land exchanges between landowners of covered lands and Federal, State, or other, existing HCP lands could both increase and decrease FPHCP covered lands. Lands that are converted from forestry to

other land uses would no longer be subject to the Washington Forest Practices Rules or the FPHCP. Lands that become newly forested could become subject to the Washington Forest Practices Rules and the FPHCP. For instance, if an old field is planted to hybrid poplar and is harvested before it is 25 years old, it remains subject to agricultural rules; but, if that plantation is allowed to grow past 25 years of age, it would become subject to the Washington Forest Practices Rules and, thereby, to the proposed FPHCP.

3.2 SPECIES COVERED BY THE FPHCP

The State seeks incidental take coverage under the ESA for FWS species listed in Table 3-1.

Table 3-1. Species covered in the Incidental Take Permit for the State of Washington's Forest Practices Habitat Conservation Plan

Common Name	*Scientific Name*
Threatened Species	
Bull trout	*Salvelinus confluentus*
Unlisted Fish Species	
Dolly Varden	*S. malma*
Cutthroat trout [1]	*Oncorhynchus clarki*
Rainbow/ Redband trout [2]	*O. mykiss*
Kokanee	*O. nerka*
Pacific lamprey	*Lampetra tridentata*
River lamprey	*L. ayersi*
Western brook lamprey	*L. richardsoni*
Pygmy whitefish	*Prosopium coulteri*
Mountain whitefish	*P. williamsoni*
Olympic mudminnow	*Novumbra hubbsi*
Chiselmouth	*Acrocheilus alutaceus*
Redside shiner	*Richardsonius balteatus*
Longnose dace	*Rhinichtys cataractae*
Speckled dace	*R. osculus*
Leopard dace	*R. falcatus*
Umatilla dace	*R. umatilla*
Northern pikeminnow	*Ptychocheilus oregonensis*
Tui chub	*Gila bicolor*
Lake chub	*Couesius plumbeus*
Peamouth	*Mylocheilus caurinus*
Largescale sucker	*Catostomus macrocheilus*
Bridgelip sucker	*C. columbianus*
Longnose sucker	*C. catostomus*
Mountain sucker	*C. platyrhynchus*
Salish sucker	*C. carli (species pending)*
Three-spine stickleback	*Gasterosteus aculeatus*
Sandroller	*Percopsis transmontana*
Coastrange sculpin	*Cottus aleuticus*

Table 3-1. Species covered in the Incidental Take Permit for the State of Washington's Forest Practices Habitat Conservation Plan (continued)

Common Name	*Scientific Name*
Prickly sculpin	*C. asper*
Reticulate sculpin	*C. perplexus*
Riffle sculpin	*C. gulosus*
Shorthead sculpin	*C. confusus*
Torrent sculpin	*C. rhotheus*
Slimy sculpin	*C. cognatus*
Paiute sculpin	*C. beldingi*
Margined sculpin	*C. marginatus*
Mottled sculpin	*C. bairdi*
Longfin smelt	*Spirinchus thaleichthys*
Burbot	*Lota lota*
White sturgeon [3]	*Acipenser transmontanus*
Unlisted Amphibian Species	
Columbia torrent salamander	*Rhyacotriton kezeri*
Cascade torrent salamander	*R. cascadae*
Olympic torrent salamander	*R. olympicus*
Dunn's salamander	*Plethodon dunni*
Van Dyke's salamander	*P. vandykei*
Pacific tailed frog	*Ascaphus truei*
Rocky Mountain tailed frog	*A. montanus*

[1] The cutthroat trout includes two subspecies: the coastal cutthroat (*Oncorhynchus clarki clarki*) and the westslope cutthroat (*Oncorhynchus clarki lewisi*).

[2] The rainbow trout includes two subspecies: the coastal rainbow trout (*Oncorhynchus mykiss irideus*) and the Columbia (a.k.a. Interior) redband trout (*Oncorhynchus mykiss gairdneri)*.

[3] White sturgeon in this opinion excludes the endangered Kootenai River Distinct Population Segment. The Kootenai population is located wholly upstream and outside of this action area. Those sturgeon that are landlocked and occur within Washington State, and those that are marine and/or anadromous (downstream of Bonneville Dam), are addressed in this consultation.

3.3 ACTIVITIES COVERED BY THE FPHCP

Forest-practices activities covered by the FPHCP include road and skid-trail construction, road maintenance and abandonment, final and intermediate harvesting, pre-commercial thinning, reforestation, timber salvage, and brush control. In addition, adaptive management research and monitoring activities—some of which include experimental treatments—are also covered by the FPHCP. The FPHCP includes protection measures to avoid, minimize, and mitigate potential impacts caused by these activities. These activities are described in Chapter 4 of the FPHCP in greater detail, as well as in this section below and under Effects to the Environment.

3.3.1 FPHCP Conservation Program

The applicant (Washington State) developed the FPHCP as a programmatic plan. The programmatic nature of the FPHCP would provide ESA coverage for forest landowners through the Forest Practices Program. Forest landowners would conduct forest practices activities according to Washington Forest Practices Act and Rules as described in the FPHCP, and therefore become beneficiaries of take coverage for which the State has applied.

The Forest Practices Program includes State statutes and the Washington Forest Practices Rules that govern forest-practices activities in Washington. The program also includes the public and private agencies and organizations that work cooperatively to administer the program throughout the State. The Forest Practices program includes both regulatory and collaborative dimensions. Collaborative efforts include adaptive management (discussed below) as well as the overall TFW process.

The Forest Practices program has been in existence for many years and is administered by the WDNR – Forest Practices Division. The Forest Practices Program includes staff and managers in each region, as well as oversight in the headquarters office in Olympia. Many standardized procedures and interpretations have been developed over the years, by WDNR, in cooperation with other TFW stakeholders, and upheld through the courts. These procedures and interpretations are supported by: (1) staff that make consistent findings and determinations in the field, (2) a series of training classes provided in cooperation with other TFW stakeholders, (3) standardized operating guidance, (4) procedures for automated public involvement, (5) oversight and technical participation by TFW stakeholders, and (6) legal staff in the State's Attorney General's office.

Forest practices foresters review and approve forest practices applications. These FPA documents are available on-line to the requesting public for review and comment to WDNR. Once an application is approved, forest-practices foresters may consult on operations and issue approval for minor adjustments in the field. These adjustments may have been requested by the landowner or operator, by WDNR, or any other reviewer of an FPA. WDNR makes final approval decisions on FPAs. These are often recorded in the form of Informal Conference Notes and are signed by all participating parties. Often, when adjustments are more significant, regardless of who requested the adjustment, WDNR may issue a Notice to Comply. When WDNR observes infractions or resource damage occurring from authorized activities, they issue a Stop Work Order. Work on that activity must cease until the issue is resolved. WDNR also has the ability to levy civil penalties in extreme cases. These processes are part of the framework of the Forest Practices program.

Although not covered by the proposed FPHCP, the WDFW administers a program whereby they issue Hydraulic Project Approval (HPAs). That program, authorized by the "Hydraulic Code" (Chapter 77.55 RCW), is referenced several times in the body of this Opinion as the activities described are often subject to additional limitations associated with HPAs. HPAs are required to conduct any construction activity that will use, divert, obstruct, or change the bed or flow of State waters (including streams within lands regulated by the Forest Practices Act). The purpose of the program is to prevent damage to the State's fish, shellfish, and their habitat. WDFW has area and regional biologists that administer that program at the field-level, as well as support from headquarters in Olympia. The HPA program is not proposed for coverage by the FPHCP, this information is merely provided to apply context to discussions within this Opinion. However, the approval of some forest practices applications on Type N streams serves as approval for specific forest practices-related hydraulic projects, effective June 1, 2005.

3.3.2 Compliance Monitoring

A number of efforts are ongoing that would address compliance monitoring of activities conducted under the FPHCP. They are as follows:

- The existing forest practices enforcement program would continue whereby forest practices foresters check on a number of FPAs prior to, during, and following activities. Visits prior to activities may be conducted to verify existing pre-activity conditions and review the site for

sensitive resources. Visits during activities may be conducted to ensure activities are occurring, or being avoided, as planned. Close-out visits may be conducted to verify that post-activity conditions meet applicable requirements. The specific FPAs to visit, and the timing of such visits, are determined by WDNR forest practices foresters. The amount and distribution of effort depends on the sensitivity of the resources involved as well as local and practical knowledge regarding the individual operations.

WDNR would continue the inspection of forest lands, before, during, and after the conducting of forest practices as necessary for the purpose of ensuring compliance with the Washington Forest Practice Rules and to ensure that no material damage occurs to the natural resources of the State as a result of such practices. Any authorized representative of WDNR shall have the right to access forest land at any reasonable time to enforce the provisions of the Washington Forest Practices Rules (RCW 76.09.150).

- There is ongoing involvement in the compliance of forest practices by other TFW staff, specifically WDFW and tribal biologists, who review forest practices in their local geographic area on a regular basis. Irregularities observed during the course of such visits are brought to the attention of WDNR. This level of cooperative activity is variable across the State and depends on the commitment of the local TFW staff.

- WDNR has initiated an FPHCP Compliance Monitoring Program. The Washington Forest Practices Rules, WAC 222-08-160 (4), define the WDNR compliance monitoring responsibilities as:

  > "The department shall conduct compliance monitoring that addresses the following key question: "Are forest practices activities being conducted in compliance with the Washington Forest Practices Rules?" The department shall provide statistically sound, biennial compliance audits and monitoring reports to the board for consideration and support of rule and guidance analysis. Compliance monitoring shall determine whether Washington Forest Practice Rules are being implemented on the ground. An infrastructure to support compliance will include adequate compliance monitoring, enforcement, training, education and budget."

  This program resides within the WDNR Forest Practices Division and is still undergoing refinement. Preliminary data have been gathered and reported. This program's goal is to characterize the level of compliance that is occurring; therefore, a substantial emphasis is placed upon adequate sample sizes and unbiased procedures for site selection so that WDNR can determine if forest landowners/operators in the State of Washington are conducting forest practice activities in accordance with the Washington Forest Practices Rules. Over time, the information gained from this program will help the WDNR to more-effectively utilize limited forest practices resources. Information gathered will also assist the Washington Forest Practices Board in the development of new and/or revised Washington Forest Practices Rules.

- The U.S. Fish and Wildlife Service and the National Marine Fisheries Service would monitor the implementation of the FPHCP. The Services would bring specific issues of non-compliance to the attention of WDNR to resolve in coordination with the Services. In addition, the Services are participating in the ongoing development and refinement of the FPHCP Compliance Monitoring Program as described in #3 above.

The FPHCP consists of two parts: an administrative framework and a set of protection measures. The administrative framework supports the development, implementation, and refinement of the Washington Forest Practices Rules and therefore contributes to the overall effectiveness of the FPHCP in meeting the needs of the covered species. The administrative framework bears on the protective aspects of the FPHCP in that it includes the Washington Forest Practices Rules and guidance, the forest practices permitting process, compliance monitoring, enforcement actions, and training and technical support. The administrative framework also incorporates an adaptive management process to address uncertainty associated with the effectiveness of protection measures. The adaptive management program is designed to assess the effectiveness of the protection measures in achieving established resource objectives. It also includes programs to monitor the status and trends of key environmental parameters and to evaluate watershed-scale cumulative effects.

The protection measures are described in the FPHCP, the Washington Forest Practices Rules, and Forest Practices Board Manual guidance and are designed to minimize and mitigate forestry-related impacts and conserve habitat for species covered by the FPHCP. The protection measures determine the level of on-the-ground habitat protection for covered species. The two major sets of protective measures are presented as two separate, but related, conservation strategies: Riparian Strategy and Upland Strategy.

3.3.3 Description of Washington Forest Practices Rules under the Proposed FPHCP

This summary description is provided for the convenience of the reader. This summary does not supplant or supersede the operating conservation program as described in the FPHCP, nor the contents of the applicable Washington Forest Practices Rules. In matters where such documents are in disagreement, the reader should consult the Washington Forest Practices Rules, including WAC (Title 222 WAC). The authority for such rules can be found in Chapters 76.09, 76.13, 77.85 RCW. These rules are available on the WDNR website at www.dnr.wa.gov. The Forest Practices Board Manual should not be interpreted as rules, but as guidelines to assist landowners and operators in meeting the intent of the rules.

3.3.3.1 Definitions

Below is a summary of the Water and Wetland Typing Systems. Full details are contained in the Washington Forest Practices Rules cited above.

Water Typing System

The WDNR in cooperation with WDFW and WDOE, and in consultation with affected Native American Indian Tribes will classify waterbodies, including streams, lakes, and ponds. The WDNR will prepare water type maps showing the location of Type S, F, and N (Np and Ns) Waters within the forested areas of the State. The maps will be based on a multiple-parameter, field-verified geographic information system (GIS) logistic-regression model. The multiple-parameter model will be designed to identify fish habitat by using geomorphic parameters such as basin size, gradient, elevation, and other indicators. The modeling process shall be designed to achieve a level of statistical accuracy of 95 percent in separating fish-habitat streams from those that do not contain fish habitat. Furthermore, the demarcation of waters supporting and not supporting fish habitat shall be equally likely to over and under estimate the presence of fish habitat. Water-type maps will be updated every 5 years where necessary to better reflect observed,

in-field conditions. Until water-type maps delineating fish habitat are adopted by the Forest Practices Board, the Interim Water Typing System will continue to be used.

The waters will be classified using the following criteria:

"Type S Water" means all waters, within their bankfull width, as inventoried as "Shorelines of the State" under chapter 90.58 RCW including periodically inundated areas of their associated wetlands. Estuarine and marine shorelines are classified as Type S waters.

"Type F Water" means segments of natural waters other than Type S Waters, which are within the bankfull widths of defined channels and periodically inundated areas of their associated wetlands, or within lakes, ponds, or impoundments having a surface area of 0.5 acre or greater at seasonal low water and which in any case contain fish habitat or are described by a number of factors including diversion for domestic use by more than a specified number of users and will extend upstream for a specified distance; diverted for use by fish hatcheries; waters, which are within a campground of specified size; and riverine ponds, wall-based channels, and other channel features that are used by fish for off-channel habitat.

"Type Np Water" means all segments of natural waters within the bankfull width of defined channels that are perennial streams without fish habitat. Perennial streams are waters that do not go dry any time of a year of normal rainfall. However, for the purpose of water typing, Type Np Waters include the intermittent dry portions of the perennial channel below the uppermost point of perennial flow. If the uppermost point of perennial flow cannot be identified with simple, nontechnical observations, then Type Np Waters may be determined by the size of the contributing basin area.

"Type Ns Water" means all segments of natural waters within the bankfull width of the defined channels that are not Type S, F, or Np Waters. These are seasonal streams without fish habitat in which surface flow is not present for at least some portion of a year of normal rainfall, and are not located downstream from any stream reach that is a Type Np Water. Ns Waters must be physically connected by an above-ground channel system to Type S, F, or Np Waters.

Wetland Typing System

The WDNR in cooperation with WDFW, WDOE, and affected Native American Indian Tribes shall classify wetlands in order to distinguish those which require wetland management zones and those which do not. Wetlands which require wetland management zones shall be identified using the following criteria:

"Nonforested wetlands" means any wetland or portion thereof that has, or if the trees were mature would have, a crown closure (generally interpreted as canopy cover) of less than 30 percent.

> "Type A Wetlands" are all nonforested wetlands which are greater than 0.5 acre in size, including any acreage of open water where the water is completely surrounded by the wetland; and are associated with at least 0.5 acre of ponded or standing open water. The open water must be present on the site for at least 7 consecutive days between April 1 and October 1 to be considered for the purposes of these rules. All forested and nonforested bogs greater than 0.25 acres shall be considered Type A Wetlands.
>
> "Type B Wetlands" are all other nonforested wetlands greater than 0.25 acre.

"Forested wetland" means any wetland or portion thereof that has, or if the trees were mature would have, a crown closure of 30 percent or more.

3.3.3.2 FPHCP Riparian Strategy

The Riparian Strategy addresses practices affecting certain ecological functions that are important for creating, restoring, and maintaining aquatic and riparian habitats. The strategy protects these functions along typed waters by restricting forest practices activities from the most sensitive parts of riparian areas and by limiting activities in other areas. The strategy accomplishes protection within the riparian management zone (RMZ) and the equipment limitation zone (ELZs) for typed waters. RMZs are areas adjacent to Type S, Type F, and Type Np waters where trees are retained so that ecological functions such as large woody debris (LWD) recruitment, shade, litterfall, streambank stability, and nutrient cycling are maintained. ELZs apply to Type Np and Type Ns waters and are areas where equipment use is limited so that forest practices-related erosion and sedimentation are minimized. Other riparian protection measures that apply to typed waters include restrictions on the salvage of down woody debris and the disturbance of stream banks. Some riparian requirements differ between western and eastern Washington.

Western Washington

Protection measures for typed waters in western Washington include establishing riparian management zones along Type S, Type F, and Type Np waters. The FPHCP applies no-harvest buffers adjacent to Type Np-associated sensitive sites. The FPHCP applies ELZs along Type Np and Type Ns waters. Note that all measurements regarding buffers and ELZs are measured horizontally, not on-the-slope.

Type S and Type F Waters

RMZs associated with Type S and Type F waters in western Washington are made up of three sub-zones: the “core zone,” the “inner zone” and the “outer zone.” The core zone is closest to the water, the inner zone is the middle zone and the outer zone is farthest from the water (FPHCP Figure 4.5).

Core Zone

The core zone begins at the bankfull or channel migration zone (CMZ) edge and is 50 feet wide. No timber harvest is allowed in the core zone except for the construction and maintenance of road crossings and the creation and use of yarding corridors in accordance with applicable rules. Any trees cut for, or damaged by, yarding corridors in the core zone must be left on-site. Any trees cut as a result of road construction to cross a stream may be removed from the site, unless they are to be used as part of an LWD placement strategy (see Inner Zone discussion below) or as needed to reach stand requirements.

Inner Zone

The inner zone begins at the outside edge of the core zone, and its width depends on site class, bankfull width, and the management option selected by the landowner. Management options in the inner zone include: (1) thinning from below, (2) leaving trees closest to the water, (3) hardwood conversion, and (4) no harvest. Timber harvest is allowed within the inner zone if certain stand requirements are met. Stand requirements apply to the combined core and inner zones, and are minimum values for the following parameters: (1) the number of conifer trees per acre, (2) the basal area of conifer per acre, and (3) the proportion of conifer.

If stand-level requirements are met, the combined core and inner zones are capable of attaining a target condition known as “desired future condition” (DFC). DFC is the condition of a mature riparian forest stand at 140 years of age and is based on basal area per acre. DFC targets for basal area per acre have been developed for five site classes in western Washington.

Growth modeling is used to determine if a particular stand meets the DFC basal area target. Stand-attribute data are collected and input to a model that "grows" the stand to 140 years of age. If, at age 140, the estimated future basal area would exceed the DFC target, harvesting may occur within the inner zone in accordance with applicable rules. In these cases, only the "surplus" basal area (i.e., basal area beyond that needed to meet the DFC basal area target) may be harvested. When the combined core and inner zones for a particular riparian stand do not meet the DFC stand requirements, no harvest is allowed in the inner zone, except in cases where the landowner chooses the hardwood-conversion option. When no harvest is permitted in the inner zone, or the landowner elects to forego harvesting in the inner zone, the width of the core, inner, and outer zones follow the requirements in FPHCP Table 4.5.

Landowners can harvest within the inner zone of stands not meeting stand requirements, to convert a hardwood-dominated inner zone to one that is dominated by conifers. The site must meet certain minimum requirements such as evidence that the site can be successfully converted to conifer, a maximum number and size of existing conifers, and contiguous ownership upstream and downstream of the site. Even in these situations, the FPHCP limits the spatial extent of conversion and the number and type of trees that can be harvested.

Harvesting in the inner zone must be either thinning from below (thinning), or leaving trees closest to the water (packing). Under thinning from below, harvesting focuses on retention of most co-dominant and all dominant trees in the stand. Larger trees generally provide greater ecological benefits, particularly in terms of LWD recruitment and shade. The width of the core, inner, and outer zones must follow the requirements in FPHCP Table 4.6. In addition, harvesting cannot decrease the proportion of conifers in the stand. Any harvest within 75 feet of the bankfull edge or CMZ edge must meet minimum shade requirements. Following harvest, there must be at least 57 conifer trees per acre in the inner zone. These 57 conifer trees must be 12 inches or larger in diameter at breast height (dbh).

Under the harvests leaving trees closest to the water, the width of the core, inner, and outer zones must follow the requirements in FPHCP Table 4.7. This option only applies to Site Class I, II, and III RMZs on streams less than or equal to 10 feet bankfull width and to Site Class I and II RMZs on streams greater than 10 feet bankfull width. In addition, inner zone harvest must meet the prescriptions described in FPHCP Table 4.6 and 4.7. Within the inner zone, areas harvested using even-aged methods must leave 20 conifer trees greater than 12 inches dbh per acre of harvest. A minimum of 20 conifers per acre will be retained in any portion of the inner zone where harvest occurs (e.g., within the harvest unit), and these trees will not be counted or considered towards meeting the applicable stand requirements.

Stream-Adjacent Parallel Roads

When the basal area component of the stand requirements cannot be met due to the presence of a stream-adjacent parallel road in the core and/or inner zones, two parameters must be estimated: 1) the basal area that would have been present if the road was not occupying the space, and 2) the corresponding shortfall in the basal area component of the stand requirements.

The total basal area equivalent to the shortfall must be retained elsewhere in the inner and/or outer zones as mitigation. If the inner and/or outer zones contain insufficient trees to address the shortfall, trees within the RMZ of other Type S or Type F waters in the same harvest unit or along Type Np or Ns waters in the same harvest unit must be retained as mitigation. In cases where other in-unit RMZs are unavailable, the landowner may implement an LWD placement strategy to address the shortfall in basal area (see Forest Practices Board Manual Section 26 for guidelines).

YARDING CORRIDORS IN CORE AND INNER ZONES

When yarding corridors are necessary to facilitate harvesting within RMZs, all calculations of the basal area component of the stand requirements are to be made as if the corridors were established prior to any other harvest activity. All trees cut in the core zone must be left on site. Inner-zone trees cut or damaged by yarding may be removed if they represent surplus basal area. Trees cut or damaged by yarding in a unit that does not meet the DFC basal area target may not be removed from the site. The size and spacing of corridors are limited by the Washington Forest Practices Rules (see Cable Yarding).

Outer Zone

The outer zone begins at the outside edge of the inner zone and—like the inner zone—its width is dependent on site class, bankfull width, and management option selected by the landowner (see FPHCP Tables 4.5 through 4.7). Timber harvest is allowed in the outer zone; however, 20 riparian leave trees per acre must be retained in either "dispersed" (even distribution throughout), or "clumped" (grouped around sensitive features to the extent the features are present in the outer zone). Under either leave tree strategy, retained trees must be conifers and 12 inches minimum dbh.

An LWD placement strategy involves the voluntary placement of woody debris in stream channels by forest landowners. The intent of the strategy is to enhance fish habitat in streams on managed forestlands by creating incentives for landowners to place wood. Guidance for placing woody debris in streams is found in Section 26 of the Forest Practices Board Manual. Wood-placement projects require an HPA permit from WDFW and are subject to additional requirements under the State's Hydraulic Code.

Type Np and Type Ns Waters

Protection measures for waters without fish in western Washington include the establishment of ELZs adjacent to Type Np and Type Ns waters and the establishment of RMZs adjacent to Type Np waters and associated sensitive sites. ELZs minimize ground and soil disturbance, protecting streambank integrity and preventing sediment delivery to waters without fish. ELZs apply to all Type Np and Type Ns waters, are 30 feet wide and are measured from the bankfull width.

To minimize equipment-based exposure of soil on more than 10 percent of the surface area of the ELZ, the FPHCP includes mitigation measures regarding operating ground-based equipment, constructing and using skid trails and stream crossings, and yarding partially suspended, cabled logs. Mitigation measures to address lost function as it relates to the prevention of sediment delivery include—but are not limited to—water bars, grass seeding, and mulching.

Protection of Type Np waters includes the establishment of no-harvest RMZs along portions of Type Np waters and around sensitive sites. The RMZs are either 50 or 56 feet in width (depending on the feature being protected). Requirements ensure that two-sided RMZs are established along at least 50 percent of the Type Np water length. The approach targets the most ecologically sensitive parts of Type Np waters, resulting in a discontinuous network of buffers that protects areas most important to aquatic resources (FPHCP Figure 4.6). No timber harvest is permitted in an area within 50 feet of headwall seeps and side-slope seeps, and within 56 feet of a point of intersection of two or more Type Np waters, headwater springs, or points of initiation of perennial flow. No timber harvest is allowed within an alluvial fan. Beginning on the point of confluence with a Type S or Type F water, 50-foot RMZs will be established for the greater of 300 feet or 50 percent of the entire length of the Np water, up to a maximum of 500 feet. Additional buffered reaches may be needed according to tables in the Washington Forest Practices Rules.

Required areas for RMZ protection include the lower reaches of Type Np waters immediately above the confluence with Type S or Type F waters and designated sensitive sites including seeps, springs, Type Np confluences, Type Np initiation points, and alluvial fans. If RMZ establishment adjacent to these areas does not protect 50 percent of the Type Np water length, additional buffers must be left along other priority areas, including low-gradient stream reaches, tailed-frog habitat, groundwater-influence zones, and areas downstream from other buffered reaches. To the extent that it is reasonable, yarding corridors and road crossings will be avoided through RMZs for Np streams, as well as sensitive sites and associated buffers. Should cable yarding or roads affect the sensitive sites, landowners must leave additional acres to account for those removed.

The width of RMZs adjacent to sensitive sites varies according to the type of sensitive site. Headwall and side-slope seep RMZs are measured from the perennially saturated soil edge and are 50 feet wide. RMZs for Type Np confluences, headwater springs, and Type Np initiation points are measured from the center of the feature or point of confluence, are circular in shape and are 56 feet wide (i.e., have a radius of 56 feet). No-harvest RMZs along areas not designated as sensitive sites are 50 feet wide, measured from the bankfull edge. Harvest is not allowed within the full extent of alluvial fans—irrespective of shape or size.

Eastern Washington

Protection measures for eastern Washington waters are 3-fold. First, measures include the establishment of RMZs along Type S, Type F, and Type Np waters. Second, the FPHCP provides for the protection of Type Np-associated sensitive sites. Finally, the FPHCP establishes ELZs adjacent to Type Np and Type Ns waters.

Type S and Type F Waters

RMZs associated with Type S and Type F waters in eastern Washington consist of three sub-zones; the "core" zone, the "inner" zone, and the "outer" zone. The core zone is closest to the water, the inner zone is the middle zone and the outer zone is farthest from the water (FPHCP Figure 4.5).

Core Zone

The core zone is 30 feet wide, beginning at the bankfull or CMZ edge. No timber harvest or road construction is allowed in the core zone except for the construction and maintenance of road crossings and the creation and use of yarding corridors. Any trees cut for, or damaged by yarding corridors in the core zone must be left on-site. Any trees cut as a result of road construction to cross a stream may be removed from the site unless they are to be used as part of an on-site, LWD replacement project. LWD placement projects are required in cases where a landowner wants to reduce the number of outer zone leave trees below the standard requirement (see description outer zone below).

Inner Zone

The inner zone begins at the outside edge of the core zone and its width depends on bankfull width (FPHCP Tables 4.9 and 4.10). The inner zone width is 45 feet for waters with bankfull widths of 15 feet or less. For waters with bankfull widths that exceed 15 feet, the inner zone width is 70 feet. FPHCP tables 4.9 and 4.10 provide more-detailed information on zone widths prescribed in the FPHCP and are incorporated here by reference.

Inner zone harvest includes leave-tree retention. Leave-tree requirements vary by timber habitat type. Three timber habitat types are recognized: 1) ponderosa pine, 2) mixed conifer, and 3) high elevation.

The ponderosa pine timber habitat type is 2,500 feet or lower in elevation, the mixed-conifer timber habitat type is 2,501 to 5,000 feet in elevation, and the high-elevation timber habitat type is above 5,000 feet. Inner-zone, leave-tree requirements for each timber habitat type are described below.

PONDEROSA PINE TIMBER HABITAT TYPE

The FPHCP divides stands in the ponderosa pine timber habitat type into two classes: 1) stands with high basal areas, and 2) stands with low basal areas and high densities.

For stands with high basal area (greater than 110 square feet per acre for all species in the inner zone), harvest is allowed within the inner zone. Harvest must retain at least 50 trees per acre (21 largest and 29 over 10 inches dbh) and at least 60 square feet of basal area per acre must be retained following harvest. Where there are not 29 trees over 10 inches in dbh, the landowner will retain the 29 next largest trees. Where the 60 square feet of basal area per acre cannot be met with 50 trees per acre, the landowner will be required to leave additional trees to achieve basal area per acre target. The landowner may be required to retain up to 100 trees per acre.

For stands with low basal area and high density, harvest is also allowed. Thinning is permitted if the basal area of all species is less than 60 square feet per acre and there are more than 100 trees per acre. The 50 largest trees must be retained as well as another 50 trees that are either greater than 6 inches dbh, or the next largest diameter. The landowner is required to retain 100 trees per acre.

To the extent down wood is available on-site prior to harvest, at least 12 tons of down wood per acre must be left following harvest. Where available, at least 6 pieces greater than 16 inches diameter and 20 feet in length and 4 pieces greater than 6 inches diameter and 20 feet in length must be left. These requirements apply both to stands with high basal area and stands with low basal area and high density.

MIXED-CONIFER TIMBER HABITAT TYPE

Washington Forest Practices Rules divide stands in the mixed conifer timber habitat type into two classes: 1) stands with high basal areas, and 2) stands with low basal areas and high densities. Stands must meet existing criteria by site index in order to be harvested. Inner zone leave tree requirements differ between the two stand classes.

For stands with high basal area (110 to 150 square feet per acre of all species, depending on site index), harvest is allowed and must retain at least 50 trees per acre in addition to a variety of basal-area requirements (70 to 110 square feet per acre of all species, depending on site index). The 50 trees per acre must be composed of the 21 largest and 29 over 10 inches dbh. Where there are not 29 trees over 10 inches in dbh, the landowner will retain the 29 next largest trees. Where the basal-area requirements cannot be met with 50 trees per acre, the landowner will be required to leave additional trees over 6 inches dbh to achieve basal area per acre target. The landowner may be required to retain up to 100 trees per acre.

For stands with low basal area and high density, harvest is allowed in the inner zone of RMZs depending on number of existing trees and density. Following thinning, a minimum of 120 trees per acre must be retained. The 120 trees must be composed of the 50 largest trees plus 70 trees greater than 6 inches dbh or next largest available.

To the extent down wood is available on-site prior to harvest, at least 20 tons per acre of down wood of certain sizes must be left following harvest. The FPHCP requires retention of down wood, where available.

HIGH-ELEVATION TIMBER HABITAT TYPE

Harvesting in the inner zone of RMZs in the high-elevation timber habitat type is allowed if stand requirements can be met. Stand requirements and harvest rules are the same that apply to inner zone harvest for western Washington RMZs for Type S and Type F. To the extent down wood is available on-site prior to harvest, at least 30 tons per acre of down wood of certain sizes must be left following harvest, where available.

STREAM-ADJACENT PARALLEL ROADS, ALL TIMBER-HABITAT TYPES

For sites limited by roads in the inner zone, the allowable harvest is determined by the bankfull width and proximity of the road to the outer edge of the bankfull width or CMZ. Minimum shade requirements must be met whether or not the inner zone contains a stream-adjacent parallel road. No harvesting is allowed in that portion of the inner zone located between the road and water. When the edge of the road closest to the water is located within 75 feet (for waters with a bankfull width of more than 15 feet) or 50 feet (for waters with a bankfull width of less than 15 feet) of the outer edge of the bankfull width or CMZ, the FPHCP requires the retention of leave trees near streams in or adjacent to the harvest unit to offset those missing because of the road. Where WDNR identifies leave-tree limitations, the FPHCP prescribes site-specific management strategies to replace lost riparian functions. Such management strategies may include placement of LWD in streams.

Outer Zone

The outer zone begins at the outside edge of the inner zone and its width depends on site class and bankfull width (see FPHCP Tables 4.9 and 4.10). Timber harvest is allowed in the outer zone. Harvests must retain riparian leave trees depending on the timber habitat type. In the ponderosa pine timber habitat type, a minimum of 10 dominant or co-dominant trees per acre must be retained. In the mixed conifer timber habitat type, a minimum of 15 dominant or co-dominant trees per acre must be retained. Finally, requirements for high-elevation timber habitat type follow those for western Washington RMZs for Type S and Type F waters (e.g., 20 trees per acre).

Minimum tree counts must be met regardless of stream-adjacent parallel road presence. Outer zone leave-tree requirements for eastern Washington RMZs for Type S and Type F waters may be reduced to 5 trees per acre in the ponderosa pine timber habitat type, 8 trees per acre in the mixed-conifer timber habitat type and 10 trees per acre in the high-elevation timber habitat type if the landowner implements a LWD placement plan consistent with guidance contained in Forest Practices Board Manual Section 26.

Type Np and Type Ns Waters

As in western Washington, the FPHCP protection measures for non-fish-bearing waters in eastern Washington include ELZs adjacent to Type Np and Type Ns waters, RMZs adjacent to Type Np waters, and mitigating the effects of stream-adjacent parallel roads within RMZs of Type Np waters. ELZs would apply to all Type Np and Type Ns waters, are 30 feet wide and are measured from the bankfull width. As for ELZs in western Washington, operations exposing soil on more than 10 percent of a site in an ELZ requires mitigation. Mitigation will include replacing the equivalent lost riparian function,

particularly as it relates to the prevention of sediment delivery. Example measures include—but are not limited to—water bars, grass seeding and mulching.

RMZs for Type Np waters in eastern Washington consist of 50-foot wide RMZs on each side of the water. The FPHCP does not proscribe management strategies (i.e., partial or clearcutting) within these RMZs, except that the clearcutting option is not provided within 500 feet of a Type S or Type F confluence. For partial cuts, the FPHCP requires the same minimum basal area requirements as it does for Type S and Type F inner zones (see FPCHP, pp 184-188). For clearcut management, the FPHCP requires a 50-foot wide no-harvest RMZ along each side of a stream reach in the harvest unit. The RMZ must be equal in total length to the unbuffered portion of the stream reach in the harvest unit. Unbuffered portions may not exceed 30 percent of the stream length within the harvest unit. On a harvest unit basis, no more than 30 percent may be unbuffered, another 30 to 70 percent may be contained in no-harvest buffers, and up to another 40 percent may be partial harvest buffer. It is also possible for greater portions of the stream length to be managed with partial-harvest buffers.

Stream-Adjacent Parallel Roads within Type Np Riparian Management

If a road exists in a Type Np RMZ, and the basal area required to be left cannot be met within 50 feet of the outer edge of bankfull width of the stream due to the presence of the road, then the distance of the road to the stream determines the allowable harvest. If the edge of the road closest to the water is between 30 feet and 49 feet from the outer edge of the bankfull width, a total of 100 feet of RMZ (both sides of the stream count towards the total) must be left in a manner to provide maximum functions. If harvest is occurring on only one side of the water, an RMZ that is 50 feet wide must be retained that does not include the width of the stream-adjacent parallel road. If the edge of the road closest to the water is less than 30 feet from the outer edge of the bankfull width, in addition to the previous requirement, all trees between the water and the edge of the road closest to the water must also be retained.

Exempt Parcels

State law exempts parcels that are 20 contiguous acres or less and are owned by individuals whose total ownership is less than 80 forested acres statewide. These parcels are not subject to certain FPHCP riparian requirements. However, State law requires RMZs for Type S and Type F waters. The RMZ width cannot be less than 29 feet measured from the bankfull width (as opposed to bankfull width or CMZ as with standard Washington Forest Practices Rules) nor more than the maximum widths listed in FPHCP Table 4.7. When the RMZ overlaps a Type A or B wetland or wetland management zone (see Section 4d), the measure that best protects public resources must be applied.

Leave-tree requirements for Type S and Type F waters on exempt 20-acre parcels in western Washington are listed in FPHCP Table 4.8. The required ratio of conifer to deciduous leave trees—and the number and minimum diameters of leave trees—varies with water type and bankfull width. The number of leave trees also differs between gravel/cobble-bedded waters and boulder/bedrock waters. Landowners must still meet shade requirements on Type S or Type F streams as outlined in WAC 222-30-040; however, the 75-foot shade requirement would be measured from the bankfull width.

Along Type Np waters, WDNR can require tree retention on exempt 20-acre parcels where necessary to protect public resources. Washington Forest Practices Rules authorize WDNR to require the retention of at least 29 trees, 6 inches dbh, on each side of every 1,000 feet of stream length within 29 feet of the stream. More information on riparian protection on exempt 20-acre parcels in western Washington is contained in WAC 222-30-023(1).

In eastern Washington, RMZs for Type S and Type F waters in exempt parcels associated with partial harvests cannot be less than 35 feet or more than 58 feet. For other harvest types, buffers cannot be less than 35 feet, must average 58 feet, and are limited to a maximum width of 345 feet. Leave-tree requirements apply to these zones. When the RMZ overlaps a Type A or B wetland or wetland management zone, the measure that best protects public resources must be applied.

However, for eastern and western Washington, an exemption exists for situations where greater than 10 percent or more of the harvest unit lies within any combination of a riparian management zone of a Type S or F water, or a wetland management zone, then only 50 percent of the required trees must be left. Even so, the shade rules still apply.

Along Type Np waters in eastern Washington, WDNR can require tree retention on exempt 20-acre parcels where necessary to protect public resources. Washington Forest Practices Rules authorize WDNR to require the retention of 29 trees of at least 6 inches dbh on each side of every 1,000 feet of stream length within 29 feet of the stream.

Statewide Requirements

In addition to the riparian protection measures that are specific to western and eastern Washington, the Washington Forest Practices Rules include riparian requirements that apply throughout the State. These include requirements for the retention of shade along Type S and Type F waters, restrictions on the salvage of down trees and woody debris, and requirements for the maintenance of streambank stability. Each set of protection measures is described below.

Shade Retention

Shade requirements differ for forestlands within the Bull Trout Overlay and lands outside the Bull Trout Overlay. The Bull Trout Overlay includes portions of eastern Washington streams containing bull trout habitat as identified on FPHCP Figure 4.7. Within the Bull Trout Overlay, all available shade must be retained within 75 feet of the bankfull edge or CMZ edge, whichever is greater.

Outside of the Bull Trout Overlay, a temperature-prediction method must be used to determine shade requirements. The temperature-prediction method is used to establish the shade level necessary to meet the temperature standard. If pre-harvest shade levels do not meet the shade requirement, no harvest is allowed within 75 feet of the bankfull edge or CMZ edge. If pre-harvest shade levels exceed the shade requirement, harvest in the RMZ inner zone is allowed provided that shade levels are not reduced below the minimum required and that all other applicable rules are met. If anti-degradation standards under the State water quality standards are modified in the future, we expect that the Washington Forest Practices Rules would be modified as needed.

Salvage Logging

Washington Forest Practices Rules protect ecological functions and associated habitats by restricting salvage of down wood in typed waters, CMZs, and RMZs. Salvage logging is not allowed within the bankfull width of any typed water or within a CMZ, including salvage logging of any portion of a tree that may have fallen from outside the zone. Salvage logging within an RMZ for a Type S or Type F water is based on the sub-zone (core, inner, and outer zones) from which the tree originated, applicable stand requirements, and extent of previous harvest activity in the zone (FPHCP Table 4.11). Salvage

logging is not allowed within an RMZ for Type Np water or associated sensitive site, but may occur adjacent to Type Ns waters and the unbuffered portions of Type Np waters.

Streambank Integrity

Activities in the RMZ core zone for Type S and Type F waters and in RMZs for Type Np waters must ensure streambank integrity is maintained. Activities must avoid disturbing stumps, root systems, and any logs embedded in the streambank, as well as brush and other similar understory vegetation. Where necessary, high stumps must be left to prevent felled and bucked timber from entering the water. Trees with large root systems embedded in the stream bank must also be left.

3.3.3.3 FPHCP Wetland Protection Strategy

The FPHCP includes measures to avoid, minimize, and mitigate forest practices-related impacts to wetland habitats. Measures are intended to protect important ecological functions such as LWD recruitment, shade retention, sediment filtration, and the maintenance of surface and shallow subsurface hydrology. Protection measures include a wetland typing system, a wetland management zone (WMZ) adjacent to Type A and Type B wetlands, and the use of low-impact harvest systems in forested wetlands. Wetland protection measures are the same statewide.

Wetland Typing System

The FPHCP covers two broad categories of wetlands: forested and non-forested. Forested wetlands include any wetland or portion thereof that has—or if the trees present were mature would have—at least 30 percent canopy closure. Non-forested wetlands include any wetland or portion thereof that has—or if the trees present were mature, would have—less than 30 percent canopy closure. Non-forested wetlands are classified as either Type A or Type B. Type A wetlands include all non-forested wetlands greater than 0.5 acre in size, including any acreage of open water where the water is completely surrounded by the wetland, and are associated with at least 0.5 acre of ponded or standing open water. The open water must be present on the site for at least seven consecutive days between April 1 and October 1, or are bogs greater than 0.25 acre in size. Type B wetlands include all other non-forested wetlands greater than 0.25 acre in size.

Protection Measures for Forested Wetlands

The FPHCP allows harvest in forested wetlands. Harvest is limited to low-impact harvest systems to minimize effects on soils and hydrology. Low-impact harvest systems generally include ground-based equipment with tracks (e.g., shovel), cable-yarding machines, helicopters, and balloons. Also, when yarding logs, operators must keep at least one end of the log suspended when feasible.

When forested wetlands lie within a proposed harvest unit, landowners are encouraged to leave 30 to 70 percent of required wildlife reserve trees within the wetland. Wildlife reserve trees are defective, dead, damaged, or dying trees that provide or have the potential to provide habitat for wildlife species dependent on standing trees. In western Washington, the Washington Forest Practices Rules require the retention of three wildlife reserve trees and two green recruitment trees (i.e., trees left for the purpose of becoming future wildlife reserve trees) for each acre harvested. In eastern Washington, two wildlife reserve trees and two green recruitment trees must be retained for each acre harvested.

Protection Measures for Non-Forested Wetlands

Protection measures for Type A and Type B non-forested wetlands include limitations on harvesting in the wetlands. Harvest is not allowed in a Type A wetland that meets the definition of a bog. Individual trees or forested wetlands less than 0.5 acre in size that occur within a non-forested wetland, must be retained. They may be counted toward the WMZ leave tree requirement (see below). Harvest of upland areas or forested wetlands surrounded by a Type A or Type B wetland must be conducted in accordance with a plan that has been approved by WDNR in writing. No trees can be felled into or yarded across a Type A or Type B wetland without written approval from WDNR.

Non-forested wetlands are also protected through WMZ. WMZs must be established adjacent to all Type A and B wetlands. They are measured horizontally from the wetland edge or the point where the non-forested wetland becomes a forested wetland (see Forest Practices Board Manual Section 8 for delineation procedures). The required WMZ width depends on the wetland type and size. The average WMZ width must meet the requirement listed in FPHCP Table 4.12. To meet the average width, it can vary from the minimum width to the maximum width listed in FPHCP Table 4.12. When a WMZ overlaps an RMZ, the requirement that best protects public resources must be applied.

Harvest is allowed within WMZs according to several conditions. At least 75 trees per acre must be retained. These 75 trees should be greater than 4 inches in eastern Washington or 6 inches for western Washington. Of those 75 trees, 25 trees shall be greater than 12 inches dbh, of which 5 trees shall be greater than 20 inches dbh, where they exist. Leave trees shall be representative of the species found within the WMZ. The Washington Forest Practices Rules encourage that wildlife reserve trees should be located within the WMZ where feasible.

Partial cutting or removal of groups of trees within the WMZ is acceptable, within constraints of maximum width and spacing. Tractors, wheeled skidders, or other ground-based harvest equipment is not allowed within the minimum WMZ width without written approval from WDNR. And finally, when at least ten percent of a harvest unit lies within a WMZ, and either the harvest unit is a clearcut of 30 acres or less or the harvest unit is a partial cut of 80 acres or less, at least 50 percent of the 75 trees-per-acre requirement must be retained within that WMZ.

3.3.3.4 Protective Approaches in Logging Practices

The FPHCP includes protection measures that regulate the methods of harvest in riparian and wetland areas. Measures include limits on the felling and bucking of timber, on the use of ground-based equipment, and on cable yarding. Many of these measures are designed to minimize soil disturbance and reduce the potential for erosion and sedimentation and maintain other ecological functions as described below.

Felling and Bucking

Felling trees and bucking logs (cutting felled trees to length) in or adjacent to typed waters and RMZs must be conducted in a manner that protects riparian and in-stream habitat and water quality. Limitations on felling include no felling into the RMZ core zone of Type S or Type F waters, sensitive sites, or Type A or Type B wetlands. There is a limited exception for safety. Within the RMZ inner and outer zones of Type S and Type F waters, and within WMZ, felling must facilitate yarding away from typed waters. Trees may be felled into Type Np waters, but logs must be removed as soon as practical. Slash introduced to the Type Np water as a result of the falling must be removed. Reasonable care must be

taken to fell trees in directions that minimize damage to residual trees. Bucking or limbing of any portion of a tree lying within the bankfull width of a Type S, Type F, or Type Np water; in the core zone of RMZs, in sensitive sites, or in open water areas of Type A or Type B wetlands is not allowed.

Ground-based Equipment

Ground-based equipment use is prescribed to limit direct physical impacts to waters and wetlands and to minimize indirect impacts such as soil disturbance and associated erosion and sedimentation. Ground-based equipment is not allowed in Type S or Type F waters except with approval by WDNR and with an HPA issued by WDFW. Ground-based transport of logs across Type Np and Type Ns waters must minimize the potential for damage to public resources, and an HPA may be required. For Type A and Type B wetlands, ground-based equipment is not allowed. Where harvest occurs in forested wetlands, ground-based logging is limited to low-impact harvest systems. Ground-based equipment operating in wetlands is only allowed during periods of low soil moisture or frozen soil conditions.

In RMZs, use of ground-based equipment within an RMZ must be approved in writing by WDNR. When yarding logs in or through an RMZ with ground-based equipment, the number of routes through the zone must be minimized. Logs must be yarded to minimize damage to leave trees and vegetation in the RMZ.

In WMZs, ground-based equipment is not allowed within the minimum WMZ width unless approved in writing by WDNR. Where feasible, logs must be skidded with at least one end suspended from the ground to minimize soil disturbance and minimize damage to leave trees and vegetation in the WMZ.

Finally, skid trails must be sized, shaped, and located to minimize the contribution to overland sediment transport, through erosion and other means. Placement of side-cast material is limited to above the 100-year flood level. Skid trails running parallel or near parallel to waters must be located outside the no-harvest portions of RMZs and at least 30 feet from the bankfull edge of unbuffered portions of Type Np or Ns waters, unless approved in writing by WDNR. Skid trails must cross the drainage point of swales at an angle that minimizes the potential for delivering sediment to typed waters or where channelization is likely to occur. Skid trails out of use must be water-barred to prevent soil erosion. Skid trails located within 200 feet of any typed water that directly delivers to the stream network must have water bars, grade breaks, and/or slash to minimize sediment delivery to the water. Water bars must be placed at a frequency that minimizes gullying and soil erosion. In addition to water barring, skid trails with exposed, erodible soil that may be reasonably expected to cause damage to a public resource must be seeded with a non-invasive plant species (preferably native to the State) and adapted for rapid revegetation of disturbed soil, or be treated with other erosion control measures acceptable to WDNR.

Cable Yarding

No cable yarding in or across Type S or Type F waters, except where logs will not materially damage the bed of waters, banks of sensitive sites or RMZ. Yarding corridors through RMZ of a Type S or Type F water must be no wider or more numerous than necessary to accommodate safe and efficient transport of logs. On Type S or Type F streams, logs must be fully suspended unless exempted by an HPA. On Type Np or Ns streams, logs must be fully suspended unless exempted by a Forest Practices permit. When yarding logs across flowing Type N waters, the log must be fully suspended. A Forest Practices permit cannot be used to allow partial-suspension yarding across flowing waters. Generally, yarding corridors should be located at least 150 feet apart (measured edge to edge), and each should be no wider than 30 feet. Total openings resulting from yarding corridors must not exceed 20 percent of the stream length associated with the forest practices application. When changing cable locations, care must be taken to

move cables around or clear of the riparian vegetation to avoid damaging it. In Type A and Type B wetlands, cable yarding is not allowed without written approval from WDNR.

Yarding from or across FPHCP protected areas requires reasonable care to minimize damage to the vegetation that provides shade to the water, and to minimize disturbance to understory vegetation, stumps, and root systems. Uphill yarding is preferred. Where downhill yarding is used, reasonable care must be taken to lift the leading end of the log to minimize downhill movement of slash and soils. When yarding parallel to a Type S or Type F water, and below the 100-year flood level or within the RMZ, reasonable care must be taken to minimize soil disturbance and to prevent logs from rolling into the water or RMZ.

3.3.3.5 Other Programs for Riparian Protection

The FPHCP includes two programs that provide for the long-term conservation of riparian and aquatic habitats. The Forestry Riparian Easement Program and the Riparian Open Space Program were established to acquire, through purchase or easement, the most ecologically important habitats for species covered under the FPHCP. Unlike most FPHCP protection measures, the Forest Riparian Easement Program and Riparian Open-Space Program are voluntary programs that complement the mandatory requirements of the Washington Forest Practices Act and Rules. As part of the complete set of protection measures, these voluntary programs will help ensure that the Forest Practices program meets its goals, resource objectives and performance targets.

Forestry Riparian Easement Program

The Forestry Riparian Easement Program provides long-term protection for aquatic resources by acquiring easements from small forest landowners in riparian areas and other ecologically important areas. Easement areas typically include CMZs, RMZs, and WMZs, but may also include other areas, such as unstable slopes. Landowners interested in participating in the Forestry Riparian Easement Program must meet the definition of a “small forest landowner,” which is related to his/her prior 3-year average harvest level. Forestry Riparian Easement Program easements apply to “qualifying timber” and not the land on which the trees grow. “Qualifying timber” is trees that are covered by a forest practices application and that the small forest landowner is required to leave unharvested for the duration of the easement (i.e., 50 years). Landowners are compensated for the value of the qualifying timber between 50 and 100 percent of the value. This easement provides no public access to the property. The landowner may remove timber that is not part of the qualifying timber with the inner zone.

Riparian Open Space Program

Riparian Open Space Program ensures the long-term conservation of aquatic resources by acquiring a fee interest in, or easement on, lands and timber within a specific type of CMZ known as an “unconfined avulsing CMZ.” These areas typically have very high ecological value as spawning and rearing habitat for salmon and other fish species. Under the Washington Forest Practices Rules, no timber harvesting or road construction may occur within CMZs due to their ecological importance. The Riparian Open Space Program provides financial compensation for landowners with these types of CMZs who voluntarily sell the land to WDNR or place a permanent easement on the trees, land, or both. Participation is based on available WDNR funding and priorities.

3.3.3.6 Upland Protection and Roads

The FPHCP Upland Strategy consists of protection measures that are implemented in upslope areas outside riparian zones and wetlands. These measures are intended to limit forest practices-related changes in physical watershed processes—such as erosion and hydrology—that may adversely affect the quality and quantity of riparian and aquatic habitat lower in the watershed. The goal of the Upland Strategy is to prevent, avoid, minimize, or mitigate forest practices-related changes in erosion and hydrologic processes and the associated effects on public resources. Specific objectives of the Upland Strategy include preventing forest practices-related landslides, addressing the affects of forest roads on fish passage at all life stages, limiting sediment delivery to all typed waters, surface water and other hydrologic management, woody debris passage, protecting streambank stability, minimize the construction of new roads, and ensure that there is no net loss of wetland function.

Unstable Slopes

Protection measures related to unstable slopes and landforms are outcome-based, rather than prescriptive. Measures are derived through process in which, WDNR evaluates proposed timber harvest and road-construction activities on unstable slopes to determine if the activities will have a "probable significant adverse impact." The only exception to this outcome-based, decision-making process occurs in areas where watershed analysis has been conducted and approved, management prescriptions are in place to address unstable slopes, the prescriptions are specific to the site or situation and do not call for additional analysis, and the prescriptions are followed on the proposed activities.

The FPHCP recognizes four classes of unstable slopes: 1) landforms typically associated with debris avalanches, flows, and torrents (inner gorges, bedrock hollows, and convergent headwalls with slopes greater than 35 degrees or 70 percent); 2) landforms susceptible to debris avalanches (toes of deep-seated landslides with slopes greater than 33 degrees or 65 percent and the outer edges of meander bends along valley walls or high terraces of unconfined meandering channels); 3) groundwater-recharge areas of deep-seated landslides in glacial sediments; and 4) areas with indicators of potential slope instability that cumulatively indicate the presence of unstable slopes.

The FPHCP summarizes the process through which unstable slopes are identified in forest practices applications, and the procedures by which management practices are derived for each area identified. When unstable slopes are identified, the application must include an expert geotechnical assessment. WDNR staff also conduct an evaluation of proposals involving unstable slopes.

After review, WDNR issues a decision under the SEPA considering several issues. The first is if the proposal is likely to increase the probability of mass movement on or near the site. The second issue is whether sediment or debris would be delivered to a public resource or be delivered in a manner that would threaten public safety. Finally, the WDNR will consider whether such movement and delivery are likely to cause significant adverse impacts.

If WDNR determines the effects are likely to be significant under SEPA, the WDNR will accord mitigation measures. These will range from avoiding unstable slopes to altering the methods or techniques used in timber harvest and/or construction operations. Unstable slopes avoidance is the most commonly used mitigation measure and results in the lowest hazard and risk. Where timber harvest and/or construction activities occur on unstable slopes, a variety of mitigation measures are employed to reduce the likelihood of mass wasting. Harvest-related mitigation measures typically include minimum stand-density requirements to maintain rooting strength and slope hydrology, and full-suspension log

yarding to reduce soil disturbance and damage to residual vegetation. Construction-related mitigation measures often relate to the design and/or location of roads and landings. Full-bench end-haul (i.e., no fill or side-cast material) construction techniques are routinely required on unstable slopes. Where fill material is necessary, the use of quarried rock rather than "native" soil or fill is often required to increase the structural strength of road prisms and stream crossings. These are just a few examples of the many mitigation measures used to address unstable slopes issues. The measures used in a given situation are dependent upon the nature of the impact being mitigated.

Forest Roads

The FPHCP includes the Washington Forest Practices Rules that are designed to minimize negative road impacts through the proper location, design, construction, maintenance, and abandonment of forest roads.

Location and Design

Roads must fit to the topography to minimize alteration of natural features. This includes avoiding at-risk areas such as surface waters, wetlands, CMZs, RMZs, sensitive sites, unstable slopes, and ELZs. The FPHCP prohibits new road construction that would lead to duplicative or unnecessary roads. Design standards are mainly related to construction techniques and water management. The FPHCP encourages road designs that utilize balanced cut-and-fill construction to avoid side-casting of excess fill material. In steep terrain (>60 percent slopes), the FPHCP requires "full-bench" designs in which no fill material is used to construct the road prism and waste material is end-hauled or over-hauled to stable locations (e.g., on slopes less than 60 percent). Water-management requirements focus on maintaining hydrologic flow-paths and minimizing sediment delivery by limiting road-induced rerouting of water. Forest practices under the FPHCP include design standards for culvert sizing and drainage-structure spacing. The Washington Forest Practices Rules also require that roads be designed so that ditch water is relieved onto the forest floor to facilitate infiltration and minimize sediment delivery.

Construction

Road-construction requirements focus on maintaining stable road prisms and water-crossing structures, and on minimizing sediment delivery to surface waters and wetlands. The requirements are also intended to limit impacts to habitat during the construction process. New roads must maintain stable, intact prisms and water crossing structures to control erosion and sediment delivery. Road prism-related measures include limiting the volume of organic matter that can be incorporated into the road prism, compacting fills, removing construction-related debris and slash from culvert inlets, installing ditches and drainage structures concurrent with construction, depositing waste materials in stable locations and preventing side-casting of excess fill material on steep slopes. Measures that focus on maintaining the stability of water-crossing structures require the installation of structures that pass the 100-year flow, the construction of fills and embankments to withstand the 100-year flow, and the construction of headwalls and catch basins to accommodate the 100-year flow.

Road-construction measures in the FPHCP are designed to minimize sediment delivery from roads during and after construction. Requirements include limiting construction to periods of low soil moisture, end-hauling or over-hauling of waste material when side-casting would deposit sediment in areas where delivery to waters or wetlands may occur, sloping roads and landings to prevent water accumulation, and stabilizing exposed soils by seeding or other techniques approved by WDNR. If WDNR determines that the installation of a water crossing structure would result in unacceptable water quality impacts, the agency may require flow diversion around the site during construction.

Construction must also minimize impacts to riparian and in-stream habitats. The channel bed, stream banks, and riparian vegetation disturbance will be minimized. Disturbed areas must be stabilized and restored according to established schedules and procedures.

Maintenance and Abandonment

The FPHCP includes a road maintenance and abandonment program to prevent sediment- and hydrology-related impacts to public resources. Forest landowners must operate according to Road Maintenance and Abandonment Plans (RMAP) for roads within their ownership. Planning requirements differ for small and large forest landowners.

Large Landowners

The FPHCP requires large forest landowners to prioritize road maintenance and abandonment planning based on a "worst first" principle. Prioritization criteria include: 1) the presence of Federal or State listed threatened or endangered fish species or 303(d) listed water bodies; 2) the presence of sensitive geologic formations with a history of mass wasting; 3) the presence of planned or ongoing restoration projects; and 4) the presence of roads likely to have a high amount of forest-practices use in the future. Within each RMAP, maintenance and abandonment work is also prioritized: 1) removing fish blockages; 2) preventing or limiting sediment delivery; 3) disconnecting the road and stream networks; 4) repairing or maintaining stream-adjacent parallel roads; 5) restoring hydrologic flow-paths; and 6) capitalizing on operational efficiencies.

Small Landowners

Small forest landowners have two options for meeting road maintenance and abandonment planning requirements. Small forest landowners may follow the RMAP process for large landowners described above, or they may submit a "checklist" RMAP with each forest practices application or notification. Where watershed analysis has been conducted and approved, small forest landowners may elect to follow the watershed administrative unit-road maintenance plan rather than working under an RMAP. The smallest landowners (individual ownership of less than 80 acres of forestland in Washington and an application to operate on 20 acres or less) are not required to submit an RMAP or checklist RMAP for that parcel.

RMAP Implementation

Road maintenance and abandonment work carried out under a WDNR-approved RMAP must: 1) keep drainage structures functional, 2) divert captured groundwater from ditchlines onto stable portions of the forest floor, 3) maintain road surfaces to minimize erosion and delivery of water and sediment to typed waters, and 4) slope or waterbar road surfaces to prevent water accumulation. When abandoning roads, landowners must slope or waterbar roads to minimize erosion and maintain drainage, leave ditches in a condition that minimizes erosion, block roads so that 4-wheel off-road vehicles cannot pass the point of closure, and remove water-crossing structures and fills.

Practices Addressing Rain-on-Snow

The FPHCP addresses road-induced changes in hydrology by establishing standards for road construction, maintenance, and abandonment in areas affected by snowmelt. The Washington Forest Practices Rules address rain-on-snow effects in two ways in areas that have either undergone watershed analysis or have not. Watershed analysis in Washington State includes an assessment of timber-harvest-induced changes

in rain-on-snow generated peak flows and potential impacts to fish habitat, water quality, and public capital improvements. Specific management prescriptions are developed to address rain-on-snow effects in parts of the Watershed Analysis Unit (WAU) where significant hydrologic change is likely to occur and resources are sensitive to those changes. Prescriptions typically involve limits on clearcut harvesting.

Where watershed analysis has not been performed, a forest practices rule commonly known as the "rain-on-snow rule" gives WDNR authority to set conditions on permits for forest practices applications and notifications that propose clearcut harvesting in the significant rain-on-snow zone. Under the rain-on-snow rule, WDNR may limit clearcut size when it determines that peak flows have caused material damage to public resources including water, fish, wildlife, and public capital improvements. WDNR has prepared conditioning guidelines for implementing the rain-on-snow rule (FPHCP Appendix M). The guidelines describe the process for evaluating forest practices applications and notifications, and rely on a risk-based approach when conditioning clearcut size. Maximum clearcut size decreases as the risk of rain-on-snow effects increases. The guidelines direct applicants and WDNR to consider alternatives to clearcutting in high-risk situations.

3.3.3.7 Alternate Plans

An alternate plan is a tool forest landowners can use to develop site-specific management plans for forest practices regulated under the Forest Practices Act. WAC 222-12-0401 describes the alternate plan process, including their review by interdisciplinary teams. An alternate plan may deviate from the standard Washington Forest Practices Rules, as long as the plan provides public resource protection at least equal in overall effectiveness to the protections afforded by the Washington Forest Practices Act and Rules. Each plan must contain: 1) a map of the area covered; 2) a description of how the alternate plan provides public resource protection to meet the WDNR approval standard; 3) a list of the Washington Forest Practices Rules that the alternate plan is intended to replace; 4) descriptions of any monitoring or adaptive management strategies associated with the plan; 5) a description of an implementation schedule; and 6) justification showing that sufficient common physical characteristics exist for forest practices applications submitted separately under the same alternate plan.

Upon receipt of a forest practices application associated with an alternate plan, WDNR appoints an interdisciplinary team to determine if the plan provides resource protection at least equal in overall effectiveness to the protections afforded by the Washington Forest Practices Act and Rules. The composition of the interdisciplinary team is determined by WDNR; however, representatives of FWS, NMFS, WDFW, WDOE, and affected Native American Tribe are invited to participate. The team determines if the proposal meets the WDNR approval standard. If the interdisciplinary team provides WDNR with a consensus recommendation regarding alternate-plan approval, conditional approval, or disapproval, the agency is directed to give substantial weight to that recommendation when making its decision.

Guidelines for alternate plans are in the Washington Forest Practices Rules and Board Manual and include template prescriptions specific for small forest landowners. Template prescriptions are prescriptions for common situations that are repeatedly addressed in alternate plans. If a small landowner chooses to follow a template, the standardization of a template alternate plan will make the plan layout and approval process more efficient, while continuing to maintain protection of public resources. An example of a small forest landowner template is provided for overstocked conifer stands in western Washington (Forest Practices Board Manual section 21). The template includes a forest practices application for the overstocked stand template that small forest landowners would fill out and submit to

WDNR when proposing harvest in an overstocked conifer stand. The forest practice application includes information on how the prescriptions in this alternate-plan template provide for public-resource protection at least equal in overall effectiveness to the protections afforded by the Washington Forest Practices Act and Rules.

It is anticipated that the alternate-plan process for large and small forest landowners will continue to evolve and improve over the life of the FPHCP. Alternate plans for small forest landowners may incorporate longer timeframes and encompass a landowner's entire forestland property. WDNR's approval criteria for longer-term management plans will be developed in conjunction with the Federal agencies and will meet Federal ESA requirements. WDNR is responsible for conducting audits of landowners' compliance with the terms of alternate plans. The audit includes review and approval of each landowner's scheduled performance reports (either in the office or on-site) when a performance report is required. The audits will be consistent with the terms of any agreements with the Federal government regarding the protection of fish and water quality.

3.3.4 Administrative Framework within the FPHCP

The FPHCP administrative framework is the structure within which program participants work cooperatively to develop, implement, and refine the Forest Practices program over time. The four administrative components are: 1) program participants; 2) program development; 3) program implementation; and 4) adaptive management. The first three components are briefly summarized below.

Participants in the Forest Practices program include the Washington Forest Practices Board, certain programs within the WDNR, the Forest Practices Appeals Board, cooperating agencies, Native American Tribes, other natural-resource organizations, and the general public. These entities do the work of the program. They develop, implement, and refine the Forest Practices program to help it meet its goals.

Program development includes the processes by which the Washington Forest Practices Rules, Forest Practices Board Manual guidelines, internal policies, and technology-based tools are created. Forest practices activities conducted on covered lands must adhere to the Washington Forest Practices Rules; therefore, the rules represent the habitat-protection measures for covered species. Forest Practices Board Manual guidelines, WDNR internal policies, and technology-based tools supplement the protection measures by providing WDNR staff, forest landowners, and cooperating agencies and organizations with additional direction and information related to rule implementation.

Forest Practices program implementation follows program development. Once new or revised Washington Forest Practices Rules, Forest Practices Board Manual guidelines, internal policies, and technology-based tools have been developed, WDNR works with those program participants affected by the change to implement the new program components. This typically includes forest landowners who must comply with provisions of the Washington Forest Practices Act and Rules, and cooperating agencies and organizations that support WDNR in program implementation.

3.3.4.1 Adaptive Management and Program Refinement

The FPHCP includes a formal, structured adaptive management program that includes each of these components. The Services define adaptive management as a method for examining alternative strategies for meeting measurable biological goals and objectives and then, if necessary, adjusting future conservation management actions according to what is learned. The Services require an adaptive management strategy for HCPs that pose a significant risk to covered species at the time a Permit is

issued due to significant data or information gaps. The adaptive management strategy should: 1) identify the uncertainty and the questions that need to be addressed to resolve the uncertainty; 2) develop alternative strategies and determine which experimental strategies to implement; 3) integrate a monitoring program that is capable of detecting the necessary information for strategy evaluation; and 4) incorporate feedback loops that link implementation and monitoring to a decision-making process that results in appropriate changes in management. The FPHCP adaptive management approach follows the Services definition and requirements. The adaptive management program, like the broader Forest Practices program, consists of multiple components, each of which has a specific role in the adaptive management process. The following sections describe the components of the adaptive management program, the process by which adaptive management occurs, and the research and monitoring programs currently underway.

Components of the Adaptive Management Program

The Washington Forest Practices Rules instruct the Forest Practices Board to manage three adaptive management program participants: TFW Policy Committee (Policy); the Cooperative Monitoring, Evaluation, and Research (CMER) Committee; and the Adaptive Management Program Administrator (Administrator). The adaptive management program is divided into three functions: Policy; Science; and Implementation. WDNR is responsible for implementation.

The Forest Practices Board, established under the Act, is an independent State agency that establishes the Washington Forest Practices Rules. By law, the 12-member Board is constituted as follows: Commissioner of Public Lands (an elected official), four State Agency Directors, one elected member of a county commission or council (and appointed by the Governor), and six members of the general public, each of whom serves a four-year term after being appointed by the Governor. The law requires that one of those members own less than 500 acres of forest land; another member must be an independent logging contractor.

The Forest Practices Board manages the adaptive management program. The Board approves CMER Committee members, establishes key research and monitoring questions and resource objectives, approves research and monitoring priorities and projects, approves CMER budgets and expenditures, oversees fiscal and performance audits of CMER, participates in the dispute resolution process and considers recommendations from Policy for adjusting the Washington Forest Practices Rules and Board Manual guidance.

Policy makes recommendations to the Forest Practices Board regarding CMER priorities and projects, final project reports and the Washington Forest Practices Rule and/or Board Manual guidance amendments. Policy membership is self-selecting and generally includes the WDNR, WDFW, and WDOE; Federal agencies (including NMFS, FWS, EPA, and the USDA Forest Service (Forest Service)); forest landowners; Native American Tribes; local governments; environmental interests; and the Governor's office.

The CMER oversees and conducts research and monitoring related to Forest Practices program goals, resource objectives and performance targets. Its purpose is to advance the science needed to support the adaptive management process. CMER is charged with developing and managing, as appropriate: 1) scientific advisory groups and sub-groups; 2) research and monitoring programs; 3) a set of protocols to define and guide the execution of the CMER process; 4) a baseline dataset used to monitor change; and 5) a process for policy approval of research and monitoring projects and use of external information.

CMER is composed of individuals who have expertise in scientific disciplines to address forestry, fish, wildlife, and landscape-process issues, including mass wasting, hydrology, and fluvial geomorphology. Membership is approved by the Forest Practices Board and is open to the WDNR, WDFW, and WDOE; Federal agencies (including NMFS, FWS, and EPA); forest landowners; Native American Tribes; local governments; and environmental interests.

The Administrator is a full-time employee of WDNR and is responsible for overseeing the adaptive management program and for supporting CMER. The Administrator makes regular reports to Policy and the Forest Practices Board on program and project priorities, status, and expenditures. The Administrator has credentials as a program manager, scientist, and researcher.

CMER contracts the Scientific Review Committee (SRC) to carryout an independent, peer review process to determine if work performed by CMER is scientifically sound and technically reliable. The SRC is comprised of individuals who have experience in scientific research and who have no affiliation with CMER. SRC members are selected by the SRC coordinator and can be nominated by CMER. CMER determines what products should be subject to review by the SRC; however, the SRC generally reviews final reports of CMER studies, study proposals, final study plans, certain CMER recommendations, and pertinent studies not published in a CMER-approved, peer-reviewed journal. Other products that may require review include external information or data, work plans, requests for proposal, and progress reports.

Scientific review is conducted in a manner similar to the peer-review process used by many scientific journals. Communications are handled through the Administrator and include roles for a Managing Editor and Associate Editors. The Managing Editor receives materials from the Administrator, evaluates their readiness for review, and then transfers them to the appropriate Associate Editor. The Associate Editor selects a panel of two or three reviewers from a list developed by the Managing Editors, with nominations from Associate Editors and CMER. Forest Practices Board Manual Section 22 provides a more-detailed description of the adaptive management program and the guidelines for conducting adaptive management.

Research and Monitoring in Adaptive Management

The CMER Committee produces an annual work plan that describes the various adaptive management research and monitoring programs, associated projects, and work schedule. The plan will include several types of monitoring including Extensive, Intensive, Effectiveness, and Validation Monitoring. Effectiveness monitoring is designed to evaluate the degree to which Washington Forest Practices Rules and guidance meet performance targets and resource objectives. Validation monitoring will determine if the performance targets are appropriate for meeting the stated resource objectives. Effectiveness and validation monitoring are conducted at a site scale and generally focus on specific rule prescriptions or practices.

“Extensive” monitoring evaluates the statewide status and trends of key watershed processes and habitat conditions across lands covered under the FPHCP. Extensive monitoring is a landscape-scale assessment of the effectiveness of the Washington Forest Practices Rules to attain specific performance targets. This is different from effectiveness monitoring, which evaluates the effect of specific prescriptions or practices at the site scale. Extensive monitoring is designed to provide periodic measures of rule effectiveness that can be used in the adaptive management process to determine if progress is consistent with expectations. For example, extensive monitoring might address the question: Are higher than expected stream temperatures on covered lands decreasing with time and, if so, at what rate is the reduction occurring?

"Intensive" monitoring is a watershed-scale research program designed to evaluate cumulative effects and provide information that will improve our understanding of the interactions between forest practices and covered resources. An evaluation of cumulative effects at a watershed scale requires an understanding of how individual actions or practices influence a site and how the associated responses propagate downstream through the system. This understanding will enable the evaluation of the effectiveness of forest practices applied at multiple locations over time. Evaluating biological responses is similar and requires an understanding of how various actions interact to affect habitat conditions, and how system biology responds to habitat changes.

The FPHCP includes so-called "rule-implementation tools" that are projects designed to develop, refine, or validate protocols, models, and targets used to facilitate the implementation of the Washington Forest Practices Rules. Two types of "rule-tool" projects have been identified. First, Methodological Projects involve the development, testing, or refinement of field protocols and models used in the identification and location of important landscape features such as water-type breaks, unstable slopes, and sensitive sites. Current projects focus on developing a GIS-based, water-typing model, and a statewide landslide-hazard screen. Second, target verification projects are designed to assess the validity of performance targets thought to have an uncertain scientific foundation, such as the DFC basal-area targets for RMZs.

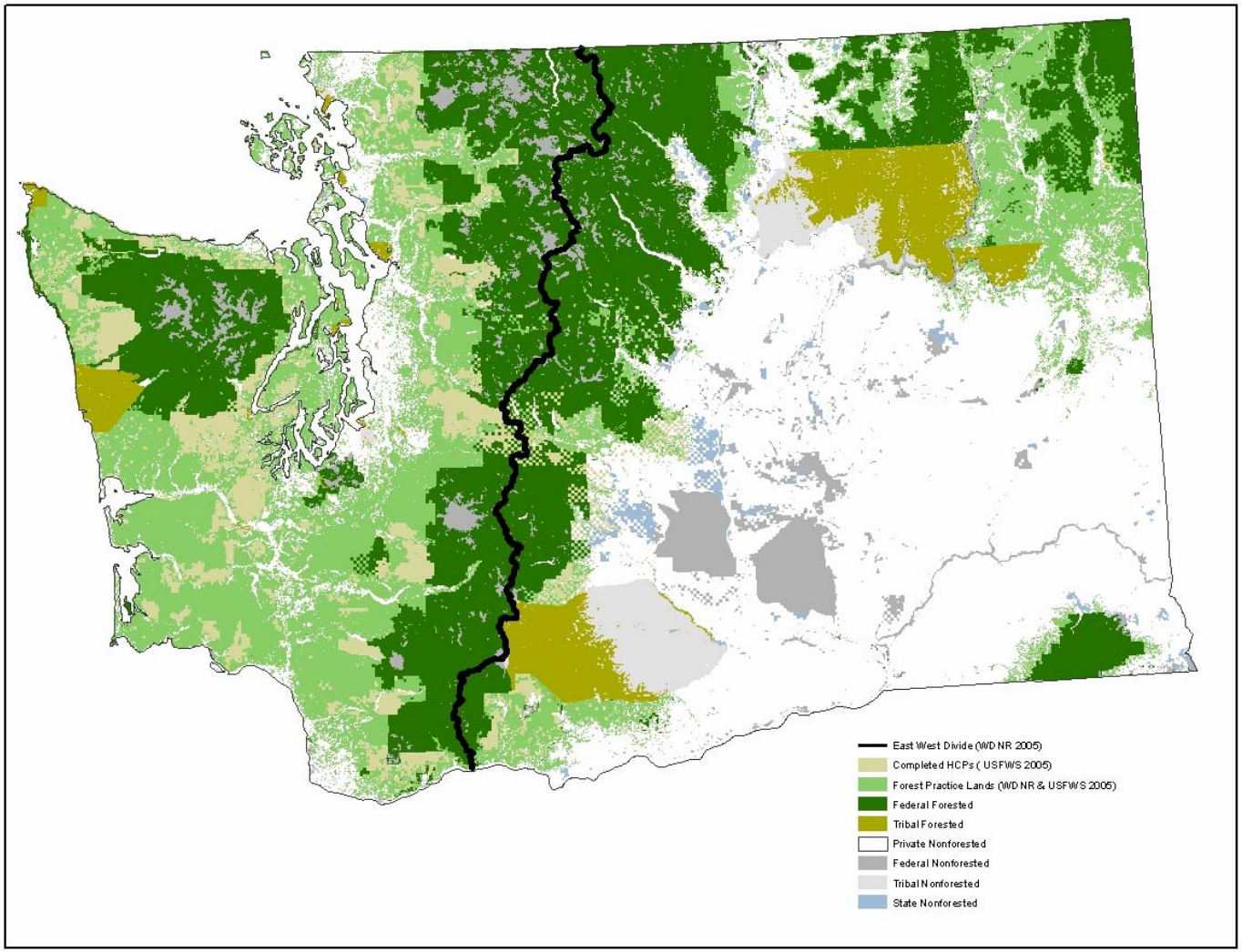
4. ACTION AREA

'Action area' means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 402.02). For purposes of this consultation, the action area includes all of the approximately 9.3 million acres of non-Federal, non-tribal forestland included as covered lands under the FPHCP; approximately 6.1 million acres of which are located west of the crest of the Cascade Range, and approximately 3.2 million acres are east of the crest of the Cascade Range in Washington (Figure 4-1). This acreage excludes all forestlands covered under existing, currently permitted HCPs with two exceptions. One is the Western Pacific Timberlands (*nee* Boise Cascade Corporation) single-species HCP that encompasses 620 acres and provides coverage for the northern spotted owl, but does not include coverage for aquatic species. The other is approximately 228,000 acres of the WDNR HCP on the eastside of the Cascade Crest of Washington. East of the Cascade Crest, the WDNR HCP provides coverage for a limited set of listed terrestrial species in this area (grizzly bears, wolves, spotted owls, and bald eagles), but does not include coverage for aquatic species. The forestlands contained within the Boise HCP and the WDNR HCP (on the eastside of the Crest) are considered covered lands under the FPHCP (FPHCP, Section 1-5 Lands covered by the plan, 2004).

Because physical effects from the proposed action may propagate onto other lands and waters, the action area also includes the following:

- The streams, rivers, and all stream-and river-associated wetlands downstream of the covered lands to the extent that physical effects such as turbidity or sedimentation may continue to be transported downstream. Although in most cases, the physical effects will cease to be measurable prior to confluence with the Columbia River, Snake River, and near-shore marine waters; however, those waters may in some cases be considered part of the action area.
- Lands surrounding the covered lands, where effects from factors such as windthrow, noise, and smoke may emanate as far as 400 feet onto those surrounding lands. The estimate of 400 feet resulted from estimated distances the above factors would travel with noticeable physical effects, and in consideration of typical distances from property boundaries that these activities would occur.

Figure 4-1. Forest lands proposed for coverage under the Forest Practices HCP, Washington



- Along roads adjacent to the covered lands, which are not on forested lands and are neither Federal or tribal lands, where roads located on adjacent lands may be subjected to additional effects resulting from hauling to and from the covered lands. These effects would only be measurable on smaller arterial and spur roads which are not generally managed for public use.

Much of the lands adjacent to covered lands are also forested (Federal, tribal, and HCP lands), but nonforested lands are also found adjacent to covered lands and may be considered to be part of the action area. As mentioned earlier, the action area may in some cases also include major rivers, lakes, and near-shore marine areas.

Finally, some FPHCP covered lands are adjacent to Canada, Idaho, and Oregon. Also, some FPHCP streams flow into Canada, Idaho, and Oregon. Therefore, minor portions of the action area may occur outside Washington State.

5. COMPREHENSIVE ENVIRONMENTAL BASELINE

Regulations implementing the Act (50 CFR § 402.02) define the environmental baseline as the past and present impacts of all Federal, State, or private actions and other human activities in the action area. Also included in the environmental baseline are the anticipated impacts of all proposed Federal projects in the action area that have undergone section 7 consultation, and the impacts of State and private actions that are contemporaneous with the consultation in progress.

The proposed action directly and indirectly affects major portions of Washington State. To adequately describe the current baseline, it is necessary to discuss many of the current conditions and past and on-going activities on a statewide basis. Various statistics used to describe these conditions and activities are not available specifically for the action area alone. This section of the Opinion will first describe a broad set of conditions and activities within Washington State. Much of the background provided in this section will provide a foundation for discussions regarding the context in which project-related effects are assessed and will provide information to be used in assessing cumulative effects.

The landscapes in the state of Washington are diverse: ranging from coastal rain forests, lowlands, and rich marine and estuarine habitats along the coast and Puget Sound in western Washington to prairies, forests, agricultural fields, and semi-deserts in eastern Washington. The Olympic Mountains and the Cascade Range, along with several volcanic mountains, contribute to the vast climatic differences in the state, creating rain shadows in some areas, and supporting rainfall amounts of over 180 inches per year in other areas. The State also contains numerous rivers, the largest of which, the Columbia River, flows over 1,200 miles and connects two countries and seven states to the Pacific Ocean.

The numerous ecosystems in Washington State support many different species of biota, including at least 140 mammal species, 470 freshwater and saltwater fish species, 341 bird species, 150 additional vertebrate species, 20,000 invertebrate species, and 3,100 vascular plants (Carlson 2005). Animal species may be permanent or seasonal residents of the state, with some using the available habitat as a resting and foraging stopover during migration to other areas.

5.1 POPULATION GROWTH AND DEVELOPMENT

Population growth in Washington affects the natural resources of this state on a day-to-day basis. As numbers of people increase, the demand for and use of natural resources increases, resulting in conversion

of lands and the extraction and expenditure of numerous types of resources for residences, employment centers, recreation opportunities, utilities, and associated new or expanded infrastructure to support this development. This section and the following sections will discuss population growth and associated development in Washington State, as well as some of the changes that have occurred as a result of population pressure.

Between 1990 and 2000, Washington's population grew by 1,027,452 people to a total of 5.9 million (U.S. Census Bureau). Approximately 62.7 percent of the state's population growth resulted from net migration (WSDH 2002). In 1998, the WDNR (1998a) estimated that in the following two years, Washington would experience a net gain of one person every five minutes. On the western side of the Cascades, the increase in the Puget Sound area accounted for 50 percent of the total population growth in the 1990s, down from 75 percent in the 1980s (U.S. Census Bureau 2000). In 1999, the Puget Sound portion of the Georgia Basin (i.e., the watershed of the Straits of Georgia, Juan de Fuca, and the Puget Sound) was home to nearly 3.9 million people—double the population of the mid-1960s. In Washington, as of 2004, approximately four million people live in the counties that border Hood Canal and Puget Sound (PSAT 2005).

Eleven Washington counties had populations of over 100,000 in 2000 (U.S. Census Bureau 2000): King, Pierce, Snohomish, Spokane, Clark, Kitsap, Yakima, Thurston, Whatcom, Benton, and Skagit Counties. In western Washington, which contains more than 75 percent of the state's residents (WSDH 2002), population growth and residential development are centered in the Puget Trough near Seattle (King County), Tacoma (Pierce County), and Olympia (Thurston County), as well as in Vancouver (Clark County). These developed areas have expanded east toward the Cascade foothills and passes, west toward the Kitsap Peninsula, and north and south along the Interstate 5 corridor. Residential and commercial development generally has tended to occur in low-elevation, low-gradient flood plains. This pattern of development has permanently converted other land-use types to a developed land base with increasing effects to, and with fewer benefits for, the natural environment. Population increases have generally occurred in the areas surrounding metropolitan areas. From 1990 to 1997 in western Washington, Thurston, Kitsap, Skagit, and Snohomish county population increases exceeded 20 percent. King and Pierce Counties gained the most in absolute terms (U.S. Census Bureau 2000).

The most-concentrated, major populations in Eastern Washington are found in metropolitan areas. According to the 2000 census, the Wenatchee area surpassed the 50,000-population threshold needed to designate the community as a metropolitan area, becoming the fourth such area in eastern Washington, along with Spokane, Yakima, and the Tri-Cities. While many counties have experienced growth in eastern Washington, most of the growth has centered around these largest cities.

As the population has grown, housing and infrastructure development has also increased. Approximately 45,727 housing permits were issued in Washington in 1998. The average home requires 120,528 pounds of concrete, 15,300 pounds of concrete block, 75,400 pounds of sand, gravel, and bricks, and 14,105 board feet of lumber (WDNR 1998a), which must ultimately be mined or harvested from natural sources and manufactured or processed. These figures do not include the raw materials necessary for the associated increases in commercial, industrial, community, and recreational facilities, such as schools, hospitals, and stores.

Aside from procurement of materials, urbanization results in other impacts to natural resources (Ferguson et al. 2001). Riparian habitats and their associated buffering abilities are reduced or lost as vegetation is reduced or replaced by impervious surfaces, structures, and bank stabilization. Materials such as LWD,

snags, and trees are often removed, limiting and sometimes eliminating future recruitment of LWD in aquatic systems, along with the complex habitat components (e.g., pools, riffles, off-channel habitats) that are formed by LWD. Streams and wetlands are often directly affected by dredging, filling, channelization, culverts, and other activities that impact biota and habitats. Water quality is degraded by inputs of pesticides, herbicides, and other contaminants via stormwater runoff on lawns, streets, and other impervious surfaces. Fluctuations in surface water and groundwater levels affect hydrology and biotic communities in the watershed. While each of these impacts is significant, their collective effects can be highly destructive to ecosystems without adequate planning.

Statewide efforts have been implemented to deal with large-scale development and habitat issues. The Washington State Legislature passed the Growth Management Act (GMA) (RCW 36.70A) in 1990 to encourage local jurisdictions to develop comprehensive plans to address several areas, including but not limited to, urban growth, reduction of sprawl, transportation, housing, economic development, natural-resource industries, and the protection of open space and the environment (RCW 36.70A.020). The Shoreline Management Act (SMA) was adopted by a public referendum in 1972 "to prevent the inherent harm in an uncoordinated and piecemeal development of the state's shorelines." The SMA applies to all counties and cities that have shorelines of the state located within their jurisdictional boundaries. Planning efforts for incorporating GMA and SMA goals in local jurisdictions is ongoing. While these and other tools have the potential to significantly reduce impacts of development on habitats and biota, the planning process is relatively complex and the outcome varies by jurisdiction. Because these processes are relatively new, are often considered controversial in many areas, and have not been finalized in all jurisdictions, any attempts to determine the relative success of the GMA and SMA in adequately protecting Washington's ecosystems would be premature.

5.2 INDUSTRY

Washington State supports a variety of industries (Washington State Employment Security Department 2005). These include, but are not limited to, transportation, manufacturing of durable (e.g., wood, metals, machinery, etc.) and nondurable (e.g., petroleum, chemical, plastics, paper and paper products, etc.) goods, construction, logging, agriculture, and mining.

Although not by definition an industry, there is also a network of military bases in Washington, with major facilities in several counties: Pierce (Ft. Lewis, McChord Air Force Base), Kitsap (Bangor and Bremerton Naval Stations, Keyport Undersea Warfare Center, Northwest Regional Maintenance Center), Snohomish (Naval Station Everett), Island (Naval Air Station Whidbey, Spokane (Fairchild Air Force Base), and Yakima (Yakima Training Center) Counties.

The impacts to natural resources from these entities vary, but many contribute to air pollution, water pollution and/or diversion, and habitat modification or destruction. To address these impacts, some companies and/or their associated regulatory agencies have initiated or participated in planning, restoration, or recovery efforts for species and habitats. Such efforts include, but are not limited to, HCPs, recovery plans (e.g., for bull trout, marbled murrelets, etc.), or project-specific conservation measures designed to reduce impacts to species and their habitats.

5.3 TRANSPORTATION

Extensive transportation networks have been constructed within the Puget Sound region. The construction and maintenance of these networks result in a number of impacts to ecosystems.

Construction and maintenance require extraction, transportation, and often the manufacture of materials. For example, some of the materials required for a construction project might include rock (e.g., gravel, riprap, etc.), asphalt, metal (e.g., for railroad tracks), concrete, creosote (e.g., to treat wooden bridge piers), and other natural resources that must be extracted, treated, processed, and hauled to the construction site via large vehicles. Impacts to species and habitats often result during the extraction and/or creation of these materials. Species and habitats may also be affected by physical modification of the environment as a result of construction, through fragmentation of habitat, reductions in floodplain connectivity and/or area, and the placement of barriers to fish and wildlife. For example, as bridges, culverts, and other artificial structures have been placed in various locations across Washington, associated impacts such as erosion, chemical contamination, and fish-passage barriers have degraded habitat for fish and other aquatic species.

Use of the transportation networks also contributes to ecosystem degradation as a result of spills, air pollution, contaminants from stormwater runoff, and other factors. Pipelines transport oil, gasoline, and other fuels throughout the region. Spills can occur from a variety of events, including transfer activities, vehicle collisions, and leaks. Air pollution comes from a number of sources, including, but not limited to, cars, trucks, ships, and other vehicles, as well as transportation network construction and maintenance activities. Roads and other impervious surfaces provide pollutants quick passage into waterbodies throughout Washington.

The following sections will describe the main categories of transportation in the state of Washington. These include unimproved and improved roadways, railways, ferry systems, pipelines, and ports.

5.3.1 Roadways

As of 1994, the State had approximately 80,000 miles of road which carried over 5 million vehicles (Green et al. 2000). The majority of these roads were in the Puget Sound area, with other significant areas in or near Spokane, Vancouver, and Yakima.

There are four major highway systems within western Washington, which also support a number of associated arterial networks. These include the Interstate 5 corridor running north and south along Puget Sound, which crosses all west Cascade river systems discharging into Puget Sound, the State Route 20 corridor running east and west through the Skagit River watershed, the U.S. Route 2 corridor running east and west through the Snohomish-Skykomish watershed, and the Interstate 90 corridor running east and west through portions of the Lake Washington and Snoqualmie watersheds. The most-intensive development in the region has occurred along these transportation corridors. Numerous arterial networks expand along these corridors, but the densest are associated with the urban centers along the Interstate 5 corridor.

There are two main interstate highways in eastern Washington. Interstate 90 bisects the state east to west, from Seattle through Spokane, and Interstate 82 provides a north-south route from Ellensburg through the Tri-cities into eastern Oregon. Secondary highways are the primary road link to international trade with Canada.

Pollutants from vehicles and roads include leaks (e.g., gasoline, oil, grease, transmission and radiator fluids), traction materials, de-icing chemicals, grit and contaminants from the roadways and easements, and air pollutants (e.g., carbon monoxide, nitrous oxides, particulates, lead, and trace toxins) (Green et al.

2000). On contact with rain, pollutants are dissolved from the air and can become water pollutants (Green et al. 2000).

5.3.2 Railways

In western Washington, a number of railways have been constructed along the lower reaches of major watersheds, along the Puget Sound nearshore, and roughly adjacent to the Interstate 5 corridor. These railways have links to the major shipping ports in the region, the Ports of Tacoma and Seattle, which are located in what was once extensive estuarine habitat (WSCC 1999b; KCDNR and WSCC 2000). Similar to the highway and arterial road networks in the region, these railway corridors cross numerous stream systems, or travel along or across nearshore habitat areas.

Railways are also extensive in eastern Washington. Three main lines cross west over the Cascades, generally paralleling U.S. Highway 2, Interstate 90, and Washington 14; eastbound lines cross into Idaho through Spokane and Clarkston. In addition, railways extend north into Canada along U.S. Highway 97 and 395, and Washington Highway 25, and are a primary link to international trade with Canada. Railways also extend south into Oregon near the Tri-cities. A well-developed rail network is associated with the U.S. Department of Energy Hanford site, but is controlled by the Federal government and does not carry commercial products.

Construction of these railways has contributed to the loss of side-channel habitat, the filling of estuarine habitat, the degradation of nearshore habitat, and constrained river CMZs (WSCC 1999a; WSCC 1999b; KCDNR and WSCC 2000; WSCC 2002a; WSCC 2002b). Spills or leaks may also occur during operations.

5.3.3 Ferries

A unique transportation network in western Washington is the Washington ferry system. Ferries have operated in the state since the early 1900s, with Washington State Ferry (WSF) Service beginning in 1951. Existing WSF service includes 10 routes, 20 terminals, and 28 vessels[1]. The WSF system transported over 11 million vehicles and 26 million people in fiscal year 1999. Other smaller systems, such as the Pierce County ferry system and the Kitsap Ferry Company, are also in use in western Washington.

Although relatively small when compared to other transportation networks, the construction and maintenance of infrastructure associated with ferry terminals have contributed to loss in continuity and degradation of some nearshore habitats. For example, treated-wood dolphin pilings and sheet pilings have contributed creosote or other contaminants, which are toxic to aquatic biota, into the substrate and water column in areas surrounding ferry terminals. Spills or leaks from a vessel or the vehicles it carries may also occur during operations or during collisions. Shading from infrastructure and turbulence generated from vessel propellers during arrival and departure has the potential to damage aquatic habitats (e.g., eelgrass beds).

[1] Washington State Ferry statistics are from the Washington State Department of Transportation website, accessed November 7, 2005. (http://www.wsdot.wa.gov/ferries/your_wsf/index.cfm?fuseaction=our_history)

5.3.4 Pipelines

Washington State contains approximately 43,000 miles of pipeline, including both large- and small-diameter pipes[2]. Natural-gas transmission, distribution, and/or associated service lines comprise the largest components of interstate (1,650.0 miles) and intrastate (>40,000 miles) pipeline transmission in Washington, with the remaining volume consisting of hazardous liquids (e.g., anhydrous ammonia, highly volatile liquids, crude oil, and other refined products). In addition to these pipelines, other Washington facilities transport water, wastewater, and other products.

Pipeline spills can happen due to a number of events[3]. For example, causes attributed to reported liquid pipeline spills over the past decade (with an average of 732.0 barrels/year from 1995-2004) included failure of a component, corrosion, incorrect operation, pipe failure, damage from outside forces, and "other" (undefined). Causes of natural-gas pipeline incidents for the same time period were similar to those for liquid pipeline spills, with incidents also caused by damage from excavation in the vicinity of the pipeline, fire and/or explosion, and problems with the equipment (e.g., weld). Spills can result in water pollution and air pollution, impacting habitats and species in the short or long-term.

5.3.5 Ports and Navigation

Washington supports a great deal of transportation that is dependent on water and air. There are a number of major water-based ports in several areas of Washington, including Puget Sound, Grays Harbor, the Columbia River, and the Snake River (WDNR 2000a). Washington is also home to 139 public-use airports[4] and other facilities.

Much of the navigation in western Washington is commercial, although recreational navigation is also extensive. The ports in Puget Sound are a significant and highly diversified destination for commercial shipping operations, with the Seattle and Tacoma ports hosting the second-highest volume of container traffic in the United States (PSAT 2005). Most navigation in eastern Washington waterways is recreationally based; commercial navigation occurs primarily on the lower Columbia and Snake Rivers, moving grain barges from as far as Lewiston, Idaho. There are also a number of barges that transport materials and equipment to and from the Hanford site.

Several types of activities have occurred to create and maintain the water-based ports. Tidelands have been filled, and waterways are dredged, channelized, and otherwise modified to accommodate deep-draft shipping vessels. In the Duwamish waterway in Seattle, more than 1,400 acres were filled by 1917, with approximately seven miles of dredged and channelized river currently associated with the port (WDNR 2000a). Industry is often concentrated in areas near ports, and can contribute to the introduction of contaminants into waterways. The shorelines of the lower Duwamish River have been used for port activities and industry since the early 1900s, and is on the National Priority List of Environmental Protection Agency Superfund Sites. As shipping traffic has increased over time, there has been an

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[2] From Office of Pipeline Safety Communications, accessed December 1, 2005. (http://www.cycla.com/stakeholders/StatePages/Washington.htm)

[3] From Office of Pipeline Safety Communications, accessed December 1, 2005. (http://www.cycla.com/stakeholders/StatePages/htmGen/WA_detail1_dd.html)

[4] Washington State Department of Transportation, accessed November 17, 2005. (www.wsdot/wa/gov/aviation/DocLibrary/WAStatePublicUseAP.pdf)

increased need for additional land-based transportation (e.g., trucks and rail cars) to transport goods that are transferred through the ports (WDNR 2000a)

Washington is one of the country's leading petroleum-refining centers. Large amounts of crude oil and petroleum products enter and leave the Georgia Basin (which includes Puget Sound and the Straits of Juan de Fuca and Georgia) via tankers, barges, and pipelines. Approximately 15 billion gallons of crude oil and other refined petroleum products are transported through Puget Sound annually (PSAT 2005). About 28 ocean-going commercial cargo vessels transit the Strait of Juan de Fuca daily, carrying up to two million gallons of heavy fuel oil (PSWQAT 2000). In the northern part of the State and southern British Columbia, spills (greater than 1,000 barrels) of crude oil are expected every 2.5 years and of all petroleum products every 1.3 years. Chronic oil pollution, including small spills, bilge seeps, dumping, and undetected slow leaks from coastal tanks, pumps, and pipelines is poorly documented, making an assessment of the level of threat difficult. More than 418,500 gallons of oil were spilled in the Puget Sound basin from 1993 to 2003, primarily from a single major pipeline spill and spillage from vessels (PSAT 2005). Spills during fueling and from pumping bilges of small commercial and recreational boats occur fairly commonly and may go unreported. Although individual spill releases of this type may be small, repeated releases to sensitive and productive near-shore areas can be very damaging to the Puget Sound environment. (PSWQAT 2000).

5.4 EFFECTS TO NATURAL RESOURCES

Human activities have significant and sometimes devastating effects on species and habitats through pollution and/or modification of the environment. Anthropological effects to surface water and groundwater resources generally occur through actions that influence water quantity or water quality, or both (Everest et al. 2004). Air-quality effects often result from emission from vehicles, industry, and other sources.

There are many different kinds of habitat-modification activities that have occurred in Washington throughout its settlement history. Habitat modifications in Washington include water diversion and storage, shoreline development, replacement of pervious surfaces with impervious surfaces, and loss of riparian buffers and wetlands. While human-induced impacts have occurred in Washington throughout its settlement history, recent activities have also included strategies and actions to reduce these impacts.

5.4.1 Water Quantity

There are approximately 265,129 stream miles in Washington; of these, 98,433 stream miles are located on lands subject to the Washington Forest Practices Rules, including existing HCPs (USFWS and NMFS 2006). Approximately 75,975 stream miles are located in western Washington, which includes the northern, southern, and western Puget Sound regions, together with the Islands region, Olympic coast, southwest Washington, and the Lower Columbia River regions. The remaining 22,458 stream miles are in eastern Washington, in the Middle and Upper Columbia River regions, the Columbia basin, and a portion of the Snake River basin that occurs in Washington.

Stream channels in many areas have been significantly altered by dredging, channelization, and the construction of dikes and revetments for flood control and bank protection. These activities have simplified once complex stream channels, degrading and eliminating important foraging, migration, and overwintering habitat for salmonids and other biota. Such changes can also result in the removal of riparian vegetation, precluding recruitment of LWD. Developments such as these can also reduce or

preclude options for restoration of floodplain areas important for reestablishing off-channel habitats and maintaining groundwater recharge.

5.4.2 Water Diversion

Dikes, levees, dams, and other diversions have reduced the level of watershed connectivity in several areas of Washington. Diversion projects have been implemented for a number of human needs, including but not limited to, flood control, conversion of wetlands to agricultural lands, bank protection, water supply, road construction, or a combination of these objectives.

Impacts to species and habitats from these actions have been significant. Palmisano et al. (1993) report that the most-severe effects to wild anadromous salmonids from dams and other fish-passage barriers have occurred in the Columbia River Basin, although there are several problem areas in western Washington.

5.4.2.1 Dikes and Levees

Many of the streams in Washington have been channelized, diverted, and confined through the construction of dikes, levees, berms, revetments, embankments, and other structures. The shapes and configurations of the structures vary based on their purpose; however, the construction of each kind of structure results in physical and biological impacts to the stream morphology and community (Bolton and Shelberg 2001). The construction of flood-control structures, tide gates, and water-diversion structures have contributed to the degradation and fragmentation of migratory corridors, and elimination of historical foraging, migration, and overwintering habitats within the region. Channelization (and often its associated bank armoring) results in simplification of the stream, and has resulted in changes in flow, velocity, and movement of water in many streams. These changes are often at least a portion of the goal of a project, which may be designed to reduce flood damage to property, exclude water, or store water for future use. While these changes may be favorable to property owners or project proponents, such actions often result in substantial changes to aquatic and terrestrial habitats and their use by biota.

The construction of dikes and levees has affected parts of the state since the 1800s. In western Washington, dikes were constructed to create and protect farmland, particularly in the lower-elevation areas of watersheds, including mainstem rivers, major tributaries, and estuaries. For example, the Nooksack, Lower Skagit, Stillaguamish, Snohomish-Skykomish, and Puyallup watersheds have been significantly altered by diking of their floodplains and estuaries. The Skagit River delta, the largest estuary in Puget Sound, was one of the first to be converted from tidal wetlands to agriculture. The Nooksack is one of the few rivers in Puget Sound where significant estuarine habitat loss from diking has not occurred, although the river was diverted from Lummi Bay to Bellingham Bay about 100 years ago. Levees have been constructed for flood protection and other purposes. Some levees are constructed or maintained by government agencies (e.g., U.S. Army of Corps Engineers); others are maintained by local entities (e.g., counties or diking districts).

Dikes and levees result in a number of impacts to aquatic species and habitat. Aside from loss of estuarine habitat from construction, dikes reduce tidal flushing, sometimes resulting in increased sedimentation; dikes also may have marked effects on tidal channel biota on the seaward side of the structure (Hood 2004). The construction of dikes may result in decreased sinuosity and complexity in certain channels, and prevent energy dissipation during flood events.

Recent restoration efforts have focused on the benefits of restoring ecosystem functions affected by diversion structures. In 2002, the Nisqually Tribe removed a portion of a dike in Red Salmon Slough, reconnecting 31 acres of former pastureland to the Nisqually River Estuary (SPSSEG 2002, Carlson Personal Communication, 2005a). This action was undertaken to benefit juvenile salmonids, other fish species, and migratory birds. At Spencer Island in Snohomish County, two 250-foot-long breaches were made in an estuary dike to reconnect approximately 250 acres of estuarine marsh (Carlson, Personal Communication, 2005b).

5.4.2.2 Culverts and Other Fish-Passage Barriers

Improperly installed, sized, or failed culverts have been identified as barriers for fish movement and migration throughout Washington. WDFW estimates that 33,300 road crossings are high-priority (partial or complete) fish-passage barriers, and impair access to 40,000 miles of significant upstream habitat (B. Peck, Personal Communication 2005a). Approximately 8 percent of these barriers occur on state-owned land, while higher percentages occur on Federal (14 percent), county and local jurisdictional (14 percent), and private lands (64 percent) (B. Peck, Personal Communication 2005a). WDFW also estimates that an additional 13,000 barrier culverts exist with limited upstream habitat, and 5,600 dams are barriers to fish passage in Washington (B. Peck, Personal Communication 2005a).

Although historically placed, fish-passage barriers continue to impede fish passage in many streams in Washington. A number of groups have made efforts to inventory and remove fish barriers under their jurisdiction, often either removing barrier culverts or replacing them with a more-suitable structure (Peck, Personal Communication, 2005b). Removal of fish barriers may be achieved through several different kinds of activities (Peck, Personal Communication, 2005c). Several design options are described in detail and design criteria are provided in WDFW's Design of Road Culverts for Fish Passage (Bates et al. 2003). Removal of a barrier culvert is often undertaken when a crossing is no longer needed. If a crossing is necessary, other options include bridges or other specific methodologies: stream simulation, roughened-channel design, no-slope methodology, or hydraulic design.

Statewide, WDFW is coordinating with other entities to correct fish-passage barriers at a rate of approximately 10 barriers per year, and estimate an additional 30-60 barriers are addressed annually by other entities (B. Peck, Personal Communication 2005a). Examples of planned or recently completed projects include culvert removals in Stearns Creek (Lewis County), Peterson Creek (Mason County), and Glover Creek (Snohomish County); respectively, these projects will allow access by salmonids to over 7.5 miles (12,000 meters), 3.5 miles (5,600 meters), and 1.2 miles (2,000 meters) of rearing and spawning habitat (B. Peck, Personal Communication, 2005b). The Washington State Department of Transportation reports that 142 barriers have been removed as of March 2005[5], with more than 391 miles (630 linear kilometers) of salmonid habitat reopened. The Salmon Recovery Funding (SRF) Board (2005) provided funding for projects to modify or remove 132 barriers for fish passage, reporting an estimated 456 miles of habitat access for salmonids. The South Puget Sound Salmon Enhancement Group (SPSSEG) (2002) reported the replacement of a culvert with a bridge to remove a barrier for salmonids on Sherwood Creek (Mason County). Other barrier culverts and/or tidegates have been replaced in several areas, including Jefferson County (Upper Tarboo Creek) and Skagit County (McElroy Slough), reconnecting spawning grounds and refugia areas for anadromous salmonids (Carlson, Personal Communication, 2005b). Recent

[5] From WSDOT website: http://www.wsdot.wa.gov/environment/fishpass/default.htm (accessed November 7, 2005)

examples in eastern Washington include culverts replaced by the Okanogan and Wenatchee National Forests in the Entiat and Twisp Rivers (Krupka, Personal Communication, 2005).

5.4.2.3 Dams

There are currently approximately 1,025 dams obstructing the flow of water in Washington, with approximately 10 new dams added each year, generally small facilities on off-channel or side streams (WDNR 2000a; Green et al. 2000). Dams are built for many purposes, including power generation, irrigation, flood control, recreation, and water supply (WDNR 2000a). These facilities have far-reaching effects on both aquatic and terrestrial habitat and biota. The controlled flow from a dam facility often slows the movement of the rivers, and changes the natural cycle of river flows, resulting in areas that are either drier than normal (because the water is being held behind the reservoir) or flooded by much higher levels of water. Changing the depth and flow of rivers also affects the water's temperature, either increasing or decreasing temperatures from the normal state. Dams affect the flow of many different materials (e.g., sediments, nutrients, and other materials such as LWD) carried in the river waters. Free-flowing rivers regularly flood and recede, collecting and depositing these materials both laterally and downstream. For example, rivers carry a great deal of sediment and nutrients down river, eventually depositing it in the deltas and estuaries where freshwater enters saltwater. Dams arrest this process; consequently, reservoirs eventually fill with sediments and inadequate amounts of sediment reach the downstream deltas and estuaries. Coastal beaches in turn lose the source of sand normally deposited on them by coastal currents that would ordinarily redistribute the sediments.

Dams often delay or block passage of anadromous fish to upstream reaches of the stream; such an obstacle can increase predation rates on these fish, cause injury or mortality as fish are trapped in unscreened canals or attempt to travel through turbines. In many cases, dams have likely been constructed at or near historical natural barriers to anadromous fish passage (USFWS 2004). The ability of anadromous fish to access areas above man-made barriers is important not only for the survival of individuals and populations of the species, but also for the integrity of the ecosystems they support (Cederholm et al. 2000). Anadromous fish provide organic matter and nutrients to both aquatic and terrestrial habitats via their carcasses, eggs, milt, excrement, and fry. Staging and spawning adults are also consumed as prey by aquatic and terrestrial predators. The organic matter and nutrients contributed by anadromous fish enrich macroinvertebrate and terrestrial communities, which in turn provide food for other organisms, including anadromous salmonid fry and juveniles. Scavenging and predatory fish, birds, mammals, and other animals also consume fry, juvenile, and adult salmon, their eggs, and their carcasses, often leaving remnants of carcasses in a more-accessible form for smaller scavenging fauna. Rich marine-derived nutrients from anadromous fish are transported to the reach of stream in which they die, into the lower reaches of the stream and estuary through downstream drift, and across habitat or ecosystem boundaries by mobile mammals, birds, and fish.

Certain facilities have implemented fish-passage structures or transport systems to allow upstream movement of anadromous fish; however, the risk of disease, stress, and other interference with migration and reproduction may occur as a result of these systems. The major facilities for each subregion of Puget Sound[6] and the Columbia Basin are described below.

[6] Some regions of Puget Sound do not have major dams associated with them, although smaller facilities may exist. These include the Island (e.g., San Juan Islands) and Olympic Coast regions.

Western Washington/Puget Sound

A number of dams exist in the Northern Puget Sound region. Two dams on the upper Skagit River and two dams on the Baker River are major hydropower storage facilities that modify the seasonal and daily discharge in the Skagit River, and have a substantial impact on the Skagit System (WSCC 2003). Smaller dams are scattered elsewhere, but have relatively little effect on mainstem hydrology. The upper Skagit River, above the Gorge Dam, was naturally inaccessible to anadromous fish, with the possible exception of steelhead. The Skagit River dams have prevented the transport of large wood to downstream areas; in conjunction with past wood-removal efforts, this has significantly contributed to the reduction of historical habitat complexity in the Lower Skagit River mainstem and estuary (USFWS 2004).

The dams on the Baker River have altered the historical anadromous connectivity with the rest of the lower Skagit system. The Baker River dams have upstream and downstream fish-passage structures. A trap-and-haul facility exists at the Lower Baker Dam and smolt traps are used at both Baker and Shannon Lakes. In recent years, these structures have functioned well enough to contribute to the recovery of Baker River sockeye salmon (Gary Sprague, Personal Communication, WDFW, 2003).

A small hydropower project reduces total discharge on the Tolt River, a tributary to the Snoqualmie River. In addition, at least four run-of-the-river hydropower projects exist in the region; one on the Nooksack River and three on the Snoqualmie River. Except for run-of–the-river projects, these river facilities have been trapping substrate for decades, and the downstream reaches are gravel deficient. Most of the dam sites also intercept LWD and do not pass it downstream. These two actions can cause the downstream channel to incise and/or become simplified, thus impacting fish habitat. Water withdrawal can reduce available fish habitat and alter sediment transport. Hydropower projects can also fluctuate stream flows, stranding and often killing fish and reducing aquatic invertebrate productivity (Hunter 1992).

The southern region of eastern Puget Sound also contains several dams. The Cascade headwaters of the Cedar and Green Rivers are both managed as municipal water supplies and are dammed to provide storage to meet summer water demands for urban areas. The activities of Seattle and Tacoma are addressed by HCPs; U.S. Army Corps of Engineers' dams are not covered by HCPs. The Mud Mountain Dam on the White River diverts flow to Lake Tapps, a recreational and residential development. Discharge from Lake Tapps is used to generate power. Both facilities use trap-and-haul facilities for adult anadromous salmonids, although the timing of operations (e.g., year round or seasonally) have varied throughout their history. The Electron Dam is a run-of-the-river project that reduces flow in the upper Puyallup River for approximately 8 miles. A new fishway was constructed at this facility to improve upstream fish passage and has been fully operational since October 13, 2000 (USFWS 2004).

The Nisqually River watershed is affected by three major dams. The upper Nisqually River has two large dams, the Alder and LaGrande. Alder Dam is the largest in this region. For nearly 30 years, the facility at LaGrande was operated for peak power, creating rapid changes in downstream flows. This was especially adverse during the summer and fall low-flow months, and is attributed with driving Nisqually spring Chinook salmon to the point of extinction by the early 1950s (NCRT 2001). In downstream reaches of the watershed, the Yelm Hydropower Project on the lower Nisqually River reduces flow in a 10-mile stretch of the river. This project historically provided varying degrees of fish passage, with a standard fish ladder installed in 1955.

Except for the two run-of-the-river projects, these dams have been trapping substrate for decades, and the downstream reaches are gravel-deficient. Most of the dam sites also intercept LWD and do not pass it

downstream. These two actions tend to promote downstream channel incision and/or simplification, limiting fish habitat. Water withdrawals reduce available fish habitat and alter sediment transport. Hydropower projects often result in fluctuating flows, which often strand and kill fish and reduce aquatic invertebrate productivity (Hunter 1992). At some storage dam sites, benefits to fish habitat may be realized by increased summer flows.

In the western Puget Sound region, hydropower storage dams are operating on the Elwha River and the North Fork Skokomish River, and both dams contribute to downstream gravel depletion (WSCC 1999, WSCC 2003b). Other small hydropower projects and municipal water diversions may have localized impacts to the aquatic environment (WSCC 1999, WSCC 2003b). The Elwha River dams (Elwah and Glines Canyon dams) block anadromous fish access to 70 miles of the upper Elwha River (however these dams are slated for removal in 2008). The dams on the Elwha are examples of structures that result in significant downstream impacts. The dams have impacted the estuary, beach morphology, and eelgrass beds. The dams have prevented recruitment of fluvially transported sediment, and at least 366 meters of shoreline have been eroded during the period from 1939 to 1994 (WSCC 2000a; USFWS 2004).

On the North Fork Skokomish River, historical anadromous fish access to the dam sites is uncertain; however, the hydropower plant diverts flow directly to Hood Canal, and thus bypasses a substantial portion of the flow from 17 miles of habitat. Loss of flow in the North Fork Skokomish River has resulted in reduced sediment-transport capacity, loss of fish spawning and rearing habitat, reduced channel capacity, and more-frequent flooding (USDA 1995). Reduced flows have also significantly altered sediment size and sedimentation patterns in the delta, which has resulted in increased erosion at the outer edge of the delta and increased sediment deposition at the inner edge. These impacts to the intertidal zone have contributed to reduced biological productivity of the estuary and reduced sizes of eelgrass beds at the mouth of the Skokomish River. Herring, a prey species for many piscivores, rely on eelgrass beds for spawning habitat (O'Toole et al. 2000). Eelgrass beds also provide important habitat for juvenile salmonids. Decreasing eelgrass beds create negative cascading effects on these and other aquatic species.

Southwest Washington

Medium-sized dams currently exist on the Wynoochee River and Skookumchuck River. These dams capture sediment and contribute to channel incision and bedrock dominated channels downstream. Gravel supplementation is currently occurring at the Wynoochee Dam. Both the Wynoochee Dam and the Skookumchuck Dam use storage to enhance summer flows (WSCC 2001). The Wynoochee River Dam has upstream and downstream fish-passage facilities. The downstream passage facilities are still only partially effective (DeMond, Personal Communication, 2003); however, self-sustaining runs of coho and other species return to the upper river. The Skookumchuck Dam has upstream fish-passage facilities, which are used to pass steelhead above the dam.

Columbia and Snake Rivers

There are 15 major hydroelectric dams on the main stems of the Columbia and Snake rivers in Washington. This is the most hydroelectrically developed river system in the world (WDNR 2000a). According to Bonneville Power Administration, there are 55 major hydroelectric projects on the Columbia River and its tributaries, 30 of which are owned and operated by the U.S. Army Corps of Engineers, and the remaining 25 facilities are operated by various private and public entities. The dams erected in the river and its tributaries created large reservoirs that provide flood control and water for vast

irrigation systems on the Columbia Plateau. As with dams in western Washington, these dams have caused drastic changes in seasonal flow, sediment discharge, water temperature, fish communities and water chemistry. General impacts to salmonids, other biota, and habitats from the Federal Columbia River Power System include the following (USFWS 2002; WDNR 2000a):

- fish-passage barriers and entrainment
- inundation of fish spawning and rearing habitat
- modification of the stream-flow and water-temperature regime
- dewatering of shallow water zones during power operations
- reduced productivity in reservoirs
- gas supersaturation of downstream reaches
- loss of native riparian habitats
- water-level fluctuations interfering with establishment of riparian vegetation along reaches affected by power-peaking operations, and establishment of non-native vegetation along affected reaches
- loss of sediment loads at the mouth of the Columbia River, and associated lack of distribution to other coastal areas by north-south currents along the Pacific Coast

Lower Columbia River

Three dams were constructed on the Cowlitz River, the latest of which (Cowlitz Falls) was constructed in the early 1990s. These facilities significantly modified gravel supply, resulting in a decline in the quality of downstream spawning substrate. A number of studies suggest that much of the natural spawning occurring below the dams is from hatchery strays, and not a result of self-sustaining natural production (DeVore 1987 in WSCC 2000b). The third dam on the Cowlitz River (Cowlitz Falls) was constructed in the early 1990s. Downstream fish-passage screens were constructed as part of the structure. Currently, juvenile fish coming down the river are trapped and trucked around the dams; many of these fish would have previously residualized in Riffe Lake, the large reservoir behind the second dam. This trap has been mostly successful in establishing self-sustaining runs of spring Chinook, coho, and steelhead in the upper Cowlitz basin. However, the downstream migrant trap cannot capture fish during flood flows; thus many juvenile out-migrants still end up in Riffe Lake (Craig Olds and Lauri Vigue, Personal Communication, 2003). Even if this trap becomes completely successful, only part of the historical potential of this watershed would be restored. A substantial section of the middle Cowlitz Basin remains inundated or inaccessible.

Three hydropower dams were built on the Lewis River, modifying the hydrology and gravel supply. The mainstem of the Lewis River below the lowest dam is largely bedrock and boulders. Flow fluctuations from hydropower peaking may cause stranding and fish kills (WSCC 2000a). The dams on the Lewis River remain a total blockage to anadromous fish use (WSCC 2001).

The construction of the Cowlitz and Lewis River dams constitute the two largest losses of anadromous fish access in western Washington State. In both systems, the loss of natural fish production was compensated with the construction of hatcheries, a common practice during 1940s and 1950s when these dams were constructed. Over 300 miles of accessible fish habitat were lost above Mayfield Dam on the Cowlitz, and roughly 150 miles above Merwin Dam on Lewis River. In both cases, 80 to 90 percent of the production potential had been lost (WSCC 2000b, 2000d).

Following the eruption of Mt. St. Helens, a sediment-retention structure (SRS) dam was constructed on the North Fork Toutle River. A fish trap was constructed to pass fish over the SRS dam. Despite elaborate measures to flush silt out of the trap, operation of the trap was only partially successful. Since the habitat above the dam is still recovering from the eruption and associated disturbances, fish production above this structure is quite limited at this time. However, most of the land above the SRS is preserved in parks and wildlife refuges, thus the long-term prospects for habitat recovery are good (Craig Olds, Personal Communication, WDFW, 2003).

Condit Dam, on the White Salmon River, was built in 1913, and blocked anadromous fish access to most of the basin. Negotiations are currently underway to remove this dam and restore access. Hydropower dams on the Lower Columbia mainstem that affect fish passage include Bonneville, The Dalles, and McNary dams.

Middle Columbia River

Of the five major storage reservoirs in the Yakima Core Areas (Kachess, Keechelus, Cle Elum, Bumping, and Rimrock), all but Rimrock Lake (Tieton Dam) were historically natural lakes. The dams built across the lake outlets greatly enlarged their surface area and flooded large areas of stream habitat. In 1948, the Columbia Basin Project began transporting Columbia River water to more than 600,000 acres on farms in Central Washington. Construction of dams within the Yakima River Basin in the 1900s to provide water storage for irrigation precluded anadromous salmonid passage to 112 miles of highly productive reaches upstream. Downstream of the Cle Elum, Tieton, Wapatox, Keechelus, Sunnyside, and Prosser Dams, the dewatering of extensive reaches of the Yakima River precluded upstream migration of adult salmonids, reduced spawning habitat, dewatered redds, and impaired/eliminated juvenile salmonid rearing in these reaches (WSCC 2001).

Within the Columbia River mainstem, hydropower operations have resulted in either complete or partial fish-passage barriers both up and downstream. Power operations have also affected fish movement through reservoirs by stranding fish in shallow areas and removing access to important spawning areas in tributary streams during drawdowns (Mainstem/Systemwide Habitat Summary 2002). Adult and juvenile salmonids have been precluded from historical spawning and rearing habitats by dams at major storage reservoirs (e.g., Tieton, Bumping, Cle Elum, Keechelus, and Kachess dams within the Yakima; Hemlock Dam within the Wind; Ice Harbor, Lower Monumental, Little Goose, and Lower Granite in the Middle Columbia mainstem). In addition, upstream adult fish passage was precluded at Roza Dam from its completion in 1940 until the installation of the fish ladder in 1989.

Upper Columbia River

Twenty-one dams exist within the U.S. portion of the Okanogan watershed. The Similkameen River is impassable to all anadromous salmonids at Enloe Dam, with 95 percent of the available potential fish habitat upstream. Diversions in Loup Loup, Salmon Creek, and Antoine Creek prevent full use of the habitat potentially available in those systems (Okanogan/Similkameen Subbasin Plan 2002). Dams are also present in the Entiat system. With the construction of the Grand Coulee Dam in 1939, anadromous salmonids were barred from 1,140 miles of potential spawning and rearing habitat in the upper Columbia River drainage (Fish and Havana 1948, WSCC 2000). Grand Coulee Dam is a complete barrier to anadromous fish.

There are also a number of dams located above Grand Coulee Dam. Five hydroelectric dams, all lacking fish-passage facilities, are located on the Pend Oreille River (WDFW 1998). The construction and

operation of Albeni Falls, Box Canyon, and Boundary Dams on the Pend Oreille River have fragmented habitat and negatively impacted migratory salmonid trout. Other dams and diversions without fish-passage facilities in tributaries to the Pend Oreille River have further fragmented habitat and reduced connectivity (USFWS 2002). These dams have altered habitats (i.e., stream flows, sediment, temperature regimes), migratory corridors, and interspecific interactions. Upper Columbia River mainstem dams have changed the habitat from that of a cold fast-moving river, to a warm reservoir and include Priest Rapids, Wanapum, Rock Island, Rocky Reach, Wells, and Chief Joseph (NPPC 2001). Typical spawning, rearing, and overwintering habitat in a free-flowing river with pools, glides, riffles, and side-channel habitats have been eliminated (USFWS 2002). The historical salmon fishery, already in decline, was brought to an abrupt end by the construction of Little Falls Dam on the Little Spokane River in 1910 (WDNR 1997a).

Within the upper Columbia River mainstem, hydropower operations have resulted in impacts to fish passage that are similar to those in the mainstem of the Mid-Columbia (Mainstem/ System-wide Habitat Summary 2002).

Snake River

Storage dams and their associated impoundments have eliminated spawning and rearing habitat and have altered the natural hydrograph of the Snake River, decreasing spring and summer flows and increasing fall and winter flows (Mainstem/Systemwide Habitat Summary 2002). Snake River dam construction has also converted riverine habitat to more reservoir-like habitat, impacting species composition and increasing predator abundance (USFWS 2002). Dams within the Tucannon River and Asotin Creek watersheds have had significant historical impacts on salmonids in both streams. Two of these dams are still present and may be affecting salmonid migrations.

With the completion of four dams on the lower Snake River during the 1970s, a series of slack-water lakes was created that allows barges to navigate more than 465 miles from the Pacific Ocean to the inland port of Lewiston, Idaho. Tow boats push the barges up through navigation locks on eight of the major dams on the Columbia and Snake Rivers.

5.4.3 Water Use

The diversion, storage, and use of water is based on increasing demand, fueled by population and economic growth. The amount of water available has remained relatively constant, although it varies based on annual weather patterns and may change in the future as climate change affects weather patterns and water supply (WDOE 2000). WDOE (2000) reports that year-round water withdrawals are no longer available from approximately 350 lakes and streams, to protect aquatic species and existing water rights; over 200 additional waterbodies have partial closures or flow limits.

A significant amount of water is used for irrigation of agricultural lands, which can affect ecosystems. In 2000, approximately 3,005 million gallons of water per day (mg/d) were used for irrigation, the largest water-use category when compared to industrial water use (681 mg/d), domestic water use (674 mg/d), and irrigation of golf courses (23.6 mg/d) (Lane 2004). The Columbia and Yakima River basins are the two major irrigation regions in the State (Green et al. 2000), and most of this water (92 percent) was used in eight eastern Washington counties (Lane 2004): Grant, Yakima, Franklin, Benton, Kittitas, Adams, Walla Walla, and Okanogan. The key structure of the Columbia Basin Project, Grand Coulee Dam, is on the mainstem of the Columbia River about 90 miles west of Spokane. The extensive irrigation works

extend southward on the Columbia Plateau 125 miles to the vicinity of Pasco, where the Snake and Columbia Rivers join. There are over 300 miles of main canals, about 2,000 miles of laterals, and 3,500 miles of drains and wasteways on the project, which delivers water to about 1.1 million acres of land previously used only for dry farming or grazing. The Yakima Project provides irrigation water for a comparatively narrow-strip of fertile land that extends for 175 miles on both sides of the Yakima River in south-central Washington. The irrigable lands presently being served total approximately 464,000 acres.

Irrigation systems are more extensive in eastern Washington than in lands west of the Cascades. However, an extensive irrigation system exists within the Dungeness River Valley (WSCC 2000a). Approximately 70 to 80 percent of the agricultural land in the Dungeness Valley is irrigated with water diverted from the Dungeness River and area streams through approximately 280 kilometers of main ditch canals and secondary ditches and laterals (Montgomery 1999 *in* WSCC 2000c).

In addition to agriculture, irrigation is heavily used in eastern Washington to maintain urban irrigated lands, forest nurseries, seed orchards, and recreational areas. In the U.S. Columbia River Basin, approximately 7.6 million acres receive irrigation (USDOE et al. 1991). Water withdrawal also occurs as a source for rural domestic use, stock watering, municipal and light industrial water supply, and for industrial use; however, the dominant off-channel water use is for irrigation (Wissmer et al. 1994).

Effects associated with irrigation-water withdrawal includes effects from water storage and drainage, increased water temperatures (which can become thermal barriers for salmonids and other aquatic species), pollutants (such as runoff containing pesticides and fertilizers), high sediment levels, and lower stream flows (Wissmer et al. 1994; Krupka, Personal Communication, 2005). Lower flows and associated stream dewatering affect aquatic habitat and biota (Wissmer et al. 1994). Diversions and fish ladders associated with irrigation also have a variety of effects since not all are screened or pass all life stages of fish; irrigation systems may also divert a substantial amount of stream flow. The effects of these structures in aggregate to anadromous fish and other aquatic biota can be severe. However, through permitting and the Federal Energy Regulatory Commission relicensing processes, several efforts have been initiated to reduce existing effects. These efforts include, but are not limited to: proper screening of existing diversions and other structures; reduction of temperature, sediment, and pesticide effects to waterways; reduction of the quantity of water diverted to provide access; and reduction of fish-passage barriers.

There have been several attempts to reduce impacts from dams, irrigation-water withdrawal, and other water-diversion activities. Some of the efforts to minimize effects to anadromous fish were undertaken relatively early (Palmisano et al. 1993). For example, irrigation diversions were screened in the 1930s, although the screens did not protect all life stages, nor were they adequately maintained. More recently, watershed-planning units have been organized in some areas in response to the Watershed Planning Act, to address issues regarding water availability and quality, instream flow, and habitat protection (WDOE 2000). Some projects have been proposed specifically to address flow issues. For example, between 2000 and 2004, the Salmon Recovery Funding Board (2005) funded projects to alter river flows over 85 acres, slowing the stream flows to enhance salmon spawning and rearing habitats. As mentioned previously, certain dams have been slated for removal (e.g., Elwha, Glines Canyon, and Condit dams) because it has been determined that they are no longer necessary.

5.4.4 Water Quality

Good water quality is essential to the health of Washington habitats and the biotic communities that depend on them. Poor water quality affects both aquatic terrestrial species and communities through the food chain. There are many different kinds of pollutants or contaminants that affect water quality in Washington's waterways, many of which are direct results of the activities described elsewhere in the baseline discussion. In addition to contaminants, such as metals or fecal coliform, water quality is also determined by abiotic (temperature, dissolved oxygen levels, pH, turbidity, etc.), and biotic (invertebrates, fish, etc.) indicators.

This analysis will look at a number of contaminants in Washington's aquatic habitats, and then examine water quality from the perspective of abiotic and biotic indicators associated with marine and freshwater environments. It should be noted that analyses of many pollutants that "exceed recommended levels" are based on statistics for human exposure and health. While effects to animals (e.g., fish) are often used in acute and chronic tests, such tests generally are limited to observations of mortality or relatively short-term growth and development, and are not commonly performed on Washington species of concern (such as bull trout). Sublethal effects, such as behavior and long-term survival, are also not generally analyzed.

5.4.4.1 Contaminants

Contaminants enter waterways through a variety of pathways. Contaminants in stormwater runoff, for example, may include oil, grease, and heavy metals from roadways and other paved areas, and pesticides from residential developments. Recent observations of high numbers of pre-spawn mortalities in coho salmon returning to small streams in urban and developing areas of Puget Sound have caused increasing concern over stormwater runoff (Ylitalo et al., *in litt*. 2003). Other sources of toxic contaminants are discharges of municipal and industrial wastewater, leaching contaminants from treated wood (e.g., creosote) and other components of shoreline structures, and channel dredging, which can result in resuspension of contaminated sediments. Discharges from sewage-treatment plants may be treated prior to discharge into receiving waters. However, according to the literature, the treatment likely does not adequately remove potentially harmful compounds that are considered persistent, bioaccumulative, and toxic, or those that may have endocrine-disrupting properties (Bennie 1999; CSTEE 1999; Daughton and Terns 1999; Servos 1999). Estuarine and nearshore areas (such as Bellingham Bay and Commencement Bay) are on the State 303(d) list for a number of industrial-and development-related contaminants.

Many of the contaminants are associated with sediments, and are taken up by bottom-dwelling biota and many of the organisms at the base of the food chain. Many sediment contaminants do not break down very quickly. According to studies in Puget Sound, approximately 5,700 acres of submerged habitat are considered highly contaminated, with many of these sediments present in industrial areas (PSAT 2005); other areas covered by the survey showed 179,000 acres were of intermediate quality, while the remaining 400,000 acres of the areas surveyed were considered clean[7]. While the areas that are considered contaminated are relatively small, the effects from these areas can be far-reaching. Animals that live in contaminated sediments can accumulate high levels of these substances, with concentrations in biota sometimes thousands of times higher than background levels in the surrounding habitat. As these animals move into other areas, or are preyed upon by more-mobile animals, the contaminants are transmitted up the food chain and may biomagnify. Consequently, predators can have very high

[7] The study area was limited to certain locations within Puget Sound and did not include the sediments in the entire basin, which consists of approximately 1.8 million submerged acres.

contaminant levels, even if they have spent little or no time within the contaminated areas. For example, Chinook salmon in Puget Sound have levels of polychlorinated biphenyls (PCB) that are three times higher than Chinook in other areas.

Several contaminants have been examined in various areas of the State. These contaminants (and their concentrations in the environment) vary by region and habitat type, and include inorganic (e.g., metals) and organic chemicals (e.g., certain pesticides, pthalates). Some chemicals, such as chlorinated organic compounds and their breakdown products, persist in the environment because bacteria and chemical reactions break them down slowly. (PSWQAT 2000). Although the effects from many of these chemicals have been at least partially analyzed, little is known about the synergistic effects of the chemicals; in many areas, multiple substances are present in the habitat and/or biota. The synergistic effects of these chemicals to aquatic and terrestrial biota are unpredictable at best.

Inorganic Chemicals

Inorganic chemicals include, among other substances, metals and certain pesticides. Sources of mercury, lead, and other metals in Puget Sound and other parts of Washington include hazardous material spills, pipes, vehicle emissions, discarded batteries, paints, dyes, and stormwater runoff and can cause neurological or reproductive damage in humans and other animals (PSAT 2005). Metals, especially zinc, nickel, lead, and tri-butyl tins (used in some paints, for example), occur at relatively high concentrations at a few Puget Sound locations (PSAT 2005). The presence of certain metals in marine waters have triggered fish and shellfish consumption advisories in many areas. Overall, however, levels of arsenic, copper, lead, and mercury have either declined or remained steady (as opposed to increasing) in sediments and shellfish tissues during the past decade (PSAT 2005).

Organic Chemicals

A variety of organic chemicals have been detected in Washington, including, but not limited to, polycyclic aromatic hydrocarbons (PAHs), PCBs, poly-bromated diphenyl ethers (PBDEs), chlorinated pesticides (e.g., DDT [(dichloro diphenyl trichloroethane]), dioxins, certain pharmaceuticals and other emerging compounds.

PAHs are present in fossil fuels and other sources; certain types of PAHs are formed when fossil fuels and other organic materials are burned. Other sources include coal, oil spills, leaking underground fuel tanks, creosote, and asphalt. PAHs are found in urban and industrial areas, and have been associated with liver lesions in English sole in small concentrated areas of sediment or “hot spots” (PSAT 2005). Fish and shellfish consumption advisories have been issued in some areas due to the presence of this chemical. Exposure is linked to increased risks of cancer and to impaired immune function, reproduction, and development. Concentrations of PAHs in the Sound are often quite high compared to concentrations measured elsewhere around the United States.

Another group of organic chemicals of concern are PDBEs (e.g., flame retardants), members of a class of brominated chemicals. Flame retardants are added to a number of products to reduce the risk of the products catching fire if exposed to high heat or flame. PDBEs have been detected in several Pacific Northwest[8] aquatic species and their predators, including Dungeness crab (west coast of Canada), bald eagle (Lower Columbia River) and heron (British Columbia) eggs, orca (northeastern Pacific Ocean),

[8] WDOE and WSDH (2004) also report detections in biota from other parts of North America, including Murre, Fulmar, and Herring gull eggs, Beluga whales, lake trout, and carp.

mountain whitefish (Columbia River, Spokane River, British Columbia), rainbow trout (Spokane River), and largescale sucker (Spokane River) (WDOE and WSDH 2004). Although there is still some debate as to the effects of these substances, the molecule is similar to the thyroid hormone, which affects growth and reproduction (PSAT 2005); growth and reproduction of fauna could be affected by this contaminant. WDOE and Washington State Department of Health (2004) indicate that there are differences in the way species either metabolize or accumulate PDBEs; although the overall risk to different species of biota is unknown, there is sufficient evidence to merit concern.

Chlorinated organic compounds, such as PCBs, dioxins, and DDT are found in solvents, electrical coolants and lubricants, pesticides, herbicides, and treated wood (PSAT 2005). These compounds and their breakdown products persist in the environment because bacteria and chemical reactions break them down slowly (PSWQAT 2000). The use of PCBs was common until the 1970s when they were phased out in the United States and Canada. These chemicals are now banned in the United States; however, they continue to leach from landfills, other disposal sites, and contaminated sediments in Puget Sound. PCBs enter Washington's natural environments and biota from these sources and from airborne fallout deposited after circulating across the globe from continuing sources in Asia (WDNR 2000a). PCBs are slow to degrade, float in air and water, permeate soil, and accumulate in animal fat. Generally speaking, the higher an animal is on the food chain, and the longer lived, the greater the concentrations of these toxins. In Puget Sound, concentrations of PCBs are found primarily in urban and industrial areas, and concentrations do not appear to be declining in recent years, unlike many other chemicals that were introduced historically into the waters and sediments of Puget Sound. The sources of PCBs include certain solvents, electrical coolants and lubricants, pesticides, herbicides, and some types of treated wood (PSAT 2005).

Chemicals such as dioxins and furans are generated as industrial process byproducts, and are linked to cancer, liver disease, and skin lesions in humans. Chlorinated pesticides, such as DDT, are linked to liver disease, cancer, hormone disruption, the thinning of bird eggshells, and reproductive and developmental damage. Fry (1995) identified organochlorine compounds as a prevalent non-oil pollution threat within the range of the murrelet. Specifically, polychlorinated dibenzo-dioxins (PCDD) and polychlorinated dibenzo-furans (PCDF) which are contained in pulp-mill discharges, cause significant injury to fish, birds, and estuarine environments. PCDDs and PCDFs bio-accumulate in marine sediments, fish, and fish-eating birds and impair bird health and production. There has been no record of bio-accumulated residues or breeding impairment in marbled murrelets to date, although murrelets that feed in areas of historical or current discharge from bleached-paper mills could be at risk from eating fish with bio-accumulated organochlorine compounds. Active chlorine-bleach mills in Washington were located in Port Angeles, Bellingham, Everett, and Gray's Harbor as recently as 1997, and may still exist.

Other chemicals include phthalates, which come from plastics, certain soaps, and other products. Much of the exposure from these chemicals to biota occurs via wastewater from treatment plants. The effects from these chemicals are not well known, but may affect growth and development in fish (PSAT 2005). Pharmaceuticals and personal-care products, such as oral contraceptives, antibiotics, and other prescription drugs, as well as soaps, fragrances, and other compounds, enter the aquatic environment through sewage and wastewater-treatment plants. Effects and risks to aquatic biota from these substances have not been fully analyzed; however, Daughton and Ternes (1999) note that even substances that are not persistent but are frequently or continually released may impact aquatic species, which may have exposure throughout entire life-cycles and multiple generations. Daughton and Ternes (1999) also note

that many of these products are being released worldwide in volumes comparable to chemicals associated with agriculture.

Fecal Coliform

The presence of fecal coliform bacteria is a significant water-quality issue in some areas of Washington. Fecal waste enters waters from sources such as poorly managed septic systems, wastewater treatment facilities, stormwater (which washes fecal matter in upland areas into waterways), and animal operations, and contains bacteria and viruses that can result in the contamination of shellfish beds and other resources (WDOE 2000, PSAT 2005). In Puget Sound, fecal coliform is reported to make up approximately 41 percent of the water-quality problems in the basin. Since 1980, 30,000 acres of commercial shellfish beds have been closed because of pathogens from fecal waste. Since 1995, the following areas experienced at least a partial or temporary closure: Drayton Harbor, Rocky Bay, Port Gamble, Portage Bay, Lilliwaup Bay, Burley Lagoon, Dungeness Bay, Similk Bay, Nisqually Reach, Henderson Inlet, and Filucy Bay (PSAT 2005).

This water-quality issue is being addressed through a number of actions to limit the amount of fecal matter and associated bacteria and viruses that affects the waterways of Washington State, including education and outreach, modifications in the amount and types of treatment at treatment facilities, fencing of livestock away from streams, and other activities. Even with these measures being used in some areas, the problem continues to exist. During the past two years, 1,655 acres of shellfish growing areas were added to the list of approved growing areas, indicating improvement; however, the growing areas that are on the list of threatened shellfish beds doubled from 1997 (nine sites) to 2004 (18 sites).

Levels of fecal coliform in streams and rivers are measured along with other water-quality parameters. The WDOE (2000) reports that 52 freshwater monitoring stations have been consistently surveyed since 1995 for fecal coliform, and that, with one exception, the stations are indicating that stream conditions regarding this parameter are either improving or there has been no change (i.e., no significant deterioration) in stream conditions.

Excess Nutrients

Excessive amounts of nutrients can come from many sources, including lawn fertilizers applied to yards and other areas, agricultural chemicals applied to fields, and fecal matter[9] from septic fields and failing septic systems. Excess nutrients can affect both surface water and groundwater. For example, WDOE (2005a) reports that seven percent of public-water-supply wells have high nitrate-nitrogen levels, with many of the affected sites clustered in highly populated and rural farming areas. As a result of the input of excess nutrients, aquatic systems and the biota that depend on them have experienced a number of effects (WDNR 2000a). Excessive nutrients in water cause algae and phytoplankton to grow prolifically. This prolific growth results not only in increased photosynthesis, but also in increased respiration by algae, phytoplankton, and other aquatic plants, which depletes the oxygen necessary for aquatic fauna survival. An increase in numbers of algae and phytoplankton decreases light penetration, reducing the depth to which freshwater and marine aquatic plants (e.g., eelgrass) can grow, especially in lacustrine and marine environments. In turn, there are fewer aquatic plants to provide oxygen and high volumes of decomposing organic matter further consumes valuable oxygen. Although Puget Sound has two tidal

[9] To clarify, bacteria (and viruses) are associated with fecal matter, and these concerns are discussed in the fecal coliform section; in addition to bacteria and viruses, feces also contribute excess nutrients in the form of nitrates.

cycles per day, marine waters in some areas of Puget Sound appear to be sensitive to water-quality problems that might be caused by the excess addition of nutrients because of the physical mixing characteristics in these areas (e.g., Hood Canal) (PSWQAT 2000).

Toxic algae blooms are another result of excess nutrient input into aquatic systems. In the past, toxic algae blooms occurred in warm summer months, and in the northern part of Puget Sound; more recently, toxic blooms have resulted in closures during the winter months, and have been reported in other areas of Puget Sound (WDNR 2000a). Certain types of algae cause Paralytic Shellfish Poisoning, also known as red tide, which affects organisms (including humans) that consume shellfish, although they seem to be harmless to the shellfish themselves.

5.4.4.2 Other Pollutants

In addition to the pollutants listed above, other contaminants have impacted Washington's aquatic (and terrestrial) habitats. Hazardous waste is generated by a variety of sources (WDOE 2000). Large industries, which generate most of the hazardous waste in Washington, include (in order of decreasing contributions) equipment manufacturing, primary and fabricated metals, chemicals and petroleum, lumber and wood products, and other sources. Smaller businesses, such as dry cleaners, printers, and auto repair shops, also generate hazardous waste, which can pollute aquatic and terrestrial habitats if the waste is not handled properly. According to WDOE (2000), the amount of hazardous waste being generated per person has been decreasing since 1992, and the decrease is likely attributable to reductions in the amounts of hazardous chemicals used in industrial business practices.

Nuclear waste has been generated at the Hanford Nuclear Reservation beginning in the 1940s (WDOE 2000). Approximately 54 million gallons of highly radioactive waste was reported to remain in 2000 (WDOE 2000). Many of the tanks are either leaking or are suspected of leaking, with reports of waste having contacted groundwater, potentially impacting habitats and biota.

Solid waste (i.e., trash) is generated in almost all aspects of society. As populations have grown in Washington, the amount of solid waste generation has also increased. Solid waste in Washington is generated primarily from municipal sources (74 percent), and to a lesser degree from demolition, inert, and wood waste (13 percent); industrial and commercial waste (7 percent); petroleum-contaminated soil (4 percent); and other sources (3 percent) (WDOE 2000). WDOE (2000) notes that the amount of daily solid waste generated per capita increased slightly from 1991 to 1998, averaging between six and eight pounds/day per person during this period. During the entire study period, a large part of the disposed waste consisted of materials that were otherwise potentially recyclable. In addition, approximately one ton of litter accumulates along each mile of interstate highway annually, with this amount increasing to 1.5 tons along urban stretches of highway (Thomas 2000). The primary components were glass, wood products, tires, metals, and plastic materials. Leakages from landfills as well as unauthorized dumping of garbage and waste chemicals can be a problem whether they occur directly into waters or whether they occur on land with the potential to later impact aquatic habitats.

5.4.4.3 Remediation of Contaminated Sites

The WDOE (2005a) has identified 142 contaminated sediment sites (Table 5-1). Of these, the majority are marine (81 percent); however, new contaminated freshwater sites are being identified as a higher rate than marine sites, as the agency has focused increasing attention on the freshwater environment. Sources of contamination for the these sites include a historical municipal landfill; wood, timber, paper, mining, petroleum, and other industrial sites; shipping and shipyard operations; military operations; combined

sewer outfalls; leaking underground storage tanks; spills; and stormwater (WDOE 2005a). WDNR (2000) reported that, of the contaminated sites identified in 2000 by the WDOE in the state, over half occur from industrial activities; the remaining sites were a result of other activities: combined sewer overflows (13 percent), U.S. Navy operations (11 percent), stormwater (10 percent), and "other" activities (14 percent).

Most of the cleanup activities in the state are found in a few urbanized marine embayments, harbors, lakes, and rivers. Other contaminated sites are likely to be identified in the future, particularly in areas that have been less studied. On average, total numbers of identified sites increases by 5 percent annually.

Other projects have been recently undertaken to better understand the effects of chemicals on biota. For example, the effects of carbaryl on the ability of a salmonid (cutthroat trout) to avoid predation was assessed in relation to the use of a pesticide (carbaryl) to control mud shrimp and ghost shrimp in shellfish culturing areas in estuarine littoral flats in Washington (Davis and Scholz 2005a). The use of carbaryl in Willapa Bay has been investigated because of concerns with its effects on native biota. The effects of this pesticide are not limited to the area in which it is applied, as it is transported to other areas through tidal activity. In this study, cutthroat trout did not show an olfactory response to the presence of carbaryl, nor did they try to avoid carbaryl-contaminated seawater as they might with other contaminants such as copper; however, exposure to carbaryl appeared to affect the swimming performance of cutthroat trout, and made them more vulnerable to predation. Other studies have been performed in Longfellow and Des Moines Creeks (King County) to investigate the effects of other pollutants on salmonids (Davis, Personal Communication, 2005). The researchers determined that results to date suggest that stormwater runoff has important negative impacts on both the survival and reproductive success of salmonids in urban and urbanizing watersheds.

Table 5-1. Sediment cleanup sites: location and estimated areas of sites (WDOE 2005a)

Waterbody	# Sites	Total Reported Area[1]	Estimated Area[2]
Bellingham Bay	12	466	466
Columbia River	7	0	80-160
Commencement Bay	13	276	322-368
Duwamish River (lower waterway)	12	495	495
Elliott Bay/Harbor Island	24	377	377
Everett/Port Gardner	11	131	177-223
Fidalgo Bay	8	4	80-160
Kitsap Peninsula/Sinclair Inlet	16	367	367
Lake Union	7	107	107
Lake Washington	6	23	23
Other waterbodies	26	191	380-598
Total	142	2,407	2,510-2,980

5.4.4.4 Water Quality Indicators

Abiotic Indicators

In addition to the presence of contaminants, other parameters are also indicative of water quality. These indicators include (but are not limited to) temperature, dissolved oxygen, pH, turbidity, and instream flow. Many of the activities discussed elsewhere in the baseline section can have effects on these indicators. For example, sediment erosion may transport substances such as pesticides or fertilizers into a stream. The addition of excess nutrients from fertilizers often result in a decrease in the levels of dissolved oxygen as described above, potentially resulting in impaired function in the stream. The excess amount of sediments introduced during an acute or chronic erosion event may also result in suspended sediment and turbidity impacts to aquatic biota, which would further stress fauna experiencing low impact levels. An increase in temperature (as a result of removal of shading riparian vegetation, for example) is another type of stressor on aquatic biota, and when such an increase occurs in concert with other impacts, the result can be devastating to aquatic biota. If conditions do not result in lethal or sublethal effects to biota, they may influence the amount of time a mobile organism spends in the affected reach of a stream.

The WDOE has several monitoring activities to evaluate water quality in freshwater environments. For long-term trend and annual monitoring, basin stations are used to monitor 12 water-quality parameters and flow at several stations across the state. In 2003, 86 percent of the monitoring stations identified at least one of the water-quality indicators as impaired, or does "not support aquatic life and recreational uses" (Butkus 2004). These stations are found in a number of different WRIAs (Table 5-2). Although these stations indicate impaired function, Butkus (2004) also notes that statewide, a "slight but statistically significant improvement in water quality conditions," with the most improvement reported in the Columbia Basin Ecoregion.

Table 5-2. Basin monitoring stations showing 2003 conditions that did not meet water quality standards (Butkus 2004)

WRIA	WRIA Name	Stream	Indicators not meeting water-quality standards (and month not met)
10	Puyallup/White	Puyallup River	Mercury (Aug)
		White River	pH (May)
15	Kitsap	Union River	Fecal coliform bacteria (Oct-Dec, Jun, Jul), Dissolved oxygen (Nov, Sep)
		Little Mission Creek	Fecal coliform bacteria (Dec, Jun)
		Stimson Creek	Fecal coliform bacteria (Dec)
		Big Mission Creek	Fecal coliform bacteria (Dec), Temperature (Jul)
		Olalla Creek	Fecal coliform bacteria (Nov, Dec, Jul)
23	Upper Chehalis	Chehalis River	Temperature (Jun-Aug)
28	Salmon/Washougal	Columbia River	Temperature (Jul-Aug)
32	Walla Walla	Touchet River	Temperature (Jun-Aug), Fecal coliform bacteria (Jul-Sep), Dissolved oxygen (Jul, Aug)
		Mill Creek	Fecal coliform bacteria (Oct), Dissolved oxygen (Aug)
41	Lower Crab	Lind Coulee	Fecal coliform bacteria (Aug, Sep), Temperature (Jul, Aug), pH (Nov, Feb, Jun)
43	Upper Crab/Wilson	Goose Creek	Dissolved oxygen (Nov)
45	Wenatchee	Chumstick Creek	Fecal coliform bacteria (Aug, Sep)

		Brender Creek	Fecal coliform bacteria (Aug, Sep)
		Mission Creek	Fecal coliform bacteria (Aug, Sep), Temperature (Aug), pH (Oct, May)
		Eagle Creek	Fecal coliform bacteria (May)
		Noname Creek	Fecal coliform bacteria (Oct-Feb, Apr, Jun-Sep)
62	Pend Oreille	Pend Oreille River	Temperature (Jul-Sep), pH (Aug)

Other types of monitoring evaluate temperature and fecal coliform in water bodies (Butkus 2004). Continuous temperature monitoring is conducted at 54 of the basin and long-term monitoring stations in both eastern and western Washington to determine whether streams are meeting current and proposed water-quality standards. In 2003, temperatures exceeded current standards at 83 percent of the stations. Fecal coliform was evaluated in a sampling project at 10 lakes in King and Pierce Counties in western Washington; of these, five had at least one fecal coliform exceedance based on current water-quality standards. Additionally, 13 percent of surveyed streams had bacterial levels that exceeded the recommended levels for swimming. These streams are listed in Table 5-3, which indicates the amount of reduction required to allow safe contact by humans; however, it is likely that levels would have to be reduced even further to minimize lethal or sublethal effects to aquatic life. Furthermore, basins that meet swimming standards for fecal coliform may not necessarily meet fecal coliform levels necessary to sustain aquatic biota.

Table 5-3. Locations where 2003 bacteria levels were higher than recommended for swimming, and the pollution reduction needed to meet water quality standards (Butkus 2004)

WRIA	WRIA Name	Stream	Reduction Required
34	Palouse	South Fork Palouse River	91%
56	Hangman	Hangman (Latah Creek)	70%
34	Palouse	Palouse River	51%
13	Deschutes	Deschutes River	44%
54	Lower Spokane	Spokane River	37%
8	Cedar/Sammamish	Cedar River	9%
35	Middle Snake	Tucannon River	8%
10	Puyallup/White	Puyallup River	7%

When specific problem areas have been identified, plans have often been introduced to address the problem; the actual amount of success depends on local conditions and causes as well as funding issues and other factors. Butkus (2004) listed several specific examples of water-quality problems that have been recognized throughout Washington and the ways in which they have been addressed. In the Snoqualmie River basin, several plans (total maximum daily load or TMDLs) were initiated to control biochemical oxygen demand (related to dissolved oxygen), ammonia, and fecal coliform bacteria exceedances. Through cooperation with a variety of public and private entities, impacts from several different nonpoint pollution sources were addressed, including dairy waste and other livestock management, septic systems, and other factors for the protection of groundwater quality. Although there are occasional problems with fecal coliform bacteria, Butkus (2004) indicates that the overall changes have been positive.

Many sites have ongoing issues that have yet to be successfully addressed. For example, Hood Canal in western Washington has historically experienced relatively low dissolved oxygen levels due to the topography and circulation dynamics of the water body. In recent times, however, Hood Canal has experienced deterioration of conditions resulting in increasing levels of hypoxia. The available evidence suggests that human-related sources of excess nutrients are likely contributing to the increased hypoxia. Fagergren et al. (2004) identified major categories of human-influenced nitrogen sources which collectively introduced 86 to 319 tons of nitrogen per year. Human sewage (onsite systems) made up the largest component (at 39 to 241 tons annually). Other contributors with maximum estimated levels less than 25 tons annually were: stormwater runoff (including lawn fertilizers), agriculture/animal waste, forestry, and discharges from point sources, with the last two contributors ranging from 0.5 tons to 5 tons (forestry) and 0.3 tons to 3 tons (point sources) annually. This area is an example of how many different kinds of impacts can collectively impact an ecosystem. Although a number of groups have been working together for the past two decades to improve water quality in Hood Canal, Fagergren et al. (2004) report that hypoxia has continued to increase in frequency and extent in Hood Canal, and continued efforts to address the problem will be necessary.

Biotic Indicators

Certain types of organisms have been used to indicate the health of aquatic systems. The species evaluated may focus on specific concerns, such as the effects of fisheries on certain fish populations, or may provide general information regarding water-quality trends. For example, the status of two types of fish has been evaluated by Puget Sound Action Team (PSAT) (2005) as indicators for the health of Puget Sound. Rockfish and Pacific herring populations have been monitored for several years, and have life histories that provide insight into the result of various impacts to Puget Sound waters. Rockfish are a category of long-lived, slow-maturing fish that grows more fecund as it ages. Sexual maturity is reached at five to seven years, and some species live up to 100 years. Some rockfish populations are at less than 7 to 12 percent of their historical levels; the causes for their decline are not fully understood, but fishing pressure is believed to be a contributor (WDNR 2000a).

The evaluation of herring populations may provide insight into water-quality issues. Pacific herring and other small marine fish, such as the sand lance and surf smelt, are called “forage fish,” because they are important prey species for many other organisms. They make up a large part of the diet of several species of fish, marine mammals, and birds. WDNR (2000) reports that the following species depend on herring for a large percentage of their diet: lingcod (71 percent), Chinook (62 percent), coho (58 percent), Pacific halibut (53 percent), Pacific cod (42 percent), Pacific whiting (32 percent), and harbor seal (32 percent).

There are 19[10] known stocks of Pacific herring in Puget Sound. Of these populations, 15 are considered healthy or moderately healthy, three are considered depressed or critical, and the status of the remaining stock is unknown. According to WDNR (2000), herring spawning stocks decreased from over 20,000 tons in the 1970s to less than 10,000 tons in recent years. Cherry Point, within the Strait of Georgia, supports the largest herring stock in Washington and has experienced a precipitous decline. The decline of this stock may be affecting the forage base for salmonids in this region of Puget Sound. There is a moderate likelihood that organic contaminants are incrementally affecting this stock. Past research has shown that exposure to contamination reduces reproductive capability, growth rates, and resistance to disease, and may lead to lower survival for salmon (WDNR 2000a).

[10] A spawning ground at Wollochet Bay was not included in surveys prior to 2002. In previous publications, the number of stocks of Pacific herring has been reported at 18 (PSAT 2005).

Other fish have also experienced declines, and can be considered biotic indicators. A number of salmon stocks have declined in abundance in the Puget Sound region. On March 24, 1999, the NMFS listed the Puget Sound Chinook salmon Evolutionarily Significant Unit as threatened (64 FR 14308), while the Puget Sound-Strait of Georgia coho salmon Evolutionarily Significant Unit remains a species of concern.

Other predators that may be affected by contaminants or other water-quality issues include marine mammals such as harbor seals and whales, which eat fish and other aquatic life from all over Puget Sound. Harbor seals (*Phoca vitulina*) are considered to be indicator species because they eat a large variety of fish, including herring, bottom fish, and salmon. Some scientists surmise that if harbor seals are at risk from eating contaminated aquatic organisms, other marine mammals such as whales are likely to be at risk as well. Orcas (*Orcinus orca*) are among the most-contaminated aquatic mammals in the world, and PCBs are the main contaminant of concern. Elevated levels of chemicals in these animals probably have come from contaminated food (WDNR 2000a).

A number of marine bird species have declined by 50 percent or more in the past 20 years. Scoters declined by 57 percent in the past 20 years. During the same period, 13 out of 18 other marine diving birds in Puget Sound have showed significant population losses. Marbled murrelet numbers have declined by more than 90 percent in Puget Sound (PSWQAT 2002). More information is needed to determine the cause(s) of these declines, including water quality causes.

Not all biotic indicators are considered "charismatic megafauna" (such as orcas). Aquatic invertebrates can also provide site-specific information on the health of aquatic systems such as streams, lakes, or estuaries. For example, protocols have been designed to assess water quality and habitats by sampling benthic invertebrates in streams (Barbour et al. 1999) and in estuarine environments (Simenstad et al. 1991). Biological monitoring was also conducted for 31 sites throughout Washington in 2003. Biological monitoring provides better information for aquatic biota because degradation of sensitive ecosystem processes is more often detected. This type of monitoring directly measures the most sensitive at-risk resources, and looks at human influence on stream characteristics over time. Of the 31 sites, data on 24 reaches were reported (Butkus 2004). Results of this monitoring indicated that 50 percent of the sites were not meeting conditions supportive of the aquatic community, and only 21 percent were designated as fully supportive.

5.4.5 Air Quality

There are many sources of air pollution in Washington State (WDOE 1999). The main source of air pollution is motor vehicles, which contributes an annual average of 57 percent of the total air pollution in the state. Motor vehicles contribute carbon monoxide and ozone, with many of the urban areas of the state (e.g., King, Pierce, Snohomish, Spokane, and Clark Counties) experiencing significant problems. Although the sources of these emissions may be concentrated in urban areas, certain pollutants, such as ozone, can travel great distances, affecting downwind areas. Emissions checks have been instituted in the State, reducing air-pollution levels by approximately 146,400 tons each year, this reduction is partially offset by annual increases in both the number of cars and the total miles traveled (WDOE 1999).

Other sources of air pollution in Washington include industrial emissions (17 percent), woodstoves and fireplaces (11 percent), outdoor burning (5 percent), and other sources (10 percent), such as lawnmowers, boats and other recreation vehicles, aircraft, and trains (WDOE 1999). The amounts from each category have shifted in the past decade, when industrial emissions comprised 25 percent of emissions, while woodstoves and outdoor burning contributed 20 percent and 10 percent, respectively. These shifts likely

occurred from increases in emission of vehicles and miles driven, improvements in certain instances of industrial air-quality emissions through state or local permitting processes, and restrictions on outdoor burning.

While air quality is generally good in eastern Washington, health advisories associated with agricultural burning are not uncommon, particularly in the Spokane area. This is exacerbated during the fall and winter months, when local inversions afflict many communities and trap pollutants in the airshed. Prescribed fire also impacts air quality in the spring and fall when State, Federal and tribal entities burn areas as part of natural-resource management. Wildland fire is a fairly common occurrence, but is unpredictable in its location, intensity, and duration. As a result, substantial investment is being made in and around eastern Washington forestlands to restore forest structure and disturbance regimes, often resulting in more prescribed burning and air-quality degradation. Areas commonly impacted by smoke include the Methow Valley (Winthrop and Twisp), Chelan, Leavenworth, and Wenatchee.

5.4.6 Habitat Modification

Washington's habitats have been modified to varying degrees throughout human history. The earliest modifications likely included the use of fire to encourage or discourage the growth of certain plant communities. The extent of modification has increased through time, with much of Washington's lands used for agriculture, forestry, urban and industrial development, and/or mining. Each of these land-use types affects species and habitats differently. The following paragraphs discuss some of the general types of habitat impacts that have been caused by development. Subsequent sections will discuss impacts from various categories of land-use activities.

5.4.6.1 Shoreline Development

Significant development and urbanization has occurred within much of Washington. In western Washington, the greatest impacts have been to mainstem river channels, estuarine, and nearshore marine habitats, but many sub-basins in the lower part of major watersheds have been altered as well. Impacts have also occurred in salmonid spawning and rearing areas, which may be well upstream of the lowlands. In western Washington, approximately one-third of Puget Sound's shoreline has been modified, with over half of the main basin of Puget Sound having been altered (PSWQAT 2000). In eastern Washington, shoreline development has also affected the region's lakes and reservoirs, many of which were created with the construction of dams.

In western Washington lowlands, more than 50 percent of the tidal flats and intertidal areas in major embayments of Puget Sound have been lost since 1850 (Bortleson et al. 1980 *cited in* PSWQAT 2000). Some highly urbanized areas, such as Commencement Bay, have lost more than 99 percent of historical marsh habitat and more than 89 percent of historical intertidal mudflats (USACOE et al. 1993). Recent reports state that over 98 percent of the historical intertidal and subtidal habitats in Commencement Bay have been lost (WSCC 1999b). Many estuarine and nearshore areas of Puget Sound have been filled or have had overwater structures installed to provide upland development sites for commercial/industrial uses and, to some extent, residential development. They have also been dredged extensively to maintain navigation and provide access to piers.

Significant portions of nearshore and shoreline habitats in estuarine areas and certain freshwater lakes (e.g., Lake Washington, Lake Whatcom) have been altered with vertical or steeply sloping bulkheads and revetments to protect various developments and structures (e.g., railroads, piers) from wave-induced

erosion, to stabilize banks and bluffs, to retain fill, and to create moorage for vessels (BMSL et al. 2001). Nearly 100 percent of the Duwamish estuary and Elliott Bay shoreline has been modified by some type of armoring (BMSL et al. 2001). In areas where nearshore habitats currently remain intact or are only partially modified, development continues to threaten these habitats (WSCC 1999a; BMSL et al. 2001). Habitats at risk from direct human alteration include riparian buffers, freshwater habitats (e.g., streams, lakes), and Puget Sound's fringe of shallow subtidal, intertidal, and shoreline habitats known collectively as the "marine nearshore." Depending on placement in relationship to drift cells, and other shoreline characteristics, armoring of the shoreline can interrupt the natural inputs of sand from landward bluffs, resulting in sediment deficits within the landscape.

Shoreline development has affected many sensitive habitats in western Washington. One such sensitive habitat type is eelgrass. Eelgrass beds grow in the intertidal zone and in mud and sand in the shallow sub-tidal zone and support numerous aquatic species, from geese and dabbling ducks to spawning forage fish. Available information suggests eelgrass has declined substantially over last 100 years (WDNR 2000a). Significant areas containing eelgrass beds have been impacted due to harbor development, dock building, dredging, and bottom trawling. Shipping, docks, bulkheads, and other shoreline developments likely contribute to the reduction in eelgrass and other spawning and rearing areas for forage fish.

In eastern Washington, poor compliance with the state's GMA, in conjunction with extensive dam and irrigation networks, has dramatically affected shoreline development and resulted in degraded conditions. Increased development along larger lakes (e.g., Lake Chelan, Potholes Lake, Lake Wenatchee) has strained septic designs, making sewer hookups the only feasible approach to restore water quality. Increased impervious surface accompanies increased development, degrading water quality by collecting contaminants, and affecting hydrologic function. Land conversion into residential development has also directly impacted shorelines, as waterfront property is often very desirable.

In response to some of these changes, enhancement and restoration activities have been planned and implemented in many areas throughout Washington. For example, a number of restoration projects have been constructed in the lower Duwamish waterway (Tanner 2000), an urbanized and heavily used ship channel that has historically had serious challenges with contaminants. Recent reports indicate that, although there have been challenges associated with construction, maintenance, and monitoring efforts at the sites, these projects have successfully attracted foraging and migratory salmonids, birds, and other wildlife (Burgdorf and Gearns 2004).

5.4.6.2 Impervious Surfaces

Scientific studies indicate there is a strong relationship between the amount of forest cover, levels of impervious and compacted surfaces in a basin, and the degradation of aquatic systems (Klein 1979; Booth et al. 2002). Impervious surface associated with residential development and urbanization creates one of the most-lasting impacts to stream systems. Changes to hydrology (increased peak flows, increased flow duration, reduced base flows) as a result of loss of forest cover and increases in impervious surfaces are typically the most-common outcomes of intensive development in watersheds (May et al. 1997; Booth et al. 2002). Increased peak flows and flow duration often lead to the need to engineer channels to address flooding, erosion, and sediment-transport concerns.

Stormwater runoff continues to be a significant contributor of non-point source water pollution in core spawning and rearing areas and foraging, migration, and overwintering habitat areas for salmonids (WSCC 1999a; WSCC 1999b; KCDNR and WSCC 2000). Although not typically a direct measure of the influence of development, basin imperviousness is commonly used as an indicator of basin degradation

(Booth et al. 2002). Reduction in forest cover and conversion to impervious surfaces can change the hydrological regime of a basin by altering the duration and frequency of runoff, and by decreasing evapotranspiration and groundwater infiltration (May et al. 1998, Booth et al. 2001). Such changes can be detected when the total percentage of impervious surface in the watershed is as low as 5 to 10 percent (Booth et al. 2002). Watershed degradation, however, likely occurs with incremental increases in impervious surfaces below these levels, and is exacerbated by other factors such as reduced riparian cover and pollution (Booth 2000; Karr and Chu 2000; Booth et al. 2002). Booth et al. 2002 state, "[t]he most commonly chosen thresholds, maximum 10 percent effective impervious area and minimum 65 percent forest cover, mark an observed transition in the downstream channels from minimally to severely degraded stream conditions." They further assert, "Development that minimizes the damage to aquatic resources cannot rely on structural best management practices (BMP) because there is no evidence that they can mitigate anything but the most egregious consequences of urbanization. Instead, control of watershed land cover changes, including limits to both imperviousness and clearing, must be incorporated."

The amount of new impervious surfaces has increased significantly in recent history, and this trend will likely continue this trend in the future. Nonetheless, actions have been implemented by several entities to begin to counter the effects of impervious surface water and stormwater runoff on natural resources. Projects using low-impact development technologies have been planned or constructed in Whatcom, Thurston, Pierce, Island, Kitsap, and King Counties (PSAT 2001). Projects in various areas have included the construction of swales, rain gardens, and narrower roads, and the installation of permeable pavement, among other technologies. Some jurisdictions have provided guidance for region-wide planning. A technical guidance manual was recently released by the Puget Sound Action Team (Hinman 2005), outlining low-impact development strategies and tools for development in the state.

5.4.6.3 Loss of Riparian Buffers

The riparian zone along a stream is a transitional area between the stream and uplands, and performs a variety of functions in the ecosystem (WDNR 2000a). Trees and shrubs along the bank provide shade and cover for fish and other aquatic biota, while their roots provide bank stabilization and help to control erosion and sedimentation into the stream. The riparian zone also contributes nutrients, detritus, and fallout insects into a stream, which supports aquatic life. Vegetation and soils in the riparian zone protect the stream against excess sediments and pollutants. The riparian zone contributes to the reduction of peak stream flows during floods, and acts as a holding area for water, which is released back into the stream during times of low flow. The trees in the riparian zone serve the ecosystem even after they fall, many of them altering flow and creating habitat features (e.g., pools, riffles, slack areas and off-channel habitats) which benefit fish and other aquatic biota at various life stages. WDNR (2000) reports that approximately 85 percent of wildlife species in Washington depend on riparian habitats.

Since the early 1800s, over 50 percent of Washington's riparian habitats have been modified or lost (WDNR 2000a). Many different kinds of human activities have impacted riparian zones along streams in Washington. These activities include, but are not limited to, urbanization, agriculture, grazing, mining, channelization and damming of streams, logging, and recreational activities (Bolton and Shellberg 2001). In both eastern and western Washington, the riparian areas along streams are often converted to agricultural uses: croplands, pastures, dairies, and fields. These uses are often preceded by logging (Kauffman et al. 2001).

While human-related activities conducted within the riparian zone can damage the integrity of a riparian system, activities that occur outside the riparian zone can also create impacts (Kauffman et al. 2001). Riparian zones are often relatively flat and/or are situated at low elevations when compared to adjacent upland topography within a watershed; as a result, sediment and soils, nutrients, water, and substances carried by these vectors from upslope or upstream activities are often deposited by gravity within riparian zones. While the riparian zone helps to buffer streams against these materials, too large a volume can impact the riparian zone's ability to properly function in either the short- or long-term. The buffering ability of a riparian zone can be affected by landslides, erosion, altered flow regimes, degraded water quality, contaminant inputs, or other sources. Logging, agriculture and grazing, road construction, or other activities can generate these impacts, if appropriate safeguards are not in place.

Several efforts have been made to restore and/or protect riparian buffers along Washington streams. The Salmon Recovery Funding Board (2005) funded restoration or enhancement projects along 96 miles of streams between 2000 and 2004. Some activities have been designed to improve conditions along streams adjacent to farmland (Canty and Wiley 2004). Incentive programs, such as the Conservation Reserve Enhancement Program, encourage the maintenance of riparian buffers to protect water quality and habitat. By 2003, 216 farms in the Puget Sound area were participating in the Conservation Reserve Enhancement Program, resulting in the protection of almost 2,000 acres of stream. By the end of the same year, 80 percent of almost 600 registered dairy farms in Washington had implemented nutrient-management plans for their facilities. Riparian planting projects are sometimes done in conjunction with the removal of invasive, non-native species. For example, in a Thurston County project, Scots broom (*Cytisus scoparius*) and Himalayan blackberry (*Rubus discolor*) plants were removed and replaced with approximately 3,000 native riparian plants on 15 acres of conserved land along the Nisqually River and maintained by the Nisqually Land Trust (Carlson, Personal Communication, 2005c). Some groups are working to restore stream structure and function, and these characteristics are often related to functions that are normally provided by the riparian zone. For example, the Nisqually Tribe and the Northwest Indian Fisheries Commission have implemented a project to add LWD to a tributary to the Nisqually River (Mashel River), with associated monitoring of the effectiveness of the project (SPSSEG 2002).

Although recent changes have been made to most regional and local development regulations to provide protection (i.e., buffer zones) for riparian areas, the integrity of these areas is frequently compromised by encroachment (May et al. 1997). There is no prescribed buffer size to protect a stream or other water body from all potential impacts. Different buffer widths are required depending on the characteristics of each potential pollutant and the integrity and/or quality of a particular riparian zone; therefore, unless riparian zone buffers are carefully evaluated based on adjacent land use and threats, the success of the riparian zone in adequately buffering pollutants is uncertain at best. For many small stream systems, riparian areas are highly degraded or no longer exist, and their restoration is precluded by existing development. Although functional riparian areas have the capacity to mitigate for some of the adverse impacts of development (Morley and Karr 2002), they cannot effectively address significant impacts from changes to stream hydrology resulting from significant losses of forest cover (May et al. 1997; Booth i.e., 2002).

5.4.6.4 Loss of Wetlands

Wetlands provide habitat and perform functions that contribute to the health of ecosystems used by many species within Washington. There are many different kinds of wetlands (e.g., bogs, fens, estuaries, marshes, etc.), each of which has different characteristics and functions. Wetlands are found in diverse landscapes, including forests, prairies, deserts, and within floodplains of streams (WDNR 2000a).

Wetlands help maintain cool water temperatures, retain sediments, store and desynchronize flood flows, maintain base flows, and provide food and cover for fish and other aquatic organisms (Beechie et al. 1994, Mitsch and Gosselink 1993; WDOE 1998). Wetlands also can improve water quality through nutrient and toxic-chemical removal and/or transformation (Hammer 1989; Mitsch and Gosselink 1993).

Since the time of colonization, Washington State has lost between 30 to 50 percent of its wetlands through various efforts to modify or "reclaim" them for human uses (USFWS 1999a, WDNR 2000a). Certain types of wetlands have been particularly affected by development and modification. For example, WDNR (1998a) reports that by 1979, Washington had lost about 70 percent of estuarine wetlands that existed prior to 1800; some important river delta and estuarine areas, particularly those on the eastern shores of Puget Sound, have lost up to 99 percent of their wetland areas (WDNR 1998a, WDNR 2000a). Additionally, the functions of existing wetlands have been reduced. Various factors have contributed to wetland loss and wetland function reduction including agricultural development, urbanization, timber harvest, road construction, and other land-management activities. It is difficult to assess the current condition of wetlands in forested lands and other areas across the entire State. However, some wetlands on lands subject to the Washington Forest Practices Rules were altered in the past due to timber harvest and road building. These actions can affect wetland sites directly through vegetation alteration, soil compaction, changes in hydrologic regime, and degradation of water quality; or indirectly through sedimentation from adjacent land-management practices. Increases in impervious surface within a watershed have also been shown to affect wetlands (WDNR 2000a). Additionally, harvest of trees in or adjacent to wetland sites can affect the associated microclimate (Brosofske et al. 1997; Chen et al. 1995, 1999). Other impacts to wetlands have likely occurred from fires and other natural disturbances.

5.5 AGRICULTURE AND GRAZING

Agriculture is one of the principal industries in the State, with all production, processing, distribution, and marketing operations comprising $29 billion of the total economy of the State (Canty and Wiley 2004). Green et al. (2000) reports the existence of over 15,000 operations in Washington State, covering over 15,000,000 acres. Agriculture operations, which in this Opinion will address both farming and animal operations, exist in both western and eastern Washington, but there are differences between the kinds and sizes of operations between the two regions (Canty and Wiley 2004). In western Washington, individual farms are relatively small, with the primary products including dairy, poultry, and berries. In the eastern part of the state, large farms are common, producing wheat, barley, potatoes, fruit, and vegetables.

Many animal husbandry operations exist in Washington. Large operations in the State include cattle (beef and dairy) and poultry (Green et al. 2000). Other smaller operations raise horses, pigs, sheep, geese and ducks, dairy goats, rabbits, and exotic animals (e.g., llamas, emus, alpacas, ostriches). About one-third of the state is grazed by livestock, according to a study by the Washington Rangeland Committee and the Conservation Commission (in Green et al. 2000). The study indicates that rangeland acreage in the state totals approximately 7 million acres, while an additional 5.5 million acres of forested habitats have the potential to support grazing.

With the steady increase in urbanization and population growth in Puget Sound, agricultural lands are steadily being converted to residential and urban developments. Canty and Wiley (2004) report that more than one million acres of farmland was converted for other uses between 1982 and 1997, and with 20 percent of the Puget Sound-area farmland converted during this period. Conversion of farmland results in the fragmentation of surrounding farmlands (Canty and Wiley 2004), and displacement of new farmland development and/or expansion to marginal growing areas, in which lower yields may require conversion

of a greater amount of forested habitats. These factors have also resulted in a net decrease in agricultural areas.

5.5.1 History

Many natural habitats were converted in both eastern and western Washington to support agricultural operations, with such conversions beginning in earnest by the mid-1800s, and continuing into the 1950s (Edge 2001). Many of the areas deemed suitable for agriculture were converted by the 1930s and were located in floodplains, estuaries and other wetlands, and prairies. West of the Cascades, farmlands are generally found in low-elevation, low-gradient areas, and most conversion to agricultural lands has occurred along lower elevations of the watersheds, estuarine and nearshore areas, or along floodplains of mainstem river reaches. For example, the Estuarine Research Federation estimates that 93 percent of the historical wetlands in the lower Skagit have been converted by agricultural activities over the past 150 years (Dean et al. 2000). In the Snohomish River estuary, approximately 74 percent of the wetlands were diked and drained for agricultural purposes (WSCC 2002b) and in the lower Stillaguamish, tidal marsh and wetland habitats within the anadromous zone have been reduced by 96 percent of historical levels (WSCC 1999a). Most of the major effects occurred in the early part of the century but construction of revetments and water-control structures continued into the 1960's in some areas.

East of the Cascades, deep arable soils and water availability have historically been significant determinants of agricultural lands. In these areas, agriculture began in the 1800s, with some of the first major modifications of habitat occurring with the construction of irrigation ditches to provide water for small areas of rangeland (WDNR 2000a). Other modifications soon followed. Before the 1930s, the majority of agricultural lands in eastern Washington were located in the grasslands of the Palouse Prairie area, which did not rely on irrigation to raise the main crops of grain, corn, and dry peas (WDNR 1998a). However, by the early 1900s, over 100,000 acres were being irrigated in the Yakima River Basin, with the water in the river already over-appropriated (WDNR 2000a). Flood-control dikes were constructed to prevent damaging floods, but resulted in habitat destruction and floodplain disconnection (WDNR 2000a). Beginning in the 1930s, dams and irrigation projects, including the Yakima Basin Irrigation Project, were constructed by Federal Bureau of Reclamation projects to increase the area in which crops could be grown (WDNR 1998a, WDNR 2000a). Complex systems of dams and irrigation canals (previously described in this section of the Opinion) were constructed, permanently affecting water quality, water quantity, and habitat.

Grazing began in Washington in the mid 1800s, with sheep and cattle herds initially using the lush grasses that covered many parts of eastern Washington (Oliver et al. 1994). Sheep grazing peaked in the 1930s, and then rapidly declined, while cattle grazing increased steadily in most areas (Oliver et al. 1994). In the early 1900s, livestock grazing was authorized on National Forest lands (Oliver et al. 1994). Grazing fees and regulations were implemented in 1906, with grazing allotments initiated the following year, although enforcement efforts were not substantial enough to prevent trespass by unregulated livestock. Grazing resulted in a number of effects, including: a general decline in range conditions; excessive use of available forage and resulting conflicts between livestock owners; removal of highly flammable fuels and reduction in ground fires; purposeful setting of fires (by livestock owners) leading to uncontrolled fires; establishment of invasive, non-native vegetation; and increase in siltation of water bodies.

As a result, the Bureau of Land Management began regulating grazing on public rangelands in the 1930s. Asian grasses were introduced as stabilizing vegetation for the erosion caused by overgrazing and other

practices. The reduction in the number of sheep and localized declines in grazing pressure by cattle in some areas allowed recovery of some of the rangelands (which included forestlands) (Oliver et al. 1994). By the 1960s and 1970s, legislation allowed for monitoring, improvements, and better stewardship of rangeland (including those in National Forests).

5.5.2 Effects to Natural Resources

Agricultural lands provide some benefit for fish and wildlife species in comparison with certain other land uses. For example, there is generally less impervious surface associated with agricultural lands than in urbanized or industrial areas. However, there are a number of impacts associated with farms and animal operations. Agricultural practices have contributed to the loss of side-channel areas and riparian vegetation in the floodplain. The effects of livestock grazing, dairy operations, and crop production often extend many miles upriver and into areas managed primarily for timber. In the Skagit Valley, farms and pastures extend approximately 112 kilometers (70 miles) upriver to the community of Concrete. In the northern Puget Sound area, agriculture is most pronounced in the Nooksack River, where farming activities comprise almost 12 percent of the entire watershed and extend at least 69 kilometers (43 miles) up the mainstem and another 16 kilometers (10 miles) up the South Fork Nooksack River. In the Stillaguamish, the construction of dikes and revetments has resulted in a loss of over 31 percent of the historical side-channel habitat and the combined impact of agriculture and residential development has reduced the riparian vegetation in these areas by nearly 90 percent.

Agricultural operations also result in the degradation of water quality due to contaminants, such as excess nutrients, fertilizers, pesticides, and other chemicals. Livestock production often degrades water quality with the addition of excess nutrients, while pesticides are often applied to crops which can leach into the water table and enter streams from surface water runoff (Rao and Hornsby 2001; Spence et al. 1996). A number of pesticides have been detected in small streams and sloughs within agricultural and urban sites tested within Puget Sound (Bortleson and Davis 1997). In addition, elevated nutrient concentrations from animal manures and agricultural fertilizer application can contribute to excessive growth of aquatic plants and reduced levels of dissolved oxygen in Puget Sound and other waterbodies in the State, which can adversely affect fish (Embrey and Inkpen 1998) and other aquatic organisms.

Water quality can also be affected by increases in temperature and sediment loading from agricultural operations. As described previously, irrigation systems often result in warmer water temperatures in canals and streams. Warmer temperatures can result from the clearing of shade-providing riparian areas along streams or other waterways, and from solar heating of water flowing across fields or in shallow waterways. Sediment loading is a significant contribution of dryland agriculture in eastern Washington, and results from storms and rain and snow runoff (Palmisano et al. 1993).

Effects from livestock grazing can be considerable if management practices are not sufficient to protect habitat functions (WDNR 1998a, Wissmar et al. 1994, Belsky et al. 1999). Livestock grazing is currently the primary land use in existing eastern Washington shrub-steppe habitats; this grazing, together with fire suppression, has altered the nature of the habitat in several ways (WDNR 1998a). Shrubs are more numerous because many are not eaten by livestock, while bunchgrasses are less common because they are consumed or trampled by livestock. Trampling also damages the fragile moss and lichen layer that protects the soil against erosion and non-native invasive vegetation colonization (e.g., cheatgrass) and provides nutrients to the soil. Additional impacts may result from other practices, including: (1) improper spreading, of manure; and (2) increased surface runoff from overgrazed pastureland or other areas in which large numbers of animals are confined (Green et al. 2000).

A number of different kinds of habitats can be affected by grazing. Riparian and wetland habitats and stream water quality is often degraded by grazing, resulting in cascading effects to fish and riparian habitat in both eastern and western Washington (Wissmar et al. 1994). Kauffman et al. (2001) reported that livestock grazing is probably the most-extensive land use in the Pacific Northwest, significantly influencing the structure of riparian areas. Overstocking and overgrazing in eastern Washington since the 19th century were slowly recognized to be damaging to rangeland, resulting in changes in grazing practices; however, the adaptations in management have not fully addressed the problems created by grazing. Wissmer et al. (1994) notes that recent changes in grazing practices have resulted in additional concerns about damage to sensitive riparian and wetland habitats. For example, the grazing of cattle instead of sheep often leads to increased damage to riparian habitats (which cattle, especially bulls often seem to prefer) if they are not excluded from these areas. Many grazing operations have adopted limits to the amount of current annual vegetative growth removed to protect riparian shrubs that decrease under heavy grazing pressure. Instream restoration is used to try to reverse stream down-cutting and dropping water tables, alternate water supplies are developed on slopes to encourage use of secondary range, and sensitive reaches of streams are sometimes precluded from cattle use. Reintroduction of beaver to watersheds where they were extirpated is being considered in some cases to help reverse stream down-cutting and dropping water tables. Typical impacts to forested habitat includes removal of native vegetation, change in vegetative species composition, introduction of invasive non-native species, degradation of water quality, and erosion of stream banks and springs.

Other impacts result from the maintenance of grazing lands. Fence construction, reconstruction, and maintenance activities require transport of materials, digging of holes, and stringing or re-stringing wires or fences. Treated-wood posts are often used at corners with braces, with interspersed metal posts, wooden posts, or live trees. On flat terrain, power equipment may be used to auger holes and construct fence. On steep terrain, hand tools and chain saws become more common. Rock cribs are often used when crossing areas of bedrock.

Attempts have been made to begin correcting some of the past impacts on the State's ecosystems from agricultural operations. In 1988, the EPA implemented the Federal Insecticide, Fungicide, and Rodenticide Act to regulate the acceptance and use of chemical pesticides, although some authors note challenges associated with use of the Federal Insecticide, Fungicide, and Rodenticide Act (Edge 2001). Additionally, State and Federal landowner-assistance programs have been organized to aid landowners in voluntarily managing their properties to improve water and habitat quality (Edge 2001). In western Washington, Puget Sound was selected for inclusion in the National Water Quality Assessment program to begin addressing these issues. Certain actions have been specifically implemented to reduce impacts from grazing. Fords have been created by adding rock to streams beds that have been muddied by livestock use, fencing and guzzlers are often installed to reduce livestock disturbance to riparian areas.

5.6 MINING AND MINERAL PRODUCTION

Mining and mineral production includes sales of rock, gravel, and sand; prospecting and mining contracts; and oil and gas leases. Washington State (2005) indicates that the value of mineral production has steadily increased since 1975, despite the fact that data are not always available for all categories due to disclosure laws. It is likely that additional mineral deposit discoveries will lead to further activities in mining (with development possibly preceded by timber harvest) and mineral processing in the action area. Potential effects from such activities include loss of habitats, displacement during activities, harassment, and decreases in habitat quality.

As of 1998, there were 1,173 active rock, sand, and gravel mines over three acres in size permitted in the State (WDNR 1998a). Of these, 30 were over 200 acres in size. Some unknown number of pits are less than three acres in size and thousands of pits (averaging at least one per square mile) are used for construction and maintenance of commercial forest roads. During 1995, Washington produced over 41 million tons of sand and gravel and over 17 million tons of rock. On average, each person in the State is responsible for the consumption of over three tons of stone and over seven tons of sand and gravel each year. This average annual use of almost 11 tons would be about 16 tons if the production from smaller pits, such as forest roads, was also considered. Continued population growth is rapidly depleting the larger mineral deposits in Washington (WDNR 1998a).

Mining activities in eastern Washington can be described in terms of locatable, leaseable, and salable minerals. Much of the mining industry east of the Cascades has focused on metals (gold, silver, copper, nickel, and chromium), gravel, and stone (Wissmer 1994). While exploration for locatable minerals (e.g., copper, gold, silver, iron, etc.) is fairly common where the geology suggests they may be present, large-scale extraction is relatively uncommon. Current large-scale commercial mining occurs primarily in Okanogan and Ferry Counties, but smaller operations are relatively widespread. Larger operations are regulated by State and Federal agencies, so effects can be assessed and minimized through the permitting process. Smaller-scale mining operations are not generally analyzed individually, but rather can result in lesser impacts to ecosystems if appropriate guidance is followed (e.g., "Gold and Fish pamphlet; WDFW 1999a). Leasable minerals (e.g., oil, natural gas, coal, and geothermal mining) are relatively uncommon in eastern Washington or are not in sufficient amounts to be considered profitable. Notable exceptions include coal in the Cle Elum area, and natural gas in the Tieton River and Tri-cities area. Salable minerals (e.g., sand, stone, gravel, cinder, and clay) are widespread and typically abundant, but are of low relative value. They are generally used for construction purposes, but may be used for decoration and landscaping as well.

5.6.1 History

Historical operations occurred primarily in north-central and northeast Washington in the late 1800s and in the Yakima and Grande Ronde River basins in the early 1900s (Oliver et al. 1994). Many of the early mining activities targeted coal (initially in Bellingham Bay and King, Pierce, and Kittitas Counties) and gold (eastern and western Washington) (Palmisano et al. 1993). Other products included metals (zinc, copper, lead, silver, gold), which peaked in production between 1940 and 1970, and industrial mineral mining. The latter group includes a number of materials (e.g., sand, gravel, clay, diatomite, gypsum, peat, barite, dolomite, talc, etc.), and has experienced a rapid increase in production since the mid-1900s.

As of 1994, mining activities were relatively uncontrolled in National Forests (Oliver et al. 1994). Oliver et al. (1994) reports that from 1967 to 1992, there were 1,105 active claims in the Yakima Drainage Basin, covering just under 20,000 acres (compared to 112 claims over 2,012 acres from 1946 to 1966).

5.6.2 Effects to Natural Resources

Past mining for minerals has had a range of effects in eastern Washington from relatively minor, to qualifying for EPA's Superfund status. Impacts from historical operations included effects to stream and riparian ecosystems through habitat modification (including ditching and diversion operations), erosion/siltation, leaching, and dredging. Recent effects of mining include contaminants from leach mining (e.g., resulting in releases of cyanide or other chemicals) and excavation of stream channels and

floodplains from sand and gravel operations (Wissmer et al. 1994; Oliver et al. 1994, Martin and Platts 1981).

Recreational mining and commercial mining can significantly alter the physical structure and stability of instream habitat (Spence et al. 1996). In-channel gravel mining can result in both upstream and downstream channel incision, which further destabilizes stream banks, leads to channel simplification, changes bed-load movements, and alters groundwater hydrology, which may reduce summer base flows (Spence et al. 1996). Although there have been recent revisions to the State rules and regulations for mineral prospecting and placer mining to be more protective of aquatic species ("Gold and Fish" pamphlet; WDFW 1999a), habitat impacts (especially cumulative and frequency impacts) from ongoing recreational mining are still a concern in salmonid spawning and rearing streams.

The negative effects of small-scale dredge mining may be minor and localized if the extent of the dredging is small (area or length of stream) and operations are timed to avoid direct excavation of salmonid eggs and fry. Effects can also be reduced if operators do not disturb or destabilize stream banks, vegetation, LWD, or boulders, and the reconfigured streambed does not reduce the stability of interstitial spawning and rearing habitats during subsequent peak-flow events (MBTSG 1998).

Wissmer et al. (1994) notes that, although some limitations have been placed on the method and extent of gravel excavation, habitat impacts are still likely to occur. Overall, mining effects in the past have resulted in substantial degradation of stream habitats and associated fisheries. Some of these effects continue to occur, degrading baseline conditions; actions are on-going in some areas in an attempt to restore ecosystem function. Current mining operations are generally better regulated, and should therefore result in comparatively fewer effects; however, attempts to determine long-lasting changes would be premature.

5.7 FORESTRY

The State encompasses 42,613,000 acres (66,582 square miles), including 21,892,000 acres, (51.4 percent) of public and private forests (Table 5-4 below). Government entities own about 13,350,000 acres of forestlands, with approximately 9,000,320 acres under Federal management. The remaining forestlands, approximately 8,542,000 acres, are private- and/or corporate-owned (i.e., not Federal and not WDNR) forestland in Washington (WDNR: 1991-1993 The Rate of Timber Harvest in Washington State (August 1997) in WFPA 2001; WFPA 2001).

The forest products industry in Washington is the second-largest manufacturing sector in the State after transportation (primarily aircraft production). The industry directly employed 50,060 workers in 2000, or 13 percent of total manufacturing employment. Lumber, plywood, paper, and other forest-products industries account for more than 15 percent of the total manufacturing income in the State. Foreign export of raw logs and lumber as a percent of total timber harvest has sharply declined from a high of 49 percent in 1989 to just under 15 percent in 2000 (WFPA 2001, page 11).

Approximately 4.1 million acres of forests in western Washington and 2.3 million acres of forests in eastern Washington are closed to harvest, due to some form of protected status (e.g., National Parks). Forestlands in western Washington account for about 57 percent of the forestland in the State, but have historically provided over 80 percent of the total timber harvest (Adams et al. 1992).

Table 5-4. Forest Land Ownership in Washington State. (WFPA 2001).

Forest Land Ownership	Subgroup	Acres
Government		**13,350,000**
Federal		9,541,000
	National Forest - Non-Wilderness	5,272,000
	National Forest - Wilderness	2,576,000
	National Forest - Scenic and Recreation	189,000
	National Parks	1,451,000
	National Wildlife Refuge	3,000
	Bureau of Land Management	50,000
State Trust		2,270,000
Native American		1,269,000
County and Municipal		270,000
Private		**8,542,000**
Industrial		4,305,000
Nonindustrial		4,237,000
Totals		**21,892,000**

5.7.1 History

The first report of timber harvest in Washington was the 1827 activity by the Hudson Bay Company near Vancouver, Washington (Palmisano 1993). By the mid-1850s, a series of mill towns had been established along Puget Sound, with steam sawmills operating in a number of areas in Puget Sound (Palmisano 1993). As with western Washington, forestry activities in eastern Washington originally occurred in areas that were easily accessible, such as near settlements, mines, and railways (Oliver et al. 1994). Forested areas that were considered unsuitable for agriculture were managed for timber harvest. Selective cutting, high grading, and overstory removal were harvest systems that were used in eastern Washington, with relatively low volumes harvested due to inaccessibility and costs.

Pioneers used Washington's river systems to transport logs and other goods. Trees were felled directly into streams, rivers, and salt water and floated to their destinations, or pulled to streams and trapped behind splash dams, which were dynamited or pulled away, causing logs to sluice downstream. Roads for oxen, then railroads, followed transportation by water. In railroad logging, powerful steam-powered "donkey" engines pulled logs across great distances on the ground, crossing streams and anything else in the way. Following World War II, truck road systems replaced railroads, but smaller streams continued to be used as transportation corridors (CH2MHill 2000).

After 1930, the introduction of motorized trucks and chainsaws allowed for substantial increases in harvest. Fueled by the demand for new housing and development after World War II, harvest increased dramatically. Harvest initially focused on large-diameter trees; smaller trees were then harvested, ultimately reducing the number of large-diameter trees. Harvest of uneven-aged trees was practiced until 1940; by the 1950s, even-aged management was practiced.

Much of the lowlands initially harvested for timber were subsequently cleared for agriculture and residential development. Early riparian and stream clearing and the construction of splash dams to facilitate water transport of logs were common practices in western Washington streams (Sedell et al. 1991). Repeated splash damming resulted in major long-term damage to fish habitat, as the practice caused severe scouring of stream channels, often down to bedrock (Murphy 1995). In tributaries too

small for splash dams, trees were typically yarded downstream, degrading stream channels and banks in the process. Railroad systems were also constructed for transporting timber to mills in many watersheds. Although these forest-management practices improved by the 1950s, clearcutting to the stream banks remained a common practice until the 1980s. Many of the destructive effects of these practices were usually the result of a lack of awareness, but sometimes even well-intended practices resulted in negative effects. For example, as recently as the 1970s, fish biologists were advising (and agencies requiring) foresters to "clean" log jams and other LWD from streams, in the mistaken belief that it would improve fish habitat or serve other values (SRGC 1983; Cited in CH2MHill 2000; Murphy 1995). Stream cleaning was common, affecting 58 percent of watersheds surveyed in a recent summary of watershed analyses completed to date (Beak 1998; Cited in CH2MHill 2000). Until recently, State forest practices allowed timber harvest to occur within 7.6 meters (25 feet) of salmon-bearing streams; these minimum widths were often insufficient to fully protect riparian ecosystems.

Forestry practices on the Olympic Peninsula have included instream salvage, stream cleaning, and the conversion of old-growth coniferous riparian forests to young stands of deciduous species. These practices have altered both the abundance and recruitment of LWD, especially decay-resistant conifers, such as western red cedar, in Olympic Peninsula streams. The LWD in many streams is now dominated by smaller diameter alder that tends to decay quickly and exert less influence on channel-forming processes. Such wood is often too small to influence river channel hydraulics, especially the formation of pools in large mainstem rivers. The rapid loss of large wood from streams may also be related to increased flooding and sediment in channels modified by intense logging (McHenry et al. 1998).

While timber harvest continues to occur in Washington, conversion of forestland to other uses has become more common as the population of Washington has grown. Comprehensive tracking of forestland conversion rates began in the late 1970s, with the Forest Service Forest Inventory and Analysis data (Bolsinger et al. 1997). These data, combined with limited data from the 1930s to the 1970s, indicate general trends in forestland conversion. The earliest data indicates there were approximately 26.5 million acres of forestlands in Washington State during the 1930s, with 25.2 million acres available for harvest; 15.2 million (60 percent) acres were found in western Washington , and 10 million (40 percent) in eastern Washington. By 2004, a net loss of approximately 3.5 million acres of forestland was reported, with 80 percent of this loss occurring in western Washington. The data indicate that reductions in the amount of privately owned forestland accounted for the majority of this loss.

During the period of 1945 to 1970, approximately 630,000 acres of commercial forestlands were converted to non-forest uses (e.g., urban-industrial, agriculture, and road use) in Washington (Bolsinger et al. 1997). By 1970, there were an estimated 23.1 million acres of forestland in Washington, with 4.7 million acres in reserve status or not considered capable of growing commercial timber. Between 1978 and 1991, Bolsinger et al. (1997) estimated that lands available for timber production in Washington outside of the National Forests decreased by 488,000 acres. This includes approximately 117,000 net acres of private timberlands that were transferred to the National Forest System, and an additional 92,000 acres (mostly tribal) that were reclassified to reserve status (i.e., forested, but not available for timber harvest). Conversions to other uses, such as urban development and rights-of-way for roads, pipelines, and other uses, accounted for approximately 279,000 acres.

5.7.2 Effects to Forests

Forestlands in Washington have experienced effects related to many different changes, which often vary by area. These changes, which disrupt natural processes that influence forest health, are produced by

direct and/or indirect human activities that have occurred in the past and present (WDNR 1998a). These activities include timber harvest, grazing, fire suppression, road construction, and management practices and other influences that have resulted in increases in disease and pests. The impacts of grazing have been discussed previously, and will not be addressed in this section.

Intensive forest management generally results in adverse effects such as loss of older forest habitats and habitat structures, increased fragmentation of forest age classes, loss of large contiguous and interior forest habitats, decreased water quality, degradation of riparian and aquatic habitats, and increased displacement of individual species members.

Intensive forest management on most private lands generally maintain these lands in an early seral stage (e.g., 40 to 50 years of age) with relatively few structures such as snags, down logs, large trees, variable vertical layers, and endemic levels of forest "pests" and "diseases," when compared to what was historically present prior to intensive management.

5.7.2.1 Timber Harvest

Washington boasts some of the most-productive forests in the world, with harvest on many private ownerships occurring at intervals of 40 to 60 years. The rate of timber harvest from commercial forestland in Washington State is about 1.1 percent (WDNR: 1991-1993 The Rate of Timber Harvest in Washington State (August 1997) as cited in WFPA 2001). Patterns of timber harvesting are influenced by natural events (fire, ice, insects, and disease), management practices, public policies, and market conditions. The average size of harvest units depends on harvesting methods. Clearcutting is a common harvesting method in forests dominated by Douglas-fir. Clearcut size is limited by State law to 120 acres, without special review. Actual sizes of clearcut areas vary by region of the State, but regional averages are generally between 20 and 40 acres on the Westside and 50 to 60 acres on the eastside (WFPA 2004). Where it previously occurred on steep slopes, clearcutting often resulted in slope instability, mass wasting (landslides), high silt loads, and reduced water quality.

There are many different kinds of activities associated with timber harvest, with varying degrees or types of impacts associated with each activity. Timber harvest and associated activities, such as road construction and skidding, can increase sediment delivery to streams, clogging substrate interstices and decreasing stream channel stability and formation. Harvest in riparian areas decreases woody debris recruitment and negatively affects the stream's response to runoff patterns. Stream temperatures may rise with decreases in the forest canopy and riparian zone shading. Runoff timing and magnitude can also change delivering more water to streams in a shorter period, which causes increased stream energy and scour and reduces base flows during summer months.

Other impacts from logging practices include modifications to forest composition. For example, prior to Euro-American settlement of Washington in early 1800's, the different forest age classes were well represented across the State (WDNR 1998a). Since that time, declines in old-growth forests have occurred on both Federal and non-Federal lands. For example, since World War II, old growth in the Olympic National Forest has declined by 76 percent (Morrison 1990).

Much of the old-growth in western Washington (~54 percent) in the mid 1930s was on private lands (WDNR 1997); by 1992, only about 8 percent of that amount remained on private lands. Approximately 50 years ago, there were more than 9 million acres of old growth (WDNR 1997). By 1999, old growth was limited to 2.6 million acres and occurred mostly on Federal lands and at higher elevations where they were less available (or unavailable) for harvest. Today, old growth is found on less than 3 percent of non-

Federal lands in western Washington, and most forests outside of the National Parks and National Forests are younger than 50 years old (Spies and Franklin 1991).

In addition, studies have shown that large trees in temperate coastal rainforests collect moisture from fog, and this collection of moisture may contribute an estimated 35 percent of the annual precipitation (Quinault Indian Nation and USDA 1999). Significant reductions in large trees in these habitats may result in less moisture retention, affecting future runoff and/or precipitation patterns.

In eastern Washington, specific impacts from timber-harvest management have included the removal of LWD, reduction in riparian areas, increases in water temperatures, increases in erosion and simplification of stream channels (Quigley and Arbelbide 1997). Past timber harvest practices include the use of heavy equipment in channels, skidding logs across hill slopes, splash damming to transport logs downstream to mills, and road construction (USFWS 2002). Improvements in methodologies have reduced some of the effects from these practices (Oliver et al. 1994). Harvest units have been restricted in size, and greater consideration has been given to the health and appearance of forest landscapes and the biotic communities that depend on them. In some cases, equipment is used and/or engineered in ways to minimize soil disturbance and other habitat impacts. In other cases, however, the methods used may result in increased soil disturbance and extreme fire hazards (e.g., machine piling and burning, accumulation of dead slash from thinning activities, etc.) (Oliver et al. 1994).

5.7.2.2 Fire Suppression

Under historical fire regimes, natural disturbance to streams from forest fires resulted in a mosaic of diverse habitats. However, forest management and fire suppression over the past century have increased the likelihood of large, intense forest fires in some areas.

Prior to European settlement, both natural and human-initiated fires are believed to have affected the forests in eastern Washington (Oliver et al. 1994). Eastern Washington forests consisted of open, park-like areas with fire-resistant trees in the lowlands, and Douglas-fir/western larch and true fir forests in the middle and high elevations, respectively (Oliver et al. 1994). In the lowlands, most fires were frequent, and not highly destructive, primarily burning off revegetation; at higher elevations, and in cooler areas, fires were less frequent, and highly destructive. Fire suppression began in the late 1800s when a forestry commission was convened to begin studying the conditions of Forest Reserves (precursors of National Forests), which were created in 1891. Although fire suppression was viewed as necessary to protect resources and private property, some advocated the use of prescribed fire to reduce fuels and protect stands against damaging fires.

From 1930 to 1960, forest management began in earnest on National Forest lands, and many rural settlers moved to urban areas. Grazing occurred in previously burned areas, while other areas developed into dense stands. Fire-suppression efforts were intensified, with additional funding and crews made available to respond effectively to fight fires. The buildup of fuels likely led to larger, more-destructive fires. From the 1960s to the 1990s, fire prevention allowed the development of dense, closed stands of trees, which varies significantly from pre-management times. Oliver et al. (1994) report that this growth pattern makes stands increasing susceptible to disease and pests. In the 1960s, attitudes towards burning began to change, and the beneficial role of fire was recognized. The use of prescribed fire in certain environments was also encouraged, with certain precautionary measures. However, since the 1960s, fire frequencies in eastern Washington have been relatively low, as a result of either fire suppression, or the absence of fuels from previous severe burns.

Although scientists have recognized the value of prescribed burning as one of many tools to help return landscapes to natural conditions, managers have been slow to embrace prescribed burning partially due to the issues surrounding liability. There are also other constraints upon prescribed burning including short-term expenses and air-quality regulations.

5.7.2.3 Disease and Pests

Pests and disease were present in Washington's forestlands prior to European settlement. Several kinds of defoliating insects have been documented, including, but not limited to, Tussock moths, pine butterflies, and bark beetles (Oliver et al. 1994). Starting in the 1930s, pest surveys and control were used to combat these pests. Pest control included selective harvesting/or salvage harvest to remove infested trees, the spraying of pesticides (e.g., ethylene dibromide, DDT, and other insecticides), and removal of host plants (e.g., currant [*Ribes* spp.], host of white pine blister rust).

Since the 1960s, integrated pest management (IMP) has been used to control insect outbreaks. With IPM, several different management and pest-control alternatives are rated against cost/benefit analyses, alternative strategies, ecological considerations, and other concerns to determine the best recourse against the target pest(s). Examples of IPM alternatives include: favoring resistant stand structures and/or species in thinning and planting activities; fire prescription; selective use of pesticides; and salvage logging (Oliver et al. 1994).

5.7.2.4 Roads

Road construction in watersheds can promote simplification and channelization of streams, which reduce the connectivity of surface water and groundwater. Activities associated with road construction, maintenance, and use can also result in loss or damage to riparian areas, sedimentation, high erosion and slope hazards, installation of undersized culverts, and reduction or elimination in the ability of salmonids to access upstream reaches of a stream. Palmisano et al. (1993) reports that a substantial percentage of roads and railroads in the State are along streams or floodplains, and many have been placed within streams' riparian zones.

Historical methods of road construction were destructive to stream habitats (Palmisano et al. (1993). Stream gravel and cobbles were often used as fill, and excess excavation materials were pushed over the side of the road bank, where it frequently entered streams. Riparian vegetation and stream banks were damaged by the use of heavy equipment adjacent to and in streams. Side channels were often cutoff or eliminated, and stream channels were confined, resulting in increased bank erosion in certain areas. Lack of adequate drainage led to saturation of roadside soils. Constriction of floodplains resulted in increased flooding, which continues today in certain areas.

Little specific information is available on the historical origins and use of roads in forested areas outside of the Forest Service lands. Within the Forest Service lands, most forest roads were originally constructed by harvesters for access to forested areas, who then deducted the costs of road construction from final payments to the Forest Service (Oliver et al. 1994). Oliver et al. (1994) reports that less than 150 miles of road existed in Washington National Forests in 1907; by 1920, this number had increased with 176 miles of road per million acres in the Yakima River Basin (Washington), and 287 miles per million acres in the Grand Ronde River Basin (Washington and Oregon). Beginning in the 1950s, the Forest Service began to assert more direct control over the road network on Forest Service lands, and the

network increased. In the Yakima Drainage Basin, road totals increased from 99 miles per million acres (before 1900) to 2,251 miles per million acres in 1992[11].

Road decommission and removal is one way in which the impacts from roads are being reduced. Between 2000 and 2004, the Salmon Recovery Funding Board[12] funded projects to repair or abandon 222 miles of road to reduce sediment input into streams (SRF 2005). In Pacific County, 5,800 feet of road was removed in the Ellsworth Creek watershed, including ripping of the surface, relocation of sidecast to restore the natural slope, revegetation of the area, and removal of several culverts and crossdrains (Carlson, Personal Communication, 2005b).

5.7.3 History of the Washington Forest Practices Rules

Hydraulics Code Guidelines, administered by WDFW, were established in 1949; but it was not until 1974 that the Forest Practices Act, administered by WDNR through the Forest Practices Board, was passed. The Forest Practices Act was designed to protect public resources (e.g., water, fish, wildlife, and capital improvements of the State or its political subdivisions), and created the Forest Practices Board. One of the Board's duties is to promulgate the Washington Forest Practices Rules (Chapter 222 WAC) necessary to implement the purposes, policies, and provisions of the Washington Forest Practices Act. These rules provide minimum standards for forest practices such as road construction, timber harvest, pre-commercial thinning, reforestation, fertilization, and brush control.

In 1987, Federal and state agencies, environmental groups, Native American Tribes, industrial and non-industrial forest landowners entered in the Timber, Fish, and Wildlife (TFW) Agreement. The TFW Agreement has five common goals: (1) Wildlife; (2) Fisheries; (3) Archeological and Cultural; (4) Water Quality and Quantity; and (5) Timber. For instance, the wildlife goal is to provide the greatest habitat diversity (particularly riparian, wetlands, and old growth) and assure the greatest species diversity within those habitats for the survival and reproduction of enough individuals to maintain the native wildlife of Washington's forestlands. On the other hand, the timber goal is to assure the continued growth and development of the State's forest-products industry, which has a vital stake in the long-term productivity of both the public and private forestland base. While TFW has numerous goals, the need to balance these goals serves as an important directive to the participants.

Advisory Groups under the TFW Agreement have been in place for almost 20 years under different names (i.e., Wildlife Steering Committee), and are organized under the Cooperative, Monitoring, Evaluation, and Research committee (CMER). For instance, the Wildlife Steering Committee (now know as Landscape Wildlife Advisory Group, or LWAG) is tasked with addressing wildlife research and monitoring issues associated with the Forest Practices Act on State and private lands. Wildlife biologists from Federal and State agencies, Native American Tribes, Environmental Groups, and the timber industry voluntarily participate to provide technical guidance to CMER.

The result of this cooperative approach to continuous improvement has been a proactive yet changing set of Washington Forest Practices Rules. For instance, prior to 1974, there was no requirement to retain wildlife reserve trees (including snags) or green recruitment trees. The Washington Forest Practices

[11] During this same period, railroad transportation in the basin increased from 26 miles/million acres before 1900, up to 53 miles/million acres beginning in the early 1900s, then 0 miles/million acres from 1967 to 1992 (Oliver et al. 1994).

[12] The SRF board statistics did not specifically denote roads associated with forestry. The reported projects (abandonment or repair of roads) were intended to reduce sedimentation into streams.

Rules have been amended and strengthened 13 times since they were established in 1975. As a result of rule changes and changes in common practices, many stands bear characteristics that are indicative of the era in which they were last harvested.

5.7.3.1 Northwest Forest Plan

In 1994, the Northwest Forest Plan (NWFP) was implemented. The total area of Federal lands covered under the NWFP in Washington State is approximately 8,839,040 acres 913,811 square miles). Several areas of research were instituted under the NWFP, including, but not limited to wildlife conservation and population viability issues, aquatic conservation strategy, adaptive management areas, ecological processes and function, and the creation of new stand development strategies for the Douglas-fir region covered under the plan (Snow and Perez 2001).

5.7.3.2 Conclusion

Over the last 25 years, forest management of Washington's forestlands has changed. Changes have resulted from revisions to the Washington Forest Practices Rules, restrictions due to federally listed species, voluntary efforts on private lands, new planning efforts on Federal and municipal forests, and increased efforts to preserve unique forested habitat through local, State, and Federal conservation programs and exchanges. These changes will influence the spatial array of habitat conditions.

The current Washington Forest Practices Rules are the rules that are contemplated in the proposed action of this Opinion. The State began implementation of the current Washington Forest Practices Rules contained in the FPHCP prior to receiving any incidental take authorization that might be needed from the Federal Services. These rules are described in greater detail within this document and the FPHCP, but are contained in their entirety within the Washington Forest Practices Rules: Title 222 of the WAC. Those rules are supplemented with guidance known as the Forest Practices Board Manual, which provides additional guidance to assist land managers in complying with the rules.

Major changes in the Washington Forest Practices Rules which were incorporated between November 1998 and the early implementation of the FPHCP (began in January 1999), are summarized later in this Opinion. The adverse effects and beneficial changes which have occurred between November 1998 and the date of the preparation of this document are part of the environmental baseline.

5.7.4 HCPs

In 1982, the ESA was amended to authorize the incidental taking of endangered and threatened species by private landowners and other non-Federal entities, provided they develop HCPs that minimize and mitigate the taking. In the first 10 years after the HCP process was established, only 14 permits were issued. Since 1992, the number soared to more than 400 HCPs nationwide.

In Washington, the FWS has completed HCPs for over 2 million acres. As of November 2005, there are 13 HCPs in the State of Washington that have been approved by the Services. Two HCPs were completed by NMFS only (Tagshinny Tree Farm and the Mid-Columbia Public Utilities District), and one was combined and then sold (Native Fish HCP with Plum Creek Timber Company.) Although the specific activities covered under each HCP and their mitigation requirements vary, depending on the interests of the landowners, most were developed for forest-management activities. The only exception to this is the Daybreak Mine HCP (Stordahl), which covers flood-plain adjacent mining. The HCPs for the State are listed in Table 5-5.

Table 5-5. Washington Habitat Conservation Plans and Similar Agreements as of March 2006.

Applicant/Name	Contribution	Incidental Take Permit Issuance Date
Scofield Corporation (Chelan County)	Low-effect, single species HCP for 40 acres in a scenic area; one-time selective timber harvest. The permit was issued for 1 year.	04/03/1996
Day Break Mine/J.L. Storedahl & Sons, Inc. (Clark County)	Multi-species HCP on a 300-acre gravel mining operation on the East Fork Lewis River; includes coverage for the anadromous fish and the Oregon spotted frog.	04/16/2004
Western Pacific Timberlands (Boise Cascade) (Klickitat County)	Low-effect, single-species HCP for ~620 acres of Spruce-budworm-damaged forests.	09/14/2001
Washington Department of Natural Resources (various areas in Washington)	Multi-species HCP for 1.6 million acres throughout Washington.	01/30/1997
City of Seattle, (Cedar River Watershed)	Multi-species HCP to enhance second growth for northern spotted owl and marbled murrelet conservation. No commercial timber harvesting; a 90,500-acre watershed will be in LS/old growth reserves; fish passage will be built at Landsburg Dam. Instream flows in Cedar River will be maintained for salmon and steelhead.	04/21/2000
City of Tacoma, Tacoma Water (Green River watershed)	Multi-species HCP for 14,888 acres of forested lands.	07/09/2001
Plum Creek Timber (I-90 corridor, King and Kittitas Counties)	Multi-species HCP across 130,000 acres. Riparian protection and management in addition to watershed analyses.	06/27/1996
Port Blakely/Robert B. Eddy Tree Farm (Grays Harbor and Pacific Counties)	Multi-species HCP over 11,334 acres.	07/19/1996
Green Diamond Resource (Simpson Timber) Company (Grays Harbor, Mason, and Thurston Counties)	Multi-species HCP for 214,000 acres.	10/13/2002
West Fork Timber Company/Murray Pacific Corporation (Lewis County)	Multi-species HCP with ≥18-20% reserves primarily in riparian habitat through 53,000 acres.	06/1995
Tagshinney Tree Farm (Lewis Co.)	This plan covers 133 acres with respect to effects from forestry regarding 17 species for 80 years. It serves as an HCP per section 10 (a)(1)(B) for NMFS; and a Safe harbor and candidate conservation agreement with assurances for FWS per section 10(a)(1)(A). Covers spotted owl, marbled murrelet, bald eagle, steelhead, coho, and a number of unlisted species.	09/2004
Mid-Columbia PUD HCPs	These HCPs with NMFS cover salmon and hydroelectric operations on Wells Dam (Douglas PUD), as well as Rock Island and Rock Reach Dams (Chelan PUD).	04/2005
Native Fish HCP with Plum Creek Timber Co. (Multiple Counties)	This multi-state HCP covered 1.5 million acres in parts of Washington, Idaho, and Montana with respect to native fish species and effects from forestry and grazing. It no longer applies to Washington State: lands in the Lewis, Tieton, and Ahtanum watersheds.	10/ 2000
White River Habitat Management Agreement (King and Pierce Counties)	This plan covers owls on 12,279 acres in the Green and Green River Watersheds for about 50 years. Authorization for take is based upon section 7 consultation in association with Huckleberry Land Exchange.	05/02/1997

Forestlands covered by existing federally approved HCPs are generally not considered part of FPHCP covered lands; however, there are two exceptions. The Western Pacific Timberlands (*nee* Boise Cascade Corporation) HCP encompasses 620 acres and provides coverage for a single species (Northern spotted owl); this HCP does not include coverage for bull trout or other aquatic species. The other exception is approximately 228,000 acres of WDNR managed land on the east side of the Cascade Crest. The WDNR State Lands HCP provides coverage for terrestrial species in this area, but does not include coverage for aquatic species. The WDNR HCP is the largest HCP in Washington, which covers approximately 1.6 million acres of state trust lands managed by the agency. The forestlands contained within the Boise HCP and the east side of the WDNR HCP are considered covered lands under the Forest Practices HCP.

The development of HCPs and other wildlife-management plans has altered the basic management of forestlands in western Washington. Conservation measures included in the HCPs are designed and expected to adequately minimize and mitigate the effects of the taking to the maximum extent practicable. The FWS acknowledges that the HCP process is complex, often difficult, and relatively new on the landscape (in terms of natural history); therefore, while we expect that HCPs will provide substantial benefits to species and their habitats, attempts to evaluate the full ecological success of these plans would be premature.

5.8 LAND ACQUISITION

During the period from 2000 through 2005, the State of Washington received over $61 million through the U.S. Fish and Wildlife Service's Cooperative Endangered Species Conservation Fund for land acquisition to benefit federally listed species and their recovery. Two grant programs under this fund, HCP Land Acquisition and Recovery Land Acquisition, have resulted in the purchase and permanent protection of more than 40,000 acres of old-growth forests, oak woodlands, shrub-steppe, coastal bluffs, prairie, riparian, and wetland habitats.

5.9 OTHER FACTORS AFFECTING THE ENVIRONMENTAL BASELINE

5.9.1 Fisheries

There are three major categories of fish harvest in Washington: commercial, recreational, and subsistence. These activities are supported by State and tribal management of fisheries, including hatcheries, aquaculture, designation of marine reserves, and other actions.

Fisheries management has contributed to habitat degradation and impacts to species. Managers from the 1950s to 1970s promoted the removal of LWD and log jams from streams because they were perceived to hinder fish migration (Murphy 1995). This practice eliminated or greatly reduced the habitat complexity in many streams. Overfishing has been considered a major cause of decline in certain salmon runs since the late 1800s, with closures noted as early as 1915 in the Columbia River (GSRO 1999). Harvest rates of adult salmon can sometimes reach 50 to 80 percent of the population, an amount that is not sustainable for all salmon stocks, particularly those that are struggling with poor productivity or unfavorable ocean conditions (GSRO 1999).

5.9.1.1 Commercial Fishing

The principal commercial and subsistence species categories in the region are salmon, tuna, groundfish, crab, and shrimp. The effects of commercial harvest on fisheries are difficult to determine fully;

however, reported catches over time may offer limited insight into these effects. Although fish canneries have existed in Washington since 1866, the first commercial salmon fishing records were not reported until the 1890s. During this time, the largest annual production occurred in the Columbia River (20 million pounds). From 1899 to 1935, fishing technology improved, and fisheries in Puget Sound increased substantially over the Columbia River production.

Although the volume and value of commercial seafood landed in Pacific Northwest ports fell substantially from 1989 to 1991, the most-significant decline occurred in salmon catch (FEMAT 1993). A variety of factors contributed to this including depressed fish prices, unfavorable ocean conditions, decreased habitat, and increased competition. However, due to the complex relationship between ocean conditions, quality of freshwater and estuarine habitat, and size of fish populations, short-term changes in abundance of fish cannot be extrapolated to determine long-term projections for potential harvest.

Another imperfect indicator of commercial fisheries is the number of licensed fishing boats in the state. The number of licensed fishing vessels under 50 tons has generally decreased over time, from 7,500 in 1980, to approximately 2,000 in 1998 (WDFW in WDNR 2000a). Vessels under 5 tons have decreased from 4,504 in 1980 to 947 in 1998 and vessels between 5 and 50 tons have decreased from 3,006 in 1980 to 1,115 in 1998. However, vessels over 50 tons have remained relatively stable (379 in 1980 and 432 in 1998). During the last 15 years, the volumes of catch for salmon have generally declined. The volume of catch for other marine fish has also decreased.

Commercial fisheries operations have had effects on various aquatic species (Morishima and Henry 2000). Certain methods or types of equipment used (e.g., trawls) capture large quantities of non-target organisms or life stages. Individual stocks or species can be over-fished.

Other aquatic species are harvested commercially in Washington. For example, wild stocks of sand shrimp are harvested as bait for steelhead, salmon, bottom fish, and other types of sport fish. Harvesters obtain sand shrimp onsite, generally at low tide in a small boat, using a hydraulic pump connected to a long hose, at the end of which is a three-foot rigid pipe often called a “wand.” The wand is hand-held and instills the hydraulic pressure into the sand shrimp burrows in the substrate, pushing sand shrimp to the surface where they are picked up by hand and placed in buckets. The whole operation involves one or two harvesters and a small boat (approximately 18 feet). The sand shrimp are then sold as bait.

During the 1950s, United States Navy divers in Puget Sound observed vast populations of sub-tidal geoducks throughout the region. The commercial harvest of wild geoduck began in 1970 following this discovery, but at that time, market demand was limited. Demand grew significantly, however, with the establishment of a major new market in Japan. Today the geoduck fishery is the largest and most-economically important clam fishery on the west coast of North America (WDNR 2001). To harvest geoducks commercially, harvesters use water-jets to loosen the substrate and allow the clams to be removed. After the diver locates a clam by its siphon (which extends out of the substrate) or by locating the depressions left by a burrowing clam, the nozzle is inserted next to the exposed geoduck siphon (or in the hole which is left when the siphon is retracted). A short burst of water, with a pressure of 40 to 60 pounds per square inch, liquefies the sediment allowing individual geoducks to be easily removed. A diver using this method can harvest 1,500 pounds per day (approximately 800 clams) on a productive tract (WDNR 2001).

5.9.1.2 Recreational Fishing in Washington

Recreational fishing is an important activity in Washington, especially in Puget Sound, the Olympic Peninsula, lakes, and many of the streams throughout the state. USFWS and U.S. Census Bureau (2003) report that approximately 938,000 Washington residents fished the waters in this State. Freshwater and marine recreational fisheries in Washington are managed by WDFW using specific quotas by species and catch areas (GSRO 1999).

5.9.1.3 Subsistence fishing

In addition to commercial and recreational fisheries, Native American Tribes in the Pacific Northwest also participate in fishing activities to procure salmon and other fish for ceremonial and subsistence purposes. Although the manner, volume, and extent of such subsistence fishing vary among tribal members and regions, subsistence harvest is used to provide basic nutritional benefits to Tribal members and to maintain essential cultural values that are intrinsic to the community through their traditional fishing practices (GSRO 1999).

5.9.1.4 Hatcheries

Many salmonid fisheries are supported by Federal, State, and Tribal hatcheries. Hatcheries have been used in the Pacific Northwest since the late 1800s as a means to compensate for the effects of overfishing and the declining numbers of salmonids (Burger 2000). Current hatcheries are operated for a variety of goals, including production for harvest and/or to strengthen depressed fish populations. There are 11 Federal hatcheries in Washington, designed to mitigate fishery losses, create fishing opportunities, and as one part of an integrated approach for the management and restoration of aquatic species and their habitats. As of 2000, WDFW operated 91 hatcheries in the State for the purposes of providing fisheries opportunities, fulfill State tribal treaty obligations, and to help recover and conserve naturally spawning salmon populations (WDFW 2000).

Burger (2000) reports that approximately 80 percent of the current anadromous salmonid production is believed to be of hatchery origin. A number of effects to species and habitats from the release of hatchery fish have been reported in the literature (Booker 2000). Hatchery-produced fish may compete with wild fish for limited food resources, or may prey on smaller wild juveniles. Hatchery and wild fish stocks may intermingle in streams or marine habitats; commercial or recreational harvest targeted towards hatchery-raised fish may result in disproportionately high impacts to limited wild fish stocks. Intermingling of hatchery and wild stocks may also affect the genetic integrity of the wild stocks, affecting the survival of future generations. Finally, abundance of hatchery fish can mask declines in numbers of wild fish.

The need for improved hatchery management has been recognized by Congress, with the funding of the Western Washington Hatchery Reform Project (Mobrand et al. 2005). This project was initiated to identify solutions to problems with hatchery management so that facilities could more-effectively meet their dual goals of supporting sustainable fisheries and assisting with the conservation of wild fish populations. Various other entities have also developed plans or recommendations for reducing ecological effects of hatchery-reared fish on wild fish and their habitats (e.g., McMichael et al. 2000; MacDonald et al. 2000). While these efforts are expected to result in positive resolutions to sometimes-controversial issues, the process is ongoing. Therefore, any attempts to gage their success would be premature at this time.

5.9.1.5 Aquaculture

The WDNR (2000) reports that aquaculture, the production of aquatic plants, shellfish, and fish, is currently the fastest-growing sector of the world food economy. In Washington, aquaculture operations are generally in marine habitats, and predominantly focus on penned salmonids, clams, and oysters, although other species are also produced.

Aquaculture has both direct and indirect effects on the benthic habitats and organisms near and/or under both harvest and production sites. Organisms may suffer lethal or sublethal impacts from increased sedimentation, decreases in dissolved oxygen, decreases or increases in nutrients, or mechanical harvest. They may also be indirectly affected by the chemicals or practices associated with the site. Other potential negative impacts of aquaculture include:

- Alteration of marine and/or nearshore bird nesting, feeding and migratory habitats
- Disruption of intertidal water and substrate movement through diking or other habitat modifications
- Depletion of microorganisms in the water column
- Decreased biodiversity from cultivation of a single species
- Introduction of target or non-target non-native species and their parasites
- Synergistic effects from the preceding impacts

The predominant type of fish aquaculture in Washington (Pacific and Atlantic salmon) is generally pen-based aquaculture, concentrating large groups of salmonids in relatively small areas. Pen-rearing of salmonids has existed in Washington since 1969 (Sylvia et al. 2000); although pen-rearing operations previously existed in both Oregon and California, Washington is currently the sole producer of pen-reared salmon within the western United States (Sylvia et al. 2000; Toba and Chew 2001). From 1990 to 1999, there was a marked increase in Atlantic salmon production in Washington. In 1990, less than 4 million pounds of Atlantic salmon was produced; however, in all but two of the following 7 years, annual production was over 8 million pounds, reaching 12 million pounds in both 1997 and 1999 (WDNR 2000a; Toba and Chew 2001).

Chinook and coho salmon have also recently been cultured in Washington, with production of these species decreasing significantly in the late 1990s (Toba and Chew 2001); Toba and Chew (2001) predicted that production of coho would reach 9,000 pounds in 2004 (down from 72,000 in 1996), while no Chinook would be produced in 1999 (from 44,000 pounds in 1997, when production of Chinook began).

Other fish that are raised in Washington include rainbow trout, channel catfish, arctic char, and largemouth bass (Toba and Chew 2001). Rainbow trout production reached 2.5 million pounds in 1999, and was projected to reach 3.5 million pounds by 2004. Annual production of catfish production is relatively low (2,000 to 3,000 pounds during the 1990s), and was expected to remain at these levels through 2004. Arctic char production was estimated at 131,000 pounds in 1999, with an expected increase of 250,000 pounds by 2004. Largemouth bass production was relatively minor (less than 500 pounds), with production not expected to increase significantly. While the tilapia has not yet been commercially cultured in Washington, Toba and Chew (2001) indicated that there is commercial interest in production, and reported the development of an experimental farm to explore this aquaculture opportunity.

In addition to foodfish operations, aquaculture operations generate other products. The aquaculture industry supplies eggs and juveniles of several salmonids, including Chinook, coho, Atlantic salmon, and rainbow trout (Toba and Chew 2001). Toba and Chew (2001) also noted that Washington is the largest producer of rainbow trout eggs in the world. Other non-foodfish products include baitfish and fish for the aquarium trade. In Washington, much of the non-foodfish production has consisted of koi (1,000 pounds in 1999) (Toba and Chew 2001).

The import and culture of fish species may result in several of the impacts listed above. For example, aquaculture of the non-native Atlantic salmon may result in the accidental introduction of parasites of Atlantic salmon, which may also affect Pacific salmon or other native fish species. Cultured Atlantic salmon may also occasionally escape aquaculture operations into nearshore or riverine habitats, competing with or displacing Pacific salmon from foraging, rearing, and spawning areas. Furthermore, operations may influence the behavior of cultured fish. For example, Toba and Chew (2001) indicated that delayed release of pen-reared smolt Chinook and coho salmon results in the fish often remaining in Puget Sound, instead of migrating to the ocean.

The shellfish industry has been particularly lucrative in parts of Washington. The state dominates the West Coast shellfish industry with extensive culture of a variety of species. Washington produces over 82 percent of the shellfish in the West Coast (Toba and Chew 2003), and there are currently 338 licensed shellfish companies and approximately 690 identified growing areas in Washington State[13]. Traditionally, shellfish aquaculture occurs in or on naturally occurring substrates, with the harvest done by hand. More recently, growers throughout the area have been using rafts similar to finfish net pens to increase production densities and minimize predation. Washington State does allow harvest by hydraulic escalator for commercial operations, provided they are 500 feet away from residential zones (Chapter 79.96.030 RCW).

The majority of the Washington shellfish production targets oysters. Pacific oysters (*Crassotrea gigas)* were originally introduced to Washington State from Japan in the 1920s and 1930s in order to replace diminishing populations of the native Olympia oyster (*Ostrea lurida*) (Washington Sea Grant, 2002). Two types of methods are used to culture oysters: bottom and off-bottom culture methods. Bottom culture is the most-common method of oyster farming: natural or hatchery produced seed are spread over the beds and then harvested when they reach an appropriate size. Off-bottom methods have been developed to expand the areas that are cultured, or used to culture single oysters for the half-shell trade. Oysters can be raised on intertidal longlines or in bags placed in the intertidal area. Oysters can also be suspended from longlines or rafts utilizing beds in navigable waters. Unlike the fishery for the eastern oyster (*Crassotrea virginica*) on the East and Gulf coasts of the United States, which is based almost entirely upon wild stock harvest, Washington's oyster industry has developed into a complete farming operation from larval rearing to planting and product harvest (Dumbauld et al. 2001). Other varieties of "specialty" oysters, such as Kumamoto oysters (*Crassostrea sikamea*), the Eastern oyster, European flat oysters (*O. edulis*) and the native Olympia oyster, are also produced (PCSGA 2002).

Intertidal clam production is the second largest type of shellfish aquaculture, and includes Manila clams (*Tapes philippinarum)*. Manila clams were accidentally introduced along with the Pacific oyster seed from Japan, and soon became established throughout Puget Sound. Manila clams have become the dominant intertidal clam cultured in the area. Intertidal clams are grown most commonly using bottom culture and can utilize predator exclusion methods. These range from lightweight plastic netting to

[13] Washington State Department of Health (www://doh.wa.gov/ehp/sf/commercial.htm).

heavyweight bags placed in the ground. Other culture methods include substrate modification, which creates suitable habitat for the growth and survival of Manila clams. Gravel, or a combination of gravel and crushed oyster shell, is added to mud and sand substrate. This increases the amount of area capable of producing Manila clams.

Mussel aquaculture began in the mid-1970s, with mussel rafts in Penn Cove, off Whidbey Island. Two species are commonly cultured, the native Puget Sound blue mussel (*Mytilius trossulus*) and the introduced Mediterranean mussel (*M. galloprovinicialis*). There is an increasing trend to use the non-native species, because of a naturally occurring disease that causes high mortalities that affects the native mussels. While the vast majority of the commercial mussel production is from floating rafts, there is some intertidal culture using bags.

The harvest of wild geoduck is now complemented by significant investments and advances in intertidal geoduck aquaculture by Washington shellfish growers. Geoduck aquaculture is not currently authorized on State-owned aquatic lands; however, an on-going pilot project is evaluating the feasibility of intertidal and subtidal geoduck aquaculture on State-owned aquatic lands.

5.9.1.6 Marine Protected Areas

In recent years, marine protected areas have been used or planned as conservation or preservation areas for fisheries or habitats that have been over-exploited (PSAT 2002). Marine and ecological reserves created by WDFW are found in the San Juan Islands, near Edmons, Des Moines, Steilacoom, and in Hood Canal, among other areas. Their effectiveness has not been fully documented, but studies are being conducted on rockfish and other species.

5.9.2 Non-native Species

A variety of human activities accelerate the process of introduction and spread of aquatic nuisance species that can cause extensive ecological damage. Many non-native, invasive species of plants and animals have been documented in Washington. While most non-native species are unable to survive in habitats that are very different from the ones in which they evolved, other introduced species thrive in the absence of their natural competitors, predators, parasites, and diseases. These species often become invasive, affecting native species and habitats through competition, predation, hybridization, and/or other mechanisms.

Some non-native animals have been introduced purposefully, as game species (e.g., bass, sunfish, non-native trout species, pheasants), through the aquarium trade (e.g., goldfish), for aquaculture (e.g., Manila clam, Pacific oyster), or for a variety of other purposes. Other species, particularly small or secretive species, are often transported unnoticed in packing materials, ballast water, as parasites of other species, or in other ways. Some non-native animal species (e.g., European starlings) were introduced in other parts of the continent and slowly spread to Washington. Non-native animal species can greatly impact native species populations. For example, introduced piscivores such as largemouth and smallmouth bass increase the predation pressure on outmigrating juvenile salmonids. Atlantic salmon (*Salmo salar*) have escaped from aquaculture operations, and natural spawning of these escapees has been documented in British Columbia (Volpe et al. 2005). Goodwin et al. (2004) note that non-native viruses can be introduced into habitats where native species have limited resistance.

Non-native plant introductions are an emerging threat to ecosystems. Non-native plants have been introduced both intentionally and unintentionally in the past through agriculture practices, erosion control,

development, and for ornamental purposes, and non-native plants are slowly replacing less-aggressive native species. Cordgrass (*Spartina* spp.) has invaded nearshore habitats in north Puget Sound and threatens to exclude native fish species and reduce intertidal acreage (WSCC 1999a). WDNR (2000) reports that the amount of Spartina in Willapa Bay is predicted to grow from 3,200 acres in 1997 to 30,000 acres by 2030 (covering most of the intertidal zone). Intertidal areas provide critical foraging habitats for anadromous salmonids and their prey species. In a number of areas, invasive plant species are invading disturbed riparian areas and stream channels. Invasive species are altering and impairing these habitats and impeding the restoration and natural recovery of these areas by out competing native vegetation, including trees, which provide more important habitat benefits such as increased shade and LWD. All regions of Washington are probably affected by one or more of these species.

Although the control of non-native species is challenging, many attempts are being made to reduce the impacts or extent of invasive species. For example, in Thurston and King Counties, the respective removal of Scots broom and Japanese knotweed has been performed using Integrated Pest Management (Carlson, Personal Communication, 2005b). The removal of Scots broom was done in concert with re-vegetation in certain areas with grasses, forbs, and conifers. Western Washington prairie conservation activities often include control of Scots broom.

5.9.3 Recreational Activities

Washington supports many different types of outdoor recreation activities, including but not limited to skiing, hiking, mountain biking and other off-road vehicle use, climbing, fishing, camping, hunting, boating, and wildlife viewing. The Interagency Committee for Outdoor Recreation (IAC) (2002) estimates that over half of the state's population engages in some form of outdoor recreation. Recreational settings and experiences range from primitive areas (such as remote hiking trails or campsites) to sites that have vehicle access and associated development (such as campgrounds and summer homes), although the majority of developed recreation sites occurs in roaded settings.

There is evidence of an existing surplus of venues for highly developed and/or motorized forms of recreation, with a significant and increasing demand for recreational settings with minimal development and/or management activities, and with no motorized access (FEMAT et al. 1993). WDNR (2000) reports that the demand for water-related recreation increased by 32 percent from 1987 to 2000.

Hunting activities fluctuate in response to game population levels, weather, and regulation by WDFW. The number of deer and elk licenses sold has decreased from around 230,000 and 104,000, respectively, in 1975 to 190,000 and 85,000 in 1994. Numbers of resident small game harvested have also declined steadily from nearly 1.48 million in 1975 to around 0.43 million in 1994 (Washington State 1995). Carlson (2005) reported that in 2001, 227,000 Washington residents hunted. Generally, adverse impacts to wildlife are minor and include displacement during hunting activities.

There are many recreation destinations for the public in the State. Washington has approximately 10 million acres of public land that is managed at least in part for outdoor recreation and habitat (IAC 2002). The IAC (2002) notes that approximately 648,498 acres of State lands are available for outdoor recreation. The Washington State Parks system is comprised of approximately 260,000 acres (IAC 2002). Visits to Washington State Parks increased 300 percent between 1965 (12.9 million visitors) and 1997 (50.9 million visitors), with an increase of more than 10 million from 1987 to 1996 alone (Washington State Data Book 2000; WDNR 1998a, 2000). State trust lands are managed by WDNR and are comprised of approximately five million acres of forest, range, agricultural and aquatic/submerged lands. Examples

of trust forest lands that are highly used include (by county): Capitol Forest (Thurston), Tahuya Forest (Mason), Yacolt Burn (Skamania), Tiger Mountain (King), and Loomis State Forest (Okanogan). State Wildlife Recreation Lands (WRL) are used primarily for hunting and fishing. Large WRLs are generally found in eastern Washington (e.g., L.T. Murray Wildlife Area), while small, scattered WRLs are found in western Washington.

National Parks, National Forests, and National Monuments in Washington State also receive heavy visitation. The National Park Service manages three National Parks (Mt. Rainier, Olympic, and North Cascades National Parks) and three significant National Recreation Areas (Ross Lake, Lake Chelan, Lake Roosevelt) (IAC 2002). Approximately nine million acres of National Forests exist in Washington. The State has seven National Forests (Colville, Umatilla, Gifford-Pinchot, Mt. Baker-Snoqualmie, Okanogan, Olympic, and Wenatchee), and one National Monument (Mt. St. Helens). National Forestlands include developed or undeveloped facilities for visitors. The IAC (2002) reports that 38 percent of recreation activities in National Forests occurs in conjunction with road use.

Private lands are also used for outdoor recreation, from parks on private timberlands to developed access areas (e.g., RV parks, resorts, ski areas, etc.) (IAC 2002). Private landowners often offer recreational opportunities for the public for hiking, hunting, and/or other consumptive or non-consumptive uses. The IAC (2002) also reports that certain landowners have habitat-access agreements with entities such as WDFW for restoration purposes.

Recreational activities in forested areas include many of the uses described above. Additionally, visitors in certain areas may also engage in permitted or opportunistic gathering of resources, such as fruits, wood, mushrooms, or other natural products. Some activities, such as camping, trail use, off-road vehicle use, or other activities have caused significant localized impacts. These are typically associated with riparian vegetation removal and degradation, sedimentation, and degradation of stream banks and channels.

5.9.4 Climatic Effects

Climatic effects on Washington species and habitats can be divided into two broad categories. The North Pacific environment is governed in part by decadal or multi-decadal cycles with changes in pressure and wind patterns, which affect ocean currents and water temperatures (Anderson 2000). The cycles (e.g., El Niño/La Niña years) are relatively short-term. Ocean conditions created by these cycles affect numbers and distributions of fish and other oceanic species. For example, it appears that during years when the climate regime in the Pacific Northwest is warm and dry, ocean conditions for some of the Columbia River salmon are poor, while Alaska salmon experience good conditions. When the climate regime is dominated by cool and wet years, the opposite is true, with the Columbia River salmon generally experiencing better conditions than Alaska salmon (Anderson 2000). The success or failure of management (e.g., of fisheries), restoration, enhancement and other actions has not always been considered in context with climate cycles, and the cycles may mask success or failure if they are not carefully evaluated (Anderson 2000).

Although the existence of these cycles is a natural phenomenon, anthropogenic factors also appear to be driving climate patterns (Mote et al. 2005). Increases in globally-averaged temperatures during the last three to five decades appears to be related to increasing levels of greenhouse gases in the atmosphere. The effects from this phenomenon include, but are not limited to, changes in air and ocean temperatures, amount and distribution of precipitation, changes in sea level and associated coastline impacts, and water

quality. Mote et al. (2005) indicated that Puget Sound and Washington habitats have been and will continue to be directly affected by these effects. During the past 50 years, there have been hydrologic changes that are consistent with warming of the atmosphere. These changes include a reduction in the amount of spring snowpack in high elevations, earlier snowmelt runoff, and changes in seasonal stream flows (i.e., winter flow increases/summer flow decreases). Sea levels are rising, with local sea levels rising in southern Puget Sound up to twice the global average. Other parameters, such as water temperatures, dissolved oxygen, nutrient levels are currently being evaluated, as are the potential effects of atmospheric warming to sensitive habitats (e.g., salt marshes, eelgrass beds) and biota (Mote et al. 2005).

5.9.5 Wind Generation

Wind-power generation is becoming more common in eastern Washington as the industry's potential is being developed. The Bureau of Land Management recently completed an analysis of its lands in the western United States, identifying only 60 acres in central Washington as suitable for power generation (J. Krupka, Personal Communication, 2005). However, several existing and proposed wind-power-generation projects occur (or are proposed) on non-Federal lands. For example, four projects are currently online in eastern Washington (near the Tri-cities and Walla Walla), while four future projects have been proposed[14] (Tri-cities area, Walla Walla, Skamania County, and Klickitat County). The Wild Horse Wind Power Project has proposed the construction of 158 turbines in eastern Kittitas County in 2004; the application of the site certification for this project is in progress and is being assessed through State and Federal permitting processes. The second project, the Hopkins Ridge Wind Project, is currently under construction in Columbia County.

Potential impacts from wind-power generation to biota include direct effects, such as mortality to birds and bats, or indirect effects, such as habitat alteration (Government Accountability Office [GAO] 2005). Based on existing studies[15] evaluated by the GAO (2005), direct mortality to birds appeared to be correlated with both the location of wind-power facilities in relation to their migratory flyways as well as various designs of the turbines.

5.10 SUMMARY

The current baseline status for the state of Washington is complex and dynamic. It is impossible to analyze the environmental baseline as a moment in time because past regional and larger-scale development and its associated effects are ongoing and will continue to impact natural resources in the future. Actions, such as urban development, road building, and recreation, on private and public lands have and will continue to contribute to habitat degradation and loss, which have impacted habitat structure and function for many species of fish and wildlife. Increasing development and sprawl in Washington State have fragmented and destroyed habitats, and will continue to contribute to the decline of many species and their habitats. The development of private lands and associated loss of fish and wildlife habitat is anticipated to continue, although certain plans and guidance (e.g., HCPs, Salmon

[14] According to the American Wind Energy Association Website, accessed November 22, 2005. (www.awea.org/projects/washington.html), and L. Wedemeyer (pers. comm. 2005)

[15] The facilities studied in GAO's (2005) report were located in Oregon, California, Pennsylvania, West Virginia, Minnesota, and New York; no facilities in Washington were included in this report. GAO noted that information regarding impacts to species was limited or nonexistent in many areas of the country, as was data on how to minimize these impacts.

Recovery Funding Board) have been produced to help reduce the impacts. Habitat loss and habitat degradation are expected to continue as development creates a demand for new public services and facilities. Disturbances caused by human development in low-elevation areas, as well as recreation at all elevations, have, and will continue to have, a cumulative impact on some species through loss of habitat and displacement of individuals.

Lingering effects of past pollution and ongoing delivery of pollutants affect species and habitats, and the effects are expected to continue. Certain previously-banned chemicals continue to be found at elevated levels in many top predators such as orcas (*Orcinus orca*). Poor air and water quality, as well as hazardous wastes and oil spills have diminished the quality and usability of fish and wildlife habitats. Potential impacts include displacement and loss of individuals of some species, as well as decreased habitat quality. Recovery of fully-functioning habitat conditions in many areas, if possible, will take much time and effort, and new problem areas will certainly be detected in the near-term future.

Agriculture, mining operations, timber harvest, and other industries and their associated infrastructure (dams, canals, impervious surfaces, etc.) have impacted and will continue to impact natural resources. Certain actions are being implemented to reverse or reduce these impacts through the removal of dams, use of low-impact-development technologies, restoration and enhancement projects, and other activities.

Shoreline development has affected and will continue to impact coastal processes. Shipping, bulkheads, and other shoreline developments have contributed to the reduction in eelgrass beds and other spawning and rearing areas for forage fish such as herring. To counter these impacts, certain rules and guidance (e.g., Shoreline Management Act) have been enacted and adopted by some jurisdictions.

Within Washington, a significant amount of the forestlands are federally managed. Much State land and some private lands are already being managed under HCPs or similar agreements. This management is part of the environmental baseline. Any change from the current rate of protection for Federal forestlands would require separate section 7 consultation under the ESA.

6. COMPREHENSIVE CUMULATIVE EFFECTS

Cumulative effects, as defined in 50 CFR 402.02, include the effects of future State, tribal, local, or private actions that are reasonably certain to occur in the action area considered in this Opinion. Future Federal actions that are unrelated to the proposed action are not considered because they require separate consultation pursuant to section 7 of the ESA. Some of the activities described below are already addressed in the Comprehensive Environmental Baseline, but because they are ongoing and anticipated to continue in the future, they are also addressed herein.

Cumulative effects can result from individually minor but collectively substantial actions taking place over a period of time. Numerous non-Federal actions that could affect listed and covered species are reasonably certain to occur within the action area. These will typically include: (1) rural and residential development; (2) transportation improvements and expansion; (3) mining; (4) agricultural activities; (5) grazing; (6) changes in road density; (7) timber harvest on FPHCP covered lands that occurs outside the Riparian Zone; and (8) timber harvest on private lands conducted under four counties and one city (Thurston, King, Spokane, and Clark Counties and Port Townsend) that WDNR has transferred authority to regulate Class IV-General forest practices that are likely to be converted to non-forest uses. Each of these future activities could contribute to cumulative effects on listed and covered species or their habitats in the action area.

6.1 ACTIVITY-SPECIFIC ASSESSMENTS

6.1.1 Population and Development

Population growth and development is likely to continue to increase in Washington. The Washington State Office of Financial Management (WSOFM 2001) indicates that several assumptions can be made about growth patterns in Washington. First, future growth will probably occur near existing population centers, such as Seattle, Tacoma, Vancouver, Spokane, Wenatchee, Yakima, and the Tri-cities area in Washington; while limited developable space is available within the cities themselves, growth around their peripheries is likely to be high. While much of the population growth and development in eastern Washington will likely be limited to these metropolitan areas, developed areas in western Washington are expected to continue to expand east toward the Cascade foothills and passes, west toward the Kitsap Peninsula, and north and south along the I-5 corridor.

Another assumption regarding growth is that although much of the growth would likely occur along existing transportation corridors (such as highways), other off-corridor areas would likely see some growth through immigration of telecommuters and retired persons, among others (WSOFM 2001). Recent advances in technology have allowed settlement of more-rural areas throughout Washington, and development of support services often follows, leading to development in areas and distribution of development that were previously not feasible. Finally, rural counties with relatively small populations are less likely to experience substantial growth in the future.

Areas may experience different levels of future growth based on local conditions. According to the Puget Sound Action Team (PSAT 2005), all of the counties in western Washington surrounding the Puget Sound and the Strait of Juan de Fuca will experience at least 20 percent in population growth by 2025, with some counties expected to have population growth levels of over 50 percent (Jefferson, Mason, Thurston, Snohomish, Skagit, and Island Counties). In the 12 counties bordering Puget Sound alone, the Puget Sound Action Team (2004) reports that the population will increase by over 1 million people by 2025. The expected increase in population is likely to result in substantial effects to the natural resources of Washington State (WDNR 1998a).

Washington's Growth Management Act was enacted to help communities plan for growth and address growth effects on the natural environment. Under the Growth Management Act, many counties have enacted critical-area ordinances that impose a variety of restrictions on development. These critical-areas ordinances, while having variable environmental protection value, should continue to address a number of natural-resource issues.

Natural fish and wildlife habitat outside of protected lands will likely decline in both quantity and quality as a result of increases in population and development. As the population increases, there is likely to be an increase in demand for space for new homes, businesses, associated infrastructure, and other facilities. Production of solid and human waste is also likely to increase with the population. As the demand for water continues to increase, it will exacerbate water shortages and result in effects to habitat (Wissmer et al. 1994). New construction will result in the conversion of forested, agricultural, and other rural-land uses into residential, commercial, and industrial uses. In the 5-year period between 1992 and 1997, rural lands in Washington were developed at the average rate of 48,200 acres per year. About half (48 percent) of converted land was forested land (WFPA 2001). Many areas of non-industrial private forestlands in Washington were converted from primary forestland to non-primary forest use (e.g., residential development) between 1979 and 1989 at a rate of almost 100 acres per day (WDNR 1998a). We

anticipate that the conversion of forestland to other uses will continue to accelerate as the population increases. Increased development will also likely place increased demands on the existing infrastructure, such as transportation, natural-resource extraction and manufacture (e.g., timber harvest, mining), and agricultural production.

Development is expected to continue to place pressure on the marine environment, as well as large lakes and rivers. For instance, Puget Sound has the highest per capita boat usage in the Nation (WDOE 2006). Docks are expected to continue reducing the light that reaches important habitats such as eelgrass meadows, which provide critical support for a variety of fish species. While each dock and boat may be small, the combined effect of many over-water structures can add up. Bulkheads (i.e., seawalls) are expected to continue damaging beaches. Shoreline armoring, landfill, and over-water structures continue to reduce both sediment supplies and transport from sources along the shore as well as sources further up the beach. Over time, seawalls constructed to protect property along retreating beaches often exacerbate beach erosion. They confine the wave energy and intensify the erosion by concentrating the sediment-transport processes in an increasingly narrow zone. Eventually, the beach disappears, leaving the seawall directly exposed to the full force of the waves.

Dumping of human waste and discharge of engine waste are expected to continue. Cleaning and repainting of boats are expected to release toxic chemicals into the environment. Stormwater and wastewater discharges increase nutrient inputs. The decomposition of these nutrients utilizes oxygen and lowers dissolved oxygen levels. During periods of thermal stratification, when layers of water develop with different temperatures and densities that resist mixing, layers of low dissolved oxygen can develop and can result in fish kills. Contaminants from wastewater and stormwater discharges will continue to accumulate in tissues of marine organisms. Habitat loss, degradation, contamination, and, in some cases, over-utilization have contributed to the decline of many marine species. Habitat loss, degradation, and contamination are influenced by population size and are expected to continue.

6.1.2 Transportation

Highway expansion and upgrading of the current road system will likely continue to be emphasized over new highway construction, although new construction may also occur. Beginning in 2000, seaports were expected to grow an average of 4 to 5 percent each year for the next 15 to 20 years, with shipping-container traffic expected to more than double by 2020 (WDNR 2000a). As the ports expand in size and capacity, other development to support these facilities will also increase. Increases in shipping and the use of larger ships will likely lead to increases and deeper dredging (WDNR 2000a). Because dredging requires a Federal permit, and thus would be subject to section 7 consultation, it is not discussed herein. Removal of large wood by the USCOE from rivers and marine waters will also not be addressed as these actions would be subject to future section 7 consultations.

Utility rights-of-way will increase for power, water, and petroleum transport and for phone, cable, and other communications. Many of these corridors will be addressed through future section 7 consultations with the respective Federal agencies. Other effects expected to increase as a result of these corridors include off road vehicle access and associated habitat destruction and contamination, illegal dumping of solid and liquid waste, and continued effects from poorly constructed and poorly maintained access roads.

6.1.3 Mining

Increases in construction and development related to population growth will require the increased extraction and use of natural materials such as sand, gravel, and rock. Mining effects in the past have resulted in substantial degradation of stream habitats and associated fisheries. Some of these effects are still degrading the environmental baseline conditions, but some restoration activities have been implemented to restore ecosystem function. Most mining activities without a future Federal nexus are currently more regulated than they were in the past and are generally expected to result in relatively fewer effects; however, locations of sand and gravel extraction relative to streams and rivers may determine the level of effects experienced.

6.1.4 Pollution

The cycling of contaminants delivered to waters in the past is expected to continue. High concentrations of polychlorinated biphenyls (PCBs) and other chemicals in marine mammals indicate that the food chain continues to bio-accumulate environmental contaminants. For some chemicals, such as polybrominated diphenyl ethers (PBDEs), the effects are not just lasting effects from past use, but their concentrations in the environment are still increasing. Although environmental regulations may continue to restrict use of these chemicals, the growing human population and existing infrastructures may exacerbate problems associated with reducing delivery of chemicals to the aquatic environment.

FWS anticipates that chemicals such as pesticides, herbicides, fertilizers, and fire retardants will continue to be used within the action area. Chemical application is under the jurisdiction of several Federal, State, and local agencies and their use is expected to be conducted under applicable laws.

6.1.5 Agriculture

Agricultural activities within the action area include dairy farming and crop cultivation. Effects to water quality from manure, fertilizer, and other chemicals are likely to continue, although these issues are being addressed in some areas of the State, as described in the Comprehensive Environmental Baseline section of this Opinion. Water diversion and irrigation associated with agricultural activities are expected to continue, contributing to water-quality and water-quantity effects. The construction and use of dikes to reduce flooding is common in agricultural lands, and has historically caused a significant loss of secondary channels in major valley floodplains. Confined channels create high-energy, peak-flow events that remove smaller substrates and LWD, a condition likely to persist into the future in any diked system. The loss of side-channels, oxbow lakes, and backwater habitats in the action area will continue.

Crop conversion (i.e., converting from one crop species to a new crop species) can have environmental effects on streams that can either benefit or degrade habitat function. For example, pasture lands and row crops in eastern Washington are increasingly being converted to intensively managed orchards and vineyards in Washington State in response to market pressure. Orchards and vineyards require more-intensive applications of insecticides and fungicides than do pasture lands or row crops. The statewide trend of converting farmland to other uses, such as development, has a far greater environmental effect than the possible beneficial and/or detrimental effects of changing from one agricultural practice to another. One reason the loss of farmland is occurring is because of an increasing demand for residential and commercial development as the population of the State grows.

The negative effects from agricultural operations are continuing to decline from historical levels, due in part to improved practices and coordinated resource-management plans between State and Federal agencies. County extension staff, Universities, and State and Federal agencies are cooperatively conducting a number of programs to provide incentives and assist landowners in improving management and conservation actions. As described previously in the Comprehensive Environmental Baseline section, some private landowners are including protective measures (e.g., riparian fencing, grassed swales) in the management of their lands to reduce the effects to stream habitats and other ecosystems.

6.1.6 Grazing

Grazing activities currently permitted by Federal agencies are governed by the Aquatic Conservation Strategy of the Northwest Forest Plan or the PACFISH / INFISH (i.e., aquatic management strategy for U.S. Forest Service and Bureau of Land Management lands outside the Northwest Forest Plan area). Grazing on State lands is conducted in conjunction with the guidelines provided by Washington House Bill 1309 (1994) and codified in 1996 in RCW 79.13.600, 610, and 620. Future grazing leases on Federal lands are not part of this cumulative effects analysis because they would be subject to future ESA section 7 consultations. Grazing on private lands has fewer restrictions, and thus potentially greater negative effects on forestlands and adjacent streams.

Livestock grazing in riparian areas is a controversial issue because the effects of grazing on fish populations are not well understood (Platts 1991; Mosley et al. 1997; Rinne 1999). Although extensive information exists on the direct effects of grazing on certain components of fish habitat and stream conditions, the effects of grazing (i.e., of grazing-induced habitat alterations) on the fish themselves is less easily demonstrated (Rinne 1999). Also, less information is available on the relationship between grazing and fish populations in forested environments compared to open rangeland environments.

Platts (1991) summarized 21 studies and stated that, generally, salmonid populations in streams passing through grazed areas are reduced compared to ungrazed areas because of more fine sediment in stream channels, more unstable and fewer undercut stream banks, and higher summer water temperatures. Changes to naturally-occurring, stream-system processes and associated riparian structure and functions have been implicated in the decline of fish abundance (Platts 1991). However, the effects of grazing on fish populations are directly related to how grazing is managed, in that well-managed grazing can be compatible with healthy, functioning riparian ecosystems (Mosley et al. 1997; Ehrhart and Hansen 1997; Ehrhart and Hansen 1998).

In summary, numerous studies have shown that improper livestock grazing can damage streams and degrade fish habitat (see review by Platts 1991). However, less is known about grazing effects in riparian forest environments which may be more resilient than rangeland riparian environments. There is evidence that certain livestock grazing practices can be employed that will protect stream fisheries (Platts 1982; Rinne 1999). Management of cattle stocking rates and distribution, vigor of riparian vegetation, and protective measures for stream banks and channels are important considerations in maintaining the environment where grazing occurs.

6.1.7 Water Diversion and Storage

Potential negative effects associated with water diversions include: (1) the delivery to streams of agricultural chemicals and silt present in irrigation return flows; (2) the diversion of water from streams, making streams unusable at certain times of the year for certain life stages of fish; (3) the reduction in a

stream's capacity to transport sediment; and (4) the exacerbation of water temperature problems because of low stream flows. Reservoirs used to store irrigation water and subsequent releases will continue to create stream flows that are much higher than natural when water is being released from reservoirs and much lower than natural when reservoirs are being filled. As a result, fish spawning, migration, and rearing can be disrupted by either high flow or low flow events. Potential effects to fish of substantial water diversions are expected to include entrapment and impingement of younger life stages; localized de-watering of reaches; and depleted flows necessary for spawning, migration, rearing, flushing of sediment from the spawning gravels, gravel recruitment, and transport of LWD. Water impoundments also contribute to the introduction and spread of invasive species.

6.1.8 Aquaculture

Aquaculture activities in the State are expected to increase with associated degradation of water quality. Some harvest and hatchery practices may have diminished the genetic diversity of salmonids (reviewed in Allendorf and Waples 1996; NRC 1996 as cited in IMST 2004), potentially limiting their ability to cope with climate fluctuations. The ongoing Puget Sound and Coastal Washington Hatchery Reform Project is multi-stakeholder supported effort in western Washington that is expected to address some of these effects. Under this new model of hatchery reform, productive, available habitat is essential to an effective hatchery program. In addition, managers have to consider whether a hatchery program is the best means to help achieve the stated resource goal, once the risks and benefits from the program are considered.

6.1.9 Fishing

Recreational fishing within the action area is expected to continue, subject to WDFW regulations. The level of harvest of covered species within the action area from angling is not precisely known, but is expected to be managed at long-term sustainable levels. Subsistence fishing will also continue subject to regulations by specific Native American Tribes and tribal organizations.

6.1.10 Motorized Recreation

The effects of motorized recreation (e.g., motorcycles, off-road vehicles) are numerous. Lawfully constructed trails may introduce sediment to streams. Unauthorized trails compact wetland and riparian soils, degrade and remove vegetation from sensitive sites, collapse stream banks, and create ruts which can accelerate delivery of sediment to waters. Motorized recreation that crosses stream channels can have direct adverse effects such as destroying fish spawning redds in streams and indirect adverse effects such as leaking fuel when crossing streams. Off-Road Vehicles (ORVs) provide access to remote areas thereby facilitating activities in locations where effects may be greater. ORVs create water and air pollution through poor combustion of gasoline and oil.

ORV use has been shown to reduce species of amphibians, likely through a combination of direct crushing of individuals and also damage to habitat (Maxell and Hokit 1999). Snowmobiles may result in snow compaction that can affect subsequent run-off. Personal water craft and small outboard engines on boats can have a variety of effects. Nearly all personal water craft equipment has a 2-stroke engine. Out of every 10 gallons ingested, as much as 3 gallons are discharged unburned by personal water craft equipment, and as much as 4 gallons are discharged unburned by outboard engines. A typical 2-hour ride on personal water craft equipment may discharge 3 gallons of a gas-oil mixture into the water. Such engines also release oil and can depress dissolved oxygen levels in the water. The combustion process

discharges additional toxic compounds into water. Concentrations of polycyclic aromatic hydrocarbons (PAH) in lakes and reservoirs with high motorboat activity have been found at levels dangerous to aquatic organisms and human health (Joslin and Youmans 1999).

6.1.11 Habitat Restoration

The State of Washington has various strategies and programs designed to improve the habitat of listed species of fish and wildlife and assist in recovery planning, including the Salmon Recovery Planning Act. Other restoration programs funded, permitted, or carried out by the Federal Government are not considered in this cumulative effects analysis, as they would be addressed in the future under ESA section 7. A variety of non-governmental (e.g., land trusts and conservation groups) and psuedo-governmental (e.g., lead entities) organizations are cooperating with the State and Federal agencies in restoring habitat.

Instream and riparian restoration activities (e.g., large wood placement, dam removal) typically cause temporary effects on the quality of fish habitat, during construction. These effects include increases in turbidity, altered channel dynamics and stability, and temporary isolation of work areas displacing fish. Properly constructed stream-restoration projects are likely to increase habitat complexity, stabilize channels and streambanks, increase spawning gravels, decrease sedimentation, and increase shade and cover. Upland restoration projects that benefit riparian and instream habitat will continue to occur in the future. These projects often focus on identifying source problems in an area (i.e., road-associated problem areas) and apply corrective measures to eliminate or minimize the adverse effects to aquatic resources.

6.1.12 Other Activities

Other activities, including those described earlier in the Comprehensive Environmental Baseline section, will continue to degrade Washington's ecosystems. Lands and waters used for recreation will become more crowded, and stress on native species and habitats will likely intensify, further affecting species and their habitats. Increasing trends in modification to and/or conversion of lands for pipelines, aqueducts, power lines, rail system transportation, and other facilities are likely to occur; construction, maintenance, and operations of these facilities may affect species and their habitats through modification of habitat, disturbance, or mortality to species and/or their forage base.

6.1.13 Timber Harvest

WDNR has transferred authority for Class IV-General forest practices, for Thurston, King, Spokane, and Clark Counties and Port Townsend, where the forestland is likely to be converted to non-forest uses. In other parts of the State, WDNR addresses Class IV-General forest practices, although other counties are actively working on obtaining authority from WDNR in the near future. These activities could affect aquatic resources and would not be considered FPHCP covered activities or lands. Also, timber harvest under the 20-acre exemption rule that is outside of the proposed FPHCP permit coverage (e.g., conversions) would have a cumulative effect on listed and covered species.

Upland timber harvest on FPHCP covered lands, and the associated location of additional roads, is anticipated to continue as it has in the past, and in a manner that is not influenced by issuance of a Permit for incidental take. Upland timber harvest may affect stream flows. Most studies conducted on flows have indicated that summer low flows and annual water yield are generally increased by timber harvest.

Peak flows may be increased as well. Increased peak flows have been recorded during small to moderate events, usually during spring and fall. Larger peak flows from winter storms and/or rain-on-snow events are generally not known to be affected by timber harvest (Austin 1999; MacDonald et al. 1997; Scherer 2001).

Upland harvest may accelerate surface erosion. Forest soils are generally characterized by low rates of surface erosion. When erosion occurs, most soil particles that are mobilized remain on the slope (Reid 1993). Vegetated buffers, including the litter, duff, and soils of those buffers, are effective at filtering particles above approximately 40 microns (0.0016 inches) in size. According to Gharataghi et al. (2005), almost all of the aggregates larger than 40 microns in diameter were captured within the first 16 feet (5 meters) of a vegetated buffer strip. However, the remaining, small-size aggregates are very difficult for a buffer to capture before delivering a stream. Therefore, while surface erosion may be increased by timber harvest several-fold, it is not common for delivery of sediment to streams to be substantially increased. In some cases, delivery may be increased (e.g., along unbuffered Np streams). Upland timber harvest conducted according to the Washington Forest Practices Rules would have little potential to increase the rate or magnitude of mass-wasting events. The FWS anticipates that delivery of some sediment and turbidity to streams may continue as a result of upland timber harvest.

Increased roading has allowed greater access for forest management and some types of recreation, and has both contributed to the ability to protect forests from the spread of fires as well as provided human access that may contribute to ignitions. The decision, of where and when to build roads, depends on the logistics of timber harvesting. As the density of roads increases, the adverse effects on riparian areas will potentially increase (Knutson and Naef 1997).

Even the most cautious road-construction methods are likely to yield some degree of effect. Increased road densities provide additional opportunities for hydrologic interception and increased sediment discharge. Road densities alone do not cause sediment delivery. Outcomes of a number of Watershed Analyses in Washington State and Montana have indicated that application of high-quality road-management standards can substantially reduce the production and delivery of road-generated sediment to streams. However, within a given watershed, increasing the density of roads, with all other factors being held constant, may result in additional adverse effects to streams and covered species.

Following timber harvest and both prior to and following planting, herbicides may be used to ensure forest regeneration by controlling competing vegetation. Chemicals used, application rates, and application methods depend on a number of variables such as characteristics of target plants versus desired vegetation, treatment objective (containment versus eradication), accessibility, topography, size of treatment area, location of sensitive areas in immediate vicinity, anticipated costs, equipment limitations, and weather and vegetative conditions at time of treatment. We anticipate that all applications will be consistent with requirements of specific herbicide labels, State laws, and other applicable laws. Even when properly applied, chemicals such as herbicides, insecticides, and fertilizers can have a variety of negative effects on water quality and aquatic life.

6.1.14 Fire Suppression

Fires (naturally- and accidentally-caused) in Washington range from frequent, low-intensity events to infrequent, stand-replacing events. The amount of land burned is variable between years. For instance, 23,511 acres under WDNR jurisdiction burned in 1998, but only 4,649 acres burned in 1997 (WDNR, Resource Protection Division, 2001-2003 Annual Fire Statistics as cited in WFPA 2001; 2004). In most

years, less than 25,000 acres of forest burn. The number of fires does not change much from year to year, but generally only 1,000 to 2,000 acres of forest burn each year. In most years, lightning is the leading cause of fires (by acreage) but during some years slash debris burns and other causes may result in more acres burned.

Some believe that severe fire years are inevitable based on past forest-management practices which limited the role of natural fires in ecosystem maintenance. Recent efforts at fire suppression, especially in the Eastern Cascades, and selective timber-harvesting practices have resulted in shifts in tree species composition and forest structure in some areas. These shifts have moved from open stands of shade-intolerant ponderosa pine and towards higher density stands with more shade-tolerant species such as grand fir and Douglas-fir. Forests east of the Cascade crest have become increasingly susceptible to catastrophic fires and epidemic attacks of insects and disease. Historic "natural" fire patterns also vary from the fire patterns observed within the last 100 years as a result of forest management and fire suppression that has occurred since. The result of highly intense fires, is that soils may become hydrophobic and subject to surface erosion, as less infiltration will result in greater surface flow.

WDNR is responsible for suppressing fires on private lands, in addition to State and some Federal lands – about 12 million acres in total. Landowners share the fire-supression costs. Negative effects can emanate from fire suppression. Fire camps established in forest openings and meadows can result in destruction of vegetation, compaction of soil, generation of sediment, and introduction of waste to the environment. Sites for maintenance and fueling of equipment, including heliports, may also affect environmental conditions. Within the burn area, hazard trees may need to be felled. Fire-lines and equipment trails will be constructed and soil compaction may result. Fire-lines and trails may act as conduits for sediment transport. Bringing equipment onto a site with substantial soil disturbance and removed vegetation can facilitate introduction and the spread of noxious weeds. Activities designed to reduce post-fire surface erosion may also introduce weeds.

6.1.15 Natural-disturbance Regimes

Fires tend to burn variably across landscapes leaving patterns of severely and lightly burned areas as well as unburned areas. Fires can remove shade and can both remove and recruit large wood to forestlands and adjacent streams. Fires can temporarily reduce vegetation on side slopes which can contribute to surface erosion and sediment delivery to streams.

Other natural disturbance regimes expected to continue include high-flow events, flooding, avalanches, mass-wasting events, soil creep, sediment delivery and transport, channel migration, bank erosion, windthrow, forest insects and disease, log-jam formation, and construction of beaver dams. These natural processes are considered cumulative effects as well as habitat-forming processes/events.

6.1.16 Ocean Cycles

The ocean habitat fluctuates and is dynamic, changing over several time scales. There are inter-decadal variations in climate, as well as shorter-term variations, that affect ocean productivity for salmonids and other fish. A major assumption is that improved conditions of freshwater and estuary habitat are buffers to years with low productivity ocean conditions. Without improvement of the condition of these habitats, the years with low productivity ocean conditions, in the future, will be more devastating to anadromous and marine fish than what was experienced in the early 1990s (Lawson 1993).

6.1.17 Climate Change

Recent precipitation patterns in the Pacific Northwest appear to be changing from historical patterns. Depending on the region, more or less precipitation is occurring, and the seasons of precipitation are shifting (Mote et al. 2003). Researchers have projected the Cascade Mountain (Oregon and Washington) snowpack to decrease by as much as 60 percent based on changes occurring in the snowpack since the 1950s (Service 2004). The decrease in snowpack could significantly decrease summer stream discharges. Over the last 100 years in the Northern Hemisphere, scientists have measured a general air temperature increase of less than 1.0 degree Celsius superimposed on the natural variability of climate (Diaz and Bradley 1995; Mote et al. 2003). However, there is no evidence that the effect of slight variations in climate on stream temperatures would be equal to or greater than the documented effects that land-use impacts have had on stream temperatures (IMST 2004).

6.1.18 Invasive Species

Effects from invasive, non-native species are expected to continue through future introductions associated with aquaculture, hatcheries (e.g., Atlantic salmon), transportation (e.g., ballast water from ships), water impoundments, and other activities, affecting native species and their habitats. The introduction of non-native fish species has contributed to declines in native fish; one example is brook trout. Brook trout mature at an earlier age than bull trout and have higher reproductive rates. These differences may favor brook trout over bull trout when they occur together; often leading to the replacement of bull trout with brook trout. Brook trout also appear to adapt better to degraded habitats than bull trout.

A number of authors have suggested some correlation between stream temperature and interactions of bull trout and brook trout. Given that brook trout have a wide optimum temperature range and that they seek groundwater upwelling sites for spawning, it may be that brook trout can displace bull trout even at cold temperatures that bull trout prefer (Cavallo 1997). Brook trout have demonstrated higher individual growth rates than bull trout across even the coldest temperatures. The FWS expects that negative effects as a result of introduced fish and other invasive species will continue.

6.2 RELATIONSHIP OF CUMULATIVE EFFECTS TO FPHCP

In the following discussion, we describe relationships between the FPHCP and additional contributions to any of the cumulative effects.

The timber industry and supporting industries make up only a part of Washington's economy. However, some small rural communities are dependant in large part on the timber industry. Any difference as a result of Permit issuance is not likely to make a difference at a regional scale. The level of certainty brought by Permit issuance is expected to increase the likelihood that a forest landowner would retain their lands in forestry rather than converting those lands to other uses. However, many other factors (e.g., current land market values) would affect a landowner's decision of whether to convert their land.

Transportation corridors outside the forested environment are not dependent on traffic harvesting timber. Even if they were, the small differences imparted by the FPHCP regarding outgoing wood or incoming rock would not be significant. The FPHCP also would not affect hydroelectric facilities; water withdrawals for agriculture, industry, or human consumption; flood control; and the overall pattern of commercial, industrial, and residential development. Few, if any, industries would be affected by the difference resulting from the proposed Permit issuance. Fish hatcheries may eventually be affected in the

long-term as the recovery of anadromous fish is facilitated by improved conditions in the forested environment, along with other regional salmon recovery efforts in the State. But other habitats, especially low-elevation habitats have been so badly degraded and have affected fish populations to such a degree that any short-term influences of the FPHCP on hatchery programs are mostly speculative.

The FPHCP is not expected to significantly affect recreation. The FPHCP is expected to result in better maintenance of roads that may facilitate access by some for recreation, but may result in reduced access in some cases to avoid excessive wear on roads during wetter conditions. Increased riparian buffer widths may make their experiences somewhat more aesthetic, but will not likely change the overall distribution and types of recreation on FPHCP covered lands.

The FPHCP does not include Native American tribal lands. However, it does affect Native American trust resources (e.g., fish populations). The FPHCP should enhance and not diminish their ability to harvest fish. The FWS does not expect that other tribal resources (e.g., bark, berries, medicinal plants) or access to FPHCP covered lands will be significantly altered by the FPHCP.

6.3 CONCLUSION

In general, many of the activities described in the comprehensive environmental baseline are expected to continue in Washington in the future. Many timber-harvest, mining, and agricultural practices have improved over time, and are not anticipated to result in the extreme effects that occurred in the past. Enhancement and restoration projects and other corrective activities are in the planning and/or implementation process. These actions are expected to improve natural-resource conditions in the future. However, the effects from increased population and development, if not sufficiently mitigated, have the potential to overwhelm the benefits of these activities.

7. EFFECTS OF THE ACTION

The effects of the action include an analysis of direct and indirect effects, together with the effects of the interdependent and interrelated activities. Direct effects are those impacts from the action that immediately affect the species or its habitat. Indirect effects are those impacts from the action that are later in time and may occur outside of the area directly affected by the action. Indirect effects must be reasonably certain to occur before they can be considered as an effect of the action. An interrelated activity is an activity that is part of the “larger” proposed action and depends on the proposed action for its justification. An interdependent activity is an activity that has no independent utility apart from the proposed action. At times, there are other activities that are interrelated or interdependent with the proposed action under consideration that result in additional effects to the species or its habitat that must be considered along with the proposed action.

In determining whether an action is likely to jeopardize a species or destroy or adversely modify critical habitat, the FWS analyzes the effect of the action, and the effect of other activities that are interrelated or interdependent with the action, in the context of the environmental baseline and cumulative effects. The environmental baseline includes the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone consultation under section 7, and the impacts of State or private actions which are contemporaneous with the consultation in process. Cumulative effects are those of

future State or private activities, not involving Federal actions that are reasonably certain to occur within the action area of the Federal action subject to consultation.

7.1 FRAMEWORK FOR ANALYSIS

Section 7 of the ESA requires the Services to consult (regarding their respective species) on Federal actions which "may affect" listed species. For Federal actions which are likely to affect listed species, the consultation culminates in the preparation of a written Opinion. An Opinion must detail how the agency action affects the species or its critical habitat, in consideration of the species status, environmental baseline, and cumulative effects. The following information describes the framework used by the FWS in this Opinion to identify the effects of the agency's action.

The proposed Federal action in this instance is to issue a Permit for the FPHCP that addresses forest practices on non-Federal, non-tribal, lands in Washington. This Permit would authorize incidental take, but would not permit or authorize the underlying activities. The permittee would be the State and the underlying activities would be a specific set of rules regarding the regulation of forest practices, such as timber harvest and road management, in Washington State. The State promulgated the current Washington Forest Practices Rules partly in anticipation of applying for a Permit and with the assumption that such changes would be necessary for the Services to issue Permits. Therefore, those rule changes are considered effects of the contemplated permit issuance. The incidental take that would be authorized by the Permit would be associated with the set of activities that are described in the FPHCP. It should be noted that the Permit would not constitute an authorization for the Covered Activities themselves, but only for take that may result from those activities. The take which would be authorized by the Permit would be incidental take, which is take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity (50 CFR 17.3). The term "take" means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in such conduct (ESA Section 3(18)). "Harass" in the definition of take in the ESA means an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering. "Harm" in the definition of take in the ESA means an act which actually kills or injures wildlife. Such act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering (50 CFR 17.3).

Therefore, incidental take may include harm or harassment so long as the harm or harassment is not the purpose of the activity, and the activity resulting in harm or harassment is an otherwise lawful activity. In other words, the activities addressed by the proposed Permit must be in compliance with Federal, State, and local laws. The Permit proposed in this instance would authorize incidental take of native fish and several species of stream-associated amphibians, where such take is anticipated to be caused by Covered Activities. Should an activity be determined to result in take of a listed species that is not included in the Permit, and for which there is no other take authorization, that activity would violate ESA Section 9 and hence would not be an "otherwise lawful" activity. Consequently, it would not be a Covered Activity. Such activities will not be addressed by the incidental take statement in this Opinion; as such activities are not an effect of the proposed action.

Next, we determined how the proposed Federal action (issuance of the Permit) would change or alter the status quo for listed species, and for unlisted species covered under the Permit (native fish and stream-associated amphibians). There are two potential ways in which the issuance of the Permit could effect a change in forest practices over the course of the Permit period of 50 years: (1) some forest practices

activities were changed as a direct result of Washington Forest Practices Rules, based on the Forests and Fish Report negotiations – such as riparian management zones, and therefore resulted in a distinct modification in the implementation of forest practices (whether or not take of any covered species would result); and (2) some forest practices that remained the same (i.e., were unchanged by the Forests and Fish Report negotiations) may, over the life of the Permit, result in the take of covered (listed or unlisted) species. In either case, these are the activities ("primary activities") which would be effects of the Permit and these activities will be directly addressed in the action-related analysis in this Opinion.

In order to determine if the specific rules governing forest practices changed as a result of negotiating the FPHCP, the FWS examined the November 1998 Forest Practices Rules as these were the most recent Rules prior to implementation of the requirements of the current Washington Forest Practices Rules (adopted permanently in 2001) that are also in the FPHCP. The FWS also considered the Watershed Analysis Process which was in effect under the November 1998 Forest Practices Rules and is acknowledging that many watershed analyses were completed and essentially became legally binding for those watersheds prior to 1998. Since then, a number of these efforts have continued where they were already initiated, but few new analyses were initiated after the current Washington Forest Practices Rules were developed, thereby minimizing the emphasis on watershed analysis. The FWS also recognized and considered that many protective aspects of the Washington Forest Practices Rules, such as those pertaining to unstable slopes, were already in the process of improvement through efforts such as education and training, and this trajectory of improvement is part of the environmental baseline. If those activities are ongoing or expected to occur in the future, the impacts emanating from them will be addressed under the Cumulative Effects section.

In addition, other activities (whether or not they may be listed as covered activities within the FPHCP) may occur solely because of the "primary" activities resulting from the Permit issuance. In situations where these activities would not have independent utility they are considered either interrelated or interdependent to the primary activities. They will also be addressed in the action-related analysis in this Opinion. Interrelated activities that were listed as covered activities will be referred to as "related activities" within this Opinion.

For all activities addressed in the action-related analysis, the FWS will assess the direct and indirect effects emanating from these activities in relation to any listed plant or animal species (and designated critical habitat) that may be affected, as well as the unlisted covered species. Other activities which have occurred and are occurring, regardless of permit issuance, are addressed in this Opinion under the Comprehensive Environmental Baseline section. Therefore, activities conducted between November 1998 and the date of this Opinion are considered within the Comprehensive Environmental Baseline.

7.1.1 Summary of Framework for Analysis

The effect of the Permit consists of the effects of all activities that are anticipated to occur under the FPHCP that were: (1) changed in the Washington Forest Practices Rules because of the Forests and Fish Report negotiations; and (2) unchanged by the Forests and Fish Report negotiations but that we expect to result in take of covered species during the 50-year proposed Permit term. Most forest-management activities on the 9.3 million acres of land covered by the Permits will occur outside of riparian areas and road corridors and, while they fall within the definition of FPHCP "Covered Activities," are not reasonably expected to take aquatic species and have not changed in recent rule revisions. Because a Permit is not required for those activities for coverage of aquatic, covered species, any impact that those activities might have would not be an effect of the Permit.

The effects of the Permit is constrained by the ability of the FWS to reasonable anticipate "take" of covered species. Forestry activities that occur near streams and that affect aquatic habitat will not necessarily cause take of listed species. "Take" under the ESA involves more than just adverse impacts on habitat. To prove take, the FWS must prove that a person committed an act that actually killed or injured wildlife, such as through habitat modification that significantly impaired essential behavioral patterns such as breeding, feeding, or sheltering. For aquatic species, habitat impairment typically is not attributable to a single act or person. More often, it is the result of the continuing effects of past land-management activities, combined with the effects of numerous current activities by multiple landowners within a watershed. Under these circumstances, it may be difficult to show that the incremental effect of an individual landowner's actions causes take, even if the aggregate effects of many actions harm the species.

Moreover, the likelihood that any activity will cause take depends on a number of site-specific factors, such as whether the species occupies the area, whether the habitat in question is already degraded, the season in which the activity occurs, and soil conditions and slope stability. Consequently, it is very difficult at the broad scale to determine with confidence whether certain classes of activities can be expected to cause take in all or even most instances.

Nonetheless, for purposes of analysis in this Opinion, we expect that certain Covered Activities cause take in some circumstances. The effect of the Permit, therefore, is the direct and indirect effect of those activities that are expected to cause take, as well as those activities that were modified through changes to the Washington Forest Practices Rules. This analytical approach is necessarily conservative, in that it overstates the actual effect of the Permit by including many activities that could proceed without a permit.

7.2 INCREMENT OF EFFECTS – BASES FOR COMPARISONS

Once we identified the activities which are effects of the proposed permit issuance (as described above), we determined how to analyze the effects of those activities. Typically, we would analyze (where possible) the incremental effects of activities that are conducted in a modified manner. However, in this Opinion, we do not use that approach, and instead, analyze the effects of those activities as they are proposed to be conducted.

Activities to be conducted under the Washington Forest Practices Rules and the FPHCP are in many cases improved in comparison to the November 1998 Forest Practices Rules. The development of the FPHCP resulted in changes (often substantive changes) to some, specific Washington Forest Practices Rules, and also allowed some rules (that may result in "take" of covered species) to remain unchanged in the face of current and future ESA listings of covered species because of the minimization and mitigation provided. The FWS herein analyzes both types of rules discussed above as "primary activities." We also analyze activities that do not have independent utility. These are either covered "related activities" or those activities which are not covered, but are nonetheless interrelated and interdependent to the "primary" activities. Other activities whether they are "covered activities" in the FPHCP or not, are analyzed in the Environmental Baseline and/or Cumulative Effects, as appropriate. For more detailed information, see Framework for Analysis above.

Throughout this assessment, the effects are often discussed through a comparison with a scenario in which the activities do not occur. The FPHCP, as is commonly done in HCPs with aquatic systems affected by forestry, relies on avoidance and minimization measures. Because of this, we can attempt to view the effects in a comparison to an absence of these activities.

The determination about how effects under this proposed Federal action relate to effects that would occur in the absence of a Permit is difficult at best, due to uncertainty about defining the bases for comparison. On one hand, the November 1998 Forest Practices Rules existed before any changes were made as a result of the proposed FPHCP. Then, beginning in 1999, rule changes were made which, under different circumstances, might be considered part of the current environmental baseline. Under the circumstances here, however, it would not make sense to consider the rule changes from 1999 to present as part of the baseline, because the current Washington Forest Practices Rules were adopted expressly for the purpose of seeking Permits. Two other possible approaches to defining the baseline would be: (1) assuming that covered activities are conducted in a manner that would be certain to avoid take of covered species statewide, even where listed fish were not known to occur; and (2) assuming that covered activities are conducted in a manner that would be certain to avoid take of covered species, in consideration of site-specific factors relevant to whether any risk of take exists. The former is probably unrealistic as the State would have difficulty in justifying a basis for such inclusive Washington Forest Practices Rules. The latter could be employed in conjunction with either the current Washington Forest Practices or the November 1998 Forest Practices Rules in locations where listed fish were not known to occur. In all cases, speculation is required.

It is difficult to anticipate how the activities would be conducted in adherence to a take-avoidance strategy depending on the presence of listed species now and in the future. Not only would the presence of currently listed species be difficult to identify with certainty, but additional listings might occur during the 50-year period. For listed species, land managers/owners would be expected to conduct site-specific risk assessments. For instance, riparian buffers required to avoid take might be larger in some geographic areas or at a local scale. References to what would be required to avoid take are occasionally used in the Opinion as examples to clarify the actual effect of the permit issuance. It is important to remember that no single prescription can describe take-avoidance across a broad landscape with varying existing conditions, management strategies, and varying site-specific conditions. Additionally, conducting an activity under a take-avoidance scenario may still result in adverse effects. However, we intend to use a variety of comparisons as we attempt to identify the additional effects and benefits that may result from the proposed FPHCP. Many of the effects that will manifest themselves over the next 50 years will emanate from activities that pre-date the FPHCP, and also pre-date the development of the current Washington Forest Practices Rules, and therefore would not be effects of permit issuance, but continuing effects of past actions and part of the baseline. We are attempting to conduct this analysis in full consideration of the baseline and the role of management in improving habitat conditions (e.g., required culvert upgrading, allowed thinning of densely stocked riparian areas), as well as the negative effects of management. We also assess the effects of the action in the context of natural disturbance regimes. Even unmanaged forests, within which the covered species evolved, were prone to, and dependant upon, natural disturbance regimes.

Comparing the current Washington Forest Practices Rules with the November 1998 Forest Practices Rules or other scenarios would just confuse the analysis. The purpose of this Opinion is not to determine whether the current Washington Forest Practices Rules included in the FPHCP are better than what existed before, but to analyze the effects of the Federal action. This requires making some assumptions about what activities would be changed by permit issuance, and comparing (a) a world with those activities to (b) a world without those activities. Therefore, we focus on the effects of those changed activities, rather than some increment of difference that would be difficult to articulate. However, only as needed, our discussion of effects may at times incorporate comparisons of the changes made to the current Washington Forest Practices Rules under the FPHCP to the November 1998 Forest Practices

Rules, and, only as appropriate, comparisons with a site-specific, take-avoidance scenario. These comparisons are not simple. For instance, some of the current Washington Forest Practices Rules regarding road construction and maintenance changed slightly. There were minor changes in guidelines regarding placement of fill and water-crossings.

A similar situation exists with respect to riparian buffers. In general, the Washington Forest Practices Rules, included in the FPHCP, requiring buffers on fish-bearing streams were developed with the objective to provide for the growth and development of a properly functioning riparian zone, that will provide over the life of the FPHCP the following riparian functions - suitable substrates, sufficient shade, bank stability, litter inputs for healthy nutrient supply, and a continual source of large wood for instream structural elements important to fish. These buffers are improved over those in place previously. In addition, buffers are now placed on many segments of perennial streams without fish, whereas previously these were rare. The overall buffering of streams is a considerable change above the November 1998 Forest Practices Rules.

The FPHCP riparian buffering prescriptions are aimed at minimizing take, but are not designed to avoid all possible take. A take-avoidance strategy likely would have to be implemented on a site-specific basis, to avoid ESA section 9 take prohibitions, and is therefore difficult to describe. In some cases, buffers equivalent to or less than those under the FPHCP might be sufficient to avoid take. However, where listed fish are present, a take-avoidance strategy would most likely equal or exceed the buffering requirements of the FPHCP. On the other hand, a take-avoidance strategy would not likely be employed where listed fish are not known to be present. In those situations, the FPHCP buffering likely exceeds that of a take-avoidance strategy.

Still, there could be effects that would emanate from activities conducted in accordance with a take-avoidance strategy, as such a strategy would seek to avoid take of covered species that were listed at the time the activities would be conducted, but would not likely seek to avoid all impacts to all covered species. Similarly, effects would also emanate from activities conducted under the November 1998 Forest Practices.

For these reasons described above, the FWS has chosen to conduct the majority of its analysis at the "gross" level rather than the "net" comparison level. Each basis for comparison has its own disadvantages. Descriptions of effects in this document often use the words "reduced," "enhanced," "decreased," "increased," etc. These terms are meant to be relative to pre-activity conditions. Those terms should only be interpreted by the reader to be comparative to other alternate prescriptions (e.g., November 1998 Forest Practices Rules or take-avoidance) when explicitly stated.

7.3 ASSUMPTIONS

A number of assumptions are made for the analyses in this Opinion and will often be stated within the appropriate sections. For clarity, we have listed these assumptions as follows:

- There will be no take of listed species which are not covered by the permit. Such take would invalidate the Permit with respect to all listed species for that forest practices application and activity.
- Limited salvage will occur within buffers retained in 20-acre exempt parcels. This assumption is based on the fact that salvage must be conducted in compliance with WAC

222-30-45; therefore, unless additional trees were originally retained when the 20-acre exempt parcel was harvested, there would not likely be any available wood to salvage.

- Alternate plans will be processed and approved as intended, with protection of the aquatic and riparian resources equal in overall effectiveness to the current Washington Forest Practices.
- Road crossings will require major repair, replacement, or renewal at least once during the 50-year Permit term. This assumption is based upon the fact that the Permit term is longer than the average lifespan of road crossing structures.
- Chemicals will be used in some cases to control competing vegetation resulting from hardwood conversion and other timber harvest within the riparian zone before and after subsequent planting of conifers. This assumption is based on the fact that chemical use to control competing vegetation is a common practice especially where aggressive understory vegetation exists. Chemical use is not a covered activity, and use of some of these chemicals could injure or kill fish. Therefore, we only analyze the use of glyphosate (e.g., in the form of Rodeo®), with the least-toxic surfactants available (e.g., Agridex®). Glyphosate applied as anticipated is not likely to kill or injure fish. See Effects of the Action – Instream Responses – Water Quality – Chemicals for more discussion on glyphosate. **Note**: the use of Trademark (™) names, registered names (®), or brand- or vendor-specific terms is not intended to imply endorsement. Our choice of terms merely refers to commonly identified materials, but should also be interpreted to apply to similar materials used for the same purposes.
- We assume that: 1) forest managers will assess potential conversion sites carefully as successful planting with conifers would be extremely costly in areas that are likely to release significant amounts of shrubs; 2) foresters will promptly plant high-quality stock in converted areas; 3) riparian zones are narrow and therefore are not as difficult to address through manual non-chemical control; and 4) when chemical use is necessary, single or repeated use of glyphosate should be sufficient to address competing vegetation in conjunction with additional non-chemical control.
- Glyphosate will not be applied to typed waters as part of a forest practices application. This assumption is based upon the fact that application of glyphosate directly to the aquatic environment is not addressed by the Washington Forest Practice Rules, even though Rodeo® and Agridex® are licensed for aquatic use. It is noted that hardwood conversions will be limited to areas farther than 30 feet (eastside) and 50 feet (westside) from such waters. Additionally, it is assumed that managers will maximize efficacy and minimize economic costs and therefore avoid costly spraying in areas and situations where the chemicals will be wasted. The FWS has no evidence of over-spraying with hand application.
- Failure to identify features requiring buffers or avoidance (e.g., seeps, streams, and wetlands) will be rare. This assumption is based upon the fact that harvest units are generally visited numerous times in the assessment/cruising stage, harvest-unit layout, as well as during harvest unit review by landowners and managers, WDNR forest practices foresters, and others (e.g., interdisciplinary teams).
- The FWS assumes that Class IV Special forest practices applications, including SEPA review, will result in activities that are consistent with the biological goals and objectives of the FPHCP. This assumption is based upon the fact that, following SEPA review, WDNR may approve, deny, or approve an FPA with conditions. Those conditions can include minimization and mitigation measures. These measures are expected to achieve the

biological goals and objectives of the FPHCP. In addition to SEPA policies that must be implemented, specific guidance is contained within the Washington Forest Practices Rules, such as WAC 222-10-030 (SEPA policies for potentially unstable slopes and landforms), which would further ensure these expectations.

- Failure to identify unstable features will be infrequent for smaller features and rare for larger features, and will generally be limited to situations where the risk of failure and consequences if failure occurs would both be low. This assumption is based upon the fact that the Washington Forest Practices Rules provide clear guidance on which features may be unstable, training is provided to foresters, and the State has additional procedures in place to screen applications and review them for potential instability. It is also expected that gradual improvement in identifying the recharge zones of deep-seated landslides within glacial deposits will continue.
- Failure to correctly identify fish-bearing waters will occur and is assumed to lessen over time. It is assumed that any methods used to map or delineate such waters will have an approximately equal probability of identifying waters as fish-bearing where fish do not actually occur or the reverse, identifying waters as non-fish-bearing where fish actually do occur. It is further assumed that such errors will be relatively small and largely offset at the landscape scale. This assumption is based upon the fact that this concept of equal error probabilities was inherent to the FPHCP.
- When Riparian Management Option 1 (thinning) is used for riparian harvest in western Washington, the stand-level requirement to retain 57 trees per acre within the inner zone will exceed the requirements for Desired Future Condition under the current basal area targets. This assumption is based upon preliminary calculations performed by the FWS, as well as information provided by Steve McConnell (Personal Communication, January 9, 2006) from sampling western Washington stands, that the 57 trees per acre was sufficient to meet or exceed the requirements of the Desired Future Condition in 144 of 150 stands that were sampled.
- Forest practices are conducted to the maximum extent allowed by the FPHCP and the Washington Forest Practices Rules. Although information is available that indicates some forest practices are typically conducted in a manner more conservative than would be allowed under the FPHCP, the assumption of "maximum extent" is based on the possibility that conditions may change as a result or market conditions, education, improved technology, lower operating costs, or changes in other constraining factors.
- The FWS recognizes the substantial effort that the State of Washington and other stakeholders are conducting with respect to Adaptive Management. Both Federal Services are participating and supporting that effort and believe it is an important component of the FPHCP. However, the FWS cannot predict which aspects of the FPHCP may be modified through adaptive management in the future, nor can we anticipate the manner in which, or degree to which, these changes may occur. For those reasons, this Opinion analyzes only the existing prescriptions and requirements of the current Washington Forest Practices Rules and does not rely on Adaptive Management in reach the conclusions contained herein.
- Summaries or descriptions of the applicable rules within this Opinion do not supplant or supercede the operating conservation program as described in the FPHCP, nor the contents of the applicable Washington Forest Practices Rules. In matters where such documents are in disagreement, the reader should consult the FPHCP and/or the Washington Forest Practices Rules.

7.4 DESCRIPTION OF ACTIVITIES THAT ARE EFFECTS OF THE PERMIT

Throughout this description, we use the term Riparian Zone of Influence (Riparian Zone) to describe the zone surrounding streams that is under riparian influence. Here the stream influences the surrounding vegetation and, in turn, the surrounding vegetation influences characteristics of the stream. This is not the same area as the buffers required by the Washington State Forest Practices Rules.

For this analysis, we generally consider the width of the Riparian Zone on most perennial streams as a site potential tree height (not a 100-year index tree height). Site potential tree heights commonly range from 200 to 300 feet on the westside of the Cascades, and are often less than 160 feet on the eastside of the Cascades. As described earlier in the Framework for Analysis, we expect that its action of issuing a Permit may influence and facilitate actions within this Riparian Zone, as well as along roads outside the Riparian Zone. Therefore, this Riparian Zone has relevance throughout the discussion of the effects of the action. It is important to remember that the term “Riparian Zone” does not refer to any specific regulatory guideline or buffer prescription. We describe the Riparian Zone here merely to help clarify the area in which permit issuance could have certain results. Please note that although some actions within this Riparian Zone may have adverse effects that rise to the level of take, we do not consider this distance from streams to represent the best distance to use in estimating take of covered species. See Extent and Amount of Take for additional information regarding estimates of anticipated take.

This section of the Opinion describes the activities resulting from the issuance of the Permit in detail, including interrelated and interdependent actions. Regulations implementing section 7 of the ESA require the FWS to consider the effects of activities that are interrelated with and interdependent on the proposed Federal Action (50 CFR 402.02). The ESA regulations define *interrelated activities* as those activities which are part of a larger action and depend upon the larger action for their justification. The ESA regulations define *interdependent activities* as those activities which have no independent utility apart from the action that is under consideration. Both interdependent and interrelated activities are assessed by applying the "but-for test," which asks whether any action and its associated impact would occur "but for" the proposed action.

The activities directly affected by the permit issuance are the “primary activities” considered in this analysis in this Opinion. The following discussion of activities would differentiate between the primary activities and the interrelated and interdependent activities, as appropriate. Interdependent and interrelated actions may also occur on adjacent lands, and may include the actions of hauling materials across roads outside, but adjacent to the FPHCP covered lands.

The Washington Forest Practices Rules are complex and have already been summarized earlier in the Description of the Rules and are not repeated below, except as necessary for clarity.

7.4.1 Permit Condition Limiting the Effects of the 20-acre Exemption Rule

During our section 7(a)(2) consultation process, we determined the need for a permit condition for the 20-acre Exemption Rule. We did not have enough information to complete our analysis on the 20-acre Exemption Rule, as it might be applied to future land divisions, for the proposed 50-year Permit term. Additionally, we determined the need for protection of covered species on Type Np streams in association with 20-acre exempt parcels. Therefore, if a Permit is issued, we would condition the Permit to limit the 20-acre Exemption Rule and provide conservation measures on Type Np streams, as follows:

- The Permit shall only apply to the following:

A. Forestlands owned by a person who affirms in writing on a forest practices application of qualifying as an eligible person under the "20-acre exemption" as of and since the date of Permit issuance.

B. Forestlands that are purchased, inherited, or otherwise lawfully obtained by a person who affirms in writing on a forest practices application of qualifying at the time that person takes possession of the forestlands under the following provisions:

   i. the forestlands have continually been qualified for the "20-acre exemption" since the date of Permit issuance; or,

   ii. the forestlands have not been subject to commercial harvest under the jurisdiction of the Washington Forest Practices Act since the date of Permit issuance and are being converted to forestland from another land use.

C. Forestlands subject to a Class IV General Forest Practices Application only when the otherwise-qualifying applicant indicates on the application that he or she is not converting those forestlands to another use within three years.

D. Forestlands in any Wastershed Administrative Unit (WAU) for which the permittee has previously established, with the review and approval by the Service, an estimate of the length of streams on FPHCP Covered Lands. The permittee shall establish, with review and approval of the Service, a method to reasonably estimate post-harvest the length of classified streams on a 20-acre exempt site and the proportion of riparian function as measured by recruitable LWD from the site when compared to that which would have been provided under the standard riparian strategies. The permittee shall monitor 20-acre exempt timber harvest activities and maintain a reasonable estimate of the cumulative change in riparian function provided by FPHCP Covered Lands as measured by recruitable LWD in each WAU that results from 20-acre exempt forest practices covered by this Permit.

   i. The Permit shall not apply to forestlands subject to subsequent 20-acre exempt forest practices applications when the permittee anticipates that forest practices on those forestlands will result in a cumulative reduction in riparian function as measured by recruitable LWD greater than 10 percent of what would have been provided under the standard riparian strategies.

   ii. The Permit shall not apply to forestlands subject to subsequent 20-acre exempt forest practices applications in a WRIA once the WAUs within the WRIA exceeding the "10 percent limit" (above) represent more than 15 percent of the total stream length on FPHCP Covered Lands in the WRIA.

   iii. The Permit shall not apply to 20-acre exempt forestlands in any WAU where there is found the spawning and rearing habitat of bull trout populations identified in Table 3-51 of the Opinion until the permittee has established, with review and approval of the Service, that forest practices under the 20-acre exempt provisions will not measurably diminish the level of riparian function provided by FPHCP Covered Lands in the WAU as measured by recruitable LWD when compared to that which would have been provided under the standard riparian strategies.

- The permittee shall require trees to be left along Type Np waters under the 20-acre exemption unless it is determined that such leave trees are not necessary to protect covered species and their habitats. Unless determined by WDNR to be unnecessary, leave at least 29 conifer or deciduous trees, 6 inches in diameter or larger, on each side of every 1,000 feet of stream length within 29 feet of the stream. These leave trees may be arranged to accommodate the forest practices operation.

7.4.2 Timber Harvest

7.4.2.1 Riparian Timber Harvest

The Washington Forest Practices Rules address areas close to the stream within the Riparian Zone with required riparian management zones (also called buffers). The Rules generally treat areas not included within these buffers as uplands, by default. The Washington Forest Practices Rules regarding riparian harvest, including buffer retention and management, were substantially changed from the November 1998 Forest Practices Rules. Timber harvest in the Riparian Zone under the current Washington Forest Practices Rules has some potential to result in effects that may rise to the level of "take" of listed fish and/or other covered species. Therefore, we presume that such timber harvest would result from permit issuance and that the effects of such harvest are also the effects of permit issuance.

Limited riparian timber harvest (e.g., consistent with Desired Future Conditions and minimum tree-density and basal-area requirements) may occur within the Riparian Zone and inside the buffered areas of fish-bearing streams. In addition, some harvest of trees may occur within the Riparian Zone that may be outside of the buffer. Timber harvest could also occur within the Riparian Zone of perennial streams without fish and along seasonal streams. The above-described harvest activities must be consistent with the FPHCP. The activity of riparian timber harvest and its effects are described separately, below for fish-bearing streams and for streams without fish.

Fish-bearing Streams

Fish-bearing streams include all streams with fish, including seasonal streams. Buffers would be applied along streams with fish (Type S or F streams) as directed by the FPHCP. Within the buffers, tree removal would occur consistent with the guidelines in the FPHCP and as dictated by current stand conditions and the Desired Future Condition. No timber harvest would occur within the 30- to 50-foot Core Zone (nearest the stream) although as discussed below, some trees may be felled and left in yarding corridors, and for road construction. Harvest within the Inner Zone (between the Core Zone and the Outer Zone) must be consistent with the stand requirements to achieve the Desired Future Condition (DFC) as well as leave-tree requirements.

The combination of stand-level DFC and leave-tree requirements establishes minimum requirements for post-harvest Inner Zone conditions that keep the stand on trajectory for meeting the DFC. This also serves to minimize the amount of timber removed and reduces effects of the current harvest.

For example, in a 2003 Washington Forest Protection Association member survey (Pete Heide, WFPA, Olympia, Washington, *in litt.*, November 30, 2004), WFPA assessed 834 FPAs submitted by its members between April 2000 and August 2003. For 376 FPAs (or 45 percent) which included 222 miles of stream buffers, they assessed types of harvest along fish-bearing streams on a stream-mileage basis. Most of the Inner Zones (58 percent) were not entered. When entry did occur within the Inner Zone (only 93 miles of the 222 miles), thinning from below (i.e., Option 1) occurred on 17 percent of the entries and harvest under option 2 (packing) occurred on 83 percent of the entries. When packing was used, approximately

half of the entries retained more than the required "floor" widths of 80 or 100 feet, depending on stream width.

McConnell et al. (2005) assessed a number of FPAs as part of an evaluation of the DFC strategy. During that study, McConnell and others analyzed FPAs on which landowners did some Inner Zone management and were working on sites where either thinning or packing were permitted (site class 1 and 2, and site class 3 along small streams). When given such a choice, landowners used packing 102 out of 108 times (94.4 percent) (Steve McConnell, NWIFC, Lacey, Washington, *in litt.*, December 20, 2005). In all of the FPAs McConnell et al. (2005) evaluated, thinning was used 48 out of 150 times (32 percent), but 42 of those instances occurred when thinning was the only choice available (i.e., site class 4, 5 and 3 along large streams). McConnell et al. (2005) noted that packing was used 68 percent of the time when Inner Zone harvest occurred; this is similar to the 83 percent reported by Heide. McConnell et al. (2005) did not tabulate information on how often landowners chose to do no Inner Zone management as compared to conducting Inner Zone harvest. The FPAs he selected for this study had at least one stream reach in which Inner Zone management was implemented. Yet, McConnell et al. (2005) noted that FPAs with at least a single reach in which the Inner Zone was entered, often had several reaches in which no Inner Zone harvest occurred (Steve McConnell, NWIFC, Personal Communications, December 20, 2005).

The WDNR Compliance Monitoring Preliminary Assessment for Riparian Zone Management (WDNR 2005) yielded additional information regarding variability of harvest options selected. WDNR reported that of 43 FPAs including western Washington Type F RMZs, 5 percent conducted no harvest and 65 percent conducted only Outer Zone harvest, for a total of 70 percent conducting no Inner Zone harvest. This is similar to the 58 percent reported by Heide (2004). Inner zone harvests were evenly split between thinning (16 percent) and packing (14 percent), which implies greater use of thinning than reported by Heide (2004) or McConnell et al. (2005). In eastern Washington, 35 FPAs were examined and 51 percent conducted no RMZ harvest (Inner or Outer Zone) and 11 percent conducted only Outer Zone harvest, for a total of 62 percent conducting no Inner Zone harvest.

It should be emphasized that the WDNR compliance monitoring data was collected during a preliminary assessment phase of the program. The main focus of this effort was to determine the best way to collect and analyze data for the program. In 2006, the WDNR would be starting another round of collecting field data for Type F RMZ compliance monitoring and this information would be added to the data collected during the preliminary assessment phase.

We do not expect timber harvest within the Core Zone. Only under certain circumstances (e.g., yarding corridors where trees may interfere with lowering and raising of cables or may fall upon cables) would trees be felled and then they must be retained on site. Timber harvest within the Inner Zone (managed for Desired Future Condition) would result in only minor to moderate levels of tree removal. Additionally, Inner Zone harvest may occur where trees closest to the water are generally retained. In all cases, tree removal may result in temporary openings in the canopy.

For instance, in a Douglas-fir dominated stand that is about 45 years-old, that has been pre-commercially thinned, most trees would likely be between 16 and 20 inches in diameter at breast height (dbh). There might be around 120 to 200 trees per acre. These trees would currently provide about 240 to 270 square feet of basal area. The rules for Inner Zone harvest would require retention of the 57 largest trees, which would result in retention of about 124 square feet or more of basal area, roughly half the existing basal area. Those 57 trees, even with 10 percent mortality, would be expected to exceed the DFC target by year 140 (as defined under the Inner Zone harvest rules) in the vast majority of cases. Even though DFC

requirements may specify a basal area target that must be retained, the 57 trees per acre requirement would usually result in a greater number of trees being retained than the requirements to meet DFC. Based upon experiences from sampling western Washington stands, the 57 trees per acre would be sufficient to meet or exceed requirements of DFC in 95 to 98 percent of stands (Steve McConnell, Personal Communication, January 9, 2006).

Generally, within the Outer Zone, the required number of conifer trees (WAC 222-30-021(1)(c) and WAC 222-30-022(1)(c)) must be retained per acre in a dispersed or clumped manner. The required number of trees may be reduced for situations where large-wood placement is planned or where special features require buffering. Within those portions of the Riparian Zone that are outside the Outer Zone, timber harvest may occur according to Washington Forest Practices Rules pertaining to upland areas.

Harvest within the Riparian Zone may affect the wind-firmness of remaining trees. In some cases, this might lead to windthrow of trees within the riparian buffer; in other cases, it may alter wind paths such that wind pressure is alleviated resulting in more wind-firm trees within the buffer. Some landowners, depending on their goals, may choose to retain windbuffers and in some cases may count windbuffers as part of their upland leave-tree requirement. Wind-firmness varies greatly by species of trees, characteristics of the soil, and positioning on the landscape relative to prevailing storm patterns. In most cases, it is expected that the integrity of the buffer would be maintained, even if some windthrow occurs. Minor amounts of salvage may occur and would be conducted consistent with the requirements for downed wood retention within the buffers and according to the descriptions for bucking, limbing, and yarding activities. However, the requirement for downed wood would most often preclude any salvage within the Inner Zone.

Harvest within the Riparian Zone of Type S or F streams would likely lead to the removal of some snags or cavity trees (when defined as hazard trees by State Labor and Industry guidelines) from within the buffer when operations within the immediate vicinity are planned (WDLI 1992) (**see Interrelated and Interdependent Activities–Hazard Tree Removal)**. Removal of suppressed or stressed trees may be a component of riparian harvests depending on the management option chosen. Landowners often choose wildlife reserve trees and/or green recruitment trees from trees located within the riparian buffers, either due to logistical considerations and a desire to not leave trees in upland areas, or because there are better wildlife reserve trees within riparian areas as a result of a) past logging practices, or b) differences in growing site. In cases where the upland leave-tree requirements would be met for that harvest unit by the trees retained in the riparian buffers, harvest outside the Outer Zone may not retain many, if any, standing trees so long as the spacing requirements for leave trees can be met.

Felling of trees by cutting with a chainsaw or with mechanized cutters may impact surrounding trees and understory vegetation. Rarely would trees be felled into Type S or F Core Zones. Yet, the Washington Forest Practices Rules do allow for this if trees cannot be practically and safely felled outside these areas. Limbing and bucking (cutting tree into merchantable log lengths) by chainsaw would likely have no effect to the habitat. However, limbing and bucking of the timber with heavy equipment and movement of heavy equipment may affect the surrounding buffer. Forest managers are expected to exercise great care to avoid damage to potential future crop trees within the mid-story and overstory. For instance, landowners and operators may armor trees next to yarding corridors to avoid bark rubbing when operating in conifer stands during the spring sap-flow period.

Movement of heavy equipment within the Riparian Zone would be limited and would generally not occur within the Core Zone without prior approval from the WDNR. Heavy equipment is rarely used in the

Core Zone and infrequently in the Inner Zone of Type F waters because many of these areas are inaccessible due to topography. Best Management Practices (such as reduction of pressure from tires and tracks) would be used to minimize rutting and other soil disturbance. Such equipment would generally operate on top of logging slash and downed vegetation. Established skid trails would be used to avoid multiple-passes where soil compaction is an issue. Only a minor amount of felling and bucking is expected to occur within the inner and outer riparian buffers of fish-bearing streams, and as such, the need for equipment to access these areas would be very limited. Felled trees within the Core Zone would be left on-site and a limited number of trees are expected to be removed from the Inner Zone. Generally, directional felling would be used to fall trees away from streams, which would further distance bucking and other timber-harvest activities from streams.

The Washington Forest Practices Rules in the FPHCP regarding slope stability have not changed in their goals, or their trajectory of continuous improvement and refinement, since the November 1998 Forest Practices Rules. The intent of the current slope stability rules remains that of prevention or avoidance of management-induced delivery of slope failures to typed waters. While these slope stability rules themselves are not viewed as an activity that would be changed by permit issuance, other rules that would be effects of permit issuance (e.g., RMZs) may affect activities which can influence the delivery of slope failures to typed waters. Timber harvest within the Riparian Zone along fish-bearing streams may occur on unstable slopes when existing processes fail to identify unstable slopes and unstable features, or because incorrect prescriptions are applied to identified areas. Timber harvest within the Inner Zone would seldom accelerate any instability because very few trees would generally be removed, root strength would generally be retained, and unstable features should be identified and addressed. Timber harvest in the Outer Zone or outside the riparian buffer may, on occasion, result in accelerated slope failure to the local area and result in delivery to typed waters. Failure to identify such areas is expected to be rare and would most likely occur only in marginal cases. These marginal cases would include situations where the unstable feature is too small to be easily identified, and where the feature would represent a low risk of failure.

The minimum Type F requirements under the FPHCP apply to all Type S waters regardless of less-restrictive Shoreline Management Act regulations developed by individual counties. If county regulations are more restrictive than the FPHCP, the county regulations would apply. In counties with no regulations, the default 200-foot buffers would apply. Some counties may have adopted regulations which are less restrictive than the FPHCP, in those cases, timber harvest conducted under the FPHCP must apply the more-restrictive prescriptions. Activities conducted under the less-restrictive county regulations (e.g., development) are not addressed by the proposed permit issuance.

On some 20-acre parcels (those where a landowner's total ownership is less than 80 forested acres), harvest may occur under the Washington Forest Practices Rules specific to 20-acre parcels (WAC 222-30-023) known generally as the 20-acre exemption. Buffers would be retained according to November 1998 Forest Practices Rules plus 15 percent of the volume. In addition, shade requirements must still be met on Type S and F streams. The FPHCP reported that in a statewide sample of 37 RMZs established on 20-acre exempt parcels during 2002/20033, 32 (or 86 percent) were treated as no-harvest areas and only two had 15 percent or more of the trees removed from the RMZ. Further analysis of an additional 39 RMZs established on 20-acre exempt parcels during 2004/2005 showed the same trend. The FPHCP attributes the low frequency of RMZ harvest to shade-retention requirements and shade-analysis requirements. Buffers on Type S and F streams are measured from the bankfull width for 20-acre exempt parcels (as opposed to the outside of the CMZ for standard Washington Forest Practices Rules).

Generally, the requirements of the 20-acre exemption (in the absence of the shade rule) could be met with retention of about 20 trees per acre dispersed within the first 50 feet of the stream, or clumped retention on less than 1 percent of the buffer width area. We assume there would be limited salvage of windthrown trees from buffers under the 20-acre exemption because salvage is only allowed where the Inner Zone stand requirements, Outer Zone stand requirements, and downed wood requirements can be met. Timber harvest conducted to the specifications of the 20-acre exemption would not typically retain a sufficient number of trees to allow salvage consistent with the rules. Salvage may not occur within typed waters, CMZs, or Core Zones, even if trees fell from outside these zones. Under the 20-acre exemption, yarding in riparian areas would occur closer to streams than under standard Washington Forest Practices Rules.

Under the 20-acre exemptions on fish-bearing streams, shade requirements must be met; but 20-acre exemptions would not account for CMZs as the 75-foot distance for shade is measured from the Ordinary High Water Mark only. Due to the combination of reduced buffer width, density, and point of measurement, it is expected that the Riparian Zone would receive less large woody debris recruitment than would occur under the standard Washington Forest Practices Rules. Operation under the 20-acre exemption should generally maintain root strength, bank integrity, and detrital inputs to fish-bearing streams at or near the same level as the standard Washington Forest Practices Rules. RMZs would be narrower and would not provide the same amount of habitat to forest wildlife species. In addition, reductions in windfirmness, microclimate buffering, and recruitment of downed logs to the Riparian Zone are expected. The level of effects assessed in this Opinion assumes there would be limited salvage of windthrown trees from buffers under the 20-acre exemption. There would likely be slightly greater effects from windthrow and greater effects from yarding in riparian areas under the 20-acre exemption as logs would be closer to the stream than under the standard Washington Forest Practices Rules.

It is difficult to quantify the proportion of small landowners who are eligible for the 20-acre exemption within a watershed. In 2004, a report was prepared to provide riparian ownership statistics for forestland parcels that would be eligible for the 20-acre exemption (Rogers 2003). The most critical step in the analysis involved identifying those 20-acre parcels using county GIS data and tax-assessor records that would allow an adequate analysis. Although the report provided a detailed and thorough look at the geographies of potentially exempt 20-acre parcels in Washington, the report acknowledges that the percentages of small forest landowners that would be eligible is likely underestimated due to lack of adequate data for a statewide analysis. The estimate of small forestland ownership based on the available information ranges from 0.5 percent to 5.8 percent. Where small forestland ownership is proportionally high or concentrated along a stream there would be an increased risk of adverse effects to riparian and aquatic resources.

Alternate Plans

Alternate plans for timber harvest along fish-bearing streams would be developed to address situations where landowners can meet riparian and aquatic functions at least equal in overall effectiveness as provided by the Forest Practices Act and the Washington Forest Practices Rules. Alternate plans would better meet landowners' operational needs. Over time, the FWS expects the use of alternate plans to increase as landowners become more familiar with developing them. Alternate plans would address site-specific considerations and would therefore be difficult to describe in a programmatic manner. Alternate plans must, by definition, accomplish the same biological goals with respect to riparian and aquatic functions as the standard Washington Forest Practices Rules. Because of this, it is expected that the impacts to the aquatic and riparian environment would be essentially the same as what would occur under the standard Washington Forest Practices Rules. In addition, alternate plans may allow activities within

the Core Zone, such as hardwood conversion, as long as the benefits to aquatic and riparian functions outweigh the short-term effects to functions, such as shade.

Harvest under alternate plans may occur under templates for common situations for small forest landowners. One example of an alternate plan is the overstocked-stand template. A Core Zone of 14 to 30 feet (equal to the average crown radius) would be retained and large wood placement would occur (see description of large wood placement and its impacts and benefits). Stand-density minimum requirements would be applied outside the Core Zone according to tree size.

Management of overstocked stands is expected to provide a long-term benefit by reducing competition among trees and improving the health of the remainder of the stand. Trees that would have succumbed to suppression mortality would be harvested; however, it is expected that few of these trees would have fallen into the stream or provided meaningful value to the stream or riparian area. Smaller suppressed trees are less likely to provide key piece size and they are more likely to rot in place (rather than falling intact) while being held up by branches of surrounding trees. Larger trees that develop over time through management are expected to provide better value in the future to stream and riparian areas when they eventually fall. Understory vegetation would often respond and re-establish itself in a short period of time.

Equipment Use

Timber harvest activities may include the use of chainsaws, heavy equipment, and in some cases, blasting, which would cause noise and vibration. Equipment would require refueling and maintenance, which would most often be accomplished at designated sites (S**ee Interrelated and Interdependent Actions–Refueling and Maintenance**). As mentioned earlier, heavy equipment is rarely used in the Core Zone and infrequently in the Inner Zone of Type S and F waters because many of these areas are inaccessible due to topography.

Streams without Fish

Harvest may occur along unbuffered reaches of perennial streams without fish (Type Np), along buffered reaches of Type Np streams outside of the 50-foot Core Zone, or along seasonal streams without fish (Type Ns). Generally, in western Washington, there would be no timber harvest within a 50-foot buffer along the first 300 to 500 feet of stream length, upstream of a confluence with a fish-bearing stream. In eastern Washington, limited harvest under the partial-cut option may occur within 500 feet of a confluence with a fish-bearing stream. Due to required buffers on Type S and F streams, it is expected that little to no harvest would occur within 100 feet or more of intersecting Type Np or Ns segments.

For Type Np streams less than 1,000 feet in total length in western Washington, the lower 300- to 500-foot reach may comprise the entire buffered portion of the stream. For longer streams, beyond the 300- to 500-foot lower reaches, a variable percentage of the stream may be buffered. The Washington Forest Practices Rules guide the percentage of stream buffered and the placement of the buffered reaches. In eastern Washington, up to 30 percent of Type Np length may go unbuffered; however, these segments would not occur within 500 feet of a confluence with a fish-bearing stream.

For Type Ns streams, any buffering required would be provided through prescriptions to address slope instability or other resources. In many landscapes where there is steep and unstable topography, it is expected that up to 50 percent of the seasonal streams without fish may receive a convergent headwall or inner gorge classification and receive buffers accordingly. The FWS bases this assessment upon the

outcomes typically observed from Watershed Analyses completed within western Washington, such as those completed in the Green River Watershed. On other landscapes, seasonal streams without fish may not be buffered. All seasonal streams with fish are treated as fish-bearing streams. In all cases, a 30-foot ELZ would be maintained.

Felling and bucking in riparian areas along seasonal streams and unbuffered segments of perennial streams without fish may occur in proximity to the stream, but directional felling may increase the distance from the stream where most bucking activities would occur. Felling and bucking adjacent to buffers on perennial streams should occur outside of, and at some distance from the 50-foot buffer due to the use of directional felling. Partial-cut buffers in eastern Washington may be entered for harvest and some felling and bucking may occur within those buffers.

Timber harvest may occur on unstable slopes within the Riparian Zone of streams without fish (e.g., convergent headwalls, inner gorges) when existing processes fail to identify unstable slopes and features or because incorrect prescriptions are applied to identified areas. This may result in accelerated slope failure to the local area and may result in delivery to aquatic resources. Failure to identify such areas is expected to be rare and would most likely occur in marginal cases. These would include cases where the degree of instability is small, features are not readily apparent, and effects of failure would likely be smaller than more obvious cases.

On some 20-acre parcels (those where total ownership is less than 80 acres), harvest may occur under rules specific to 20-acre parcels (WAC 222-30-023) known generally as the 20-acre exemption. Trees would be required to be retained along Type Np streams where such practices are necessary to protect public resources including FPHCP covered species and their habitat. Where such practices are necessary, the FPA shall be conditioned by WDNR to require at least 29 conifer or deciduous trees, 6-inch diameter or larger, be retained within 29 feet of the stream on each side of the stream for every 1,000 feet of stream length. The leave trees may be arranged to accommodate operations. Retaining 29 trees per acre in a 29-foot wide zone along a 1,000-foot stream reach is equivalent to about 44 trees per acre.

Alternate plans for timber harvest along streams without fish would be written with site-specific considerations to address situations where landowners can meet riparian and aquatic functions at least equal in overall effectiveness to the standard Washington Forest Practices Rules, while better meeting their operational needs. However, because of the effort by the landowner to develop a site-specific alternate plan and the less-onerous buffer requirements for Type Np and Ns streams, the FWS does not expect many alternate plans to be submitted for Type Np streams and very few for Type Ns streams.

Timber harvest activities may include the use of chainsaws, heavy equipment, and in some cases, blasting, which would cause noise and vibration. Equipment would require refueling and maintenance, which would most often be accomplished at designated sites (WAC) (**see Interrelated and Interdependent Actions–Refueling and Maintenance)**.

7.4.2.2 Yarding in Riparian Areas

Yarding is the process where logs are transferred to a loading site. This often involves the movement of heavy equipment over the understory vegetation, logging slash, and soil. The Washington Forest Practices Rules for yarding timber have changed regarding yarding corridors across streams, when compared to the November 1998 Forest Practices Rules. In addition, yarding within the Riparian Zone has potential to result in effects that might rise to the level of “take” of covered species. Yarding may occur within and adjacent to buffers on streams with and without fish. Yarding is expected to occur

closer to streams without fish than to streams with fish because of the wider buffer requirements on streams with fish.

Logs may be removed from the Riparian Zone by a number of methods. Various types of equipment may be used with the Riparian Zone. The manner in which yarding would be conducted would be heavily influenced by slope and soil characteristics. Impacts from yarding include soil compaction, collapsing interstitial spaces in soil, collapsing burrows, and crushing downed wood which may be habitat to a number of animal species.

Low-impact equipment is required when soils are saturated or otherwise subject to rutting. Low-impact equipment includes equipment with low pressure tires or shallow tread, and those that are not prone to spinning, grinding, or scraping soil. Soil disturbance and compaction are expected to be avoided and/or minimized by the use of Best Management Practices applied to the handling and moving of the logs within the Riparian Zone. Tractor yarding and skid trails may occur within the Riparian Zone, however, they would not be expected in the Core Zone on buffered portions. Additionally, within unbuffered portions of Type Np streams, tractor yarding and skid trails would only occur infrequently due to the ELZ requirement. The FPHCP states that "On-site mitigation is required if any of the following activities exposes the soil on more than 10 percent of the surface area of the (ELZ) zone: ground-based equipment; skid trails; stream crossings (other than existing roads); or cabled logs that are partially suspended." Mitigation, such as waterbars, grass seeding, and mulching would be used to address such damage. Skid trails are expected to be minimized due to BMPs in the Washington Forest Practices Rules, such as repeated use of established skid trails.

No logs are expected to be ground-yarded across Type S or F streams and equipment may only be used within the Core Zone of Type F or S water if WDNR grants approval. Directional felling is anticipated to be used so that felled trees may be reached by ground-based equipment from the same side of the stream from which they were felled.

Few entries are expected into the buffered portions of the Riparian Zone in any given location. However, multiple entries with heavy equipment may occur along unbuffered portions of streams without fish where most would be harvested. Movement of heavy equipment is expected to occur during yarding and would generally move over understory vegetation, logging slash, and soil. Heavy equipment is rarely used in the Core Zone and infrequently in the Inner Zone of Type F waters. Ground-based equipment is seldom used on slopes greater than 35 percent, especially within the Riparian Zone.

In addition to ground-based yarding, there are two other options. Helicopter yarding may be used on occasion but is often expensive and is used only when other yarding methods are not feasible. Helicopter yarding can produce noise and wind that may disturb certain wildlife species. Cable yarding is much more common and can be done in a variety of ways. High-lead yarding raises one end of the log off the ground (i.e., partial suspension) while sky-line yarding raises the entire log off the ground (i.e., full suspension). Logs are generally attached to cables (i.e., chokers) and are attached to a carriage which runs along the mainline. In some operations, the carriage is motorized and provides additional flexibility in extracting timber during thinnings or around interspersed clumps of retained trees. In some cases, logistical difficulties in extracting logs may be overcome by a complex series of pulleys and cables, or by utilizing ground-based equipment in association with cable systems.

Cable yarding is used when topography precludes ground-based equipment. Logs are expected to be directionally felled away from riparian buffers or exposed segments of stream. Only a minimal amount of the distance over which the logs would be yarded would be within the Riparian Zone. Partial suspension

is expected on most logs being yarded across upland areas. Full suspension would most often be expected when yarding across typed waters. On Type S or F waters, an exception must be addressed in an HPA. On a Type N waters, an exception could be approved in the FPA, but would seldom be provided on flowing waters as that exception would only be allowed if an HPA were to authorize it.

In some situations, yarding corridors may be placed across streams. When trees are felled to construct yarding corridors they would generally be left in place and are unavailable for harvest. Where sufficient deflection exists, logs would be yarded above the riparian buffer or through the upper portion of the riparian canopy. In almost all cases, full suspension would be used when crossing streams unless an HPA or FPA approves of other options. Yarding through these corridors may result in some scarring of retained trees. Hazard trees may be required to be felled when they could interfere with cable lines (**see Interrelated and Interdependent Activities–Hazard tree Removal)**.

Trees within the Riparian Zone may be used as tailhold trees for yarding logs. This entails stringing a small cable across the harvest unit and riparian buffer, and then using this cable to pull a lead cable across the riparian buffer. Once the lead cable is in place, it is tightened and raised. When the cables are tightened during installation, or slackened and tightened during use, they may rub some trees and remove some branches. This damage may resemble a lightning scar. In extreme cases, a tree or several trees may need to be cut. Such trees would be unavailable for harvest.

Under the 20-acre exemption, yarding would occur closer to perennial streams without fish than yarding along Type S and F stream segments. In general, yarding adjacent to Type Np streams under the 20-acre exemptions would be the same or similar to these activities along unbuffered Type Np stream segments under the standard Washington Forest Practices Rules.

Sorting logs for transport may occur in several locations. Usually, logs are piled according to species, size, grade, and/or other characteristics. Most sorting would occur at or near landings. Loading of logs is expected to occur at roads or landings and not otherwise expected to occur within the Riparian Zone.

7.4.2.3 Special Activities in Riparian Zone

Hardwood Conversion

The Washington Forest Practices Rules addressing hardwood conversions have changed. Effects that may rise to the level of "take" of covered species may occur from these actions, and therefore we consider that this activity may result from issuance of the Permit.

Stand conversion may be employed to restore riparian management zones to more natural or historical conditions. Hardwood (i.e., red alder) or brush stands often resulted from logging over the past century, especially those stands that were naturally regenerated instead of planted. Conversion of riparian hardwood or brush stands to conifer stands is often conducted with the intent of creating a stand of mature conifers that can provide large woody debris that would be more persistent, once delivered to the stream, than large woody debris derived from hardwood species. Generally, stand conversion from hardwood to conifer is only attempted on sites where evidence exists that such sites naturally supported mature conifers prior to previous management. Lands that are best-suited for hardwoods are generally retained as hardwood stands because they are difficult to convert, biologically inappropriate to convert, or may bring higher economic returns as hardwood stands. In western Washington, red alder has proliferated in stands once dominated by conifer, and conversion back to conifer is often considered desirable. In contrast, hardwoods are often a preferred species for retention in eastside riparian forests, recognized for their

benefits to wildlife. Therefore, hardwood conversion is less common on the eastside than it is on the westside.

In older hardwood stands, some yarding, as described previously, may occur. In younger stands, hardwoods may be slashed and left. Hardwood conversion would often include running chainsaws and heavy equipment. During hardwood conversion the no-harvest Core Zone would be retained adjacent to the stream. The no-harvest Core Zone would help retain bank stability, shade, and detrital inputs, as well as diversity of tree species for wildlife habitat.

Reduction in canopy cover outside the Core Zone may allow some additional sunlight to reach the stream but is unlikely to affect summer time temperatures in the immediate reach or increase autochthonous primary production within the stream. Stream-side shade would continue to be provided by the Core Zone. Canopy reduction or removal would increase the amount of sun reaching the ground in the Riparian Zone during the growing season and would stimulate understory vegetation. However, shading of the Riparian Zone would return relatively quickly as the canopy of retained trees closes, tall shrubs become established, and young trees grow quickly in height. Reduction of hardwood canopy may result in some loss of detrital production from hardwoods (i.e., alder) outside the Core Zone. Conversion may result in some reduction in detrital input to the riparian zone and eventual reduction of nutrient inputs from hardwood trees into the stream.

Removal of hardwood boles would result in a short-term loss of wood recruitment and eventual reduction in short-lived hardwood on the forest floor and within the stream. This would also reduce the number of cavities within hardwoods and number of hardwood snags, as well as a general reduction in forest structure in some cases. Loss of existing snags would occur due to harvest, logistical needs, and felling and bucking activities. Hazard trees may need to be removed during hardwood conversion (**see Interrelated and Interdependent Activities–Hazard Tree Removal**).

Resulting conditions following hardwood conversion would differ depending on the level of removal. In some cases, hardwoods may be the only overstory trees and hardwood conversion would result in a stem-initiation condition, with conifer seedlings. In other cases, a number of conifers may be retained and represent a variety of species and sizes. Reduction in the hardwood canopy would only result in minor increases in wind-throw vulnerability of the Core Zone as hardwoods decrease in ability to deflect wind in the winter because they lose their leaves during this time of year.

When stream segments adjacent to hardwood conversion activities are depauperate in large wood, trees with root wads attached may be added to the stream if equipment can do so without damaging public resources. In other cases, trees may be cut and felled into the stream. Placement of this wood in the stream may require an HPA. See next section for more detail.

Log Placement

Large wood placement in streams is generally done to benefit fish and their habitat. However, adverse effects that may rise to the level of “take” may result in the short-term (e.g., during log placement and until winter rains commence). Occasionally, riparian restoration in the form of placement of large wood would be proposed as part of an FPA. Placement of large wood requires approval from the WDNR to work in the Core Zone and an HPA from WDFW to work within the wetted portion of the stream. Board Manual section 26 contains guidelines including limiting log placement to fish-bearing streams, minimum log length and width criteria, and other specifications. Root wads must be placed entirely within the bankfull width. HPAs are required for all in-channel placements and may result in additional restrictions

and guidelines. For instance, public-safety issues such as downstream bridge or culvert crossings that could be damaged may necessitate anchoring of placed wood. Anchoring is generally accomplished either by placing large boulders on top of the log, burying one end of the log in the bank (sometimes in conjunction with boulder placement), or cabling the log to an anchor (such as a boulder, buried ecology block, screw anchor, or driven anchor bar).

Placement would generally be accomplished in one of two ways: equipment would be used to place the bole with attached root wad into the stream; and/or the bole would be anchored to the bank or bed. Placement of a bole without an attached root-wad would generally require (through HPA restrictions) other methods to secure the piece within the stream as described above. Work using heavy equipment may take one or more days and may result in some soil exposure. It is only expected that such placement activities would occur once per rotation. According to Chapter 26 of the Washington Forest Practices Board Manual, ground disturbance must be less than 5 percent of the stream reach within the harvest unit. Crawler tractors and rubber tired skidders are discouraged.

While placement of wood with attached root-wad would provide better stability of large wood, it would also increase the probability of sediment delivery and may generate a short-term sediment pulse or turbidity. Placement of a bole without an attached root wad would generally require other methods to anchor the piece within the stream. This is generally less desirable from a stream-dynamics standpoint, but may result in less short-term sediment delivery.

Within the stream, substrate may be disrupted by movement and positioning of logs. Following placement, large wood may shift and may migrate downstream, having positive and/or negative effects lower in the stream system. This potential for movement is especially true for large wood placed without an attached root wad, and may be true even if anchored in other ways. Large wood that remains in place is expected to alter the stream dynamics by creating pools, increasing the amount of local sediment deposition resulting in a temporary storage of that sediment, and acting as a host site for aquatic invertebrates. Large-wood placement occurs at limited spatial scales, and therefore would provide limited abundance at the watershed scale.

Longevity of wood-placement projects is relatively short (5 to 25 years) and expensive (Cederholm et al. 1997). It is generally believed that artificially added wood pieces are more likely to move than naturally occurring pieces. The limited lifespan of wood-placement projects is frequently a result of artificially placed wood being “blownout” or washed downstream during high flow events.

7.4.2.4 Related Covered Activities in the Riparian Zone

The Washington Forest Practices Rules regarding regeneration, site-preparation, vegetation control, and clearing of slash from streams have not been changed from the November 1998 Forest Practices Rules. However, these activities would accompany other activities (e.g., riparian Inner Zone harvest) which would be facilitated and influenced by the Permit.

Regeneration

Riparian Zone harvest, including hardwood conversion, would be followed by replanting the stand. Artificial regeneration (planting) would generally be done in the winter and spring months and most stands would be replanted within 12 months or less of harvest. Regeneration would utilize a variety of seedling types (bare root, plug, transplants, and wild seedlings) and a variety of species to meet resource objectives. Even where natural seeding is expected, some naturally seeded areas would be supplemented

with planted stock to meet reforestation objectives and requirements. Generally, crews of individual planters would conduct planting in riparian areas, disturbing surface vegetation or duff, and digging and cutting roots with hand tools to create plantable spaces. Use of mechanical augers may occur on rare occasions.

Special precautions may be necessary when conifers, especially western red cedars, are planted so that browsing by ungulates can be reduced. These may include wire or plastic cages, bud caps, and repellants. All species other than Sitka spruce may require protection. Other tree species may be protected as well through a variety of methods collectively known as browse control or animal damage control (**see Interrelated and Interdependent Activities–Browse Control**).

In some situations where there is insufficient natural shade provided by stumps, logs, etc., artificial shade materials, such as cards or mesh shade cloth, would be secured next to seedlings with wire pins to protect planted seedlings from the mid-day sun.

Vegetation Control

A description of the application of herbicides outside the Riparian Zone is not considered part of this action according to our framework for analysis, but is addressed in the Comprehensive Environmental Baseline.

Within the Riparian Zone, timber harvest that significantly removes some of the riparian canopy may occur within riparian buffers subjected to hardwood conversion. Hardwood conversions may occur within the Inner and Outer Zone of buffers on fish-bearing streams, or outside buffers but within the riparian zone.

Vegetation management is used for site preparation and to control competing vegetation in order to increase survival, growth, and health of planted stock. Vegetation control may occur within the Riparian Zone, including hardwood conversions. The goal is to reduce or control, not eliminate, competing vegetation. Various methods can be used. Site-specific conditions and management objectives are considered when choosing a control method. However, aerial application of herbicide is not permitted within riparian areas and application of chemicals is not a covered activity under the FPHCP. Hand slashing or cutting of unwanted vegetation, pulling or grubbing with hand tools, ground application or injection of herbicides, or a combination of these methods may be used to control competing vegetation. Mowing, tilling, disking, and plowing competing vegetation are not expected in the Riparian Zone. All noxious weed material would be disposed in a manner that would prevent its spread.

Young alder competing with conifer seedlings are often hand-slashed, while big-leaf maple coppicing (production of new shoots from stumps or roots) is usually controlled by fine stem spraying or injection with herbicides. Ground application of herbicide is more likely to control salmonberry (*Rubus spectabilis*). Control of broadleaf plants often involves the use of a variety of chemicals. Regardless of application type, multiple applications may be necessary in some situations until seedlings are “free to grow,” usually a period of less than 10 years.

In contrast, control of broadleaf plants within the Riparian Zone would be more limited. The FWS assumes that landowners would try to avoid the use of chemicals by careful harvest planning. For instance, some sites considered for hardwood conversion may be deemed likely to generate problems for regeneration due to existing abundance of salmonberry which would likely thrive following harvest. Landowners would also consider the planting of superior and advanced planting stock in these areas.

Because these riparian areas are narrow and involve relatively smaller areas than upland harvest areas, they would be easier to address through mechanical and manual means. We assume that manual treatments would be sufficient in most cases, but in other cases chemicals may be used to control competing vegetation resulting from hardwood conversion and other timber harvest activities within the Riparian Zone, before and after subsequent planting of conifers. This assumption is based on the fact that chemical use to control competing vegetation is a common practice especially where aggressive understory vegetation exists.

However, chemical use is not a covered activity, and use of some of these chemicals could injure or kill covered species. Therefore, we only analyze the use of glyphosate (e.g., in the form of Rodeo®), with the least-toxic surfactants available (e.g., Agridex®). Glyphosate applied as anticipated is not likely to kill or injure fish.

Application of chemicals when applied as described above is considered an interrelated and interdependent activity. Because application of chemicals is not a covered activity, it would be subject to the section 9 prohibition if it were to result in the take of species protected under the ESA (**see Interrelated and Interdependent Activities–Herbicide Application**).

Slash Clearing

Following timber harvest or hardwood conversion in riparian areas, clearing excessive slash and fine debris from streams occasionally may occur. Slash clearing is most likely upstream (50 to 100 feet) of culverts where potential exists for debris to plug culverts. Slash clearing would generally be done by hand unless equipment is necessary. Avoidance of soil compaction, rutting, and destabilizing banks is a primary consideration in designing slash clearing activities. HPAs would be required to do this work in a Type S or F stream, and may also be required in Type Np or Ns waters. During clearing, workers may walk in the stream and churn substrates or have direct impacts to species. Running power tools over and adjacent to stream is occasionally allowed and would be conditioned on a site-specific basis by WDNR. Use of heavy equipment in the Riparian Zone, as well as power tools, may lead to contamination from exhaust and leakage during operation.

Site Preparation

Harvestable areas within the Riparian Zone may be subject to even-aged harvesting (clear cutting) and subsequently site preparation to prepare the area for the next stand of trees. Uneven-aged harvest techniques may also require some site preparation and slash disposal or management. Various methods of site preparation are used to control competing vegetation, reduce fuels, and ensure seedling establishment and survival.

Cutting and slashing was once a common technique to remove trees from a clear-cut which were too small to be marketable, and were perceived to interfere with regenerating the next stand. Previously, cutting and slashing were followed by broadcast burning to prepare stands for replanting. When cutting and slashing were not followed by burning, the slashed smaller trees contributed to the downed wood on the forest floor.

Current forest managers recognize the value of slash as a ground cover that makes the harvest areas more suitable for reforestation activities. However, excessive amounts of downed wood (slash) are not desirable for reforestation purposes. Such slash may be treated in a variety of methods. Piling is a common practice where excessive slash is placed in a number of piles distributed across the harvest unit.

This is generally done by using ground-based heavy equipment. However, in those cases where heavy equipment is used to conduct site preparation activities, the slopes are generally less than 35 percent. Piles are almost always associated with cable-yarding or helicopter-yarding landings as there is usually some waste that is yarded to the landing, but not loaded for hauling. They may also be associated with shovel logging, especially with stands that have a lot of brush or non-merchantable trees. Piles may either be burned or left intact to provide wildlife habitat in the short-term and eventually decompose.

In addition to piling, other mechanical treatment may include lopping and scattering, chopping (roller chopping), shredding, and mulching slash. Impacts to the environment from mechanical slash treatment would generally be limited to the impacts of the equipment used. All equipment would be used away from surface waters and in locations where any leaks would not contaminate water bodies (**see Interrelated and Interdependent Activities–Maintenance and Fueling of Heavy Equipment**). Operators would use equipment with treads or tires appropriate for soil conditions to minimize rutting and compaction.

Soil scarification is a technique used to aid in artificial planting as well as natural seeding. Scarification involves the removal of organic matter to expose mineral soil for planting. This generally is done with equipment, with a variety of blades or rakes, to remove plants and roots and to rip the topsoil and sod, exposing the mineral soil. Some machines are designed to scarify patches, while others do more extensive soil disturbance. Chaining is another mechanical treatment used to remove or destroy vegetation in areas with dense shrubs or small trees. Various levels of scraping, plowing, and tilling may also occur, but are used less frequently. The FWS expects that only minor site preparation would occur within the Riparian Zone because most areas would retain adequate understory trees on the site and also would not accommodate access for mechanized equipment. Most site preparation would likely occur at least 80 feet from the stream.

Scarifying planting sites may lead to soil compaction and rutting as a result of heavy equipment use. Scarification also disturbs the understory layer, duff, and debris layer. Conifers become established more quickly after site-preparation and eventually shade out much of the understory vegetation.

7.4.3 Road Management

The aspects of road construction and maintenance in the Washington Forest Practices Rules, that are effects of permit issuance, are discussed in this section. For example, some of these rules changed slightly; there were minor changes in guidelines regarding placement of fill and water-crossings. Other aspects of these rules that represent a moderate to high risk of take of covered species, even though the rules did not change, are also considered to be a “result” of permit issuance. Therefore, the following aspects of road Management are expected to result from permit issuance:

1. Increased emphasis on existing water-crossing structures to improve fish, flood, wood, and bedload passage.
2. Utilization of additional BMPs to reduce or eliminate the delivery of road-generated sediment.
3. Improved hydrological connectivity from repair of existing road problems and improvement in design of new roads. Landowners are now required to inventory roads and identify maintenance needs and schedule work to correct them to prevent or curtail impacts to public resources. The requirements regarding the completion of Road Management and Abandonment Plans (RMAP)

by 2006 and subsequent road improvements by 2016 is a substantial change from the November 1998 Forest Practices Rules.

4. Some additional road maintenance activities would occur. Road maintenance was already required under the November 1998 Forest Practices Rules. Road surfaces were maintained in specified conditions to prevent accelerated erosion, interruption of water movement within wetlands, mass wasting, or direct delivery of water or sediment to typed water. Although the November 1998 Forest Practices Rules generally addressed these same factors, the new road-maintenance measures are more-specifically and more-frequently articulated in the Washington Forest Practices Rules and the FPHCP.

5. Construction of some roads slightly closer to streams may occur under FPHCP because there would be take authorization, however, the FPHCP severely limits the ability of road building within 200 feet of streams.

7.4.3.1 Types of Roads

There are various kinds of roads within the forest that are subject to the Washington Forest Practices Rules. Many are closed for long periods of time and opened only for specific forest practice activities. Although most roads have rocked surfaces, some have no surfacing and are composed of native soils. These roads may be difficult for many vehicles to maneuver and may even require re-installation of stream crossing structures prior to use. Some roads are opened seasonally or intermittently and may have gates. Hard, structurally-competent rock is often required west of the Cascade Crest because of the amount of precipitation. Therefore, more roads on the eastside of the State are composed of native soils. Many forest roads require high-clearance vehicles. However, a number of forest roads are open to passenger vehicles. Some of these roads are single lanes with turnouts and surfaced with aggregate material or pavement. All of these roads are subject to the FPHCP. Also, the effects of rock quarries and borrow pits, which functionally may result in similar effects as roads, are discussed in this section.

7.4.3.2 Road Construction Standards

Issuance of the incidental take permit would not affect the number and geographic location of roads; however, the standards to which roads are constructed would be altered. The maintenance and construction standards have improved the way roads are constructed and maintained, but may still result in some level of impact to the physical environment and may result in take of covered species.

Regardless of the permit issuance, the construction and maintenance of road systems would be expected to continue. Road construction is expected to take three forms: new road construction, re-construction of an inactive road, or an active road being altered so substantially that it cannot be categorized as just maintenance. Re-construction is expected as orphaned roads are upgraded or new roads are constructed at previous locations to accommodate future timber harvest.

Road re-opening and reconstruction would occur under normal and emergency situations. During emergency situations, closed roads may be re-opened to allow for emergency vehicles and personnel access. Re-opening closed roads may require removing barriers, knocking down excessively tall water bars, clearing vegetation and downed trees in the right-of-way, snow-plowing, and/or reconditioning other roadway features. Temporary culvert crossings of streams may be installed. Closed roads that have been re-opened may then need to be closed after use. Re-construction is often needed when old roads were primarily composed of uncompacted cut-and-fill slopes (side cast) and used only native soils as surface

materials under inappropriate situations (e.g., over culverts with no addition of rock). Reconstruction must meet the road-construction standards in the current Washington Forest Practices Rules.

New road construction would be expected to decrease in amount (number of miles and density per unit area) over the life of the 50-year Permit as the need for new roads decreases. New road construction would also include the construction of temporary roads, spurs, and landings. Permit issuance is not expected to change the number, density, or general placement of these roads, only the standards to which they are built and maintained.

Road construction requires a variety of activities depending on the type of road being constructed. These may include removal of surface vegetation and soil, potential blasting of rock, excavation of slopes, placement of fill material (cut-and-fill), excavation of slopes and removal (and disposal -- endhaul) of excavated material (full-bench), grading and compacting of sub-grade, rock placement, installation of drainage and structural features, placement and finishing of road surface, marking of roads, installation of signs, and installation or construction of other safety features.

Vegetation Removal

Road construction would likely involve the removal of individual trees, or swaths of trees, resulting in the creation of linear forest openings which may vary from 20 to 60 feet in width. Openings may expand as a result of windthrow, depending on site-specific conditions. Hazard trees along constructed roads may also need to be removed to provide a safe work environment and travel corridor. Merchantable trees are often cut, bucked, and stored to the side of the road until loaded onto a log truck. Where the road right-of-way only supports small trees and brush, there may be no need for cutting and the area can be cleared by machine. Trees, brush, and all other vegetative materials are cleared from the area so that roadbed construction can begin. Vegetation removal may occur at anytime of the year and often with the use of power tools, including chainsaws. Where heavy equipment is used, seasonal restrictions may apply to protect soils and prevent erosion. Bulldozers, graders, backhoes, and power tools such as chainsaws and roadside brushers may all be used. Vegetation is seldom cleared beyond the immediate top of a cut slope, or toe of a fill slope. Sometimes vegetation is left in the lower section of the fill area on temporary roads.

Establishing Road Grade

The excavation of material to make a level road surface, hauling of material, and filling across drainages and depressions may be necessary to establish a road grade. Machinery such as a bulldozer would be used to establish the topographic subgrade that would serve as the road foundation. Machinery would be used to scrape off vegetative remnants (e.g., stumps, roots, and brush) and remove top soil to prepare the base surface. In some situations, rock features may need to be removed or reduced. Drilling and subsequent blasting may be used. Diameter and depth of drilled holes would be related to distance between holes and desired diameter of resulting rubble. Following blasting, rock may be removed or left on-site. Slopes would be excavated and excavated material would be removed and disposed off-site (**see Interrelated and Interdependent Activities–Hauling and Spoil Disposal),** side-cast, or end-hauled, or left on-site. Such excavation would require heavy machinery and may be seasonally limited.

Road construction on steep slopes is limited to full-bench construction with end hauling of spoils to limit side-casting. Road integrity is expected to be maintained because all roads on side slopes exceeding 60 percent slope with potential to deliver sediment must utilize full-bench construction. Side-casting of fill is prohibited on all slopes greater than 60 percent unless specifically approved by WDNR. In all cases

where used, cut-and-fill roads must be designed and constructed in a manner that would remain stable throughout the life of the road.

Control of road-generated sediment is an integral part of the road construction design standards and includes requirements for cross drain culverts. Roads would be either out-sloped or ditched on the uphill side. Road BMPs focus on a number of items including keeping water in its natural drainage, dissipating the flow on the cross-drain outlet side with rock or allowing the water once diverted onto the forest floor to infiltrate the ground minimizing sediment delivery to streams. Structures for flowing waters (e.g., culverts) are usually installed during road excavation activities. See Feature Installation below.

Fill

Where fill is needed in constructing a road, it is often excavated from on-site sources. In some cases, additional fill or a different type of fill may be needed that is not available on-site. This may result in additional hauling and delivery of fill by dump trucks. Clean, structurally competent rock is a valuable commodity and is often unavailable regionally. This requires trucking from quarries outside the covered lands **(see Interrelated and Interdependent Activities–Hauling)**. In most cases where additional fill is delivered to streams, it would be clean and structurally competent rock material.

Fill and other exposed surfaces must be treated as necessary to avoid erosion or failure. Measures to minimize sediment delivery from recently filled areas during and following construction may include sediment-control fences, slash-filter windrows, or other techniques.

Finish Sub-grade

Once excavation and placement of fill are complete, the base road surface would be coarsely graded and may be further compacted. Drainage features such as Geotextile material, or structural features such as culverts and cross-drainage structures, may also be added at this time. In some cases, this may complete the road construction process, especially in drier areas on acceptable soil types (see Feature Installation below).

Ballast/Base Course

The base course (road base) would be created by dumping and spreading rock. The size of rock would vary. In some cases, smaller crushed rock would be placed upon or within the larger rock to increase stability. Smaller rock may be hauled to the site **(see Interrelated and Interdependent Activities–Hauling)** or may be crushed on site. Surface material from rock pits or quarries would likely be used during this phase of operations.

Surface Course

The road surface would be designed to meet anticipated road use. Native surfacing would generally be used on low traffic roads. On occasion, aggregate rock material would be used to help stabilize moisture-sensitive sub-grades and protect against erosion. Materials for the surface course may be brought in by truck **(see Interrelated and Interdependent Activities–Hauling)** and composed of small diameter rock. Once the road construction is complete, it may be allowed to “set-up” for up to a year. Surface preparation may include paving. Paving involves spreading of gravel and asphalt and may include sealing. Trucks and paving equipment may drip or leak asphalt, but it is expected that this equipment would be used and maintained in locations where such leakage would be containable and not reach the stream system **(see Interrelated and Interdependent Activities–Fueling and Maintenance)**.

Feature Installation

Geotextile fabric may be used to prevent soil or water movement within the road prism. Water stops (i.e., barriers to movement of water within the ballast and fill) may be installed during construction to prevent "pipelining" of water within the road prism. This also allows the road construction to proceed using less rock for ballast and surface material.

Depending on the design of the road, the road would be either in-sloped, out-sloped, or crowned. Each surface profile would be designed to direct water would be done in association with features to control water drainage.

A variety of cross-drainage structures are available for consideration in road construction. Cross-drain structures are designed to intercept flows from road surfaces and divert flows onto the forest floor, away from stream channels. The Washington Forest Practices Rules provide guidelines for the number and placement of cross-drain structures depending on site-specific features. Cross-drainage features are designed to reduce road-surface erosion and minimize the potential for sediment delivery to streams. Frequent cross drains avoid accumulation of large amounts of water running down the road-side ditch with increased energy and allow diversion on to the forest floor away from streams.

Control of road-generated sediment is an integral part of the design standards including requirements for cross drains. Roads would be out-sloped or ditched on the uphill side. A variety of surface drainage may be used that would ensure water is removed from the road prism and delivered to the forest floor to disperse the flow. Rock armoring may be used as needed to protect headwall inlets at stream crossings, at cross-drainage structure headwalls, and on fill slopes above stream crossings. Slash-filter windrows may be used on road sides.

Construction of stream crossings generally requires diversion of stream water during installation of culverts and during in-stream work to prevent excessive sediment delivery and turbidity. Water would either be diverted or pumped around the work site. This may require installation of block dams and may include fish salvage (discussed later). A small portion of the stream would therefore be "de-watered" (short-term loss of stream-flow from a channel segment). Water may be diverted from a work site by constructing a temporary dam across the stream to divert flow through a bypass pipe. Dams are typically constructed by hand using sandbags and/or fabric barriers and dirt. Dams are usually in place for a few days and generally would be required only once per stream crossing for the effective life of the crossing structure. Following completion of the project, water flow would be returned. This work is generally restricted to summer months to comply with in-water-work windows required by HPAs or other seasonal restrictions. Impacts include short-term desiccation of a segment of streambed (generally less than 100 feet total) and short-term disruption to passage of water, stream materials, and fish.

Features (e.g., culvert and bridge features) would be installed. For culverts, the culvert must be properly positioned in the stream, including any armoring at the head or tail end. This would be followed by placement of rock bedding and fill. Clean "drain rock" bedding and backfill (at least halfway up on culvert) are common practices. Countersinking is also a common practice on fish passable culverts and involves burying about 20 percent of the bottom of a culvert and filing it with pea gravel or similar stream substrate.

In the case of bridges, it may be necessary to construct abutments. In some cases, support features may require drilling and/or blasting. This would result in creation of debris, sediment, and slurry. Drilling procedures would be established to manage slurry waste from drilling. Some bridges may be able to span

the floodplain and can be permanent or temporary. Temporary bridges that would be removed prior to high water events may be placed at a lower level across the channel. When bridges cannot span the floodplain, abutments and other support may be necessary.

Erosion control

Erosion control may be needed to reduce sedimentation in streams during construction, as well as avoid erosion after construction. Erosion control may include placing sediment fencing, straw or straw bales, debris (e.g., tree tops and limbs), or mulch on recently filled areas and on exposed surfaces. It may also include prompt revegetation. These actions are designed to dissipate the energy of falling rain and surface flow, and retain soil on the slope thus minimizing delivery to streams and decreasing the loss of soil from slopes. Project timing may be modified to ensure minimum surface erosion from exposed slopes and fill deposits. Proper timing would allow sufficient time for germination and growth of ground-covering vegetation so that effective revegetation can be accomplished prior to the rainy season.

Finishing

Finishing the road construction project may involve a number of smaller tasks such as the marking of the road course with reflective posts and installation of signs or other needed safety features. It may also include paving and painting of pavement. Monitoring and follow-up activities may also be required with regard to exposed slopes and fills and the progress of revegetation and efficacy of erosion-control measures.

Summary of Road Construction Activities

The activities and impacts described herein include construction activities and standards. They do not include general placement or location of roads on the landscape (i.e., within a watershed), as that aspect of road management is not influenced by the issuance of the Permit.

7.4.3.3 Road Maintenance

Road maintenance includes the activities that are needed to protect water quality and aquatic resources, meet access needs, provide safe and efficient road operations, and protect the capitol investment of the road itself. Road maintenance consists of a variety of activities that contribute to the preservation of the existing road and public resource protection.

The number and location of roads would not be affected by the issuance of the incidental take permit; however, the standards to which roads are maintained would be altered by permit issuance. The maintenance standards have improved the way roads are maintained, but may still result in some level of impact to the physical environment and may result in take of covered species. In this section, we discuss the activities and tasks used to maintain, repair, remove, and replace portions of roads and their features.

Many forest roads were built at a time when aquatic ecology was not well-understood, and primary objectives in road design and construction were focused on diverting water away from and off roads as efficiently as possible. Water on roads can damage them and lead to failure of roads–an expensive investment. Road grades, ditches, and cross-drains were designed to collect water and divert water away from the road. Often, this meant that water collected from roads, as well as sediment, would be delivered directly to nearby streams. Many early roads were built on old railroad grades which generally followed streams due to the gentle grade. Many early roads on side slopes utilized side casting during road construction. Roads were often built with stream crossings that were not constructed to handle flood

events. Because of this legacy, many of the repair and maintenance issues on today's roads can be particularly challenging.

Slopes and Road Bed

Cut slopes along roads may be subject to excessive raveling, rilling, and slumping which may block the ditch. This may require flattening the cut slope, widening the ditch, and re-vegetating exposed soils. Ravel barriers, rip-rap, or retaining structures may be needed on the slope. Fill slopes may settle and movement may occur. Armoring may be attempted to stabilize such slopes. Excavating unstable fill slopes and replacing with stable material may be needed. Sometimes, addition of features to address water movement may be needed. These activities would often require the use of heavy equipment.

Slide Removal

Cut banks along roads may slump and block the ditch. Ditches may be cleared with a variety of equipment types, a grader, loader, backhoe, excavator, or bulldozer. On aggregate-surfaced roads, the waste material is loaded into a dump truck and hauled to a designated stable waste area. Waste sites would not be located on slopes greater than 60 percent. However, material could be placed on stable slopes adjacent to a slide if found to be suitable and thus approved by WDNR.

Emergency Storm Repair and Patrol

Emergency storm repair may involve the placement of fill, wash-out repair, establishing new crossings, etc. The removal of material caused by a large slide generally requires the construction of some type of structure to re-stabilize the roadway. Re-vegetation or other erosion control measures are often taken to reduce future erosion from the site.

Environmental consequences from fires can put additional pressure on structures and other road features needed for a properly functioning road. Vegetation can be burned off stabilized slopes and banks, increasing the probability of erosion and mass-wasting events; very hot burns can cause soils to become hydrophobic. Water yield can be magnified in these instances and can put increased stress on culverts and drainage capacity. Woody debris can become mobilized, causing culverts to become plugged. Wind storms can cause branches and other debris to fall and excessive rains can mobilize branches and other material which may plug cross-drainage features. Timely maintenance required under the FPHCP can prevent major damage.

Road Surface Maintenance

Snow and Ice Removal – Plowing snow is often necessary to gain access for harvest activities or planting. In the spring, the majority of the snow blocking the road is often in drifts. In these cases, drifts may be plowed. Runoff may continue to wet the road surface as snow melt continues from roadside areas. Sometimes when snow is deep, most of the snow is plowed leaving several inches to melt and the road to dry before vehicle use. Snow plowing can result in some sediment mobilization. De-icing agents are not commonly applied on forest roads.

Surface Treatments – Driving on upland roads, especially when dry, disturbs the road surface material and creates loose layers of soil and rock powder (dust). These are loose materials that can then erode and flow into ditches. Dust abatement methods are used to help control dust on heavily used forest roads not having a hardened or paved surface. This is especially needed when the volume and frequency of use keeps the surface stirred and fines become separated and airborne in the form of dust. Water dust

abatement is generally accomplished by spreading water on roads with a truck carrying a water tank and a spreader bar attached to the back of the truck. Only approved sources of water can be used for abatement, and sometimes this may require water-source development, which would be subject to applicable laws and regulations. We do not anticipate any increase in dust abatement as a result of the proposed Permit.

Road Surface Grading – Road surface material eventually breaks down or is moved through the action of water and traffic. Grading restores the shape of the road, redistributes aggregate material evenly on the roadbed, and eliminates potholes, tire-wear ruts, and other surface features that tend to concentrate water and accelerate erosion. Grading would reduce rutting and ponding, making the surface of the roadbed more even, and the substrate more drainable. Surface grading is important to prevent the road from channelizing water, which would increase the damage to the road, and is important to maintain a safe driving surface. Grading cuts into the road surface are used to loosen material that would re-mix, compact, and bind with underlying materials. Graders are used to redistribute rock/gravel by pulling it back to the middle of the road, and then spreading it back over the road. Blading can be implemented to ensure road materials do not get too far off the roadbed which otherwise can widen the road surface. A roller may be used to compact the road surface following the final grading passes to prevent further sedimentation.

Road grading is done to maintain the integrity of the road surface and associated drainage features. Grading is avoided during excessively wet or dry conditions. Grading that results in a berm along the edge of the road can redirect flow and cause road surface erosion. Routine grading is expected to occur on bridge approaches to keep road surface materials from accumulating at bridges. Fine sediments mobilized by road grading may be delivered to stream channels. Road sediments may contain traces of oil, gasoline, hydraulic fluid, or other compounds. Grading can re-mobilize this source of water-quality contamination and hasten its delivery to the stream system. However, due to the low-level of traffic associated with forest management on most forest roads, such contamination is expected to be negligible. In addition, no increase in such contaminants is expected to result from proposed permit issuance.

Road Surface Re-shaping – Road surfaces would need to be reshaped from time-to-time. Eventually, road surfacing materials would break down and are inadvertently moved off to the side of the road. When this material can no longer be retrieved, this can result in the need to resurface the road bed. The road bed would then be ripped and new rock would be spread, mixed, and compacted into the existing materials. Surface reshaping is most likely to occur during periods of heavy traffic or truck hauling and is avoided during excessively wet or dry conditions.

Road Surface Patching (rock replacement) – This is commonly needed for road maintenance. Over time and from a multitude of uses, original surface rock becomes washed, bladed, worn off, and pushed into muddy sub-grade soil. Eventually surface rock needs to be replaced. This is accomplished by loading a dump truck at a commercial source or landowner stockpile with surface rock, hauling the rock to a designated site, then dumping the rock onto the road. Moving the truck forward distributes the rock over the road, and a grader is used to further spread the rock. Subsequently, a roller may be used to compact and harden the road surface. When the aggregate is dry, it is particularly important to add water prior to blading to prevent segregation and facilitate compaction. Spot surfacing is a type of surface rocking and is limited to a dump truck spreading the rock at specific spots and is followed by grading.

Ditches

Ditch maintenance is necessary to ensure that road surface runoff is intercepted and diverted onto the forest floor. Occasionally ditches would become plugged or filled with material. Ditch cleaning is

necessary when ditches no longer meet the objective of transporting water to the next cross drain or away from a road or stream culvert. Water running down the road can increase road surface generated sedimentation, and may overload the next drainage structure, causing a fill failure. A bulldozer or grader cleans ditches by dropping a corner of the blade into the ditch and pushing the material along the ditch. Occasionally an excavator is used to clean out (pull) ditches that have been filled in by large amounts material and/or vegetation. This re-establishes designed road drainages. When possible, grass, brush, and minor debris is left in place to stabilize the surface, trap sediment, and slow the velocity of water, as long as the ditch adequately handles the expected flow without scour damage. Excess material pulled from ditches is loaded on a dump truck and hauled to pre-approved disposal sites **(see Interrelated and Interdependent Activities–Spoil Disposal)**. Sometimes suitable fines are used to replace lost ones in the aggregate surface of the road. Sediment traps may need to be cleared on a frequent basis. This work may occur in the spring and summer, but should cease in time to allow re-vegetation of ditches.

Roadside brushing is done to prevent vegetative growth in the roadbed which may damage the roadbed or interfere with functioning of ditches, and to improve sight distance. Most roadside brushing is done by mechanical removal of trees, branches, and brush. Occasionally, hand tools such as chain saws with standard bars or brushing bars are used. Mechanical brushing is generally done with a road brushing machine that may use a bar or rotating brush head. A number of passes may be made on each side of the road and generally the uphill side takes more passes. Sometimes a pole saw may be needed to reach limbs on the lower side of the road. Chainsaws are used to cut and remove fallen logs from the roadway and roadsides. Ditch maintenance sometimes may include use of herbicides to control ditch-line vegetation; however, chemical application is not a covered activity.

Cross drainage Structures

Cross drainage structures are designed to capture and divert flows off of road surfaces and onto the forest floor, away from stream channels. The Washington Forest Practices Rules provide guidelines for the number and placement of cross drain structures depending on site-specific features. Cross drainage features are designed to reduce road surface erosion and minimize the potential for sediment delivery to streams. Accumulation of large amounts of water running down the road-side ditch with increased energy can be avoided by frequent cross drains that allow diversion of intercepted water onto the forest floor and away from streams. Debris may plug cross drains and other features and require removal. Regular maintenance results in reduced risk for road fill failures, wash-outs, and mass wasting. Short-term mobilization and deposition of sediment and turbidity associated with cleaning debris from drainage structures may occur. Cross drainage is important to maintain because insufficient drainage could result in road failures or mass wasting.

Existing roads may have inadequate or poorly located cross-drainage features that deliver road and ditch-line runoff directly to streams. This situation requires existing features be repaired or adjusted and/or the installation of additional cross drains. Cross drain culverts are added to areas where water would otherwise travel through excessively long ditches. Depending on the size of the cross drain culvert, a backhoe with rubber tires or metal tracks may be used for installation. Depending on the topography and site characteristics, catch basins may also need to be installed. Culverts are installed with a certain amount of fill placed over the top of the culvert. Much of this should be addressed early in the RMAP process through relocation or improvement of cross-drainage features. Therefore, the FWS expects a pulse of such work within the next decade. Some of this work has already occurred.

Stream-crossing Culverts

Occasionally culverts would become plugged or filled with material. Culverts may become plugged on their own or through the action of beavers. Culverts plugged by beavers may need to be cleared on a frequent basis. Beaver-exclusion devices may need to be installed and beaver removal may become necessary (**see Interrelated and Interdependent Activity–Beaver Control).** Culverts on streams with heavy sediment loads or moveable woody debris may also be more likely to plug. Plugged culverts may require removal or relocation of large wood.

Stream crossings may become plugged or may fail and result in diversion of streams. Plugged stream crossings may cause streams to flow across roads increasing road-surface erosion and sediment transport and delivery. When diverted across roads, streams are shallow and mostly impassable. The FWS expects that the FPHCP would better protect against such failures than the November 1998 Forest Practices Rules. The FPHCP construction standards are expected to improve passage for fish, allowing access to almost all available habitat, with few exceptions. The standards should also provide better transport of water and large wood than under the November 1998 Forest Practices Rules. The FWS expects a reduced potential for mass-wasting of roads and hill slopes due to culvert blockage or failures under the current Washington Forest Practices Rules and the FPHCP.

Culverts may require repair when struck by large woody debris or equipment. Outlets and headwalls may require additional rock or energy dissipaters. Such repairs may vary in extent from hand-clearing of slash and debris from the culvert, to major repair with heavy equipment. In some cases, access to conduct repairs may need to be constructed or reconstructed to complete work.

Culverts may also be replaced when they can no longer effectively handle expected water and storm events, and can be improved to better facilitate the passage of fish (**see Road Upgrading below**). Sometimes when replacing a temporary culvert in a flowing stream, backfill such as drain rock is used. This allows for culvert installation directly in the water with no additional compaction needed for the backfill.

Removal and/or replacement of stream-crossing structures, such as culverts may require diversion of stream water during instream work to prevent excessive sediment delivery and turbidity. Water would either be diverted or pumped. This may require installation of block dams and may include fish salvage (**see Interrelated and Interdependent Activity–Fish Salvage)**. A small segment of the streambed (generally less than 100 feet total) would therefore be “de-watered” (short-term loss of streamflow from a channel segment). Water may be diverted from a work site by constructing a temporary dam across the stream to divert flow through a bypass pipe. Dams are typically constructed by hand using sandbags and/or fabric barriers and dirt. Dams are usually in place for a few days and generally would be required only once per stream crossing for the effective life of the crossing structure. Following completion of the project, water flow would be returned. This work would generally be restricted to summer months to comply with in-water-work windows required by HPAs or other seasonal considerations. Following culvert installation or replacement, follow-up remedial treatments may be needed within 1 to 2 years. These remedial treatments may be in response to unexpected bedload movement or other unexpected circumstances.

Replacement of improper crossings with improved crossings may reverse some of the negative effects to the aquatic system over time. Culverts that were insufficient for the stream have in some cases impounded water and created a wetland with significant amounts of stored sediment. Once the crossing is retrofitted, the stored sediment may be mobilized and transported downstream. This process may take

many years, during which the downstream channel is subject to increased sediment transport and/or delivery. However, the stream should eventually return to a natural sediment-routing regime and existing problems should dissipate. Fish passage at stream crossings, as well as passage of flows and wood, would be improved by better stream-crossing standards and the requirements and schedule requirements of the RMAP program.

Bridges

Woody debris may need to be extracted by chainsaw and/or heavy machinery if it is obstructing flow under a bridge or causing damage to the bridge itself. Riprap maintenance, deck cleaning, guardrail repair, or abutment repair may be needed. This may occur on decks and guardrails, abutments and sills, protecting riprap, bridge approaches, ramps, and wing walls when needed. Many of these activities would require the use of mechanical tools and heavy equipment. Bridges may occasionally require stabilization of banks or construction or maintenance of abutments. If these have an influence on fish-bearing waters, as they usually do, they are regulated by WDFW and would require an HPA. Such work on Type N streams may be permitted through WDNR on individual FPAs.

7.4.3.4 Road Upgrading

Road upgrading often requires components used for both maintenance and reconstruction. Generally, the function of road upgrading is to improve road drainage capacity and to add a margin of safety for increased water flow. Upgrading can reduce the need for recurrent road maintenance. Adding more cross drains, rolling dips, or culverts would reduce existing load on roadside ditches. Replacing existing culverts with larger culverts; and/or changing the inlet structure to better handle flows and debris are common upgrading measures.

Storm-proofing – This involves the implementation of management practices that substantially reduce the potential for erosion, sedimentation, and mass wasting, while still allowing road use. Storm-proofing for road upgrading may require constructing drivable dips or waterbars, installing additional culverts, and/or upgrading existing culverts with larger or newer culverts, or with special inlet sections and/or debris racks. It may also involve reshaping the roadway, disconnecting ditches (diverting flow to the forest floor–not relying on ditch flow) and surfacing the roadway. Slope stability can be restored with re-vegetating efforts such as seeding, fertilizing, mulching, vegetation mats, or sediment filters.

Bridge Replacement – Bridges are replaced when they are damaged or have become too old to function safely. Bridges are also replaced when they cannot provide access and mobility as needed (e.g., updating from single to double lane), and/or when the original design cannot pass anticipated flood events. Bridge replacement can range from replacing the decking to replacing the entire bridge including the abutments. Bridge replacement procedures would vary according to the design, size, type, and configuration of the bridge. Large cranes and other heavy equipment are used to remove and install bridges. Minor impacts to water quality are likely to occur. For instance, small pieces of chemically-treated wood may fall into streams when an old bridge is being removed, or old bridge decking and/or stringers are being replaced.

Installation of Drainage Dips and Waterbars – For most road types, roadbed drainage features, such as dips and waterbars, are preferred to facilitate roadbed drainage. Dips or waterbars are not as “maintenance dependent” as culverts or cross drain culverts and work almost indefinitely, even with minor slumping of cut banks into the roadbed. They have the added benefit of helping to storm-proof the road, or providing an added measure of safety for storm events in the event of overtopping. Installing water bars and dips usually requires the use of mechanical tools and heavy equipment.

Culvert Installation and Upgrade – Culverts are installed where they are needed to reduce soil erosion and run-off. Installation requires implementation of procedures that would minimize sedimentation and turbidity during the installation of in-channel structures, properly accommodate stream discharge, bedload, and debris to reduce road failure risk, provide for stream function (by installing a buffering device that intercepts road surface erosion), and provide fish passage if needed. All culverts must be sized to accommodate 100-year flood events. Culvert installation usually requires the use of mechanical tools and heavy equipment such as backhoes, bulldozers, and dump trucks. After a trench to accommodate a culvert is dug, rock may be placed where the culvert would lie in the trench. Fill is placed on top of the culvert in layers that are compacted. In some cases, access to install and upgrade culverts may be constructed or reconstructed to be able to complete work.

Recent experience in western Washington has shown that about 25 percent of fish-passage barriers at culverts have required full replacement of the culvert (WDFW 2003–Design of Road Culverts for Fish Passage). About 5 percent have required replacement of the culvert with a bridge or abandonment of the roadway. These percentages may vary by topographical areas, between low-gradient and higher gradient streams, and between forested and non-forested land uses.

Surface Shaping and Draining – On high-traffic roads, surface shaping and drainage are needed to keep the road dry. Simply grading the road usually completes shaping the surface and allows for proper drainage.

Surface Material Processing – Processing surface materials at a rock/gravel pit or on-site at a harvest operation can be accomplished many different ways, from crushing operations to blading and re-distributing rock on the road. Binding substance may be added to an aggregate being used to surface the road, and this can be re-mixed while it is being graded on the road surface. Rock pit plans are designed to minimize adverse effects of excavation and processing of rock materials. The pit plans cover erosion-control measures needed during and after pit preparation.

7.4.3.5 Road Re-location

Relocation means that a segment of old road would be discontinued and a new segment of road would be constructed and would be linked at both ends to an existing road system. The new road bed would follow an alternate and separate route from that of the old road. This would most commonly occur where a road currently parallels a stream or crosses a sensitive site or unstable slope. Generally, relocation would move a road from within the Riparian Zone to adjacent upland areas.

A road in a riparian area which would no longer be used may be abandoned according to the applicable Washington Forest Practices Rules. The new segment of road would also be constructed according to the Washington Forest Practices Rules. In some cases, a portion of this road construction may need to occur within or across a riparian area and, as such, an interdisciplinary team would be convened if the road would parallel the stream or did not cross using a direct route.

The road corridor that remains following abandonment may be 20 to 60 feet wide initially, would likely be replanted with suitable tree species, and the forest gap would eventually close. The new road location would be cleared of existing vegetation and that corridor may initially be 20 to 60 feet wide, closing to 20 to 40 feet or less over time. Where the new road would merge with the old road, the two corridors would meet and may result in a temporary opening of up to 120 feet, which again would eventually close to 20 to 40 feet or less.

The construction of the new segments of road may require preparing the bed including cut-and-fill or full-bench construction. This may necessitate the removal of individual trees or swaths of trees. Some of these trees may constitute wildlife habitat. Standing dead trees along such roads may need to be removed to provide a safe work environment and travel corridor. Suitable material would be brought to the site to create the road prism and would be hauled over adjacent covered and non-covered FPHCP forestland roads.

Preparing the road bed (subgrade) and building the road prism are expected to expose bare ground along slopes and in areas of deposited fill. The road prism would be constructed of clean and structurally competent material (often rock). Revegetation activities would likely occur.

In addition, in order to connect the old and new roads, portions of the old road would need to be excavated and cleared from the work area. This would generate some fill that would either be used in new road construction or may require disposal at an appropriate site.

7.4.3.6 Road Re-alignment

Road re-alignment means that only minor changes in road location would result. In some cases, improvements to stream crossings or installation or expansion of other features contributing to sediment abatement or road stability may require that the road be re-aligned. An approach to a bridge may require a different type than that which had been previously used for a culvert crossing. Road re-alignment work may occur through widening of the road prism on one side and removing the road prism on the other, or in some cases, a new road prism would be constructed adjacent to or in immediate proximity to the existing prism.

The effects of these re-alignments are very similar to the construction of a short segment of road. The prism bed would need to be created or modified and the road prism would need to be established. This may necessitate the removal of individual trees or swaths of trees. Some of these trees may constitute wildlife habitat. However, unlike new road construction or relocation, removal of vegetation is usually expected to expand existing forest openings rather than create new and separate openings. In rare situations, a new corridor through the forest might be created with a narrow band of trees separating the old prism from the new prism. In such situations, the potential for windthrow of the narrow band of trees may be substantial, depending on site-specific conditions and the number and juxtaposition of trees to be retained. In some cases, in anticipation of wind-throw, trees may be removed rather than retained. Standing dead trees or hazard trees along such roads may need to be removed to provide a safe work environment and travel corridor (**see Interrelated and Interdependent Activities–Hazard Tree Removal**).

Preparing the road bed and laying the road prism are expected to expose bare ground along slopes and in areas of deposited fill. The road prism would be constructed of clean and structurally competent material. Material would be brought to the site to create the road prism and would be hauled over adjacent covered and non-covered FPHCP forestland roads (**see Interrelated and Interdependent Activities–Hauling**).

7.4.3.7 Road Prism Widening

Road prisms may need to be widened for a variety of reasons, including creating turn-outs, to increase visibility. In some cases, the prism could merely be widened to accomplish needed re-alignment. This could be the case when a cut-and-fill, constructed road required conversion to a full bench construction road. The prism would be widened by cutting further into the slope and then removing the previously

deposited fill. Additional excavation may require the removal of trees. This may expand the openings in the forest canopy on a temporary basis from about 20 to 60 feet, up to approximately 80 to 100 feet. Over time it is expected that the forest canopy would partially return to its previous width. Removal of fill, as well as cutting of the slope, would expose slopes and fill surfaces as previously discussed above.

7.4.3.8 Road Abandonment

Abandoning roads would involve different combinations of activities, from closing active roads to full road obliteration. Roads chosen for abandonment are those no longer needed for transportation purposes. Such roads may be in poor locations, causing unacceptable sediment loads, disturbance to wildlife, or may involve unacceptable maintenance costs. Abandonment may require the use of bulldozers or other heavy machinery. The most-noteworthy activity associated with road abandonment is any associated restoration of hydrological functions. Generally, abandonment is done at a terminal point of the road. Necessary work is completed as the equipment is moved toward the beginning point.

Culvert Removal – In many cases, culverts and their associated fills are completely removed to return the stream channel to its original width, gradient, and function (s**ee Interrelated and Interdependent Activities–Hydraulic Modification**). Culvert removal requires the use of mechanical equipment. In some cases, access for heavy equipment may be needed above or below the culvert and road. Small culverts can be removed with rubber-tired backhoes but large culverts may require the use of larger backhoes with metal tracks. Culverts are removed from the site for salvage and re-use, or disposal. Appropriate re-vegetation and temporary erosion control measures are generally needed at culvert removal sites.

Culvert removal includes removal of fill and other supporting structures, and may include stabilization of slopes, steps to address run-off and erosion control, and re-vegetation. Slopes are pulled back to match the natural contour so that the stream channel can return to its original form and function.

Effects of stream-crossing structure removal are generally short-term (i.e., generally about 12 to 18 months). Sediment mobilization and turbidity associated with structure removal and site contouring are short-term (i.e., during construction and again during first rains) and localized. Removal can be followed by ongoing surface erosion of exposed surfaces for one or more years until surfaces are revegetated. Scouring of unconsolidated materials may occur during flood events. Potential loss of downed wood and riparian vegetation may occur at crossing and access sites. Long-term benefits include restoration of natural stream gradient, channel width, and aquatic habitat connectivity as well as restoration of the natural riparian vegetation. Removal of such structures can alleviate the risk of mass-wasting of road fill due to culvert blockages or failures.

Side-Cast Pullback – This operation requires the use of an excavator to pull the side-casted material away from a fill slope and is often restricted to summer months to comply with seasonal restrictions. Heavy equipment is used to excavate road side-cast material and reposition it against cut slope areas, or end-haul it via dump truck to a waste disposal site. Work may be confined to road segments that have a potential of failing and delivering to streams and wetlands. When only those areas with potential for delivery are treated, caution is usually exercised in selection of segments to be left untreated—once work is complete, access is unavailable for future additional pullback work.

Re-contouring –Road abandonment may involve re-contouring the road surface to restore the original slope angle. Side-cast material or replacement material is placed back onto the road surface using a large backhoe. Heavy equipment such as excavators are used to re-contour the abandoned road surfaces. Re-

contouring helps disperse runoff and reduce potential for failure, and is generally restricted to summer months to comply with regulations and other seasonal considerations.

Roadbed Ripping – Roadbed ripping can be accomplished with a bulldozer pulling a bar with teeth, or by using an excavator to scarify the roadbed with a toothed bucket. Ripping helps restore water infiltration and facilitates vegetative growth. Prior to actual ripping, cross-drains and other structures are removed, as is the excessive overburden, running surface, and base. Tank traps (barriers) may also be installed at this time.

Water Barring – Water barring is the excavation of troughs or trenches from abandoned road surfaces. Waterbars prevent erosion and decrease sediment distribution by intercepting and forcibly interrupting surface water flow that would otherwise have followed the road bed. It is accomplished by using a bulldozer or excavator to dig a trench across the road surface. They are usually placed at 30- to 40-degree angle to road direction. Water bar spacing are more frequent on steeper roads or where substantial surface water is expected to accumulate. Water barring is usually accompanied with road surface out-sloping, as appropriate, to reduce potential for cut slope erosion. Water-barring is generally restricted to summer months to comply with seasonal restrictions.

Erosion Control – Controlling erosion includes excavating excessive fill, re-contouring surfaces, installing slope-stabilization features, straw or straw bales, debris, or mulch on surfaces. It also includes prompt revegetation. These actions are designed to dissipate energy of falling rain and surface flow, and retain soil on slope thus minimizing delivery to streams. When decommissioning roads, rock or woody debris may be placed in streams to restore the channel, dissipate energy, or prevent erosion. An HPA would likely be required for these activities. Project timing for erosion control may be modified to ensure sufficient time for germination and growth of ground-cover so that effective revegetation can be accomplished prior to the rainy season. This would minimize surface erosion from exposed slopes and fill deposits (see Revegetation section below).

Berm/Barrier Construction – A berm is a barricade placed to restrict road access and is generally composed of natural material such as mounded soil, either alone or in combination with ditches, logs, rocks, vegetation, boulders, logs, root wads, gates, guard-rail barriers, or other constructed barriers. Potential sources of soil for construction of a berm include side cast, road surface, or the adjacent ditches. Berm construction is generally done with a small bulldozer, excavator, or backhoe. More elaborate berms may require excavation, digging post-holes, pouring cement, welding, and may also include a minor amount of clearing vegetation to accommodate construction of barrier. Dump trucks may be used to haul material to the site. Rehabilitation of the area with revegetation may be needed.

Revegetation – Re-vegetating areas is important for re-establishing soil and slope stability, and reducing surface erosion of exposed materials. Re-vegetating activities may be accomplished by mechanical or manual means, and by planting or distributing seeds (or seed mixes) or planting seedlings or other vegetative propagules (such as cuttings). Exposed erodible surfaces are often revegetated using hydro-mulching, hay, or bio-matting to protect the soil surface during revegetation and to facilitate sprouting and establishment of vegetation. Mulching and fertilizing are also common practices. Vegetation mats and sediment filters may all be used during re-vegetation. In most cases, non-invasive species are used to re-vegetate and stabilize exposed slopes to the extent possible. Perennial rye grass, creeping fescues, timothy, orchard grass, or bluegrasses are commonly used.

Native seed mixes, or other acceptable mixes, should contain no invasive species and may be spread over the disturbed areas. Also, the area may be replanted with native or nursery stock plants. In some cases, heavy equipment may be used to rip road surfaces to facilitate revegetation.

Management – Monitoring of site for signs of use or misuse, or for effectiveness and progress of restoration may be needed. Trash removal, alteration and enhancement of traffic barriers, noxious weed control, and other appropriate responses may result from this monitoring.

7.4.3.9 Exceptions for Road Maintenance

Small forest (non-industrial) landowners must replace fish passage barriers only as the need arises or as otherwise identified through proposed FPAs. Small forest landowners may submit an RMAP checklist in lieu of a complete RMAP. In Watershed Administrative Units where watershed analysis has been conducted and approved, small forest landowners may elect to follow the watershed's road maintenance plan rather than development an RMAP. WDNR maintains authority to regulate road impacts associated with individual forest practices activities so that public resources are not damaged. Owners of 20-acre exempt parcels are not required to complete RMAPs or RMAP checklists, but must abide by the road construction and maintenance requirements and would be required to address repairs needed to protect public resources.

Based on the RMAP exceptions, barriers would be replaced at a slower pace than industrial landowners and, then, only based upon State priorities and funding availability. Some small landowners are choosing to replace fish passage barriers at their own expense and others are pursuing non-State sources (for example, private and tribal restoration groups) for replacement and cost-share assistance. Non-industrial landowners with a barrier on their land have three options at the time they submit an FPA: 1) fix it during the term of the FPA, 2) develop an RMAP checklist and schedule its repair, or 3) enroll in the Family Forest Fish-Passage Program (FFFPP). However, landowners may also sign-up for the FFFPP on a voluntary basis in the absence of an FPA. Approximately 70 to 80 percent of the current enrollment was derived from voluntary sign-up (Kirk Hanson, Personal Communication, January 13, 2006). The FFFPP was developed to help small landowners with the often high cost of correcting fish-passage barriers. This cost-share program was developed cooperatively between the WDNR and WDFW. The Interagency Committee for Outdoor Recreation is responsible for managing grant funds allocated to projects. The State legislature allocated $2 million for the FFFPP in the 2004-05 biennium and $4 million for the 2006-07 biennium.

Landowners who submitted an FPA for timber harvest on or after May 14, 2003, may be required to provide a limited share (match) of the overall cost of the barrier correction. The most a landowner must pay is 25 percent of project costs, or $5,000, whichever is less. The cost-share program provides 75 to 100 percent of the cost of correcting the barrier and also provides technical assistance. The State would pay 100 percent of project costs under two scenarios:

1. A Forest Practices Application or Hydraulic Project Approval was previously provided for the existing barrier.

2. A Forest Practices Application for timber harvest has not been submitted by the landowner between May, 14, 2003, and the time the project has been selected for funding.

The second item serves as an incentive for landowners to repair passage barriers now rather than waiting until a future date. If a landowner corrects more than one barrier in a calendar year, the maximum

required match per year varies according to the average annual timber volume harvested from the landowner's lands in this State during the three preceding calendar years, and whether the barrier is in eastern or western Washington. In addition, a number of conservation groups are involved in identifying, prioritizing, and funding correction of fish-passage barriers and would often sponsor such projects, including providing engineering and logistical experience and providing the matching funding for the landowner. The FFFPP helps link local project sponsors experienced in implementing fish-passage projects with landowners in need of technical assistance and project management.

Because many small landowners are located lower in the stream system, passage often becomes an issue affecting a considerable amount of potential habitat. Such culverts would be prioritized for replacement or upgrading. Fish-passage barriers are ranked within each WRIA. Projects are prioritized based on the number and location of other upstream and downstream barriers, amount and quality of fish habitat addressed, the number of species benefiting, and project cost. In the first year of the FFFPP (2004), over 58 miles of habitat were opened to access as part of 36 projects. In comparison, as of the end of 2004, Statewide RMAPs had removed or replaced 1,217 structures and had opened 647 miles of fish habitat to passage.

FFFPP is utilizing county data and satellite imagery, in association with fish databases to identify existing barriers. They are working with local groups to contact landowners and encourage participation. In addition, FFFPP is advertising in newspapers and setting up public meetings to inform landowners about the program. On-the-ground inventories are ongoing and are being done in cooperation with the Lead Entity organizations (quasi-governmental planning groups under the State's Salmon Recovery Act), but completion of a statewide inventory is not expected for several years. In the meantime, annual ranking and repair of barriers is ongoing.

It is likely that high-priority, fish-passage barriers would receive State cost-share funding and would be replaced on non-industrial lands if the barrier occurs in conjunction with a proposed FPA. There is also a likelihood that other high-priority barriers would be identified through a number of other processes and that such potential projects would be addressed through a number of other funding sources (e.g., Salmon Recovery Funding Board). Lower-priority barriers (e.g., those that access very little upstream habitat) that occur in conjunction with a proposed FPA and those projects not associated with a proposed FPA may be replaced at any time, but non-industrial forest landowners are not required to replace these culverts prior to the same 2016 deadline that applies to industrial landowners. However, the State legislation on the FFFPP program requires legislative reports on the status of fish-passage barriers and replacements on small forest landowner forestlands in 2008 and 2013.

Orphaned roads are roads constructed prior to 1974 that have not been used for forest practices since that time (WAC 222-24-052*(4)). Such roads are typically not maintained, and many were constructed without a requirement to consider public resource and channel impacts. The mileage of orphaned roads in Washington is unknown; however, the associated hazards have been identified. The concern with orphaned roads is the lack of knowledge about their location and potential for failure and initiation of debris avalanches, debris flows, and debris torrents. Although the FPHCP would require landowners to inventory and assess orphaned roads, their repair or abandonment is not required. However, landowners may voluntarily fix problems identified during the inventory and assessment of orphaned roads.

7.4.4 Other Related Activities

7.4.4.1 Spoil Disposal

Activities such as excavation, grading, cleaning culverts, and cleaning ditches can all generate spoils. These spoils would generally be hauled to an approved local disposal site (an area that is stable and distant from typed water and has a minimal potential of delivery to typed water) where disposal material is placed or held until a later date. These sites must be located on stable ground, free of sensitive plants and animals, usually out of view of recreation areas, above the 100-year flood level of typed waters, outside Type A and B wetlands and wetland management zones, and otherwise suitable for the purpose. Disposal sites would be carefully selected and may be prepared prior to use. This preparation may include the removal of trees. Disposal sites would be designed to ensure run-off is dispersed. Disposal material may be buried or piled and may consist of soil, tree stumps, slash, brush, or other items such as old culverts. Piled soil may be stabilized with mulch and vegetation. When disposal sites are located off the project site, spoils would be hauled by dump truck and may be hauled by other machinery when nearby. During and following deposition, the site would be maintained by re-vegetating and/or mulching spoils and checking and addressing channelization and potential delivery to typed water.

7.4.4.2 Timber, Rock, and Spoil Hauling on FPHCP Covered Lands

Harvest units would potentially produce a different amount of harvestable wood as an effect of the Permit (more in some cases and less in others, also depending on the baseline used for comparison). This would change the amount and distribution of wood being hauled across FPHCP covered lands. Also, additional attention to road maintenance, adequate cross drainage, and sediment abatement may increase the use of rock on forest road surfaces, in cross-drainage structures and at their headwalls and outfalls, and in sediment-abatement and slope-stabilization structures. This would increase the amount of rock hauled onto FPHCP covered lands and may also result in larger and/or more rock pits or quarries in use on forestlands covered by the FPHCP. Also, there would be additional spoils from excavated roads as more roads are built to full-bench construction standards or the amount of fill incorporated into road design and construction is reduced. As more fill in road constructions comes from off-site rock sources, this would replace, to some degree, the use of native fill and increase the amount of native fill that becomes spoil instead. The combination of these factors would likely increase the amount of spoils that are hauled across FPHCP covered lands.

Additional traffic on FPHCP covered forestland roads due to increased hauling of rock and spoils may result in some additional margin of wear-and-tear on roads and may create some additional sediment from roads. The large amount of traffic experienced by most roads managed to the standards of the Highway Safety Act (i.e., mainlines and public roads) would likely obscure the marginal effects resulting from the FPHCP covered activities.

7.4.4.3 Hazard Tree Removal

Hazard trees are defined as trees that may pose a danger to workers, the public, or equipment. Washington Department of Labor and Industries regulates when such hazard trees must be removed. Common situations requiring removal of hazard trees include:

1. Sawyers operating within a distance equal to 1.5 times the height of a hazard tree.
2. Trees that may fall on cables, guy wires, or equipment at landings.

3. Trees that may interfere with safe operations at landings or in the slacking and tightening of cables in corridors.

4. Trees which may fall across roads or endanger the public.

Generally, Type 3 or 4 wildlife reserve trees (i.e., moderate to heavy decay) are those with potential to be a hazard tree; Type 1 and 2 reserve trees are most often not considered hazard trees. Hazard trees may often be avoided during operations by retaining a buffer surrounding the hazard tree. Hazard trees may be felled using chainsaws, heavy equipment, or blasting, and such removal may occur at any time of the year. The Washington Forest Practices Rules regarding felling assist landowners to avoid disturbing spotted owls or marbled murrelets.

7.4.4.4 Blasting

The method in which blasting is conducted and the potential for disturbance is dependent on the situation. Generally, the smallest charge that would work effectively is used to reduce cost. Drilling in rock may often need to precede blasting for the desired effect. The Washington Forest Practices Rules regarding blasting and road construction assist landowners to avoid disturbing spotted owls or marbled murrelets.

7.4.4.5 Hill slope and Exposed Slope Erosion Control

Erosion control may be achieved by trenching, terracing, or placement of logs, straw bales, silt fences, erosion-control blankets, or mulch. Erosion control may also involve contour felling (following fires) of trees to slow surface run-off. Other more-extreme measures may be needed, but would be subject to necessary protections for public resources.

7.4.5 Interrelated and Interdependent Activities

Regulations implementing section 7 of the ESA require the FWS to consider the effects of activities that are interrelated with and interdependent on the proposed Federal Action (50 CFR 402.02). The regulations define interrelated activities as those projects which are part of a larger action and depend upon the larger action for their justification, and interdependent activities as those projects which have no independent utility apart from the action that is under consideration. Both interdependent and interrelated activities are assessed by applying the "but-for test," which asks whether any action and its associated impact would occur "but for" the proposed action.

Interrelated and interdependent actions may occur on adjacent lands and may also be actions which are not covered by the FPHCP, but occur on FPHCP covered lands. Interrelated and interdependent activities include timber, rock, and spoil hauling on adjacent non-forested lands; hydraulic modification (in-stream road and stream-crossing work); beaver-exclusion devices or beaver removal; riparian application of glyphosate; milling on site (small kerf band saws or “chain saw mills”); monitoring and research; and fish salvage.

7.4.5.1 Timber, Rock, and Spoil Hauling on FFR-adjacent Lands

A few roads located adjacent to FPHCP covered lands on non-forested ownerships may be affected by the marginal increase in hauling discussed above in the **Timber, Rock, and Spoil Hauling on FPHCP Covered Lands** section. The only roads affected to a measurable degree would be small arterial roads located on non-forested lands designed specifically for local access. On larger roads with more-frequent traffic, any marginal increase in hauling of timber, rock, or spoils would be an insignificant change and

would not result in measurable effects. A number of road-access agreements, cooperative agreements, and road-use permits already exist and are part of the environmental baseline. New agreements regarding Federal roads or lands would be future Federal projects subject to Federal discretion at the time such agreements would be requested. These agreements as well as new agreements with non-Federal landowners are not contingent on the proposed issuance of the Permit, as access would be needed for upland harvest as well. As a result, such agreements are not considered further herein.

7.4.5.2 Hydraulic Modification (in-stream "road & stream-crossing" related work)

A number of actions may require an HPA from WDFW but are also related to and part of covered activities resulting from the Permit. As part of such a process for new crossings, it is common to address the question of whether the crossing is needed, or whether there are alternative routing options that would be less damaging to public resources (e.g., a road-use agreement with a neighboring landowner). It is also common that these activities address replacement of poor-quality road crossings with improved crossing structures. Sometimes, structures may be retrofitted. For example, a weir may be used near the outlet to slow velocity and raise water levels. In some cases, fords may be a preferred method of crossing where traffic levels are small, such as a gated road. This may be especially true on streams with intermittent flows. Less frequently, these activities may also involve regrading of a stream segment or the placement of grade-control features, such as large wood. Projects designed to remove fish-passage barriers would avoid and minimize long- and short-term impacts to stream and riparian habitat. Such projects would be implemented with the oversight of WDFW through an HPA. However, landowners would be required to follow the requirements in the Washington Forest Practices Rules and the State guidelines for stream-crossing design and installation.

Instream Bypass Procedures

The instream work area would be isolated from stream flow by temporarily diverting the flow from the work area or bypassing the work area altogether. Flow would be diverted using structures such as cofferdams or aqua barriers. Where fish are present in the isolated work area, they would be removed prior to the start of construction and actions would be taken to minimize effects on fish adjacent to the work area (s**ee Fish Removal Procedures)**.

Diversion may be accomplished by constructing a temporary channel, piping, pumping, or utilizing existing culverts during portions of the construction. When pumping stream water to an area downstream of the fish-exclusion reach, bypass pumping shall occur only in the stream reach isolated by upstream and downstream block nets, but not from within the work area. Sometimes a combination of methods would be used, such as pumping the stream flow downstream during work hours and piping it through the work area during off-hours.

Temporary bypasses are sized large enough to accommodate the predicted peak flow rate during construction. Dissipation of flow at the outfall of the bypass system (e.g., splash protection, sediment traps) diffuses the erosive energy of the flow. Steps would be taken to ensure that the water quality below the bypass outfall would be protected to minimize effects on habitat and associated fish downstream of the bypass. Water removed from the de-watered work area would be pumped to upland areas and treated as necessary to ensure it retains water quality upon re-entering any wetland, stream, or any other water body. To ensure that the work area is not exposed to flowing water (i.e., due to unexpected rain during the work period), bypass requirements may also be applied to seasonally dry streams as well as streams with perennial flow.

7.4.5.3 Herbicide Application

Hardwood conversion would be allowed within the Inner Zone riparian buffers and other timber harvest would be allowed within the Riparian Zone. As a result, conifer planting would occur within these areas and it would be necessary to ensure adequate survival of those young trees. Chemical application is therefore anticipated as an interrelated or interdependent activity even though it is not covered by the FPHCP. However, if these activities were to result in the take of species protected under the ESA, they would be subject to ESA section 9 take prohibitions.

There are limitations on broadcast spraying within the Riparian Zone such as prohibiting drift that may damage plants in the Inner and Core Zone. Broadcast spraying is defined by the State as any chemical application other than by a hand-operated wand for individual plant treatment. Manual or mechanical treatment would be utilized whenever feasible with sufficient efficacy.

Glyphosate (e.g., in the form of Rodeo®) may be used when it has sufficient efficacy for the target plants. In order to help the efficacy of glyphosate, surfactants are used because they increase the absorption of the active ingredient across the plant's surface membrane. Toxicity of surfactants and formulations are expected to be major considerations within the Riparian Zone and all steps to minimize delivery of toxic chemicals are expected to be used even if they result in a slight reduction of efficacy. The economic incentives of managing conifers for rapid growth are more limited than in upland areas. Several surfactants have been approved in Washington State. We expect that only the least toxic surfactants, and those producing the least toxic break-down products, would be used. At this time, we expect that only a surfactant such as Agridex® may be used. Rodeo® and Agridex® are licensed for aquatic application. We assume, however, that land managers would want to maximize efficacy and minimize economic costs and therefore would avoid allowing spray to reach water surface. As addressed earlier, although application of glyphosate directly to the aquatic environment is not addressed by the Washington Forest Practices Rules, Rodeo® and Agridex® are licensed for aquatic use.

Hardwood conversion would not occur within the first 50 feet of Type S and F streams. Forest managers would generally apply the lowest application rate consistent with the intended purpose using a low-pressure back-pack sprayer for spot treatments. When feasible, a spray hood would be used to direct chemicals at the immediate vicinity of the planted tree. All applications would be made in accordance with label instructions to ensure proper timing, correct rate of application, and appropriate application methodology. Application would not be made when rain is anticipated within 24 hours.

We expect a limited portion of the planted area would be sprayed. Other areas would not be sprayed at all. Application may need to be repeated. We expect permit issuance would not result in a need for other chemicals and have determined that the use of glyphosate (e.g., Rodeo® and Agridex®) as described above is not likely to adversely affect covered fish or amphibian species.

7.4.5.4 Maintenance and Fueling of Equipment

Backhoes, bulldozers, tractors, feller-bunchers, forwarders, and other road-related and yarding-related equipment would require maintenance and refueling in the field. All such work on heavy equipment should occur in staging areas to contain any leaking fuel, oil, and cleaning solvents and prevent contamination of adjacent streams and riparian areas. At times, repair or refueling may be required to occur in the work area. Chainsaws and other hand-held power tools require fueling, oil, sharpening, and other maintenance that may occur at the worksite.

7.4.5.5 Worker Camping

Crews working on harvest units, tree planting, or other forest activities may camp near the work site to reduce travel time. Such crews are usually responsible for their own clean-up and are held responsible by the respective landowners. Campgrounds on Federal, State, or other lands may also be used; but, any effects from camping in these campgrounds would be indistinguishable from effects resulting for recreational camping which are already addressed in the environmental baseline.

7.4.5.6 Livestock

Where livestock such as horses or oxen are used to pack in materials or for yarding, corals or hobble areas would be used and may be trampled, resulting in soil compaction. Some localized grazing pressure may result. Feed, including hay, would usually be provided. Because landowners can be held responsible for control and eradication of noxious weeds, caution is generally used to avoid introduction of weeds through hay, transport trailers, or on coat of animals. The FWS expects the use of livestock, to aid in conducting forest practices, to occur infrequently.

7.4.5.7 Browse Control

Special precautions may be necessary to reduce animal damage to replanted areas. The many methods available are collectively known as browse control or animal damage control. Western red cedars are particularly vulnerable to browsing by ungulates. Protection against ungulates includes applying wire cages, bud caps, and repellants to young trees. For protection from other animals, stems may also need to be wrapped to prevent girdling by rodents, especially in grassy environments. Fencing or other barriers protect plants from both ungulates and rodents. Co-planting cedars with spruce creates a successful barrier in some cases.

Some animal damage control methods come with risks. Fencing and barrier material (e.g., netting or Vexar® tubing) may be pulled off and may find its way into a stream. Also, repellants may wash off and eventually reach a stream. Most repellants are naturally occurring organic solutions such as putrescent egg solids, dog or coyote urine, or organic chemicals mimicking the scent of predators or decay.

7.4.5.8 Monitoring and Research

Issuance of the Permit is also expected to result in a variety of CMER-approved monitoring, evaluation, survey, and research efforts. These activities are intended to support the monitoring and adaptive management components of the FPHCP and attendant reporting requirements. The monitoring of stream conditions, riparian conditions, performance and efficacy of road standards, baseline condition monitoring, and compliance monitoring are not expected to result in effects to covered species. General categories of monitoring and research expected to have the potential for adverse effects to covered species are addressed below:

Habitat Manipulations – reductions in RMZ prescriptions may occur in order to test the effectiveness of various buffer designs. The FWS expects that habitat manipulations would likely occur on less than 0.1 percent of RMZ buffers. The range of treatments may vary. The most-aggressive experiments anticipated may result in some Type Np streams receiving no buffer. Type F streams may receive reduced buffers. These treatments may result in reduced large wood delivery, shade, nutrient input, and bank stability; treatments that involve enhanced buffers may locally provide additional function beyond that provided by the Washington Forest Practices Rules. These impacts are expected to occur along a

very small percentage of streams, be localized, and have minor impacts at a watershed scale. Two specific CMER projects are described below.

One example of an ongoing, adaptive-management research project with alternative riparian-management prescriptions is the Eastside Riparian Shade and Temperature Effectiveness Project (CMER FY 2006 Work Plan). This project is designed to evaluate the effectiveness of both the "all available shade" prescription (required within the mapped, bull trout overlay) and the standard eastside riparian prescription. The primary objective of the project is to determine if a difference exists between shade and stream temperature provided by the "all available shade" prescription and the standard eastside riparian prescription. The two riparian harvest treatments were assigned randomly among study sites and are as follows: (1) the "all available shade" prescription that requires all shade trees remain unharvested within 75 feet of fish-bearing streams within the bull trout overlay; and (2) the standard eastside riparian prescription. In some of treatment assignments, the standard eastside riparian prescription was randomly assigned to a study site that occurred within the bull trout overlay, which would require the "all available shade" prescription if harvest were to occur under normal circumstances (i.e., outside of an adaptive-management research project). This is an example of an alternative prescription under adaptive management.

Another example of an experimental riparian-management prescription, under the adaptive management program, is the Type N Experimental Buffer Treatment Project (CMER FY 2006 Work Plan). This project is currently in the site-selection phase. The project is designed to compare the effect, on a variety of riparian and aquatic resources, of three different Type N riparian buffer treatments with an untreated riparian control. One of the treatments is a clearcut prescription along Type Np streams. Outside of an adaptive-management research project, at least 50 percent of Type Np streams would receive 50-foot no-harvest buffers. So, the clearcut treatment is an example of an experimental prescription under adaptive management.

Species Handling – a variety of methods may be used to handle fish and wildlife species. Amphibians may be collected by hand or net. Fish may be captured by net alone or in conjunction with electrofishing (s**ee Electrofishing)**. However, species may be subject to handling stress, injury, and/or mortality as well as directly or indirectly contributing to transmission and increased susceptibility to disease. Species handling may occur as an activity authorized by the proposed Permit during studies proposed as part of the CMER process. Such studies may require repeated sampling to determine habitat use, growth rates, or other response variables. The FWS would continue to participate in CMER and guide such studies to reduce unnecessary effects to listed and at-risk species.

Additional specific features of sampling are expected to include:

A written description of the year's sampling and reporting plans would be sent to the FWS prior to each field season which would include estimates of the amount of work to be conducted and the names and qualifications of all personnel that would be supervising the field operations. They would sample at times and locations that avoid disturbing spawning native salmonids, incubating eggs, or newly emerged fry. If WDNR used electrofishing activities for these purposes, such use would comport with appropriate requirements (**see Electrofishing**). Sampling activities that would involve extensive shocking or handling of fish would likely be conducted at times or in locations (e.g., cold, groundwater-dominated streams) that avoid temperature stress of fish.

Live specimens would typically be released as soon as possible, and as close as possible to the point of capture. Fish would be held in live wells in the natural stream environment during measuring and

weighing. The fish would be inspected periodically to ensure they are not being crowded or stressed. Holding time would usually be minimized. Water-to-water transfers, the use of shaded, dark containers, and supplemental oxygen would all be considered in designing fish-handling operations. Prior to conducting activities that may involve handling fish, researchers would ensure that hands are free of sunscreen, lotion, and insect repellent.

Fry and larger individuals would be held separately to prevent predation. All incidental mortalities would be preserved in a fashion to best provide maximum scientific information. Any specimen killed would be kept whole and put on ice or frozen as soon as possible. As requested by the FWS following review of study plans, additional information may be collected from incidental mortalities. For instance, in specific cases, a small tissue sample (e.g., fin clip of 0.2 square inch (1 square centimeter) would be preserved in a vial of 95 percent ethanol and sent to the Western Washington Fish and Wildlife Office for storage or processing.

Following such work, results of the year's surveys would be reported to the FWS on an annual basis. Reports of incidental injury or killing would include the date, time, location of the injured animal or carcass, and any other pertinent information such as the cause of death or injury. Such reports would generally include the following information:

i. A summary of the findings relevant to listed species and their recovery in the context of the FPHCP.

ii. Maps and descriptions of locations sampled where listed species were encountered.

iii. Estimates of the fish populations in the sampled reaches, if possible.

iv. Estimated quantification of take, including numbers of fish incidentally killed or injured, and the locations where this take occurred. The report should also include any insight derived from this work that may contribute to minimizing sources of injury or mortality in the future.

v. Other pertinent observations relevant to the status and ecology of listed species, including size and presumed life-history form.

Determining Fish Presence – Electrofishing to validate and update the water-typing model would be covered by the proposed Permit. Effects may occur to headwater fish and amphibians when electro-fishing is used to validate and update the water-typing model (extent of fish use). The FWS expects that electrofishing associated with model validation is expected to affect less than 0.1 percent of streams. When fish are discovered, electrofishing is expected to occur on those streams only once during the life of the Permit (50 years). When fish are not discovered, model validation or updating may occur at 5-year increments. Electro-fishing does not usually kill fish or amphibians, but disrupts their movements and behaviors at the time of shocking (**see Electrofishing)**. However, in some circumstances, electrofishing may cause injury and mortality. Electrofishing to determine fish presence on a given stream as an elective activity by a landowner is not related to the proposed permit issuance and is not a covered activity.

7.4.5.9 Fish Removal Procedures (Salvage)

Fish-removal, as may be authorized through a section 10(a)(1)(A) permit, may occur during stream crossing construction or maintenance. A site-specific assessment usually informs decisions about when diversion and fish salvage are necessary. During diversion, fish would be removed from the work area

using a variety of methods. First, the work area is isolated by installing block nets at up and downstream locations to isolate the entire affected stream reach. This is done to prevent fish and other aquatic wildlife from moving into the work area. Block nets require leaf and debris removal to ensure proper function. Block nets are installed securely along both banks and in channel to prevent failure during unforeseen rain events or debris accumulation and are checked frequently to ensure they remain functional. Some locations may require additional block net support. Block nets are normally left in place throughout the fish removal activity and not removed until flow has been bypassed around the work area.

Drag netting or seining is a technique to remove fish from the isolated area with less potential for adverse effects to fish compared to electroshocking. Other possible techniques include collecting aquatic life by hand or with dip nets as the site is slowly de-watered, trapping using minnow traps, or by electrofishing. Electrofishing in stream channels is normally done only where other means of fish exclusion and removal are not feasible (s**ee Electrofishing**).

When removing fish out of the isolated stream reach, attempts would be made to remove fish from of the existing stream-crossing structure. Often, a connecting rod snake is inserted and wiggled through the pipe or other structure, creating noise and turbulence to get the fish to move out so they can be captured and removed out of the stream reach.

Pumps used to temporarily bypass water around work sites are normally fitted with mesh screens to prevent aquatic life from entering the pump hose. The mesh screens are installed as a precautionary measure to exclude any fish and other wildlife which may have been missed in the fish exclusion process, or may have entered the work area through a failed block net. Screens are generally located several feet from the inlet of the pump hose to avoid subjecting fish to the suction of the pump.

Captured fish are immediately either released or put in dark colored 5-gallon buckets or other suitable containers filled with clean stream water. Frequent monitoring of container temperature and well-being of the specimens ensures that specimens are released unharmed. Any injuries or mortalities to ESA-listed species usually require the event to be documented and reported to the one of the Federal Services (e.g., NMFS or USFWS); and, any listed fish that are inadvertently killed are provided to the appropriate Service. Captured fish would be released upstream of the isolated stream reach in a pool or area which provides some cover and flow refuge.

7.4.5.10 Electrofishing

Backpack electrofishing surveys are used to gather fish distribution and abundance data to inform operational decisions and for the aquatic monitoring and adaptive management commitments in the FPHCP. The surveys are used for three main purposes.

The first and most-widespread use is for verification of fish presence or absence in streams to test the water typing model. This use of electrofishing would be covered by the proposed Permit and typically involves electrofishing in smaller headwater streams, at or near the upstream limit of fish distribution. Standard methods would be used with any supplementary protocols described in the appropriate CMER Project Description and provided to the FWS for approval. When electrofishing is used for this purpose, it is applied in consideration of likely fish habitat and it ceases upon the first identified fish and as a result, only a small fraction of the stream is surveyed by electrofishing. Electrofishing is only used as needed and fish are not often encountered when it is used. The need for these surveys has diminished due to historical surveys. Use of electrofishing merely to determine fish presence on a given stream as an

elective activity by a landowner is not related to the proposed permit issuance and is not a covered activity.

The second purpose of electrofishing surveys covered by the Permit is to conduct monitoring and research. For instance, in conjunction with certain other investigations (e.g., fish-passage effectiveness), it may be necessary to collect information about covered species. Such work may be conducted annually during certain years or may be conducted only periodically (e.g., every 10 years). Surveys may be conducted using standard multiple-pass removal electrofishing techniques, with block nets, or using modified procedures provided by the Services. Habitat surveys generally would be conducted concurrently.

The third purpose for electrofishing is to move fish during stream-channel diversion projects. This use of eletrofishing would be addressed through section 10(a)(1)(A) of the ESA and may require individual permits when bull trout are present. These types of projects are not very frequent, but may occur during culvert replacements and in-channel work (**see Fish Salvage**).

7.5 EFFECTS OF THE ACTION

7.5.1 Introduction

The activities that are the effects of this Federal action have been discussed earlier in the section entitled **Description of Activities that are Effects of the Permit**. In this section of the Opinion, we assess those primary activities (as well as related, interrelated, and interdependent activities) and their effects on aquatic and riparian resources. These activities would affect aquatic and riparian resources directly and indirectly. Indirect effects "are caused by or result from the proposed action, are later in time, and are reasonably certain to occur". These activities could affect inputs to streams directly, or indirectly, through the effects to riparian conditions. Lisle (1999) identified five types of inputs to watersheds: wood, sediment, water, heat, and detritus. Activities could also affect how inputs are transported and the level of connectivity within the fluvial system. For each of the resource topics regarding aquatic inputs and transport, we discuss the sources of effects, and discuss the level of effects. Changes to inputs and transport processes would also manifest themselves as changes to instream habitat which is discussed. The conditions that are expected to occur from these potential changes in riparian conditions, aquatic inputs, transport factors, and instream responses are compared to the range of variability expected under natural-disturbance regimes. Finally, some activities would affect habitat or animals in ways that are not readily captured within the above framework. We discuss the effects to individuals (of the collective covered species) that would be expected from activities such as work-site-isolation techniques (fish salvage), related to road-stream crossings, designed to minimize effects on fish; handling associated with fish salvage, monitoring, or research; and other sources of potential injury not stemming from habitat alteration.

Fish habitat includes the physical, chemical, and biological components of riverine, lacustrine, and estuarine/near-shore environments. Spence et al. (1996) suggested four general principles for consideration when determining habitat requirements for salmonids, and presumably for other aquatic species as well: (1) watersheds and streams differ in their flow, temperature, sedimentation, nutrients, physical structure, and biological components; (2) fish populations adapt and have adapted – biochemically, physiologically, morphologically, and behaviorally – to the natural environmental fluctuations that they experience and to the biota with which they share the stream, lake, or estuary; (3)

specific habitat requirements of salmonids differ among species and life-history types, and these requirements change with season, life stage, and the presence of other biota; and (4) aquatic ecosystems change over evolutionary time.

Consequently, there are no simple definitions of fish habitat requirements, and the goal of conservation should be to maintain habitat elements within the natural range for the particular system (Spence et al. 1996). Fish habitat is the product of many components, including water quality, hydrology / flows, channel structure, sediment supply, access or connectivity throughout the watershed / floodplain, riparian areas, and estuarine / near-shore environments. When properly functioning, these components are closely intertwined to form habitat conditions favorable to healthy populations of fish and other aquatic species. Key processes regulating the condition of aquatic habitats are the delivery and routing of water, sediment, and wood.

This section describes the factors affecting habitat, status, reproduction, and distribution of covered fish and amphibian species. Much of the information cited in the following text is specifically referring to salmonids. This is because there has been more research conducted on salmonids in the Pacific Northwest than on the other species. However, much of the information and many of the limiting factors apply to other fish species, as well as amphibians.

7.5.2 Riparian Features and Conditions

In this section, we discuss the existing and expected characteristics of the riparian forest that form the riparian buffers, the integrity expected from those buffers and the streambanks they are designed to protect, and some of the functions these areas provide in terms of soil protection, sediment filtering, and microclimate stabilization.

7.5.2.1 Riparian Forest Characteristics

Riparian forests occupy the areas adjacent to streams, lakes, and wetlands, and both influence those waters and are influenced by them. Because they are in the ecotone between streams and uplands, are subject to a variety of disturbance factors, and have strong gradients in microclimate, these forests often have distinct vegetation and wildlife communities, and tend to be more diverse than the surrounding upland areas. Riparian forests are often more structurally complex than surrounding upland stands.

Typical species composition of riparian stands in eastern and western Washington is described in Franklin and Dyrness (1973). Upland species are often dominant along small and confined streams. Valley-bottom riparian areas, subject to flooding and other effects, are generally characterized by species that can tolerate moist soils and riparian processes.

Riparian forests often are subject to disturbance regimes that are distinct from the surrounding uplands. Riparian forests are often more prone to flooding or debris flows. Flood frequency in riparian areas is a primary driver of vegetation composition and dynamics. Riparian forests tend to burn less frequently, but are generally more prone to stand-replacing fires when they do burn than their surrounding upland forests. Wind also plays a role in riparian forests, especially within the Sitka spruce (*Picea sitchensis*) / western hemlock (*Tsuga heterophylla*) coastal zones and Pacific silver fir (*Abies amabilis*) zone in higher elevations. These are also areas where moisture has limited the role of fire. Riparian forests tend to be long and narrow and edge effects are commonly associated with them, although the cool and moist microclimate of intact riparian forests can be similar to interior forests.

Baseline

Current riparian conditions on State and private lands are mostly a function of past forest-management practices, but natural phenomenon such as wildfire, windthrow, landslides, and disease have also contributed to conditions in many areas. The majority of riparian forests on State, private, and some Federal lands have been logged at least once. Today it is believed that red alder (*Alnus rubra*) dominates more riparian sites in western Washington than was "typical" under natural disturbance regimes (Washington Forest Practices Board 2001a; McHenry et al. 1998).

In-stream woody debris presence and recruitment potential are related to the extent of decay of in-stream wood and seral stage of current riparian vegetation. The most-durable wood pieces in streams are large sizes of conifer heartwood; conifer sapwood and softwood are less durable. The largest sizes and most-durable wood are from riparian forests upwards of 60 to 200 years old (Abbe and Montgomery 1996). Seral stage provides a general picture of riparian condition and quality, and potential large-wood recruitment. See **Effects of Activities by Resource Topic – Large Wood** section of this Opinion.

A Washington Forest Practices Board study concluded that unnaturally high levels of early seral stage vegetation existed in riparian areas on private forestland, primarily as a result of timber-management activities and, to a lesser extent, from fire, windthrow, and other natural processes in riparian areas (Washington Forest Practices Board 2001a). In general, early seral stages produce riparian vegetation that provides lower riparian values for aquatic and terrestrial biota. In contrast, later seral stages that are typically more diverse in species composition and stand structure can more fully provide for riparian functions. However, early seral (tree size less than 12 inches in diameter at breast height) hardwood riparian forests provide large amounts of high-quality detrital inputs from nitrogen-rich leaves. Data regarding seral stages of riparian areas indicate that within the lands subject to Washington Forest Practices Rules up to 2001, approximately 78 percent of western Washington stream miles and 61 percent of eastern Washington stream miles flow through riparian areas in early seral stages, while about 1 percent of western Washington miles and 5 percent of eastern Washington miles are late seral. Though natural variability is expected in riparian areas, the level of alteration due to past logging and road building is apparent.

Lunetta et al. (1997) used digital-elevation modeling of stream channels to determine channel gradient, and then characterized riparian seral stage by gradient category. The analysis looked at forest vegetation in 179 watersheds across western Washington. Stream channels were classified into three categories based on channel slope: response reach, transport reach, and source reach. The response-reach, seral-stage data are the only raw data still available from this study and are, thus, the only data reported here. Response reaches were defined as channel reaches with less than 4 percent slope, and were considered the area where most anadromous fish production occurs. The most-common seral stage was early seral, ranging from 52 percent in the West Puget Sound Region to 72 percent in the Lower Columbia Region. Late seral made up the lowest percentage, ranging from 5 percent in the Southwest and South Puget Sound Regions to 19 percent in the North Puget Sound Region. Riparian condition and function (e.g., floodplain condition, bank stability, large wood, shade, stream temperature, and water quality) vary from good to poor within each region, depending on site scale and location.

Beak (1998) conducted an assessment of 1,426 miles of streams in 28 Watershed Administrative Units (WAUs). They reported that nearly 55 percent of forest lands along fish-bearing waters have good to fair recruitment potential for riparian large wood. They also noted that the near-term potential for large-wood recruitment in eastern Washington is greater than the recruitment potential along western Washington streams. The shade assessment covered 1,637 miles of streams in 29 WAUs. They reported that 57

percent complied with the temperature/ elevation screen and should meet water-quality standards. They also noted that 17 percent were assessed as being streams naturally low in shade regardless of potential canopy condition, such as large, wide Type 1 waters of the State.

Many riparian stands in eastern Washington are currently stocked with an abnormally high density of trees and the species composition is dominated by shade-tolerant species. Historically, forest stands consisted of the more fire-resistant species such as ponderosa pine (*Pinus ponderosa*), Douglas-fir (*Psuedotsuga menzesii*), and western larch (*Larix occidentalis*)(Agee 1994). Fire suppression over the last 100 years has greatly altered forest conditions. Since the early 1900s, fire suppression has resulted in an increase in the number of trees and fuel on the forest floor. It has also resulted in a shift to less-fire-resistant tree species (Kauffman 1990), for instance, grand fir (*Abies grandis*). These conditions can put stands at additional risk from stress, insects, disease, and eventually more-intense and destructive fires. Many forested riparian areas in eastern Washington have also been subject to grazing, which also has reduced streamside vegetation.

Many riparian forests within the FPHCP Action Area are either early- or mid-seral. In some cases, riparian forests have been subject to repeated timber harvest and resemble the surrounding uplands in terms of stand age and simplification. In other cases, riparian areas were not harvested as intensively due to logistical considerations and contain residual trees and stands offering significant ecological value to the surrounding landscapes.

A review of the baseline for each Water Resource Inventory Area (WRIA) (See USFWS and NMFS 2006 Appendix A) shows that many Washington rivers have altered riparian forests due to previous timber harvest and other land uses. Specific information on these past and ongoing effects is provided in the **Comprehensive Environmental Baseline** section and **Comprehensive Cumulative Effects** section of this Opinion.

Importance of Riparian Forest Characteristics

In addition to being highly diverse, riparian forests perform important functions in controlling stream-channel form, microclimate, biodiversity, and water and nutrient cycling. Large wood originating in riparian forests influences routing of water and sediment in stream channels and modifies the channel form. Riparian areas are especially important as the source of large wood input to streams, a phenomenon that directly influences several habitat attributes important to fish such as pool formation and maintenance, food sources (such as capture and retention of adult salmon carcasses), and sediment storage (FEMAT 1993; Spence et al. 1996). Riparian areas along larger rivers also serve as storage areas for large woody debris until transported by fluvial processes.

Riparian vegetation enhances bank stability, captures suspended particles from receding floods, and buffers the movement of nutrients. Forest canopies provide shade above stream channels and contribute organic matter to aquatic systems. Riparian vegetation produces insects that fall into the stream and supplement the diet of fish (Murphy and Meehan 1991).

Hardwoods play a variety of ecological roles in riparian forests. Red alder is a nitrogen-fixing species. Alders within a stand can contribute to the soil-nitrogen pool and may in some cases improve general tree growth. Alder are also resistant to certain tree diseases. Big-leaf maple (*Acer macrophylum*) and other hardwoods have been implicated in improved nutrient cycling in conifer forests. The easily decomposed litter of these species mixes with and hastens the decomposition of conifer litter, thus increasing the rate of nutrient cycling. Hardwood stands often support a different understory community compared to

conifer stands. The Core Zones of RMZs in western Washington are variable, but tend to have species composition with about 10 percent greater hardwood component than adjacent Inner Zones. Fox (2003) noted that species diversity in the first 5 meters was attributable to hardwoods. He also noted that most of the species richness in riparian areas came from the first 35 meters and dropped abruptly in the next two 15-meter intervals.

Large trees by virtue of their size, age, and resistance to fire, floods, and decomposition play a central role in shaping the physical and chemical conditions within aquatic areas and, thereby, strongly affect the aquatic community. Tall trees cast long shadows and can shade even wide streams. Large trees that enter streams due to blowdown, bank undercutting, or mass-wasting can remain for decades or even centuries, functioning as stream features that rival bedrock sills or outcrops in regulating channel processes. Large wood creates habitat for a wide range of terrestrial species and is important in cycling nutrients (Harmon et al. 1986). Riparian areas of large rivers function not only as sources of most very large wood, but also as storage locations for organic material and substrate until redistributed during future flood events.

The direct influence of the riparian areas on streams and rivers declines with increasing distance from the channel, and is strongly related to dominant tree species and height, stream size, and drainage-basin morphology. A natural riparian zone includes a composite of tree stands of different age, size, and species (Spence et al. 1996; National Research Council 1996).

Effects of FPHCP on Riparian Forest Characteristics

Riparian timber harvest

Timber harvest within Riparian Zone of Influence of Type S or F streams would likely result in loss of some existing snags and cavity-capable trees. Washington State Department of Labor and Industry guidelines may require removal of some snags from within the buffer when operations within the immediate vicinity are necessary (WDLI 1992). These guidelines may also require removal of hazard trees from buffers when operations occur outside the buffer, but within the hazard zone of such trees. Snags and downed wood are one of the most-critical factors influencing the presence and abundance of wildlife species in Washington forests.

Timber harvest within fish-bearing stream buffers would not only result in the loss of some existing snags and cavity-capable trees, but may also retard the recruitment of future snags and downed logs. When buffers would be harvested under the thinning option, removal of suppressed or stressed trees during harvest would result in loss of some potential future snags, as well as some loss of future downed logs. However, thinning would remove smaller trees and would accelerate diameter growth on remaining trees, thus having some positive effect on the quality of future snags. Thinning can promote development of structural characteristics that are found in older forests (Barbour et al. 1997; Hayes et al. 1997). Short-term influences of thinning are negligible or positive for many species. Although the long-term effects of thinning on wildlife are less clear, current information suggests that the influences of thinning would be positive for species associated with older forest stands (Hayes et al. 1997).

In some cases, when stand conditions allow, trees may be removed from the Inner Zone while retaining a specified number of the largest trees. For instance, on the Westside, 57 of the largest trees would be retained following a thinning. The 57 trees would be a minimum number of trees that would be retained whether the pre-harvest stand contained 100 or 400 trees per acre. In a high basal area ponderosa pine stand, 21 of the largest trees per acre would be retained, as well as another 29 trees per acre over 10 inches dbh. However, the Core Zones would remain in tact for a distance of 50 and 30 feet, respectively.

When buffers would be harvested under the "packing" option, riparian forests would remain intact within the buffer but would be narrower than under the thinning option. Such stands would not benefit from the positive effects of thinning. However, in a number of situations, windthrow of a portion of the trees would simulate the effects of thinning. See **Effects of Activities by Resource Topic – Windthrow** section. Harvests outside the Outer Zone, but within the Riparian Zone of Influence, may not retain standing trees to contribute to future snags or downed logs.

Felling of timber and movement of heavy equipment may also result in degradation of existing downed wood. Pre-harvest downed wood may have debris piles accidentally placed upon them, but should not be relocated to debris piles or to landings.

Timber harvest along Type F and Type S streams and resulting reduction in canopy cover should result in some additional sunlight reaching the forest floor and should generally stimulate understory plants. It is expected that there would be minimal effects to understory vegetation in most cases because the amount of removal from the Core and Inner Zones would be minor, location of removal would be primarily from the Outer Zone or at least the outer portion of the Inner Zone, and branches and leaves of remaining trees composing the riparian canopy would generally respond quickly to available light.

Harvest under Alternate Plans may occur in a modified manner according to individual or grouped alternate plans. Landowners may create an alternate plan to harvest timber so long as it is deemed by WDNR to be at least equal in overall effectiveness at addressing the riparian functions as the standard rules. No significant or measurable physical effects to the stream are expected due to the "equal in overall effectiveness" provisions of alternate plans with respect to aquatic and riparian function. However, there may frequently be a reduction in wildlife habitat in both quantity and quality at the local level, so long as the Alternate Plan does not violate the "equal in overall effectiveness" provision. The standard of "equal in overall effectiveness" applies to "aquatic and riparian functions" and does not guarantee the same level of function for wildlife habitat. In other cases, effects may be neutral or beneficial.

For instance, some alternate plans, such as those that address young over-stocked stands, may provide enhanced forest structure. Young, dense stands that are not managed would be subject to suppression mortality, but much of this mortality would occur to trees that are substantially smaller than those trees that would result following thinning treatment. Thinning from below would retain the largest trees and they would grow in diameter faster as a result of thinning. Under the overstocked stand template for nonindustrial forest landowners, some trees could be removed as close as 14 to 30 feet from the stream. This removal would benefit the remaining stand in terms of growth, diameter increase, and increasing windfirmness. In addition, such treatments would provide sunlight for improved understory development. Young, dense stands are a relatively common part of the environmental baseline.

Due to felling of trees, yarding of logs, and movement of equipment, understory vegetation would be damaged including the breakage of taller shrubs and some understory trees. Damage would also occur to some existing hardwoods and conifers in the overstory or mid-story. Harrington et al. (2005) in observing effects of variable-density thinning operations on the Olympic Peninsula noted that some advanced regeneration and understory plants were damaged by equipment. Some understory shrubs were killed and others re-sprouted. Harrington et al. (2005) stated that, overall, logging damage to the residual timber and soils was low. Activities were halted when soils became too wet to continue without risking rutting or compaction. The usual breakage and occasional stem scarring associated with timber falling and extraction were observed, but few trees were affected overall. Removal of bark on the lower bole and

exposure or damage to shallow roots were the most common forms of damage observed. Falling branches from overstory trees also damaged some residual understory and mid-story trees, resulting in top or branch breakage or stem scarring.

Only rarely would trees be felled into Type S or F Core Zones, and then they may only be removed under an HPA. Forest managers typically exercise great care to avoid damage to future crop trees within the mid-story and overstory. Special precautions (e.g., avoidance of bark rubbing and armoring some trees next to yarding corridors) are often used when operating in conifer stands during the spring sap-flow period.

Yarding through corridors may result in some scarring of retained trees. Scarring of retained trees may hasten the development of snags or other defect. Yarding-caused injuries and damage would likely increase the probability for formation of cavities or other structures in the riparian zone. Trees felled in the Core Zone to create yarding corridors would result in a localized pulse of downed wood for the stream and riparian area as such trees would be retained on the forest floor. Snags and "hazard trees" may be required to be felled when they could reach cable lines, but should be retained on site. Yarding may damage taller shrubs and understory trees. Yarding corridors may increase diversity of riparian forest by introducing areas of defect, directly or indirectly creating snags, or creating small openings. Trees required to be left on site in corridor creation would be left as downed logs.

Effects from tailholds and tailhold cable corridors are expected to be negligible. When the cables are tightened they may rub some trees and remove some branches. This damage may resemble a lightning scar. In extreme cases, a tree or several trees may need to be felled. Such trees would generally remain within the riparian zone as downed wood, because they are required to be retained within the Core Zone and must be retained if they were needed to meet DFC within the Inner Zone. The effects from this activity would generally be indistinguishable from an individual downed tree, pocket of windthrow, or root-rot pocket, with the exception of the presence of a cut stump. Usually straps are used to attach tailhold lines to trees. Sometimes, tailhold trees would be notched, but minimal lasting damage is expected.

Canopy reduction or removal as a result of hardwood conversion would increase the amount of sun reaching the ground in the riparian zone during the growing season and would stimulate understory vegetation. Eventually, removal of hardwoods and replacement with conifers would restore the riparian forest to its historical species composition and functioning. However, in the interim, removal of alder boles would mean a decline in structure, cavities, downed logs, and nutrient inputs. Declines in structure, cavities, downed logs may last for several decades. Hardwood conversion would also reduce the number of cavities within alders and number of alder snags, as well as a general reduction in forest structure in some cases. Loss of existing snags would occur due to implementation of safety standards, logistical needs, and accidental felling and bucking activities, and there would be a loss of cavity-capable hardwood trees. Hardwood conversion may on occasion remove more than just dominant alder, therefore removing species important for mast and bio-diversity, such as bitter cherry, beaked hazelnut, cascara, etc. However, hardwood conversions would eventually re-establish a natural conifer stand capable of providing durable large wood and other functions.

Long-term benefits are expected from hardwood conversion, but shorter-term effects are also expected. Replacement of alder by conifer as a component of the riparian forest may take several decades. Short-term effects are expected to be minimized by the Core Zone; but, long-term benefits may also be reduced by retention of the Core Zone. Core Zones that are presently under-stocked, hardwood-dominated stands

as the result of operations under previous regulatory regimes might not attain shade levels typical of an old-growth conifer forest (Washington Forest Practices Board 2001a). Past logging practices caused these conditions and effects, and they are common in the environmental baseline in the action area. A large portion of forest land in the action area is under-stocked, or in early- to mid-seral stages as the result of historical fires (Bisson et al.1997**)**. The legacy effects of past logging practices are measurable, as are the effects of other historical processes. Hardwood conversions may assist in the restoration of properly functioning riparian zones, relative to how conditions would have developed under natural occurrences. However, hardwood conversions under standard rules may not provide rapid benefits, or may not be deemed effective at achieving desired future condition. Some landowners may not be able to meet other constraints of those standard rules. Alternate plans may be utilized where the standard hardwood-conversion rules are not sufficient or flexible enough to meet restoration objectives.

Hand-slashing competing vegetation in the Riparian Zone and possible use of herbicides (e.g., glyphosate) would reduce the amount and diversity of riparian vegetation for a short time period. Hand slashing would primarily reduce the height of target species such as salmonberry (*Rubus spectabilis*), big-leaf maple, for a very short time period (e.g., less than 2 to 3 years). Vegetative control would enhance conifer survival and accelerate development of conifer-dominated stand. As a result of site-preparation, planting, and subsequent husbandry, conifers would be established more quickly, and the conifers would eventually shade out much of the understory in an accelerated time-frame.

Timber-stand improvement within the Riparian Zone may improve the health and vigor of remaining trees and therefore the stand as a whole. However, it may reduce the bio-diversity through simplification of the species composition and therefore also affect stand structure. Nonetheless, the effects of timber-stand improvement are considered as a consequence of riparian timber harvest and need not be separately addressed.

Timber harvest along fish-bearing streams under 20-acre exemptions would result in a local reduction in riparian function. Riparian areas would be narrower and would not provide the same amount of habitat to forest wildlife species. Recruitment of downed logs to the Riparian Zone would be substantially less than under standard rules. Mature stages of forested riparian habitat retained along Type Np streams under 20-acre exemptions would be minimal. With respect to streams without fish, those riparian areas managed under standard rules would provide some narrow forested corridors (e.g., along half or more Type Np streams where 50-foot or wider buffers would be retained, and Type Ns streams buffered for slope stability). These corridors could provide refugia and would function at a higher level when surrounding stand reaches height and condition to help provide interior forest condition as well as provide connectivity between refugia.

Roads

Effects associated with road construction include the creation of a road corridor. When roads are constructed or relocated within or across riparian areas, this activity removes trees which otherwise would have contributed to habitat or riparian downed wood. At time of installation of stream-crossing structures, there may be loss of downed wood and riparian vegetation at the crossing site and at any required access sites. Riparian vegetation would generally regrow within several years outside of road prisms and ditches. Construction and retention of stream-adjacent parallel roads has the potential to impede large wood from recruiting into the riparian area and has the potential to introduce other effects to the riparian forest. Road corridors in riparian stands can influence the rate of windthrow. Roads adjacent to and within riparian areas may reduce the delivery of downed wood directly by removing trees which

would have eventually fallen. They may also alter the delivery of downed wood by increasing windthrow potential, replacing long-term delivery with a short-term pulse. Maintenance, repair, and road upgrading may also have minor effects to adjacent riparian stands by increasing sediment or removing trees adjacent to roads. The presence of roads may result in requirement to remove hazard trees, thereby reducing the number of snags. Cutting of hazard trees along roads will not necessarily result in additional downed logs as roadside areas are convenient places to cut firewood.

Unused roads often are naturally revegetated by red alder and scattered conifer. Abandonment may remove some young vegetation (most likely less than 10 to 20 year old alder with understory conifer less than 6 to 10 feet tall) resulting in a short-term setback to secondary succession, but would usually result in long-term benefits as the area returns to a natural forest.

Research

Effects associated with habitat manipulations for research purposes are expected to occur along a very small percentage of riparian areas, be localized, and have negligible effects at a watershed scale. Habitat manipulations may locally reduce the amount of canopy for a short time period and may reduce downed wood and potential future downed wood. For instance, where thinning was employed, canopy cover would usually be expected to recover to near pre-treatment levels in less than a decade. Stand-level recovery of suppression-mortality rates would follow.

Summary of FPHCP Effects to Riparian Forest Characteristics

Riparian forests along Type F and Type S streams managed according to the standard Washington Forest Practices Rules or alternate plans would generally continue to improve in condition, although short-term effects may be realized on a site-specific basis. Where thinning occurs, it typically would be beneficial in the long term (decades) to the development of late-seral characteristics with only minor short-term (generally less than 2 to 5 years) effects in most cases. Where harvest occurs under the “packing” option, riparian forest would be left intact and composed of a more-narrow arrangement of trees. Lack of thinning within the 80 to 100 foot RMZ under the packing option may forestall the improvements expected in RMZs. Riparian forests along perennial streams without fish often could be fragmented by intervening harvests and, as such, would not provide as much riparian forest connectivity until the intervening areas regrow. Some intervening functions would recover in 2 to 5 years (such as shade and cover) while other functions may take decades (wood recruitment). Hardwood conversion would return riparian forests to their natural condition; however, no conversion would occur within 50 feet of the stream under standard hardwood-conversion rules. Alternate plans may frequently address hardwood conversion on a site-specific basis and would ensure “equal in overall effectiveness” protection of riparian and aquatic function. Riparian forest in CMZs would be maintained, except on 20-acre exempt parcels.

Roads would interrupt connectivity of riparian forests and may create a source of additional effects, such as windthrow, but FPHCP would minimize roads within RMZs and would remove some existing roads. Harvest conducted under the 20-acre exempt parcel rule would result in a reduction in riparian forests and function along both streams with fish and streams without fish.

7.5.2.2 Windthrow

Windthrow is an important consideration in evaluating buffer integrity. Strong winds can uproot trees, disturbing the soil, reducing the stabilizing influence of tree roots on steep slopes and substantially increasing the potential for mass soil movements. Windthrow (as well as stem breakage) can be chronic

(endemic), episodic, or catastrophic. Catastrophic windthrow occurs infrequently and affects both stable and unstable areas. Chronic windthrow is mostly found in less-stable stands (Miller 1985). Windthrow frequently occurs along streams because winds tend to follow the natural pathways provided by the drainage system, but is also common elsewhere where trees are exposed to winds and/or high water tables. Windthrow is also influenced by harvest patterns.

Windthrow is a significant disturbance process in many parts of Washington, especially in coastal areas, Southwest Washington, and in certain elevated areas. Windthrow can include trees that are blown down as well as boles that are broken in the wind. Most windthrow occurs during the winter months when soils are saturated and winter storms bring sustained and high-velocity winds. Generally, windthrow has an increased probability of occurrence and severity in areas dominated by shallow-rooted species such as western hemlock, Sitka spruce, or Pacific silver fir; in areas with and at times of high water tables; and on slopes or topographic features exposed to prevailing or storm winds.

Some soils are more susceptible than others, for instance, some soils lack sufficient rock to provide strength while others are too rocky to allow good root penetration or too close to bedrock. Depth of organic layer is positively correlated with vulnerability. Increasing damage with site quality was observed by Fleming and Crossfield (1983) in boreal forests and Harris (1989) in southern Alaska.

Increased damage with higher stocking is a function of slenderness and lower stability of individual trees (Becquey and Riou-Nivert 1987; Mitchell 2000). Stem taper may be an important factor affecting susceptibility to stem breakage. The height-to-diameter ratio of dominant trees in even-aged stands has been found to be a good indicator of risk of stem breakage (Stathers et al. 1994).

Root and bole rots have been found to be associated with high frequencies of both windthrow and stembreak, because of their effects on root anchorage and bole strength. Surveys of windthrow in high elevation Engelmann spruce (*Picea engelmannii*) – subalpine fir (*Abies lasiocarpa*) forests have found root or bole rots associated with about one-third of the wind damage. Other studies have shown that 20 to 50 percent of wind-damaged trees have evidence of infection by various types of rot (Stathers et al. 1994).

Relevant Issues

Windthrow can also be influenced by management. Harvest within the RMZ can affect the wind-firmness of remaining trees. Generally, clearcutting adjacent to riparian sites increases the windthrow risk. Rollerson and McGourlick (2001) noted that windthrow in riparian reserves on northern Vancouver island was chronic and varied from individual trees to occasional areas where all trees are windthrown.

Selection of windfirm leave trees, pre-harvest thinnings designed to increase windfirmness of remaining stands, and pruning and topping are a few techniques that may reduce windthrow risk. In addition to increasing diameter growth, thinning has also been shown to influence wind firmness in residual trees. The ability of a tree to resist being blown down during high winds is related to root architecture, soil characteristics, and the ratio of height to diameter (Ruth and Harris 1979). Even if a tree has a well-developed root system and is growing in well-drained soils, the bole of the tree may snap under high winds if the tree is tall relative to its diameter.

Thinning from above removes dominant overstory trees, leaves trees which are about as tall but much more narrow, and can significantly increase wind damage of residual trees. Rollerson and McGourlick (2001) noted that strips with only smaller merchantable trees retained experienced substantially higher windthrow and that windthrow penetrated further in these stands. Trees with slender boles are less stiff

and thus are more likely to move widely in wind. In taller stands, wide movement of trees in a windstorm can result in violent collisions with neighboring trees; this results in crown abrasion and narrow crowns with unoccupied space between crowns (Lieffers and Silins 2005).

On the other hand, thinning from below does tend to retain the most-windfirm trees within a stand and generally decreases the risk of wind damage as the stand develops (Ruth and Harris 1979). Thinning opens up growing space within the stand and increases photosynthate production in residual trees. This additional production is allocated to fine-root growth and diameter growth (Oliver and Larson 1996). While wind firmness may be lower immediately following thinning, the increased growth of roots and diameter eventually increases windfirmness as the stand develops. Jull (2001) found that trees with height-to-diameter ratios of less than 50 (i.e., a tree one foot in diameter would be less than 50 feet tall) had a loss rate of 3.9 percent, while trees with height-to-diameter ratios of over 90 had loss rates over 20 percent.

Brown (1971) cautioned that buffer strips were susceptible to wind damage, and other specific characteristics of the buffer must be used in determining proper widths. Narrow riparian buffer strips exposed to storm winds are highly susceptible to windthrow for 5 to 10 years after their formation (Steinblums et al. 1984). In a study pertaining to windthrow in forested buffers strips on Type 4 streams (roughly equivalent to current Type Np streams) in northeast Washington, it was noted that trees within small stream buffers (adjacent to clearcut harvest units) are subject to increased wind exposure (Grizzel and Wolff 1998). Because of this increased wind exposure, windthrow is often the primary mechanism of wood delivery in managed forests (Grizzel et al. 2000). If too much of the riparian vegetation blows down at once over a long distance, some of the target buffer functions can be impaired (Grizzel and Wolff 1998). The short-term benefits to the stream can be followed by a long-term shortage of instream wood once the current debris washes away or decays.

Grizzel and Wolff (1998) studied buffer strips on small streams without fish in northwestern Washington and reported there was a prevalence of RMZs along the studied streams even though the regulations in effect at the time did not require them. About 33 percent of buffer trees were affected by windthrow. However, only 3 of 40 sites had more than two-thirds of the trees windthrown. The level of windthrow varies among trees species. Western hemlock, Sitka spruce, and Pacific silver fir tend to be more vulnerable. Pacific silver fir and western hemlock experienced the highest levels of windthrow reported by Grizzel and Wolff (1998). Grizzel and Wolff (1998) reported windthrow occurrence by species: Pacific silver fir 37.3, western hemlock 36.0, western red cedar (*Thuja plicata*) 21.8, Douglas-fir 20.2, red alder 17.2, and big-leaf maple 7.5 percent.

To reduce windthrow when operating in dense hemlock stands in situations that may be vulnerable to windthrow, foresters often use a “rule-of-thumb” to remove no more than one-third of the basal area at one time. Lancaster (1985) recommended that no more than one-third of the total basal area should be removed at one time when thinning heavily stocked stands of eastern hemlock (*Tsuga canadensis*). Excessive cutting results in reduced growth and increased mortality, and contributes to windthrow. Stathers et al. (1994) recommended removal of no more than 15 to 20 percent of basal area during initial harvest when operating on high-hazard sites in British Columbia, and they further stated that amount of canopy removal should reflect the windfirmness of the original stand. They further recommended retaining opportunity for branch-to-branch contact between trees so that sway is dampened in stands of high initial density.

Measured windthrow rates are a factor of the geography and geology in which the research is conducted, prevalent species of trees and soils, as well as timing relative to strong storms. Windthrow rates in Washington and Oregon are variable and have been reported to average 5 percent (Mobbs and Jones 1995; Hobbs and Hallbach 1981 *as cited in* Grizzel and Wolf 1998), 10 percent (TFW 1994), 12 percent (Sherwood 1993), 22 percent (Andrus and Froehlich 1988), and 29 percent (Steinblums 1978). In a study by Rollerson and McGourlick (2001), riparian windthrow averaged about 21 percent of the standing timber along stream edges. They note there were a large number of plots with only a minor amount of windthrow and conversely only a limited number of areas with substantial amounts of windthrow. The average distance of penetration into standing timber was about 12 m (40 feet). They also noted that buffers exposed on both sides were more vulnerable and that "feathered edges" had lower amounts of windthrow.

Harrington et al. (2005) in a study of variable-density thinning on the Olympic Peninsula noted that wind-related damage differed substantially from plot-to-plot. In terms of total number of wind-damaged stems, only 1 of the 14 thinned plots had moderate to heavy damage (>50 trees damaged per hectare), 2 of the thinned plots had minor to moderate damage (20 to 25 trees per hectare), and damage at the other 11 thinned plots and the 4 control plots was very minor (fewer than 5 trees per hectare). Only two plots had more than 10 trees per hectare greater than 20 cm in diameter damaged by wind following thinning. Height-to-diameter ratios appeared to play a role in predisposing stands to wind damage. Most of wind-damaged trees were western hemlock.

Harrington et al. (2005) also noted that even the 3 stands that lost more than 10 trees per hectare, retain adequate stocking to meet the original management objectives. Greater loading of coarse woody debris and increased spatial variability of tree distribution resulting from windthrow are both characteristics consistent with the objectives.

Effects of FPHCP on Windthrow

Riparian timber harvest

Timber harvest within the Riparian Zone of Influence and adjacent to, or within, regulatory buffers has the potential to increase windthrow. Pollock and Kennard (1998) state that buffers less than 75 feet are more susceptible to windthrow. Type F and S buffers would not be as likely to be subject to intensive windthrow. Type Np streams with discontinuous buffers of 50 feet are anticipated to experience a greater proportion of windthrow than buffers of fish-bearing streams.

Windthrow has a higher possibility of occurring with harvest along fish-bearing streams under 20-acre exemptions, as well as 20-acre exemptions on streams without fish. Because fewer trees would be retained and buffers would be narrower, there is an increased probability of windthrow occurrence and an increased possibility of deleterious effects, depending on geography and other factors. Also, the minimum requirements for size and type of leave trees may not result in retention of the most-windfirm trees.

Due to the "equal in overall effectiveness" constraints of Alternate Plans, it is expected that the effects to the aquatic and riparian environment would be essentially the same or less than what would occur under the standard rules. No significant or measurable physical effects from windthrow (in comparison to standard rules) are expected due to the "equal in overall effectiveness" provisions of alternate plans with respect to aquatic and riparian function. Due to the age of trees and type of thinning to occur under the over-stocked template, we do not anticipate a short-term increased risk of windthrow. In the long term,

thinning can increase tree stability in stands which are not differentiating well, so long as the thinning occurs before the trees become too unstable. As a result of harvest conducted under the overstocked stand template, windfirmness should be improved in the long term and would strengthen trees within 14 to 30 feet of the bank, as well as retained trees along the streambank.

Reduction in alder canopy from hardwood conversion would only result in minor increases in windthrow vulnerability of the Core Zone as alder decrease in ability to deflect wind in the winter. Core Zones in areas subjected to hardwood conversion are also likely to be composed of hardwoods which are generally more resistant to windthrow.

In most cases, it is expected that the integrity of fish-bearing buffers would be maintained because the width of these buffers and the density and type of retained trees would generally pose little risk of windthrow. Additionally, the greater retention of trees in proximity to streams would reduce the possibility of windthrow penetrating the buffer and compromising the integrity of trees contributing root strength to stream banks. However, in less-frequent cases, riparian areas would experience substantial windthrow that would reduce the density of trees, increase downed wood, and alter understory vegetation. Such cases of more-intense windthrow often increase the spatial diversity of riparian areas.

Roads

Effects associated with road construction, re-alignment, or reconstruction include the creation or re-establishment of a road corridor. Existing stream-adjacent parallel roads are also associated with road corridors in riparian areas. Relocation and re-alignment may increase openings beyond the standard right-of-way widths. Removing trees from within the Riparian Zone can increase windthrow concerns for remaining trees, but the contribution of a road corridor to catastrophic windthrow that would compromise the riparian buffers would be very infrequent and localized.

Research

Effects associated with habitat manipulations for research purposes are expected to occur along a very small percentage of riparian areas, be localized, and have negligible effects at a watershed scale. Habitat manipulations may locally reduce the density of stands for a short time period but are not expected to substantially affect windthrow risk beyond the effect of standard rules.

Summary of FPHCP Effects to Windthrow

Windthrow is one of the processes by which large wood is recruited to the stream and riparian floor. Downed wood contributes to shade of stream and a variety of riparian and instream functions, such as sediment storage. Windthrow is one of the natural habitat-forming processes. Loss of some scattered trees within a buffer to windthrow, as well as loss of small segments of buffers (pockets), to windthrow does not compromise the integrity of the buffering system. Remaining trees would generally respond by retaining a higher live-crown ratio, more-expansive root systems, increased epicormic branching in some cases, and increased diameter growth and vigor, thus accelerating development of late-seral characteristics. Yet, in a few cases, trees that don’t blow down during an episodic event, would have their root systems compromised by uprooting of adjacent trees and would also fall or blow down within a few years. This would be most common where trees have not differentiated much and are composed of shallow-rooted species. Lack of differentiation implies that individual trees are actively competing with each other, resulting in taller, narrow boles, shallow and narrow live crowns, and correspondingly narrow root systems. Stands composed primarily of shallow-rooted species are common in Coastal regions –

such as western hemlock and Sitka spruce, as well as within the Pacific silver fir or true-fir zone in the Cascades and Olympic Mountains. In most cases, it is expected that the integrity of the stream buffers under FPHCP would be maintained, even if some windthrow occurs; because, the majority of stands experience little if any windthrow, severe windthrow is quite infrequent, and downed wood in riparian zones serves multiple functions including sediment storage and shade.

7.5.2.3 Other Damage

Felling in riparian areas adjacent to buffers on perennial streams should result in minimal damage to the buffers due to the use of directional felling. Limbing and bucking of the timber and movement of heavy equipment may also result in damage to smaller existing conifers and hardwood trees in the overstory or mid-story; however, it is anticipated that integrity of dominant and co-dominant conifers (potential future crop trees) would be protected. However, a certain amount of damage is expected to occur to leave trees. These trees would then be susceptible to insects and pathogens that may further introduce risks to the tree, but may also increase defect and abnormal characteristics which are valued as wildlife habitat (e.g., broken and regrown tops, hollow boles). A discussion of some damage expected within buffers from thinning was discussed with respect to felling, bucking, and yarding under the **Effects of Activities by Resource Topic -- Riparian Forest Characteristics** section of this Opinion.

Forest health of riparian buffers is a major concern, especially in portions of eastern Washington. Many riparian stands in eastern Washington are currently stocked with abnormally high densities of trees and the species composition is dominated by shade-tolerant species. These conditions can put the stand at additional risk from moisture stress, insects, disease, and eventually more-intense and destructive fires. In some situations, buffer integrity may benefit from silvicultural treatment to control species composition and stocking density, as well as addressing ladder fuels. However, dynamics of snags, downed wood, and large-wood recruitment to streams, may, in some areas, be more dependent on episodic and catastrophic events, rather than on chronic processes. Insects, disease, and fire are integral parts of a natural process of riparian development and large-wood recruitment. The standard Washington Forest Practices Rules for riparian areas attempt to address these considerations; and, through the “equal in overall effectiveness” provisions of the alternate plans, development of future alternate plans is expected to adequately address these considerations as well.

7.5.2.4 Bank and Channel Integrity

Erosion and weathering of the landscape naturally contribute to sedimentation in streams; however, unstable banks may produce an excessive, chronic source of fines. Bank stability varies with channel and forest types (Newton 1993). Roots of vegetation help to develop soil structure, stabilize streambanks by binding soil in place, and provide resistance to erosive forces of flowing waters (Beschta 1991), especially the root masses of live trees, shrubs, and herbs nearest the channel (Swanson et al. 1982a). Soil is strong in compression, but weak in tension. Plant roots are weak in compression, but strong in tension. When combined, the soil-root matrix produces a type of reinforced earth which is much stronger than the soil or roots separately. Roots are effective in both adding tensile strength to the soil and, through their elasticity, distributing stresses through the soil, thereby avoiding local stress development and progressive failures (Thorne 1990; Simon and Collison 2002).

Mass failure of non-cohesive banks occurs by shearing along shallow, planar or slightly curved surfaces. The motivating force is shear stress on the potential failure plane due to the downslope component of weight (Thorne 1990). Most mass failures of cohesive banks occur following rather than during high

flows in the channel. This is because the switch from submerged to saturated conditions that accompanies drawdown in the channel approximately doubles the bulk weight of the bank material, while simultaneously reducing the soil strength by means of increased pre-water pressure (Thorne 1990).

The amount of bank stability provided by roots is influenced by fine root abundance and density (Thorne and Tovey 1981). Factors that appear to influence root strength are soil productivity, hydroperiod, species composition, and frequency and intensity of disturbances. Roots of all plant species increase soil strength to varying degrees (Castelle and Johnson 1995). Diverse assemblages of woody and herbaceous plants may be more effective in maintaining bank stability than single species assemblages (Spence et al. 1996). This implies that mature forest with diverse understory, developed naturally or though thinning, may provide better, more-effective, root strength than stem-exclusion stage forest. In general, the deeper the penetration of roots, the more effective they are in enhancing soil strength. Thus, trees tend to enhance bank stability greater than woody shrubs, which are in turn better than grasses and forbs. Woody roots, once exposed, are also more effective at armoring the soil against hydraulic forces, and contribute to overall reduction in near-bank shear stress. Roots also stabilize banks by means of their hydrologic effect, increasing the cohesion of the soil particles by their effect on water content (Simon et al., 2000), although this effect is only significant during the conditions when transpiration is active.

Root-stabilized banks may facilitate bank building during high flow events by slowing stream velocities, which in turn helps to filter sediment and debris from suspension (Swanston 1991; Spence et al. 1996). This combing action allows existing channels to narrow and deepen (Elmore 1992). Vegetated stream banks can reduce stormflow damage by increasing channel roughness and reducing velocity of flows (Spence et al. 1996). Root systems allow undercut banks to provide fish shelter (Beschta 1991; Murphy and Meehan 1991), and contribute to the dynamic stream-channel morphology and the diversity of fish habitats (Swanston 1991). In larger, lower-gradient streams, undercut banks in forest and meadow riparian areas can provide high-quality resident habitat as well as cover for migrating fish. The margins or banks of streams, estuaries, marine waters, and river channels provide important habitats for both aquatic and riparian-dependent species.

High-velocity flows can undercut vegetated banks, dropping trees into the water, which can redirect flow against the banks and cause further erosion. Soil exposed at root wads of fallen trees may be transported to the stream channel, increasing sedimentation (Spence et al. 1996). Streambank erosion is a natural process that delivers sediment to streams, affecting many stream-channel features. Accelerated bank erosion contributes a great deal of fine material to downstream reaches (CH2MHill 2000).

Root strength is only one of numerous factors contributing to streambank stability (Castelle and Johnson 1995). Factors other than root strength, such as sediment load and large wood, generally have a greater effect on stream-morphology characteristics (Kleinfelder et al. 1992).

Buffer distance to maintain the effectiveness of root strength for bank stability probably does not extend beyond 30 to 50 feet (Newton 1993; Newton et al. 1996), or one-half a tree crown diameter (Wu 1986 as cited in CH2MHill 2000). However, these buffer distances may not allow for natural channel migration and bank erosion processes in the long term. In wide valleys where stream channels are braided, meandering, or highly mobile, the zone of influence of root structure is substantially greater, especially over long time periods (Spence et al. 1996). Data quantifying the effective zone of influence relative to root strength is scarce (Spence et al. 1996).

Effects of FPHCP on Bank and Channel Integrity

Riparian Timber Harvest

In assessing bank and channel integrity, we consider that activities that cut streambank trees or result in areas of exposed streambank soil can adversely affect these habitats by altering the character of stream banks and perhaps diminishing large-wood recruitment. However, forest practices prescriptions in the FPHCP require that activities in the RMZ Core Zone for Type S and Type F waters and in RMZs for Type Np waters must ensure streambank integrity is maintained. Retention of trees closest to the streambank would help protect streambanks and channels. Where necessary, high stumps near the streambank must be left to prevent felled and bucked timber from entering the water. Trees with large root systems embedded in the streambank must also be left. In addition to these requirements, activities that affect streambank integrity such as road construction or log yarding would require an HPA permit from WDFW. Activities that require an HPA are subject to additional conditions under the State's Hydraulic Code (WAC 220-110-030(17)). Streambank-protection measures require operators to avoid disturbing stumps, root systems, and logs embedded in the stream bank, as well as brush and other understory vegetation rooted in the stream bank. Light et al. (1999) concluded that if enough trees or other vegetation are maintained after harvest to sustain an interlocking root network, then bank integrity should be protected, but also that the strip of vegetation retained should be wide enough to anticipate channel movement.

Root strength and bank stability would generally be maintained during riparian timber harvest through conservative treatment within buffers along fish-bearing streams and ELZs on other streams. However, some reduction in stream-bank integrity may be expected along unbuffered segments of streams without fish, especially between 5 to 20 years following harvest when roots of harvested trees have decayed and new plantations are still developing their root systems. In most cases, it is expected that greater tree retention in proximity to fish-bearing streams and buffered Type Np streams would ensure that root strength is retained at functional levels.

Due to the "equal in overall effectiveness" constraints of Alternate Plans, it is expected that the effects to the aquatic and riparian environment would be essentially the same or less than what would occur under the standard rules. No significant or measurable physical effects to the streambank integrity are expected due to the "equal in overall effectiveness" provisions of alternate plans with respect to aquatic and riparian function. Under the over-stocked stand template, maintenance of 14 to 30 feet of untreated stand (based upon crown diameter) should maintain one rooting diameter and help protect root strength and streambank integrity. Hardwood conversions under standard rules would retain 30 to 50 feet untreated in the Core Zone.

Operation under the 20-acre exemption along fish-bearing streams should generally maintain root strength and bank integrity, so long as the stream-adjacent trees are retained in consideration of the shade rule. However, there is no requirement for distribution of the leave trees in the 20-acre exemption except for the shade rule measured from the bankfull width. Where few trees are retained along banks and additional equipment traffic occurs, root strength and bank integrity may be compromised. Where CMZs exist, streambank protection may not be provided for migrating channels.

Buffers would be required for Type Np streams on 20-acre exempt parcels where covered species may be affected; however, due to the small number of required trees and ability to clump these trees, these buffers would provide less function. In cases where covered species would not be affected, these streams may

not receive any buffer. Streambank stability would likely decrease for a number of years, and may not return to previous levels for several decades.

Equipment limitation zones may not fully protect bank integrity on unbuffered Type Np streams. However, ELZs requiring on-site mitigation for any damage exceeding 10 percent of the area would also apply to 20-acre exempt parcels, as would requirements for HPAs. As a result of the increased harvest along the Type Np streams, it is more likely that effects such as soil compaction, rutting, and scraping could occur. There are also additional effects expected to understory vegetation. Mitigation would be applied when more than 10 percent of the area is disturbed, however, not all aspects of this level of activity would be mitigated by actions such as mulching and seeding. Greater traffic within near-stream areas are expected to contribute to potential bank collapse in some cases, which may result in introduction of fine and coarse sediment.

It should be noted that while 20-acre exempt parcel distribution has not been conclusively determined, we presume that these parcels are far-more common in low-elevation areas near rapidly expanding development centers. In these landscapes, fish would likely be present in a greater proportion of streams partly due to the low gradient of streams. This means that Type Np streams likely comprise a smaller proportion of the total stream network in these landscapes; and, therefore, a smaller portion of the stream network would be exposed to effects associated with 20-acre exempt treatments for Type Np streams. There is a high proportion of such streams which are low-gradient, low-energy streams where delivered sediment may not be efficiently transported. Such streams may also occur in proximity to streams with land uses other than forestry, may be degraded, and may be poorly equipped to receive additional sediment. These are also areas where soil compaction may be a particular concern, due to lack of frost heaves and soil vulnerability.

Roads

Existing stream-adjacent parallel roads may be sufficiently close to streams to compromise bank stability in rare occasions. These roads should be high priority candidates for abandonment if feasible. Stream crossings when improperly installed or maintained may contribute to local scour and destabilization of streambanks.

Research

Effects associated with habitat manipulations for research purposes are expected to occur along a very small percentage of riparian areas, be localized, and have negligible effects at a watershed scale. Habitat manipulations that would affect vegetation within a rooting diameter of steams with fish would likely be rare. Some effects may be realized on perennial streams without fish, but effects similar to those experienced under the standard rules are expected.

Summary of FPHCP Effects to Bank and Channel Integrity

Because of the retention along banks, limited yarding along most fish-bearing streams, and the preclusion of equipment from the stream channel, few direct effects are expected to the channel integrity of most fish-bearing streams. Some effects may occur along unbuffered Type Np and Ns streams, but damage within ELZs would be subject to on-site mitigation under Washington Forest Practices Rules if the damage exceeds specified limits. Effects along 20-acre exempt parcels may be more intense locally, but would still be subject to ELZs which should help reduce those effects or at least provide remediation when those effects do occur.

7.5.2.5 Soil Compaction

Much of the following discussion is derived from Technical Note 4: Soil Biology and Land Management (NRCS 2004).

Forest soils of the Pacific Northwest have very high infiltration rates due to their high porosity. Porosities ranging from 50 to 75 percent of soil volume and infiltration rates of over 200 inches per hour in the upper soil horizons are common in some soil types (Dryness 1969). Because of these conditions, overland flow and associated surface-erosion processes are not common on forest lands. High organic-matter properties make many Pacific Northwest forest soils generally low in bulk density, high in porosity, but low in strength. As a consequence, these soils are often susceptible to compaction by machines. Site preparation, harvest, yarding, and other activities that utilize heavy equipment can increase soil compaction (Spence et al. 1996). The effects of compaction are especially important because of the potential long-term consequence (on the scale of decades and centuries) of the hydrologic characteristics of soils and site productivity of second growth forests (Everest et al. 1987). In many cases, natural ameliorative processes do not rapidly loosen compacted soil, and where it remains compacted, stand growth losses can be measurable for many years.

Forest soils in Washington State are variable with their respect to vulnerability to compaction and erosion. Ideally, soils are approximately 50 to 60 percent pore space comprising a variety of pore sizes and lengths. Pressure placed upon the surface of the soil (e.g., from wheels of heavy vehicles) can compact the soil. Compaction created under roads, skid trails, and landings compresses soil particles together and reduces pore sizes. Compaction increases in severity and extends deeper into the soil profile with increased pressure and with moister/wetter soil conditions. Approximately 80 percent of soil compaction occurs on the first pass of equipment. The use of designated skid trails and restoration of landings after harvest minimizes the amount of forest land affected.

Soil compaction reduces air spaces; limits gas exchange with atmosphere; slows water movement in soil; increases ponding; slows infiltration; increases surface run-off which leads to increases in surface erosion; increases splash erosion; reduces water-holding capacity; lengthens periods of saturation; causes anaerobic conditions and can cause a shift from aerobic to more anaerobic organisms; increases denitrification (increases losses of nitrogen to the atmosphere); decreases rate of root growth and may limit rooting-depth in highly compacted soils; and reduces vegetative cover which can also lead to increases in erosion. Compaction changes the movement of air and water through soil, and can have direct effects of increasing erosion and direct discharge to streams.

Compaction can reduce infiltration of water (Tackle 1962) impede root penetration (Heilman 1981; Minore et al 1969; Taylor and Gessel 1956); therefore, compaction can effect seedling growth. It has been reported that the major effects appear to occur during the first 10 to 30 years (Power 1974), but that severely affected soils may not recover for 30 to 40 years or longer (Perry 1964; Oiwer 1974; Wert and Thomas 1981). However, Heninger et al. (2004) found that effects of compaction and rutting on seedling Douglas-fir lasted about 7 years in the Oregon Cascades, compared with about 2 years in coastal Washington, and noted that generalizations about negative effects of skid trails on tree growth have limited geographic scope. Heninger et al. (2004) noted that slightly shorter trees on skid trails represent an accumulation of small deficits in annual growth, but that annual growth was increasingly similar once seedlings exceeded breast height (about 4.5 feet).

In eastern Oregon and Washington, sites logged 14 to 23 years earlier on volcanic ash soils were measured to have 19 percent of the logged area had bulk densities which were at least 20 percent higher

than unlogged areas (Geist et al. 1989). In Central Washington, average soil bulk density was 15 percent greater on skid trails than on undisturbed soils on a ponderosa pine site 23 years after logging and 28 percent greater on a lodgepole pine site 14 years after logging (Froehlich et al, 1986). Compacted volcanic and granitic soils were slow to recover on skid trails in western Idaho, and after 23 years, only the bulk density of the granitic soil's top 5 cm had returned to undisturbed values (Froehlich et al. 1985). Page-Dumroese et al. (1998) noted that stump removal to control *Armillaria* root disease increased soil bulk density by 15 to 20 percent to a depth of 30 cm.; and noted that volcanic ash soils are apparently particularly susceptible to vibrational compaction. Douglas-fir seedlings in the soil compaction treatment had lower root volumes, lower height, and smaller root collar diameters than seedlings in other areas. However, western white pine seedling root volumes were not affected and they had smaller root collar diameters but greater height in the compaction treatment.

Although trees planted on skid trails and landings are subjected to the most-severely disturbed soil (Froehich and McNabb 1984; Helms and Hipkin 1986), altered soil properties do not always result in poorer survival or tree growth (Greacen and Sands 1980; Firth and Murphy 1989; Miller et al. 1996; Senyk and Craigdallie 1997b). In some coarse-textured soils, seedling performance can be better on compacted than on undisturbed soils (Powers et al. 1999). Heninger et al (2004) found that the percentage of trees surviving two growing seasons after planting averaged slightly greater in ruts of skid trails than in nearby logged areas, in spite of increased bulk densities. Others (Youngberg 1959; Miller et al 1996) also report that survival of Douglas-fir planted on primary skid trails in clearcuts is similar to that on adjacent logged areas. For naturally seeded areas, however, Steinbrenner and Gessel (1955) and Wert and Thomas (1981) report about 20 percent less stocking on skid trails compared with adjacent areas. Trees that grow on persistent compacted surfaces may be more prone to windthrow due to shallow rooting systems. Froehlich et al. (1981 as cited in Poff 1997) indicate that modern harvesting equipment, such as cut-to-length processors and forwarders, does not compact soil, even when operating on moist soils. Compaction can also be reduced to acceptable levels using conventional ground-based equipment if designated skid trails and end-hauling are used. However, with repeated entires under uneven-aged management, skid trails may increase from the typical 8 to 10 percent of the area with each subsequent entry (Poff 1997).

Commonly used site-preparation treatments are almost as variable as the sites on which they are applied (Minore 1986). Although severely burned sites can be difficult to regenerate (Stewart 1978) and poor seedling growth has been associated with severely burned soils (Baker 1968), the effects of slash burning do not seem to last as long as soil compaction (Minore 1986). Burning can decrease the subsequent number of mycorrhizae on Douglas-fir seedlings (Wright 1971), but the resulting ash can act like a slow-release fertilizer. The direct effects of burning logging slash are usually confined to the top 2 inches of soil depth (Austin and Baisinger 1955), but this may depend on burn severity and duration, soil type, and soil moisture. Minore (1986) found that in southwestern Oregon, piling and burning slash tends to be associated with less seedling growth in 5-year old seedlings than does broadcast burning, but other factors such as equipment used in piling slash may have contributed.

Machine or hand-piling of slash also concentrates nutrient-rich branches, foliage, and sometimes topsoil. This can increase soil organism populations and activity locally. Excessive nutrient leaching can occur in areas where microbial activity increases (NRCS 2004).

Soil compaction occurs during several site-preparation treatments. Compaction may sometimes be beneficial where moisture is limiting and aeration is adequate (Lull 1959), and moderate compaction may not seriously affect plant nutrient status where moisture conditions remain satisfactory in fertile soils

(Kemper et al. 1971). Soil compaction is detrimental under most conditions, however, and the compaction that occurs during logging and slash disposal generally has a negative effect on most sites.

Effects of Soil Compaction to Soil Organisms

Soil organisms play an important role in forming and stabilizing soil structure. Fungal filaments and exudates from microbes and earthworms help bind soil particles together into stable aggregates that improve water infiltration, and protect soil from erosion, crusting, and compaction. Macropores formed by earthworms and other burrowing creatures facilitate the movement of water into and through soil. Good soil structure enhances root development, which further improves soil. By improving or stabilizing soil structure, soil organism dynamics help reduce runoff and improve the infiltration and filtering capacity of soil. Compaction reduces the diversity of pore sizes and the amount of space and pathways available for larger organisms to move through the soil. Poorly drained soils have a high level of anaerobic microsites and therefore a higher rate of dentrification (conversion of nitrate to gaseous nitrogen – which is then lost to the atmosphere) compared to well-drained soils. Ground cover at or near the surface moderates soil temperature and moisture; provides food and habitat for fungi, bacteria, and arthropods; and prevents the destruction of microbial habitat by erosion.

Reducing /Reversing Effects of Soil Compaction

Approximately 80 percent of soil compaction occurs on the first pass of equipment so repeated passes should utilize established trails whenever possible to minimize the area affected. Recovery from soil compaction may occur naturally through freeze-thaw cycles or through alternating wet and dry cycles. In severe cases, tillage (as well as ripping and subsoiling) can break-up compacted soils. Tillage of compacted soil can be effective with properly designed and used implements, but can introduce a host of other negative effects.

Prohibiting the use of tractive machines on soils most susceptible to compaction, suspending operations above specified soil-moisture content levels, or requiring the use of low-ground-pressure machines do not always reduce soil compaction. Reducing the area of compacted soil by designating skid trails may be the most economical means to maintain site productivity in the Pacific Northwest.

Effects of FPHCP on Soil Compaction

Riparian Timber Harvest

Vehicle traffic across forest soils or on heavily used trails can create ruts that compact soil and channel water. The resulting accelerated erosion, rills, and gullies can strip or bury topsoil and can have a negative effect on soil organisms. Erosion associated with vegetation shifts often results in the redistribution of top soil, organic matter, resources, and habitat across short distances. Compaction that negatively affects ground cover can lead to more erosion.

Compaction may occur whenever heavy equipment is used, including log placement, slash treatment, site preparation, road construction, road abandonment and decommissioning, etc. Equipment used in logging and yarding generally operates on top of logging slash and downed vegetation that generally forms a protective cover on much of the ground during logging operations. Ground-based logging over snow and frozen ground also can reduce the effects to the soil. Movement of heavy equipment may result in some level of soil compaction within the uppermost layers of the soil profile.

The level of compaction should be minimized by exclusion from the Core Zone. Movement of heavy equipment during timber harvest in buffers of fish-bearing streams may result in some level of soil compaction in the Inner Zone, and perhaps some additional level of compaction within the Outer Zone. Soil compaction is expected to be minimized during tractor yarding through the use of a variety of BMPs. A number of Washington Forest Practices Rules require reasonable care to minimize soil disturbance and protection of public resources. Specifically, WAC 222-30-070(5)(b) addresses high soil moisture and minimizes soil compaction.

When timber harvest occurs in proximity to streams, wetlands, and saturated soils, the potential for soil compaction is increased. Because buffered areas preclude the need for equipment to a large degree, risk of soil compaction adjacent to streams is minimal along fish-bearing streams, buffered wetlands, and buffered segments of perennial streams without fish. Soil compaction may occur within 30 feet from perennial streams without fish in unbuffered sections and from seasonal streams without slope-stability retention. Within 30 feet of streams in unbuffered stream reaches, equipment may operate under the provisions of the ELZs, but would also be subject to the mitigation requirements of those ELZ rules.

Only a minor amount of felling and bucking is expected to occur within riparian buffers of fish-bearing streams, and as such, the need for equipment to penetrate these areas would be very limited. Felled trees within the Core Zone would be left and few trees are expected to be removed from the Inner Zone. Felling and bucking within the Outer Zone and adjacent to buffers should result in minimal effects due to the use of directional felling.

Felling and bucking in riparian areas along seasonal streams and unbuffered segments of perennial streams may occur in proximity to the stream, but directional felling may increase the distance from the stream where most bucking activities would occur, and would also distance equipment needed for yarding from the stream. Provisions of the ELZ would require on-site mitigation if more than 10 percent of the area is effected. However, affecting 10 percent of the riparian zone can result in negative effects to stream habitat as well as riparian habitat. In some cases, damage may exceed 10 percent.

Skid trails are expected to be minimized as specified in the Washington Forest Practices Rules. Repeated use of designated skid trails and minimizing the number of trails reduces soil compaction providing better opportunities for replanting. Because few trips are expected into the buffered portions of riparian areas in any given location, repeated compaction should not occur. Additional trips may occur along unbuffered portions of streams where larger numbers of trees are cut. Minor rutting and soil compaction from skidding of logs may result in localized run-off and erosion, and thus to an increase in sediment delivery. Within areas being logged by the use of cable-yarding systems, soil compaction is not expected outside of landing areas. Landing areas are located at some distance from streams, usually in an elevated area alongside a road.

Minor amounts of soil compaction and rutting may occur as a result of use of heavy equipment to scarify planting sites. Understory disturbance and disturbance of duff and debris layer would be expected as a direct result of scarification.

Due to the “equal in overall effectiveness” constraints of Alternate Plans, it is expected that the effects to the aquatic and riparian environment would be essentially the same or less than what would occur under the standard rules. No substantial or measurable physical effects to soil compaction are expected due to the “equal in overall effectiveness” provisions of alternate plans with respect to aquatic and riparian function. Hardwood conversion and harvests conducted under the over-stocked template may include the use of equipment within the Inner Zone and as close as 14 to 30 feet from the streambank. Use of heavy

equipment close to the streambank may result in soil compaction, especially if equipment must travel to the end of the management zone.

There would likely be slightly greater effects from yarding in riparian areas along fish-bearing streams under the 20-acre exemption as logs would be closer to stream than under standard rules. Yarding may also occur closer to streams without fish under the 20-acre exemption, especially in situations where trees are clumped for logistical convenience. Equipment limitation zones would be provided along 20-acre exempt parcels. The 20-acre exemptions are most-likely to occur at lower elevations at the urban interface. Many low-elevation areas that do not experience frost heaves during the winter may be more-susceptible to compaction. Minor rutting and soil compaction from skidding of logs may result in increased run-off and erosion

Roads

In addition, heavy equipment used for road repair and upgrading that may need to operate outside of the road prism may cause localized soil damage and compaction. This may occur in order to access fill at road crossings, for instance.

Research

Research involving habitat manipulation may at times require equipment with riparian buffers. This is expected to occur infrequently and soil compaction would typically be avoided. Nonetheless, some soil compaction may result from research activities.

Summary of FPHCP Effects to Soil Compaction

Where soil compaction occurs, it typically results in retarded soil functions until it is reversed, by frost heaves or repeated wetting and drying cycles. This recovery can take from several years to several decades to be completed. Soil compaction can result in direct effects to ground-dwelling and burrowing vertebrates and invertebrates, destruction and closing of animal burrows, and increased run-off from the soil surface that can lead to erosion. Soil compaction can change the chemical processes of the soil by reducing porous space and thus changing an aerobic environment to an anaerobic environment. This can alter the microbial composition of the soil and contribute to a loss of permeability. Heavy equipment passing over the soil can affect the surface crust of the soil, the organic-rich topsoil layer (A-horizon), and deeper layers depending on the effect of the equipment and soil conditions. A combination of rutting and soil compaction which reduces the infiltration capacity of the soil can accelerate erosion from splash erosion and channelized runoff. If left untreated, ruts from heavy equipment can provide a conduit for erosion and sediment delivery to the stream channel.

The BMPs and Washington Forest Practices Rules are expected to minimize soil compaction and rutting by requiring operators to reduce pressure of tires and tracks and to minimize rutting and other soil disturbances. Damage is also expected to be lessened due to the presence of logging slash and residual downed vegetation that generally forms a protective cover on much of the ground during logging operations. Designated skid trails would be used to manage multiple-passes where compaction is an issue. Where damage within ELZs affects more than 10 percent of the area, damage to soil would be mitigated. Some short-term effects are expected in high-elevation areas where frost heaves regularly occur. However, concern is high for some low-elevation areas, especially where frost heaves are less common. Concern is particularly high regarding susceptible soil types where significant harvest would occur in streamside areas, such as 20-acre exempt parcels. Many of these parcels may not be harvested

by operators with the proper equipment and knowledge of techniques to minimize soil damage. Operators selected by small landowners can be variable in their abilities, as well as in their access to specialized equipment.

7.5.2.6 Diffuse Sediment Filtering

We examine a number of studies, including those that address routing of sediment from roads and under influences of culverts, to examine relationships between routing and filtering in consideration of all available information. We also examine specific travel distances of sediment as a result of surface erosion of harvested areas in an attempt to discern the differences.

Source of Diffuse Sediment

Erosion is the detachment and movement of soil particles whether individually, in small aggregates, or in large masses (Brooks et al. 1991). The two dominant processes of erosion on forest lands are surface erosion and mass wasting. Surface erosion is the detachment and subsequent removal of soil particles and small aggregates from land surfaces by wind or water and generally occurs gradually. Sediment-particle detachment and transport can be initiated by a variety of mechanisms including raindrop splash and/or overland flow of water. The amount of erosion generally increases with rain intensity, overland flow of water, and hillslope gradient (CH2MHill 1999). Diffuse sediment can be delivered to streams through processes such as soil creep and surface erosion. Surface erosion in Washington forest lands commonly occurs during run-off when the rainfall and/or snowmelt exceed the soil's infiltration capacity and excess water flows across the soil surface.

The role of the protective surface residue layer on the forest floor is critical in controlling erosion (Elliot et al. 1999). Loss or disturbance of this litter and duff layer through mechanical means can significantly increase erosion. Further, the decomposing root system reduces infiltration capacity resulting in increased surface runoff with the potential for increased sediment delivery to stream channels.

Not all hillside surface erosion reaches stream channels, but conduits such as roads, ditches, and skid trails increase this probability, particularly if buffer strips are not left between treated areas and stream channels (Chamberlin et al. 1991). The potential for surface erosion is directly related to the amount of bare compacted soil exposed to rain and runoff, and timber harvesting tends to compact the soil (Chamberlin et al. 1991). Skidding logs to landing sites compacts and scarifies the soil. Skid trails are responsible for most of the erosion on timber harvest units because of the removal or disturbance of the surface organic layers (Elliot et al. 1999) and the reduced infiltration rates as a result of compaction of the forest soil (Everest et al. 1987).

Some yarding activities, such as tractor yarding, can cause extensive soil disturbance and compaction that can increase splash erosion and channelize overland flow. If this occurs within riparian areas, the potential for fine-sediment delivery to streams significantly increases. Cable yarding and helicopter systems that suspend logs usually cause less soil disturbance (Murphy 1995). Site preparation and other actions which result in loss of the protective organic layer can also increase the potential for surface erosion (Hicks et al. 1991).

Soil compaction caused by heavy equipment and yarding can decrease infiltration capabilities, increasing surface runoff. Forest-management activities that substantially disturb the soil, such as yarding, burning, or road and skid trail construction, can alter both surface and subsurface pathways that transport water to streams (Thomas et al. 1993, Murphy 1995, Keppeler and Brown 1998). Logging can also alter the

internal soil structure. As tree roots die, soil "macropores" collapse or are filled in with sediment. These subsurface pathways are important for water transmission and filtration. When subsurface flow pathways are destroyed over a sizable area of steep slope, the flow can be routed to the surface and increase gully erosion and sediment delivery (Keppeler and Brown 1998).

Piling and burning debris may have localized effects. Burning organic cover decreases interception capability and exposes the soil to the direct effect of raindrops, which can detach the soil and lead to increased erosion. Burning also reduces litter and vegetation that obstruct overland flow and disrupt sediment transport. Another effect fire can be the formation of a hydrophobic layer. Hydrophobic layers form when organic compounds volatilized in the surface litter are driven into the soil and condense on the underlying, cooler soil particles. This can create a water-repellent coating that may restrict, or in some cases completely impede, water movement into the soil, substantially increasing the runoff and erosion hazard on the site. The amount of water repellency that occurs is a complex interaction that depends upon fire intensity, soil texture, soil-moisture content, and the type and amount of organic matter. Water repellency does not occur as a result of fires which are too hot or not hot enough. Shrubs with waxy coatings or high oil content may be particularly prone to contributing to this phenomenon. Strongly hydrophobic layers create an effectively very shallow soil, making the wettable surface soil very vulnerable to erosion. Hydrophobic layers may also form at the surface if soils are moist or clayey, or where fire intensity is low. Surface hydrophobicity protects the soil from erosion but can greatly increase channel scour by causing rapidly accelerated runoff. Poff (1997) stated that the formation of hydrophobic layers under prescribed burning is probably rare. Hester et al. (1997) noted decreases in infiltration from prescribed burning in oak juniper types, but infiltration was still higher than adjacent unburned grassland.

Megahan et al. (1995) found accelerated soil erosion in a study where forest was clearcut and broadcast burned. The accelerated surface erosion noted by Megahan et al. (1995) occurred primarily as a result of the prescribed burning. The detailed plant surveys showed that percent bare soil and length of bare soil openings were considerably greater on burned areas of the cutting units. In addition, the prescribed burning consumed much of the litter and killed most of the residual understory vegetation. Thus, there was no long-term source of litter to protect the soil surface. They further noted that only 50 percent of the logged area was burned; the remainder had less bare soil than surrounding unlogged areas because of accumulations of logging slash. Megahan et al. stated that "Thus, it is reasonable to assume that the accelerated surface erosion occurred on the burned portions of the area logged." They also pointed out that erosion rates need to be adjusted for delivery; and, based upon sediment budgets prepared in nearby watersheds; they used an average of 7 percent for a sediment-delivery ratio.

Travel of Diffuse Sediment

Factors affecting travel distances include hillslope gradient (Benoit 1978; Brake et al. 1997; Megahan and Ketcheson 1996; Packer 1967), density of hillside obstructions (Brake et al. 1997; Megahan and Ketcheson 1996; Packer 1967), and total eroded volume (CH2MHill 1999). Benoit's (1978) data indicate that sediment-filtration effectiveness decreases with increasing gradient in an approximately linear fashion. Brake et al (1997) showed a positive linear relationship between sediment travel distance below culverts and hillslope gradient, while Megahan and Ketcheson (1996) found that sediment travel distance below culverts was proportional to square root of the gradient.

Several studies have demonstrated that sediment travel distances below culverts decreases with increasing obstruction density (Brake et al. 1997; Megahan and Ketcheson 1996; Packer 1967; Burroughs and King 1989), with the exact nature of the relationship varying between different studies.

Megahan and Ketcheson (1996) and King (1979) both found that sediment travel distance increases with increasing volume of eroded material. Similarly, Brake et al. (1997) and Packer (1967) demonstrated positive linear relationships between sediment travel distance and contributing road length between culverts, the trend most likely due at least in part to increased sediment volume from longer road lengths (CH2MHill 1999).

In the Oregon Coast Range, Brake et al. (1997) found mean travel distances of 16.7 and 30.6 feet from culverts draining old and new roads, respectively. In highly erodible granitic soils of Idaho, Megahan and Ketcheson (1996) found mean sediment travel distances of 173, 39, and 21 feet for culverts, rock drains, and fillslopes respectively. Also in Idaho, Burroughs and King (1989) found average sediment travel distances ranging from 26 to 80 feet for fillslopes with varying amounts of flow contribution from culverts.

Adding logging slash barriers to the fillslopes significantly reduced average sediment travel distance to 4 feet (Burroughs and King 1989). Burroughs and King (1989) stated that although the initial rate of fillslope erosion can be high compared to erosion rates on other road components; it is the transport of eroded material below the fillslopes that determines the degree to which streams are affected by fill erosion. For most mid-slope forest roads, only those fillslopes near stream crossings have a high potential to contribute eroded material to streams.

Packer (1967) found that hillslope obstructions explained one-third of the variability in sediment travel distances below roads. Obstructions on the ground clearly play a large role in sediment interception. Heatherington (1976) also found that a buffer strip prevented sediment transport to streams, whereas nearby streams without buffers had sediment delivered where soils were disturbed. In Montana, Pfister and Sherwood (1991) determined that a streamside management zone of 50 feet would suffice for sediment interception except where wetlands, steep slopes, or erodible soils occurred. The most-effective strategy for reducing management-related inputs of sediment to streams is to stop erosion at the source (McGreer et al. 1998).

Forest Roads are considered the most-detrimental forest-management operation to forest soil and water quality, perhaps accounting for 90 percent of sediment yield for forest lands (Megahan 1972a, 1974; as cited in Grace 2002). Megahan and Ketcheson (1996), Ketcheson and Megahan (1996), King (1979), and many others have studied sediment delivery to streams that originated from road surfaces. Other studies have also reported similar findings from road-diverted water (e.g., ditch-relief culverts). Travel distances from roads and ditch-relief culverts would be expected to be greater due to the additional volume of eroded material and the influence of concentrated water.

The degree of surface roughness and vegetation may be more important than distance (CH2MHill 1999). In a study of grass seeding and soil erosion, Helvey and Fowler (1979) concluded that grass seeding had little or no effect on soil surface changes in the clearcut. Their conclusion was based on their measurements, as well as observations of places where overland flow occurred. The maximum soil movement was 240 cm downslope in a severely disturbed skid trail. They observed evidence of overland flow only in the deep skid trails; and even there, soil movement was limited to a few meters. According to Gharataghi et al. (2005), almost all of the aggregates larger than 40 microns in diameter were captured within the first 5 meters of a vegetated filter strip. However, the remaining, smaller-size aggregates are very difficult to remove by filtering.

Many factors influence the ability of the buffer to remove sediments from land run-off, including the sediment size and loads, slope, type and density of riparian vegetation, presence or absence of a surface

litter layer, soil structure, subsurface drainage patterns, and frequency and force of storm events (Osborne and Kovacic 1993).

Role of Riparian Zone and Vegetation in Filtering Diffuse Sediment

Streamside buffers can substantially reduce fine sediment that is transported overland (Rashin et al. 1999). The capacity of riparian buffers to control sediment inputs from surface erosion depends on several site characteristics including the presence of vegetation or organic litter, slope, soil type, and drainage characteristics. Additionally, the filtering capacity is affected by timber-harvest activities within the buffer. Although soil disturbance generally increases the sediment delivery potential, the addition of obstructions on the forest floor from tree limbs and boles associated with partial logging can offset diminished filtration (Burroughs and King 1989; Benoit 1979). These factors influence the ability of buffers to trap sediment by controlling the infiltration rate of water and the velocity of overland flow.

After evaluating the effectiveness of previous Washington Forest Practices Rules in controlling sediment-related, water-quality effects, Rashin et al. (1999) recommend that buffers "of at least ten meters should be maintained on all streams in order to avoid chronic sediment delivery and direct physical disturbance of streams from harvest-related erosion." Five relevant studies examined by CH2MHill (1999) suggest that sediment filtration typically is about 80 percent effective within 80 feet of the stream, and approaches 100 percent within 150 feet of the stream. Effectiveness depends on whether the sediment source is concentrated (road drainage, landslide scars) or diffuse (road fills, harvest activity). The inclusion of road fills and road drainage in these studies likely overestimates travel distances of sediment particles from harvest activities because total eroded volume and water concentration are likely important factors.

Effects of Proposed FPHCP on Diffuse Sediment Filtering

Obstructions on the ground, ground vegetation, duff, and litter clearly play a large role in sediment interception, as does soil-infiltration capacity, slope, aspect, and patterns of precipitation. Timber harvest measures within the RMZs of Type F or S streams, as well as buffered portions of Type Np streams would minimize ground disturbance, thus allowing natural roughness elements and intact duff on the forest floor to capture most of the fine sediment generated and delivered from upslope areas. With respect to unbuffered Type Np streams, sediment from outside the Riparian Zone would likely be filtered within the ELZ, but additional sediment generated within the Riparian Zone, especially when generated and mobilized in proximity to the stream, is likely to result in sediment delivery. Harvests under the 20-acre exemption along Type F streams should maintain sediment filtering capacity as a result of additional retention to meet the shade rule, so long as channel migration does not occur. Where the channels migrate, sediment filtering may be reduced or eliminated. Minimal buffers are expected to be retained on 20-acre exempt parcels with respect to Type Np streams where covered species may be affected. Equipment limitation zones should generally help maintain soil infiltration, duff, litter, and ground vegetation to assist with sediment filtering, yet because equipment may operate in proximity to stream, some additional sediment may be mobilized and delivered. In highly degraded reaches, this additional amount of sediment, in conjunction with reduced wood recruitment, may have detrimental instream effects – see **Effects of Activities by Resource Topic – Sediment** section.

Use of machines to construct piles has similar effects as using machines for yarding or site preparation. Burn piles may result in local changes to soil including development of hydrophobic conditions leading to small-scale increases in surface flow and erosion. Landings must be located according to WAC 222-24-035(1) and landings are essentially extensions of the road system. Broadcast burning may result in some

increased surface erosion and sediment production, as well as reduced filtering. Broadcast burning requires a separate permit and does not need to be addressed on an FPA. Broadcast burning is allowed per the Washington Forest Practices Rules (WAC 220-30-100), but is becoming exceedingly rare. Over the last 5 years, approximately 2,000 acres on State and private land have been permitted. According to Darrel Johnston (WDNR, Resource Protection Division - the permit authority for this type of burning), they have issued one burn permit for broadcast burning in the last three years. WAC 222-30-100(2)(a) states that any conventional method of slash disposal may be used except in certain situations. Those exceptions include where WDNR determines that a particular method would cause unreasonable risk to public resources or site productivity. Permittees are required to follow WAC 332-24 (Forest Protection Regulations) and the State Smoke Management Plan for both broadcast and slash-pile burning. WDNR reserves the authority to impose additional requirements through the use of written burning permits and the smoke management plan (WAC 332-24-205 (13)).

7.5.2.7 Microclimate

Microclimate is a general term used to define local, fine-scale conditions. These conditions are often influenced by topography, vegetation, or presence of water (Knutson and Naef 1997). Factors that are often measured when assessing microclimate include ambient air temperature, relative humidity, wind speed, short-wave radiation, surface temperature, and soil temperature and moisture content. Riparian microclimate may differ from the surrounding macroclimate.

Generally, water, topography, and vegetation combine to make riparian areas more moist and mild, with higher humidity, higher rates of plant transpiration, and less air movement than upland areas (Knutson and Naef 1997). However, Risenhoover (Personal Communication, March 15 and 17, 2006) found that relative humidity was higher in upland areas during nights. It should also be noted that while streamside areas are often viewed as having interior forest conditions provided by riparian buffers; streamside areas are often edges of forests and streams, often resulting in various influences depending on channel width, gradient, discharge, confinement, and other factors. Risenhoover et al. (2004) reported on observed differences between 55 to 65 year old mature stands, riparian areas, and clearcuts. He found that soil moisture was highly variable and showed no consistent trend in relation to distance from streams. Soil moisture was higher in clearcuts than in forested areas. He noted that the range in microhabitat conditions in clearcuts did not differ greatly from those found in riparian buffers or mature forest stands. Diel patterns of ambient temperature and relative humidity suggested that microclimate conditions in clearcut and unharvested forests were similar except during 4 to 6 hours of the mid-afternoon. Clearcuts exhibited greater variation in temperature and humidity, being slightly cooler and wetter at night.

Riparian microclimate is reported to influence productivity, abundance, and richness of plant, invertebrate, and vertebrate communities (Hicks et al. 1991; Cummins 1975); as well as incidence of windthrow and wood delivery to streams. Changes in microclimate within riparian areas resulting from removal of adjacent vegetation can influence a variety of ecological processes that may affect the long-term integrity of riparian ecosystems (Spence et al. 1996). Microclimate affects water temperature (Geiger 1965; Beschta et al. 1987); however, riparian buffer width had no effect on stream temperature, except in the case of almost complete absence of streamside trees (Brosofske et al. 1997). See discussion under the **Effects of Activities by Resource Topic -- Water Temperature** section.

Microclimate is believed to be important to stream/riparian species such as amphibians and fish. However, microclimate effects on aquatic conditions are not well understood. No know relationships exist between microclimate and stream temperature; dissolved oxygen; production of instream organisms;

or fish species composition, production, and health (Hicks et al. 1991; Murphy et al 1986; Bisson et al. 1988; Reeves et al 1987; Magnuson et al 1979). Brosofske et al. (1997) showed little or no relationship between buffer width and air temperature or wind speed; and only weak relationships between buffer width and solar radiation or relative humidity. They found that soil temperatures, to the extent they are influenced by buffer width, appear to exert a strong influence on shallow soil-water temperature. The effects of incremental changes in microclimate on riparian and aquatic areas are essentially unknown (Ledwith 1996).

Although elevated ambient air temperatures have been an area of concern, evidence from studies of microclimate in clearcuts strongly suggests that air temperatures do not provide a good indicator of available conditions on the ground. Although temperatures and relative humidity showed larger diel fluctuations in clearcuts, soil temperatures and soil moisture remained well within the normal range found in adjacent mature forest and buffered areas along streams. A study of microclimate conditions in southwestern Washington found that air temperature at 15 cm above the ground varied more widely in clearcut areas than within forested areas (K. Risenhoover, Port Blakely Tree Farms, Personal Communication on unpublished data, January 4, 2006). The study also found that soil temperature at 15 cm below the soil-surface were extremely constant, at approximately 15 degrees C, both in clearcut areas and forested areas. Risenhoover's data indicated that air temperature was warmer in clearcut areas during the day and cooler during the nights compared to forested areas. The data also showed that clearcut areas exhibited greater diel variation in humidity and were actually more humid than forested areas during the night. Available cover conditions in clearcut areas were measured and less than 90 percent of these areas were composed of exposed soil or herbaceous cover (areas that may be more susceptible to increases in soil-surface temperatures through direct exposure to solar radiation). The majority of areas were covered with litter, organic duff, woody debris, or shaded by shrubs and that both soil moisture and soil-surface temperature were maintained by this cover. Risenhoover's study also indicated that the distribution of suitable cover typically found in clearcuts was adequate to maintain cool and humid conditions were available to amphibians. Amphibians are generally in the soil, under the duff layer or beneath some debris and living in an environment that remains pretty much constant with respect to soil temperature and soil moisture

The extent to which microclimate effects may act additively or synergistically is unknown (Brosofske et al 1997). We note that advances in technology that can be used to measure aspects of microclimate in real-time situations in multiple locations are expected to add to our knowledge of these factors in the near future. This should be especially true as investigations are designed to explore microclimate relationships in ways that are relevant to the species of interest.

Effects of FPHCP upon Microclimate

Vegetation removal causes riparian areas to become drier and hotter in the summer, colder in the winter, and accumulate more snow and ice (Knutson and Naef 1997; Geiger 1965; Beschta et al 1987). These changes occur as a result of loss of shading vegetation, loss of fog drip and sources of humidity, increased evaporation due to exposure and wind, reduced or lost interception of snowfall by forest canopies, and loss of heat- and cold-moderating forest canopy and interior microclimate.

However, substantial vegetated areas would be retained surrounding streams with fish in the FPHCP. On stable seasonal streams and perennial streams without fish, buffers would be intermittent depending on location of sensitive sites and unstable areas. Microclimate changes are expected to occur in areas that are not buffered. To the extent that these changes can affect stream temperature, and to the extent that

stream temperature changes can propagate downstream, these effects are discussed under the **Effects of Activities by Resource Topic -- Water Temperature** section. To the extent that microclimate changes along streams without fish can affect amphibians, these effects are further discussed in the **Effects to the Headwater Habitat Association** section. However, it should be noted that not all changes in microclimate are directly relevant to amphibians. For instance, air temperature 6 feet above the ground may be relevant to arboreal lichens and other bryophytes, arthropods, and even nesting vertebrates. The primary determinants of suitable habitat for amphibians are likely soil temperature and moisture, both near the surface and further under the soil and/or logs and vegetation.

In general, we expect minor changes to microclimate within Type F and S buffers, including small changes in situations where roads cross such buffers. Moderate microclimate effects may occur within 50-foot buffers on Type Np streams or within de facto buffers left to address instability. Buffers on features such as inner gorges would be expected to be no larger than 50 feet from the edge of the feature because that is the most likely distance needed to avoid accelerating failure and providing root strength to the edge of the feature. We expect greater effects, especially in the short term, where no buffers would be retained or where only scattered trees are retained. Retention of shrubs and downed logs would moderate conditions at the surface and within the first few inches of soil for ground-dwelling amphibians. On the eastside, many areas are naturally drier and warmer during the summer. Where the shrub layer and understory vegetation is sparse, additional effects may occur.

7.5.3 Wood

The term “large wood” includes entire trees, rootwads, and larger branches that enter the stream system. “Functional” large wood is large enough to influence hydraulics and form a pool (Bilby and Ward 1989). “Key pieces” of large wood are larger than merely functional and are considered large enough to be effective at trapping other smaller, more-mobile pieces of large wood (Abbe and Montgomery 1996).

7.5.3.1 Baseline

Historically, there were significant amounts of wood in Washington streams and rivers. Many riparian zones were dominated by large old-growth trees that eventually served as key pieces. These riparian zones, in many cases, were not burned during successive fires as were the upland areas. Current conditions are variable; riparian conditions vary be ownership and land-use, which in turn determine streamside recruitment. Currently, large wood is often reduced in abundance and quality, especially within larger rivers. Smaller streams do not require key pieces of wood as large as those required by larger streams and rivers, and pieces of wood in small streams are subject to fewer depletion processes; therefore, because functions such as sediment storage and channel morphology can be met by smaller wood (Bilby 1995), smaller streams generally do not have as degraded a baseline condition as larger rivers.

Several recent studies have found that streams flowing through second-growth forests have reduced amounts of large wood compared with pre-timber harvest levels (Reeves et al. 2003). Past management practices and regulations tended to only address the riparian zone along fish-bearing streams and not streams without fish, which resulted in a greater proportion of wood being removed from headwater stream riparian areas and less wood being available for recruitment to these streams.

Beginning over 150 years ago, trees were often felled directly into streams, rivers, and salt water and floated to their destinations. Wood was removed from stream channels, especially larger streams and

rivers, for a variety of reasons, including transportation and travel. Because many riparian areas along rivers are degraded and it takes many years to grow very large trees, large wood in rivers may continue to decrease through decomposition and transport, for some time before large key-piece wood can again be routinely recruited. Due to various land-use practices in non-forested areas, many riparian areas do not currently contribute large wood. Within forested areas west of the Cascade Mountains, many riparian areas are dominated by red alder where very large conifers once grew.

In 36 percent of the stream reaches surveyed by Beak (1998), the abundance of in-channel large wood was either fair or good for fish habitat; in 64 percent the abundance was rated poor. Results were similar for both western and eastern Washington. Approximately 55 percent of the forestlands measured had good to fair near-term, large-wood-recruitment potential in riparian zones along fish-bearing streams. Six percent were naturally poor, and 39 percent were rated poor. TFW Ambient Monitoring (Ralph et al. 1991) reported that wood loading was relatively low for flat channels with only 13 of 40 examined (32 percent) having more than 40 pieces per 1,000 feet. They also found that steeper, more-confined segments had higher counts.

Large deep pools in many areas of the Columbia River Basin had been reduced by about 58 percent on National Forests and by about 80 percent on private lands according to Sedell and Everest (1991) as referenced in FEMAT (1993). FEMAT (1993) describes this reduction in pools as being related to the loss of pool-forming structures such as large wood and refers to Bryant (1980) and Sullivan et al. (1987).

In managed forests, the past and present supply of large wood may restrict pool development in Washington streams. However, Bilby and Ward (1991) reported that the average abundance of residual large wood in streams flowing through 40-year-old second growth is 102 pieces / 1,000 feet (0.34/m), and that large-wood abundance recovers much more rapidly in small streams than larger streams. Bilby and Ward (1991) found that frequency of large wood in clear-cut and second-growth sites for steams 50 feet wide (15 m) was 50 percent and 59 percent, respectively of that found in old-growth streams of the same width. In channels 16.5 feet wide (5 m), this relationship was found to increase to 56 percent and 77 percent, respectively. The length of time needed for riparian areas to produce functional large wood after harvest depends upon the size of the stream, residual stand composition, and site potential.

Large streams that are deficient in large wood and have adjacent and upstream riparian areas bordered by riparian stands in early seral stages are likely to remain deficient in large wood longer than smaller streams because of their requirement to have large key pieces (MacDonald et al. 1991; Abbe and Montgomery 2003). However, if numerous key-piece-size wood were available in these wide stream reaches, and because wood transport distance increases with stream size, these large streams may be able to increase large wood locally by capturing downstream-transported large wood in jams developed by key pieces (Abbe and Montgomery 2003; Martin and Benda 2001; Collins et al. 2002). However, the development of key pieces of large wood is infrequent in most early-seral forests.

Although existing levels of wood might currently provide functional habitat elements in some streams, as the existing instream wood load gradually decays or washes from the watershed, existing riparian stands in many managed forests might not be of sufficient size and quantity to maintain wood loadings. In the estuarine and near-shore marine areas, the historical amount of large wood was much greater than it is today (Gonor et al. 1988). Since the mid- to late-1880s, much of the large wood has been lost to human-related activities, including timber harvest and removal of large wood to establish and maintain safe navigation channels (Gonor et al. 1988).

Large-wood enhancement has recently become a more common method for improving large-wood content in stream reaches and estuarine and marine shorelines with insufficient large wood. Large-wood placement can provide benefits to these systems by providing bank stabilization, a more-complex habitat structure, nutrient input, and substrate for invertebrate colonization, all of which would benefit fish habitat. However, it is important to note that studies regarding addition of wood have not shown consistent results, especially over the long-term. Although estuaries and marine habitats might benefit from the increased input of large wood, much of the large wood entering rivers and marine waters is removed to provide safe navigation, thereby reducing the benefits of wood placement and wider buffers to some lower reaches of major rivers and marine areas.

7.5.3.2 Importance of and Variation in Distribution of Large Wood

Large wood is one of the most important components of stream habitat for fish populations, of stream hydrology, and of stream-channel morphology (USFWS 2000). Native fish species evolved in streams that were often wood-rich. Large wood physically alters stream-flow patterns and channel characteristics, stores sediment and food, provides cover, and represents a long-term food source for aquatic organisms.

The importance of large wood varies within watersheds, within individual streams, and within individual areas or reaches of streams. Some streams are less sensitive to large wood inputs than others. The locations and principal roles of large wood change throughout the river system. In general, the influence of large wood on stream channel-forming processes and sediment storage is thought to decrease in a downstream direction. In steep headwater streams where logs span the channel, debris creates a stepped longitudinal profile that governs the storage and release of sediment and detritus. When the stream channel becomes too wide for spanning by large logs, wood is often found deposited along the channel margins. In these wider channels, large wood related fish habitat is primarily found near the stream margin and in secondary channel systems of the floodplain (Bisson et al. 1987). Some studies in western Washington suggest that as the width of the stream increases so do the diameter, length, and volume of large wood (Bilby and Ward 1989). In most fish-bearing streams, there is some degree of clumping, and the magnitude and spacing of debris clumps generally increase progressively in a downstream direction (Bisson et al. 1987). Some channels contain boulders that provide channel roughness and pool formation; other channels are dependent on large wood to form pools, store and sort sediment, and form important habitat features for fish and amphibians.

There are number of factors that may contribute to variation in large wood recruitment and channel responses. Changes in tree species composition, abundance, and input rates to streams resulting from forest management practices have differed according to location in the watershed (Bisson et al. 1987). Not all riparian areas contribute the same types and quantities of large wood. For example, some stream reaches flow through riparian areas where large-wood contributions are not possible, e.g., meadows. Not all channels respond in the same manner to large wood (Montgomery and Buffington 1997); and different channels support different amounts and quality of fish habitat. In comparing 12 studies, Light et al. (1999) found that these relationships of frequency and volume of wood changing with channel width did not hold true for Interior Columbia Basin streams.

Although large wood in streams can be very dynamic, stability of large wood pieces is important. If large wood is too unstable, its functions are diminished. Tree form may also contribute to stability; deciduous trees with broadly branching, large limbs may be less susceptible to transport than conifers of similar volume. Relatively few of the wood structures delivered to streams actually contribute significantly to aquatic function (Martin et al. 1998). Tree tops just reaching the edge of large streams do not introduce

large durable wood. Structures composed of sapwood and branches are more temporary than heartwood and large pieces. Braudrick and Grant (2000) stated that large wood pieces with rootwads attached were more stable in streams.

Large-wood aggregates (log-jams) can impound gravel and water. Aggregates may be more successful at forming large pools than all but the largest individual pieces of wood. Larger pools formed by aggregates may be important habitat during low-flow periods. Wood from upstream/upslope may be important in forming aggregates, but so are key pieces.

Channel Morphology

By dissipating stream energy and creating local channel scour and deposition, large wood is a determining factor in channel morphology of many streams. Large wood of appropriate size forms and maintains a variety of structures within the stream by modifying the flow of the stream. Large wood increases the hydraulic roughness of a channel and tends to locally influence the time-rate dissipation of potential energy of flowing water. Roughness also depends on other factors such as particle sizes of bed and bank materials, stream sinuosity, bank characteristics, and streamside vegetation (Light et al. 1999). Features such as large wood are particularly important for low-gradient, unconstrained streams because they dissipate energy, stabilize banks and channels, and influence meander. Bisson et al. (1987) describe in detail how pools are formed or their geometry is modified by scour and deposition associated with stream flow over, under, and around large wood. They also describe how large wood can increase pool frequency and variability in pool depths. “Steps” in the longitudinal profile are created where a large log or accumulations of large wood form a dam that traps a wedge of sediment (Bisson et al. 1987).

The effects of large wood on channel profile decrease with increasing stream order (Harmon et al. 1986). For example, Bilby (1981) reported that channel drop formed by large wood decreased from 52 percent to 46 percent to 10 percent from small first-order streams to larger third-order streams in New Hampshire. The degree to which large wood controls stream profile is related to abundance and size of large wood and the ability of channels to bypass obstructions (Harmon et al. 1986).

Trees that fall directly onto the bank and large wood that drifts on to the shoreline can provide protection for unstable and erodible banks and beaches. Large wood also acts as a barrier to wind-transported sand and can form the nucleus for a temporary accumulation of sand (Gonor et al. 1988). Additionally, large wood can contribute moisture and nutrients necessary for the establishment of woody vegetation (Stembridge 1979, as cited in Gonor et al. 1988). Forage fish may use woody debris for spawning substrate in estuaries and near-shore areas.

Storage of Sediment and Organic Matter

The role of large wood in forming pools and storing sediment varies in relation to channel type, size, and position in the network (Swanson and Lienkaemper 1978; Montgomery and Buffington 1993; Martin et al. 1998). Large rivers sediment storage sites tend to be located on point bars and floodplains. These sites tend to be absent in steep low-order streams and large wood may account for a much greater portion of the total sediment storage in these streams (May and Gresswell 2003). In headwater streams, instream large wood influences channel morphology, sediment transport, the retention and processing of organic matter, and invertebrate communities.

Large wood creates a temporary storage of inorganic sediment and organic matter in stream channels. In these small headwater channels, large wood creates a stepped-bed profile that influences sediment

storage, channel morphology, and organic-matter processing (Beschta et al. 1987). In bedrock channels where solid rock is exposed, pools may be formed by large wood, but there is no clear relationship between pool frequency and large-wood loading (Montgomery et al. 1995). On the other hand, large-wood loading can have a large influence on sediment storage and the formation of alluvial segments in bedrock channels, especially in moderate-gradient (3 to 10 percent) bedrock channels, where sediment is deposited and transported (Montgomery et al. 1996). Sediment storage by large wood also is influenced by channel size, with storage declining as channel width increases downstream (Bilby and Ward 1989).

Fish and Amphibian Habitat

Woody debris presence/absence and features of woody debris, such as surface area and cover complexity, were the dominant factors influencing distribution and abundance of summer rearing juvenile coho salmon in the relatively large river channel sampled by Peters et al. (In Prep.). Results from Peters et al. (In Prep.) suggest that river-management activities should attempt to maintain or restore complex woody debris in large river channels. In the short term, the greatest challenge for restoring woody debris is adding woody debris that will remain stable in the higher discharges associated with these larger channels. In the longer term, restoration of natural riparian trees, which gradually contribute large wood to streams, will provide optimal large-wood-based coho salmon rearing habitat, among other benefits (Berg et al. 2003).

A number of wood-removal studies are summarized in Light et al. (1999) and Rentmeester (2004). These studies showed decreased number and average size of salmonids following wood removal. The studies described indicate that a decreased supply of large wood can change the quality of salmonid habitat by reducing cover, pool habitat, protection from high flows, storage of gravels and organic matter, and hydraulic complexity. The potential consequences for salmonid growth and survival include increased vulnerability to predation and reduced winter survival, rearing and spawning habitat, food production, and species diversity (Hicks et al. 1991). In the long term, the loss of large wood in the stream channel reduces the retention of spawning gravels, the frequency of pools, the habitat complexity necessary for cover and productivity and the structure necessary for natural energy dissipation to maintain stream-channel function (USFWS 2000). However, studies regarding addition of wood have not shown consistent results.

Characteristics important for stream-associated amphibians include hydrology, the level of downed woody debris, suitable substrates, and, for some species' adults, riparian microclimate.

Some important microclimatic parameters that can be influenced by large wood include maintenance of cool soil and air temperatures, soil moisture, and air humidity, as well as reductions of solar radiation and wind velocity. Increased sedimentation in headwater streams is thought to negatively affect some amphibian species by filling interstitial spaces in the stream substrate that are important for movement and larval development (Corn and Bury 1989; Diller and Wallace 1996). Large wood forms pools, sorts gravels, and provides substrates for primary production such as diatoms and algae upon which other organisms, including amphibian larvae feed. Large wood forms habitat complexity and hydraulic complexity within the channel. Large wood also creates cover and substrates for egg deposition.

7.5.3.3 Channel Sensitivity to Large Wood

Although there is general consensus that large wood contributes to diversity within stream channels, which is beneficial to fish and other aquatic organisms, there is less agreement on the minimal amount of large wood that is necessary to support viable fish populations.

Channel reaches located where debris flows deposit are expected to have very high wood loading and fine sediments, while reaches located in the scour and run-out phase of a debris flow are expected to be devoid of wood and alluvium. Headwater segments have greater wood abundance, volume, and more key pieces than mainstem channels (Rentmeester 2004).

Large wood in alluvial streams may be the most-important component of the environment for forming salmonid habitat, particularly in coastal streams (NRC 1996). Light et al. (1999) provides a discussion regarding the channel classes (Montgomery et al. 1995) most used by salmonids and the channel classes most sensitive to large wood loading with respect to formation of fish habitat. In addition to the relationships between channel morphology and sensitivity to large wood discussed above, a channel's propensity to migrate laterally across its valley bottom may influence channel sensitivity to large wood. CMZs can have a range of channel migration potential, as well as a range of sensitivity to inputs of coarse sediment and large wood.

7.5.3.4 Sources of Large Wood

Large-wood recruitment originates from a variety of processes including tree mortality, windthrow, undercutting of streambanks, debris avalanches, snow avalanches, deep-seated mass soil movements, and redistribution from upstream. Natural wood recruitment to streams is governed by a relatively small set of landscape disturbance factors, which can be categorized as: Near-stream Riparian (bank erosion, windthrow, chronic or acute mortality), Upstream and/or Upslope (mass-wasting from landslides, debris flows, and snow avalanches), and Upstream Transport (flotation from floods and high flows). Van Sickle and Gregory (1990) suggested that, although sliding and rolling may indeed result in significant downslope movement of large wood, it may not add a significant number of new pieces of instream large wood.

Studies of large-wood recruitment processes have provided insight into the proportion of wood from various sources. Taken as a whole, these studies indicate that recruitment processes vary across landscapes. Wood enters streams via chronic and episodic processes. Chronic process, such as tree mortality and bank undercutting (Murhpy and Koski 1989) generally deliver single pieces or small numbers of trees at frequent intervals from nearstream riparian areas. When episodic processes occur, they typically add large amounts of wood to a stream rapidly in large but infrequent events, such as severe floods, landslides, and debris flows, which may originate upslope or within riparian areas (Reeves et al. 2003).

Near-Stream Riparian: Until recently many studies on wood sources in streams have focused on chronic input from the adjacent riparian zones. Such studies often found that most of the wood found in streams was derived from within a distance of about 100 feet (Reeves 2006). Such studies have acknowledged the potential role of other sources, especially in watersheds where topographic features influence the relative contribution of upslope sources of wood.

Light et al. (1999) report that Martin et al. (1998) found that 42 percent of large wood came from within 3 feet of the bank, that Long (1987) found 18 percent from that distance, and Benda and Sias (1998) found a significant percentage came from within 3 feet of the bank even where bank-erosion rates are low; possibly overwhelming all other sources where bank erosion is rapid. In some streams, especially in alluvial channels, natural stream bank erosion provides a disproportionately high degree of recruitment from the near-stream (less than 3 feet) riparian area.

Murphy and Koski (1989) report that, in a southeastern Alaska study, bank erosion was the dominant wood-recruitment mechanism in alluvial channels, and windthrow was the dominant mechanism in bedrock channels. Mass-wasting was the least-important process across all channel types and gradients studied. Martin et al. (1998 as cited in Light et al. 1999) reported that 65 percent of the trees in 1 to 7 percent gradient channels were recruited by bank erosion. In steeper, small (first- to third-order) channels, McDade et al. (1990) reported that only 11 percent of the large wood whose source could be identified reached the stream by bank erosion as evidenced by attachment to the bank, and 89 percent was derived from windthrow and other processes. They stated that although many of the specific delivery mechanisms were unknown, much of the wood probably was derived from pieces that floated in from upstream, and many probably were recruited by upstream bank erosion. Long (1987) studied large-wood recruitment mechanisms for an entire fourth-order basin in the Oregon Coast range with a history of active mass wasting, logging, and fire. Near-stream riparian sources contributed 41 percent of large-wood pieces by windthrow and 19 percent by bank cutting, while landslides contributed only 2 percent.

Upstream/Upslope: In mountainous environments, shallow and deep-seated landslides and debris flows can recruit large wood to channels and valley floors (Swanson and Lienkaemper 1978; Keller and Swanson 1979; Reeves et al. 1995). The primary recruitment zones for large wood from mass wasting include inner-gorge landforms along streams of all orders (sizes) and debris flows that start in headwalls and scour first-and second-order streams. Inner gorges can occur along both fish-habitat streams and non-fish-habitat streams. The large-wood source areas of unstable slopes vary in width, depending on the geologic hazard and travel distance of soil material.

Colluvial channels (as defined by Montgomery and Buffington, 1997) receive wood from further upslope than alluvial channels. Colluvial channels lack the capacity to transport wood by fluvial redistribution, and therefore, small streams often store large volumes of wood that can be episodically transported by debris flows (May and Gresswell 2003). Accumulated sediment and wood may be episodically evacuated by debris flows and transported to larger channels (Benda et al. 2005).

In steep terrain, landslides and debris flows are potentially important mechanisms. Stream-side-derived pieces tend to be more evenly distributed among reaches within the stream system. Upslope-derived pieces tend to be located primarily in the middle stream reaches, often located in aggregates at or near tributary junctions, and were often broken and debarked (Reeves et al. 2003). Stream-side-derived pieces were predominantly in the influence zones (per Robison and Beschta 1990) that had least contact with the low-flow channel and upslope-derived pieces were predominantly in the zones of influence that had the most contact with the low-flow channel (Reeves et al. 2003). Topographic features of a watershed influence the relative contribution of upslope sources. Steeper, more-dissected watersheds will likely have a greater portion of wood from upslope sources. Stream-side-derived pieces were on average 3-times the volume of upslope-derived pieces. The combined volume derived from streamside sources was twice the combined volume of upslope sources in pool and glide habitat, although the volume of upslope derived pieces was approximately equal in riffle habitat. Reeves et al. (2003) stated that in this instance the difference between the mean volumes of the pieces of wood from each source was likely a result of the fire history of the studied watershed.

Debris flows scour sediment and organic matter from steep 1st-order and 2nd-order channels and create deposits (debris fans) at tributary junctions in higher-order streams (Benda et al. 2003). Debris flows are known to originate in reaches with slopes of 20 percent or greater and to deposit in reaches with slopes ranging from 3 to 11 percent (Swanson and Lienkaemper 1978; Benda and Cundy 1990). Additional material may be entrained in intervening areas. Typically, landslide deposits function as fans or terraces,

causing the entrained pieces of large wood to become accessible to the stream channel only gradually over many years (Swanson and Lienkaemper 1978; Benda 1990). However, debris flows may deposit at tributary junctions or along main-stem channels. Landslides are more likely to deliver large wood to non-fish-habitat and small, steep, mountain streams than to fish-habitat and alluvial streams due to steeper topography surrounding the former. Debris flow deposits at confluences act as sources of increased morphological heterogeneity depending on volume of deposit and energy of receiving channel. In small channels, high wood storage may persist for a century or more following a debris flow (Benda et al. 2003).

Mass-wasting can be locally important, especially when a landslide event occurs above a fish-habitat reach. However, the long-term recruitment of large wood to 1st- and 2nd-order channels from debris flows on a 500-year cycle was estimated to be a relatively low 12 percent (Swanson et al. 1982b; Benda and Dunne 1997; Benda and Sias 1998). Hence, landslides and debris flows may create the highest point loading of wood in streams, but the long-term contribution will be less important. It will usually be a fraction of the contribution from bank erosion and windthrow.

In the steep, forested terrain of the Pacific Northwest the contribution of large wood delivered by landslides or debris flow from the upslope may account for more than half of the wood in a stream (Reeves et al. 2003; May and Gresswell 2003). In Coastal Oregon, preliminary results suggested large-wood recruitment from upstream sources ranged between 11 and 59 percent (Gresswell and May 2000). Murphy and Koski (1989) found landslides accounted for 4 percent. Wood delivered by landslides and debris flows may be higher in V-shaped valleys than in broad U-shaped valleys, because V-shaped valleys have high connectivity between hillslopes and channels and between headwater streams and larger rivers (Martin and Benda 2000). Reeves et al. (2003) found that the amount of upslope-derived wood was greatest in reaches with narrow valley floors.

Landslides and debris flows are capable of forming large accumulations of wood at locations in the network where fluvial processes may not be competent to transport large quantities of wood. In channels that are narrow or have a small drainage area, it may not be possible to transport large wood by flotation during high flows (Swanson and Lienkaemper 1978; Martin and Benda 2001). Even in watersheds where the potential contribution from upslope sources of wood is high, the ability of individual upslope sources to contribute wood to fish-bearing streams can differ widely.

Wood can be transported from upstream during high-flow events, avalanches, and from debris torrents, which includes dam-break floods and debris flows (Swanson and Lienkaemper 1978). However, movement of wood in high-flow events are more common in third- to fifth-order streams because much of the wood that falls into streams is too large to float in smaller streams (Swanson and Lienkaemper 1978). Although less frequent than high-flow events, debris torrents can introduce and move large amounts of large wood (Lamberti et al. 1991). The majority of debris flows and dam-break floods are initiated in low order streams, primarily second-order streams (Coho and Burges 1991). Transported wood, although individually small, is important to the formation of aggregates, which are important habitat features in larger rivers.

Flotation from upstream reaches increases in importance as stream size, order, and upstream watershed area increase. During high-flow events, logs are moved downstream resulting in depletion from one channel reach and recruitment to another. Depletion of wood from a given reach occurs through downstream transport, decay, and fragmentation (Bilby and Bisson 1998).

Debris torrents contribute only relatively minor quantities of large wood to downstream channels over time and across the landscape (Benda and Sias 1998). The channel gradient and degree of channel migration also are key variables that affect wood delivery from upstream. Long (1987) recognized upstream processes (flotation and debris torrents) as potential, but less-important, delivery sources. Long (1987) found flotation contributed only 28 percent and debris torrents contributed only 2 percent. Clearly, the percentage of large wood contributed by flotation decreases with increasing distance upstream, as stream size and hydraulic energy decrease.

The transport of large wood in headwater streams may be even more restricted than transport of sediment. Numerous studies have documented that wood longer than the BFW is less likely to be transported by streamflow. Because headwater streams commonly have widths of only a few meters and contain wood that is substantially longer, transport in them of large wood by streamflow would be very rare. This leads to large buildups of wood in headwater streams. However, in certain topographies, debris flows are an effective agent for scouring stored wood from headwater channels and transporting it downstream to larger channels (Benda et al. 2005).

Comparison of Coastal and Interior Large Wood Relationships

Compared to equivalent situations on the westside, Light et al. (1999) found that large wood frequency is generally lower and volume was generally smaller. Light et al. (1999) found that frequency of pieces increased as stream gradient increases. They also examined whether pieces per channel width in unmanaged interior streams was related to pool spacing or percent pool area and found no consistent relationship. Examination of the studies did not support the hypothesis that, in managed stands, frequency of large wood was lower, size was smaller, or pool spacing or pool area were lower. Light et al. (1999) found that some studies indicated a lower volume of large wood in managed stands while other studies did not.

Although most large-wood studies were conducted in coastal forests of the Pacific Northwest, the role of large wood in Rocky Mountain streams appears to be quite similar. Richmond and Fausch (1995; Cited in Light et al. 1999) found that although large wood in Rocky Mountain streams had smaller diameter, length, and volume than in coastal Pacific Northwest streams, its abundance and function were similar. They concluded that the function of large wood in forming fish habitat in small Rocky Mountain streams was strongly influenced by the stream's location within the watershed. Stream size and gradient appeared to exert significant influence on the characteristics and function of large wood in the studied streams.

Eastside riparian forests and functions differ from those on the westside. Differences include the size and density of riparian stands, species compositions, mortality factors and rates, large-wood-recruitment processes, and lack of large wood/channel width relationships as reported for westside streams (Bilby and Wasserman 1989; Knight 1990).

For example, mass-wasting is a more important mechanism in steep, highly dissected topography receiving significant amounts of rain or rain-on-snow, such as is commonly found on the westside. Tree heights on the eastside are generally shorter. The tree-diameter distributions for unmanaged, mature eastside forests tend to have a wider range of diameters and be skewed towards smaller trees; whereas westside forests have very high timber volumes associated with a narrower range of diameter trees (Powell et al. 1994). Tree densities in eastside riparian forests often are lower. Naturally-open meadows, willow thickets, other hardwood stands, and riparian areas lacking trees are more common in the eastside (Beschta 1997). eastside tree mortality more often is caused by fire, insects, and disease, and less often by windthrow. Fire would be more prevalent if not controlled by fire-suppression efforts. Insect and

disease are responsible for about 40 percent of tree mortality in ponderosa pine forests (Harmon et al. 1986). Relatively low depletion and transport rates may be likely for large wood in Interior/eastside streams as evidenced by the lack of a relationship between channel size and characteristics of large wood (Light et al. 1999).

Consequently, large-wood recruitment mechanisms for trees to the stream channel are unique for the eastside. Stream capture and deadfall are the most-common recruitment mechanisms; and mass wasting, windthrow, and transport from upstream are the least-common mechanisms cited by watershed analyses (Light et al. 1999). Also, slower growth and different or changing mortality agents suggest unique mechanisms for eastside forests. These differences contribute to important differences in the frequency and volume of in-channel large-wood loading levels, which are naturally lower in eastside streams (Knight 1990; Overton et al. 1994; Bilby and Ward 1989; Bilby and Wasserman 1989; Bilby 1996).

Summary of Sources and Mechanism of Recruitment

The field studies cited above describe a limited time frame for large-wood recruitment. It remains difficult to assess the relative importance of recruitment processes over decades or centuries. These studies indicate that delivery processes vary substantially by stream segment. Stream size and topographic setting strongly influence processes that deliver wood to the channel network (May and Gresswell 2003). Bank erosion is limited in steeper channels (i.e., first- and second-order non-fish-habitat streams), and more prevalent in flatter channels (i.e., third-and fourth-order fish-habitat streams). Steeper, more-highly dissected watersheds will likely have a greater proportion of wood coming from upslope sources than will watersheds that are less dissected or steep (Reeves et al. 2003).

Quantity of large wood in streams is variable in space and time because wood recruitment and transport are driven by episodic disturbances. Relative importance of recruitment mechanisms varies with time and space. Variables in recruitment include riparian stand conditions (height, species composition, density, etc.), relative importance of streambank erosion, and landscape processes (debris flows and floods). Relative contributions of near-stream riparian zones and upstream/upslope processes vary by geographic area and remain a subject of scientific discussion. However, adjacent riparian areas are perhaps the better predictors of the larger LWD pieces (i.e., key pieces), which are less easily entrained and thus more readily remain in close proximity to their origin (Fox 2003). Yet, forest management that relies primarily on recruitment of wood from riparian buffers along the larger fish-bearing streams may result in much lower levels of wood recruitment than the historical range of conditions (IMST 1999).

7.5.3.5 Source - Distance Relationships

CH2MHill (1999) compares a number of studies regarding source-distance relationships. Primary factors in determining probability of delivery are distribution of tree fall directions, height of tree, and distance from stream. Often a uniform distribution of fall directions is assumed in modeling, which under estimates the number of trees that fall towards the stream. Probability of tree fall intersecting stream is related to distance to stream, height of tree, taper, diameter, slope, wind direction during storms, bank erosion, mortality rates, soils, etc. McGreer and Andrus (1992) report that windthrown conifer trees in the Oregon Coast Range had an 83 percent probability of falling into the channel when located within 10 feet, but only a 19 percent probability when located at 100 feet. Recent studies in western Washington and Oregon demonstrate some effect of slope on tree-fall direction (Minor 1997, Andrus 1998; as cited in Light et al. 1999). To determine the probability that a tree will deliver functional large wood, height of tree to “effective” size should be substituted for total height. Unpublished data by Beschta (referenced in

Robison and Beschta 1990) suggest that on hillslopes of 17 percent to 70 percent slope, the probability of a tree falling downhill is 75 percent.

While a portion of a tree may fall and land within the stream, it may not be a piece of sufficient size for formation of pools, thus, even large trees may not produce large wood (key piece) if located far from the stream. Gehringer (2004) modeled mean cumulative percent of volume for various stream classes with distance from stream. Depending on bankfull width, between 94 and 98 percent of the functional large wood volume was recruited within 70 feet from the stream. For larger streams (75 feet bankfull width), 95 percent of the functional volume was recruited within 50 feet. For smaller streams, 3 feet to 33 feet bankfull width, 85 percent to 87 percent of the functional volume was recruited within 50 feet of the stream. McKinley (1997 Cited in HCP) found that 95 percent of large wood originated within 50 feet of the streambank for small streams bordered by second growth in northwestern Washington.

7.5.3.6 Wood-Loading Levels

Wood loading is controlled by channel size, riparian forest condition, channel type, landscape type, and frequency of catastrophic events. As channel size increases, so does the ability of the stream to move increasingly larger logs. Wood loading is a function of existing wood, wood recruitment, and wood depletion. Abundance of wood at a given time is likely to affect future abundance for 50 to 100 years, with the effect decreasing over time.

Martin et al. (1998) suggested that maximum pool development in alluvial channels occurs at about 3 channel widths per pool, and under a load of approximately 120 pieces per 1,000 feet. This hypothesis is generally supported by Montgomery et al. (1995) and Beechie and Sibley (1997). The effectiveness of large wood for forming pools declines with an increase in large wood load, and the relationship varies by geomorphic channel type. Montgomery et al. (1995) and Beechie and Sibley (1997) provided a geomorphic context (i.e., gradient, channel confinement, channel width, and substrate size composition) for interpreting the differences in large-wood relationships. Both studies showed that the relationship between pool formation and large wood was stronger in moderate-gradient (2 to 5 percent) plane-bed channels than in low-gradient (less than 2 percent) pool-riffle channels. Montgomery et al. (1995) examined higher-gradient (step-pool) channels and did not find a significant relationship between large wood and pool formation. None of the studies explicitly address the amount of large wood needed to form habitat, though the Montgomery et al. (1995) data showed a clear reduction in channel response (i.e., pool formation) to increased large wood load when large wood was greater than about 91 pieces/1,000 feet of stream length. Beechie and Sibley (1997) concluded that when the number of large wood pieces (greater than 8 inches in diameter) reaches about 122 pieces/1,000 feet of stream length, pool formation is less sensitive to further increases in loading of large wood.

In small- to moderate-sized alluvial streams, pool frequency increases with increasing large wood load. At higher loads, the effectiveness of large wood to influence pool frequency diminishes.

The influence of large wood on pool frequency is less effective in low-gradient channels (less than 1.5 percent, with a pool-riffle morphology) compared to moderate-gradient channels (1.5 to 3 percent, with a plane-bed or forced pool-riffle morphology) (Montgomery and Buffington 1993; Montgomery et al. 1995; Beechie and Sibley 1997).

Headwater Streams

In steep and bedrock channels, pool formation is not closely related to the large-wood load. The primary function of large wood in these channels is for debris dams and sediment storage, not pool formation. Debris dams formed by large wood can influence sediment storage, local channel gradient, substrate size, and the creation of alluvial habitat (Keller and Swanson 1979; O'Connor and Harr 1994; Montgomery et al. 1996).

Data from the TFW small streams study (TFW and Sullivan 1999) show that the size of logs that form steps equals the size mix in the channel (Dieu 1999). Therefore, all sizes of wood, not just large wood, function to form debris steps and provide sediment storage in small streams. Bilby (1995) projected that the amount of large wood in the channel would range from 86 to 125 pieces/1,000 feet over two 40-year rotations after clearcutting under then current Oregon forest practices rules, with a slowly increasing trend over time. The amounts of large wood at their peak would be similar to the median large wood loads reported for old-growth forests (i.e., 76 to 88 pieces/1,000 feet of stream length (Bilby and Ward 1989; Ralph et al. 1994). Importantly, Bilby (1995) found that large wood delivered from regrowth would exceed the amount lost by depletion over the rotation period. Based on the TFW small streams study, nearly all of the large wood would be large enough to function in debris jams and sediment storage sites (TFW and Sullivan 1999).

It is difficult to predict the actual large wood yield of proposed prescriptions without site-specific modeling or empirical data. Forest growth models are available to predict ingrowth and mortality, and the size and timing of large-wood delivery (e.g., Andrus 1998; Welty and Sullivan 2000), but none can anticipate all of the reach-specific conditions and processes found across the landscape. Short- and long-term large-wood recruitment would depend on actual large wood delivery by riparian areas relative to the depletion of large wood in the stream (Bilby and Wasserman 1989). For the short term, functional wood loads would depend on the current status of riparian forest, wood-delivery processes, and individual tree growth and mortality rates.

In general, over the long term, functional large-wood loads decrease as stands approach maturity (Bisson et al. 1987). Stem exclusion processes provide large initial inputs of wood over the first 150 years (Fox 2003). Fox (2003) also reports that mortality of trees is again high in stands approximately 550 years of age. Huff (1995) illustrates that significant mortality of Douglas-fir occurs around 400 to 500 years. The amount of large wood declines as stands mature because tree input decreases with decreasing stand density. Therefore, mid-succession stands provide for production of large-wood pieces and maintaining aquatic habitat, at least along smaller confined streams where size of large wood is less important. Delivery of large wood continues to exhibit cyclical pulses timed to forest growth and tree harvest and, perhaps, natural-disturbance events in some regions (Agee 1993; Everett et al.1994).

Large wood in channels with boulder and bedrock material contributes relatively little to pool formation. However, some bedrock channels were formerly forced pool-riffle systems which lost their ability to retain sediment deposits due to reductions in large wood presence (Montgomery and Buffington, 1997). In constrained channels, about 10 percent of large wood pieces function to affect spawning gravel retention. In alluvial channels, about 40 percent of large wood pieces functioned to influence gravel bar stability (Martin et al. 1998). Loading in streams is heavily influenced by both chronic and episodic recruitment, and chronic and episodic depletion. Wood loading is therefore difficult to predict.

7.5.3.7 Effects to Large Wood Resource

To predict the amount of potential recruitment provided during the 50-year permit term, FWS believes it is appropriate to use the 100-year site index tree height for estimates of stand height in association with streamside source-recruitment distance curves. Most existing stands are less than 50 years old and would achieve an age of 100 or less during the permit term. However, to assess long-term effects that may continue beyond the 50-year permit term, it is more appropriate to use the 250-year site potential tree height estimates for stand height.

As an example, a tree that is currently 50 years old might be harvested 30 years from now in 2036 when it might be 150 feet tall. If this tree is 120 feet from the channel, it may have had a small probability of reaching the stream had it fallen naturally, and even then would have had limited ability to contribute functional size wood (e.g., only the upper 30 feet would have reached the stream). However, in 2136, that tree might have grown to exceed 200 feet tall and had a higher probability of delivering large wood to the channel if it had fallen naturally. The FWS considers these longer-term conditions and effects in this analysis. Estimates will also vary by Site Class – values presented in this analysis are generally for site class II, unless otherwise indicated.

Potential Effects from Forestry

Forest practices can have positive or negative effects on the rate and magnitude of large-wood recruitment. They affect the rate of large-wood delivery through silvicultural treatments that influence forest and individual tree health and that influence a forest's susceptibility to catastrophic disturbance events such as wildfire. Thinning and partial harvest influence the growth rates of residual trees and the rates at which trees attain functional sizes for large-wood recruitment. Also, forest practices can influence the future composition of large wood by favoring certain species; for example, treating alder-dominated riparian forests to favor longer-lasting conifers. Woody debris produced by deciduous trees tends to be smaller, more-mobile, and shorter-lived in streams when compared to conifers. Practices that remove trees from riparian areas (harvest, thinning, and salvage) can have the potential to directly and indirectly affect delivery of large wood. Trees damaged during logging may die soon afterwards and be recruited quickly, as opposed to surviving longer and growing to a larger size prior to recruiting. As an indirect result, a pulse of mortality may occur following harvest in adjacent areas from causes such as logging or yarding damage, sun scald, or windthrow.

The following assessment is based primarily on expected harvest upon attainment of economic maturity (stand age about 50 years) and upon watersheds composed of lands under FPHCP jurisdiction. We attempt to project effects through and beyond the proposed 50-year permit term. We recognize that the common practice of uneven-aged management east of the Cascade crest will alter the timing and nature of harvests.

7.5.3.8 Effects of the Proposed Action on Large Wood

Fish-bearing Streams

Riparian Management Zones: There will be no timber harvest within Core Zones of fish-bearing streams, and post-harvest Inner Zones must meet DFC as well as specified retention levels, which will limit the removal of recruitable large wood. Management in the Inner Zone would be allowed only if growth projections for Core Zone and Inner Zone indicate that the stands would be retained on a trajectory toward DFC. Moderate levels of removal may occur within the Inner Zone during westside

thinning as only 57 trees per acre need be retained and DFC is unlikely to require a greater number of trees. Substantial removal of trees could occur from the Outer Zone and beyond, but this is an area where the probability of delivery is less likely and the size of wood delivered would also be smaller (e.g., only tops).

The combination of the zones is expected to provide over 90 percent of the recruitable wood expected during the permit term regardless of which management option is chosen. Beyond the permit term, the effects may persist through time. When assessed against the 250-year estimate of the SPTH, 80 to 85 percent of the recruitable wood is expected to be retained as a result of thinnings along small and large streams respectively. However, this estimate does not account for the off-setting accelerated growth of retained trees following thinning. Using the 250-year SPTH, 90 percent of the recruitable wood would be retained as a result of harvests under the packing option.

The majority of the large wood delivered to the channel originates within 50 feet of the channel. The benefit of each additional increment of buffer width decreases precipitously beyond the first 50 feet. Only a small portion of the large wood delivered to the stream is derived from beyond 100 feet. The Core Zone would supply the majority of wood that could be recruited during the next 50 years. The Core Zone may supply about half of the wood that could be recruited in the next 200 to 250 years. Together with additional no-harvest areas or partial-harvest options within the Inner Zone, the majority of recruitable wood is expected to be retained. The timber harvest in the Outer Zone would affect only a small portion of the recruitable wood supply. These relationships developed for large wood are even more pronounced for functional wood or key-piece-sized wood. A greater portion of the key-piece-sized wood will be recruited from closer to the stream.

However, as stated above, timber harvest would not be allowed in the Inner Zone until sufficient trees could be retained in the Core Zone and Inner Zone to meet DFC. The thinning option would only be used to remove the smallest trees and the proportion of trees that are conifer would be retained. When harvest would be permissible under FPHCP, the requirement to retain 57 trees per acre in the Inner Zone is expected to be more restrictive than DFC requirements.

The thinning option would accelerate the diameter growth of the leave trees within the Inner Zone by removing competition. This makes it more likely that when trees eventually fall into the stream, the tree bole reaching the stream will be large enough to provide functional habitat attributes. However, thinning would inhibit suppression mortality even though most of these trees were unlikely to reach the stream or be large enough to function in many streams. Suppression mortality affects the smaller, weaker trees in a stand which often fall apart in place rather than fall intact. The largest trees within the Inner Zone would be retained and thinning would promote faster tree growth. Thinning would produce a larger proportion of functional-sized trees at an accelerated pace that would compensate for the loss of smaller, thinned trees.

The thinning option is expected to maintain 91 to 96 percent of recruitable wood during the permit term (along small and large streams respectively), based upon estimates of typical amounts of tree removal during thinning. In some cases, such as stands with dense, smaller-diameter trees, the actual amount of removal may be higher resulting in decreased potential recruitment. Even under the worst-case scenario, the FWS expects retention of more than 80 percent of the potential recruitable wood. In these situations, the retained trees should grow at an accelerated rate.

In contrast, the packing option, concentrates retained trees where competition will be higher and growth rates diminished. The packing option does retain trees closer to the stream where they will have a high

probability of recruitment. One effect of no-harvest options within the Inner Zone is that there will be no opportunity to accelerate diameter growth. Only a small portion of the recruitable large wood is derived from the Outer Zone, and the portion of these trees that could reach the stream would consist mainly of tops. Therefore, production of functional and key-piece wood is dependent on the condition of the Core and Inner Zones. Yet, clumping leave trees around sensitive areas and minimum tree-retention requirements (i.e., 10 to 20 trees per acre) in Outer Zones would maintain some of the large-wood supply for those sites.

On the eastside, the FPHCP would allow management of RMZs in a manner that can address forest-health concerns. A Core Zone of 30 feet would retain about two-thirds of the recruitable wood during the 50-year permit term. The remainder of the RMZ could be managed, but only in a manner that would retain the largest trees. This will allow managers to managed species composition and stocking density in the face of current forest-health issues. However, removal of suppressed and off-site species will still influence the recruitment of large wood. Management under the various categories of treatment (based on basal area and species composition) would retain approximately 90 percent of the recruitable wood during the permit term. Using the 250-year SPTH, it is estimated that management would retain over 80 percent of the recruitable wood.

Retention of potential large wood recruitment does not include all potentially recruitable wood. Some of the potential recruitment will be removed during harvest along Type F and S streams. However, due to diminishing return of additional large wood in terms of pool formation and sediment storage, retaining the majority of potential wood recruitment should provide the vast majority of potential function. In addition, wood closer to the stream channel (that most likely to be retained) is the most likely to provide higher-quality pieces. In spite of this, some adverse effects to instream habitat may result from less than natural rates of large-wood recruitment.

Alternate Plans: Timber harvest within fish-bearing stream buffers under alternate plans is expected to provide similar levels of potential large-wood recruitment. However, some alternate plans may provide enhanced large-wood recruitment such as those Alternate Plans that addressed young over-stocked stands. Young, dense stands will be subject to suppression mortality, but this mortality would be smaller than functional or key-piece size for most streams, and such smaller trees will decay upright rather than deliver (due to small size of dead tree and support from branches of adjacent trees). However, following treatment, density of stands will be reduced and allow accelerated growth of boles to functional or key-piece size. Due to the “equal in overall effectiveness” constraints of Alternate Plans, it is expected that the effects to the aquatic and riparian environment will be essentially the same or less than what would occur under the standard Washington Forest Practices Rules. No significant or measurable physical effects to large-wood recruitment are expected due to the “equal in overall effectiveness” provisions of alternate plans with respect to aquatic and riparian function.

20-acre Exempt Parcels: Where the 20-acre exemption would be applied to timber harvest along fish-bearing streams, there may be a substantially higher level of harvest than discussed above for standard RMZs, resulting in a substantial reduction in potential large-wood recruitment. WDNR (2005) (Appendix J, part 2, Exempt 20-acre parcel riparian management zones: an assessment of riparian function) reported that in a statewide sample of 37 RMZs established on 20-acre exempt parcels during 2003, 32 (or 86 percent) were treated as no-harvest areas and only two had 15 percent or more of the trees removed from the RMZ. This assessment attributes the low frequency of RMZ harvest to shade-retention requirements and shade-analysis requirements. According to the assessment, potential large-wood recruitment from 20-acre exempt riparian buffers would range from 45 to 95 percent and 75 to 100 percent for mature

conifer and mature hardwood forests, respectively. In the worst of these reported conditions, recruitment of conifer could be reduced up to 55 percent if there were no other factors involved.

However, 20-acre exempt buffers are only measured from the bankfull width and not the outside of the CMZ, even if that distance is greater. As a result, large-wood recruitment may be reduced even further in riparian areas associated with CMZs. Additional trees within the RMZ may need to be retained to meet the Shade Rules, but a reduction in potential large-wood recruitment is nonetheless expected along fish-bearing streams, especially those with CMZs. Additional effects to large wood recruitment could result if harvests were conducted more aggressively than assessed in WDNR (2005) (Appendix J, part 2). Harvests per the 20-acre exemption will reduce instream functions as a result of less large-wood recruitment.

Species Control and Hardwood Conversion: Red alder is a common species in RMZs of western Washington. Stands of alder often begin to senesce at about 60- to 80-years of age. Some RMZs are dominated by red alder and there is little or no conifer understory. Conifers and some hardwoods are relatively resistant to decay and abrasion in the stream channel, other hardwoods, such as red alder, decay and break up more rapidly after falling into channels (Harmon et al. 1986; Newton et al.1996). A recent study reported that 30 to 52 percent of the riparian forests along westside streams currently supporting fish are dominated by red alder (Washington Hardwood Commission 2000).

Hardwood conversions would remove a source of large wood (harvested deciduous trees) that would have been available in the short term, but would not have been very persistent once delivered. Removal of alder and planting conifer would eventually result in conifer of key-piece size with potential to deliver to stream and to persist as large wood for extended periods of time. When adjacent stream segments are large-wood depauperate, hardwoods with root wads attached may be added to the stream, but large-wood placement is limited and often is not persistent. Large wood from conifers will take longer to recruit than if alder were retained, but conifer will eventually provide more-persistent large wood. The effects resulting from hardwood conversion will be ameliorated by a no-harvest Core Zone adjacent to the stream which will help retain some recruitable wood during the interim period which may last several decades.

Controlling species composition is often a silvicultural objective on the eastside, along with management of ladder fuels, to address forest health and risk of catastrophic fire. When timber-stand-improvement activities are conducted within RMZs some eventual reduction in large wood may result. However, these effects are generally negligible as only very small trees are slashed and the remaining riparian forest is alleviated from some moisture stress. These activities are not expected to change the assessment of post-harvest RMZs in eastside stands.

Channel Migration Zones: CMZs will not be subject to timber harvest. Wherever CMZs occur, with the exception of 20-acre exempt parcels, RMZs are measured from the outer edge of the CMZ. Therefore, along streams with CMZs, there will be a much higher level of large wood retained than assessed for fish-bearing streams in general. All of the wood available to streams from within the CMZ is expected to be retained under the standard Washington Forest Practices Rules.

Yarding Corridors: Although they are not common, yarding corridors will be placed across fish-bearing streams in some situations. The number and size of clearings in RMZs are to be minimized. Total openings must not exceed 20 percent of the stream length associated with the harvest unit. Trees cut to create yarding corridors within the Core Zone must be retained as downed logs. When trees are felled to construct yarding corridors, those trees will remain in place as downed wood, or may be recruited into the streams. Trees felled to create yarding corridors will result in a localized pulse of downed wood for the

stream and riparian area. Where yarding corridors are used in association with Type Np streams, additional trees would be required elsewhere to account for lost basal area.

Downed Wood Retention: The removal of downed logs from RMZs could have an indirect effect on current and future in-stream large wood. Removal of downed wood in riparian areas may affect reestablishment of some conifers, such as western hemlock and spruce because they may rely on decomposing nurse logs elevated above the forest floor (Spence et al. 1996).

On the eastside, 12 to 30 tons/acre of down wood in specified material sizes must be retained in the Inner Zone following harvest, if initially present, depending on the forest-habitat type. Down wood retention is intended to provide surface roughness and detain overland flow. Retaining downed wood under FPHCP would provide a balance between retention of woody debris and reduction of fire hazard. Retained downed wood within RMZs may be recruited during high flows.

Large-Wood Placement: Large-wood placement is an available option to reduce the number of leave trees in the outer RMZ. Placement of large wood in Type F or S waters would be conducted under an HPA. Wood placement guidelines are contained in the WFPB manual. Even assuming that all guidelines are followed and that appropriate sites are selected, these activities are unlikely to be very effective at the landscape scale. The persistence of such large-wood-placement projects may be short, and these activities are limited in number and can therefore only affect a small area. However, when such activities are conducted, they are more likely to contribute to aquatic habitat than trees in the outer RMZ that were replaced.

Streams without Fish

There will be some reduction in large-wood recruitment from riparian timber harvest with retention of 50-foot buffers along Type Np streams. It is estimated that about 70 percent of the recruitable wood during the permit term may be retained by 50-foot buffers. Partial harvest buffers on the east side along Type Np streams will be subject to some wood removal, but must meet the basal requirements for that forest zone. It is expected that 24 percent to 36 percent of the wood that could be recruited during the permit term would be retained in partial harvest buffers. On the eastside, no more than 30 percent of the stream length within a harvest unit would be left without a buffer. The portions of perennial and seasonal streams without fish that are left unbuffered (either through standard Washington Forest Practices Rules or the 20-acre exemption) will result in a more-acute reduction in large-wood recruitment as a result of elimination of standing potential recruitment trees.

For perennial non-fish-habitat streams on the westside, the prescriptions are designed to protect sensitive sites (e.g., headwall seeps, springs, alluvial fans, and stream junctions) by requiring 50-foot buffers along at least 50 percent of the unit length. Where buffers are located, the prescriptions would maintain unmanaged timber stands supplying about 70 percent of the potential large wood available in the next 50 years.

Using the 250-year SPTH, we estimate that only about half of the wood that could be recruited in the long term would be retained along Type Np streams. The amounts estimated without considering unstable slopes or sensitive sites are 38 percent in eastern Washington and 44 percent in western Washington. Recruitment will vary depending on stream length and special sites (e.g., factors affecting the resultant percentage of stream buffered), but recruitment should be about 40 percent or more of the potential recruitment. Additional wood, albeit smaller pieces of wood, would be recruited during typical harvest rotations and this smaller-sized wood may often function in smaller streams with respect to pool

formation and sediment storage. It is unclear whether such smaller wood would meet the needs of stream-associated amphibians.

In harvested reaches of units, clearcut harvest would typically eliminate recruitable wood in the short term. On the westside, cleared areas along these streams would be expected to produce functionally sized pieces of large wood from stands as young as 25 years old (Hall et al. 1985). By the end of a 40-year rotation in a typical Douglas-fir stand, about 23 pieces of wood (greater than 6 inches diameter) per acre would be produced by natural suppression (Hall et al. 1985). Assuming that trees within 70 feet of the channel are close enough to contribute large wood, and allowing for the probability of trees hitting the stream channel after falling (Andrus et al. 1993), about 44 pieces of large wood per 1,000 feet of channel could be delivered to the stream from in-growth within 40 years after harvest (Bilby 1995).

Wood suitable for sediment storage in small confined channels is likely to result from normal mortality of the managed stand during its growth cycle. The ability of large wood to affect many channel forms in Type Np streams is relatively limited. Pool frequency and depth are relatively insensitive to wood abundance and size in headwater streams. Steps created by large wood are a relatively small fraction of the step population, and step size is only weakly related to the size of key wood (Liquori and Jackson 2003). In larger perennial streams without fish, smaller wood may not be as functional in formation of pools and storage of sediment. In addition, when such unbuffered reaches occur on steeper topography, mass-wasting events originating from upslope would not include the wood from these channels that they might otherwise include indirectly through downstream run-out of debris flows.

Generally, minimal buffers will be required on Type Np streams on 20-acre exempt parcels which will reduce the amount of large-wood recruitment. When such harvests occur on steeper topography, mass-wasting events originating from upslope would not include the wood from these channels that they might otherwise include either directly through failures or indirectly through downstream run-out of debris flows. However, most 20-acre exempt parcels will occur in lower elevations, flatter topography, with less mass-wasting, and with a greater proportion of fish-bearing streams. The greater proportion of fish-bearing streams will reduce the frequency and/or amount of 20-acre exempt harvests on Type Np streams. Application of 20-acre exemption to Type Np streams will retain buffers in situations where covered species may be affected. These buffers will consist of at least 29 trees per 1,000 feet. If all these trees were retained within the first 25 feet from the bank, it would represent only about 50 trees per acre, as small as 6 inches in diameter, only half of which must be conifer. The Shade Rules would not apply, so no additional trees would be required to be retained. In watersheds where 20-acre exemptions are common, this may substantially affect the recruitment of large wood. Retention of 50 trees per acre may represent less than 20 percent of the potential wood recruitment within 25 feet of the bank. Additional trees would not likely be retained within a 100-year site index tree height for large wood recruitment. The persistence of these buffers may be questionable and the size of retained trees may only be minimally effective as large wood within these streams.

For seasonal streams without fish, timber harvest would not be restricted except where potentially unstable slopes occur near the channel. In reaches with stable side slopes, nearly all timber would be removed from potential large-wood source areas. In reaches with potentially unstable side slopes, a portion or majority of the timber probably would be retained within and adjacent to unstable features. Seasonal streams may receive large wood from several sources. On the eastside, where selective harvest is a common practice, the FWS and NMFS estimated that 18 percent of the recruitable wood may be retained along Type Ns streams. In steep and often unstable terrain, the FWS experience with watershed analyses suggests that as much as 50 percent or more of Type Ns streams may require buffers of 50 feet

or more to address instability from inner gorges. Additional areas may be left unharvested to address convergent headwalls and other features. FWS is not relying on these estimates of instability within this analysis and total percentages for large wood retained do not reflect protection for unstable features.

Unstable Slopes: Practices that affect mass-wasting can affect the delivery or stability of areas, as well as the opportunities these and downslope/downstream areas have to develop standing large trees prior to episodic events. The objective of the FPHCP for unstable slopes is to limit management-induced increases in the rates and magnitudes of landslides, and provide tree retention in areas most likely to fail. More-rigorous environmental analysis and review are required where potentially unstable slopes or landforms are identified. The current Washington Forest Practices Rules require forest practices that minimize the probability that slope movement would threaten public safety and maximize the probability of natural rates and magnitudes of landslides. Leaving trees on and around at-risk landforms would ensure wood recruitment to streams from mass wasting, if the potentially unstable areas fail. In cases where it can be demonstrated to be prudent through geotechnical review, partial harvest might be applied. If a slope would be partially harvested, large-wood recruitment would be less than 100 percent if the slope failed, and if the slide reached a stream channel. However, it should be noted that most landslides fail to reach or contribute large wood to fish-bearing streams due to topographic barriers. Protection of features such as steep bedrock hollows, convergent headwalls, and inner gorges is expected to provide essentially the full amount of large wood that would be delivered through failures, and is expected to maintain a natural rate of failures. The maintenance of a natural rate of failures will not influence other large wood relationships in downstream areas.

Salvage Logging: On the westside and eastside, removal of large wood from fish-bearing streams, CMZs, or Core Zones would not be permitted during salvage logging. Salvage of wood embedded in the banks of Type Np steams is restricted. Salvage logging in Inner Zones and Outer Zones is permitted only if specified minimum numbers of down logs are retained. Salvage of trees from the Inner Zone required to meet DFC targets or eastside basal area or tree-count requirements would be prohibited. As a result, buffers retained to minimum 20-acre exempt parcel standards are unlikely to be eligible for salvage logging.

Forest Road Management: Effects associated with road construction include the creation of a road corridor. When roads are constructed within or across riparian areas, this activity removes trees which otherwise would have become large wood. Road construction adjacent to and within riparian areas may reduce the delivery of large wood directly by removing trees which would have eventually been recruited. It may also alter the wood-recruitment regime by increasing windthrow potential, replacing long-term recruitment with a short-term pulse depending on wind direction, tree size, etc. Stream-adjacent parallel roads can disrupt the recruitment and transport of large wood. Removal of road-side hazard trees can affect large-wood recruitment depending upon the road location.

Where the presence of stream-adjacent parallel roads influences the potential to recruit large wood to streams or meet the leave tree requirements for Inner Zones or Outer Zones, harvest within RMZs is additionally restricted to make up for or replace the shortfall. Prescriptions address the potential passage of large wood across roads and the future supply of large wood from abandoned orphan roads. Requirements for off-setting retention of trees to compensate for lost potential delivery due to stream-adjacent parallel roads provide an incentive for abandonment or relocation of these roads.

At the time stream-crossing structures are installed, there may be some loss of downed wood at the crossing site and any needed access sites. Large-wood recruitment lost due to activities at stream

crossings, whether construction, repair, or abandonment, are expected to be minimal. Realignment, prism widening, and road re-location are also expected to result in negligible impacts to large-wood recruitment at a watershed level.

Where adequate drainage patterns are not provided and culverts or bridges do not accommodate extreme flood events, large-wood transport can be interrupted. Under the FPHCP, road upgrading is expected to improve passage of floods and associated large wood. Standards for road maintenance and construction provide for increased sizes of hydraulic openings for stream conveyance. Abandoning roads would increase large wood delivery in the long term.

Wetland Protection: Landowners would be encouraged to maximize large-wood functions in the Outer Zone of riparian areas by clumping retained trees around forested wetlands. Nonforested wetlands would be buffered according to Washington Forest Practices Rules, which have not changed substantially since the November 1998 Forest Practices Rules.

Research: Habitat manipulations may be conducted for research purposes and are expected to occur along a very small percentage of streams, be localized, and have minor effects on large wood recruitment at a watershed scale. Such research proposals that deviate from the prescriptions within the FPHCP would be reviewed by the FWS. As a result, we expect negligible effects to the large wood resource as a result of research activities associated with the Adaptive Management Program.

Stream Typing: In situations where fish distribution is under-estimated, fish-bearing streams may receive less wood than otherwise anticipated. This may occur if fish distribution extends into the 300- to 500-foot sensitive site at the confluence of Type F and Np streams, or if fish distribution extends into unbuffered stream reaches. The FWS anticipates that such under-estimations of fish distribution will only occur in a small number of situations (e.g., less than 5 percent of stream reaches) and will be somewhat off-set by over-estimations of fish distribution in other cases.

7.5.3.9 Large-Wood Summary

Baseline

The large wood baseline has been degraded by past actions within streams, rivers, riparian zones, and on unstable slopes. Many of Washington's streams presently are low in habitat-forming large wood. Functional loading of large wood in smaller streams is generally quicker to recover due to the generally smaller size of wood required for a functional or key piece. Steeper, more-confined stream segments are expected to have better conditions than low-gradient streams of larger size. Many larger rivers remain deficient in key-pieces of wood. Large streams that are deficient in large wood, and have adjacent and upstream riparian areas bordered by early seral stage riparian stands, are likely to remain deficient longer than smaller streams because of their requirement to have large key pieces. Most wood, and the vast majority of key-piece-sized wood, along major streams and rivers is expected to be recruited from stream-side riparian zones.

The current Washington Forest Practices Rules regarding retention of large wood have changed significantly since the November 1998 Forest Practices Rules. A number of years of improved protection for large wood are therefore already part of the baseline. Regardless of such improvements, large wood conditions in some reaches (i.e., larger streams and rivers) may continue to decline while riparian areas are growing wood large enough to become key-piece size. Regulations can do little to change those situations.

Summary of FPHCP Effects

Removal of trees that might have contributed to large-wood recruitment is expected along fish-bearing streams as a result of timber harvest and related activities, but this is expected to only represent a small portion of the total potential recruitment. Due to a diminishing return of additional wood with respect to pool formation and sediment storage, the portion of large wood (standing trees) retained for future delivery should exceed the amount needed for responsive channel conditions. Some short-term loss of hardwood debris may occur as a result of hardwood conversion, but will be offset by long-term recruitment of larger and more-persistent conifer large wood. However, in the interim, large wood would continue to be recruited, as available, from the Core Zone.

Many of Washington's streams presently are low in habitat-forming large wood. Forest practices may affect the amount and timing of large-wood recruitment to streams from riparian areas and unstable hillslopes, but cannot reverse past actions in the near term. Most large wood delivered to alluvial fish-habitat streams comes from bank erosion and windthrow. Landslides and debris flows may create local wood loading in streams, but their long-term contribution is less important than the other processes.

Where riparian areas already have been altered by human activity, the long-term prospects for recovery of large conifers may be limited without active manipulation of riparian vegetation. Conditions in riparian areas may not improve quickly unless active management is used to increase current and future large wood for floodplain and stream-channel complexity. Even so, during this period of riparian recovery, instream depletion may continue, especially within larger streams and rivers.

Loss of large-wood recruitment along Type Np streams as a result of FPHCP is expected to be greater than reductions along Type F and S streams. Approximately half of the streams will receive a 50-foot buffer and up to another 30 to 50 percent may receive no buffer. Effects will vary by stream type.

As a result of timber harvest, it is expected that large-wood delivery to Type Np and stable Type Ns streams will be diminished. Large wood does not function similarly in all streams. In some streams, boulders provide channel roughness, create pools, and facilitate the sorting of substrates. In some lower-gradient, low-energy streams, large wood may not enhance the ability of the stream to store sediment. However, decreased delivery of large wood will decrease the number and quality of pools in streams sensitive to large wood input and, in turn, would decrease the sediment-storage capacity of such streams. Yet Type Np streams are generally small and smaller wood can function within small streams. Therefore, functional wood may be replenished during typical harvest rotations in many cases.

Reduced recruitment of large wood to Type Np and Ns streams may also reduce the amount of wood delivered downstream to fish-bearing streams through episodic events. Fish habitats most likely to be effected by such reductions are those in steep tributary streams, closest to the affected reaches. Reduction in large-wood loading may occur at tributary junctions and upstream portions of response reaches due to smaller or less wood being included from debris flows as they pass through Type Np and stable Type Ns areas. This reduction would most likely occur in steep topographic watersheds and would most-likely affect steep tributaries of fish-bearing waters. However, delivery points of debris flows are still expected to be concentration points of large wood.

Reduced recruitment of large wood to Type Np and Ns streams may directly impact amphibian habitat, to the extent that larger wood is needed to meet their life-history requirements. This may be a substantial effect upon Plethodon salamanders that may rely on large wood to meet certain life-history requirements.

Seasonal streams without fish (Type Ns) will not normally be provided with buffers unless they are required to address mass-wasting concerns. In many mountainous areas, up to 50 percent of Type Ns stream segments may require inner-gorge protection. As a result of unstable-slope protections, delivery to downstream fish-bearing waters that would occur through episodic events is not anticipated to be diminished. Reduction in large-wood delivery to stable Type Ns stream segments may result in diminished sediment-storage capacity. Yet such streams are generally small and smaller wood can function within small streams. Therefore, functional wood may be replenished during typical harvest rotations in many cases. Where amphibian habitat occurs within stable Type Ns streams, it may be diminished in quality by the reduction in large wood.

Marine and estuarine areas that receive discharge directly from Type Np or Ns streams may receive less wood as a result of portions of Type Np and Ns streams not being buffered. Delivery of such wood may be through debris flows that, should they occur, would contain less wood than if those Type Np and Ns streams had not been harvested. We do not anticipate changes in wood delivery to marine and estuarine areas through Type F and S waters.

Large-wood recruitment along fish-bearing streams under the 20-acre exemption could be reduced up to 55 percent or more. The effects assessed in this plan assume there would be limited salvage of windthrown trees from buffers under the 20-acre exemption. Application of 20-acre exemption to Type Np streams will retain a buffer when covered species may be affected. These buffers would contain at least 29 trees (6 inches or larger) per 1,000 feet. Only half of these trees would be required to be conifer. Salvage must be conducted in compliance with WAC 222-30-45; therefore, unless additional trees were originally retained when the 20-acre exempt parcel was harvested, there would not likely be any available wood to salvage.

Road-management provisions are designed to address the effects of roads on the recruitment and transport of large wood. The effects of road management are therefore expected to be minor.

7.5.3.10 Conclusion

Stream size and topographic setting strongly influence processes that deliver wood to the channel network (May and Gresswell 2003). In larger alluvial channels the majority of the functional large wood along fish-bearing streams comes from near-stream processes (streambank erosion, wind throw, and near-bank tree mortality), with the remainder coming from channelized landslides or debris flows, and stream-adjacent hillslope landslides (Murphy and Koski 1989; Pollack and Kennard 1998). Riparian buffers adjacent to fish-bearing streams prescribed in the FPHCP are expected to maintain 91 to 100 percent of the potential large wood that originates adjacent to these streams during the 50-year permit term. This percentage would be substantially less along 20-acre exempt parcels bordering fish-bearing streams. In small colluvial channels draining steep hillslopes, processes associated with slope instability can dominate large-wood recruitment.

Due to the portions of many of Type Np or Ns streams without buffers, there will be some reduction in large-wood recruitment to fish-bearing streams. The portions of Np and Ns streams that are left unbuffered will result in a reduction in large-wood recruitment to fish-bearing streams, especially fish-bearing streams nearer headwaters. When debris flows occur, we expect initiation points to provide some wood in most cases. Debris flows will entrain additional wood as they travel downstream. Due to the presence of harvested reaches, a lesser amount of wood would be entrained. Additional wood may also be delivered in the run-out reach in lower segments. Not all debris flows will deliver to fish-bearing streams. When debris flows do deliver to fish-bearing streams, a lesser amount of wood may be delivered

due to riparian timber harvest along Type Np and Ns streams. However, wood delivered through debris flows may be damaged and broken as a result of the transport mechanism and may not be as effective at retaining sediment as larger whole pieces recruited lower in the stream reaches affected by these processes. For instance, wood recruited by debris flows or other mechanisms within the 300 to 500 foot sensitive site at the confluence of Type F and Np streams may be longer and less broken, less transportable by fluvial processes, and may be more important for retaining sediment. Regardless of these considerations, the FWS expects that some negative effects will result for the incremental difference in wood delivered at these points. As a result, at these delivery points and in downstream reaches, there may be fewer deep pools, reduced stability of streambanks, channel widening, and additional bedload movement.

This assessment indicates that the standard prescriptions (and alternate plans) proposed in the FPHCP have a high probability of delivering functional levels of large wood and protecting and restoring fish habitat where buffers are retained. Although the amounts of large wood that would be delivered under the FPHCP would be less than the maximum possible, the amount delivered would approach, or be similar to, the amounts of wood that commonly occur under natural circumstances, or at least the amount that would be available for recruitment with site-potential tree height, no-harvest buffers. There should still be enough large wood recruited for maximum pool formation in most cases. The amount of large wood needed in a stream is not a function of recruitment potential; instead, it is dependent on channel sensitivity to large wood and on the site-specific role that large wood performs. Therefore, it appears that the proposed prescriptions would contribute less than the full large-wood recruitment potential, but an amount likely to be functionally effective for forming fish habitat.

Buffers would be provided along fish-bearing streams and many perennial streams without fish. Potentially unstable slopes would be avoided or managed to maintain a supply of large wood. Alternate plans would also be expected to provide equivalent or improved levels of large-wood recruitment, in comparison to the standard Washington Forest Practices Rules.

Major points in this consideration include: (1) Delineation of CMZs and potential fish habitat, in association with buffers for Type F and S waters will substantially minimize the effects of timber harvest along fish-bearing waters; (2) Reduction of potential large-wood recruitment along harvested sections of Type Np and stable Type Ns streams; (3) Protection of large-wood sources where they appear most needed and at locations where large wood could be most effective (e.g., along fish-bearing streams, and on perennial streams prior to confluence with fish-bearing streams, at confluences with other perennial streams, low-gradient reaches, initiation points, side-slope seeps, etc.); (4) Protection of potentially unstable slopes to maintain large-wood supply should they fail, and to avoid increasing the rate or magnitude of slope failures; (5) Gradual improvement in hydraulic passage of large wood through bridges and culverts; and (6) Reduction in potential large-wood recruitment along fish streams within 20-acre exempt parcels, and retention of only minimal large-wood recruitment along streams without fish within 20-acre exempt parcels.

Therefore, FPHCP should provide an amount of large wood within the natural range of variability, and likely to be effective for forming fish, amphibian, and riparian habitat. Headwater species and habitats would be affected to a greater degree than species and habitats lower in watersheds.

However, fish and amphibians found in association with 20-acre exempt parcels may be exposed to effects due to habitat degradation at a local level. Unless 20-acre exempt parcels are concentrated, we would not anticipate negative effects at a watershed level. Yet, most 20-acre exempt parcels are expected

to occur in and adjacent to areas already exposed to habitat degradation from conversion and development and may occur in local concentrations. In these contexts, 20-acre exempt parcels will not likely contribute substantially to further degradation of habitat conditions, as habitat conditions in many of these areas (e.g., urban and rural residential areas) are already degraded. We expect that proportionately few 20-acre exempt parcels occur in concentrations within the general forest-practices landscape at higher and middle elevations.

7.5.4 Sediment

Sediment is generally divided into two broad categories when its effects are addressed in relationship to the aquatic environment. These are divided based on particle size into the two categories of coarse and fine sediments. Fine sediments are typically described as sand- and silt-sized particles, while coarse sediments are essentially categorized as all larger particle sizes. Sediments are naturally recruited to the aquatic environment through processes collectively referred to as erosion. The three dominant processes of natural sediment recruitment on forestlands are surface erosion, erosion of stream channel boundaries and mass wasting.

Much of the following discussion of baseline conditions, importance of sediments, and the issues surrounding sources, amounts, and function of sediments in streams was adapted from discussions in the Review of the Scientific Foundations of the Forests and Fish Plan (CH2MHill 2000); and the Final EIS for the Forest Practices HCP (USFWS and NMFS 2006).

7.5.4.1 Baseline Summary

Riparian and stream clearing, and the construction of splash dams to facilitate water transport of harvested logs, was common practice in Washington streams (Sedell et al. 1991). Early logging used rivers and streams to transport logs. Trees were often felled directly into streams and rivers and were floated or yarded down these channels to their destinations. Sometimes, logs were pulled to streams and trapped behind splash dams, which were dynamited or pulled away, causing logs and sediment to sluice downstream. Repeated splash damming resulted in major long-term damage to fish habitat as the practice caused severe scouring of stream channels, often down to bedrock (Murphy 1995). With the advent of railroad logging, grades were cleared along large channels, and logs were yarded down the small tributaries to the rail bed which resulted in additional sediment impacts. In this way, impacts extended up to the headwater channels. Whole watersheds were logged as convenience. Logs were yarded downhill, moving debris and sediment into stream channels. Later, trucks and road systems replaced railroads, requiring additional clearing of forest vegetation and frequently resulting in substantial mass wasting and sediment runoff due to construction techniques or the placement of roads on unstable slopes. For more than 100 years, wood was removed from stream channels in the United States to facilitate boat traffic, floating of logs or log drives downstream, for protection of property, bridges, and roadways, and for improving fish migrations (Murphy 1995; Spence et al. 1996). Although forest management practices were improved somewhat by the 1950's, clearcutting to the streambank remained a common practice on fish bearing streams until at least the mid-1970's, and clearcut harvesting of unstable landforms having delivery potential was common until the late 1980's.

These forest activities have significantly altered natural recruitment rates, storage, and transport (routing) of sediments within aquatic systems. Large networks of forest haul roads, skid trails/roads, and yarding corridors now exist in the majority of watersheds. In many watersheds, the road networks are so large that much of it cannot be maintained to current regulatory standards until sometime in the future. Many

of these road networks cross or parallel stream channels, leaving a legacy of problems such as chronic bank erosion, debris flows, chronic delivery of fine sediments, stream channel capture, crossing roadfill washout and slope failures.

According to CH2MHill (2000), there is no systematic assessment of current stream-habitat conditions on forestlands in Washington. Beak (1998) collected data from completed Watershed Analyses including certain types of data that were collected under a defined set of protocols (See Baseline – Large Wood for additional details). In 44 percent of the stream reaches surveyed across Washington State, the substrate quality was rated as fair (12-17 percent fines) to poor condition (>17 percent fines). Results were poorer for eastern Washington than for western Washington (Beak 1998). This may be a result of a higher proportion of weathered granitics and ash-derived soils on the east side. However, the results of the Beak review should be used with caution, because they do not reflect a statistically sound or unbiased monitoring program.

Over short time scales (i.e., a few years to a few decades), landscapes may appear static and tranquil. However, sediment budgets have consistently shown that mass wasting (e.g., shallow and deep landslides, debris flows, and earthflows) is a major source of sediment to stream channels in the Pacific Northwest in managed and unmanaged basins (Dietrich and Dunne 1978; Reid 1981; Swanson et al. 1982; Lehre 1982; Roberts and Church 1986; Benda and Dunne 1987 cited in CH2MHill 2000).

Over longer time periods (i.e., decades to centuries), periodic fires and windstorms create a changing mosaic of vegetation (Spies and Franklin 1988; Agee 1993 cited in CH2MHill 2000). Wildfires, which were an important part of most landscapes in the region prior to European settlement (Agee 1993 cited in CH2MHill 2000), probably played an important role in triggering episodes of increased landsliding (Benda et al. 1998 cited in CH2MHill 2000). Wildfires are presently suppressed in the region, and suppression has resulted in significantly fewer large fires (Agee and Flewelling 1983 cited in CH2MHill 2000). Infrequent large storms, sometimes occurring in conjunction with wildfires, trigger mass wasting, sheetwash, and gullying (the latter two surface erosion processes being more prevalent in eastern Washington). Episodic cycles of increased erosion followed by a relatively quiescent recovery period is characteristic of many landscapes in the Pacific Northwest region, including eastern Washington (Klock and Helvey 1976 cited in CH2MHill 2000), the more humid portions of the Cascade mountains (Swanson et al. 1982 cited in CH2MHill 2000), and the Pacific coastal rainforests (Dietrich and Dunne 1978; Benda et al. 1998 cited in CH2MHill 2000).

7.5.4.2 Importance of Sediment

Overview

Coarse sediment is an important component of aquatic habitats. It creates channel complexity and physical structure (cover), and provides substrate for spawning and the development of a hyporheic zone. It comprises the streambed and governs channel morphology (cross sectional shape, planform pattern, and longitudinal profile) in segments of the stream system most biologically important to salmonid fishes. The streambed substrate characteristics, including particle size distribution, bedforms, and the frequency, magnitude and depth of sediment mobility, depend on the watershed flow regime (pattern, duration and magnitude of peak flows), the modes and source characteristics of sediment input, and interactions with large wood and other hydraulic roughness elements that retain sediment. Thus, the response of a channel to an altered coarse sediment input regime may depend on its initial condition, reflecting the timing since the last episodic sediment input, presence or absence of chronic sediment sources, legacy of past

management actions (e.g., removal of large wood, channel destabilization by streambed or riparian disturbance, etc.), and watershed hydrologic condition. For example, a landslide delivering coarse debris to a channel with a low supply of sediment and wood (e.g., a bedrock channel) may bring about the return of mobile, alluvial streambed features and habitat complexity, provided the channel can retain these deposits. Such retention is more likely if the deposits contain large wood in the mix, since bedrock channels tend to be hydraulically smooth and thus non-retentive. On the other hand, landslide deposits delivered to a sediment-rich channel may result in aggradation (increase in streambed elevation) with associated channel destabilization (e.g., accelerated bank erosion or avulsion), shifts in channel type (such as evolution into a braided reach), increase in streambed mobility and scour, a decrease in average grain size of the channel bed, and a decrease in bed porosity and permeability. Episodic large-scale sediment input such as from landslides initiates a cycle of recovery towards pre-disturbance conditions which may take a decade or more. Alteration of the frequency of mass wasting thus shifts the stream morphology and substrate characteristics towards earlier phases in this recovery cycle.

In cases where sediment supply is very low, a streambed consisting of coarse, seldomly-mobile particles may develop. Such channels tend to form poor spawning habitat. Channel complexity created by obstructions such as large woody debris, boulders, channel meanders, and bedrock outcrops dissipates hydraulic energy, thus increasing the sediment retentiveness of the system. This allows stable depositional features to develop and plays a key role in the formation of clean, well-sorted gravel deposits. There is an equilibrium between sediment input and sediment routing that must be maintained to have a geomorphically stable stream system, conducive to salmonid productivity and healthy riparian-aquatic interactions (Everest et al. 1987 as cited in FPHCP).

Fine sediment typically has negative impacts to the aquatic environment either while suspended (turbidity) or when deposited (siltation). Siltation and turbidity adversely affect fish at every stage of their life cycle (Iwamoto et al. 1978 cited in Spence et al. 1996). In streams, turbidity is usually a result of suspended particles of silts and clay, but may also include organic matter, colored organic compounds, plankton, and microorganisms. Suspended sediment is the portion of the sediment load suspended in the water column. The grain size of suspended sediment is usually less than 1 to 2 mm (Sullivan et al. 1987); however most suspended sediment in typical streams is probably less than 0.5 mm in diameter. Ecological effects of increased turbidity may include a decrease in primary productivity of algae and periphyton due to the decrease in light penetration. Declines in primary productivity can adversely affect the productivity of higher trophic levels such as macroinvertebrates and fish (Gregory et al. 1987).

If present in amounts large enough to dominate the streambed composition, fine sediment in the sand particle size classes (0.0625 – 2 mm) can dissipate stream energy through bed-form roughness (dunes, ripples) and the effects of suspended sediment in transport on increased effective dynamic viscosity. In sufficient volumes, fine sediment can cause channel shoaling, further reducing sediment transport capacity and channel competence. Fine sediment is an important component of overbank deposition, and thus is essential in floodplain development processes and riparian zone dynamics (CH2MHill 2000). Fine sediment may also bind with some particulates and dissolved chemical solids that are harmful to salmonids. However, this reduction in water-column bioavailability is counteracted by increased concentrations in the bed sediments, which are subject to periodic re-mobilization during scour events. Organisms dwelling within interstitial gravels, including salmonid eggs and juvenile stages, may be disproportionately exposed to toxic sediments. The toxicity of some dissolved chemicals may increase because of interactions with suspended sediments (Spence et al. 1996). In general, deposited sediments tend to have a greater overall impact on fish than do suspended sediments, with spawning and incubation

habitats being the most directly affected (Spence et al. 1996). However, suspended sediment can settle out of suspension in the water column and become part of the bedload (i.e., sediment carried along the bed of the stream). Fine sediments are recruited to aquatic systems through the same processes as coarse sediments, but are more easily recruited through surface erosion (such as road wash, rilling and gullying) than are coarse sediments.

High concentrations of suspended sediments may physically abrade and mechanically disrupt respiratory structures (e.g., fish gills) or surfaces (e.g., respiratory epithelia of benthic macroinvertebrates), modify or delay migration in fish, and impair foraging behavior (Spence et al. 1996). Potential sublethal effects of chronic suspended sediment to fish include reduced growth rate, greater susceptibility to disease, and reduced competitive ability for space and food with larger cohorts (Everest et al. 1987).

Siltation results when fine sediments settle out of suspension, cover intergravel crevices, and fill flow pathways within the gravel layers. This may degrade or reduce the amount of available spawning habitat for fish by embedding spawning substrates; reduce fry and embryo survival by entrapping eggs within the streambed and reducing intergravel flow and oxygen availability; decrease carrying capacity of streams by eliminating interstitial spaces used as shelter (cover) and foraging habitat by juvenile fish and amphibians; reduce or eliminate available forage base by filling habitats required by macroinvertebrates; and reduce the quality of pool habitats by filling pools (Everest et al. 1987; Spence et al 1996).

Role of Sediment in Aquatic Habitat Formation

Sediment, especially coarse sediment, is an important component of aquatic habitats. It both directly and indirectly creates habitat used by fish, amphibians, and their prey. The level of habitat use is ultimately influenced by the composition, quantity, and distribution of these sediments within the waterbody. Fish require sufficient substrate (e.g., gravel, sand, cobbles) of the appropriate size and mixture for spawning and rearing, but this varies among species.

Generally, coarse sediments play a key role in forming interstitial spaces which are used as concealment from predators, shelter from fast currents, and habitat for foraging (Bjornn and Reiser 1991; Spence et al. 1996). Populations of tailed frogs can be severely reduced or eliminated by increased sediment (Corn and Bury 1989; Welsh 1990) presumably because of their dependence on unembedded interstitial areas in the stream substrate where they hide and overwinter (Daugherty and Sheldon 1982a; Brown 1975). Coarse substrates are also used by a variety of fish for spawning. Fish may use coarse substrates to bury their eggs (e.g., lamprey, salmon, and trout), broadcast their eggs over (e.g., mountain whitefish), or as a surface to lay there eggs upon (e.g., sculpins and dace) (Wydowski and Whitney 2003).

Sediments that are delivered to the stream channel also work in combination with natural geomorphic features, flowing water, riparian vegetation, and large wood to create habitat structure (Spence et al. 1996). This structure is composed of macro- and microhabitat attributes that are used by fish (especially salmonids) at various stages of their life history. Macro-habitat features include pools, glides, and riffles, while microhabitat attributes include feature characteristics such as substrate type, cover, depth, hydraulic complexity, and current velocity.

At the watershed or landscape scale, coarse sediments enter the aquatic system mainly through mass wasting processes and erosion of stream-adjacent unconsolidated deposits such as terraces. The long-term budget of coarse sediment input is governed by the spatial patterns and density of mass wasting and debris flows, their frequency of occurrence and timing, and the nature of the sediment and wood involved (e.g., particle and wood size distribution, rock and soil type). This coarse sediment input is then routed

through the fluvial system, stored in various places in the system (e.g., floodplains, terraces, and alluvial fans), and eventually weathered and abraded to finer particles which become deposited and stored in long-term accumulations such as coastal valley floodplains, depositional fans, deltas and estuarine mudflats over geologically-significant time scales. A long-term sediment budget exists, which determines the overall system characteristics (e.g., source, transport, and depositional response zones), as well as the channel morphology of river segments. Reach morphology (channel form, pattern, profile and streambed texture) adjusts to create a quasi-equilibrium between sediment input, output and storage over intermediate time scales (e.g., years to decades).

Landslides and debris flows represent episodic disturbances which are followed by recovery of quasi-equilibrium conditions over years to decades or even centuries. The rate and form of the recovery process depends on factors such as the timing and magnitude of peak flows and the abundance and persistence of large wood. Increases or decreases in the frequency or magnitude of episodic mass wasting alters this recovery cycle, pushing the system towards either an earlier or later phase in the process, respectively. Early phases are characterized by sediment-rich systems with greater rates of channel migration and evolution. Later phases are more coarse-sediment poor, with lower rates of channel migration and stable channel types. Thus, long-term patterns of mass wasting on a landscape scale create a cumulative morphologic legacy of coarse sediment deposits which dictate the types, diversity, and distribution of many of the channel and riparian environments found within watersheds (Swanson et al. 1988; Benda et al. 1998 cited in CH2MHill 2000).

Mechanism of Recruitment

In forested mountain basins, sediment enters stream channels from natural mass-wasting events (landslides and debris torrents), channel bank erosion (including localized mass wasting), surface erosion, and soil creep. Channel bank erosion, surface erosion, and soil creep tend to occur regularly, as a part of ongoing erosion processes, whereas landslides and debris torrents are more episodic in nature, and tend to occur during rain-on-snow and extreme rainfall events.

Mass Wasting: Across much of the landscape, mass wasting is the principal mechanism by which coarse sediment enters stream channels, when viewed over long temporal scales. Mass wasting can be classified into several processes according to the mechanism of movement (flowing versus sliding), the temporal behavior (slow and continuous versus rapid and discontinuous), and the type of material involved (Schuster and Krizek 1988; Easterbrook 1993). In the Pacific Northwest, it is common to classify mass wasting as shallow-rapid landslides (including debris flows), and deep-seated landslides and earthflows (CH2MHill, 2000).

Landslides and debris flows have an extremely low probability of occurrence at any particular site or point in time, but over a broad landscape (i.e., areas more than 200 km^2) they are more common, and their pattern and frequency are related to lithology and geomorphology. The rate of landsliding can be considered for a single site, referred to as a recurrence interval, or a rate can be described for a specific area containing a population of slide areas (e.g., number/area/time). Along with topography, lithology, and geomorphic position, vegetation, and climate cause landslide rates to vary across the region (Benda and Dunne 1997 cited in CH2MHill 2000). Landsliding cannot be represented as a single rate, but only as a distribution of rates, with each landslide rate (number of slides per specified time period per area) associated with a particular likelihood or probability of occurrence (Benda and Dunne 1997 cited in CH2MHill 2000).

Surface Erosion: Surface erosion and fine sediment delivery to streams are natural processes that occur to various degrees in every watershed. As described in the Review of the Scientific Foundations of the Forests and Fish Plan (CH2MHill 2000), surface erosion can be differentiated into two component processes (fine sediment generation and fine sediment transport), both discussed below in more detail.

Fine Sediment Generation. The potential for surface erosion is a function of climate, topography, vegetation, and other organic cover and soil characteristics. Fine sediment can be generated naturally from on-site processes, such as physical and chemical weathering of rocks and bedrock. Raindrop splash, expansion and contraction of soil from freeze and thaw cycles, wind, and overland flow can detach soil particles. Loss of vegetation or organic duff from fire or ground disturbance can increase surface erosion. Finally, the effects of all of these causes of surface erosion are more pronounced on steep slopes, on bare managed surfaces such as roadbeds and fill, and wherever local microtopography allows water to concentrate into rills or channels (also see **Soil Compaction** section).

Fine Sediment Transport. Fine sediment can be transported off-site by wind (e.g., volcanic ash) or surface water runoff (e.g., seeps, rills, gullies, and streams). Most undisturbed forest soils in Washington State have little potential for sediment transport by surface water because runoff is deterred by a thick, protective layer of organic material (duff layer), relatively low intensity rainfall, and relatively high soil infiltration rates (Bennett 1982; Dunne and Leopold 1978 cited in CH2MHill 2000). In forested environments, ground surface disturbances from natural events such as wildfire can increase the potential for surface erosion and delivery of fine sediment to streams (Swanson 1981 cited in CH2MHill 2000). Where human activities leave soils bare, rills can develop and transport fine sediments in places where compaction has reduced infiltration capacity or where saturation develops due to subsurface water originating upslope.

Erosion of Stream Channel Boundaries: Streambank erosion and avulsion associated with channel migration dynamics is another important source of fine and coarse sediments. The rate of bank erosion can vary depending on a number of factors including flood discharge, soil saturation, bank material type and stratification, and vegetation type, density and maturity. Most bank erosion occurs during larger floods where saturated soils are easily washed away. More-cohesive soil types and soil containing a healthy root network of riparian trees will have reduced rates of bank erosion (Hooke 1980 cited in CH2MHill 2000). Channel incision can increase bank erosion rates by concentrating hydraulic forces within the channel boundaries and creating bank heights greater than soil stability thresholds. Aggradation can result in rapid channel migration rates, also increasing bank erosion. Erosion of the edges of high terraces, particularly glacial deposits, is a major source of sediment to some stream reaches.

Where geomorphic instability occurs, streambank erosion can temporarily overshadow other sediment sources. However, accelerated streambank erosion is unsustainable over long time periods, resulting in shifts in channel type (morphology) which tend to restore sediment equilibrium over years to decades. In the geomorphic sense, streambank erosion represents a re-mobilization of sediment in storage.

Transport and Storage of Sediments within Streams

The timing, frequency, and type of precipitation influence the hydrologic patterns, which in turn govern the rate at which sediment is mobilized, transported and deposited within streams. Topography (slope steepness, length, elevation, and aspect) further influences runoff energy, which determines the volume and velocity of water moving downslope and the energy it has to transport coarse sediments downstream. Stream gradient and retentive in-channel structures are also important in determining whether sediments are deposited locally or transported further downstream (Spence et al. 1996). Any sediment not too

coarse in particle size to be mobilized by a stream would be routed downstream over a time period that depends on the system. Instream features such as large boulders and large woody debris result in complex velocity and depositional patterns, creating pools and riffles, scour and fill zones, coarse-sediment bedforms and undercut banks. Woody debris-dams buffer downstream reaches from rapid changes in sediment loading. Large woody debris also retains coarse sediments that are essential for spawning salmonids (Spence et al. 1996).

Large pulses of sediment can be be propagated downstream over a temporal scale of years to decades. Recent studies have shown that these sediment pulses take the form of a wedge, lengthening and thinning as it translates downstream over time (Cui et al. 2003). Sediment pulses create associated changes in channel form and bed texture (Miller and Benda 2000). The onset of a sediment wave may result in aggradation and braiding of the channel, reduction in average grain size of sediment making up the surface of the channel bed, and burial of riparian zones. The pulse's passage may leave a channel incised to a coarse, immobile bed (lag deposit) inset between terraces cut by numerous, shallow side channels.

Fine-sediment transport and deposition within streams can be extremely variable. Some silt and smaller-sized particles are rapidly transported downstream as suspended sediment. However, some become embedded on and within the streambed gravels. Once fine sediments are drawn into inter-gravel-flow pathways, they readily settle out. These embedded fines are typically routed on though the system only by scour and fill events that cause major streambed disruption. These are generally the larger peak-flow events (i.e., those greater than bankfull discharge). Sand-sized particles can also be transported during a flood event. As a flood recedes, sand, along with some finer material, is deposited on floodplains and channels where still water occurs (e.g., in the bottoms of pools in low-gradient reaches and in side channel and slough environments). Larger woody debris-dams store fine sediment and organic materials, reducing their rate of transport downstream (see additional discussion on sediment storage under **Wood** section).

7.5.4.3 Classification of Sediment Effects to Aquatic Species and Habitats

Specific effects of sediment on fish and their habitat can be put into three classes that include (Newcombe and MacDonald 1991; Waters 1995; Bash et al. 2001):

Lethal: Direct mortality to any life stage, reduction in egg-to-fry survival, and loss of spawning or rearing habitat. These effects damage the capacity of the ecosystem to produce fish and future populations.

Sublethal: Reduction in feeding and growth rates, decrease in habitat quality, reduced tolerance to disease and toxicants, respiratory impairment, and physiological stress. While not leading to immediate death, may produce mortalities and population decline over time.

Behavioral: Avoidance and distribution, homing and migration, and foraging and predation. Behavioral effects change the activity patterns or alter the kinds of activity usually associated with an unperturbed environment. Behavior effects may lead to immediate death or population decline or mortality over time.

Aquatic systems are complex interactive systems, and isolating the effects of sediment on fish is difficult (Castro and Reckendorf 1995). Environmental factors affecting direct sedimentation impacts on salmonids include duration of exposure, frequency of exposure, toxicity, temperature, life stage of fish,

angularity and size of particle, severity/magnitude of pulse, time of occurrence, general condition of biota, and availability of and access to refugia (Bash et al. 2001). The difficulty in determining which environmental variables act as limiting factors has made it difficult to establish the specific effects of sediment impacts on fish (Chapman 1988). For example, reduction in suitable spawning habitat as a result of excess fines in the spawning gravels may not lead to smaller populations of adults if the amount of naturally occurring juvenile winter habitat limits the number of juveniles that reach adulthood. Often there are multiple independent variables with complex inter-relationships that can influence population size. For some species of fish, it has been suggested that there is no threshold below which exacerbation of fine-sediment delivery and storage in gravel bedded rivers will be harmless (Rieman and McIntyre 1993; Suttle 1995).

Direct Effects

Gill Trauma: High levels of suspended sediment and turbidity can cause fish mortality by damaging and clogging gills. Fish gills are delicate and easily damaged by abrasive silt particles (Bash et al. 2001). As sediment begins to accumulate in the gill filaments, fish excessively open and close their gills to expunge the silt. If irritation continues, mucus is produced to protect the gill surface, which may impede the circulation of water over the gills and interfere with fish respiration (Bash et al. 2001). Gill flaring or coughing abruptly changes buccal cavity pressure and is a means of clearing the buccal cavity of sediment. Gill sediment accumulation may result when fish become too fatigued to continue clearing particles via the cough reflex (Servizi and Martens 1991).

Spawning, Redds, Eggs, and Alevins: The effects of suspended sediment deposited in a redd may include reduction in water flow, smothering of eggs or alevins, and/or impeding fry emergence. These effects are related to sediment particle sizes of the spawning habitat (Bjornn and Reiser 1991). Sediment particle size determines the pore openings in the redd gravel. With small pore openings, more suspended sediments are deposited and water flow is reduced compared to large pore openings.

Egg survival depends on a continuous supply of well-oxygenated water through the streambed gravels (Cederholm and Reid 1987). Eggs and alevins are generally more susceptible than adults to stress from suspended solids. Accelerated sedimentation can reduce the flow of water and, therefore, oxygen to eggs and alevins which can decrease egg survival, decrease fry emergence rates (Cederholm and Reid 1987; Chapman 1988; Bash et al. 2001), delay development of alevins (Everest et al. 1987), reduce growth, and cause premature hatching and emergence (Birtwell 1999). Fry delayed in their timing of emergence are less able to compete for environmental resources than other fish that have undergone normal development and emergence (intra- or interspecific competition) (Everest et al. 1987).

For example, several studies have documented that fine sediment can reduce the reproductive success of salmonids. Natural egg-to-fry survival of coho salmon, sockeye salmon and kokanee has been measured at 23 percent, 23 percent, and 12 percent, respectively (Slaney et al. 1977). Substrates containing 20 percent fines can reduce emergence success by 30-40 percent (MacDonald et al. 1991). A decrease of 30 percent in mean egg-to-fry survival can be expected to reduce salmonid fry production to extremely low levels (Slaney et al. 1977).

Individuals: Resultant large influxes of sediment (both coarse and fine) into streams has the potential for direct fish kills through burial, an increase in the potential for dam-break floods (Coho and Burges 1993), and influx of excess fine sediment (Beschta 1981). Fish species (e.g., cottids) that dwell within or close to the substrate are more likely to be buried by large influxes of sediment.

Indirect Effects

Macroinvertebrates: Turbidity and suspended solids can affect macroinvertebrates in multiple ways through increased invertebrate drift, feeding impacts, respiratory problems, and loss of habitat (Cederholm and Reid 1987). Certain groups of macroinvertebrates are favored by salmonids as food items. These include mayflies, caddisflies, and stoneflies. These species prefer large substrate particles in riffles and are negatively affected by fine sediment (Everest et al. 1987; Waters 1995).

The effect of light reduction from turbidity has been well documented and results in increased invertebrate drift (Waters 1995; Birtwell 1999). This may be a behavioral response associated with the night-active diel drift patterns of macroinvertebrates. While increased turbidity results in increased macroinvertebrate drift, it is thought that the overall invertebrate populations would not fall below the point of severe depletion (Waters 1995). Increased turbidity due to suspended sediments may also include a decrease in primary productivity of algae and periphyton due to a decrease in light penetration. Declines in primary production can adversely affect the productivity of higher trophic levels such as macroinvertebrates and fish (Gregory et al. 1987), as well as amphibians.

Increased suspended sediment can affect macroinvertebrates by abrasion of respiratory surface and interference with food uptake for filter-feeders (Birtwell 1999). Increased suspended sediment levels tend to clog feeding structures and reduce feeding efficiencies, which results in reduced growth rates, increased stress, or death of the invertebrates (Newcombe and MacDonald 1991). Invertebrates living in the substrate are also subject to scouring or abrasion which can damage respiratory organs (Bash et al. 2001).

Benthic invertebrates inhabit the stream bottom. Therefore, any modification of the streambed by deposited sediment will most likely have a profound effect upon the benthic invertebrate community (Waters 1995). Increased sediment can affect macroinvertebrate habitat by filling of interstitial space and rendering attachment sites unsuitable. This may cause invertebrates to seek a more-favorable habitat (Rosenberg and Snow 1975). The degree to which substrate particles are surrounded by fine material was found to have a strong correlation with macroinvertebrate abundance and composition (Birtwell 1999). Increased fines can shift invertebrate assemblages from available prey organisms to unavailable burrowing taxa, lowering food availability for salmonids (Suttle et al. 2005). At an embeddedness of one-third, insect abundance can decline by about 50 percent, especially for riffle-inhabiting taxa (Waters 1995).

Feeding Efficiency: Increased turbidity and suspended sediment can affect a number of factors related to the feeding efficiencies of salmonids, including feeding rates, reaction distance, and prey selection (Bash et al. 2001). Changes in feeding behavior are primarily related to the reduction in visibility that occurs in turbid water. Effects on feeding ability and prey availability are important as salmonids must meet energy demands to compete with other fishes for resources and to avoid predators.

Distance of prey capture and prey capture success both were found to decrease significantly when turbidity was increased (Berg and Northcote 1985). Waters (1995) states that the loss of visual capability, leading to reduced feeding, is one of the major sublethal effects of high suspended sediment. Increases in turbidity was reported to decrease the percentage of prey captured (Bash et al. 2001). At 0 NTUs, 100 percent of the prey items were consumed; at 10 NTUs, fish frequently were unable to capture prey species; at 60 NTUs, only 35 percent of the prey items were captured. At 20 to 60 NTUs, significant delay in the response of fish to prey was observed. Loss of visual capability and the ability to capture of prey leads to depressed growth and reproductive capability. While most effects of elevated suspended

sediment (or turbidity) are negative, in some cases turbidity can enhance juvenile fish cover from predatory fish (Gregory and Levings 1998).

Sigler et al. (1984) found that a reduction in growth occurred in steelhead and coho salmon when turbidity was as little as 25 NTUs. The slower growth was presumed to be from a reduced ability to feed; however, more-complex mechanisms such as the quality of light may also affect feeding success rates. Redding et al. (1987) found that suspended sediment may inhibit normal feeding activity, as a result of a loss of visual ability or as an indirect consequence of increased stress. Suttle et al. (2005) found that juvenile steelhead growth declined steeply and generally linearly with increasing concentrations of fine-sediment in habitat substrates, which was consistent with the effects they observed of sedimentation on macroinvertebrate prey availability.

Physiological Effects: Sublethal levels of suspended sediment may cause undue physiological stress on fish, which may reduce the ability of the fish to perform vital functions (Cederholm and Reid 1987). At the individual fish level, stress may affect physiological systems, reduce growth, increase disease, and reduce its ability to tolerate additional stress (Bash et al. 2001). At the population level, the effects of stress may include reduced spawning success, increased larval mortality, and reduced recruitment to succeeding life stages resulting in overall population declines (Bash et al. 2001).

Tolerance to suspended sediment may be the net result of a combination of physical and physiological factors related to oxygen availability and uptake by fish (Servizi and Martens 1991). The energy needed to perform repeated coughing (see Gill trauma section) increases metabolic oxygen demand. Metabolic oxygen demand is related to water temperature. As temperatures increase, so does metabolic oxygen demand, but concentrations of oxygen available in the water decreases. Therefore the fish's tolerance to suspended sediment may be primarily related to the capacity of the fish to perform work associated with the cough reflex. However, as sediment increases, fish have less capability to do work, and therefore less tolerance for suspended sediment (Serizi and Martens 1991).

Turbidity can adversely affect fishes at every stage of their life cycle. Auld and Schubel (1978) found that larval survival in American shad (*Alossa sappidissima*), a clupeid fish, was reduced under conditions of elevated suspended sediment, but hatching was not. Redding *el al*. (1987) observed higher mortality in young steelhead trout exposed to a combination of suspended sediment (2500 mg/l) and a bacteria pathogen, than when exposed to the bacteria alone. Physiological stress in fishes may decrease immunological competence, growth, and reproductive success (Bash et al. 2001).

Behavioral Effects: Increased turbidity and suspended sediment may result in behavior changes in salmonids. This may include changes in avoidance, distribution, homing, and migration. Many behavioral effects result from changes in stream habitat. As suspended sediment concentration increases, habitat may be degraded which results in abandonment and avoidance of previously preferred habitat. Stream-reach emigration is a bioenergetic demand that may affect the growth or reproductive success of the individual fish (Bash et al. 2001). Pulses of sediment result in downstream migration of fish, which disrupts social structures, and causes downstream displacement of other fish (McLeay et al. 1987; Bash et al. 2001). Loss of territoriality and the breakdown of social structure can lead to secondary effects of decreased growth and feed rates, which may lead to mortality (Berg and Northcote 1985; Bash et al. 2001).

High turbidity may delay migration back to spawning sites, although turbidity alone does not seem to affect homing (Murphy 1995). Delays in spawning migration and associated energy expenditure may reduce spawning success and, therefore, population size (Bash et al. 2001).

Habitat Effects: High inputs of both coarse and fine sediments to aquatic habitats will lead to aggradation within streams. When substantial erosion occurs in a watershed, pool habitats diminish by aggradation (net accumulation of sediment on the streambed) (Madej 1984). Increases in sediment supply from mass movements or surface erosion, bank destabilization, or in-stream storage losses can cause aggradation, pool filling, and a reduction in gravel quality. Typically, if sediment delivery to the channel is increased, it is expected that the channel would become wider, shallower, and less stable (Spence et al. 1996). Aggradation often triggers a shift in channel type, as from a single-thread to a braided type, or from a relatively straight plane-bed system with few bars to a deposit-rich pool-riffle system with high channel migration rates (Thorne, 1997). Such changes can be unstable, evolving rapidly as the system recovers.

Increases in sediment supply to the channel can have a major influence on in-stream biological conditions. For instance, increased sediment supply can result in reduced fish rearing and overwintering habitats (loss of pools and undercut bank areas), decreased juvenile fish survival and smolt production, and impaired spawning and incubation environments (degraded riffle sites) (Waters 1995). It may also result in modification of habitats to such an extent as to be no longer used by some fish species. For example, cottids typically require well-oxygenated rubble to rubble-gravel substrate and are absent or rare in areas where fine-grained substrate or highly embedded cobble substrate predominate (Mebane et al. 2003). The Pacific, river, and brook lampreys, in their larval stage (ammocoetes), prefer small substrates in coldwater streams for rearing such as mud and fine-silt deposits (Kostow 2002; Moyle 2002; Wydoski and Whitney 2003). These conditions are generally located in backwaters and quiet eddies along the banks of streams and rivers (Wydoski and Whitney 2003). Although typically associated with fine sediments, lamprey do require gravel habitats (for spawning) as adults, and pool habitats as ammocoetes (rearing) and as adults (overwintering) (Kostow 2002; Wydoski and Whitney 2003). Torgersen and Close (2004) found that larvae selected pools over riffles because the morphology of pool margins was more conducive to sediment deposition than riffle margins. Native fish species within the region have evolved with a range of sediment conditions (i.e., different habitats). Therefore, they and their habitats are best conserved in freshwater environments by supporting the natural occurring levels of sediment input, transport, delivery, and storage.

Although large inputs of sediment (e.g., mass-wasting events) represent disturbances that have negative impacts on aquatic habitats, new channel habitats and riparian plant communities are established as the system recovers from the disturbance by transporting and sorting the deposits, and as the channel evolves into a stable morphology. Episodic, large disturbances of this nature initiate a cycle of recovery towards pre-disturbance conditions which may take a decade or more. Increasing the frequency of mass wasting thus shifts the stream morphology and substrate characteristics towards earlier phases in this recovery cycle. These earlier phases are generally characterized by sediment-rich channels, less channel stability, and finer substrates. However, the natural disturbance regime, which included mass wasting events, is responsible for the mosaic of habitat types to which the aquatic species are adapted, and for the continued functioning of processes which maintain the channel morphology and streambed characteristics.

Regardless of the source, past management-related mass wasting has caused persistent changes to stream habitats throughout the Pacific Northwest. Reeves et al. (1995, as cited in NMFS 2005a) observed that the frequency and pattern of watershed disturbances (e.g., mass wasting with large wood) strongly influenced the quality and distribution of salmonid habitat on the Oregon Coast. While channelized landslides cause short-term adverse changes in aquatic habitats, and many stream channels have segments that receive excessive sediments or scour, some streams would become sites of good-quality habitat as

landslide-deposited boulders and wood become stable channel features and mobile sediments were processed by peak flows.

In estuarine and marine waters, substrate grain-size has been shown to be a determining factor in habitat selection by a variety of species that are either covered by the FPHCP, or are similar to those that are covered (Becker 1988; Howell et al. 1999; McConnaughey and Smith 2000; Stein et al. 2004). Storm-induced siltation of a previously-sandy lagoon in California has been blamed for the significant reduction in numbers of shiner surfperch (Onuf and Quamment 1983). Spawning habitat for surfsmelt and sandlance is particularly vulnerable. These species utilize sandy/gravelly upper intertidal beaches for spawning (Pentilla 1997) and could be susceptible to degradation should large amounts of fine sediment be delivered to these beaches. Upstream sources of sediment are controlling factors for accretion or erosion in the estuary. Excess sedimentation can result from timber harvest in the catchment (Levings and Northcote 2004). Therefore, a range of potential impacts to the habitat of covered species in the estuarine and marine waters from sediment delivered by mass-wasting events is possible. These changes include increased rates of sedimentation leading to reduced rearing capacity (Tschaplinski 1987) and changes in grain-size composition in areas where some covered species spawn and rear.

7.5.4.4 Effects of the Proposed Action on Sediment Resource

FPHCP Effects on Sediment

Covered activities under the FPHCP that are expected to generate sediment that could directly and indirectly affect aquatic life as described above, can be grouped into one of two general categories. These categories include 1) riparian timber-harvest activities, and 2) road system management (i.e., construction, upgrading, maintenance, and abandonment activities). In watersheds containing potentially unstable slopes, some increase in the frequency of slope failures due to timber harvest is anticipated. Slope failure, although dependent on soil conditions, lithology, slope angle and geomorphic position, is generally initiated by elevated pore-water pressures in the soil during storm events. Timber harvest can result in a short-term increase in soil moisture due to reduced evapotranspiration and interception. This may result in an earlier and later persistence of soil water conditions conducive to slope failure during which storms could trigger a failure event. Soil condition during the rainy season would likely be unaffected.

Mass wasting can be an effect of forestry when unstable areas are not properly identified or categorized (e.g., likelihood of delivery). Some portion of such events may occur from outside the channel system, and some portion of those events may deliver to Type Np or F streams. The Services believe that those features likely to be misidentified are those smaller in size and less apparent. Where accidental misidentification of features is likely, we are analyzing those possibilities including the adverse effects that would emanate from such misidentification. We believe larger, more obvious features, with a high probability of delivery to public resources, are less likely to be misidentified. Mass wasting events are controlled by multiple factors, and we also note that uncertainties concerning causal mechanisms make it difficult to attribute these events to a specific FPHCP activity. When such events would occur, it is generally difficult to attribute specific adverse effects that rise to the level of harm to such events.

In addition, potentially unstable landforms may not be avoided during harvest if the delivery zone is predicted to lie outside of typed streams. These predictions can sometimes be erroneous, as they are made without the benefit of a geotechnical report or SEPA review. Thus, some opportunities to reduce mass wasting hazard or reduce potential resource impacts are missed if mass wasting should exceed

anticipated runout distance or severity. The degree to which these unanticipated effects occur is not expected to change as a result of the FPHCP.

Riparian Timber Harvest: Timber-harvest activities in the Riparian Zone can cause soil erosion and can cause sediment generation, mobilization, and delivery. Timber harvest and associated activities such as yarding can be a significant source of sediment if improperly conducted. Rashin et al. (1999) identified several timber harvest activities permitted by the State of Washington's previous forest practices rules that contributed significant amounts of sediment to adjacent streams. Riparian buffers of at least 10 meters, 10-meter equipment-exclusion zones (no ground disturbing activity except directional tree falling), and directional falling of trees away from typed water are all measures identified by Rashin et al. (1991) as effective means to avoid chronic sediment delivery and direct disturbance of streams from harvested-related erosion. The FPHCP protective measures are designed to minimize soil disturbance, reduce the potential for erosion, and minimize the amount of sediments reaching typed streams and wetlands where it could be harmful to fish and fish habitat. Generally, the amount of sediment created from riparian timber-harvest activities is related to the amount of bare and compacted soils exposed to rainfall and runoff, and the degree to which streambank disturbance or loss or footing strength affects bank stability. Measures in the FPHCP that regulate aforementioned timber harvest practices are designed to minimize the amount of exposed and compacted soils (see additional discuss in **Soil Compaction** section) close to the stream channel or wetlands. In addition, the FPHCP includes measures to regulate timber harvesting on all high-hazard unstable-slopes. However, even with these minimization measures in place, sediment is expected to be generated by timber harvest activities and will enter streams in a number of cases. This is a result of entries by equipment into riparian zones and ELZs, equipment crossing Type Np and Ns streams, partial suspension yarding across Type Np and Ns streams, and harvest within 10-meters of Type Np and Ns streams. Occasional failure to detect and appropriately regulate high-hazard unstable slopes, and naturally occurring slope failures, are addressed within the baseline and cumulative effects sections.

Under the FPHCP, there would be no timber harvest within the Core Zone of fishbearing streams, and the post-harvest Inner Zone must meet Desired Future Condition as well as specified retention levels, which would limit the amount of ground disturbance and vegetation removal near streams. Substantial removal of trees is permitted from within the Outer Zone and beyond, but this is an area of the buffer where the probability of delivery of sediment is less, as long as core and Inner Zone buffer strips remain in place. Riparian protection is extended from the outer edge of channel migration zones associated with fish-bearing streams. This ensures that as streams actively move within valleys due to natural processes, riparian buffer areas are retained to prevent sediment generated from harvest-related ground disturbance and forest roads from entering streams. Riparian prescriptions on Type S and F streams are thought to be adequate to prevent excessive (above natural levels) amounts of streambank erosion that could increase the amount of sediment delivery downstream. Trees in the 50 foot (westside) and the 30 foot (eastside) no-harvest Core Zone of Type S and F streams and along the buffered portions of Type Np streams are intended to provide the majority of stability to stream banks. According to FEMAT (1993), trees within one-third of a tree height from the channel provide the rooting strength important for maintaining the integrity of the streambank. In most instances, all buffered portions of typed streams meet or exceed this criterion (see **Streambank Stability**).

Timber harvest within Type S and F stream buffers under alternate plans is expected to provide similar levels of protection for aquatic habitats. Due to the "equal in overall effectiveness" constraints of Alternate Plans, it is expected that the impacts to the aquatic and riparian environment would be

essentially the same or less than what would occur under the standard rules. No significant or measurable differences in effects to sediment recruitment are expected due to the "equal in overall effectiveness" provisions of alternate plans with respect to aquatic and riparian function.

Where the 20-acre exemption would be applied to timber harvest along fishbearing streams, there may be a higher level of harvest, resulting in an increase in the level of ground disturbance near streams. Unlike the standard prescription, requirements for 20-acre exempt buffers are only measured from the bankfull width and not the outside of the channel migration zone, even if that distance is greater. As a result, timber harvest and ground disturbance may occur within riparian areas associated with channel migration zones, which would facilitate sediment inputs to streams. This is particularly problematic in cases where a stream would reoccupy the inner boundary of a channel migration zone after harvest, and would result in the loss of the riparian buffer which was intended to ameliorate harvest related sediment impacts generated outside of the buffer. Additional trees within the RMZs of 20-acre exempt parcels may need to be retained to meet the shade rules, but an increase in ground disturbance is nonetheless expected along fishbearing streams with channel migration zones.

There would be some harvest-related sediment impacts along perennial streams without fish (Type Np streams) and seasonal streams without fish (Type Ns streams). A 50-foot riparian buffer is required along at least 50 percent of the Type Np on the westside, and on the eastside, only 30 percent of the stream can be left unbuffered (with a corresponding length in no-harvest buffer). A provision also exists for potential to use partial harvest within 50-feet of the stream on the eastside. Partial harvest buffers along Type Np streams would be subject to some tree removal, but must meet the basal requirements for that forest zone. The portions of perennial and seasonal streams without fish that are left unbuffered (no more than 50 percent of Type Np streams on the west side and 30 percent on the east side, and up to 100 percent of stable Ns streams) would result in more-acute, sediment-related effects to streams as a result of more-intense harvest activities and ground disturbance near or across these waterbodies. Harvest adjacent to all non-fishbearing streams are subject to the 30-foot ELZ.

Generally, minimal buffers would be required on Type Np and Ns streams on 20-acre exempt parcels which would increase the amount of harvest-related streambed and streambank disturbance, as well as ground disturbance adjacent to these streams, and would significantly reduce the amount of large wood recruitment in these areas. Although sediment would not directly enter fish bearing streams, it would eventually be routed to Type S and F streams. When such harvests occur on steeper topography, sediments from mass-wasting events may be routed more-rapidly downstream, because large wood, which tends to increase sediment retention, would be present in reduced supply. However, most 20-acre exempt parcels generally occur in lower elevations, flatter topography, proportionally fewer areas with mass-wasting potential, and with a greater proportion of fishbearing streams, and therefore a smaller proportion of their stream system will be composed of Type Np streams. In addition, timber harvest along streams under the 20-acres exception rule is still subject to the 30-foot ELZ rule. Application of 20-acre exemption to Type Np streams would retain buffers of at least 29 trees per 1,000 feet when covered species could be affected. The shade rules would not apply on Type Np streams. For a more complete discussion of riparian buffer widths, refer to **Description of the Rules** Section.

Riparian vegetation aids in maintaining stream-channel dimensions and bank stability, and affects where erosion and sedimentation of channels and floodplains occurs (IMST 2004). The reduction of riparian vegetation on portions of Type Np and Ns streams can lead to the instability and eventual failure of the streambanks, resulting in delivery of sediment to the stream channel (see **Streambank Stability** section). Sediment from streambank erosion is more likely to originate from the unbuffered portions of Type Np

streams and the unbuffered Type Ns streams. These stream segments have a 30-foot ELZ and harvest activities must avoid disturbing stumps, root systems, and any logs embedded in the stream bank, as well as brush and similar understory vegetation. However, where no riparian buffers are required, harvest can occur up to the edge of the stream. A decrease in riparian vegetation may destabilize the streambank, resulting in an increase in sediments being deposited downstream. In turn, the deposition of sediments can cause the channel to widen increasing the amount of solar radiation reaching the stream. As a result, some habitat impairment within the unbuffered stream segments from sedimentation is expected to occur. In addition, the routing of sediment through non-fish-bearing streams into fish bearing streams will also occur over time, circumventing the effectiveness of riparian buffers on other typed streams (Rashin et al. 1999).

Felling and Bucking. The felling of trees and bucking of logs in or adjacent to typed streams and RMZs must be conducted in a manner that protects riparian and in-stream habitat and water quality. Under the FPHCP, application of the following measures when harvesting in or adjacent to typed water, RMZs, and WMZs, are designed to minimize soil disturbance, damage to residual trees, and the delivery of excessive slash to typed streams.

Only a minor amount of felling and bucking is expected to occur within inner portions (80 to 100 feet) of riparian buffers of fishbearing streams, and as such, the need for equipment to penetrate these areas will be very limited (see expected effects from Ground-based Equipment Use and Cable Yarding below). Felled trees that fall within the Core Zone are required to be left and few trees are expected to be removed from the Inner Zone. In some cases, when stand conditions allow, the majority of trees may be removed from the Inner Zone while retaining a specified number of the largest trees. For instance, on the westside, 57 of the largest trees would be retained following a thinning. In a high basal area Ponderosa pine stand, 21 of the largest trees would be retained, as well as another 29 trees over 10 inch dbh. However, even with this removal, the Core Zone (30 ft eastside and 50 ft westside) should ameliorate the small amount of sediment generated by felling and bucking. Felling and bucking within the Outer Zone and adjacent to buffers should result in minimal effects due to the use of directional felling. Directional feeling away from Type S and F streams is not expected to contribute sediment to streams, especially since it maintains the integrity of the riparian buffers which would likely prevent any sediment generated from this activity from reaching the stream. Effects including the introduction of sediment from felling and bucking adjacent to buffered reaches of Type Np streams are also expected to be minor.

Felling and bucking along unbuffered portions of Type Np streams and Type Ns streams may result in the direct delivery of some sediment to these waters, but is likely to be minor to insignificant amounts. Some of this sediment could reach fish-bearing streams. The more-significant levels of sediment delivered from timber-harvest activities to Type Np streams would be from stream bed and bank disturbance (i.e., if equipment were allowed to cross streams) and ground disturbance associated with the actual removal of felled trees.

Ground-Based Equipment Use. Ground-based equipment is commonly used to fell and yard timber, and to construct, maintain, and abandon skid trails used during timber-harvest activities. Under the FPHCP, ground-based equipment is regulated to limit physical impact to typed streams and wetlands and to minimize indirect effects such as soil disturbance and associated erosion and sedimentation that could impact typed streams and wetlands. Measures regulating ground-based equipment vary with local conditions and address typed streams, wetlands, RMZs, WMZs, soil-moisture conditions, residual trees, skid trails, and slope conditions. Low-impact equipment would be used when soils are saturated or

otherwise subject to rutting. Soil disturbance and compaction are expected to be avoided or minimized by the use of Best Management Practices applied to the handling and moving of the logs within the RMZ.

FPHCP states that on-site mitigation "is required if equipment use exposes soil on more than 10 percent of the surface area of the ELZ. These activities include operating ground-based equipment, constructing and using skid trails and stream crossings, and yarding partially suspended, cabled logs" (WDNR 2004a). The FPHCP further states, "Mitigation must be designed to replace the equivalent of lost function, particularly as it relates to the prevention of sediment delivery". Mitigation, such as waterbars, grass seeding, and mulching would be used to address such damage, however, damage of less than 10 percent could go unmitigated. Although no width is specified, Washington Forest Practices states that, "Skid trails shall be kept to the minimum width" (WFPB 2002). For the purposes of this assessment we assume the width of skid trails will typically be no wider that that of the width of the equipment used at a particular site. However, equipment will not always follow its previous trail exactly, so there may be a small increment of width added with additional passes. In some locations, equipment will need to maneuver and turn, increasing some trail width at these particular portions of the trail.

Sediment may be mobilized during yarding by ground-based and cable equipment. Rutting and soil compaction (See additional discussion in **Soil Compaction** section) from skidding of logs may result in increased run-off and erosion rates, and thus may lead to an insignificant to small increase in sediment delivery where streams have intact riparian buffers of 10 meters or more. Where yarding is permitted across streams or equipment enters the ELZ, delivery of sediment becomes more probable. Rashin et al. (1999) in evaluating timber harvest best management practices in place during the summers of 1992 to 1995 in Washington, found that based on the extent of exposed soil associated with erosion features that delivered sediment to streams, the main causes of erosion at harvest sites were skid trails and other timber-yarding activities. Based on observations of erosion and sediment routing from several different harvest practices (including skid trails) over a range of topographic conditions in both eastern and western Washington, Rashin et al. (1999) also expected that a 10–meter setback for ground disturbance would prevent sediment delivery to streams from about 95 percent of harvest-related erosion features. Gomi et al. (2005) found that streams with buffers ranging from 10 to 30 meters wide had relatively small increases in sediment yield from physical disturbances (i.e., tractor yarding). Based on these findings, in most cases riparian prescriptions for Type S and F streams and buffered portions of Type N streams under the FPHCP are expected to sufficiently minimize the amount of sediment that would otherwise be delivered from disturbance caused by ground-based equipment (see **Sediment Filtering** section).

There will likely be greater sediment yields from yarding in riparian areas under the 20-acre exemption as harvestable timber will be closer to the stream than under standard rules. Greater effects from yarding in riparian areas under the 20-acre exemption would be likely since timber can be harvested along Type Np streams, more-frequent entry into the ELZ is expected, and more numerous yarding corridors within 20-acre-exempt riparian zones would be expected. Type Np stream channel crossings will also result in significant disturbance and compaction to stream beds. Although mitigation will be required in cases where soil exposure exceeds 10 percent, these mitigation measures will typically be effective in alleviating or preventing chronic sediment input from surface erosion, and not necessarily the episodic input of sediment that will result from any streambank disturbance. Waters (1995) suggested that the erosion of streambanks, as a result of cutting or skidding directly in the riparian zone, may be second in importance only to roads in producing excessive sediment. Waters (1995) further pointed out that the only way to eliminate this source of sediment appeared to be by avoiding working in the riparian zone altogether.

Cable Yarding. According to Rashin et al. (1999), cable yarding, although a less-frequently used yarding technique, actually produces more relative amounts of erosion than ground-based yarding. Erosion features at cable-yarding sites had a higher frequency of delivery to streams. Under previous forest practices rules, cable yarding without buffers resulted in sediment routing to the stream. Substantial disturbance of stream channels, valley walls, and steep inner gorge areas by cable-yarding practices were observed resulting in chronic sediment delivery and extensive fine-sediment deposition on streambeds. This is largely because cable yarding tends to be used in steeper sites relative to ground-based yarding.

The FPHCP limitations on cable yarding in and across typed streams and wetlands are intended to minimize soil disturbance and impacts to their beds and banks. Cable yarding in or across Type S and F streams is not allowed, except where logs will not materially damage the stream bed, banks, sensitive sites, or the riparian management zones. Yarding over Type S and F streams also requires a HPA from WDFW that may carry additional restrictions to protect fish and fish habitat. If permitted, yarding is usually limited to cable or other aerial logging methods that suspend the logs above the riparian zones.

When it is necessary to create yarding corridors through the RMZ of Type S or F streams, the corridors must be no wider than or more numerous than necessary to accommodate safe and efficient transport of logs. Total openings resulting from yarding corridors must not exceed 20 percent of the stream length associated with the forest practices application. When trees within the Core Zone are felled to construct yarding corridors they will remain in place as downed wood, or may be recruited into the streams. Where logs are yarded from or across RMZs, WMZs, and sensitive sites, reasonable care must be taken to minimize damage to vegetation that provides shade and to understory vegetation, stumps, and root systems. When practical and safe, logs must be yarded uphill, in the direction in which they lay, and away from RMZs, WMZs, and sensitive sites. Where downhill yarding is necessary, reasonable care must be taken to lift the leading end of the log to minimize downhill movement of slash and soils. When yarding is parallel to Type S or F streams, below the 100-year flood level, or within the RMZ, reasonable care must be taken to minimize soil disturbance and to prevent logs from rolling into the water or RMZs.

Even with these protections, cable yarding will result in the delivery of some sediment to Type S, F, and N streams. However, as with ground-based equipment use, there will likely be greater sediment yields from cable yarding in riparian areas under the 20-acre exemption as harvestable timber will be closer to the stream than under standard rules. Greater effects from cable yarding in riparian areas under the 20-acre exemption would be likely since timber can be harvested closer to Type Np streams, more-frequent entry into the ELZ is expected, and more-numerous cable crossings (settings) across Type Np streams are expected. Although mitigation will be required in cases where soil exposure exceeds 10 percent, mitigation measures will generally be effective in alleviating or preventing chronic sediment input due to surface erosion, but may not necessarily be effective in preventing episodic input related to ground or stream bank disturbance within the ELZ.

Clearing of Slash and Debris. Large accumulations of slash may contribute to the initiation or exacerbation of mass-wasting events (e.g., debris slides and debris torrents). Conventional methods of slash disposal include pile or windrow and burn; pile or windrow without burning; mechanical scatter and compaction; scarification; chip, mulch, or lop and scatter; burying; and physical removal from the forest lands. Controlled broadcast burning is used less often due to air-quality concerns and fire risk. Forest practices rules prohibit slash disposal methods that employ machine piling, mechanical scatter and/or compaction, scarification, or other techniques that result in soil disturbance within ELZs. In addition, limbing and bucking (activities that usually generate slash) is prohibited within the bankfull channel of Type S, F, Np streams, in RMZ Core Zones, sensitive sites, or open water areas of Type A wetlands.

Where slash and debris is expected to plug culverts on Type Np and Ns streams, it must be cleared from the channel for a distance of 50 feet upstream. Site preparation through scarification will result in a range of soil disturbance, but will typically be minor (See **Soil Compaction** section).

There are some benefits to retaining slash and debris. Small woody debris provides cover for juvenile fish, amphibians, and prey species and may trap leaf litter and other detritus important to aquatic insects. Slash and debris left on flood plains also traps leaf litter and detritus, which subsequently decomposes and enriches the soil. Accumulations of small woody debris and slash may also help moderate fine-sediment transport from the forest floor to downstream habitats. Larger woody debris provides important structural components to stream channels, trapping gravels used for spawning and providing habitat for fish and aquatic insects. While Type Np and Ns streams do not support fish, woody debris in these streams helps prevent excessive erosion during peak flows. To prevent the removal of beneficial woody debris, forest practices rules limit the type and amount of material that can be removed. HPAs are required to remove harvest-related slash or debris from Type S and F streams (e.g., material removed upstream of culverts to prevent culverts from plugging) and, depending on the circumstances, may be required for Type Np and Ns streams.

Small woody debris is more easily transportable than large wood, and tends to form small, relatively unstable debris jams. Large wedges of sediment can temporarily accumulate behind these debris jams. This sets the stage for "dam-outburst" sediment dynamics, in which the jam breaks apart, suddenly releasing its wood and sediment, which is transported downstream until caught in another jam nucleation point, initiating another jam and sediment wedge. In this manner, large pulses of sediment can move downstream, far exceeding the transport rates normally associated with the given hydraulic conditions (Bryant 1980; O'Connor and Harr 1994). Small debris jams and their movement damage and destabilize channels and habitat, and can block road crossing culverts. Some of the debris generated from harvest activities on Type Np and Ns streams is expected to become incorporated in small debris jams of this sort, possibly increasing their occurrence over natural levels. The effects of small debris jam formation and outburst events on habitat and channel stability has not been well studied.

Only a minor amount of clearing of slash and debris is expected to occur within riparian buffers of fishbearing streams, and as such, the need for equipment to penetrate these areas will be very limited. Impacts including the introduction of sediment from clearing of slash and debris adjacent to buffered portions of Type Np streams are also expected to be minor. Although machine piling, mechanical scatter and compaction, scarification, chip, mulch or lop and scatter, and burying is not allowed within 30 ft of unbuffered Type Np and Ns streams, clearing of slash and debris may result in the direct delivery of some sediment to nonfish bearing streams. The amount of sediment reaching these unbuffered streams depends on the level of ground disturbance from activities within this zone. Some of this sediment will eventually reach fish-bearing streams.

Large Woody Debris In-Channel Placement Strategy. Occasionally, riparian restoration in the form of placement of large woody debris may be proposed as part of an FPA, but this currently appears to be rare (C. Rodgers, WDNR, pers. comm. 2006). Placement of large wood requires approval from the WDNR to work in the Core Zone and an HPA from WDFW to work within the wetted portion of the stream. Root wads must be placed entirely within the bankfull width. HPAs are required for all in-channel placements and may result in additional restrictions and guidelines. For instance, public-safety issues such as downstream bridge or culvert crossings that could reasonably be assumed to be endangered by stream-borne logs may necessitate anchoring of placed wood. Where unavoidable, anchoring is generally accomplished either by placing large boulders on top of the log, burying one end of the log in the bank

(sometimes in conjunction with boulder placement), or cabling the log to an anchor (such as a boulder, buried ecology block, screw anchor, or driven anchor bar).

While large-wood placement in streams is generally done to benefit the aquatic system as well as the fish species which depend upon those habitats, sediment effects as well as other effects (e.g., modification of existing habitat) may result in the short term. For example, while placement of wood with attached root-wad will provide better stability of large wood, it will also increase the probability of sediment delivery and may generate a short-term sediment pulse or turbidity. Placement of a bole without an attached root-wad will generally require other methods to secure the piece within the stream, is less desirable from a stream-dynamics standpoint, and may result in more short-term sediment delivery depending on the amount of bank and ground disturbance required to anchor the piece within the stream.

Within the stream, substrate may be disrupted by movement and positioning of logs. Following placement, large wood may not remain in place and may migrate downstream, causing additional sediment mobilization and/or sediment storage lower down in the stream system, but adding to the channel habitat complexity. This potential for movement is especially true for large wood placed without attached root wad, and may be true even if secured in other ways. Large wood that remains in place is expected to increase the amount of local sediment deposition and result in a temporary storage of that sediment. The amounts of sediment mobilized due to large wood placement are expected to be small and temporary in nature.

Road Construction, Upgrading, Maintenance, and Abandonment

Logging roads and their designs are particularly important factors affecting surface erosion and subsequent stream sedimentation. Surface drainage concentrated within roadside ditches, that is not dissipated or redirected to reduce its effects can lead to erosive cuts (resulting in soil erosion and stream sedimentation) and concentrated water flow onto slopes that may exceed a slope's capacity to hold the weight (resulting in mass soil movements or landslides). Surface erosion on gravel roads also can lead to high levels of suspended sediment moved into streams. Inadequate road designs, such as inappropriate placement of backfill, undersized culverts, and other factors, can lead to mass-wasting events such as land slides or debris torrents. During periods of heavy rainfall, roads and ditches can become temporary stream systems, speeding water runoff and reducing water absorption into forest soils.

Everest et al. (1987) found that logging roads, not the tree-harvesting practices themselves (unless both sides of a stream bank were clear-cut), were responsible for a majority of the sediment that enters an aquatic system. Roads can modify natural drainage networks and accelerate erosion processes. These changes can alter physical processes in streams, leading to changes in streamflow regimes, sediment transport and storage, channel bank and bed configurations, substrate composition, and stability of slopes adjacent to streams. These changes can have important biological consequences, and they can affect all stream ecosystem components (Furniss et al. 1991). Road construction can also cause the stream channel network to increase, because the roads act as tributaries, creating a more-efficient, sediment-delivery system (Castro and Reckendorf 1995). McCashion and Rice (1983) found that logging roads were responsible for 61 percent of the soil volume displaced by erosion in northwestern California. Reid and Dunne (1984) found that gravel forest roads generated up to 300 tons of sediment/mile/year from surface erosion in the Olympic Mountains of Washington. They found sediment loss was found to be related to traffic intensity and was highest on heavy-use gravel roads compared to unused roads or paved roads. Sediment yield from cutbanks and ditches alongside paved roads was less than 1 percent of that from gravel roads in their study. Heavily used roads were calculated to produce 300 tons of sediment/mile/year

over the period of study, compared to lightly used roads with 2.6 tons/mile/year and paved roads with 1.4 tons/mile/year.

Severe erosion is almost inevitable if roads are not properly constructed and regularly maintained. Road construction and maintenance associated with timber harvest typically increases the amount of sediment delivered to streams through surface erosion, as compared to natural delivery rates. Roads can rarely be constructed that do not have adverse effects to streams (Furniss et al. 1991). Roads constructed within riparian areas and parallel to streams typically have pronounced adverse effects to aquatic systems, compared to roads built in other locations. In particular, stream crossings pose the greatest risk to fish habitats of any road feature. When culverts are plugged by debris or overtopped by high flows, road damage, channel realignment, and severe sedimentation can occur (Furniss et al. 1991). Wash-out of a road crossing fill can input large volumes of sediment directly to the channel. Even greater inputs result when a plugged culvert diverts the stream out of its channel and into the road ditch. As the diverted stream seeks a new path down the hillslope, it can carve a substantial gully (Furniss et al. 1998). Failure to properly maintain road drainage can also result in large sediment inputs to streams (Furniss et al. 1991). "Roads, which are the major source of management-related sedimentation in streams associated with logging regionally, continue to have adverse effects to stream communities even when not actively utilized", and they continue to contribute high sediment loads until they are stabilized and abandoned (Cederholm and Reid 1987). Furniss et al. (1991) found soil erosion rates were 30 to 300 times higher on forests with roads than undisturbed forest. Roads can also alter streamflow rates and volumes, which along with increased sedimentation, can result in altered stream channel geometry (Furniss et al. 1991). Acting as new flowpaths for water, roads can increase the channel network over watersheds, increasing the drainage density. By increasing the frequency, magnitude, and altering the composition of debris flows, road-caused erosion and delivery can affect the long-term potential for developing complex channel morphology and aquatic habitat (Jones et al. 2000).

The premise behind the road construction and maintenance program in the forest practices rules and the FPHCP is that a well-designed, located, constructed, and maintained system of forest roads is essential to forest management as well as the protection of public resources. To protect public resources such as fish habitat and water quality, roads must be constructed and maintained in a manner that will prevent potential and actual damage. This will be accomplished by constructing and maintaining roads so as not to result in the delivery of sediment and surface water to any typed water in amounts, at times, or by means that preclude achieving desired fish-habitat and water-quality goals. These goals are to be achieved by eight objectives: 1) providing for fish passage at all life stages; 2) preventing mass wasting; 3) limiting delivery of sediment and surface runoff to all typed streams; 4) avoiding capture and redirection of surface or ground waters; 5) diverting most road runoff to the forest floor; 6) providing for the passage of some woody debris; 7) protecting streambank stability; and 8) minimizing the construction of new roads and abandoning old roads.

Road-generated sediment may be delivered to streams unless prevented by active management. FPHCP road maintenance and design standards are expected to address the delivery to road-generated sediment to a high degree, however, a number of road maintenance tasks are also expected to generate and/or mobilize sediment (e.g., flattening cut slopes, widening ditches, ditch maintenance). FPHCP road construction, grading (including cutting into existing slope), and placement of fill will result in exposed, un-vegetated surfaces that may be subject to erosion. Most of this work usually will be done in the drier summer months and revegetated or addressed in alternate ways prior to the wetter winter season. Installation of drainage features may result in additional mobilization during construction, but will reduce

potential for mobilization and delivery during the life of the road. During stream-crossing structure installation there maybe short-term mobilization and deposition of sediment and turbidity, and erosion at improperly armored culvert inlets. Road construction, as well as re-construction, repair, upgrading, and installation or improvement of stream crossings may require drilling which will create debris, sediment, and slurry. Drilling procedures will be established to manage slurry waste from drilling. Excavation, grading, cleaning culverts, pulling ditches, and other activities can generate spoils, however, spoil disposal is not expected to result in sediment run-off that would enter the stream system (see **Spoil Disposal** section for description of activity).

Obliteration of abandoned roads adjacent to streams can also result in adverse effects to fish, amphibians, and their habitat through sedimentation of spawning and rearing habitat, degraded water quality (turbidity/contaminants), and direct injury to fish and amphibians from heavy equipment used for instream work (e.g., culvert removal). If properly done, road obliteration or full decommissioning will ultimately reduce the potential for excess sediment delivery to streams from roads and would eliminate further effects of road use. On that basis, road obliteration or full decommissioning is generally considered to have long-term beneficial effects to fish, amphibians, and their habitat.

RMAPs. Forest practices rules require all forest landowners to develop road maintenance and abandonment plans (RMAPs) to prevent sediment and hydrology related impacts to public resources including aquatic habitats utilized by fish and amphibians. Road maintenance and abandonment work carried out under approved RMAPs must meet forest practices standards. These standards require landowners to: 1) keep drainage structures functional; 2) divert captured groundwater from ditchlines onto stable portions of the forest floor; 3) maintain road surfaces to minimize erosion and the delivery of sediment to typed streams; and 4) slope and waterbar road surfaces to prevent water accumulation. Large landowners are required to have all roads within their ownership covered by an approved RMAP by July 1, 2006. The RMAP process is intended to bring all roads owned by large landowners into compliance with forest practices standards by July 1, 2016.

Implementation of the FPHCP is intended to substantially reduce road-related erosion and sediment delivery from current and future roads, both in the near-term (< 10 years) and over the long-term (10 to 40 years) relative to current levels of sediment delivery. Near-term reductions from existing sources are expected to result largely from implementation of RMAPs. These standards require that roads be disconnected from the stream network through the installation of drainage structures, that road fills susceptible to mass wasting be removed, and that stream-adjacent parallel roads be repaired and maintained, or abandoned. Sediment reductions from small forest landowner lands will occur in a different manner and on a different schedule (see Exceptions to Road Maintenance in **Description of Activities that are Effects of the Permit** section). FPA approval by WDNR will include a requirement for improving roads to the new forest practices standards as part of timber harvest operations, or small forest landowners must enroll in the FFFPP. Therefore, sediment reductions accrued from small landowner lands will likely be distributed over a longer timeframe. In cases where roads on lands of small forest landowners are causing or have the potential to cause damage to public resources, WDNR can, at any time, require the landowner to take corrective actions to minimize and mitigate the impacts. Approximately 40 percent of covered lands are owned by small forest lands owners.

Forest practices rules also require large forest landowners to prioritize road maintenance and abandonment planning based on a “worst first” principle. This means that road systems or watersheds where RMAPs implementation would produce the greatest benefit for public resources receives the highest priority. The highest-priority areas identified in the FPHCP are areas where listed and vulnerable

species occur. This is likely to benefit listed salmonids, other fish, and amphibians, as roads in or near their habitat will be addressed first, minimizing the time that the most-severe sediment impacts from roads will continue into the future. Small forest landowners have two options for meeting RMAP requirements: 1) They may follow the RMAP process for larger landowners or they can submit a checklist RMAP with each forest practices application or notification, or 2) The can fix any road-related problems at the time they conduct the FPA. With respect to fish passage barriers, they have a third option of enrolling in the FFFPP. This may mean that road-related sediment on some lands owned by small forest landowner will not be corrected as timely as a similar situation on land owned by large forest landowners. The effects of this schedule to fish and amphibians will vary depending on the species, its distribution, and the option selected by each particular small landowner. Delayed repair will mean that the benefits of improved passage may be delayed. Impacts are likely greatest for sensitive species such as bull trout and tailed frogs in watersheds where a significant number of small landowners choose to submit a checklist RMAP with each application, or where such a small landowner is located on a particularly important piece of habitat within the watershed. However, WDNR retains the authority to require any landowner to address road-related impacts where the road has affected or could potentially affect public resources. As of December of 2005, approximately 89.8 percent of the required RMAPs had been completed, with an expected 8.8 percent to be completed by June of 2006.

The FPHCP area currently has over 60,000 miles of mapped roads, which yields an average road density of 4.1 miles per square miles on FPHCP lands (Appendix G). According to our GIS analysis, about 9 percent of these roads occur within the riparian zones (100-year site-index tree height) of Type S, F, or Np streams. In addition, there are over 130,000 road-stream crossings in the FPHCP, including over 18,000 crossings on fish-bearing streams. Stream-adjacent parallel roads (those roads with in a 100-year site-index tree height) and stream crossing are the likely the two features on FPHCP covered lands that will deliver the greatest amount of sediment to streams.

Orphan roads are roads constructed prior to 1974 that have not been used for forest practices since that time (WAC 222-24-052*(4)). Such roads are typically not maintained, and many were constructed without a requirement to consider public resource and channel impacts. The mileage of orphan roads in Washington is unknown; however, the associated hazards have been identified. The concern with orphan roads is the lack of knowledge about their location and potential for failure and initiation of debris avalanches, debris flows, and debris torrents. Although FPHCP would require landowners to inventory and assess orphaned roads, their repair or abandonment is not required. However, landowners may voluntarily fix problems identified during the orphaned road inventory and assessment.

Some cases will occur where unused or seldom used roads are not maintained to FPHCP standards. This is more likely to happen on small landholder parcels, where reporting requirements do not occur until filing of an FPA, which could be many years into the future. Such roads are vulnerable to the various failure mechanisms discussed previously which can result in sediment input to stream channels. In addition, some roads may be abandoned without full implementation of specified sediment reduction measures if it is believed that the likelihood of delivery to water is small. In some cases, these determinations may be in error, resulting in inadvertent sediment delivery. In the past, efforts to stabilize abandoned roads have sometimes not been successful, and have resulted in unintentional sediment delivery.

Road Construction. The first step toward limiting the delivery of sediment from forest roads to the aquatic environment is to properly locate news roads. FPHCP requires that roads be fit to the topography to minimize alteration of natural features. This includes avoidance of aquatic features such as surface

waters, wetlands, channel migration zones, riparian management zones, and sensitive sites such as seeps, springs, and initiation points of perennial flow. Road and landing construction are also regulated on all high-hazard unstable slopes.

Conceivably the most-important mitigation measure related to sediment delivery from road erosion to streams depends on the location of the road with respect to the stream. The closer the road to the stream the more the mitigation should focus on the road ditch or traveled way (Elliot and Tysdal 1999). Some have observed that sediments discharged from the road do not reach streams due to the filtering and sediment trapping effects of intervening buffer strips (Ketcheson and Megahan 1996; Megahan and Ketcheson 1996; WFPB 1997).

Drainage near a stream crossing (whether the crossing is a culvert or bridge) is important. It has been assumed that 100 percent of the sediment carried by road ditches which discharge into streams at stream crossings will be delivered to the stream (WFPB 1997). Miller et al. (1995 as cited in USFWS and NMFS 2000) observed that when runoff was discharged directly to stream channels, 50 percent of the deposited sediment and 100 percent of the suspended sediment reached the stream, in contrast to only 1 percent of road sediment reaching the stream channel when runoff was directed to the forest floor. At least 10 percent sediment delivery can be expected when culvert outflow occurs within 200 feet of a stream, so hydrologic decoupling would only be possible for portions of the road located more than 200 feet from a stream (WFPB 1997).

Design standards included in the FPHCP are mainly related to construction techniques and water-management requirements to minimize or prevent sediment delivery to aquatic habitats. In general, forest practices rules encourage road designs that utilize balanced cut-and-fill construction to avoid side-casting of excess fill materials. Specifically, in steep terrain (> 60 percent slopes), forest practices rules require full-bench designs in which no fill material is used to construct the road prism and waste material is end-hauled or over-hauled to stable locations where sediment would not enter the aquatic environment. In addition, no fills will be placed within the 100-year flood plain. Water-management requirements under the FPHCP focus on maintaining hydrological flow paths and minimizing sediment delivery by limiting road-induced rerouting of water. This includes design standards for culvert sizing and the spacing of drainage structures and requirements that roads be designed so that ditch water is routed onto the forest floor to facilitate infiltration and prevent or minimize sediment delivery to the stream network.

Placement of relief culverts is considered effective as long as discharge and sediment are not delivered to surface waters. Because of this, road location relative to stream location becomes the over-riding factor determining the effectiveness of drainage relief practices (Rashin et al. 1999). The further a road is located from a stream the less likely that road will deliver sediment to the stream. Rashin et al. (1999) found that the observed range of sediment transport from road to stream was 160 meters. Within that distance, adequate road-design measures where key to disconnecting road sediment from the stream channel.

FPHCP road-construction requirements focus on maintaining a stable road prism and water-crossing structures, and on minimizing sediment delivery to streams and wetlands. Road prism-related measures include limiting the volume of organic matter that can be incorporated into the road prism, compacting fills, removing construction-related slash and debris from culvert inlets, installing ditches and drainage structures concurrent with construction, depositing waste materials in stable locations, and preventing side-casting of excess fill materials on steep slopes.

FPHCP rules are also designed to minimize sediment delivery from new roads during and after construction. Measures include limiting construction to periods of low soil moisture, end-hauling or over-hauling waste material when side-casting would potentially result in delivery of sediment to streams, sloping roads and landings to prevent water accumulation, and stabilizing exposed soil. Other construction-related measures under the FPHCP minimize sediment delivery from new roads both during and following construction. Sediment can be delivered to streams and wetlands during road construction from exposed cut and fill surfaces and newly constructed roadbed surfaces and drainage ditches; even though special precautions are expected during construction, including the use of silt fencing, hay bales, etc. Sediment delivery may occur during construction and repair, but chronic sediment delivery may persist for long periods of time depending on location and design of road. Inadequate or poorly located cross-drain features may deliver road and ditch-line runoff directly to streams. However, we expect roads and their drainage features that would be designed and built according to the HCP standards should greatly minimize the delivery of road-generated sediment to the stream system. A study by Toth (1998) indicated that sediment delivery in the Chehalis, Stillman, and Taneum watersheds was reduced by 48, 34, and 44 percent, respectively, within 5 years. Although each watershed is unique and road maintenance and abandonment plans varied, the results provide a reasonable indication of the expected benefits from implementing such road plans.

The majority of roads that will be needed for timber harvest and related activities, especially mainline roads during the permit term, have already been constructed. Because road density has been linked to fine-sediment effects to streams (Cederholm and Reid 1987; Opperman et al. 2005), road densities will be addressed in **Cumulative Effects** section. Additional roads are expected to be constructed during the next 50 years whether or not the proposed permit is issued. The amount of new roads that can be constructed during the permit term is not limited by the FPHCP, nor is the FPHCP expected to substantially change the number or location of such roads. Current road density averages approximately 4.1 miles of road per square mile statewide (Appendix G). As a result of changes in equipment (i.e., generally shorter yarding towers), smaller harvest units, more-intricate harvest-unit design, and the need for access to currently inaccessible areas, additional roads would continue to be built. Obliteration or abandonment of many roads may reduce roads, but may also create the need for alternate routes.

Road Maintenance and Use. Road surface grading and re-shaping may re-mobilize fine sediments. Fine sediments mobilized by road grading may be delivered to stream channels. Road sediments may contain traces of oil, gasoline, hydraulic fluid, or other compounds (see **Water Quality** section). Road surface re-shaping and grading can re-mobilize sediment and hasten its delivery to the stream system, resulting in increased fine sediment loading in the stream substrates above natural levels. Sediments delivered to wetland areas can alter water quality and the wetland character by increasing eutrophication processes. Surface blading can temporarily increase sediment production and delivery can ensue during intense rains or through movement of dust.

Stream crossings may become plugged or may fail and result in diversion of streams. Plugged stream crossings may cause streams to flow across roads increasing road-surface erosion and sediment transport and delivery into downstream reaches. When diverted across roads, streams are shallow and mostly impassable. Debris may jam ditches and result in road failures or mass wasting. However, regular maintenance results in reduced risk for failures of road fill and mass wasting. Short-term mobilization, delivery, and deposition of sediments and turbidity may occur with cleaning debris from ditches or from culverts.

Timing of road use affects the generation of sediment from roads (Reid and Dunne 1984; Mills et al. 2003). Wet-season road use is a significant source of chronic turbidity and fine sediment in streams (Reid and Dunne 1984). Although the FPHCP does not specify seasonal restrictions, landowners will, in practice, minimize sediment production associated with the various road-related measures by conducting many construction activities in the dryer months (WAC 222-24-030). This will also serve to reduce the traffic of trucks hauling rock during wet periods. Landowners will often manage public traffic on their roads to ensure road surface degradation from public traffic does not interfere with their ability to haul over those roads.

A recent study in the Oregon Coast Range indicated that detectable turbidity increases at stream crossings during wet-weather hauling were limited to approximately 10 percent of the sites when road surfaces were adequately treated (Mills et al. 2003). The limited number of sites that delivered fine material to streams also displayed rapid dilution as turbid water moved into larger receiving tributaries, rendering effects undetectable (Mills et al. 2003). However, turbidity increases were noted where roads paralleled streams. The quality of aggregate used to surface roads is a key predictor of potential sediment yield from rocked roads (Foltz and Truebe 1995). Results from Oregon and Washington suggest that hauling on roads surfaced with high-quality aggregate can reduce sediment delivery by several orders of magnitude (Reid and Dunne 1984; Bilby et al. 1989; Foltz and Truebe 1995). By engaging in more activity in dryer months, FPHCP participants will significantly reduce the volume of chronic sedimentation that occurs from roads, relative to the historical practices that inform the present environmental baseline conditions.

Road Upgrading (Fish Barrier Removal). Road upgrading may be done for a variety of reasons including to reduce sediment delivery, decrease maintenance requirements, reduce potential for road damage, and improve passage of fish, water, wood, or bedload. Fish-passage barriers at culverted crossings are created by several conditions. Improperly designed or placed culverts do not have the roughness and natural variability of stream channels and therefore do not dissipate energy as readily. In many instances high water velocities amplified by undersized culverts have created large scour pools at the culvert discharge point, altering the stream elevation below the natural gradient (i.e., downcutting). Over time, culverts become elevated or perched above the stream and create a physical barrier to fish passage. In other cases, water also drains under and around culverts, and migrating fish attempting to follow these flows can become stranded or impinged against the culvert or road fill.

Under the FPHCP roads must be constructed and maintained in such a manner that provides for fish passage at all life stages. In addition to striving for fish passage for all age classes of fish, the replacement or removal of fish-blocking culverts should result in more-naturally maintained stream hydraulics, including bedload movement, sediment transport, and passage of moderately-sized woody debris, leading to more-natural stream dynamics and stream geometry. The overall impact of this requirement of the FPHCP on fish and fish habitat is expected to be beneficial because it will restore spatial and temporal connectivity of waterways within and between watersheds where movement of fish and habitat elements are currently obstructed. Although the long-term impact of restoring fish passage and more of the natural stream dynamics to stream systems statewide is beneficial, the on-the-ground construction activities employed to correct fish-passage barriers can typically result in short-term adverse sediment impacts to a number of fish species and all life-history stages.

Sedimentation and turbidity will occur from heavy equipment operation on access roads, excavation areas, and fill locations by exposing, destabilizing, and/or compacting streambanks, streambeds, and riparian soils. Additional sedimentation may occur from excavating the roadfill, backfilling, bank

armoring, clearing and restoring the riparian area, culvert maintenance, and restoration of streambeds following high-flow events, as needed. Sediment can be expected to be generated as the existing culvert is excavated, the work area is enlarged, and the new structure is installed and buried. Sediment generation downstream of the site is also expected after initial redirection of a stream back into its channel after construction. In addition, sediment may be generated during the installation of grade controls, large wood, boulders, spawning gravels, or other mitigation as required by the FPHCP or other permits. The effects of sediment to fish, amphibians, and their aquatic habitat are expected to be minimal during construction if it occurs in dewatered streams and if other BMPs are being implemented at each construction site. However, rain events during and after the construction period will likely mobilize sediment into the stream, even with sediment control measures in place, as sediment control measures are not always effective at precluding sediment deposition into streams (Rashin et al. 1999). Therefore, sediment effects may occur to fish and amphibians inhabiting stream reaches during initial rain events following construction. Sediment generated at these sites will typically have short-term impacts to aquatic habitat downstream of the construction site. Effects to individual fish from dewatering and fish-salvage activities are addressed under the **Fish Salvage** section.

As a result of changes in gradient, sediment stored behind the old culvert may also be mobilized and transported downstream. Several rain events may be necessary before all the sediment is mobilized and redistributed downstream of the culvert. In some cases, a culvert that was insufficient sized for a stream may impound water and create a wetland upstream with significant amounts of stored sediment. Once the crossing is retrofitted, the stored sediment may be mobilized and transported downstream. This process may take many years, during which the downstream channel is subject to increased sediment transport and/or delivery.

The removal or replacement of culverts can also result in head cutting upstream of the project. Culverts may be acting as a stable nick point, preventing the upstream migration of reach-scale channel incision. Should head cutting occur, this could result in loss of instream and riparian habitat due to channel instability, accelerated streambank failure, and increased sedimentation which can cause localized channel braiding and instability of streambanks (Castro 2003). Such impacts are likely to occur until new channel equilibrium is reached. Although removal and replacement designs will typically incorporate measures to limit headcutting in cases where regrade is over 1 foot (WDFW, in litt. 2003), it is currently unknown how frequently headcutting will occur in cases where regrade is less than this threshold, and how frequently grade controls may fail. Where breaks in grade are $\leq$ 0.6 feet, the risk of channel incision is considered low (USFWS 2004c). We are unable to cumulatively estimate the extent of such headcutting (i.e., amount of stream impacted) for culvert removal and replacement projects addressed under the FPHCP. However, where it does occur we expect localized effects to fish and amphibian habitat. We anticipate that fish and amphibian habitat may either be permanently lost or made unsuitable (e.g., for spawning, for cover, for foraging) for a period of time until it naturally recovers after a new channel equilibrium is reached.

There is generally a low probability of direct mortality to fish and amphibians from sediment generated during the actual removal of fish barriers. Outside of an emergency (see Emergency Road Work), the work will most likely be performed when ESA-listed fish species are least likely to be present based on in-water timing restrictions. However, ESA-listed, non-listed fish species, and amphibian species, are found in some locations at all times of the year and therefore, in some situations they will be directly affected by an increase in suspended sediments. Due to in-water timing restrictions, any major input of sediment generated during project construction would generally not occur during the actual spawning

period for salmonids. However, spawning and rearing habitat for salmonids and other fish species and amphibians may still be degraded as a result of sediment generated during construction activities. Spawning and rearing habitat, and potentially redds, could be affected by post-construction sediment releases that could enter the stream during subsequent high flows from either areas disturbed during construction or from sediment that has accumulated behind the fish barrier. This could result in the mortalities of a range of life stages (from eggs to adults) depending on fish species immediately below the construction site. In the cases of headcutting, fish (Erman et al. 1988) and possibly amphibian mortalities are likely to occur immediately upstream of the construction site as a result of channel instability and bedload movement. The magnitude of the impact will depend on the severity of head-cutting and the abundance of susceptible fish and amphibian species in the affected reaches. As disturbed areas and the channel itself begin to stabilize, the amount of sediment generated during high flow events is expected to subside to background levels. With most sites, this is expected to occur within the first couple of years following construction (removal and/or replacement).

Road Abandonment. Sediment effects to streams are likely to result from road abandonment, since they may involve removal of culverts and associated fill, ripping the road for revegetation, or full obliteration (return to natural slope). Removal of culverts and any associated fill can temporarily increase sediment loads to streams. Heavy equipment used to rip road surfaces to facilitate revegetation will expose sediment to surface erosion. However, this activity is generally restricted to summer months to comply with regulations and other seasonal restrictions. Sediment effects of fill pullback and re-contouring are generally short term. On roads that are water-barred, some surface erosion may also occur. Some of this work may need to occur within riparian areas and may generate some additional sediment which could be delivered to adjacent streams if BMPs employed are not fully effective. All these activities may result in exposure of cut slopes and fill areas and may mobilize sediment, with some short-term surface erosion continuing until exposed surfaces at these sites are revegetated.

Sediment effects of crossing-structure removal are generally short term, but in some cases may be long term (also see Road Upgrading section). Mobilized sediment and turbidity associated with project implementation (structure removal and site contouring), may be followed by ongoing surface erosion of exposed surfaces for one or more years until surfaces are revegetated. Scouring of unconsolidated materials may occur during flood events. Long-term sediment benefits include restoration of natural stream gradient, channel width, and sediment transport, and also the elimination of risk from mass-wasting of road fill due to culvert blockage or failures.

Emergency Road Work. Heavy equipment might be used in the stream for emergency activities (e.g., unblocking culverts, brushing, spot rocking). In-water equipment use could temporarily affect fish, amphibians, and their habitat, including effects on redds, smothered or crushed eggs and alevins, crushed amphibians, increased turbidity and sediment deposition, blocked migration, and disrupted or disturbed overwintering behavior. Many fish are particularly vulnerable during the fall and winter, when adults are migrating and spawning, and the spring, when eggs and fry are still present in the substrate. Emergency work could move juveniles out of overwintering habitats such as side channels and deep pools, into inferior habitats or high-velocity waters. The effects of sediment mobilized by emergency activities during the winter and spring are likely to be localized and short-term, but can be locally intense, especially if redds are destroyed. Additionally, such emergency activities could deliver fine sediments to estuarine and marine waters, causing degradation of the habitats used by covered species in those environments. With the assessment and stabilization schedules established under the RMAPs, the frequency of occurrence for such extensive emergency stabilization treatments will be low. Also, over

time, as roads and stream crossings are upgraded to the specifications required in the FPHCP, the necessity for emergency stabilization work will decline. The short-term impacts would be further offset by the immediate and long-term benefits provided from stabilizing fill, preventing culvert blowouts, and minimizing erosion problems.

Research. Under the FPHCP, habitat manipulations may be conducted for research purposes and are expected to occur along a very small percentage of streams, be localized, and have minor sediment effects at a watershed scale. Localized effects to listed species (e.g., bull trout spawning and rearing areas) are expected to be limited due to screening and coordination with the Services in the site selection process for studies.

Screening and coordination with the Services in the site-selection process for studies should ensure that sensitive areas are avoided and that status of covered species is considered so as to avoid unnecessary population effects.

7.5.4.5 Conclusion

The FPHCP is expected to provide moderate to high levels of protection from sediment impacts to fish, amphibians, and their habitats. However, it is not expected to completely eliminate sediment impacts to fish, amphibians, or their habitat. FPHCP would result in stream-bed aggradation, a risk of habitat degradation from pool filling and modified channel capacity, and risk of direct impacts to fish from turbidity and suspended sediments.

Sediment impacts from activities covered under the FPHCP are expected to have direct and indirect adverse effects to fish and amphibians ranging from mortality to sublethal effects. Adverse effects to fish and amphibian habitat will range from short-term impairment to long-term change or degradation. However, any long-term degradation effects are expected to be infrequent and highly localized in nature (i.e., individual stream reaches) due to the types and locations of FPHCP activities. For example, a gravel spawning or rearing habitat could scour to bedrock during head-cutting.

Sediment effects that will have adverse effects to fish and amphibians will most likely result from the following forest practice activities: road construction/reconstruction and abandonment, and yarding. Sediment effects of a much lesser magnitude may also be generated from clearing of slash and debris, and large woody debris in-channel placement. Clearing of slash and debris may generate sediment effects, as will small woody debris jams that may form as a result of debris made accessible to Type Np and Ns streams, but the likelihood of impact is variable and site specific. It is highly dependent on the level of riparian buffering left on Type Np and Ns streams and the degree of ground disturbance (both mitigated and unmitigated) that occurs from other allowed activities within ELZs. Large woody debris in-channel placement is expected to be an infrequently implemented option due to the specificity in site condition that must be met before it is applied. As a result, the potential short-term sediment effects of large woody debris in-channel placement are projected to be highly localized and limited in nature. The most-acute sediment effects from timber harvest activities will be on Type Np and Ns streams, particularly on private forest lands with 20-acre exemptions. However, sediment effects from these actions are generally not expected to be chronic in nature due to the minimization and mitigation measures outlined in the FPHCP to minimize or avoid such effects. Any sediment effects from riparian timber-harvest activities are also expected to be tempered, since harvest will be spread out over the life of the FPHCP (i.e., 50 years), and across the State. Therefore cumulative effects from forest-practice activities are unlikely to be concentrated at a particular time (e.g., year) or within a particular watershed(s). This will likely allow some of the sediment reaching streams within a watershed to be processed through the aquatic system

prior to receiving additional timber-harvest sediment effects. However, 20-acre exempt parcels are often on the edge of development (and agricultural lands) and sediment baselines may already be degraded on these lands immediately downstream and adjacent to forested parcels.

Depending on the time of year, sufficient germination and growth of ground-covering vegetation may be accomplished prior to the rainy season to minimize surface erosion from exposed slopes, fill deposits, and ground disturbance, which should help minimize the generation and delivery of sediment. Other methods to minimize sediment generation and delivery may include sediment-control fences, slash-filter windrows, mulching, etc. At other times, ground-covering vegetation may not be adequately developed, and short-term inputs of sediment will still result.

Road management may occasionally result in sediment effects from mass-wasting events on unstable slopes. However, these events triggered by road construction or management under the FPHCP are anticipated to be uncommon across private forest lands due to the existing unstable-slopes protection measures. FPHCP has not changed the States emphasis on unstable slope protection and supports its continuation. Effects from any mass wasting events will be most severe after the initial event, and then decrease overtime as slopes stabilize and sediment is transported through the stream system. Mass-wasting events that occur in the near future at a frequency or severity beyond the natural background will likely be caused by roads constructed and harvests performed under previous rules. For instance, root strength may decrease for 15 to 20 years following harvest as the roots from the previous stand rot, until the new stand develops its root system. Mass-wasting events are not uncommon in stands of this age where unstable features were not identified at the time of harvest.

Chronic sediment effects will still be seen on private timber lands, but will typically be legacy effects from past timber harvest and road construction activities conducted under previous Forest Practices Rules, as well as from existing roads. These legacy sediment effects (e.g., mass-wasting events, ongoing road effects, culvert failures) are not the direct result of the FPHCP, but in some cases (i.e., roads or culverts) the effect or the risk of effect may persist over the life of the agreement until corrected. Without permit issuance, there may be no requirement to fix these legacy problems unless it could be proven that omission of actions were causing adverse effects to listed species that rose to the level of harm. However, severe and chronic sediment effects are not expected to continue for this period of time since WDNR retains the authority to require any landowner to address road-related effects where the road has affected or could potentially affect public resources. We expect WDNR will be using this authority to significantly reduce the period of time that ongoing, chronic effects remain uncorrected.

7.5.5 Hydrology

Surface waters may consist of perennial and seasonal streams, lakes, ponds, and wetlands. Subsurface (soil) waters consist of water that is stored in or transported shallowly through hillslope soils or colluvium. Groundwater is water moving through, or stored in rock, or deep unconsolidated strata called aquifers. Groundwater is often connected directly or indirectly to rivers, streams, lakes, and other surface water bodies, with exchange and mixing occurring between the sources. Depending on the geologic and hydrologic conditions, water entering the groundwater system may again reach surface waters within days or may take hundreds or even thousands of years (Domenico and Schwartz 1990).

Streamflow results from precipitation on a watershed, with water entering the stream channel by precipitation falling into the channel, surface runoff of rain or snowmelt, or sub-surface flow. The sum of these is often called stormflow or runoff. Additionally, groundwater and any long-term sub-surface

drainage from uplands sustain streamflows year around in perennial streams, particularly between periods of snowmelt and rainfall. Often called baseflow, such flows are common in the summer months when high stream temperatures typically occur. Subsurface flow is shallow lateral flow below the soil surface but above an impermeable or slowly permeable layer above the groundwater table. Subsurface flows occur early during storms and contribute to stormflow. Groundwater is recharged by infiltration from portions of the landscape called recharge areas. Recharge areas for a particular aquifer may be extensive or more narrowly distributed, depending on topography, climate, and soil permeability. The boundary layers between aquifers and overlying unsaturated soils is the watertable. Baseflow is the typical flow rate for a given stream at a particular time of year and is sustained by groundwater inputs, which may be localized as springs or distributed across the entire stream reach.

The amount of water provided to aquatic ecosystems at critical times is important for sustaining fish and other aquatic species. Soil water and groundwater provide cool, clean water to streams and help to maintain adequate water quantities and temperatures for aquatic organisms. The outflow of soil water and groundwater, especially at perennial seeps and springs, can be important for amphibians and aquatic insects (Petranka et al. 1993; Kelsey 1995; Bury and Corn 1988). Fish adapt to natural flow cycles for feeding, spawning, migration, and survival needs. The timing, magnitude, and duration of peak and low flows must be sufficient to create and maintain riparian and aquatic habitat. Flooding and sediment transport are normal events critical for formation and development of streams and floodplains (Waring and Schlesinger 1985). However, hydrologic regimes outside of the normal range of variability can cause excessive erosion and result in channel alteration.

Rain-on-snow events are a common reason for flooding and streambed scour in parts of the State where snow or a transient snow zone exists. In some watersheds, extreme low flows there can be detrimental to water quality and habitat availability during the summertime.

Regional differences in runoff patterns, ranging from rain-dominated to snow-melt dominated systems (Swanston 1991), affect how land-management practices can affect basin hydrology and stream habitat (Chamberlin et al. 1991). For example, in rain-dominated coastal systems, frequent high winter floods elevate the importance of maintaining and protecting side channels. In interior snow-dominated watersheds, management practices to augment low late-summer rearing flows are important. These regional streamflow differences also influence management practices related to sedimentation. Spring flows related to snowmelt-dominated systems are responsible for most road erosion and channel-sediment movement, but within rain-dominated areas, frequent rains provide sufficient energy to transport sediments during many months of the year.

Although high- or low-flow events may affect fish and amphibian populations, dynamic flows are also needed to perform essential functions important for the long-term persistence of these populations. High-flow events redistribute sediments in streams, flushing fine sediments from spawning gravels and allowing recruitment of gravels in downstream reaches. In addition, extreme flow events are essential in the development and maintenance of healthy floodplain systems through deposition of sediments, recharge of groundwater aquifers, recruitment and transport of large wood, and creation of side channels. Low flows and the timing of low-flow recession may also be important for establishing riparian vegetation on gravel bars and along stream banks (Spence et al. 1996).

In general, low- or base-level stream flows that occur during the late summer often limit habitat and survival for rearing juvenile salmon and trout. They can also negatively affect migration and access to habitat and food resources, as well as disrupting spawning behavior. Such conditions can occur naturally

during this period due to lack of precipitation. However, low flows can be exacerbated by water withdrawals, silting (which can decrease pool depth), and stream widening resulting from unstable banks. Decreased base flows, especially at critical low-flow periods in late summer, can diminish available fish habitat and increase stream temperatures (Chamberlain et al. 1991; Murphy 1995). Low summer flows can be a problem for juvenile fish due to reduced available habitat, increased stranding, decreased dissolved oxygen, increased water temperature, concentrated toxic materials and increased predation. Low summer flows may also affect upstream migration for spawning fish.

High winter flows and floods that scour the streambed can be detrimental to eggs or young fish that may be incubating in the stream gravels (Thorne and Ames 1987). Fish need suitable stream flows, particularly for migration, spawning, and rearing. Increases in peak flow magnitudes or timing can be as much of a problem as reduced summer baseflow. Increases in peak flows beyond natural levels may cause increased channel bedload movement and bank erosion. The resulting scouring of spawning gravels reduces egg-to-fry survival. In addition, movement of large wood decreases bed and bank stability, which can, in turn, increase egg-to-fry mortalities.

7.5.5.1 Hydrologic Processes

Processes that control water movement in forests include: evaporation, transpiration, snowmelt, infiltration, percolation, lateral flow, and capillary rise (Waring and Schlesinger 1985). Surface water is mainly controlled by precipitation, topography, vegetation, evaporation, and soil characteristics (Hewlett and Nutter 1970; Dunne and Black 1970). The three primary factors affecting surface-water quantity in forested watersheds are climate, vegetation, and transport pathways. Precipitation amount and form (snow or rain) determine the rates of delivery of water to a watershed. The rate and volume of surface water flow is largely controlled by seasonal precipitation patterns and the timing of individual storms.

Vegetation primarily influences flow through interception (collection of rain and snow by the canopy), evapotransporation (water lost back to the atmosphere), condensation, and canopy snowmelt. These processes influence delivery of water to the forest floor and are controlled mainly by vegetation. On an average annual basis, forests lose more water to the atmosphere than any other vegetative cover or land-use type (Dunne and Leopold 1978). Canopy cover also alters the amount (Troendle and Olsen 1993), frequency, and intensity of precipitation delivery to forest floors.

Water-transport pathways (surface and subsurface) determine runoff from the forest floor to the streams. These pathways are controlled by the interaction of condensation, precipitation, evapotranspiration, interception, snowmelt, and other physical and biological factors.

Streams draining forestland are fed almost entirely by drainage through (not across the surface of) soils. Over most of the forested landscape, overland flow does not occur. Rain ordinarily infiltrates as fast as it falls, the exceptions being compacted soils or soils saturated by subsurface water originating upslope, which function as variable source areas (see below). Furthermore, the incessant tug of gravity gradually pulls enough water from upslope soils to supply streams between storms, with some augmentation from regional groundwater input (Patric 1994).

Streamflow between storms, or baseflow, results largely from the slow migration of water as unsaturated flow from drying soils upslope (Patric 1994). At the onset of a storm, rain falling directly into channels increases streamflow immediately. With continuing rain, water infiltrating riparian soils along the channel soon percolates to the depth of streamside soil saturation. The level of saturation in riparian soil rises, water begins to drain more rapidly into the stream, and stormflow begins. The longer the rain

continues, the farther upslope the streamside areas of saturation extend, the faster soil water drains to streams, and the greater the volume of stormflow produced. In effect, the source area providing water immediately to the stream extends farther into riparian areas and upslope, laterally and longitudinally as rain continues (Hewlett and Hibbert 1967; Dunne and Black 1970; Troendle and Leaf 1980).

Watershed features can influence the magnitude and timing of storm discharge. The physiography of watersheds influences storm flow by affecting the timing of runoff arriving from the various parts of the watershed. Large watersheds exhibit proportionately smaller, but longer duration peakflows than small watersheds on a per area basis, if precipitation is similar. Watersheds with steeper channels, or higher densities of channels, route water to the main channel faster. Natural wetlands and lakes retain water and dampen the storm hydrographs. Climatic variation can influence the magnitude and duration of floods within a basin, thus flood hydrographs are highly variable.

Increases in flow volume result from successively greater storms and expanding zones of saturated soil (termed variable source areas) within individual watersheds (Hewlett 1982). Floods occur when bankfull stage of channels is exceeded, and overbank flow occurs. The magnitude of floods is determined by the amount of rainfall, the rate of snowmelt, and soil antecedent conditions. Rain-on-snow events have generated some of the largest floods on record in western and eastern Washington (Coffin and Harr 1992; MacDonald and Hoffman 1995). The highest flows (of rare occurrence) produce the greatest sediment discharges and increases in habitat complexity, in part because streambanks erode and large-woody-debris jams are created. Flows with higher recurrence intervals, and enough power to transport bedload (bankfull flows), tend to be the dominant force in shaping a stream or river.

Headwater riverine and depressional wetlands can delay discharge of peak run-off into streams and impede passage of over-bank flow downstream during storm events, thus reducing the potential for downstream flooding (Winter 1988; Roth et al. 1993). Depressional wetlands can help maintain minimum stream base flow by naturally regulating the release of groundwater discharge into streams and by recharging aquifers that discharge groundwater to streams (Dinicola 1990; Hidaka 1973; O'Brien 1988; Mitsch and Gossselink 1993).

7.5.5.2 Management Influence

Human activities also influence the magnitude and timing of peak flows. Road building, drainage ditches, channel simplification, compaction of soil surfaces, channelization, levees and dykes, and impervious surfaces and buildings route water more quickly, increase peak flows, and cause them to occur more frequently. Man-made reservoirs can detain water and dampen peak flows. Widespread canopy openings can increase water yield and summer low flows temporarily by decreasing the interception of precipitation by trees and evapotranspiration loss of soil water (Dunne and Leopold 1978).

In forested areas, the vegetative cover plays a key role in rainfall/runoff relationships and snowmelt processes affecting basin yields and flow characteristics. Densely vegetated areas generally lose more water to evapotranspiration than areas with sparse vegetation and, therefore, densely vegetated areas may generate less runoff during the growing season. Removal of vegetation typically reduces water loss to evapotranspiration, resulting in increased water yield from the watershed. Precipitation is intercepted by vegetation and either evaporated directly or transported to the forest floor through stem flow. As vegetated surfaces become saturated, more precipitation reaches the forest floor through stem flow and through fall. A similar process of interception and evaporation occurs on the forest floor, with saturation ultimately resulting in infiltration to groundwater and overland flow to surface water. Uptake and use of precipitation by vegetation can also factor into the amount of water running off and reaching surface

water. The amount of precipitation intercepted, evaporated, transpired and infiltrated varies depending upon factors such as antecedent moisture conditions, temperature, the intensity and duration of precipitation, slope of the land, as well as the age and composition of vegetation. Dense vegetation also tends to create a lag effect on the runoff resulting from any given precipitation event—runoff tends to be delayed from reaching surface water bodies by all the mechanisms described above. Some precipitation events in heavily forested areas result in little or no measurable runoff due to these effects (Dunne and Leopold 1978).

Presumably, forests that are abnormally highly stocked (i.e., forests overstocked because of decades of fire suppression) have reduced water yields. These conditions may result in lower water yields and reduced low flows. It is logical that historical fire suppression and the build up of abnormal quantities of biomass in riparian areas have altered forest hydrology and its associated ecological processes to create conditions outside the natural ranges of variability, particularly in many Eastside forest locations (WFPB 1995).

Stocking and species control can make more water available to residual trees, increasing their vigor and the health of forest stands. Certainly, stocking control can reduce evapotranspiration on a landscape scale, resulting in greater soil moisture and an increase in water available for aquifer recharge.

Also, decreases in water yield and summer low flows may be associated with establishment of hardwoods in riparian areas (WFPB 1995), because hardwoods transpire more than conifer. Water yield can increase following logging, but the extent of increase depends on the type and amount of forest vegetation removed, climatic conditions, and the percentage of land area harvested and roaded. In mountainous watersheds, the soil and bedrock are key storage areas for water (Hewlett and Hibbert 1963; Anderson et al. 1997). Where present, lakes, ponds, and wetlands may also play a significant role in moderating the extremes in high and low flows. Soil and bedrock storage can sustain summer flows even through droughts of many months.

Water Yield

Water yield is the amount of water that is transported from a watershed, usually discussed as an annual water yield. Various studies (Helvey 1980; Bosch and Hewlett 1982; Harr 1983; Kattlemann et al. 1983; Troendle 1983; King and Tennyson 1984; Trimble and Weirich 1987; Keppeler and Ziemer 1990) have shown short-term increases in water yields following timber harvest. Much of this increased water yield appears as increased baseflow during the growing season, and increases in small peak discharges, especially those occurring at the beginning and end of the wet season (i.e., transitional between wet season and growing season). Forested lands, compared to other land uses, also tend to reduce peak flow magnitude while increasing flow duration. This is because forested lands tend to have better infiltration capacity and a high capacity to retain water than nonforested lands (Jones and Grant 1996; Intergovernmental Panel on Climate Change 2003), and because forest vegetation slows the routing of precipitation into the ground. Soils on agricultural and urban lands have lower percolation rates due to compaction or pavement. Overland flows during peak storm events occur often on those lands. Increases in peak flows and more-frequent bankfull flows are more common there than in managed forestlands with the same topography and precipitation (Knutson and Naef 1997).

Removal of substantial amounts of vegetation can be so great as to reduce evapotranspiration for several years following clearcutting, which can increase the amount of water that infiltrates the soil and ultimately reaches the stream. Therefore, streams draining recently logged areas generally see increased summer base flows (Keppeler 1998, Lewis et al. 2001). However, in some cases, removing trees can also

result in less delivery of water to streams. In one study, researchers found that about half the yearly water inputs to a higher elevation conifer forest came from fog-drip, i.e., cloud water that condenses on tree limbs (Lovett et al. 1982). Cutting trees in a coastal and mountainous fog-drip zone could remove a large fraction of annual water inputs, and significantly reduce summer baseflows (Harr 1982).

Several researchers found increases in annual water yield proportional to the amount of timber harvest in western Oregon (Rothacher 1970; Harris 1973; Harr et al. 1979). In general, the increase in water yield is directly proportional to the area harvested (Spence et al. 1996). Small patch cuts probably result in less water yield than large clear-cuts, and selective thinning or selective harvest may also have minimal effect on water yield (Beschta et al. 1995). Bosch and Hewlett (1982, as cited in Spence et al. 1996) after reviewing over 90 studies concluded that water yield usually increases after 20-30 percent of the watershed has been harvested. These effects may persist until revegetation approaches recovery, which can take 30 to 40 years assuming no further disturbance (Spence et al. 1996). Higher yields in logged watersheds can occur in the spring in snow-dominated systems; and in rain-dominated systems, the greatest flows can occur in the fall with the onset of fall rains (Spence et al. 1996). In some cases, however, harvest intensity alone was not found to be a good indicator of harvest effects on water yield (Connelly and Cundy 1992; Fowler et al. 1987).

Another potential pathway of effects for altered hydrology is when a substantial area of forest ground cover is disturbed from felling and yarding, resulting in less infiltration and perhaps more surface flows.

Low Flows

Low flows are often referred to as base flows, dry-weather flows, and groundwater flows. Low flows are the flows provided by groundwater to the streams during the lowest precipitation months of the year. In western Oregon, increases in low flow are generally short-term (5 years) following clearcut timber harvest (Rothacher 1970; Harr et al. 1982). In a northern California study, summer low flows were increased following selection harvest and then declined irregularly for 5 years until they were indistinguishable from low flows prior to harvest (Keppeler and Ziemer 1990). Base flows typically increases after timber harvest, benefiting aquatic species by maintaining higher water levels, but benefits can be short-lived as vegetation recovers. Small volumetric increases may provide improved habitat conditions (lower stream temperature, increased instream wetted area and volume) and survivability of aquatic species.

Scherer and Pike (2003) summarized eight research studies relevant to the Okanogan basin that addressed low flows. Four studies identified increased volume of flow subsequent to timber harvest and four studies document no significant changes in low flows. None documented a reduction of water volume during low flows. These findings are consistent with Austin (1999) who reviewed almost 350 international studies concerned with low flows and peak flows. Twenty-eight of the studies evaluated by Austin examined changes in low flows related to timber harvesting. In summary, 16 of the studies identified an increase in volume, 10 studies identified no changes, and only 2 studies identified a decrease in water quantity during low flows. This demonstrated that in the majority of forest types, forest harvesting causes no change or an increase in streamflow during the low flow period subsequent to timber harvesting. Austin (1999) concluded that: (1) low flows typically increase after harvesting; (2) changes in low flows are highly variable and difficult to analyze statistically, and (3) low flows rarely decrease in quantity. These results are intuitive from the fact that reductions in evapotranspiration following timber harvest will occur and will be greatest during the summer and autumn.

It is important to note that two studies reported lower water quantity in low flows after forest harvesting. These studies were both from the coastal forests in northwestern Oregon. In the first study, Harr (1982) attributed reductions in low flow volumes to a reduction in fog drip. Prior to timber harvesting, summer fog intercepted by the forest canopy subsequently dripped onto the forest floor. The water that was intercepted by the forest canopy contributed to the low flow volume. Even without substantial amounts of water entering the soil through this mechanism, the fog condensation augmented the dry season water budget, presumably reducing the amount of water taken up from deeper soil strata by trees to support transpiration. Upon removal of the forest canopy, the process of fog drip was greatly reduced, thereby reducing low flow volumes. In the second study, Hicks et al (1991) identified reductions in low flow volumes 8 and 15 years after timber harvesting. Reductions in this case were attributed to changes in riparian vegetation, from coniferous to deciduous. Because deciduous tree species transpire more water than conifers, lower water quantities were observed. It is important to note that this study involved riparian harvest. Both of the exceptions occurred in the coastal area of northwest Oregon. In the first case, fog-drip interception was offered up as a plausible explanation of the unexpected results. In the second example, the exception was due to harvest, and subsequent regrowth, of the riparian zone.

Peak Flows

Peak flow is the maximum instantaneous discharge measured in stream channels during high flow periods. Management activities can affect peak flows based upon their site-specific effect, elevational location within a watershed, and proportion of basin forest that has been altered by timber-related activities, such as roads and timber harvest (Bauer and Mastin 1997).

Although several mechanisms for alteration of peak flows by forest practices have been identified, changes in peak flow hydrology resulting from forest practices are difficult to interpret due to the numerous confounding factors present. Research into the effects of forest practices on peak flows in the Pacific Northwest has shown varying results. Some studies have documented increased peak flows following timber harvest (Harr et al. 1975; Ziemer 1981; Heatherington 1987), while others have observed decreased peak flows (Rothacher 1973; Cheng et al. 1975) or no change (Harr et al. 1975; Wright et al. 1990).

In Washington, it is commonly thought that the greatest potential for forest practices effects on peak flows is through the influence of clearcut timber harvest on snow accumulation and melt rates (DNR 1997). In general, harvested openings have greater snow accumulations and higher wind speeds than adjacent forested areas, leading to potentially faster melt rates and more water available for runoff (Coffin and Harr 1992). How this increased water delivery to the soil is routed to the stream network ultimately determines the effect on peak flows. The physical characteristics of a watershed—including the topography, soils, geology and vegetation—all influence water routing. Therefore, peak flow responses to timber harvesting are likely to be watershed-specific and may vary widely within and among different regions of the state.

Western Washington (and some of eastern Washington) receives moderate to high precipitation and is influenced by rain-on-snow events. The significance of rain-on-snow events is the increase in water delivered to the stream system during these events compared to rainfall alone. When warm air and rain occur on areas with a snowpack, rapid melting of the snow can occur, resulting in a pulse of water into the drainage network. Rain-on-snow events can occur on mountain slopes in the transient snow zone, which extends from altitudes of approximately 1,000 feet to 3,000 feet above sea level (Harr 1986), but can shift upward or downward during any given storm due to varying meteorological conditions.

Peak-flow events associated with rain-on-snow can be of greater magnitude than rain-only events because the rainfall is augmented by snowmelt. The direct effects of substantially increased peak flows include stream-channel alteration, bank erosion, redistribution of sediment and large organic debris, and flooding. Peak flows can be as great as to have direct effects on salmon when the resulting increased stream power can scour stream channels, killing incubating eggs (Murphy 1995), changing pool volume and frequency (Sullivan et al. 1987), and displacing juvenile salmon from winter cover (McNeil 1964, Tschaplinski and Hartman 1983). Increased freshwater flows into estuaries may result in reduced penetration of the salt wedge upstream into the lower reaches of rivers (Allanson and Barid 1999, as cited in Levings and Northcote 2004). In addition to the direct effect of peak flows, rain-on-snow events generate large inputs of water to the soils and can generate unstable conditions on hillslopes by increasing the pore-water pressure, which decreases the strength of the soil (Sidle et al. 1985); a reduction in soil strength increases the potential for slope failure.

In eastern Washington, the buildup of snowpack over winter contributes to large amounts of spring runoff. Rain-on-snow events are less common, but do occur, and are responsible for some of the largest floods. In forested areas east of the Cascades, snowmelt is the dominant mechanism for producing peak flows, most commonly in February to July depending upon location and elevation. Snowpack depths are often greater in forest openings in eastern Washington forests (Kattlemann et al. 1983; Troendle 1983). Peak flows are predominantly generated by snowmelt and may account for most of the 2- to 10-year peak flows. The timing of snowmelt runoff is important for many eastern Washington watersheds because this runoff is vital for irrigation supplies and fish habitat. Snowmelt-generated peak flows tend to be of longer duration and with less rapid variations than rain-generated or rain-on-snow peak flows. This is due to the fairly consistent energy input from full sunlight.

Timber Harvest Influences on Peak Flows: Increased peak flows can occur in the winter, when a warm, wet storm brings rain after a cold storm deposits substantial amounts of snow. Many floods in Washington, mostly on the westside of the Cascades, have occurred as a result of rain-on-snow events. The rain-on-snow zone in western Washington typically occurs between 1,200 and 4,000 feet in elevation (WDNR 1997a), depending on geographic area (WDNR 1991: September 26, 1991, Memorandum on Implementation of the Rain-on-snow Rule WAC 222-16-046(7))(WDNR 2006: Appendix M). Forest openings are conducive to increased snow pack accumulations because more snow reaches the ground as a result of less snow interception by the tree canopy, which is also a source of long-wave infrared radiation and shielding from the thermal effects of night sky exposure.

Extremely high flows can be detrimental to salmonids and their habitat. However, information about increased peak flows and forest cover removal is highly variable. One line of reasoning states that timber harvest can influence peak flows. Some authors have reported that while rain-on-snow events are a natural occurrence, their effects can be exacerbated when a watershed has been logged in a short amount of time (25 to 30 years) (Coffin and Harr 1992; Troendle and Leaf 1981). It has been said that the two most-important watershed variables that affect rain-on-snow events are elevation and extent of timber harvest. Timber harvest has the potential to alter snow accumulation and melt rates in any portion of a watershed, but predominantly in the “rain-on-snow” zone. Once rainfall associated with a storm occurs, the forest openings are believed to be more conducive to higher rates of melting of the snow pack than the surrounding forest. The combination of greater snow accumulation and potential increased melt rates can lead to a greater rate of moisture available at the soil surface in forest openings during a rain-on-snow event than occurs in the adjacent forest (Coffin and Harr 1992). The net result is that an increase in runoff is expected from forest clearcuts in areas where rain-on-snow is prevalent.

Because timber harvest can cause increased snow accumulation in openings, areas where runoff is dominated by snowmelt can theoretically experience increased peak flows. However, research in the Pacific Northwest has not consistently demonstrated this effect. Cheng (1989) found as much as a 35 percent increase in peak flows with 30 percent clearcuts in British Columbia. Anderson and Hobba (1959) found an 11 percent increase in spring peak flows across 21 watersheds in eastern Oregon. However, Fowler et al. (1987) found no effect in small watersheds in Oregon.

Extensive reviews of the literature on the response of peak flows to forest harvesting have been completed by Moore and Wondzell (2005), MacDonald et al. (1997), Austin (1999), and Scherer (2001). MacDonald et al. (1997) reported no consistent relationship between the percent of a basin that had been harvested and the percent change in peak flows. MacDonald et al. also noted that increases in peak flows greater than 150 percent generally occurred in the growing season as a result of rainfall and wetter antecedent soil-moisture conditions following forest harvesting; and further noted that peak flows are generally much smaller during the growing season and this means that a small increase in absolute discharge can yield very large increases in terms of a percentage change. Austin (1999) concluded that large peak flows increased only a small amount. The smaller increases in the larger peak flows may be attributed to their occurrence when soil moisture levels are high regardless of the forest cover.

Largest peak flows in the action area likely result from rain-on-snow events. The assumption by many people is that, because snow accumulates to greater depths on the ground in clearcuts, and because greater exposure to moist, turbulent winds occurs in openings, that clearcutting must result in higher volume of flows during rain-on-snow events. However, in cases where rain-on-snow occurs during a time when substantial amounts of snow still clings to tree branches, the increased surface area of that snow relative to the snow pack on the ground can facilitate greater melt rates within the trees than in clearings (Harr and McCorison 1979). Peak flows may increase due to harvest for events with substantial antecedent ground snowpack, whereas events with a smaller snowpack may show a decrease (Harr 1986). Another confounding factor that plays a part in the inconsistent field observations is the effect of timing of water routed from different parts of the watershed. Synchronization of peaks due to watershed physiography and clearcut distribution could produce enhanced peaks, while de-synchronization would have the opposite effect (Moore and Wondzell 2005). Timing and synchronization issues make it difficult to extrapolate the results of small watershed studies or stand-scale mechanisms to larger watersheds.

Rain-dominated watersheds, such as those along the coast, may also be subject to increased peak flows, but for different reasons. Studies that have shown peak-flow increases in rain-dominated watersheds (Harr et al. 1975; Harr 1986), but have correlated the increases with soil compaction, rather than timber harvest. Yet other studies indicate no change in peak flow after harvest (Benda et al. 1998). Smaller peak flows at the beginning or end of the wet season (i.e., transitional periods between the wet and growing season) may be expected to increase due to the influence of reduced evapotranspiration rates on antecedent soil moisture.

Road Management Influences on Peak Flows: Roads can alter runoff by collecting subsurface and road-surface water and routing it efficiently and directly to stream channels (Chamberlin et al. 1991, McIntosh et al. 1994). These road effects potentially can increase peak flows during rainstorms (Ziemer 1998).

The design, construction, and maintenance of roads interact with watershed characteristics of soil, topography, and geology and natural disturbances (such as large storms) to determine the effects of roads on the hydrology of a particular watershed. The interception of surface runoff during storms and

interception of shallow groundwater flow by a road prism and associated ditches can affect the routing of surface water, extend the channel network (Wemple et al. 1996), increase the potential for higher peak flows, and increase the potential for mass wasting (Montgomery 1994). In a general sense, roads can act as extensions of the drainage network if the roads drain to streams. Road-influenced peak flows have been demonstrated in small watersheds (Ziemer and Lisle 1998); however, the effects of roads on a river basin scale are less consistent (Jones and Grant 1996; Beschta and Boyle 1995). Logging in large drainages generally results in proportionally smaller effects to the hydrology than in smaller drainages, probably due to the spatial distribution and timing issues discussed earlier (Duncan 1986).

Two summaries of recent research studies on roads in forested areas demonstrate that roads can have significant effects on peak flows if roads are improperly constructed and if their drainage networks are allowed to become connected to the stream network through improper construction or inadequate maintenance or abandonment procedures (USDA Forest Service 2001; CMER 2004). CMER (2004) has issued a draft review of published literature that suggests that roads alter runoff processes by the production of overland flow, by interception of subsurface stormwater flow, and by piracy of streams by road ditches. Road runoff may create additional channels in the stream network by incision (Montgomery 1994), potentially leading to adverse consequences for both hydrology and slope stability, depending on the road location.

A road-maintenance survey conducted by the WDNR (1999) indicated that in 36 subbasins surveyed, the majority were out of compliance with road-maintenance objectives for road-surface drainage, ditch drainage, and water-crossing structures. The authors stated that the rules in effect on January 1, 1999 were “subjective and inadequate,” and recommended that outsloping or water dips would be the first priority in improving performance of road drainage on forest roads. Based on recent research and modeling studies, the USDA Forest Service (2001) made the following recommendations on a national scale: that forest-road locations should be carefully chosen based on a geologic study; that road design should minimize interception, diversion, and concentration of water using out-sloping and drainage structures; that crossings should be designed to pass all stream materials (including water, fish, debris, and sediment); that design and removal of roads should take into account the sensitivity and orientation of the road; and that roads should be designed with failure in mind.

Rashin et al. (1999) recommended a variety of improvements to road BMPs. Those that apply to reduction of peak flows and direct input of road runoff to streams include: minimization of road location within 485 feet (150 meters) of streams, revised spacing of relief culverts, adequate sediment traps, and spreading or dissipation measures to prevent incision from runoff. They also recommended against the use of ambiguous language in BMPs.

Roads can affect hydrologic regimes by interrupting hillslope drainage patterns, which can alter the magnitude and timing of peak flows and change base flows of streams (Quigley and Arbelbide 1997). Changes in peak flows from roads have been observed in some studies (Harr et al. 1975; Harr 1979; King and Tennyson 1984; Jones and Grant 1996). However, similar research in other Pacific Northwest watersheds found no significant difference or a decrease in peak flows following substantial soil compaction from roads and skid trails (Rothacher 1970; Ziemer 1981; King and Tennyson 1984; Wright et al. 1990). Still others have found different effects depending on the relative size of the peak flow, and have emphasized the difficulty in making statistically-valid conclusions (Thomas and Megahan 1998). The variability in these results suggests that watershed-specific factors influence the effects of timber harvest and road construction on peak flows.

7.5.5.3 Discussion

Historical road routing and construction practices have, at times, led to substantial effects on riparian systems, and in turn, on hydrology. Roads were often built along flat floodplains, which resulted in the removal of riparian vegetation. In narrow canyons with limited floodplains, roads were commonly located on the sideslope within the riparian zone or encroached on the stream channel; some roads even used the actual stream channels. Even in the absence of these longitudinal effects, the continuity of the riparian corridor has been interrupted at each bridge and culvert crossing (Kondolph et al. 1996).

Stream-adjacent roads can cause the degradation of some or all riparian functions, including hydrologic processes, within riparian lands depending on where road construction has occurred. One example is the loss of large-wood recruitment potential from trees on the upland side of roads within riparian areas. Most of the trees on the upland side are not be recruited as large wood because they are typically removed when the tree falls onto the road. Major changes to the aquatic system have also occurred from riparian land modifications due to road development, including the straightening or simplification of the stream channel system (Knutson and Naef 1997; Oregon Department of Forestry 1999a).

Consideration of elevation, aspect, stand age, and hydrologic response improves the predictions of harvest effects on stream flows (Connelly and Cundy 1992). Increases in peak flows have been noted for areas of the Pacific Northwest after timber harvest and road construction (Harr et al. 1975; Harr et al. 1979; Thomas and Megahan 1998). However, other researchers have found either no effects or even decreased and delayed peak flows following harvest and road construction (Duncan 1986; Harr 1976; Harr 1980; Cheng et al. 1975; Harr and McCorison 1979). Rothacher (1965, 1973) reported that peak flows showed little or no increase from timber harvesting, but low flows showed a modest increase.

Concentrated flows from any source can exacerbate potentially unstable conditions on hillslopes by increasing the pore-water pressure, which decreases the strength of the soil (Sidle et al. 1985); a reduction in soil strength increases the potential for shallow-rapid slope failure. Where peakflows increase and the spatial pattern within a basin is synchronous or additive to peak flows downstream, channel erosion in lower-order channels could increase; resulting in an increased volume of sediment and perhaps woody debris transported to downstream fish-bearing reaches. In some watersheds, peak flow increases might be undetectable or asynchronous and not measurable downstream. Forest practices may affect hydrologic processes through the alteration of vegetation characteristics and soil properties. However, detectable changes may be difficult to demonstrate except in cases where large portions of a watershed are harvested over a short period of time.

It has been surmised that because harvested areas have reduced evapotranspiration, and soils in these areas are subsequently wetter, they may potentially reach saturation sooner during a rain storm. This accelerated saturation point may result in attainment of surface flow somewhat quicker than on a site that was not harvested. This seems to be the case during the growing season (e.g., summer and fall). Reduced evapotranspiration may cause wet antecedent soil conditions, conducive to small peakflows, to occur earlier in the year, and later into the spring. The extent to which timber harvest alone has triggered substantially increased peak flows is unknown and likely limited to smaller peaks (Storck et al 1995). Most recent research suggests that peak flow changes due to forest practices are difficult to detect on large river systems; effects of peak flow changes due to forest practices in small basins are highly variable, but small peaks are apparently affected more than large peaks (e.g., Thomas and Megahan 1998; Beschta et al. 2000).

Disruption of subsurface flow could, potentially, affect freshwater seeps along the shorelines of estuaries and the marine near-shore. Inside Puget Sound, spawning of certain forage fish is thought to be associated with freshwater seepage, where the water keeps the spawning gravel moist (WDFW 2005a). Disruption of these seeps could potentially cause reduced spawning success, and reduced available forage for certain marine and anadromous fish.

7.5.5.4 Effects of FPHCP on Hydrology

Introduction

The old forest practices rules (i.e., in place November 1998) reduced the potential for significant hydrologic effects from timber harvest and road construction. The November 1998 rules limited a contiguous clearcut area to 120 acres. Areas under the same ownership adjacent to existing clearcuts could not be harvested until young trees were reestablished (green-up rules). Proposed forest practices in the rain-on-snow zone were screened for potential to affect peak flows if the area contained hydrologically immature vegetation. Hydrologically immature vegetation was defined as young forest stands that did not hold significant snowfall in the tree canopy and did not moderate the effects of wind and rain on the snow pack at ground level. Furthermore, the November 1998 rules provided for voluntary watershed analysis that included a hydrologic assessment of the past and current effects of timber harvest within the basin. Watershed analysis resulted in binding, site-specific prescriptions to address any effects revealed in the assessment, particularly those related to rain-on-snow peak flows. See the **Comprehensive Cumulative Effects** section of this Opinion. Many watershed analyses were completed prior to the proposed FPHCP and are considered part of the environmental baseline.

The November 1998 rules reduced the potential for significant hydrologic effects from timber harvest and road construction by:

1. Limiting clearcut size and distribution (green-up rules).
2. Using a rain-on-snow rule to help control peak flows.
3. Identifying wetlands and limiting harvest operations.
4. Establishing best management practices (BMPs) for road construction and maintenance.
5. Road Maintenance and Abandonment Plans (albeit, not on an established schedule).
6. Promoting voluntary watershed analysis.

The November 1998 Forest Practices Rules addressed timber harvest effects on rain-on-snow peak flows directly through watershed analysis and the rain-on-snow rule, and indirectly through the green-up rule. Each of these regulatory mechanisms includes provisions that reduce the potential for harvest-related increases in rain-on-snow peak flows. Watershed analysis addresses peak flow increases through the development of watershed-specific management prescriptions that typically restrict clearcut timber harvesting by requiring the retention of minimum levels of “hydrologically mature” forest cover. “Hydrologically mature” generally means forests with canopy structures that are effective at intercepting and retaining snow above the forest floor. The sum experience with the modeling approach in the Watershed Analysis Hydrology Module (over 60 watershed analyses) indicates that rain-on-snow was rarely a concern relative to the WDNR conditioning guidelines. Outside areas where watershed analysis has been performed, the rain-on-snow rule gives the WDNR authority to limit clearcut timber harvesting

in the significant rain-on-snow zone in order to reduce peak flow effects, although as currently implemented, the rain-on-snow rule is not used often. This appears to be largely due to two considerations. First, the implementation criteria of both a significant portion of a watershed being within the rain-on-snow zone and a significant portion of the watershed being in hydrologically immature vegetation are seldom triggered. The prevailing patterns of harvest in these areas do not result in large clearcuts dominating, or being concentrated in, a single watershed. Second, there is a stipulation that evidence of in-channel damage due to excessive peak flows must be readily apparent prior to imposing these rain-on-snow rules. While channels may be degraded due to a combination of factors, it is difficult to identify whether observed degradation may result from increases in peak flows or from other factors. WDNR-issued guidance for implementing the rule includes a risk-assessment method and conditioning strategies for minimizing peak flow increases. While not specifically designed to address rain-on-snow, the green-up rule minimizes its effects by limiting the size and timing of clearcut timber harvesting within the rain-on-snow zone as well as other portions of the State, provided that adjacent parcels fall under the same ownership. In cases where ownership is mixed or small landowners dominate, however, the green-up rule would not apply.

The Forest and Fish Report (1999) set an objective to "maintain surface and groundwater hydrologic regimes (magnitude, frequency, timing, and routing of stream flows) by disconnecting road drainage from the stream network, preventing increases in peak flows from causing scour, and maintaining hydrologic continuity of wetlands." In addition to the improvements discussed below, the FPHCP would continue to apply protection to unstable slopes and would continue applying the "green-up" and "rain-on-snow" rules, and the other protective measures discussed above.

Compared to the November 1998 rules alone, the FPHCP further reduces the potential for management-related effects on hydrologic processes on covered forestlands. The FPHCP provides additional provisions (see below) to further reduce the effect of forest practices on hydrologic processes. FPHCP is expected to reduce soil disturbance and compaction at areas with significant shallow subsurface flow and reduce the amount of concentrated road drainage flowing directly to streams.

Riparian Timber Harvest

Improved wetland mapping, combined with rules for operations within wetlands, should protect the hydrologic functions of these sensitive systems. Protection of the hydrologic continuity of forested and non-forested wetlands would be continued. Buffers would continue to be retained around non-forested wetlands.

Prescriptions are designed to maintain the hydrologic functions of wetlands. All road and landing construction within wetlands would have to employ a mitigation plan to avoid, minimize, and restore, reduce, or replace affected areas. Small wetlands within an RMZ would be identified and mapped. The threshold for mapping forested wetlands outside RMZs would be lowered to 3 acres. WDNR would be required to maintain a map record of wetlands identified in FPAs. However, hydrology may be adversely affected when forested wetlands are harvested. Forested wetlands may have saturated soils or small amounts of surface water during significant portions of the growing season.

No-harvest buffers on Type S and F streams, including CMZs, would retain vegetation and downed wood and would protect the shallow subsurface flows beneath and adjacent to these riparian areas. Channel migration zones are recognized as part of the channel, and therefore are included within the no-harvest portion of the RMZ. These measures protect shallow subsurface flows beneath and adjacent to these streams, which are important for supporting a variety of aquatic organisms.

Type Np streams would receive buffers on strategic areas including thermal recovery zone and sensitive sites. These buffers would also protect the shallow subsurface flows beneath and adjacent to these streams. Type Ns streams on unstable slopes would also be protected. Equipment limitation zones would be established along Np and Ns stream channels and would further reduce soil disturbance and compaction at areas likely to have significant shallow subsurface flow.

Sensitive-site RMZs emphasize tree retention around seeps, and springs, which may be hydrologically sensitive. These measures protect shallow, subsurface flows beneath and adjacent to these streams, which are important for supporting a variety of aquatic organisms. Sensitive sites receive 50- to 56-foot, no-harvest buffers on the westside and partial harvest buffers on the eastside. There would be no harvest within alluvial fans on the westside.

Riparian activities involving heavy equipment can cause soil compaction and rutting which can reroute water and alter ability of water to infiltrate soils. Skid trails and ruts may also enlarge the drainage system routing water to the stream system more quickly. No-harvest buffers and ELZs that prevent or minimize disturbances to the riparian forest floor would help maintain water infiltration rates and subsurface flow through riparian soils. Also, retention of down wood in RMZs after harvest would help maintain normal patterns of surface roughness and overland flow when it occurs (Megahan and Ketcheson 1996; McGreer 1981; Benoit 1979).

Hardwood conversion would not occur within the Core Zone and would have little if any effect on hydrology. Changing the Inner Zone from a deciduous canopy to a coniferous canopy would have little effect when the magnitude of affected stream length and incremental evapotranspiration rates are considered. No significant or measurable physical effects to stream hydrology are expected due to the "equal in overall effectiveness" provisions of alternate plans with respect to aquatic and riparian function. The overstocked template would retain trees within an approximate rooting diameter of the streambank and is not expected to greatly influence evapotranspiration of remaining stand over time.

Ground-based yarding would generally be conducted outside the Core Zone and may result in some localized compaction or rutting. This may lead to minor changes in infiltration and surface flow. Equipment would operate closer to streams and would operate across a greater portion of the ground within riparian areas on 20-acre exempt parcels, increasing the potential for soil compaction and other effects that could alter the local hydrology. However, the shade rule would assist in reducing some of these effects. The retention of small buffers on Type Np streams within 20-acre exempt parcels would result in some effects to hydrology. The effects on these Type Np streams may be more severe in cases where trees would be excessively clumped to accommodate operations.

Road Management

Road surfaces can alter natural infiltration rates and can result in the interception and diversion of near-surface flow to the surface. The interception and diversion can increase the area of a watershed that is composed of small streams and increase the short-term water yield to the stream system. These factors may potentially influence the frequency and amplitude of small to moderate peak flows, especially in small watersheds. There could be some increased potential for higher peak flows during mild to moderate rain or rain-on-snow events when surface / subsurface flows are captured by the roads and redirected to streams via roadside ditches. Large rain-on-snow events or large flood events are unlikely to be modified by forest roads or harvest units.

The FPHCP would considerably reduce the potential for road-related delivery of water to streams by restoring the natural flow paths of surface and shallow subsurface water when roads are abandoned, disconnecting road drainage from directly entering streams, and minimizing the length of forest roads that deliver water directly to streams, as well as improving road crossings so they do not impede natural flow. These practices address the water-delivery mechanisms with the greatest potential for changing water-routing patterns and increasing peak flows. These would be accomplished through both new road standards and RMAPs. BMPs for road maintenance and construction would continue to disconnect ditches from streams and minimize effects of routing intercepted water, and would provide higher standards for passage of wood, sediment, debris, and fish. RMAPs would be accelerated beyond the potential requirements of the previous (November 1998) rules, thereby correcting existing problem areas and providing for passage of wood, sediment, debris, and fish.

Other important effects are the rate at which the road maintenance and abandonment plans would be implemented and the prioritization of watersheds with listed species. The condition of all roads (including orphan roads) would be inventoried and assessed to address direct delivery of water from roads to streams. Road systems or basins potentially affecting listed fish species would be given highest priority, generally starting at the mouth of the basin and working upstream.

The FPHCP would necessitate a much more-rapid rate of road-condition assessment and improvement than would be done under the existing watershed-analysis process. Since the Washington Forest Practices Board adopted watershed analysis into regulation in 1992, original assessments have been completed for only 56 of the 754 (7 percent) of the forested watershed analysis units (WDNR 2000b). That translates to approximately eight units (WAUs) per year. At that rate, it would take about 87 years to complete original watershed analyses on all forested watersheds in Washington.

Watershed analyses contain a requirement for review 5 years following implementation. Five-year reviews of surface erosion in several watersheds estimated a 34 to 48 percent reduction in delivery of sediment to streams following implementation of road maintenance and abandonment plans (Baitis 1999; Toth 1997). It is reasonable to expect a proportionate increasing trend toward the normal delivery of surface waters to streams as a result of implementing the plan. Management measures for forest roads would reduce the potential disruption of hydrologic regimes by requiring landowners to minimize construction of new roads in riparian areas, upgrade existing roads to reduce disturbances of water-routing patterns, and construct new roads to higher standards.

Coffer dams (for culvert replacement) are usually in place for 1 to 2 days and generally required only once per stream crossing for the effective life of the crossing structure. Most often, such structures are not required for culvert replacement. When they are used, effects include short-term desiccation of a segment of streambed (generally less than 100 feet total) and short-term disruption to passage.

Under FPHCP, intercepted water from direct rainfall and exposure of hillslope soil in roadcuts is expected to be re-directed onto the downslope forest floor in a diffuse manner. Such change as a result of road interception of water may still concentrate surface flow in a manner that could increase the amount of stream system and could contribute to some increase in the frequency and amplitude of peak flows. However, these effects depend on watershed size and the relative size of the peak flows in question.

Research

Habitat manipulation research within RMZs may later the hydrology of smaller streams. This may occur through deviations from standard timber-harvest rules that result in soil compaction or alterations of

riparian vegetation. This may also occur as a result of instream measurements involving measurement weirs or other structures that may affect stream flow in individual small streams for a short timer period (during measurement activities). Such changes in stream flow would be subtle and would only occur on a very small number of streams. Effects would be indistinguishable from addition of a large tree to the stream.

Conclusions

Based on several studies in Washington (Coffin and Harr 1992, O'Connor and Harr 1994, Storck et al, 1995, and Bowling and Lettenmaier 2000, Moore and Wondzell 2005), we expect that peak flow increases during small to moderate peak-flow events might occur as a result of timber harvest, particularly in small watersheds, during the beginning and end of the wet season. In watersheds comprised of elevations falling dominantly within the rain-on-snow zone, peak flow increases may occur if the proportion of the watershed in recently harvested condition is substantial. Due to difficulties in detectability, presence of cumulative and confounding effects, and a lack of ability to determine causation, it is extremely difficult to link a contribution to a peak-flow event, or incremental effects of such an event, with any single harvest unit.

Small and moderate peak flows may be increased, however, due to water interception and routing by road networks, which may be independent of season, except in the zone of permanent snowpack. Increases in peak flows as a result of the road network may cause premature scour of redds.

The FPHCP proposes a number of measures that would reduce the potential effects of forest practices on hydrologic processes. The FPHCP prescriptions should reduce undesirable effects on the surface-water network by requiring road maintenance and abandonment plans, upgrading existing roads, and constructing new roads to minimize effects on water routing. The FPHCP proposes substantive measures to disconnect road drainage from the stream network, reducing the possible effects of road runoff on peak flows and their potential effects on channel scouring.

These factors should reduce ability of road system to contribute to frequency or amplitude of peak flows or their ability to scour. New roads and newly repaired roads might cause localized, increases in small to moderate peak flows and in sediment delivery, but the net effect over longer time periods, across the action area, would be an overall decrease in road-related peak flow increases when other proposed measures (i.e., road upgrading and removal) are considered, with little detectable effect on redd stability and overall habitat conditions. Similarly, in estuarine habitats, there would be little detectable difference in the location of the estuarine salt wedge, or area of maximum turbidity; nor would there be substantial effects on the covered species that use these areas.

Summary: While an increase in peak flows from timber harvest is possible, it is likely to be confined to smaller watersheds and small to moderate, early and late season peak flows, or possibly to watersheds lying in the rain-on-snow zone where substantial portions of the watershed are cut within a short time period. Some increases in summer low flows would occur in sub-watersheds that drain recently harvested areas. However, we expect increases in low flows will generally be a benefit or neutral during periods of low flow. In some small coastal streams, reduced flow may occur from removal of trees contributing to fog drip. Any increases in peak flows would generally occur in the summer or at the beginning or end of the wet season and be of little measurable consequence for covered species. Influences on larger peak flows (storm flows) resulting from timber harvest are expected to be inconsequential.

While an increase in peak flows from forest roads is possible, it is likely to be confined to smaller watersheds and small to moderate peak flow events, or to watersheds lying in the rain-on-snow zone. Fishes are more likely to be affected by the effects of altered inputs and routing of sediment than the effects of altered flows. Some increases in peak flows and summer low flows may occur in sub-watersheds that drain areas with many road crossings and stream-adjacent parallel roads.

Hydrologic regimes that occur within the range of natural variation are presumed to maintain cool clean water with natural flow rates and adequate aquatic habitat for covered species. Baseline conditions should continue to improve as a result of the proposed FPHCP.

7.5.6 Water Temperature (Heat)

Water temperature is a product of complex interactions between geomorphology, soil, hydrology, vegetation, climate, elevation, and aspect of the watershed. The relative influence of these factors can vary spatially across the landscape and over time. Water temperature can vary along the length of a stream as a result of local topographical and geological factors. Thermal heterogeneity within streams and rivers and can be affected by local energy inputs and outputs (IMST 2004).

Temperature influences many biological and ecological processes in a stream, including nutrient cycling and productivity. Temperature is also important because it influences the metabolic rates and physiology of aquatic organisms, including fish. Cold water is able to absorb more oxygen than warmer water; therefore, oxygen-richness of water is directly linked to water temperature. Likewise, many processes influence temperature. For example, elevated temperatures are often linked with other signs of stream degradation including loss of riparian vegetation and wider than expected stream channels (IMST 2004).

Many of the FPHCP covered species require relatively cold water throughout their life-history stages. Overly warm, oxygen-poor waters are detrimental to these species and their ecosystems. Most of the native fish species in Washington are classified as cold- or cool-water species. Native aquatic species that are sensitive to warm temperatures include bull trout, shorthead sculpin, and Dolly Varden, and a number of other fish species. In fact, due to bull trout's required lower temperature than other salmonids, specific temperature standards to protect this species are needed within the species known historical distribution (IMST 2004). The stream-associated, FPHCP covered amphibians are also sensitive to water temperature, especially tailed frogs tadpoles. Small, headwater streams are particularly important to amphibians, in part because they are free from competition and predation by fish.

The survival of cold-water fish is dependent on water temperatures, and increases in temperature have been linked to fish mortality, sub-lethal effects such as increased presence of disease, and distributional or habitat preferences (Johnson and Jones 2000). Temperature directly and indirectly affects physiology, development, growth, and behavior of fish, as well as food-web dynamics, predator-prey relationships, and the incidence of parasitism and disease (Spence et al. 1996, McMahon et al. 1999, Sullivan et al. 2000).

Although lethal temperatures do occur in streams and can be locally problematic, sub-lethal effects of temperature determine the over-all well-being of our native fish. Sub-lethal and chronic effects may include reduced growth, disease, and interrupted smoltification. Responses by fish to changes in stream temperature occur through physiological and behavioral adjustments that depend on the magnitude and duration of temperature exposure (Sullivan et al. 2000).

7.5.6.1 Baseline

Several historical documents provide data on stream temperatures in the Columbia River Basin (Stone 1878; McDonald 1895; Gilbert and Evermann 1895; Evermann 1896). Sullivan et al. (1990) and Caldwell et al. (1991) reported on stream conditions on small streams in western Washington.

A 1998 review of shade inventories conducted through watershed analysis found that more than half (57 percent) of fish-habitat streams complied with the riparian shade requirements (Shade Rule) of the Washington Forest Practices Board Manual and would result in streams that meet the current numeric temperature criteria (16 or 18 degrees Celsius) in the State water-quality standards (Beak 1998). In consideration of more than a century of logging combined with the relatively recent requirement of riparian buffers when harvesting timber, this majority of streams was considered to be "good" according to Beak (1998). However, streams that meet this standard may not meet the needs of some cold water fish. Westside and eastside streams were similar in their capacities to comply with the Shade Rule.

Beak (1998) reported that about 17 percent of streams had riparian areas that are naturally low in their capacity to provide shade (e.g., low-productivity sites, rocky slopes, and wet meadows). Under these circumstances, many of these streams may not achieve the numeric temperature criteria, regardless of forest practices (Beak 1998). Most of these situations occurred in large and wide Type 1 waters of the State (currently referred to as Type S waters) (Beak 1998). In these streams, natural temperatures will likely define the water-quality standards.

The remaining streams (26 percent of the total) had the potential for riparian canopy conditions to meet the State temperature criteria, but had shade levels below that predicted to meet the standard. The majority of these low-shade situations were legacy conditions resulting from shade removal prior to adoption of the Washington Forest Practices Act in 1974 or the Shade Rule in 1992. The 1998 report was a compilation of information from completed Watershed Analyses, so the actual data had been collected across the 53 watershed administrative units during some time previous to 1998. The level of improvement in shade conditions between the time of data collection and the current time is uncertain, but we expect that shade conditions have improved during this interval because requirements on riparian buffers have increased since the data was collected for the 1998 report.

7.5.6.2 Physical and Behavioral Adjustments

There are numerous reasons why fish may be present in waters where temperature exceeds the predicted suitable range. According to the IMST (2004), they may do so: (1) with physiological or genetic adaptations to survive brief exposures to high temperatures; (2) as transient fish, not members of healthy populations resident in the warm stream reach; (3) with impaired performance (e.g., earlier emergence, faster growth, changes in migration timing, increased susceptibility to disease, altered response to competition and predation), the effects of which could be cumulative or obviated at some later life stage; (4) because they are utilizing cold-water refugia in these warm streams; (5) because variations in stream temperatures over the course of a day or week might allow fish to survive short-term unexpectedly hot conditions; or (6) because the upper extreme of temperatures that fish populations can tolerate may be higher than scientists assume. Acclimation and seasonal acclimatization to temperature changes are important in the ecology of fish. Behavioral mechanisms allow organisms to tolerate short-term extreme temperatures (McCollough et al. 2001). Some evidence suggests that fish can cope with high temperatures if the daily highs do not persist too long and/or the daily lows are sufficiently low or there are adequate thermal refugia available; however, the ways fish adapt to or cope with fluctuating temperatures are not yet well understood.

Summer

A rise in stream temperature increases the metabolic rate of aquatic species. Consequently, more energy is required, even during periods of low activity. In addition, dissolved oxygen decreases as water temperature increases, potentially increasing stress on fish. Water temperatures in the range of 21 degrees Celsius or greater can cause death in cold-water species such as salmon and trout within hours or days (ODEQ 1995). Long-term sub-lethal effects as well as short-term acute effects of warm water temperatures can be detrimental to the overall health of aquatic species. Heat stress may accumulate such that increased exposure for juvenile fish increases their susceptibility to disease, reduces swim speed, and reduces growth, especially when food is limiting as it is in many northwest streams (ODEQ 1995). Since the timing of life history events, such as migration from natal rearing streams to larger tributaries or rivers is an adaptation to local conditions, changes in those environmental conditions such as to stream temperatures, may reduce the fitness of affected populations of fish (Beschta et al. 1987).

There are numerous conditions that can result in summer temperature increases in streams. These conditions include: 1) reduced canopy cover; 2) increased coarse and fine sediment delivery to stream channels, which can lead to channel widening and loss of pools; 3) reduced large wood recruitment, which results in reduced number of pools, reduced channel capacity, and loss of thermal buffering and cold-water refugia; 4) interception of shallow groundwater by road systems; 5) increased air temperature over streams by loss of microclimate buffering; 6) riparian roads, which reduce the interaction of the floodplain with the channel; 7) loss of off-channel wetlands; 8) loss of streambank stability leading to increased sediment delivery and channel widening; 9) increased in sediment delivery due to forest-related road systems, leading to pool loss and channel widening (Beschta et al. 1987; Brosofske et al. 1997; Johnson and Jones 2000; IMST 2004).

Winter

Sugden et al. (1998) provides an overview of salmonid biology and habitat use during the winter, including habitat changes and sources of mortality from formation of ice within streams, especially anchor ice. Cunjak (1996) provides additional information on this topic.

In the winter, riparian canopy cover may help moderate water temperatures by inhibiting energy losses through evapo-transpiration, convection, and long-wave radiation. Channel width and depth also affect stream temperatures in the winter. Wide, shallow streams are more likely to become super-cooled than deep, narrow streams (Chisholm et al. 1987; Swanston 1991). Chisholm et al. (1987) also reported that snow bridging was more likely to occur on deep, narrow streams and would prevent surface and anchor ice from forming by insulating the stream.

7.5.6.3 Factors Controlling Stream and River Temperatures

Stream temperatures are affected by many environmental factors including, but not limited to, direct and indirect solar radiation, watershed elevation, aspect and topography, regional and seasonal climate, local climate (air temperature, vapor pressure, humidity, wind, cloud cover, etc.), time of year (day length and sun angles), precipitation amounts and timing, channel dimension, streambank entrenchment, streamflow (water quantity), groundwater inputs, and riparian vegetation. Although shade does not physically cool a stream down, it can help reduce further heating of the stream and therefore it can maintain the cool temperature associated with groundwater inputs and tributaries (Beschta et al. 1987). Water temperatures decrease when heat energy is transferred from the water to the surrounding environment via convection (mass movement of heat within a liquid or gas) and conduction (heat transfer by substances coming in

direct contact with each other). Temperature indicates the direction heat energy will move; heat will move from the warmest to the coolest substance. Temperatures will also decrease when heat in the water is diluted by cool water inputs from groundwater, tributary inputs, or precipitation.

The major source of heat added to streams is from solar radiation. Shade blocks radiation from reaching the surface of the stream and decreases the amount of heat added to the water. With increasing amounts of heat blocked and not allowed to reach the water's surface, cooling via evaporation, convection, conduction, and possibly hyporheic exchange will be more effective. However, water temperature may remain relatively unchanged in shaded reaches until it mixes with other cooler water within the reach (Beschta et al. 1987).

Average daily stream temperatures are regulated by many factors: ambient air temperature, relative humidity, groundwater influx, stream channel morphology (including discharge rate), and substrate composition (Bryam and Jemison 1943; Brown 1969; Patton 1974 as cited in Cross 2002; Adams and Sullivan 1989; NCASI 2000). Solar radiation has a relatively small impact on daily mean stream temperatures (Adams and Sullivan 1989). However, solar radiation is most responsible for deviations from average daily temperatures (Adams and Sullivan 1989; Ice 2001), and is almost the only factor that can be directly controlled by (active or passive) forest management. Increases in direct solar radiation due to reduction of riparian vegetation are most responsible for high stream temperatures (Brown and Krygiers 1970; Barton et al. 1985; Ice 2001).

It is well established that riparian timber harvesting can increase maximum stream temperatures (see review by Beschta et al. 1987) and diurnal fluctuations (Beschta et al. 1987; Spence et al. 1996). The primary mechanism for this stream warming is an increase in direct-beam solar radiation that reaches the stream surface when shading is removed (Brown 1969). Because direct-beam solar radiation is a principal source of heat energy inputs to streams (Brown 1969), it follows that vegetation immediately adjacent to streams provides the greatest relative benefits for intercepting solar radiation. Vegetation farther from the stream may increase the density of the canopy and thereby help reduce solar inputs, but these benefits diminish with increasing distance from the channel (Light et al. 1999).

Small streams that are wide and shallow with low discharge rates are at the highest risk of temperature problems (Welch et al. 1998). Low-order, narrow stream channels are more likely to be well-shaded in comparison to wide stream channels that can be expected to have lower levels of shade simply due to their geometric relationship between vegetation height and channel width. On large streams and rivers, riparian shade may be present only along bank edges or secondary channels.

Riparian vegetation can regulate temperatures by blocking incoming solar radiation, and maintaining channel morphology, and floodplains. The amount of influence riparian vegetation may have on stream temperatures is dependant on multiple factors including the size of the stream, water depth, groundwater and tributary inputs, riparian vegetative community, length of stream channel shaded, slope, aspect, and region.

The primary factors influencing shade, and therefore solar input, are: (1) density of vegetation – buffer width alone is not a good predictor of canopy characteristics, shade, or solar energy transmitted to the stream (Brazier and Brown 1973; Newton and Zwieniecki 1996); (2) height of vegetation – site-potential tree height varies physiographically, trees that lean over streams provide more-effective shade than their height suggests (Cross 2002); (3) stream width – effective shade generally decreases as stream width increases, and less sunlight is blocked by the adjacent canopy (Betscha et al 1987; Sullivan and Adams 1991), small streams can be effectively shaded by understory vegetation (Lorensen et al. 1994); (4)

stream-reach orientation – interception of solar radiation is dependent on location of vegetation relative to the stream and solar path (i.e., the amount of sunlight that is blocked) (Cross 2002); (5) latitude and time of year. – the angle of the sun decreases with increasing latitude which causes more potential shade, low winter sun angles maximize reflection at the water surface and shading effects of riparian vegetation, while high summer sun angles maximize direct-beam solar radiation (Beschta et al. 1987); (6) time of day – the angle of the sun increases in the morning and decreases in the afternoon, low morning and afternoon sun angles maximize reflection at the water surface and shading effects of riparian vegetation, while high midday sun angles maximize direct-beam solar radiation.

Air temperature is cited in some studies as strongly influencing stream temperatures (e.g., Edinger et al. 1968; Smith and Lavis 1975; Sullivan and Adams 1991; Larson and Larson 1996). Bartholow (2005) attributes long-term changes in water temperatures within the Klamath Basin to changes in air temperatures. However, when describing cumulative effects of clearcutting on stream temperatures, Bartholow (2003) states that stream shading is important because general air temperature did not appear to be as important in governing the increase in maximum daily water temperature as direct solar radiation. Johnson (2003) points out that the relationship between air and stream temperatures can be misleading because air temperatures are strongly correlated with stream temperatures. Correlations have been reported by several researchers (e.g., Pilgrim et al 1998; Mohseni and Stephan 1999) with very good results obtained at monthly and weekly time-scales (Mohseni et al. 1998). Strong correlations do not indicate a cause and effect relationship; such a relationship can only be determined under completely randomized experimentation, not with observational or case studies (Ramsey and Schafer 1997). Since solar radiation strongly influences both air and stream temperatures, the correlations are understandable. Hagan (2000a) reiterated that when air temperature is greater than water temperature, water temperature will rise at a rate governed by physics. Hagan (2000b) also pointed out that cold water naturally warms faster than warmer water when in contact with warmer air. Bartholow (2003) concluded that although air temperature is influential in increasing maximum water temperatures, it is less influential than both solar radiation and the effect of stream widening.

In summary, correlations have been documented between summer air temperatures and summer water temperatures. However, these correlations do not indicate a single cause-and-effect relationship. Long-term and multi-seasonal studies show that air-water temperature relationships vary and that other environmental factors also influence the relationship.

7.5.6.4 Variability in Conditions

Stream temperatures inherently and naturally increase in a downstream direction (Dent and Walsh 1997). Caldwell et al. (1991) noted that maximum stream temperatures are strongly influenced by elevation with warmer temperatures observed at lower elevations. The majority of researchers has found relationships between stream temperature and either basin size or distance from divide, as well as canopy cover. Many people have speculated about the role of air temperature as a determining factor and have discussed whether air temperature is causative or merely correlated with stream temperatures. Yet, there is good agreement that stream temperatures tend to increase in a downstream direction and that riparian shade is not as effective in preventing heating in larger streams and rivers as it is in smaller streams.

As stream order increases, so usually does stream width, stream discharge, and number of tributaries. As width increases, surface area exposed to solar radiation usually increases because riparian vegetation may shade less of the stream surface. During the summer when stream temperatures are the highest, the combination of increased direct solar radiation, warmer air temperatures, and decreased stream flows are

the major factors affecting stream temperature (Beschta et al. 1987). Of these three factors, forest management can have the greatest effect on direct solar radiation by reducing shade. In several studies, the largest increases in stream temperature after riparian removal occurred not in the late summer, the usual time of maximum stream temperatures, but in early summer, which coincides with the timing of maximum solar inputs (Johnson and Jones 2000).

Beschta et al. (1987) reported that daily temperature fluctuations in lower stream sections are more pronounced because of increased exposure to solar warming – a function of wider, less-confined channels. Temperatures at the bottom of pools may be 5 to 10 degrees Celsius cooler than surface layers. Sullivan et al. (1991) discuss what is known about stream temperatures at the basin or watershed level. Temperatures tend to increase in stream reaches as water flows from headwaters to lower elevations. They state that this appears to be caused by several factors: air temperature tends to increase as elevation decreases, groundwater inflow is less in proportion to in-channel flow, and wider stream channels result in decreased shading from riparian vegetation (Beschta et al. 1987).

7.5.6.5 Shade

A number of studies have been conducted to describe the relationship between buffer width and amount of shade provided. These studies are described in CH2MHill (1999, 2000), Castelle and Johnson (2000), and in other publications. These authors have generally found that incremental shade effectiveness diminishes with distance from the stream (Brazier and Brown 1973; Steinblums et al. 1984; Brosofske et al. 1997). Relationship of shade and distance from stream developed by Brosofske et al (1997) for western Washington were similar to Steinblums et al. (1984) despite measured differences in total solar radiation related to buffer width. In Oregon, it appears that riparian buffers of 30 meters or more in width along small streams provide approximately the same level of shading as an old-growth forest (Beschta et al. 1987).

Steinblums et al. (1984) identified that shade could be delivered to streams from beyond 75 feet and potentially out to 140 feet. In some site-specific cases, forest practices between 75 and 140 feet from the channel have the potential to reduce shade delivery by up to 25 percent of maximum. However, any reduction in shade beyond 75 feet would likely be relatively low on the horizon, and the impact on stream heating would be low or negligible because direct-beam radiation declines in effectiveness as the angle approaches the horizon, according to Lambert's Law (the law that the illumination of a surface by a light ray varies as the cosine of the angle of incidence between the normal to the surface and the incident ray) (CH2MHill 2000). Only direct solar radiation is thought to affect stream temperatures (Ice 2001).

7.5.6.6 Channel Morphology, Discharge, and Water Source

Channel characteristics, particularly width and depth, influence the amount of heat gained or lost from a stream. As streams widen, the more stream surface area increases, providing more surface area for heat energy exchange with the atmosphere (Boyd 1996). Streams with a well-defined pool/riffle sequence may have more water forced into the hyporheic zone due to hydraulic pressure. Floodplain roughness is increased by riparian vegetation which slows stream velocities and increases retention time of water on the floodplain while reducing local shear stresses and bank erosion. Channel morphology can be as important as shade in moderating summer temperatures (Blann et al. 2002 as cited in Cristea 2005). The temperature increase in a stream is directly proportional to the area exposed to sunlight and inversely proportional to the volume of water in the stream. The effect of canopy removal on stream temperatures

is greatest for small streams and diminishes as streams get wider (Sugden et al. 1998). Consequently, small streams respond faster to changes in canopy cover than larger streams (Sugden et al. 1998).

In Oregon, most summer flow out of the high Cascade Mountains is not due to snow melt (USDA 2002). Instead, the Cascades form a vast hydrologic sponge that stores many decades worth of water as deep groundwater. At the point of stream initiation, the temperature of water entering a forest stream system typically resembles that of the watershed's subsoil environment. Black and Bolton (1996) found that groundwater (spring) temperatures were very cool and remained constant, but that wetland source temperatures tended to follow air temperature. Mellina et al. (2002) found that streams headed by small lakes or swamps cool as they flow downstream during the summer, and that headwater streams warmed, regardless of whether they were harvested or not. They concluded that lentic water bodies and groundwater inflows are important determinants of stream-temperature patterns in sub-boreal forests. Stream flow is a significant parameter leading to temperature changes, and low-flow streams are very sensitive to temperature changes (Boyd 1996). Stream temperatures may be greatly influenced by the thermal characteristics of the dominant water source (e.g., snow melt, rain fall, or groundwater).

7.5.6.7 Floodplains and Wetlands

Local water temperatures can change where cooler or warmer tributary waters, or groundwater, enter a stream channel. The magnitude of change is in proportion to the temperatures and amounts of flow in each source (Brown et al. 1971). Natural riparian and floodplain wetlands collect and distribute flood flows, recharge groundwater aquifers, and store water for slower releases. Wetlands play an important role in storing water from winter floods, making water available for recharging groundwater aquifers, and later providing water to surface streams during summer low flows. Normally, wetland soils store water from winter rains, and slowly release the water over longer periods of time. Loss of wetlands has reduced the potential recharge of groundwater aquifers and reduced their ability to provide flow during dry summer and fall months (IMST 2002). Streams that have well-connected terraces and large amounts of deep gravel will typically have cooler water temperatures. Alluvial gravel in both large and small floodplains store cold water from periods of high runoff and releases the water gradually during periods of low runoff (Coutant 1999). Adequate recharge of alluvial gravels depends on high spring peaks in river elevation (Coutant 1999). Stream reaches with sloughs and side-channels can also supply large amounts of subsurface flow to the main channel.

7.5.6.8 Small Streams

Shade in clearcuts and heating following harvest

Riparian timber harvest has been shown to produce increases in stream temperatures, and the magnitude of these increases varies among sites and regions (Johnson and Jones 2000). Sites where only overstory riparian vegetation was removed generally had smaller increases in stream temperature than where the understory was also removed. Mellina et al. (2002) noted that streams in harvested areas had 40 percent to 60 percent shade during post-harvest years (i.e., 1-3 years). Robison and Runyon (2003) found shade from understory and slash and narrow channels provided 50 percent shade and noted that the areas without buffers were reduced from 87 to 52 percent shade cover. Chan et al. (2005) found that a narrow vegetated buffer of trees or dense shrubs along headwater streams in clearcuts lowered insolation to the stream. Caldwell et al. (1991) stated that logging debris and brush provided substantial shade, as did ravine steepness, immediately after harvest. On the Coast Range of Oregon, however, it took about 5 years before 50 percent of a stream was shaded following harvesting and in the higher elevations of the

Cascades it took up to 25 years to reach 50 percent stream shading (Beschta et al. 1987). In a study by Johnson and Jones (2000) in the western Cascades, it took 15 to 20 years for summer maximum temperatures to return to normal following clear-cutting and burning.

Johnson and Jones (2000) found that maximum stream temperatures increased 7 degrees Celsius and occurred earlier in the summer after clearcutting and burning in one basin, and after debris flows and patch cutting in another. Diurnal fluctuations in June increased from approximately 2 to 8 degrees Celsius. Mellina et al. (2002) reported minor changes (averaging 0.05 to 1.1 degrees Celsius) following harvest. Results from a cooperative temperature study in Washington State, covering 92 sites in several ecoregions, found an average 5 degrees Celsius increase in maximum water temperatures as shading decreased from 75-100 percent to 0-25 percent (Sullivan et al. 1990). For small streams, complete shade removal can increase water temperature as much as 3 to 10 Celsius, but the actual change will be determined by local conditions (Beschta et al. 1987). The IMST (2004) reviewed 49 studies on the influence of riparian vegetation on shade. In 44 of these studies, the stream temperatures increased from as little as 1.09 degrees Celsius to as much as 12.7 degrees Celsius after vegetation was removed. Macdonald et al. (2003 as cited in Cristea 2005 and IMST 2004) recorded increases in daily stream temperature fluctuations from 1.0 to 1.3 degrees Celsius before harvesting to 2.0 to 3.0 degrees Celsius after harvesting. They also observed increases in maximum mean weekly temperatures of 4 degrees Celsius (from 8 to 12 degrees Celsius).

In another study, Summers (1983) found that small streams that had been clearcut and burned at various times in the past to assess the recovery of shade. On average, 50 percent of a stream was shaded within 5 years of harvesting and burning in the Coast Range of Oregon, and within 15 years at lower elevations in the Cascade Range. Caldwell et al. (1991) made similar observations and concluded that shade reduction along small clearcut streams in western Washington would recover within 5 years. Since nearly all Type Np streams are small (i.e., <20 feet BFW), shade reductions and any associated temperature increases are not likely to persist for long periods. Much of the early recovery in shade levels is attributable to the rapid growth of understory vegetation, which can almost completely shade small streams with a few years after harvest (Summers 1983).

Gravelle and Link (2005) found that water temperature maximum in the streams without fish increased by 1.4 to 3.6 degrees Celsius in clearcut first-order watersheds, probably due to increased solar radiation from decreased canopy cover. There was also an apparent, yet slight, increase in the year immediately following harvest at the selective cut sites when compared to the control tributaries. Chan et al. (2003), in Oregon, found that thinning had minimal effects on temperature in streams and soils at depths of 5 cm. However, Beschta et al. (1987) found that the effect of partial canopy removal is directly proportional to the reduction of canopy providing shade to the stream. Chan et al. (2005) in studying streams in clearcut, thinned, and unthinned areas found the percentage of radiation penetrating the forest canopy at stream center averaged 57, 10, and 3 percent respectively. Maximum streambed temperatures were similar for streams flowing through thinned and unthinned areas, and were about 2 degrees Celsius higher in streams flowing through clearcuts.

There has been less research on the effects of riparian canopy removal on winter water temperature, and its connection to habitat alteration or changes in fish behavior. Holtby (1987), summarized changes associated with timber harvest in a Vancouver Island stream and found monthly average temperature increases in the February-April period of 1 to 2 degrees Celsius. Sullivan et al. (1990), looking at eight monitoring sites mostly in Western Washington, noted temperatures decreased with increasing elevation, and noted a 0.5 degrees Celsius difference in average February temperatures between two neighboring

streams with similar elevation, and aspect and different shading levels. Both Holtby and Sullivan et al. found the greatest temperature differences between shaded and unshaded sites occurred in April (i.e., early spring).

Cunjak (1996) reports that the most-prevalent effects on winter habitat in northern-latitude streams are reductions in streamflow, which increase ice formation and decrease available space. He also notes that removal of riparian trees can change the amount of shallow edge habitat, scoured channel areas, and can reduce winter habitat.

Heat budgets

The main components of a heat budget (physics of stream heating and cooling) are discussed in Sullivan et al. (1991), Beschta et al. (1987) and IMST (2004). There are several factors that make up the heat balance of water, including: solar radiation, air temperature, evaporation, convection, conduction, and advection (Brown 1983; Adams and Sullivan 1989). Water temperatures at a given location are a function of a balance between heat inputs and heat loss. Heat inputs are driven by solar radiation, which varies daily and seasonally, and are affected by shading from riparian vegetation and topography. There is some disagreement among studies whether or not water warmed in streams with no riparian canopy will decrease in temperature when it flows into and through shaded sections of stream. Although there are some differences of opinion about the relative contribution of factors, heat loss appears to be largely the result of groundwater inflow, hyporheic exchange, and conduction of heat to the stream bed (Story et al. 2003; Beschta et al. 1987; Johnson and Jones 2000; IMST 2004). Johnson (2004) states that "heat budget analyses show that convection, or the transfer of heat energy from warmer air to cool stream water is, in fact, only a small portion of the energy exchange influencing stream temperature. Therefore, air temperature is a relatively weak determinant of stream temperature. The major factor influencing both air and stream temperature is incoming solar radiation." IMST (2004) emphasizes that although correlations have been documented between summer air temperatures and summer water temperatures, these correlations do not indicate a cause-and-effect relationship.

In an experimental shading study on a second-order stream in the west slopes of the Oregon Cascade Range, Johnson (2004) reported that maximum water temperatures declined significantly in an artificially shaded reach, but minimum and mean temperatures did not change. Heat budgets calculated prior to adding artificial shade indicated that solar energy was the dominant factor influencing temperatures in the stream. In a similar heat budget for a shaded reach, convection became the dominant source of heat even though its overall magnitude changed little. Evaporation decreased in the shaded area, but other losses of heat remained similar. A net loss of heat occurred within the shaded reach. During shading, energy fluxes other than direct solar input showed little change, although their relative importance increased. Johnson (2004) also reported that under the artificial shade, the largest energy fluxes were evaporation and net long-wave radiation. Johnson (2004) reiterated that "Convective fluxes are determined by temperature differences between the water and air" and that "the heat budget also showed that convective or sensible heat exchanges between warm air and cooler streams comprise a relatively small portion of the heat flux." However, Johnson cautioned that several factors in this experiment, such as the type of material used for shading or that shading only covered the wetted portion of the stream channel, may not have functioned in a similar manner to the influence of riparian vegetation on stream temperatures.

Equilibration

Water warmed in streams with no riparian canopy may decrease in temperature after entering fully shaded sections. IMST (2004) refers to a number of authors that have documented stream temperature decreases after streams flow through a shaded reach. The cooling reported by these authors, is not necessarily a direct result of shading. Heat in a stream is lost through convection, conduction, and evaporation. Evaporation can be a major cooling agent for streams when temperature gradients, vapor pressure gradients, and winds are high enough and humidity is low enough to transfer heat from the water to the air. The riparian canopy will intercept direct solar radiation and slow down the rate of heating. The riparian canopy can lower local daytime air temperatures over the stream channel and change the rate of evaporation, although the rate of evaporation is dependent upon a number of variables including humidity and wind speed. Heat energy can be lost to the air, stream channel, and streambank in shaded reaches until equilibrium occurs.

IMST (2004) identified other studies where no detectable change in temperature was seen once a stream entered a shaded stretch. For example, in a small western Oregon tributary Brown et al. (1971) reported stream temperatures approaching 80 degrees downstream from a large clearcut. No significant reduction in temperature was seen after the stream entered a 600-foot reach with a forested canopy. The authors found that there were insufficient wind speeds, temperature gradients, and vapor pressure gradients to cause either evaporative or convective cooling of water once the stream entered a shaded reach.

Cold groundwater or tributary inputs will also contribute to water temperature cooling in shaded sections (Brown et al. 1971; Story et al. 2003). A thermal-recovery zone is a reach with relatively similar riparian and channel conditions for a sufficient distance in order to allow the stream to reach equilibrium with surrounding conditions (Lewis et al. 2000). The length of stream reach required to reach equilibrium will depend on stream size (especially water depth) and morphology (TFW 1993). In some studies, the distance of similar riparian and channel conditions required to establish equilibrium with those conditions in fish-bearing streams is relatively short, in others, it was estimated to be approximately 1,000 feet (Lewis et al. 2000).

In some situations, no detectable change in temperature may be seen once a stream enters a shaded stretch as there may be insufficient wind speeds, temperature gradients, and vapor pressure gradients to cause either evaporative or convective cooling of water once the stream entered a shaded reach.

The magnitude of potential temperature change varies with stream size and elevation. Smaller streams will both heat and cool more quickly without shade than larger streams (Adams and Sullivan 1990). In an old-growth Douglas-fir stand in the Cascades, a temperature decrease of 4.5 degrees Celsius was observed after water flowed from an unshaded reach through 700 feet of shaded channel (Levno and Rothacher 1967). In one study, the distance of similar riparian and channel conditions required to establish equilibrium with the conditions in fish-bearing streams was estimated to be approximately 1000 feet (Lewis 2000). In another study in a small stream, temperatures decreased 6.6 degrees Celsius after the stream had crossed 400 feet of channel that was shaded (Swift and Messer 1971). Since small streams respond faster to changes in shading than larger streams, we would assume that small headwater streams would cool down in the shorter range of the distances if shading was present.

Dilution

The ability of a small stream to affect the temperature of a larger stream depends in part on the sizes of the contributing and receiving waters (Sugden et al. 1998). A small tributary will produce little change in

the temperature of a larger river unless the small stream's temperature is greatly different (Beschta et al. 1987). When several tributaries flow into a large river their cumulative temperature contributions can affect the temperature of the larger river. In addition the confluences of these small tributaries with the larger rivers can provide important cold water refugia for salmonids.

Role of Substrate

Conduction between water and alluvial substrates is often underestimated as an important mechanism influencing stream temperature (Brown 1969; Beschta et al. 1987). Conduction from near-stream soils and alluvial substrates may account for more of the stream temperature dynamics than is generally recognized (Hondzo and Stefan 1994). Conduction can have a different magnitude of influence on stream temperature in bedrock versus alluvial reaches. Johnson and Wondzell (2005) found that gravel, as compared to bedrock, moderates peaks in temperature.

Role of Hyporheic Zones

Recent studies of dynamic thermal regimes in the hyporheic zone along with improved understanding of the hyporheic zone as an important flow path of surface water now suggest that the hyporheic zone may play an important role in influencing stream temperature in alluvial reaches (Johnson 2004). Johnson (2004) found temperatures changed over very short distances – as the stream flowed through a 656-foot (200-meter) bedrock reach, daily maximums increased several degrees; in the 1148-foot (350-meter) alluvial reach, daily maximums decreased by as much as 8.7 degrees Celsius and minimums increased by 3.9 degrees Celsius. Johnson (2004) found that, throughout the summer, diurnal fluctuations of stream temperature in the bedrock reach were much greater (higher maximums and lower minimums) than downstream in the alluvial reach.

Johnson (2004) stated that hyporheic flow could influence downstream temperature maximums and minimums by several possible mechanisms: (1) residence time is lengthened by hyporheic flow paths, which could lead to simple mixing of daytime water and nighttime water; (2) increased hydraulic retention and the large volume of subsurface storage could lead to simple mixing of warm daytime water and cooler nighttime water, thereby moderating downstream temperatures; and (3) conduction with substrate surfaces could transfer heat to substrates. However, substrate that has been impacted by increased sediment is less able to provide the porosity and connectivity required to maintain hyporheic flows.

In small streams, pool-step sequences were found to be the dominant feature driving the hyporheic exchange (Wondzell 2004 as cited in Cristea 2005). Pool-step sequences can influence the hyporheic exchange rates at a smaller time scale (hours) than the complexity of flow paths created by a meandering stream (days) (Wondzell 2004). Bilby (1996) described one of the roles of large wood in headwater streams as creating wedges of stored sediment, and causing subsurface flows, which forces interchange with the hyporheic zone and cools the stream. Debris-flow topography will tend to slow down water and accelerate mixing. Large wood tends to slow down water and accelerate mixing through formation of sediment wedges.

Johnson (2004) found that estimates of velocities between bedrock and alluvial reaches differed dramatically depending on methods used. Median retention time of water in the 656-foot 200-meter section of bedrock was 1.1hours but was 18 hours in the 1148-foot (300-meter) alluvial reach. Not only are bedrock channels more responsive to solar inputs, but they have shorter hydraulic retention times, and therefore less mixing and dampening. Gravel substrates provide opportunity for exchange with substrate.

She notes that the potential influence of alluvial substrates on surface temperature is related to the proportion of total stream flow passing through the hyporheic zone, which in the lower 328 feet (100 meters) of one of her experimental streams was the majority of stream flow. Johnson (2003) notes travel time of water through a reach is not a homogenous process. Characterizing the hydraulic retention time through a reach, and, therefore, the contact time during which energy exchanges can occur, requires understanding of potentially very complex surface and subsurface flow paths. Johnson (2003) stated that more research is needed on the effects of turbulence of water on evaporative fluxes and energy absorption, the influences of substrate type, hydraulic retention time, and stream flow paths on conduction.

Role of Groundwater

Groundwater is insulated from daily and seasonal warming and cooling, so groundwater temperatures fluctuate very little. Therefore, groundwater inflow to a stream usually has a cooling effect on warm summer water temperatures and a warming affect on colder winter water temperatures. As summarized in Moore and Wondzell (2005), forest harvesting was found to increase soil moisture and groundwater levels due to decreased interception losses and transpiration. All heat exchange processes are influenced by the volume of the flowing water (Poole and Berman 2000 as cited in Cristea 2005). Harr et al. (1982) found an increased water yield in two small central Oregon watersheds cut to varying degrees. Increased yield was substantial (20 cm to 40 cm), and the number of low-flow days during the summer, including drought years, decreased, perhaps due to reduced evapo-transpiration. Small perennial streams typically have a large proportion of groundwater inputs which tends to be very cool. Groundwater temperature typically mirrors soil temperature. These streams are thus typically cooler than downstream receiving waters.

Stream Variability

Stream temperature is a product of complex interactions between geomorphology, soil, hydrology, vegetation, climate, elevation, and aspect of the watershed. The relative influence of these factors can vary spatially and across the landscape and over time. Water temperature can vary along the length of a stream as a result of local topographcial and geological factors. Thermal heterogenity varies in streams and rivers and can be affected by local energy inputs and outputs (IMST 2004).

The magnitude of potential temperature change with streamside vegetation varies with stream size (Adams and Sullivan 1990). Stream temperatures are very reach-specific, and responsive to reach-level parameters such as shading and groundwater inflow rate. Thus, the potential exists for stream temperatures to increase or decrease in response to local conditions. Smaller streams will both heat and cool more quickly, in response to changes in environmental parameters, than larger streams.

Other Habitats

In the upper intertidal zone of estuarine and marine habitats, temperature is an important factor in the ecology of at least two species of forage fishes as well as for most salmonids. Although these two forage fish are not species under FWS jurisdiction, we note that surf smelt and Pacific sandlance may provide us with insight regarding other covered marine fish, as well as effects to covered marine and anadromous fish with respect to prey availability. These species spawn in upper intertidal beaches with substrates of sand and/or fine gravel (Pentilla 1997). Elevated temperatures on beaches have been linked to a significant reduction in the hatching success of surf smelt (Pentilla 2001). Rice (2006) recently linked this reduction in hatching success to the loss of riparian shade, which was responsible for significantly

higher daily mean light intensity, air temperature, and substrate temperature, and significantly lower daily mean relative humidity on these altered intertidal beaches. Pacific sandlance are known to burrow into intertidal beaches during the winter (Quinn 1999). During periods of elevated temperatures and low tides, interstitial dissolved oxygen is depleted, and these fish may emerge from the sediment and either dry out thoroughly or become easy prey for a host of predators (Quinn and Schneider 1991). Loss of riparian shade could also contribute to the high substrate temperatures and low oxygen events that adversely affect Pacific sandlance. These effects may also be experienced by other marine fish. Reductions in forage fish may affect both marine and anadromous predatory fish.

7.5.6.9 Summary of Relevant Issues

Intact riparian vegetation traps sediments, influences watershed hydrology, maintains favorable width-to-depth ratios, maintains water table depth, reduces solar radiation, and allows for heat exchange with substrate, thereby indirectly influencing stream temperature. If riparian canopies are removed, increases in stream temperature may occur. The largest increases in stream temperatures after riparian canopies are removed can be expected to occur in small headwater streams. Small streams that flow though harvested areas (particularly unbuffered reaches) may have elevated temperatures. Shade alone cannot cool a stream, but it can prevent further warming from occurring (IMST 2004). Water temperatures decrease when heat energy is transferred from the surrounding environment. Depending on the length of shaded reaches and also site-specific conditions, the amount of heat leaving the stream may be greater than the amount entering the stream, causing water temperatures to decrease. The extent to which stream warming may transfer to downstream fish-bearing streams depends upon a number of site specific factors and can be affected by a number of features including substrate (bedrock versus alluvial channels), discharge of affected waters, discharge of receiving waters, coldwater inputs from hyporheic areas and tributaries, and the condition of riparian areas and other sensitive sites such as tributary junctions.

7.5.6.10 Effects of Proposed FPHCP on Water Temperature (Heat Input)

Human land-use activities typically affect stream temperature by altering one or more of the following factors: 1) the width and depth of a channel; 2) the amount of flow in the stream; 3) the exchange between the surface water in the stream and the water flowing through its streambed and banks; and 4) the shade and vegetation along a stream. These four factors are highly interrelated and the overall influence that individual factors may have on stream temperature will depend on stream size. Timber harvest has the potential to affect stream temperatures primarily through removing riparian vegetation. The potential for riparian vegetation to mediate stream temperatures is greatest for small to intermediate size streams and diminishes as streams increase in size lower in the floodplain (Spence et al. 1996).

Shorelines of the State

The influence of riparian timber harvest on stream temperatures in wider channels (i.e., greater than 30 feet) tends to be less than narrower channels, because the channel can only be partially shaded by riparian trees. Therefore, water temperatures are naturally higher. However, trees do affect water temperature on larger channels, meaning temperature recovery from riparian timber harvest can take longer than for small streams. In some areas, this problem is compounded by the fact that the majority of the riparian buffers affected by timber harvest have regenerated as hardwood-dominated stands (i.e., greater than 70 percent hardwood composition).

The RMZ prescriptions under the FPHCP protect most shade along Type S waters by requiring the retention of trees within a certain distance of the bankfull width or the CMZ. The size of the RMZ

needed to meet shade requirements varies depending on whether the RMZ is located in western or eastern Washington and the specific provisions of the Shoreline Management Act.

Streams with Fish

In western Washington, the Core Zone provides the majority of the shade to streams. Tree retention in the Inner Zone would be dependent on pre-harvest stand conditions and the selected management option. Some stands would not contain sufficient tree density to qualify for any harvest in the Inner Zone. If harvest options are available, the conifer density in Core and Inner Zones would control the intensity of harvest.

The thinning option (Option 1) would not reduce shade substantially due primarily to retention of the Core Zone, but also because of the canopy that would be retained in the Inner Zone. Thinning is not being used as frequently as packing (Option 2). Applying the packing option would extend the no-harvest zone to 80 or 100 feet from the bankfull width or CMZ edge. The potential reduction in shade delivery under this option would be minimal because the rate of shade reduction decreases with increasing distance from the stream. For purposes of this analysis, we considered that the thinning option could be selected more often than is occurring currently. The thinning option provides more opportunity for shade reduction than the packing option. With the retention of the canopy associated with the 57 largest trees per acre in the thinned Inner Zone, we would expect that only solar radiation at indirect angles would reach the stream. Diffuse radiation has little effect on stream warming and because solar radiation at indirect angles has reduced intensity, and less effect on stream warming.

In addition, the Shade Rule will require that minimum levels of shade are retained, depending on elevation, in order to meet the 16 or 18 degree Celsius temperature standard. In Western Washington, the Shade Rule requires trees be retained within 75 feet of a Type S or F stream, or CMZ, to meet water-quality standards. The Shade Rule must be satisfied whether or not a stream-adjacent parallel road is present. Shade requirements must be met regardless of harvest opportunities provided in the Inner Zone. However, the Shade Rule may not be sufficient to achieve the objectives of cold water temperatures and may not ensure adequate shade where existing shade is below target levels.

In eastern Washington, riparian management prescriptions for tree retention depend on the existing basal area and forest vegetation zone. The intention is to address the forest health of residual stand while retaining the most-desirable species and largest trees within the stand. In all cases, the Core Zone is 30 feet wide and not subject to timber harvest. The Inner Zones are 45 or 70 feet, for small and large streams respectively. A minimum of 50 trees per acre must be left where basal areas are high and a minimum of 100 to 120 trees per acre must be retained where basal areas are low. Minimum basal-area targets are also required. The combination of the Core Zone and the Inner Zone (75 to 100 feet) provide for a majority of the available shade.

The Bull Trout Habitat Overlay includes portions of perennial, fish-bearing streams in eastern Washington. Within the Bull Trout Habitat Overlay, all available shade must be retained within 75 feet from the edge of the bankfull width or outer edge of the CMZ (whichever is greater) along Type S or F waters. Outside the bull trout habitat overlay in eastern Washington, the Shade Rule provides some level of shade for streams with fish, but is expected to provide less shade than provided by the Bull Trout Overlay or westside prescriptions. The effectiveness of eastside prescriptions in maintaining stream temperatures outside the Bull Trout Overlay is less certain.

Alternate Plans: Alternate plans may allow deviations from the standard Washington Forest Practices Rules as long as they are determined to be at least equal in overall effectiveness in meeting riparian and aquatic habitat protection as the standard rules. Short-term effects to shade may occur from operations that would enhance long-term shade, wood, or other functions. Depending on the level of canopy removal, stream temperature may increase locally in the short-term under alternate plans.

20-acre-Exemption Rule on Streams with Fish: Streams on 20-acre exempt parcels may be exposed to greater amounts of solar radiation. For instance, on a small, westside Type F stream, a landowner would be required to retain at least 29 trees along a 1,000-foot reach within an area that would be 29 feet wide. The distribution of those trees can accommodate operational considerations, so some clumping would be allowed. Provisions also would exist to leave as few as half of these trees when criteria of harvest unit size and overlapping wetlands are considered.

However, 20-acre-exempt parcels must still meet the Shade Rule in the current Washington Forest Practices Rules. Yet, these rules apply to RMZs which are measured from the outer edge of the bankfull width. Where such RMZs and the associated Shade Rule are applied on streams with CMZs, long-term loss of shade may occur with channel movement. In the absence of the 20-acre exemption, shade must be left on the outside of the CMZ. Our conclusion is that where small landownership is proportionally high or concentrated along streams, diminished shade may occur along streams, resulting in increased risk of elevated stream temperatures. This is especially true where CMZs exist. While shade is generally ineffective at controlling water temperature of an entire large stream or river, it may be effective at maintaining cold-water refugia important to FPHCP covered fish.

Streams without Fish

Perennial Streams without Fish: For Type Np streams in western Washington, a 50-foot, no-harvest riparian buffer is required for the first 500 feet if the Type Np water is 1,000 feet or greater; or at least 50 percent of its length or 300 feet, whichever is longer, if the Type Np water is less than 1,000 feet. The buffer starts at the confluence of the Type Np water to the Type S or F water. Along the portions of Type Np streams that receive a 50-foot no-harvest buffer, it is expected that approximately 65 to 90 percent of the maximum potential shade (ACD) would be left (Brazier and Brown 1973; Steinblums et al. 1984). For those areas of the stream without buffers, these reaches would be subject to heating from solar radiation. Natural topographic features will shade small streams in some situations. In some areas, protection measures for sensitive sites and unstable-slope protections will complement Type Np RMZ prescriptions resulting in buffers along Type Np streams exceeding 50 percent of their lengths. Given the large degree of variability in the occurrence of sensitive sites and unstable slopes throughout the State, it is difficult to quantify the degree of protection that would result from these features.

Within 50 feet of the Type Np waters in eastern Washington, three scenarios are possible: no-harvest buffers, partial-harvest buffers, and clearcut areas. Within the partial-harvest buffers, the basal-area requirements are the same as those for Type S and F waters and may not provide complete protection of shade, but run the total length of the Type Np stream. If timber harvest along Type Np streams is conducted, no-harvest buffers must be at least equal in length to the clearcut portion of the stream in the harvest unit. No more than 30 percent of a harvest unit's stream length or 300 continuous feet may be clearcut. Clearcut reaches cannot be within 500 feet of a confluence with a Type S or F stream and may not occur within 50 feet of sensitive sites.

Many Type Np streams will have spatially intermittent sections. Sections of Type Np streams which flow subsurface will reduce the effects of solar radiation. No harvest buffers may occur along 50 percent or

more of stream reaches (west and eastside respectively), with other considerations (e.g., unstable slopes and mandatory leave areas) providing additional shade to the streams. As a result of these considerations, 50 percent or less of eastside and westside Type Np streams would remain unbuffered. Consideration of intermittent subsurface flow would result in estimates for unbuffered reaches being even less. Conversely, partial-harvest buffers on eastside streams would not necessarily provide complete retention of shade along Type Np streams, but would be buffered their entire length.

Unbuffered reaches may be subject to reduced effects of heating if the reach is subsurface during the late spring and early summer. However, all unbuffered reaches may be subject to some effects of elevated or reduced temperatures at other times of the year. In some areas, stochastic events such as severe debris torrents in steep channels can remove enough riparian trees to impact shade and water temperature as well, and also alter the sensitive site protection measures at the confluence of Type F and Np streams. Windthrow may occur within buffered reaches, potentially increasing the consequences of upstream unbuffered areas.

Type Np streams are more-easily shaded because of their relatively small size compared to other stream types. The 50-foot no-harvest buffers should address most direct-beam solar radiation. Windthrow along narrow buffers is likely to occur; however, these fallen trees and their boles could provide some shade, as well as insulation from solar radiation. In the unbuffered portion of the stream system, the amount of residual vegetation would vary by prescription and forest composition and structure. Slash, logs, bank, brush, and early seral vegetation have been found to provide up to 50 percent shade for small streams. Where discontinuous buffers or partial harvest is practiced, the riparian overstory would be at least partially removed and shade would be reduced. Natural topography would provide site-specific amounts of shade, depending on the physical setting and aspect, but localized effects to water temperature may occur within these Type Np streams.

Harvest along Type Np and Ns streams under the standard Washington Forest Practices Rules may also result in some reduction of large wood delivery to Type F streams in areas with steep topography – see Large Wood section. This may affect the delivery of large wood to Type F streams and the difference in amount of large wood could potentially result in changes in channel morphology at these sites and for some distance downstream, and could result in some stream warming in these areas.

In summary, 50-foot buffers (thinned or unthinned) would be provided on at least 50 percent of westside and 70 percent of eastside Type Np streams. However, many other previous harvest units in a watershed would be shaded due to recovery of shade since harvest. Assuming that at least partial shade would recover in 10 years, in a watershed that would be harvested evenly over the 50-year period, one-fifth of the stream reaches would be in past harvest units which may be young enough to contain Type Np streams not yet receiving shade. However, about half or more of the streams in those harvest units would be buffered. Thus, a total of 10 percent or less of the watershed would be unbuffered at any particular time. A watershed that was harvested more-aggressively in a short time, and had few sensitive sites, might theoretically have as much as 50 percent in an unbuffered condition at any particular time. As mentioned earlier, these unbuffered reaches would likely have some shade from understory vegetation, topography, and slash. These streams may experience adverse effects to water temperatures until shade was provided from regrowth.

Seasonal Streams without Fish: Operations near Type Ns streams will not likely affect temperature because these streams are typically dry during the warmest summer months, when the waters are most vulnerable to warming. However, the few Type Ns streams that have water present (including

intermittently) during this time might not have adequate shade from overstory trees to maintain cool stream temperature as these streams generally receive no specified buffers under the FPHCP. Local topography, shrubs, and debris along the streams can provide some shade. On steeper topographies up to 50 percent or more of Type Ns stream reaches may be buffered. There is a high likelihood of water temperature increases in Type Ns streams where water is present during the early spring and summer months (June through September), when the sun is at its highest and temperatures are at their greatest. This may negatively affect some amphibian species present in Type Ns streams.

It is uncertain what the effects to downstream water temperatures are from unbuffered Type Ns streams. When Type Ns streams flow directly into Type F streams, in some cases they will have limited effect due to differences in discharge volume. Type Ns streams would likely contribute a small proportion to receiving Type F streams. When Type Ns streams flow into Type Np streams, the principles limiting potential delivery of heat (as discussed earlier and below for Type Np streams) would apply.

Delivery of Heat to Fish-bearing Streams: Because some headwater streams are very small, understory vegetation and younger age class coniferous forests can provide shade sufficient to influence water temperature. For small headwater streams, streams should be mostly reshaded within 10 years following riparian timber harvest. For larger Type F streams, recovery may take 25 years or more (Beschta et al. 1987). Therefore, a number of Type Np and Ns streams may experience warmer water temperatures for a number of years following timber harvest.

Research has shown that temperature increases in small headwater streams have a limited, localized effect on the temperature of downstream reaches, with the affected downstream distance influenced by stream size, water velocity, and amount of heating or cooling (Castelle and Johnson 2000).

For both the eastside and westside, water that may be warmed as it flows through unbuffered reaches of Type Np or Ns streams could potentially affect stream temperatures in fish-bearing streams. The degree to which temperature increases in Type Np streams would affect downstream fish streams is uncertain and could be influenced by a number of factors including hyporheic and groundwater input, volume of water in both in the Type Np waters and the receiving fish-bearing waters, substrate, condition of the buffered stream reaches, as well as adjacent land uses between FPHCP lands and receiving Type F waters (USFWS et al. 2001).

Conversely, Type Np and Ns streams may cool excessively during the winter when left unbuffered. This loss of heat may manifest itself in increased in-stream icing and therefore, reduced habitat availability and even injury or death of individual fish through gill abrasion, entrapment, or scouring and lifting of redds. These effects would generally be limited to high elevations and would tend to be more likely on the eastside. These effects are not well-understood, but are likely somewhat ameliorated by groundwater influx. While these effects are likely not common, they can have severe effects when they do occur.

20-acre-Exemption Rule on Streams without Fish: Under the 20-acre exemption rule, no buffer is required on Type Np streams unless required to protect public resources (e.g., covered species, shade). When such is required, at least 29 trees per 1,000 feet would be retained. These trees may be conifer or deciduous and may generally be 6 inches in diameter or the next largest available. Clumping is allowed to accommodate operations. In watersheds with a high proportion of small landowners that qualify for the 20-acre exemption, the lack of RMZs on both Type Np and Ns streams would diminish shade and produce a high probability of increased water temperatures. Reduced delivery of large wood from 20-acre exempt parcels may decrease the habitat complexity, reduce the formation of deep pools, destabilize

streambanks, and widen channels. These habitat effects may also result in subsequent stream warming that could affect cold-water fish.

Wetlands: Maintenance of buffers on non-forested wetlands would be expected to maintain shade at moderate to high levels. Other requirements to protect hydrology within wetlands should also protect natural flows and avoid disruption of cooling flows. However, the FPHCP would allow forested wetlands (not connected to Typed waters) to be harvested without shade retention. Where such wetlands contain year-round water or are saturated near the surface during the summer, solar radiation may warm these areas and result in delivery of warmer water to fish-bearing streams or streams with amphibians.

Other Considerations: Landowners are also required, to the extent practical, to avoid creating yarding corridors and road crossings through sensitive sites and to avoid vegetation removal in perennially moist areas. Minimal impacts are expected to the hydrological regime (see Hydrology section). Effects from other activities and relationships with other habitat features (e.g., channel morphology) resulting from FPHCP are not expected to affect temperature beyond negligible levels. Reductions in shade created by openings in riparian areas for road crossings (typically only 25 to 50 feet of stream length), and yarding corridors (no more than 30 feet wide) should have little measurable effect on stream temperature. Identification of 30-foot ELZs, and associated BMPs and mitigation, as well as identification of and prescriptions for RMZs, are expected to protect near-bank areas and off-channel features that may contribute to groundwater influx.

Research: Habitat manipulation of riparian buffers for CMER research purposes may result in small and localized reductions of shade beyond that allowed under the standard Washington Forest Practices Rules and FPHCP. The effects of the research activities on water temperature are expected to be relatively small and only affect specific reaches of streams associated with study sites.

7.5.6.11 Summary of Water Temperature (Heat Input)

Prior to any harvest in Type S or F RMZs, the FPHCP would require assessment regarding existing conditions relative to DFC and the Shade Rule. If there are insufficient trees to meet basal area requirements, harvest opportunities would be limited or not allowed in the Inner Zone. Where harvest may occur, Core Zones would be retained, and Inner Zone requirements would add additional shade. Where the harvest option of packing trees (Option 2) is selected, it would increase the no-harvest buffers to at least 80 and 100 feet, for small and large streams, respectively. Where the thinning option is selected (Option 1), Inner Zones could be thinned to 57 trees per acre. Harvested eastside stands would retain at least 50 to 120 trees per acre depending on vegetation zone and existing basal area. However, additional trees might also be retained under the requirements of the Bull Trout Habitat Overlay or the Shade Rule. Therefore, the amount of shade produced along Type S and F streams under the FPHCP would be high and the amount of shade available across the extent of FPHCP covered lands would continue to increase relative to baseline conditions that resulted from past practices.

While the long-term landscape conditions are improving, short-term reductions in local shade may occur under the FPHCP. The likelihood of adverse temperature effects from reductions of shade along Type S and F streams is considered low for most Type S and F westside streams and marine and estuarine areas, including areas where thinning and partial harvest would be implemented. The likelihood of adverse temperature effects are also expected to be low in eastside Type S and F streams within the Bull Trout Habitat Overlay, which includes much of the action area on the eastside. In low-elevation basins where water temperatures are more sensitive to changes in shade and in eastside streams outside the Bull Trout Overlay, there may be adverse effects in some situations, depending on site-specific conditions.

Along Type Np streams, reductions in shade are likely to continue to occur in site-specific situations and water temperature may increase over limited distances as a result of these unbuffered Type Np reaches. In some unknown number of cases, increases in temperature may be delivered to downstream Type F waters. This is most likely in moderate-sized bedrock channels, where multiple streams converge in one area, where a single stream changes from Type Np to Type F, and where the sensitive site protections at the confluence of Type Np and F streams have been degraded. Within Type F streams, cool water sources usually result from a cold tributary stream or from groundwater input. When water delivered to Type F streams has not completely equilibrated, it may reduce the effectiveness of cold-water refugia at these tributaries for a period of years until shade recovers. The rate of shade recovery depends on streamside conditions and vegetation. Where warming of Type Np or Ns streams transmits heat downstream, warming may also disrupt the ability of cold-water fish to survive and/or reproduce within the delivery area. The degree to which temperature increases in Type Np streams would affect downstream fish-bearing streams could be influenced by a number of factors in addition to those stated above: distance of harvest unit from fish-bearing streams; past harvest; debris flows; windthrow; fire; intermixed land uses other than forestry; groundwater input; volume of water in both the Type Np and receiving fish-bearing waters; shade provided within the harvest unit; and the type of substrate and hyporheic exchange within the stream.

Riparian timber harvest on 20-acre exempt parcels could have adverse effects to the survival and reproduction of cold-water fish. The most-severe effects would likely occur to eggs, alevins, and fry, potentially resulting in the injury or death of individual eggs or small fish. Fortunately, 20-acre-exempt parcels do not represent a large proportion of covered lands in most basins. Ownerships meeting the 20-acre exemption are most likely to be concentrated in areas adjacent to other non-forestry land uses. In these areas, habitat conditions may already be degraded. Additionally, at lower elevations, water temperatures are more likely to be naturally warmer. Degraded and or naturally warmer conditions may mask or exacerbate temperature effects from 20-acre exempt harvests.

In the long-term, the FPHCP is expected to lower water temperatures from baseline conditions (where baseline conditions are elevated above natural conditions) through improved riparian management. Although the magnitude of changes in stream temperatures for any given stream is difficult to predict, improved canopy cover, increased streambank stability, increased amount and quality of large wood, and reduced sediment delivery to streams are anticipated to typically result in improvements to the temperature regime of most waters supporting fish. Sediment reduction as a result of improved road management is also expected to maintain or improve water temperatures (see **Sediment** section). Overall, the effects of potential temperature increases due to FPHCP activities are most likely to occur in headwater reaches of Type F streams, at confluences of Type F and Np streams, unbuffered Type Np and Ns streams, and in areas adjacent to 20-acre exempt parcels that are harvested.

7.5.7 Nutrient Input

Much of the following discussion of the issues surrounding nutrient input was adapted from discussions in Review of the Scientific Foundations of the Forests and Fish Plan (CH2MHill 2000) and the Final EIS for the Forest Practices HCP (USFWS and NMFS 2006).

Organic litter (Detritus) inputs to streams are important food and energy sources for a variety of organisms that, in turn, provide food and energy for fish and other aquatic organisms. The base of the aquatic food chain is supported by the combination of dissolved chemical nutrients and detrital materials. The chemical constituents such as nitrogen (usually in the form of nitrates and nitrites), phosphorus, and

carbon can be derived from the breakdown of detritus and through leaching and runoff from surrounding soils (Gregory et al. 1987). Also, organic litter influences water quality and habitat quality in riparian areas. Forest practices have the potential to affect organic litter generation and transport from riparian forests to aquatic areas. In addition to surface inputs, dissolved nutrients may reach the stream through shallow groundwater or hyporheic flow paths. Little quantitative information is available to describe the relationship between cumulative inputs of these materials (Light et al. 1999).

There are two primary sources of organic matter within streams: Photosynthetic algae and other aquatic plants within the stream (i.e., autochthonous sources); and Terrestrial inputs from outside the stream (i.e., allochthonous sources). In forested ecosystems, terrestrial sources provide streams with most of their organic matter (Anderson and Sedell 1979; Gregory et al. 1987; Richardson 1992, 1991). For example, 98 percent of the organic material in a forest stream in the eastern U.S. came from terrestrial sources (Fisher and Likens 1973).

Organic litter includes leaves, needles, cones, twigs, bark, propagules, and other small plant materials. It also includes animal material, such as insects, that fall into or are delivered to the stream. Leaves and other organic matter entering streams contribute to nutrient cycling and support food chains and aquatic community structures. Stream microbial communities, algae, and invertebrates encrust fallen litter, and then the litter is slowly decomposed. These processes provide nutrient and energy sources to fish and other animals that ingest them. Terrestrial sources of organic matter compose the largest proportion of the energy base for many smaller streams. In addition to providing energy and nutrients to streams, fallen organic litter and partially decomposed humus in riparian areas may intercept muddied waters and catch silt (Knutson and Naef 1997), and may provide food and cover for aquatic insects.

Most litter is supplied by tree crowns, but important amounts come from understory vegetation. In deciduous riparian forests, about 80 percent of the organic material input to streams is derived from leaf litter. In coniferous riparian forests, needles contribute a major portion of the terrestrial input to streams (Bilby and Bisson 1992), and fallen cones or wood may account for 40 to 50 percent of the total terrestrial litter input (Naiman et al. 1992). Up to 90 percent of the organic matter that ultimately remains in small coniferous forest streams is composed of woody material (Naiman and Sedell 1979; Triska and Cromack 1980).

Most litterfall enters streams as a pulse in autumn, but species composition of forests affects the seasonality of inputs (Beschta et al. 1987). Hardwood litter provides short-term pulses during summer and fall (Naiman et al. 1992), and conifer litter provides a longer-lasting, year-round food source. When present in riparian areas, a mix of deciduous and conifer species should be maintained (Light et al. 1999). In southeastern Alaska, young-growth alder sites were documented to export significantly greater counts and biomass densities of macro-invertebrates than young conifer sites (Piccolo and Wipfli 2002). Floods and overland flows flush large quantities of organic materials into streams during large storms.

Litter production is related to canopy density, site productivity, and stand age. More-productive (higher site index) sites produce more forest biomass. There appears to be a relationship between stream order and litter production whereby litterfall volume is highest in first-order (headwater) streams, gradually diminishes along a stream size continuum, and is lowest in the largest-order streams (Conners and Naiman 1984). Generally, a relatively higher proportion of litter function is provided by near-stream vegetation as stream size decreases.

The nutrient values of litter and rates of decay vary by plant species and part. The complete decay process takes about one year for most high-quality materials such as leaves and herbaceous plants and

may take several years or decades for low-quality materials such as cones and wood (Gregory et al. 1991). Instream large wood influences the retention and processing of organic matter, sediment transport, and invertebrate communities. Large wood creates a temporary storage of inorganic sediment and organic matter in stream channels that allows an opportunity for processing of the organic debris. Fallen limbs provide food and cover for aquatic invertebrates (Knutson and Naef 1997).

Food production for aquatic insects and fish is not necessarily maximized (i.e., fully effective) when litterfall is maximum. Site factors other than litterfall, such as instream photosynthesis, control food availability; and, instream photosynthesis is inversely related to forest canopy density. A dense canopy that provides abundant litterfall also blocks sunlight, a dense canopy therefore also reduces productivity of the stream.

Terrestrial organic litter may reach streams by direct fall or lateral movement (e.g., blowing or sliding down stream banks or steep slopes) (Benfield 1997). Although no known studies have been conducted to specifically determine the horizontal source distance within which terrestrial litter is input to streams, Rhoades and Binkley (1992) noted that very little of the nutrients and litterfall from red alder falls beyond the live crown.

It can be assumed that most litterfall to streams is generated close to the channel. The Forest Ecosystem Management Assessment Team (FEMAT) litterfall-effectiveness curve suggests that approximately 90 percent of the litterfall to streams originates within half a site-potential tree height from the stream (FEMAT 1993). However, reports by Newton et al. (1996) and Rhoades and Binkley (1992) suggest that the FEMAT litterfall relationship overemphasizes the contribution of litter from trees more than 0.2 site-potential tree height from the channel and underestimates contributions from trees within 0.2 site-potential tree height. Richardson (1992) estimated that 14 to 25 percent of the total litter input to a stream can originate from the banks due to wind action alone. Culp and Davies (1983 cited in Light et al. 1999) found that compared with complete clearcutting, a 10-m (33-foot) riparian buffer would provide leaf litter inputs to streams that were similar to pre-logging conditions.

Indirect evidence of litterfall effectiveness is suggested by benthic invertebrate communities. Several studies describe the role of various types of litter and associated processes to maintain aquatic macroinvertebrates and stream productivity (Hawkins et al. 1982; Meehan et al. 1977; Gregory et al. 1991). Studies in streams with managed riparian zones at least 100 feet (30 m) wide had benthic communities that were indistinguishable from streams flowing through unlogged watersheds (Erman et al. 1977; Newbold et al. 1980; Belt et al. 1992). However, maintenance of overhanging trees and shrubs within just 10 feet (3 m) of the bank maintains the source of most litterfall (Newton et al. 1996).

Although streamside litterfall is highly localized, stream transport systems readily move litter within streams from source areas to sink areas (Newton et al. 1996). Richardson (1992) estimated that 70 to 94 percent of all leaves that enter a stream segment are transported downstream until stored in a large pool or lake. Gregory et al. (1987) indicated that the greater the roughness elements (e.g., boulders, gravels, wood, roots) of a stream and the lower the hydraulic energy, the greater the retention of litter input. Thus, areas having large amounts of existing woody debris may retain more of the litter input.

Litter input to upstream headwater reaches contributes to downstream segments that support fish. Thus, within watersheds, upstream litter source areas tend to compensate for areas where litter inputs are low. The overall importance and magnitude of upstream contributions to litter input is not known, but they probably vary among watersheds with varying physiographic and biological conditions.

7.5.7.1 Management Implications

Forest practices that affect litterfall processes have the potential to modify the vegetation-stream relationship, including nutrient and energy sources to streams. More specifically, some forest practices can affect the productivity and quality of organic material, the timing of its delivery, and, to a lesser extent, litter transport processes. Silvicultural practices tend to improve biomass production over time, but can reduce litter production in localized, disturbed areas. Practices that alter the species composition and structure of riparian forests can change the quality of litter produced, as well as the timing of delivery.

Forestry effects that are within the historical ranges of natural disturbances are less likely to have a measurable effect on organic inputs. Practices that cause litter production and delivery processes to dramatically shift have the greatest potential to enhance or disrupt ecosystem processes and aquatic communities, particularly if their effects are cumulative over the watershed. However, cumulative effects remain relatively speculative for litterfall processes of riparian areas (Beschta 1998).

Among forest stands, the quantity and quality of organic inputs are related to forest development stage and structure. The type of silvicultural system (i.e., even- versus uneven-aged management) affects the annual pulsing of litter production, with uneven-aged forests providing more regular inputs over time. Total input of terrestrial litter to streams within old-growth forests was found to be approximately five times higher than in streams within clearcut forests (Bilby and Bisson 1992). Furthermore, Richardson (1992) found that terrestrial litter input was approximately twice as high in old-growth forests as compared to either 30- or 60-year-old forests.

On the other hand, forestry effects are considered temporary because many organic and nutrient inputs recover to pre-activity levels rapidly after a disturbance event (ODF 1994). Input of litter, especially to small channels, recovers rapidly following timber harvest. Studies indicate that nutrients from a variety of sources increase in the first few years following logging (Hicks *et al.* 1991). Where light is provided to the stream, these increases in primary productivity can enable increases in individual fish and amphibian growth. Increases in individual juvenile fish growth have been attributed to increases in primary productivity, but effects on overall production have not been detected related to these increases (Hicks *et al.* 1991). Canopy closure in planted stands typically occurs within 7 to 15 years (i.e., within approximately one-fifth of a 50-year rotation age). Input of all types of organic matter from terrestrial sources, except large wood, often returns approximately to pre-harvest levels within 20 to 25 years (i.e., within approximately two-fifths to one-half of a 50-year rotation age). Meehan (1996) found no overall change in macro-invertebrate inputs with canopy removal. Although he found some changes in the minor taxa significant, he found large amounts of *Ephemeroptera* and *Diptera* in both canopied and non-canopied reaches and determined that the differences overall did not appear to be of practical importance.

The potential effects of forest practices on litterfall processes are moderated by compensating factors, including in-stream photosynthesis, replacement of woody biomass by herbaceous and understory plants, and transport systems that move litter and detritus from source areas to deficient areas. Reduced forest canopy in the riparian zone leads to increased light levels in the aquatic zone, thereby increasing algae production in streams (Sedell and Swanson 1984; Bilby and Bisson 1992). Possible adverse effects of removing riparian vegetation often are outweighed by the increased primary production resulting from increased light levels, instream productivity, and nutrients (Beschta et al. 1987). In situations where the ability of riparian overstory trees to produce litter is reduced, shrubs and overhanging tree cover compensate for most of the litter production (Newton et al. 1996). Therefore, there probably is a broad range of riparian canopy conditions compatible with primary and secondary production needs of streams (Newton 1993).

A change in the origin of litter (allocthonous versus autochthonous sources) would have uncertain effects on community structure in streams. However, several studies have documented increases in aquatic insect production after canopy removal (Murphy and Hall 1981; Bisson and Sedell 1984; Gregory et al. 1987; Hicks et al. 1991). Also, aquatic community structure and function adjust to be in equilibrium with the physical stream conditions at each reach across the broad continuum of stream conditions (Vannote et al. 1980).

The river-continuum concept (Vannote et al. 1980; Minshall et al. 1983; Minshall et al. 1985, Minshall et al. 1992) indicates that natural stream communities undergo predictable changes from headwater areas to lower elevations in response to fluvial processes; changes in the relative contributions of riparian versus aquatic primary producers (plants); and the size and type of organic material being transported from upstream areas. Small, headwater streams have steep gradients, confined channels and cool temperatures when adequately shaded by riparian vegetation. Consequently, they obtain most of their organic material in the form of leaves, needles, branches and other plant parts from the riparian zone rather than from primary producers within the stream. Farther down the river continuum, stream channels are less confined and have more-extensive flood plains. Instream primary production increases in response to greater light penetration. Daily temperature fluctuations in these lower stream sections also are more pronounced because of increased exposure to solar warming (Beschta et al. 1987).

7.5.7.2 Effects of Proposed FPHCP on Nutrient Input

Timber harvest or tree cutting within the portion of the Core Zone (no harvest except for yarding corridors) and the Inner Zone (managed for desired future condition and stand-level requirements) would result in temporary openings in the canopy, at a localized level. As branches and leaves of remaining trees composing the riparian canopy would generally respond quickly to available light, amount of removal would be minor, and location of removal would be primarily from the outer portion of the Inner Zone, it is expected that there would be minimal effects to detrital inputs. The greater retention in proximity to the stream would ensure that detritus delivery is retained at functional levels.

Prescriptions protecting CMZs would maintain additional near-stream litter source areas important to fish-habitat streams. Most of the Type S and Type F streams maintain maximum litter input sources. Core and Inner Zones would provide most of the litter-producing potential of riparian areas. These buffers would supply over 90 percent of the normal litter recruitment to streams.

Early seral (tree size less than 12 inches in dbh) hardwood riparian forests provide large amounts of high-quality detrital inputs of nitrogen-rich leaves. Red alder is one of the most-important sources of detrital inputs to lower-order streams. Red alder, a common early-seral tree in RMZs (Murphy and Meehan 1991), fixes atmospheric nitrogen and the leaves rapidly decompose in the stream, providing a ready source of nitrogen for primary productivity.

Past harvest activities are believed to have reduced leaf and litter supply in some places throughout the action area. As forest practices regulations in the action area have required increasing conservation of streamside vegetation during operations, detrital inputs have likely increased. Before no-harvest zones were applied along streams, hardwood (i.e., red alder) or brush stands often replaced harvested conifers in the riparian zone, especially when natural regeneration was common practice. Currently, at least 50 percent of the riparian vegetation in western Washington is composed of hardwoods, largely red alder and bigleaf maple.

Under the FPHCP, landowners in western Washington have the option of converting hardwood-dominated riparian stands to conifer-dominated stands in the Inner Zone of the RMZ. Conversion of "artificial" stream-side hardwood or brush stands to conifer stands is often conducted with the intent of creating a stand of mature conifers that can provide large wood from conifers that is more persistent once delivered to the stream than wood derived from hardwood species. Hardwood-to-conifer stand conversion is only allowed on sites that naturally supported mature conifer before previous management. Lands that are best-suited for hardwoods are generally retained as hardwood stands because they are difficult to convert and biologically inappropriate to convert.

Hardwood-dominant riparian stands might also naturally convert to mixed hardwood-conifer stands. Over time, as alder trees age, die, and fall, already established conifers typically out-compete the next generation of red alder, resulting in a gradual reduction of red alder inputs to the stream and some change in detrital input to the riparian zone and stream.

During hardwood conversions, possible reductions in alder detrital inputs would be ameliorated by: (1) the untreated CMZ and the no-harvest Core Zone adjacent to Type S and F streams and portions of Type Np streams; and (2) the fact that few landowners (i.e., less than one percent of all forest practices applications) have converted riparian hardwood stands to conifer stands since the current Washington Forest Practices Rules went into effect in 2001. Given the prevalence of red alder across the action area, and the inherent patterns of riparian disturbance, alder would continue to be a significant source of allochthonous inputs.

Spraying glyphosate following hardwood conversion would have little effect on detritus. Even though application would temporarily reduce production of litter from shrubs such as salmonberry, these areas would be farther than 50 feet from the stream and only a small portion of this detritus would be delivered directly to streams. See the **Effects of Activities by Resource Topic -- Water Quality** section for a discussion on glyphosate use and invertebrates.

Due to the "equal in overall effectiveness" constraints of Alternate Plans, it is expected that the effects to the aquatic and riparian environment would be essentially the same or less than what would occur under the standard rules. No significant or measurable physical effects to stream detrital inputs are expected due to the "equal in overall effectiveness" provisions of alternate plans with respect to aquatic and riparian function. Implementation of the overstocked template would remove some trees as close as 14 to 30 feet from the streambank, but would retain a fully stocked stand of conifer.

Along fish streams, 20-acre exemptions would maintain a slightly reduced level of detrital input. It is anticipated that the majority of retained trees would be along the stream bank where most of the detritus input would originate. .

Litter from trees and understory vegetation along the channel is an important source of organic matter for headwater streams. Generally, a relatively higher proportion of litter function is provided by near-stream vegetation as stream size decreases. Many of the invertebrates living in these systems use this material as their primary food source. Removal of the overstory canopy would temporarily reduce the amount of material delivered to the channel and change its composition from a mixture of conifer needles, deciduous leaves, twigs, and other material to almost entirely deciduous leaves and herbaceous vegetation. The litter delivered to the stream after riparian area conifer harvest tends to be more nutritious for the invertebrates than material provided by older stands; albeit, less material comes from herbaceous material than came from the harvested stand.

Type Np streams would receive buffers at sensitive sites such as reaches near confluences with fish-habitat waters, and sensitive and priority areas. Buffered reaches would be expected to provide the majority of potential detritus input. Full-retention riparian areas would be left along at least 50 percent of the affected non-fish-habitat reaches to provide conditions for litter delivery. However, a much greater percentage of the reaches in upper watersheds typically would be fully vegetated because portions of watersheds would be in various stages of forest growth at any one time. Recovery of litter production along small channels occurs within 7 to 15 years (Summers 1983), riparian forests between 15 and 50 years of age would be delivering overstory litter, and forests less than 15 years of age would be in recovery, but providing some early seral litter as well.

Because headwater streams are net exporters of organic matter and nutrients, and compensating factors modify food and energy processes and distribution within the reach, it would be reasonable to assume that the amount of detritus would be adequate to maintain aquatic functions, and would vary over space and time. However, there are no studies that measure the total amount and timing of litter inputs required to maintain aquatic functions. Furthermore, there are no studies that indicate the desirable loadings of nutrients and organic matter downstream. The total litter input to a given reach probably would be reduced temporarily as a result of staggered harvest openings rather than continuous buffers along a harvest unit. The magnitude of the reduction would depend on the actual amount of canopy loss and on transport factors (e.g., steepness of slope, prevailing wind direction). But the reduction in litterfall may not be important or may be compensated by adjustments in instream photosynthesis, terrestrial vegetation, and aquatic communities that change in equilibrium with the physical stream conditions. Also, dense concentrations of fine woody and herbaceous material from logging may provide significant litter inputs to small perennial streams – but these would soon be depleted. Such inputs would likely be depleted within a few years, providing nutrients partly through the recovery period until overstory inputs are once again attained.

At sensitive sites (i.e., unstable slopes, wetlands, seeps, springs, the initiation point of perennial flow, and the intersection of two or more perennial non-fish-habitat streams) and priority areas (i.e., low-gradient areas, steep perennial stream reaches of non-sedimentary rock, hyporheic and groundwater influence areas, and downstream areas such as thermal recovery zones), the prescriptions for perennial streams would require that 50-foot-wide buffers be allocated. This would maintain litter and nutrient processes in habitat areas potentially important for amphibians and other aquatic fauna. Newton and others (1996) reported that a great proportion of the total litterfall to these small streams originates from trees and shrubs overhanging the stream and streambank.

Under standard rules, detrital inputs would remain intact for the lower 300 to 500 feet and the remaining buffered stream length of perennial streams. Detrital inputs should remain high in those sensitive sites and reaches receiving buffers, which may also be the reaches most important to amphibians.

Timber harvest along streams without fish under the 20-acre exemption would not necessarily maintain substantial overstory vegetation for detrital input. Where covered species could be affected, 29 trees per 1,000 feet would be retained as described earlier. These trees may be either deciduous or conifer. Trees may be distributed to accommodate operations, which may result in some streambank areas being subjected to vegetation removal and thereby reducing available litter.

Many Type Ns streams in steep topography would receive buffers to address potentially unstable slopes. These areas would provide approximately maximum amounts of detritus. Additionally as described above, effects of reduced overstory would be expected to be temporary and short term. Only a small

portion of Type Ns streams would be less than 10 years old, especially in steep topography where potentially unstable slopes would require retention of trees on up to (or exceeding) 50 percent of seasonal streams (e.g., inner gorges).

Significant amounts of understory vegetation would be retained along unbuffered Type Np and Ns streams, and natural nutrient input processes should be protected by the ELZ requirements and mitigation. Although the probable amount of litter input would be less than the maximum in Type Np and Ns waters, the reduction in litter delivery may not be important for maintaining aquatic systems, or may be compensated by adjustments of instream photosynthesis, terrestrial vegetation, and aquatic communities that change in equilibrium with the physical stream conditions.

Road Management

Effects associated with road construction include the creation of a road corridor. When roads are constructed or relocated within or across riparian areas, this activity removes trees which otherwise would have provided detrital input. This amount of removal is minor, although some portion of this removal is a long-term effect.

Research

Habitat manipulations that might affect detrital inputs may be conducted for research purposes and are expected to occur along a very small percentage of streams, be localized, and have negligible effects at a watershed scale.

Summary

Maintenance of overhanging trees and shrubs near the stream channel would sustain the source of most litterfall. The potential effects of forest practices on litterfall processes would be moderated by compensating factors, including in-stream photosynthesis, replacement of terrestrial woody biomass by herbaceous and understory plants, and transport systems that move litter and detritus from source areas to deficient areas. Also, aquatic community structure and function would adjust to equilibrium levels with the physical stream conditions at each reach.

Hardwood conversion would result in reduced detrital inputs, especially detrital inputs from deciduous leaves, although this should be ameliorated by the “no-harvest zone”. Reduction of canopy may result in some loss of detrital production from alder outside the Core zone. Hardwood conversion may result in some reduction in detrital input to the riparian zone and eventual reduction of nutrient input into the stream. Detrital inputs from hardwood and deciduous shrubs are particularly important for aquatic life (Piccolo and Wipfli 2002). The ultimate result of hardwood conversion is a return to natural riparian conditions and amount and type of detrital inputs.

Areas subject to harvest under 20-acre exemptions would retain less input of detritus than those harvested under the standard rules. However, overall, the amount of detrital input would remain high, and benthic invertebrate production diverse, even in recently harvested riparian areas, mainly because of retention of detrital sources in CMZs and the no-harvest Core Zones of RMZs, conservative removals from inner zones, and maintenance of buffers along substantial portions of the Type Np streams, and the rapid recovery and compensating processes. Compared to baseline conditions, the amount of leaf and needle delivery is expected to improve as riparian stands grow into older mixed hardwoods and conifers.

Retained streamside vegetation would, over time, provide nutrient input levels that meet the biological requirements of covered species.

Therefore, covered activities should cause no detectable changes in production from changes in stream nutrient loads. The covered activities would contribute nearly, but perhaps somewhat less than, the maximum potential organic litter delivery, but an amount and quality likely to be functionally effective for fish and other aquatic resources. However, the persistent lack of other sources of nutrients, particularly those supplied from adult anadromous salmonid carcasses, which are already low because of presently low anadromous salmonid abundance in many areas, would remain low in those areas until local numbers are increased and improved passage is achieved.

7.5.8 Transport and Process Factors

7.5.8.1 Habitat and Process Connectivity

In this section we discuss the processes that may be affected by forest activities such as lateral processes of deposition, erosion, storage, and recharge associated with floodplains and off-channel habitats, as well as longitudinal processes of transport and delivery associated with other habitats. We use this opportunity to discuss anticipated effects of the FPHCP to these connected habitats (e.g., lakes, ponds, wetlands, and near-shore marine habitats).

Floodplains and Wetlands

Floodplains are low-elevation, low-gradient portions of a watershed that are periodically flooded by the lateral overflow of rivers and streams. They can contain a variety of aquatic habitats, such as side channels, sloughs, backwaters, oxbows, wetlands, and lakes. Some of these features have a permanent hydrologic connection to the main channel. However, many are connected only seasonally or during periods of higher flows.

Floodplains are focal points for growth of many riparian plant communities. Riparian habitat is often a product of dynamic processes that continually operate within a watershed. Aggradation may occur in one area and degradation may occur in another. The characteristics of riparian habitat and its interaction with the stream environment is mainly a function of stream size. The influence exerted by riparian areas on the aquatic stream environment is greater in small streams, and is less in larger streams. Large streams receive less shade from the riparian area. However, as stream size increases, its influence on the riparian forest increases. Riparian forests along large streams are often associated with floodplains and may be subject to periodic and prolonged flooding, lateral channel migration, meanders, oxbow lakes, and wetlands in old river channels. These areas often have a diverse vegetative and faunal community dependent on moist soils. Floodplains and riparian areas provide (1) natural storage of flood waters and hence amelioration of flood events; (2) settling of suspended matter and thus can clean muddied waters; (3) uptake of excess nutrients; and (4) recharge of hyporheic and sources of groundwater to provide later amelioration of low-flows.

Floodplains, wetlands, and other connected habitats have been altered in the past due to timber harvest and road building. These actions can affect these sites through vegetation alteration, soil compaction, changes in hydrologic regime, degradation of water quality, or sedimentation from adjacent or upstream activities. Other effects to floodplains, wetlands, and other connected habitats have likely occurred from floods, fires, and other natural disturbances, as well as often intense change from land-use activities (i.e.,

agricultural, residential, commercial, and industrial development). Floodplains and coastal wetlands and estuaries may comprise some of the most-altered aquatic-related habitats in Washington State.

Floodplains and off-channel areas are an important component of aquatic habitat as well as terrestrial plant community types. This habitat includes side channels, backwater alcoves, ponds, and wetlands. They provide important habitat seasonally to particular life stages as well as input of organic matter and large wood. Off channel habitats such as wetlands, may be a source of warmer water to stream temperatures, but they also provide fish habitat and a source of nutrients, and can provide cooling discharge through hyporheic influences. Seasonally flooded channels and ponds are particularly important for rearing coho salmon and other fish species during winter months. Physical and vegetative succession processes occur in these specialized riparian habitats. Side channels from via channel migration processes (e.g., avulsions, chute cut-offs), then gradually become blocked and filled with fine sediment, eventually becoming wetlands or forest unless reactivated by channel migration dynamics. Channel migration and overbank flow thus are part of a suite of processes that create and maintain elements of the riparian habitat mosaic, including functional off-channel habitat types.

Many wetlands provide habitat for resident and anadromous fish (including, but not limited to coho, cutthroat, steelhead and rainbow), depending on surface area, cover, water depth, food sources and other attributes necessary for overwintering (Peterson 1982). Wetlands also provide important habitat for many amphibians. Connection to sloughs, springfed seeps, and side channel habitat is critically important for salmonid rearing and overwintering (Spence et al. 1996).

Large floodplains can also function as filters for subsurface flows and maintenance of water quality (Gregory and Bisson 1997). Floodplains also provide for sediment storage, modulating the pulses of sediment from upstream sources to downstream habitat. Wetlands can improve water quality through nutrient removal and transformation (Hammer 1989). For example, wetlands can remove nitrate and phosphorus from agricultural runoff. Nutrient-rich sediments may also become trapped and removed from the water. Wetlands can reduce shoreline and bank erosion by binding soil substrates in wetland plant roots. Thus, wetlands protect upland habitats along streams and rivers from erosion, and protect downstream habitats from sedimentation and pollution.

Wetlands provide a vital role in watershed health as a whole, thereby benefiting fish, amphibians and other wildlife habitat. Water-quality benefits include conversion of inorganic nutrients to organic forms, primary productivity, and breakdown of pollutants and storage of sediments. Wetlands recharge groundwater by storing precipitation and surface flows, thereby increasing infiltration (Richardson 1994). Wetlands also help maintain minimum stream base flow by naturally regulating the release of groundwater discharge into streams and by recharging aquifers.

Floodplains help dissipate water energy during floods by allowing water to leave the channel and inundate the adjacent terrestrial landscape, thereby lessening the effect. Floodplains and their associated aquatic features play an important role in mediating flood flows by storing water and slowly releasing this storage back to the river during lower flows. Based on their morphology, wetlands have a greater storm-water holding capacity than typical upland environments. Wetlands, therefore, reduce peak flows on streams and rivers by slowing and storing overbank flow and by holding upslope stormwater runoff (Reinelt and Horner 1990). Wetlands are known for their high primary productivity and export of organic matter to adjacent aquatic ecosystems (Mitsch and Gosselink 2000).

Approximately 4.4 percent of the FPHCP lands are comprised of wetland habitats. Wetland areas comprise approximately 2 percent of the land base in eastern Washington and approximately 6 percent in

western Washington (USFWS and NMFS 2006). Previous logging and road building has reduced the function of some wetlands by vegetation alteration, soil compaction, changes in hydrologic regime, and through sedimentation.

Some backwater alcoves and ponds result from groundwater seeps and may have shade levels higher than the main channel. These areas provide cool water refugia during high summertime temperatures. Off channel habitats such as wetlands, may also be a source of warmer water to stream temperatures. Major floodplains in the planning area generally are located in the lowest reaches of major rivers. Beavers can play a substantial role in the development of ponds and wetlands important as habitat for fish. By creating and maintaining deeper ponds with greater water volume, beaver activity modulates thermal fluctuations from off-channel water sources. Wetlands, which discharge cool groundwater, can help maintain desirable stream temperatures in the summer. Forested riparian and wetland areas serve an important role in shading streams from direct solar heating. Other wetlands, without cool groundwater discharge, may be a source of warmer water to stream temperatures, but they also provide fish habitat and a source of nutrients.

Rivers and their valleys are linked by exchanges of water between the true groundwater and hyporheic zones, and these linkages influence nearly all aspects of the physical and chemical habitat of aquatic organisms (Ward and Stanford 1989). Floodplains provide hyporheic connectivity through coarse beds of alluvial sediments that filter chemicals and ultimately regulate nutrient availability to primary producers in streams and rivers. These interchanges in groundwater are critical to maintaining productivity in rivers and streams and to maintaining healthy and productive fish habitat (NRC 1996).

In alluvial rivers, the hyporheic zones are one of the dominant links between riparian vegetation and the stream channel (Edwards 1998). Natural river floodplains can store cold water during high spring discharge events and can release this cooler water gradually to surface flow in the summer when discharge is reduced. During floods, riparian areas can temporarily store excess water which delays and attenuates the flood peak in downstream areas (NRC 2002). Bank storage occurs when surface waters move laterally from the channel into the subsurface areas when river stages are high and the water is released when the river stages go down. Bank storage in riparian areas can affect water storage, surface water temperatures, and riparian vegetation communities (NRC 2002).

Hyporheic zones (the saturated sediment region under and along streams) are often the connections between groundwater and surface water in these habitat areas and often supply substantial habitat for hyporheic organisms such as insects, bacteria, and fungi (Edwards 1998; Naiman et al. 2000). The presence of a hyporheic zone is most often associated with the alluvium below the stream and in the floodplain adjacent to streams. Nutrients and organic matter is processed in this zone by bacteria and other organisms (e.g., invertebrates, specialize insects, and crustaceans) (Boulton et al. 1998). Where this water surfaces it may be high in nutrients producing locally high primary production areas (Edwards 1998; Boulton et al. 1998). The overall exchange of organisms and effects on stream production is not well known, and in most systems may be relatively minor; however, it could be more important in some floodplain habitats (Boulton et al. 1998). In dry summer months or during floods this zone may provide a refuge for some aquatic organisms (Boulton et al. 1998). Substrate porosity may affect its function and size, but the relationship is not clear (Boulton et al. 1998).

Extensive valley floodplains with alluvial deposits and groundwater flows are extremely important where the upwelling of groundwater affects temperatures and reduces the probability that eggs or embryos would become dewatered and/or freeze (Weaver and Fraley 1991b). Habitats influenced by groundwater

inflows can be critical thermal refugia for riverine species when river temperatures warm in the summer and when overwintering in deep pool habitat in winter (MBTSG 1998). Floodplains having hydraulic connectivity within channels can support flowing groundwater (hyporheic) habitats and serve as refugia for macroinvertebrate communities (Quigley and Arbelbide 1997).

Effects from logging and roading on wetlands may include removal of nutrients, reduction of soil productivity resulting from extraction methods (road construction, skid trails and staging areas), increased sedimentation, increased soil temperature, alteration in water yield and stream flow patterns and reductions in available habitat (Trettin et al. 1997). Results from studies outside the Pacific Northwest suggest that proper harvesting techniques can minimize effects to forested wetlands (Shepard 1994).

Channels can be disconnected laterally from their floodplains through the construction and placement of roads and flood-control structures within the floodplain. Roads parallel to streams isolate the stream system from the uplands, and can constrain the natural development of meanders, side channels, and attached wetlands (Everett et al. 1994). Forest harvesting can affect alluvial systems by weakening channel banks, removing the source of large wood, altering the frequency of channel-modifying flows and changing sediment supply. Off-channel fish habitats in the floodplain such as side and flood channels, ponds, and swamps also can be strongly influenced by forest harvesting (Chamberlin et al. 1991).

As river channels are simplified and constrained, connectivity of surface waters with the hyporheic zone is lost (Frissell 1999). These groundwater interchanges can also be strongly disrupted by activities that remove groundwater or inhibit the movement of water into or out of rivers and floodplains (National Research Council 1996).

Other Connected Habitats

Lakes and Reservoirs

Lakes and reservoirs provide areas for spawning, early rearing, and growth for many fish species. They also function as migratory pathways. The nearshore environment of lakes and reservoirs depends on riparian areas in many ways that are similar to streams, relying at least partly on input of large wood from shoreline areas (Harmon et al. 1986; Christensen et al. 1996) and on terrestrial nutrient input and leaf and litter input as an aquatic food base (Wetzel 1975). However, much of the production is based on autochthonous growth (e.g., algae) within the system, typically much more so than most flowing water systems (Wetzel 1975). Nearshore areas are often a sink for nutrients and organic matter entering from streams and rivers that enter these systems (Washington Department of Fish and Wildlife 1997a). Temperature and flow conditions in lakes and reservoirs influence suitability of these environments for various fish species (Washington Department of Fish and Wildlife 1997a). Habitat structure along shorelines influences species use, including species that may be prey on juvenile salmonids (Wedge and Anderson 1979; Savino and Stein 1989).

Lakes and reservoirs serve as an important habitat component during the life histories of many fish species. Fish exhibiting the “adfluvial” life history strategy (e.g., populations of bull trout, cutthroat and rainbow) use lakes and reservoirs for much of their juvenile and adult rearing, but spawn in tributaries. In addition to rearing in these waters, sockeye and kokanee both spawn within tributary streams, as well as along shorelines of lakes and reservoirs.

Because lakes and reservoirs often have more-abundant food availability (i.e., plankton and prey species), fish exhibiting the adfluvial life history strategy often reach the largest sizes (Goetz 1989). For instance,

adfluvial bull trout have been reported to reach 40.5 inches and 32 pounds (Goetz 1989); whereas, the resident life history form may only reach 6 to 12 inches (Wydoski and Whitney 2003). Other fish such as coho often use lakes or reservoirs for rearing—especially winter rearing. Other fish species, such as pygmy whitefish, mountain whitefish, chiselmouth, minnow species (e.g., chubs, peamouth, redside shiner), suckers, burbot, stickleback and sculpin, use lakes and/or reservoirs for a large part of their life histories (Wydoski and Whitney 2003). It is important for connectivity to be maintained within inlet and outlet streams, so that fish are able to have free access during all seasons.

Literature is limited relating to effects of forest practices on lake and reservoir habitats. Watershed analyses, however, have been conducted on a number of watersheds including larger reservoirs and lakes (e.g., Lake Whatcom, Keechelus Lake and Thompson Creek). Causal Mechanism Reports have documented that coarse and fine sediment from mass-wasting and road-maintenance problems can directly deliver into lakes/reservoirs and/or into inlet channels, which then could be rapidly transported to the lake/reservoir. Very large, persistent increases of coarse and fine sediment could have negative effects on the stream habitat immediately upstream of the lake/reservoir margin, as aggradation may lead to channel dewatering, channel avulsion, and reduction of pool habitat. This aggradation and channel dewatering can disconnect access for adfluvial fish from the lake/reservoir to their spawning tributaries (Draft Keechelus Lake Watershed Analysis, DNR; Lake Whatcom, WDNR 1998b). The Thompson Creek Watershed Analysis (WDNR 1997b) notes that shallow eutrophic lakes, such as Newman Lake, could be vulnerable to filling with sediment. Lake filling is a natural geological process that may take thousands of years, but may be accelerated by human activity. The Lake Whatcom Watershed Analysis noted that fine sediment deposition can result in loss of lacustrine habitat, yet gaining wetland characteristics. In extreme cases, such as Mirrow Lake in the Anderson Creek drainage, unnatural prolonged periods of suspended sediments can cause unsuitable living conditions for salmonids. Also, excessive sedimentation in lakeshores has been found to adversely affect spawning sockeye salmon (McHenry et al. 1996).

Nearshore marine

Nearshore marine areas are generally the shallow portions of the marine environment. They may be shallow “open” water, or may contain estuaries. The habitat features contained within or influencing the near-shore marine may include bluffs, beaches, marshes, riparian vegetation, sandflats, mudflats, rock and gravel habitats, non-vegetated subtidal areas, kelp beds, inter-tidal algae, and eelgrass beds. It generally does not include deeper marine waters, but species associated with this habitat association may also use deeper water at times.

Estuaries are the zones in which fresh and saltwater mix, extending from the ocean to the uppermost extent of tidal influence. Estuaries support a variety of shallow and deep-water habitats and often include extensive areas of tidal fresh water and brackish and marine habitats (Shreffler and Thom 1993). Because of the physical, chemical, and biotic diversity of estuarine systems, they are among the most biologically diverse and richest systems found on earth (Castro and Reckendorf 1995).

There are 3 basic types of estuaries based on salinity classification: freshwater, brackish, and marine. Freshwater estuaries are dominated by inflow from the rivers, which keeps the salt water pushed out of the estuary. Brackish estuaries exhibit a mixing of salt water and fresh water. Marine estuaries are dominated by tidal action and can have salt levels very close to those of the offshore ocean. The relative mixing between fresh water and salt water in each of these types depends on relative salinity and temperature differences between the two sources of water. It is common to have a wedge effect. If two

sources of water (one saline and the other fresh) of the same temperature converge, the salt water will wedge beneath the fresh water because the fresh water has a lower density than salt water. However, if the salt water is warmer, a thermohaline convection current may form causing vertical mixing (Dyer 1973 as cited in Castro and Reckendorf 1995). Estuaries can also be classified into 3 topographic or morphologic types: drowned river valley, fjords, and bar-built estuaries (Pritchard 1952 as cited in Castro and Reckendorf 1995).

A characteristic of estuaries is that their beds are constantly moving because of river inflow and tidal fluctuations. Transport prcesses in estuaries are often dominated by tida fluctuations rather than river peak flows. Thus, estuary morphology and physical evolution can be drastically altered by actions that change the volume of the tidal prism, such as dikes and levees or dredging. The bedload in estuaries is composed mainly of sand-sized particles which are easily entrained and moved for long distances. Depending on tidal influences, material may be moved up and down the channel. Fine silts and clays flocculate in the salt water and are deposited in tidal marshes (Castro and Reckendorf 1995).

Like lakes and reservoirs, estuaries are often considered a sink for a variety of upland and riverine processes. River flow and transported nutrients, sediment, and other organic matter including large wood are important to estuaries. Large wood provides structure and nutrients for marine habitats (Maser and Sedell 1994), although its relative importance and use by fish in these habitats is not clear (Simenstad et al. 2003).

Large wood generally accumulates in backshore areas at extreme high tides, and can help stabilize the shoreline (Zelo and Shipman 2000). Although not well documented in marine systems, large wood provides structurally complex roosting, nesting, refuge and foraging opportunities for wildlife; foraging, refuge and spawning substrate for fish; and foraging, refuge, spawning and attachment substrate for aquatic invertebrates. Logs embedded in beaches also provide a source of organic matter, moisture and nutrients that assist in the establishment and maintenance of dune and marsh plants (Williams and Thom 2001).

Historically, large wood was found in great abundance in some Pacific Northwest estuaries, influencing the formation and distribution of estuarine channels (Collins et al. 2002). In the estuarine and nearshore marine areas, the historical amount of large wood was much greater than it is today (Gonor et al. 1988). Since the mid- to late-1880s, much of the large wood has been lost to human-related activities, including timber harvest and removal of large wood to establish and maintain safe navigation channels (Gonor et al. 1988). Today, considerable large wood is cleared from marine waters to reduce interference with commercial and recreational transportation.

Large-wood enhancement has recently become a common method for improving large wood content in stream reaches and estuarine and marine shorelines lacking wood. Large-wood placement can provide benefits to these systems by providing bank stabilization, a more-complex habitat structure, nutrient input, and substrate for invertebrate colonization, all of which would benefit fish habitat. Expected beneficial changes in freshwater fish habitat include increased pool quality and quantity for juvenile rearing and adult holding, and a greater abundance of functional wood in smaller, non-fish bearing channels to ameliorate the effects of sediment inputs. Similarly, estuarine and marine habitats are expected to benefit from the increased input of woody debris. However, because much of the large wood entering the estuaries and marine water is removed by the U.S. Army Corps of Engineers to maintain safe navigation, the benefits of wider RMZs is expected to be less in these habitats than in the freshwater habitats.

Trees that fall directly onto the bank and large wood that drifts on to the shoreline can provide protection for unstable and erodible banks and beaches and can stabilize banks and beaches. Large wood also acts as a barrier to wind-transported sand and can form the nucleus for a temporary accumulation of sand (Gonor et al. 1988). Additionally, large wood can contribute moisture and nutrients necessary for the establishment of woody vegetation (Stembridge 1979, as cited in Gonor et al. 1988). Pacific herring may use woody debris for spawning substrate in estuaries and nearshore areas.

Estuaries are utilized by specialized organisms that have adapted to fine sediments, high sedimentation rates, and mobile substrate. The macroinvertebrates that are found in the substrate of estuaries are much smaller than those found in the streambeds with larger particle sizes. Common benthic organisms found in the estuaries tend to be opportunistic rather than an equilibrium type of species (Schaffner et al. 1987 as cited in Castro and Reckendorf 1995). Within the estuary, the density of fauna is commonly greater in the freshwater tidal areas than in other parts of the estuary. The species diversity of macroinvertebrates is usually lower in fine-sediment substrates than that in coarser-particle substrates. The diversity and eveness of species decline with an increasing percentage of silt/clay and organic matter (Junoy and Vietez 1990 as cited in Castro and Reckendorf 1995). However, fine-sediment beds are important for burrowing tube-making invertebrates and other burrowing species (Minshall 1984 as cited in Castro and Reckendorf 1995).

Nearshore obligates—including salmonid forage fish such as surf smelt, Pacific sand lance, and Pacific herring—are dependent upon beaches and intertidal areas for spawning. Abundant food supplies, wide salinity gradients, and diverse habitats make nearshore/estuarine areas particularly valuable to anadromous fish for rearing, feeding, and osmoregulatory acclimatization during the transition between fresh water and marine habitats (MacDonald et al. 1987). Near-shore marine areas have many similarities to that of lakes and reservoirs as they provide important rearing and migratory areas for many fish. Estuaries are often considered very important for development and growth of many salmonid species during outmigration (Simenstad et al. 1982, Groot and Margolis 1991); as well as for species known as "forage fish" (e.g., surf smelt, herring, sand lance, etc.) because they provide forage to a wide variety of fish and wildlife species. Some juvenile salmonids may spend more than a month rearing in estuaries prior to migrating to the open ocean.

Chum, coho, sockeye, pink, and chinook juveniles are known to utilize estuarine habitat, including salt marsh and tidal channels that are dewatered during normal low tides. Pink and chum rely heavily on estuaries for early growth. Chinook utilize salt marsh habitat, estuarine sloughs and tidal channels. Coho use estuaries primarily for interim food while they adjust physiologically to saltwater and prior to migrating offshore. The spawning of Pacific herring—an important forage fish for salmonids—has been documented in estuarine salt marshes. Eelgrass supports copepods, a favored food for juvenile chum salmon. Estuarine habitats are also important for anadromous Dolly Varden and bull trout, where their movement is believed to follow after the timing and behavior of forage fish (i.e., surf smelt, sand lance and herring) (C. Kraemer, Personal Communication 1999). The majority of searun coastal cutthroat migrate to the mouths of rivers and estuaries, where they remain for varying lengths of time (most remain an average of 90 days) and feed along beaches in water usually less than ten feet deep (Wydoski and Whitney 2003).

Estuaries provide ideal areas for rapid growth of juvenile salmonids because they contain abundant food sources (Healy 1982; Simenstad 1983). The food supply is supported by abundant detrital sources provided by eelgrass beds, kelp forests, salt marshes and terrestrial vegetation coupled with high levels of primary production in the shallow, nutrient-rich waters (Phillips 1984). Riparian areas bordering

estuaries (i.e., bluffs, banks) are important for maintaining slope stability, shading, organic-matter delivery and large-wood recruitment.

The dynamics of sediment transport in and through estuaries is extremely complex due to the complex hydraulics associated with movement of water comprising the tidal prism across networks of branching and anastomosing channels. Philips (1991 as cited in Castro and Reckendorf 1995), in studying Atlantic estuaries, found that estuarine sediment is derived from fluvial sediment input, shoreline erosion, and migration of marine sediments inland. In many estuaries, fluvial sediments inputs are the dominant process affecting those estuaries. Increased fluvial sediment in estuaries may result in extended tidal marshes, shoaling, infilling of navigation channels, reduction of benthic and aquatic habitat, and reduced primary productivity due to turbulence and limited light penetration (Phillips 1991 as cited in Castro and Reckendorf 1995). Sediment quality is very important in estuaries because of the residence time of the sediment. Chemical bonding that occurs between many chemicals and fine sediments is important; these chemicals can remain stored in the estuary sediment and do not disappear. Similar sediment quality issues exist for all chemicals that enter estuaries and are bound to sediment. The sediment is stored on the bottom of the estuary until it is disturbed by natural processes or human activities. The effects of dredging become a critical issue when sediments are the storage reservoir for industrial and agricultural chemicals (Cunningham et al. 1987 as cited in Castro and Reckendorf 1995).

In estuarine and marine waters, substrate grain-size has been shown to be a determining factor in habitat selection by a variety of species that are either covered by the FPHCP, or are similar to those that are covered (Becker 1988; Howell et al. 1999; McConnaughey and Smith 2000; Stein et al. 2004). Storm-induced siltation of a previously-sandy lagoon in California has been blamed for the significant reduction in numbers of shiner surfperch (Onuf and Quamment 1983). Spawning habitat for surf smelt and sand lance is particularly vulnerable. These species utilize sandy/gravelly upper intertidal beaches for spawning (Pentilla 1997) and could be susceptible to degradation should large amounts of fine sediment be delivered to these beaches.

Turbidity can adversely affect fishes at every stage of their life cycle. For example, Auld and Schubel (1978) found that larval survival in American shad (*Alossa sappidissima*), was reduced under conditions of elevated suspended sediment, but hatching was not. Increased freshwater flows (from peak flows) into estuaries may result in reduced penetration of the salt wedge upstream into the lower reaches of rivers (Allanson and Barid 1999, as cited in Levings and Northcote 2004).

In the upper intertidal zone of estuarine and marine habitats, temperature is an important factor in the ecology of at least two species of forage fishes. Surf smelt and Pacific sandlance spawn in upper intertidal beaches with substrates of sand and/or fine gravel (Pentilla 1997). The loss of shade provided to the spawning beaches by riparian vegetation produces elevated substrate temperatures at low tide. Elevated temperatures on beaches have been linked to a significant reduction in the hatching success of surf smelt (Pentilla 2001).

Pacific sandlance are known to burrow into intertidal beaches during the winter (Quinn 1999). During periods of elevated temperatures and low tides, interstitial dissolved oxygen is depleted, and these fish may emerge from the sediment and either dry out thoroughly or become easy prey for a host of predators (Quinn and Schneider 1991). Loss of riparian shade could contribute to the high substrate temperatures and low oxygen events and adversely affect Pacific sandlance.

Shoreline armoring, over-water structures, landfill, and stormwater/wastewater discharge, lead to altered physical processes that affect habitat conditions and juvenile salmonid survival, as well as the survival of

other near-shore obligates (i.e., fish species that are dependent upon nearshore habitats such as surf smelt, sand lance, herring, etc.). Trees along the shoreline provide shade, which moderates temperatures in littoral spawning habitats used by near-shore obligates. Trees and downed beach wood help to moderate the rate of beach erosion. Downed wood functions to hold substrate (i.e., pea gravel and sand) needed for spawning habitat, to provide organic matter and nutrients and to provide habitat complexity and cover for fish and wildlife.

The recruitment of large wood to all these areas contributes organic input to the system but also influences the development of habitat structure for potential fish rearing habitat. The rate and type of sediment accumulation in the shallows also influences habitat, foodwebs, and production (Simenstad et al. 1979). The maintenance of estuarine habitat through sediment and large-wood inputs is important. For example, Collins et al. (2002) reported that large-wood jams in major Puget Sound estuaries historically influenced intertidal channel formation, pool depth, and sediment distribution.

Effects of the Proposed FPHCP

Floodplains

Riparian Timber Harvest: Buffers on Type F and S streams would be placed beginning at the CMZ. Harvest inside the CMZ would be prohibited. Road construction inside the CMZ would likewise be prohibited. Retaining natural vegetation within and adjacent to the floodplains would protect their soils, hydrology, and riparian vegetation and should ensure their continuing function. Hardwood conversion and treatments for overstocked stands under the template would occur outside CMZs. Yarding activities would be limited to the creation of yarding corridors. Alternate plans would provide equivalent protection for aquatic and riparian functions; therefore, effects from implementation of alternate plans would be expected to be the same or less than operations under standard rules.

Riparian harvests associated with 20-acre exempt parcels may have negative effects upon floodplains as the buffers are only required to begin at the BFW and do not need to consider the CMZ. As a result, harvest of trees could begin immediately outside the CMZ, or in some cases harvest may occur within the CMZ. Provisions of the Hydraulic Code (WAC 222-110-160) may regulate harvest within CMZs but adverse effects may occur nonetheless. Roads would not be constructed within CMZ, except as needed for crossing streams, and then alternative crossing locations would likely be sought.

Increases in the frequency of mass wasting is minimized by protective measures of the FCHCP, although, some portions of the managed landscape have higher rates of mass wasting than during pre-management times. Mass-wasting events may deliver less wood as a result of FPHCP if they initiate above unbuffered or partially buffered Type Np or Ns reaches, and subsequently deliver to floodplains or channels of larger streams. Deposits from the latter mass-wasting events could be less retentive of transportable sediment and have less large wood available to downstream reaches during future events capable of re-mobilizing large wood and sediment. A reduced amount of wood may delay recovery from such events. Potentially unstable landforms may not be avoided during harvest if the delivery zone is predicted to lie outside of typed waters. These predictions can sometimes be erroneous, as they may be made without the benefit of a geotechnical report or SEPA review.

Wetlands

Where wetlands contain surface water occupied by fish, those wetlands would be treated as Type S or F waters. In those situations, the effects analyzed below are not appropriate and the actual effects would be

the same as described earlier for fishbearing waters. Below is an assessment of effects to wetlands that do not contain fish.

Forested wetlands may be harvested. Retention of a buffer is not required and there is no retention requirement for trees within the wetlands. Voluntary retention is suggested, but trees left for other purposes may also be counted toward this voluntary goal. Harvest would reduce the large wood recruited to the wetland floor and would effect the understory. Soil compaction is a concern when equipment is used within forested wetlands. Activities in forested wetlands shall be limited to low-impact harvest or cable systems. However, partial suspension of logs is not required. Some potential exists for vegetation removal in forested wetlands to influence the temperature of surface and shallow subsurface water, which could then affect the temperature of nearby surface waters (Olson and Wissmar 2000) This effect is also possible where certain other hydrogeomorphic features result in emergence or near-emergence of the local or intermediate groundwater system (Wondzell and Swanson 1999; Frissel 1999). However, the occurrence of this effect is likely to be small, given the buffering provided by CMZs and riparian buffers on fish-bearing streams. Forested wetlands may be degraded by riparian timber harvest and associated activities under the proposed FPHCP. An incentive is provided in that the distribution requirement for leave trees within the unit may be adjusted if the voluntary targets for the forested wetland are met.

Nonforested wetlands above 0.5 acres (0.25 acres for bogs) are provided with wetland management zones (WMZs). WMZs are variable in size depending on wetland type and size. WMZ tree retention requirements of 75 trees (with specified numbers in size categories) would provide large wood, shade, and other functions to the wetlands. Because wetlands are areas of high water tables, retention of wetland buffers may be subject to windthrow. In some cases (e.g., clearcuts of less than 30 acres or partial harvest of less than 80 acres) when the WMZ comprises more than 10 percent of the harvest unit, the leave tree retention requirement may be reduced to no less than 50 percent (38 trees per acre) of what would otherwise be required (75 trees per acre). This would also reduce the number of larger trees required for retention. The wetland rules provide some additional protective features, addressing individual trees or small forested wetlands within non-forested wetlands. Other harvest of upland or forested wetlands which are surrounded by non-forested wetlands must be conducted in accordance to a plan approved by WDNR. No timber shall be felled into or cable yarded across non-forested wetlands without written approval by WDNR. No harvest is permitted within bogs.

Tractors, wheeled skidders, or other ground-based harvesting systems shall not be used within the minimum WMZ width (25 to 50 feet) without written permission of WDNR. Landings within forested wetlands would be minimized, but some adverse effects to hydrology may result where landings are placed within forested wetlands. Landings would not be placed within nonforested wetlands or their WMZs.

Road construction should avoid wetlands under the proposed FPHCP. When filling or draining more than 0.5 acre of wetland, 2-for-1 substitution /replacement would be required. Road construction may occur in proximity to wetlands and may deliver sediment to forested wetlands. Non-forested wetlands would have WMZs that should help filter sediment from roads. Altered hydrology may result from roads in proximity to wetlands. Small, isolated wetlands (e.g., less than 0.5 acres) may not be identified and may be subject to adverse effects associated with timber harvest and road system management.

Lakes and Reservoirs

Buffers for Type S waters would maintain a direct source of large wood for lakes and reservoirs. These buffers are also expected to provide the shoreline with shade and bank or bluff stability. Large wood that

is delivered directly to shorelines would often remain in place due to anchoring by rootwads. Such wood has the ability to alter lateral movement of sediments and provide habitat diversity along beaches and shores. Increases in the frequency of mass-wasting is minimized by protective measures of the Washington Forest Practices Rules, although, some portions of the managed landscape likely has higher rates of mass-wasting than during pre-management times. Mass-wasting events may deliver less wood as a result of FPHCP if they initiate above unbuffered or partially buffered Type Np or Ns reaches, and these events may sometimes deliver deposits to Nearshore areas of lakes and reservoirs. In addition, potentially unstable landforms may not be avoided during harvest if the delivery zone is predicted to lie outside of typed waters. These predictions can sometimes be erroneous, as they may be made without the benefit of a geotechnical report or SEPA review. Erosion of lakes shores should be minimized by the protective measures of the FPHCP.

Indirect effects may occur to lake and reservoir habitat from implementation of the FPHCP. The measures to address roads and near-stream areas may reduce the elevated levels of sediment delivered from upstream. Buffers on streams should provide for maintenance of large wood delivered from upstream areas and should protect the temperatures of waters that flow into lakes and reservoirs. These cool waters should provide refugia where cooler waters flow into lakes. Where Type Np streams flow directly into lakes, there may be rare situations where water warmed in a clearcut harvest has not cooled prior to entering the lake or reservoir. In these infrequent situations, the effects are expected to be short-lived (e.g., 5 to 10 years at most) until stream-side shade is re-established. Sediment delivery through tributaries should be reduced by a combination of large wood storing sediment in streams and measures to reduce sediment delivery to those streams. Where Type Np streams flow directly into lakes, there may be situations where increased sediment input occurs, although these effects are expected to last only until hydrologic and riparian zone recovery have occurred (10 years at most). Upstream road crossings may deliver sediment that is eventually routed to lakes and reservoirs.

Near-shore Marine

Type S buffers are expected to provide shade to beaches, shorelines, and estuaries. Small streams flowing directly into estuaries are also expected to be protected as described earlier for Type F or Type N streams (as appropriate). Type S buffers should provide the natural rate of large-wood recruitment to estuaries and shorelines. We also expect maintenance of natural levels of sediment, nutrient, and detrital inputs. There may be some effect from small coastal Type N streams that deliver wood, nutrients, and sediment, and water to estuaries and to marine near-shore areas. However, most connecting waters are expected to be fishbearing and the lower 300 to 500 feet of perennial streams without fish would be protected as discussed earlier. In addition to stream effects and delivery, many such waters are influenced by tidal inputs as well. Tidal delivery further confounds our ability to predict effects and would likely mitigate and reduce effects that may otherwise have resulted.

Marine and estuarine areas that receive discharge directly from Type N streams may receive smaller amounts of wood from these sources, however, the Type N streams make up a smaller source, overall, than the Type F streams, which receive more substantial protective measures. The margins or banks of streams, estuaries, marine waters, and river channels provide important habitats for both aquatic and riparian-dependent species. Forest practices that cut streambank trees or result in areas of exposed streambank soil would adversely affect these habitats by altering the character of stream banks and perhaps diminishing large-wood recruitment.

Disruption of subsurface flow could, potentially, affect freshwater seeps along the shorelines of estuaries and the marine nearshore. Inside Puget Sound, some forage fish spawning is thought to be associated with freshwater seepage, where the water keeps the spawning gravel moist (WDFW 2005a). Disruption of these seeps could potentially cause reduced spawning success of forage fish species, which in turn could reduce the prey available for marine and anadromous predator species such as searun cutthroat trout.

New roads might cause localized, increases in peak flows and sediment delivery, but the net effect over longer time periods, across the action area, would be an overall decrease in road-related peak flow increases when other proposed measures (i.e., road upgrading and removal) are considered. Because FPHCP would not result in significant increases to large peak flow events, there would be no detectable difference in the location of the estuarine salt wedge in lower reaches of rivers, or area of maximum turbidity in estuarine habitats during large peak flow events. Some increases in small to moderate peak flows are expected, especially in estuaries of smaller watersheds. Likewise, some increases in growing season baseflows are anticipated, which could have small effects on the summer season estuarine water-quality dynamics, temperature, and salt content. These effects would likely be short-lived, becoming undetectable as hydrologic recovery occurs.

Overall, the likelihood of adverse temperature effects are considered low for most westside coastal streams and marine and estuarine areas, including areas where harvest Option 1 (thinning) would be implemented, and eastside streams within the bull trout overlay, which includes most of the action area on the eastside. In low-elevation basins where water temperatures are already elevated and eastside streams outside the bull trout overlay there are moderate probabilities of thermal effects. However, these effects would be less likely where Type S streams receive 200 foot buffers. Temperature conditions, and therefore protection of fish resources, are expected to improve relative to baseline conditions. Where Type Np or Ns streams enter directly into lakes or estuaries, it is unlikely that there would be sufficient discharge to influence the water temperatures of these larger water bodies if heating of these streams occurred and did not dissipate prior to delivery, except for a very small area at the mouth of the stream. In most cases, Type N streams would cool prior to entry into lakes or estuaries and provide areas of thermal refuge.

Passage of Water, Wood, and Sediment

Stream-crossing structure installation and maintenance must consider connectivity to floodplains, estuaries, and other stream-connected habitats, in terms of passing flows, sediment, and large wood. FPHCP construction standards are expected to provide better transport of water, sediment, and large wood than under previous regulations, and RMAPs are expected to address existing problems. While stream-adjacent parallel roads may disconnect large-wood delivery and overbank sediment deposition from the floodplain, and may also serve to constrict the floodplain in some situations, the FPHCP would result in fewer floodplain roads and would also result in the removal of many existing stream-adjacent roads. The FPHCP would require that a substantial component of current problem areas be addressed in the near future (many have already been addressed).

FPHCP road standards (Culverts and bridges at stream crossings designed to accommodate 100 year flood event) are expected to provide passage for fish, other covered species, large wood, sediment, and flood flows in excess of what was previously required and above what currently exists in many cases. However, there still remains a potential that inadequate stream crossings may restrict the natural channel and floodplain width. Not all stream crossings will be fixed in the short term. Those culverts meeting

passage criteria (i.e., those that can pass 150 mm fish), existing on currently eligible 20-acre exempt parcels, and some proportion of culverts on non-industrial lands may not be fully upgraded in the short term so that meet the FPHCP standards for passage of floods and wood. Where inadequate crossings persist, they may result in changes to channel morphology, increased scouring at crossings, stream-bank erosion, and undermining of the crossing structures. There is the potential for long-term scouring downstream, upstream aggradation, channel constriction, and reduced capacity for instream large-wood transport. In addition, some stream crossings are at risk for upstream headcutting and channel incision when culvert replacement or removal is performed in cases where there is pre-existing reach-scale incision downstream (Castro 2003). Where this happens, it may result in channel destabilization and bank erosion for a distance upstream that depends on local soils, channel and valley topography and streambed characteristics. Proper culvert design should include examination of geomorphic factors which would indicate a risk of headcutting, and result in incorporation of grade control measures to prevent headcutting from occurring. However, under current practices, opportunities to prevent headcutting are sometimes missed or incorrectly mitigated, and we anticipate some continued occurrence of this problem. Flotation of large wood and importance of delivery from upstream was already discussed in the **Effects of Activities by Resource Topic – Large Wood** section.

7.5.9 Instream Responses

This section examines changes within the stream system that may occur from altered inputs and processes, which were discussed earlier.

7.5.9.1 Stream Channel Morphology

Baseline of Stream Channel Morphology

Large pools have been lost in many tributaries of the Columbia River in the past 50 years (Sedell and Everest 1991; McIntosh et al. 1994; USDA 1996). Overall, there has been a 58 percent reduction in the number of large, deep pools in resurveyed streams in National Forests within the range of the northern spotted owl in western and eastern Washington (FEMAT 1993). In western Washington, Bisson and Sedell (1984), reported a similar loss of pools in sub-basins with moderate to intensive levels of timber harvest. Historical grazing practices in some locations have contributed to degraded riparian zones with reduced summer flows in streams, unstable and eroding stream banks, and reduced productivity of fish. Reduction of wood in stream channels, from past activities, generally reduced pool frequency, habitat quality, and channel complexity (Bisson et al. 1987; House and Boehne 1987; Spence et al. 1996). Road construction and timber harvest on unstable slopes resulted in the loss of pools from mass-wasting events and sedimentation (Janda et al. 1975; Morrison 1975; Swanson and Dyrness 1975; Ziemer and Swanston 1977; Betcha 1978; Ketcheson and Froehlich 1978; Marion 1981; Swanson et al. 1981; Coats 1987; Kelsey et al. 1981; Madej 1984; Nolan and Marron 1985; Grant and Wolff 1991). Ralph et al. (1991) summarized the status and trends of instream habitat in forested lands of Washington.

Upslope activities (e.g., timber harvest, land clearing, and road development) can change channel morphology by altering the amount of sediment or water contributed to the streams. This, in turn, can disrupt the balance of sediment input, output, and storage in a stream (Sullivan et al. 1987). Stream habitat conditions in Washington are affected by a wide range of factors, including geophysical changes (e.g., volcanic eruptions, earthquakes, and associated uplifting), extremes of flow (e.g., flooding and low flow), existing geological conditions (e.g., erodible soils), and land-use practices (e.g., timber harvest, grazing, urban development, road construction and operation, and gravel mining). Many rivers and

streams flowing through urban and agricultural areas have been channelized to facilitate rapid storm runoff and reduce local flooding. The effects of these combined factors result in the existing stream-habitat conditions.

Factors affecting Stream Morphology

Natural channels are complex and contain a mixture of habitats differing in depth, velocity, and cover (Bisson et al. 1987). Stream-channel morphology is often described in terms of width/depth ratios related to bankfull cross-section (Rosgen 1996). Bankfull, in this sense, refers to the edge of the floodplain or incipient floodplain surface adjacent to the channel, which is a depositional surface formed under the current sediment regime and climate, and inundated by commonly occurring peak flows (Leopold et al. 1964). Studies of watershed function have confirmed that changes in bankfull channel dimensions correspond to changes in the magnitude and frequency of bankfull discharge or changes in sediment load. Natural habitat features are often formed during storm events with associated flows that mobilize sediment in the channel bed (Murphy 1995). The hydrologic regime of a watershed, combined with its geology, hillslope characteristics, and riparian vegetation determines the nature of stream channel morphology (e.g., number and spacing of pools and width-to-depth ratio) (Beschta et al. 1995; Sullivan et al. 1987).

Channel condition and dynamics indicators of streams considered to be functioning appropriately are dependent on the stable or equilibrium stream type for the reach in question. For example, most meandering, single-thread “pool-riffle” channels are expected to have a bankfull width: depth ratio in the range from 13 to 29 (Rosgen, 1996). A ratio significantly larger than this could be indicative of instability. Here, “stability” means persistence of a particular stream type over time, not the absence of streambank erosion or channel migration. Criteria can also be developed for the amount of streambank erosion present at any one time, or the rate of channel migration, based on observations of similar stream types in undisturbed condition. Criteria for other processes important to stream function are also important, such as the frequency and duration of overbank flows that occur and maintain wetland function, riparian vegetation, and succession (USFWS 1998a [from NFHCP BO]).

In streams, channel morphology is largely influenced by geomorphic setting, sediment load, and riparian vegetation (Sullivan et al. 1987 cited in Murphy 1995), and by climate (Leopold 1994). Human factors influencing channel morphology are changes in sediment and streamflow regime, channelization, changes in riparian vegetation that can influence bank characteristics, and solid structures such as large wood, bedrock, and boulders (Murphy 1995; Rosgen 1996). Structurally diverse streams in watersheds unmodified by human activity typically have a great deal of buffering capacity to moderate the effects of floods on channel patterns and bed configuration (Cross and Everest 1995).

Off-channel areas should be hydrologically linked to the main channel, and overbank flows need to occur to maintain wetland function, riparian vegetation, and successional diversity. Riparian vegetation along streambanks ensures stability and minimizes sediment input. Intact off-channel areas that are functioning properly help dissipate the energy of water during high flow events and provide additional shoreline habitat at higher flows.

Habitat components representative of stream channels where channel morphology is considered stable and complex are: large and diverse pools; large woody debris; overhanging vegetation; undercut banks; areas of coarse substrate; diversity in water depth and turbulence; aquatic vegetation; diverse stream margins; side channels; groundwater-surface water linkages; and connectivity (Graham et al. 1981; Pratt 1984; Hoelscher and Bjornn 1989; Goetz 1991; Pratt 1992; Murphy 1995).

Riparian vegetation aids in maintaining stream-channel dimensions and bank stability, and affects where erosion and sedimentation of channels and floodplains occurs. Healthy riparian vegetation contributes to good root growth and root strength in streambanks. Riparian vegetation communities are critical in maintaining channel stability during high flow to allow maintenance of stream dimension, pattern, and profile (Kleinfelder et al. 1992; Cornwall 1998; Lyons et al. 2000; Toledo and Kauffman 2001; Liquori and Jackson 2001; Micheli and Kirchner 2002 as cited in IMST 2004). Millar (2000) reported that vegetation communities had significant influence in determining whether systems would become braided or single thread systems in gravel bed rivers. Beeson and Doyle (1995) reported that vegetated bends experienced significantly less erosion during high flow periods than channel bends without riparian vegetation.

Another mechanism by which riparian vegetation maintains the dimensions of a stream channel is by increasing the roughness of the banks and floodplain, thereby decreasing erosion and increasing sediment deposition. If the rooting strength of riparian vegetation and the surface roughness is sufficient, sediments will be deposited, not eroded. Reduction in root mass through removal of riparian vegetation can lead to increased bank erosion and sedimentation rates. During high discharge events, water naturally overtops stream banks and inundates stream floodplains. In healthy riparian communities, high floodplain roughness traps sediments on stream banks and floodplain surfaces during these floodplain inundations. Riparian communities in poor condition lose this ability to trap material, and sediments are actually eroded from the floodplain surface during high discharge events (IMST 2004).

Importance of Stream Channel Morphology

Some fish species are known to be associated with large pools, consisting of a wide range of water depths, velocities, substrates, and cover (Watson and Hillman 1997). Large wood in streams enhances the quality of habitat for salmonids and many other fish species and contributes to channel stability (Bisson et al. 1987). It creates pools and undercut banks, deflects streamflow, retains sediment, stabilizes the stream channel, increases hydraulic complexity, and improves feeding opportunities (Murphy 1995). By forming pools and retaining sediment, large wood also helps maintain water levels in small streams during periods of low stream flow (Lisle 1986a *cited in* Murphy 1995). Cover is a component of habitat complexity used by fish at all stages.

Some fish show strong affinity for stream bottoms and a preference for deep pools of cold water streams, lakes, and reservoirs (Goetz 1989). Cobble or fist-size stones provide the most-favorable streambed habitat for stream algae and invertebrates, in turn influencing the amount of benthic biomass available to sustain various fish species (Goldeman and Horne 1983). Stream channels that are either lacking cobble-sized substrate, have elevated cobble embeddedness, or are unstable in nature (shift or scour), generally have less-abundant aquatic insects and have decreased species diversity.

Groundwater-surface water linkages have also been shown to be important habitat components for a number of species. As channels are simplified, connectivity of surface waters with the floodplain and hyporheic zone is lost (Stanford and Ward 1992; Stanford and Ward 1993; Ward 1993 as cited in USFWS and NMFS 2000). Sedimentation appears to play an important role in decoupling groundwater and flow exchange processes, especially when chronic increases in fine sediment are experienced (Brunke and Gonser 1997 in Frissell 1999). It is possible for fine sediment to seal downwelling sites that could in turn reduce downstream up-welling.

Erosion within channels occurs naturally during high flows, but in a stable channel, erosion at one point is balanced by deposition at another location. Severe erosion of streambanks, at rates greater than the

natural range, can cause channels to widen, while erosion of the bed can cause channels to incise, disconnecting the floodplain from the stream system.

Sedimentation, or sediment deposition, occurs when streamflows no longer have sufficient hydraulic shear stress to transport sediments. Hydraulic friction increases as the channel becomes wider and shallower, reducing available energy for transporting sediments. Riparian vegetation, large wood, or boulders can also decrease water velocities, causing deposition of sediments. Sediments that enter a stream can be deposited 1) directly into the streambed, 2) along the streambank, 3) along gravel bars, or 4) on the floodplain during flooding. Sediments may also remain suspended in the water column and be transported downstream. Excessive deposition in the stream channel can contribute to a decrease in stream channel depth. A large sediment supply may cause aggradation (i.e., filling and raising the streambed level by sediment deposition) and widening of the stream channel, pool filling, and a reduction in gravel quality (Madej 1982). Shifts in channel morphology and channel stability can be triggered by increases in sediment input rates, such as from increasing erosion in upland areas. Changes to the hydrology, either increasing or decreasing the hydraulic energy available to move sediment, can affect channel morphology and stability as well. Such changes may exhibit positive feedback behavior, as when increased sediment input causes shallowing, which in turn reduces hydraulic energy and induces more deposition.

Sedimentation also reduces pool depth, alters substrate composition, reduces interstitial space, and causes channels to braid, and increases the rate of channel migration (Rieman and McIntyre 1993 citing others). Impoundments and diversions have altered natural sediment-transport processes, causing deposition of fine sediments in slackwater areas, reducing flushing of sediments through moderation of extreme flows, and decreasing recruitment and increasing erosion of coarse material (including spawning gravels) downstream of the obstruction (Spence et al. 1996). Channel morphology can be affected indirectly by changing frequency and magnitude of scour and fill in the stream channel.

Many fish species are strongly associated with various components of habitat complexity, including cover, large wood, side channels, undercut banks, boulders, pools, and interstitial spaces in coarse substrates. Reductions in habitat complexity include decreases in: large wood; pool quality; channel stability; substrate quality; and groundwater inflows. Side channels, stream margins, and pools are sensitive to activities that directly or indirectly affect stream-channel stability and alter natural flow patterns. Some species are strongly associated with the habitat characteristics of stable stream channels. Increased bedload exacerbates the scouring effect of high water, increasing channel instability, leading to a loss of habitat diversity, especially pools (Henjum et al. 1994; McIntosh et al. 1994). Eggs and fry of fish species that utilize gravels likely survive such scouring at lower rates (Henjum et al. 1994). Reduced recruitment of large woody debris can reduce stream habitat complexity. Loss of riparian vegetation destabilizes streambanks and increases erosion and sediment delivery to streams. Road construction that involves channelizing streams may cause reduced habitat complexity and increased sediment delivery.

Persistence and sustainability of side-channel habitat depends on functioning channel-migration processes. Side channels go through a natural succession process in which they eventually fill in, become disconnected from the main channel and cease to function well as fish habitat. New side channels are generated by channel migration, including log-jam dynamics and avulsion at naturally sustainable rates. Thus, sustainability of side-channel habitat depends on having deformable (unhardened) stream-channel boundaries and water access to overbank areas during peak flows.

Highly variable stream flows, mobilization of streambed materials, and channel instability influence the survival of young fish. Substantial increases in size, duration, and frequency of peak flows can cause streambed scour and bank erosion. Low habitat complexity, the frequency of bed load scour, and the frequency of low flows (which may cause freezing within the substrate) may be aggravated by watershed disruption and problems of channel instability. Cover is another important component of habitat complexity. Cover can include woody debris, overhanging vegetation, undercut banks, cobble and boulder substrate, water depth and turbulence, and aquatic vegetation

All biota in streams are influenced by water-velocity distribution. The water velocities control the physical structure of the streambed and the amount of suspended material that is transported (Goldman and Horne 1983). When channel morphology/complexity is diminished, a greater proportion of the total hydraulic energy is available to scour the streambed. Greater levels of streambed disturbance can then occur during high flow events resulting in negative effects to benthic biota, which in turn, affect fish species at all life-stages through the loss of food sources.

Streams that lack a balance between pools and riffles are often less productive than streams that have more complex structure. Pools are used as holding and resting areas for adult fish prior to spawning, deep water cover for protection, and cool water refugia during low flow summer months. Riffles are important for re-oxygenation of water, habitat for food organisms such as aquatic macroinvertebrates, and as rearing areas for fish (Gregory and Bisson 1997).

Sediment eroded from headwater channels and debris flow deposits is transported to lower channel reaches (Cross and Everest 1995), which tend to be response zones, where channel morphology and channel migration rates are highly influenced by sediment input. Lower-elevation channel reaches historically constituted some of the most-important habitats for fish. These habitats are more-easily developed and have been exceedingly degraded by human activities.

Complex aquatic habitats are necessary to accommodate the diverse needs of various fish species (Murphy 1995; Spence et al. 1996). Complex habitats not only provide fish with critical habitat for all life-history stages in freshwater, but provide refuges from environmental variability (e.g., extreme flows) and stochastic events (e.g., catastrophic fires), buffering populations from the effects of environmental perturbations (Sedell et al. 1990; Rieman and McIntyre 1993). See the **Effects of Activities by Resource Topic -- Refugia and Movement** section.

Effects of proposed FPHCP on Channel Morphology

Riparian Timber Harvest

Riparian timber harvest would result in some reduction of large wood along Type Ns and Np streams. Decreased delivery of large wood could potentially decrease the number and quality of pools in some streams (such as forced-step-pool streams), and, in turn, could decrease the sediment-storage capacity of such streams. Downstream routed sediment might then affect downstream pool depth. In order to be effective at reducing pool depth in this manner, the amount of sediment input would necessarily be quite large. This amount of sediment would not commonly be associated with chronic sources (e.g., soil erosion due to riparian timber harvest or exposed slopes at road crossings), but would be indicative of episodic events such as slope or road failures, accelerated streambank erosion, or upstream channel incision.

Unbuffered Type Np streams may also reduce the amount of wood that could be incorporated into debris flows that originate further upstream. Where debris flows deposit at major junctions or at gradient changes, there may be some increment of reduced wood delivered to those locations. Decreased sediment stored upstream or decreased large wood delivered from upstream may have some effect to fishbearing streams. For instance, where two Type Np streams converge to form a fishbearing stream, reduced wood from above and/or increased sediment delivery may have effects to channel morphology. Direct effects to local channel morphology should be minor in most cases because debris flows would incorporate wood from other reaches, including the thermal-recovery reach, as they travel. However, reduction in wood content could affect the rate at which sediment in these accumulations is routed downstream. In general, smaller streams subject to loss of large wood can recover channel complexity more quickly than larger streams, since relatively smaller pieces of wood can store and processes sediment in small stream systems.

Slope failures may occur upstream and large sediment pulses may be delivered to the stream system. If woody debris is less available to store that sediment (either due to less wood within failure deposits, or less wood in headwater streams, it may have a moderate effect to the routing regime. Sediment may be more likely to fill pools, redirect streams, and/or cause shifting of substrate for a number of years. However, in most cases, FPHCP would avoid initiation of man-caused failures that deliver directly to fish-bearing streams, and would provide moderate amounts of wood on areas naturally prone to failures and debris-flow pathways. The magnitude of effects from mass-wasting events would likely mask the margin of difference from a reduced increment of wood recruitments from certain reaches of Type Np or Ns streams.

Retention of buffers along Type F and S streams within 20-acre exempt parcels (in conjunction with the Shade Rule) would provide some large wood but may not provide enough quality pieces of large wood to protect channel morphology. On 20-acre exempt parcels along Type Np streams, minimal buffers could be retained that would provide few pieces of functional large wood. Harvest along these Type Np streams may also result in increase in sediment delivery, thereby having an increased risk of affecting channel morphology.

Bank stability is influenced directly by root strength of trees in riparian forest and protection from ground-based equipment. Bank stability is also influenced by episodic events such as slope failures, debris flows, floods, windthrow, and fire. Activities that alter these episodic events could also influence bank stability. The combination of Core Zone retention on Type F and S streams, retention of buffers on sensitive sites, and retention of buffers for certain reaches of Type Np streams, in combination with ELZs, would help maintain root strength and would minimize disturbance from ground-based equipment. As discussed under the **Effects of Activities by Resource Topic -- Windthrow** section, windthrow is not expected to be increased at the catastrophic level by the proposed FPHCP. Minor amounts of windthrow are expected in association with riparian harvest, but the majority of this effect is anticipated to occur in the outer portions of riparian zones and would seldom affect trees contributing to bank stability.

Forest management cannot alone determine fire risk. Management of species composition and stocking density, as well as fuel type and loading, are the major management factors that can be controlled. The FPHCP provides for the ability of landowners to address forest health to a certain degree, but does not mandate such treatment. Fire is variable in its occurrence and effects, which contributes to its value as a landscape-level habitat-forming feature. It is not expected that the FPHCP would negatively affect bank stability due to altered fire risk.

Road Management

In-channel habitats can be affected in areas where peak flows increase (Chamberlain et al. 1991; Spence et al. 1996) resulting in changes to channel scour frequency and depth, which affects survival of incubating eggs (Murphy 1995), and in pool volume and pool frequency (Sullivan et al. 1987), which can displace juvenile salmonids from winter cover (Tschaplinski and Hartman 1983). Hydrologic changes that alter normal bedload movement and scour and fill patterns can excavate or bury redds. These effects to redds may expose eggs to stream flow and may trap or crush eggs or fry. The effects of road management on peak flows are variable, depending on watershed size and magnitude of peak flows. The potential exists for roads to intercept shallow subsurface flows and convert those to surface flows which are more efficiently and quickly routed to the stream system. More-rapid routing of road runoff to streams is addressed by the proposed FPHCP, yet some increase in this routing and resultant influence on timing and magnitude of peak flows is possible. In this way, some influence on channel morphology is possible as a result of road-system management that changes peak flows.

Stream-crossing structures can restrict the natural channel and floodplain width, which can change channel morphology, increase scouring at crossing sites (as well as increase scouring below crossings), increase stream-bank erosion, undermine stream-crossing structures and associated road fills, increase upstream aggradation, destabilize upstream channels through aggradation or interference with channel migration processes, and reduce the capacity for instream wood and bedload transport. Some replacements of road crossings result in unexpected channel incision upstream (Castro 2003). Culverts sometimes act as barriers to upstream progression of pre-existing reach-scale incision. If these barriers are removed without identifying the need for, and successfully establishing, grade-control elements, incision may migrate into the upstream reach causing channel destabilization and accelerated streambank erosion. Sediments mobilized during this period can then cause aggradation and pool infilling downstream.

Road management would result in sediment delivery despite measures to avoid delivery. Sediment is expected to result primarily from road crossings and stream-adjacent parallel roads. Channel morphology may be affected by road failures, instream road work, and exposed soil surfaces associated with stream crossings, and to a lesser degree by chronic road-related delivery. Channel morphology in streams with road crossings is expected to improve as culverts that constrict the channel would generally be replaced within the first 10 years of the Permit term. Stream-adjacent parallel roads that constrain the channel would be considered for abandonment. Stream and bank stability, both upstream and downstream, are affected by crossings and constrictions by stream-adjacent parallel roads. These conditions are expected to improve from the current baseline conditions.

7.5.9.2 Water Quality

The 1998 Washington State Water Quality Assessment, Section 305(b) Report (Butkus 1997) used a sampling approach to assess all streams in the State for use impairment under EPA guidelines. Although 65 percent of the streams in the State were found to be use impaired for at least one category, silviculture was a possible source for use impairment on only 4 percent of the State's streams. This is among the lowest effects identified, and was less than half of the number of possible natural sources for use impairment, which was 11 percent.

Chamberlain et al. (1991) reported the primary water-quality constituents that may be influenced by timber harvesting are temperature, suspended sediment, dissolved oxygen, and nutrients. Because temperature and fine sediment (including turbidity) have already been addressed separately as Aquatic

Inputs earlier in this Opinion, the topic of Water Quality included herein pertains to contaminants such as chemicals and excess nutrients as well as their effects such as lower dissolved oxygen levels.

Chemicals

Water quality and anadromous and resident fish species can be adversely affected by the accidental introduction of forest chemicals and petroleum products to drainages. Timber harvest and yarding along streams may involve chainsaws and heavy equipment, resulting in equipment exhaust and leakage of petroleum-based products such as gasoline, oil, hydraulic fluid, and anti-freeze. The same is true for large-wood placement, mechanical slash treatment, soil scarification and site preparation, road work, and other activities involving heavy equipment. Equipment would generally be staged and maintained at locations away from surface waters and in locations where any leaks would not deliver to the stream system or surface waters.

Water-quality contaminants (e.g., petroleum products) can severely impair aquatic ecosystems either by sublethal (e.g., reduced growth) or lethal effects (e.g., fish kills). Petroleum products are used in conducting forest practices, such as gasoline and lubricants. Chain-saws and other power tools are often inefficient in their gasoline consumption. These tools can discharge unburned gasoline. Such engines also release oil which can depress dissolved oxygen levels in the water. The combustion process discharges additional toxic compounds such as polycyclic aromatic hydrocarbons (PAH). EPA initiated control standards in 1995 (Tier 1) out of concern from hydrocarbon and oxides of nitrogen, and continued improvement in emissions is expected. Staging of large equipment away from waters during storage and maintenance would help reduce the probability (or severity) of any leaks or spills reaching typed waters.

Road grading and ditch cleaning may mobilize contaminants present in road surface material and may accelerate their transport and hasten their delivery. Fine sediments mobilized by road work may be delivered to stream channels and may contain traces of oil, gasoline, hydraulic fluid, or other compounds. Therefore, road work can re-mobilize this source of water-quality contamination and hasten its delivery to the stream system. Furniss et al. (1991) reported that wherever roads are near streams or road drainages enter streams, a potential chemical-spill hazard exists. Chemicals used to suppress dust, control or fertilize roadside vegetation, and stabilize or de-ice road surfaces also can enter streams directly or be transported by runoff. These are considered to be Cumulative Effects. There is similar potential for adversely affecting water quality, aquatic habitat, and aquatic organisms because of possible spills and leaks of petrochemical products (fuels, lubricants, hydraulic fluids) along roads or at activity sites near drainages.

Wetlands and floodplains can also remove toxic chemicals, such as pesticides, heavy metals, or excess nutrients from water (Mitshc and Gosselink 1993). Water-quality contaminants such as insecticides and fertilizers are addressed under Cumulative Effects, as are herbicides which are not interrelated or interdependent to the proposed issuance of the subject Permit.

As a result of timber harvest and hardwood conversion in the riparian zone, reforestation and attendant activities may be necessary. Of these, vegetation management through use of chemicals may provide a source of contamination. Active ingredients, surfactants, and adjuvants should be selected based on the least toxic available that still maintain efficacy for application. All BMPs and label restrictions should be strictly followed so that there would be no direct application to streams or wetlands. Due to tree-specific spraying and anticipated planting densities, we expect that less than 20 percent of an area would likely be sprayed when chemical application is necessary. We also expect that in most cases, alternate methods of

control would be tried before resorting to chemical use. Herbicide use would have very reduced potential for introduction to water due to 50-foot Core Zone.

Herbicides

Herbicide use to control competing riparian vegetation would be an interrelated and interdependent activity associated with hardwood conversion on Type S and F streams and rivers. Similar activities may occur along Type Np streams; however, riparian areas along Type Np streams are more likely to transition quickly into upland conditions and are less likely to present conifer-regeneration challenges. The use of forest chemicals of any type is not an FPHCP covered activity.

A number of constraints currently apply to application of chemicals in forests. Only chemicals approved by the Washington Department of Agriculture may be used, and those chemicals must be used in accordance with label directions and the current Washington Forest Practices Rules. However, in this Opinion we are only analyzing the application of glyphosate that is factory-formulated with no carrier other than water and only surfactants that are very low in toxicity (e.g., Agri-Dex®). We are only analyzing this combination of herbicide and surfactants because we do not have enough information about other pesticides and combinations to conduct a rationale effects analysis. Many chemicals have potentially harmful by-products and the combination of chemicals and tank mixes may have potential synergistic effects. The number of potential chemicals available for use, multiplied by the potential combinations, preclude us from reasonably assessing effects to covered species. In addition, interrelated activities that are not covered activites are expected to be lawful activities. We are confident that use of glyphosate and a surfactant such as Agri-Dex® would not result in effects that would be expected to rise to the level of take for the covered species. We cannot be equally confident of this for other chemicals and combinations of chemicals.

Active Ingredients

Glyphosate is the common name for N-(phosphonomethyl) glycine. Trade names for aquatic products with glyphosate as the active ingredient include: Rodeo®, AquaMaster®, and AquaPro®, among others. Glyphosate is an herbicide that is used in the forest for conifer release, noxious-weed control, and site preparation. All commercial formulations of glyphosate that are used in forestry applications contain the isopropylamine salt of glyphosate. Some formulations contain only this salt of glyphosate as an aqueous solution. The EPA has determined that 92 percent of technical grade glyphosate contains an impurity, N-nitrosoglyphosate, at less than one part per million and that this amount is toxicologically insignificant. Several liquid formulations of glyphosate contain glyphosate alone in water (e.g., AquaMaster®, Glyfos Aquatic®, Roundup Custom®, and Rodeo®) (USDA 2003). Other glyphosate formulations generally contain surfactants. While surfactants are typically classified as “inert” ingredients in herbicides, these compounds may be more toxic than the herbicides with which they are used. Differences in acute toxicity among the various glyphosate formulations appear to be largely due to the use of surfactants that are toxic to fish and invertebrates (USDA 2003).

Action Mechanism

The herbicidal activity of glyphosate is due primarily to the inhibition of the shikimate pathway which is involved in the synthesis of aromatic amino acids in plants and microorganisms. This metabolic pathway does not occur in animals and thus this mechanism of action is not directly relevant to animal-health risk assessment. Studies on the mechanism of action of glyphosate are numerous and standard toxicity studies are available on seedling emergence and vegetative vigor in a number of different plant species (USDA

2003). This systemic, broad-spectrum herbicide is often used to control undesirable floating-leaved plants and shoreline plants. It is generally applied as a liquid to the leaves and does not work on underwater plants.

Application Method

All product labels and requirements of the Washington Department of Agriculture, and application requirements of WDOE and/or WDNR would be followed. We expect that only the minimum area necessary would be treated. Before application, applicators would thoroughly review the site to identify and mark, if necessary, buffer requirements. Application, as well as mixing, would only occur in places and at times specified by the manufacturer's label and other restrictions. All spill contingency planning and notification would be expected to conform to applicable restrictions and guidelines.

The most-common method of application for glyphosate is backpack-applied directed foliar spray. In directed foliar applications, the herbicide sprayer or container is carried by backpack and the herbicide is applied to targeted vegetation. Glyphosate may also be applied in hack and squirt applications, in which the bark and cambium of a standing tree is cut with a hatchet and the herbicide is then applied to the cut using a squirt bottle. This treatment is used to eliminate young trees during site preparation or conifer-release operations. Although glyphosate is a broad spectrum, non-selective herbicide, proper application can selectively remove targeted plants by focusing the spray only on the plants to be removed. Plants may take several weeks to die and a repeat application is often necessary to remove plants that were missed during the first application.

Surfactants are added to a spray tank to improve herbicide application by modifying the wetting and deposition characteristics of the spray solution resulting in a more even and uniform spray deposit. Surfactants and adjuvants can improve pesticide efficacy. Glyphosate would be mixed with water as a carrier and may contain surfactants or adjuvants to promote saturation and adherence. For instance, Agri-Dex® is a proprietary blend of heavy range, paraffin-based petroleum oil and non-ionic surfactants designed for use with a broad range of herbicides where a crop oil concentrate adjuvant is recommended.

Application Rate

The typical application rate is about 0.5 to 2 pounds of active ingredient per acre. The maximum label application rate is 3.75 pounds of active ingredient per acre. A typical dilution rate is taken as 10 gallons per acre. Glyphosate is absorbed primarily through the foliage, and the absorption is rapid. Approximately 33 percent of the applied glyphosate is absorbed within a few hours after application. The retention of glyphosate on foliage is affected by the use of adjuvants with a wash off of about 50 percent with adjuvants and 64 percent without adjuvants (Leung 1994). According to manufacturer's label instructions for ground application, Agri-Dex® would be mixed at the rate of about 1 to 4 pints per 20 to 100 gallons of spray solution.

Fate and By-Products

Glyphosate is very immobile in the soil and is rapidly rendered inactive over a period of several weeks. Glyphosate is not generally active in the soil and is not usually absorbed from the soil by plants. Glyphosate dissolves easily in water. The potential for leaching is low as glyphosate is strongly adsorbed to soil particles (USDA 2003), even those soils with lower organic and clay content (Extoxnet 1996). Glyphosate does not evaporate easily. Glyphosate remains unchanged in the soil for varying lengths of time, depending on soil texture and organic matter content. Glyphosate is moderately persistent in soil

with an estimated average half-life of 47 days (Extoxnet 1996), with a range from 3 to 130 days; the half-life for glyphosate in water ranges from 35 to 63 days (USDA 2003).

Glyphosate quickly adheres to vegetation and other organic matter, adsorbs strongly to the soil, and is not expected to move vertically below the 6-inch soil layer. Residues are expected to be immobile in soil (USDA 2003). One estimate indicated that less than 2 percent of the applied chemical is lost to runoff. Microbes are primarily responsible for the breakdown of the product, and volatilization or photo-degradation losses will be negligible (Extoxnet 1996). Glyphosate is readily degraded by soil microbes to aminomethyl phosphonic acid, which is further degraded to carbon dioxide. Thus, it is highly unlikely that there could be movement to groundwater (U.S. EPA 1993b). Glyphosate may be translocated throughout the plant, including the roots. It is extensively metabolized by some plants, while remaining intact in others (Extoxnet 1996).

Herbicides can potentially enter streams through run-off, leaching, or percolation. However, adsorption onto soil particles reduces these potential pathways. Glyphosate though very soluble, binds well with organic matter in soils and therefore is not easily leached. Glyphosate does have the potential to contaminate surface water through erosion, as it adsorbs to soil particles which can then be suspended in runoff. The likelihood of delivery through surface erosion will be a function of soil-erosion risk. Because glyphosate binds tightly to soil particles, it is unlikely that toxic levels would occur in aquatic systems through erosion, especially where water is constantly moving. Glyphosate is rated as “very low” for herbicide movement (Vogue et al. 1994).

Acute Toxicity

Like all chemicals, glyphosate may be toxic at sufficiently high exposure levels. However, glyphosate is “practically non-toxic” to fish, aquatic invertebrates, and honeybees (U.S. EPA 1993). For instance, Rodeo®, with the low-level toxicity surfactant Agri-Dex®, has been determined to be practically non-toxic to rainbow trout and *Daphnia magna* (WSDA 2004). Available toxicity data suggest that amphibians are no more sensitive to glyphosate than fish (USDA 2003). See **Potential Direct Effects** section below.

Sub-lethal Effects

Studies do not indicate a basis for suggesting that glyphosate is an endocrine disruptor. Nonetheless, glyphosate has not undergone an extensive evaluation for its potential to interact or interfere with the estrogen, androgen, or thyroid hormone systems. Thus, the assessment of the potential endocrine effects of glyphosate cannot be overly interpreted (USDA 2003). The Re-registration Eligibility Decision document on glyphosate (U.S. EPA 1993b) indicates that glyphosate is classified as Group E: “Evidence of non-carcinogenicity for humans.”

Glyphosate produces reproductive changes in test animals very rarely and then only at very high doses. According to the USDA Forest Service (2003), glyphosate does not appear to be teratogenic (i.e., causing malformations of an embryo or fetus) and glyphosate mutagenicity (i.e., increase the frequency of mutation to an organism) and genotoxicity (i.e., result in mutations to genetic material) assays have been negative. USDA Forest Service (2003) summarizes several studies that noted some decreased body weight and decreased weight of several organs in studies of effects to mammals. Glyphosate has no significant potential to accumulate in animal tissue (Extoxnet 1996). There is a very low potential for the compound to build up in tissues of aquatic invertebrates or other aquatic organisms (Extoxnet 1996).

Potential Direct Effects

Amphibians: Available toxicity data suggest that amphibians are no more sensitive to glyphosate than fish (USDA 2003). Relyea (2005) in a test conducted in cattle tanks containing no sediment, found that Roundup (formulated with surfactants) application resulted in mortality of tadpoles from a number of amphibian species. However, Dr. Relyea has not yet analyzed the effects of unformulated glyphosate on amphibians (Relyea, Personal Communication, February, 14, 2006). A number of studies have concluded that technical glyphosate has little toxic effects on amphibians (Trumbo 2005; Howe et al. 2004; Wojtaszek et al. 2003; Thompson and Wojtaszek 2003). Mann and Bidwell (1999) found that technical glyphosate was "practically non-toxic," producing no mortality among tadpoles of any of the four species over 48 hours, at concentrations between 503 and 684 parts per million.

USDA (2003) noted that there are a number field studies that have assessed the effects of glyphosate on groups of terrestrial organisms, both animals and plants. These studies indicate that effects on terrestrial animals are likely to be secondary to the effects on vegetation when glyphosate is applied at application rates comparable to those considered in the studies. In some cases, the effects noted in field studies appeared to be beneficial to some species under study. In most cases, the effects noted were changes in population density that reflected changes in food availability or suitable habitat**.** For instance, Cole et al. (1997) reported no effect on populations of six species of amphibians (based on capture rates) among clearcut sites with and without glyphosate applications. Species included rough-skin newt (*Taricha granulose*), ensatina (*Ensatina eschscholtzii*), Pacific giant salamander (*Dicamptodon copei*), Dunn's salamander (*Plethodon dunni*), western redback salamander (*Plethodon vehiculum*), and red-legged frog (*Rana aurora*). However, Cole et al. (1997) noted that removal of red alder from the habitat reduced amphibian populations regardless of the method used to remove the alder.

Fish: USDA (2003) summarizes a number of studies regarding fish species. EPA (1993b) classified technical grade glyphosate as "practically non-toxic" in freshwater fish and concluded that: "technical glyphosate should not cause acute or chronic adverse effects to aquatic environments."

USDA (2003), in summarizing a number of studies, noted there is information indicating that some fish species, such as salmonids, are more sensitive to glyphosate than other species of fish. But the study also noted that the information is complicated by the fact that some surfactants are very toxic to fish as well as gaps in the available literature. Bioassays of the direct toxicity of herbicides suggest that glyphosate herbicides used at recommended rates pose little or no risk of acute toxicity to salmonids (Chapman 1989; Holtby and Baillie 1989; Morgan et al. 1989; Janz et al. 1991; Folmar 1976; Hildebrand et al. 1982; Morgan and Kiceniuk 1992).

Potential Indirect Effects

Based on reports summarized in USDA (2003), we conclude that it is unlikely that there would be indirect adverse effects on fish, amphibians, aquatic plants, soil microorganisms, and terrestrial or aquatic invertebrates.

FPHCP Effects

We anticipate glyphosate use, in the general form and application described above, to occur within the Inner Zone and Outer Zone of Type S and F streams and rivers. Further, the Washington Forest Practices Rules require a minimum 50-foot distance from unbuffered Type Np and Ns streams when applying forest chemicals. Since glyphosate is very immobile in the soil, we do not expect glyphosate to enter streams, except where the soil-erosion risk is high in localized areas. Thus, we expect that the fish and

stream-associated amphibians would rarely be exposed to glyphosate. Even if they were exposed, we do not expect any fish or amphibian mortality or changes in growth rates or reproductive success because of the low toxicity to fish and amphibians from glyphosate. Application of glyphosate during dry conditions would reduce the possibility of migration from the application site to typed waters and hand application would further reduce the possibility of drift because spray nozzles would be in close proximity to target plant species and to the ground.

In summary, we do not expect covered or listed species and their habitat in the FPHCP Action Area to be adversely affected by the use of glyphosate as described in the above discussion.

Nutrients

Inorganic nutrients commonly associated with forest-practice activities, such as nitrogen or phosphorus, may show moderate increases following timber harvest although levels are typically limited to moderate amounts that persist no more than 10 years following harvest (Hicks et al. 1991; Chamberlin et al. 1991). Water-quality criteria for nitrogen are rarely exceeded, but the criteria are based on human health (nitrates) and fish toxicity (ammonia) rather than ecological disturbances (Anderson 2002). Algal response to additional nutrients could be greatest in downstream reaches (Anderson 2002). Excessive algal growth can lead to high pH from photosynthesis (Erickson 1999) and to low oxygen from decay of dead algae (Roberts et al. 2004). High pH and low dissolved oxygen can be harmful to salmon (Bell 1991). In nutrient-limited streams, large algal blooms triggered by the release of the limiting nutrient in the water column can potentially affect aquatic life if algal remnants settle into inter-gravel spaces and their decay reduces dissolved oxygen levels (Chamberlin et al. 1991).

The effect of nutrient input on surface waters as a function of land use is illustrated by the findings of a U.S. Geological Survey study of nutrient transport (U.S. Geological Survey 2000). This study reported that forested watersheds in the Puget Sound Region have much smaller yields of organic nitrogen and nutrients than do watersheds that are urbanized or have agricultural land uses, due to higher inputs from these developed areas. Phosphorous yields were not related to phosphorous inputs, however, because phosphorous adsorbs to soil particles.

Reduced large wood in headwater reaches could potential reduce the pattern of nutrient delivery downstream. Large and small wood pieces can store sediment and organic matter (detritus) in headwater streams which allow for organisms to process this detritus into usable size particles and useable forms for downstream organisms. Reduced large wood could result in minor disruption of these patters. Decreased shade in some headwater reaches may result in an increase in primary production having a mixture of negative and beneficial effects to nutrient and energy flow within the stream system. Improving fish passage may provide nutrients to the system as a result of anadromous fish access in the form of eggs and carcasses. Wetlands can improve water quality through nutrient removal and transformation (Hammer 1989). For example, wetlands can remove nitrate and phosphorus. Nutrient-rich sediments may also become trapped and removed from the water.

Dissolved Oxygen

Adequate dissolved oxygen levels are important for supporting fish, invertebrates, and other aquatic life. Salmonids are particularly sensitive to reduced dissolved oxygen (Oregon Department of Environmental Quality 1995). Inter-gravel dissolved oxygen has been recognized as crucial to the survival of salmonid embryos. Inter-gravel dissolved oxygen depends on several interrelated factors such as water temperature, surface-water concentrations, percentage of fine sediment and gravel in pores, and the

oxygen demand of the eggs. Management-induced depletion of dissolved oxygen in stream water can occur from harvest activities, such as excessive amounts of logging debris left in a stream that can result in decreased dissolved oxygen (MacDonald et al. 1991). Critical levels of dissolved oxygen also depend on the velocity of the water passing over the eggs, as oxygen consumption would rapidly reduce oxygen supply to the egg without replenishment through adequate inter-gravel flow (velocity). Therefore, at lower velocities, higher initial oxygen concentrations are needed for proper egg development (Oregon Department of Environmental Quality 1995). Forest-management activities can exacerbate any inter-gravel dissolved oxygen problems through increases in fine sediment, which reduce inter-gravel water velocity (Bjornn and Reiser 1991; Ringler and Hall 1975; Moring 1975).

Dissolved oxygen levels in the water column also can be depressed during extreme low-flow periods, especially during warm summer months, and adversely affect aquatic organisms.

Chamberlin et al. (1991) noted that for dissolved oxygen, concentrations in intergravel spaces may be reduced if deposits of fine sediment restrict the flow of water through the streambed, potentially adversely affecting incubating or pre-emergent individuals.

High water temperatures can contribute to low dissolved oxygen because warm water cannot hold as much oxygen in solution as cold water can. Dissolved oxygen is often lower in surface waters that have a large percentage of their volume coming from poorly oxygenated groundwater, especially during summer low flows. Excess nutrients, especially phosphorus from sediments, fertilizers, or waste products, can stimulate algae and aquatic plant growth in surface water. When dead plant material decays, and when plants are taking up oxygen at night, dissolved oxygen levels decline. Fish and other aquatic life need sufficient levels of dissolved oxygen to survive. As temperature increases, metabolism increases and the demand for oxygen also increases. For maintenance of the health of fish and many other aquatic organisms, levels of dissolved oxygen concentrations in the water should approach saturation.

The primary water-quality problem on forestlands throughout the State is temperature, which also happens to be the most prominent water-quality problem for the State's water bodies (USFWS and NMFS 2005, Appendix A). Some of these streams may be naturally elevated for temperature (USFWS and NMFS 2005). Stream temperature has already been addressed in this analysis. Increased heat and sediment and reduced flow can also lower dissolved oxygen. There are over 200 freshwater segments listed for dissolved oxygen. Many of the elevated values for dissolved oxygen can be linked to temperature effects (dissolved oxygen decreases with increasing temperature) (WDOE 2004a).

Minimizing fine organic loading (i.e., prevent slash and debris inputs) help to maintain the appropriate dissolved oxygen concentrations. While providing access to anadromous fish is desirable for a number of reasons (e.g., improved anadromous fish populations, nutrient source for resident fish), decaying salmon carcasses can also reduce the amount of dissolved oxygen in streams.

7.5.9.3 Aquatic Community Composition

The base of the aquatic food chain is supported by the combination of dissolved chemical nutrients and detrital materials. The chemical constituents such as nitrogen (usually in the form of nitrates and nitrites), phosphorus, and carbon can be derived from the breakdown of detritus and through leaching and runoff from surrounding soils (Gregory et al. 1987). Many bacterial and macroinvertebrate species rely directly on detrital material from leaf and needle litter, branches, and stems from the surrounding riparian zone vegetation. Some estimates indicate that leaf and needle recruitment may provide up to 60 percent of the total energy input to stream communities (Richardson 1992). Other macroinvertebrate species rely on

aquatic algae that primarily use dissolved chemical nutrients and require solar radiation. In streams containing spawning habitat for Pacific salmon, substantial influxes of nutrients from the marine environment occur during the decomposition of carcasses (Bilby et al. 1996).

The abundance and diversity of macroinvertebrate food sources to fish and amphibians is dependent upon the primary algae and detrital food sources. Some amphibians at certain life stages depend directly upon algal food sources. Riparian timber harvest can affect the food chain by changing the relative macroinvertebrate production between herbivores and detritivores (Gregory et al. 1987). The magnitude and duration of the change is dependent upon a variety of factors, including stream size, gradient, location (headwater versus mainstem), and the type of riparian vegetation and management prescriptions. Gregory et al. (1987) suggest that tree harvest in riparian areas initially leads to higher total invertebrate abundance, but fewer invertebrate species, and that recovery of the macroinvertebrate community occurs over periods similar to recovery of riparian zones. Bilby and Bisson (1992) observed higher summer production of coho fry in a stream flowing through a clearcut area relative to a nearby stream reach in an old-growth riparian stand. However, no differences in coho production were present during fall censuses, and the high summer fish production was attributed to high algae production (Bilby and Bisson 1992). Bilby and Bisson (1992) and Spence et al. (1996) have noted that other changes in habitat features (e.g., numbers of pools) required by yearling and adult fish could likely offset any increases in sub-yearling production. Gregory et al. (1987) argued that short-term higher fish productivity might occur downstream of timber harvest units in some areas, but at the expense of long-term stability in the overall abundance and diversity of the aquatic community.

Turbidity and suspended solids can reduce nutrients for fish and amphibians by decreasing phytoplankton abundance. The diminished light penetration can also result in reductions in primary production of algae and periphyton. Particulate materials physically may abrade macroinvertebrates and their body parts. Suspended sediments usually consist of clays or silts. Suspended sediments are the portion of the sediment load suspended in the water column which can be measured by turbidity, although organic matter, plankton, and micro-organisms are also part of a turbidity measurement. Decreases in primary productivity can adversely affect the productivity of macroinvertebrates, amphibians, and fish.

As a result of past logging, it has been noted that nutrients can become more available to the stream immediately following harvest, resulting in part from addition of slash to the forest floor, accelerated decomposition of litter, and increased runoff and erosion (Spence et al. 1996). Increased sunlight immediately following harvest also contributes to higher algal primary productivity and a greater abundance of invertebrates, with an associated increase in abundance of predators (Salo and Cundy 1987; Murphy and Meehan 1991).

Meehan (1996) found no overall change in macro-invertebrate inputs with canopy removal. Although he found some changes in the minor taxa significant, he found large amounts of Ephemeroptera and Diptera in both canopied and non-canopied reaches and determined that the differences overall did not appear to be of practical importance.

Hardwood conversion may result in some reduction in detrital input to the riparian zone and eventual reduction of nutrient input into the stream. Detrital inputs from hardwood and deciduous shrubs are particularly important for aquatic life (Piccolo and Wipfli 2002). The ultimate result of hardwood conversion is a return to natural riparian conditions and amount and type of detrital inputs. Yet, in southeastern Alaska, young-growth alder sites were documented to export significantly greater counts and biomass densities of macro-invertebrates than young conifer sites (Piccolo and Wipfli 2002). Murphy et

al. (1986) compared old-growth, buffered, and unbuffered riparian areas and the effects on juvenile salmonids. The buffered reaches did not differ consistently from the old-growth forest reaches. He did note that clear-cut reaches had more periphyton and increased fry abundance in the summer, but also noted that clearcutting without a buffer may reduce abundance of parr in winter, especially if debris is removed from channels. Wipfli (1997) found that a riparian overstory with more alder and denser shrub understory may increase abundance of terrestrial invertebrates in streams.

Improved passage can affect the aquatic community in several ways. Bilby et al. (1998) noted that the proportion of marine-derived nitrogen in the muscle tissue of juvenile salmonids increased as much as 39 percent following carcass placement, indicating that eggs and carcasses of adult salmon provide a very important resource during a period when other food items are often scarce. Densities of age 0+ coho salmon and age 0+ and age 1+ steelhead increased following carcass additions to treated steams.

Another potential effect of improved passage is access by invasive species. For instance, brook trout may currently be prevented from accessing habitat by fish-passage barriers such as culverts. Repairing and replacing culverts may allow brook trout access to areas where they can compete with or hybridize with native salmonids.

Effects of proposed FPHCP on Aquatic Community Composition

Fish access may increase the number of species using some stream reaches. This may have a negative effect on some species (competing and prey species) or a beneficial effect on other species (predator species, or species benefiting from other interactions). In the case of anadromous access, increases in marine-derived nutrient delivery can also change the local stream community.

Reduction in wood recruitment due to activities under FPHCP in headwater reaches could potentially reduce the pattern of nutrient delivery downstream. Large and small wood pieces can store sediment and organic matter (detritus) in headwater streams which allow for organisms to process this detritus into usable size particles and useable forms for downstream organisms. Reductions in wood could result in minor disruption of these patters. Reduced shade in some headwater reaches may result in an increase in primary production having a mixture of negative and beneficial effects to nutrient and energy flow within the stream system. Reductions in shade would be expected to be a short-lived phenomenon on most narrow streams. Increased sunlight for 1 or 2 years may increase primary production (algae and diatoms) within streams during that period of time. Recovery of shade would like occur between 2 and 5 years from harvest.

7.5.9.4 Resource Relationships

This section examines interrelated topics and the indirect effects to resource topics (associated with aquatic inputs) that may emanate from changes to riparian forests, aquatic inputs, and hydrologic processes. This section is necessarily complicated in that it discusses the effects of one subject upon other subjects. For instance, large wood stores sediment in small headwater streams. These storage sites influence flows. Redirection of flows into alluvium alters surface flow, but also can affect temperature at downstream sites.

Large Wood Responses

The effects of the FPHCP upon large-wood recruitment were discussed earlier. Large wood in streams may respond to a number of other factors (such as debris flows, high flows, and channel size) that

influence transport and depletion. Reduced recruitment of large wood to streams without fish may also reduce the amount of wood delivered downstream to fish-bearing streams through episodic events. This was already discussed in the discussion regarding large-wood recruitment. Large-wood depletion primarily occurs through two processes: decomposition and transport. Decomposition is influenced by size, species, and location of wood. These factors, with respect to key-piece wood, are influenced primarily by factors addressing the riparian forest. Management for a fully stocked Core Zone, RMZ management to return original species composition, and RMZ management to improve diameter growth should contribute to recruitment of more-persistent wood. Transport is also influenced by the character of the individual pieces of wood (e.g., wood size, branching, presence of a root-wad), as well as by strength of flows. Strength of flows are determined by stream size, drainage area, and individual storm events. Peak flows during large storm events have not been demonstrated to be significantly influenced by either timber harvest or road management. While small and moderate flows can be influenced by those management factors, they do not appear to alter significant storm events – See the **Effects of Activities by Resource Topic – Hydrology** section.

In areas dominated by steep topography, a portion of the large wood in fish streams is delivered through episodic and catastrophic processes. These processes have historically occurred naturally and as a result of management activities. FPHCP objectives are to avoid the acceleration of slope failures, and to provide wood with such failures when they do occur. In this way, it is not expected that delivery or persistence of large wood in fishbearing streams would be affected by slope failures as a result of the FPHCP. We do expect that debris flows would in some cases entrain fewer pieces of large wood; and, if such debris flows were to deliver to Type F streams, the incremental difference in amount of wood may have localized effects.

Hydrology Responses

Peak flows are the primary aspect of hydrology affecting instream responses and habitat formation and degradation. Increases in peak flows are generally poorly understood and can be either increased or decreased by forest management. However, large peak flows with the ability to influence habitat features (e.g., during storm events) appear relatively uninfluenced by forest management. Large peak flows are primarily a function of storm event severity and basin size. Other factors that may influence hydrology include slope failures. As mentioned above, slope failures have historically occurred naturally and as a result of management activities. FPHCP objectives are to avoid the acceleration of slope failures, and to provide wood with such failures when they do occur. In this way, it is not expected that hydrology would be affected by slope failures as a result of the FPHCP, because slope failures are expected to occur at natural rates and continue to incorporate wood which is important to the ameliorating of negative effects and realization of many of the positive attributes of slope failures. Slope failures provide coarse sediment that is used for spawning gravels. Slope failures also produce aggradation which may facilitate exchange between stream water and water within substrate that modifies stream temperatures.

Hydrological processes can be influenced by the presence of fine sediment. Sediment-laden reaches may be more prone to avulsion and erosion. Deposition of large amounts of sediment may accelerate channel migration and may increase the rate of sedimentation. The FPHCP would not be expected to result in such large amounts of sediment so as to alter hydrologic processes and channel migration in such a manner.

The importance of large wood in forming habitat features was already discussed in large wood recruitment. Large wood can influence hydrology by forming steps and sediment wedges in high-

gradient streams. It can facilitate exchange with hyporheic zone and can modify flow rates. Large wood can armor banks from erosion, or it can deflect flow toward banks facilitating avulsion and bank cutting. The FPHCP is not expected to result in large changes in recruitment and distribution of large wood. There may be some local reductions of large wood within stable Type Np streams when left without buffers. However, on a system wide basis, functional levels of large wood are expected to be recruited and distributed and any reductions are not expected to affect these hydrological processes.

Substrate Responses

Substrates within streams can be affected by more than the addition of fine and coarse sediments. Decreased delivery of large wood could decrease the number and quality of pools in forced-step-pool streams, and in turn could decrease the sediment-storage capacity of such streams. As discussed earlier, within stream work may affect channel substrates. Substrate may also be disrupted by movement and positioning of logs during large wood placement. There is also the potential for loss of natural stream-channel substrates in locations where conventional culverts are placed. Culvert placements completed under the FPHCP (and HPA) should provide a high likelihood of retaining natural substrates within, upstream, and downstream of such culverts. Hydrologic changes can alter normal bedload movement and alter scour and fill patterns. This can excavate or bury redds, exposing eggs to stream flow or trapping and crushing eggs or fry. Such hydrological changes resulting from FPHCP would be expected to be minimal.

Temperature Responses

Changes in channel shape may potentially affect stream temperatures within fish-bearing streams more than the reduction in shade on Type Np streams. Due to some decrease in large wood in headwater streams, there may be some subsequent change in routing of sediment. Changes in sediment routing and storage regime could result in some level of change in channel morphology downstream. As discussed in the **Effects of Activities by Resource Topic -- Channel Morphology** section, changes in channel morphology to this extent are more likely in the case of episodic sediment input, rather than chronic inputs. It would require considerably large sediment inputs to achieve habitat changes of this scale. It is unlikely that sediment from erosion in harvest units would provide measurable sedimentation levels outside of reaches adjacent to the harvest unit. Road-related sediment delivery would need to be considerable to effect such a change in the sediment regime and fill pools and widen the stream. Such road-related sediment inputs are most likely a result of an episodic event. When habitat alteration does occur, such as filling of pools and stream widening, changes in temperature are possible depending on stream size and other characteristics. However, the FPHCP is not expected to increase such episodic events, and in fact, should decrease the occurrence of such events with respect to roads through the RMAP process.

When naturally occurring episodic events such as debris flows do occur, and during the course of the debris flow encounter areas where wood is lacking (e.g., an unbuffered Type Np reach), the debris flows may deliver a reduced level of large wood. This altered level of large wood would still be likely to contribute to functional levels of large wood. Even though changes in habitat structure could potentially have some effects on temperature, the described scenario would only involve moderate habitat alterations that would be expected to have minimal effects on stream temperature. Mass-wasting events, however, when considered as a whole, do have the ability to substantially modify stream-channel characteristics and influence stream temperature both by causing stream channel and riparian changes that may increase stream temperature, but also by creating conditions conducive to cooling of streams.

Riparian timber harvest, outside of forested wetlands, is not expected to result in warming of groundwater. Riparian and upslope timber harvest may increase the annual water yield and may provide increased flows during summer low flows. Increase groundwater is most likely to have cooling effect on surface streams. Riparian harvest in forested wetlands may remove canopy that allows shallow subsurface water to warm, although the extent to which such harvests may increase the temperatures of water within streams in uncertain.

Nutrient Responses

See the discussion in the Effects of Activities by Resource Topic -- Water Quality (Nutrients) section, as well as the discussion in the Effects of Activities by Resource Topic -- Aquatic Community section.

7.5.10 Habitat Access

7.5.10.1 Refugia and Movement

Fresh water and estuarine habitat in the Pacific Northwest has been a continuously shifting mosaic of disturbed and undisturbed habitats. One of the legacies of fish evolution in a highly fluctuating environment is the ability to colonize and adapt to new or recovered habitat. Wild salmonid stocks historically accommodated changes in their environment through a combination of three strategies. Long-term adaptation produced the highly varied life-history forms of these species, providing the genetic diversity needed to accommodate a wide range of changing conditions. High fish abundance distributed in multiple locations (stocks) increased the likelihood that metapopulations and their gene pools would survive. Occupation of refugia (higher-quality habitat) provided the base for recolonization of poor habitat as conditions improved over time (IMST 2004).

Well-distributed and interconnected local populations of fishes across the landscape help maintain their long-term productivity and survival. Should a natural disturbance event occur, these areas where habitats remain undisturbed can act as local refuges and can aid recolonization of the disturbed area. However, if refugia habitat is inadequate in terms of size, quality, number, and/or connectivity, the affected fish species may be vulnerable to regional extirpation. Small, isolated, local populations of native fish are more likely than larger local populations to become extirpated over long time scales due to stochastic events (e.g., landslides, catastrophic fires, and floods). Further isolation of local populations in shrinking habitat is likely to lead to increasing rates of extirpation not proportional to the simple loss of habitat area (Lee et al. 1997). Connectivity between populations of amphibians can also aid those species in recolonization following stochastic events.

Connectivity is also needed between habitats used by fish within a local population. Migratory corridors provide the necessary connection between spawning, rearing, and over-wintering and foraging areas. Disruption of migratory corridors can increase stress, reduce growth, decrease survival, and prevent reproduction. Movement of individual fish is essential to the persistence and interaction of local populations.

Movement and migration in tributary streams by native fish is typically in response to developmental and seasonal habitat requirements. Some fish commonly make long-distance annual or seasonal movements among various riverine and estuarine habitats searching for foraging opportunities and refuge from warm, low-water conditions in mid-summer and ice in winter.

Fish usually move upstream to spawn, but they also move to feed, hide and find better habitat as conditions in a stream change over time. Downstream migration may provide more opportunity to access denser forage, find improved protection from avian and terrestrial predators, and alleviate intra-specific competition in rearing areas. Even though juvenile fish tend to move downstream, this is not always the case when they are moving in response to unfavorable habitat conditions such as increased stream temperature or fall migrations into overwintering areas. Even resident fish need connectivity to various areas needed to fulfill all of their life-history requirements. On temperature-sensitive streams, juvenile fish may move upstream to seek sources of cool water within that system. Juvenile salmon are known to migrate upstream from main stem areas and into small tributary streams, or "off-channel" habitats to overwinter. Adult bull trout are known to move into smaller, colder tributaries from mainstem river systems during the summer in response to increasing river temperatures. For many species, juvenile fish need to move downstream to the ocean, and adults need to return to natal streams to spawn.

Habitat fragmentation can cause metapopulation systems to shift to smaller, more-isolated units. Barriers such as water diversions, dams, impassable culverts, and dewatered reaches limit or exclude the number of individual fish that can emigrate to spawning and rearing areas. Local refugia provide a protective mechanism; where refugia for fish exist in close proximity to a depopulated area, recolonization can occur rapidly. For instance, Reiman et al. (1995) found that bull trout and redband trout were greatly reduced in some stream reaches after an intense burn on the Boise National Forest, but these species rapidly recolonized the affected reaches.

It is well known that the loss of the migratory life form of westslope cutthroat trout, and of other salmonid species, has been due to the reduction of connecting corridors for dispersal (as summarized in USFWS and NMFS 2000 [NFHCP BO]). In these cases, refugia habitats become isolated in a system due to lack of connectivity, so that refounding or support for lost local populations is diminished.

Habitats influenced by groundwater inflows can be critical thermal refugia for riverine fish when river temperatures warm in the summer and when deep pool habitat becomes limiting in the winter. Floodplains having hydraulic connectivity within channels can support flowing groundwater (hyporheic) habitats and serve as refugia for macroinvertebrate communities (Quigley and Arbelbide 1997). Some of the most productive juvenile rearing habitats in streams are located in backwaters along the edge of the channel and in side-channel areas.

7.5.10.2 Impediments to Access and Connectivity

Overall, there is likely a lack of connectivity for many populations of native fish within the action area of the FPHCP. Quigley and Arbelbide (1997) suggested that the extensive heavily managed landscapes throughout the Columbia River basin have contributed to the fragmentation and simplification of most watersheds and that most watersheds are compromised, particularly in terms of persistence of local populations of native fish in light of catastrophic events. It is apparent that useable corridors, both within and among tributary streams, mainstem rivers, and lake systems are critical for native salmonids and other fish to locate refugia habitat and ultimately maintain viable populations. Land-management activities can influence the function of refugia habitats for native fish mainly through interruption of hydrologic connections and habitat degradation. Culverts and diversion dams can block or impede fish movement thereby precluding dispersal to refugia habitats. Migrations occur at certain times of the year that can be critical for survival. Impediment or delay in fish migration can be the result of culvert hydraulics, which create water-velocity barriers, depth barriers, and/or vertical jump barriers.

Upstream migration of adult salmonids to spawning areas or redistribution of rearing fish to potential habitat in upstream areas can be impeded or blocked by a number of different mechanisms. Various fish species may have other requirements, but much information has been gathered on this topic with respect to salmonids. These mechanisms can include the following:

- Water Temperature—Elevated water temperatures (e.g., 15.6 degrees C and 20 degrees C for coho salmon and fall chinook salmon, respectively) are known to stop the migration of fish (Bjornn and Reiser 1979).
- Dissolved Oxygen—At least 5 milligrams per liter (mg/l) of dissolved oxygen is recommended to provide oxygen needs for migrating fish (Bjornn and Reiser 1979). Decreased oxygen can occur as a result of high water temperatures and oxygen consumption created by decay of organic debris, chemicals, and respiration.
- Turbidity—High levels of sediment (e.g., 4,000 mg/l) have been reported (Bjornn and Reiser 1979) as ceasing upstream migration.
- Streambed Aggradation and Subsurface Flow—Debris flow deposits in fish-bearing streams have been found to cause fish blockages (Pearce and Watson 1983; Bryant 1983). High stream bedload accumulations have been found to result in subsurface flow and isolating stream reaches either inhibiting or delaying passage (Furniss et al. 1991; Hartmen et al. 1995).
- Physical Barriers—High waterfalls or cascades that are beyond the jumping or physical capabilities of fish can prevent upstream migration. Similarly, excessive water velocities that result in conditions beyond the physical capabilities of a given fish species can also restrict or prevent upstream migration. The maximum velocity beyond which coho and chinook salmon cannot successfully move upstream is about 8 feet per second (Bjornn and Reiser 1979). Shallow water depths from conditions such as low flow can impede or prevent passage (e.g., chinook and coho salmon are generally not successful at upstream migration at water depths less than about 0.8 feet or 0.6 feet, respectively (Bjornn and Reiser 1979). Such conditions can occur during low flow periods where riffles between pools can become completely dry or lack sufficient depths for fish passage.
- Man-made Barriers—Man-made barriers include features such as dams and stream crossings (usually culverts, but sometimes bridges as well).

Road crossing across streams can restrict channel geometry and prevent or interfere with migration of adult and juvenile fish (Furniss et al. 1991). Stream crossings by forest roads are the most-common passage barrier influenced by Washington Forest Practices Rules. A Hydraulic Project Approval is needed for the construction of stream crossings, which are regulated by the WDFW under the Hydraulic Code (WAC 220-110-070). Barriers such as culverts used at stream crossings can prevent passage due to high water velocities, restricted depths, excessive elevation for successful entry, size and length of the culvert, and other factors.

7.5.10.3 Passage Barriers

Habitat fragmentation and the subsequent isolation of populations is a key factor in the status of many fish species. Some of the most productive juvenile rearing habitats in streams are located in backwaters along the edge of the channel and in side channel areas. Roads built next to streams often disrupt access to these off-channel habitats by physically isolating them from the main channel (NRC 1996).

Overall, within the action area, there is a general lack of connectivity among local populations of native fish. Quigley and Arbelbide (1997) found this is true with respect to the Interior Columbia Basin. Isolating mechanisms include, physical passage blockages at mainstem impoundments that have isolated

whole sub-basins (Brown 1992; Pratt and Houston 1993; Rieman and McIntyre 1995), water diversions preventing spawners access to formerly suitable habitat, poorly designed culvert installations at forest road crossings that block upstream migrations into spawning and rearing tributaries, and thermal passage barriers at both tributary and mainstem scales.

Forest roads frequently cross streams, and such crossings typically involve culverts or bridges. Bridges generally cause less physical habitat disturbance of the stream channel than culverts and generally provide better fish passage (Furniss et al. 1991). Poorly designed and installed culverts can act as barriers to migratory and resident fish movements. Barriers at road crossings can be caused by impassable outfalls at culvert exits, excessive water velocity, insufficient water depth in culverts, disorienting turbulent flow patterns, lack of resting pools below culverts, or a combination of these conditions (Furniss et al. 1991).

Fish movements may be blocked fully for all fish species and age classes, or fish movements may be impeded fully or partially for certain species and/or age classes depending on the type and timing of the obstruction or barrier. Generally, culverts can impede passage in three different ways: water-velocity barriers, depth barriers, and/or vertical jump barriers (Bell 1991; Bates 1997; Barber and Downs 1996). Different species and sizes of fish have different swimming abilities. Healthy adult fish swim more strongly than juvenile fish and can pass upstream through a culvert with less difficulty. If the culvert is too long, a fish may become exhausted while attempting to swim all the way through. If the velocity of water in the culvert is too great, a fish will not be able to swim fast enough to overcome it (Bell 1991). The value to be used in culvert design should be based on the lowest maximum average water velocity for the weakest-swimming fish requiring passage. In many situations this should be determined by the requirement to safely pass juvenile fish (Bell 1991).

Impediments to, or delay in, fish migration often is the result of culvert hydraulics (WDFW 1999b). WDFW (1999b) recommends that the culvert design allow for passage 90 percent of the time during the migration of target species and appropriate age class. Meehan (1991) recommends not providing passage during 5 percent of the year when flows are at their greatest and Baker and Votapka (1990, as cited in Meehan 1991) imply that migration delays should not exceed 3 days. Minimum water depth is a difficulty that is limited to those structures that have no natural streambed or simulated streambed. WDFW (1999b) recommends a minimum depth of 8 inches and Oregon Department of Transportation (1998) recommend a minimum depth of 9.6 inches, based on anadromous fish studies.

Culverts that are installed with a perched outlet or culverts that cause erosion at the outlet due to inadequate sizing often are characterized by increased pipe velocities which cause scour and a perched condition. This in turn can lead to a vertical barrier. New culverts should be designed without a vertical jump by placing the culvert on the average natural stream gradient (USFWS and NMFS 2000). The Services also recommended that existing culverts should be assessed to determine if the water velocity within the pipe is more of a limiting factor than the vertical jump itself. Culverts that are designed for adequate flow, for bedload and debris passage, and installed on a natural stream gradient would be expected to eliminate the vertical-jump problem.

7.5.10.4 Effects of Proposed FPHCP on Refugia and Connectivity

FPHCP construction standards would be expected to improve passage for fish, allowing access to all available habitats with few exceptions. These standards would also provide better transport of water and large wood than currently exists in the baseline condition. New and replaced culverts must meet the WDFW standards. Design guidelines are described in detail and design criteria are provided in WDFW's Design of Road Culverts for Fish Passage (Bates et al. 2003).

Stream crossings may become plugged or may fail and result in diversion of streams. Plugged stream crossings may cause a stream to cross the road, thereby increasing road-surface erosion and sediment transport and delivery. Plugged culverts would likely inhibit fish passage. When diverted across roads, streams are shallow and mostly impassable. The FPHCP standards for stream crossings and culverts are expected to greatly reduce the incidence of plugged culverts.

Crossing-structures (e.g., culverts) and cross-drainage structures would be the subject of assessment and upgrading under the RMAP process. While some of this work may generate some small amount of sediment in the short term, the improvements are expected to greatly reduce the long-term delivery of sediment. As importantly, the RMAP process also focuses on identifying and remedying fish-passage barriers. All such barriers on industrial lands are expected to be addressed by 2016.

During instream work for new roads or for other forms of maintenance, repair, or upgrading, it is often necessary to divert a stream. Such diversions ("coffer dams") are usually in place for no more than 1 to 2 days and generally are required only once per stream crossing for the effective life of the crossing structure. This is expected to be a minor short-term disruption to fish passage and have minor effects to the stream and its biological and physical components. De-watered segments would be short, already affected areas, and would typically only be dewatered once in a several decade period. Effects include short-term desiccation of a segment of streambed (generally less than 100 feet total) and short-term disruption to passage.

On that portion of current crossings where passage is identified as a potential issue (and that would only be some subset of all culverts), we note that recent experience in western Washington indicates that about 25 percent may require full culvert replacement and about 5 percent may require bridges or abandonment (Bates et al. 2003). This experience may have been based on lower-gradient streams than would be encountered on FPHCP lands, and therefore may be an overestimate for forestlands as many of these culverts have been maintained as well or better than lower-elevation lands under other land uses. In addition, many of these crossings have already been addressed by RMAP and other processes. Some of those crossings that were addressed by RMAPs were identified as barriers. Of those barriers, some may require full replacement and, based upon our experience with forest landowners, many of those have already been replaced. Therefore, we expect that the combination of the baseline improvements made regarding fish passage in the last 10 years together with the improvements required during the next 10 years, substantial changes in connectivity will occur within the forested environment for these fish species.

There is a low level of risk that some fish-passage barriers on industrial forestlands may not be accurately assessed and may fail to be replaced. There is a moderate level of risk that some fish-passage barriers would persist on certain nonindustrial forest ownerships, especially those that are not actively harvesting timber, unless they are identified and addressed through another process such as local recovery efforts or the FFFPP. Exemptions for nonindustrial landowners as well as exemptions for 20-acre exempt parcels may therefore limit fish distribution and overall productivity to a minor, but locally relevant, degree. Blockages that preclude access to significant amounts of habitat are expected to be addressed through one of the many ongoing efforts including the FFFPP.

In addition, landowners may not be required to replace culverts that provide for passage of 150 mm fish. While such culverts may generally provide for most fish passage, there is still risk that not all fish at all times will be able to pass, and that such culverts may not fully function in passage of all wood and flows.

Riparian timber harvest is only expected to have minor effects to thermal refugia, and even these effects are expected to be short in duration (e.g., less than 2 to 5 years). Riparian timber harvest is not expected to change flow regimes, increase sediment delivery or routing, increased turbidity, decreased dissolved oxygen, or have other effects that would rise to a level that could degrade refugia or interfere with connectivity.

Road management may have effects upon sediment delivery, although in general, we expect the proposed FPHCP to contribute to improvement in the baseline of sedimentation. Sediment effects from instream work at road crossings may have localized effects, but are not expected to persist for long periods of time (e.g., not greater than 2 years on average) and we do not anticipate that these effects would rise to the level of degrading refugia or interfering with connectivity. We also expect that ongoing sediment inputs at road crossings would occur at generally low levels if crossings are properly maintained, however, short-term effects to reach-level refugia habitats may occur from road-generated sediment in proximity to road crossings (e.g., on the order of a hundred or several hundred feet downstream).

7.5.10.5 Summary: Effects of Proposed FPHCP on Refugia and Connectivity

Considering all of the actions that would occur under the proposed FPHCP, the refugia and connectivity for covered species should continue at the landscape level. Riparian timber harvest may have minor effects to temperature and sediment regimes that would be short term. Delivery of sediment from roads may be locally high during instream work, but is expected to subside following such work and subsequent flushing flows and exposed soil revegetation. Road-management standards under the FPHCP are expected to improve baseline conditions beyond the current conditions. Although passage barriers would likely persist in major rivers and in streams crossing non-forest lands, the FPHCP is expected to have a significant beneficial effect on access and connectivity through accelerated identification and remediation of fish-passage barriers. Improved access and connectivity across FPHCP lands is expected to benefit migrations as well as allow re-occupancy of extirpated locations. In addition, improved connectivity on FPHCP lands would reduce the threat of stochastic events to local population extirpations.

7.5.11 Direct Disturbance, Injury, and Death

This section addresses research, monitoring, and validation efforts (which may include species capture and handling); fish salvage in preparation for stream dewatering, electrofishing (which can be a component of any of the above activities); as well as emergency and routine work within and adjacent to streams. Research, monitoring, and model validation are components of the conservation measures of the FPHCP and would be authorized by the proposed Permit. The salvage activities involving species capture and handling are not directly addressed by the FPHCP, but have little independent utility and are therefore considered to be interrelated with or interdependent upon the proposed FPHCP. Fish salvage activities include a series of steps to minimize the potential for take of listed species related to certain road activities, but these salvage activities are not regulated by WDNR. Although such salvage activities could require future section 7 consultation regarding the issuance of a section 10(a)(1)(A) permit, the effects of these activities are analyzed herein as interrelated actions of the proposed section 10(a)(1)(B) permit. Where these actions would rely on Federal authorization, certain standards and constraints are anticipated and are described herein. Where these actions would not require Federal authorization, such standards might not be followed. These applications of electrofishing are analyzed in this Opinion. Operational stream typing using electrofishing (e.g., a landowner wishing to survey his streams for fish) is not addressed by the proposed action and is not analyzed herein. Such operational surveys would

require a separate permit under section 10(a)(1)(A) or similar authorization if there was a likelihood of affecting listed species.

7.5.11.1 Research, Monitoring, and Model Validation

Activities conducted under CMER with respect to research, monitoring, and model validation are covered activities and support the conservation measures in the FPHCP. NMFS and FWS participate with other stakeholders in the CMER process and we would participate in the development and/or review of such individual proposals. Where effects may occur to listed species and would be authorized through the incidental take permit currently being contemplated, we would review proposals including methods to be used and other information and would provide either approval or recommendations for revision. While such recommendations and approval may include both exceptions from standard protocols and/or additional constraints, at this time, we are assuming standard agency protocols would be followed.

Direct effects may occur when such work requires walking or working in streams. Walking may inadvertently disturb and/or injure individual fish or amphibians, especially less-mobile life stages. Equipment may be placed in or adjacent to the stream and may require some excavation, anchoring, or other habitat modifications in the immediate area. For some surveys, block nets may be used. Block nets would only be in place for a short period of time (typically less than 1 day). Amphibian surveys sometimes involve "rubble rousing" (e.g., removing and overturning rocks and searching through substrate by hand or with rakes). This activity has the potential to injure individuals as well as displace individuals from preferred habitats.

Effects may occur to fish species in the Steep Tributary or Low-Gradient Tributary Habitat Associations when electrofishing to validate and update the water-typing model (upper extent of fish use). Electrofishing associated with model validation is expected to affect less than 0.1 percent of streams and stream-typing model verification would be preceded by visual surveys. When fish are discovered, model-validation work would cease; and, therefore, electrofishing usually would be expected to occur on those streams only once during the life of the permit (50 years). However, to address concerns about annual and seasonal variability in fish distribution, or for other model-validation purposes, some areas may be re-surveyed. Therefore, some stream reaches may be surveyed multiple times during the permit term. When fish are not discovered, model validation or updating may occur at 5-year increments. Exposure to this activity is expected to be low because generally electrofishing would be used only where fish presence would be questionable and would often be located near the upper extent of known or actual fish use, and therefore few fish would be affected. It may also be used where fish are absent, in which case, potential effects to amphibians may increase. Electrofishing does not usually kill fish, but can injure them and disrupts their movements and behaviors at the time of shocking – see the discussion regarding **Potential for Injury or Mortality from Electrofishing** in this section.

During research and monitoring, electrofishing may be used and would be authorized through the proposed incidental take permit as described above. Electrofishing for these purposes would be subject to a permit condition requiring a study plan for our approval, as well as requirements for qualified staff and reporting – See the **Terms and Conditions** section of this Opinion for the text of proposed permit conditions. Electrofishing for research and monitoring would only involve a very small portion of streams, but may occasionally involve repeated surveys. Such electrofishing proposals would be reviewed and may be limited to reduce adverse effects to covered species.

7.5.11.2 Capture and Handling

Where listed species are present, Federal authorization may be necessary and standard protocols would likely be required. Where listed fish are absent, such Federal authorization may not be necessary and standard protocols may not be followed.

For research and monitoring activities conducted under CMER, we anticipate utilizing the proposed section 10(a)(1)(B) incidental take permit to convey such authority for take. To be compliant with this permit, a study plan must be approved by us prior to CMER conducting or approving these activities. During such review, we may consult with local State, Federal, and tribal biologist to ensure these activities are compatible with the conservation of the listed species. We may provide stipulations beyond those that are generally anticipated herein, particularly where local populations are at a depressed status, or may provide exceptions to the conditions that are generally anticipated herein. As this program of activities is implemented, we would help provide monitoring and oversight.

For fish salvage in areas containing listed species, we anticipate utilizing section 10(a)(1)(A) or other tools to convey ESA authority as appropriate. We may consult with local State, Federal, and tribal biologist to ensure these activities are compatible with the conservation of the listed species. Permit(s) would be conditioned as necessary. For fish salvage where no listed species under FWS jurisdiction are present there are two possible scenarios. First, where listed species under NMFS jurisdiction are present, activities would be conducted in compliance with NMFS Limit #3 under the 4(d) Special Rule (July 10, 2000, 65 FR 42441-42443). Else, where there are no listed species that may be affected, activities would be conducted according to landowner procedures as discussed with and agreed to by WDFW. In this analysis, we assume these activities in the absence of listed species will be conducted as they have in the recent past.

A variety of methods may be used to handle fish and amphibian species. Fish or amphibians may be captured by hand, by net alone, or by net in conjunction with electrofishing. Fish or amphibians may be subject to handling stress and/or injury, as well as directly or indirectly contributing to disease transmission and susceptibility, or increased post-release predation.

Capture and handling of fish and amphibians has the potential to result in their injury or death. Mortality may be immediate or delayed. Handling of fish and amphibians increases their stress levels and can cause a variety of injurious conditions, including reduced disease resistance, osmoregulatory problems, decreased growth, decreased reproductive capacity, increased vulnerability to predation, and increased mortality (Kelsch and Shields 1996). Amphibians may suffer from thermal stress during handling. Fish may receive subtle injuries such as de-scaling and loss of slime layer. Handling stress; use of seines, dip nets, and traps; impingement on block nets; and electrofishing each have a probability of resulting in some injury. Serious injury and death due to handling stress and due to use of seines, dip nets, and traps is believed to be less common, however, post-release mortality is generally not known. Fish that have been stressed are more vulnerable to predation (Mesa et al. 1994; Mesa and Schreck 1989). The actual numbers of fish and amphibians affected by capture and handling is difficult to anticipate. In most cases, the handled fish and amphibians would be released shortly after their capture, minimizing stress. Depending on the number of fish or amphibians that need to be handled during each operation, some deaths may occur during the handling and/or transfer process. For example, juvenile salmonids are often vulnerable to predation by larger fish in a trap. Small fish can be trampled in a seine and can even be overlooked. Even though injury to fish may occur from capture and handling, adverse affects from electrofishing are more likely to occur.

In situations where Federal authorization is not needed for capture and handling, we are available for consultation and technical assistance to reduce effects to fish and amphibian species and can provide operating protocols for fish and amphibians to interested parties. We encourage handlers to observe standard sterilization techniques to avoid spreading diseases and parasites between geographic locations.

7.5.11.3 Fish Salvage

Fish salvage may occur when diverting a stream for instream work and consists of capturing fish and placing them back into the stream in a secure location. The likelihood of fish being present can be lessened in many areas when work is conducted during recommended fish-timing windows. However, while the likelihood of fish being present during these timing windows may be lowest for eggs and fry of salmonids of concern (listed species and anadromous salmonids); other fish species may be more likely to be present. Where no listed species are present, individual HPAs can be written with other timing based on site-specific needs and mitigation measures that would avoid effects.

When fish or amphibians are present in the reach of stream being dewatered, they would be captured and placed back into the flowing stream. This may affect individual fish, should de-scaling or other injury occur. The risk also exists that fish may not be captured and relocated, and would die during dewatering of the stream. Amphibians would be relocated when observed. Effects from actual handling have already been addressed in the discussion on **Capture and Handling** contained in this section. Depending on the number of fish or amphibians that need to be relocated during each fish-salvage operation, some deaths may occur during the handling and transfer process. Amphibians may also be present and avoid detection within the substrate, but later be subject to effects – see the discussion on **Stream and Streambank Work** within this section (below).

The salvage and handling of fish would not always occur in conjunction with the removal of a fish-passage barrier. A site-specific assessment usually informs decisions about when a diversion of stream flow and fish salvage are necessary. These decisions are generally made by WDFW during the HPA review process. During the diversion and prior to work commencing, fish (if present) are removed from the work area. Where listed species are present, this would be done according to standard protocols.

Stream Reach Isolation

Prior to dewatering a stream section, block nets, sand bags, or other obstructions would generally be placed upstream and downstream from the culvert to prevent fish entering the stream segment that would be dewatered. The use of block nets poses a mortality risk to fish, even when monitored on a continuing basis. The stream reach would usually be isolated on the same day that fish would be captured and relocated. The stream flow would be completely diverted around the project area in the same day, when possible. On rare occasions, block nets or obstructions may remain in the stream overnight when the fish capture and diversion activities require additional time to complete. This may result in some additional mortality of fish.

Seines, Dip Nets, and Traps

Seines and dip nets may be used as the first method of capture to remove any fish which may be trapped in the isolated reach. Fish are not generally injured using these methods, although these methods may disrupt foraging temporarily. Minnow traps, used in conjunction with seining, involve the use of wire-mesh traps placed in key instream fry habitat overnight prior to dewatering. Captured fish are removed, transported in large buckets filled with stream water, and relocated into flowing waters adjacent to or

upstream of the project area. The fish and water temperature should be monitored to ensure the health and condition of the fish until they are released. Given the low level of effect of these capture and relocation techniques, few fish are expected to be injured using these capture methods. Nonetheless, fish would be temporarily disrupted from their normal behavior during the capture and relocation activities.

Electrofishing for Fish Salvage

Where listed species are not likely to be affected, operators may decide to proceed without further authorization from Federal agencies. Methods used and requirements for operators are developed in discussions between WDFW and landowners. Where electrofishing is used during fish salvage, and listed species may be affected, operators may require authorization from FWS and/or NMFS.

Where listed species are present or likely to be affected, electrofishing has the potential to harm and kill fish even when used according to Agency-approved protocols. Regardless of whether a project may affect NMFS and/or FWS listed species, we currently anticipate similar requirements. Electrofishing for fish salvage (even when conducted under NMFS Limit #3 for fish salvage) must comply with the NMFS guidelines of June 2000, or as they may be revised from time-to-time. Protocols used, including requirements for pre-work notification, must also comply with any such direction from WDFW. Electrofishing shall be attempted only after less harmful methods of fish removal have been used. See the discussion on **Electrofishing Conservation Measures where Listed Species may be Affected** within this section (below).

Based on studies conducted by Nielson (1998), we estimate that up to 25 percent of the salmonids remaining in the stream following stream-reach isolation would not be collected by the use of seining, trapping, and/or dip-netting, and therefore could be exposed to effects from electrofishing. This estimate may be conservative, yet reasonable, for adult and juvenile salmonids and other large species given the wide range of water bodies and habitats where projects could occur. For other smaller species, fewer individuals may be captured using those methods and therefore proportionately larger number of individuals may be subjected to electrofishing. Fewer fish of all types would be captured by these methods in larger streams with deep pools and abundant complexity (e.g., large wood pieces and large substrates). Based on our experience, sculpins are often the most-numerous type of fish in forested streams, and capturing a large proportion of sculpins may be difficult.

Instream work at road crossings that require stream diversion would likely be conducted no more than once or twice during the life of the permit and would affect a short reach of stream for each crossing. Dewatering for instream work therefore would affect a very small portion of the total stream system. Some of the effects (stress, displacement, disruption of behaviors) of actual capture and handling of fish using electrofishing during culvert removal and/or replacement would be short term in nature, typically occurring intermittently over the period of one to two days. Fish may be subjected to stress, temporarily disrupted from their normal behavior patterns, and temporarily displaced from preferred habitats. However, electrofishing may result in permanent, adverse effects to individual fish such as injury. Where agency protocols are not followed, effects may be more frequent and/or more severe.

It should be noted that use of electrofishing as part of this activity is a minimization measure to avoid death of fish from stranding. While some proportion of fish not caught by other methods may be affected, they would be stranded and likely die if not caught through the use of electrofishing. The use of electrofishing, in conjunction with the other capture methods, thereby reduces the negative effects of stream diversion for instream work. It is expected that most, if not all, adult fish of larger species would be removed using other methods of capture and release, because they are easier to see and capture that

juveniles. For such species, most fish remaining following netting and thus subjected to electrofishing and/or stranding would therefore be juveniles. In some species, adult fish can be relatively small and, therefore, not readily seen or captured, e.g., sculpin and dace. For these species, adult fish may also be subjected to electrofishing or stranding.

Stream Dewatering and Stranding

Once fish capture has ceased, dewatering would be completed. The installation of the water diversion and retention structures and the dewatering of the stream could result in the stranding of fry or juvenile fish. However, sequential dewatering may allow for fish to move downstream as the water in the channel recedes, rather than be trapped in the work area.

During stream dewatering, including when sandbags are used to focus stream flows, there is a potential that some juvenile or small salmonids may avoid being captured and relocated, and thus may die because they remain undetected in stream margins under vegetation, rocks, or gravels. In a programmatic assessment of culvert replacements in eastern Oregon and Washington, we (USFWS 2004c) estimated that up to 5 percent of juvenile bull trout may avoid capture and be stranded. The portion of the fish that would be affected in this way may be considerably higher for smaller species of fish. A gradual dewatering approach should enhance the efficacy of fish removal and thus reduce, but not eliminate this risk. Large salmonids are also wary and likely to use cover (Grant and Noakes 1987). Yet, we continue to estimate that the capture methods applied to such projects would typically remove approximately 95 percent of the individual fish of salmonid species or other larger species prior to dewatering. In addition, due to the timing of the activities, the risk to adults of some fish species should be minimized because of the reduced likelihood of migratory and/or spawning fish being present in the stream reach during the construction period. Nonetheless, resident fish may be present and a lower proportion of smaller species may be removed.

For larger species, mortality is expected to be primarily limited to juvenile fish which, because of their small size (less than 120 mm), may avoid capture, become stranded, remain undetected on the dewatered streambed, or may be killed due to electrofishing or impingement on block nets. Because of their size, adults are relatively easy to detect and capture using seines or dip nets during the slow dewatering process, thereby reducing the exposure of adult fish to electrofishing procedures. However, large salmonids are more difficult to catch, and are harder to handle, therefore more likely to get injured during capture and handling. There may also be a high post-release mortality with larger fish. For smaller fish species, adults may also elude capture and become stranded.

7.5.11.4 Potential for Injury or Mortality from Electrofishing

Electrofishing can result in mortality and/or direct injuries to fish, including spinal hemorrhages, internal hemorrhages, fractured vertebra, spinal misalignment, and separated spinal columns (Hollender and Carline 1994; Dalbey et al. 1996; Thomspon et al. 1997). Even though 60 Hertz (Hz) would seldom be used in Washington, we utilize these data regarding injury that were collected from fish captured under these frequencies because they represent the maximum expected use, and because of the availability of data regarding these collection methods. For additional and more-detailed information on potential injury as a result of electrofishing see Snyder (2003). The following discussions of injury reports are often from studies using backpack style 60 Hertz (Hz) direct current (DC) pulse electrofishing equipment.

Thompson et al. (1997) found an average of 22 percent of the rainbow trout and an average of 32 percent of the brown trout sustained spinal injuries from electrofishing. Dalbey et al. (1996) found 37 percent of

rainbow trout sustained spinal injuries from electrofishing. Hollendar and Carline (1994) found 22 percent of brook trout sustained injuries from electrofishing, of which 13 percent were spinal injuries, 4 percent had both spinal and hemorrhage injuries, and 11 percent had a spinal injury but no hemorrhage. Hollendar and Carline (1994) found most spinal injuries were rating class 2 (40 percent) or 3 (40 percent) (Table 7-1), involved on average 7 vertebrae, and were usually located in the region of the spinal column between the dorsal and anal fins. Thompson et al. (1997) found more than half of the injured fish were judged to have the lowest severity of spinal injury and 2.1 percent or less sustained the most severe class of injury.

Table 7-1. Injury rating system used to identify and rate the severity of electrofishing injuries (Thompson et al. 1997).

Rating Class	Internal hemorrhage	Spinal Damage
0	None apparent	None apparent
1	Mild hemorrhage with 1 or more wounds in the muscle, separate from the spine	Compression (distortion) of vertebrae only
2	Moderate hemorrhage with 1 or more small wounds on the spine (<= width of 2 vertebrae)	Misalignment of vertebrae, including compression
3	Severe hemorrhage with 1 or more large wounds on the spine (> width of 2 vertebrae)	Fracture of 1 or more vertebrae or complete separation of 2 or more vertebrae

Thompson et al. (1997) found an average of 34 percent of the rainbow trout and average of 24 percent of brown trout sustained hemorrhage injuries from electrofishing. Hollender and Carline (1994) found 13 percent of brook trout sustained hemorrhages, 10 percent had a hemorrhage but no spinal injury, and rating class 2 hemorrhages were the most common (71 percent).

Dalbey et al. (1996), Thompson et al. (1997), and Hollender and Carline (1994) all found longer fish had a higher probability of being injured. Incidence and severity of injury were positively correlated with fish length, in that 40 percent of rainbow trout longer than 8 inches sustained injury compared to 27 percent in smaller fish (Dalbey et al. 1996). The injury rate was lowest (12 percent) for brook trout smaller than 5 inches, intermediate (26 percent) for the 5- to 7-inch- length group, and was highest (43 percent) for the 7-inch-and-longer-length group (Hollender and Carline 1994). Snyder (2003) in a comprehensive review of harmful effects from electrofishing reported that importance of size remains questionable. Thompson et al. (1997) speculated that fish in better condition may be more likely to be injured because of more powerful muscle contractions. Snyder (2003) reports that such claims are based upon supposition. He notes that fish in poor health may respond less strongly, but may also be less able to withstand the stress. Dalbey et al. (1996) found a higher and more-severe incidence of spinal injury to rainbow trout from pulsed DC (40-54 percent) than smooth DC (12 percent). Therefore, they recommend using smooth DC or pulse frequencies of 30 Hz or less to reduce the overall injury rate, especially among larger fish.

Rainbow trout with moderate to severe injuries had markedly lower growth and body condition after 335 days than fish with no or low spinal injuries (Dalbey et al. 1996). Dalbey et al. (1996) speculate that in a dynamic stream environment (rather than a pond) skeletal damage could possibly have an even greater negative effect on growth and survival.

Very few of the fish collected by Thompson et al. (1997) exhibited external signs of injury although a higher percentage of rainbow and brown trout were injured by electrofishing than would have been

suspected from external examination. Dalbey et al. (1996) found that rainbow trout X-rayed soon after capture, exhibited no detectable signs of spinal injury, but later showed calcification indicative of old injuries when X-rayed again after 335 days in a pond. Hollender and Carline (1994) found hemorrhages and spinal compressions in the smallest fish were small and difficult to see and might have been overlooked. Therefore, their reported injury rate (average of 22 percent) may be a conservative estimate. In addition, most studies have focused on injuries exhibited by adults, but stress from electrofishing can be the main problem for juveniles (P. Bisson, USDA Forest Service; S. Parmenter, California Department of Fish and Game, Personal Communications as cited in Nielson 1998).

Snyder (2003) noted that evidence to date strongly indicates that salmonids seem especially susceptible to brands, spinal injuries, associated hemorrhages, and probably mortality during electrofishing than most other fishes. Data on the harmful effects of electrofishing on fishes other than the salmonids are limited and seldom comparable, but among species included in such reports, and under at least some environmental and electrical-field conditions, burbot and sculpins may be particularly sensitive to electrofishing mortality and some suckers may be sensitive to electrofishing-induced spinal injuries and associated hemorrhages. However, according to Barrett and Grossman (1998), sculpins do not appear to be readily affected by electrofishing. Mountain whitefish are at least sometimes especially susceptible to bleeding at the gills when subjected to electrofishing fields (Snyder 2003). Most investigators addressing the matter reported little or no electrofishing mortality among non-salmonids. However, differences in rates and degree of injury, especially between investigations, are often difficult to attribute to species, fish size or condition, environment (including water conductivity and temperature), field intensity, or other current or field characteristics. Fredenberg (Personal Communication as cited in Snyder 2003) found spinal injuries in 2 to 20 percent of rainbow trout captured with DC, 15-Hz PDC, or CPS, but only 0 to 2 percent of mountain whitefish, white sucker, or longnose sucker captured with the same currents. When specimens with only hemorrhages along the spine or associated musculature (all minor) were added to these figures, the percentages of injured fish increased to 6 to 42 percent for rainbow trout, 2 to 29 percent for mountain whitefish, and 4 to 18 percent for the suckers. However, results for smaller species should be considered with caution because injuries in small fish are difficult to detect. The Chondrostei, sturgeon, have electroreceptors, but whether these fish are also more susceptible to electric fields has not been reported. Snyder (2003) summarizes information regarding paddlefish (*Polyodon spathula*) indicating they may be highly susceptible to spinal injuries including ruptured notochords. Catfish (Order: *Siluriformes*) which also have electroreceptors are easy to catch with extremely simple low-voltage devices.

Summary of Potential Injury and Mortality from Electrofishing

This information indicates that, while the data is not conclusive, assuming other fish species are equally susceptive to injury and mortality as salmonids would be a conservative assumption. Although often not externally obvious or fatal, spinal injuries and associated hemorrhages sometimes have been documented in up to and over 50 percent of fish examined internally (Snyder 2003). Other harmful effects, such as bleeding at gills or vent and excessive physiological stress, are also of concern. Mortality, usually by asphyxiation, is a common result of excessive exposure to tetanizing intensities near electrodes or poor handling of captured specimens. Reported effects on reproduction are contradictory, but electrofishing over spawning grounds can harm embryos.

Snyder (2003) noted significantly fewer spinal injuries are reported when direct current, low-frequency pulsed direct current (no more than 30Hz), or specifically designed pulse trains are used. Zeigenfuss (1995) found injuries were lower for fish shocked in colder temperatures. Long-term effects from

proposed electrofishing would likely include reductions in growth rate and/or body condition in individual fish during variable periods of time after electrofishing (Gatz et al. 1986; Taube 1992; Dwyer and White 1995).

We estimate that up to 50 percent of fish exposed to electrofishing could be injured or killed. With respect to stream-typing model validation, our estimate is that up to 50 percent of the fish in the immediate area or reach that is checked could be injured or killed. For research, we estimate that up to 50 percent of the fish in an area addressed in an approved study plan could be injured or killed. Requests of this nature would be scrutinized based on need, as well as sensitivity of the species in the area and their population status. For fish salvage, we estimate that 75 percent of the fish in a stream reach would escape during isolation or be removed prior to use of electrofishing. We estimate that 20 percent would be removed by the use of electrofishing and the remaining 5 percent would be stranded and killed. Therefore, we estimate that up to 50 percent of the 20 percent removed via electrofishing would be injured or killed as a result of electrofishing during fish salvage.

Electrofishing Conservation Measures Where Listed Species May Be Affected

Where electrofishing for fish-salvage operations may affect listed species and Federal authorization is necessary, all such operations must be conducted in accordance with guidelines developed by NMFS (NMFS 2000, or as revised), and all applicable State and Federal permits shall be obtained. Procedures required by WDFW, whether under an HPA or a scientific-collection permit, must be followed, and in case of conflict, such conflicting guidance must be resolved by the agencies prior to conducting work. Operators must also follow WDFW direction regarding pre-work notification. Where FWS listed species may be affected by fish salvage, operators would require authorization from FWS. Electrofishing for research, monitoring, or stream-type model validation would require a study plan and approval by the Federal Services, and we expect that such plans would generally comport with the NMFS guidelines. In either case, whether a section 10(a)(1)(A) recovery permit is issued or whether work is conducted under the proposed section 10(a)(1)(B) incidental take permit, we would utilize the opportunity to assess the effects upon listed species and further condition such activities – see below.

Generally, there would be no electrofishing in anadromous waters from October 15th to May 15th and no electrofishing in resident waters from November 1st to May 15th. Sampling shall only occur at times and locations that avoid disturbing spawning native salmonids, incubating eggs, or newly emerged fry, unless specifically approved by the Services as part of a necessary research project. Only trained and experienced professionals may perform electrofishing surveys under Federal permits. Personnel conducting electrofishing would carefully survey the area to be sampled before beginning electrofishing. This pre-electrofishing survey should ensure that they do not contact spawning adult salmonids or active redds. To be compliant with the NMFS guidelines, equipment must be in good working condition and operators shall go through the manufacturer's pre-season checks, adhere to all provisions, and record major maintenance work in a logbook. Operators must also ensure that an adequate number of trained personnel are available.

Operators shall measure conductivity in the stream to be sampled and shall set voltage accordingly. Only Direct Current (DC) or Pulsed Direct Current (PDC) shall be used, unless otherwise approved. Each session shall begin with pulse width and rate set to the minimum needed to capture fish. If needed, these settings would be gradually increased only to the point where fish are immobilized and captured.

Electrofishing shall be performed in a manner that minimizes harm to fish. Operators shall not allow fish to come in contact with the anode. The zone of potential fish injury is within 0.5 m of the anode. Care

shall be taken in shallow waters, undercut banks, near structures such as wood, or where fish may be concentrated in high numbers because, in such areas, fish are more likely to come into close contact with the anode. The stream segment shall be worked systematically, moving the anode continuously. Each area shall not be electrofished for an extended period of time. Fish shall be removed from the electrical field immediately and not held in the net while continuing to net additional fish.

The condition of the sampled fish shall be carefully observed. Dark bands on the body and long recovery times are signs of injury or handling stress. When such signs are noted, the settings for the electrofishing unit would be adjusted. Specimens shall be released in an area that provides refuge. Each fish shall be completely revived before releasing.

After capture, holding time shall be minimized, with no overcrowding in the containers. Large fish shall be kept separated from smaller fish to avoid predation during containment. Water-to-water transfers; the use of shaded, dark containers; and supplemental oxygen shall all be considered in designing fish-handling operations. Also, unless otherwise approved, electrofishing activities that involve extensive shocking or handling of fish shall be conducted at times or in locations (e.g., cold, groundwater-dominated streams) that avoid temperature stress of fish.

With respect to the electrofishing and species handling activities that would be authorized under the proposed section 10(a)(1)(B) Permit, adaptive management shall be applied to electrofishing procedures, applications, as well as the amount of electrofishing conducted. We will screen proposals to avoid electrofishing within certain areas containing depressed local populations (i.e., local populations listed as high risk within the Bull Trout Risk Analysis), or where necessary, to modify procedures used within these areas to further minimize effects to bull trout.

7.5.11.5 Stream and Streambank Work

Emergency repair work at road crossings may involve the use of heavy equipment within steams. While equipment may be allowed to operate within streams, it is typically only the bucket which enters the stream. Wheeled or tracked equipment is rarely allowed within the stream. These types of activities are typically done so as to minimize adverse effects by incorporating timing windows, isolation and dewatering or the reach, and other measures. Emergency projects likely have a higher risk of adverse effects to aquatic life because they are typically done on short notice during urgent events such as floods. The intent of these projects is usually to prevent damage from events such as road wash-out or failure that would have greater adverse effects than the activities themselves. These activities would occur infrequently but may occur at any time of year, although winter storms may be associated with the need for such work. Emergency instream work may injure or kill fish (e.g., primarily eggs and alevins) and amphibians. Culvert repair, replacement, and similar work may also injure or kill fish and amphibians, whether or not fish-salvage operations are attempted. Work with heavy equipment within the ELZ may also result in injury and death for adult amphibians.

7.5.11.6 Summary of Effects on Direct Injury and Mortality

In an effort to reduce lethal effects on fish from dewatering the stream, capture and relocation of fish from project construction sites are attempted prior to the initiation of construction activities. Seines, traps, dip-nets, block nets, and electrofishing may be used. Although fish-salvage operations should reduce the overall negative effect to fish from stream-reach dewatering, in some cases, fish may experience immediate or delayed injury or death from the use of nets and/or electrofishing techniques. Minimization measures can be utilized during stream diversion and fish salvage that should reduce the level of effect.

Effects from electrofishing would likely be minimized when appropriate measures are followed, including work-timing windows, use of qualified personnel, and appropriate electrofishing unit settings dependent on site conditions. Regardless of the purpose, when electrofishing is conducted, procedures should be followed that minimize injury to fish or other aquatic organisms. Sampling should only occur at times and locations that avoid disturbing spawning native salmonids, incubating eggs, or newly emerged fry.

Blocknets are typically in place during daylight hours and for less than a day. Removing blocknets prior to nightfall would reduce the likelihood of impingement, especially for nocturnally active species. Sand bags are more likely to be used than blocknets during water diversion and should further reduce the threat of impingement. Impingement and stranding are primarily anticipated to affect fish which are less than 120 mm in length. The most-significant effects for larger fish species should be the loss of some juvenile fish from an age class. For smaller fish species, some adults may also be lost. Effects would also include temporary displacement, stress, and injury. We expect fish injuries and death could occur from stranding, block nets, and electrofishing; while mortality associated with handling stress, seines, traps, and dip nets is less likely based upon our experience with these capture techniques.

In stream work may result in injury or death for fish and amphibians within the work area. Amphibians may also be injured or killed by ground-based equipment operating within the Riparian Zone. In all cases, we expect death or serious injury would occur to but a small portion of fish or amphibians within a stream reach. We do not expect long-term population effects to occur as a result of such direct effects under the FPHCP.

7.6 EFFECTS TO GUILDS (HABITAT ASSOCIATIONS)

7.6.1 Introduction

In this section we explain the approach we are taking to address the needs of the 47 unlisted species covered by the FPHCP. We identify guilds (Habitat Associations) that are being used to relate effects to habitat features to the individual species in an efficient and understandable manner. We address situations where species may be associated with more than one Habitat Association or are affected by other relevant factors. For each Habitat Association, we summarize the baseline and cumulative effects, as well as the major effects of the action which were previously discussed in **General Effects by Resource Topic**. Each species will be affiliated with at least one Habitat Association. For a species-specific discussion regarding the effects to individuals and the population, please see the **Effects of the Action** and **Incidental Take Statement** for each species.

7.6.2 Habitat Approach

Analysis of the effects to unlisted fish and amphibian species as a result of the proposed action (issuance of an ITP) is habitat-based. That is, this Opinion analyzes the likely effects of the FPHCP on aquatic and riparian habitat. The most-significant effects of the FPHCP on covered species are through its influence on riparian characteristics and processes, aquatic inputs, aquatic connectivity, and hydrologic and geomorphic responses of stream systems to these above factors. Effects of the FPHCP on native fish and amphibian populations are more subtle, and difficult to predict.

Therefore, effects of the FPHCP on native fish and amphibian populations are generally considered in this Opinion as consequences of habitat effects. To conduct this analysis, the best scientific and commercial

data available is used to characterize potential changes to riparian processes and characteristics, aquatic inputs (such as solar radiation, large woody debris, sediment, detritus, and water quantity), aquatic connectivity (such as physical barriers to migration and floodplain and off-channel habitats), and hydrologic and geomorphic responses of stream systems (such as channel condition and complexity).

An underlying assumption of this analytical approach is that the covered species will experience demographic changes (that is, changes in vital rates, population size, and distribution) commensurate with changes in these habitat-related variables. Positive changes in the habitat variables would result in positive population trends; negative changes in the variables would result in negative population trends. Thus, habitat variables described above are used as surrogates or indices of covered species population trends for purposes of this analysis. This approach is consistent with approaches used in previous Opinions involving unlisted species.

The relationship between changes in habitat quantity, quality, and connectivity and the status and trends of fish and wildlife populations has been the subject of extensive scientific research and publication, and the assumptions underlying the habitat approach in this Opinion are consistent with this extensive scientific background. For more-extensive discussion of and data supporting the relationship between changes in habitat variables and the status and trends of fish and wildlife populations, readers are referred to the work of Fiedler and Jain (1992), Gentry (1986), Gilpin and Soulé (1986), Nicholson (1954), Odum (1971,1989), and Soulé (1986,1987). For detailed discussions of the relationship between habitat variables and the status and trends of fish populations, readers are referred to the work of the Forest Ecosystem Management Assessment Team (FEMAT 1993), Gregory and Bisson (1997), Hicks et al. (1991), Murphy (1995), National Research Council (1996), Nehlsen et al. (1991), Spence et al. (1996), MBTSG (1998), and any of the numerous additional references contained in this rich body of literature.

The relationship between habitat and populations is embodied in the concept of carrying capacity. The concept of carrying capacity recognizes that a specific area of land or water can support a finite population of a particular species because food and other resources in that area are finite (Odum 1971). By extension, increasing the carrying capacity of an area (that is, increasing the quality or quantity of resources available to a population within that area) increases the number of individuals the area can sustain over time. By the same reasoning, decreasing the carrying capacity of an area (that is, decreasing the quality or quantity of resources available to a population) decreases the number of individuals the area can support over time.

Restoring habitat that has been previously destroyed or degraded can increase the size of a population the habitat can support; conversely, habitat destruction and alteration can reduce the size of a population the habitat can support. In either case, there is a corresponding, but often non-linear, relationship between changes in the quality and quantity of resources available to a species in an area and the number of individuals that area can support.

The approach used in this Opinion is intended to determine whether the proposed action is likely to contribute to restoration or maintenance of properly functioning stream and riparian processes and conditions or to degrade those processes. Ultimately, the Opinion, with respect to unlisted covered species, is intended to determine whether implementation of the proposed FPHCP is likely to decrease the size, number, dynamics, or distribution of unlisted covered species populations in the action area in ways that would appreciably reduce the likelihood of their survival and recovery in the wild.

To accomplish this, the analysis examines specific habitat characteristics that are essential to supporting populations of the covered species. These characteristics have been derived from a synthesis of published

reviews on the status and trends of native fish and amphibian species in or near the action area, and must be present to ensure that watersheds and nearshore marine habitats function properly for these native populations. These habitat characteristics include water quality, water quantity, channel conditions, physical barriers to fish migration, and specific habitat variables such as stream temperature, sediment, large wood, nutrients, and refugia (USDA Forest Service et al. 1993; Murphy 1995; Gregory and Bisson 1997). These characteristics, or variables, are relevant to many species considered in this Opinion.

To facilitate an understanding of the likely effects of the proposed action to these species, an overview of the general effects of forest, road, and other management activities on native fish habitats has already been presented (see **General Effects by Resource Topics**). That overview was a synthesis of information from the literature and other sources that discussed how the specific forest practices can change or would change important habitat parameters. The following section addresses specific effects of these management actions with respect to specific habitats in the Habitat Associations so that the general effects can be better related to the individual species. For each Habitat Association, this discussion will address the major effects on those individual habitat parameters most important to the covered species.

7.6.3 Definition of Habitat Associations

Each of the covered species has been categorized into a "guild", mainly according to the habitat characteristics where the species spends most of its life history. Because this categorization is primarily reliant on the habitats used by the species, we refer to these as Habitat Associations. Montgomery and Buffington (1997) provide a useful classification of channel-reach morphology that reflects the relationship between stream morphologies and the relative magnitudes of sediment supply and transport capacity.

It should be noted that many species are placed in a "guild" (e.g., Habitat Association) for discussion purposes, but that during the assessment of effects to those species, the other Habitat Associations used by the species are also considered. These Habitat Associations are described below:

7.6.3.1 Headwater Habitat Association

Species in this Habitat Association are heavily reliant on small headwater streams. These streams include perennial and seasonal streams (Type Np and Type Ns) located beyond the range of fish. Frequently, they are too steep to be accessible to fish, have natural or artificial barriers to fish, or fail to provide suitable fish habitat. These streams may be commonly referred to as "source reaches" for sediment and rock debris from lateral-transport processes adjacent to the streams. Often, these streams will have spatially intermittent reaches of surface and subsurface water.

7.6.3.2 Steep Tributary Habitat Association

The streams that are generally inhabited by species in this guild are typically high-gradient, cold, narrow, confined, nutrient-poor waters, located above most non-forest human influences (e.g., residential, industrial, commercial, and agricultural developments). These may be high-elevation streams and are generally low-order streams. These streams are generally located just below headwater streams and are often the smaller fishbearing (Type F) streams within the stream system. These streams may be comprised of streams known as "transport reaches".

7.6.3.3 Low-Gradient Tributary Habitat Association

The streams in this Habitat Association are not as steep as the steep tributary streams and therefore are often less confined. These may be found in less-dissected watersheds (less steep topographically) or may be found in lower portions of highly dissected watersheds. Low-gradient tributary streams may contain streams that would be called "response reaches."

7.6.3.4 Mainstem Stream and River Habitat Association

These streams and rivers are comprised of lower-gradient reaches. These streams and rivers are often wide and meandering and may be associated with floodplains or channel migration zones. Many of these streams and rivers will be Shorelines of the State (Type S waters).

7.6.3.5 Lentic Habitat Association

This Habitat Association contains a variety of lakes, ponds, wetlands, low-gradient, and low-velocity waters within the action area. These waters are often associated with shallow wetlands and dense aquatic vegetation, but also include large deep lakes.

7.6.3.6 River System Habitat Association

Unless otherwise noted, the species in this guild are found in the Snake and/or Columbia Rivers. In some specific cases, a species may be associated with other large river systems (e.g., Nooksack dace). These fish are almost exclusively associated with the mainstem of these major rivers.

7.6.3.7 Near-shore Marine Habitat Association

This area is generally the shallow portion of the marine environment. These habitats may be shallow "open" water, or may be estuaries. The habitat features contained within or influencing the near-shore marine may include bluffs, beaches, marshes, riparian vegetation, sandflats, mudflats, rock and gravel habitats, non-vegetated subtidal areas, kelp beds, inter-tidal algae, and eelgrass beds. It generally does not include deeper marine waters, but species associated with this Habitat Association may also use deeper water at times.

7.6.4 Species Contained within Habitat Associations

7.6.4.1 Headwater Guild

Amphibian species are grouped as their own guild. Even though their requirements differ from each other to some degree, these species are heavily reliant on headwater streams, and as such are placed in the Headwater Guild. These amphibians include both species of tailed frog, all three species of torrent salamanders, and both species (Van Dykes and Dunn's) of lungless salamanders. At times, we discuss effects according to three groupings: tailed frogs (adults and larvae), torrent salamanders, and lungless salamanders.

This guild includes all of the covered amphibian species: Columbia torrent salamander (*Rhyacotriton kerzeri*), Cascade torrent salamander (*Rhyacotriton cascadae*), Olympic torrent salamander (*Rhyacotriton olympicus*), Dunn's salamander (*Plethodon dunni*), Van Dyke's salamander (*Plethodon vandykei*), Pacific tailed frog (*Ascaphus truei*), and the Rocky Mountain tailed frog (*Ascaphus montanus*).

7.6.4.2 Nearshore Marine Guild

There are no species in this guild. However, we retain the Habitat Association for our analysis because several species associated with other Habitat Associations are also found extensively in the near-shore marine habitats, and therefore we analyze the effects of the FPHCP to these habitats so that those effects may also be considered for those species.

7.6.4.3 Lentic Guilds

Although we differentiated between less-sensitive and more-sensitive species with respect to sediment and temperature, this had little utility in terms of numbers of species except for the Lentic Habitat Association. Yet, even for this Guild, we discuss effects to the entire Habitat Association within this effects analysis. Individual sensitivity of each species is only discussed in detail with respect to temperature and sediment within the sections on **Effects of the Action** for each species.

7.6.5 Exceptions to Guilds

While this analysis is primarily based upon Habitat Associations, a number of species will be associated with more than one Habitat Association. For instance, some lake (Lentic Habitat Association) species spawn in associated streams. Amphibians do not only use stream habitat, but are found in adjacent riparian areas, especially within the splash zone, and in associated sensitive habitats such as side-slope seeps. They may also be found within channels of seasonal streams. The torrent salamanders would be expected to occur along both Type Np and Ns streams. Dunn's and Van Dyke's salamanders are included in the headwater guild along Type Np and Ns streams; however, they would also be expected to occur in riparian areas along Type S and F streams. Juveniles and adults of both of the tailed frog species would be expected to occur primarily along Type Np streams and possibly the upper portions of Type F streams; tadpoles would occur within these streams. The species in this guild also use special habitats, such as seeps, springs, and waterfall splash zones. Some species also use upland habitats periodically, especially during rainy seasons.

These deviations from the groupings will be discussed in the **Status of the Species** section for each such species, and will again be considered when assessing baseline, effects, and cumulative effects on a species-specific basis.

7.6.6 Baseline of Habitat Associations

Many of these streams have been affected by historical logging and road building. Many of the larger streams, lower-elevation streams, lakes, and other waters have experienced effects associated with other land and water uses described in the **Comprehensive Environmental Baseline**. The section below identifies some of the baseline conditions on the covered lands and within the action area.

7.6.6.1 Headwater Streams

These reaches were often affected by landslides, debris torrents, and debris flows. In some extreme cases, such streams were scoured to bedrock leaving little if any habitat. Other streams are not associated with unstable slopes, but were likely subject to several rotations of timber harvest and resulting sedimentation. These streams may not have abundant large wood of considerable size, but often have functional wood loading to meet their requirements for sediment storage and channel morphology due to presence of smaller wood which may function in these channels.

7.6.6.2 Steep Tributaries

These reaches were often affected by landslides, debris torrents, and debris flows. In some extreme cases, such streams were scoured to bedrock leaving little if any habitat structure to support fish. However, in segments with deep alluvial cover and less steep gradients, the post-debris-torrent channel bed is often composed of large cobbles in step-pool channel morphology. Fish movements were likely affected by undersized culverts in many areas. These streams may not have abundant large wood of considerable size, but often have functional wood loading for sediment storage and channel morphology due to presence of smaller wood which may function in these channels and the presence of boulders and other channel roughness features.

7.6.6.3 Low-Gradient Tributaries

These reaches have been affected by a variety of stream-simplification effects. Riparian harvest, large-wood removal, and cedar salvage, have all affected channel complexity. These reaches have also experienced accumulations of coarse and fine sediments, associated with delivery from upstream. Low-gradient tributaries may also have low amounts of large wood. Due to locations on forest lands and away from other land and water uses, many of these streams may currently be in functional condition; but, in some cases, these streams may be still recovering from past timber harvests.

7.6.6.4 Mainstem Streams and Rivers

These are generally larger meandering streams and rivers, often with floodplains or channel migration zones. Many of these streams and rivers have been subject to water-withdrawal, diking, channelization, bank hardening, and flood-control efforts. Historical logging often included splash dams and these streams and rivers also were impacted by activities associated with transportation and removal of large wood. These streams and rivers often lost key pieces, log jams, deep pools, and complex habitat. Additionally, they were often disconnected from off-channel habitats within the floodplain, and from the floodplain itself due to changes in streambed elevation.

7.6.6.5 Lentic Habitats

These habitats are highly variable. Some of these habitats are naturally dynamic, for instance beaver ponds or oxbows and backwaters of larger streams and rivers. Some of these habitats have been created or modified by the construction of dams. In some situations, natural lakes or wetlands were impounded and managed for deeper lakes. Many of these lakes and reservoirs are subject to a variety of effects including changing water depth and loss of natural habitats, shoreline development, reduced water quality, negative effects associated with cooler temperatures as well as warmer temperatures, water withdrawal, water quality, and a variety of effects associated with development, industry, transportation, and recreation on those waters and adjacent shorelines.

7.6.6.6 River Systems

Large river systems such as the Columbia and Snake Rivers suffer from some of the same effects as Mainstem Streams and Rivers, as well as the effects mentioned for larger impoundments. Construction of a series of major dams on both these rivers has had major influence over the character of these waters. Many species are isolated from populations upstream and downstream. Dams affect habitat features both above and below dams. Sediment and wood is no longer passed downstream. Anadromous species no

longer supply nutrients to portions of these systems. These habitats have also been subject to introduction of nonnative species.

7.6.6.7 Nearshore Marine

A variety of effects have occurred to nearshore marine areas. Loss of estuaries and coastal wetlands has often been locally severe. Construction of bulkheads and simplification of shoreline habitats has reduced spawning and foraging habitats for many species. These shallow marine waters also suffer from contaminant issues associated with coastal development (commercial and residential), transportation (e.g., oil spills and leakage), and industry.

7.6.7 Effects to Habitat Associations

The **General Effects** section contained earlier in this document forms a basis for the assessment of effects to guilds. Because the foundations in the science and literature for conclusions were presented with respect to fish and fish habitat throughout those discussions, the foundations (including literature citations) are not repeated for each of the guilds. However, because stream-associated amphibians may not have been as fully discussed as the fish throughout each of the relevant topics in the **General Effects** section, the headwater Habitat Association (amphibian) section that follows contains additional details to form the foundations of our conclusions, including literature citations.

7.6.7.1 Headwater Habitat Association

Headwater Habitat Association - Overview

The primary effects of the action, as described in the **Description of the Activities that are Effects of the Permit** section, on the headwater amphibian guild are expected from riparian timber harvest adjacent to Type Np and Ns streams. Secondary effects may result from road construction and maintenance activities. Other activities such as electrofishing related to adaptive-management research may have limited effects as well. Riparian timber harvest along Type Np and Ns streams may have adverse effects on the guild due to the removal of overstory canopy that may in turn increase solar radiation that reaches riparian ground surface areas and adjacent streams, potentially increasing water temperatures. The equipment used to remove timber (e.g., rubber-tired skidders) may cause adverse effects on the guild by causing direct mortality of an amphibian.

Timber harvest may also have adverse effects on the guild by the removal of potential recruitable wood that serves as: (1) habitat for the guild; (2) substrate for aquatic invertebrates that are food sources for the guild; and (3) sediment storage. Adverse effects on the guild may result from increased sediment being transported to streams from adjacent harvested areas and from forest roads that are hydrologically connected to nearby streams (this latter effect is expected to decrease over time under the proposed action and associated road maintenance prescriptions). Sediment may fill interstitial spaces between stream bed cobble and gravel substrate that is important to several members of the guild. Fine sediment may also settle on substrate surfaces where some members of the guild feed on algae.

Changes in Type Np and Ns stream channel morphology may sometimes occur under the proposed action. Equipment operating within the ELZ may affect streambanks and may cause localized changes within the riparian area. Localized portions of the Riparian Zone may experience soil compaction and rutting which would route water into streams more quickly and may also increase soil erosion. Localized changes that may lead to adverse effects on the guild may be experienced in rain-dominated watersheds, particularly in

coastal areas of Washington, and in smaller watershed basins (USFWS and NMFS 2006). These localized changes may increase peak flow rates and debris slides in adjacent non-buffered Type Np and Ns channels during storm events. Increased peak flow rates and debris slides as a result of roads may result in stream scouring adversely affecting guild habitat. In reaches where riparian timber harvest occurs and buffers are not retained, the lack of riparian forest adjacent to those streams may reduce the resiliency of these species with respect to effects that may emanate from other processes (e.g., peak flows, sedimentation, and scouring).

Aside from forest roads that may transport sediment to streams, as mentioned above, road construction and particularly culvert and bridge installations may have adverse effects on the guild in that construction efforts may crush or bury some less-mobile members of the guild. These adverse construction effects are short term, from the standpoint of the amphibian population. The long-term beneficial effects of improved roads and stream-crossing structures on guild habitat are acknowledged.

Specific Effects of the Action on the Headwater Guild

The discussion on the effects of the action, as described in the **Description of the Activities that are Effects of the Permit** section, are discussed in terms of three groups within the headwater guild. These three groups are as follows: (1) the torrent salamander group that includes the Columbia torrent salamander, Cascade torrent salamander, and the Olympic torrent salamander; (2) the Plethodon salamander group (whose group name, meaning lungless, was selected from their common genus name) that includes the Dunn's salamander and the Van Dyke's salamander; and (3) the tailed frog group that includes the Pacific tailed-frog and the Rocky Mountain tailed frog.

Effects from Changes in Riparian and Streambank Conditions

Changes in Type Np and Ns riparian and streambank conditions have a high potential to adversely affect the torrent salamander group. As described in more detail in the **Status of the Species** section for these species, they are found primarily in cool-water, stream-margin habitat where the cobble and gravel substrate is moist or water-washed, yet out of the direct fast flow of water in the stream. Waterfall splash zones, seeps, and springs are specialized habitats used by the torrent salamander group. Changes to the overstory canopy through timber harvest may increase solar radiation, thus warming the water in shallow stream margins and reducing the quality of the habitat for the torrent salamander group. Any direct damage to streambank conditions through yarding timber within yarding corridors or from yarding equipment would also have a high potential to have an adverse effect on the stream margin habitat of this group. It is acknowledged that ELZs should minimize the direct damage to streambank conditions.

The changes in conditions from riparian timber harvest, particularly along the non-buffered portions of Type Np and Type Ns streams, have a high potential to adversely affect the Plethodon salamander group. As described in detail in the Status section for these species, they are found primarily in shaded, moist riparian areas and along stream edges. The removal of riparian timber may change the microclimate of these areas by increasing solar radiation that reaches the riparian ground surface and causing greater diurnal fluctuations in surface humidity and moisture (Nordstrom and Milner 1997; Petranka 1998; Ken Risenhoover, Personal Communication, Port Blakely Tree Farms, January 23, 2006). Any direct damage to streambank conditions through yarding timber within yarding corridors or from yarding equipment would also have a high potential to have an adverse effect on the stream margin habitat of this group. It is acknowledged that ELZs should minimize the direct damage to streambank conditions.

The tailed frog group is not as likely to experience adverse effects from changes in riparian and streambank conditions as the torrent and Plethodon salamander groups. As opposed to the torrent and Plethodon salamander groups, whose juveniles and adults use similar habitats, the tailed frog group is discussed here in terms of effects to adults/juveniles and then effects to tadpoles. Adults/juveniles use a range of habitats from instream to riparian areas and, periodically, upland sites for migration and foraging. Because adults/juveniles are quite mobile, changes in overstory riparian conditions are not expected to have significant adverse effects. However, other changes to instream conditions due to riparian timber harvest may have adverse effects, as discussed later on in this section. Tadpoles are not expected to be significantly adversely affected by changes in overstory riparian conditions as they are exclusively found instream. However, as with the adults/juveniles, other changes due to riparian timber harvest may have adverse effects, as discussed later on in this section. The same conclusions are drawn for changes in streambank conditions for the tailed frog group.

Effects from Changes in Wood Recruitment Potential

The torrent salamander group is expected to experience a moderate potential of adverse effects from reduced wood recruitment along Type Np and Ns streams, particularly non-buffered portions of these streams. While the torrent salamander group is not known to depend on riparian or instream wood as a primary habitat element, the presence of adequate wood (i.e., the amount of wood that occurs in streams adjacent to unmanaged forests) plays a role in storing sediment, as substrate for aquatic invertebrate production, and in the maintenance and dynamics of channel morphology, as described in detail in the **General Effects** section under **Aquatic Inputs** and **Wood**. These elements of wood function are important to the torrent salamander group to maintain cool, clear waters with abundant invertebrate production as a source of food. A reduction in wood recruitment would be expected to impair these functions to some degree and adversely affect the torrent salamander group.

A reduction in wood recruitment potential along Type Np and Ns streams is expected to result in a high potential to adversely affect the Plethodon salamander group. A study under the State's Adaptive Management Cooperative Monitoring, Evaluation, and Research committee that is nearing completion has found that both Van Dyke's and Dunn's salamanders utilize downed wood as habitat. Van Dyke's salamanders were found in downed wood more than 75 percent of the time they were captured and preliminary analysis indicates that they seem to differentially use large-sized pieces (i.e., greater than 50 centimeters in diameter) than other sizes of downed wood (Marc Hayes, Personal Communication, Washington Department of Fish and Wildlife, January 26, 2006). More investigation is needed to determine how the availability of large-sized, downed wood pieces relates to Van Dyke's salamander occurrence.

The tailed frog group is expected to experience a moderate potential of adverse effects in buffered portions of Type Np streams due to reduced wood recruitment potential from a no-harvest buffer width of only 50 feet that would not encompass all the potentially recruitable wood to riparian and instream areas used by tailed frogs. There is a high potential for adverse effects in the non-buffered portions of Type Np and Ns streams, as all potentially recruitable wood is subject to harvest. The reduction or complete removal of potentially recruitable wood adversely affects the tailed frog group because recruited wood serves to store sediment as described in detail in the **General Effects** section under **Aquatic Inputs and Wood.** As shown in Dupuis and Steventon (1999) and Ashton et al. (2005), increased sediment input may be the most-important factor behind tailed frog population declines. Further discussion on the effects of sediment on the tailed frog group is provided in the next section, Effects from Changes in Sediment Inputs.

Effects from Changes in Sediment Inputs

The effects of increased sediment inputs following timber harvest are expected to have a moderate potential of adversely affecting the torrent salamander group. These effects would be more likely in non-buffered portions of Type Np and Ns streams than in buffered portions of Type Np streams because buffers would likely provide more recruitable instream wood and organic material that would serve to filter and trap sediment more effectively than non-buffered streams. Increased sedimentation is suspected to reduce habitat quality for torrent salamanders by filling interstitial spaces in stream substrate that impairs movement, egg deposition, and larval development (Corn and Bury 1989; Diller and Wallace 1996; Nordstrom 1997). However, available research is inconclusive and geology, substrate, and stream gradient may override sediment levels. Regardless, sedimentation is considered to have a moderate potential of adversely affecting the torrent salamander group. Increased sediment inputs from hydrologically connected forest roads or from road construction across Type Np and Ns streams would also have the potential to adversely affect the torrent salamander group.

There is a low potential of adversely affecting the Plethodon salamander group from increased instream sedimentation following timber harvest in either buffered or non-buffered portions of Type Np and Ns streams. This is because the Plethodon salamander group is a riparian associate and not an instream associate and is thus not expected to be significantly affected by instream sedimentation.

The tailed frog group has a high potential of being adversely affected by increased sediment inputs into Type Np and Ns streams following timber harvest. These effects would be more pronounced in non-buffered portions of Type Np and Ns streams than in buffered portions of Type Np streams because buffers would likely provide more filtering and trapping of sediment than non-buffered streams. Several studies have indicated that increased sediment levels may result in negative effects on tailed frog adults, juveniles, and tadpoles. Bury and Corn (1988) found that tailed frogs were sensitive to increased levels of fine sediment that filled interstitial spaces and reduced instream refugia. Another study indicated a negative association between tailed frog presence and the increasing percentage of fine sediments and increasing amounts of substrate embeddedness (Diller and Wallace 1999). The density of tailed frogs also was lower in substrates with greater than 40 percent embeddedness (Hawkins et al. 1988). Tailed frog tadpoles are expected to be especially sensitive to increased sedimentation following clearcutting, particularly in non-buffered portions of Type Np streams and also from the Type Ns downstream effects, as they cannot adhere as well to rocks that are coated with fine sediment with their sucker-like mouth that is used to cling to instream rocks and scrape food (i.e., algae) off the rocks (Jackson et al. 2003). Increased sediment levels may also reduce the availability of algae and other foods that the tadpoles feed on (Welsh and Ollivier 1998). Dupuis and Steventon (1999) and Ashton et al. (2005) suggest that increased sediment inputs may be the most-important factor behind tailed frog population declines following timber harvest. Riparian buffers would help to ameliorate the effects of timber harvest on tailed frogs.

Effects from Changes in Shade on Stream Temperatures

As described in detail in the Status section for these species, the torrent salamander group is found in stream margins and in other specialized habitats (e.g., seeps, waterfall splash zones) with permanent, cold flowing water and they are among the most desiccation-intolerant salamander genera known. Because of the type of habitat they use and their dependence on constant moisture contact with their skin, the torrent salamander group would have a moderate potential of being adversely affected by reductions in shade and thus increases in stream temperatures following timber harvest in non-buffered portions of Type Np and

Ns streams. In contrast, the potential of adverse effects in buffered portions of Type Np streams is expected to be low as much of the potential shade to streams is expected to be provided by the 50-foot no-harvest buffers. These buffers should reduce the likelihood of significant increases in stream temperatures, thus maintaining moist microclimates in the stream margins.

The Plethodon salamander group is found in moist sites in riparian areas, streambanks, and other wet sites, as described in the Status sections for these species. Riparian buffers would be expected to maintain stable, moist microsites more so than non-buffered riparian areas. However, because the Plethodon group is a riparian associate and not an instream associate, changes in stream temperatures would have a low potential of adversely affecting the Plethodon group.

Reductions in shade that result in increased stream temperatures, along non-buffered portions of Type Np and Ns streams, would have a moderate to high potential to adversely affect the tailed frog group. As described in the Status section for these species, tadpoles (exclusively) and juveniles and adults (at times) are found in cold, fast-flowing waters of headwater streams. Increases in stream temperatures would be expected to adversely affect the habitat of the tailed frog group. This conclusion is supported by Hawkins et al. (1988) that found tailed frogs in streams less than 18 degrees C and absent in streams near or above 20 degrees C. Diller and Wallace (1999) also found a negative association between tailed frog presence and increased water temperatures. The potential for adverse effects in buffered portions of Type Np streams would be low as stream temperatures are not expected to be significantly affected with the presence of a 50-foot no-harvest buffer.

Effects from Changes in Hydrology and Channel Responses

The potential for adverse effects is expected to be low to moderate for all species in the headwater guild. Changes in hydrology and thus channel responses (in the form of peak and debris flow increases) are expected to be localized in rain-dominated or rain-on-snow zones, particularly in the smallest of basins. Changes in hydrology and channel responses from timber harvest are not expected to be widespread. The Plethodon group would likely be affected the least by peak and debris flow increases as they are a riparian associate; the tailed frog group is found in fast-flowing waters and also is not expected to be susceptible to these increases except in extreme events; finally the torrent salamander group that is found along stream margins would likely be impacted the most by increasing peak and debris flows as these changes could scour these local areas and potentially cause mortality of individuals.

Effects from Electrofishing, Culvert/Bridge Work, and Heavy Equipment Use

Adverse effects in the form of stress, wounding, or mortality from electrofishing, related to adaptive-management research and stream typing to determine the extent of fish habitat, may occur with the torrent salamander group and the tailed frog group that are associated with instream and stream margin habitats where electrofishing would be used. Culvert and bridge maintenance and installation could have adverse effects (stress or mortality) on all species of the headwater guild in that these activities potentially affect instream and riparian habitats. Instream, heavy equipment use could have adverse effects (stress or mortality) on the torrent salamander group and the tailed frog group; heavy equipment use for harvesting timber in riparian areas could have adverse effects (mortality) on the Plethodon salamander group.

7.6.7.2 Steep Tributary Habitat Association

Riparian and Bank Condition

Effects to these small Type F streams are difficult to measure or quantify. Where effects do occur they are expected to be localized in nature. Effects to fish-bearing streams are also possible where distribution of fish is underestimated (see Headwater Streams). In these cases where fish distribution is underestimated, the narrower buffers left on Type Np streams (in comparison to Type F streams) may be more likely to be subject to some windthrow. Beyond the first 300 to 500 feet upstream from the confluence with a Type F stream, ground-based equipment may be more likely to be used in proximity to the stream where buffers are not retained than if Type F buffers were retained, which may result in some soil compaction, effects to interstitial spaces within the soil, and potentially collapsed banks in some cases. However, along properly classified Type F streams, riparian and bank condition would be expected to be retained, with occasional small openings for yarding corridors.

Wood

Where distribution of fish is underestimated in small streams, wood recruitment may be reduced as a result of non-buffered segments or segments with 50-foot buffers, but wood should still be delivered from within-rotation suppression mortality as these streams have low-energy and smaller wood may function in sediment storage and channel morphology. However, to the extent that large pieces of wood are necessary, there may currently be a degraded baseline with a possible low potential for near-term recruitment. When mature timber is available along such Type Np streams, it could be reduced in some reaches as a result of riparian timber harvest along streams misclassified as streams without fish. Portions of these streams will receive buffers, including special sites, alluvial fans, and sensitive site at the confluence of Type F and Np streams, and these areas will provide about half to most of the potential recruitment, depending on geographic area, forest vegetative zone, and management option. Other reaches may be left unbuffered during harvests which would result in removal of potential large wood recruitment.

Streams in steep topography may have wood delivered with debris flows. Recruitment of wood may be reduced as a result of riparian timber harvest in that episodic debris flows (emanating from above Type Np streams) may not incorporate as much wood from Type Np riparian areas as they otherwise might have prior to harvest. Debris flows naturally deliver wood in a sporadic and uneven pattern. Wood would be expected to accumulate at tributary junctions, abrupt channel direction changes, and low-gradient reaches. At these points, the accumulations of wood may be somewhat reduced due to the riparian harvest along portions of Type Np streams. Regarding Type F stream buffers, key-piece wood would continue to be recruited to the channel from near-bank sources and is expected to be more-evenly distributed than wood from episodic sources. When debris flows deliver to Type F streams, incremental changes in amount of large wood may influence sediment storage and routing at these depositional sites as well as pool formation and other changes in channel morphology.

Hydrology

As a result of riparian timber harvest, low base flows may be somewhat improved or remain unchanged where harvest occurs upslope. Exceptions may include some small streams in the coastal fog-drip zone. Peak flows may be influenced during small peak flow events, or to a minor degree at moderate peak flows. Peak flows may occur sooner and may be somewhat larger as a result of the road network, resulting in some incremental increase in stream dynamics and redd scour.

Sediment

Sediment delivered directly through the Riparian Zone of Type F streams and 50-foot no-harvest buffers is expected to be negligible, except where the distribution of fish may be underestimated by more than 300 to 500 feet. In those cases, sediment input may be somewhat higher where equipment operation occurs within the ELZ. Sediment delivery at road crossings and stream-adjacent parallel roads may occur and may be locally heavy. In smaller streams, inputs of sediment from roads may be proportionally high compared to stream size and may overwhelm the ability of smaller streams to route sediment.

Due to the limited strength of flows in small streams, sediment may enter interstitial spaces and be stored over a period of time from one to several years. On larger tributaries, sediment residence time may be shorter due to the ability of these streams to transport sediment. Some sediment from upstream may be stored in low-gradient reaches, eddies, and backwater areas. Sediment may settle into substrate during low flows, but would be resuspended during subsequent increases in flows.

Detritus

Where the distribution of fish is underestimated by more than 300 to 500 feet, detritus inputs may be affected by harvest in non-buffered reaches. This may reduce the year-round inputs (e.g., from conifer needles and other plant parts), but would increase the quality of detritus in coming years during recovery of harvested areas. Canopy openings would provide for off-setting primary production within the stream for a short period of time (several years to a decade).

On larger steep tributaries, detritus input may decrease from upstream headwater streams following harvest along headwater streams (Type Np). This also may slightly reduce year-round inputs (conifer needles) while slightly increasing the quality of detritus in short term. Organic matter transported from above may change somewhat in response to changes following upstream harvest, including a change in macroinvertebrate composition reflecting change in leaf input and increase in primary production

Shade / Temperature

Where distribution of fish is underestimated, some streams with fish may be treated as Type Np streams. Where fish distribution is underestimated by more than 300 to 500 feet, effects from lack of shade may be locally severe for the short term (2 to 7 years) following adjacent riparian timber harvest in non-buffered reaches. Species found in this Habitat Association (e.g., coastal cutthroat trout, shorthead sculpin, Dolly Varden trout) are generally temperature sensitive and increases in water temperature may be detrimental. In some cases, stream velocities will be sufficiently swift through harvested sections, banks will be steep, and alluvium may be present so that stream warming is less likely to occur. However, where stream velocities are slower, the channel is composed of bedrock, and banks or vegetation do not provide much shade, water temperature may be adversely affected especially during the middle of the day, for a number of days during the late spring and summer months. Diurnal fluctuations are expected as nighttime temperatures will likely be as cool as or cooler than in buffered reaches, especially in bedrock channels.

In some cases, portions of steep tributaries may be affected by upslope harvest. When streams flow through harvested areas, they may have some potential to warm or cool downstream areas. Delivery of warmed waters is more likely to occur in landscapes where debris flows are not common and there is little interchange between surface waters and groundwater. However, it may be likely in situations where debris flows have scoured stream beds down to the bedrock. A major factor in ability of headwater streams to warm and their ability to cool as they travel through downstream shaded reaches appears to be

the condition of the channel substrate. A bedrock channel will have less hydraulic retention time, less mixing, and less heat exchange with the substrate than a stream with a gravel bed.

Streams of significant discharge and velocity are less likely to warm while passing though a harvest unit; conversely, streams with low discharge may warm but would have less ability to affect temperature of downstream receiving waters. Streams of moderate discharge, but still contributing substantial discharge relative to downstream fish-bearing receiving waters, would be relatively uncommon. But such a stream may have some potential to alter temperature regimes within receiving waters. Such a change could occur through a small amount of warming when received by a cooler fishbearing stream, or a slightly dampened cooling effect when received by warmer fishbearing water. In addition, two headwater streams that combine to form a small fishbearing stream would have some potential to influence the temperature regime of the downstream receiving water, especially if they both flowed through a recently harvested area.

Steep-tributary fish may also be exposed to some thermal effects when fish distribution is underestimated. This may reduce or eliminate the distance between fish and unbuffered reaches normally provided by the sensitive site at the confluence of Type F and Np streams of 300 to 500 feet. The potential for Type Np streams to delivery excessively warm or cold water is more likely to be realized when the intervening sensitive site at the confluence of Type F and Np streams is not functioning as intended; perhaps due to previous harvests (e.g., over the last several decades); natural events such as windthrow, fire, or debris flows having denuded the adjacent riparian zones; or other land uses. It is possible that Type Np streams under forest practices jurisdiction could directly enter into reaches under alternate land uses just prior to joining with fish-bearing waters. In these cases, however, the level of degradation to stream temperatures caused by timber harvest will likely be overwhelmed by the impacts associated with the other land uses. It should be noted that not all harvests will occur adjacent to the sensitive site at the confluence of Type F and Np streams. In most cases, harvests would occur further up the stream network allowing for additional time and distance over which stream temperatures would equilibrate to normal levels.

Some stream velocities will be sufficiently swift through harvested sections so that stream warming is less likely to occur. However, where stream velocities are slower, water temperature within the Type Np streams may be warmed during the middle of the day, especially for a number of days during the late spring and summer months. These low-discharge streams will have a reduced ability to alter receiving waters. The substrate controls many aspects of the heat budget. Streams with alluvium are expected to heat more slowly in the open sun and cool more quickly in the shade than bedrock channels. Bedrock streams of moderate discharge in areas with low levels of groundwater interchange are a subject of concern. Yet a number of factors moderate this concern. Diurnal fluctuations are expected as nighttime temperatures may in some cases be cooler in unbuffered reaches than in buffered reaches. In other cases, minimum temperatures may remain unchanged even where maximum temperatures are increased as these two temperature parameters (daytime highs and nighttime lows) result from different heat budgets. Where long travel times are involved, water mixing may modify peaks and troughs in temperature and will provide additional opportunities for heat exchange with substrate and hyporheic zone, equilibration with air temperature, long-wave radiation, and groundwater inputs. On landscapes where mixing with groundwater is common, the overwhelming influence of groundwater may negate these concerns about downstream thermal effects. Additionally, in a number of cases, low flows in harvested reaches will be increased due to enhanced groundwater inputs following harvest. Harvest generally removes a significant source of water loss from evapo-transpiration and may increase the amount of cool groundwater entering the headwater stream.

However, where thermal recovery does not completely occur prior to the confluence with a Type F stream, thermal refugia at the tributary junction may suffer from reduced effectiveness for a period of several years or more until shading of the upstream harvested reach recovers. Some steep-tributary fish such as shorthead sculpin and Dolly Varden trout may depend on such thermal refugia during hot summer periods.

In larger steep tributaries (e.g., properly classified Type F streams), stream temperature changes from activities within the buffers of westside Type F streams are expected to be small to negligible. On the eastside, the risk of stream temperature increase is low within the Bull Trout Overlay. Some additional probability of effects (e.g., moderate risk) may occur to eastside Type F streams which are not within the Bull Trout Overlay. Substantial portions of eastern Washington are outside the Bull Trout Overlay, but would continue to receive a 30-foot Core Zone, as well as an additional 50 to 120 trees per acre retained depending on the vegetative zone and existing stand density. The degree of shading and protection from stream warming is somewhat less certain along these small eastside streams outside the Bull Trout Overlay.

Another concern is abnormal cooling of streams that may contribute to direct mortality and injury, or to habitat degradation and loss, from icing. Headwater streams flowing though harvest units may cool excessively, and may contribute to negative effects during the winter. These effects, should they occur, would be geographically limited to high elevation areas and to eastside streams, and would likely be influenced to only a moderate degree by riparian timber harvest under the proposed FPHCP.

Channel / Habitat Responses

Where extent of fish distribution is underestimated by over 300 to 500 feet, streambanks within the ELZ may be subject to heavy equipment use. Streams may become simplified and banks flattened, reducing cover for these species. In some cases, banks may be collapsed due to heavy equipment.

As mentioned earlier under effects to large wood, reduced delivery of wood could occur as a result of debris flows that pass through unbuffered Type Np streams. Minor changes in pools and sediment routing may be expected where differences in wood delivery from upstream are able to influence wood-pool relationships. In many cases, areas of accumulation will already exceed levels at which the stream will respond to additional wood. In some cases, channel morphology may be affected at and immediately below such delivery sites.

Sediment transported from upstream may alter water quality to some degree. Road-generated sediment may be proportionally high in these small steep streams and interstitial spaces within stream substrate may become filled and may remain filled until flushing flows occur. This may occur rapidly in some locations, or may take several years in low-flow backwater portions of these streams.

7.6.7.3 Low-Gradient Tributary Habitat Association

Riparian and Bank Condition

Adverse effects to riparian and bank condition are not expected, with the exception of small openings for occasional yarding corridors.

Wood

Recruitment of wood may be reduced in that episodic debris flows emanating from upstream of harvested Type Np stream reaches may not incorporate as much wood from Type Np riparian areas as they otherwise might have prior to harvest. These debris flows would deliver wood in a sporadic and uneven pattern. Such delivery to low-gradient tributaries is only likely in locations where one geomorphic province intersects another. The effects would be similar to that seen in the Steep Tributary Habitat Association, but would be less frequent.

Hydrology

Low base flows may be somewhat improved where harvest occurs upslope. Exceptions may include some small streams within the coastal fog-drip zone. Peak flows may be influenced during small peak flow events, and to a minor degree at moderate peak flows. As a result of roads, peak flows may occur sooner and may have somewhat higher discharge.

Sediment

Sediment delivered through the Riparian Zone is expected to be negligible; however, as discussed for previous Habitat Associations, sediment delivery at road crossings and stream-adjacent parallel roads may occur and may be locally heavy. Sediment residence time may be longer than in steep tributaries because low-gradient tributary streams are likely to be response reaches. Sediment from upstream may be stored in these low-gradient reaches. The upper end of low-gradient tributaries may be an initial site of deposition, with gradual movement through the system over the course of several to many years. Some sediment may settle into substrate during low flows, but would be resuspended during subsequent increases in flows. Sediment may alter channel morphology by altering bank erosion, braiding, aggradation, and avulsions. However, the proposed FPHCP would continue to reduce the amount of sediment introduced into the stream system from anthropogenic sources from the current high level in the baseline.

Detritus

Detritus input may decrease from upstream headwater streams following harvest. This may slightly reduce year-round inputs (conifer needles); but may slightly increase quality of detritus in the short term. Organic matter transported from above may change somewhat in response to changes following upstream harvest, including a change in macroinvertebrate composition reflecting change in leaf input and increase in primary production.

Shade / Temperature

Temperature effects from removal of shading along near-bank areas are expected to be negligible. Effects from upstream unshaded reaches are similar to that expected for Steep Tributary Streams. However, many low-gradient tributary streams will naturally be warmer than steep tributaries. In some cases, where landscape gradients change from steep to moderate, groundwater upwelling sites may occur and the areas downstream may be marked by cool stream temperatures. In other areas, low-gradient tributaries may be susceptible to warming due to their naturally higher surface area to volume ratio, as well as trend toward less influence of shade with increasing stream width. Effects of sedimentation discussed earlier may exacerbate this situation, causing filling of pools and degradation of banks, and having the overall effect of making the stream wide and shallow. However, these effects would only be expected to occur

following major events such as mass-wasting events, road failures, accelerated streambank erosion, or upstream channel incision. Beaver ponds may both warm the water contained within them, as well as cool the downstream flow through recharge and downstream release of groundwater. Beaver ponds would also help stabilize summer low flows, thus ameliorating temperature peaks. Low-gradient tributaries on the eastside, outside of the Bull Trout Overlay, may have some reduction in shade that could influence stream temperatures, but these streams would still receive the 30-foot Core Zone, and 50 to 120 trees per acre depending on vegetative type and stand density.

Channel / Habitat Responses

Changes in pools may be expected where sediment is sufficient to fill pools. Small changes in the sediment regime (e.g., inputs related to riparian timber harvest) are unlikely to have this level of response. Changes in large-wood loading are also unlikely to have this level of response. Mass-wasting events, road failures, accelerated streambank erosion, and upstream channel incision may produce enough sediment to fill pools and change channel morphology. Bedload movement and instability may result when more sediment is imported than the stream can transport. Positive feedback can occur as when increased sediment input causes shallowing, which in turn reduces hydraulic energy and induces more deposition.

7.6.7.4 Mainstem Stream and River Habitat Association

Riparian and Bank Condition

Adverse effects to near-bank riparian and bank condition are not expected due to presence of the Core Zone and the low likelihood of yarding across mainstem streams and rivers.

Wood

As mentioned earlier, harvests along some Type Np streams may result in less wood delivered with debris flows and eventually less wood may reach Mainstem streams and rivers by flotation. To a small degree, this may decrease the number of wood pieces available for contribution to aggregates. Key-piece wood would come from near-bank areas and wood transported from upstream would be aggregated into log jams at close to natural rates. Potential recruitment of large wood from near-bank areas would remain in the recovery phase along many streams and rivers; but, in many other areas, large wood from near-bank areas would be contributing to improvement of the instream baseline by contributing key-piece-size wood.

Hydrology

No changes would be observed in low or high flows, or average annual yield as a result of riparian timber harvest. The FWS also does not expect to see measurable changes as a result of road-system management under the proposed FPHCP.

Sediment

Sediment delivered through the Riparian Zone is expected to be negligible. Sediment delivery at road crossings may occur and may be locally heavy, but quickly transported in most situations, and would only comprise a small portion of natural load of the river. Some small amount of sediment from upstream forested areas may be stored in low-gradient reaches, eddies, and backwater areas. This may be especially true when sediment delivery occurs to floodplains and off-channel habitats during flood events.

While sediment may alter channel morphology by altering bank erosion, braiding, aggradation, and avulsions; the relative contribution of sediment load in Mainstem Streams and Rivers as a result of FPHCP is expected to be very low. FPHCP would continue to reduce the amount of sediment introduced into the stream system from anthropogenic sources from the current high level in the baseline.

Detritus

Negligible (if any) changes are expected as a result of the proposed FPHCP.

Shade / Temperature

Temperature effects from shading along near-bank areas are expected to be negligible, as are most temperature effects from upstream harvested areas. In some cases, at tributary junctions, the effectiveness of thermal refugia may be decreased as a result of upstream harvest and may persist for several years until shade levels recover. Larger streams and rivers tend to be diurnally more variable in temperature fluctuations and slightly warmer on average than headwater streams. Large streams are less affected by riparian shade.

Channel / Habitat Responses

Changes in pools may be expected where sediment is sufficient to fill pools. Bedload movement and instability may result when more sediment is imported than the stream or river can transport. However, the relative contribution of sediment load in Mainstem Streams and Rivers as a result of FPHCP is expected to be very low.

7.6.7.5 Lentic Habitat Association

Riparian and Bank Condition

Changes in near-bank riparian condition and bank condition are not expected to result from the proposed FPHCP.

Wood

Essentially no change in wood delivery is expected from either near-bank or upstream sources. An exception may be where Lentic habitats occur immediately downstream of headwater streams. See the discussion regarding decreased wood delivery from unbuffered Type Np streams as discussed in **Steep Tributary Habitat Association – Wood.**

Hydrology

No change would be observed in low or high flows, or average annual yield as a result of timber harvest. Where smaller Lentic habitats occur immediately below headwater streams, small changes to moderate peak flows may occur or as a result of road-system management.

Sediment

Sediment delivered through the Riparian Zone is expected to be negligible; however, sediment delivery at road crossings may occur and may be locally heavy. Some sediment from upstream forested areas may be delivered to lakes, beaver ponds, and other low-gradient reaches. This may be especially true when sediment delivery occurs to floodplains and off-channel habitats during flood events. While these areas

naturally accumulate such sediments, FPHCP could potentially accelerate such accumulation and exacerbate sediment-habitat problems in some local situations. However, road-related BMPs and completion of RMAPs should help reduce sediment delivery to streams and should benefit these habitats. The relative contribution of sediment load in large lakes as a result of FPHCP is expected to be very low. The contribution to smaller Lentic habitats located higher in the watershed (e.g., beaver ponds) could be proportionately larger. Even though individual actions under the FPHCP may locally contribute sediment for short periods of time, FWS expects implementation of the FPHCP at the landscape level would continue to reduce the amount of sediment introduced into the stream system from anthropogenic sources from the current high level in the baseline.

Detritus

Negligible (if any) changes are expected.

Shade / Temperature

Temperature effects from shading along near-bank areas, as well as from upstream unshaded areas, are expected to be negligible. Lentic habitats are generally wide and only a small portion of their surface may be shaded. The FPHCP is expected to provide near maximum levels of shade along Type F and S waters, and is expected to provide shade along nonforested wetlands. Some effects from harvest of forested wetlands may occur.

Channel / Habitat Responses

The degree to which the FPHCP could affect processes within large lakes is extremely limited. Smaller low-gradient streams, ponds, and other backwater habitats may be affected by accumulation of fine sediments in excess of natural levels, but such conditions are expected to generally improve under the proposed FPHCP.

7.6.7.6 River System Habitat Association

Riparian and Bank Condition

No adverse effects to near-bank riparian and streambank condition are expected.

Wood

No change in wood delivery expected from either near-bank or upstream. Potential recruitment of large wood from near-bank areas would remain in recovery phase along many rivers; but, in many other areas, would be contributing to improvement of the instream baseline by contributing key-piece-size wood. Due to the presence of dams, much of the large wood traveling down the rivers would not continue to lower reaches.

Hydrology

No change would be observed in low or high flows, or average annual yield. Flow would be primarily dictated by dams in many cases.

Sediment

Sediment delivered through the Riparian Zone is expected to be negligible. Sediment delivery at road crossings is not likely to result from the proposed FPHCP as road crossings of these rivers would be major Washington Department of Transportation or county projects and would generally not involve forest landowners. Any sediment delivered from forest lands would only comprise a small portion of the natural load of the river. Some sediment from upstream forested areas may be stored within reservoirs but would be unlikely to be routed downstream. The relative contribution of sediment load in these major river systems as a result of FPHCP is expected to be negligible.

Detritus

No changes are expected as a result of the FPHCP.

Shade / Temperature

Temperature effects from shading along near-bank areas, as well as from upstream unshaded areas, are expected to be negligible. These rivers as so wide that riparian vegetation will not influence the river's water temperature. Thermal refugia from small streams entering these rivers should generally be maintained by the FPHCP when FPHCP lands exist within proximity of these larger rivers; however, in some cases, short-term reductions in the effectiveness of thermal refugia at tributary junctions may occur as a result of upstream timber harvest along Type Np streams.

Channel / Habitat Responses

The degree to which the FPHCP could affect channel forming and habitat creating and reducing processes is negligible.

7.6.7.7 Near-shore Marine Habitat Association

Riparian and Bank Condition

Type S buffers are expected to adequately address banks, bluffs, beaches, and other shorelines of marine waters.

Wood

No change in wood delivery is expected from either near-bank or upstream, except where steep topographic areas are found adjacent to marine waters and debris-flow delivery of large wood may be slightly reduced either to beaches or estuaries indirectly through Type Np streams feeding estuaries. FWS expects no change to "key piece" wood delivered to beaches and expects large wood to continue acting as a stabilizing force.

Hydrology

Low base flows may be somewhat improved where harvest occurs upslope of estuarine waters. However, in some cases, low flows in small coastal streams may be reduced due to a decrease in fog drip following timber harvest. Peak flows may be influenced during small peak flows, or to a minor degree at moderate peak flows where harvest occurs upslope of estuarine waters. Some changes in peak flows may result from roads in small drainages that provide water to estuaries. No changes are expected to the degree that the distribution or concentration of brackish water would be effected. Penetration of salt wedge upstream

into lower reaches of rivers would not be altered. Tidal processes and freshwater seepage would be unaffected.

Sediment

Sediment delivered through near-shore riparian areas is expected to be negligible as a result of the FPHCP. Sediment delivery at road crossings may occur and may be locally heavy where roads cross streams near estuaries. Some sediment from upstream forested areas may be delivered to estuaries; this may be especially true during flood events. While these areas may naturally accumulate such sediments, forest practices could, in some local situations, contribute sediment and exacerbate sediment-habitat problems. However, implementation of FPHCP at the landscape level would reduce such sedimentation from existing baseline levels. The relative contribution of sediment load in marine waters (outside estuaries) as a result of FPHCP is expected to be very low. FPHCP would continue to reduce the amount of sediment introduced into the stream system from anthropogenic sources from the current high level in the baseline. Delivery of coarse sediment and sediment of sand-sized particles may be important to many near-shore environments.

Detritus

Negligible (if any) changes are expected.

Shade / Temperature

Temperature effects from shading along near-bank areas (such as beaches and bluffs), as well as from upstream unshaded areas, are expected to be negligible as a result of the proposed FPHCP.

Channel / Habitat Responses

The degree to which the FPHCP could affect processes within near-shore marine areas is extremely limited. Large wood would continue to be provided from near-shore areas as described earlier. Some of the benefit from large wood being recruited into major rivers may not be realized in estuary and marine areas as large wood in major rivers and marine transportation channels may be removed to aid navigation.

7.6.8 Cumulative Effects to Habitat Associations

There are additional cumulative effects anticipated on lands covered by the FPHCP since not all commercial forestry activities anticipated by landowners are evaluated in this Opinion. Some of the activities conducted as “covered activities” under the FPHCP would not be altered as result of permit issuance and therefore are addressed as cumulative effects. In addition, covered lands are subject to uses by other people with and without the permission of landowners. Lastly, lands and waters within the action area will likely be subject to activities that will affect waters within the action area. Cumulative effects were summarized in the **Comprehensive Cumulative Effects** section

Cumulative effects may occur in the action area on lands adjacent to FPHCP lands. FPHCP lands are interspersed with lands managed for a wide variety of purposes by many different landowners. The majority of forested lands adjacent to FPHCP lands are managed principally for commercial timber and / or other forest amenities. However, Federal, tribal, and HCP forests are either already part of the environmental baseline or subject to future Section 7 consultation and are therefore not considered to be cumulative effects for purposes of this consultation. Other activities such as grazing, mining, recreation,

agriculture, and residential development also occur on adjacent lands. These types of activities were described in the **Comprehensive Cumulative Effects**. Below is a brief synopsis of the major considerations regarding cumulative effects.

Changes in land use and population expansion are likely to occur in the action area. Conversion of forest lands to residential, urban, or industrial uses could potentially degrade or fragment fish and wildlife habitat. Many lands in the action area that were historically managed for timber production are now being converted into residential, commercial, and industrial developments. It is reasonable to assume that some of the forested areas that provide fish and wildlife habitat, especially riparian corridors in valleys and low-lying areas near metropolitan areas and major transportation corridors, will eventually be converted to these land uses. Urbanization can create a lasting effect on streams through increases in impervious surfaces, loss of riparian vegetation, alterations in stream-channel configuration, and changes in water quality through urban runoff and effluents.

Further, over the 50-year permit period, population expansion is expected to continue. It is likely that acts that could negatively affect native fish species, such as introduction (i.e., illegal private action) and/or establishment of non-native fish species, or poaching of native fish species, will continue to occur. Some native fish are subject to various fishing seasons. Recreational fishing occurs in streams, lakes, rivers, and marine waters. Subsistence fishing most often occurs in rivers and marine waters. Commercial fishing occurs in marine waters. See **Comprehensive Cumulative Effects** for additional information.

The potential magnitude of cumulative effects varies across the action area, depending on the land-ownership pattern. Sub-basins with a high percentage of either FPHCP, other forest HCP, or Federal ownership have lower potential for cumulative effects than areas with low percentage of HCP and Federal land. This is because the Northwest Forest Plan, PACFISH, and INFISH management strategies for Federal lands, and completed forest HCPs provide numerous measures to reduce adverse effects to fish and are generally not subject to other land and water uses. Completed forest HCPs are considered part of the environmental baseline. Areas with high percentages of Federal lands are expected to have fewer cumulative effects since most actions on Federal lands are subject to future section 7 consultations, and areas with high percentages of Federal land have correspondingly smaller percentages of other ownerships.

In general, streams and species located higher in the watershed may be relatively less affected by cumulative effects. Streams located higher in watersheds will likely be affected by recreation and other forest uses. Streams lower in watersheds will integrate the actions and effects above them, and will be subject to effects emanating from a variety of land uses, including agriculture, commerce, industry, and residential development, as well as flood-control and water withdrawals. The challenges faced by species that depend on lower reaches and lower-elevation streams may be more severe than those that are found higher in watersheds and in higher elevation areas away from such development. The FPHCP appears to have the greatest effects on those habitats and species least affected by cumulative effects.

8. Species Status through Conclusions

8.1 BALD EAGLE

8.1.1 STATUS OF THE SPECIES: Bald Eagle

8.1.1.1 Range-wide

The bald eagle was federally listed in 1978 as an endangered species in all lower 48 states except Michigan, Minnesota, Wisconsin, Washington, and Oregon, where it was designated as threatened (43 FR 6230-6233). The listing was a result of a decline in the bald eagle population throughout the lower 48 States. The decline was largely attributed to the widespread use of the pesticide DDT and other organochlorine compounds, in addition to habitat loss, disturbance, shooting, electrocution from power lines, poisoning, and a decline in the food base.

The bald eagle was reclassified in 1995 from endangered to threatened as a result of a significant increase in the number of nesting pairs, increased productivity, and expanded distribution (59 FR 35584-35594). Since 1989, the bald eagle nesting population has increased at an average rate of approximately 8 percent per year (64 FR 36454-36464). The national average for fledglings per occupied breeding area is greater than one; therefore, the bald eagle population continues to increase. The bald eagle population in the lower 48 States has increased from approximately 487 active nests in 1963 to an estimated minimum 7,066 breeding pairs today (71 FR 8238-8251). Based on the achievement of recovery goals throughout the lower 48 States, the FWS has proposed to remove the bald eagle from the list of Endangered and Threatened wildlife (71 FR 8238-8251).

In establishing a recovery program for the species in the mid-1970s, the FWS divided the bald eagles of the lower 48 States into five recovery regions, based on geographic location. A separate recovery plan was prepared for each region. The individual recovery plans set forth goals for recovery and identified tasks to achieve those goals. Delisting and reclassification of the bald eagle in the Pacific Recovery Region is not dependent on the progress of bald eagle populations covered by other regional recovery plans. Therefore, for purposes of this analysis, we are evaluating the effects of the action on the Pacific Recovery Area in the context that this area is essential to the survival and recovery of the bald eagle. Based on that context, this Opinion describes how the proposed action affects the condition of the bald eagle in this area.

8.1.1.2 Pacific Recovery Area

A detailed account of the taxonomy, ecology, and reproductive characteristics of the bald eagle is presented in the Pacific Bald Eagle Recovery Plan (USDI 1986), the final rule to reclassify the bald eagle from endangered to threatened in all of the lower 48 states (59 FR 35584-35594), and the proposed rule to delist the bald eagle (64 FR 36454-36464). The most-current information regarding bald eagles in Washington State and a detailed description of their biology and conservation can be found in the Washington State Status Report for the Bald Eagle (Stinson et al. 2001). A summary is provided below.

The delisting goals for the Pacific Recovery Area include: 1) a minimum of 800 nesting pairs; 2) an average reproductive rate of 1.0 fledged young per occupied breeding area per year, with an average success rate for occupied breeding areas of not less than 65 percent over a 5-year period; 3) breeding

population goals attained in at least 80 percent of management zones; and 4) wintering populations that are stable or increasing (USDI 1986).

In the Pacific Recovery Area, population delisting goals have been met since 1995 (71 FR 8238-8251). According to the Pacific Bald Eagle Recovery Plan, the estimated number of nesting pairs for the entire recovery unit in 1985 was 527. However, between 1985 and 2001 the number of nesting pairs of bald eagles for this recovery unit more than tripled, totaling 1,627 nesting pairs. The number of nesting pairs exceeded the recovery goal of 800 in 1990, and has continued to increase. Productivity has averaged approximately 1.0 young per nesting pair since 1990. In 1998, six of the seven Pacific Region States reported an average success rate of 75 percent. Distribution of nesting pairs among management zones was achieved in 1999, with the Olympic Peninsula and Central California Coast meeting their recovery goals. The Pacific Recovery Plan identifies 47 management zones with recovery goals identified for 37 of the zones. As of 1999, 30 of the 37 targeted management zones had met their goals, or 81 percent of the zones. Of the 30 zones where target levels have been met, at least 11 have more than doubled the established objective. At least three zones where no targets were set have one or more nesting pairs of bald eagles. Data indicate that the objective of stable to increasing trends in wintering populations of bald eagles has been attained on the average for the recovery region (71 FR 8238-8251).

Wintering populations have been tracked in the Pacific and many other States using the mid-winter bald eagle surveys. Wintering populations are difficult to assess because bald eagle concentrations depend upon weather and food supply and consequently will vary from year to year. With these constraints, the information suggests that Washington, Oregon, Idaho, and California have experienced an increasing trend in wintering populations of 1.5 to 4.5 percent, while Nevada and Montana report a decline of about 2.5 percent for 1986-2000. As of 2002, the Pacific Coast Region's counts increased at 1.6 percent per year, and the Great Basin counts increased 1.3 percent per year (71 FR 8238-8251).

Of the seven states covered in the Pacific Recovery Area, Washington State supports the largest breeding and wintering populations (USDI 1986). Most nesting territories in Washington are located on the San Juan Islands, along the coastline of the Olympic Peninsula, along the Straits of Juan de Fuca, Puget Sound, Hood Canal, and the Columbia River. Wintering concentration areas in Washington are along salmon spawning streams and waterfowl wintering areas (Stinson et al. 2001). Stinson et al. (2001) indicated that wintering bald eagle populations are increasing in Washington.

8.1.1.3 Conservation Needs of the Bald Eagle in the Pacific Recovery Area

Habitat

Nesting and wintering habitats are critical to the continued survival of the bald eagle (64 FR 36454-36464). Development-related habitat loss has been a significant threat to bald eagles in the Pacific Recovery Area of Washington, Idaho, Nevada, California, Oregon, Montana, and Wyoming (59 FR 35584-35594), although availability of habitat does not appear to be limiting bald eagle populations at this time (64 FR 36454-36464). Urban and recreational development, logging, mineral exploration and extraction, and other forms of human activities can adversely affect the suitability of breeding, wintering, and foraging habitat. While individual and small-scale actions may not appear to significantly affect the species as a whole, the cumulative long-term effects throughout the recovery area pose an important threat to the recovery of the species (64 FR 36454-36464).

Availability of suitable trees for nesting and perching is critical for maintaining bald eagle populations. The primary objective of the bald eagle recovery process is to provide secure habitat for bald eagles

within the recovery area, and to increase population levels in specific geographic areas to the extent that the species can be delisted. Achieving the recovery goal of increasing the number of nesting pairs within the recovery area requires protection of existing habitat for breeding and wintering bald eagles, and restoring habitat that has been lost due to development or habitat modification.

Nesting Habitat

Suitable habitat for bald eagles is characterized by accessible foraging areas and trees that are large enough for nesting and roosting (Stalmaster 1987). Food availability, such as aggregations of waterfowl or salmon runs, is a primary factor attracting bald eagles to wintering areas and influences nest and territory distribution (Stalmaster 1987; Keister et al. 1987).

Bald eagles generally nest in the same territories each year and often use the same nest repeatedly, although alternate nests in the territory may be used as well. Bald eagle nests in the Pacific Recovery Area are usually located in uneven-age stands of coniferous trees with old-growth forest components (USDI 1986) that are located within 1 mile of large bodies of water (Stalmaster 1987). Several factors, such as relative tree height, diameter, tree species, form, position on the surrounding topography, distance from the water, and distance from disturbance, influence nest site selection. Anthony and Isaacs (1989) found that bald eagles construct nests in Douglas-fir (*Pseudotsuga menziesii*) or Sitka spruce *(Picea sitchensis*) trees with an average diameter of 170.7 centimeter diameter at breast height and a height of 185.7 feet (56.6 meters) in Douglas-fir forests, and an average diameter of 67.2 inches (106.8 centimeters) diameter at breast height and a height of 126.6 feet (38.6 meters) in mixed-conifer forests. Suitable perch trees, which bald eagles use for guarding the nest, loafing, and foraging, are also a component of suitable nesting habitat (Stalmaster 1987; Buehler 2000a).

Wintering Habitat

Wintering bald eagles typically congregate in large aggregations where, most importantly, food is abundant (see Foraging section below). Suitable perch sites adjacent to foraging areas and winter roost habitat are also necessary. In Washington, these criteria are typically met where waterfowl and salmon populations are present, as well as in marine areas (Stinson et al. 2001).

When foraging, bald eagles select perches that provide an unobstructed view of the surrounding area, generally the tallest trees in the area. Tree species commonly used in Washington for winter perching include black cottonwood (*Populus trichocarpa*), bigleaf maple (*Acer macrophyllum*), Douglas-fir, or Sitka spruce (Stalmaster and Newman 1979).

Wintering bald eagles often roost at communal sites, which provide shelter during inclement weather. Bald eagles may roost communally in single trees or large forest stands of uneven ages. Bald eagles may remain at their daytime perches throughout the night, but typically gather at large communal roosts in the evening.

Communal night roosting sites are traditionally used year after year. Roost trees are usually the largest and have the most-open structure (Keister and Anthony 1983; Watson and Pierce 1998a). They are often located in areas that provide a more-favorable microclimate during inclement weather (Keister et al. 1985; Knight et al. 1983; Watson and Pierce 1998a). Prey sources may be available in the general vicinity, but for roosting bald eagles, close proximity to food is not as critical as the need for shelter. In Washington, 26 roosts studied by Watson and Pierce (1998a) were all within 3,609 feet (1,100 meters) of

foraging areas. However, Stalmaster (1987), in reviewing a variety of studies, found that only 40 percent were within 3,280 feet (1 kilometer) of water.

Human Disturbance

Human disturbance is a continuing threat, which may increase with increasing human populations and development (64 FR 36454-36464). Bald eagles vary in their sensitivity to disturbance, but generally nest away from human disturbance (Stinson et al. 2001). Distance, duration, visibility, and position of an activity affect eagle response, with distance being the most-important factor (Grubb and King 1991; Grubb et al. 1992; Watson 2004). The response of nesting bald eagles to human activity can range from behavioral, such as flushing or reduced nest attendance, to nest failure (Fraser et al. 1985; McGarigal et al. 1991; Grubb and King 1991; Grubb et al. 1992; Anthony et al. 1995; Steidl and Anthony 1996; Watson and Pierce 1998a). Wintering bald eagles may also be displaced from foraging areas by human activities (Stalmaster and Newman 1978; Stalmaster and Kaiser 1998). The magnitude of response varies inversely with distance, and increases with duration of disturbance, the number of vehicles or pedestrians per event, visibility, sound, and position in relation to nest (e.g., above, at eye-level, or below the nest) (Grubb and King 1991; Watson 2004). Watson and Pierce (1998a) found that vegetative screening and distance were the two most-important factors determining the impact of disturbances. Effective vegetative screening can dramatically reduce bald eagle response to human activity. Human activities that are distant, quiet, of short duration, out of sight, few in number, and below the nest have the least impact (Grubb and King 1991; Watson 2004).

The effects from disturbance to nesting bald eagles vary, depending on the stage of nesting. In western Washington, most bald eagles engage in courtship behavior in January and February, and begin to incubate their eggs by the third week in March. Young eagles hatch by late April, and generally fledge during early to mid-July (Watson and Pierce 1998a). Adult, parent eagles are very protective of their nest and subsequent eggs and eaglets. However, adults are able to spend time increasing time off the nest as the time from incubation to brooding progresses, (Watson and Pierce 1998a), and the eaglets began to thermoregulate at the age of 15 days (Bortolotti 1984). This indicates that eaglets would be less affected by disruption of adult nest attendance as the nesting season progresses.

Contaminants

Contaminants, in particular organochlorine compounds such as the pesticide DDT, are recognized as one of the primary causes of the decline of bald eagle populations (USDI 1986, 1999). DDT was banned, and registrations cancelled for other toxic persistent chemicals such as dieldrin, heptachlor, and chlordane for all but the most-restricted uses. The use of PCBs (Polychlorinated Biphenyls) also has been phased out. The reduction of these chemicals in the environment has resulted in a reduction of these levels of contaminants in bald eagles and a steady increase in bald eagle numbers (Schmitt and Bunck 1995). However, residues of PCBs and dichloro-diphenylethylene continue to depress productivity in certain locations such as the Channel Islands in California, the Great Lakes, and the Lower Columbia River (64 FR 36454-36464). Bald eagles continue to be affected by accumulated chemicals such as mercury (64 FR 36454-36464), and poisoned by lead, organophosphorus, and carbamate (Franson et al. 1995).

Foraging

An important component of bald eagle nesting and wintering habitat is a consistent source of food. Fish and waterfowl are typically the most-important food resources for bald eagles (Stalmaster 1987). Coastal and estuarine areas provide abundant prey resources, including seabirds and marine invertebrates (e.g.,

crabs and shellfish) (Watson et al. 1991; Watson and Pierce 1998b). The availability of food resources is critical during brood rearing, when food limits survival of young (Stalmaster 1987).

Food resources govern the distribution of bald eagles in the winter. In Washington, salmon carcasses, particularly those of chum salmon (*Oncorhynchus keta*), are the most important food source (Watson and Pierce 2001). Because survival of bald eagles in their first year is typically low (Stalmaster 1987), winter food availability is important for survival. Stalmaster and Kaiser (1998) and Hansen and Hodges (1985) also have suggested that winter food shortages or disrupted winter foraging may result in reduced reproductive rates.

8.1.1.4 Summary of Bald Eagle Status in the Pacific Recovery Area

Current data indicate that the bald eagle population in the Pacific Recovery Area continues to increase, and recovery objectives have been met. The recovery of the bald eagle is due in part to habitat protection and management actions, and the reduction in levels of persistent organochlorine pesticides (such as DDT) occurring in the environment. Due to the achievement of recovery goals throughout the lower 48 States, the bald eagle is currently proposed for delisting under the ESA (71 FR 8238-8251).

8.1.2 ENVIRONMENTAL BASELINE: Bald Eagle

8.1.2.1 Analysis Methods

We used GIS to estimate the number of bald eagle nest sites and communal roost sites that are located on or adjacent to FPHCP covered lands. Bald eagle sites are based on point locations documented in the WDFW Priority Habitats and Species database. Based on management recommendations listed in the Pacific Bald Eagle Recovery Plan (USDI 1986), we selected 0.5 mile and 0.25 mile radius circles to identify the number of bald eagle sites that may be affected by FPHCP covered activities. We used maps of spotted owl habitat developed by Davis and Lint (2005) to evaluate the amount of mature conifer habitat in riparian zones, and timber harvest information was derived from Healey et al. (2003). The GIS map data used in this analysis are derived from satellite imagery. The GIS values presented in the following analyses are estimates only, and are not intended to be interpreted as absolute values. It is important to note that all values reported here are general estimates based on our interpretation of the GIS data. (For more information on the FWS's GIS analysis used to derive these estimates, refer to the GIS memo in the administrative record for this Opinion).

8.1.2.2 Bald Eagles in Washington

Bald eagles can be found in all the forested parts of Washington throughout the year, but they are substantially more abundant in the coastal regions. Nearly 40 percent of bald eagle nest sites in Washington are located in the San Juan, Soleduc, Island, and Kitsap WRIAs (Table 8-1). In Washington, nearly all bald eagle nests are located within 1 mile of a lake, river, or marine shoreline, and most are within 450 to 1,000 feet of the shore (mean = 635 feet from water) (Stinson et al. 2001). The seasonal home range that contains the foraging and nesting habitat of a pair averages about 2.6 square miles in the Puget Sound region, and about 8.5 square miles in the Columbia River estuary (Stinson et al. 2001). Core use areas (which include the nest tree, key perch trees, and the most frequently used foraging perches) and lengths of shoreline used by bald eagles are much smaller, averaging about 0.73 square miles and 2.36 miles, respectively, within 55 Puget Sound territories (Watson and Pierce 1998a). Territories vary in size depending upon habitat types, with progressively larger ranges found on lakes, rocky marine shorelines,

rivers, and marine embayments. Important habitats in bald eagle territories are riparian areas along rivers, streams, lakes, sloughs, and reservoirs; coastal estuaries and beaches; freshwater beaches; and mature and old-growth forest within 1 mile of shorelines.

Watson et al. (2002) determined that the nesting bald eagle population in Washington during the period from 1980 through 1998 had increased at an exponential, annual rate of 10 percent as adult eagles have reoccupied habitat vacated during the period of widespread persecution and DDT use. Productivity and nest success of bald eagles affected by contaminants along Hood Canal and the Columbia River estuary also increased during the study period, and by 1998, the bald eagle population was widely distributed across the State and there were indicators that the population had stabilized (Watson et al. 2002).

There are currently 2,057 documented bald eagle nest locations in Washington (WDFW 2005b). Not all nest locations are likely to be currently occupied, because many bald eagle territories have multiple nest sites. Other nest sites may no longer exist due to blowdown, decay, or other causes, although these sites may not yet have been removed from the WDFW database that tracks nest sites and wintering areas. In 1998, WDFW estimated there were 664 occupied nests in the State, with a wintering population of 3,500 to 4,000 bald eagles (Stinson et al. 2001). Population modeling completed by Watson et al. (2002) indicated an ecological carrying capacity of 733 breeding pairs in Washington, suggesting the available habitat in Washington may be nearing saturation. The breeding population of bald eagles in Washington has increased steadily in the past 20 years, two-thirds of the nest sites are located on private lands. Only about 10 percent of bald eagle nests are on lands where their habitat could be considered secure in the absence of habitat protection rules (i.e., National Parks, Wildlife Refuges, etc.).

8.1.2.3 Bald Eagles on FPHCP Covered Lands

Of the 2,057 bald eagle nest sites documented in Washington, 1,068 sites are located on FPHCP lands (52 percent) and 1,778 sites (86 percent) are located within 0.5 miles of FPHCP covered lands. Of the 272 communal roost sites in Washington, 211 sites (78 percent) occur within 0.25 miles of FPHCP covered lands (Table 8-1). Relatively few bald eagle nest sites (n = 93, or 4 percent) are located in the FPHCP RMZs along Type S or Type F streams. The majority of bald eagle nest sites are either located along marine shorelines, or are located farther than 150 to 200 feet from rivers or streams beyond RMZs.

Only about seven percent of bald eagle nest sites are located in eastern Washington, and these occur primarily in the Middle Lake Roosevelt, Pend Oreille, and Okanagon WRIAs. Of the 145 bald eagle nest sites in eastern Washington, only 29 sites (20 percent) are located on FPHCP covered lands. However, about 74 percent of the nest sites (n = 107) are located within 0.5 miles of FPHCP covered lands, and therefore may be influenced or directly affected by FPHCP covered activities (Table 8-1).

Table 8-1. Summary of bald eagle nests and communal roosts on FPHCP lands in western Washington, ordered by WRIAs with the highest number of nest sites.

WRIA Number	WRIA Name	Total Bald Eagle Nest Sites by WRIA	Percent of WA Bald Eagle Nest Sites in WRIA	Bald Eagle Nest Sites Located on FPHCP Lands	Percent of Bald Eagle Nest Sites Located on FPHCP Lands	Bald Eagle Nest Sites located within 0.5 miles of FPHCP Lands	Percent of Bald Eagle Nest Sites located within 0.5 miles of FPHCP Lands	Bald Eagle Nest Sites located within 0.25 miles of FPHCP Lands	Percent of Bald Eagle Nest Sites located within 0.25 miles of FPHCP Lands	Number of Nest Sites that have had timber harvested within 0.25 miles of nest (1992-2003)	Percent of Nest Sites that have had timber harvested within 0.25 miles of nest (1992-2003)	Total Bald Eagle Roost Sites by WRIA	Bald Eagle Roost Sites located within 0.25 miles of FPHCP Lands	Percent Bald Eagle Roost Sites located within 0.25 miles of FPHCP Lands
2	San Juan	266	13%	180	68%	262	98%	249	94%	9	3%	1	1	100%
20	Soleduc	204	10%	29	14%	99	49%	84	41%	32	16%	-	-	-
6	Island	163	8%	123	75%	158	97%	145	89%	13	8%	1	-	-
15	Kitsap	158	8%	115	73%	149	94%	142	90%	19	12%	-	-	-
17	Quilcene-Snow	128	6%	76	59%	116	91%	108	84%	14	11%	2	1	50%
3	Lower Skagit / Samish	115	6%	67	58%	109	95%	97	84%	14	12%	16	15	94%
19	Lyre-Hoko	111	5%	59	53%	102	92%	89	80%	25	23%	1	1	100%
1	Nooksack	102	5%	35	34%	90	88%	75	74%	13	13%	54	44	81%
21	Queets-Quinault	73	4%	4	5%	19	26%	13	18%	23	32%	2	1	50%
8	Cedar-Sammamish	56	3%	39	70%	56	100%	56	100%	1	2%	-	-	-
25	Grays/Elochoman	54	3%	39	72%	52	96%	49	91%	13	24%	1	1	100%
24	Willapa	51	2%	25	49%	51	100%	43	84%	8	16%	-	-	-
26	Cowlitz	50	2%	43	86%	50	100%	50	100%	26	52%	1	1	100%
7	Snohomish	46	2%	21	46%	38	83%	35	76%	4	9%	18	17	94%
18	Elwha-Dungeness	42	2%	24	57%	42	100%	41	98%	1	2%	-	-	-
22	Lower Chehalis	40	2%	16	40%	39	98%	38	95%	10	25%	-	-	-
27	Lewis	31	2%	18	58%	31	100%	31	100%	2	6%	20	15	75%
14	Kennedy-Goldsborough	27	1%	17	63%	25	93%	23	85%	9	33%	6	6	100%
28	Salmon-Washougal	27	1%	11	41%	27	100%	22	81%	1	4%	1	1	100%

Table 8-1. Summary of bald eagle nests and communal roosts on FPHCP lands in western Washington, ordered by WRIAs with the highest number of nest sites (continued)

WRIA Number	WRIA Name	Total Bald Eagle Nest Sites by WRIA	Percent of WA Bald Eagle Nest Sites in WRIA	Bald Eagle Nest Sites Located on FPHCP Lands	Percent of Bald Eagle Nest Sites Located on FPHCP Lands	Bald Eagle Nest Sites located within 0.5 miles of FPHCP Lands	Percent of Bald Eagle Nest Sites located within 0.5 miles of FPHCP Lands	Bald Eagle Nest Sites located within 0.25 miles of FPHCP Lands	Percent of Bald Eagle Nest Sites located within 0.25 miles of FPHCP Lands	Number of Nest Sites that have had timber harvested within 0.25 miles of nest (1992-2003)	Percent of Nest Sites that have had timber harvested within 0.25 miles of nest (1992-2003)	Total Bald Eagle Roost Sites by WRIA	Bald Eagle Roost Sites located within 0.25 miles of FPHCP Lands	Percent Bald Eagle Roost Sites located within 0.25 miles of FPHCP Lands
11	Nisqually	22	1%	11	50%	19	86%	17	77%	6	27%	1	1	100%
13	Deschutes	22	1%	14	64%	22	100%	19	86%	5	23%	-	-	-
16	Skokomish-Dosewallips	22	1%	20	91%	22	100%	21	95%	19	86%	8	5	63%
12	Chambers-Clover	21	1%	10	48%	21	100%	21	100%	2	10%	-	-	-
5	Stillaguamish	19	1%	9	47%	18	95%	17	89%	2	11%	23	17	74%
23	Upper Chehalis	19	1%	9	47%	19	100%	16	84%	2	11%	-	-	-
4	Upper Skagit	14	1%	9	64%	9	64%	9	64%	4	29%	59	53	90%
10	Puyallup-White	14	1%	7	50%	13	93%	13	93%	3	21%	1	1	100%
9	Duwamish-Green	12	1%	7	58%	11	92%	11	92%	2	17%	-	-	-
29	Wind-White Salmon	3	<1%	2	67%	2	67%	2	67%	-	-	5	5	100%
	Westside Subtotals	1,912	93%	1,039	54%	1,671	87%	1,536	80%	282	15%	221	186	84%
58	Middle Lake Roosevelt	26	1%	-	-	6	23%	4	15%	Not calculated	Not calculated	1	1	100%
62	Pend Oreille	26	1%	7	27%	25	96%	24	92%	nc	nc	-	-	-
49	Okanogan	15	1%	-	-	13	87%	12	80%	nc	nc	2	1	50%
54	Lower Spokane	11	1%	5	45%	11	100%	11	100%	nc	nc	1	1	100%
59	Colville	11	1%	7	64%	9	82%	8	73%	nc	nc	-	-	-
50	Foster	8	<1%	1	13%	3	38%	3	38%	nc	nc	4	2	50%
53	Lower Lake Roosevelt	8	<1%	-	-	4	50%	1	13%	nc	nc	-	-	-
61	Upper Lake Roosevelt	7	<1%	5	71%	7	100%	7	100%	nc	nc	-	-	-

Table 8-1. Summary of bald eagle nests and communal roosts on FPHCP lands in western Washington, ordered by WRIAs with the highest number of nest sites (continued)

WRIA Number	WRIA Name	Total Bald Eagle Nest Sites by WRIA	Percent of WA Bald Eagle Nest Sites in WRIA	Bald Eagle Nest Sites Located on FPHCP Lands	Percent of Bald Eagle Nest Sites Located on FPHCP Lands	Bald Eagle Nest Sites located within 0.5 miles of FPHCP Lands	Percent of Bald Eagle Nest Sites located within 0.5 miles of FPHCP Lands	Bald Eagle Nest Sites located within 0.25 miles of FPHCP Lands	Percent of Bald Eagle Nest Sites located within 0.25 miles of FPHCP Lands	Number of Nest Sites that have had timber harvested within 0.25 miles of nest (1992-2003)	Percent of Nest Sites that have had timber harvested within 0.25 miles of nest (1992-2003)	Total Bald Eagle Roost Sites by WRIA	Bald Eagle Roost Sites located within 0.25 miles of FPHCP Lands	Percent Bald Eagle Roost Sites located within 0.25 miles of FPHCP Lands
42	Grand Coulee	4	<1%	-	-	4	100%	-	-	nc	nc	5	-	-
48	Methow	4	<1%	-	-	4	100%	3	75%	nc	nc	11	10	91%
60	Kettle	4	<1%	-	-	4	100%	4	100%	nc	nc	-	-	-
52	Sanpoil	3	<1%	-	-	-	-	-	-	nc	nc	-	-	-
55	Little Spokane	3	<1%	3	100%	3	100%	3	100%	nc	nc	-	-	-
57	Middle Spokane	3	<1%	1	33%	3	100%	3	100%	nc	nc	-	-	-
38	Naches	2	<1%	-	-	2	100%	1	50%	nc	nc	-	-	-
39	Upper Yakima	2	<1%	-	-	2	100%	2	100%	nc	nc	1	1	100%
45	Wenatchee	2	<1%	-	-	2	100%	2	100%	nc	nc	-	-	-
30	Klickitat	1	<1%	-	-	1	100%	-	-	nc	nc	6	6	100%
34	Palouse	1	<1%	-	-	1	100%	1	100%	nc	nc	-	-	-
36	Esquatzel Coulee	1	<1%	-	-	-	-	-	-	nc	nc	-	-	-
37	Lower Yakima	1	<1%	-	-	1	100%	1	100%	nc	nc	1	1	100%
40	Alkali-Squilchuck	1	<1%	-	-	1	100%	-	-	nc	nc	12	-	-
46	Entiat	1	<1%	-	-	1	100%	-	-	nc	nc	3	1	33%
	Eastside Subtotals	145	7%	29	20%	107	74%	90	62%	nc	nc	47	24	51%
	Washington Totals	2,057	100%	1,068	52%	1,778	86%	1,626	79%	nc	nc	272	211	78%

Notes: Bald eagle nest sites and communal roost site data are based on the WDFW Priority Habitats and Species database (2005b). Timber harvest information was calculated by using GIS to estimate harvest acres derived from Healey et al. (2003). The Healey et al. (2003) map data depicts stand replacing disturbance associated with timber harvest and wildfire, but does not portray changes associated with partial harvests such as commercial thinning. The values presented here are estimates only, and are not intended to be interpreted as absolute values. It is important to note that all timber harvest estimates generated from the Healey et al. (2003) data are general estimates based on our interpretation of the data.

Most bald eagle nests and communal roost sites are located in western Washington (93 percent). Of these, about 87 percent of bald eagle nest sites and 84 percent of communal roost sites are located within 0.5 miles and 0.25 miles of FPHCP covered lands, respectively. Due to their close proximity to FPHCP lands, bald eagle territories associated with these sites are likely to be influenced or affected by forest practice activities. On the over 6 million acres of FPHCP covered lands in western Washington, there are over 13,000 miles of fish-bearing streams that are potentially important for bald eagle foraging habitat. FPHCP RMZs in this part of the State represent about 13 percent of the total FPHCP acres (Table 8-2). Due to a legacy of past timber harvest, and a predominance of broadleaf forests in some riparian areas, there is relatively little mature conifer or old-forest habitat in the FPHCP RMZs. On average, about 6 percent of RMZ areas are forested with mature conifer habitat (Table 8-2). The paucity of large conifers in the FPHCP RMZs suggests that high-quality nesting sites immediately adjacent to rivers and streams are limited to a relatively small percentage of the current landscape.

Table 8-2. Mature and old-forest habitat in FPHCP riparian management zones (RMZs) in western Washington

PhysiographicProvince	Total FPHCP Acres in Province	Total RMZ Acres on FPHCP Lands	% of Acres on FPHCP Lands in RMZs	Total Mature/Old-Forest Acres in RMZs on FPHCP Lands	% of RMZ area with Mature/Old-Forest Acres on FPHCP Lands
Olympic Peninsula	715,300	113,000	16%	4,200	4%
Western Washington Lowlands	3,941,200	507,200	13%	23,200	5%
Western Washington Cascades	1,430,900	193,800	14%	20,100	10%
Western Washington Totals	**6,087,400**	**814,000**	**13%**	**47,500**	**6%**

Notes: All figures are approximate values derived from GIS data. Mature/old-forest estimates are based on suitable spotted owl habitat maps developed by Davis and Lint (2005) and account for stand-replacing timber harvest and fire losses that occurred from 1992 to 2002 (Healey et al. 2003). Riparian areas include average RMZ widths along Type S, F, and Np streams based on the average 100-year site-potential tree height for site index 2 and 3.

8.1.2.4 Bald Eagle Management Plans

Washington State's bald eagle protection rules of 1986 (WAC 232-12-292) established a legal requirement for private, State, and municipal landowners to reach agreement with WDFW on measures to protect breeding and roosting habitat. These rules are the most important mechanism for the protection of habitat on private lands in Washington (Stinson et al. 2001). Each site-management plan is based on the unique characteristics of individual bald eagles and their territories. Bald eagle management plans under these rules seek to protect nesting and roosting eagles from disturbance, and preserve habitat by protecting large nest, perch, and roost trees, as well as protecting trees that provide a visual screen and windthrow buffers adjacent to nest sites.

As of 2001, over 1,100 bald eagle management plans had been signed by Washington landowners since 1986 (Stinson et al. 2001). About 72 percent of these plans were for residential developments, and 23 percent were for forest practice activities. These management plans represented agreements for 393

discrete bald eagle sites, indicating multiple plans may be developed for a single eagle territory depending on landownership and types of activities. Management plans have been useful, but are not perfect habitat protection because they involve compromises between landowner goals and bald eagle needs. Because each plan is developed for an individual landowner, the plans do not represent comprehensive territory management plans, and each plan is subject to amendments depending upon landowner needs and bald eagle occupancy. The rules do not protect habitat that is not currently occupied by bald eagles. Residential development along the shorelines of Puget Sound is considered to be the most-significant threat to bald eagle habitat in Washington (Stinson et al. 2001).

The FWS generally does not participate in or have oversight in the development of bald eagle management plans. However, the FWS does review many Federal activities in Washington that deal primarily with transportation projects and/or and actions authorized through Army Corps of Engineers permits. For the 5-year period from 2000 to 2004, the FWS completed over 1,800 consultations considering effects to bald eagles, including 40 consultations that documented adverse effects associated with nesting disturbance or loss of habitat. Although there has been some loss of bald eagle habitat associated with these actions, the majority of these activities (98 percent) have had only minor effects to bald eagles, due to the use of seasonal restrictions that minimize disturbance to nesting or roosting bald eagles.

In addition to the bald eagle management plans described above, activities must be in compliance with the Migratory Bird Treaty Act of 1918, as amended (16 U.S.C. §§703-712); the Bald and Golden Eagle Protection Act of 1940, as amended (16 U.S.C. §§668-668d); and other applicable rules and regulations, such as the Washington State Shoreline Management Act discussed below.

Washington Forest Practices Rules and Shoreline Management Act

Under the Washington Forest Practices Rules (WAC 222-16-080), certain activities are considered Class-IV Special activities. These activities include timber harvesting, road construction, aerial application of pesticides, or site preparation within 0.5 miles of a known active nest site documented by WDFW between the dates of January 1 and August 15 (or 0.25 miles at other times of the year) and within 0.25 miles of communal roost sites. These rules are designed to protect nesting bald eagles from disturbance during the nesting season, but do not necessarily preclude timber harvest within the nesting territory. A review of timber harvest in western Washington from the period from 1992 to 2002 indicates that 282 bald eagle nest sites (15 percent) have had clearcut timber harvest located within 0.25 miles of the nest site (Table 8-3). Under the bald eagle protection rules, landowners that intend to harvest timber near a bald eagle nest are required to work with WDFW to develop a bald eagle management plan for the area surrounding the nest. Upon completion of such a plan with WDFW (WAC 222-16-080 (6)(d)), a landowner is then exempt from the Class IV special rules if the landowners activities are consistent with the bald eagle management plan.

The Shoreline Management Act also provides some protection for bald eagle habitat along major rivers, lakes, and marine shorelines. The current regulation restricts timber harvest to 30 percent of the volume of timber every 10 years within a buffer that extends 200 feet from the “shorelines of statewide significance.” These shoreline areas provide important perching and roosting habitat for bald eagles, particularly along the marine shorelines of Puget Sound. However, if the land within the shoreline buffers is converted to non-forestry uses (such as residential development), the timber can be clearcut (unless restricted by other regulations) (Stinson et al. 2001). Counties have the discretion to create their own shoreline management guidelines for residential areas that supersede the State’s shoreline rules. These

guidelines may be more or less restrictive than the State's shoreline rules, and many counties now use an abbreviated bald eagle management plan template developed by WDFW that is tailored for residential developments (Stinson et al. 2001). Conversion information available from WDNR's forest practice applications database indicates that 53,821 acres of forestland were converted to other uses between 1997 and 2003, with an average of 7,687 acres per year statewide (USFWS and NMFS 2005:3-20). The rate at which timber lands are being converted to non-forestry uses in the shoreline areas is unknown, but only about one percent of bald eagle management plans reviewed were for this type of activity. Residential developments located primarily in Island, Kitsap, and San Juan Counties accounted for over 70 percent of bald eagle site-management plans (Stinson et al. 2001).

Table 8-3. Changes to NRF[1] habitat acres from activities subject to ESA section 7 consultations and other causes range-wide from May 1994 to April 2004 (the first decade of the Northwest Forest Plan).

Northwest Forest Plan Group/Ownership		ESA Section 7 Consultation Habitat Changes[2]		Other Habitat Changes[3]	
		Removed/ Downgraded	**Degraded**	**Removed/ Downgraded**	**Degraded**
Federal -Northwest Forest Plan	Bureau of Land Management	61,015	8,627	760	0
	Forest Service	88,650	414,868	11,557	5,109
	National Park Service	908	2,861	0	0
	Multi-agency[4]	15,175	23,314	0	0
	NWFP Subtotal	165,748	449,670	12,317	5,109
Other Management and Conservation Plans (OMCP)	Bureau of Indian Affairs and Tribes	99,062	27,890	0	0
	Habitat Conservation Plans	295,889	14,430	0	0
	OMCP Subtotal	394,951	42,320	0	0
Other Federal Agencies & Lands[5]		241	1	28	70
Other Public & Private Lands[6]		10,323	878	30,240	20,949
TOTAL Changes		**571,263**	**492,869**	**42,585**	**26,128**

Source: Table A from the FWS Northern Spotted Owl Consultation Effects Tracker (web application and database) Feb. 23, 2006.

1 Nesting, roosting, foraging habitat. In California, suitable habitat is divided into two components; nesting – roosting (NR) habitat, and foraging (F) habitat. The NR component most closely resembles NRF habitat in Oregon and Washington. Due to differences in reporting methods, effects to suitable habitat compiled in this, and all subsequent tables include effects for nesting, roosting, and foraging (NRF) for 1994-June 26, 2001. After June 26, 2001, suitable habitat includes NRF for Washington and Oregon but only nesting and roosting (NR) for California.

2 Includes both effects reported by U.S. Fish and Wildlife Service (2001a) and subsequent effects compiled in the Northern Spotted Owl Consultation Effects Tracker (web application and database).

3 Includes effects to NRF habitat (as documented through technical assistance) resulting from wildfires (not from suppression efforts), insect and disease outbreaks, and other natural causes, private timber harvest, and land exchanges not associated with consultation. Information from all fires occurring since 1994 is not yet available for entry into the database and thus is not included here but is compiled in Table 8-6.

4 The 'Multi-agency' grouping is used to lump a variety of Northwest Forest Plan mixed agency or admin unit consultations that were reported together prior to June 26, 2001, and cannot be separated out.

5 Includes lands that are owned or managed by other Federal agencies not included in the Northwest Forest Plan.

6 Includes lands not covered by Habitat Conservation Plans that are owned or managed by states, counties, municipalities, and private entities. Effects that occurred on private lands from right-of-way permits across U.S. Forest Service and Bureau of Land Management lands are included.

8.1.2.5 Role of the Action Area in the Conservation of the Bald Eagle

The action area constitutes a large area, which is critical to the conservation of bald eagles. The FPHCP covered lands provide important breeding, feeding, and sheltering habitat for over 80 percent of the nesting and wintering bald eagles in Washington.

Existing nest sites and winter communal roost sites should receive similar protection. Overstory trees near these sites should be retained to provide wind breaks and screening from disturbances. Even old unused sites should be protected, as they may be re-used. Thinning and selective harvest can be used to help create proper tree species composition and stand structures. Thinning is needed to create tree characteristics of large well-spaced limbs. These tree characteristics cannot develop within dense stands (USDI 1986). Forest management is helpful in addressing forest health issues. Important sites should be protected from habitat loss and degradation. Disturbance surrounding these sites should be minimized, and these areas should be prioritized for fire suppression. Snags and other potential perch trees should be retained in association with nesting, roosting, perching, and foraging sites.

Foraging areas should be protected. Foraging areas are important for breeding and non-breeding individuals, as well as for wintering birds. An available supply of inland and anadromous fish is important. Helpful measures include fish habitat protection to provide a healthy population of fish, as well as limiting recreation and other disturbances to ensure the supply of fish is available to bald eagles. Water levels should be managed to maintain and restore a supply of fish. Winding and braided rivers should be preserved to ensure deep pools and open gravel bars. Stream and river channelization and levees should be discouraged. In addition, prey should be maintained. Waterfowl make up a significant portion of the bald eagles diet throughout the West. Suitable perch trees in important foraging areas should be retained and developed.

In summary, the action area is important for a variety of reasons: feeding, breeding, and sheltering; and there are a number of factors that should be addressed. These include reducing common forms of mortality and sub-lethal effects of habitat loss and disturbance.

8.1.3 EFFECTS OF THE ACTION: Bald Eagle

8.1.3.1 Summary of How the FPHCP Affects Bald Eagle Habitat

The FPHCP RMZ prescriptions in combination with the existing shoreline management rules will provide for the protection of shoreline trees along the margins of rivers, streams, lakes, marine waters, and wetlands on lands that are managed for timber production. The total RMZ width varies depending on stream type, site class, and stream width. RMZs are defined by the 100-year site-index tree-height (or 200 feet for shoreline management zones), along with any additional protected areas associated with CMZs. The Washington Forest Practices Rules for western Washington include a minimum 50-foot no-harvest buffer, and a limited entry buffer from 50 to 200 feet, from rivers and fish-bearing streams. Overall, the FWS estimates a range of 40 to 60 percent, depending on site class, of the existing trees within the RMZs that will likely be retained in the short-term to provide for the desired future condition of mature, fully stocked riparian stands over time.

The riparian buffers will be managed to retain the largest trees that are immediately adjacent to streams, rivers, and shorelines. These trees will provide potential bald eagle nesting, roosting, and perch trees. Currently, only about five to seven percent of riparian zones in the FPHCP area provide large conifer habitat. As early and mid-seral riparian areas mature over time, large trees suitable for nesting, roosting,

or perching in the FPHCP riparian zones will increase, ultimately improving bald eagle habitat conditions in the RMZs. Riparian thinning has the potential to accelerate the development of larger diameter trees and to promote the development of larger lateral branches which are important habitat features for bald eagles.

Although the development of large trees in the RMZs is expected to be beneficial to bald eagles over the long-term, these narrow shoreline strips of trees do not protect all forested areas that are important for eagles. In Washington, only about 35 percent of bald eagle nests are located within 200 feet of a shoreline (Stinson et al. 2001). The other 65 percent of nest sites are located more than 200 feet from shore. In the absence of an active nest site or a communal roost, there are no provisions in the FPHCP to protect bald eagle habitat beyond the RMZ, or beyond the core use areas protected by bald eagle management plans under the Washington Forest Practices Rules.

Potential bald eagle habitat that is currently unoccupied may be harvested in upland areas and in riparian areas. Only a small portion of this harvest (i.e., Inner and Outer Zone RMZ harvest) is considered an effect of the proposed Permit issuance. Retention of habitat within the RMZ would also be considered an effect of the proposed Permit issuance. Where thinnings are conducted, there would likely be long-term benefits derived for bald eagles as a result of retention of the largest trees and providing for the growth of lateral branches. In many cases, the thinnings will retain too many trees for the realized benefits to be dramatic.

Under the Migratory Bird Treaty Act and the Bald and Golden Eagle Protection Act, take includes a variety of actions, but does not provide protection from the harvest or degradation of unoccupied habitat. Also, the ESA does not protect the harvest or degradation of unoccupied habitat. Therefore, the effects discussed above would be “otherwise lawful” so long as they do not violate other State or local laws.

8.1.3.2 Effects of the FPHCP to Bald Eagle Nesting Territories

Over 50 percent (1,068 sites) of the documented bald eagle nests sites in Washington are located on FPHCP covered lands, and about 86 percent (1,778 sites) of nest sites are located within 0.5 miles of FPHCP covered lands (Table 8-1) and are, therefore, likely to be affected or influenced by FPHCP activities. We expect landowners on FPHCP covered lands will continue to work with WDFW to develop bald eagle management plans for any forest practices activities that occur within a 0.5-mile radius of occupied bald eagle nest sites. We expect that activities conducted according to such plans will comport with applicable Federal laws, including the Migratory Bird Treaty Act, Bald and Golden Eagle Protection Act, and the ESA. In a recent review cited by Stinson et al. (2001), nearly all bald eagle management plans (97 percent) assigned habitat protection or a combination of habitat protection and timing restrictions to avoid disturbance to nesting bald eagles. The remaining three percent involved only timing restrictions and were typically for forest practice activities. In bald eagle plans prescribing habitat protection measures, four general types of vegetation management strategies were employed, often in combination: no-cut buffers, partial retention of trees, large-tree retention, and tree planting. Partial retention strategies were most frequently used for habitat protection, appearing in 76 percent of bald eagle plans.

Bald eagle management plans are designed to protect the nest tree and provide screening vegetation surrounding the nest tree. Management plans may also provide for the protection of prominent perch trees along shoreline areas adjacent to the nest tree. These plans do not employ set buffer distances that protect all trees within a certain distance from the nest or roost site. The FPHCP will complement the bald eagle site plans by providing for the protection of existing riparian trees, and allowing for the

development of large riparian trees over time both within existing territories, and along all forest shorelines managed for timber production. The bald eagle site plans are designed to protect nesting bald eagles from disturbance in close proximity to the nest during the nesting season, but do not necessarily preclude timber harvest within the nesting territory. A review of timber harvested in western Washington from the period 1992 to 2002 indicates that 282 bald eagle nest sites (15 percent) have had clearcut timber harvest (greater than 1 acre) located within 0.25 miles of the nest site (Table 8-1).

Stinson et al. (2001) provides a review of the effects of habitat alteration and human disturbance to nesting bald eagles. This review indicates that bald eagle pairs vary widely in their response to disturbance depending on previous nesting history, the birds' previous experience with humans, the availability of alternative nest sites, and the amount of development in the area. Assuming the presence of an adequate food supply, the most important factor associated with bald eagle nest locations and success is the presence of large, super-dominant trees (Watson and Pierce 1998a). Timber harvest that results in a loss of nest trees or potential nesting habitat, or prevents trees from attaining the size capable of supporting a nest, reduces the capability of the landscape to support bald eagle nesting territories (Stinson et al. 2001).

Anthony and Isaacs (1989) recommended a 1,312 foot- (400 meter) primary buffer zone around nests to minimize vulnerability of the nest area to blowdown from wind, fire, or insect and disease damage. Anthony and Isaacs' (1989) findings suggested that forest practices (timber harvest and road construction) and associated human activities within 1,312 feet (400 meters) of bald eagle nests were correlated with reduced productivity and reproductive success. Although timber harvest can result in the loss of trees that would otherwise be used by bald eagles, nest productivity and reproductive success is not clearly affected by the loss of a few trees within the territory (Watson and Pierce 1998a). In their study of bald eagles in the Puget Sound area, Watson and Pierce (1998a) concluded that optimal habitat management for bald eagle nest sites would protect habitat within 1,969 feet (600 meters) of the nest site, protect shoreline trees within 4,921 feet (1.5 kilometers) along each shoreline from the nest, and avoid activities within 1,312 feet (400 meters) of the nest during the nesting season to protect bald eagles from potentially adverse effects associated with increased flushing, reduced incubation time, and reduced feeding of eaglets.

We expect that activities implemented under the FPHCP would not remove occupied bald eagle nest trees or important perch trees within the core-use areas of occupied bald eagle territories. If such activities were conducted, they would violate the Washington Forest Practices Rules for bald eagle protection. Further, the Migratory Bird Treaty Act of 1918, as amended (16 U.S.C. §§703-712), and the Bald and Golden Eagle Protection Act of 1940, as amended (16 U.S.C. §§668-668d) protect bald eagle nests. Other potential nest and perch trees could be harvested from within active bald eagle territories, leading to eagle avoidance of portions of their territories while timber harvest or road construction activities are underway. Bald eagle nesting territories often encompass several miles of shoreline habitat. Watson and Pierce (1998a) reported that bald eagle core-use areas average 0.73 square miles and the length of shoreline used averaged 2.36 miles in the Puget Sound area. Under the Washington Forest Practices Rules, timber harvesting and road construction within 0.5 miles of a bald eagle nest during the bald eagle nesting season is considered a Class IV-Special activity (WAC 222-16-080). Therefore, we expect that most forest practices activities within a 0.5-mile radius of the nest site would be restricted to the months outside of the bald eagle nesting season (i.e., September through December). This would preclude disturbance to nesting bald eagles in the core-use area surrounding the nest tree, but would not necessarily protect all important perch trees within nesting territories, or provide for the protection and development

of bald eagle habitat beyond the RMZ areas. Nest trees or territories that are vacated by bald eagles for more than five years may also be harvested.

With implementation of the FPHCP, no fewer nesting bald eagles are expected on FPHCP covered lands than currently nest on these lands for the following reasons. We expect that the requirement for bald eagle management plans will adequately protect existing sites and that management of riparian areas will provide potential future habitat. The FPHCP should also protect key habitat for forage species such as fish and waterfowl, to the degree that such habitats are subject to forest practices jurisdiction. There may be additional bald eagle nesting habitat produced as the FPHCP would provide for growth of riparian areas in conjunction with some active management. However, in areas where numbers of bald eagles are limited by spacing of territories or through non-habitat-related mechanisms, there may be no additional territories or nesting sites established. The FPHCP would provide for opportunities on the landscape for bald eagles to feed, breed, and shelter and the FPHCP would not contribute to the negative effects causing the types of mortality (e.g., shooting, trapping, poisons, electrocution, etc.) discussed earlier. Because the conservation role of the action area would be maintained or enhanced by the FPHCP, we believe the few negative effects (e.g., removal of potential, unoccupied nest trees or perch trees) that may result from the proposed FPHCP would not degrade the existing bald eagle population.

We do not anticipate biological effects to bald eagles caused by this action that would result in take. Actions that would result in take (e.g., harvest of active, occupied nest trees) are not authorized by the Permit. Activities that would result in take of bald eagles would invalidate the proposed Permit with respect to covered species.

8.1.3.3 Effects to Wintering Bald Eagle Communal Roost Sites

About 78 percent (211 sites) of communal roost sites in Washington are located within 0.25 miles of FPHCP covered lands (Table 8-1) and are, therefore, likely to be affected or influenced by FPHCP activities. The FWS anticipates that covered activities implemented under the FPHCP would not remove stands that provide communal bald eagle roost sites. Other trees that could provide potential roosting habitat, or provide buffers to adjacent roosting stands could be harvested in close proximity to active roost sites. Over 80 percent of roost-management plans developed in Washington were for forest practices activities, and the majority of these plans used no-harvest or partial-retention buffers to protect bald eagle roosting habitat (Stinson et al. 2001). These plans protect habitat within and immediately adjacent to the roost sites, but do not necessarily protect all of the surrounding forest that contributes to the integrity of the roosting habitat.

Communal roost sites in Washington vary in size (less than 5 acres to greater than 70 acres), are typically located near important foraging areas, and provide some protection from prevailing winds (Watson and Pierce 1998a). Clearcut timber harvest and heavy thinning associated with upland timber harvest can create abrupt forest edges along the FPHCP RMZs. Exposed areas associated with clearcut edges are likely to have increased levels of blowdown and wind damage compared with a contiguous forest stand. This may result in the loss of additional trees in FPHCP RMZs, thereby further reducing the quantity and quality of suitable bald eagle habitat in these areas. The harvest of tree buffers around roost sites, or the loss of roost trees or stands to timber harvest may increase the exposure of wintering bald eagles to inclement weather, potentially affecting the health of wintering bald eagles. The FPHCP will generally complement the roost-management plans by providing for the protection of existing riparian trees, and allowing for the development of large riparian trees over time both within existing roost areas, and along all forested shorelines managed for timber production.

With implementation of the FPHCP, no fewer wintering bald eagles are expected on FPHCP covered lands than currently winter on these lands for the following reasons. We expect that the requirement for bald eagle management plans will adequately protect existing communal roost sites and that management of riparian areas will provide potential future habitat. The FPHCP is expected to protect key habitat for forage species such as fish and waterfowl, to the degree that such habitats are subject to forest practices jurisdiction. There may be additional communal roost sites as the FPHCP would provide for growth of riparian areas in conjunction with some active management. The FPHCP would provide for opportunities on the landscape for wintering bald eagles to feed and shelter, and the FPHCP would not contribute to mortality. Because the conservation role of the action area would be maintained or enhanced, we believe the few negative effects (e.g., loss of potential, unoccupied nest trees and perch trees) that may result from the FPHCP would not degrade the current bald eagle population.

We do not anticipate biological effects to bald eagles caused by this action that would result in take. Actions that would result in take of wintering bald eagles are not authorized by the Permit. Activities that would result in take of wintering bald eagles would invalidate the proposed Permit with respect to covered species.

8.1.4 CUMULATIVE EFFECTS: Bald Eagle

Cumulative effects include the effects of future State, Tribal, local, or private actions that are reasonably certain to occur in the action area considered in this Opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA. Cumulative activities were discussed earlier in the section entitled **Comprehensive Cumulative Activities**. Many of these are relevant to bald eagles. Cumulative actions that are particularly relevant to bald eagles are also discussed below.

Upland areas and the stands adjacent to RMZs are likely to be managed on a 40- to 80-year harvest rotation. These rotations essentially preclude the development of large trees suitable for nesting (with the exception of wildlife retention trees), thus limiting the development of potential bald eagle nesting habitat to those areas within the FPHCP that are protected within RMZs, high-hazard slopes, occupied bald eagle territories, or other areas that are protected for marbled murrelet or northern spotted owl conservation. The bald eagle population in Washington has increased substantially in the past 20 years, but two-thirds of the State’s nests are on private lands. Conversion of forestland to residential uses near marine waters is the greatest threat to bald eagles in Washington (Stinson et al. 2001). These activities also require bald eagle site-management plans, but they may not provide the highest quality bald eagle habitat due to the proximity to developments and human activities compared with bald eagle habitat in non-developed areas.

8.1.5 CONCLUSION: Bald Eagle

After reviewing the current status of the bald eagle, the environmental baseline for the action area, the effects of the FPHCP, and the cumulative effects, it is the FWS's Opinion that the FPHCP, as proposed, is not likely to jeopardize the continued existence of the bald eagle. No critical habitat has been designated for this species, therefore, none will be affected.

Bald eagles associated with approximately 87 percent of the nesting territories in Washington are expected to be affected by the impacts from habitat removal or alteration. However, several factors serve to limit adverse effects to bald eagles. We anticipate that covered activities implemented under the

FPHCP would not remove habitat that is essential to the integrity of nesting territories from within the core areas of occupied bald eagle nesting territories or communal roost sites. Essential habitat in these areas will be protected and managed through the development of bald eagle site-management plans that will provide for the protection of breeding and wintering bald eagles and maintain bald eagle productivity. Other potential nest, perch, or roost trees could be harvested from within bald eagle territories, or from the limited-entry timber harvesting allowed in RMZs. Although some habitat loss is likely to occur, the potential adverse affects to bald eagle occupancy and productivity would be minimized through the retention of essential habitat and seasonal restrictions to avoid disturbance to nesting and roosting bald eagles.

The bald eagle population in Washington has been increasing steadily for 20 years, despite the fact that most sites are located on private lands and most have been affected by past forest practice activities or residential development. Current State and Federal laws have effectively protected the bald eagle and contributed to its recovery. Numeric delisting goals within the Pacific States Recovery Region have been met since 1995, and goals for nest productivity and average success rates for occupied breeding areas have been met or exceeded (64 FR 36454-36464). Where suitable nesting and roosting habitat does not currently exist, the FPHCP will eventually produce potential nesting and roosting sites in the RMZs. However, it will require several decades for the habitat to develop. Although the development of large trees in the RMZs is expected to be beneficial to bald eagles over the long-term, these narrow shoreline strips of trees do not protect all forested areas that are important for bald eagles. In the absence of an active nest site or a communal roost, there are no provisions in the FPHCP to protect bald eagle habitat beyond the RMZs. These protections will maintain the current distribution of bald eagles on FPHCP lands, but will limit the recovery of suitable habitat in the RMZs.

Based on the information presented above, implementation of the FPHCP is not expected to cause significant adverse effects to the overall reproduction, numbers, and distribution of bald eagles in the Pacific States Bald Eagle Recovery Region. The bald eagle population on FPHCP covered lands is likely to remain stable or increase during the term of the proposed Permit. Implementation of the FPHCP is not expected to cause take of the bald eagle.

8.2 NORTHERN SPOTTED OWL

8.2.1 STATUS OF THE NORTHERN SPOTTED OWL

8.2.1.1 Legal Status

The northern spotted owl (*Strix occidentalis caurina*) was listed as federally threatened on June 26, 1990 under the ESA. It was listed due to widespread habitat loss across its entire range and the inadequacy of existing regulatory mechanisms to provide for its conservation (U.S. Fish and Wildlife Service 1990a).

8.2.1.2 Life History

Detailed accounts of the taxonomy, ecology, and reproductive characteristics of the northern spotted owl are found in the 1987 and 1990 U.S. Fish and Wildlife Service Status Reviews (U.S. Fish and Wildlife Service 1987, 1990b), the 1989 Status Review Supplement (U.S. Fish and Wildlife Service 1989), the Interagency Scientific Committee (ISC) Report (Thomas et al. 1990), the Forest Ecosystem Management Assessment Team (FEMAT) Report (Thomas and Raphael 1993), the final rule designating the northern

spotted owl as a threatened species (U.S. Fish and Wildlife Service 1990a), and the Scientific Evaluation of the Status of the Northern Spotted Owl (Courtney et al. 2004).

Taxonomy

The northern spotted owl is one of three subspecies of spotted owls currently recognized by the American Ornithologists' Union and is typically associated with old-growth forest habitats throughout the Pacific Northwest. The taxonomic separation of these three subspecies is supported by genetic (Barrowclough and Gutiérrez 1990), morphological (Gutiérrez et al. 1995) and biogeographic information (Barrowclough and Gutiérrez 1990).

Physical Description

The northern spotted owl is a medium-sized owl, approximately 18-19 inches (46-48 centimeters) in length and approximately 1.1-1.9 pounds (490-850 grams) in weight (Gutiérrez et al. 1995), and is the largest of the three subspecies (Gutiérrez et al. 1995). It is dark brown with a barred tail and white spots on the head and breast, and has dark brown eyes that are surrounded by prominent facial disks. Three age classes can be distinguished on the basis of plumage characteristics (Forsman 1981; Moen et al. 1991). The northern spotted owl superficially resembles the barred owl (*Strix varia*), a species with which it occasionally hybridizes (Kelly et al. 2003). Hybrids exhibit characteristics of both species (Hamer et al. 1994).

Current and Historical Range

The current range and distribution of the northern spotted owl extends from southern British Columbia through western Washington, Oregon, and California as far south as Marin County (U.S. Fish and Wildlife Service 1990b). The southeastern boundary of its range is the Pit River area of Shasta County, California. The range of the northern spotted owl is partitioned into 12 physiographic provinces (provinces), based upon recognized landscape subdivisions exhibiting different physical and environmental features (Thomas et al. 1993). These provinces are distributed across the range as follows: four provinces in Washington (Washington Cascades East, Olympic Peninsula, Washington Cascades West, Western Lowlands); five provinces in Oregon (Oregon Coast Range, Willamette Valley, Oregon Cascades West, Oregon Cascades East, Klamath Mountains); and three provinces in California (California Coast, California Klamath, California Cascades). The current range of the northern spotted owl is similar to its historical range where forested habitat still exists. The distribution of habitat is influenced by the natural and human-caused fragmentation of vegetation and natural topography. The northern spotted owl has been extirpated or is uncommon in certain areas. For instance, there have only been a few nesting pairs in southwestern Washington for a number of years, although they have persisted there for the past decade. Timber harvest activities have eliminated, reduced, or fragmented northern spotted owl habitat and decreased overall population densities across its range, particularly within the coastal provinces where habitat reduction has been concentrated (Thomas and Raphael 1993).

Behavior

Northern spotted owls are territorial. However, home ranges of adjacent pairs overlap (Forsman et al. 1984; Solis and Gutiérrez 1990) suggesting that the area defended by an owl pair is smaller than the area they use for foraging. Territorial defense is primarily done through hooting, barking and whistle type calls.

Northern spotted owls are monogamous and usually form long-term pair bonds, although separations of pairs do occur. There are no known examples of northern spotted owl polygyny, although associations of three or more birds have been reported (Gutiérrez et al. 1995).

8.2.1.3 Habitat Relationships

Home Range

Northern spotted owl home range size varies by province. Home range size generally increases from south to north, which is likely in response to decreasing habitat quality (U.S. Fish and Wildlife Service 1990b). Home range size has been linked to habitat type, availability, and abundance of prey (Zabel et al. 1995).

Based on available radio-telemetry data (Thomas et al. 1990), the FWS estimated median annual home range size for the northern spotted owl by province throughout its range. Because the actual configuration of the home range is rarely known, the estimated home range of a northern spotted owl pair is represented by a circle centered upon a northern spotted owl activity center, with an area approximating the provincial median annual home range. For example, estimated home range area varies from 3,340 acres (based on a 1.3-mile radius area) in California to 14,271 acres (based on a 2.7-mile radius circle) in Washington. The FWS uses a 0.7-mile radius circle (984 acres) to delineate the area most heavily used (core area) by northern spotted owls during the nesting season. Variation in the size of the actual core area also varies geographically. For example, northern spotted owls in northern California focused their activities in core areas that ranged from about 167 to 454 acres, with a mean of about 409 acres; approximately half the area of the 0.7-mile radius circle (Bingham and Noon 1997). Northern spotted owls maintain smaller home ranges during the breeding season and often dramatically increase their home range size during fall and winter (Forsman et al. 1984; Sisco 1990).

Although differences exist in natural stand characteristics that influence provincial home range size, habitat loss and forest fragmentation effectively reduce habitat quality in the home range. A reduction in the amount of suitable habitat reduces northern spotted owl abundance and nesting success (Bart and Forsman 1992; Bart 1995).

Habitat Use

Forsman et al. (1984) reported that northern spotted owls have been observed in the following forest types: Douglas-fir (*Pseudotsuga menziesii*), western hemlock (*Tsuga heterophylla*), grand fir (*Abies grandi*s), white fir (*Abies concolor*), ponderosa pine (*Pinus ponderosa*), Shasta red fir (*Abies magnifica shastensis*), mixed evergreen, mixed conifer hardwood (Klamath montane), and redwood (*Sequoia sempervirens*). In parts of the Oregon Coast Range, northern spotted owls have been recorded in pure hardwood stands (Glenn et al. 2004). In California, northern spotted owls are found from near sea level in coastal forests to approximately 6988 feet (2,130 meters) in the Cascades (Gutiérrez 1996). The upper elevation limit at which northern spotted owls occur decreases gradually with increasing latitude in Oregon and Washington (Lint 2005). In all areas, the upper elevation limit at which northern spotted owls occur corresponds to the transition to subalpine forest, which is characterized by relatively simple structure and severe winter weather (Gutiérrez 1996).

Roost sites selected by northern spotted owls have more complex vegetation structure than forests generally available to them (Barrows and Barrows 1978; Forsman et al. 1984; Solis and Gutiérrez 1990).

These habitats are usually multi-layered forests having high canopy closure and large diameter trees in the overstory.

Northern spotted owls nest almost exclusively in trees. Like roosts, nest sites are found in forests having complex structure dominated by large diameter trees (Forsman et al. 1984; Hershey et al. 1998). Even in forests that have been previously logged, northern spotted owls select forests having a structure (i.e., larger trees, greater canopy closure) different than forests generally available to them (Folliard 1993; Buchanan et al. 1995; Hershey et al. 1998).

Foraging habitat is the most variable of all habitats used by territorial northern spotted owls (Thomas et al. 1990). Descriptions of foraging habitat have ranged from complex structure (Solis and Gutiérrez 1990) to forests with lower canopy closure and smaller trees than forests containing nests or roosts (Gutiérrez 1996).

Habitat Selection

Northern spotted owls generally rely on older forested habitats because they contain the structures and characteristics required for nesting, roosting, foraging, and dispersal. These characteristics include the following: (1) a multi-layered, multi-species canopy dominated by large overstory trees; (2) moderate to high canopy closure; (3) a high incidence of trees with large cavities and other types of deformities, especially dwarf mistletoe brooms; (4) numerous large snags; (5) an abundance of large, dead wood on the ground; and (6) open space within and below the upper canopy for northern spotted owls to fly (Thomas et al. 1990; U.S. Fish and Wildlife Service 1990b). Forested stands with high canopy closure also provide thermal cover (Weathers et al. 2001), as well as protection from predation. Recent landscape-level analyses in portions of the Klamath Province suggest that a mosaic of late-successional habitat interspersed with other vegetation types may benefit northern spotted owls more than large, homogeneous expanses of older forests (Zabel et al. 2003; Franklin et al. 2000; Meyer et al. 1998).

Dugger et al. (2005) found that apparent survival and reproduction was positively associated with the proportion of older forest near the territory center in the Klamath Province. Survival decreased dramatically when the amount of non-habitat exceeded approximately 50 percent (Dugger et al. 2005). Northern spotted owl territories with habitat fitness potentials (i.e., expressed as a lambda estimate for the territory) of less than 1.0 were generally characterized by less than 40 to 50 percent old forest habitat near the territory center (Dugger et al. 2005). The authors concluded that they found no support for either a positive or negative direct effect of intermediate-aged forest on either survival or reproduction.

Olson et al. (2004) found that survival in the Oregon Coast Range had a quadratic relationship with the amount of late- and mid-seral forest near nesting centers. Reproductive rates fluctuated biennially and were positively related to the amount of edge between late- and mid-seral forests and other habitat classes. Olson et al. (2004) conclude that their result indicated that while mid- and late-seral forests are important to northern spotted owls, a mixture of these forest types with younger forest and non-forest may be best for northern spotted owl survival and reproduction in their study area.

In redwood forests along the coast range of California, northern spotted owls may be found in younger forest stands with structural characteristics of older forests (Thomas et al. 1990). However, northern spotted owls do not generally appear to select for stands of intermediate or younger ages (Solis and Gutiérrez 1990; Thomas et al. 1990). Where northern spotted owls have been found nesting in young forest, such occurrences have been attributed to the presence of large residual trees with cavities (Buchanan et al. 1993), climatic conditions conducive to the use of platform nests (Forsman and Giese

1997), and/or alternate sources of prey that do not rely on cavities for reproduction (Zabel et al. 1995). In Washington, foraging occurs in nesting and roosting habitat, as well as in coniferous forest with smaller trees and less structural diversity, if prey such as the northern flying squirrel are present (Hanson et al. 1993).

In mixed conifer forests of the Eastern Cascade Mountains, Washington, 27 percent of nest sites were in old-growth forests, 57 percent in the understory reinitiation phase of forest stand development, and 17 percent in the stem exclusion phase of forest stand development (Buchanan et al. 1995). In the Western Cascade Mountains, Oregon, 50 percent of northern spotted owl nests were in late-seral/old-growth stands (greater than 80-years-old) and none were found in stands less than 40-years-old (Irwin et al. 2000).

Ward (1990) found that northern spotted owls foraged in areas that had lower variance in prey densities (prey were more predictable in occurrence) within older forests and near ecotones of old forest and brush seral stages. Zabel et al. (1995) showed that northern spotted owl home ranges are larger where flying squirrels are the predominant prey and, conversely, are smaller where woodrats (*Neotoma* spp.) are the predominant prey.

In the Western Washington Cascade Mountains, northern spotted owls used mature/old forests dominated by trees greater than 20 inches (50 centimeters) diameter-at-breast height with greater than 60 percent canopy closure more often than expected for roosting during the non-breeding season and used young forest trees 8 to 20 inches (20 to 50 centimeters) diameter at breast height with greater than 60 percent canopy closure) less often than expected based on availability (Herter et al. 2002).

8.2.1.4 Reproductive Biology

Northern spotted owls exhibit high adult annual survival rates and are relatively long-lived (U.S. Fish and Wildlife Service 1992a; Anthony et al. 2004). Northern spotted owls do not typically reach sexual maturity until after two years of age (Miller et al. 1985; Thomas et al. 1990). Adult females lay an average of 2 eggs per clutch with a range of 1 to 4 eggs. Northern spotted owl pairs do not typically nest every year, nor are nesting pairs successful every year (U.S. Fish and Wildlife Service 1990b). The small clutch size, temporal variability in nesting success, and somewhat delayed maturation all contribute to the relatively low reproductive rate of this species (Gutiérrez 1996).

Nest sites are usually located within stands of old-growth and late-successional forest dominated by Douglas-fir (*Pseudotsuga menziesii*), and they contain structures such as cavities, broken tree tops, or mistletoe (*Arceuthobium* spp.) brooms (Forsman et al. 1984; Blakesley et al. 1992; LaHaye and Gutiérrez 1999). Northern spotted owls do not build their own nests. Most nesting occurs within naturally formed cavities in live trees or snags, but abandoned platform nests of the northern goshawk (*Accipiter gentilis*) and common raven (*Corvus corax*) have also been used (Buchanan et al. 1993). In general, courtship and nesting behavior begins in February to March with nesting occurring from March to June; however, timing of nesting and fledging varies with latitude and elevation (Forsman et al. 1984). After young fledge from the nest, they depend on their parents until they are able to fly and hunt on their own. Parental care continues post-fledging into September (U.S. Fish and Wildlife Service 1990a), and sometimes into October (Forsman et al. 1984). During this time the adults may not roost with their young during the day, but they respond to begging vocalizations by bringing food to the young (Forsman et al. 1984).

Some northern spotted owls are not territorial but either remain as residents within the territory of a pair or move among territories (Gutiérrez 1996). These birds are referred to as “floaters.” Floaters have

special significance in northern spotted owl populations because they may buffer the territorial population from decline (Franklin 1992). Little is known about floaters other than that they exist and typically do not respond to calls as vigorously as territorial birds (Gutiérrez 1996).

8.2.1.5 Dispersal Biology

Natal dispersal of northern spotted owls from Oregon and Washington typically begins from mid- to late-September, and it is remarkably synchronous across broad areas (Forsman et al. 2002). When data from many dispersing northern spotted owls are pooled, the direction of dispersal away from the natal site appears random (Miller 1989; Ganey et al. 1998; Forsman et al. 2002). Dispersal direction from individual territories, however, may be non-random in response to the local distribution of habitat and topography (Forsman et al. 2002). Natal dispersal occurs in stages, with juvenile northern spotted owls settling in temporary home ranges between bouts of dispersal (Forsman et al. 2002). Median natal dispersal distance is about 10 miles for males and 15.5 miles for females (Forsman et al. 2002; Miller 1989; Ganey et al. 1998). Successful dispersal of juvenile northern spotted owls may depend on their ability to locate unoccupied suitable habitat in close proximity to other occupied sites (LaHaye et al. 2001).

Breeding dispersal occurs among a small proportion of adult northern spotted owls; these movements were more frequent among females and unmated individuals (Forsman et al. 2002). Breeding dispersal distances were shorter than natal dispersal distances and also apparently random in direction (Forsman et al. 2002).

Large non-forested valleys are apparent barriers to natal and breeding dispersal. Forested foothills between valleys may provide the only opportunities for dispersal (Forsman et al. 2002). The degree to which water bodies, such as the Columbia River and Puget Sound, function as barriers to dispersal is unclear. Analysis of genetic structure of northern spotted owl populations suggests adequate rates of gene flow may occur across the Puget Trough between the Olympic Mountains and Washington Cascades and across the Columbia River between the Olympic Mountains and the Coast Range of Oregon (Haig et al. 2001). Both telemetry and genetic studies indicate inbreeding is rare.

Dispersing juvenile northern spotted owls experience high mortality rates, exceeding 70 percent in some studies (U.S. Fish and Wildlife Service 1990a; Miller 1989). Leading known causes of mortality are starvation, predation, and accidents (Miller 1989; U.S. Fish and Wildlife Service 1990a; Forsman et al. 2002). Parasitic infection may contribute to these causes of mortality (Forsman et al. 2002). In a study on habitat use by dispersing juvenile northern spotted owls in the Oregon Coast Range, Klamath and Western Oregon Cascades Provinces (Miller et al. 1997), mature and old-growth forest were used slightly more than expected based on availability during the transient phase and nearly twice its availability during the colonization phase. Closed pole-sapling-sawtimber habitat was used roughly in proportion to availability in both phases; open sapling and clearcuts were used less than expected based on availability during colonization.

8.2.1.6 Food Habits

Composition of prey in the northern spotted owl's diet varies regionally, seasonally, annually, and locally, which is likely in response to prey availability (Carey 1993; Forsman et al. 2001; Forsman et al. 2004). Northern spotted owls are mostly nocturnal (Forsman et al. 1984), but they may forage opportunistically during the day (Laymon 1991; Sovern et al. 1994). Northern flying squirrels and woodrats are usually the predominant prey both in biomass and frequency (Barrows 1980; Forsman et al. 1984; Ward 1990; Bevis

et al. 1997; Forsman et al. 2001; 2004) with a clear geographic pattern of prey availability, paralleling differences in habitat (Thomas et al. 1990). Northern flying squirrels are generally the dominant prey item in the more mesic Douglas-fir/western hemlock forests characteristic of the northern portion of the range, whereas woodrats are generally the dominant prey item in the drier mixed conifer/mixed evergreen forests typically found in the southern portion of the range (Forsman et al. 1984; Thomas et al. 1990; Ward et al. 1998, as reviewed by Courtney et al. 2004). These prey items were found to be co-dominant in the southwest interior of Oregon (Forsman et al. 2001, 2004).

Other prey species such as the red tree vole (*Arborimus longicaudaus),* red backed voles (*Clethrionomys gapperi),* mice, rabbits and hares, birds, and insects may be seasonally or locally important (as reviewed by Courtney et al. 2004). For example, Rosenberg et al. (2003) showed a strong correlation between annual reproductive success of northern spotted owls (number of young per territory) and abundance of deer mice (*Peromyscus maniculatus*) ($r^2 = 0.68$), despite the fact they only made up 1.6 ± 0.5 percent of the biomass consumed. However, it is unclear if the causative factor behind this correlation was prey abundance or a synergistic response to weather (Rosenberg et al. 2003). Ward (1990) also noted that mice were more abundant in areas selected for foraging by northern spotted owls. Nonetheless, foraging northern spotted owls deliver larger prey to owls on the nest and eat smaller food items themselves to reduce foraging energy costs; therefore, the importance of smaller prey items, like *Peromyscus*, in the northern spotted owl diet should not be underestimated (Forsman et al. 1984, 2001, 2004).

8.2.1.7 Population Dynamics

The northern spotted owl is a relatively long-lived bird; produces few, but large young; invests significantly in parental care; experiences later or delayed maturity; and exhibits high adult survivorship. The northern spotted owl's long reproductive life span allows for some eventual recruitment of offspring, even if recruitment does not occur each year (Franklin et al. 2000).

Annual variation in population parameters for northern spotted owls has been linked to environmental influences at various life history stages (Franklin et al. 2000). In coniferous forests, mean fledgling production of the California spotted owl (*Strix occidentalis occidentalis*), a closely related subspecies, was higher when minimum spring temperatures were higher (North et al. 2000), indicating a relationship that may be a function of increased prey availability. Across their range, northern spotted owls have previously shown an unexplained pattern of alternating years of high and low reproduction, with highest reproduction occurring during even-numbered years (e.g., Franklin et al. 1999). Annual variation in breeding may be related to weather (i.e., temperature and precipitation) (Wagner et al. 1996 and Zabel et al. 1996 *In*: Forsman et al. 1996) and fluctuation in prey abundance (Zabel et al. 1996).

A variety of factors may regulate northern spotted owl population levels. These factors may be density-dependent (e.g., territorial behavior, habitat quality, habitat abundance) or density-independent (e.g., climate). Interactions may occur among factors. For example, as habitat quality decreases, density-independent factors may have more influence on variation in rate of population growth (Franklin et al. 2000). For example, weather could have increased negative effects on northern spotted owl fitness for those owls occurring in relatively lower quality habitat (Franklin et al. 2000). At some point, lower habitat quality may also cause the population to decline (Franklin et al. 2000).

Olson et al. (2005) used population modeling of site occupancy that incorporated imperfect and variable detectability of northern spotted owls and allowed modeling of temporal variation in site occupancy, extinction, and colonization probabilities (at the site scale). The authors found that visit detection probabilities averaged less than 0.70 and were highly variable among study years and among their three

study areas in Oregon. Pair site occupancy probabilities declined greatly at one study area and slightly at the other two areas. However, for all northern spotted owls, including singles and pairs, site occupancy was mostly stable through time. Barred owl presence had a negative effect on these parameters (see barred owl discussion in the New Threats section below).

8.2.1.8 Threats

Reasons for Listing

The northern spotted owl was listed as threatened throughout its range "due to loss and adverse modification of suitable habitat as a result of timber harvesting and exacerbated by catastrophic events such as fire, volcanic eruption, and wind storms" (U.S. Fish and Wildlife Service 1990a). More specifically, significant threats to the northern spotted owl included the following: (1) low populations; (2) declining populations; (3) limited habitat; (4) declining habitat; (5) distribution of habitat or populations; (6) isolation of provinces; (7) predation and competition; (8) lack of coordinated conservation measures; and (9) vulnerability to natural disturbance (U.S. Fish and Wildlife Service 1992a). These threats were characterized for each province as severe, moderate, low, or unknown. Declining habitat was recognized as a severe or moderate threat to the northern spotted owl in all 12 provinces, isolation of provinces within 11 provinces, and declining populations in 10 provinces. Consequently, these three factors represented the greatest concern range-wide to the conservation of the northern spotted owl. Limited habitat was considered a severe or moderate threat in nine provinces, and low populations a severe or moderate concern in eight provinces, suggesting that these factors are a concern throughout the majority of the range. Vulnerability to natural disturbances was rated as low in five provinces.

The degree to which predation and competition might pose a threat to the northern spotted owl was unknown in more provinces than any of the other threats, indicating a need for additional information. Few empirical studies exist to confirm that habitat fragmentation contributes to increased levels of predation on northern spotted owls (Courtney et al. 2004). However, great horned owls (*Bubo virginianus*), an effective predator on northern spotted owls, are closely associated with fragmented forests, openings, and clearcuts (Johnson 1992; Laidig and Dobkin 1995). As mature forests are harvested, great horned owls may colonize fragmented forests, thereby increasing northern spotted owl vulnerability to predation.

New Threats

Barred Owls

Since the listing of the northern spotted owl under the ESA, new information suggests that hybridization with the barred owl is less of a threat (Kelly and Forsman 2004) and competition with the barred owl is a greater threat than previously anticipated (Courtney et al. 2004). Since 1990, the barred owl has expanded its range south into Marin County, California, and the central Sierra Nevada Mountains, such that it is now roughly coincident with the range of the northern spotted owl (Courtney et al. 2004). Further, barred owl populations appear to be increasing throughout the Pacific Northwest, particularly in Washington and Oregon (Zabel et al. 1996; Dark et al. 1998; Wiedemeier and Horton 2000; Kelly et al. 2003; Pearson and Livezey 2003; Anthony et al. 2004), notwithstanding the likely bias in survey methods towards underestimating actual barred owl numbers (Courtney et al. 2004). Barred owl numbers now may exceed northern spotted owl numbers in the northern Washington Cascades (Kuntz and

Christopherson 1996) and in British Columbia (Dunbar et al. 1991) and appear to be approaching northern spotted owl numbers in several other areas (e.g., Redwood National and State Parks in California [Schmidt 2003]). Barred owl populations in the Pacific Northwest appear to be self-sustaining based on current density estimates and apparent distribution (Courtney et al. 2004).

Barred owls apparently compete with northern spotted owls through a variety of mechanisms: prey overlap (Hamer et al. 2001), habitat overlap (Hamer et al. 1989; Dunbar et al. 1991; Herter and Hicks 2000; Pearson and Livezey 2003), and agonistic encounters (Leskiw and Gutiérrez 1998; Pearson and Livezey 2003). New information on encounters between barred owls and northern spotted owls comes primarily from anecdotal reports which corroborate initial observations that barred owls react more aggressively towards northern spotted owls than the reverse (Courtney et al. 2004). There is also limited circumstantial evidence of barred owl predation on northern spotted owls (Leskiw and Gutiérrez 1998; Johnston 2002). Information collected to date indicates that encounters between these two species tend to be agonistic in nature, and that the outcome is unlikely to favor the northern spotted owl (Courtney et al. 2004).

Although barred owls were initially thought to be more closely associated with early successional forests than northern spotted owls from studies conducted on the west slope of the Cascade Mountains in Washington (Hamer 1988), recent studies conducted elsewhere in the Pacific Northwest indicate that barred owls utilize a broader range of habitat types than do northern spotted owls (Courtney et al. 2004). For example, a telemetry study conducted on barred owls in the fire prone forests of eastern Washington showed that barred owl home ranges were located on lower slopes or valley bottoms, in closed canopy, mature, Douglas-fir forest (Singleton et al. 2005). In contrast, northern spotted owl sites were characterized by closed canopy, mature, ponderosa pine or Douglas-fir forests, on southern or western exposure, mid-elevation areas (Singleton et al. 2005).

The only study comparing northern spotted owl and barred owl food habits in the Pacific Northwest indicated that barred owl diets overlapped strongly (greater than 75 percent) with northern spotted owl diets (Hamer et al. 2001). However, barred owl diets were also more diverse than northern spotted owl diets, including species associated with riparian and other moist habitats, and more terrestrial and diurnal species.

Evidence that barred owls are causing the displacement of northern spotted owls is largely indirect, based primarily on retrospective examination of long-term data collected on northern spotted owls. Correlations between local northern spotted owl declines and barred owl increases have been noted in the northern Washington Cascades (Kuntz and Christopherson 1996; Herter and Hicks 2000; Pearson and Livezey 2003), on the Olympic peninsula (Wiedemeier and Horton 2000; Gremel 2000, 2003), in the southern Oregon Cascade Mountains (e.g., Crater Lake National Park [Johnston 2002]), and in the coastal redwood zone in California (e.g., Redwood National and State Parks [Schmidt 2003]). Northern spotted owl occupancy was significantly lower in northern spotted owl territories where barred owls were detected within 0.5 miles (0.8 kilometers) of the northern spotted owl territory center than in northern spotted owl territories where no barred owls were detected (Kelly et al. 2003). Kelly et al. (2003) also found that in northern spotted owl territories where barred owls were detected, northern spotted owl occupancy was significantly lower ($P < 0.001$) after barred owls were detected within 0.5 miles (0.8 kilometers) of the territory center. Occupancy was “only marginally lower” ($P = 0.06$) if barred owls were located more than 0.5 miles (0.8 kilometers) from northern spotted owl territory centers. In a Roseburg, Oregon study area, 46 percent of northern spotted owls moved more than 0.5 miles (0.8 kilometers), and 39 percent of northern spotted owls were not relocated again in at least two years after barred owls were detected within

0.5 miles (0.8 kilometers) of the territory center. Observations provided by Gremel (2000) from the Olympic National Park are consistent with those of Kelly et al. (2003); he documented significant displacement of northern spotted owls following barred owl detections "coupled with elevational changes of northern spotted owl sites on the east side of the Park" (Courtney et al. 2004). Pearson and Livezey (2003) reported similar findings on the Gifford Pinchot National Forest where unoccupied northern spotted owl sites were characterized by significantly more barred owl sites within 0.5 miles (0.8 kilometers), 1 mile (1.6 kilometers), and 1.8 miles (2.9 kilometers) from the territory center than in occupied northern spotted owl sites. Because barred owl presence is increasing within the range of the northern spotted owls, Olson et al. (2005) suggest that further declines in the proportion of sites occupied by northern spotted owls are likely.

At two study areas in Washington, investigators found relatively high numbers of territories previously occupied by northern spotted owls that are now apparently not occupied by either northern spotted or barred owls (e.g., 49 of 107 territories in the Cascade Mountains [Herter and Hicks 2000]; 23 of 33 territories in the Olympic Experimental State Forest [Wiedemeier and Horton 2000]). Given that habitat was still present in these vacant territories, some factor(s) may be reducing habitat suitability or local abundance of both species. For example, weather conditions could cause prolonged declines in abundance of both species (Franklin et al. 2000). Because northern spotted owls have been anecdotally reported to give fewer vocalizations when barred owls are present, it is possible that these supposed vacant territories are still occupied by northern spotted owls that do not respond to surveys. Likewise, survey protocols for northern spotted owls are believed to under-detect barred owls (Courtney et al. 2004). Olson et al. (2005) showed that barred owl presence had a negative effect on northern spotted owl detection probabilities, and it had either a positive effect on local-extinction probabilities (at the territory scale) or a negative effect on colonization probabilities for three study areas in Oregon. Olson et al. (2005) concluded that future analyses of northern spotted owls must account for imperfect and variable detectability, and barred owl presence, to properly interpret results. Thus, some proportion of seemingly vacant territories may be an artifact of reduced detection probability of the survey protocol. Nonetheless, previously occupied territories apparently vacant of both northern spotted and barred owls suggest that factors other than barred owls alone are contributing to declines in northern spotted owl abundance and territorial occupancy (Courtney et al. 2004).

Two studies (Kelly 2001, Anthony et al. 2004) attempted to determine whether barred owls affected fecundity of northern spotted owls in the long-term demographic study areas. Neither study was able to clearly do so, although the Wenatchee and Olympic demographic study areas showed possible effects (Anthony et al. 2004). However, both studies described the shortfalls of their methods to adequately test for this effect. Iverson (2004) reported no effect of barred owl presence on northern spotted owl reproduction, but his results could have been influenced by small sample size (Livezey 2005). Barred owls had a negative effect on northern spotted owl survival on the Wenatchee and Olympic study areas and possibly an effect on the Cle Elum study area (Anthony et al. 2004). Olson et al. (2005) found a significant (but weak) negative effect of barred owl presence on northern spotted owl reproductive output but not on survival at a Roseburg, Oregon study area (Courtney et al. 2004).

Uncertainties associated with methods, analyses, and possible confounding factors such as effects of past habitat loss and weather warrant caution in interpretation of the patterns emerging from the data and information collected to date on interactions between barred and northern spotted owls (Courtney et al. 2004). Further, data are currently lacking that would allow accurate prediction of how barred owls will affect northern spotted owls in the southern, more xeric provinces in California and Oregon Klamath

regions. In spite of these uncertainties, the preponderance of the evidence gathered thus far is consistent with the hypothesis that barred owls are playing some role in northern spotted owl population decline, particularly in Washington, portions of Oregon, and the northern coast of California (Courtney et al. 2004).

Although the barred owl currently constitutes a significantly greater threat to the northern spotted owl than originally thought at the time of listing (Courtney et al. 2004), at present it is unclear whether forest management influences the outcome of interactions between barred and northern spotted owls (Courtney et al. 2004 as summarized by Lint 2005). Some of the most recent summaries compiled on the barred owl (Courtney et al. 2004; Lint 2005; U.S. Fish and Wildlife Service 2004d) do not provide recommendations about how to deal with this potential threat. However, Buchanan et al. (2005) offer research and management options to address inter-specific relationships between barred and northern spotted owls. Due to uncertainties surrounding barred owl interactions, the FWS's status review of the northern spotted owl (U.S. Fish and Wildlife Service 2004d) did not consider the risks sufficient to reclassify the northern spotted owl as endangered.

Wildfire

The short-term (i.e., a few years) affects of wildfires on northern spotted owl demography is an important consideration for resources managers. Bond et al. (2002) examined the demography of northern spotted owls post-wildfire, in which wildfire burned through northern spotted owl nest and roost sites in varying degrees of severity. Depending on the severity of the burn, wildfires may have relatively little short-term impact on northern spotted owl demography (i.e., survival, reproduction, and site fidelity). In a preliminary study conducted by Anthony and Andrews (2004) in the Klamath Province of Oregon, their sample of northern spotted owls appeared to be using a variety of habitat types within the Timbered Rock Fire, including areas which had experienced moderate burning. In 1994, the Hatchery Complex wildfires burned 43,498 acres (17,603 hectares) in the Wenatchee National Forest, eastern Cascades, Washington, affecting six northern spotted owl activity centers (Gaines et al. 1997). Northern spotted owl habitat within a 1.8 miles (2.9 kilometers) radius of the activity centers was reduced by 8 to 45 percent (mean equals 31 percent) due to direct effects of the fire and by 10 to 85 percent (mean equals 55 percent) due to delayed mortality of fire-damaged trees and insect caused tree mortality. Northern spotted owl habitat loss was greater on mid- to upper-slopes (especially south-facing) than within riparian areas or on topographical benches (Gaines et al. 1997). Direct mortality of northern spotted owls was assumed to have occurred at one site. Data were too sparse for reliable comparisons of site occupancy or reproductive output between sites affected by the fires and other sites on the Wenatchee National Forest. Two wildfires burned on the Yakama Indian Reservation, eastern Cascades, Washington, in 1994, affecting home ranges of two radio-tagged northern spotted owls (King et al. 1997). Although the amount of home ranges burned was not quantified, northern spotted owls were observed using areas that received low and medium intensity burning. No direct mortality of northern spotted owls was observed even though thick smoke covered several owl site centers for a week.

At the time of the northern spotted owl listing there was recognition that large-scale wildfire posed a threat to the northern spotted owl and its habitat (U.S. Fish and Wildlife Service 1990a). New information suggests that fire may be more of a threat than previously thought (U.S. Fish and Wildlife Service 2004d). In particular, the rate of habitat loss in the relatively dry East Cascades and Klamath provinces has been greater than expected (see "Habitat Trends" below). However, overall, the total amount of habitat affected by wildfires has been relatively small (Lint 2005). It may be possible to influence, through silvicultural management, how fire prone forests will burn and the extent of the fire

when it occurs. Silvicultural management of forest fuels are currently being implemented throughout the northern spotted owl's range, in an attempt to reduce the high levels of fuels that have accumulated during nearly 100 years of effective fire suppression. However, our ability to protect northern spotted owl habitat and viable populations of northern spotted owls from large fires through risk-reduction endeavors is uncertain (Courtney et al. 2004). The Northwest Forest Plan (USDA and USDI 1994a) recognized wildfire as an inherent part of managing northern spotted owl habitat in certain portions of the range. The distribution and size of reserve blocks as part of the Northwest Forest Plan design may help mitigate the risks associated with large-scale fire (Lint 2005).

West Nile Virus

West Nile Virus (WNV) has killed millions of wild birds in North America since it arrived in 1999 (McLean et al. 2001; Caffrey 2003; Marra et al. 2004). Mosquitoes are the primary carriers (vectors) of the virus that causes encephalitis in humans, horses, and birds. Mammalian prey may also play a role in spreading WNV among predators, like northern spotted owls. Owls and other predators of mice can contract the disease by eating infected prey (Garmendia et al. 2000; Komar et al. 2001). Recent tests of tree squirrels, including flying squirrels, from Los Angeles County, California, found over 70 percent were positive for WNV (R. Carney, Personal Communication, 2004, as cited in Courtney et al. 2004). One captive northern spotted owl in Ontario, Canada, is known to have contracted WNV and died.

Health officials expect that WNV will eventually spread throughout the range of the northern spotted owl (Courtney et al. 2004), but it is unknown how WNV will ultimately affect owl populations. Susceptibility to infection and mortality rates of infected individuals vary among bird species, even within groups (Courtney et al. 2004). Owls appear to be quite susceptible. For example, breeding screech owls (*Megascops asio*) in Ohio experienced 100 percent mortality (T. Grubb, Personal Communication, as cited in Courtney et al. 2004). Barred owls, in contrast, showed lower susceptibility (B. Hunter, Personal Communication, as cited in Courtney et al. 2004). Some level of innate resistance may occur (Fitzgerald et al. 2003), which could explain observations in several species of markedly lower mortality in the second year of exposure to WNV (Caffrey and Peterson 2003). Wild birds also develop resistance to WNV through immune responses (Deubel et al. 2001). The effects of WNV on bird populations at a regional scale have not been large, even for susceptible species (Caffrey and Peterson 2003), perhaps due to the short-term (a few years) and patchy distribution of mortality (K. McGowan, pers. comm., cited in Courtney et al. 2004) or annual changes in vector abundance and distribution.

Courtney et al. (2004) offer competing propositions for the likely outcome of northern spotted owl populations being infected by WNV. One proposition is that northern spotted owls can tolerate severe, short-term population reductions due to WNV, because northern spotted owl populations are widely distributed and number in the several hundreds to thousands. An alternative proposition is that WNV will cause unsustainable mortality, due to the frequency and/or magnitude of infection, thereby resulting in long-term population declines and extirpation from parts of the northern spotted owl's current range.

Habitat restoration for northern spotted owls will take decades to be realized. As such, it is too early to evaluate the long-term effectiveness of conservation efforts under the Northwest Forest Plan (U.S. Fish and Wildlife Service 2004d). Thus far, no mortality in wild, northern spotted owls has been recorded from west nile virus (Courtney et al. 2004). However, the potential threats to the northern spotted owl, like WNV, may not respond to or be affected by habitat management or improvement (U.S. Fish and Wildlife Service 2004d) including conservation efforts under the Northwest Forest Plan.

Sudden Oak Death

Sudden oak death was recently identified as a potential threat to the northern spotted owl (Courtney et al. 2004). This disease is caused by the fungus-like pathogen, *Phytopthora ramorum*, that was recently introduced from Europe and is rapidly spreading in northern California. At the present time, sudden oak death is found in natural stands from Monterey to Humboldt Counties, California, and has reached epidemic proportions in oak (*Quercus* spp.) and tanoak (*Lithocarpus densiflorus*) forests along approximately 186 miles (300 kilometers) of the central and northern California coast (Rizzo et al. 2002). It has also been found near Brookings, Oregon, killing tanoak and causing dieback of closely associated wild rhododendron (*Rhododendron* spp.) and evergreen huckleberry (*Vaccinium ovatum*) (Goheen et al. 2002). It has been found in several different forest types and at elevations from sea level to over 2625 feet (800 meters). Sudden oak death poses a threat of uncertain proportion because of its potential impact on forest dynamics and alteration of key prey and northern spotted owl habitat components (e.g., hardwood trees - canopy closure and nest tree mortality); especially in the southern portion of the northern spotted owl's range (Courtney et al. 2004). However, uncertainty about the likely scale of habitat effects and the potential for management to address the additive effects of sudden oak death on habitat availability mediated against placing too much weight on this factor in the FWS's Five-Year Review Evaluation of the northern spotted owl (U.S. Fish and Wildlife Service 2004d).

Inbreeding Depression, Genetic Isolation, and Reduced Genetic Diversity

Inbreeding and other genetic problems due to small population sizes were not considered an imminent threat to the northern spotted owl at the time of listing. Recent studies show no indication of reduced genetic variation and past bottlenecks in Washington, Oregon, or California (Barrowclough et al. 1999; Haig et al. 2004; Henke et al. 2005). However, in Canada, the breeding population is estimated to be less than 33 pairs and annual population decline may be as high as 35 percent (Harestad et al. 2004). Canadian populations may be more adversely affected by issues related to small population size including inbreeding depression, genetic isolation, and reduced genetic diversity (Courtney et al. 2004). Low and persistently declining populations throughout the northern portion of the species range (see "Population Trends" below) may be at increased risk of losing genetic diversity.

Climate change

Climate change, a potential additional threat to northern spotted owl populations, is not explicitly addressed in the Northwest Forest Plan. Climate change could have direct and indirect impacts on northern spotted owls and their prey. However, the emphasis on maintenance of seral stage complexity and related biological diversity in Matrix Lands under the Northwest Forest Plan should contribute to the resiliency of the Federal forest landscape related to impacts of climate change (Courtney et al. 2004).

Based upon a global meta-analysis of climate change data, Parmesan and Yohe (2003) discussed several potential implications of global climate change to biological systems, including terrestrial plants and animals. Results indicated that 62 percent of species exhibited trends indicative of advancement of spring conditions. In bird species, climate change trends were manifested in earlier nesting activities. Because the northern spotted owl exhibits a limited tolerance to heat relative to other bird species (Weathers et al. 2001), subtle changes in climate have the potential to affect northern spotted owls. However, the specific impacts to the species are unknown.

8.2.1.9 Conservation Needs of the Northern Spotted Owl

Based on the above assessment of threats, the northern spotted owl has the following habitat-specific and habitat-independent conservation (i.e., survival and recovery) needs (adapted from Courtney et al. 2004):

Habitat-specific Needs

1. Large blocks of suitable habitat to support clusters or local population centers of northern spotted owls (e.g., 15 to 20 breeding pairs) throughout the owl's range;
2. Suitable habitat conditions and spacing between local northern spotted owl populations throughout its range to facilitate survival and movement;
3. Suitable habitat distributed across a variety of ecological conditions within the northern spotted owl's range to reduce risk of local or widespread extirpation;
4. A coordinated, adaptive management effort to reduce the loss of habitat due to catastrophic wildfire throughout the northern spotted owl's range, and a monitoring program to clarify whether these risk reduction methods are effective and to determine how owls use habitat treated to reduce fuels; and
5. In areas of significant population decline, sustain the full range of survival and recovery options for this species in light of significant uncertainty.

Habitat-independent Needs

1. A coordinated, research and adaptive management effort to better understand and manage competitive interactions between northern spotted and barred owls; and
2. Monitoring to better understand the risk that West Nile Virus and sudden oak death pose to northern spotted owls and, for West Nile Virus, research into methods that may reduce the likelihood or severity of outbreaks in northern spotted owl populations.

8.2.1.10 Conservation Strategy

Since 1990, various efforts have addressed the conservation needs of the northern spotted owl and attempted to formulate conservation strategies based upon these needs. The various efforts began with the Interagency Scientific Committee's Conservation Strategy (Thomas et al. 1990). The efforts continued with the designation of critical habitat (U.S. Fish and Wildlife Service 1992a); the Draft Recovery Plan (U.S. Fish and Wildlife Service 1992b); the Scientific Analysis Team report (Thomas et al. 1993); and the report of the Forest Ecosystem Management Assessment Team (Thomas and Raphael 1993). The efforts culminated with the Northwest Forest Plan (U.S. Department of Agriculture and U.S. Department of Interior 1994a). Each conservation strategy was based upon the reserve design principles first articulated in the Interagency Scientific Committee's report, which are summarized as follows:

Species that are well distributed across their range are less prone to extinction than species confined to small portions of their range.

Large blocks of habitat, containing multiple pairs of the species, are superior to small blocks of habitat with only one to a few pairs.

Blocks of habitat that are close together are better than blocks far apart. Habitat that occurs in contiguous blocks is better than habitat that is more fragmented.

Habitat between blocks is more effective as dispersal habitat if it resembles suitable habitat.

8.2.1.11 Conservation and Recovery Efforts on Federal Lands

The Northwest Forest Plan is the current conservation strategy for the northern spotted owl on Federal lands. It is designed around the conservation needs of the northern spotted owl and based upon the designation of a variety of land-use allocations whose objectives are either to provide for population clusters (i.e., demographic support) or to maintain connectivity between population clusters. Several land-use allocations are intended to contribute primarily to supporting population clusters: Late Successional Reserves, Managed Late-Successional Areas, Congressionally Reserved Areas, Managed Pair Areas, and Reserve Pair Areas. The remaining land-use allocations (Matrix, Adaptive Management Areas, Riparian Reserves, Connectivity Blocks, and Administratively Withdrawn Areas) provide connectivity between habitat blocks intended for demographic support.

The range-wide system of Late Successional Reserves set up under the Northwest Forest Plan captures the variety of ecological conditions within the 12 different provinces to which northern spotted owls are adapted. This design reduces the potential for extinction due to large catastrophic events in a single province. Multiple, large Late Successional Reserves in each province reduce the potential that northern spotted owls will be extirpated in any individual province and reduce the potential that large wildfires or other events will eliminate all habitat within a Late Successional Reserve. In addition, Late Successional Reserves are generally arranged and spaced so that northern spotted owls may disperse to two or more adjacent Late Successional Reserves. This network of reserves reduces the likelihood that catastrophic events will impact habitat connectivity and population dynamics within and between provinces.

FEMAT scientists predicted that northern spotted owl populations would decline in the Matrix over time, while populations were expected to stabilize and eventually increase within Late Successional Reserves, as habitat conditions improve over the next 50 to 100 years (Thomas and Raphael 1993; U.S. Department of Agriculture and U.S. Department of Interior 1994a and 1994b). Based on the results of the first decade of monitoring, the Northwest Forest Plan's authors cannot determine if the declining population trend will be reversed because not enough time has passed to provide the necessary measure of certainty (Lint 2005). However, the results from the first decade of monitoring do not provide any reason to depart from the objective of habitat maintenance and restoration as described under the Northwest Forest Plan (Lint 2005). Other stressors that operate in intact suitable habitat, such as barred owls (already in action) and West Nile virus (yet to occur) may complicate the conservation of the northern spotted owl. Recent reports about the status of the northern spotted owl offer few management recommendations to deal with the emerging threats. The arrangement and distribution and resilience of the Northwest Forest Plan land use allocation system may prove to be the most appropriate strategy in responding to these unexpected challenges (Courtney et al. 2004).

Under the Northwest Forest Plan, the agencies involved (FWS, U.S. Forest Service, Bureau of Land Management, and the National Park Service) anticipated a decline of northern spotted owl populations during the first decade of implementation. Recent reports (Courtney et al. 2004; Anthony et al. 2004) identified greater than expected northern spotted owl declines in Washington and northern portions of Oregon, and more stationary populations in southern Oregon and northern California. The reports did not find a direct correlation between habitat conditions and changes in vital rates of northern spotted owls at the meta-population scale. However, at the territory scale, there is evidence of negative effects to northern spotted owl fitness due to reduced habitat quantity and quality. Also, there is no evidence to suggest that dispersal habitat is currently limiting (Courtney et al. 2004; Lint 2005). Even with the

population decline, Courtney et al. (2004) noted that there is little reason to doubt the effectiveness of the core principles underpinning the Northwest Forest Plan conservation strategy.

The current scientific information, including information showing northern spotted owl population declines, indicates that the northern spotted owl continues to meet the definition of a threatened species (U.S. Fish and Wildlife Service 2004d). That is, populations are still relatively numerous over most of the northern spotted owl's historic range, which suggests that the threat of extinction is not imminent.

8.2.1.12 Conservation Efforts on Non-Federal Lands

FEMAT noted that limited Federal ownership in some areas constrained the ability to form an extensive reserve network to meet conservation needs of the northern spotted owl. Thus, non-Federal lands were determined to be an important contribution to the range-wide goal of achieving conservation and recovery of the northern spotted owl. The FWS's main expectations for private lands are for their contributions to demographic support (pair or cluster protection) and/or connectivity with lands. In addition, timber harvest within each state is governed by rules that may provide protection of northern spotted owls and/or their habitat to varying degrees.

There are 16 current or completed Habitat Conservation Plans (HCPs) with incidental take permits issued for northern spotted owls, eight in Washington, four in Oregon, and four in California. They range in size from 40 acres to over 1.6 million acres, though not all acres are included in the mitigation for northern spotted owls. In total, the HCPs cover approximately 2.9 million of the 32 million acres of non-Federal forestlands in the range of the northern spotted owl. Most HCPs are fairly long in duration, though they range from only five years up to 100 years. While each HCP is unique, there are several general approaches to mitigation of incidental take of northern spotted owls, including: 1) reserves of various sizes, some associated with adjacent Federal reserves; 2) forest harvest that maintains or develops suitable habitat; 3) forest management that maintains or develops dispersal habitat; and 4) deferral of harvest near specific sites. Individual HCPs may employ one or more of these mitigation measures. Similarly the conservation objectives of individual HCPs vary from specified numbers of breeding northern spotted owls, with specified levels of reproductive success, to management objectives for nesting/roosting/foraging habitat or dispersal habitat (Courtney et al. 2004).

Washington

In 1996, the Washington Forest Practices Board adopted rules (Washington Forest Practices Board 1996) that would "contribute to conserving the northern spotted owl and its habitat on non-Federal lands" based on recommendations from a Science Advisory Group which identified important non-Federal lands and recommended roles for those lands in northern spotted owl conservation (Hanson et al. 1993; Buchanan et al. 1994). The 1996 rules designated 10 northern spotted owl special emphasis areas (SOSEAs) in Washington that comprise over 1.5 million acres of State and private lands where owl protections on non-Federal lands would be emphasized. At all sites within SOSEAs, any proposed harvest of suitable spotted owl habitat within a territorial owl circle is considered a "Class-IV special" and would trigger State Environmental Policy Act (SEPA) review. Within SOSEAs, all suitable habitat within 0.7 miles of northern spotted owl activity centers, and 40 percent of suitable habitat within the provincial median home range circle surrounding an occupied activity center is generally protected from timber harvest. Proposed harvest that would reduce habitat amounts below these levels are considered to have a significant probable adverse affect on the environment with respect to SEPA. If a determination of significance is made, preparation of a SEPA Environmental Impact Statement is required prior to

proceeding. If a determination of non-significance or mitigated determination of non-significance is reached, the action can proceed without further environmental assessment. Until recently, these habitat protections could be lifted if a northern spotted owl activity center was determined to be unoccupied (Buchanan and Swedeen 2005). In 2005, the Forest Practices Board adopted emergency rules to further protect suitable habitat in northern spotted owl circles within SOSEAs (Washington Forest Practices Board 2005). Under the 1996 Washington Forest Practices Rules, suitable northern spotted owl habitat located on non-Federal lands outside of owl management circles or located outside of a SOSEA boundary was not protected from timber harvest, unless the habitat was protected by an approved HCP. Northern spotted owl-related HCPs in Washington cover over 1.92 million acres and generally provide both demographic and connectivity support as recommended in the draft northern spotted owl recovery plan (U.S. Fish and Wildlife Service 1992b). (A more detailed discussion of the Washington Forest Practices Rules is provided in the northern spotted owl environmental baseline).

Oregon

The Oregon Forest Practices Act provides for protection of 70-acre core areas around known northern spotted owl nest sites, but does not provide for protection of northern spotted owl habitat beyond these areas (Oregon Department of Forestry 2006). In general, no large-scale northern spotted owl habitat protection strategy or mechanism currently exists for non-Federal lands in Oregon. The four northern spotted owl-related HCPs currently in effect in Oregon cover over 300,000 acres of non-Federal lands. These HCP's have provided, and will continue to provide, some nesting habitat and connectivity over the next few decades.

California

In 1990, the California Forest Practice Rules, which govern timber harvest on private lands, were amended to require surveys for northern spotted owls in suitable habitat and to provide protection around activity centers (California Department of Forestry 2005). Under the California Forest Practices Rules, no timber harvest plan can be approved if it is likely to result in incidental take of federally listed species, unless authorized by a Federal HCP. The California Department of Fish and Game initially reviewed all timber harvest plans to ensure that take was not likely to occur; the FWS took over that review function in 2000. Several large industrial owners operate under Spotted Owl Management Plans that have been reviewed by the FWS; the plans specify basic measures for northern spotted owl protection. Four HCPs authorizing take of northern spotted owls have been approved covering over 669,000 acres of non-Federal lands. Implementation of these HCPs has provided, and will continue to provide, for northern spotted owl demographic and connectivity support to Northwest Forest Plan lands.

8.2.1.13 Current Condition of the Northern Spotted Owl

The current condition of a species incorporates the effects of all past human and natural activities or events that have led to the present-day status of the species and its habitat (U.S. Fish and Wildlife Service and NMFS 1998).

Range-wide Habitat Trends

Habitat Trends

The FWS has used information provided by the U.S. Forest Service, Bureau of Land Management, and National Park Service to update the habitat baseline conditions on Federal lands for northern spotted owls

on several occasions since the northern spotted owl was listed in 1990. The estimate of 7.4 million acres used for the Northwest Forest Plan in 1994 (U.S. Department of Agriculture and U.S. Department of Interior 1994a) was determined to be representative of the general amount of northern spotted owl habitat on these lands. This baseline was used to track relative changes over time in subsequent analyses. In 2005, a new map depicting suitable northern spotted owl habitat throughout their range was produced as a result of the Northwest Forest Plan's effectiveness monitoring program (Lint 2005). However, the spatial resolution of this new habitat map currently makes it unsuitable for tracking habitat effects at the scale of individual projects. The FWS is evaluating the map for future use in tracking habitat trends. Additionally, there are no reliable estimates of northern spotted owl habitat on other land ownerships; consequently, acres that have undergone ESA section 7 consultation can be tracked, but not evaluated in the context of change with respect to a reference condition on non-Federal lands. The production of the Northwest Forest Plan monitoring program habitat map does, however, provide an opportunity for future evaluations of trends in non-Federal habitat. The following analyses indicate changes to the baseline condition established in 1994.

Range-wide Analysis 1994 – 2001

In 2001, the FWS conducted an assessment of habitat baseline conditions, the first since implementation of the Northwest Forest Plan (U.S. Fish and Wildlife Service 2001a). This range-wide evaluation of habitat, compared to the Final Supplemental Environmental Impact Statement, was necessary to determine if the rate of potential change to northern spotted owl habitat was consistent with the change anticipated in the Northwest Forest Plan. In particular, the FWS considered habitat effects that were documented through the ESA section 7 consultation process since 1994. In general, the analytical framework of these consultations focused on the reserve and connectivity goals established by the Northwest Forest Plan land-use allocations (U.S. Department of Agriculture and U.S. Department of Interior 1994a), with effects expressed in terms of changes in suitable northern spotted owl habitat within those land-use allocations. The FWS determined that actions and effects were consistent with the expectations for implementation of the Northwest Forest Plan from 1994 to June, 2001 (U.S. Fish and Wildlife Service 2001a).

During the 2001 assessment, the FWS developed an intranet database for compiling and tracking habitat losses anticipated through ESA section 7 consultations and other habitat effects (e.g., wildfire effects, though this data is incomplete). Information in the database is updated with each new consultation across the range of the species. The total acres of habitat loss changes over time as additional consultations are completed. As projects are implemented, Federal agencies report the actual acres implemented, and in some cases, the implemented acres are substantially less than the acres that were analyzed in the consultation. The FWS uses these reports to update the database and add or subtract habitat acres. For each ESA section 7 consultation, the FWS uses the current information in the consultation database to track the effects across the range of the northern spotted owl and update the information on the status of the northern spotted owl. As a result, the acres from ESA section consultation reported in this Opinion may vary from previous consultations due to updated information in the consultation database. Copies of the summary tables from the database used for this Opinion are filed in the administrative record for this Opinion.

Range-wide Analysis 1994 – 2004 (first decade of the Northwest Forest Plan)

This section updates the information considered in U.S. Fish and Wildlife Service (2001a), relying particularly on information in documents the FWS produced pursuant to ESA section 7 and information

provided by Northwest Forest Plan agencies on habitat loss resulting from natural events (e.g., fires, windthrow, insects, and disease).

In 1994, about 7.4 million acres of suitable northern spotted owl habitat were estimated to exist on Federal lands (U.S. Department of Agriculture and U.S. Department of Interior 1994a). As of April, 2004, the FWS had consulted (under ESA section 7) on the proposed removal of 571,263 acres of northern spotted owl habitat range-wide, including 165,748 acres on Federal lands managed under the Northwest Forest Plan (Table 8-3). Federal lands were expected to experience an approximate 2.6 percent decline in suitable northern spotted owl habitat due to all management activities (not just timber harvest) over the past decade, with approximately 2.3 percent being removed by timber harvest. The consulted-on effects for the Northwest Forest Plan area indicated a decadal loss of approximately 2.2 percent. These anticipated changes in suitable northern spotted owl habitat were consistent with the expectations for implementation of the Northwest Forest Plan.

There was little available information regarding northern spotted owl habitat trends on non-Federal lands. Yet, we do know that internal FWS consultations conducted since 1994 have documented the eventual loss of 411,200 acres of habitat on non-Federal lands (Table 8-4). Most of these losses have yet to be realized because they are part of large-scale, long-term HCPs.

In 2005, the WDFW released the report, *An Assessment of Spotted Owl Habitat on Non-Federal Lands in Washington between 1996 and 2004* (Pierce et al. 2005). This study estimates the amount of northern spotted owl habitat in 2004 on lands affected by State and private forest practices. The study area is a subset of the total Washington forest practice lands, and statistically-based estimates of existing habitat and habitat loss due to fire and timber harvest are reported. In the 3.2-million acre study area, Pierce and others (2005) estimated there were 816,000 acres of suitable northern spotted owl habitat in 2004, or about 25 percent of their study area. Most of the suitable northern spotted owl habitat in the Pierce et al. (2005) study area in 2004 (56 percent) occurred on Federal lands, and lesser amounts were present on State-local lands (21 percent), private lands (22 percent) and tribal lands (1 percent). A total of 172,000 acres of timber harvest occurred in the 3.2 million-acre study area, including harvest of 56,400 acres of suitable northern spotted owl habitat. This represented a loss of about 6 percent of the northern spotted owl habitat in the study area distributed across all ownerships (Pierce et al. 2005). Approximately 77 percent of the harvested habitat occurred on private lands and about 15 percent occurred on State lands. Pierce and others (2005) also evaluated suitable northern spotted owl habitat levels in 450 owl management circles (based on the provincial annual median owl home range). Across their study area, they found that northern spotted owl circles averaged about 26 percent suitable habitat in the circle across all landscapes. Values in the study ranged from an average of 7 percent in southwest Washington to an average of 31 percent in the eastern Cascade Mountains, indicating that many northern spotted owl territories in Washington are significantly below the 40 percent suitable habitat threshold used by the State and FWS as a viability indicator for northern spotted owl territories (Pierce et al. 2005).

The FWS estimated an increase of approximately 600,000 acres of late-successional forest across the range of the northern spotted owl since 1994 (U.S. Fish and Wildlife Service 2004e). This estimate was based on a projection of forest age and size class over time. Because stand age and size class do not necessarily account for the complex forest structure often associated with northern spotted owl habitat, Courtney et al. (2004) believed the FWS's in-growth estimate likely overestimates actual habitat development. Also, without more detailed spatial information, the availability of these additional acres of late-successional forest to northern spotted owls and their significance to northern spotted owl conservation remains unknown.

Table 8-4. Changes to NRF[1] habitat acres from activities subject to ESA section 7 consultations and other causes range-wide from May 1994 to present (February 23, 2006).

Northwest Forest Plan Group/Ownership		ESA Section 7 Consultation Habitat Changes[2]		Other Habitat Changes[3]	
		Removed/ Downgraded	Degraded	Removed/ Downgraded	Degraded
Federal Northwest Forest Plan	Bureau of Land Management	82,474	16,637	760	0
	Forest Service	100,282	450,007	12,897	5,481
	National Park Service	2,642	3,300	3	0
	Multi-agency[4]	15,175	23,314	0	0
	NWFP Subtotal	200,573	493,258	13,660	5,481
Other Management and Conservation Plans (OMCP)	Bureau of Indian Affairs and Tribes	104,494	27,890	0	0
	Habitat Conservation Plans	295,889	14,430	0	0
	OMCP Subtotal	400,383	42,320	0	0
Other Federal Agencies & Lands[5]		241	466	28	70
Other Public & Private Lands[6]		10,576	880	30,240	20,949
TOTAL Changes		**611,773**	**536,924**	**43,928**	**26,500**

Source: Table A from the FWS Northern Spotted Owl Consultation Effects Tracker (web application and database) Feb. 23, 2006.

1 Nesting, roosting, foraging habitat. In California, suitable habitat is divided into two components; nesting – roosting (NR) habitat, and foraging (F) habitat. The NR component most closely resembles NRF habitat in Oregon and Washington. Due to differences in reporting methods, effects to suitable habitat compiled in this, and all subsequent tables include effects for nesting, roosting, and foraging (NRF) for 1994-June 6, 2001. After June 26, 2001, suitable habitat includes NRF for Washington and Oregon but only nesting and roosting (NR) for California.

2 Includes both effects reported by U.S. Fish and Wildlife Service (2001a) and subsequent effects compiled in the Northern Spotted Owl Consultation Effects Tracker (web application and database).

3 Includes effects to NRF habitat (as documented through technical assistance) resulting from wildfires (not from suppression efforts), insect and disease outbreaks, and other natural causes, private timber harvest, and land exchanges not associated with consultation. Information from all fires occurring since 1994 is not yet available for entry into the database and thus is not included here but is compiled in Table 8-6.

4 The 'Multi-agency' grouping is used to lump a variety of Northwest Forest Plan mixed agency or admin unit consultations that were reported together prior to June 26, 2001, and cannot be separated out.

5 Includes lands that are owned or managed by other Federal agencies not included in the Northwest Forest Plan.

6 Includes lands not covered by Habitat Conservation Plans that are owned or managed by states, counties, municipalities, and private entities. Effects that occurred on private lands from right-of-way permits across U.S. Forest Service and Bureau of Land Management lands are included.

Range-wide Analysis from 1994 to the Present

As stated previously, in 1994 about 7.4 million acres of suitable habitat were estimated to exist on Federal lands. As of February 2006, the FWS has consulted on the removal of 611,773 acres of northern spotted owl habitat range-wide, of which 200,573 acres occurred on Federal lands managed under the Northwest Forest Plan (Table 8-4). From April, 2004, to the present, the FWS has consulted on the removal or degradation of 34,825 acres of northern spotted owl habitat range-wide on Federal lands managed under the Northwest Forest Plan (Table 8-4).

Habitat loss from Federal lands has varied by province with most losses concentrated in the Oregon physiographic provinces. Habitat removed from the Oregon Klamath Mountains province and the two Oregon Cascades provinces made up 79 percent of the habitat loss on Northwest Forest Plan lands range-wide since 1994 (Table 8-5).

Table 8-5. Aggregate results of all adjusted, suitable habitat (NRF[1]) acres affected by ESA section 7 consultation for the northern spotted owl; baseline and summary of effects by state, physiographic province, and land use function from 1994 to present (February 23, 2006).

Physiographic Province[4]		Evaluation Baseline[2]			Habitat Removed/Downgraded[3]			% Provincial Baseline Affected	% Range-wide Affected
		Reserves[5]	Non-Reserves[6]	Total	Reserves[5]	Non-Reserves[6]	Total		
WA	Olympic Peninsula	548,483	11,734	560,217	867	24	891	-0.12	0.47
	Eastern Cascades	506,340	200,509	706,849	1,749	4,242	5,991	-0.85	3.17
	Western Cascades	864,683	247,797	1,112,480	1,180	11,001	12,181	-1.09	6.44
	Western Lowlands	0	0	0	0	0	0	0	0
OR	Coast Range	422,387	94,190	516,577	399	4,145	4,544	-0.88	2.40
	Klamath Mountains	448,509	337,789	786,298	2,434	80,301	82,735	-10.52	43.76
	Cascades East	247,624	196,035	443,659	1,243	9,352	10,595	-2.39	5.60
	Cascades West	1,012,426	1,033,337	2,045,763	2,926	53,542	56,468	-2.76	29.87
	Willamette Valley	593	5,065	5,658	0	0	0	0	0
CA	Coast	47,566	3,928	51,494	181	69	250	-0.49	0.13
	Cascades	61,852	26,385	88,237	0	4,808	4,808	-5.45	2.54
	Klamath	734,103	345,763	1,079,866	1,470	9,143	10,613	-0.98	5.61
Total		**4,894,566**	**2,502,532**	**7,397,098**	**12,449**	**176,627**	**189,076**	**-2.56**	**100.00**

Source: Table B from the FWS Northern Spotted Owl Consultation Effects Tracker (web application and database) Feb. 23, 2006.

1 Nesting, roosting, foraging habitat. In California, suitable habitat is divided into two components; nesting – roosting (NR) habitat, and foraging (F) habitat. The NR component most closely resembles NRF habitat in Oregon and Washington. Due to differences in reporting methods, effects to suitable habitat compiled in this, and all subsequent tables include effects for nesting, roosting, and foraging (NRF) for 1994-June 26, 2001. After June 26, 2001, suitable habitat includes NRF for Washington and Oregon but only nesting and roosting (NR) for California.

2 1994 FSEIS baseline (USDA and USDI 1994).

3 Includes both effects reported by USFWS (2001a) and subsequent effects compiled in the Northern Spotted Owl Consultation Effects Tracking System (web application and database).

4 Defined by the Northwest Forest Plan as the twelve physiographic provinces, as presented in Figure 3 and 4-1 on page 3 and 4-16 of the Final Supplemental Environmental Impact Statement.

5 Land-use allocations intended to provide large blocks of habitat to support clusters of breeding pairs.

6 Land-use allocations intended to provide habitat to support movement of northern spotted owls among reserves.

In summary, habitat loss in Washington accounted for 10.06 percent of the range-wide loss, but it only resulted in a loss of 0.80 percent of available habitat on Federal lands in Washington (Table 8-5). In Oregon, habitat loss accounted for 81.63 percent of the range-wide losses, but only 4.06 percent of available habitat on Federal lands in Oregon (Table 8-5). Loss of habitat on Federal lands in California accounted for 8.28 percent of the losses range-wide, but only 1.28 percent of habitat on Federal lands in California (Table 8-5).

The FWS has limited information on the impacts of recent wildfires. From 1994 to 2004, the FWS estimated that approximately 168,300 acres was lost due to natural events. About two-thirds of this loss was attributed to the Biscuit Fire that burned over 500,000 acres in southwest Oregon (Rogue River basin) and northern California in 2002. This fire resulted in a loss of approximately 113,000 acres of northern spotted owl habitat, including habitat within five Late Successional Reserves.

Northern Spotted Owl Numbers, Distribution, and Reproduction Trends

There are no estimates of the historical population size and distribution of northern spotted owls, although they are believed to have inhabited most old-growth forests throughout the Pacific Northwest prior to modern settlement (mid-1800s), including northwestern California (U.S. Fish and Wildlife Service 1989). According to the final rule listing the northern spotted owl as threatened (U.S. Fish and Wildlife Service 1990a), approximately 90 percent of the roughly 2,000 known northern spotted owl breeding pairs were located on federally managed lands, 1.4 percent on State lands, and 6.2 percent on private lands; the percent of northern spotted owls on private lands in northern California was slightly higher (Forsman et al. 1984; U.S. Fish and Wildlife Service 1989; Thomas et al. 1990).Using data from 1986-1992, Gutiérrez (1994) tallied 3,753 known pairs and 980 singles throughout the range of the northern spotted owl. At the time the Northwest Forest Plan was initiated (July 1, 1994), there were 5,431 known locations of, or site centers of northern spotted owl pairs or resident singles: 851 sites (16 percent) in Washington, 2,893 (53 percent) in Oregon, and 1,687 (31 percent) in California (U.S. Fish and Wildlife Service 1995). The actual population of northern spotted owls across the range was believed to be larger than either of these counts because some areas were, and remain, unsurveyed (U.S. Fish and Wildlife Service 1992a; Thomas et al. 1993).

Because existing survey coverage and effort are insufficient to produce reliable population-size estimates, researchers use other indices, such as demographic data, to evaluate trends in northern spotted owl populations. Analysis of demographic data can provide an estimate of the rate and direction of population growth [i.e., lambda (λ)]. A λ of 1.0 indicates a stationary population (i.e., neither increasing nor decreasing), a λ less than 1.0 indicates a declining population, and a λ greater than 1.0 indicates a growing population. Demographic data are analyzed during workshops that occur at 5-year intervals.

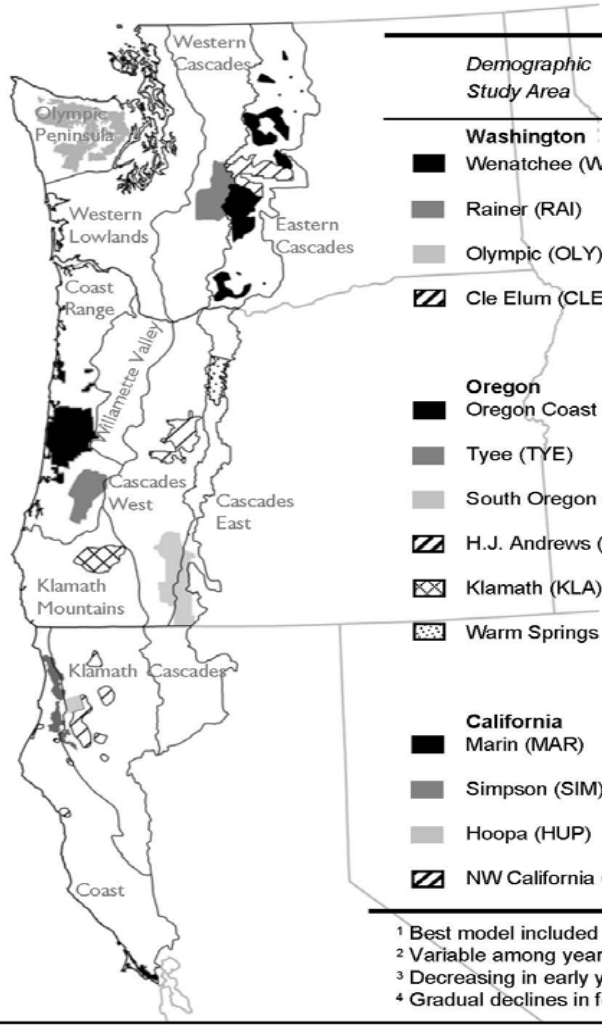
In January 2004, at a meta-analysis workshop northern spotted owl demographic studies, two meta-analyses were conducted on the rate of population change using the re-parameterized Jolly-Seber method (λRJS); 1 meta-analysis for all 13 study areas and 1 meta-analysis for the 8 study areas that are part of the Effectiveness Monitoring Program of the Northwest Forest Plan (Anthony et al. 2004). Data were analyzed separately for individual study areas, as well as simultaneously across all study areas (true meta-analysis). Estimates of λRJS ranged from 0.896-1.005 for the 13 study areas, and all but 1 (Tyee) of the estimates were <1.0 suggesting population declines for most areas (Anthony et al. 2004) (Figure 8-1). There was strong evidence that populations on the Wenatchee, Cle Elum, Warm Springs, and Simpson study areas declined during the study, and there also was evidence that populations on the Rainer, Olympic, Oregon Coast Range, and HJ Andrews study areas were decreasing (see Figure 8-1). Precision

of the λRJS estimates for the Rainier and Olympic study areas were poor and not sufficient to detect a difference from 1.00. However, the estimate of λRJS for Rainier study area (0.896) was the lowest of all of the areas. Populations on the Tyee, Klamath, South Oregon Cascades, Northwest California, and the Hoopa study areas appeared to be stationary during the study, but there was some evidence that the South Oregon Cascades, Northwest California, and Hoopa study areas were declining (λRJS <1.00). The weighted mean λRJS for all of the study areas was 0.963 (SE = 0.009, 95 percent confidence Interval = 0.945-0.981), suggesting that populations over all of the study areas were declining by about 3.7 percent per year from 1985-2003. The mean λRJS for the 8 demographic monitoring areas on Federal lands was 0.976 (SE = 0.007, 95 percent confidence interval = 0.962-0.990) and 0.942 (SE = 0.016, 95 percent confidence interval = 0.910-0.974) for non-Federal lands, an average of 2.4 versus 5.8 percent decline, respectively, per year. This suggests that northern spotted owl populations on Federal lands had better demographic rates than elsewhere, but interspersion of land ownership on the study areas confounds this analysis.

The number of populations that have declined and the rate at which they have declined are noteworthy, particularly the precipitous declines on the four Washington study areas (Wenatchee, Cle Elum, Rainier, Olympic) (estimated at 30 to 50 percent population decline over 10 years) and the Warm Springs study area in Oregon (Anthony et al. 2004). Declines in adult survival rates may be an important factor contributing to declining population trends. Survival rates declined over time on five of the 14 study areas: four study areas in Washington, which showed the sharpest declines, and one study area in the Klamath province of northwest California (Anthony et al. 2004). In Oregon, there were no time trends in apparent survival for four of six study areas, and remaining areas had weak non-linear trends. In California, two study areas showed no trend, one showed a slight decline, and one showed a significant linear decline (Anthony et al. 2004). Like the trends in annual rate of population change, trends in adult survival rate showed clear declines in some areas, but not in others. Anthony et al. (2004) provide the only range-wide estimate of northern spotted owl demographic rates.

Loehle et al. (2005) sampled a small portion of the range of the northern spotted owl and questioned the accuracy of lambda estimates computed in Anthony et al. (2004), suggesting that the estimates were biased low by 3 to 4 percentage points. Loehle et al. (2005) contends the lambda estimates in Anthony et al. (2004) do not accurately account for northern spotted owl emigration. Therefore, more of the northern spotted owl demography study areas would have a lambda closer to 1.0, a stationary population. The Loehle et al. (2005) statement could be accurate if Anthony et al. (2004) used Leslie matrix models to compute survival and lambda. Instead, Anthony et al. (2004) used the Pradel reparameterized Jolly-Seber method to compute survival and lambda to avoid the biases associated with the Leslie matrix method.

British Columbia has a small population of northern spotted owls. This population is relatively isolated, apparently declining sharply, and absent from large areas of apparently-suitable habitat (Courtney et al. 2004). Breeding populations have been estimated at fewer than 33 pairs and may be declining as much as 35 percent per year (Harestad et al. 2004). The amount of interaction between northern spotted owls in Canada and the U.S. is unknown (Courtney et al. 2004). The Canadian population has reached the point where it is now vulnerable to stochastic demographic events that could cause further declines and perhaps extirpation (Courtney et al. 2004, pgs. 3-26 to 3-27).



Demographic Study Area	Land Ownership	# Owls Banded	Fecundity	Apparent Survival	λ_{RJS}	Population Trend Based on $\Delta\lambda$
Washington						
Wenatchee (WEN)	Private	1,200	Stable	Declining	0.917	Declining
Rainer (RAI)	USFS	217	Stable	Declining	0.896	Declining
Olympic (OLY)	NPS & USFS	985	Stable	Declining	0.956	Declining
Cle Elum (CLE)	USFS	724	Declining[1]	Declining?[2]	0.938	Declining
Oregon						
Oregon Coast Range (COA)	USFS & BLM	1,025	Declining?[1]	Stable	0.968	Declining
Tyee (TYE)	BLM & Private	1,032	Increasing	Stable	1.005	Stationary
South Oregon Cascades (CAS)	USFS & BLM	881	Declining	Stable	0.974	Stationary
H.J. Andrews (HJA)	USFS	1,095	Stable?[3]	Stable	0.978	Declining
Klamath (KLA)	BLM & Private	1,147	Stable	Stable	0.997	Stationary
Warm Springs (WSR)	Tribal	381	Stable	Stable	0.908	Declining
California						
Marin (MAR)	NPS	96	Stable	Stable	NA	NA
Simpson (SIM)	Private	1,344	Declining[1]	Stable	0.970	Declining
Hoopa (HUP)	Tribal	279	Increasing	Stable	0.980	Stationary
NW California (NWC)	USFS	1,026	Declining	Declining	0.985	Declining?[4]

[1] Best model included age and even-odd year effects, but a competing model had a negative time effect on productivity.
[2] Variable among years, but with a declining trend.
[3] Decreasing in early years, increase in last 5 years, stable overall.
[4] Gradual declines in fecundity and apparent survival, plus estimates of realized population change suggest a decline in last 8 years.

Figure 8-1. Physiographic provinces, northern spotted owl demographic study areas, and demographic trends (Anthony et al. 2004).

8.2.2 STATUS OF NORTHERN SPOTTED OWL CRITICAL HABITAT

8.2.2.1 Legal Status

On January 15, 1992, the FWS designated critical habitat for the northern spotted owl within 190 Critical Habitat Units which encompass nearly 6.9 million acres across Washington (2.2 million acres), Oregon (3.3 million acres), and California (1.4 million acres) (U.S. Fish and Wildlife Service 1992b). These individual units are coded by the state they occur in and then they are individually numbered (e.g., WA-1…, OR-1…, CA-1…). Only Federal lands were designated as critical habitat in the final rule (FR 57:10:1796-1838). The northern spotted owl critical habitat final rule states: "Section 7 analysis of activities affecting owl critical habitat should consider provinces, subprovinces, and individual Critical Habitat Units, as well as the entire range of the subspecies (page 1823)." The rule goes on to assert the basis for an adverse modification opinion should be evaluated at the provincial scale (page 1823).

Primary Constituent Elements

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. PCEs identified in the northern spotted owl critical habitat final rule include those physical and biological features that support nesting, roosting, foraging, and dispersal (U.S. Fish and Wildlife Service 1992b). Features that support nesting and roosting habitat typically include a moderate to high canopy (60 to 90 percent); a multi-layered, multi-species canopy with large [greater than 30 inches diameter at breast height] overstory trees; a high incidence of large trees with various deformities (e.g., large cavities, broken tops, mistletoe infections, and other evidence of decadence); large snags; large accumulations of fallen trees and other woody debris on the ground; and sufficient open space below the canopy for northern spotted owls to fly (Thomas et al. 1990). Foraging habitat generally consists of attributes similar to those in nesting and roosting habitat, but may not always support successful nesting pairs (U.S. Fish and Wildlife Service 1992b). Dispersal habitat, at minimum, consists of stands with adequate tree size and canopy closure to provide protection from avian predators and at least minimal foraging opportunities; there may be variations over the northern spotted owl's range (e.g., drier sites in the east Cascades or northern California) (U.S. Fish and Wildlife Service 1992b).

Conservation Role of Critical Habitat

Northern spotted owl critical habitat was designated based on the identification of large blocks of suitable habitat that are well distributed across the range of the northern spotted owl. Critical habitat units were intended to identify a network of habitats that provided the functions considered important to maintaining stable, self-sustaining, and interconnected populations over the range of the northern spotted owl, with each Critical Habitat Unit having a local, provincial, and a range-wide role in northern spotted owl conservation. Most Critical Habitat Units were expected to provide suitable habitat for population support, some were designated primarily for connectivity, and others were designated to provide for both population support and connectivity.

The Northwest Forest Plan was developed using conservation principles similar to those used to designate critical habitat and is considered the Federal contribution to the conservation of northern spotted owls and its habitat in the United States. Specifically, Late Successional Reserves were created under the Northwest Forest Plan to provide large blocks of suitable habitat capable of supporting multiple pairs of northern spotted owls. Standards and Guidelines under the Northwest Forest Plan establish that Late Successional Reserves will be managed to protect and enhance late-successional and old-growth forests

ecosystems. Riparian Reserves and other Northwest Forest Plan land use allocations provide for connectivity between reserves. Approximately 70 percent of suitable habitat in Critical Habitat Units overlaps with Northwest Forest Plan Late Successional Reserves on a range-wide basis and will therefore be managed to protect and enhance habitat characteristics.

8.2.2.2 Current Condition of Critical Habitat

Range-wide

In 1994, the Final Supplemental Environmental Impact Statement for the Northwest Forest Plan established that 3,141,987 acres of nesting, roosting, and foraging habitat existed within northern spotted owl Critical Habitat Units on federally administered public lands. To assess changes to the baseline condition since implementation of the Northwest Forest Plan, the FWS relies on information in ESA section 7 consultations and available information on natural events. Hereafter, effects to critical habitat refer to nesting, roosting, and foraging habitat habitat within northern spotted owl critical habitat.

Across the range of the northern spotted owl between 1994 and February 2006, the FWS has consulted on the removal or degradation of 46,705 acres (1.49 percent) of critical habitat due to management-related activities (Table 8-6). The majority of these effects (32,915 acres) have been concentrated in the Oregon Cascades West and Oregon Klamath Mountains Provinces. In addition, natural events (including fire and insect outbreaks) have resulted in the removal or downgrading of approximately 42,679 acres (1.39 percent) of critical habitat extant in 1994 (Table 8-7). In general, fires have had more of an impact to northern spotted owl critical habitat in the interior provinces of Washington and California and the southern and interior provinces of Oregon than the coastal provinces. Over 50 percent of northern spotted owl critical habitat removed or downgraded by fire can be attributed to the 1999 Megram Fire that burned in north-central California and the 2002 Biscuit Fire that burned in southwestern Oregon and northern California.

Although most provinces within the range of the northern spotted owl have experienced some degree of habitat loss since 1994, total effects have been disproportionately distributed. The majority of effects to critical habitat (approximately 98 percent) have been concentrated in just six physiographic provinces (Washington East Cascades, Washington West Cascades, Oregon Klamath Mountains, Oregon Cascades East, Oregon Cascades West, and California Klamath) (Tables 8-6 and 8-7). Of the remaining six provinces, one (Oregon Willamette Valley) had no designated critical habitat, one (Washington Western Lowlands) had no suitable habitat within critical habitat, and four provinces (Olympic Peninnsula, Oregon Coast Range, California Coast Range, California Cascades) had less than one percent of their critical habitat removed or downgraded since 1994.

Provinces

Washington East Cascades

This province, which contains 18 Critical Habitat Units, is located east of the Cascade Crest and provides the easterly extension of the northern spotted owl in Washington.

Table 8-6. Aggregate results of all adjusted, suitable critical habitat acres affected by ESA section 7 consultation for the northern spotted owl; baseline and summary of effects by state, physiographic province, and land use function from 1994 to present (February 23, 2006).

Physiographic Province[3]		Evaluation Baseline[1]			Habitat Removed/Downgraded[2]			% Provincial Baseline Affected	% Range-wide Affected
		Reserves[4]	Non-Reserves[5]	Total	Reserves[4]	Non-Reserves[5]	Total		
WA	**Olympic Peninsula**	193,081	3,928	197,009	-12	-59	-71	-0.04	0.15
	Eastern Cascades	225,855	100,737	326,592	-87	-4,549	-4,636	-1.42	9.93
	Western Cascades	424,273	90,305	514,578	-3	-5,040	-5,043	-0.98	10.80
	Western Lowlands	0	0	0	0	0	0	0	0
OR	**Coast Range**	332,562	16,155	348,717	-50	-1,200	-1,250	-0.36	2.68
	Klamath Mountains	228,112	85,157	313,269	-4	-12,830	-12,834	-4.10	27.48
	Cascades East	86,882	51,802	138,684	-138	-1,372	-1,510	-1.09	3.23
	Cascades West	532,571	361,563	894,134	-122	-19,959	-20,081	-2.25	43.00
	Willamette Valley	0	0	0	0	0	0	0	0
CA	**Coast**	2,589	27	2,616	0	0	0	0	0
	Cascades	47,947	2,740	50,687	0	-472	-472	-0.93	1.01
	Klamath	322,372	33,329	355,701	0	-808	-808	-0.23	1.73
Total		2,396,244	745,743	3,141,987	-416	-46,289	-46,705	-1.49	100.00

Source: Table D from the FWS Northern Spotted Owl Consultation Effects Tracker (web application and database) Feb. 23, 2006.

[1] 1994 FSEIS baseline (USDA and USDI 1994).

[2] Includes both effects reported in U.S. Fish and Wildlife Service 2001 and subsequent effects reported in the Northern Spotted Owl Consultation Effects Tracking System (web application and database.)

[3] Defined by the Northwest Forest Plan as the twelve physiographic provinces, as presented in Figure 3 and 4-1 on page 3 and 4-16 of the Final Supplemental Environmental Impact Statement.

[4] Land-use allocations intended to provide large blocks of habitat to support clusters of breeding pairs.

[5] Land-use allocations intended to provide habitat to support movement of northern spotted owls among reserves.

Table 8-7. Change in northern spotted owl suitable critical habitat from 1994 to December 10, 2004, resulting from Federal management actions and natural events by physiographic province.

Physiographic Province	1994 Final Supplemental Environmental Impact Statement Provincial Critical Habitat Baseline1994-2004	Critical Habitat (acres) Removed/Downgraded,				% of 1994 Final Supplemental Environmental Impact Statement Provincial Critical Habitat Baseline	% of all Rangewide Habitat Effects
		Management	Fire	Insect/Disease	Total		
WA:							
Olympic Peninsula	197,009	71	0	0	71	0.04	0.08
East Cascades	326,592	1,035	6,925[1,2]	532	8,492	2.60	9.67
West Cascades	514,578	4,994	0	0	4,994	0.97	5.69
Western Lowlands	0	0	0	0	0	0.00	0.00
OR:							
Coast Range	348,717	1,224	0	0	1,224	0.35	1.39
Klamath Mountains	313,269	13,912	17,453	0	31,365	10.01	35.72
Cascades East	138,684	1,706	6,878[2]	0	8,584	6.18	9.78
Cascades West	894,134	21,003	1,216	0	22,219	2.48	25.31
Willamette Valley	0	0	0	0	0	0.00	0.00
CA:							
Coast Range	2,616	0	0	0	0	0.00	0.00
Cascades	50,687	365	0	0	365	0.72	0.41
Klamath	355,701	808	9,675	0	10,483	2.95	11.95
Total	**3,141,987**	**45,118**	**42,147**	**532**	**87,797**	**2.79**	**100.00**

Note: Fire effects were compiled by the FWS northern spotted owl coordination group from unpublished agency reports. Management effects portrayed in this table may vary from values reported elsewhere due to updates in information since December 2004.

[1] Habitat effects from some 1994 fires were included in the 2001 update, and thus, appear as consulted-on effects in the Northern Spotted Owl Consultation Effects Tracking Database. For the purpose of this critical habitat update, habitat effects associated with those fires are included in the fire effects column.

[2] Includes fires in 2003.

Between 1994 and December 2004, approximately 8,492 acres of critical habitat, or 2.6 percent of its provincial baseline, have been removed or downgraded (Table 8-7). The majority of the effects has been concentrated in the northern half of the province and have resulted primarily from the Tyee, Needles, North 25 Mile, and Maple Fires. The largest of these fires, the Tyee, removed or downgraded approximately 3,600 acres of suitable habitat from WA-06, WA-09, and WA-11. The Maple Fire removed or downgraded an additional 300 acres of suitable habitat from to WA-06. The Needles and North 25 Mile Fires removed or downgraded approximately 2,500 acres (23 percent) and 474 acres (28 percent) of suitable habitat from WA-02 and WA-04, respectively. Collectively, the units impacted by these fires are important for the range-wide distribution of the northern spotted owl as they occur on the eastern and northeastern edge of their range (Tehan 1991). Additionally, these Critical Habitat Units provide habitat for intra-provincial connectivity (Tehan 1991).

Since December 2004, efforts have continued to refine estimates of additional critical habitat lost due to wildfires during recent seasons. Preliminary estimates indicate that as much as 3,600 acres of nesting, roosting, and foraging habitat may have been removed or downgraded from critical habitat units in this province. At present, this estimate has not been finalized and entered in the range-wide database for tracking effects on critical habitat.

Washington West Cascades

This province, which contains 23 Critical Habitat Units and the most critical habitat of the Washington provinces, is located west of the Cascade Crest. It is characterized by significant differences in topography and distribution of habitat between its northern and southern portions.

Since 1994, the FWS has consulted on the removal or downgrading of approximately 5,043 acres of critical habitat within six Critical Habitat Units, representing about 1.42 percent of the provincial baseline (Table 8-6). Although impacts to five of these units have been relatively minor (less than 2.5 percent of their baseline), WA-39 has had 1,776 acres of suitable habitat (46 percent) consulted-on for removal or downgrading. WA-39 is expected to provide connectivity between the Western Cascades and Western Lowlands Provinces and improve the distribution of northern spotted owls and habitat in the portion of the province impacted by the 1980, Mount St. Helens eruption (Tehan 1991). Fire has not resulted in measurable impacts to northern spotted owl critical habitat in this province.

Oregon Klamath Mountains

The Oregon Klamath Mountains Province contains 16 Critical Habitat Units and provides the link between the Oregon Cascades West and Oregon Coast Ranges Province south into California.

Since 1994, the FWS has consulted on the removal or downgrading of 12,834 acres of critical habitat, representing about 4.1 percent of the provincial baseline. Wildlfire events have resulted in the additional loss of at least 17,453 acres (Table 8-7). Although effects noted determined from ESA section 7 consultations were distributed across 11 Critical Habitat Units, approximately 36 percent of effects have occurred in two adjacent units (OR-74 and OR-75). Together, these units provide an east-west linkage in the southern portion of the Klamath Mountains Province and provide nesting, roosting, and foraging habitat, and dispersal habitat in a highly fragmented area (Tweten 1992). The majority of fire effects in this province can be attributed to the Biscuit Fire. This fire removed or downgraded approximately 23, 46, and 37 percent of the suitable habitat within OR-68, OR-69, and OR-70, respectively.

These units were identified for their important contributions to inter- and intra-provincial connectivity and to provide nesting, roosting, and foraging habitat, and dispersal habitat, in areas where habitat is lacking (Tweten 1992).

Oregon Cascades West

This province is located in the geographic center of the northern spotted owl's range and contains more critical habitat (over 894,000 acres) than any other province. It provides links with the Washington Cascades, Oregon Coast Range, and Klamath Mountains Provinces.

Since 1994, the FWS has consulted on the removal or downgrading of approximately 20,081 acres or 2.25 percent of the provincial baseline (Table 8-6). Fire effects have resulted in the the additional loss of at least 1,216 acres (Table 8-7). Effects determined from ESA section 7 consultations have been widely dispersed within 26 of the 29 Critical Habitat Units in this province. In general, this has resulted in relatively small impacts to individual units. However, two adjacent units, OR-23 and OR-24, have experienced relatively concentrated effects, with 215 acres (14.3 percent) and 946 acres (48.8 percent) removed or downgraded, respectively. Together these units were identified as being important inter-provincial links between the Coast Ranges and the Oregon Cascades West Provinces (Tweten 1992). Fire has had limited effects to northern spotted owl critical habitat in this province: 1,216 acres or less than 0.5 percent of the provincial baseline have been removed or downgraded by fire.

Since December 2004, the Oregon Cascades West Province critical habitat baseline, for activities that have undergone ESA section 7 consultation that will remove or downgrade suitable habitat, has been adjusted by -922 acres (i.e., 922 acres of suitable habitat have been added back to the environmental baseline). As stated above, this is usually due to modifications in proposed activities. Once projects are completed, and monitoring reports submitted, acres that are not affected are amended and the consultation is closed.

Oregon Cascades East

The Oregon Cascades East Province provides the easterly extension of the northern spotted owl's range in Oregon and contains all or portions of 10 Critical Habitat Units.

Since 1994, the FWS has consulted on the removal or downgrading of approximately 1,510 acres or 1.09 percent of the provincial baseline (Table 8-6). Fire effects have resulted in the additional loss of at least 6,878 acres (Table 8-7). The impacts of these fires were concentrated in the central portion of this province where approximately 20 percent of the extant suitable habitat in OR-3 and OR-4 and over 36 percent of the suitable habitat in OR-7 were removed or downgraded. OR-3 and OR-4 were designated to maintain suitable habitat and support dispersal along the eastern slope of the Oregon Cascades (Tweten 1992). OR-7 provides a north-south link within the province and an inter-provincial link with the Oregon Cascades West Province. Effects determined from ESA section 7 consultations have been evenly distributed, occurring in 8 of 10 Critical Habitat Units, and have resulted in less than a 5 percent reduction (through removal or downgrading) of suitable habitat within any individual Critical Habitat Unit.

California Klamath

The California Klamath Province contains all or portions of 36 Critical Habitat Units and over 85 percent of northern spotted owl critical habitat in California.

Since 1994, the FWS has consulted on the removal or downgrading of approximately 808 acres or 0.23 percent of the provincial baseline (Table 8-6). Fire effects have resulted in the additional loss of at least 9,675 acres (Table 8-7). The majority of effects to these acres can be attributed to the Megram Fire. This fire removed or downgraded 9,390 acres (22 percent) of the suitable habitat within CA-30; this Critical Habitat Unit is located in the west/central portion of this province and links the interior sub-provinces with the coastal provinces and is expected to provide for up to 24 northern spotted owl pairs overtime (Spangle 1992). Two other small Critical Habitat Units, CA-10 (9,637 acres) and CA-35 (12,470 acres), have had approximately 20 percent of their suitable habitat removed or degraded from activities that have undergone ESA section 7 consultation. The primary function of these Critical Habitat Units is to provide intra-provincial connectivity in the eastern and south-central portion of this province, respectively (Spangle 1992).

8.2.3 ENVIRONMENTAL BASELINE – Northern Spotted Owl and Northern Spotted Owl Critical Habitat

Regulations implementing the ESA (50 CFR § 402.02) define the environmental baseline as the past and present impacts of all Federal, State, or private actions and other human activities in the action area. Also included in the environmental baseline are the expected impacts of all proposed Federal projects in the action area that have undergone ESA section 7 consultation, and the impacts of State and private actions that are contemporaneous with the consultation in progress. Such actions include, but are not limited to, previous timber harvests and other land-management activities.

8.2.3.1 Northern Spotted Owls in Washington

The range of the northern spotted owl in Washington includes four physiographic provinces covering an area of over 21 million acres. The four provinces are the Olympic Peninsula, the western Washington lowlands, the western Washington Cascades, and the eastern Washington Cascades. Northern spotted owls now occur primarily on the eastern and western slopes of the Cascades and on the Olympic Peninsula. Historically, northern spotted owls were likely distributed throughout much of the western Washington lowlands, but now are considered rare in that portion of their range. Northern spotted owls occur at elevations ranging from sea level up to 3,500 - 5,000 feet depending on the region, and as in other parts of their range, northern spotted owls in Washington primarily use mature and old forest habitats for nesting, roosting, and foraging.

There are no current estimates of the total number of northern spotted owls. However, past assessments have indicated that approximately 15 to 20 percent of the rangewide population occurs in Washington (U.S. Fish and Wildlife Service 1995; 2004d). The most recent demographic-monitoring information indicates that the northern spotted owl population in Washington is declining at an annual average rate of 7.3 percent, compared to an average rate of 2.6 percent per year in the remainder of the range (Anthony et al. 2004). The realized population change estimates (i.e., the proportion of the population remaining each year, given the rates of decline) indicate that currently only about 40 to 60 percent of the initial 1990 northern spotted owl population in Washington remains (Anthony et al. 2004; Lint 2005). Anthony and others (2004) suggest that the combined influences of high densities of barred owls; lag effects associated with rapid habitat loss prior to the Federal listing of the northern spotted owl in 1990; continued habitat loss from wildfire, timber harvest and defoliation; and poor weather conditions are the likely causes for these declines.

Recent habitat assessments indicate that about 25 to 30 percent of the rangewide northern spotted owl habitat occurs in Washington (Davis and Lint 2005). Due primarily to historical timber harvest, approximately 84 percent of the known northern spotted owl site centers (Buchanan and Swedeen 2005) and about 60 to 70 percent of extant northern spotted owl habitat in Washington is located on Federal lands managed under the Northwest Forest Plan (Davis and Lint 2005). Since the Federal listing in 1990, the FWS has consulted on the removal or downgrading of about 240,000 acres of suitable northern spotted owl habitat in Washington under ESA section 7. Most (89 percent) of this consulted-on habitat loss is associated with approved Habitat Conservation Plans (≈ 143,000 acres) or tribal forest management plans (≈ 70,000 acres).

8.2.3.2 Assessments of Northern Spotted Owl Habitat in Washington

Two recent assessments of northern spotted owl habitat in Washington have been completed. The first study is a range-wide analysis of northern spotted owl habitat completed for monitoring the Northwest Forest Plan (Davis and Lint 2005). This study is a provincial-scale analysis of northern spotted owl habitat derived from vegetation maps, and includes map data of northern spotted owl habitat in Washington for the period of 1992 to 1996. The map data are derived from satellite imagery. Northern spotted owl habitat was modeled from vegetation maps using the Biomapper ecological niche-factor analysis model developed by Hirzel and others (2002). The northern spotted owl habitat suitability maps are based on the physical and vegetative attributes adjacent to known northern spotted owl pair locations for each province. The resulting raster maps are a grid of 269 square feet (25 square meters) cells (0.15 acres per pixel). Each cell in the raster is assigned a value of 0-100. Values closer to 100 represent areas that match the northern spotted owl nesting locations; values closer to 0 are likely unsuitable for nesting (Davis and Lint 2005). These habitat maps do not provide absolute habitat estimates, but rather a range of habitat suitability values, which can be interpreted in different ways. Davis and Lints' (2005) report was developed to evaluate the Northwest Forest Plan and does not provide summary information concerning northern spotted owl habitat on non-Federal lands. However, the map data developed for their study includes state and private lands, and we used these data to estimate northern spotted owl habitat in the FPHCP action area due to the comprehensive coverage of this map data.

One of the difficulties of working with the Biomapper habitat data is that there are no absolute values, and it is difficult to interpret which values represent "suitable" northern spotted owl habitat. We chose the mean habitat suitability values reported by Davis and Lint (2005) that accounted for 90 percent of northern spotted owl pair locations to represent suitable habitat. Based on the information provided by Davis and Lint, we believe the 90 percent values provide a reasonable estimate of "potential" northern spotted owl habitat in Washington. We use the term "potential" habitat to emphasize the idea that the habitat suitability index values that we selected from the Biomapper results represent forest cover that has the general attributes of northern spotted owl habitat (i.e., mid-seral or late-seral conifer forests with high canopy cover), whether or not northern spotted owls are actually using the habitat.

It is important to note that all suitable habitat estimates that we generated from Davis and Lints' (2005) data are general estimates based on the FWS's interpretation of data. The values reported here are coarse estimates used for the purposes of this analysis, and are not intended to represent absolute values. The habitat acres depicted by Davis and Lint's (2005) data are not expected to accurately depict all areas that would meet the regulatory definitions of "suitable" habitat defined at WAC 222-16-085.

Although dated, these data represent the best provincial-scale maps of northern spotted owl habitat currently available, and we used these maps in our assessment of northern spotted owl habitat on FPHCP

covered lands. Using the mean habitat suitability scores, Davis and Lints data indicates there were approximately 3.68 million acres of suitable northern spotted owl habitat in Washington (all ownerships) in 2003. (For more information on the FWS's GIS analysis to derive these estimates, refer to the northern spotted owl GIS memo in the administrative record for this Opinion).

The second study of northern spotted owl habitat is an assessment of completed by the Washington Department of Fish and Wildlife (WDFW) (Pierce et al. 2005). This study estimates the amount of northern spotted owl habitat in 2004 on lands affected by State and private forest practices. The study area is a subset of the total State and private forestlands, and statistically-based estimates of existing habitat and habitat loss due to fire and timber harvest are provided. In the 3.2 million acre study area, Pierce and others (2005) estimated there were 816,000 acres of suitable northern spotted owl habitat in 2004, or about 25 percent of their study area. Based on their results, and the results of Davis and Lints (2005) analysis of Federal lands, Pierce and others (2005) estimated there were less than 2.8 million acres of northern spotted owl habitat in Washington in 2004. This differs substantially from the 3.68 million acres that we derived from Davis and Lints' (2005) habitat data, but is not unexpected because the values from Davis and Lints' map data can vary widely depending on which habitat suitability values are selected. Additionally, there are approximately 378,000 acres potential spotted owl habitat on non-Federal lands in the western Washington lowlands province that were not included in Davis and Lint's (2005) published report.

The study completed by Pierce and others (2005) did not produce a comprehensive GIS map for all State and private lands. These data represent the best estimates for suitable habitat and timber harvest rates on State and private lands within their study area, but because these data do not cover the entire FPHCP covered lands area, we chose not to use this information to evaluate conditions on the FPHCP covered lands. However, data provided in this study were used as a cross-reference for the results derived from the Davis and Lint (2005) data, and so information from both studies is presented in this Opinion. Both Davis and Lint (2005) and Pierce et al. (2005) relied on the work of Healy et al. (2003) to evaluate the impacts of the stand-replacing fires and harvests on northern spotted owl habitat that occurred between 1994 and 2002, although the Pierce et al. (2005) study included harvest data up to 2004, and includes estimates of partial harvest acres in the East Cascade Mountains.

8.2.3.3 Northern Spotted Owl Habitat on Forest Practices Habitat Conservation Plan Lands

Of the 9.3 million acres of FPHCP covered lands in Washington, over 6.9 million acres (74 percent) of the covered lands are within the range of the northern spotted owl. Suitable northern spotted owl habitat (i.e., nesting, roosting, and foraging habitat) currently exists on approximately 3.68 million acres in Washington. About 18 percent of suitable northern spotted owl habitat is located on FPHCP covered lands (Table 8-8). However, much of the suitable habitat on FPHCP covered lands exists as small isolated patches which are too small to support northern spotted owls. The 18 percent figure likely over estimates that actual suitable northern spotted owl habitat on FPHCP covered lands. Pierce and others (2005) estimated that 7 to 13 percent of suitable northern spotted owl habitat was located on private lands in their study area.

Table 8-8. FPHCP covered lands within the range of the northern spotted owl in Washington.

Province	FPHCP Covered Lands (acres)	Total Northern Spotted Owl Habitat (acres - all ownerships)	Northern Spotted Owl Habitat on FPHCP Covered Lands (acres)	% of Northern Spotted Owl Habitat in Province on FPHCP Covered Lands
Olympic Peninsula	715,300	717,000	40,700	6%
Western WA Lowlands	3,941,200	378,600	235,100	62%
Western WA Cascades	1,430,900	1,616,300	178,200	11%
Eastern WA Cascades	860,600	972,500	205,800	21%
Totals:	**6,948,000**	**3,684,400**	**659,800**	**18%**

Note: All figures are approximate values derived from GIS data. Northern spotted owl habitat estimates represent approximate conditions in 2003, as depicted by Davis and Lints' (2005) map data, and accounting for stand-replacing timber harvest and fire losses that occurred from 1992 to 2002 (Healey et al. 2003).

8.2.3.4 Northern Spotted Owls on FPHCP Covered Lands

As of October 2004, there were 1,044 territorial sites (status 1, 2, or 3) documented in the WDFW database (Buchanan and Swedeen 2005). Status 1-3 sites represent known northern spotted owl pair locations, pairs of unknown breeding status, or resident singles. This figure likely over estimates the actual number of active northern spotted owl territories in Washington because once a site is documented, the status of the site at the time of the last survey remains in the database until new information is available to revise the status (Buchanan and Swedeen 2005).

Given the annual declines in the northern spotted owl population in Washington, it is likely that some northern spotted owl sites classified as status 1, 2, or 3 are no longer occupied, but are still considered active in the database (Buchanan and Swedeen 2005).

Most (84 percent) of the northern spotted owl sites in Washington are located on Federal lands (n = 878) (Buchanan and Swedeen 2005). Of the 166 northern spotted owl territories that occur on non-Federal (or tribal) lands in Washington, 62 sites (37 percent) are centered on FPHCP covered lands (Table 8-9). Northern spotted owls in Washington use large annual homerange areas that vary from less than 3,000 to more than 30,000 acres (Hansen et al. 1993). Because the actual configuration of a home range is rarely known, a circle centered on an owl activity center is used to identify the area approximating the provincial median annual home range. For example, median northern spotted owl circles used in Washington range from a 1.8-mile radius circle in the Cascades to a 2.7-mile radius circle on the Olympic Peninsula (WAC 222-10-041(4)(b)(i)(ii)). Because northern spotted owls use large areas, owl site centers that are located on Federal lands or other ownerships may have circles that overlap the FPHCP covered lands.

We analyzed northern spotted owl circles in Washington and found that about half (n = 531) have at least 5 acres of FPHCP covered lands within the circle, and about 25 percent (n = 263) have at least 10 percent or more FPHCP covered lands within the circle (Table 8-9). We used 5 acres of FPHCP covered lands within an owl circle as a "may affect" indicator in this Opinion. We expect that all northern spotted owl circles with 5 acres or more of FPHCP covered lands within the circle have the potential for measurable effects from forest practices activities. We expect that northern spotted owl circles with less than 5 acres of FPHCP covered lands are not likely to be adversely affected by forest practices activities on the

FPHCP covered lands, because 5 acres represents less than 0.1 percent of the area within an owl circle. We used 10 percent in FPHCP covered lands within an owl circle as a threshold to identify circles with significant FPHCP ownership (i.e.,greater than 10 percent).

Table 8-9. Northern spotted owl sites on FPHCP Covered Lands by province in Washington.

Province	Total number of northern spotted owl sites (all ownerships)	No. of northern spotted owl site centers located on FPHCP covered lands	No. of northern spotted owl circles with ≥5 acres located on FPHCP covered lands	% of northern spotted owl circles with ≥5 acres located on FPHCP covered lands	No. of northern spotted owl circles with ≥10 percent located on FPHCP covered lands	% of northern spotted owl circles with ≥10 percent located on FPHCP covered lands
Olympic Peninsula	244	3	124	51%	54	22%
Western Washington Lowlands	21	12	21	100%	21	100%
Western Washington Cascades	456	11	189	41%	89	20%
Eastern Washington Cascades	323	36	197	61%	99	31%
Washington Totals	**1,044**	**62**	**531**	**51%**	**263**	**25%**

Notes: Includes only status 1,2,3, sites documented in the WDFW northern spotted owl database. Status 1 = known pair location; status 2 = two owls (male and female) located, but pair status unknown; status 3 = resident single.

Using Davis and Lints' (2005) habitat maps, we estimated the amount of habitat associated with northern spotted owl circles that overlap FPHCP covered lands (Table 8-10). The map data provide general estimates, but lack sufficient detail to be applied for site-specific analysis with confidence (Davis and Lint 2005). In general, these data indicate that over 60 percent of the owl circles that overlap the FPHCP covered lands have less than 40 percent suitable habitat within the circle. About 14 percent of the owl circles had less than 20 percent suitable habitat in the circle. A landscape assessment by Bart and Forsman (1990) showed that both the rate of occurrence of northern spotted owls and reproductive output were higher in landscapes that had at least 40 percent suitable habitat. The FWS uses the 40 percent habitat threshold as a general guideline for analytical purposes. We recognize that there are many examples of northern spotted owl sites that have persisted with habitat below 40 percent, that home ranges are not circular, and that the 40 percent threshold is not an absolute indicator of site-viability (U.S. Fish and Wildlife Service 1990c; U.S. Fish and Wildlife Service 1995). This 40 percent value has also been used by the Washington Forest Practices Board as a guideline for maintaining suitable habitat in northern spotted owl circles to maintain the viability of the northern spotted owl territories (WAC 222-10-041).

The relatively low amount of suitable habitat inside the northern spotted owl circles as indicated by Davis and Lints' (2005) data is not unexpected. Northern spotted owl habitat is highly fragmented from a

legacy of clearcut timber harvest throughout the owl's range in Washington prior to the owl's listing as a threatened species in 1990. Pierce and others (2005) evaluated suitable habitat levels in 450 owl circles in their study area and found a similar pattern of low suitable habitat within the circles. Across their study area, they found that owl circles averaged about 26 percent suitable habitat in the circle across all landscapes. Values in this study ranged from an average 7 percent in southwest Washington to an average of 31 percent in the east Cascades (Pierce et al. 2005, p. 53).

Table 8-10. Number of northern spotted owl circles by amount of suitable habitat (percent area) that overlap FPHCP covered lands.

	Amount of Suitable Habitat (percent (%) area) in Northern Spotted Owl Circles				
Province	**0-19%**	**20-39%**	**40-59%**	**60-79%**	**Total Circles**
Olympic Peninsula	22	53	44	5	124
Western Washington Lowlands	16	5	-	-	21
Western Washington Cascades	9	94	77	9	189
Eastern Washington Cascades	25	103	60	9	197
Washington Totals	**72**	**255**	**181**	**23**	**531**
Percent	**14 %**	**48%**	**34%**	**4%**	**100 %**

Notes: Suitable habitat acres were calculated on all ownerships within the circles and estimates represent approximate conditions in 1996, as depicted by Davis and Lints' (2005) map data. Data includes only status 1,2,3, sites documented in the WDFW northern spotted owl database.

8.2.3.5 Conservation Role of the FPHCP Covered Lands for Northern Spotted Owls

The draft recovery plan for the northern spotted owl identified specific conservation roles that non-Federal lands provide for the conservation and recovery of northern spotted owls. These roles include: 1) providing habitat (suitable or dispersal) to support the conservation of northern spotted owls in Federal reserves in areas where non-Federal lands are mixed with Federal lands; 2) providing for clusters of breeding pairs on non-Federal lands in locations where Federal lands are not adequate to provide for recovery; 3) provide habitat for existing northern spotted owl pairs to avoid take of those owls as defined by the ESA; and 4) providing dispersal habitat for connectivity between Federal reserves (U.S. Fish and Wildlife Service 1992b, p.106).

Currently about 18 percent of the extant suitable habitat acres in Washington is located on the FPHCP covered lands. In areas with few Federal acres (e.g., southwest Washington), the conservation of northern spotted owls is entirely dependent upon conservation efforts on State or private lands. The FPHCP covered lands provide important nesting, roosting, foraging, and dispersal habitat for at least 25 percent of the existing territorial northern spotted owls in Washington, due to the substantial overlap of the territorial circles with FPHCP covered lands. In southwest Washington, FPHCP covered lands comprise the majority of that landscape, and over 60 percent of the suitable habitat acres in this province are located on the FPHCP covered lands. Although there are only a few territorial northern spotted owls sites in the Western Lowlands province, the FWS considers these sites to be increasingly important for the conservation of northern spotted owls in Washington, due to their location between clusters of northern spotted owls on the Olympic Peninsula, the western Cascades, and northwest Oregon. The relative importance of these areas for northern spotted owl recovery will be evaluated in a revised northern

spotted owl recovery plan, currently scheduled to be completed in 2007. Much of the northern spotted owl habitat that occurs on the FPHCP covered lands is widely scattered in small patches across large landscapes, and that much of this habitat does not exist in sufficient quantities to support territorial northern spotted owls. However, these small patches of habitat are potentially important for northern spotted owl connectivity, and provide important dispersal and foraging habitat functions for northern spotted owls dispersing across private lands between areas with large blocks of habitat on adjacent State and Federal lands.

8.2.3.6 Northern Spotted Owl Habitat in the FPHCP Riparian Management Zones

Due to the high density of rivers and streams in Washington, riparian areas occupy a substantial portion of the landscape. In western Washington, the RMZs comprise about 13 percent of the total FPHCP covered land acres. About 10 percent of all suitable northern spotted owl habitat on the westside FPHCP covered lands is located in RMZs (Table 8-11). The amount of owl habitat within different RMZ types varies by province. On the Olympic Peninsula, only about 4 percent of the RMZ acres contain owl habitat. This is presumably due to a low percentage of conifer cover in Olympic Peninsula RMZs, and a high percentage of RMZ areas with second-growth forest.

In the east Cascades province, the FPHCP RMZs occupy a much smaller part of the landscape (7 percent) and only about 5 percent of the suitable northern spotted owl habitat is located in the eastside RMZs. However, FPHCP RMZs in the East Cascades province contains the highest percentage of owl habitat within RMZs (18 percent) of any of the provinces (Table 8-11).

Table 8-11. Northern spotted owl habitat (nesting, roosting, and foraging (NRF)) in riparian management zones (RMZs) on the FPHCP covered lands (acres).

Province		Acres in Type S RMZs	Acres in Type F RMZs	Acres in Type Np RMZs	Total Acres in RMZs	Total Acres of FPHCP Covered Lands	% of Acres on FPHCP Covered Lands in RMZs
Olympic Peninsula	Total Acres	29,400	66,700	16,900	113,000	715,300	16%
	NRF Habitat	900	2,300	1,000	4,200	40,700	10%
	Percent of acres with NRF habitat	3%	3%	6%	4%	6%	na
Western Washington Lowlands	Total Acres	133,500	303,300	70,400	507,200	3,941,200	13%
	NRF Habitat	4,700	12,300	6,200	23,200	235,100	10%
	Percent of RMZ acres with NRF habitat	4%	4%	9%	5%	6%	na
Western Washington Cascades	Total Acres	60,300	77,300	56,200	193,800	1,430,900	14%
	NRF Habitat	4,700	7,500	7,900	20,100	178,200	11%
	Percent of RMZ acres	8%	10%	14%	10%	12%	na

Table 8-11. Northern spotted owl habitat (nesting, roosting, and foraging (NRF)) in riparian management zones (RMZs) on the FPHCP covered lands (acres). (continued)

Province		Acres in Type S RMZs	Acres in Type F RMZs	Acres in Type Np RMZs	Total Acres in RMZs	Total Acres of FPHCP Covered Lands	% of Acres on FPHCP Covered Lands in RMZs
	with NRF habitat						
Eastern Washington Cascades	Total Acres	17,800	22,200	19,600	59,600	860,600	7%
	NRF Habitat	2,200	4,700	4,100	11,000	205,800	5%
	Percent of RMZ acres with NRF habitat	12%	21%	21%	18%	24%	na
Washington Totals	Total Acres	241,000	469,500	163,100	873,600	6,948,000	13%
	NRF Habitat	12,500	26,800	19,200	58,500	659,800	9%
	Percent of RMZ acres with NRF habitat	5%	6%	12%	7%	9%	na

Notes: na= not applicable. All figures are approximate values derived from GIS data. Northern spotted owl habitat estimates represent approximate conditions in 2003, as depicted by Davis and Lints' (2005) map data, and accounting for stand-replacing timber harvest and fire losses that occurred from 1992 to 2002 (Healey et al. 2003). Riparian areas include average RMZ widths along Type S, F, and Np stream types based on the average 100-year site-potential tree height for site index 2 and 3.

8.2.3.7 FPHCP Riparian Management Zones in Territorial Northern Spotted Owl Circles

We analyzed provincial owl circles that had at least 50 percent (n = 71) or more of the circle located on FPHCP covered lands to estimate the average proportion of the northern spotted owl circles that are located within RMZs (Table 8-12). Fifty percent was used because: (1) there are few owl circles with 100 percent of the circle located on FPHCP covered lands, and (2) using something much less than 50 percent would have skewed the average proportion of circles within RMZs to a very low average percentage since RMZs make up a relatively small part of any given owl circle. The analysis indicates that in western Washington, the FPHCP RMZs comprise a substantial portion of the owl circles on FPHCP covered lands, averaging from 8 to 12 percent of the total circle area. However, only about 3 to 8 percent of the current suitable habitat within the circles is located in the RMZs, and owl circles that have the majority of ownership on FPHCP covered lands tend to have low amounts of suitable habitat within the circles (i.e., less than 40 percent).

In the east Cascades, the FPHCP RMZs occupy a much smaller portion of northern spotted owl circles, averaging about 3 percent, and the amount of suitable habitat in circles located in the FPHCP RMZs also equals about 3 percent. About a third of the east Cascades northern spotted owl circles are centered on WDNR eastside HCP lands or Federal lands. The overall average percent of suitable habitat in the eastside owl circles is substantially higher (38 percent) than in the westside provinces (i.e., 14 to 23 percent). Although the FPHCP RMZs on the eastside occupy less area, they are likely important source

areas for northern spotted owl prey (Peffer 2001), and are therefore important for northern spotted owl recovery over the long-term.

Table 8-12. FPHCP Riparian Management Zones (RMZ) in provincial owl circles. Average values for total acres in RMZs are presented. Owl circles analyzed included only those circles that had greater than or equal to 50 percent of the circle located on FPHCP covered lands.

Province	No. of sites with ≥50% of owl circle area on FPHCP Lands	Average acres of FPHCP Lands within provincial owl circle	Average percent of owl circle located on FPHCP Lands	Average total NRF[1] acres within provincial owl circle (all owner-ships)	Average % of owl circle with NRF habitat	Average acres of FPHCP-RMZs within owl circles	Average % of acres of FPHCP-RMZs within owl circles	Average acres of NRF habitat in RMZs on FPHCP Lands	Average % of NRF habitat in owl-circle located in RMZs on FPHCP Lands
Olympic Peninsula	5	8,330	57%	2,040	14%	1,340	9%	70	3%
Western Washington Lowlands	14	11,790	80%	1,910	13%	1,810	12%	150	8%
Western Washington Cascades	16	4,580	70%	1,500	23%	530	8%	70	5%
Eastern Washington Cascades	36	5,270	81%	2,450	38%	220	3%	80	3%

Note: All figures are approximate values derived from GIS data. Northern spotted owl habitat estimates represent approximate conditions in 1996, as depicted by Davis and Lint's (2005) map data. The provincial owl circle used for the Olympic Peninsula and the Western Washington lowlands = 14,658 acres (2.7-mile radius). The provincial northern spotted owl circle area used for the Western and Eastern Cascades = 6,514 acres (1.8-mile radius).

[1] NRF means nesting, roosting, and foraging habitat.

8.2.3.8 Northern Spotted Owl Habitat Management under the Washington Forest Practices Rules

Northern spotted owls in Washington are protected under both State and Federal regulations. The Washington Fish and Wildlife Commission listed the northern spotted owl as a State endangered species in 1988, and the northern spotted owl was listed as a federally threatened species in 1990. The Washington Forest Practices Rules require that both State and federally listed species be considered for designation of "critical habitat state" – a designation that serves as a trigger for State Environmental Policy Act (SEPA) review (WAC 222-16-050(1)(b)). In addition, ESA section 9 prohibits "take" of listed species. Together, the State and Federal regulations provide a framework for northern spotted owl management guidelines in Washington.

Important Definitions Pertaining to Northern Spotted Owls

The Washington Forest Practices Rules contain several specific definitions that pertain to the identification and management of northern spotted owl habitat (WAC 222-16-085):

1. **Suitable northern spotted owl habitat** means forest stands which meet the description of old forest habitat, sub-mature habitat or young forest marginal habitat found in (a) and (b) of this

subsection. Old forest habitat is the highest quality, followed in descending order by submature habitat and young forest marginal habitat.

a. **Old forest habitat** means habitat that provides for all the characteristics needed by northern spotted owls for nesting, roosting, foraging, and dispersal, described as stands with:

    i. A canopy closure of 60 percent or more and a layered, multispecies canopy where 50 percent or more of the canopy closure is provided by large overstory trees (typically, there should be at least 75 trees greater than 20 inches diameter at breast height per acre, or at least 35 trees 30 inches diameter at breast height or larger per acre); and

    ii. Three or more snags or trees 20 inches diameter at breast height or larger and 16 feet or more in height per acre with various deformities such as large cavities, broken tops, dwarf mistletoe infections, and other indications of decadence; and

    iii. More than two fallen trees 20 inches diameter at breast height or greater per acre and other woody debris on the ground.

b. **Sub-mature habitat and young forest marginal habitat.** Sub-mature habitat provides all of the characteristics needed by northern spotted owls for roosting, foraging, and dispersal. Young forest marginal habitat provides some of the characteristics needed by northern spotted owls for roosting, foraging, and dispersal. Sub-mature habitat and young forest marginal habitat stands can be characterized based on the forest community, canopy closure, tree density and height, vertical diversity, snags and cavity trees, dead and down wood, and shrubs or mistletoe infection. They are described in Tables 8-13 and 8-14.

Northern spotted owl dispersal habitat means habitat stands that provide the characteristics needed by northern spotted owls for dispersal. Such habitat provides protection from the weather and predation, roosting opportunities, and clear space below the forest canopy for flying. Timber stands that provide for northern spotted owl dispersal have the following characteristics:

a) **For western Washington,** timber stands 5 acres in size or larger with:

    i. 70 percent or more canopy cover; and

    ii. 70 percent or more of the stand in conifer species greater than 6 inches diameter at breast height; and

    iii. A minimum of 130 trees per acre with a diameter at breast height of at least 10 inches or a basal area of 100 square feet of 10 inch diameter at breast height or larger trees; and

    iv. A total tree density of 300 trees per acre or less; and

    v. A minimum of 20 feet between the top of the understory vegetation and the bottom of the live canopy, with the lower boles relatively clear of dead limbs.

Table 8-13. Western Washington Northern Spotted Owl Sub-Mature and Young Forest Marginal Habitat Characteristics from the Washington Forest Practices Rules (WAC 222-16-085).

Characteristic	Habitat Type	
	Sub-Mature	**Young Forest Marginal**
Forest Community	conifer-dominated or conifer hardwood (greater than or equal to 30% conifer)	conifer-dominated or conifer hardwood (greater than or equal to 30% conifer)
Canopy Closure	greater than or equal to 70% canopy closure	greater than or equal to 70% canopy closure
Tree Density and Height	115-280 trees/acre (greater than or equal to 4 inches dbh) with dominants/codominants greater than or equal to 85 feet high OR dominant/codominants greater than or equal to 85 feet high with 2 or more layers and	115-280 trees/acre (greater than or equal to 4 inches dbh) with dominants/codominants greater than or equal to 85 feet high OR dominant/codominants greater than or equal to 85 feet high with 2 or more layers and
Vertical Diversity	25 - 50% intermediate trees	25 - 50% intermediate trees
Snags/Cavity Trees	Greater than or equal to 3/acre (greater than or equal to 20 inches dbh and 16 feet in height)	greater than or equal to 2/acre (greater than or equal to 20 inches dbh and 16 feet in height) OR greater than or equal to 10% of the ground covered with 4 inch diameter or larger wood, with 25-60% shrub cover
Dead, Down Wood	N/A	
Shrubs	N/A	

The values indicated for canopy closure and tree density may be replaced with a quadratic mean diameter of greater than 13 inches and a basal area of greater than 100.

b) **For eastern Washington,** timber stands 5 acres in size or larger with:

i. 50 percent or more canopy closure; and

ii. A minimum of 50 conifer trees per acre, with a diameter at breast height of 6 inches or more in even-aged stands or 4 inches or more in uneven-aged stands, and an average tree height of 65 feet or more; and

iii. Total tree density of 200 trees per acre or less; and

iv. A minimum of 20 feet between the top of the understory vegetation and the bottom of the live canopy, with the lower boles relatively clear of dead limbs; or

v. Conifer stands with a quadratic mean diameter of 9 inches or more and a relative density of 33 or more or a canopy closure of 55 percent or more.

c) Suitable northern spotted owl habitat provides all of the required characteristics needed by northern spotted owls for dispersal.

Table 8-14. Eastern Washington Northern Spotted Owl Sub-Mature and Young Forest Marginal Habitat Characteristics from the Washington Forest Practices Rules (WAC 222-16-085).

	Habitat Type		
Characteristic	**Sub-Mature**	**Young Forest Marginal (closed canopy)**	**Young Forest Marginal (closed canopy)**
Forest Community	greater than or equal to 40% fir	greater than or equal to 40% fir	greater than or equal to 40% fir
Tree Density and Height	110-260 trees/acre (greater than or equal to 4 inches dbh) with dominants/codominants greater than or equal to 90 feet high OR dominants/codominants greater than or equal to 90 feet high with 2 or more layers and 25-50% intermediate trees	100-300 trees/acre (greater than or equal to 4 inches dbh)	100-300 trees/acre (greater than or equal to 4 inches dbh)
Vertical Diversity		dominants/codominants equal to or greater than 70 feet high 2 or more layers 25-50% intermediate trees	dominants/codominants equal to or greater than 70 feet high 2 or more layers 25-50% intermediate trees
Canopy Closure	greater than or equal to 70% canopy closure greater	greater than or equal to 70% canopy closure greater	greater than or equal to 50% canopy closure
Snags/Cavity Trees	greater than or equal to 3/acre (greater than or equal to 20 inches dbh 16 feet in height) OR high or moderate infection	N/A	2/acre or more (greater than or equal to 20 inches dbh 16 feet in height)
Mistletoe		N/A	high or moderate infection
Dead, Down Wood	N/A	N/A	N/A

The values indicated for canopy closure and tree density may be replaced with the following:

a) For sub-mature a quadratic mean diameter of greater than 13 inches and a relative density of greater than 44;

b) For young forest marginal a quadratic mean diameter of greater than 13 inches and a relative density of greater than 28.

Northern Spotted Owl Special Emphasis Areas

Timber harvest on the FPHCP covered lands is subject to the provisions of the Washington Forest Practices Rules for northern spotted owls that were adopted by the Forest Practices Board in 1996 (WAC 222-10-041). The 1996 rules identified 10 landscapes or Northern Spotted Owl Special Emphasis Areas (SOSEAs) where northern spotted owl protections would be emphasized. The 10 SOSEAs in Washington comprise over 2 million acres, including about 1.5 million acres of non-Federal lands (Washington Forest Practices Board 1996). The SOSEAs were identified and adopted by the Forest Practices Board because they represent landscape areas where the protection of northern spotted owls on non-Federal lands would contribute to the overall conservation of northern spotted owls in Washington, and are generally located to complement conservation goals on adjacent Federal lands managed under the Northwest Forest Plan. Pierce and others (2005) estimated that there were 426,272 acres of suitable northern spotted owl habitat inside the SOSEAs in 2004, which represents about 21 percent of the SOSEA acres.

Each of the SOSEAs has one or more conservation functions assigned to them. These conservation functions are associated with specific areas within the SOSEA or in some cases with an entire SOSEA. The conservation functions are demographic support, dispersal support, and a combination of dispersal

and demographic support (Washington Forest Practices Board 1996). The SOSEA designations were identified to guide management decisions in the development of Landowner Option Plans under the State rules, or to inform the development of Habitat Conservation Plans (HCP). In the absence of a Landowner Option Plan or an HCP, there are default rules to protect northern spotted owl habitat in SOSEAs that is located within status 1-3 owl circles under the "critical habitat" State rules (WAC 222-16-080).

Northern Spotted Owl Habitat Management Within SOSEAs

Within SOSEAs, any proposed harvest of suitable northern spotted owl habitat (as defined by WAC 222-16-085) within a known territorial owl circle (status 1-3) is considered a "Class-IV-Special" activity that requires a SEPA review. For individual northern spotted owl site centers (status 1-3) within a SOSEA, the Washington Forest Practices Rules generally prohibit timber harvest within 0.7 miles of a site center, and require that a minimum of 40 percent of the suitable habitat within the territorial circle be maintained to protect the viability of the territory. At all sites within SOSEAs, any proposed harvest of suitable spotted owl habitat within a territorial owl circle is considered a "Class-IV special" and would trigger State Environmental Policy Act (SEPA) review. Proposed harvest that would reduce habitat amounts below the 40 percent threshold is considered to have a significant probable adverse impact on the environment with respect to SEPA. If a determination of significance is made, preparation of a SEPA Environmental Impact Statement is required prior to proceeding. If a determination of non-significance or mitigated determination of non-significance is reached, the action can proceed without further environmental assessment. Exemptions to this rule include areas that are managed under a completed HCP for northern spotted owls approved by the FWS, or a State Landowner Option Plan that has gone through SEPA review. In addition, any landowner with an ownership of less than 500 acres in a SOSEA is exempt from the Class IV-Special rules as long the proposed harvest occurs >0.7 miles from a status 1-3 northern spotted owl activity center (WAC 22-16-080 (1)(h)(iv)).

Until recently, suitable habitat within a northern spotted owl circle that was harvested under an approved HCP, ESA section 7 consultation, or a 500-acre exemption could still be counted as suitable habitat acres contributing towards the minimum 40 percent by other landowners within the same circle. Additionally, the prohibition against harvesting habitat that would bring an owl circle below the 40 percent suitable habitat threshold, or harvesting within 0.7 miles of the site center, could be lifted if surveys indicated the site was abandoned for a period of 3 years or more. These exemptions were changed on November 30, 2005, through an emergency rule making by the Forest Practices Board. The emergency rule will protect suitable habitat in northern spotted owl circles within SOSEAs under status 1-3 site rules, regardless of current status. Further, acres harvested under an approved HCP or other conservation agreement cannot be counted by other landowners as "suitable" habitat (Washington Forest Practices Board 2005).

We analyzed the FPHCP covered lands on SOSEAs and found that only about 11 percent (779,800 acres) of the FPHCP covered lands within the range of the northern spotted owl are located in SOSEAs, and that about 29 percent of the northern spotted owl habitat in SOSEAs was located on FPHCP covered lands (Table 8-15). Pierce and others (2005) estimated that there was a total of 426,200 acres of suitable habitat located within SOSEAs in 2004, and that about 59 percent of the habitat (249,600 acres) in SOSEAs is located inside northern spotted owl circles, and about 35 percent (149,000 acres) is located within approved HCPs. Of the 1,044 northern spotted owl sites in Washington, 91 sites (9 percent) are located in SOSEAs.

Table 8-15. FPHCP covered lands and northern spotted owl habitat in SOSEAs.

Province	Total SOSEA Acres in Province	FPHCP Covered Lands in SOSEAs (acres)	Percent of SOSEA Acres on FPHCP Covered Lands	Total NRF Acres in SOSEA	Total NRF Acres on FPHCP Covered Lands in SOSEA	Percent of NRF Acres in SOSEA on FPHCP Covered Lands	Total NRF Acres on all FPHCP Covered Lands in Province (1996)	NRF acres on FPHCP Covered Lands in SOSEA Owl Circles	Percent of NRF acres on FPHCP Covered Lands in SOSEA Owl Circles
Olympic Peninsula	396,800	128,600	32%	47,500	4,600	10%	40,700	2,900	7%
Western Washington Lowlands	1,000	nc	nc	nc	nc	nc	235,100	0	0
Western Washington Cascades	884,900	368,000	42%	157,000	35,600	23%	178,200	18,000	10%
Eastern Washington Cascades	775,300	283,200	37%	198,300	79,600	40%	205,800	56,600	27%
Washington Totals	**2,058,000**	**779,800**	**38%**	**402,800**	**119,800**	**29%**	**659,800**	**77,400**	**12%**

Note: nc = not calculated. All figures are approximate values derived from GIS data. Northern spotted owl habitat estimates represent approximate conditions in 2003, as depicted by Davis and Lints' (2005) map data, and accounting for stand-replacing timber harvest and fire losses that occurred from 1992 to 2002 (Healey et al. 2003).

Northern Spotted Owl Habitat Management Outside SOSEAs

Outside of SOSEAs, there are no timber harvest restrictions within northern spotted owl territories except during the nesting season (March 1 through August 31) under the Washington Forest Practices Rules. During the nesting season any harvest, road construction, or aerial application of pesticides within the best 70 acres of suitable habitat surrounding a northern spotted owl site is prohibited to prevent direct mortality of owls associated with the harvest of an active nest site during the nesting season. Outside the nesting season, there are no restrictions, and habitat surrounding a northern spotted owl site may be harvested, including the 70-acre nest grove. At the time that the Forest Practices Board was developing the SOSEA conservation strategy, the FWS had proposed a draft 4(d) rule to modify the Section 9 take prohibition for northern spotted owl sites outside SOSEAs (U.S. Fish and Wildlife Service 1995). The provisions of the proposed 4(d) rule were fundamental to the development of the Washington Forest Practices Rules adopted in 1996 (Buchanan and Swedeen 2005). However, the proposed 4(d) rule was not finalized, creating a situation where a landowner could be in full compliance with the Washington Forest Practices Rules and potentially be in violation of ESA Section 9 if their harvest activities resulted in unauthorized take. Of the 1,044 northern spotted owl sites in Washington, 62 sites (6 percent) are located on non-Federal lands outside SOSEAs (Buchanan and Swedeen 2005).

We evaluated suitable northern spotted owl habitat on the FPHCP covered lands and found that about 25 percent (188,969 acres) of the 1996 owl habitat acres were located in known owl circles (both inside and outside of SOSEAs), but that only 12 percent of the FPHCP owl habitat was located in owl circles located in SOSEAs (Table 8-16). Most of this habitat occurred in the eastern Washington Cascades province.

Overall, 89 percent of the suitable northern spotted owl habitat on the FPHCP covered lands is not associated with owl circles or is not located in SOSEAs.

Table 8-16. Suitable northern spotted owl habitat on FPHCP covered lands in known owl circles.

Province	Total FPHCP Acres in Province	Total NRF Acres on FPHCP Covered Lands (2003)	NRF Acres on FPHCP Covered Lands associated with known owl circles	Percent Total NRF Acres on FPHCP Covered Lands associated with known owl circles	NRF Acres on FPHCP Covered Lands associated with known owl circles in SOSEAs	Percent Total NRF Acres on FPHCP Covered Lands associated with known owl circles in SOSEAs
Olympic Peninsula	715,300	40,700	14,900	37%	2,900	7%
Western Washington Lowlands	3,941,200	235,100	18,400	8%	0	0%
Western Washington Cascades	1,430,900	178,200	28,900	16%	18,000	10%
Eastern Washington Cascades	860,600	205,800	99,500	48%	56,600	27%
Washington Totals	**6,948,000**	**659,800**	**161,700**	**24%**	**77,500**	**12%**

Note: All figures are approximate values derived from GIS data. Northern spotted owl habitat estimates represent approximate conditions in 2003, as depicted by Davis and Lints' (2005) map data, and accounting for stand-replacing timber harvest and fire losses that occurred from 1992 to 2002 (Healey et al. 2003).

The FWS recognizes that not all suitable northern spotted owl habitat is currently occupied by territorial northern spotted owls. Suitable habitat that occurs outside of the known northern spotted owl circles is also important for supporting territorial northern spotted owls because territories are not circular but vary in size and configuration (Forsman et al. 1984). Many territorial circles have low amounts of suitable habitat suggesting that habitat located outside the circles may also be important for supporting territorial northern spotted owls (Buchanan and Swedeen 2005). Suitable habitat that occurs outside of known circles is also important for the successful dispersal of northern spotted owls across landscapes, and is ultimately important for species recovery because dispersing northern spotted owls are more likely to successfully colonize suitable habitat adjacent to occupied territories than random locations on the landscape (Lahaye et al. 2001).

Timber Harvest on FPHCP Covered Lands

We estimated the annual rates of timber harvest on the FPHCP covered lands for the period of 1992 – 2002 using the data compiled by Healey et al. (2003). These mapped data depict stand-replacing disturbance associated with timber harvest and wildfire, but do not portray changes associated with partial harvests such as commercial thinning. Within the range of the northern spotted owl in Washington, we

found that stand-replacing timber harvest (without fires) occurred at a rate of 1.1 to 1.3 percent per year on the FPHCP covered lands (Table 8-17). For the 10 year period of 1992-2002, there were over 800,000 acres harvested or burned. About 90 percent of these acres were identified as timber harvest. Although there were large wildfires in the eastern Washington Cascade Mountains during this period, most of the stand-replacing fires occurred on Federal lands, and a relatively small portion of the FPHCP covered lands were burned (Table 8-17).

Table 8-17. Acres of timber harvest and stand-replacing wildfire on FPHCP covered lands 1992-2002.

Province	Total Acres of FPHCP Covered Lands in Province	Timber Harvest Acres - 2000 - 2002	Timber Harvest Acres - 1996 - 2000	Timber Harvest Acres - 1992 - 1996	Total Timber Harvest Acres - 1992 - 2002	10-year average annual harvest acres	Average Percent of FPHCP Acres Harvested Annually	Total Wildfire Acres Burned - 1992 - 2002
Olympic Peninsula	715,300	19,300	40,800	33,300	93,400	9,340	1.3%	0
Western Lowlands	3,941,200	80,500	173,600	201,800	455,900	45,500	1.2%	0
Western Washington Cascades	1,430,900	31,700	64,000	87,100	182,800	18,200	1.3%	430
Eastern Washington Cascades	860,600	17,800	31,900	11,700	61,400	6,140	0.7%	7,930
Washington Totals	**6,948,000**	**149,300**	**310,300**	**333,900**	**793,500**	**79,350**	**1.1%**	**8,360**

Note: All figures are approximate values derived from GIS data depicting stand-replacing timber harvest and fire losses that occurred from 1992 to 2002 (Healey et al. 2003). Partial disturbances, such as commercial thinning or partially burned areas, are not accounted for in this data.

We estimated the acres of northern spotted owl habitat removed by overlaying the Healey et al. (2003) disturbance data with Davis and Lints' (2005) northern spotted owl habitat suitability maps. The information derived from this analysis provides a general estimate of the rate of habitat loss in Washington, but does not represent absolute values. We found that over 202,000 acres of northern spotted owl habitat was harvested between 1992 - 2002 on all lands in Washington, representing a decadal loss of about 5 percent (Table 8-18). Timber harvest on the FPHCP covered lands accounted for about 68 percent of the total habitat removed (136,900 acres). Harvest on Federal, tribal, or other HCP-covered lands accounted for the remaining 32 percent of habitat loss. Timber harvest on the FPHCP covered lands removed about 17 percent of the northern spotted owl habitat that was present in 1992-1996. Most of habitat loss occurred in the Western Washington Lowlands (44 percent) where there are few northern spotted owls, but all provinces had substantial habitat loss (Table 8-18).

Table 8-18. Estimated acres of suitable northern spotted owl habitat harvested on FPHCP covered lands 1992-2002.

Province	Total NRF Acres in Province (1994-1996)	Total NRF Acres on FPHCP Covered Lands (1994-1996)	Total NRF Acres Harvested in Province (2002)	Percent of NRF Acres in Province Harvested (1992-2002)	Total NRF Acres Harvested on FPHCP Covered Lands (1992-2002)	Percent of NRF Acres on FPHCP Covered Lands Harvested (1992-2002)
Olympic Peninsula	736,900	54,800	19,800	3%	14,100	26%
Western Washington Lowlands	449,700	295,400	71,100	16%	60,300	20%
Western Washington Cascades	1,672,400	217,000	56,100	3%	38,800	18%
Eastern Washington Cascades	1,027,700	229,600	55,200	5%	23,700	10%
Washington Totals	**3,886,700**	**796,800**	**202,200**	**5%**	**136,900**	**17%**

Note: All figures are approximate values derived from GIS data. Northern spotted owl habitat estimates represent approximate conditions in 2003, as depicted by Davis and Lints' (2005) map data, and accounting for stand-replacing timber harvest and fire losses that occurred from 1992 to 2002 (Healey et al. 2003).

Pierce and others (2005) also completed an evaluation of habitat loss from timber harvest in their study area for the period of 1996 to 2004. They also used the disturbance maps developed by Healey et al. (2003), but their study also included estimates of habitat loss associated with partial harvests. Pierce and others (2005) mapped a total of 172,000 acres of timber harvest in their 3.2 million-acre study area, including harvest of 56,400 acres of suitable northern spotted owl habitat. This represented a loss of about 6 percent of the northern spotted owl habitat in their study area distributed across all ownerships. Approximately 77 percent of the harvested habitat occurred on private lands and about 15 percent occurred on State lands (Pierce et al. 2005).

The emergency rule changes adopted by the Forest Practices Board were partly in response to data presented by Pierce et al. (2005). The Board summarized the need for the rule changes: "Since the Forest Practices Board adopted rules to protect the habitat of the northern spotted owl in 1996, the amount of suitable habitat in Northern Spotted Owl Special Emphasis Areas, outside areas being managed under a habitat conservation plan has declined by an average of 16 percent. Furthermore, fewer plans to conserve northern spotted owl habitat at a landscape level have been developed than was anticipated when the Northern Spotted Owl rules were adopted. With few landscape-level plans, the forest practices rules continue to rely heavily upon the regulation of timber harvest at individual northern spotted owl sites to provide habitat conservation."

Federally Designated Northern Spotted Owl Critical Habitat

Federally designated northern spotted owl critical habitat in Washington covers approximately 2.3 million acres distributed across 53 units. Only Federal lands were designated in the final rule (FR 57:10:1796-

1838) so the Critical Habitat Units in Washington actually comprise about 2.15 million acres of Federal lands and encompass approximately 1.02 million acres of suitable northern spotted owl habitat. Although no Federal critical habitat occurs on FPHCP covered lands, the FWS anticipates that activities that occur on FPHCP covered lands may affect northern spotted owl critical habitat where the FPHCP covered lands occur adjacent to Critical Habitat Units. Edge effects from FPHCP covered activities associated with windthrow are reasonably certain to occur in adjacent Critical Habitat Unit stands. We used GIS to estimate the Critical Habitat Unit areas that border FPHCP covered lands, and estimated that about 64,000 acres of critical habitat occurs adjacent (within 400 feet) to FPHCP covered lands (2.8 percent). This figure represents a gross estimate and includes some non-Federal acres that are embedded within the Critical Habitat Unit boundaries. We did not calculate the suitable habitat acres associated with these Critical Habitat Unit "edge" acres, but an estimate of approximately 40 percent suitable habitat would not be unreasonable given the total ratio of suitable habitat to designated critical habitat acres (Table 8-6).

8.2.4 EFFECTS OF THE ACTION – Northern Spotted Owl and Northern Spotted Owl Critical Habitat

8.2.4.1 Context of the Effects Analysis

The analysis for the northern spotted owl and its designated critical habitat include only those effects that would be expected to occur as effects of permit issuance, such as the effects of timber harvest activities in the Riparian Zone of influence and road-related activities. The framework for analysis section of this Opinion described the primary activities that are considered effects of the permit issuance for the FPHCP. Future timber harvest activities in upland areas would be essentially unchanged by the permit issuance for the FPHCP, and therefore these activities are not analyzed in this section, but will be addressed in the analysis of cumulative effects.

Our analysis in this Opinion does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat at 50 CFR 402.02. Instead we have relied upon the statute and the August 6, 2004, Ninth Circuit Court of Appeals decision in Gifford Pinchot Task Force v. U.S. Fish and Wildlife Service (No. 03-35279) to complete the following analysis with respect to critical habitat.

Effect Determinations For the Northern Spotted Owl and Northern Spotted Owl Critical Habitat

The FWS has determined that the forest practices activities covered under the FPHCP "may affect, and is likely to adversely affect" the northern spotted owl and federally designated northern spotted owl critical habitat. The effect determination for northern spotted owls is based on our assessment that the effects of activities under the Permit are likely to result in the degradation and loss of northern spotted owl habitat on the FPHCP covered lands. The effect determination for critical habitat is based on our assessment that the forest practices activities are likely to result in the degradation and loss (i.e., due to windthrow) of suitable northern spotted owl critical habitat. Therefore, in accordance with ESA section 7(a)(2), the FWS has prepared the following effects analysis of the proposed Federal action (i.e., issuance of the FPHCP incidental take permit for aquatic species) for the northern spotted owl and its designated critical habitat.

Assumptions Regarding "Incidental Take" of Northern Spotted Owls

The northern spotted owl is not a covered species under the FPHCP; therefore, the FWS does not anticipate or authorize any incidental take of northern spotted owls associated with the implementation of the FPHCP. Any "take" would violate the prohibitions in Section 9 of the ESA, and would therefore invalidate the FPHCP Permit with respect to all listed covered species for that forest practices application that resulted in unauthorized "take." ESA section 3(19) defines the term "take" to include "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to engage in any such conduct". The terms "harm" and "harass" have been further defined by regulations at 50 CFR §17.3 as follows:

Harass means an intentional or negligent act of omission that creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns that include, but are not limited to, breeding, feeding, or sheltering.

Harm means an act that actually kills or injures wildlife. Such an act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering.

Northern spotted owls are likely to be taken as a result of activities that: (1) kill or injure birds; (2) impair essential behaviors by adversely affecting occupied or unsurveyed suitable breeding habitat; or (3) cause significant disturbance of breeding birds, leading to reduced reproductive success. Timber harvesting can result in the direct loss of suitable habitat important for northern spotted owl nesting, roosting or foraging. As a result, northern spotted owls may abandon a territory and seek out habitat elsewhere that may be marginal or occupied by other northern spotted owls that compete for the same resources. Timber harvest can adversely affect northern spotted owls by reducing the total amount of suitable habitat within a northern spotted owl's home range. The result may be that the northern spotted owls continue to persist at the territory, but marginal habitat conditions in the territory compromise the northern spotted owls' ability to survive and successfully reproduce. The FWS uses 40 percent as a minimum threshold for suitable habitat within a northern spotted owl median home range circle (U.S. Fish and Wildlife Service 1995) to avoid incidental take of that owl circle. We use the 40 percent habitat threshold as a general guideline for analytical purposes. We recognize that there are many examples of northern spotted owl sites that have persisted with habitat below 40 percent, that home ranges are not circular, and that the 40 percent threshold is not an absolute indicator of viability. However, we continue to use the 40 percent threshold for our section 7 consultation analyses because it is supported by numerous studies that indicate that northern spotted owls commonly have between 30 to 50 percent suitable habitat within a home range (e.g., Thomas et al. 1990; Hanson et al. 1993; Bart 1995; Dugger et al. 2005). The 40 percent threshold is a general guideline that is also used by WDNR to manage northern spotted owl sites in SOSEAs.

In the absence of a federally approved HCP or a State-approved Landowner Option Plan, suitable northern spotted owl habitat on non-Federal lands is only protected by the Washington State Forest Practices rules where protocol surveys have documented a status 1-3 northern spotted owl site within a SOSEA boundary. Under the Washington Forest Practices Rules, a landowner in Washington could be in full compliance with the Washington Forest Practices Rules and have some risk of causing "take" if their forest practices activities resulted in the loss of occupied northern spotted owl habitat (i.e., take). These situations include:

1. Outside of SOSEA boundaries, there are no restrictions on the harvest of suitable northern spotted owl habitat. Therefore, a landowner could harvest timber (habitat) without a pre-harvest survey, potentially resulting in the loss of a northern spotted owl site center or essential habitat within a

median home range circle (For the purpose of this discussion, "essential" habitat is defined as all suitable habitat within 0.7 miles of a site center, and all habitat required to meet a minimum of 40 percent of the suitable habitat within a territorial circle to protect the viability of the territory). If a known owl territory is present, timber harvest is restricted only during the nesting season (March 1 through August 31). Outside the nesting season, there are no restrictions, and the habitat surrounding a northern spotted owl nest site may be harvested, including the 70-acre nest grove. When a nest grove is harvested, or essential habitat surrounding the nest grove is removed, northern spotted owls are likely to be permanently displaced from their territory, potentially resulting in take.

2. Within SOSEA boundaries, there are no timber harvest restrictions to protect habitat within median home range circles where the site center occurs outside of the SOSEA boundary on non-Federal lands. (This exemption only applies to site centers located on non-Federal lands. Owl sites centered on adjacent Federal lands are protected, except in the Entiat SOSEA, where only owl site centers located within areas indicated for demographic support are protected). Habitat that occurs within SOSEA boundaries may be important for northern spotted owls nesting on adjacent lands. The removal of suitable habitat below 40 percent of the area within a median home range circle is one of the FWS's indicators of the potential for incidental take for this species. Loss of essential habitat due to timber harvest within a SOSEA boundary could result in take of northern spotted owls nesting outside the SOSEA boundary.

3. Timber harvesting in suitable northern spotted owl habitat that occurs where a landowner owns less than 500 acres and the land is not located within 0.7 miles of a northern spotted owl site center (WAC 222-16-080(h)(iv). Landowners with less than 500 acres are not required by the Washington Forest Practices Rules to protect northern spotted owl habitat on their lands where the habitat is located farther than 0.7 miles from a northern spotted owl activity center. Loss of habitat due to small landowner timber harvest could result in take of northern spotted owls if the harvest resulted in effects that rise to the level of harass or harm.

4. Timber harvesting along Federal boundary areas with suitable northern spotted owl habitat. Outside of SOSEA boundaries, there are no restrictions on the harvest of suitable northern spotted owl habitat. Therefore, a landowner could harvest timber (habitat) up to a Federal boundary, potentially resulting in a significant disruption of northern spotted owl breeding if the harvest occurs during the nesting season (harassment), and loss of habitat essential for survival and reproduction if the harvest occurs within an occupied median home range circle (harm). Northern spotted owl surveys have not been conducted on most Federal land areas for the past 10 years, so the locations of northern spotted owls on Federal lands are largely unknown. Some Federal boundary areas may be identified and protected under the SEPA review process, but it is not clear to the FWS that WDNR will identify suitable northern spotted owl habitat on Federal boundary areas as likely to be occupied habitat.

The above situations represent the greatest risk for landowners to have a potential violation of section 9 of the ESA (i.e., unauthorized incidental take). Other situations that have the potential to result in take of northern spotted owls include harvesting of suitable northern spotted owl habitat that is located outside of median home range circles; disturbance harassment associated with forest practices, or, harvesting occupied northern spotted owl habitat that has been surveyed to protocol, but the surveys failed to detect northern spotted owls (i.e., survey error). Even though each of these situations has the potential to result

in the loss of occupied northern spotted owl habitat, the risk of incidental take in these situations is relatively low.

Northern spotted owls in Washington use large annual home range areas that vary from less than 3,000 to more than 30,000 acres (Hansen et al. 1993). Because the actual configuration of a home range is rarely known, a circle centered on a northern spotted owl activity center is used to identify the area approximating the provincial median annual home range. Because northern spotted owl territories are variable, the median home range circle may or may not identify all essential habitats within an owls' territory. Without radio telemetry data for individual northern spotted owls, it is difficult to know which stands are used by northern spotted owls. Therefore, the FWS and WDNR both use the median home range circle to assess the potential impacts of forest practices activities. We recognize that the home range circle is an imperfect management tool, and that habitat essential to a northern spotted owl territory could occur outside a median home range circle. However, we expect that the majority of habitat that is essential to a northern spotted owl territory will occur within the median home range circle.

We expect that some sound and activity- related disturbances to nesting northern spotted owls could potentially occur on the FPHCP covered lands and adjacent ownerships, but the risk for potential injury to northern spotted owls is relatively low due to the 0.25 mile disturbance restrictions required by the Washington Forest Practices Rules during the nesting season (March 1 to August 31). The Washington Forest Practices Rules minimize the potential for adverse effects from disturbance to nesting northern spotted owls, but they do not ensure that all northern spotted owls will be protected from disturbance under all circumstances. Blasting within a mile of an occupied northern spotted owl site, or, timber harvesting or other forest practice activities adjacent to unsurveyed suitable habitat on Federal lands could result in harassment of nesting northern spotted owls.

Both the FWS and the State management agencies (i.e., WDNR and WDFW) are currently relying on the FWS northern spotted owl survey protocol to determine if potential habitat is occupied by nesting northern spotted owls (U.S. Fish and Wildlife Service 1992c). This protocol is not error-free, and some researchers have expressed concern regarding the efficacy of the protocol in landscapes occupied by barred owls (Courtney et al. 2004). Despite these uncertainties, the protocol represents the best available method for determining the northern spotted owl occupancy in potential habitat. Therefore, we expect that take of northern spotted owl is not likely in suitable habitat that has been surveyed to protocol with no occupancy detected (even though incidental take may occur due to the potential for survey error).

8.2.4.2 Effects of Timber Harvest to Northern Spotted Owl Habitat in FPHCP Riparian Management Zones

Assumptions Regarding Effects to Northern Spotted Owl Habitat in RMZs

For this analysis, we use the terms "suitable" habitat or "NRF" (nesting, roosting, foraging) to refer to areas with forest cover that have the general attributes of northern spotted owl habitat (i.e., mid-seral or late-seral conifer forests with high canopy cover) as depicted by the habitat maps developed by Davis and Lint (2005). "Essential" habitat is defined as all suitable habitat within 0.7 miles of a northern spotted owl site center, and all habitat required to meet a minimum of 40 percent suitable habitat within a territorial circle to maintain the viability of the territory. In the following analysis, we also refer to "dispersal" habitat. We use the term "dispersal habitat" to refer to areas with some forest cover (i.e., a riparian buffer adjacent to a clearcut area) that a transient northern spotted owl could potentially use when moving between areas of suitable habitat.

The environmental baseline analysis indicates that about 9 percent of the suitable northern spotted owl habitat on the FPHCP covered lands is located in RMZs (≈ 71,400 acres). Therefore, suitable habitat in RMZs that is not identified as essential habitat within northern spotted owl median home range circles is likely to be removed by stand replacing timber harvest in the Outer Zones of RMZs, or adversely affected by thinning from below treatments in the Inner Zones of RMZs. The environmental baseline indicates that approximately 24 percent of the suitable northern spotted owl habitat on FPHCP covered lands is located in median home range circles. Due to the low levels of suitable habitat in most median home range circles (i.e., less than 40 percent), we expect that few acres will be available for RMZ harvest in owl circles. However, there are approximately 54,000 acres of suitable northern spotted owl habitat in RMZs that are not associated with known circles, and are therefore likely to be affected by timber harvest in RMZs.

Because suitable northern spotted owl habitat consists of both intermediate and old-forest habitats, we are assuming that Option 1 (thinning from below) or Option 2 (leaving trees closest to the water) are both options that could be used to manage RMZs with suitable northern spotted owl habitat. Therefore, we estimated the potential effects associated with both options and present the results as a range of potential effects to suitable northern spotted owl habitat in RMZs.

Estimates of RMZs managed per decade and effects to northern spotted owl habitat were calculated by applying simple ratios. For example, in the West Cascades, RMZs comprise about 14 percent of the FPHCP covered lands (Table 8-11). Timber harvest on the FPHCP covered lands in the West Cascades affects about 182,800 acres per decade (Table 8-17). We assumed this rate of harvest would continue into the future. Since RMZs occupy about 14 percent of the landscape, we assume that about 14 percent of 182,800 acres (≈ 25,600 acres) would include managed RMZs. RMZs were further analyzed by Type. For example, Type F RMZs comprise 40 percent of the total RMZ acres in the West Cascades. Therefore out of 25,600 acres of RMZs managed per decade, we assume that 40 percent (≈ 10,200 acres) would be in Type F RMZs. The environmental baseline analysis for the West Cascades RMZs indicated that about 10 percent of the area in Type F RMZs contains suitable northern spotted owl habitat (Table 8-11). Therefore, we assumed that about 10 percent of the Type F RMZs managed per decade (≈ 1,000 acres) would include northern spotted owl habitat affected by timber harvest in the West Cascades. We applied similar calculations to Type S and Type Np RMZs for each province. This analysis provides rough estimates of the amount of northern spotted owl habitat that could be affected by timber harvest in RMZs. The values presented in the following effects analysis are estimates only, and are not intended to be interpreted as absolute values. (Detailed information regarding our methods to estimate effects associated with RMZs is available in a northern spotted owl GIS memo in the administrative record for this Opinion).

Westside Option 1 (Thinning From Below) and Eastside Mixed Conifer/Ponderosa Pine Zones

Westside Option1 (thinning from below) and eastside mixed conifer zone and ponderosa pine zone riparian rules all have similar harvest guidelines for Type S or Type F RMZs. The rules protect Core Zones and allow limited entry thinning in the Inner Zones. Outer Zones can be managed with a light retention harvest prescription (i.e., clearcut with leave trees). Overall, the FWS estimates that 30 to 60 percent of the trees within the 100-year site index tree height (75 – 200 feet) of Type S or Type F waters will be retained in managed RMZs.

Effects to Northern Spotted Owl Habitat in Core Zones

In western Washington, the Core Zone includes the channel migration zone (CMZ) and a 50- foot no-harvest buffer measured from the outer edge of the CMZ or the bankful width of fish-bearing waters. In eastern Washington, the Core Zone is a minimum of 30 feet wide and also includes additional protected areas for CMZs. No timber harvest is allowed in Core Zones except for road crossings and yarding corridors. Patches of northern spotted owl habitat in Core Zones would be adversely affected by timber harvest in the adjacent Inner and Outer Zones due to indirect effects associated with habitat fragmentation and reduced patch size. Habitat patches retained in Core Zones will vary in width from 30 to 50 feet wide along either side of a stream or river, plus any additional area associated with protected CMZs. Affected Core Zones will become narrow strips of trees, with increased solar radiation (which stimulates understory growth), and an increased risk of windthrow.

Northern spotted owl habitat protected in Core Zones will be of marginal value for northern spotted owl nesting, roosting, or foraging, due to the small patch size of the protected area. The Core Areas will likely continue to provide some cover for northern spotted owl dispersal, particularly in areas that border adjacent patches of suitable habitat. Trees retained in the adjacent Inner Zones will provide some additional forest cover and act as a "managed buffer" to reduce edge effects normally associated with a clearcut boundary (e.g., increased risk of windthrow). The adverse effects associated with small patch sizes in Core Zones will gradually diminish and transition into a closed-forest habitat as adjacent Inner Zone and Outer Zone stands regenerate over a period of 40 to 50 years. In the long-term (50+ years), the northern spotted owl habitat retained Core Zones will provide important legacy features (large trees and snags) adjacent to upland young forest patches. These legacy features will likely provide habitat for prey species, and may support nesting, roosting, and foraging opportunities in areas that are largely forested with "young-forest marginal" or dispersal habitats (WAC 222-16-085). The FWS estimates that an average of 39 percent of the suitable northern spotted owl habitat associated with managed Type S or Type F RMZs will be retained in Core Zones (Table 8-19).

Effects to Northern Spotted Owl Habitat in Inner Zones

Inner Zones can be managed with a "thinning from below" timber harvest treatment, but dominant trees and some overstory canopy cover would be retained. At minimum, at least 57 trees per acre must be retained within the Inner Zones under the westside Option 1 rules. In the eastside mixed-conifer and ponderosa pine zones, trees can be thinned to a minimum density of 100 trees per acre in stands with low basal area, and a minimum density of 50 trees per acre in stands with high basal area (defined as greater than 110 square feet per acre for trees greater than 6 inches diameter at breast height). Inner Zones vary in width from 45 to 70 feet wide on the eastside, and from 10 feet to 100 feet wide on the westside, depending upon site class. Most westside Inner Zones will vary from 43 to 78 feet wide (site classes II and III).

Thinning treatments in the Inner Zones will adversely affect northern spotted owl habitat by reducing total stem density (trees per acre), and reducing overstory canopy cover, reducing the number of standing snags, and potentially reducing decayed down logs on the forest floor. Suitable northern spotted owl habitat in western Washington (as defined at 222-16-085) consists of conifer stands with a stem density of 115 to 280 trees per acre and an overstory canopy cover greater than or equal to 70 percent. In eastern Washington, suitable northern spotted owl habitat has a minimum density of 100 trees per acre and an overstory canopy cover of greater than or equal to 50 percent (WAC 222-16-085).

Table 8-19. Summary of the estimated effects (per decade) to northern spotted owl habitat (NRF) in RMZs managed under Westside Option 1 (Thinning from Below) or Eastside Mixed Conifer/Ponderosa Pine Zone Rules

Province	Estimated Acres in Type S and Type F RMZs Managed Per Decade	Estimated NRF Habitat Acres in Managed RMZs	Estimated NRF Acres Protected in Core Zones	Estimated NRF Acres Adversely Affected by Thinning in Inner Zones	Estimated NRF Acres Removed in Outer Zones
Olympic Peninsula	12,550	420	160	150	110
Western WA Lowlands	50,540	1,960	770	690	500
West Cascades	17,570	1,560	620	550	390
Western WA Subtotals	80,660	3,940	1,550	1,390	1,000
		100%	40%	35%	25%
East Cascades Subtotals	4,750	820	290	400	130
		100%	35%	49%	16%
Totals	85,410	4,760	1,840	1,790	1,130
		100%	39%	37%	24%

Notes: Values in this table are estimates derived from a GIS analysis of northern spotted owl habitat in RMZs and have been rounded to the nearest 10. We used past timber harvest rates and the percent area within RMZs to estimate acres of RMZs managed per decade. The values listed here are estimates only, and do not represent absolute values.

NRF = Nesting, roosting, foraging habitat.

Inner Zones harvested with a maximum thinning treatment (i.e., thinned to 50 or 57 trees per acre) would be rendered unsuitable for northern spotted owl nesting, roosting, foraging or dispersal habitat, because stem density and overstory canopy cover would be reduced to such an extent that northern spotted owls would likely avoid these areas (Hansen et al. 1993; Meiman et al. 2003). An exception would be that some eastside stands thinned to 50 trees per acre may meet minimum requirements for dispersal habitat if the treated stands have at least 50 percent canopy cover (WAC 222-16-085). Thinning can also have short-term (i.e., less than 10 years) adverse affects for northern spotted owl prey species through the destruction of understory plants and fungi, and the loss of forest canopy connectivity important for northern flying squirrels (Carey 2004). There are relatively few studies that have examined the effects of thinning to northern flying squirrels (Gomez et al. 2005). Gomez et al. (2005) found that flying squirrel densities in managed forests in coastal Oregon were highly variable and were positively correlated with the biomass and frequency of fungal sporocarps, suggesting that flying squirrels were limited by the availability of food resources rather than forest structure. Gomez et al. (2005) found that commercial thinning had no measurable short-term effects (within 3 years) on the density, survival, or body mass of flying squirrels. In the Puget Sound area, northern flying squirrels were observed in thinned stands, but at much lower densities than those found in unmanaged second-growth stands (Wilson and Carey 2000). Other prey species such as deer mice respond positively to thinning treatments and are more abundant in thinned stands than in unmanaged second-growth stands (Wilson and Carey 2000).

Not all Inner Zones are likely to be harvested to the maximum extent allowed under the Option 1 rules. Some thinned areas may retain sufficient trees and overstory canopy to provide dispersal habitat functions for northern spotted owls, but we have no reliable way of estimating how much area would be affected by such treatments. Regardless of the intensity of thinning treatments in Inner Zones, all northern spotted

owl habitat in managed Inner Zones would be adversely affected by clearcut harvest in Outer Zones due to reduced patch size and habitat fragmentation effects. For this analysis, we expect that suitable habitat acres subjected to thinning in managed Inner Zones will be unsuitable for northern spotted owls. The FWS estimates that about 35 percent of the northern spotted owl habitat in managed Type S or Type F RMZs would be adversely affected by thinning treatments in Inner Zones and clearcut harvest in Outer Zones (Table 8-19).

Although there are short-term (i.e., less than 10 years) negative effects associated with thinning, treated stands that are relatively young (i.e., 40-60 years old) tend to recover quickly with increased tree growth (U.S. Forest Service 2002). Positive long-term effects of thinning can include increased growth of trees, increased crown differentiation, increased development of understory vegetation, and increased flowering and fruiting of understory plants that provide important foods for northern spotted owl prey species (Carey 2004). In eastern Washington, thinning can be beneficial for forest health by reducing competition between trees and reducing risks associated with fire hazard, insects, and disease (Quigley et al. 2001).

The time required for treated stands to recover from the short-term (i.e., less than 10 years) negative effects of thinning and regenerate an overstory canopy cover suitable for northern spotted owl habitat will vary depending upon the intensity of the thinning treatments. Recovery of habitat functions could occur in less than 10 years in locations harvested with light understory thinning treatments (Carey 2001), or could require much longer (30-40 years) in heavily thinned stands. However, due to the narrow width and small patch sizes associated with managed RMZs, habitat retained in the Core Zone and managed Inner Zone areas will be of marginal value to northern spotted owls. As noted for Core Zone areas, the adverse effects associated with small patch sizes in Inner Zones will gradually diminish and transition into a closed-forest habitat as adjacent Outer Zone stands regenerate over a period of 40 to 50 years. In the long-term (50+ years), the northern spotted owl habitat retained in Inner Zones will provide important legacy features (large trees and snags) adjacent to upland young forest patches. These areas will likely provide habitat for northern spotted owl prey species, and may support nesting, roosting, and foraging opportunities in areas that are largely forested with “young-forest marginal” or dispersal habitats (WAC 222-16-085). The FWS estimates that an average of 39 percent of the suitable northern spotted owl habitat associated with managed Type S or Type F RMZs will be retained in Core Zones (Table 8-19).

Effects to Northern Spotted Owl Habitat in Outer Zones

Outer Zone timber harvest will adversely affect northern spotted owl habitat by removing most of the overstory trees and rendering the harvested area unsuitable for northern spotted owl nesting, roosting, foraging, or dispersal. Timber harvest in the Outer Zones will result in clearcut areas with a few scattered leave trees retained in dispersed or clumped groups to meet the average 20 trees per acre retention requirement. In eastern Washington, we assume that 60 percent of Outer Zones will be clearcut, and 40 percent will be harvested with partial harvest methods. Clearcut areas will remain unsuitable as northern spotted owl habitat for a minimum of 40 to 50 years until forest regeneration produces trees large enough to support dispersal habitat functions. The FWS estimates that about 24 percent of the suitable northern spotted owl habitat associated with managed Type S or Type F RMZs will be harvested in Outer Zones (Table 8-19).

Summary of Effects under Western Washington Option 1/Eastern Washington Mixed Conifer/Ponderosa Pine Zones

Within the range of the northern spotted owl in Washington, there are approximately 710,500 acres associated with Type S or Type F RMZs, encompassing approximately 39,300 acres of northern spotted owl habitat (5.5 percent) (Table 8-11). Based on past harvest trends, we estimate that 85,410 acres of Type S or Type F RMZs would be affected by timber harvest per decade, encompassing a total of 4,760 acres of northern spotted owl habitat (Table 8-19). Approximately 39 percent of the northern spotted owl habitat acres would be protected in Core Zones (1,840 acres) and approximately 37 percent of suitable habitat would be managed by thinning in Inner Zones (1,790 acres). All habitat retained in Core Zones or Inner Zones would be of marginal quality for northern spotted owl foraging or dispersal due to the small patch size and linear nature of managed RMZs. The remaining 24 percent of northern spotted owl habitat would be removed by timber harvest in Outer Zones, resulting in a loss of 1,130 acres of northern spotted owl habitat per decade (Table 8-19).

Effects of Western Washington Option 2 – Leaving Trees Closest to the Water

Under Option 2 (leaving trees closest to the water), landowners may forego the thinning from below guidelines and harvest trees within the Inner and Outer Zones if the Desired Future Condition objectives for the RMZ can be met. In Option 2, trees located 80 to 100 feet from the outer edge of the CMZ along Type S or Type F streams (depending on stream size) will be remain intact (no timber harvest except at road crossings and yarding corridors), while trees from 80 to 100 feet out to 140 to 200 feet (Inner and Outer Zones) may be harvested down to a minimum of 20 trees per acre. This option is not applicable in eastern Washington due to the narrower riparian zone widths.

Effects to Northern Spotted Owl Habitat in Core/Inner Zones

Under Option 2, patches of suitable northern spotted owl habitat in Core/Inner Zones would be adversely affected by timber harvest in the adjacent Inner/Outer Zones due to indirect effects associated with habitat fragmentation and reduced patch size. Habitat patches retained in Core/Inner Zones will vary in width from 80 to 100 feet wide along either side of a stream or river, plus any additional area associated with protected CMZs.

Northern spotted owl habitat protected in Core/Inner Zones will be of marginal value for northern spotted owl nesting, roosting, or foraging, due to the small patch size of the protected area. The Core/Inner Zone areas will likely continue to provide some cover for northern spotted owl dispersal, particularly in areas that border adjacent patches of suitable habitat. Habitat for northern spotted owls prey species such as northern flying squirrels would be present (i.e., canopy connectivity) but reduced patch sizes could result in the abandonment of some areas by flying squirrels. Rosenberg and Raphael (1986) demonstrated that there is a decreasing frequency of flying squirrel occupancy with decreasing patch size. Small habitat patches in managed Core/Inner Zones will gradually transition to a closed-forest condition as adjacent Inner Zone and Outer Zone stands regenerate over a period of 40 to 50 years. The FWS estimates that about 61 percent of the suitable northern spotted owl habitat associated with Type S or Type F RMZs will be protected in Core/Inner Zones (Table 8-20).

Table 8-20. Summary of the estimated effects (per decade) to northern spotted owl habitat (NRF) in RMZs managed under Westside Option 2 (leaving trees closest to the water).

Province	Estimated Acres in Type S and Type F RMZs Managed Per Decade	Estimated NRF Habitat Acres in Managed RMZs	Estimated NRF Acres Protected in Core/Inner Zones	Estimated NRF Acres Removed in Inner/Outer Zones
Olympic Peninsula	12,550	420	250	170
Western WA Lowlands	50,540	1,960	1,200	760
West Cascades	17,570	1,560	940	620
Western WA Totals	80,660	3,940	2,390	1,550
		100%	61%	39%

Notes: Values in this table are estimates derived from a GIS analysis of northern spotted owl habitat in RMZs. We used past timber harvest rates and the percent area within RMZs to estimate acres of RMZs managed per decade. The values listed here are estimates only, and do not represent absolute values.

NRF = Nesting, roosting, foraging habitat.

Effects to Northern Spotted Owl Habitat in Inner/Outer Zones

Timber harvest in the Inner/Outer Zones will adversely affect northern spotted owl habitat by removing most of the overstory trees and rendering the harvested area unsuitable for northern spotted owl nesting, roosting, foraging, or dispersal. Inner/Outer Zone harvest will result in clearcut areas with a few scattered leave trees retained in dispersed or clumped groups to meet the average 20 trees per acre retention requirement. Clearcut areas will remain unsuitable as northern spotted owl habitat for a minimum of 40 to 50 years until forest regeneration will produce trees large enough to support dispersal habitat functions. The FWS estimates that about 39 percent of the suitable northern spotted owl habitat associated with Type S or Type F RMZs in Western Washington will be harvested in Outer Zones (Table 8-20).

Summary of Western Washington Option 2 Effects

In Western Washington, there are approximately 670,500 acres associated with Type S or Type F RMZs, encompassing approximately 32,400 acres of northern spotted owl habitat (5 percent) (Table 8-11). Based on past harvest trends, we estimate that 80,660 acres of Type S or Type F RMZs would be affected by timber harvest per decade, encompassing a total of 3,940 acres of northern spotted owl habitat (Table 8-20). Approximately 61 percent of the northern spotted owl habitat acres would be protected in the no-harvest Core/Inner Zones (2,390 acres) but this habitat would be of marginal quality for northern spotted owls due to the small size and linear nature of Core/Inner Zones. Approximately 39 percent of northern spotted owl habitat would be removed by timber harvest in the Inner/Outer Zones, resulting in a loss of 1,550 acres of habitat per decade (Table 8-20).

Sensitive Sites and RMZs along Type Np and Type Ns Waters

In western Washington, a minimum 50-foot no-harvest buffer must be retained along the lower 500 feet of Type Np waters upstream from the confluence with Type S or F waters. Beyond 500 feet from such confluences, a 50-foot no-harvest buffer is required along approximately 50 percent of the remaining Type Np stream lengths. Sensitive sites associated with headwall seeps, sidewall seeps, and perennial flow initiation points are also protected with 50- to 56-foot radius no-harvest buffers. Type Ns streams

are not protected with no-harvest buffers, except in the vicinity of sensitive sites, unstable slopes, and/or buffers associated with Type S or Type F confluences. In eastern Washington, management along Type Np and Type Ns waters, as well as sensitive sites are similar to the westside rules. However, eastside landowners have the option to thin trees down to a density of 50 trees per acre adjacent to Type Np waters, and clearcut areas adjacent to Type Np streams are limited to 300 foot segments along the stream.

To evaluate the effects of management along Type Np streams, we used GIS to map buffers representing an average 100-year site index tree height along both sites of Type Np waters. This area represents the Riparian Zone of influence, rather than the Type Np RMZ defined in the Washington Forest Practices Rules (the 50-foot buffer). The 50-foot no-harvest buffers along portions of Type Np waters retains about 15 to 20 percent of the existing trees within the 100-year site index tree height of the stream. Outside the 50-foot no-harvest zones, all trees within the 100-year site index tree height (from 50 out to 200 feet, depending on the site) are likely to be clearcut or heavily thinned, resulting in the loss of suitable northern spotted owl habitat in these locations.

Patches of suitable northern spotted owl habitat protected in Type Np RMZs would be adversely affected by the adjacent timber harvest due to indirect effects associated with habitat fragmentation and reduced patch size. Habitat patches retained in Type Np RMZs or around sensitive sites will vary in width from 50 to 60 feet along either side of a stream or a sensitive site, but these areas may be further fragmented by clearcut areas between the protected patches. Isolated patches less than 5 acres in size would be unsuitable as northern spotted owl foraging or dispersal habitat, and would likely be too small to support northern flying squirrels. Other prey species such as deer mice would continue to persist in these small patches. Patches larger than 5 acres may provide some provide some cover for northern spotted owl dispersal, particularly in areas that border adjacent patches of suitable habitat. Small habitat patches in managed Type Np RMZs will gradually transition to a closed-forest condition as adjacent upland stands regenerate over a period of 40 to 50 years. The FWS estimates that about 17 percent of northern spotted owl habitat along Type Np streams will be protected in buffers, and 83 percent will be removed by timber harvest (Table 8-21).

Table 8-21. Summary of the estimated effects (per decade) to northern spotted owl habitat (NRF) in Type Np RMZs.

Province	Estimated Acres in Type Np RMZs Managed Per Decade	Estimated NRF Habitat Acres in Managed RMZs	Estimated NRF Acres Protected in Type Np RMZs	Estimated NRF Acres Removed within a site-potential tree height adjacent to Type Np streams.
Olympic Peninsula	2,210	130	20	110
Western WA Lowlands	8,140	720	120	600
West Cascades	7,180	1,010	170	840
East Cascades	2,330	490	80	410
Western WA Totals	19,860	2,350	390	1,960
			17%	83%

Notes Values in this table are estimates derived from a GIS analysis of northern spotted owl habitat in RMZs. We used past timber harvest rates and the percent area within RMZs to estimate acres of RMZs managed per decade. The values listed here are estimates only, and do not represent absolute values.

NRF = Nesting, roosting, foraging habitat.

Summary of Effects from Type Np Buffers

Within the range of the northern spotted owl in Washington, there are approximately 163,100 acres associated with Type Np RMZs, encompassing approximately 19,200 acres of northern spotted owl habitat (12 percent) (Table 8-11). Based on past harvest trends, we estimate that 19,860 acres of Type Np RMZs would be affected by timber harvest per decade, encompassing a total of 2,350 acres of northern spotted owl habitat (Table 8-21). Approximately 17 percent of the northern spotted owl habitat acres would be protected in the no-harvest buffer zones (390 acres) but this habitat would be of marginal value for northern spotted owl dispersal due to the small patch sizes and linear nature of protected areas. Approximately 83 percent of northern spotted owl habitat located within a 100-year site index tree height of Type Np waters would be removed by timber harvest, resulting in a loss of 1,960 acres of habitat per decade (Table 8-21). Regeneration stands in harvested areas will require a minimum of 40 to 50 years to produce stands with sufficient tree height and canopy cover to provide habitat functions for northern spotted owls.

Windthrow Effects to Northern Spotted Owl Habitat in RMZs

Northern spotted owl habitat retained in protected Core/Inner Zones will likely be degraded by the effects of windthrow. Grizzel and Wolff (1998) studied riparian buffer strips on small streams in northwestern Washington and reported that about 33 percent of buffer trees were affected by windthrow. In a study by Rollerson and McGourlick (2001), riparian windthrow averaged about 21 percent of the standing timber along stream edges. They note there were a large number of plots with only a minor amount of windthrow and conversely only a limited number of areas with substantial amounts of windthrow. The average distance of penetration into standing timber was about 40 feet. They also noted that buffers exposed on both sides were more vulnerable and that “feathered edges” had lower amounts of windthrow.

The potential effects of windthrow in RMZs are highly variable and dependant on many site-specific factors. There are no reliable methods to estimate or quantify the effects that windthrow may have on northern spotted owl habitat at the scale of the FPHCP. However, it is likely that northern spotted owl habitat retained in the protected portions of RMZs will be degraded by the loss of trees resulting in reduced canopy cover in the affected areas. In catastrophic wind events, all trees left in an RMZ could be lost to windthrow, but this will likely be uncommon.

Summary and Comparison of the Effects of the FPHCP Riparian Management Options

Within the range of the northern spotted owl in Washington, there are approximately 873,600 acres of RMZs encompassing a total of 58,500 acres of northern spotted owl habitat (Table 8-11). Northern spotted owl habitat acres represent about 7 percent of the total area in RMZs. The percentage of northern spotted owl habitat in RMZs varies by province, from 4 percent on the Olympic Peninsula, to 18 percent in the East Cascades. Based on the average timber harvest rate of approximately 12 percent per decade for the FPHCP covered lands, we estimated that 12 percent of the RMZs would be managed per decade, affecting a total of approximately 7,110 acres of northern spotted owl habitat in RMZs (Table 8-22). All northern spotted owl habitat acres in managed RMZs would be adversely affected. Some acres will be directly affected by timber harvest (thinning or clearcut), and other areas will be indirectly affected by adjacent timber harvesting in the Outer Zones, resulting in narrow, linear patches of habitat retained in Core/Inner Zone areas.

Table 8-22. Comparison and summary of the estimated effects (per decade) associated with riparian management in all RMZ Types.

	RMZ Acres		Westside Option 1 and Type Np			Westside Option 2 and Type Np	
Province	**Estimated Acres in RMZs Managed Per Decade**	**Estimated NRF Habitat Affected Acres in Managed RMZs**	**Estimated NRF Acres Protected in Core Zones**	**Estimated NRF Acres Adversely Affected by Thinning in Inner Zones**	**Estimated NRF Acres Removed in Outer Zones**	**Estimated NRF Acres Protected in Core/ Inner Zones**	**Estimated NRF Acres Removed in Inner/ Outer Zones**
Olympic Peninsula	14,760	550	180	150	220	270	280
Western WA Lowlands	58,680	2,680	890	690	1,100	1,320	1,360
West Cascades	24,750	2,570	790	550	1,230	1,110	1,460
Westside Subtotals	98,190	5,800	1,860	1,390	2,550	2,700	3,100
		100%	32%	24%	44%	47%	53%
East Cascades Zones and Type Np Subtotals	7,080	1,310	370	400	540	370	940
		100%	28%	30%	42%	28%	72%
	105,270	7,110	2,230	1,790	3,090	3,070	4,040
WA Totals per Decade		100%	32%	25%	43%	49%	51%
50-Year Totals	526,350	35,550	11,150	8,950	15,450	15,350	20,200

Notes: For this comparison, we assumed the same effects for the East Cascades to derive totals under Option 1 and Option 2. Values in this table are estimates derived from a GIS analysis of northern spotted owl habitat in RMZs. We used past timber harvest rates and the percent area within RMZs to estimate acres of RMZs managed per decade. The values listed here are estimates only, and do not represent absolute values.

NRF = Nesting, roosting, foraging habitat.

For the westside Type S or Type F RMZs, the habitat acres retained in Core/Inner Zones and associated CMZs will vary from 40 to 60 percent depending upon the management option selected, and the habitat acres directly removed by clear-cut timber harvest in Outer Zones will vary from 25 to 40 percent per decade. In the east Cascades province, fewer habitat acres are protected in Type S or Type F RMZ Core Zones (35 percent), but only 16 percent of habitat acres would be removed by harvest in Outer Zones. To date, most landowners have implemented Option 2 (leaving trees closest to the water), but this trend may change over time. Habitat impacts associated with Type Np RMZs are similar across all provinces. Approximately 83 percent of the habitat acres located within a 100-year site index tree height of Type Np waters will be removed by clearcut harvest or heavy thinning.

At the scale of the FPHCP covered lands, the FWS estimates that 4,000 to 5,000 acres of northern spotted owl habitat will be directly affected by timber harvest (thinning and clearcut) in RMZs per decade, and approximately 2,200 acres to 3,100 acres will be retained in protected Core Zone or Inner Zone areas. Over the 50 year life of the FPHCP, approximately 61 percent of the northern spotted owl habitat (35,550 acres) that is currently associated with RMZs will be adversely affected by timber harvest (Table 8-22). These effects would be distributed across 873,600 acres of RMZs (Table 8-11) from the Olympic

Peninsula to the East Cascades, which in turn are distributed across 6.9 million acres of FPHCP covered lands within the range of the northern spotted owl.

Summary of Scientific Research Regarding the Effects of Timber Harvest to Northern Spotted Owls

Habitat loss is a well-known factor influencing northern spotted owl populations throughout the species range, and is the primary reason the species was listed as a federally threatened species in 1990 (55 FR 26114-26194). Northern spotted owls have large home ranges encompassing thousands of acres of forest. Northern spotted owls prefer to use mature and old forest habitats, presumably because they are most effective at capturing their preferred prey in these habitats. Northern spotted owls move across their home ranges over the course of the year searching for prey (Forsman et al.1984). Loss of suitable habitat reduces the amount of foraging area available and likely reduces the overall population and availability of prey, and thus reduces the capability of the landscape to support northern spotted owls. Landscapes below a certain threshold of habitat amount will not support northern spotted owls. Bart and Forsman (1992) found that northern spotted owls in some landscapes were capable of reproducing in areas with 20 to 40 percent suitable habitat. However, approximately 50 times more young northern spotted owls were fledged in areas with greater than 60 percent suitable habitat than in areas with less than or equal to 20 percent suitable habitat.

Timber harvest practices have the potential to reduce availability of northern spotted owl nest and roost sites. As reported earlier, northern spotted owls do not construct their own nests, but depend upon existing structures such as cavities and broken tree tops, characteristics associated with stands in later seral stages of development (Forsman *et al.* 1984; Buchanan *et al.* 1995; LaHaye and Gutiérrez 1999). Silvicultural prescriptions that specifically target the oldest, most-decadent trees in the stand for economic purposes, or require removal of hazard trees and snags to address human safety concerns, are likely to result in loss of nesting opportunities for northern spotted owls by removing the trees that contain those structures.

Removal or downgrading of habitat within home ranges, and especially close to the nest site, can reasonably be expected to have negative effects on northern spotted owls. Bart (1995) reported a linear reduction in northern spotted owl productivity and survivorship as the amount of nesting, roosting, and foraging habitat within a northern spotted owl home range declined. Timber harvest resulting in relatively open stands or patch clear-cuts can fragment forest stands, creating more forest edge, and reducing the area of interior old forest habitat (Lehmkuhl and Ruggiero 1991). Extensive habitat fragmentation has the potential to isolate individual owls or populations of owls by increasing distances between suitable habitat patches and reducing habitat connectivity. Such isolation decreases the likelihood of successful dispersal of juvenile northern spotted owls (Miller 1989).

Although there are recognized benefits to northern spotted owls from thinning, the effects of commercial thinning on northern spotted owls are unclear and not well documented in the published literature. In a recent scientific review of the status of the northern spotted owl, Courtney et al. (2004) identified northern spotted owl responses to various silvicultural treatments as an important research need. Hansen and others (1993) suggest that commercially-thinned stands would be functionally non-suitable during project implementation because northern spotted owls are likely to avoid these areas during the commercial-thinning operation due to the presence of logging equipment and the activities associated with timber harvest. Meiman and others (2003) tracked the response of a single male northern spotted owl following commercial thinning in young Douglas-fir stands in the Oregon Coast Range. The data collected in this

study indicated that commercial thinning resulted in significantly reduced use of the thinned area during and after harvest, and a shift in use away from the thinned stand. Hicks and others (1999) documented northern spotted owls using partially harvested stands for roosting six months after treatment, suggesting that use of thinned stands by northern spotted owls may occur rapidly following treatment in some areas.

In extreme cases, timber-harvest activities can result in direct mortality of adults, eggs, or young. Such cases are rare, but direct mortality due to timber felling has been documented (Forsman et al. 2002). The potential risk for northern spotted owls to be struck and killed or injured by falling trees during timber harvest is highest in the area relatively close to the nest tree. During timber harvest, non-breeding adult northern spotted owls can reasonably be expected to move away from the area and avoid injury. However, nesting northern spotted owls tending to reproductive activities such as incubation or brooding may be reluctant to leave the area (Delaney *et al.* 1999), and therefore, may be vulnerable to such injury. Fledglings, whether in or out of the nest, may also be at risk of direct mortality due to the effects of tree falling, or might disperse prematurely in response to the disturbance and thus be subject to predation or starvation outside of the nest grove. Potential effects to eggs range from parental abandonment to destruction during tree falling. These kinds of effects are only likely during the breeding season and then only if breeding activities are underway.

Habitat loss from timber harvest has the potential to increase the competitive interactions between barred owls and northern spotted owls in the remaining habitat patches that are left. Because northern spotted owls and barred owls are competitive with each other and utilize the same habitats, the loss of suitable habitat could result in increased competitive interactions between northern spotted owls and barred owls in the remaining patches of suitable habitat (Courtney et al. 2004). It is important to note that the recent scientific review of the status of northern spotted owls completed by Courtney et al. (2004) concluded that there is no direct scientific evidence that has clearly demonstrated that forest management has an effect on the outcome of interactions between barred owls and northern spotted owls (Courtney et al. 2004).

8.2.4.3 Effects to Northern Spotted Owls Associated with the FPHCP Riparian Management Zones

Loss of suitable habitat in RMZs would adversely affect northern spotted owls by reducing the total amount of habitat on the landscape that is available for nesting, roosting, foraging, and dispersal. Northern spotted owls move across the landscape over the course of the year searching for prey (Forsman et al. 1984). Loss of suitable habitat reducing the total amount of foraging area available and likely reduces the overall population and availability of prey species, and thus reduces the capability of the landscape to support northern spotted owls. Most of the forest habitat on the FPHCP covered lands is not suitable for northern spotted owls, or consists of dispersal habitat that has minimal foraging opportunities. Therefore, the small patches of suitable northern spotted owl habitat that do occur on these lands are important for both resident territorial owls and for non-territorial owls dispersing across the landscape and searching for vacant territories to occupy.

Approximately 9 percent of the northern spotted owl habitat on the FPHCP covered lands is located in RMZs. Timber harvest in the RMZs will result in adverse affects to an estimated 7,100 acres of northern spotted owl habitat per decade, including the direct loss of 4,000 – 5,000 acres due to clear-cut harvest or thinning. Habitat patches protected in Core Zones will be reduced to small, fragmented patches that will be marginal or unsuitable for northern spotted owl nesting, roosting, or foraging for 40 to 50 years following harvest of the Outer Zones. In the long-term (50+ years), the northern spotted owl habitat

retained Core Zones will provide important legacy features (large trees and snags) adjacent to upland young forest patches. These legacy features will likely provide habitat for prey species, and may support nesting, roosting, and foraging opportunities in areas that are largely forested with "young-forest marginal" or dispersal habitats (WAC 222-16-085).

Relatively few acres of RMZs are associated with known northern spotted owl circles. There are currently 62 northern spotted owl site centers documented on the FPHCP covered lands, but only 2 of these sites are located in mapped RMZs (3 percent). In areas where FPHCP covered lands occupy 50 percent or more of a northern spotted owl circle, habitat conditions in these circles are generally at or below the assumed thresholds for territory viability (Table 8-12). The adverse effects associated with habitat loss in RMZs does not include direct adverse effects to nesting northern spotted owls, but rather a reduction in the overall suitable habitat that is available for northern spotted owl foraging and dispersal on the FPHCP covered lands.

As the RMZs on the FPHCP covered lands are managed to develop into mature forests over time, the amount of mature conifer habitat in the RMZs could increase from the current levels of approximately 7 percent to perhaps 50 percent in the Core and Inner Zone areas. This is a rough estimate based on the average amount of mature conifer habitat in unmanaged riparian areas (Diaz and Mellen 1996). Because riparian areas often support a diversity of species and age classes, the total area occupied by mature conifer habitat is usually less than 60 percent (Diaz and Mellen 1996). However, Glenn and others (2004) observed that northern spotted owls used both hardwood and mixed hardwood – conifer riparian stands for roosting and foraging in coastal Oregon second-growth forests, suggesting that mature riparian stands of any type can be important for northern spotted owls.

Northern spotted owls likely select riparian areas for roosting and foraging because of the association of some of their prey with riparian areas. Doyle (1990) reported that small mammal communities in the Oregon Cascades were more abundant and had a greater diversity of species in riparian areas compared to upland areas, and that riparian areas may act as source habitats for several small mammal species including northern flying squirrels. The availability of water and a greater availability of diverse forage such as fruits, herbs, deciduous shrubs, and mast make riparian areas important habitat for small mammals (Doyle 1990). Carey (1991) reported that bushy-tailed wood rats are more abundant in riparian forests, and that dense understory brush cover often associated with riparian areas is a key habitat feature for woodrats. In the eastern Cascades of Washington, Peffer (2001) found that the abundance of small mammals was greater in riparian habitats than in upland areas, suggesting that even though eastside riparian areas occupy a relatively small portion of the landscape, they are likely important source areas for northern spotted owl prey species.

Because northern spotted owls require large landscapes forested with mature and old-forest habitat to survive, the RMZs play a relatively minor role in the overall conservation needs for northern spotted owls. However, the RMZs do comprise a substantial portion of the FPHCP covered lands, and these areas are clearly important for northern spotted owl prey species. The management of the RMZs will ultimately complement and improve the existing conservation efforts for northern spotted owls on the FPHCP covered lands by improving habitat conditions in the RMZs and protecting high-hazard slope areas.

Approximately 27 percent (241,000 acres) of the RMZs within the range of the northern spotted owl in Washington occur along major rivers (Type S RMZs). Riparian zones along major valley-bottom rivers and streams may be of marginal value to northern spotted owls due to the preferred use of these habitats

by barred owls, which may preclude northern spotted owls from establishing territories in these areas. There is uncertainty around this, but studies in Washington have shown that barred owls tend to colonize valley bottom habitats first, and then expand into adjacent upland areas (Herter and Hicks 2000; Pearson and Livezey 2003; Buchanan et al. 2004). This is not to say that there is no benefit to northern spotted owls by increased habitat in valley bottom riparian zones. These areas would likely be important for northern spotted owl foraging and dispersal functions, but barred owls are more likely to colonize these areas for nesting than are northern spotted owls. No research studies have definitively shown that northern spotted owls are excluded from areas occupied by barred owls (Courtney et al. 2004), but anecdotal observations documented by researchers indicate barred owls are strongly territorial and that they aggressively defend their territories from incursions by other barred owls or northern spotted owls (Courtney et al. 2004).

Effects of Disturbance to Nesting Northern Spotted Owls Associated with Forest Practices Activities

Road building, maintenance, and repair; timber harvesting; and timber hauling require the use of heavy equipment, chainsaws, and large vehicles, all of which introduce an increased level of sound into the environment. The Washington Forest Practices Board recognized that noise disturbance might disrupt northern spotted owl breeding behavior; therefore, the Board adopted rules to protect northern spotted owls from disturbance by imposing an operating restriction during the northern spotted owl nesting season (March 1 through August 31) (Washington Forest Practices Board 1996). Restricted activities include road construction, operation of heavy equipment, blasting, timber felling, yarding, helicopter operations, and slash disposal or prescribed burning. These activities are prohibited within 0.25 miles of northern spotted owl site centers located within SOSEA boundaries (WACs 222-24-030 and 222-30-050, -060, -065, -070, -100).

We previously completed an analysis of the potential for injury associated with disturbance (visual and sound) to northern spotted owls (U.S. Fish and Wildlife Service 2003). In this analysis, we concluded that behaviors indicating potential injury to northern spotted owls are: flushing from the nest and aborted feedings. These determinations and the associated injury threshold distances are based on research by Delaney and others (1999) who documented that Mexican spotted owls (*Strix occidentalis lucida*) flushed from their roosts when chainsaws were operated within a distance of 197 feet (60 meters). Based on these data, we determined the injury threshold distance for chainsaws falling trees is 65 yards, and the threshold distance for heavy equipment (e.g., excavators) is 35 yards. We note that scientific data related to injury threshold distances associated with sound and visual disturbance is limited, and we continue to collect pertinent data related to the issue. Therefore, these injury threshold distances may be adjusted in the future based on best available science.

Because the 0.25-mile buffer restriction for occupied northern spotted owl sites is substantially larger than the distances where the FWS anticipates northern spotted owls are at risk to potential injury from disturbance, we expect that the existing Washington Forest Practices Rules will protect most nesting northern spotted owls associated with known sites within SOSEAs. One exception is blasting. We consider blasting within 1 mile of a northern spotted owl nest site during the early nesting season (March 1 to July 15) to be an activity that may result in potential injury to northern spotted owls. However, we do not have decibel data for blasting on which to determine potential injury threshold distances for these activities. For blasting with charges of 2 pounds or larger, we continue to use the conventional 1-mile potential injury threshold distances due to lack of decibel information to more accurately address these distances (U.S. Fish and Wildlife Service 2003).

Other situations that could lead to disturbance to northern spotted owls include harvesting suitable habitat within a median home range circle, or timber harvesting adjacent to unsurveyed habitat on Federal lands. Although timber harvesting is restricted within 0.25 miles of a site center, there is the potential that suitable habitat outside the 0.25 mile buffer zone could be harvested during the nesting season. The result could be that northern spotted owl foraging behavior would be disrupted in the harvest areas, precluding northern spotted owl use of important foraging habitat during the nesting season.

Forest practices activities that occur adjacent to suitable northern spotted owl habitat on Federal lands may also result in disturbances to nesting northern spotted owls. Most of the suitable northern spotted owl habitat that occurs on Federal lands has not been surveyed to determine northern spotted owl occupancy. The Washington Forest Practices Rules that minimize disturbance to northern spotted owls only apply in locations where surveys have documented a northern spotted owl site center. For example timber harvesting in second-growth (non-habitat) that borders suitable northern spotted owl habitat on Federal lands would not be restricted unless the Federal land habitat was located within 0.25 miles of a known site center. Because most suitable habitat on Federal lands has not been surveyed for northern spotted owls, the Washington Forest Practices Rules that apply to northern spotted owl sites do not apply to unsurveyed habitat on Federal lands. Non-Federal landowners are not required to survey adjacent ownerships for northern spotted owls, therefore it is likely that forest practices activities that occur along Federal land boundaries could result in potential injury disturbance to northern spotted owls.

Based on the information presented above, we expect that some sound and activity- related disturbances to nesting northern spotted owls may occur on the FPHCP covered lands, but the risk for potential injury to northern spotted owls is low due to the 0.25 mile disturbance buffers within SOSEA boundaries. The Washington Forest Practices Rules minimize the potential for adverse effects from disturbance associated with forest practices to nesting northern spotted owls, but they do not ensure that all northern spotted owls will be protected from disturbance under all circumstances. Blasting within a mile of an occupied northern spotted owl site, unrestricted activities outside of SOSEA boundaries, and forest practices adjacent to unsurveyed suitable nesting habitat on Federal lands during the nesting season are all situations which may result in northern spotted owls flushing from a nest or aborted feedings.

Risk of Injury or Mortality

Under the Washington Forest Practices Rules, timber harvest within a 0.7 mile radius of a northern spotted owl site center is prohibited within SOSEAs, therefore there is little risk of direct mortality to northern spotted owls within SOSEAs. Outside of SOSEAs, there are no timber harvest restrictions within northern spotted owl territories except during the nesting season (March 1 through August 31). During the nesting season any harvest, road construction, or aerial application of pesticides within the best 70 acres of suitable habitat surrounding a northern spotted owl site is prohibited to prevent direct mortality of northern spotted owls associated with the harvest of an active nest site during the nesting season.

Effects of Forest Road Management to Northern Spotted Owls

Under the FPHCP, forest roads will be managed over time to reduce road-related impacts to the aquatic environment and to improve fish passage at road-stream crossings. In western Washington, there are over 45,000 miles of roads on the FPHCP covered lands, and over 14,000 crossings on Type F streams. Many of these roads will be decommissioned over time, and other roads may be constructed to avoid riparian areas or high-hazard soils areas. Many existing stream crossings on fish-bearing streams will be replaced

and upgraded to provide fish passage for all life stages of fish. We did not analyze how many roads or stream crossings occur in northern spotted owl suitable habitat. However, about 9 percent of the FPHCP covered lands within the range of the northern spotted owl contain suitable owl habitat, so it is reasonable to expect that about 9 percent of roads and stream crossings on FPHCP covered lands could occur in northern spotted owl habitat.

The effects of roads to northern spotted owls include the long-term loss of habitat that would have otherwise been available for northern spotted owl nesting, roosting, and foraging, and the potential for noise disturbance to nesting individuals associated with logging trucks, vehicle traffic, or other heavy equipment. Minor habitat losses associated with hazard tree removal and/or culvert/bridge replacement projects may also occur. When culverts are replaced, it is sometimes necessary to clear trees adjacent to the stream crossing, thus creating a larger gap in the forest canopy. These types of habitat effects are generally minor due to the northern spotted owl's use of large landscapes, and the low risk that northern spotted owls would be nesting in these areas. The greatest risk to northern spotted owls associated with road management is the potential for noise disturbance to nesting northern spotted owls.

We used GIS to estimate the number of northern spotted owl sites located within 0.25 miles of roads on FPHCP lands. Of the 531 northern spotted owl territories that overlap FPHCP covered lands, there are 96 northern spotted owl sites (18 percent) that are located within 0.25 miles of a forest road. There was a total of 37 miles of roads on FPHCP covered lands associated with the 0.25 mile buffers. We have no reliable way of quantifying the amount of potential disturbance to northern spotted owls associated with road-related activities on the FPHCP covered lands. The GIS analysis indicated that at least 18 percent of the known northern spotted owl sites adjacent to FPHCP covered lands could be affected by road management activities. We expect that the existing Washington Forest Practices Rules which restrict forest practices activities within 0.25 miles of occupied northern spotted owl sites will minimize potential disturbance effects associated with roads to nesting northern spotted owls.

8.2.4.4 Summary of the Effects of the Action

Within the range of the northern spotted owl in Washington, we estimate that approximately 105,000 acres of RMZs would be managed per decade, resulting in adverse effects to 7,100 acres of northern spotted owl habitat, including the direct loss of 4,000 to 5,000 acres of habitat from thinning or clearcut harvest in the Inner and Outer Zones. Over a period of 50 years, we estimate the proposed action would result in adverse affects to approximately 35,550 acres of northern spotted owl habitat in RMZs, including the direct loss of 15,000 to 20,000 acres of habitat. We expect these effects would be distributed across 873,600 acres of RMZs from the Olympic Peninsula to the East Cascades, which in turn are distributed across 6.9 million acres of FPHCP covered lands. This equates to an average rate habitat loss of 400 to 500 acres per year. At the scale of the physiographic provinces in Washington, this level of habitat loss is practically immeasurable.

Northern spotted owl habitat protected in Core Zone areas would be marginal for northern spotted owls, providing dispersal habitat functions for approximately 40 to 50 years. As harvested stands regenerate over time, the small habitat patches protected in Core Zones will provide important legacy habitat features and will serve as refugia for northern spotted owl prey species in landscapes dominated by young forest habitats. As the RMZs that are currently in early- or mid-seral condition are managed to meet the Desired Future Condition of mature, fully stocked riparian stands over time, the amount of northern spotted owl habitat (i.e., young forest marginal habitat, as defined at WAC 222-16-085) in the RMZs will increase from the current levels of 7 percent to perhaps 50 percent over a period of 50+ years. Because northern

spotted owls require large landscapes forested with mature and old-forest habitat to survive, the RMZs play a relatively minor role in the overall conservation needs for northern spotted owls. The management of the RMZs that are currently in early or mid-seral stages will ultimately complement and improve the existing conservation efforts for northern spotted owls on the FPHCP covered lands by improving dispersal habitat conditions on the private lands. Therefore, the conservation role of the FPHCP covered lands (i.e., to maintain habitat in owl circles and to provide dispersal habitat) would be maintained.

Road management activities will result in minor habitat losses associated with hazard tree removal as would culvert/bridge replacement projects. These types of habitat effects are generally minor due to the northern spotted owl's use of large landscapes, and the low risk that northern spotted owls would be nesting in these areas. Approximately 18 percent of the known northern spotted owl sites adjacent to FPHCP covered lands (96 sites) could be affected by road management activities. We expect that the existing Washington Forest Practices Rules which restrict forest practices activities within 0.25 miles of occupied northern spotted owl sites will minimize potential disturbance effects associated with roads management to nesting northern spotted owls.

We expect that some sound and activity- related disturbances to nesting northern spotted owls may occur on the FPHCP covered lands, but the risk for potential injury to northern spotted owls is low due to the 0.25 mile disturbance buffers.

8.2.4.5 Effects to Federally Designated Northern Spotted Owl Critical Habitat

The effects analysis for the northern spotted owl critical habitat includes only those effects that would be expected to occur as effects of permit issuance, such as effects of timber harvest activities in the Riparian Zone of influence and road-related activities. We do not anticipate any direct effects associated with the loss of suitable northern spotted owl habitat due to timber harvesting in RMZs or road construction in designated northern spotted owl critical habitat. We anticipate that some habitat loss associated with edge effects to designated critical habitat on Federal lands are likely to occur. These effects are associated with timber harvest practices in upland areas. Therefore, these activities and their effects to northern spotted owl critical habitat are not analyzed in this section, but will be addressed in the analysis of cumulative effects.

8.2.5 CUMULATIVE EFFECTS – Northern Spotted Owl and Northern Spotted Owl Critical Habitat

Cumulative effects include the effects of future State, tribal, local, or private actions that are reasonably certain to occur in the action area considered in this Opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to ESA section 7.

8.2.5.1 Cumulative Effects to Northern Spotted Owls

The cumulative effects analysis for the northern spotted owl and its designated critical habitat include the effects of activities that are not directly associated with permit issuance, such as the effects of future timber harvest activities in upland areas. These activities are essentially unchanged by the issuance of the FPHCP permit, and will occur regardless of permit issuance.

In the range of the northern spotted owl, there are over 6.9 million acres of FPHCP covered lands. Only about 13 percent of theses lands are located in the RMZs. The other 6 million acres of FPHCP covered

lands are upland areas that are expected to be managed on a 40-year to 80-year harvest rotation. Active management in RMZs is not likely to occur without some harvest activities occurring in the adjacent uplands.

As summarized in the environmental baseline section, northern spotted owl habitat on State and private lands is managed under differing standards, depending on whether or not the habitat occurs within or outside of a SOSEA, and whether or not the habitat is associated with a known owl circle. In the absence of a federally approved HCP or a State-approved Landowner Option Plan, northern spotted owl habitat in SOSEAs is only protected within known northern spotted owl circles. Outside the SOSEAs, northern spotted owl habitat is not protected on the private lands under the Washington Forest Practices Rules. However, the prohibitions of ESA section 9 still apply.

The environmental baseline analysis indicates that stand-replacing timber harvest occurred at an average rate of 0.7 to 1.3 percent per year on the FPHCP covered lands from 1992 to 2002 (Table 8-17). Over 793,000 acres of timber were harvested (clearcut) during that period, resulting in the loss of 136,900 acres of northern spotted owl habitat (Table 8-18). This represents a loss of 17 percent of the northern spotted owl habitat that existed on the FPHCP covered lands in 1992. This information indicates that northern spotted owl habitat on the FPHCP covered lands was harvested at a rate of about 13,000 to 14,000 acres per year, or 1.5 percent to 2 percent, annually. Future rates of habitat loss due to timber harvest on the FPHCP covered lands may not be as high as rates documented for the period 1992-2002. The first 3 years of that period (1992-1995) preceded implementation of the northern spotted owl habitat rules under the 1996 Washington Forest Practices Rules. Following rule implementation (July 1, 1996), landowners proceeded to harvest finite amounts of older habitat as permitted by the rules. Opportunities for harvesting northern spotted owl habitat have steadily diminished as more and more of the habitat available for harvest under the 1996 rules has been depleted. Opportunities were further diminished in 2001, when new restrictions were placed on timber harvest on unstable slopes, groundwater recharge areas of glacial deep-seated landslides, channel migration zones, and other areas. At some future point, opportunities to harvest in excess of habitat replenishment may be exhausted, and rates of habitat harvest would be expected to equilibrate with rates of habitat development, i.e., there would be no net loss of northern spotted owl habitat on the FPHCP covered lands.

We were not able to account for growth of northern spotted owl habitat on the FPHCP covered lands from the habitat maps developed by Davis and Lint (2005). However, Davis and Lint (2005) did estimate that over 600,000 acres of forests on Federal lands in the Northwest Forest Plan area have transitioned into late-successional forest during the past decade (1994-2003), resulting in a decadal increase of approximately 5 percent of potential habitat on Federal lands. Over time, habitat acres within Federal reserves are expected to continue to increase (Davis and Lint 2005). Whether or not growth of northern spotted owl habitat on private lands is increasing at a similar rate is unknown.

We evaluated northern spotted owl habitat on the private lands and found that about 24 percent were located in known owl circles, but that only 12 percent of the habitat acres were located in known owl circles located in SOSEAs (Table 8-16). Overall, 88 percent of the northern spotted owl habitat on the private lands is not associated with known owl circles in SOSEAs, indicating that nearly 582,000 acres of northern spotted owl habitat in Washington, dispersed across each of the four provinces, is at risk of harvest (Table 8-16). This is approximately 15.8 percent of the total northern spotted owl habitat in Washington. Not all of this habitat will be subject to harvest, as some areas will be protected for marbled murrelet sites or high-hazard soils areas. For example, there are approximately 26,000 acres of habitat associated with occupied marbled murrelet sites in coastal Washington. Other habitat areas located

outside SOSEAs may also be protected in known northern spotted owl circles. We did not calculate how much habitat would be protected for other conservation needs, but we suspect these areas represent a small percentage of the total acres that are at risk. If all habitat associated with known northern spotted owl circles was protected (161,700 acres), the remaining habitat acres at risk would be 498,000 acres, representing approximately 13.5 percent of the northern spotted owl habitat in Washington.

Suitable habitat that occurs outside of the known northern spotted owl circles is important for supporting territorial owls because owl territories are not circular but vary in size and configuration (Forsman et al. 1984). Many territorial circles have low amounts of suitable habitat suggesting that habitat located outside the circles may also be important for supporting territorial owls (Buchanan and Swedeen 2005). Habitat outside of the known northern spotted owl circles is also important for the conservation and recovery of northern spotted owls, because these areas provide important connectivity (i.e., foraging and dispersal) for non-territorial northern spotted owls dispersing across the landscape searching for vacant territories. Unoccupied habitat adjacent to occupied territories is ultimately important for species recovery because dispersing northern spotted owls are more likely to successfully colonize suitable habitat adjacent to occupied territories than random locations on the landscape (Lahaye et al. 2001).

Northern spotted owl habitat on private lands in the western Washington lowlands, the northern Olympic Peninsula, and the southeast Cascades provinces are of concern, because these areas contain substantial habitat acres that are not protected by SOSEAs or existing HCPs. It is important to note that much of the suitable northern spotted owl habitat that occurs on the private lands is widely scattered in small patches across large landscapes, and that much of this habitat does not exist in sufficient quantities to support territorial northern spotted owls. For example, the western Washington lowlands province has an estimated 378,000 acres of northern spotted owl habitat distributed across over 4.5 million acres. There are only 21 documented northern spotted owl sites in this province, and all of these circles are currently below minimum habitat thresholds. However, these small patches of habitat are potentially important for northern spotted owl connectivity, and may provide important dispersal and foraging habitat functions for northern spotted owls dispersing across private lands.

The northern spotted owl populations in Washington are currently experiencing substantial annual declines, and the current range of the species is essentially contracted to landscapes with large State or Federal ownership. Although habitat loss on Federal lands has slowed in the past decade, habitat loss on State and private lands continues to occur at a rate of 1-2 percent per year. The current Washington Forest Practices Rules have resulted in circle-by-circle management within SOSEAs. Buchanan and Swedeen (2005) summarized the current northern spotted owl circle management: "The predominant management strategy utilized under the Forest Practice Rules is to manage based on individual circles that are the size of the average northern spotted owl home range, regulating harvest inside circles, and allowing all proposed harvest outside the circles…The circle approach provides a certain amount of protection but it is not likely adequate in many cases and especially at the level of sub-populations. Telemetry data from Washington indicate that northern spotted owl home ranges are irregularly shaped and are often not contiguous patches of forest…Consequently, an owl's actual home range typically extends beyond the bounds of "management circles" used in Washington Forest Practice Rules. Most if not all of the owl circles in the SOSEAs were below the SEPA threshold when the current rules were adopted, and many of these circles use – and – likely require other areas of habitat outside of the management circles. In some landscapes, habitat outside of circles is not available, thus owls with lesser amounts of habitat available to them will likely be unable to persist…Circle management, particularly

when site abandonment provisions are exercised, is clearly incompatible with landscape-level population management" (Buchanan and Swedeen 2005).

Of the 1,044 northern spotted owl sites documented in Washington, approximately 25 percent (263 sites) are likely to have measurable cumulative effects due to the presence of greater than or equal to 10 percent of the area of these owl circles being located on FPHCP covered lands. Northern spotted owl site centers on FPHCP covered lands in southwest Washington are particularly at risk, because none of these sites are protected by SOSEAs. The most-recent demographic-monitoring information indicates that the northern spotted owl population in Washington is declining at an annual average rate of 7.3 percent, compared to an average rate of 2.6 percent per year in the remainder of the range (Anthony et al. 2004). The realized population change estimates (i.e., the proportion of the population remaining each year, given the rates of decline) indicate that currently only about 40 to 60 percent of the initial 1990 northern spotted owl population in Washington remains (Anthony et al. 2004; Lint 2005). The environmental baseline analysis indicated that over 60 percent of the northern spotted owl circles that overlap the FPHCP covered lands are currently at or below recognized viability thresholds for habitat, suggesting that the documented declines in northern spotted owl numbers in these circles is likely to continue into the near future, regardless of whether or not there are further losses of habitat.

Recent habitat assessments indicate that about 25 to 30 percent of the rangewide northern spotted owl habitat occurs in Washington (Davis and Lint 2005). Due primarily to historical timber harvest, approximately 84 percent of the known northern spotted owl site centers (Buchanan and Swedeen 2005) and about 60 to 70 percent of extant northern spotted owl habitat in Washington are located on Federal lands managed under the Northwest Forest Plan (Davis and Lint 2005). Since the Federal listing in 1990, the FWS has consulted on the removal or downgrading of about 240,000 acres of suitable northern spotted owl habitat in Washington under ESA section 7. Most (89 percent) of this consulted-on habitat loss is associated with approved Habitat Conservation Plans (≈ 143,000 acres) or tribal forest management plans (≈ 70,000 acres). The additional 500,000+ acres of habitat (i.e., all suitable habitat outside known northern spotted owl circles) that are at risk on the FPHCP covered lands represent a potentially substantial reduction in habitat on non-Federal lands in Washington.

Given the persistent and rapid declines of northern spotted owls in Washington, and the apparently increasing population of barred owls, the FWS considers all northern spotted owl sites that are currently occupied as increasingly important to protect and maintain for species recovery. If barred owl densities continue to increase in Washington the competition for available habitat between the two species is very likely to result in further declines to northern spotted owls in Washington, including northern spotted owl populations in protected landscapes such as National Parks. As habitat loss continues on the non-Federal lands, an increasing proportion of northern spotted owls will remain within the habitat blocks on Federal lands, where they are also subjected to the negative interactions with barred owls.

8.2.5.2 Cumulative Effects to Federally Designated Northern Spotted Owl Critical Habitat

The FWS anticipates that activities that occur on private lands may affect northern spotted owl critical habitat where the private lands occur adjacent to Critical Habitat Units. Edge effects associated with clearcut timber harvest in the uplands could result in an increased risk of windthrow, resulting in adverse effects to critical habitat on adjacent Federal lands. The FWS anticipates that windthrow could occur for distances up to 400 feet into adjacent Critical Habitat Unit stands.

Windthrow Effects

Windthrow is a natural phenomenon affecting forests throughout the Pacific Northwest. Every year hundreds of acres of trees are blown over in natural stands and along clearcut boundaries and road corridors (Strathers et al. 1994). The factors that influence windthrow include individual tree characteristics, stand characteristics, root zone soil characteristics, topographic exposure characteristics, and meteorological conditions (Strathers et al. 1994; Harris 1999). Windthrow usually occurs in the first few years after harvesting, particularly where more susceptible trees are exposed to stronger winds as a result of harvesting. Trees can become more windfirm after a few years of exposure as they develop reaction wood in response to swaying (Strathers et al. 1994). Timber harvesting can increase the windthrow hazard by increasing the wind speed and turbulence along the downwind edge of clearcut boundaries. Winthrow damage can extend into adjacent stands for hundreds of feet, although most damage is usually concentrated within the first 30 to 60 feet of the cutting boundary edge (Strathers et al.1994).

Effects to Northern Spotted Owl Critical Habitat

We used GIS to estimate the Critical Habitat Unit areas that border private lands, and estimated that about 64,000 acres of critical habitat occurs adjacent (within 400 feet) to private lands (2.8 percent). This figure represents a gross estimate and includes many non-Federal acres that are embedded within the Critical Habitat Unit boundaries. We did not calculate the suitable habitat acres associated with these Critical Habitat Unit "edge" acres, but an estimate of approximately 40 percent suitable habitat would not be unreasonable given the total ratio of suitable habitat to designated critical habitat acres (Table 8-6).

Assuming an annual harvest rate of about 12 percent per decade on the private lands, we estimate that approximately 7,700 acres of designated critical habitat may be affected by clearcut edges on adjacent private lands per decade (i.e., 12 percent of 64,000 acres of Critical Habitat Unit edge areas ≈ 7,700 acres), for a total of up to 38,500 acres affected over 50 years. The amount of potential nesting habitat exposed will be substantially less than this figure, probably on the order of 3,000 acres per decade (i.e., 40 percent of the affected area). Over a 50-year period, approximately 15,000 acres of suitable northern spotted owl habitat located along the edges of designated Critical Habitat Units would be exposed to an increased risk of windthrow.

The potential effects of windthrow are highly variable and dependent on many site-specific factors. There are no reliable methods to estimate or quantify the effects that windthrow may have on northern spotted owl habitat at the scale of the FPHCP covered lands. However, it is likely that northern spotted owl habitat in Critical Habitat Units will be adversely affected by the loss of individual trees that provide cover and structure for nesting, roosting, and foraging habitat functions. For the purposes of this analysis, we are assuming that 15 percent of the suitable habitat along affected Critical Habitat Unit boundaries will be adversely affected by windthrow. This assumption is based on the review by Strathers et al. (1994) who found that most windthrow damage occurs within 30 to 60 feet of a clearcut boundary (i.e., 60 feet represents 15 percent of the 400-foot area of potential edge effects). Based on this assumption, we estimate that up to 2,250 acres of suitable northern spotted owl habitat could be lost along Critical Habitat Unit boundaries due to windthow effects over a 50-year period.

Summary of Cumulative Effects to Northern Spotted Owl Critical Habitat

Forest practices on the FPHCP covered lands that share boundaries with Critical Habitat Units could result in edge effects to 15,000 acres of suitable northern spotted owl habitat, including the loss of up to

2,250 acres of habitat due to windthrow damage. These effects will be distributed across 53 Critical Habitat Units which encompass over 2.3 million acres and contain over 1,028,000 acres suitable northern spotted owl habitat. We recognize that the loss of habitat from a catastrophic windthrow event could be substantial at an individual site scale. However, we have no way of predicting the location or extent of such events.

Individual Critical Habitat Units in Washington vary in size from 5,000 acres to over 170,000 acres in size, and average 40,000 acres. Edge effects will be confined to the boundary areas of the Critical Habitat Units, potentially affecting less than 1 percent of the habitat in an individual unit.

The loss of potential nesting habitat could be an adverse effect to critical habitat at an individual site scale. At the scale of individual Critical Habitat Units, there could be a loss of 1 percent of potential habitat. At the scale of Critical Habitat Units in Washington, the estimated loss of potential habitat would be 0.2 percent, over a 50-year period. The cumulative effects associated with FPHCP forest practices will be confined to the boundary areas of individual Critical Habitat Units and therefore should have only minor adverse effects to the overall function of the critical habitat. Each Critical Habitat Unit was designated to include large blocks of suitable habitat to support the successful nesting, roosting, foraging, and dispersal of northern spotted owls. Overall, the loss of up to 2,250 acres of suitable habitat due to windthrow over a 50-year period is not expected to have a substantial adverse effect on the function or conservation role of the critical habitat units in Washington.

8.2.6 CONCLUSION – Northern Spotted Owl and Northern Spotted Owl Critical Habitat

8.2.6.1 Conclusion for Northern Spotted Owls

After reviewing the current status of the northern spotted owl, the environmental baseline for the action area, the effects of the proposed action, and the cumulative effects, it is the FWS's biological opinion that implementation of the proposed action discussed herein is not likely to jeopardize the continued existence of the northern spotted owl.

The northern spotted owl is not a covered species under the FPHCP; therefore, the FWS does not anticipate or authorize any incidental take of northern spotted owls associated with the implementation of the FPHCP. Any unauthorized "take" would violate the prohibitions in Section 9 of the ESA, and would therefore invalidate the FPHCP Permit with respect to all listed covered species for that forest practices application that resulted in unauthorized "take."

Based on our analysis, we estimate that the proposed action would result in adverse affects to approximately 35,500 acres of northern spotted owl habitat in RMZs, including the direct loss of 15,000 to 20,000 acres of suitable habitat. These effects would be distributed across 873,600 acres of RMZs from the Olympic Peninsula to the East Cascades, which in turn are distributed across 6.9 million acres of FPHCP covered lands within the range of the northern spotted owl, over a period of 50 years. This equates to an average rate habitat loss of 400 to 500 acres per year. At the scale of the physiographic provinces in Washington, this level of habitat loss is practically immeasurable. We conclude that these activities pose a low risk to northern spotted owl reproduction and nesting success.

The draft recovery plan for the northern spotted owl identified specific conservation roles that non-Federal lands provide for the conservation and recovery of northern spotted owls. These roles include: 1) providing habitat (suitable or dispersal) to support the conservation of northern spotted owls in Federal

reserves in areas where non-Federal lands are mixed with Federal lands; 2) providing for clusters of breeding pairs on non-Federal lands in locations where Federal lands are not adequate to provide for recovery; 3) provide habitat for existing northern spotted owl pairs to avoid take of those owls as defined by the ESA; and 4) providing dispersal habitat for connectivity between Federal reserves (U.S. Fish and Wildlife Service 1992b). Due to the widely distributed effects associated with harvest in RMZs, we conclude that the issuance of a Permit for the FPHCP for covered aquatic species would not be expected to appreciably affect the overall reproduction, numbers, and distribution of northern spotted owls.

8.2.6.2 Conclusion for Northern Spotted Owl Critical Habitat

After reviewing the current status of northern spotted owl critical habitat, the environmental baseline for the action area, the effects of the proposed action, and the cumulative effects, it is the FWS's biological opinion that the proposed action is not likely to destroy or adversely modify designated critical habitat for the northern spotted owl.

The effects associated with private forest practices will be confined to the boundary areas of individual Critical Habitat Units and therefore should have only minor adverse effects to the overall function of the critical habitat. At the scale of individual subunits, there could be a loss of up to 1 percent of potential habitat. At the scale of Critical Habitat Units in Washington, the estimated loss of potential habitat would be 0.2 percent, over a 50 year period. Each Critical Habitat Unit was designated to include large blocks of suitable habitat to support successful nesting, roosting, foraging, and dispersal of northern spotted owls. Overall, the loss of up to 2,250 acres of habitat due to windthrow over a 50 year period is not expected to have a substantial adverse effect on the function or conservation role of the Critical Habitat Units in Washington.

8.3 MARBLED MURRELET

8.3.1 STATUS OF THE SPECIES: MARBLED MURRELET

8.3.1.1 Legal Status

The marbled murrelet (*Brachyramphus marmoratus*) (murrelet) was federally listed as a threatened species in Washington, Oregon, and northern California effective September 28, 1992 (U.S. Fish and Wildlife Service 1992). The final rule designating critical habitat for the murrelet (61 FR 26256) became effective on June 24, 1996. The species' decline has largely been caused by extensive removal of late-successional and old-growth coastal forests which serve as nesting habitat for murrelets. Additional listing factors included high nest-site predation rates and human-induced mortality in the marine environment from gillnets and oil spills.

We recently determined the California, Oregon, and Washington distinct population segment of the murrelet does not meet the criteria set forth in the FWS 1996 Distinct Population Segment policy (61 FR 4722) (U.S. Fish and Wildlife Service 2004f). However, the murrelet retains its listing and protected status as a threatened species under the ESA until the original 1992 listing decision is revised through formal rule-making procedures, involving public notice and comment.

The Marbled Murrelet Recovery Plan (U.S. Fish and Wildlife Service 1997a) (Recovery Plan), identified six Conservation Zones throughout the listed range of the species: Puget Sound (Conservation Zone 1), Western Washington Coast Range (Conservation Zone 2), Oregon Coast Range (Conservation Zone 3), Siskiyou Coast Range (Conservation Zone 4), Mendocino (Conservation Zone 5), and Santa Cruz Mountains (Conservation Zone 6).

As specified in the Recovery Plan (U.S. Fish and Wildlife Service and National Marine Fisheries Service 1998) pursuant to the ESA, jeopardy/non-jeopardy conclusions for the murrelet will be made for each affected Conservation Zone rather than exclusively at the species' listed range. However, our overall jeopardy/non-jeopardy determination will include consideration of the long-term viability of the overall population and metapopulations in all Conservation Zones. Accordingly, the following discussion and analysis for this action will focus on Conservation Zones 1 and 2.

Conservation Zone 1

Conservation Zone 1 includes all the waters of the Puget Sound and most waters of the Strait of Juan de Fuca south of the U.S.-Canadian border and extends inland 50 miles from the Puget Sound, including the north Cascade Mountains and the northern and eastern sections of the Olympic Peninsula. Forestlands in the Puget Trough have been predominately replaced by urban development and the remaining suitable habitat in Conservation Zone 1 is typically a considerable distance from the marine environment, lending special importance to nesting habitat close to the Puget Sound (U.S. Fish and Wildlife Service 1997a).

Conservation Zone 2

Conservation Zone 2 includes waters within 1.2 miles of the Pacific Ocean shoreline south of the U.S.-Canadian border off Cape Flattery and extends inland to the midpoint of the Olympic Peninsula. In southwest Washington, the Zone extends inland 50 miles from the Pacific Ocean shoreline. Most of the forestlands in the northwestern portion of Zone 2 occur on public (State, county, city, and Federal) lands,

while most forestlands in the southwestern portion are privately owned. Extensive timber harvest has occurred throughout Zone 2 in the last century, but the greatest loss of suitable nest habitat is concentrated in the southwest portion of Zone 2 (U.S. Fish and Wildlife Service 1997a). Thus, murrelet conservation is largely dependent upon Federal lands in the northern portion of Zone 2 and non-Federal lands in the southern portion.

8.3.1.2 Life History

Murrelets are long-lived seabirds that spend most of their life in the marine environment, but use old-growth forests for nesting. Detailed discussions of the biology and status of the murrelet are presented in the final rule listing the murrelet as threatened (U.S. Fish and Wildlife Service 1992), the Recovery Plan, Ecology and Conservation of the Marbled Murrelet (Ralph et al. 1995), the final rule designating murrelet critical habitat (61 FR 26256, U.S. Fish and Wildlife Service 1996a), and the Evaluation Report for the 5-Year Status Review of the Marbled Murrelet in Washington, Oregon, and California (McShane et al. 2004).

Physical Description

The murrelet is taxonomically classified in the family Alcidae (Alicids), a family of Pacific seabirds possessing the ability to dive using wing-propulsion. The plumage of this relatively small (9.5-10 inches) seabird is identical between males and females, but the plumage of adults changes during the winter and breeding periods providing some distinction between adults and juveniles. Breeding adults have light, mottled brown under-parts below sooty-brown upperparts contrasted with dark bars. Adults in winter plumage have white under-parts extending to below the nape and white scapulars with brown and grey mixed upperparts. The plumage of fledged young is similar to the adult winter plumage (U.S. Fish and Wildlife Service 1997a).

Distribution

The range of the murrelet, defined by breeding and wintering areas, extends from the northern terminus of Bristol Bay, Alaska, to the southern terminus of Monterey Bay in central California. The listed portion of the species' range extends from the Canadian border south to central California. Murrelet abundance and distribution has been significantly reduced in portions of the listed range, and the species has been extirpated from some locations. The areas of greatest concern due to small numbers and fragmented distribution include portions of central California, northwestern Oregon, and southwestern Washington (U.S. Fish and Wildlife Service 1997a).

Reproduction

Murrelet breeding is asynchronous and spread over a prolonged season. In Washington, the murrelet breeding season occurs between April 1 and September 15. Egg laying and incubation occur from late April to early August and chick rearing occurs between late May and late August, with all chicks fledging by early September (Hamer et al. 2003).

Murrelets lay a single-egg clutch (Nelson 1997), which may be replaced if egg failure occurs early (Hebert et al. 2003; McFarlane-Tranquilla et al. 2003). However, there is no evidence a second egg is laid after successfully fledging a first chick. Adults typically incubate for a 24-hour period, then exchange duties with their mate at dawn. Hatchlings appear to be brooded by an adult for 1-2 days and are then left alone at the nest for the remainder of the rearing period, except during feedings. Both

parents feed the chick, which receives 1-8 meals per day (Nelson 1997). Most meals are delivered early in the morning, while about a third are delivered at dusk and a few meals are sometimes scattered throughout the day (Nelson and Hamer 1995a). Chicks fledge 27-40 days after hatching. The initial flight of a fledgling appears to occur at dusk and parental care is thought to cease after fledging (Nelson 1997).

Murrelets in the Marine Environment

Courtship, foraging, loafing, molting, and preening occur in near-shore marine waters. Beginning in early spring, courtship continues throughout summer with some observations even noted during the winter period (Speckman 1996; Nelson 1997). Observations of courtship occurring in the winter suggest that pair bonds are maintained throughout the year (Speckman 1996; Nelson 1997). Courtship involves bill posturing, swimming together, synchronous diving, vocalizations, and chasing in flights just above the surface of the water. Copulation occurs both inland (in the trees) and at sea (Nelson 1997).

Vocalization

Murrelets are known to vocalize between 480 Hertz and 4.9 kilohertz and have at least 5 distinct call types (Suzanne Sanborn, Personal Communication, 2005). Murrelets tend to be more vocal at sea compared to other alcids (Nelson 1997). Individuals of a pair vocalize after surfacing apart from each other, after a disturbance, and during attempts to reunite after being separated (Strachan et al. 1995).

Loafing

When murrelets are not foraging or attending a nest, they loaf on the water, which includes resting, preening, and other activities during which they appear to drift with the current, or move without direction (Strachan et al. 1995). Strachan et al. (1995) noted that vocalizations occurred during loafing periods, especially during the mid-morning and late afternoon.

Molting

Murrelets go through two molts each year. The timing of molts varies temporally throughout their range likely due to prey availability, stress, and reproductive success (Nelson 1997). Adult (after hatch-year) murrelets have two primary plumage types: alternate (breeding) plumage and basic (winter) plumage. The pre-alternate molt occurs from late February to mid-May. This is an incomplete molt during which the birds lose their body feathers but retain their ability to fly (Carter and Stein 1995; Nelson 1997). A complete pre-basic molt occurs from mid-July through December (Carter and Stein 1995; Nelson 1997). During the pre-basic molt, murrelets lose all flight feathers somewhat synchronously and are flightless for up to 2 months (Nelson 1997). In Washington, there is some indication that the pre-basic molt occurs from mid-July through the end of August (Chris Thompson, WDFW, Personal Communication, 2003).

Flocking

Strachan et al. (1995) defines a flock as three or more birds in close proximity which maintain that formation when moving. Various observers throughout the range of the murrelet report flocks of highly variable sizes. In the southern portion of the murrelet's range (California, Oregon, and Washington), flocks rarely contain more than 10 birds. Larger flocks usually occur during the later part of the breeding season and may contain juvenile and subadult birds (Strachan et al. 1995).

Aggregations of foraging murrelets are probably related to concentrations of prey. In Washington, murrelets are not generally found in interspecific feeding flocks (Strachan et al. 1995). Strong et al. (cited in Strachan et al. 1995) observed that murrelets avoid large feeding flocks of other species and presumed that the small size of murrelets may make them vulnerable to kleptoparasitism or predation in mixed species flocks. Strachan et al. (1995) point out that if murrelets are foraging cooperatively, the confusion of a large flock of birds could reduce foraging efficiency.

Foraging Behavior

Murrelets forage at all times of the day, but most actively in the morning and late afternoon (Strachan et al. 1995). Murrelets typically forage in pairs, but have been observed to forage alone or in groups of three or more (Carter and Sealy 1990; Strachan et al. 1995; Speckman et al. 2003). Strachan et al. (1995) believe pairing influences foraging success and cooperative foraging techniques may be employed. For example, pairs consistently dive together during foraging and often synchronize their dives by swimming towards each other before diving (Carter and Sealy 1990) and resurfacing together on most dives. Strachan et al. (1995) speculate pairs may keep in visual contact underwater. Paired foraging is common throughout the year, even during the incubation period, suggesting that breeding murrelets may temporarily pair up with other foraging individuals (non-mates) (Strachan et al. 1995; Speckman et al. 2003).

Murrelets generally forage within 1.25 miles of shore (Strachan et al. 1995), but are also known to forage in freshwater lakes (Nelson 1997). Traditional feeding areas (nurseries) are used consistently on a daily and yearly basis (Carter and Sealy 1990). Activity patterns and foraging locations are influenced by biological and physical processes that concentrate prey, such as weather, climate, time of day, season, light intensity, up-wellings, tidal rips, narrow passages between islands, shallow banks, and kelp (*Nereocystis* spp.) beds (Ainley et al. 1995; Burger 1995; Strong et al. 1995; Speckman 1996; Nelson 1997).

Juveniles are found closer to shore than adults (rarely greater than 0.625 miles offshore) (Beissinger 1995) and forage without the assistance of adults (Strachan et al. 1995). Kuletz and Piatt (1999) found that in Alaska, juvenile murrelets congregated in kelp beds. Kelp beds are often associated with productive waters and may provide protection from avian predators (Kuletz and Piatt 1999). McAllister (unpublished data–cited in Strachan et al. 1995) found that juveniles were more common within 328 feet of shorelines, particularly, where bull kelp was present.

Murrelets forage most frequently in nearshore water generally less than 98 feet (30 meters) deep (Strachan et al. 1995, Burger 2001). The most common foraging depths are not known. However, murrelets are known to feed on small schools of fish within the upper 16.4 feet (5 meters) of marine waters (Mahon et al. 1992). An alcid the size of a murrelet is expected to have a maximum diving depth of about 154 feet (47 meters) (Mathews and Burger 1998), although the deepest record of a marbled murrelet was from one captured at 89 feet (27 meters) in a gill net off of California (Carter and Erickson 1992). Jodice and Collopy (1999) reported most diving in Oregon occurred in water less than 33 feet (10 meters) deep.

The duration of dives appears to depend upon age (adults vs. juveniles), water depth, and prey depth. Reported dive durations are highly variable for murrelets, ranging from 7 to 42 seconds, with an average of 14 seconds reported from observations in California (Strachan et al. 1995). Carter and Sealy (1990) reported that dive durations in British Columbia averaged 27.8 seconds and Thorensen (1989) reported dive durations in Washington ranged from 15 to 115 seconds.

Adults and subadults often move away from breeding areas prior to molting and must select areas with predictable prey resources during the flightless period (Carter and Stein 1995; Nelson 1997). During the non-breeding season, murrelets disperse and can be found farther from shore (Strachan et al. 1995). Little is known about marine-habitat preference outside of the breeding season, but use during the early spring and fall is thought to be similar to that preferred during the breeding season (Nelson 1997). During the winter there may be a general shift from exposed outer coasts into more protected waters (Nelson 1997), for example many murrelets breeding on the exposed outer coast of Vancouver Island appear to congregate in the more sheltered waters within the Puget Sound and the Strait of Georgia in fall and winter (Burger 1995). However, in many areas, murrelets remain associated with the inland nesting habitat during the winter months (Carter and Erickson 1992) and throughout the listed range, murrelets do not appear to disperse long distances, indicating they are year-round residents (McShane et al. 2004).

Prey Species

Throughout their range, murrelets are opportunistic feeders and utilize prey of diverse sizes and species. They feed primarily on fish and invertebrates in near-shore marine waters although they have also been detected on rivers and inland lakes (Carter and Sealy 1986; U.S. Fish and Wildlife Service 1992). In general, small schooling fish and large pelagic crustaceans are the main prey items. Pacific sand lance *(Ammodytes hexapterus)*, northern anchovy *(Engraulis mordax)*, immature Pacific herring *(Clupea harengus)*, capelin *(Mallotus villosus)*, and surf smelt (Osmeridae) are the most common fish species taken and are eaten year round. Squid (*Loligo* spp.), euphausiids, mysid shrimp, and large pelagic amphipods are the main invertebrate prey and are primarily eaten during the non-breeding season, thus they are not a significant part of a nestling's diet.

Murrelets usually carry a single fish to their chicks and appear to select a relatively large (relative to body size), energy-rich fish such as large sand lance, immature herring, anchovy, smelt, and occasionally salmon smolts (Burkett 1995; Nelson 1997). This forces breeding adults to exercise more specific foraging strategies when feeding chicks. Freshwater prey appears to be important to some individuals during several weeks in summer and may facilitate more frequent chick feedings, especially for those that nest far inland (Hobson 1990). As a result, the distribution and abundance of prey suitable for feeding chicks may greatly influence the overall foraging behavior and location(s) during the nesting season. The availability of abundant forage fish during the nestling period may significantly affect the energy demand on adults by influencing both foraging time and number of trips inland required to feed nestlings (U.S. Fish and Wildlife Service 1992).

Predators

At sea predators include bald eagles (*Haliaeetus leucocephalus*), peregrine falcons (*Falco peregrinus*), western gulls (*Larus occidentalis*), and northern fur seals (*Callorhinus ursinus*) (McShane et al. 2004). California sea lions (*Zalophus californianus*), northern sea lions (*Eumetopias jubatus*), and large fish may also be occasional predators (Burger 2002).

Murrelets in the Terrestrial Environment

Murrelets are dependent upon old-growth forests, or forests with an older tree component, for nesting habitat (Hamer and Nelson 1995; Ralph et al. 1995; McShane et al. 2004). Sites occupied by murrelets tend to have a higher proportion of mature forest age-classes than do unoccupied sites (Raphael et al. 1995). Specifically, murrelets prefer high and broad platforms for landing and take-off, and surfaces which will support a nest cup (Hamer and Nelson 1995). The physical condition of a tree appears to be

the important factor in determining the tree's suitability for nesting (Ralph et al. 1995); therefore, presence of old-growth in an area does not assure the stand contains sufficient structures (i.e., platforms) for nesting. In Washington, murrelet nests have been found in conifers, specifically, western hemlock, Sitka spruce, Douglas-fir, and western red cedar (Hamer and Meekins 1999; Hamer and Nelson 1995). Nests have been found in trees as small as 2.6 feet in diameter at breast height on limbs at least 65 feet from the ground and 0.36 feet in diameter (Hamer and Meekins 1999).

Murrelet populations may be limited by the availability of suitable nesting habitat. In the Ecology and Conservation of the Marbled Murrelet, Ralph et al. (1995) surmised in the book's summary that the suitable nesting habitat remaining in Washington, Oregon, and California was saturated with murrelets based on: (1) at-sea concentrations of murrelets near suitable nesting habitat during the breeding season; (2) winter visitation to nesting sites; and (3) the limitation of nest sites available in areas with large amounts of habitat removal. Murrelets have been observed visiting nesting habitat during non-breeding periods in Washington, Oregon, and California (Nelson 1997, Naslund 1993) which may indicate adults are defending nesting sites and/or stands (Ralph et al. 1995). Other studies provide further insight to the habitat associations of breeding murrelets, concluding that breeding murrelets displaced by the loss of nesting habitat do not pack in higher densities into remaining habitat (McShane et al. 2004). Thus, murrelets may currently be occupying nesting habitat at or near carrying capacity in highly fragmented areas and/or in areas where a significant portion of the historic nesting habitat has been removed.

Therefore, unoccupied stands containing nesting structures could be important to displaced breeders and first-time breeding adults. Even if nesting habitat is at carrying capacity, there will be years when currently occupied stands become unoccupied as a result of temporary disappearance of inhabitants due to death or to irregular breeding (Ralph et al. 1995). Therefore, unoccupied stands will not necessarily indicate that habitat is not limiting or that these stands are not murrelet habitat (Ralph et al. 1995) and important to the species persistence.

Radar and audio-visual studies have shown murrelet habitat use is positively associated with the presence and abundance of mature and old-growth forests, large core areas of old-growth, low amounts of edge and fragmentation, proximity to the marine environment, total watershed area, and increasing forest age and height (McShane et al. 2004). In California and southern Oregon, areas with abundant numbers of murrelets were farther from roads, occurred more often in parks protected from logging, and were less likely to occupy old-growth habitat if it was isolated > 3 miles (> 5 kilometers) from other nesting murrelets (Meyer et al. 2002). Meyer et al. (2002) also found at least a few years passed before birds abandoned fragmented forests.

Murrelets do not form dense colonies, which is atypical for most seabirds. Limited evidence suggests they may form loose colonies or clusters of nests in some cases (Ralph et al. 1995). The reliance of murrelets on cryptic coloration to avoid detection will suggest they utilize a wide spacing of nests in order to prevent predators from forming a search image (Ralph et al. 1995). However, active nests have been seen within 328 feet (100 meters) of one another in the North Cascades in Washington and within 98 feet (30 meters) in Oregon (Kim Nelson, OSU, Personal Communication, 2005). Estimates of murrelet nest densities vary depending upon the method of data collection. For example, nest densities estimated using radar range from 0.007 to 0.104 mean nests per acre (0.003 to 0.042 mean nests per hectare), while nest densities estimated from tree climbing efforts range from 0.27 to 3.51 mean nests per acre (0.11 to 1.42 mean nests per hectare) (Nelson 2005).

There are few data available regarding murrelet nest site fidelity because of the difficulty in locating nest sites and observing bands on birds attending nests. However, murrelets have been detected in the same nesting stands for many years (at least 20 years in California and 15 in Washington), suggesting murrelets have a high fidelity to nesting areas (Nelson 1997). Use of the same nest platform in successive years and multiple nests in the same tree have been documented, although it is not clear whether the repeated use involved the same birds (Hebert and Golightly 2003; Nelson 1997; Nelson and Peck 1995; Divoky and Horton 1995). The limited observed fidelity to the same nest site in consecutive years appears to be lower than for other alcids, but this may be an adaptive behavior in response to high predation rates (Divoky and Horton 1995). Researchers have suggested annual use of specific or adjacent nesting platforms may be more common in areas where predation is limited or the number of suitable nest sites are few because large, old-growth trees are rare (Nelson and Peck 1995; Singer et al. 1995; Manley 1999).

Ralph et al. (1995) speculated the annual use of nest sites or stands by breeding murrelets may be influenced by the nesting success of previous rearing attempts. Although murrelet nesting behavior in response to failed nest attempts is unknown, nest failures could lead to prospecting for new nest sites or mates. Other alcids have shown an increased likelihood to relocate to a new nest in response to breeding failure (Divoky and Horton 1995). However, murrelets likely remain in the same stand over time as long as the stand is not significantly modified (Ralph et al. 1995).

It is unknown whether juveniles disperse from natal breeding habitat (natal dispersal) or return to their natal breeding habitat after reaching breeding age (natal philopatry). Divoky and Horton (1995) predicted that juvenile dispersal is likely to be high because murrelets are non-colonial and nest in widely dispersed nest sites. Conversely, Swartzman et al. (1997 cited in McShane et al. 2004) suggested juvenile dispersal is likely to be low, as it is for other alcid species. Therefore, the presence of unoccupied suitable nesting habitat on the landscape may be important for first-time nesters if they disperse away from their natal breeding habitat.

Murrelets generally select nests within 37 miles (60 kilometers) of marine waters (Miller and Ralph 1995). However, in Washington, occupied habitat has been documented 52 miles (84 kilometers) from marine waters and murrelets have been detected up to 70 miles (113 kilometers) from marine waters in the southern Cascade Mountains (Evans Mack et al. 2003).

When tending active nests during the breeding season (and much of the non-breeding season in southern parts of the range), breeding pairs forage within commuting distance of the nest site. Daily movements between nest sites and foraging areas for breeding murrelets averaged 10 miles in Prince William Sound, Alaska (McShane et al. 2004), 24 miles in Desolation Sound, British Columbia (Hull et al. 2001), and 48 miles in southeast Alaska. In California, Hebert and Golightly (2003) found the mean extent of north-south distance traveled by breeding adults to be about 46 miles.

Murrelet nests have been located at a variety of elevations from sea level to 5,020 feet (Burger 2002). However, most nests have been found below 3,500 feet. In Conservation Zone 1, murrelets have exhibited occupied behaviors up to 4,400 feet in elevation and have been detected in stands up to 4,900 ft in the north Cascade Mountains (Peter McBride, WDNR, Personal Communication,. 2005). On the Olympic Peninsula, survey efforts for nesting murrelets have encountered occupied stands up to 4,000 feet within Conservation Zone 1 and up to 3,500 feet within Conservation Zone 2. Surveys of murrelet habitat at higher elevations on the Olympic Peninsula have not been conducted. However, recent radio-telemetry work detected a murrelet nest at 3,600 ft elevation on the Olympic Peninsula in Conservation Zone 1 (Martin Raphael, USFS, Personal Communication, 2005).

8.3.1.3 Population Status in the Coterminous United States

Population Abundance

Research on murrelet populations in the early 1990s estimated murrelet abundance in Washington, Oregon, and California at 18,550 to 32,000 (Ralph et al. 1995). However, consistent population survey protocols were not established for murrelets in the coterminous United States until the late 1990s following the development of the marine component of the Effectiveness Monitoring Program for the Northwest Forest Plan (Bentivoglio et al. 2002). As a consequence, sampling procedures have differed and thus the survey data collected prior to the EM Program is unsuitable for estimating population trends for the murrelet (McShane et al. 2004).

The development of the Effectiveness Monitoring Program unified the various at-sea monitoring efforts within the five Conservation Zones encompassed by the Northwest Forest Plan. These efforts along with efforts in Conservation Zone 6 have resulted in annual estimates of murrelet abundance for each Conservation Zone (Bentivoglio 2002; Huff et al. 2003; Lance 2004; Peery et al. 2002) with the annual listed population estimated to be 18,097 in 2000; 22,200 in 2001; 23,700 in 2002; and 22,300 in 2003.

Population Trend

Estimated population trends within each Conservation Zone or for the entire coterminous population are not yet available from the marine survey data. Trend information will eventually be provided through the analysis of marine survey data from the Effectiveness Monitoring Program (Bentivoglio et al. 2002) and from survey data in Zone 6 once a sufficient number of survey years have been completed. Depending on the desired minimum power (80 or 95 percent) to detect annual decreases, at least 8 to 10 years of surveys are required for an overall population estimate and 7 to 16 years are required for population estimates for Conservation Zones 1 and 2 (Huff et al. 2003).

In the interim, demographic modeling has aided attempts to analyze and predict population trends and extinction probabilities of murrelets. Incorporating important population parameters and species distribution data (Beissinger 1995; Beissinger and Nur 1997–cited in U.S. Fish and Wildlife Service 1997a; Cam et al. 2003; McShane et al. 2004), demographic models can provide useful insights into potential population responses from exposure to environmental pressures and perturbations. However, weak assumptions or inaccurate estimates of population parameters such as survivorship rates, breeding success, and juvenile-to-adult ratios, can limit the use of models. Thus, a cautious approach is warranted when forecasting long-term population trends using demographic models.

Most of the published demographic models used to estimate murrelet population trends employ Leslie Matrix modeling (McShane et al. 2004). Two other more complex, unpublished models (Akcakaya 1997 and Swartzman et al. 1997–cited in McShane et al. 2004) evaluate the effect of nest habitat loss on murrelets in Zone 4 (McShane et al. 2004). McShane et al. (2004) developed a stochastic Leslie Matrix model (termed "Zone Model") to project population trends in each murrelet Conservation Zone. The Zone Model was developed to integrate available demographic information for a comparative depiction of current expectations of future population trends and probability of extinction in each Zone (McShane et al. 2004). Table 8-23 lists the four latest murrelet Leslie Matrix models and the values for common demographic parameters used in each.

Table 8-23. The estimated values for demographic parameters used in four population models for the murrelet.

Demographic Parameter	Beissinger 1995	Beissinger and Nur 1997–cited in U.S.* 1997a	Beissinger and Peery 2003	McShane et al. 2004
Juvenile to Adult Ratio	0.10367	0.124 or 0.131	0.089	0.02 - 0.09
Annual Fecundity	0.11848	0.124 or 0.131	0.06-0.12	(See nest success)
Nest Success			0.16-0.43	0.38 - 0.54
Maturation	3	3	3	2 - 5
Estimated Adult Survivorship	85 - 90%	85 - 88%	82 - 90%	83 - 92%

*Fish and Wildlife Service

Regardless of model preference, the overall results of modeling efforts are in agreement, indicating murrelet abundance is declining (McShane 2004:6-27). The rates of decline are highly sensitive to the assumed adult survival rate used for calculation (Beissinger and Peery 2003). The most recent modeling effort using the "Zone Model" (McShane et al. 2004) suggests the murrelet zonal sub-populations are declining at a rate of 3.0 to 6.2 percent per year.

Estimates of breeding success are best determined from nest site data, but difficulties in finding nests has led to the use of other methods, such as juvenile to adult ratios and radio-telemetry estimations, each of which have biases. The nest success data presented in Table 8-23 under McShane et al. (2004) was derived primarily from radio telemetry studies; however the nests sampled in these studies were not representative of large areas and specifically did not include Washington or Oregon. In general, telemetry estimates are preferred over juvenile to adult ratios for estimating breeding success due to fewer biases (McShane et al. 2004), but telemetry data are not currently available for Washington or Oregon. Therefore, it is reasonable to expect that juvenile to adult ratios derived from at-sea survey efforts best represent murrelet reproductive success in Washington, Oregon, and California.

Beissinger and Peery (2003) performed a comparative analysis using data from 24 bird species to predict the juvenile to adult ratio for murrelets of 0.27 (confidence intervals ranged from 0.15 to 0.65). Demographic models suggest murrelet population stability requires a minimum of 0.18 – 0.28 chicks per pair per year (Beissinger and Nur 1997–cited in U.S. Fish and Wildlife Service 1997a). The lower confidence intervals for both the predicted juvenile to adult ratio (0.15) and the stable population juvenile to adult ratio (0.18) are greater than the juvenile to adult ratios observed for any of the Conservation Zones (0.02 – 0.09 chicks per pair, Beissinger and Nur 1997–cited in U.S. Fish and Wildlife Service 1997a; Beissinger and Peery 2003). Therefore, the juvenile to adult ratios observed in the Conservation Zones are lower than predicted ratios and are too low to obtain a stable population in any Conservation Zone, which indicates murrelet populations are declining in all Conservation Zones and will continue to decline until reproductive success improves.

Based upon: (1) the outcome of demographic modeling; (2) the observed juvenile to adult ratios; and (3) adult survivorship rates, the number of murrelets in Washington, Oregon, and California are too low to sustain a murrelet population and the rate of decline for murrelets throughout the listed range is estimated to be between 2.0 to 15.8 percent (Beissinger and Nur 1997–cited in U.S. Fish and Wildlife Service 1997a; McShane et al. 2004).

Murrelets in Washington (Conservation Zones 1 and 2)

Historically, murrelets in Conservation Zones 1 and 2 were "common" (Rathbun 1915 and Miller et al. 1935–cited in U.S. Fish and Wildlife Service 1997a), "abundant" (Edson 1908 and Rhoades 1893–cited in U.S. Fish and Wildlife Service 1997a), or "numerous" (Miller et al. 1935–cited in McShane et al. 2004).

Conservation Zone 1, encompassing the Puget Sound in northwest Washington, contains one of the larger murrelet populations in the species' listed range, and supports an estimated 41 percent of the murrelets in the coterminous United States (Huff et al. 2003). The 2003 population estimate (with 95 percent confidence intervals) for Conservation Zone 1 is 8,500 (6,000 – 11,300) and Conservation Zone 2 is 3,400 (2,000 – 4,900) (Huff et al. 2003). In Conservation Zone 2, a higher density of murrelets occurs in the northern portion of the Zone (Huff et al. 2003) where the majority of available nesting habitat occurs. In Conservation Zone 1, higher densities of murrelets occur in the Straits of Juan de Fuca, the San Juan Islands, and the Hood Canal (Huff et al. 2003), which are in proximity to nesting habitat on the Olympic Peninsula and the North Cascade Mountains.

Although population numbers in Conservation Zones 1 and 2 are likely declining, the precise rate of decline is unknown. The juvenile to adult ratio derived from at-sea survey efforts in Conservation Zone 1 is 0.09. Juvenile to adult ratio is not collected in Conservation Zone 2; however, the juvenile to adult ratio for Conservation Zone 3 is 0.08. Therefore, it is reasonable to infer that a juvenile to adult ratio for Conservation Zone 2 is likely between 0.08 and 0.09. These low juvenile to adult ratios infer there is insufficient juvenile recruitment to sustain a murrelet population in Conservation Zones 1 and 2. Beissinger and Peery (2003) estimated the rate of decline for Conservation Zone 1 to be between 2.0 to 12.6 percent and between 2.8 to13.4 percent in Conservation Zone 3. It is likely that the rate of decline in Conservation Zone 2 is similar to that of Conservation Zones 1 and 3.

Juvenile to adult ratios in Washington may be skewed by murrelets coming and going to British Columbia. At-sea surveys are timed to occur when the least number of murrelets from British Columbia are expected to be present. However, recent radio-telemetry information indicates: (1) murrelets nesting in British Columbia forage in Washington waters during the breeding season (Martin Raphael, USFS, Personal Communication, 2005) and could be counted during at-sea surveys; and (2) adult murrelets foraging in Washington during the early breeding season moved to British Columbia in mid-June and mid-July (Bloxton and Raphael 2004) and would not have been counted during the at-sea surveys. The movements of juvenile murrelets in Washington and southern British Columbia are unclear. Therefore, until further information is obtained to define the impact of exchange of murrelets between British Columbia and Washington, we will continue to rely on the at-sea derived juvenile to adult ratios to evaluate the population status in Conservation Zones 1 and 2.

8.3.1.4 Habitat Abundance

Estimates on the amount of available suitable nesting habitat vary as much as the methods used for estimating murrelet habitat. McShane et al. (2004) estimates murrelet habitat in Washington State at 1,022,695 acres, representing approximately 48 percent of the estimated 2,223,048 acres of remaining suitable habitat in the listed range. McShane et al. (2004) caution about making direct comparisons between current and past estimates due to the evolving definition of suitable habitat and methods used to quantify habitat. As part of the ongoing pursuit to improve habitat estimates, information was collected and analyzed by the FWS in 2005 resulting in an estimated 751,831 acres of suitable nesting habitat in Conservation Zone 1 and 585,821 acres in Conservation Zone 2 (Table 8-24).

Table 8-24. Estimated acres of suitable nesting habitat for the murrelet on Federal and non-Federal lands in Conservation Zones 1 and 2.

Conservation Zone	Estimated acres of suitable murrelet habitat by land management category *				
	Federal	**State**	**Private***	**Tribal**	**Total**
Puget Sound (Zone 1)	650,937	98,036	2,338	520	751,831
Western Washington Coast Range (Zone 2)	485,574	82,349	9,184	8,714	585,821
Totals	**1,136,511**	**180,385**	**11,522**	**9,234**	**1,337,652**

* Estimated acres of private land represent "occupied" habitat based on surveys submitted to WDFW. Additional suitable nesting habitat not surveyed or considered to be "unoccupied" is not included in this estimate.

Estimated acreages of suitable habitat on Federal lands in Table 8-24 are based on modeling and aerial photo interpretation and likely overestimate the actual acres of suitable murrelet habitat because: (1) most acreages are based on models predicting spotted owl nesting habitat which include forested lands that do not have structures suitable for murrelet nesting; and (2) neither modeling or aerial photo interpretation can distinguish microhabitat features, such as nesting platforms or the presence of moss, that are necessary for murrelet nesting. The amount of high quality murrelet nesting habitat available in Washington, defined by the FWS as large, old, contiguously forested areas not subject to human influences (e.g., timber harvest or urbanization) is expected to be a small subset of the estimated acreages in Table 8-24. Murrelets nesting in high-quality nesting habitat are assumed to have a higher nesting success rate than murrelets nesting in fragmented habitat near humans.

Other Recent Assessments of Murrelet Habitat in Washington

Two recent assessments of marbled murrelet potential nesting habitat were developed for monitoring the Northwest Forest Plan (Raphael et al. 2005). This study provides a provincial-scale analysis of marbled murrelet habitat derived from vegetation base maps, and includes estimates of habitat on State and private lands in Washington for the period of 1994 – 1996. Using vegetation data derived from satellite imagery, Raphael and others (2005) developed two different approaches to model habitat suitability. The first model is referred to as the Expert Judgment Model, and is based on the judgment of an expert panel that used existing forest structure classification criteria (e.g., percent conifer cover, canopy structure, quadratic mean diameter, forest patch size, etc.) to classify forests into four classes of habitat suitability, with Class 1 indicating the least suitable habitat and Class 4 indicating the most highly suitable habitat. Raphael and others (2005) found that across the murrelet range, most habitat-capable (i.e., forested lands capable of producing suitable marbled murrelet habitat) land (52 percent) is classified as Class 1 (lowest suitability) habitat and 18 percent is classified as Class 4 (highest suitability) habitat. In Washington, they found that there were approximately 954,200 acres of Class 4 habitat in 1994-1996 (Table 8-25). However, only 60 percent of known nest sites in their study area were located in Class 4 habitat.

The second habitat model developed by Raphael et al. (2005) used the Biomapper Ecological Niche-Factor Analysis model developed by Hirzel and others (2002). The resulting murrelet habitat suitability maps are based on both the physical and vegetative attributes adjacent to known murrelet occupied polygons or nest locations for each Northwest Forest Plan province. The resulting raster maps are a grid of 269 square foot-cells (25 square meter-cells) (0.15 acres per pixel). Each cell in the raster is assigned a value of 0-100. Values closer to 100 represent areas that match the murrelet nesting locations, values

closer to 0 are likely unsuitable for nesting (Raphael et al. 2005). These maps do not provide absolute habitat estimates, but rather a range of habitat suitability values, which can be interpreted in various ways. Raphael et al. (2005) noted that the results from the Ecological Niche Factor Analysis (ENFA) are not easily compared to results from the Expert Judgment Model because it was not clear what threshold from the habitat suitability ranking to use. Raphael and others (2005) elected to display habitat suitability scores greater than 60 (HS >60) as a "generous" portrayal of potential nesting habitat and a threshold greater than 80 (HS >80) as a more conservative estimate. In Washington, there were over 2.1 million acres of HS >60 habitat, but only 440,700 acres of HS >80 habitat (Table 8-25). It is important to note that HS >60 habitat map captures 82 percent of the occupied nests sites in Washington, whereas the HS >80 habitat map only captures 36 percent of the occupied nests in Washington.

Table 8-25. Comparison of different habitat modeling results for the Washington nearshore zone (0-40 miles inland = Northwest Forest Plan murrelet zone 1).

Murrelet Habitat Model	Habitat Acres on Federal Reserves (LSRs, Natl.Parks)	Habitat Acres on Federal, Non-Reserves (USFS Matrix)	Total Habitat Acres on Federal Lands	Total Habitat Acres on Non-Federal Lands (City, State, Private, Tribal)	Total Habitat Acres - All Ownerships	% of Total Habitat Acres on Non-Federal Lands	% of Known Murrelet Nest Sites in Study Area that Occurred in this Habitat Classification
ENFA HS >80	284,300	18,600	302,900	137,800	440,700	31%	36%
EJM Class 4	659,200	40,700	699,900	254,300	954,200	11%	60%
EJM Class 3 and Class 4	770,600	54,700	825,300	535,200	1,360,500	16%	65%
ENFA HS >60	927,000	85,300	1,012,300	1,147,100	2,159,400	53%	82%

ENFA = Ecological Niche Facto Analysis. EJM = Expert Judgment Model. Results were summarized directly from Tables 4 and 5 and Tables 9 and 10 in Raphael et al (2005). All habitat estimates represent 1994-1996 values.

Because the HS >60 model performed best for capturing known murrelet nest sites, Raphael et al. (2005) suggest that the ENFA HS >60 model yields a reasonable estimate of potential murrelet nesting habitat. However, we found that large areas in southwest Washington identified in the HS >60 model likely overestimates the actual suitable habitat in this landscape due to a known lack of old-forest in this landscape. Despite the uncertainties associated with interpreting the various map data developed by Raphael and others (2005), it is apparent that there is a significant portion of suitable habitat acres located on non-Federal lands in Washington, suggesting that non-Federal lands may play a greater role in the conservation needs of the species than has previously been considered. Using the most conservative criteria developed by Raphael et al. (2005) the amount of high-quality murrelet nesting habitat on non-Federal lands in Washington varies from 11 percent to as high as 31 percent (Table 8-25).

Raphael et al. (2005) note that the spatial accuracy of the map data are limited and that the habitat maps are best used for provincial-scale analysis. Due to potential errors in vegetation mapping and other potential errors, these maps are not appropriate for fine-scale project mapping. These data have not been published in their final form yet, although they have been available on the internet for public review and use since May 2005.

Conservation Zone 1

The majority of suitable murrelet habitat in Conservation Zone 1 occurs in northwest Washington and is found on Forest Service and National Park Service lands, and to a lesser extent on State lands. The majority of the historic habitat along the eastern and southern shores of the Puget Sound has been replaced by urban development resulting in the remaining suitable habitat being farther inland from the marine environment than what occurred historically (U.S. Fish and Wildlife Service 1997a).

Conservation Zone 2

Murrelet nesting habitat north of Grays Harbor in Conservation Zone 2 occurs largely on State, Forest Service, National Park Service, and tribal lands, and to a lesser extent, on private lands. Alternatively, the majority of habitat in the southern portion of Conservation Zone 2 occurs primarily on State lands, with a small amount on private lands.

8.3.1.5 Threats

Murrelets remain subject to a variety of anthropogenic threats within the upland and marine environment. They also face threats from low population numbers, low immigration rates, high predation rates, and disease.

Threats in the Marine Environment

Threats to murrelets in the marine environment include declines in prey availability; mortality associated with exposure to oil spills, gill net, and other fisheries; contaminants suspended in marine waters; and visual or sound disturbance from recreational or commercial watercrafts (U.S. Fish and Wildlife Service 1992, 1997a; Ralph et al. 1995; McShane et al. 2004).

Prey Availability

Many fish populations have been depleted due to overfishing, reduction in the amount or quality of spawning habitat, and pollution. Primary murrelet prey species have little commercial fishery value and, in general, there is little geographic overlap between murrelet distribution and areas of commercial harvest (McShane et al. 2004). However, there are several fisheries for herring and surf smelt in Puget Sound and for anchovy in Grays Harbor, Willapa Bay, and along the outer coast (Bargmann 1998). The extent of the effects of these fisheries on murrelets is unknown, but is presumed to be minor.

In addition to fishing pressure, oceanographic variation can influence prey availability. While the effects to murrelets from events such as El Niño have not been well documented, El Niño events are thought to reduce overall prey availability and several studies have found that El Niño events can influence the behavior of murrelets (McShane et al. 2004). Even though changes in prey availability may be due to natural and cyclic oceanographic variation, these changes may exacerbate other threats to murrelets in the marine environment.

Shoreline development has affected and will continue to effect coastal processes. Shipping, bulkheads, and other shoreline developments have contributed to the reduction in eelgrass beds and other spawning and rearing areas for forage fish such as herring. Pacific herring and other small marine fish, such as sand lance and surf smelt, are important prey species. They make up a large part of the diet of murrelets.

There are 19[1] known stocks of Pacific herring in Puget Sound. Of these populations, 15 are considered healthy or moderately healthy, three are considered depressed or critical, and the status of the remaining stock is unknown. According to WDNR (2000: pg. 99), herring spawning stocks decreased from over 20,000 tons in the 1970s to less than 10,000 tons in recent years. Cherry Point, within the Strait of Georgia, supports the largest herring stock in Washington and has experienced a precipitous decline. The decline of this stock may be affecting the forage base for murrelets in this region of Puget Sound. There is a moderate likelihood that organic contaminants are incrementally affecting this stock. Past research has shown that exposure to contamination reduces reproductive capability, growth rates, and resistance to disease, and may lead to lower survival for salmon (WDNR 2000).

Following the Exxon-Valdez oil spill, a study was initiated in Prince William Sound that included a comparison of oiled areas with unoiled areas and also compared pre-spill populations with post-spill populations (Klosiewski and Laing 1994). That study indicated that murrelets decreased in both oiled and unoiled areas. Total population estimates declined from 304,400 in 1972-73 to 98,400 in 1989-1991. In the conclusion of that study, which also addressed many other bird species, it was noted that a number of bird species feeding on small fish have decreased in the past several decades, while bird species feeding on benthic organisms did not decrease similarly.

Oil Spills

Murrelet mortality from oil pollution is a conservation issue in Washington (U.S. Fish and Wildlife Service 1997a). Most oil spills and chronic oil pollution that can affect murrelets occur in areas of high shipping traffic, such as the Strait of Juan de Fuca and Puget Sound. There have been at least 47 oil spills of 10,000 gallons or more in Washington since 1964 (WDOE 2004b). However, the number of oil spills has generally declined since passage of the U.S. Oil Pollution Act in 1990. The estimated annual mortality of murrelets from oil spills in Washington has decreased from 3 - 41 birds per year (1977 to 1992) to 1 - 2 birds per year (1993 to 2003) (McShane et al. 2004).

Since the murrelet was listed, the amount of oil tanker and shipping traffic has continued to increase (U.S. Fish and Wildlife Service 1997a; Burger 2002). Large commercial ships, including oil tankers, cargo ships, fish processing ships, and cruise ships, enter Washington waters more than 7,000 times each year, bound for ports in Puget Sound, British Columbia, Grays Harbor, and the Columbia River (WDOE 2004b). Additionally, 4,500 tank-barge transits, 160,000 ferry transits, and military vessel traffic occur in these same waters each year (WDOE 2004b). Individually these vessels may carry up to 33 million gallons of crude oil or refined petroleum products, but collectively, they carry about 15.1 billion gallons across Puget Sound waters each year (WDOE 2004b). These numbers are expected to increase as the human population and commerce continues to grow. Currently, there are State and Federal requirements for tug escorts of laden oil tankers transiting the waters of Puget Sound east of Dungeness Spit. However, the Federal requirements do not apply to double-hulled tankers and will no longer be in effect once the single-hull tanker phase-out is complete (WDOE 2005b). Washington State is considering revising their

[1] A spawning ground at Wollochet Bay was not included in surveys prior to 2002. In previous publications, the number of stocks of Pacific herring has been reported at 18 (PSAT 2005).

tug escort requirements (WDOE 2005b); however, the current tug escort requirements remain in place until the Washington State Legislature makes a change.

The U.S. Coast Guard rated the Dungeness area in the Strait of Juan de Fuca as being in the top five high-risk areas of the United States for being impacted by oil spills (U.S. Fish and Wildlife Service 2005). Therefore, even though the threat from oil spills appears to have been reduced since the murrelet was listed, the risk of a catastrophic oil spill remains, and could severely impact adult and/or juvenile murrelets in Conservation Zones 1 and 2.

Gillnets

Murrelet mortality from gillnet fishing has been considered a conservation issue in Washington (U.S. Fish and Wildlife Service 1997a; Melvin et al. 1999). Murrelets can also be killed by hooking with fishing lures and entanglement with fishing lines (Carter et al. 1995). There is little information available on murrelet mortality from net fishing prior to the 1990s, although it was known to occur (Carter et al. 1995). In the mid 1990s, a series of fisheries restrictions and changes were implemented to address mortality of all species of seabirds, resulting in a lower mortality rate of murrelets (McShane et al. 2004). Fishing effort has also decreased since the 1980s because of lower catches, fewer fishing vessels, and greater restrictions (McShane et al. 2004), although a regrowth in gill net fishing is likely to occur if salmon stocks increase. In most areas, the threat from gill net fishing has been reduced or eliminated since 1992, but threats to adult and juvenile murrelets are still present in Washington nearshore zones due to gill net mortality (McShane et al. 2004).

Marine Contaminants

The primary consequence from the exposure of murrelets to contaminants is reproductive impairment. Reproduction can be impacted by food web bioaccumulation of organochlorine pollutants and heavy metals discharged into marine areas where murrelets feed and prey species concentrate (Fry 1995). However, murrelet exposure is likely a rare event because murrelets have widely dispersed foraging areas and they feed extensively on transient juvenile and subadult midwater fish species that are expected to have low pollutant loads (McShane et al. 2004). The greatest exposure risk to murrelets may occur at regular feeding areas near major pollutant sources, such as those found in Puget Sound (McShane et al. 2004).

Disturbance

In coastal and offshore marine environments, vehicular disturbance (e.g., boats, airplanes, personal watercraft) is known to elicit behavioral responses in murrelets of all age classes (Kuletz 1996; Speckman 1996; Nelson 1997). Aircraft flying at low altitudes and boating activity, in particular motorized watercraft, are known to cause murrelets to dive and are thought to especially affect adults holding fish (Nelson 1997). It is unclear to what extent this kind of disturbance affects the distribution and movements of murrelets. However, it is unlikely this type of disturbance has decreased since 1992 because the shipping traffic and recreational boat use in the Puget Sound and Strait of Juan de Fuca has continued to increase.

Marine projects that include seismic exploration, pile driving, detonation of explosives and other activities that generate percussive sounds can expose murrelets to elevated underwater sound pressure levels (SPLs). High underwater SPLs can have adverse physiological and neurological effects on a wide variety of vertebrate species (Cudahy and Ellison 2002; USDD Department of Navy 2002; Fothergill et

al. 2001; Popper 2003; Stevens et al. 1999; Yelverton and Richmond 1981; Yelverton et al. 1973). High underwater SPLs are known to injure and/or kill fish by causing barotraumas (pathologies associated with high sound levels including hemorrhage and rupture of internal organs), as well as causing temporary stunning and alterations in behavior (Hastings and Popper 2005; Popper 2003; Turnpenny and Nedwell 1994; Turnpenny et al. 1994). During monitoring of seabird response to pile driving in Hood Canal, Washington, a pigeon guillemot (*Cepphus columba*) was observed having difficulty getting airborne after being exposed to underwater sound from impact pile driving (Entranco and Hamer Environmental 2005). In controlled experiments using underwater explosives, rapid change in SPLs caused internal hemorrhaging and mortality in submerged mallard ducks (*Anas platyrhnchos*) (Yelverton et al. 1973). Risk of injury appears related to the effect of rapid pressure changes, especially on gas filled spaces in the bodies of exposed organisms (Turnpenny et al. 1994). In studies on ducks (*Anas spp.*) and a variety of mammals, all species exposed to underwater blasts had injuries to gas filled organs including eardrums (Yelverton and Richmond 1981). These studies indicate that similar effects can be expected across taxanomical species groups.

Physical injury may not result in immediate mortality. If an animal is injured, death may occur several hours or days later, or injuries may be sublethal. Sublethal injuries can interfere with the ability of an organism to carry out essential life functions such as feeding and predator avoidance. Diving birds are able to detect and alter their behavior based on sound in the underwater environment (Ross et al. 2001) and elevated underwater SPLs may cause murrelets to alter normal behaviors, such as foraging. Disturbance related to elevated underwater SPLs may reduce foraging efficiency resulting in increased energetic costs to all murrelet age classes in the marine environment and may result in fewer deliveries or lower quality food being delivered to nestlings.

Threats in the Terrestrial Environment

Habitat

Extensive harvest of late-successional and old-growth forest was the primary reason for listing the murrelet as threatened. Due primarily to extensive timber cutting over the past 150 years, at least 82 percent of the old-growth forests existing in western Washington and Oregon prior to the 1840s have been harvested (Booth 1991; Teensma et al. 1991; Ripple 1994; Perry 1995). About 10 percent of pre-settlement old-growth forests remain in western Washington (Norse 1990; Booth 1991). Although the Northwest Forest Plan has reduced the rate of habitat loss on Federal lands, the threat of continued loss of suitable nesting habitat remains on Federal and non-Federal lands through timber harvest and natural events such as wildfire, insect outbreaks, and windthrow.

Natural disturbance has the potential to affect the amount and quality of murrelet nesting habitat. Wildfire and windthrow result in immediate loss of habitat and can also influence the quality of adjacent habitat. Global warming, combined with long-term fire suppression on Federal lands, may result in higher incidences of stand-replacing fires in the future (McShane et al. 2004). As forest fragmentation increases, the threat of habitat loss due to windthrow is likely to increase. In addition, insects and disease can kill complete stands of habitat and can contribute to hazardous forest fire conditions.

Between 1992 and 2003, the loss of suitable murrelet habitat totaled 22,398 acres in Washington, Oregon, and California combined, of which 5,364 acres resulted from timber harvest and 17,034 acres resulted from natural events (McShane et al. 2004). The data presented by McShane represented losses primarily on Federal lands, and did not include data for most private lands within the marbled murrelets' range.

Habitat loss and fragmentation is expected to continue in the near future, but at an uncertain rate (McShane et al. 2004). Raphael et al. (2005) recently completed a change analysis for marbled murrelet habitat on both Federal and non-Federal lands for the period from 1992 to 2003, based on stand disturbance map data developed by Healey et al. (2003). Raphael et al. (2005) estimated that habitat loss ranging from 60,000 acres up to 278,000 acres has occurred across the listed range of the species, with approximately 10 percent of habitat loss occurring on Federal lands, and 90 percent occurring on non-Federal lands. The variation in the acreage estimates provided by Raphael et al. (2005) are dependant upon the habitat model used (see Table 8-25) to evaluate habitat change over time.

Gains in suitable nesting habitat are expected to occur on Federal lands over the next 40 to 50 years, but due to the extensive historic habitat loss and the slow replacement rate of murrelets and their habitat, the species is potentially facing a severe reduction in numbers in the coming 20 to 100 years (U.S. Forest Service and U.S. Fish and Wildlife Service 1994b; Beissinger 2002).

In addition to direct habitat removal, forest management practices can fragment murrelet habitat; this reduces the amount and heterogeneous nature of the habitat, reduces the forest patch sizes, reduces the amount of interior or core habitat, increases the amount of forest edge, isolates remaining habitat patches, and creates "sink" habitats (McShane et al. 2004). There are no estimates available for the amount of suitable habitat that has been fragmented or degraded since 1992. However, the ecological consequences of these habitat changes to murrelets can include effects on population viability and size, local or regional extinctions, displacement, fewer nesting attempts, failure to breed, reduced fecundity, reduced nest abundance, lower nest success, increased predation and parasitism rates, crowding in remaining patches, and reductions in adult survival (Raphael et al. 2002b).

Predation

Predation is expected to be the principal factor limiting murrelet reproductive success and nest site selection (Ralph et al. 1995; Nelson and Hamer 1995b). Murrelets are believed to be highly vulnerable to nest predation compared to other alcids and forest nesting birds (Nelson and Hamer 1995b; U.S. Fish and Wildlife Service 1997a). Murrelets have no protection at nest sites other than the ability to remain hidden. Nelson and Hamer (1995b) hypothesized that small increases in murrelet predation will have deleterious effects on murrelet population viability due to their low reproductive rate (one egg clutches).

Known predators of adult murrelets in the forest environment include the peregrine falcon (*Falco peregrinus*), sharp-shinned hawk (*Accipiter striatus*), common raven (*Corvus corax*), northern goshawk (*Accipiter gentilis*), and bald eagle (*Haliaeetus leucocephalus*). Common ravens and Stellar's jays (*Cyanocitta stelleri*) are known to take both eggs and chicks at the nest, while sharp-shinned hawks have been found to take chicks. Common ravens account for the majority of egg depredation, as they appear to be the only predator capable of flushing incubating or brooding adults from a nest (Nelson and Hamer 1995b). Suspected nest predators include great horned owls (*Bubo virginianus*), barred owls (*Strix varia*), Cooper's hawks (*Accipiter cooperi*), northwestern crows (*Corvus caurinus*), American crows (*Corvus brachyrhynchos*), and gray jays (*Perisoreus canadensis*) (Nelson and Hamer 1995b; Nelson 1997; Manley 1999). Predation by squirrels and mice has been documented at artificial nests and these animals cannot be discounted as potential predators on eggs and chicks (Luginbuhl et al. 2001; Raphael et al. 2002b; Bradley and Marzluff 2003).

Losses of eggs and chicks to avian predators have been determined to be the most important cause of nest failure (Nelson and Hamer 1995b; McShane et al. 2004). The risk of predation by avian predators appears to be highest in complex structured landscapes in proximity to edges and human activity, where

many of the corvid (e.g., crows, ravens) species are in high abundance. Predation rates are influenced mainly by habitat stand size, habitat quality, nest placement (on the edge of a stand versus the interior of a stand), and proximity of the stand to human activity centers. The quality of murrelet nest habitat decreases in smaller stands because forest edge increases in relation to the amount of interior forest, while forest stands near human activity centers (less than 0.62 miles (1 kilometer)), regardless of size, are often exposed to a higher density of corvids due to their attraction to human food sources (Marzluff et al. 2000). The loss of nest contents to avian predators increases with habitat fragmentation and an increase in the ratio of forest edge to interior habitat (Nelson and Hamer 1995b; McShane et al. 2004). For example, Nelson and Hamer (1995b) found successful nests were farther from edges (greater than 55 meters) and were better concealed than unsuccessful nests.

The abundance of several corvid species has increased dramatically in western North America as a result of forest fragmentation, increased agriculture, and urbanization (McShane et al. 2004). It is reasonable to infer that as predator abundance has increased, predation on murrelet chicks and eggs has also increased, and murrelet reproductive success has decreased. It is also reasonable to assume that this trend will not be interrupted or reversed in the near future, as forest fragmentation, agriculture, and urbanization continue to occur.

Other Threats

Murrelets are subject to additional threats from diseases and genetic-related influences as a result of low population numbers and low immigration rates. To date, inbreeding (mating between close genetic relatives) and/or hybridizing (breeding with a different species or subspecies) have not been identified as threats to murrelet populations. However, as abundance declines, a corresponding decrease in the resilience of the population to disease, inbreeding or hybridization, and other perturbations may occur. Additionally, murrelets are considered to have low recolonization potential because their low immigration rate makes the species slow to recover from local disturbances (McShane et al. 2004).

The emergence of fungal, parasitic, bacterial, and viral diseases has affected populations of seabirds in recent years. West Nile virus disease has been reported in California which is known to be lethal to seabirds. While the amount of negative impact this disease may bring is unknown, researchers agree that it is only a matter time before West Nile virus reaches the Washington seabird population (McShane et al. 2004). Effects on murrelets from West Nile virus and other diseases are expected to increase in the near future due to an accumulation of stressors such as oceanic temperature changes, overfishing, and habitat loss (McShane et al. 2004).

Murrelets may be sensitive to human-caused disturbance due to their secretive nature and their vulnerability to predation. There are little data concerning the murrelet's vulnerability to disturbance effects, except anecdotal researcher observations that indicate murrelets typically exhibit a limited, temporary behavioral response (if any) to noise disturbance at nest sites and are able to adapt to auditory stimuli (Singer et al. 1995 cited in McShane et al. 2005; Long and Ralph 1998; Golightly et al. 2002). In general, responses to auditory stimuli at nests sites have been modifications of posture and on-nest behaviors (Long and Ralph 1998). While the unique breeding biology of the murrelet is not conducive to comparison of the reproductive success of other species, studies on other alcid and seabird species have revealed detrimental effects of disturbance to breeding success and the maintenance of viable populations (Cairns 1980; Pierce and Simons 1986; Piatt et al. 1990; Beale and Monaghan 2004).

Research on a variety of other species, including other seabirds, indicate an animal's response to disturbance follows the same pattern as its response to encountering predators, and anti-predator behavior

has a cost to other fitness enhancing activities, such as feeding and parental care (Frid and Dill 2002). Some authors indicate disturbance stimuli can directly affect the behavior of individuals and indirectly affect fitness and population dynamics through increased energetic costs (Frid and Dill 2002; Carney and Sydeman 1999). Responses by murrelet adults and chicks to calls from corvids and other potential predators include no response, alert posturing, aggressive attack, and temporarily leaving a nest (adults only) (McShane et al. 2004). However, the most typical behavior of chicks and adults in response to the presence of a potential predator is to flatten against a tree branch and remain motionless (Nelson and Hamer 1995b; McShane et al. 2004). Therefore, researcher's anecdotal observations of little or no physical response by murrelets are consistent with the behavior they will exhibit in response to a predator. In addition, there may have been physiological responses researchers cannot account for with visual observations. Corticosterone studies have not been conducted on murrelets, but studies on other avian species indicate chronic high levels of this stress hormone may have negative consequences on reproduction or physical condition (Wasser et al. 1997; Marra and Holberton 1998 cited in McShane et al. 2004).

Although detecting effects of sub-lethal noise disturbance at the population level is hindered by the breeding biology of the murrelet, the effect of noise disturbance on murrelet fitness and reproductive success should not be completely discounted (McShane et al. 2004). In recently completed analyses, the FWS concluded the potential for injury associated with disturbance (visual and sound) to murrelets in the terrestrial environment includes flushing from the nest, aborted feeding, and postponed feedings (U.S. Fish and Wildlife Service 2003). These responses by individual murrelets to disturbance stimuli can reduce productivity of the nesting pair, as well as the entire population (U.S. Fish and Wildlife Service 1997a).

8.3.1.6 Conservation Needs

The Recovery Plan outlines the conservation strategy for the species. In the short-term, specific actions necessary to stabilize the population include maintaining occupied habitat, maintaining large blocks of suitable habitat, maintaining and enhancing buffer habitat, decreasing risks of nesting habitat loss due to fire and windthrow, reducing predation, and minimizing disturbance.

Long-term conservation needs include increasing productivity (abundance, the ratio of juveniles to adults, and nest success) and population size; increasing the amount (stand size and number of stands), quality, and distribution of suitable nesting habitat; protecting and improving the quality of the marine environment; and reducing or eliminating threats to survivorship by reducing predation in the terrestrial environment and anthropogenic sources of mortality at sea. We (U.S. Fish and Wildlife Service 1997a) estimate recovery of the murrelet will require at least 50 years.

The Recovery Plan states that four of the six Conservation Zones must be functional to effectively recover the murrelet in the short- and long-term; that is, to maintain viable populations that are well-distributed. Based on the new population estimates, it appears three of the six Conservation Zones contain relatively large numbers of murrelets (Zones 1, 3, and 4). Conservation Zones 1 and 4 contain the largest number of murrelets compared to the other four Zones. This alone will seem to indicate a better condition there, but areas of concern remain. For example, the population in Conservation Zone 4 was impacted when oil spills killed an estimated 10 percent of the population (Bentivoglio et al. 2002; Ford et al. 2002), small oil spills continue to occur in Conservation Zone 1, and the juvenile-to-adult ratios in both of these Conservation Zones continue to be too low to establish stable or increasing populations (Beissinger and Peery 2003).

Murrelets in Conservation Zones 3, 5, and 6 have suffered variously from past oil spills which killed a large number of murrelets (Zone 3) (Ford et al. 2001), extremely small population sizes (Zones 5 and 6), and alarmingly low reproductive rates (Zone 6) (Peery et al. 2002). These factors have brought the status of the species to a point where recovery in Conservation Zones 5 and 6 may be precluded (Beissinger 2002). The poor status of murrelet populations in the southern Conservation Zones emphasizes the importance of supporting murrelet populations in Conservation Zones 1 and 2 in order to preserve the opportunity to achieve murrelet recovery objectives.

8.3.1.7 Conservation Strategy

Marine Environment

Protection of marine habitat is also a component of the recovery strategy. The main threat to murrelets in the marine environment is the loss of individuals through death or injury, generally associated with oil spills and gill-net entanglements. The recovery strategy recommends managing all waters within 1.2 miles of shore within the Puget Sound and Strait of Juan de Fuca, and along the Pacific Coast from Cape Flattery to Willapa Bay in such a way as to reduce or eliminate murrelet mortality (U.S. Fish and Wildlife Service 1997a). Management strategies could include exclusion of vessels, stricter hull requirements, exclusion of net fisheries, or modification of fishing gear.

In Washington State, the Washington Fish and Game Commission requires the use of alternative gear (i.e., visual alerts within the upper 7 feet of a multifilament net), prohibits nocturnal and dawn fishing for all non-treaty gill-net fisheries, and closes areas to gill-net fishing in order to reduce by-catch of murrelets.

The Olympic Coast National Marine Sanctuary was established in 1994 along the outer Washington coast from Cape Flattery south to approximately the Copalis River and extending between 25 and 40 miles offshore. Oil exploration and development are prohibited within this Sanctuary (USDC 1993).

Terrestrial Habitat Management

The loss of nesting habitat (old-growth/mature forest) has generally been identified as the primary cause of the murrelet population decline and disappearance across portions of its range (Ralph et al. 1995). Logging, urbanization, and agricultural development have all contributed to the loss of habitat, especially at lower elevations.

The recovery strategy for the murrelet (U.S. Fish and Wildlife Service 1997a) relies heavily on the Northwest Forest Plan to achieve recovery on Federal lands in Washington, Oregon, and California. However, the Recovery Plan also addresses the role of non-Federal lands in recovery, including Habitat Conservation Plans, state forest practices, and Tribal lands. The importance of non-Federal lands in the survival and recovery of murrelets is particularly high in Conservation Zones where Federal lands, and privately held conservation lands (e.g., The Nature Conservancy Teal Slough, Ellsworth), within 50 miles of marine waters are sparse, such as the southern half of Conservation Zone 2.

Lands considered essential for the recovery of the murrelet within Conservation Zones 1 and 2 are: (1) any suitable habitat in a Late-Successional Reserves within the Northwest Forest Plan; (2) all suitable habitat located in the Olympic Adaptive Management Area within the Northwest Forest Plan; (3) large areas of suitable nesting habitat outside of Late Successional Reserves on Federal lands, such as habitat

located in the Olympic National Park; (4) suitable habitat on State lands within 40 miles of marine waters; and (4) habitat within occupied murrelet sites on private lands (U.S. Fish and Wildlife Service 1997a).

Northwest Forest Plan

When the U.S. Forest Service (USFS) and Bureau of Land Management incorporated the Northwest Forest Plan as the management framework for public lands, a long-term habitat management strategy for murrelets (U.S. Forest Service and U.S. Fish and Wildlife Service 1994a, b) was established. The Northwest Forest Plan instituted pre-project surveys of murrelet habitat in areas planned for timber harvest and the protection of existing habitat at sites determined through surveys to be occupied by murrelets.

In the short-term, all known-occupied sites of murrelets occurring on U.S. Forest Service or Bureau of Land Management lands under the Northwest Forest Plan are to be managed as Late Successional Reserves. In the long-term, unsuitable or marginally suitable habitat occurring in Late Successional Reserves will be managed, overall, to develop late-successional forest conditions, thereby providing a larger long-term habitat base into which murrelets may eventually expand. Thus, the Northwest Forest Plan approach offers both short-term and long-term benefits to the murrelet.

Over 80 percent of murrelet habitat on Federal lands in Washington occurs within land management allocations that protect the habitat from removal or significant degradation. Scientists predicted implementation of the Northwest Forest Plan will result in an 80 percent likelihood of achieving a well-distributed murrelet population on Federal lands over the next 100 years (U.S. Forest Service and U.S. Fish and Wildlife Service 1994a). Although the Northwest Forest Plan offers protection of known-occupied murrelet sites, concerns over the lingering effects of the historic widespread removal of suitable habitat will remain until the habitat recovers to late-successional characteristics. This habitat recovery may require over 100 years.

Habitat Conservation Plans

Four Habitat Conservation Plans (HCP) addressing murrelets in Washington have been completed for private/corporate forestland managers within the range of the murrelet: (1) West Fork Timber Corporation (Murray Pacific Corporation 1993, 1995, U.S. Fish and Wildlife Service 1995) (Mineral Tree Farm HCP); (2) Plum Creek Timber Company (Plum Creek Timber Company 1996, 1999, U.S. Fish and Wildlife Service 1996b, 1999b) (Cascades HCP; I-90 HCP); (3) Port Blakely Tree Farms, L.P. (Port Blakely Tree Farms 1996, U.S. Fish and Wildlife Service 1996c) (R.B. Eddy Tree Farm HCP); and (4) Simpson Timber Company (Simpson Timber Company 2000b; U.S. Fish and Wildlife Service 2000a) (Olympic Tree Farm HCP). Habitat Conservation Plans have also been completed for the Washington Department of Natural Resources (WDNR 1997c; U.S. Fish and Wildlife Service1997b) (WDNR HCP) and two municipal watersheds, City of Tacoma (Tacoma Public Utilities 2001, U.S. Fish and Wildlife Service 2001b) (Green River HCP); and City of Seattle (City of Seattle 2001; U.S. Fish and Wildlife Service 2000b) (Cedar River HCP). The HCPs which address murrelets cover approximately 500,000 acres of non-Federal (private/corporate) lands, over 100,000 acres of municipal watershed, and over 1.6 million acres of State-managed lands. However, only a portion of these lands contain suitable murrelet habitat.

The WDNR HCP addresses murrelets in Conservation Zones 1 and 2. All of the others address murrelets in Conservation Zone 1. Most of the murrelet HCPs in Washington employ a consistent approach for murrelets by requiring the majority of habitat to be surveyed prior to timber management. Only poor-

quality marginal habitat (with a low likelihood of occupancy) is released for harvest without survey. All known occupied habitat is protected to varying degrees, but a "safe-harbor-like" approach is used to address stands which may be retained as, or develop into, suitable habitat and become occupied in the future. This approach will allow harvest of habitat in the future, which is not currently nesting habitat.

Washington State Forest Practices Regulations

Under the Washington Forest Practices Rules, which apply to all non-Federal lands not covered by an HCP (Washington Forest Practices Board 1996), surveys for murrelets are required prior to the harvest of stands that meets certain platform numbers and stand size criteria. These criteria vary depending on the location of the stand. For stands found to be occupied or known to be previously occupied, the WDNR makes a decision to approve individual Forest Practices Applications based upon a significance determination. If a determination of significance is made, preparation of a State Environmental Policy Act - Environmental Impact Statement is required prior to proceeding. If a determination of non-significance or mitigated determination of non-significance is reached, the action can proceed without further environmental assessment. (A more detailed discussion of the Washington Forest Practices regulations is provided in the marbled murrelet environmental baseline).

Tribal Management

The management strategy of the Bureau of Indian Affairs for the murrelet focuses on working with tribal governments on a government-to-government basis to develop management strategies for reservation lands and trust resources. The Bureau of Indian Affairs' management strategy typically focus on avoiding harm to murrelets when feasible, to facilitate the trust responsibilities of the United States. However, other factors must be considered. Strategies must foster tribal self-determination, and must balance the needs of the species and the environmental, economic, and other objectives of Indian Tribes within the range of the murrelet (Renwald 1993). For example, one of the Bureau of Indian Affairs' main goals for murrelet protection includes assisting Native American Tribes in managing habitat consistent with tribal priorities, reserved treaty rights, and legislative mandates.

8.3.1.8 Status of Designated Critical Habitat for the Murrelet

The final rule designating critical habitat for the marbled murrelet (61 FR 26256; USDI Fish and Wildlife Service 1996a) became effective on June 24, 1996. Thirty-two units totaling 3,887,800 acres were designated on Federal, State, county, city, and private lands in Washington, Oregon, and California. Of the 3,887,800 acres designated as critical habitat rangewide, approximately 1,631,100 acres were designated in Washington State (Table 8-26) (USDI Fish and Wildlife Service 1996a). The majority of these acres (78 percent) occur on Federal lands, 21 percent occur on State lands, 1.2 percent occur on private lands, 0.2 percent occur on county lands, and 0.003 percent occur on city lands. Critical Habitat Units do not include non-Federal lands covered by a legally operative incidental take permit for marbled murrelets (USDI Fish and Wildlife Service 1996a, 61 FR 26278). Therefore, critical habitat designations were excluded on State lands upon completion of the WDNR Habitat Conservation Plan. We did not include any of the marine environment as critical habitat, but instead relied on other existing regulations for protection of this area. Therefore, about 99.8 percent of the critical habitat in Washington State is on Federal lands.

Table 8-26. Land ownerships in Washington designated as murrelet critical habitat (USDI Fish and Wildlife Service 1996a). Acreage totaled 1,204,500 (1,631,300 - 426,800 = 1,204,500) after suspension of WDNR-managed lands.

Ownership	Designation	Designated Critical Habitat (Acres)
Federal	Congressionally Withdrawn	1,800
	Late-Successional Reserve	1,200,200
	Federal total	**1,202,000**
Non-Federal	State*	426,800
	Private, City, and County	2,500
	Non-Federal total	**429,300**
	Overall total	***1,631,300***

* Some lands managed by WDNR were originally designated as critical habitat, but designation was suspended following approval of the WDNR HCP.

In the 1996 Final Rule designating critical habitat for the murrelet (61 FR 26256, USDI Fish and Wildlife Service 1996a), we identified two primary constituent elements essential to provide and support suitable nesting habitat for successful reproduction. These are: (1) individual trees with potential nesting platforms; and (2) forested areas within 0.5 miles of individual trees with potential nesting platforms and a canopy height of at least one-half the site-potential tree height. These primary constituent elements were deemed essential for providing suitable nesting habitat for successful reproduction of the murrelet, and require special management considerations.

Although most of the areas designated as marbled murrelet critical habitat occur on Federal lands (Northwest Forest Plan Late Successional Reserves), we designated selected non-Federal lands that met the selection criteria where Federal lands were insufficient to provide suitable nesting habitat for the recovery of the species. The designated critical habitat units are distributed more or less evenly across the range of the species in Washington and Oregon, and less so in California.

In Washington State, there is a clear reliance on Federal lands to fulfill the functions for which critical habitat was designated. These functions are also met by non-designated Federal lands in National Parks, Wilderness Areas, and portions of Adaptive Management Areas and Matrix lands within the Northwest Forest Plan found to be occupied.

Eleven critical habitat units totaling 1,631,300 acres were originally designated in Washington State. Of these, nine units included Federal lands, seven units included WDNR-managed lands, and portions of two units occurred on private lands.*

The quality of forests occurring within the boundaries of the Critical Habitat Units ranges from non-habitat (e.g., young plantations) to high-quality habitat (i.e., large blocks of old-growth forest). While significant amounts of high-quality murrelet habitat are present in some of the Critical Habitat Units, much of the habitat in Critical Habitat Units, particularly on non-Federal lands, is of lesser quality due to its occurrence in smaller, more fragmented blocks. Some of the highest quality murrelet habitat occurs in National Parks and designated Wilderness Areas where harvest historically has not occurred. Given the high quality of this habitat and reduced threat of habitat loss or modification due to management, designation of critical habitat was deemed unnecessary in National Parks and Wilderness Areas.

8.3.1.9 Summary

The existing long-term population data for Washington, Oregon, and California can not be used to empirically identify a three-state trend, although several leading murrelet experts believe the data suggest a decline across the southern range (McShane et al. 2004). The low fecundity levels across Washington, Oregon, and California, as determined through nest success values (i.e., the number of fledglings per breeding pair of murrelets per year), indicate a population that is not stable through reproduction (Beissinger and Peery 2003).

Some of the threats to the murrelet population may have been reduced as a result of the species' listing under the ESA, such as the passage of the Oil Pollution Act and implementation of the Northwest Forest Plan. However, no threats have been reversed since listing and in some areas threats, such as predation and West Nile Virus, may be increasing or emerging.

8.3.2 ENVIRONMENTAL BASELINE – Marbled Murrelet and Marbled Murrelet Critical Habitat

Regulations implementing the ESA (50 CFR § 402.02) define the environmental baseline as the past and present effects of all Federal, State, or private actions and other human activities in the FPHCP Action Area. Also included in the environmental baseline are the expected effects of all proposed Federal projects in the FPHCP Action Area that have undergone section 7 consultation, and the effects of State and private actions that are contemporaneous with the consultation in progress. Such actions include, but are not limited to, previous timber harvests and other land-management activities.

8.3.2.1 Assessment of Marbled Murrelet Habitat in Washington

Until recently there has been limited information for estimating marbled murrelet habitat on non-Federal lands in Washington. As described in the status of the species section, two recent assessments of potential nesting habitat for murrelets in Washington were completed by Raphael et al. (2005) (Table 8-25).

We used the map data developed by Raphael et al. (2005) to evaluate murrelet habitat conditions on the FPHCP covered lands. We chose the Expert Judgment Model outputs of Class 3 (moderately suitable) and Class 4 (highly suitable) (EJM Class 3-4) to depict murrelet habitat because this model output represents the median of the range of possible values derived from the habitat models developed by Raphael et al. (2005). The EJM Class 3-4 model is consistent with our current view of the distribution of murrelet habitat in Washington. The Class 3 category was included in the model output because this category depicts some acres of "moderate suitability" murrelet habitat in southwest Washington, which is consistent with the distribution of known murrelet observations on that landscape. Based on the information provided by Raphael et al. (2005), we believe the EJM Class 3-4 model provides a reasonable estimate of potential murrelet nesting habitat in Washington; however, we recognize that this model may overestimate potential nesting habitat in some landscapes (e.g., the western Washington lowlands).

Raphael et al. (2005) produced habitat maps that were based on 1992-1996 satellite images, therefore, all habitat values listed in their study reflect 1992-1996 base values. Although dated, these data represent the best provincial-scale maps of murrelet habitat currently available, and we used these maps in our assessment of murrelet habitat on FPHCP covered lands. Raphael et al. (2005) did conduct a change analysis for murrelet habitat based on the work of Healey et al. (2003). However, they did not report their change analysis results by region or State. Therefore, we used Healey et al.'s (2003) data to evaluate the

effects of the stand-replacing fires and timber harvests on murrelet habitat that occurred between 1992 and 2002. This data only includes stand-replacing disturbance, and does not capture the effects of partial harvests such as commercial thinning. By overlaying Healey et al.'s (2003) disturbance maps with Raphael et al.'s (2005) 1992-1996 habitat maps, we were able to estimate the acres of murrelet habitat that were harvested between 1992 and 2002 in Washington. It is important to note that all potential nesting habitat estimates that we generated from the Raphael et al. (2005) data are general estimates based on our interpretation of the data. (For more information on our GIS analysis completed to derive these estimates, refer to the marbled murrelet GIS memo in the administrative record).

Using the Raphael et al. (2005) map data, we calculated the total habitat-capable acres in Washington at 9.75 million acres. Habitat-capable acres were defined as forested lands capable of producing suitable marbled murrelet habitat. High-elevation areas and naturally non-forested areas were removed from the Raphael et al. (2005) study area. Using the EJM Class 3-4 model output, the Raphael et al. (2005) data indicate there were approximately 1.57 million acres of potential marbled murrelet nesting habitat in Washington (all ownerships) in 2003, which represent about 16 percent of the total habitat-capable acres (Table 8-27).

Table 8-27. FPHCP covered lands and potential nesting habitat acres within the range of the marbled murrelet in Washington.

Murrelet Recovery Zone	Area	Total Habitat-Capable Area (acres)	Total Murrelet Nesting Habitat (acres - all ownerships)	Total Murrelet Nesting Habitat on Federal Lands (acres)	FPHCP Covered Lands (acres)	Murrelet Nesting Habitat on FPHCP Covered Lands (acres)	% of Murrelet Nesting Habitat in Zone on FPHCP Covered Lands (percent %)
Zone 1 - Puget Sound/ Strait of Juan de Fuca - Olympic Peninsula and North Cascades	Coastal (0-40 mi.)	nc	826,300	492,100	2,838,500	165,400	20%
	Inland (40-55 mi.)	nc	251,600	235,600	63,700	7,300	3%
Subtotals for Zone 1		**nc**	**1,077,900**	**727,700**	**2,902,200**	**172,700**	**16%**
Zone 2 - Pacific Coast - Olympic Peninsula and Southwest Washington	Coastal (0-40 mi.)	nc	471,600	332,400	2,176,400	59,200	13%
	Inland (40-55 mi.)	nc	25,500	10,800	380,400	10,200	40%
Subtotals for Zone 2		**nc**	**497,100**	**343,200**	**2,556,800**	**69,400**	**14%**
Washington Totals	Coastal (0-40 mi.)	8,629,500	1,297,900	824,500	5,014,900	224,600	17%
	Inland (40-55 mi.)	1,125,700	277,100	246,400	444,100	17,500	6%
Totals for Washington		**9,755,200**	**1,575,000**	**1,070,900**	**5,459,000**	**242,100**	**15%**

Note: nc = not calculated. All figures are approximate values derived from GIS data. Totals were computed prior to rounding. Marbled murrelet habitat estimates represent approximate conditions in 2003, as depicted by Raphael et al. (2005) map data, Expert Judgment Model Class 3 and Class 4, and account for stand-replacing timber harvest and fire losses that occurred from 1992 to 2002 (Healey et al. 2003). Habitat-capable acres were summarized directly from Tables 4, 5 9, and 10 in Raphael et al. (2005).

8.3.2.2 Marbled Murrelet Habitat on Forest Practices Habitat Conservation Plan Lands

Of the 9.3 million acres of FPHCP covered lands in Washington, over 5.4 million acres (58 percent) of the covered lands are within the range of the marbled murrelet. Potential murrelet nesting habitat exists on approximately 1.57 million acres in Washington. About 15 percent of potential murrelet nesting habitat is located on FPHCP covered lands (Table 8-27). However, much of the suitable habitat on FPHCP covered lands exists as small isolated patches which may be too fragmented to support murrelets. The 15 percent figure likely over-estimates the actual suitable murrelet habitat on FPHCP covered lands.

8.3.2.3 Conservation Role of the FPHCP Covered Lands for Marbled Murrelets

Lands considered essential to the recovery of the marbled murrelet within Conservation Zones 1 and 2 include all nesting habitat located within the range of the murrelet on Federal lands; nesting habitat on State lands within 40 miles of marine waters; and nesting habitat within occupied murrelet sites on private lands (U.S. Fish and Wildlife Service 1997a). Over 50 percent of the habitat-capable acres within the range of the marbled murrelet in Washington occur on the FPHCP covered lands. Currently only about 15 percent of the extant habitat acres are located on these lands. In areas with few Federal acres (e.g., southwest Washington), the conservation of marbled murrelets is almost entirely dependent upon conservation efforts on State or private lands. In southwest Washington, FPHCP covered lands comprise the majority of that landscape, and many stands have been identified as occupied by murrelets. We consider all occupied murrelet nesting habitat to be important for the conservation of the species (U.S. Fish and Wildlife Service 1997a; 2004f).

We recognize that not all suitable murrelet habitat is currently occupied by marbled murrelets. Unoccupied habitats can also be important for murrelet conservation to provide potential nesting opportunities for displaced breeders and/or first-time breeding adults seeking nesting habitat to colonize (U.S. Fish and Wildlife Service 1997a). Although much of the murrelet habitat that occurs on non-Federal lands is located in small patches or is of marginal quality, suitable habitat on non-Federal lands in landscapes with few Federal acres (e.g., southwest Washington) is important for murrelet recovery because these landscapes currently support small breeding populations of murrelets and represent a substantial portion of the historic range in Washington (U.S. Fish and Wildlife Service 1997a).

Other landscapes (e.g., the Kitsap Peninsula) have small patches (< 5 acres) of potentially suitable habitat scattered over large areas, with few or no documented murrelet detections. When counted together, these small patches of habitat may add up to a substantial figure (e.g., 22,000 acres on the Kitsap Peninsula); however, these areas likely have limited value for murrelet recovery because they lack sufficient stand size to support murrelets; there are limited State or Federal reserves in the area to provide old-growth habitat over time; and non-Federal lands in the area consist primarily of second-growth forests managed for timber production on a 40 – 80 year rotation.

8.3.2.4 Marbled Murrelets on FPHCP Covered Lands

The number of inland marbled murrelet observations documented in Washington has increased over the past few years as surveys on State and private lands have been completed. Much of the existing survey information comes from State lands where WDNR has engaged in a multiple-year survey effort for marbled murrelets on lands managed under the WDNR HCP (WDNR 1997c). Survey requirements associated with the Forest Practices regulations have also resulted in the documentation of many status 1-4 murrelet sites on the FPHCP covered lands. For the purposes of this analysis, we consider the status 1-4

murrelet sites documented in the WDFW database to be the best estimate of the current marbled murrelet sites on FPHCP covered lands.

As of July 2005, there were 4,922 occupied murrelet sites (status 1, 2, or 3) documented in the WDFW database. Status 1-3 sites represent documented nest platforms (*n* = 37), documented sites with juveniles, eggs, or eggshell fragments (*n* = 17), or documented sites where murrelets were observed flying within the forest canopy (*n* = 4,868) (WDFW 2005c). There are an additional 25,246 sites documented where murrelets were heard or observed flying above the forest canopy (site status 4). The database contains observations documented from 1993 through 2005. Due to the apparent decline in murrelet populations in Washington (Huff et al. 2003), these figures may over estimate the actual number of active murrelet sites in Washington.

Status 1-4 murrelet sites are used to identify management areas for murrelets under the Washington Forest Practices Rules (WAC 222-16-080 (j). Most (65 percent) of the potential murrelet nesting habitat in Washington is located on Federal lands (Raphael et al. 2005), but only 27 percent (*n* = 1,339) of the status 1-3 sites are located on Federal lands. This is primarily due to the limited survey effort that has occurred on Federal lands. Most of the status 1-3 murrelet sites documented in Washington (54 percent) occur on WDNR lands (*n* = 2,684). Of the 4,922 status 1-3 murrelet sites that occur in Washington, 848 sites (17 percent) occur on FPHCP covered lands (Table 8-28).

Marbled murrelets in Washington generally use large patches of old-forest or uneven-aged forest with old-growth characteristics for nesting habitat (Hamer and Nelson 1995). Hamer and Nelson (1995) described both landscape and forest stand characteristics of 36 marbled murrelet nest stands in the Pacific Northwest (a stand being defined as a contiguous group of trees with no gaps larger than 330 feet). Nest stands in the Pacific Northwest averaged 510 acres. The smallest nest stand was 7 acres, and the largest was 2,725 acres. Because it is difficult to locate marbled murrelet nests, a 1.5-mile radius circle mapped from the point where murrelets were observed flying within the forest canopy or circling above the forest canopy (occupied behavior) is used to delineate occupied murrelet habitat in Washington (WAC 222-16-080 (j)). All suitable murrelet habitat located within a contiguous stand from the point of observation within the 1.5-mile radius circle is considered to be occupied habitat (Table 8-28).

To evaluate the amount and distribution of occupied murrelet habitat in Washington, we selected the status 1-3 sites and used GIS to map 1.5-mile radius circles around each of these sites. We did not include the status 4 sites because not all status 4 sites listed in WDFW's murrelet database meet the "occupied marbled murrelet site" definition of circling within one tree-height of the forest canopy (WAC 222-16-010). However, we believe the 4,922 status 1-3 sites provide a rough estimate of occupied murrelet habitat on non-Federal lands. Because we were not able to evaluate the contiguity of suitable habitat within the 1.5-mile radius, we simply tallied the total habitat acres in the circles and used these acres as a way to estimate known occupied habitat on the FPHCP covered lands, recognizing that the acres calculated using this method likely overestimates the actual "occupied" acres within contiguous stands.

Occupied marbled murrelet sites are not evenly distributed across the murrelet range in Washington. Occupied sites in Zone 2 comprise 73 percent (*n* = 3,588) of the total status 1-3 sites in the State. This is due to the high level of survey effort in Zone 2, as compared to Zone 1, which comprises a larger area with a substantially larger murrelet population (Miller et al. 2005).

Table 8-28. Known occupied marbled murrelet (MAMU) habitat associated with Status 1-3 murrelet sites.

Murrelet Recovery Zone	Area	Total Status 1-3 MAMU Sites in Zone	Status 1-3 MAMU Sites on FPHCP Covered Lands	Total MAMU Nesting Habitat (acres - all owner-ships)	MAMU Habitat in Status 1-3 Sites – 1.5-mi. radius circles	% of MAMU Habitat in 1.5-mi. radius circles	MAMU Habitat on FPCHP Lands	MAMU Habitat on FPHCP Covered Lands in Status 1-3 Sites – 1.5-mi. radius circles	% of MAMU habitat on FPHCP Covered Lands in Status 1-3 Sites
Zone 1 - Puget Sound/ Strait of Juan de Fuca Olympic Peninsula and Cascades	Coastal (0-40 mi.)	1,327	95	826,300	207,500	25%	165,400	14,300	9%
	Inland (40-55 mi.)	7	0	251,600	9,900	4%	7,300	0	0
Subtotals for Zone 1		**1,334**	**95**	**1,077,900**	**217,400**	**20%**	**172,700**	**14,300**	**8%**
Zone 2 - Pacific Coast - Olympic Peninsula and Southwest Washington	Coastal (0-40 mi.)	3,588	753	471,600	172,000	36%	59,200	11,400	19%
	Inland (40-55 mi.)	0	0	25,500	0	0	10,200	0	0
Subtotals for Zone 2		**3,588**	**753**	**497,100**	**172,000**	**35%**	**69,400**	**11,400**	**16%**
Washington Totals	Coastal (0-40 mi.)	4,915	848	1,297,900	379,500	29%	224,600	25,700	11%
	Inland (40-55 mi.)	7	0	277,100	9,900	3%	17,500	0	0
Totals for Washington		**4,922**	**848**	**1,575,000**	**389,400**	**25%**	**242,100**	**25,700**	**11%**

All figures are approximate values derived from GIS data. Totals were computed prior to rounding. Marbled murrelet habitat estimates represent approximate conditions in 2003, as depicted by Raphael et al. (2005) map data, Expert Judgment Model Class 3 and Class 4, and account for stand-replacing timber harvest and fire losses that occurred from 1992 to 2002 (Healey et al. 2003). Habitat-capable acres were summarized directly from Tables 4, 5, 9, and 10 in Raphael et al. (2005).

Over 99 percent of the status 1-3 murrelet sites occur in the coastal areas from 0-40 miles inland. Few occupied sites (n = 7) occur in the inland area from 40 to 55 miles inland. Overall, about 25 percent of the potential murrelet nesting habitat in Washington is associated with the status 1-3 sites, and about 11 percent of the murrelet habitat on the FPHCP covered lands is associated with status 1-3 sites (Table 8-28).

8.3.2.5 Marbled Murrelet Habitat in the FPHCP Riparian Management Zones

Due to the high density of rivers and streams in Washington, riparian areas occupy a substantial portion of the landscape. Within the range of the marbled murrelet in Washington, the RMZs comprise about 13 percent of the total FPHCP acres. About 15 percent of all suitable marbled murrelet habitat on the

FPHCP covered lands is located in RMZs. However, less than 5 percent of the RMZ acres contain mature or old-forest habitat that is potentially suitable for marbled murrelets (Table 8-29).

Table 8-29. Marbled murrelet (MAMU) potential nesting habitat in riparian management zones (RMZs) on the FPHCP covered lands (acres).

Murrelet Recovery Zone	Area	Acres in Type S RMZs	Acres in Type F RMZs	Acres in Type Np RMZs	Total Acres in RMZs	Occupied MAMU Habitat in RMZs (status 1-3 sites)	FPHCP Covered Lands (acres) and %
Zone 1 - Puget Sound/Strait of Juan de Fuca - Olympic Peninsula and Cascades	Total Acres	94,600	164,600	63,900	323,100	nc	2,902,200
	Potential MAMU Habitat	9,000	11,000	4,400	24,400	2,500	172,700
	Percent of MAMU habitat in RMZs	5%	6%	3%	14%	1%	14%
Zone 2 - Pacific Coast - Olympic Peninsula and Southwest Washington	Total Acres	103,600	241,600	62,600	407,700	nc	2,556,800
	Potential MAMU Habitat	4,000	6,000	1,800	11,800	2,500	69,400
	Percent of MAMU habitat in RMZs	6%	9%	3%	17%	4%	17%
Washington Totals	Total Acres	198,100	406,200	126,500	730,800	nc	5,459,000
	Potential MAMU Habitat	13,000	17,000	6,200	36,200	5,000	242,100
	Percent of MAMU habitat in RMZs	5%	7%	3%	15%	2%	15%

Notes: nc= not calculated. All figures are approximate values derived from GIS data. Totals were computed prior to rounding. Marbled murrelet habitat estimates represent approximate conditions in 2003, as depicted by Raphael et al. (2005) map data, Expert Judgment Model Class 3 and Class 4, and account for stand-replacing timber harvest and fire losses that occurred from 1992 to 2002 (Healey et al. 2003). Riparian areas include average RMZ widths along Type S, F, and Np stream types based on the average 100-year site-potential tree height for site index 2 and 3.

Marbled murrelets are known to locate their nests throughout forest stands and fragments, including various types of natural and man-made edges (McShane et al. 2004). Riparian forests can provide potential nest sites for marbled murrelets if the appropriate structures are present (e.g., large trees with suitable nest platforms located within a patch of suitable nesting habitat). McShane et al. (2004) reviewed several studies describing murrelet nest locations and summarized their review: "Most of the nests occurred along edges (76 %), but in most cases these were natural edges (59%). [In this review, edge areas were defined as within 50 meters of an edge]….Nests on natural edges occur along streams, wetlands, forest gaps, large natural openings, or avalanche chutes". In summary, marbled murrelets may select riparian areas for nesting if the appropriate habitat features are available. Murrelets appear to require canopy gaps to access nest sites, and many nest sites documented by research studies have been

located along natural edges such as stream corridors or wetland areas. However, there are no studies that demonstrate that murrelets specifically select edge habitats over other available habitats (e.g., interior forest) (McShane et al. 2004).

There are currently 848 status 1-3 marbled murrelet sites documented on the FPHCP covered lands, and 243 sites are located in mapped RMZs (27 percent). The status 1-3 sites are locations where a murrelet observation was documented, and are not necessarily an indication of an actual nest location within the RMZ. Of the 25,700 acres of occupied murrelet habitat on the FPHCP covered lands, about 5,000 acres (19%) are located in RMZs (Table 8-29). This information suggests that riparian forests on the FPHCP covered lands can provide important habitat for marbled murrelets if suitable nesting habitat is present in sufficient quantities (i.e., large, contiguous patches of uneven-aged or old-forest habitat) to support nesting murrelets.

8.3.2.6 Marbled Murrelet Habitat Management under the Washington Forest Practices Rules

Marbled murrelets in Washington are protected under both State and Federal regulations. The Washington Fish and Wildlife Commission listed the marbled murrelet as a State threatened species, and the murrelet was listed as a Federal threatened species in 1992. The Washington Forest Practice regulations require that both State and federally listed species be considered for designation of "critical habitat state" – a designation that serves as a trigger for State Environmental Policy Act (SEPA) review (WAC 222-16-050(1)(b)). In addition, Section 9 of the ESA prohibits "take" of listed species. Together, the State and Federal regulations provide a framework for marbled murrelet management guidelines in Washington.

Timber harvest on the FPHCP covered lands is subject to the provisions of the Washington Forest Practices Rules for marbled murrelets that were adopted by the Forest Practices Board in 1996 (WAC 222-10-042). The Washington Forest Practices Rules for murrelets were adopted by the Forest Practices Board because the Board recognized that the protection of occupied murrelet habitat on State and private lands would contribute to the overall conservation of marbled murrelets in Washington (Washington Forest Practices Board 1996). Generally, the Washington Forest Practices Rules are designed to identify and protect occupied murrelet habitat on non-Federal lands through survey requirements and the SEPA review process.

Important Definitions Pertaining to Marbled Murrelets

The Washington Forest Practice Rules contain several specific definitions that pertain to the identification and management of marbled murrelet habitat (WAC 222-16-010). We refer to these definitions whenever the following terms are used in our analysis of the environmental baseline and the effects to murrelets:

"Critical nesting season" means for marbled murrelets April 1 to August 31.

"Daily peak activity" means for marbled murrelets – one hour before official sunrise to two hours after official sunrise and one hour before official sunset to one hour after official sunset.

"Marbled murrelet detection area" means an area of land associated with a visual or audible detection of a marbled murrelet, made by a qualified surveyor which is documented and recorded in the WDFW database. The marbled murrelet detection area shall be comprised of the section of land in which the marbled murrelet detection was made and the eight sections of land immediately adjacent to that section.

"Marbled murrelet nesting platform" means any horizontal tree structure such as a limb, an area where limb branches, a surface created by multiple leaders, a deformity, or a debris/moss platform or stick nest equal to or greater than 7 inches in diameter including associated moss if present, that is 50 feet or more above the ground in trees 32 inches dbh and greater (generally over 90 years of age) and is cabable of supporting nesting by marbled murrelets.

"Occupied marbled murrelet site" means:

1. A contiguous area of suitable marbled murrelet habitat where at least one of the following marbled murrelet behaviors or conditions occur:
    a. A nest is located; or
    b. Downy chicks or eggs or egg shells are found; or
    c. Marbled murrelets are detected flying below, through, into or out of the forest canopy; or
    d. Birds calling from a stationary position within the area; or
    e. Birds circling above a timber stand within one tree height of the top of the canopy; or,
2. A contiguous forested area which does not meet the definition of suitable marbled murrelet habitat, in which any of the behaviors or conditions listed above has been documented by the WDFW and which is distinguishable from the adjacent forest based on vegetative characteristics important to nesting marbled murrelets.
3. For sites defined in (1) above, the outer perimeter of the occupied site shall be presumed to be the closer, measured from the point where the observed behaviors or conditions listed in (1) above occurred, of the following:
    a. 1.5 miles from the point where the observed behaviors or conditions listed in (1) above occurred; or
    b. The beginning of any gap greater than 300 feet wide lacking one or more of the vegetative characteristics listed under "suitable marbled murrelet habitat"; or
    c. The beginning of any narrow area of "suitable marbled murrelet habitat" less than 300 feet in width and more that 300 feet in length.
4. For sites defined under (2) above, the outer perimeter of the occupied site shall be presumed to be the closer, measured from the point where the observed behaviors or conditions listed in (1) above occurred, of the following:
    a. 1.5 miles from the point where the observed behaviors or conditions listed in (1) above occurred; or
    b. The beginning of any gap greater than 300 feet wide lacking one or more of the distinguishing vegetative characteristics important to murrelets; or
    c. The beginning of any narrow area of "suitable marbled murrelet habitat" less than 300 feet in width and more that 300 feet in length.

5. In determining the existence, location, and status of occupied marbled murrelet sites, the WDNR shall consult with the WDFW and use only those sites documented in substantial compliance with guidelines or protocols and quality-control methods established by and available from the WDFW.

"Suitable marbled murrelet habitat" means a contiguous forested area containing trees capable of providing nesting opportunities:

1. With all of the following indicators unless the WDNR, in consultation with the department of fish and wildlife, has determined that the habitat is not likely to be occupied by marbled murrelets:

    a. Within 50 miles of marine waters;

    b. At least 40 percent of the dominant and co-dominant trees are Douglas-fir, western hemlock, western red cedar, or Sitka spruce;

    c. Two or more nesting platforms per acre;

    d. At least 7 acres in size, including the contiguous forested area within 300 feet of nesting platforms, with similar forest stand characteristics to the forested are in which the nesting platforms occur.

8.3.2.7 Class IV-Special Forest Practices Activities Affecting Marbled Murrelets

Timber harvesting and road construction within an occupied marbled murrelet site, or timber harvesting or road construction in suitable habitat within a marbled murrelet detection area are considered "likely to have a probable significant adverse impact on the environment." Such activities are considered "Class-IV-Special" and therefore require the development of an Environmental Impact Statement under SEPA regulations (WAC 222-10-042). Under the "Class-IV-Special" regulations, WDNR makes a decision to approve individual Forest Practices Applications based upon a significance determination. If a determination of significance is made, preparation of a State Environmental Policy Act - Environmental Impact Statement is required prior to proceeding. If a determination of non-significance or mitigated determination of non-significance is reached, the action can proceed without further environmental assessment. Other "Class-IV Special" activities include harvesting suitable habitat outside of marbled murrelet detection areas with at least a 60 percent probability of occupancy (i.e., 7 platforms per acre); or, harvesting of suitable habitat outside murrelet detection areas with at least a 50 percent probability of occupancy (i.e., 5 platforms per acre) within the southwest Washington marbled murrelet special landscape (WAC 222-16-087).

Generally, once an occupied marbled murrelet site is documented, the suitable habitat in the occupied site is protected from timber harvest. Occupied murrelet sites are further protected with a 300-foot managed buffer zone adjacent to the occupied site. This rule protects occupied sites by prohibiting clearcut timber harvest within 300 feet of the occupied stand (WAC 222-16-080 (j)(v)). Under the managed buffer rule, trees within the managed buffer may be thinned to a density of 75 trees per acre. The primary consideration for the design of the managed buffer is to mediate edge effects to occupied sites.

Occupied marbled murrelet habitat is further protected from disturbance-associated forest practice activities. Restricted activities include road construction, operation of heavy equipment, blasting, timber felling, yarding, helicopter operations, slash disposal, or prescribed burning. These activities are

prohibited within 0.25 miles of an occupied marbled murrelet site during the daily peak activity periods within the critical nesting season (April 1 through August 31) (WAC-222-30-050, -060, -065, -070, -100).

Exemptions to the "Class IV Special" Rules for Marbled Murrelets

The critical habitat (State) rules listed above do not apply where a landowner owns less than 500 acres of forestland and the land does not contain an occupied murrelet site. Therefore, if a small landowner has suitable murrelet habitat that is not part of an occupied site, this habitat could be harvested without a SEPA review. Additionally, any suitable murrelet habitat on private lands outside of occupied murrelet sites may be harvested where a protocol survey (WAC 222-12-090(14)) has been conducted and no murrelets were detected. Currently, the Washington Forest Practices Rules refer to the most recent version of the Pacific seabird survey protocol in effect January 6, 2003 (Evans Mack et al. 2003). Other exemptions to the Class IV-Special marbled murrelet rules include areas that are managed under a completed HCP for marbled murrelets approved by the FWS, or a special wildlife management plan that has gone through SEPA review (WAC 22-16-080 (6)).

In summary, the Washington Forest Practices Rules for marbled murrelets are designed to identify and protect occupied murrelet habitat on non-Federal lands within 50 miles of marine waters. There are few documented murrelet observations located beyond 50 miles from marine waters (n = 6 out of 30,168 sites), but survey efforts for murrelets in this region have been limited. The Washington Forest Practices Rules emphasize protecting habitat in occupied sites and in detection areas, and in areas with a high probability of occupancy. Potential nesting habitat that is not protected by the Washington Forest Practices Rules are areas that occur on small land ownerships that do not contain an occupied murrelet site; locations outside of murrelet detection areas with few nesting platforms (low probability of occupancy); or, areas that have been surveyed to protocol and murrelets were not detected.

8.3.2.8 Potential Marbled Murrelet Nesting Habitat in Marbled Murrelet Detection Areas

We analyzed the amount of potential murrelet nesting habitat on FPHCP covered lands that occurs in the marbled murrelet detection areas. Marbled murrelet detection areas include the section of land where a status 1-4 murrelet observation was documented, and the 8 surrounding sections. This analysis indicated that overall about 20 percent (47,900 acres) of the murrelet habitat on FPHCP covered lands is located in murrelet detection areas. In Zone 1, about 18 percent of the potential habitat in the coastal zone of the FPHCP covered lands is in detection areas; in Zone 2, about 31 percent of the potential habitat in the coastal zone FPHCP covered lands is in detection areas (Table 8-30). We also found that there was high level of overlap (>90 percent) of habitat acres located in the occupied sites (Table 8-28) and the murrelet detection areas.

The murrelet detection areas are important because all suitable murrelet habitat (i.e., ≥ 2 platforms per acre) in these areas requires a protocol survey prior to timber harvest, and occupied sites detected in these areas are managed for murrelet conservation. Outside the detection areas murrelet habitat is at a greater risk of harvest because only sites with a high probability of occupancy have a pre-harvest survey requirement. Determining which areas meet the criteria for high probability of occupancy (e.g., 5-7 platforms per acre) requires field surveys for verification. Landowners can request that WDFW perform these surveys; or they could hire a qualified contractor to conduct pre-harvest surveys.

Table 8-30. Marbled murrelet potential nesting habitat in marbled murrelet detection areas. Detection areas include the section in which a status 1-4 murrelet site is documented, and the 8 surrounding sections.

Murrelet Recovery Zone	Area	Total Murrelet Nesting Habitat (acres - all ownerships)	Murrelet Nesting Habitat in Detection Area (acres - all ownerships)	% of Murrelet Nesting Habitat in Detection Areas (acres - all ownerships)	Murrelet Nesting Habitat on FPHCP Covered Lands (acres)	Murrelet Nesting Habitat in Detection Areas on FPHCP Covered Lands (acres)	% of Murrelet Nesting Habitat in Zone on FPHCP Covered Lands
Zone 1 - Puget Sound/ Strait of Juan de Fuca - Olympic Peninsula and Cascades	Coastal (0-40 mi.)	826,300	362,900	44%	165,400	29,100	18%
	Inland (40-55 mi.)	251,600	27,600	11%	7,300	200	2%
Subtotals for Zone 1		**1,077,900**	**390,500**	**36%**	**172,700**	**29,200**	**17%**
Zone 2 - Pacific Coast - Olympic Peninsula and Southwest Washington	Coastal (0-40 mi.)	471,600	249,000	53%	59,200	18,400	31%
	Inland (40-55 mi.)	25,500	18,400	72%	10,200	200	2%
Subtotals for Zone 2		**497,100**	**267,400**	**54%**	**69,400**	**18,600**	**27%**
Washington Totals	Coastal (0-40 mi.)	1,297,900	611,900	47%	224,600	47,500	21%
	Inland (40-55 mi.)	277,100	46,000	17%	17,500	400	2%
Totals for Washington		**1,575,000**	**657,900**	**42%**	**242,100**	**47,900**	**20%**

Note: All figures are approximate values derived from GIS data. Marbled murrelet habitat estimates represent approximate conditions in 2003, as depicted by Raphael et al. (2005) map data, Expert Judgment Model Class 3 and Class 4, and account for stand-replacing timber harvest and fire losses that occurred from 1992 to 2002 (Healey et al. 2003).

We currently have no reliable way of identifying the high probability suitable habitat acres with the murrelet habitat suitability maps developed by Raphael et al. (2005). These maps provide categories of suitability, with Class 4 representing the highest-quality habitat based on coarse-scale measures such as percent conifer cover, quadratic mean diameter, patch size, etc. (Raphael et al. 2005). On the FPHCP covered lands in the coastal areas (0-40 miles inland) about 63 percent of the potential murrelet habitat is Class 3 “moderate suitability” habitat, and 37 percent is Class 4 “highest suitability” habitat. In contrast, only about 15 percent of the potential murrelet habitat on Federal lands in the coastal areas is Class 3 habitat, and 85 percent is Class 4 habitat. However, these coarse-scale indicators do not provide an indication of nesting platforms per acre.

8.3.2.9 Timber Harvest on FPHCP Covered Lands within the Range of the Marbled Murrelet

We estimated the annual rates of timber harvest on the FPHCP covered lands for the period of 1992 – 2002 using the data compiled by Healey et al. (2003). This map data depicts stand replacing disturbance associated with timber harvest and wildfire, but does not portray changes associated with partial harvests such as commercial thinning. Within the range of the marbled murrelet in Washington, we found that stand-replacing timber harvest is occurring at a rate of about 1.2 percent per year on the FPHCP covered lands (Table 8-31). For the 10 year period of 1992-2002, there were over 66,000 acres of timber harvested annually (all forest types). Over 99.3 percent of the acres were identified as timber harvest, only about 430 acres were identified as stand-replacing wildfire.

Table 8-31. Timber harvest from 1992 – 2002 within the range of the marbled murrelet in Washington.

Murrelet Recovery Zone	Area	Total Acres of Timber Harvest 1992-2002 (all ownerships)	Total Acres of Timber Harvest on FPHCP Covered Lands (1992-2002)	% of Total Acres of Timber Harvested that occurred on FPHCP Covered Lands (1992-2002)	Total FPHCP Acres in Zone	% of Acres of Timber Harvested on FPHCP Covered Lands (1992-2002)
Zone 1 - Puget Sound/Strait of Juan de Fuca - Olympic Peninsula and Cascades	Coastal (0-40 mi.)	342,600	265,100	77%	2,838,500	9%
	Inland (40-55 mi.)	16,700	6,900	41%	63,700	11%
Subtotals for Zone 1		**359,300**	**272,000**	**76%**	**2,902,200**	**9%**
Zone 2 - Pacific Coast - Olympic Peninsula and Southwest Washington	Coastal (0-40 mi.)	417,100	328,800	79%	2,176,400	15%
	Inland (40-55 mi.)	68,700	62,200	91%	380,400	16%
Subtotals for Zone 2		**485,800**	**391,000**	**80%**	**2,556,800**	**15%**
Washington Totals	Coastal (0-40 mi.)	759,700	593,900	78%	5,014,900	12%
	Inland (40-55 mi.)	85,400	69,100	81%	444,100	16%
Totals for Washington		**845,100**	**663,000**	**78%**	**5,459,000**	**12%**

All figures are approximate values derived from GIS data. Totals were computed prior to rounding. Marbled murrelet habitat estimates represent approximate conditions in 2003, as depicted by Raphael et al. (2005) map data, Expert Judgment Model Class 3 and Class 4, and account for stand-replacing timber harvest and fire losses that occurred from 1992 to 2002 (Healey et al. 2003).

We estimated the acres of potential marbled murrelet habitat removed by overlaying the Healey et al. (2003) disturbance data with the Raphael et al. (2005) EJM Class 3-4 habitat suitability maps. The information derived from this analysis provides a general estimate of the rate of habitat loss in Washington, but does not represent absolute values. We found that over 65,000 acres of marbled murrelet habitat was harvested from 1992 - 2002 on all lands in Washington, representing a decadal loss of about 4 percent (Table 8-32). Timber harvest on the FPHCP covered lands accounted for about 80 percent of the total habitat acres removed (51,900 acres). Harvest on Federal, tribal, or other HCP-covered lands accounted for the remaining 20 percent of habitat loss.

Table 8-32. Estimated acres of potential marbled murrelet (MAMU) habitat harvested on FPHCP covered lands 1992-2002.

Murrelet Recovery Zone	Area	Potential MAMU nesting habitat circa 1994 on all ownerships (acres)	MAMU potential nesting habitat harvested 1992-2002 (all owner-ships)(acres)	Potential MAMU nesting habitat on FPHCP covered lands circa 1994 (acres)	Potential MAMU nesting habitat harvested on FPHCP covered lands 1992-2002 (acres)	% of Potential MAMU nesting habitat harvested on FPHCP covered lands 1992-2002
Zone 1 - Puget Sound/Strait of Juan de Fuca - Olympic Peninsula and Cascades	Coastal (0-40 mi.)	864,400	38,100	193,600	28,200	15%
	Inland (40-55 mi.)	253,500	2,000	9,200	1,900	20%
Subtotals for Zone 1		**1,117,900**	**40,100**	**202,800**	**30,100**	**15%**
Zone 2 - Pacific Coast - Olympic Peninsula and Southwest Washington	Coastal (0-40 mi.)	492,800	21,200	77,600	18,400	24%
	Inland (40-55 mi.)	29,300	3,800	13,500	3,400	25%
Subtotals for Zone 2		**522,100**	**25,000**	**91,100**	**21,800**	**24%**
Washington Totals	Coastal (0-40 mi.)	1,357,200	59,300	271,200	46,600	17%
	Inland (40-55 mi.)	282,800	5,800	22,700	5,300	23%
Totals for Washington		**1,640,000**	**65,100**	**293,900**	**51,900**	**18%**

All figures are approximate values derived from GIS data. Totals were computed prior to rounding. Marbled murrelet habitat estimates represent approximate conditions in 2003, as depicted by Raphael et al. (2005) map data, Expert Judgment Model Class 3 and Class 4, and account for stand-replacing timber harvest and fire losses that occurred from 1992 to 2002 (Healey et al. 2003).

Timber harvest on the FPHCP covered lands removed about 18 percent of the potential murrelet habitat that was present in 1992-1996. Most of the habitat loss (54 percent) occurred in coastal Zone 1 (0-40 miles inland), and about 37 percent occurred in coastal Zone 2. Only about 10 percent of habitat loss occurred in the inland zones (40 -55 miles inland) (Table 8-32). The average rate of murrelet habitat loss on the FPHCP covered lands was about 1.5 percent per year in Zone 1, and about 2.4 percent per year in

Zone 2. It is important to note that much of the habitat loss that has occurred over the past decade has occurred in small, isolated patches that presumably had a low probability of occupancy, or, occurred in areas that were surveyed to protocol and murrelets were not detected.

8.3.2.10 Federally Designated Marbled Murrelet Critical Habitat

Federally designated marbled murrelet critical habitat in Washington covers approximately 1.2 million acres distributed across 10 critical habitat units (Critical Habitat Units). Each Critical Habitat Unit is comprised of several subunits. There are a total of 33 critical habitat subunits in Washington ranging from 200 acres to over 108,000 acres in size. Lands designated were those areas identified as essential to the conservation of the marbled murrelet, with the major foundation of the designation being Federal lands managed under the Northwest Forest Plan (U.S. Fish and Wildlife Service 1996a). For this analysis, we refer to these subunits as Critical Habitat Units. Using the Raphael et al. (2005) EJM Class 3-4 habitat model, we estimated that the Critical Habitat Units in Washington encompass a total of approximately 401,200 acres of potential murrelet habitat. This represents approximately 33 percent of the designated acres. There is a high percentage of second-growth forest and some naturally non-suitable habitat areas within the Critical Habitat Units. Over 99 percent of the Critical Habitat Units in Washington are located on Federal lands that are managed as Late-Successional Reserves under the Northwest Forest Plan.

There are approximately 2,500 acres designated critical habitat that occur on private lands, including about 2,300 acres on the FPHCP covered lands. Under the Washington Forest Practices Rules, federally designated critical habitat on non-Federal lands is managed under the provisions of the State's marbled murrelet rule (WAC 222-16-080(2)). The designated private lands occur primarily in coastal Zone 2, in southwest Washington. All of the private lands that are within designated critical habitat occur within 1.5-mile radius circles surrounding status 1-3 occupied murrelet sites. Therefore, all occupied murrelet habitat within these non-Federal Critical Habitat Units is protected under the existing Washington Forest Practice Rules.

8.3.3 EFFECTS OF THE ACTION – Marbled Murrelet and Marbled Murrelet Critical Habitat

8.3.3.1 Context of the Effects Analysis

The analysis for the marbled murrelet and its designated critical habitat includes only those effects that would be expected to occur as effects of permit issuance, such as the effects of timber-harvest activities in the Riparian Zone (of influence) and road-related activities. The framework for analysis section of this Opinion described the primary activities that are considered effects of permit issuance for the FPHCP. Future timber harvest activities in upland areas would be essentially unchanged by permit issuance for the FPHCP, and therefore these activities are not analyzed in this section, but will be addressed in the analysis of cumulative effects.

Our analysis in this Opinion does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat at 50 CFR 402.02. Instead we have relied upon the statute and the August 6, 2004, Ninth Circuit Court of Appeals decision in Gifford Pinchot Task Force v. U.S. Fish and Wildlife Service (No. 03-35279) to complete the following analysis with respect to critical habitat.

8.3.3.2 Effect Determinations For Marbled Murrelet and Marbled Murrelet Critical Habitat

We have determined that the forest practices activities covered under the FPHCP "may affect, and is likely to adversely affect" the marbled murrelet and federally designated marbled murrelet critical habitat. The effect determination for marbled murrelets is based on our assessment that the effects of activities under the Permit are likely to result in the degradation and loss of marbled murrelet habitat on the FPHCP covered lands. The effect determination for critical habitat is based on our assessment that the forest practices activities are likely to result in the degradation and loss (i.e., due to windthrow) of suitable marbled murrelet critical habitat. Therefore, in accordance with section 7(a)(2) of the ESA, we have prepared the following effects analysis of the proposed Federal action (i.e., issuance of the FPHCP incidental take permit for aquatic species) for the marbled murrelet and its designated critical habitat.

8.3.3.3 Assumptions Regarding Incidental Take of Marbled Murrelets

The marbled murrelet is not a covered species under the FPHCP; therefore, we do not anticipate or authorize any incidental take of marbled murrelets associated with the implementation of the FPHCP. Any "take" would violate the prohibitions in Section 9 of the ESA, and would therefore invalidate the FPHCP Permit with respect to all listed covered species for that forest practices application that resulted in unauthorized "take." ESA section 3(19) defines the term "take" to include "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to engage in any such conduct". The terms "harm" and "harass" have been further defined by regulations at 50 CFR §17.3 as follows:

Harass means an intentional or negligent act or omission that creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns that include, but are not limited to, breeding, feeding, or sheltering.

Harm means an act that actually kills or injures wildlife. Such an act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering.

Marbled murrelets are likely to be taken as a result of activities that: (1) kill or injure birds; (2) impair essential behaviors by adversely affecting occupied or unsurveyed suitable breeding habitat; or (3) cause significant disturbance of breeding birds, leading to reduced reproductive success (U.S. Fish and Wildlife Service 1997a).

In the absence of a federally-approved HCP or a State-approved special wildlife management plan, suitable murrelet habitat on non-Federal lands is only protected by the Washington Forest Practices Rules where protocol surveys document an occupied murrelet site. Due to specific exemptions within the Washington Forest Practices Rules, a landowner in Washington could be in full compliance with the Forest Practices regulations and have some risk of causing "take" if their forest practices activity resulted in the loss of occupied marbled murrelet habitat (i.e., take). These situations include:

3. Timber harvesting or road construction in suitable marbled murrelet habitat that occurs outside marbled murrelet detection areas. Outside murrelet detection areas, only habitat that has a high probability of murrelet occupancy (i.e., ≥ 5-7 nest platforms/acre, depending on the location) is required to be surveyed prior to harvest (WAC 222-16-080(j)(iii) and (iv)). Murrelet habitat with fewer than 5-7 platforms per acre has a lower probability of occupancy. However, lower platform density does not ensure that the habitat is unoccupied by marbled murrelets. Timber harvest that removes suitable murrelet habitat without pre-harvest protocol

surveys can potentially result in the loss of occupied habitat and take of marbled murrelets (U.S. Fish and Wildlife Service 1997a).

4. Timber harvesting or road construction in suitable marbled murrelet habitat that occurs where a landowner owns less than 500 acres and the land does not contain a known occupied murrelet site (WAC 222-16-080(j)(vi). Landowners with less than 500 acres are not required by the Washington Forest Practices Rules to conduct pre-harvest marbled murrelet surveys. Therefore, if a small landowner has suitable murrelet habitat on their property that is not part of a known occupied site, this habitat could be harvested without a SEPA review or pre-harvest surveys, potentially resulting in the loss of occupied habitat and take of marbled murrelets.

5. Timber harvesting along Federal boundary areas with suitable murrelet habitat. Unless there is an occupied murrelet site documented on the adjacent Federal lands to trigger the protections of the Washington Forest Practices Rules for marbled murrelets, a landowner could harvest timber (non-habitat) up to the Federal boundary, potentially resulting in a significant disruption of murrelet breeding if the harvest occurs during the nesting season (harassment). Clearcut harvest could also result in long-term adverse effects to the suitable habitat on adjacent Federal lands associated with exposed clearcut boundaries. There are few occupied murrelet sites documented on Federal lands, so the Washington Forest Practices Rules that require seasonal restrictions to avoid disturbance, and managed buffers to avoid edge effects to occupied murrelet sites may not be applied to Federal boundary areas. Some boundary areas may be identified and protected under the SEPA review process, but it is not clear to the FWS that WDNR will identify suitable murrelet habitat on Federal boundary areas as likely to be occupied habitat.

The above situations represent the greatest risk for landowners to have a potential violation of section 9 of the ESA (i.e., unauthorized incidental take).

Other situations that have the potential to result in take of marbled murrelets include: (1) harvesting suitable murrelet habitat that is located farther than 50 miles from marine waters; (2) disturbance harassment associated with forest practices; (3) harvesting suitable murrelet habitat that occurs in stands less than 7 acres in size; and (4) harvesting occupied murrelet habitat that has been surveyed to protocol, but the surveys failed to detect murrelets (i.e., survey error). Even though each of these situations has the potential to result in the loss of occupied murrelet habitat, the risk of incidental take in these situations is relatively low.

Although a few murrelets sightings have been documented beyond 50 miles from marine waters, there are no known nest sites or observations of behavior indicating occupancy in this region. We have not identified these far inland areas as important for recovery (U.S. Fish and Wildlife Service 1997a). The majority of suitable murrelet habitat that occurs beyond 50 miles from marine waters is located on Federal lands and is protected by the standards and guidelines for land management under the Northwest Forest Plan.

We expect that some sound and activity- related disturbances (i.e., harassment) to nesting murrelets may occur on the FPHCP covered lands and adjacent ownerships, but the risk for potential injury to murrelets is relatively low due to the 0.25-mile disturbance buffers and daily activity restrictions required by the Washington Forest Practices Rules. The Washington Forest Practices Rules minimize the potential for adverse effects from disturbance associated with forest practices to nesting murrelets, but they do not

ensure that all murrelets will be protected from disturbance under all circumstances. Blasting within a mile of an occupied murrelet site, unrestricted activities during the mid-day hours, and unrestricted forest practices during the late nesting season (September) are all situations which may result in murrelets flushing from a nest, aborted feedings, or postponed feedings. Additionally, timber harvesting or other forest practice activities adjacent to unsurveyed, suitable habitat on Federal lands could result in harassment of murrelets nesting on Federal lands.

There is no known minimum patch size for marbled murrelet nesting habitat. Murrelets occupancy has been documented in stands as small as 5 acres (D. Lynch, Personal Communication, 2006). The Washington Forest Practices Rules define suitable murrelet habitat as having a minimum stand size of 7 acres (WAC 222-16-010). Because murrelets require only a single tree with suitable nest platforms surrounded by other trees to provide some cover for nesting, suitable habitat that occurs in patches smaller than 7 acres in size could be occupied by murrelets. We have not assessed the risk associated with the potential loss of murrelet habitat that occurs in small patches (i.e., patches less than 7 acres in size). However, the risk of predation and reproductive failure for murrelets is expected to be high in small habitat patches (U.S. Fish and Wildlife Service 1997a). Small patches of habitat have a greater proportion of edge area than do large patches. Nelson and Hamer (1995b) found that successful murrelet nests were significantly further from edge than unsuccessful nests, and cover directly around the nest was significantly greater at successful nests. These findings suggest that murrelet habitat that occurs in small patches may be less important for species recovery due to higher risks of predation and nest failure, but small patch size itself does not ensure that the habitat is unoccupied by murrelets. Because murrelets have rarely been documented nesting in patches smaller than 7 acres, we expect there is a relatively low risk of take in these areas. However, there is a potential for take of marbled murrelets to occur where small patches of unsurveyed suitable habitat are removed.

Both the FWS and the State management agencies (i.e., WDNR and WDFW) are currently relying on the Pacific Seabird Groups' marbled murrelet survey protocol to determine if potential habitat is occupied by nesting murrelets (Evans Mack et al. 2003). This protocol is not error-free, but given the paucity of information on this species and its cryptic behavior, the protocol represents the best available method for determining the murrelet occupancy in potential habitat. Therefore, we assume that take of murrelet is not likely in suitable habitat that has been surveyed to protocol with no occupancy.

8.3.3.4 Summary of the Terrestrial Effects of Timber Harvest in FPHCP Riparian Management Zones

The following is a summary description of the terrestrial effects of the FPHCP riparian management rules. This general overview provides the context for the more detailed analysis of the direct, indirect, and cumulative effects to marbled murrelet and marbled murrelet critical habitat which follows.

Option 1 – Thinning from Below

Under Option 1 (thinning from below), RMZs along Type S or F streams can be managed with partial-harvest strategies in the inner and outer zones. The overall effect is that the Core Zone immediately adjacent to streams will remain intact (i.e., no harvest except at road-crossings and yarding corridors). The Inner Zones may have some "thinning from below" but large trees and a fairly contiguous canopy cover are likely to be retained. At a minimum, at least 57 trees per acre must be retained within the Inner Zone, and the percent of conifer composition within the inner zone cannot be reduced. The Outer Zone can be thinned much more heavily, down to 20 trees per acre, which results in a clearcut with a few

scattered trees retained in dispersed or clumped groups to meet the average 20 trees per acre retention requirement. Overall, we estimate 40-60 percent of the existing pre-harvest trees within a site-potential tree height (90 – 200 feet) in the Type S or F RMZs will be retained. In western Washington, upland areas beyond the Outer Zone will most likely be clearcut, although commercial thinning is another harvest method that is used in upland timber harvest.

The short-term physical effects of thinning within the Inner Zone include reduced stem density (trees per acre), reduced overstory canopy cover, reductions in the density of standing snags, and potential reduction in decayed down logs on the forest floor. Species composition may be altered as well, if Inner Zone harvest focuses on the removal of hardwoods or targets specific conifer species. The physical effects of felling trees and removing logs via yarding or other means can result in short-term destruction of understory plants and soil-dwelling organisms. Heavy thinning that occurs in the Outer Zone represents a stand-replacing disturbance that removes greater than 80 percent of the existing overstory trees. Equipment used to harvest timber generates loud sounds that may carry into adjacent forests resulting in short-term disturbance or displacement of wildlife, and post-harvest slash-burning may generate smoke that carries into adjacent stands. If upland areas adjacent to the Inner and Outer Zones are clearcut, the RMZ area which may have had some interior forest characteristics will become an exposed edge habitat, with increased solar radiation, increased fluctuations in temperatures, and increased exposure to windthrow. We anticipate that windthrow and edge effects could occur for distances up to 400 feet into adjacent stands from exposed edges. The edge habitat condition along exposed clear-cut edges will gradually dissipate over time as adjacent upland stands regenerate over a period of 30 to 40 years.

Although there are short-term negative effects associated with thinning, treated stands that are relatively young (i.e., 40-60 years old) tend to recover quickly with increased tree growth (U.S. Forest Service 2002). Positive long-term effects of thinning can include increased growth of trees, increased crown differentiation, increased development of understory vegetation, and increased flowering and fruiting of understory plants (Carey 2004).

Option 2 – Leaving Trees Closest to the Water

Under Option 2 (leaving trees closest to the water), landowners may forego the thinning from below guidelines and harvest trees within the Inner and Outer Zones if the Desired Future Condition (DFC) objectives for the RMZ can be met. In Option 2, trees within 80 to 100 feet of Type F streams (depending on stream size) will be remain intact (no harvest except at road crossings and yarding corridors), while trees from 80 to 100 feet out to 140 to 200 feet (Inner and Outer Zones) may be harvested down to a minimum of 20 trees per acre. Under Option 2, the overall width of potential mature forest development in the RMZs is reduced by 50 to 70 feet, or about 30 to 40 percent over Option 1. Overall, about 45 to 60 percent of the existing pre-harvest riparian trees (within the 100-year site index tree height, 140 to 200 feet) are retained in the short-term to provide for the DFC of a mature riparian stand over time.

Another management option available to landowners is to not harvest timber within the Inner Zone. Under this option, no timber harvest occurs within the Core Zone or the Inner Zone of the RMZ. The Outer Zone may be heavily thinned down to a minimum retention of 20 trees per acre. This option is similar to Option 2; however, no Inner Zone harvest retains about 75 to 80 percent of the existing pre-harvest trees. To date, Option 2, and the no Inner Zone harvest options have been the most-commonly used methods applied for riparian management on the FPHCP covered lands.

The physical effects under Option 2 are similar to the effects described for Outer Zone harvest above under Option 1. The Inner and Outer Zones (beyond 80-100 feet from the stream) can be thinned heavily,

down to 20 trees per acre, which results in a clearcut or shelterwood harvest condition with a few scattered trees retained in dispersed or clumped groups to meet the average 20 trees per acre retention requirement. Under Option 2, the potential beneficial effects associated with thinning (increased tree growth, etc.) in the RMZs are not realized; however, the RMZs managed under Option 2 will provide mature riparian stands over time, albeit in narrower strips of habitat than in Option 1. Upland areas beyond the Outer Zone are likely to be clearcut. When upland areas adjacent to the Inner and Outer Zones are clearcut, the RMZ area which may have had some interior forest characteristics will become exposed edge habitat, with increased solar radiation (which stimulates understory growth), increased fluctuations in temperatures, and increased risk of windthrow. We anticipate that windthrow and edge effects are reasonably certain to occur for distances up to 400 feet into adjacent stands from exposed edges. The edge habitat condition along exposed clearcut edges will gradually transition to a closed-forest condition as adjacent upland stands regenerate over a period of 30 to 40 years.

The physical effects of felling trees and removing logs via yarding or other means can result in short-term destruction of understory plants and soil-dwelling organisms. Equipment used to harvest timber generates loud sounds that may carry into adjacent forests. The stand-replacing or stand-altering physical disturbance and noise associated with timber harvest may result in short-term disturbance or displacement of wildlife in the harvest area and adjacent habitat. Post-harvest slash-burning may generate smoke that carries into adjacent stands, also potentially displacing or disturbing wildlife.

Sensitive Sites and RMZs along Type Np and Type Ns Waters

In western Washington, a minimum 50-foot no-harvest buffer must be retained along the lower 500 feet of Type Np waters upstream from the confluence with Type S or F waters. Beyond 500 feet from such confluences, a 50-foot no-harvest buffer is required along approximately 50 percent of the remaining Np stream lengths. Sensitive sites associated with headwall seeps, sidewall seeps, and perennial flow initiation points are also protected with 50-foot to 56-foot radius no-harvest buffers. Type Ns streams are not protected with no-harvest buffers, except in the vicinity of sensitive sites, unstable slopes, and/or buffers associated with Type S or F confluences. Type Ns waters, and unbuffered sections of Type Np waters, do receive some protection with a 30-foot equipment limitation zone that limits the amount of ground disturbance associated with heavy equipment, timber yarding, or skid trails.

The 50-foot no-harvest buffers along portions of Np waters and around other sensitive sites retain about 15 – 20 percent of the existing trees within the 100-year site index tree height of the stream. Outside the 50-foot no-harvest zones, all trees within the 100-year site index tree height (from 50 out to 200 feet, depending on the site) are likely to be clearcut concurrent with adjacent upland harvest. RMZ areas along Type Np waters which may have had some interior forest characteristics prior to timber harvest will become a narrow strip of trees, with increased solar radiation (which stimulates understory growth), increased fluctuations in temperatures, and an increased risk of windthrow. The edge habitat condition along exposed clearcut edges will gradually transition to a closed-forest condition as adjacent upland stands regenerate over a period of 30 to 40 years.

8.3.3.5 Assumptions Regarding Potential Marbled Murrelet Nesting Habitat in RMZs

For this analysis, we use the terms “suitable” habitat or “potential” marbled murrelet nesting habitat to refer to areas with forest cover that have the general attributes of marbled murrelet nesting habitat (i.e., patches of conifer forest with large trees present) as depicted by the habitat maps developed by Raphael et al (2005). We use the term “potential” habitat to emphasize the idea that the habitat values that we

selected from the Expert Judgement Model results represent forest cover that has the general attributes of marbled murrelet nesting habitat whether or not marbled murrelets are actually using the habitat. It is important to note that all habitat estimates that we generated from Raphael et al.s' (2005) data are general estimates based on our interpretation of data. The values reported here are coarse estimates used for the purpose of this analysis, and are not intended to represent absolute values. The habitat acres depicted by Raphael et al.'s (2005) data are not expected to accurately depict all areas that would meet the regulatory definitions of "suitable" marbled murrelet habitat defined at WAC 222-16-010.

The environmental baseline analysis indicated that about 15 percent of the potential marbled murrelet nesting habitat on the FPHCP covered lands is located in RMZs (≈ 36,200 acres). Because most RMZs on the FPHCP covered lands are forested with second-growth forests, less than 5 percent of the total RMZ acres (≈ 730,800 acres) contain mature or old-forest habitat that is potentially suitable for marbled murrelets (Table 8-29). Potential murrelet nesting habitat located in RMZs that is not associated with occupied marbled murrelet sites may be directly affected by forest practice activities in the RMZs.

There are currently 848 status 1-3 marbled murrelet sites documented on the FPHCP covered lands, and 243 sites are located in mapped RMZs (27 percent). The status 1-3 sites are locations where a murrelet observation was documented, and are not necessarily an indication of actual occupancy within the RMZ. Due to the site-specific information needed to define an occupied marbled murrelet site, we currently have no reliable way of calculating how much potential nesting habitat is associated with "occupied marbled murrelet sites" as defined by the Washington Forest Practices Rules. For this analysis, we assume that all suitable habitat depicted by the EJM Class 3-4 habitat model that occurs within the 1.5 mile-radius buffers of status 1-3 murrelet sites is "occupied habitat" that is protected from timber harvest. The environmental baseline analysis indicates that approximately 11 percent of the potential murrelet nesting habitat on the FPHCP covered lands (Table 8-28) occurred within the 1.5-mile radius buffers surrounding status 1-3 murrelets sites (≈ 25,700 acres). This is a rough estimate that likely overestimates the actual occupied stands because of the inclusion of disjunct habitat patches within the 1.5-mile radius occupied-site buffers. Of the roughly 25,700 acres of potential nesting habitat that occurs in status 1-3 site buffers, about 5,000 acres are located in RMZs (19 percent).

In summary, there are approximately 36,200 acres of potential murrelet nesting habitat in RMZs, but only about 5,000 acres are associated with known occupied sites. The remaining 31,200 acres of potential murrelet habitat in the RMZs have the potential to be directly affected by forest practices activities unless pre-project surveys document an occupied murrelet site.

Because potential murrelet nesting habitat consists of stands with large trees, we are assuming that Option 2 (leaving trees closest to the water) will be the option selected for managing Type S or Type F RMZs with potential murrelet nesting habitat. We are making this assumption because murrelet nesting habitat generally occurs in old-growth or mature forests with large trees, low tree densities, and a high basal area of dominant and co-dominant trees (Hamer and Nelson 1995). Given the requirement to maintain a minimum of 57 trees per acre within the Inner Zones under Option 1, relatively few trees are likely to be available for a thinning-from-below harvest strategy in stands that are potential murrelet nesting habitat. However, the Option 2 harvest strategy is likely to meet RMZ objectives, because the large trees retained in the no-harvest Core and Inner Zone areas are likely to meet the minimum stand requirements necessary for meeting DFC objectives.

Under Option 2, the width of the no-harvest zone varies from 80 to 100 feet along Type S or Type F waters, and 50 feet along 50 percent of the length of Type Np waters. Type S and Type F RMZs

comprise about 83 percent of all RMZ acres on westside FPHCP covered lands, and Type Np RMZs comprise about 17 percent. For the effects analysis for marbled murrelets, we are assuming an average retention of 55 percent of riparian trees in Type S or Type F RMZs, and an average 16 percent retention of riparian trees in Type Np RMZs. We note that there could be slight differences in the effects analysis between Option 1 and Option 2. However, we have determined that Option 2 represents a reasonable worst-case scenario for analysis and that our conclusion would not be different if we analyzed Option 1.

8.3.3.6 Summary of Scientific Research Regarding the Effects of Nesting Habitat Loss and Habitat Fragmentation to Marbled Murrelets

The loss of old-growth nesting habitat is a well-known factor influencing marbled murrelet populations throughout the murrelet range, and is the primary reason the species was listed as a federally threatened species in 1992 (57 FR 45328). The following summary of the effects of habitat loss is adapted from McShane et al. (2004):

Effects of Habitat Loss to the Distribution and Abundance of Marbled Murrelets

The amount of old-growth forests in Washington, Oregon, and California has been reduced from historic levels by more than 80 percent (U.S. Fish and Wildlife Service 1997a), leaving murrelets with small, isolated stands of older trees for nesting. Murrelets are thought to be sensitive to forest fragmentation (Hansen and Urban 1992), and changes in their distribution and abundance have occurred in association with habitat loss and forest fragmentation (U.S. Fish and Wildlife Service 1997a). For example, murrelets no longer occur in areas without suitable forested habitat (e.g., Marin County in California) (U.S. Fish and Wildlife Service 1997a), and they appear to abandon highly fragmented areas over time (areas highly fragmented before the late 1980s generally did not support murrelets by the early 1990s) (Meyer et al. 2002).

Detections of murrelets at inland sites and densities offshore were found to be higher in or adjacent to areas with large patches of old-growth, and in areas of low fragmentation and isolation of old-growth forest patches (Raphael et al. 1995, 2002a, b; Burger 2002; Meyer and Miller 2002; Meyer et al. 2002; Miller et al. 2002). Similarly, murrelet densities (determined with radar) increased with increasing amounts of suitable habitat, interior old-growth, and proximity of patches within specific watersheds (Burger 2002; Raphael et al. 2002a). In addition, several studies have concluded that murrelets do not "pack" into remaining habitat patches at higher densities when nesting habitat is removed (Burger 2001; Manley et al. 2001; Cullen 2002). Burger (2001) suggests that murrelets appear to abandon heavily logged watersheds rather than nesting at higher densities in remaining habitat patches. In contrast, Zharikov et al. (2006) found that murrelets nesting in a highly fragmented landscape tended to select smaller than average patches of old forest habitat for nesting, and that many successful nests were located in stands that were less than 25 acres in size.

The proximity of occupied habitat patches to other patches of suitable habitat appears to be an important factor in determining the likelihood that an unoccupied habitat patch will be colonized by murrelets. Miller et al. (2002) demonstrated that suitable forest patches > 3 miles (>5 kilometers) from known nesting areas were less likely to be occupied by murrelets, and no occupied patches were more than 6.84 miles (11 kilometers) from other occupied sites.

Effects of Nesting Habitat Loss and Habitat Fragmentation to Marbled Murrelet Reproduction and Nesting Success

Raphael et al. (2002b) reviewed the potential effects of forest fragmentation on marbled murrelets. They suggested that a reduced amount of nesting habitat would have long-term effects on the number of nests and short-term effects on nest success, both of which would affect population size. As with other alcids, adult marbled murrelets are believed to have high site fidelity and return to the same nest site in successive years (Nelson and Peck 1995; Nelson 1997). If their nest site is lost to logging or development, it is suspected that some murrelets will lose breeding opportunities in successive years or not breed again, and others may be displaced (if possible) to nearby or disjunct suitable or marginal habitat (Divoky and Horton 1995; U.S. Fish and Wildlife Service 1997a). However, Zharikov et al. (2006) found that marbled murrelets did not appear to respond to habitat fragmentation by either selecting for larger patches or avoiding recent clearcuts. Additionally, Zharikov et al. (2006) found similar breeding success rates for murrelets nesting in a landscape dominated by large patches of old-growth forest and murrelets nesting in fragmented patches of old-forest habitat.

If murrelets are forced to move into marginal habitat, nesting success could decline over time, leading to low nesting density and small populations (Raphael et al. 2002b). Because marbled murrelets nest solitarily, successful nesting is dependent upon the murrelets' ability to remain hidden at the nest site to avoid predation. A cryptic plumage (both adults and juveniles) and secretive behaviors, such as limiting activity primarily to the low light levels of dawn and dusk, visiting the nest infrequently during chick rearing, and minimizing loud vocalizations from the nest, decrease their chances of being discovered by predators (Nelson and Hamer 1995b, Nelson and Peck 1995, Nelson 1997). As suitable nesting habitat becomes scarce and more isolated, and predator populations increase, remaining hidden at the nest may become increasingly more difficult.

Habitat Fragmentation and Edge Effects to Marbled Murrelet Nesting Success

Murrelets are thought to be highly vulnerable to increased levels of nest predation associated with forest edges (U.S. Fish and Wildlife Service 1997a). While the extent of the effects of fragmentation and edge on murrelet nest success is not known, predation has consistently been the most common cause of nest failure at marbled murrelet nests. Corvids have been implicated as the primary predator of murrelet nests (Nelson and Hamer 1995b; Raphael et al. 2002b) and corvid numbers have increased significantly throughout the west in the last century in response to habitat change and human development (Marzluff et al. 1994).

Early research on the success of marbled murrelet nests with respect to edge showed that successful nests were significantly farther from forest edges than failed nests (Nelson and Hamer 1995b). More recent research demonstrates somewhat mixed results. At active murrelet nests in British Columbia, Washington, Oregon, and California, successful nests were found to be farther from forest edges (x=463 feet [141 meters]) than failed nests (x=184 feet [56 meters]) (Manley and Nelson 1999). Nest success was 38 percent (n=29 nests) within 164 feet (50 meters) of the forest edge and 55 percent (n=29 nests) at distances greater than 164 feet (50 meters) from the edge, but the differences were not statistically different (χ^2=4.55, P > 0.05). Most of these nests failed because of predation (60 percent), and predation was higher within 164 feet (50 meters) of an edge than within the forest interior. No murrelet nests >492 feet (150 meters) from the edge failed because of predation.

The replacement of native forest with small, isolated patches and abundant edge can create changes in microclimate, vegetation species, predator-prey dynamics, and other edge effects. Unfragmented, older-

aged forests have lower daily temperature fluctuations and higher humidity compared to clearcuts and other open areas (Chen et al. 1993; 1995). Edge habitat is also exposed to increased daily fluctuations in temperature and moisture, high evaporative heat loss, and increased exposure to wind. Fundamental changes in the microclimate of a stand have been recorded at least as far as 787 feet (240 meters) from the forest edge (Chen et al. 1995). The changes in microclimate regimes with forest fragmentation could stress a cold-water adapted seabird (Meyer and Miller 2002) and affect the distribution of epiphytes that murrelets use for nesting.

While there are little data on the effects of radiation and thermal stress on murrelets, both chicks and adults have been observed panting when exposed to direct sunlight (Binford et al. 1975). Exposure to increased temperatures could cause heat stress for adults and chicks and eventually cause adults to abandon the site. Likewise, increased winds at the forest edge could trigger cold stress. The effects, however, would vary with aspect, slope, elevation, and topography. Marbled murrelets do not build nests. Instead, they utilize pre-existing structural tree branch formations and lay their single egg on epiphytes or other substrate covering a large tree limb. Branch epiphytes or substrate have been identified as a key component of murrelet nests (Nelson et al. 2003). The substrate is important for insulating the egg and protecting it from falling. While there are no data on the specific effects of microclimate changes on the availability of murrelet nesting habitat at the branch and tree scales, the penetration of solar radiation, wind, and warm temperatures into the forest could change the distribution of epiphytes or blow moss off nesting platforms. In some portions of their range, murrelets may not nest in areas that lack epiphytes, such as along forest edges or in areas of extreme temperature (Hunter et al. 1998).

8.3.3.7 Risk of Injury or Mortality to Marbled Murrelets from Timber Harvest

Timber-harvest activities can result in direct mortality of adults, eggs, or young. The potential risk for marbled murrelets to be struck and killed or injured by falling trees during timber harvest is highest in the area close to the nest tree. During timber harvest, adult murrelets delivering food to the nest could reasonably be expected to fly away from the area and avoid injury. However, murrelet eggs, chicks, or incubating adults would be killed if their nest tree is felled. These kinds of lethal effects are only likely during the breeding season and then only if breeding activities are underway. Under the Washington Forest Practice Rules, protocol surveys are required to determine murrelet occupancy in murrelet detection areas and in suitable habitat patches with a high probability of occupancy. Documented, occupied sites are then protected from timber harvest, so the likelihood of direct mortality is substantially reduced in surveyed areas.

There are a variety of factors that affect the ability of observers to detect murrelets at inland sites, including weather, daily variation in detection rates, season, conditions at the survey site (tree canopy closure, amount of visible sky), and distance from marine foraging locations (O'Donnell 1995; Baldwin 2002). The error in classifying sites as unoccupied when they were indeed occupied (false negative) is estimated to approach 15.5 percent for surveys conducted prior to 1998. This rate of misclassification of occupied sites in the earlier period of surveys may have led to the loss of an unknown number of breeding sites. The survey protocol has been updated several times, with the most recent version published in 2003 (Evans Mack et al. 2003). The Washington Forest Practices Board has adopted the 2003 survey protocol (WAC-222-12-090(14)) which requires additional site visits compared to earlier versions of the protocol. The current error rate for the 2003 protocol is estimated to be 4.2 percent, indicating substantial improvement over earlier survey methods (McShane et al. 2004).

8.3.3.8 Effects to Marbled Murrelet Habitat Associated with the FPHCP Riparian Management Zones

The RMZs will be managed to retain the largest trees that are immediately adjacent to streams, rivers, and shorelines. Currently, only about 5-10 percent of riparian zones in western Washington contain mature conifer habitat, but less than 5 percent contain old-forest structure suitable for marbled murrelets. Over time, as early and mid-seral riparian areas mature, large trees capable of developing murrelet nest platforms in the FPHCP RMZs will increase, ultimately increasing the amount of potential marbled murrelet nesting habitat located in the RMZs.

In most areas, the time required for early- or mid-seral forests to mature into suitable murrelet habitat will likely be 100 to 200 years. However, riparian stands that are currently 60 to 80 years of age could develop some murrelet habitat over the next 50 years, particularly in the coastal zones where western hemlock is prevalent (Hamer and Meekins 1999). The development of large trees in the RMZs may provide some minor benefits to marbled murrelets over the long-term by increasing the amount of potential nesting habitat available on FPHCP covered lands. However, these narrow, linear-strips of riparian trees would have limited value as marbled murrelet habitat, because marbled murrelets generally select large patches of mature and old-forest habitat for nesting. Timber on the FPHCP covered lands is generally managed on a 40-80 year harvest rotation, so the development of large patches of mature or old-forest habitat is not likely to occur in most locations on the FPHCP covered lands. Exceptions include special areas that are protected for occupied marbled murrelet sites, spotted owl habitat, or high-hazard slope areas.

About 5 percent of RMZs on FPHCP covered lands contain potential murrelet nesting habitat, but relatively few of these acres are associated with known occupied sites. Therefore it is likely that murrelet habitat that is not associated with known occupied sites could be removed by timber harvest in RMZs. The stand-replacing timber harvest that is likely to occur in the Outer Zones of Type S or Type F RMZs represents a long-term loss of potential murrelet nesting habitat that would have otherwise have been available for potential use by nesting murrelets colonizing those RMZs. Stand replacing timber harvest in Inner Zones under Option 2, or in the harvested portions of RMZs along Type Np waters also represent a long-term loss of potential nesting habitat. The loss of unoccupied potential nesting habitat within RMZs on the FPHCP covered lands would adversely affect the marbled murrelet by reducing the total amount of potential nesting habitat that is available for marbled murrelet nesting, and by increasing the fragmentation of remaining habitat patches.

The potential murrelet nesting habitat that remains in the protected Core and Inner Zone areas will be reduced to narrow strips that vary in width from 80 to 100 feet-wide along either side of Type S or Type F waters, and strips of 50 feet-wide along either side of 50 percent of the length of Type Np waters. Although the habitat that remains in these retention areas may contain trees with suitable marbled murrelet nesting platforms, these narrow strips of riparian trees will be exposed to edge effects – particularly increased risk of windthrow and increased exposure to avian predators.

Grizzel and Wolff (1998) studied riparian buffer strips on small streams in northwestern Washington and reported that about 33 percent of buffer trees were affected by windthrow. In a study by Rollerson and McGourlick (2001), riparian windthrow averaged about 21 percent of the standing timber along stream edges. They noted there were a large number of plots with only a minor amount of windthrow and conversely only a limited number of areas with substantial amounts of windthrow. The average distance of penetration into standing timber was about 40 feet (12 meters). They also noted that buffers exposed on both sides were more vulnerable and that “feathered edges” had lower amounts of windthrow. The

potential effects of windthrow in RMZs are highly variable and dependant on many site-specific factors. There are no reliable methods to estimate or quantify the effects that windthrow may have to potential murrelet habitat at the scale of the FPHCP. However, it is likely that murrelet habitat retained in the protected portions of RMZs will be degraded by the loss of trees with potential nesting platforms, and the loss of trees that provide cover to trees with platforms. In catastrophic wind events, all trees left in an RMZ could be lost to windthrow, but this will likely be uncommon.

The trees retained in RMZs will continue to provide potential nesting habitat for marbled murrelets, but suitable habitat in these areas will be marginal for murrelets due to small patch sizes and loss of interior forest conditions. Research by Nelson and Hamer (1995b), and Manley and Nelson (1999) indicates that murrelets nesting along edges have a higher risk of predation and lower nest success than murrelets nesting in interior forest patches (greater than 164 feet from an edge). Suitable habitat retained in the RMZs will be available for potential colonization by nesting murrelets, but due to higher risks of predation and nest failure, these areas will have limited value as nesting habitat for up to 40 years until the regeneration of adjacent stands is advanced enough to minimize the edge effects associated with stand-replacing harvest in the Outer Zones.

Occupied murrelet sites are protected from edge effects by the Washington Forest Practices Rules that prohibit clearcut timber harvesting within 300-foot “managed buffer zones” surrounding occupied suitable murrelet sites (WAC 222-16-080(j)(v)). The potential for disturbance to nesting marbled murrelets is minimized by the Washington Forest Practices Rules that prohibit forest practices within 0.25 miles of occupied murrelet sites during the daily peak activity periods in the critical nesting season (WAC 222-30-050, -060,-065, -070, -100).

8.3.3.9 Effects of RMZ Management in Marbled Murrelet Conservation Zone 1

In Conservation Zone 1 (Puget Sound), there are over 2.9 million acres of FPHCP covered lands (Table 8-27). The environmental baseline analysis indicates that there was approximately 272,000 acres of stand-replacing timber harvest on the FPHCP covered lands in Zone 1 from 1992 to 2002 (Table 8-31). This equates to a harvest rate of 9 percent per decade on the FPHCP covered lands. For this analysis, we are assuming that this rate of harvest will continue into the future. The RMZs in Zone 1 make up about 11 percent of the FPHCP covered lands (323,100 acres) (Table 8-29). Assuming that about 272,000 acres will be harvested per decade, we estimate that about 11 percent (≈ 30,000 acres) of these acres will include managed RMZs.

About 8 percent of the estimated acres in RMZs in Zone 1 contain potential marbled murrelet nesting habitat (24,400 acres) (Table 8-29). Based on the overall percentage of potential habitat in RMZs, we expect that about 2,400 acres of unoccupied potential murrelet nesting habitat could be affected by forest practices in RMZs per decade (i.e., 8 percent of 30,000 acres = 2,400 acres). Of the 2,400 acres of potential habitat affected, 52 percent (1,240 acres) would be directly affected (i.e., removed) by stand-replacing timber harvest (Table 8-33). Approximately 48 percent (1,160 acres) of the potential habitat acres would be retained in protected Core Zones and the unharvested portions of Inner Zones. These acres would continue to provide potential murrelet habitat, but the quality of the habitat would be degraded by the indirect effects associated with reduced patch size, edge effects, and the increased risk of windthrow.

Table 8-33. Estimated acres of marbled murrelet (MAMU) habitat affected per decade by forest practice activities in RMZs in marbled murrelet Conservation Zone 1 (Puget Sound).

RMZ Type	Total RMZ acres managed per year (acres)	MAMU habitat acres retained in protected portions of RMZs (acres)	MAMU habitat acres removed by timber harvest in RMZs (acres)	Total MAMU habitat acres affected in RMZs (8 percent)
Type S or F (83 percent of RMZ acres)	24,900 acres	1,090 acres (55 %)	900 acres (45 %)	1,990 acres
Type Np (17 percent of RMZ acres)	5,100 acres	70 acres (16 %)	340 acres (84 %)	410 acres
Totals	30,000 acres	1,160 acres (48 %)	1,240 acres (52%)	2,400 acres.

Notes: All figures are approximate values derived from GIS data. Area estimates for RMZs along different water types are from Table 8-29. Marbled murrelet habitat estimates represent approximate conditions in 2003, as depicted by Raphael et al. (2005) map data, Expert Judgment Model Class 3 and Class 4, and account for stand-replacing timber harvest and fire losses that occurred from 1992 to 2002 (Healey et al. 2003). Riparian area estimates for RMZ widths along Type S, F, and Np stream types are based on the average 100-year site-potential tree height for site index 2 and 3.

Over the 50-year life of the FPHCP, a total of approximately 6,200 acres of unoccupied potential murrelet habitat would be directly affected (i.e., removed) by stand-replacing timber harvest in RMZs. Approximately 5,800 acres of potential murrelet habitat would be protected in Core Zones, but these acres would be degraded by the indirect effects associated with habitat fragmentation and edge effects. Edge effects are likely to persist in affected areas for at least 30 to 40 years following RMZ harvest before adjacent regeneration growth will ameliorate these effects. Overall, murrelet habitat in the RMZs will be reduced from the current levels of about 24,400 acres to 18,200 acres, a loss of about 25 percent.

There are currently about 2,500 acres of potential marbled murrelet nesting habitat in RMZs that are associated with occupied murrelet sites. This represents about 10 percent of the total murrelet habitat in RMZs. We expect that these acres will be protected from timber harvest throughout the 50-year life of the FPHCP.

We have no reliable way of estimating how much murrelet habitat could be recruited in the RMZs over the next 50 years due to forest growth and maturation. Our analysis of the western Washington RMZs indicated that about 5 percent of the RMZs are in mature conifer habitat that is not yet suitable as murrelet habitat. If we assume that about 1 percent of the RMZ acres would develop old-forest characteristics (i.e., mistletoe infections, etc.), we could expect a recruitment of perhaps 3,000 acres of murrelet habitat within 50 years in the RMZs in Conservation Zone 1.

8.3.3.10 Effects of RMZ Management in Marbled Murrelet Conservation Zone 2

In Conservation Zone 2 (Pacific Coast), there are over 2.5 million acres of FPHCP covered lands (Table 8-27). The environmental baseline analysis indicates that there was approximately 391,000 acres of stand-replacing timber harvest on the FPHCP covered lands in Zone 2 from 1992 to 2002 (Table 8-31). This equates to a harvest rate of 15 percent per decade on the FPHCP covered lands. For this analysis, we are assuming that this rate of harvest will continue into the future. The RMZs in Zone 2 comprise about 16 percent (407,700 acres) of the FPHCP covered lands (Table 8-29). Assuming that about 391,100 acres will be harvested per decade, we estimate that about 16 percent (≈ 62,000 acres) of these acres will include managed RMZs.

About 3 percent of the estimated acres in RMZs in Zone 2 contain potential marbled murrelet nesting habitat (11,800 acres) (Table 8-29). Based on the overall percentage of potential habitat in RMZs, we estimate that about 1,860 acres of unoccupied potential murrelet nesting habitat could be affected by forest practices in RMZs per decade (i.e., 3 percent of 62,000 acres = 1,860 acres). Of the 1,860 acres of potential habitat affected, 52 percent (960 acres) would be directly affected (i.e., removed) by stand-replacing timber harvest (Table 8-34).

Table 8-34. Estimated acres of marbled murrelet (MAMU) habitat affected per decade by forest practice activities in RMZs in Conservation Zone 2**.**

RMZ Type	Total RMZ acres managed per year	MAMU habitat acres retained in protected portions of RMZs	MAMU habitat acres removed by timber harvest in RMZs	Total MAMU habitat acres affected in RMZs (3 percent)
Type S or F (83 percent)	51,500 acres	850 acres (55 %)	700 acres (45 %)	1,550 acres
Type Np (17 percent)	10,500 acres	50 acres (16 %)	260 acres (84 %)	310 acres
Totals	62,000 acres	900 acres (48 %)	960 acres (52%)	1,860 acres

Notes: All figures are approximate values derived from GIS data. Area estimates for RMZs along different water types are from Table 8-29. Marbled murrelet habitat estimates represent approximate conditions in 2003, as depicted by Raphael et al. (2005) map data, Expert Judgment Model Class 3 and Class 4, and account for stand-replacing timber harvest and fire losses that occurred from 1992 to 2002 (Healey et al. 2003). Riparian area estimates for RMZ widths along Type S, F, and Np stream types based on the average 100-year site-potential tree height for site index 2 and 3.

Approximately 48 percent (900 acres) of the potential habitat acres affected would be retained in protected Core Zones and the unharvested portions of Inner Zones (Table 8-34). These acres would continue to provide potential murrelet habitat, but the quality of the habitat would be degraded by the indirect effects associated with reduced patch size, edge effects, and the increased risk of windthrow.

There are currently about 2,500 acres of potential marbled murrelet nesting habitat in RMZs that are associated with occupied murrelet sites. This represents about 21 percent of the total habitat acres in RMZs. We expect that these acres will be protected from harvest through the life of the FPHCP.

We have no reliable way of estimating how much murrelet habitat could be recruited in the RMZs over the next 50 years due to forest growth and maturation. Our analysis of the western Washington RMZs indicated that about 5 percent of the RMZs are in mature conifer habitat that is not yet suitable as murrelet habitat. If we assume that about 1 percent of the RMZ acres would eventually develop old-forest characteristics (i.e., mistletoe infections, etc.), we could expect a recruitment of perhaps 4,000 acres of murrelet habitat within 50 years in the RMZs in Conservation Zone 2.

8.3.3.11 Summary of the Effects of RMZ Management to Marbled Murrelet Habitat

Considering both Zone 1 and Zone 2 combined, we estimate that approximately 92,000 acres of RMZs would be managed per decade, resulting in a potential loss of 2,200 acres of unoccupied murrelet nesting habitat in RMZs per decade. Over the next 50 years, a total of approximately 11,000 acres of unoccupied potential murrelet nesting habitat could be removed by stand-replacing timber harvest in the RMZs. These effects would be distributed across over 730,000 acres of RMZs from the Olympic Peninsula to the western Cascades, which in turn are distributed across 5.4 million acres of FPHCP covered lands over a period of 50 years.

We do not anticipate that murrelets would be directly killed or displaced from potential nesting habitat in RMZs on the FPHCP covered lands. Because there would be no loss of occupied habitat, and no adverse affects to individual murrelets, there would be no effect to the current distribution or survival of murrelet populations in Zone 1 or Zone 2.

We estimated that the amount of unoccupied potential nesting habitat that would be exposed to edge effects associated with RMZs would be approximately 2,060 acres per decade across both conservation zones, with a total of up to 10,300 acres of potential habitat exposed to edge effects over 50 years. Murrelets have a low nesting success rate, and nests that are located in edge habitats are presumed to be at greater risk to predation. RMZ management will create exposed edge habitats along protected Core and Inner Zone areas, but these effects would occur only in areas that are determined to be unoccupied by murrelets. Due to the widely distributed effects associated with timber harvest in RMZs, we do not anticipate that the risks to murrelet nesting success or predation rates associated with edge habitats will change on FPHCP covered lands.

As early- and mid-seral stands mature over time, the total amount of mature conifer habitat in the RMZs will increase, but relatively few acres are likely to develop the characteristics of suitable murrelet nesting habitat. We estimate that perhaps 1 percent (e.g., 7,000 acres) of the total RMZ acres could develop the characteristics of murrelet habitat within the next 50 years.

8.3.3.12 Effects of Disturbance to Nesting Marbled Murrelets Associated with Forest Practices Activities

Road building, maintenance, and repair; timber harvesting; and timber hauling require the use of heavy equipment, chainsaws, and large vehicles, all of which introduce an increased level of sound into the environment. The Washington Forest Practices Board recognized that noise disturbance might disrupt marbled murrelet breeding behavior; therefore, the Board adopted rules to protect marbled murrelets from disturbance by imposing an operating restriction during the daily peak activity periods within the murrelet critical nesting season (April 1 through August 31) (Washington Forest Practices Board 1996). The daily peak activity period for murrelets (as defined at WAC 222-16-010) is one hour before official sunrise to two hours after official sunrise and one hour before official sunset to one hour after sunset. Restricted activities include road construction, operation of heavy equipment, blasting, timber felling, yarding, helicopter operations, and slash disposal or prescribed burning. These activities are prohibited within 0.25 miles of occupied marbled murrelet sites during the daily peak activity periods within the critical nesting season (WACs 222-24-030 and 222-30-050, -060, -065, -070, -100).

We completed an analysis of the potential for injury associated with disturbance (visual and sound) to marbled murrelets (U.S. Fish and Wildlife Service 2003). In this analysis, we concluded that behaviors indicating potential injury to marbled murrelets are: flushing from the nest, aborted feeding, and postponed feeding. These disturbance responses could lead to an increased risk of egg or chick mortality at the nest site. Reduced feedings of the chick at the nest may increase the risk of fledging mortality as they attempt to reach the ocean. During the incubation and brooding periods, we concluded that activities that generate loud noises within certain threshold distances may cause a disturbance response resulting in potential injury to murrelets. The potential injury threshold distances are based on anecdotal observations documented by murrelet researchers of murrelet flush responses to the presence of people, loud sounds, etc. (U.S. Fish and Wildlife Service 2003). Based on these observations of nesting murrelets, we determined the potential injury threshold distance for chainsaws falling trees is 45 yards, and the threshold distance for heavy equipment (e.g., excavators) is 35 yards. The FWS notes that scientific data

related to injury threshold distances associated with sound and visual disturbance is limited, and we continue to collect pertinent data related to the issue.

Because the 0.25-mile buffer restriction for occupied murrelet sites is substantially larger than the distances where we anticipate marbled murrelets are at risk to potential injury from disturbance, we expect that the existing Washington Forest Practice Rules will protect most nesting murrelets associated with known occupied sites. One exception is blasting. We consider blasting within 1 mile of occupied murrelet habitat during the early nesting season (April 1st to August 5) to be an activity that may result in potential injury to marbled murrelets. However, we do not have decibel data for blasting on which to determine potential injury threshold distances for these activities. For blasting with charges of 2 pounds or larger, we continue to use the conventional 1-mile potential injury threshold distances due to lack of decibel information to more accurately address these distances (U.S. Fish and Wildlife Service 2003).

The murrelet breeding and fledging period is asynchronous and spread over a prolonged season. Egg laying and incubation occur from April to early August and chick rearing occurs between late May and late August, with all chicks fledging by early September (Hamer et al. 2003). In Washington, Hamer et al. (2003) found that 100 percent of murrelets fledged by August 27, but cautioned that this was based on a small sample of observations. Hamer et al. (2003) suggest that the breeding season in Washington is probably similar to the breeding season in British Columbia, which extends into mid-September. Based on these data, we assume that the nesting season for murrelets in Washington is April 1 to September 15. This varies from the critical nesting season defined by the Washington Forest Practices Rules (April 1 to August 31) by 15 days. Based on the data presented by Hamer et al. (2003), we assume that over 99 percent of murrelet chicks have fledged by August 31. However, there may be a few individuals that do not fledge until mid-September. These individuals could be exposed to potential injury from missed or postponed feedings due to disturbance associated with forest practice activities, because the Washington Forest Practices Rules do not prohibit forest practices adjacent to occupied murrelet sites after August 31.

Adult murrelets typically incubate for a 24-hour period, then exchange duties with their mate at dawn. Hatchlings appear to be brooded by an adult for 1-2 days and are then left alone at the nest for the remainder of the rearing period, except during feedings. Both parents feed the chick, which receives 1-8 meals per day (Nelson 1997). Most meals are delivered early in the morning, while about a third are delivered at dusk and a few meals are sometimes scattered throughout the day (Nelson and Hamer 1995a). Based on the data presented by Nelson and Hamer (1995a), approximately 80 percent of the feedings occur during the daily peak activity periods defined by the Washington Forest Practices Rules (Washington Forest Practices Board 1996). Approximately 20 percent of feedings occur during the day, when forest practice activities are not restricted, so there is a potential for some missed or post-poned feedings during the unrestricted hours (Washington Forest Practices Board 1996).

Based on the information presented above, we expect that some sound and activity- related disturbances to nesting murrelets may occur on the FPHCP covered lands, but the risk for potential injury to murrelets is low due to the 0.25-mile disturbance buffers and daily activity restrictions required by the Washington Forest Practices Rules. The Washington Forest Practices Rules minimize the potential for adverse effects from disturbance associated with forest practices to nesting murrelets, but they do not ensure that all murrelets will be protected from disturbance under all circumstances. Blasting within a mile of an occupied murrelet site, unrestricted activities during the mid-day hours, and forest practices during the late nesting season (September) are all situations which may result in murrelets flushing from a nest, aborted feedings, or postponed feedings.

Forest practice activities that occur adjacent to suitable murrelet habitat on Federal lands may also result in disturbances to nesting marbled murrelets. Most of the suitable murrelet habitat that occurs on Federal lands has not been surveyed to determine murrelet occupancy. The Washington Forest Practices Rules that minimize disturbance to murrelets only apply in locations where surveys have documented an occupied murrelet site. For example, timber harvesting in second-growth (non-habitat) that borders suitable murrelet habitat on Federal lands would not be restricted unless the Federal land habitat contained a known, occupied site. Because most suitable murrelet habitat on Federal lands has not been surveyed for murrelets, the Washington Forest Practices Rules that apply to occupied murrelet sites do not apply to unsurveyed habitat on Federal lands. Non-Federal landowners are not required to survey adjacent ownerships for murrelets, therefore it is likely that forest practices activities that occur along Federal land boundaries could result in potential injury disturbance to murrelets. For the purposes of this analysis, we expect that WDNR will identify suitable murrelet habitat along Federal or State boundary areas through the SEPA review process, and apply the murrelet critical nesting season and managed buffer rules to areas where forest practices activities could result in adverse effects to murrelets on adjacent lands.

8.3.3.13 Effects of Forest Road Management to Marbled Murrelets

Under the FPHCP, forest roads will be managed over time to reduce road-related effects to the aquatic environment and to improve fish passage at road-stream crossings. In western Washington, there are over 45,000 miles of roads on the FPHCP covered lands, and over 14,000 crossings on Type F streams. Many of these roads will be decommissioned over time, and other roads may be constructed to avoid riparian areas or high-hazard soils areas. Many existing stream crossings on fish-bearing streams will be replaced and upgraded to provide fish passage for all life stages of fish. We did not analyze how many roads or stream crossings occur in marbled murrelet suitable habitat. However, about 4 percent of the FPHCP covered lands within the range of the marbled murrelet contain potential murrelet nesting habitat, so it is not unreasonable to expect that about 4 percent of roads and stream crossings on FPHCP covered lands could occur in or adjacent to potential marbled murrelet habitat. Under the Washington Forest Practices Rules, road construction in occupied murrelet sites, a murrelet detection area, or in suitable habitat with a high-probability of occupancy that occurs outside of murrelet detection areas are considered Class-IV special activities.

The effects of roads to marbled murrelets include the long-term loss of potential nesting habitat that would have otherwise been available for murrelet nesting; edge effects associated with road corridors, particularly the increased risk of avian predation on murrelet nests; and the potential for noise disturbance to nesting individuals associated with logging trucks, vehicle traffic, or other heavy equipment. Minor habitat losses associated with hazard tree removal and/or culvert/bridge replacement projects may also occur. When culverts are replaced, it is sometimes necessary to clear trees adjacent to the stream crossing, thus creating a larger gap in the forest canopy. These types of habitat effects are generally minor due to the low risk that murrelets would be nesting in these areas. Although the risk to murrelets is low in these areas, adverse effects associated with the loss of individual trees with nest platforms could occur. However, the loss of a few individual roadside trees usually does not pose a substantial risk to murrelets unless the habitat loss occurs during the nesting season in unsurveyed suitable habitat (e.g., there is a risk of cutting down a potential nest tree that is occupied). The greatest risk to marbled murrelets associated with road management is the edge effects associated with road corridors, particularly the increased risk of avian predation on murrelets nests.

We have no reliable way of quantifying the amount of potential disturbance to murrelets associated with road-related activities on the FPHCP covered lands. To do so would require an assumption regarding the density of nesting marbled murrelets per acre of suitable habitat, and we have no data to support such assumptions at the scale of the FPHCP covered lands. In general, we expect that the existing Washington Forest Practices Rules which prohibit timber harvesting and road construction in occupied murrelet sites, and restrict forest practice activities within 0.25 miles of occupied murrelet sites will minimize disturbance effects to over 99 percent of the potential nesting/fledging murrelets on the FPHCP covered lands.

8.3.3.14 Effects to Federally Designated Marbled Murrelet Critical Habitat

The effects analysis for the marbled murrelet includes only those effects that would be expected to occur as a result permit issuance, such as effects of timber-harvest activities in the Riparian Zone (of influence) and road-related activities. We do not anticipate any direct effects associated with the loss of suitable murrelet habitat due to timber harvesting in RMZs or road construction in designated critical habitat. There are approximately 2,500 acres designated critical habitat that occur on private lands, including about 2,300 acres on the FPCHP covered lands. Under the Washington Forest Practices Rules, federally designated critical habitat on non-Federal lands is managed under the provisions of the State's marbled murrelet rule (WAC 222-16-080(2)). The designated private lands occur primarily in coastal Zone 2, in southwest Washington. All of the private lands that are within designated critical habitat occur within the 1.5-mile radius circles surrounding status 1-3 occupied murrelet sites. Therefore, all occupied murrelet habitat within these non-Federal Critical Habitat Units is protected under the existing Washington Forest Practices Rules for occupied marbled murrelet sites.

We anticipate that some edge effects to designated critical habitat on Federal lands are likely to occur. These effects are associated with timber harvest practices in upland areas. Therefore, these activities and their effects to marbled murrelet critical habitat are not analyzed in this section, but will be addressed in the analysis of cumulative effects.

8.3.4 CUMULATIVE EFFECTS – Marbled Murrelet and Marbled Murrelet Critical Habitat

Cumulative effects include the effects of future State, Tribal, local, or private actions that are reasonably certain to occur in the action area considered in this Opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to ESA section 7.

8.3.4.1 Cumulative Effects to Marbled Murrelets

The cumulative effects analysis for the marbled murrelet and its designated critical habitat include the effects of activities that are not directly associated with permit issuance, such as the effects of future timber harvest activities in upland areas. These activities are essentially unchanged by the issuance of the FPHCP permit, and will occur regardless of permit issuance.

In the range of the marbled murrelet, there are over 5.4 million acres of private lands. Only about 13 percent of these lands are located in the RMZs. The other 4.7 million acres of private lands are upland areas that are expected to be managed on a 40 to 80-year harvest rotation. Active management in RMZs is not likely to occur without some harvest activities occurring in the adjacent uplands.

As summarized in the environmental baseline section, marbled murrelet habitat on private lands is managed under specific standards. Approved HCPs that include marbled murrelets would have unique conservation measures for murrelets specific to that HCP. However, most private forestlands would fall under the Washington Forest Practices Rules. Under these rules, marbled murrelet habitat is managed depending on whether or not the habitat occurs within an occupied marbled murrelet site or in a marbled murrelet detection area. Suitable murrelet habitat that occurs in occupied murrelet sites is protected from timber harvest. In marbled murrelet detection areas all suitable murrelet habitat that meets the minimum stand definitions (i.e., ≥ 7 acres, with ≥ 2 nest platforms/acre) requires a protocol survey prior to harvest to determine murrelet occupancy. Outside murrelet detection areas, only habitat that has a high probability of murrelet occupancy (i.e., ≥ 5-7 nest platforms/acre, depending on the location) is required to be surveyed prior to harvest. In the absence of a federally-approved HCP or a State-approved special wildlife management plan, suitable murrelet habitat on non-Federal lands is only protected if protocol surveys document an occupied murrelet site. Suitable habitat outside of occupied sites that is determined to be unoccupied may be harvested. Outside murrelet detection areas, suitable habitat that has a lower probability of occupancy (i.e., ≤ 5-7 platforms/acre) is not protected on non-Federal lands and potential habitat that is located beyond 50 miles from marine waters is not protected. Additionally, landowners who own less than 500 acres are exempted from these particular Washington Forest Practices Rules unless their lands contain an occupied murrelet site. However, the prohibitions against "take" in section 9 of the ESA still apply in all of these situations.

Cumulative Effects to Marbled Murrelet Habitat in Conservation Zone 1

The environmental baseline analysis indicates there is over 1 million acres of potential marbled murrelet nesting habitat in Zone 1. About 68 percent (727,700 acres) is located on Federal lands, and 32 percent is located on non-Federal lands. Approximately 16 percent of the potential habitat (172,700 acres) in Zone 1 is located on private lands, while the other 16 percent is located primarily on State lands, managed under WDNR HCP for State lands (WDNR 1997c).

There are approximately 2.9 million acres of private lands in Zone 1, distributed across a large landscape that encompasses portions of the Olympic Peninsula, the Puget Trough lowlands, and the western Cascades. The majority of the private lands (94 percent) in Zone 1 contain second-growth forests that are not suitable for murrelet nesting habitat. Potential murrelet habitat that does occur on the private lands is highly fragmented and occurs in small, isolated patches. Of the 172,700 acres of potential murrelet habitat on private lands, about 17 percent (29,200 acres) is located in murrelet detection areas, and about 8 percent (14,300 acres) is associated with the status 1-3 occupied site buffers. Due to the high level overlap between occupied site buffers and detection areas, we estimate that about 31,000 acres of the potential murrelet habitat is associated with murrelet detection areas or occupied sites (18 percent). Due to the requirement for pre-harvest surveys in all stands that meet minimum suitable habitat criteria, we expect that occupied stands in murrelet detections areas are likely to be documented and protected as occupied marbled murrelet sites.

The other 82 percent (142,000 acres) of potential murrelet habitat on the private lands in Zone 1 is not associated with detection areas or occupied sites, and is therefore at a higher risk of harvest. Only stands that have a high probability of murrelet occupancy (i.e., ≥ 7 platforms/acre) are protected with a pre-harvest survey requirement. We have no way of determining the number of nesting platforms per acre from the existing GIS maps, but we expect that relatively few locations on the private lands outside of detection areas will meet this criteria. For example, there are over 148,000 acres of potential murrelet nesting habitat in the Puget Trough lowlands of Zone 1 (all ownerships), yet there are only 2 occupied

sites documented in this region. Of the 9,351 murrelet observations documented in Zone 1, only 35 (0.03 percent) are located in the Puget Trough lowlands, indicating a low occurrence of murrelets in this area. This observation is likely biased by the lack of survey effort in the Puget lowlands, but it is also likely an indicator of the highly fragmented and/or marginal quality of potential habitat in this region.

Other areas, such as the west slope of the north Cascades, have many patches of potential habitat that are not currently associated with known detection areas or occupied sites. Due to their proximity to marine waters and proximity to adjacent detection areas, many of these locations may support nesting murrelets, but have not yet been surveyed to determine occupancy. Potential nest habitat that has less than 7 nesting platforms per acre could support nesting murrelets in these areas. Whether or not these areas will be surveyed prior to harvest is unknown, but there is a risk that occupied murrelet habitat outside of detection areas could be harvested.

Another area of concern is the inland zone, beyond 50 miles from marine waters, since potential habitat in this area is not protected by the Washington Forest Practices Rules. Few murrelets have been documented this far from marine waters, but occasional sightings have been reported. Of the 4,922 status 1-3 sites documented in Washington, only 1 site is located farther than 50 miles from marine waters. This particular site is located on Federal lands. Although there is substantial habitat on Federal lands beyond 50 miles from marine waters, there are relatively few acres on private lands. We estimated there were 800 acres of potential habitat on private lands located 50 to 55 miles from marine waters, and half of these acres were located east of the Cascade crest, so we expect that the risk of harvesting occupied habitat on private lands in these areas is low. We have not identified these far inland areas as important for recovery (U.S. Fish and Wildlife Service 1997a). The majority of suitable murrelet habitat that occurs beyond 50 miles from marine waters is located on Federal lands and is protected by the standards and guidelines for land management under the Northwest Forest Plan.

The environmental analysis for Zone 1 indicates that over 40,000 acres of potential marbled murrelet nesting habitat was harvested between 1992 and 2002 on all ownerships, representing a decadal loss of about 3.6 percent. Timber harvest on private lands accounted for about 75 percent of the total habitat acres removed (30,000 acres). Harvest on Federal, tribal, or other HCP-covered lands accounted for the remaining 25 percent of habitat loss. Timber harvest on the private lands removed about 15 percent of the potential murrelet habitat that was present in 1992-1996. These data suggest that potential murrelet habitat on the private lands has been harvested at a rate of about 3,000 acres per year, or a rate of about 1.5 percent annually. It is unlikely that future rates of habitat loss due to timber harvest on the FPHCP covered lands would be as high as rates documented for the period 1992-2002. The first 3 years of that period (1992-1995) preceded implementation of the marbled murrelet habitat rules under the 1996 Washington Forest Practices Rules. Following rule implementation (July 1, 1996), landowners proceeded to harvest finite amounts of older habitat as permitted by the rules. Opportunities for harvesting marbled murrelet habitat have steadily diminished as more and more of the habitat available for harvest under the 1996 rules has been depleted. Opportunities were further diminished in 2001, when new restrictions were placed on timber harvest on unstable slopes, groundwater recharge areas of glacial deep-seated landslides, channel migration zones, and other areas.

Cumulative Effects to Marbled Murrelet Habitat in Conservation Zone 2

The environmental baseline analysis indicates that there is over 497,000 acres of potential marbled murrelet nesting habitat in Zone 2. About 67 percent (332,400 acres) is located on Federal lands, and 33 percent is located on non-Federal lands. Approximately 14 percent of the potential habitat (69,400 acres)

in Zone 2 is located on the private lands, while the other 19 percent is located primarily on State lands, managed under the WDNR HCP for spotted owls and marbled murrelets (WDNR 1997c).

There are over 2.5 million acres of private lands in Zone 2, distributed across a large landscape that encompasses portions of the western Olympic Peninsula, southwest Washington, the Puget Trough lowlands, and the western Cascades. The majority of the private lands (97 percent) in Zone 2 contain second-growth forests that are not suitable for murrelet nesting habitat. Potential murrelet habitat that does occur on the private lands is highly fragmented and occurs in small, isolated patches. Of the 69,400 acres of potential murrelet habitat on the private lands, about 27 percent (18,650 acres) is located in murrelet detection areas, and about 16 percent (11,400 acres) is associated with the status 1-3 occupied site buffers. Due to the high level overlap between occupied site buffers and detection areas, we estimate that about 20,000 acres of the potential murrelet habitat is associated with murrelet detection areas or occupied sites (29 percent). Due to the requirement for pre-harvest surveys in all stands that meet minimum suitable habitat criteria, we expect that occupied stands in detections areas are likely to be documented and protected as occupied marbled murrelet sites.

The other 71 percent (49,000 acres) of potential murrelet habitat on the private lands in Zone 2 is not associated with detection areas or occupied sites, and is therefore at a higher risk of harvest. Only stands that have a high probability of murrelet occupancy are protected with a pre-harvest survey requirement. Suitable murrelet habitat with a high probability of occupancy is defined as having ≥ 5 platforms/acre in the southwest Washington marbled murrelet special landscape (WAC 222-16-087), and/or ≥ 7 platforms/acre elsewhere. We have no way of determining the number of nesting platforms per acre from the existing GIS maps, but we expect that relatively few locations on the private lands outside of existing detection areas will meet this criteria. For example, there are over 35,000 acres of potential murrelet nesting habitat in the Puget Trough lowlands of Zone 2 that occur inland from the southwest Washington special landscape area (all ownerships), yet there are no occupied sites documented in this region. Of the 20,791 murrelet observations documented in Zone 2, only 4 are located in the Puget Trough lowlands, indicating a low occurrence of murrelets in this area. This observation is likely biased by a lack of survey effort in the Puget lowlands, but is also likely an indicator of the highly fragmented and/or marginal quality of habitat in this region.

Other areas, such as the southwest Washington marbled murrelet special landscape, or the northwest Olympic Peninsula, have many patches of potential habitat that are not currently associated with known detection areas or occupied sites. Due to their proximity to marine waters and proximity to adjacent detection areas, many of these locations may support nesting murrelets, but have not yet been surveyed to determine occupancy. Potential nest habitat that has less than 5 nesting platforms per acre could be supporting nesting murrelets in these areas. Whether or not these areas will be surveyed prior to harvest is unknown, but there is a risk that occupied murrelet habitat outside of detection areas could be harvested.

The environmental baseline analysis for Zone 2 indicates that over 25,000 acres of potential marbled murrelet nesting habitat was harvested between 1992 and 2002 on all ownerships, representing a decadal loss of about 4.8 percent. Timber harvest on the private lands accounted for about 87 percent of the total habitat acres removed (21,800 acres). Harvest on Federal, tribal, or other HCP-covered lands accounted for the remaining 13 percent of habitat loss. Timber harvest on the private lands removed about 24 percent of the potential murrelet habitat that was present in 1992-1996. These data suggest that potential habitat on the private lands has been harvested at a rate of about 2,000 acres per year, or a rate of about 2.4 percent annually. It is unlikely that future rates of habitat loss due to timber harvest on the FPHCP

covered lands would be as high as rates documented for the period 1992-2002. The first 3 years of that period (1992-1995) preceded implementation of the marbled murrelet habitat rules under the 1996 Washington Forest Practices Rules. Following rule implementation (July 1, 1996), landowners proceeded to harvest finite amounts of older habitat as permitted by the rules. Opportunities for harvesting marbled murrelet habitat have steadily diminished as more and more of the habitat available for harvest under the 1996 rules has been depleted. Opportunities were further diminished in 2001, when new restrictions were placed on timber harvest on unstable slopes, groundwater recharge areas of glacial deep-seated landslides, channel migration zones, and other areas.

Summary of Cumulative Effects of Private Timber Harvest to Marbled Murrelets

Only about 21 percent of the potential murrelet nesting habitat on the private lands is associated with occupied site buffers or murrelet detections areas. The other 79 percent (roughly 190,000 acres) is not associated with these areas, and is therefore at risk of being harvested for timber over the next 50 years. This represents approximately 12 percent of the existing potential marbled murrelet habitat in Washington. Not all of this habitat will be subject to harvest, as some areas will be protected for documented marbled murrelet sites or high-hazard soils areas. We did not calculate how much habitat would be protected for other conservation needs, but we suspect these areas represent a small percentage of the total acres that are at risk. Murrelet habitat on private lands in the southwest Washington, the Olympic Peninsula, and the northwest Cascades in particular, are of greatest concern, because these areas contain substantial habitat acres that are not currently located in murrelet detection areas. The quality of habitat in these areas will determine whether or not pre-harvest surveys are completed to determine occupancy.

The risk of habitat loss on the private lands appears to be substantial over the long-term. The potential loss of 190,000 acres of potential murrelet habitat on the private lands could result in the abandonment of some landscapes that are currently marginally suitable for murrelets. We assume that the majority of murrelets in both Zones 1 and 2 are nesting in high-quality habitat patches located on Federal lands, but relatively few surveys have been conducted on Federal lands to confirm this assumption.

We have no reliable way of estimating the number of individual murrelets that could be affected by timber harvest on the private lands. To do so would require an assumption of average murrelet density per acre of habitat, and we have no data to support such an assumption at the scale of the private lands. Although McShane et al. (2004) and others developed population viability models for murrelets, these models do not include habitat variables to test the effects of habitat loss on population viability. Several studies have examined the relationship between murrelet densities and available nesting habitat, but there are no clear thresholds of landscape viability from these studies. Rather, these studies have shown that murrelets are positively associated with total watershed area, positively associated with increasing amounts of late-seral forests in a watershed, and negatively associated with increasing edge and amounts of logged or unsuitable habitat (McShane et al. 2004.).

The adverse effects associated with habitat loss do not include direct adverse effects to nesting individuals, but rather a reduction in the overall potential nesting habitat that is available for the conservation and recovery of marbled murrelets on non-Federal lands in Washington.

8.3.4.2 Cumulative Effects to Federally Designated Marbled Murrelet Critical Habitat

We anticipate that activities that occur on private lands may affect marbled murrelet critical habitat where the private lands occur adjacent to Critical Habitat Units. Edge effects associated with clearcut timber

harvest in the uplands could result in an increased risk of windthrow and microclimate changes to critical habitat on adjacent Federal and non-Federal lands. We anticipate that windthrow and edge effects are could occur for distances up to 400 feet into adjacent Critical Habitat Unit stands.

Windthrow Effects

Windthrow is a natural phenomenon affecting forests throughout the Pacific Northwest. Every year hundreds of acres of trees are blown over in natural stands and along clearcut boundaries and road corridors (Strathers et al. 1994). The factors that influence windthrow include individual tree characteristics, stand characteristics, root zone soil characteristics, topographic exposure characteristics, and meteorological conditions (Strathers et al. 1994; Harris 1999). Windthrow usually occurs in the first few years after harvesting, particularly where more susceptible trees are exposed to stronger winds as a result of harvesting. Trees can become more windfirm after a few years of exposure as they develop reaction wood in response to swaying (Strathers et al. 1994). Timber harvesting can increase the windthrow hazard by increasing the wind speed and turbulence along the downwind edge of clearcut boundaries. Winthrow damage and can extend into adjacent stands for hundreds of feet, although most damage is usually concentrated within the first 30 to 60 feet of the cutting boundary edge (Strathers et al 1994).

Microclimate Effects

When trees on adjacent private lands are felled, an opening in the canopy will be created, which can cause changes in the microclimate in the surrounding stand. Air temperature, humidity, soil temperature, soil moisture, solar radiation, and wind speed within a stand can be altered by clearings. Along clearcut edges, the amounts of windthrow and dead wood are more abundant because of exposure to strong winds and environmental stress (Chen et al. 1993). Changes between the interior of a stand and the clearing can be detected for air temperature, humidity, and wind speed up to and greater than 780 feet into a stand (Chen et al. 1995). Removal of conifers would be likely to create large openings in the canopy, thereby increasing the likelihood for microclimate changes to occur. While there are no data on the specific effects of microclimate changes on the availability of murrelet nesting habitat at the branch and tree scales, the penetration of solar radiation, wind, and warm temperatures into the forest could change the distribution of epiphytes or blow moss off nesting platforms.

Cumulative Effects to Marbled Murrelet Critical Habitat

We used GIS to estimate the Critical Habitat Unit areas that border private lands, and estimated that about 34,400 acres of critical habitat occurs adjacent (within 400 feet) to private lands (2.8 percent). This figure represents a gross estimate and includes some non-Federal acres that are embedded within the Critical Habitat Unit boundaries. There are approximately 10,900 acres of potential murrelet nesting habitat associated with these Critical Habitat Unit “edge” acres, which represents approximately 32 percent of the potentially affected Critical Habitat Unit acres. The other 68 percent of these acres are comprised of second-growth forests or other non-suitable habitat areas.

Assuming an annual harvest rate of about 12 percent per decade on private lands (Table 8-31), we anticipate that approximately 4,100 acres of designated critical habitat may be affected by clearcut edges on adjacent private lands per decade (i.e., 12 percent of 34,000 acres of Critical Habitat Unit edge areas ≈ 4,100 acres), for a total of up to 20,500 acres affected over 50 years. The amount of potential nesting habitat exposed will be substantially less than this figure, probably on the order of 1,300 acres per decade (i.e., 32 percent of the affected area). Over a 50-year period, approximately 6,500 acres of potential

nesting habitat located along the edges of designated Critical Habitat Units would be exposed to edge effects and an increased risk of windthrow.

The potential effects of windthrow are highly variable and dependant on many site-specific factors. There are no reliable methods to estimate or quantify the effects that windthrow may have to potential murrelet habitat at the scale of the private lands. However, it is likely that potential murrelet nesting habitat in Critical Habitat Units will be adversely affected by the loss of individual trees with potential nesting platforms, and the loss of trees that provide cover to trees with platforms. For the purposes of this analysis, we are assuming that 15 percent of the potential nesting habitat along affected boundaries will be lost due to the windthrow. This assumption is based on the review by Strathers et al. (1994) who found that most windthrow damage occurs within 30 -60 feet of a clearcut boundary (i.e., 60 feet represents 15 percent of the 400-foot area of edge effects). Based on this assumption, we estimate that up to 1,000 acres of potential nesting habitat could be lost along Critical Habitat Unit boundaries due to windthow effects over a 50 year period.

The Washington Forest Practices Rules minimize edge effects to suitable murrelet habitat by protecting occupied sites with a 300-foot managed buffer zone adjacent to the occupied site. This rule protects occupied sites by prohibiting clearcut timber harvest within 300 feet of the occupied stand (WAC 222-16-080 (j)(v)). Under the managed buffer rule, trees within the managed buffer may be thinned to a density of 75 trees per acre. The primary consideration for the design of the managed buffer is to mediate edge effects to occupied murrelet sites. We did not calculate the habitat acres associated occupied sites along Critical Habitat Unit boundaries, but expect that the managed buffer rule could reduce the potential effects associated with clear cut edges. There are approximately 2,300 acres of designated Critical Habitat Units on the private lands that encompass several occupied murrelet sites. The managed buffer rules would apply to the occupied sites on these lands, and reduce the potential for edge effects on the non-Federal Critical Habitat Units. Federal Critical Habitat Units are less likely to receive protection from the managed buffer rules, because there are relatively few occupied murrelet sites documented on Federal lands, and non-Federal land owners are not obligated to conduct murrelet surveys on adjacent Federal lands.

Summary of Cumulative Effects to Marbled Murrelet Critical Habitat

Forest practices on the private lands that share boundaries with Critical Habitat Units could result in microclimate effects to 6,500 acres of potential nesting habitat, including the loss of up to 1,000 acres of potential murrelet nesting habitat due to windthrow damage. These effects will be distributed across 33 Critical Habitat Units which encompass over 1.2 million acres and contain over 401,000 acres of potential nesting habitat. We recognize that the loss of potential nesting habitat from a catastrophic windthrow event could be substantial at an individual site scale. However, we have no way of predicting the location or extent of such events.

Individual Critical Habitat Units in Washington vary in size from 200 acres to over 108,000 acres in size. Potential edge-affected areas in Critical Habitat Units range from 0 to 100 percent depending on the size of the Critical Habitat Unit. Critical Habitat Units on Federal lands are typically large (≥ 20,000 acres) and have a low amount of edge-affected area (≈ 2-3 percent). Critical Habitat Units on non-Federal lands are small (≤ 1,000 acres), and have a high potential for edge effects. Potential edge effects on the non-Federal Critical Habitat Units will be minimized by the managed buffer rules required under the Washington Forest Practices Rules. Edge effects to the larger Federal Critical Habitat Units will be

confined to the boundary areas of these units, potentially affecting less than 1-2 percent of the nesting habitat in an individual unit.

The loss of potential nesting habitat could be substantial at an individual site scale, but we are unable to estimate the extent of such adverse effects. At the scale of individual Critical Habitat Units, there could be a loss of 1-2 percent of potential habitat. At the scale of Critical Habitat Units in Washington, the estimated loss of potential habitat would be 0.25 percent, over a 50 year period. The cumulative effects associated with private forest practices will be confined to the boundary areas of individual Critical Habitat Units and therefore should have only minor adverse effects to the overall function of the critical habitat. Each Critical Habitat Unit was designated to include large blocks of suitable habitat to support the successful nesting of marbled murrelets. Overall, the loss of up to 1,000 acres of potential nesting habitat due to windthrow over a 50 year period is not expected to have a substantial adverse effect on the function or conservation role of the critical habitat units in Washington.

8.3.4.3 Integration and Synthesis – Summary of the Status, Baseline, and Effects to Marbled Murrelets

Threats to marbled murrelet recovery include nesting habitat loss, mortality in the marine environment, and high rates of nest predation. These threats continue to contribute to murrelet population declines through adult and juvenile mortality and reduced reproduction. Lands considered essential for the recovery of the marbled murrelet within Conservation Zones 1 and 2 include all nesting habitat located within the range of the murrelet on Federal lands; nesting habitat on State lands within 40 miles of marine waters; and nesting habitat within occupied murrelet sites on private lands (U.S. Fish and Wildlife Service 1997a). Currently, about 68 percent (1,079,900 acres) of potential murrelet habitat is located on Federal lands in Washington, and there have been relatively few acres of habitat loss on these lands. Habitat on State lands is managed under the WDNR HCP (WDNR 1997c). Murrelet surveys conducted in support of this HCP have documented over 54 percent of the known, occupied murrelet sites on the WDNR HCP lands. These sites are currently protected from harvest through the provisions of the HCP (WDNR 1997c). About 25 percent (388,900 acres) of all potential nesting habitat in Washington is associated with 1.5 mile-radius buffers surrounding known, occupied murrelet sites.

Over 50 percent of the habitat-capable acres within the range of the marbled murrelet in Washington occur on private lands. Currently, only about 15 percent of the extant potential habitat acres (242,100 acres) are located on these lands, and about 7 percent of known occupied habitat (25,700 acres) is located on private lands. In areas with few Federal acres (e.g., southwest Washington), the conservation of marbled murrelets is almost entirely dependent upon conservation efforts on State or private lands. In southwest Washington, private lands comprise the majority of that landscape, and many stands have been identified as occupied by murrelets.

Timber harvest on the FPHCP covered land RMZs is likely to result in the long-term loss and degradation of unoccupied, potential marbled murrelet nesting habitat in RMZs. Considering both Zone 1 and Zone 2 combined, we estimate that approximately 92,000 acres of RMZs on FPHCP covered lands would be managed per decade, resulting in a potential loss of 2,200 acres of unoccupied murrelet nesting habitat in RMZs per decade. Over the next 50 years, a total of approximately 11,000 acres of unoccupied potential murrelet nesting habitat could be removed by stand-replacing timber harvest in the RMZs. These effects would be distributed over 730,000 acres of RMZs from the Olympic Peninsula to the western Cascades, which in turn are distributed across 5.4 million acres of FPHCP covered lands over a period of 50 years.

Unoccupied marbled murrelet nesting habitat on private lands is not considered to be essential to the recovery of the marbled murrelet (U.S. Fish and Wildlife Service 1997a).

This rate of loss is practically immeasurable at the scale of the conservation zones, and does not constitute a substantial effect to the distribution of potential murrelet habitat. We expect all habitat acres removed in RMZs will be unoccupied by murrelets, therefore, we do not anticipate murrelets will be directly killed or displaced from potential nesting habitat in RMZs. Because there would be no loss of occupied habitat, there would be no adverse effects to the current distribution or survival of murrelet populations in Zone 1 or Zone 2 resulting from RMZ management.

We expect that some sound- and activity- related disturbances to nesting murrelets may occur on the private lands, but the risk for potential injury to murrelets is low due to the 0.25-mile disturbance buffers and daily activity restrictions required by the Washington Forest Practices Rules. The Washington Forest Practices Rules minimize the potential for adverse effects from disturbance associated with forest practices to nesting murrelets, but they do not ensure that all murrelets will be protected from disturbance under all circumstances. Blasting within a mile of an occupied murrelet site, unrestricted activities during the mid-day hours, and forest practices during the late nesting season (September) are all situations which may result in murrelets flushing from a nest, aborted feedings, or postponed feedings.

We have no reliable way of quantifying the amount of potential disturbance to murrelets associated with forest practice activities on the private lands. To do so would require an assumption regarding the density of nesting marbled murrelets per acre of suitable habitat, and we have no data to support such assumptions at the scale of the private lands. We expect that the existing Washington Forest Practices Rules which prohibit timber harvesting and road construction in occupied murrelet sites, and restrict forest practice activities within 0.25 miles of occupied murrelet sites will minimize disturbance effects to over 99 percent of the potential nesting/fledging murrelets on the private lands.

Cumulative effects associated with forest practice activities on the uplands particularly in areas not associated with murrelet detection areas or occupied sites may pose a risk to marbled murrelets. Only about 21 percent of the potential murrelet nesting habitat on the private lands is associated with occupied site buffers or murrelet detections areas. The other 79 percent (roughly 190,000 acres) is not associated with these areas, and is therefore at a higher risk of being harvested for timber over the next 50 years. This represents approximately 12 percent of the existing potential marbled murrelet habitat in Washington. Not all of this habitat will be subject to harvest, as some areas will be protected for documented marbled murrelet sites or high-hazard soils areas. We did not calculate how much habitat would be protected for other conservation needs, but we suspect these areas represent a small percentage of the total acres that are at risk.

Murrelet habitat on private lands in southwest Washington, the Olympic Peninsula, and the northwest Cascades in particular are of concern because these areas contain substantial habitat acres that are not currently located in murrelet detection areas. The quality of habitat in these areas will determine whether or not pre-harvest surveys are completed to determine occupancy.

The risk of habitat loss on private lands appears to be substantial over the long-term. The potential loss of 190,000 acres of potential murrelet habitat on private lands could result in the abandonment of some landscapes that are currently marginal for murrelets. We assume that the majority of murrelets in both Zones 1 and 2 are nesting in high-quality habitat patches located on Federal lands, but relatively few surveys effort have been conducted on Federal lands to confirm this assumption.

During the period of 1992 to 2002, there were over 51,000 acres of potential murrelet nesting habitat removed by timber harvest on private lands, representing a loss of 18 percent of the habitat on these lands. We assume that most of these acres were documented as unoccupied, or had a low probability of occupancy due to their location or marginal habitat conditions. We have no reliable way estimating how much potentially occupied habitat has been lost on non-Federal lands. However, due to error rates associated with early survey protocols it is likely that some occupied habitat was lost during this period. Additionally, potential occupied sites located in habitat with a low probability of occupancy (i.e., ≤ 5-7 platforms/acre) or habitat on small landownership (≤ 500 acres), may have been lost as well. These threats to potential occupied murrelet habitat on private lands still exist under the current Washington Forest Practices Rules. Given the current rates of timber harvest on private lands, it is probable that all potential habitat that is not associated with documented occupied sites could be lost to timber harvest in the next 50 years, resulting in a substantial reduction in the distribution of potential habitat and potentially some loss of reproductive success of murrelet populations in both conservation Zones 1 and Zone 2.

We recognize that much of the potential habitat that occurs on private lands is highly fragmented and of marginal quality for murrelet nesting; and likely has little value for the long-term recovery of marbled murrelets. Substantial areas associated with the Puget Trough lowlands are not likely to support murrelets due to the extensive loss of old-growth habitat in these areas. However, suitable habitat patches that occur on private lands that are adjacent (i.e., within 5 miles) to known occupied sites or are adjacent to large blocks of suitable habitat on Federal or State lands may contribute to the conservation and recovery of the marbled murrelet in Washington.

We anticipate that current management strategies could result in a significant loss (i.e., > 10%) of potential marbled murrelet habitat on private lands. As habitat loss continues on the non-Federal lands, an increasing proportion of marbled murrelets will remain within the habitat blocks on State and Federal lands, where they are also subjected to the negative effects associated with increased corvid populations and a high risk of nest predation.

8.3.5 CONCLUSION – Marbled Murrelet and Marbled Murrelet Critical Habitat

8.3.5.1 Conclusion for Marbled Murrelet in Conservation Zone 1 and Conservation Zone 2

After reviewing the current status of the marbled murrelet, the environmental baseline, the effects of the proposed action on marbled murrelets, and the cumulative effects, it is our biological opinion that implementation of the proposed action discussed herein is not likely to jeopardize the continued existence of the marbled murrelet.

The marbled murrelet is not a covered species under the FPHCP; therefore, we do not anticipate or authorize any incidental take of marbled murrelets associated with the implementation of the FPHCP. Any “take” would violate the prohibitions in Section 9 of the ESA, and would therefore invalidate the FPHCP Permit with respect to all listed covered species for that forest practices application that resulted in unauthorized “take.”

Although the proposed action would result in the loss of up to 11,000 acres unoccupied, potential nesting habitat in RMZs, we conclude that these activities pose a low risk to murrelet reproduction and nesting success because no occupied murrelet habitat would be harvested in RMZs, and therefore no direct effects to nesting murrelets are anticipated. Lands considered essential for the recovery of the marbled murrelet

within Conservation Zones 1 and 2 include all nesting habitat located within the range of the murrelet on Federal lands; nesting habitat on State lands within 40 miles of marine waters; and nesting habitat within occupied murrelet sites on private lands (U.S. Fish and Wildlife Service 1997a). Under the proposed action, no habitat considered essential for the recovery of the marbled murrelet would be removed. Due to the widely distributed effects associated with harvest in RMZs, we conclude that the issuance of a Permit for the FPHCP for covered aquatic species would not be expected to appreciably affect the overall reproduction, numbers, and distribution of marbled murrelets in Washington.

8.3.5.2 Conclusion for Marbled Murrelet Critical Habitat

After reviewing the current status of marbled murrelet critical habitat, the environmental baseline for the FPHCP Action Area, the effects of the proposed action, and the cumulative effects, it is our biological opinion that the proposed action is not likely to destroy or adversely modify designated critical habitat for the marbled murrelet.

The effects associated with private forest practices will be confined to the boundary areas of individual Critical Habitat Units and therefore should have only minor adverse effects to the overall function of the critical habitat. At the scale of individual subunits, there could be a loss of 1-2 percent of potential habitat. At the scale of Critical Habitat Units in Washington, the estimated loss of potential habitat would be 0.25 percent, over a 50 year period. Each Critical Habitat Unit was designated to include large blocks of suitable habitat to support the successful nesting of marbled murrelets. Overall, the loss of up to 1,000 acres of potential nesting habitat dispersed across the landscape due to windthrow over a 50 year period is not expected to have a substantial adverse effect on the function or conservation role of the critical habitat units in Washington.

8.4 AMPHIBIANS

8.4.1 CASCADE TORRENT SALAMANDER (*Rhyacotriton cascadae*)

8.4.1.1 STATUS OF THE SPECIES

Description of Species

The Cascade torrent salamander is a small salamander with a snout to vent length of 2.2 inches (56 millimeters) for adults (Jones et al. 2005). Total length of adults is about 4 inches (105 millimeters) (Jones et al. 2005). Females are slightly larger than males (Nussbaum et al. 1983). Nomenclature follows Crother (2001).

Historical and Current Range

The Cascade torrent salamander occurs on the western slopes of the Cascade Range from the Middle Fork of the Willamette River in Oregon north to the south side of the Skookumchuck River in Washington (Good and Wake 1992; McAllister 1995; Dvornich et al. 1997). Over their range, the Cascade torrent salamander can be found from 164 feet (50 meters) to 4,429 feet (1,350 meters) in elevation (Jones et al. 2005). In Oregon, the Cascade torrent salamanders are known to range in elevations to above 4,000 feet (1,219 meters), with probability of occurrence peaking at around 2,850 feet (869 meters). Downstream, where gradients are lower, their occurrence is less frequent (Hunter 1998). In Washington, the upper limit of elevation is poorly understood, but anchor ice (i.e., ice that develops from the substrate rather

than capping flowing waters) may limit their distribution in smaller, higher-elevation streams. Historical versus current range, abundance, and density is unknown at this time, but the Cascade torrent salamander can be locally abundant (Marc Hayes, Personal Communication, 2005; Lannoo 2005).

Essential Habitat Components

Adult Cascade torrent salamanders are often found in an underground matrix of small water courses in the rock rubble and stream banks, and in cracks and fissures in stream banks and cliffs (Nussbaum and Tait 1977). Larvae have been observed more abundantly under sheltering rocks along the lower flow margins of stream channels and in the network of fissures within the streambed and banks (Nussbaum and Tait 1977), and can be common in the headwater landscape (Steele et al. 2003). General habitat information on *Rhyacotriton* describes them to be in riffles of cold, permanent streams with small water-washed or moss-covered rocks (Bury et al. 1991a) with substantial canopy and abundant understory vegetation (Stebbins and Lowe 1951). Constantly in contact with water, *Rhyacotriton* is among the most desiccation-intolerant salamander genera known (Ray 1958), probably due to a dependence on the skin surface for oxygen exchange because of reduced lung capacity (Whitford and Hutchinson 1966). The Cascade torrent salamander is rarely found more than 3.3 feet (1 meter) from water, except during major rain events when the salamander may be found greater than 32.8 feet (10 meters) from water (Jones et al. 2005). Based on southern torrent salamander data, metamorphosed juveniles and adults probably feed on invertebrates in moist, forested habitats along stream margins—notably amphipods, fly larvae, springtails and stonefly nymphs (Bury and Martin 1967; Bury 1970). Larvae diet is unknown.

Reproductive Ecology

Cascade torrent salamanders require five to six years to reach reproductive maturity (Nussbaum and Tait 1977). Reproduction occurs in low-flow aquatic habitats. The description of the one observed Cascade torrent salamander nest was that it was under a cobble within a glide of a second-order headwater stream, 1,500 feet (4572 meters) below the stream origin (MacCracken 2004). Variation in nest location is presumed to be similar to those of the Columbia torrent salamander that place their unattached eggs among the substrate spaces of low-velocity headwater streams and seeps. Female Cascade torrent salamanders have a small clutch size (2 to 14 eggs) and do not tend the eggs during prehatching development (Lannoo 2005). Larval life is thought to be three to four years, with metamorphosis typically occurring in late summer to early fall (Nussbaum and Tait 1977). Neoteny is unknown in this genus (Lannoo 2005). Metamorphosis can take place any time of the year, but occurs most often in late summer to early autumn (Lannoo 2005). Longevity is poorly understood, but they are thought to live at least ten years after metamorphosing (Nussbaum and Tait 1977).

Movements and Habitat Use

Cascade torrent salamanders are thought to be sedentary, with typical movements on the scale of a few meters (Nussbaum and Tait 1977; Nijhius and Kaplan 1998), but movement studies are limited due to sampling across a highly restricted landscape, so the true extent of movements is unknown. No breeding or seasonal migrations have been documented for this species (Lannoo 2005).

Threats to Survival and Conservation Needs of the Species

The Cascade torrent salamander is a Washington State Candidate species. Concern centers on their limited distribution, narrow range of tolerance for environmental conditions, and the associated risk of local extirpation following clearcut timber harvest and the subsequent increase in microhabitat

temperatures and sedimentation (Bury and Corn 1988; Blaustein et al. 1995; Hallock and McAllister 2002). Another historical concern has been the lack of protection for headwater streams, seeps, and springs (Wilkins and Peterson 2000). A recent study found Cascade torrent salamanders to have the highest densities at mid-rotation in the managed landscape (Steele et al. 2003), but the site-selection constraint of minimal sedimentation makes the study ambiguous as to how representative it may be of the managed landscape. Cascade torrent salamanders survived in areas affected by the 1980 eruption of Mount St. Helens. These populations persisted in locations where the vegetation was severely affected by the eruption (Jones et al. 2005). This suggests that forest cover may not be a critical habitat feature at higher elevations (Jones et al. 2005), as long as cool, wet environments persist.

Based on the above information, the conservation needs of the Cascade torrent salamander are: (1) to maintain or expand their current distribution; and (2) to avoid and minimize adverse changes to the wetted margins of headwater streams and also seeps, springs, and waterfall splash zones.

8.4.1.2 ENVIRONMENTAL BASELINE

Although a portion of the range of the Cascade torrent salamander occurs on Federal (i.e., Gifford Pinchot National Forest and Mount St. Helens National Monument) and State (mostly WDNR) lands, a significant portion (at least 70 percent; compare maps in Dvornich et al. 1997 with Atterbury Consultants, Inc. 2003) of its distribution is within privately managed landscapes, the largest segment being under industrial ownership in Washington. The Cascade torrent salamander is known to occur in parts or all of the following Water Resource Inventory Areas (WRIAs): 11, 23, 26, 27, 28, and 29 (USFWS and NMFS 2006; Appendix A Regional Summaries).

Conservation Needs of the Species in the FPHCP Action Area

Cascade torrent salamanders are restricted to the westside of the Cascade Mountains in Washington and Oregon. They inhabit the wetted margins of headwater streams and also seeps, springs, and waterfall splash zones. They seem to be dependent on cool, clear stream margin habitat. Because the Cascade torrent salamander has a limited range in Washington and Oregon and because the FPHCP Action Area overlaps a large portion of their range in Washington, maintaining the physical and ecological integrity of the wetted margins of headwater streams, seeps, springs, and waterfall splash zones in the FPHCP Action Area is essential to the long-term conservation of the Cascade torrent salamander.

8.4.1.3 EFFECTS OF THE ACTION

The effects from the proposed action on the Cascade torrent salamander are described in detail in the Effects to Guilds – Headwater Guild section of this Opinion. The Cascade torrent salamander would be adversely affected by changes in overstory riparian canopy, through timber harvest, that are expected to increase solar radiation along non-buffered portions of Type Np and Ns streams, thus warming the water in shallow stream margins. Direct damage to streambank conditions through yarding timber within riparian yarding corridors is expected on occasion and would also adversely affect the Cascade torrent salamander. These effects are expected to reduce the quality of habitat, reduce the numbers, and reduce the reproductive potential of the Cascade torrent salamander at times throughout the proposed 50-year term of the Permit. However, the distribution of the Cascade torrent salamander is not expected to be altered because the above effects will be localized and temporally and spatially staggered across its range within the FPHCP Action Area during the proposed 50-year term of the Permit.

Riparian timber harvest along Type Np and Ns streams, especially non-buffered portions, is expected to reduce the amount of wood recruited to streams. This would reduce the capacity for sediment storage, reduce substrate for aquatic invertebrate production, and possibly alter stream channel morphology. Increased sedimentation is expected to reduce the habitat quality for Cascade torrent salamanders by filling interstitial spaces in stream substrate that impairs movement, egg deposition, and larval development. A reduction in aquatic invertebrate production would reduce food for Cascade torrent salamanders. Possible changes in stream channel morphology could degrade stream margins and thus Cascade torrent salamander habitat. Increased sedimentation, decreased invertebrate production, and possibly changes in channel morphology are expected to reduce the quality of habitat, reduce the numbers, and reduce the reproductive potential of the Cascade torrent salamander at times throughout the proposed 50-year term of the Permit. However, the distribution of the Cascade torrent salamander is not expected to be altered because the above effects will be localized and temporally and spatially staggered across its range within the FPHCP Action Area during the proposed 50-year term of the Permit.

Increased sediment inputs from hydrologically connected forest roads or from road construction across Type Np and Ns streams would adversely affect the Cascade torrent salamander by filling interstitial spaces in stream substrate that impairs movement, egg deposition, and larval development. Electrofishing (related to adaptive management research and instream fish salvage for culvert and bridge maintenance and installation) would adversely affect the Cascade torrent salamander in the form of stress, wounding, or mortality. Also, culvert and bridge maintenance and installation could adversely affect the Cascade torrent salamander through short-term (i.e., days to weeks) sediment inputs and riparian and instream heavy equipment use. Increased sediment inputs from forest roads, road crossings, and culvert and bridge maintenance and installation is expected to reduce the quality of habitat, reduce the numbers, and reduce the reproductive potential of the Cascade torrent salamander at times throughout the proposed 50-year term of the Permit. However, the distribution of the Cascade torrent salamander is not expected to be altered because the above effects will be localized and temporally and spatially staggered across its range within the FPHCP Action Area during the proposed 50-year term of the Permit. Electrofishing is expected to affect few individual Cascade torrent salamanders through stress, wounding, and direct mortality over the proposed 50-year Permit term for the FPHCP.

The probability of adverse effects to Cascade torrent salamanders (especially those effects that would directly injure or kill salamanders) is low for any particular forest practice activity in a single location. However, the probability that habitat quality, numbers of individuals, and reproductive potential would be reduced across the FPHCP covered lands during the proposed 50-year Permit term is reasonably certain to occur many times in many locations.

The Cascade torrent salamander is known to occur in parts of all of the following Water Resource Inventory Areas (WRIAs): 11, 23, 26, 27, 28, and 29 (USFWS and NMFS 2006; Appendix A Regional Summaries). Because survey information for Cascade torrent salamanders does not exist for most WRIAs, it is impossible to determine how many individual Cascade torrent salamanders would be injured, killed, or affected by habitat degradation that disrupts breeding, feeding, and sheltering behaviors. Therefore, the amount of riparian harvest, the number of road crossing structures, and the miles of stream-adjacent roads are used as surrogates for quantifying the adverse affects on Cascade torrent salamanders. Thus, it is estimated that harvest of riparian timber for up to 42,170 acres along Type Np streams and 275,140 acres along Type Ns streams could adversely affect Cascade torrent salamanders over the life of the proposed 50-year Permit term. These numbers represent the maximum amount of habitat that is expected to be affected during the proposed 50-year Permit term and likely overestimate the actual habitat

would be affected as habitat surrogates lack precision. These numbers are derived from a GIS analysis described in Appendix G.

Further, it is estimated that culvert and bridge maintenance and installation, and sediment from hydrologically-connected roads, could result in adverse effects to Cascade torrent salamanders from up to 2,829 Type Np stream crossings and 41,174 Type Ns stream crossings, and 289 miles of Type Np stream-adjacent roads, over the life of the proposed 50-year Permit term within WRIAs 11, 23, 26, 27, 28, and 29 that intersect FPHCP covered lands. These numbers are derived from a GIS analysis described in Appendix G.

The conservation measures in the FPHCP minimize and mitigate adverse effects to Cascade torrent salamanders described above. These measures include: (1) no-harvest RMZs on at least 50 percent of Type Np streams; (2) sensitive site protections (e.g., seeps, springs, Type Np intersections, perennial initiation points; and (3) unstable slope protections.

8.4.1.4 CUMULATIVE EFFECTS

Cumulative effects are those effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR §402.02). Cumulative effects were addressed in the Comprehensive Cumulative Effects section of this Opinion, with respect to the aquatic and riparian environment in Washington State. It is assumed that most land surrounding and upstream of the headwater habitat of the Cascade torrent salamander would be forestland since most agricultural and developed land occurs much lower in watersheds. The cumulative effects of future State or private activities in these headwater areas would include likely include upland timber harvest under the FPHCP and recreation activities. These reasonably expected future State and private activities are not expected to substantially change the overall effects of the action, described above, on the Cascade torrent salamander.

8.4.1.5 CONCLUSION

The aggregate effects of the factors analyzed under the environmental baseline, the effects of the action, and the cumulative effects in the FPHCP Action Area, when viewed against the status of the species is not likely to jeopardize the continued existence of the Cascade torrent salamander.

8.4.2 COLUMBIA TORRENT SALAMANDER (*Rhyacotriton kezeri*)

8.4.2.1 STATUS OF THE SPECIES

Description of Species

The Columbia torrent salamander is a small salamander with a snout to vent length of 2.6 inches (66 millimeters) for adults (Jones et al. 2005). Total length of adults is about 4 inches (100 millimeters). Females are slightly larger than males (Nussbaum et al. 1983). Nomenclature follows Crother (2001).

Historical and Current Range

The Columbia torrent salamander is distributed in the Coast Range of southwest Washington and northwest Oregon from the Little Nestucca River in the south to the Chehalis River in the north (Good and Wake 1992; McAllister 1995; Dvornich et al. 1997). In Washington, the salamander occurs in the extreme southwest corner of the State. Columbia torrent salamanders can be found from near sea level to

3,110 feet (948 meters) in Washington and from near sea level to 3,283 feet (1,001 meters) in Oregon (Lannoo 2005). Historical versus current range, abundance, and density is unknown at this time, but the Columbia torrent salamander can be locally abundant (Marc Hayes, Personal Communication, 2005; Lannoo 2005).

Essential Habitat Components

Juvenile and adult habitat preferences are assumed to be similar, although definitive studies have not been undertaken. Adults prefer cold, permanent streams with small, water-washed or moss-covered rocks/rubble, seeps and small trickling tributary streams with substantial canopy and abundant understory vegetation. Likelihood of occupancy increases from low to high elevations; headwaters appear to be preferred (Wilkins and Peterson 2000). The likelihood of occurrence also increases on basalt formations as opposed to marine sediments and on northerly exposures as opposed to southerly aspects (Russell et al. 2004). The salamander is rarely found out of contact with water since *Rhyacotriton* is among the most desiccation-intolerant salamander genera known (Ray 1958), possibly due to the dependence of oxygenation through the skin rather than through its small lung capacity (Whitford and Hutchinson 1966). Based on southern torrent salamander data, metamorphosed juveniles and adults probably feed on invertebrates in moist, forested habitats along stream margins; notably they feed on amphipods, fly larvae, springtails, and stonefly nymphs (Bury and Martin 1967; Bury 1970). Larvae diet is unknown.

Reproductive Ecology

Age at maturity in Columbia torrent salamanders is unknown, but if similar to the southern torrent salamander (their most-proximate congener), they may require five to six years to reach maturity, with a total life span that probably exceeds 10 years (Nussbaum and Tait 1977). Nests have been found under rocks or moss in sandstone substrates, headwater springs and side-slope seeps, with cold (47-49 ° F (8.3-9.4 ° C)) slow-moving water trickling over loose, unattached eggs (Russell et al. 2002). Unattached eggs are at risk from scour at higher flows. Parental care of the eggs is unknown (Jones et al. 2005). Based on two nests, clutch size is 7 to 11 eggs (Lannoo 2005). Communal nesting may also take place, based on additional nest observations with reported clutches up to 75 eggs, which is more than any one female could lay (Jones et al. 2005; Lannoo 2005). Columbia torrent salamanders probably remain larvae for more than two years, preferably in stable, slow-moving stream microhabitats with loose gravel and cobble, open interstitial spaces and reduced levels of fine sediments (Lannoo 2005). Neoteny is unknown in this genus (Lannoo 2005). Metamorphosis typically occurs in late summer to early fall, but it can occur throughout the year (Nussbaum and Tait 1977).

Movements and Habitat Use

Individuals are thought to be highly sedentary; similar to Columbia torrent salamanders (Nussbaum and Tait 1977; Nijius and Kaplan 1998), but definitive movement studies of this torrent salamander have not been conducted. No breeding or seasonal migrations have been documented for this species (Lannoo 2005).

Threats to Survival and Conservation Needs of the Species

The Columbia torrent salamander is a Federal species of concern and a Washington State candidate species. Concern centers on their limited distribution, narrow range of tolerance for environmental conditions, and the associated risk of local extirpation following clearcut timber harvest (Bury and Corn 1988; Blaustein et al. 1995; Hallock and McAllister 2002). The presence of fine sediments reduces

instream habitat quality for torrent salamanders by filling interstitial spaces critical for movement, egg deposition, and larval development (Corn and Bury 1989; Diller and Wallace 1996). However, a recent study has shown Columbia torrent salamanders to be widespread and abundant in the managed landscape of northwestern Oregon (Russell et al. 2004) and parallel data exist for southwestern Washington (Marc Hayes, Personal Communication, 2003), which has reduced the level of concern for this species.

Based on the above information, the conservation needs of the Columbia torrent salamander are: (1) to maintain or expand their current distribution; and (2) to avoid and minimize adverse changes to headwater streams, including stream margins, seeps, springs, and waterfall splash zones.

8.4.2.2 ENVIRONMENTAL BASELINE

The range of the Columbia torrent salamander primarily overlaps privately managed, industrial forestlands from sea level to the highest elevations within their range.

The Columbia torrent salamander is known to occur in parts or all of the following Water Resource Inventory Areas (WRIAs): 22, 23, 24, 25, and 26 (USFWS and NMFS 2006; Appendix A Regional Summaries).

Conservation Needs of the Species in the FPHCP Action Area

Columbia torrent salamanders are restricted to coastal and near-coastal areas in southwestern Washington and northwestern Oregon. They inhabit the wetted margins of headwater streams and also seeps, springs, and waterfall splash zones. They seem to be dependent on cool, clear stream margin habitat and these other wetted sites. Because the Columbia torrent salamander has a limited range in Washington and Oregon and because the FPHCP Action Area overlaps a large portion of their range in Washington, maintaining the physical and ecological integrity of the wetted margins of headwater streams, seeps, springs, and waterfall splash zones in the FPHCP Action Area is essential to the long-term conservation of the Columbia torrent salamander.

8.4.2.3 EFFECTS OF THE ACTION

The effects from the proposed action are described in detail in the Effects to Guilds – Headwater Guild section in this Opinion. The Columbia torrent salamander would be adversely affected by changes in overstory riparian canopy, through timber harvest, that are expected to increase solar radiation along non-buffered portions of Type Np and Ns streams, thus warming the water in shallow stream margins. Direct damage to streambank conditions through yarding timber within riparian yarding corridors is expected on occasion and would also adversely affect the Columbia torrent salamander. These effects are expected to reduce the quality of habitat, reduce the numbers, and reduce the reproductive potential of the Columbia torrent salamander at times throughout the proposed 50-year term of the Permit. However, the distribution of the Columbia torrent salamander is not expected to be altered because the above effects will be localized and temporally and spatially staggered across its range within the FPHCP Action Area during the proposed 50-year term of the Permit.

Riparian timber harvest along Type Np and Ns streams, especially non-buffered portions, is expected to reduce the amount of wood recruited to streams. This would reduce the capacity for sediment storage, reduce substrate for aquatic invertebrate production, and possibly alter stream channel morphology. Increased sedimentation is expected to reduce the habitat quality for Columbia torrent salamanders by filling interstitial spaces in stream substrate that impairs movement, egg deposition, and larval

development. A reduction in aquatic invertebrate production would reduce food for Columbia torrent salamanders. Possible changes in stream channel morphology could degrade stream margins and thus Columbia torrent salamander habitat. Increased sedimentation, decreased invertebrate production, and possibly changes in channel morphology are expected to reduce the quality of habitat, reduce the numbers, and reduce the reproductive potential of the Columbia torrent salamander at times throughout the proposed 50-year term of the Permit. However, the distribution of the Columbia torrent salamander is not expected to be altered because the above effects will be localized and temporally and spatially staggered across its range within the FPHCP Action Area during the proposed 50-year term of the Permit.

Increased sediment inputs from hydrologically connected forest roads or from road construction across Type Np and Ns streams would adversely affect the Columbia torrent salamander by filling interstitial spaces in stream substrate that impairs movement, egg deposition, and larval development. Electrofishing (related to adaptive management research and instream fish salvage for culvert and bridge maintenance and installation) would adversely affect the Columbia torrent salamander in the form of stress, wounding, or mortality. Also, culvert and bridge maintenance and installation could adversely affect the Columbia torrent salamander through short-term (i.e., days to weeks) sediment inputs and riparian and instream heavy equipment use. Increased sediment inputs from forest roads, road crossings, and culvert and bridge maintenance and installation is expected to reduce the quality of habitat, reduce the numbers, and reduce the reproductive potential of the Columbia torrent salamander at times throughout the proposed 50-year term of the Permit. However, the distribution of the Columbia torrent salamander is not expected to be altered because the above effects will be localized and temporally and spatially staggered across its range within the FPHCP Action Area during the proposed 50-year term of the Permit. Electrofishing is expected to affect few individual Columbia torrent salamanders through stress, wounding, and direct mortality over the proposed 50-year Permit term for the FPHCP.

The probability of adverse effects to Columbia torrent salamanders (especially those effects that would directly injure or kill salamanders) is low for any particular forest practice activity in a single location. However, the probability that habitat quality, numbers of individuals, and reproductive potential would be reduced across the FPHCP covered lands during the proposed 50-year Permit term is reasonably certain to occur many times in many locations.

The Columbia torrent salamander is known to occur in parts of all of the following Water Resource Inventory Areas (WRIAs): 22, 23, 24, 25, and 26 (USFWS and NMFS 2006; Appendix A Regional Summaries). Because survey information for Columbia torrent salamanders does not exist for most WRIAs, it is impossible to determine how many individual Columbia torrent salamanders would be injured, killed, or affected by habitat degradation that disrupts breeding, feeding, and sheltering behaviors. Therefore, the amount of riparian harvest, the number of road crossing structures, and the miles of stream-adjacent roads are used as surrogates for quantifying the adverse affects on Columbia torrent salamanders. Thus, it is estimated that harvest of riparian timber for up to 49,881 acres along Type Np streams and 399,843 acres along Type Ns streams could adversely affect Columbia torrent salamanders over the life of the proposed 50-year Permit term. These numbers represent the maximum amount of habitat that is expected to be affected during the proposed 50-year Permit term and likely overestimate the actual habitat would be affected as habitat surrogates lack precision. These numbers are derived from a GIS analysis described in Appendix G.

Further, it is estimated that culvert and bridge maintenance and installation, and sediment from hydrologically-connected roads, could result in adverse effects to Columbia torrent salamanders from up to 2,673 Type Np stream crossings and 44,994 Type Ns stream crossings, and 265 miles of Type Np

stream-adjacent roads, over the life of the proposed 50-year Permit term within WRIAs 22, 23, 24, 25, and 26 that intersect FPHCP covered lands. These numbers are derived from a GIS analysis described in Appendix G.

The conservation measures in the FPHCP minimize and mitigate adverse effects to Columbia torrent salamanders described above. These measures include: (1) no-harvest RMZs on at least 50 percent of Type Np streams; (2) sensitive site protections (e.g., seeps, springs, Type Np intersections, perennial initiation points; and (3) unstable slope protections.

8.4.2.4 CUMULATIVE EFFECTS

Cumulative effects are those effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR §402.02). Cumulative effects were addressed in the Comprehensive Cumulative Effects section of this Opinion, with respect to the aquatic and riparian environment in Washington State. It is assumed that most land surrounding and upstream of the headwater habitat of the Columbia torrent salamander would be forestland since most agricultural and developed land occurs much lower in watersheds. The cumulative effects of future State or private activities in these headwater areas would likely include upland timber harvest under the FPHCP and recreation activities. These reasonably expected future State and private activities are not expected to substantially change the overall effects of the action, described above, on the Columbia torrent salamander.

8.4.2.5 CONCLUSION

The aggregate effects of the factors analyzed under the environmental baseline, the effects of the action, and the cumulative effects in the FPHCP Action Area, when viewed against the status of the species is not likely to jeopardize the continued existence of the Columbia torrent salamander.

8.4.3 OLYMPIC TORRENT SALAMANDER (*Rhyacotriton olympicus*)

8.4.3.1 STATUS OF THE SPECIES

Description of Species

The Olympic torrent salamander is a small salamander with a snout to vent length of 2.4 inches (60 millimeters) for adults (Leonard et al. 1993). Total length of adults is about 4 inches (100 millimeters). Females are slightly larger than males (Nussbaum et al. 1983). Nomenclature follows Crother (2001).

Historical and Current Range

Olympic torrent salamanders are endemic to Washington State and are known to occur only on the Olympic Peninsula south to the Chehalis River (Good and Wake 1992; McAllister 1995; Dvornich et al. 1997). The salamander can be found as high 3,937 feet (1,200 meters), but most are found below 3,281 feet (1,000 meters) (Jones et al. 2005). Historical versus current range, abundance, and density is unknown at this time (Marc Hayes, Personal Communication, 2005; Lannoo 2005).

Essential Habitat Components

Olympic torrent salamanders have been observed in 41 percent of 168 streams, and in 47 percent of 235 seeps surveyed within the Olympic National Park (Bury and Adams 2000). They are less abundant along

the eastern slope of the Olympics, perhaps due to the warmer, drier climate of the "rainshadow," and are more abundant in streams with northerly aspects, steep gradients, reduced fine sediments, and fewer undercut banks (Bury and Adams 2000). Juveniles and adults probably share the same habitat requirements of cold, clear streams, seeps or waterfalls, and splash zones where a thin film of water runs between or under rocks (Leonard et al 1993). As with other torrent salamanders, Olympic torrent salamanders are desiccation intolerant (Whitford and Hutchinson 1996), requiring a moist to wet microenvironment with substantial shading canopy and abundant understory vegetation (Stebbins and Lowe 1951). Due to the wet microhabitat, Olympic torrent salamanders have been observed as surface-active in winter, so overwintering in these areas may not occur (Jones and Raphael 2000). Based on southern torrent salamander data, metamorphosed juveniles and adults probably feed on invertebrates in moist, forested habitats along stream margins; notably they feed on amphipods, fly larvae, springtails, and stonefly nymphs (Bury and Martin 1967; Bury 1970). Larvae diet is unknown.

Reproductive Ecology

Reproduction is presumed to be aquatic, but nests of Olympic torrent salamander have not yet been found (Lannoo 2005). Age at maturity in Olympic torrent salamanders is unknown, but if similar to the southern torrent salamander, they may require five to six years to reach maturity, with a total life span that undoubtedly exceeds 10 years (Nussbaum and Tait 1977). Nest sites are suspected to be similar to those known for their congeners, i.e., low flow sites such as seeps, springs, or headwater streams with mixed substrates, sometimes under a layer of moss (Nussbaum 1969; Russell et al. 2002). Clutch size is unknown, but fecundity is likely low as gravid females carry relatively few eggs (an average of eight eggs, Good and Wake 1992). Little is known of the larval stage but, based on data from other *Rhyacotriton*, duration is probably greater than two years, and cover requirements include stable, low-flowing microhabitats with loose gravel and cobble and open interstitial spaces with limited fine sediments. Neoteny is unknown in this genus (Lannoo 2005).

Movements and Habitat Use

Olympic torrent salamanders are probably highly sedentary, like other members of the genus, but they may move several meters from the stream during rain events (Jones et al. 2005). No breeding or seasonal migrations have been documented for this species (Lannoo 2005).

Threats to Survival and Conservation Needs of the Species

The Olympic torrent salamander is a Federal species of concern and is on the Washington State monitor list. Concern centers on their limited distribution, narrow range of tolerance for environmental conditions, and the associated risk of local extirpation following clearcut timber harvest (Bury and Corn 1988; Blaustein et al. 1995; Hallock and McAllister 2002). The presence of fine sediments reduces instream habitat quality for torrent salamanders by filling interstitial spaces critical for movement, egg deposition, and larval development (Corn and Bury 1989; Diller and Wallace 1996). The Olympic torrent salamander may be negatively affected by timber harvest practices, under certain environmental conditions (Jones et al. 2005).

Based on the above information, the conservation needs of the Olympic torrent salamander are: (1) to maintain or expand their current distribution; and (2) to avoid and minimize adverse changes to the wetted margins of headwater streams and also seeps, springs, and waterfall splash zones.

8.4.3.2 ENVIRONMENTAL BASELINE

The range of the Olympic torrent salamander primarily occurs on Federal or State-managed lands in western Washington.

The Olympic torrent salamander is known to occur in parts or all of the following Water Resource Inventory Areas (WRIAs): 16, 17, 18, 19, 20, 21, 22, 23, and 24 (USFWS and NMFS 2006; Appendix A Regional Summaries).

Conservation Needs of the Species in the FPHCP Action Area

Olympic torrent salamanders are restricted to coastal and near-coastal areas in western Washington and on the Olympic Peninsula. They inhabit the wetted margins of headwater streams and also seeps, springs, and waterfall splash zones. They seem to be dependent on cool, clear stream habitat and these other wetted sites. Because the Olympic torrent salamander has a limited range in Washington and Oregon and because the FPHCP Action Area overlaps a large portion of their range in Washington, maintaining the physical and ecological integrity of the wetted margins of headwater streams, seeps, springs, and waterfall splash zones in the FPHCP Action Area is essential to the long-term conservation of the Olympic torrent salamander.

8.4.3.3 EFFECTS OF THE ACTION

The effects from the proposed action are described in detail in the Effects to Guilds – Headwater Guild section in this Opinion. The Olympic torrent salamander would be adversely affected by changes in overstory riparian canopy, through timber harvest, that are expected to increase solar radiation along non-buffered portions of Type Np and Ns streams, thus warming the water in shallow stream margins. Direct damage to streambank conditions through yarding timber within riparian yarding corridors is expected on occasion and would also adversely affect the Olympic torrent salamander. These effects are expected to reduce the quality of habitat, reduce the numbers, and reduce the reproductive potential of the Olympic torrent salamander at times throughout the proposed 50-year term of the Permit. However, the distribution of the Olympic torrent salamander is not expected to be altered because the above effects will be localized and temporally and spatially staggered across its range within the FPHCP Action Area during the proposed 50-year term of the Permit.

Riparian timber harvest along Type Np and Ns streams, especially non-buffered portions, is expected to reduce the amount of wood recruited to streams. This would reduce the capacity for sediment storage, reduce substrate for aquatic invertebrate production, and possibly alter stream channel morphology. Increased sedimentation is expected to reduce the habitat quality for Olympic torrent salamanders by filling interstitial spaces in stream substrate that impairs movement, egg deposition, and larval development. A reduction in aquatic invertebrate production would reduce food for Olympic torrent salamanders. Possible changes in stream channel morphology could degrade stream margins and thus Olympic torrent salamander habitat. Increased sedimentation, decreased invertebrate production, and possibly changes in channel morphology are expected to reduce the quality of habitat, reduce the numbers, and reduce the reproductive potential of the Olympic torrent salamander at times throughout the proposed 50-year term of the Permit. However, the distribution of the Olympic torrent salamander is not expected to be altered because the above effects will be localized and temporally and spatially staggered across its range within the FPHCP Action Area during the proposed 50-year term of the Permit.

Increased sediment inputs from hydrologically connected forest roads or from road construction across Type Np and Ns streams would adversely affect the Olympic torrent salamander by filling interstitial spaces in stream substrate that impairs movement, egg deposition, and larval development. Electrofishing (related to adaptive management research and instream fish salvage for culvert and bridge maintenance and installation) would adversely affect the Olympic torrent salamander in the form of stress, wounding, or mortality. Also, culvert and bridge maintenance and installation could adversely affect the Olympic torrent salamander through short-term (i.e., days to weeks) sediment inputs and riparian and instream heavy equipment use. Increased sediment inputs from forest roads, road crossings, and culvert and bridge maintenance and installation is expected to reduce the quality of habitat, reduce the numbers, and reduce the reproductive potential of the Olympic torrent salamander at times throughout the proposed 50-year term of the Permit. However, the distribution of the Olympic torrent salamander is not expected to be altered because the above effects will be localized and temporally and spatially staggered across its range within the FPHCP Action Area during the proposed 50-year term of the Permit. Electrofishing is expected to affect few individual Olympic torrent salamanders through stress, wounding, and direct mortality over the proposed 50-year Permit term for the FPHCP.

The probability of adverse effects to Olympic torrent salamanders (especially those effects that would directly injure or kill salamanders) is low for any particular forest practice activity in a single location. However, the probability that habitat quality, numbers of individuals, and reproductive potential would be reduced across the FPHCP covered lands during the proposed 50-year Permit term is reasonably certain to occur many times in many locations.

The Olympic torrent salamander is known to occur in parts of all of the following Water Resource Inventory Areas (WRIAs): 16, 17, 18, 19, 20, 21, 22, 23, and 24 (USFWS and NMFS 2006; Appendix A Regional Summaries). Because survey information for Olympic torrent salamanders does not exist for most WRIAs, it is impossible to determine how many individual Olympic torrent salamanders would be injured, killed, or affected by habitat degradation that disrupts breeding, feeding, and sheltering behaviors. Therefore, the amount of riparian harvest, the number of road crossing structures, and the miles of stream-adjacent roads are used as surrogates for quantifying the adverse affects on Olympic torrent salamanders. Thus, it is estimated that harvest of riparian timber for up to 41,002 acres along Type Np streams and 317,720 acres along Type Ns streams could adversely affect Olympic torrent salamanders over the life of the proposed 50-year Permit term. These numbers represent the maximum amount of habitat that is expected to be affected during the proposed 50-year Permit term and likely overestimate the actual habitat would be affected as habitat surrogates lack precision. These numbers are derived from a GIS analysis described in Appendix G.

Further, it is estimated that culvert and bridge maintenance and installation, and sediment from hydrologically-connected roads, could result in adverse effects to Olympic torrent salamanders from up to 1,938 Type Np stream crossings and 29,107 Type Ns stream crossings, and 187 miles of Type Np stream-adjacent roads, over the life of the proposed 50-year Permit term within WRIAs 16, 17, 18, 19, 20, 21, 22, 23, and 24 that intersect FPHCP covered lands. These numbers are derived from a GIS analysis described in Appendix G.

The conservation measures in the FPHCP minimize and mitigate adverse effects to Olympic torrent salamanders described above. These measures include: (1) no-harvest RMZs on at least 50 percent of Type Np streams; (2) sensitive site protections (e.g., seeps, springs, Type Np intersections, perennial initiation points; and (3) unstable slope protections.

8.4.3.4 CUMULATIVE EFFECTS

Cumulative effects are those effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR §402.02). Cumulative effects were addressed in the Comprehensive Cumulative Effects section of this Opinion, with respect to the aquatic and riparian environment in Washington State. It is assumed that most land surrounding and upstream of the headwater habitat of the Olympic torrent salamander would be forestland since most agricultural and developed land occurs much lower in watersheds. The cumulative effects of future State or private activities in these headwater areas would likely include upland timber harvest under the FPHCP and recreation activities. These reasonably expected future State and private activities are not expected to substantially change the overall effects of the action, described above, on the Olympic torrent salamander.

8.4.3.5 CONCLUSION

The aggregate effects of the factors analyzed under the environmental baseline, the effects of the action, and the cumulative effects in the FPHCP Action Area, when viewed against the status of the species is not likely to jeopardize the continued existence of the Olympic torrent salamander.

8.4.4 DUNN'S SALAMANDER (*Plethodon dunni*)

8.4.4.1 STATUS OF THE SPECIES

Description of Species

The Dunn's salamander is a medium-sized, secretive, and lungless (plethodontid) salamander (Stebbins 1985). The salamander can attain a maximum size of 6 inches (152 millimeters) in total length (Nussbaum et al. 1983; Leonard et al. 1993). Females are slightly larger than males (Nussbaum et al. 1983; Jones et al. 2005). Nomenclature follows Crother (2001).

Historical and Current Range

The Dunn's salamander occurs west of the Cascade Range from southwest Washington to extreme northwest California (Leonard et al. 1993; Lannoo 2005). It is a strong riparian associate and, within the Washington, occurs exclusively in the Willapa Hills in southwestern Washington (Nussbaum et al. 1983; Leonard et al. 1993; Petranka 1998). Washington encompasses the northern end of this species' range, and the Chehalis River appears to represent the northernmost limit of this species' range in Washington (Leonard et al. 1993). The salamander ranges from sea level to 3,300 feet (1,006 meters) in Oregon and sea level to 2,000 feet (610 meters) in Washington (Nussbaum et al. 1983; Leonard et al. 1993). Historical versus current range, abundance, and density is unknown at this time (Marc Hayes, Personal Communication, 2005; Lannoo 2005). There is no evidence of a population decline (Lannoo 2005).

Essential Habitat Components

Dunn's salamanders occur in heavily shaded, wet, rocky substrates such as seeps, moist talus slopes, and stream edges in forested areas (Leonard et al. 1993; Nordstrom and Milner 1997). Availability of rocky cover, as with talus or steeper sideslopes, appears to be a common denominator of Dunn's salamander habitat (Corn and Bury 1991; Wilkins and Peterson 2000), but down logs and woody debris may also represent important refuge and foraging habitat (Leonard et al. 1993; Corkran and Thoms 1996). They

have been found near streams associated with sandstone and shale outcrops in the Coast Range and basalt talus in the Cascade Range (Jones et al. 2005). The salamander forages (usually on wet nights) on the forest floor for a variety of invertebrates, such as springtails, annelid worms, snails, and insects (Jones et al. 2005; Lannoo 2005). Dunn's salamanders are not considered aquatic, but instead are considered to be riparian associates (Corkran and Thoms 1996; Gomez and Anthony 1996). Most Dunn's salamanders have been found in streambank habitats within a few meters of stream channels, as opposed to riffle or pool habitat (Bury et al. 1991b) or more remote uplands (Wilkins and Peterson 2000).

Reproductive Ecology

Reproduction occurs in terrestrial habitats. Life history data on Dunn's salamanders are sparse, only two nesting record exists (Dumas 1955; Jones et al. 2005). The first nest was a grape-like cluster of 9 eggs found in a crevice in shale (Jones et al. 2005). The second nest was an adult coiled around a cluster of 12 eggs found in a decaying log along a stream (Jones et al. 2005). The breeding season of the salamander is unknown, gravid females have been found throughout the year (Lannoo 2005), but courtship probably occurs in the spring or fall (Jones et al. 2005). Eggs (4 to 15 per clutch) are probably laid underground in rocky areas or within suitably decayed woody debris during spring, and hatch in late summer or fall. There is probably parental protection of the eggs (Lannoo 2005). Juveniles (there is no larval stage), which may take two to four years to reach sexual maturity, have been found in the same habitats as adults (Petranka 1998).

Movements and Habitat Use

There is no evidence of breeding migrations of Dunn's salamanders, but movement from forest floor habitat to underground brood sites probably occurs (Lannoo 2005). They may also move underground to escape freezing or drought conditions (Jones et al. 2005). The Dunn's salamander appears to be most active on the forest floor in April (Jones et al. 2005). There is some evidence that the salamander may be territorial, but more research is needed (Lannoo 2005).

Threats to Survival and Conservation Needs of the Species

The Dunn's salamander is a Washington State candidate species. Concern for this species in the State is prompted by its distribution in presumably small fragmented populations, and by Washington's position at the northernmost tip of the salamander's range (Nordstrom and Milner 1997). Nordstrom and Milner (1997) noted that Dunn's salamanders depend on moist, well-shaded substrates with stable microclimates. Timber harvest can remove canopy cover that maintains microclimatic conditions favored by this species, including cool substrate temperatures and high relative humidity (Chen et al. 1993, 1995; Ledwith 1996; Nordstrom and Milner 1997). Populations can persist in logged areas, but are more likely to do so when mature timber is present upstream than when stands upstream have been cut (Corn and Bury 1989). Vesely and McComb (2002) found that Dunn's salamanders were sensitive to forest practices in riparian areas, and concluded that riparian buffer strips may reduce local declines in abundance. Similarly, West and O'Connell (1998) observed that riparian buffers can promote persistence of amphibians following timber harvest. Several studies have demonstrated a direct relationship between buffer width and the maintenance of cool microclimate and high humidity (Brown and Krygier 1970; Ledwith 1996).

Based on the above information, the conservation needs of the Dunn's salamander are: (1) to maintain or expand their current distribution; and (2) to avoid and minimize adverse changes to moist, riparian and stream edge habitats and talus slopes.

8.4.4.2 ENVIRONMENTAL BASELINE

Dunn's salamanders are relatively common in the Oregon Coast Range, but are less common in Washington headwater streams (Jackson et al. 2003). Most of this species' range in southwestern Washington is currently dominated by privately managed industrial forestlands.

The Dunn's salamander is known to occur in parts or all of the following Water Resource Inventory Areas (WRIAs): 22, 23, 24, 25, and 26 (USFWS and NMFS 2006; Appendix A Regional Summaries).

Conservation Needs of the Species in the FPHCP Action Area

Dunn's salamanders are restricted to the southwestern corner of Washington, western Oregon from the coast to the Cascades, and into Del Norte County, California. They inhabit riparian areas, primarily stream edges, seeps, and moist talus areas. They seem to be dependent on moist riparian areas and are often associated with rocky substrate. Because the Dunn's salamander has a limited range in Washington and because the FPHCP Action Area overlaps a large portion of their range in Washington, maintaining the physical and ecological integrity of riparian areas, stream edges, and moist talus in the FPHCP is essential to the long-term conservation of the Dunn's salamander in Washington.

8.4.4.3 EFFECTS OF THE ACTION

The effects from the proposed action are described in detail in the Effects to Guilds – Headwater Guild section in this Opinion. The Dunn's salamander would be adversely affected by changes in overstory riparian canopy, through timber harvest, that are expected to increase solar radiation that reaches the riparian ground surface, especially along non-buffered portions of Type Np and Ns streams. Direct damage to riparian ground conditions through yarding timber and yarding corridors within RMZs along Type S, F, and Np streams and also along non-buffered Type Np and Ns streams would also adversely affect the Dunn's salamander. These effects are expected to reduce the quality of habitat, reduce the numbers, and reduce the reproductive potential of the Dunn's salamander at times throughout the proposed 50-year term of the Permit. However, the distribution of the Dunn's salamander is not expected to be altered because the above effects will be localized and temporally and spatially staggered across its range within the FPHCP Action Area during the proposed 50-year term of the Permit.

Riparian timber harvest along Type S, F, Np, and Ns streams, especially non-buffered portions of Type Np and Ns streams, is expected to reduce the amount of wood recruited to the Riparian Zone of influence. This would reduce the amount of habitat available for Dunn's salamanders. These adverse effects are expected to reduce the quality of habitat, reduce the numbers, and reduce the reproductive potential of the Dunn's salamander at times throughout the proposed 50-year term of the Permit. However, the distribution of the Dunn's salamander is not expected to be altered because the above effects will be localized and temporally and spatially staggered across its range within the FPHCP Action Area during the proposed 50-year term of the Permit.

Culvert and bridge maintenance and installation, and road construction and maintenance, could adversely affect the Dunn's salamander through direct mortality from equipment or degradation to riparian habitat adjacent to work areas. These adverse effects are expected to reduce the quality of habitat, reduce the numbers, and reduce the reproductive potential of the Dunn's salamander at times throughout the proposed 50-year term of the Permit. However, the distribution of the Dunn's salamander is not expected to be altered because the above effects will be localized and temporally and spatially staggered across its range within the FPHCP Action Area during the proposed 50-year term of the Permit.

The probability of adverse effects to Dunn's salamanders (especially those effects that would directly injure or kill salamanders) is low for any particular forest practice activity in a single location. However, the probability that habitat quality, numbers of individuals, and reproductive potential would be reduced across the FPHCP covered lands during the proposed 50-year Permit term is reasonably certain to occur many times in many locations.

The Dunn's salamander is known to occur in parts of all of the following Water Resource Inventory Areas (WRIAs): 22, 23, 24, 25, and 26 (USFWS and NMFS 2006; Appendix A Regional Summaries). Because survey information for Dunn's salamanders does not exist for most WRIAs, it is impossible to determine how many individual Dunn's salamanders would be injured, killed, or affected by habitat degradation that disrupts breeding, feeding, and sheltering behaviors. Therefore, the amount of riparian harvest, the number of road crossing structures, and the miles of stream-adjacent roads are used as surrogates for quantifying the adverse affects on Dunn's salamanders. Thus, it is estimated that harvest of riparian timber for up to 55,053 acres along Type S streams, 133,453 acres along Type F streams, 49,881 acres along Type Np streams, and 339,843 acres along Type Ns streams could adversely affect Dunn's salamanders over the life of the proposed 50-year Permit term. These numbers represent the maximum amount of habitat that is expected to be affected during the proposed 50-year Permit term and likely overestimate the actual habitat would be affected as habitat surrogates lack precision. These numbers are derived from a GIS analysis described in Appendix G.

It is estimated that culvert and bridge maintenance and installation could result in adverse effects to Dunn's salamanders from up to 665 Type S stream crossings, 6,137 Type F stream crossings, 2,673 Type Np stream crossings, and 29,107 Type Ns stream crossings. Further, it is estimated that road construction and maintenance could result in adverse effects to Dunn's salamanders from up to 552 miles of road along Type S streams, 1,033 miles of road along Type F streams, and 265 miles of road along Type Np streams. These effects would occur over the life of the proposed 50-year Permit term within WRIAs 22, 23, 24, 25, and 26 that intersect FPHCP covered lands. These numbers are derived from a GIS analysis described in Appendix G.

The conservation measures in the FPHCP minimize and mitigate adverse effects to Dunn's salamanders described above. These measures include: (1) no-harvest RMZs along Type S, F, and at least 50 percent of Type Np streams; (2) Inner and Outer Zone RMZ restrictions along Type S and F streams; and (3) equipment limitation zones.

8.4.4.4 CUMULATIVE EFFECTS

Cumulative effects are those effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR §402.02). Cumulative effects were addressed in the Comprehensive Cumulative Effects section of this Opinion, with respect to the aquatic and riparian environment in Washington State. It is assumed that most land surrounding and upstream of the headwater habitat used by Dunn's salamanders would be forestland since most agricultural and developed land occurs much lower in watersheds. The cumulative effects of future State or private activities in these headwater areas would likely include upland timber harvest under the FPHCP and recreation activities. These reasonably expected future State and private activities are not expected to substantially change the overall effects of the action, described above, on the Dunn's salamander.

8.4.4.5 CONCLUSION

The aggregate effects of the factors analyzed under the environmental baseline, the effects of the action, and the cumulative effects in the FPHCP Action Area, when viewed against the status of the species is not likely to jeopardize the continued existence of the Dunn's salamander.

8.4.5 VAN DYKE'S SALAMANDER (*Plethodon vandykei*)

8.4.5.1 STATUS OF THE SPECIES

Description of Species

Van Dyke's salamanders are shorter and stockier than other plethodontid salamanders. The salamander can attain a maximum size of 4.3 inches (110 millimeters) in total length (Jones et al. 2005). Females are slightly larger than males (Nussbaum et al. 1983). Nomenclature follows Crother (2001).

Historical and Current Range

Endemic to Washington, the Van Dyke's salamander is known from three separate population centers: the Olympic Mountains, the southern Cascade Range, and the Willapa Hills (Leonard et al. 1993). Most recorded locations come from the wetter, western slopes of these areas (Dvornich et al. 1997). Van Dyke's salamanders have been found at elevations ranging from sea level to 5,000 feet (1,524 meters), in areas with an average annual precipitation of at least 60 inches (1,524 millimeters) (Wilson et al. 1995; Jones 1999). Historical versus current range is unknown at this time (Marc Hayes, Personal Communication, 2005; Lannoo 2005).

Essential Habitat Components

Van Dyke's salamanders are most commonly associated with riparian habitats, or with cool, moist microsites within other habitat types (Nordstrom and Milner 1997; Petranka 1998; Jones 1999). Juveniles and adults have been found in the splash zones of streams, upland forests, moist talus, cave entrances, seeps, and along lakeshores (Blaustein et al. 1995; Jones 1999). Jones (1999) indicates that Van Dyke's salamanders may be found near streams and seeps that are perennial, or spatially or temporally intermittent (i.e., surface water may be absent during some periods or in some stretches). The Van Dyke's salamander can be found in rocks or woody debris in the coastal portion of its range, but it is found in moist talus on north-facing slopes in the interior portion of its range (Lannoo 2005). In a recent study, Van Dyke's salamanders were found in downed wood more than 75 percent of the time they were captured and preliminary analysis indicates that they seem to differentially use large-sized pieces (i.e., greater than 19 inches (50 centimeters) in diameter) than other sizes of downed wood (Marc Hayes, Personal Communication, Washington Department of Fish and Wildlife, January 26, 2006). The Van Dyke's salamander appears to be most active in the spring and fall; and most likely feeds on small invertebrates (Jones et al. 2005).

Reproductive Ecology

As of 2005, seven Van Dyke's salamander nests have been found, one nest was found under a rock and the remaining nests were found inside large decaying conifer logs near streams (Jones et al. 2005). Most of the nests were found near small headwater streams (Jones 1989; Blessing et al. 1999). Blessing et al. (1999) describes four Van Dyke's salamander nests that were found on the Olympic Peninsula; an adult

salamander was found associated with all four nests. Three of the four nests described by Blessing et al. (1999) were in old-growth forest habitat, and one was in a riparian buffer of old-growth trees adjacent to a ten-year-old logged stand. Clutches of eggs, apparently laid during spring, have been found under rocks or inside large, moss-covered logs. Eggs (7 to 14 per clutch) may require more than four months to hatch, nearly twice as long as the incubation period of other similar salamander species in this area (Blessing et al. 1999; Lannoo 2005). There is probably parental protection of the eggs (Lannoo 2005). Little is known of juvenile (there is no larval stage) natural history, but one was found in rocks with little soil, approximately 11.8 inches (300 millimeters) from a stream (Lannoo 2005). The salamanders have been found to live at least 12 years (Jones et al. 2005).

Movements and Habitat Use

There is no evidence of breeding migrations in Van Dyke's salamander, but vertical movement from forest floor habitat to underground sites in response to seasonal conditions probably occurs (Lannoo 2005).

Threats to Survival and Conservation Needs of the Species

The Van Dyke's salamander is a Federal species of concern and a Washington State candidate species. Limited distribution and isolation of Van Dyke's salamander populations have prompted concern for this species' persistence (Holthausen et al. 1994; Nordstrom and Milner 1997). Lehmkuhl and Ruggiero (1991) assigned this species a high risk of local extinction based on its habitat associations, frequency of occurrence, abundance, and dispersal ability. Similarly, Thomas et al. (1993) identified the Van Dyke's salamander as a high-risk species, closely associated with old-growth forest conditions. Some studies have suggested that the distribution of Van Dyke's salamander has been limited by clearcutting (Corn and Bury 1989; Wilson et al. 1995). On the other hand, the presence of this species in 30- to 60-year-old forests indicates that individuals may persist within or recolonize disturbed habitats (Nordstrom and Milner 1997). Currently, maintenance of riparian buffers on headwater streams may protect existing populations if the suitable habitat conditions of cool and moist microclimate and woody debris of the appropriate site and decay classes are maintained (Nordstrom and Milner 1997; Petranka 1998).

Based on the above information, the conservation needs of the Van Dyke's salamander are: (1) to maintain or expand their current distribution; and (2) to avoid and minimize adverse changes to riparian and stream margin habitats.

8.4.5.2 ENVIRONMENTAL BASELINE

Populations appear to be patchily distributed and of low density, and much potential habitat appears to be unoccupied (Blaustein et al. 1995; Jones 1999). Two out of three regions where this species occurs are dominated by Federal ownership (Olympic National Park and Wilderness Area, Mount St. Helens National Monument in Gifford Pinchot National Forest), and the third is dominated by private industrial forestlands (southwest Washington). Some of the Mount St. Helens National Monument populations have survived and persisted for the past 25 years, following the 1980 eruption, in some severely disturbed locations (Jones et al. 2005).

The Van Dyke's salamander is known to occur in parts or all of the following Water Resource Inventory Areas (WRIAs): 10, 11, 16, 19, 20, 21, 22, 23, 24, 25, 26, and 27 (USFWS and NMFS 2006; Appendix A Regional Summaries).

Conservation Needs of the Species in the FPHCP Action Area

Van Dyke's salamanders are restricted to four disjunct populations in Washington: (1) the Olympic mountains; (2) the Willapa Hills; (3) the west-central Cascade mountains; and (4) in the southern and west-central parts of the State in Skamania and Thurston counties. They inhabit riparian areas and other moist areas such as seeps, waterfall splash zones, and moist talus areas. They seem to be dependent on moist riparian areas and are often associated with large woody debris. Because the Van Dyke's salamander has a limited range and occurs only in Washington and because the FPHCP Action Area overlaps a large portion of their range, maintaining the physical and ecological integrity of riparian and stream margin habitats in the FPHCP Action Area is essential to the long-term conservation of the Van Dyke's torrent salamander.

8.4.5.3 EFFECTS OF THE ACTION

The effects from the proposed action are described in detail in the Effects to Guilds – Headwater Guild section in this Opinion. The Van Dyke's salamander would be adversely affected by changes in overstory riparian canopy, through timber harvest, that are expected to increase solar radiation that reaches the riparian ground surface, especially along non-buffered portions of Type Np and Ns streams. Direct damage to riparian ground conditions through yarding timber and yarding corridors within RMZs along Type S, F, and Np streams and also along non-buffered Type Np and Ns streams would also adversely affect the Van Dyke's salamander. These effects are expected to reduce the quality of habitat, reduce the numbers, and reduce the reproductive potential of the Van Dyke's salamander at times throughout the proposed 50-year term of the Permit. However, the distribution of the Van Dyke's salamander is not expected to be altered because the above effects will be localized and temporally and spatially staggered across its range within the FPHCP Action Area during the proposed 50-year term of the Permit.

Riparian timber harvest along Type S, F, Np, and Ns streams, especially non-buffered portions of Type Np and Ns streams, is expected to reduce the amount of wood recruited to the Riparian Zone of influence. This would reduce the amount of habitat available for Van Dyke's salamanders. These adverse effects are expected to reduce the quality of habitat, reduce the numbers, and reduce the reproductive potential of the Van Dyke's salamander at times throughout the proposed 50-year term of the Permit. However, the distribution of the Van Dyke's salamander is not expected to be altered because the above effects will be localized and temporally and spatially staggered across its range within the FPHCP Action Area during the proposed 50-year term of the Permit.

Culvert and bridge maintenance and installation, and road construction and maintenance, could adversely affect the Van Dyke's salamander through direct mortality from equipment or degradation to riparian habitat adjacent to work areas. These adverse effects are expected to reduce the quality of habitat, reduce the numbers, and reduce the reproductive potential of the Van Dyke's salamander at times throughout the proposed 50-year term of the Permit. However, the distribution of the Van Dyke's salamander is not expected to be altered because the above effects will be localized and temporally and spatially staggered across its range within the FPHCP Action Area during the proposed 50-year term of the Permit.

The probability of adverse effects to Van Dyke's salamanders (especially those effects that would directly injure or kill salamanders) is low for any particular forest practice activity in a single location. However, the probability that habitat quality, numbers of individuals, and reproductive potential would be reduced across the FPHCP covered lands during the proposed 50-year Permit term is reasonably certain to occur many times in many locations.

The Van Dyke's salamander is known to occur in parts of all of the following Water Resource Inventory Areas (WRIAs): 10, 11, 16, 19, 20, 21, 22, 23, 24, 25, 26, and 27 (USFWS and NMFS 2006; Appendix A Regional Summaries). Because survey information for Van Dyke's salamanders does not exist for most WRIAs, it is impossible to determine how many individual Van Dyke's salamanders would be injured, killed, or affected by habitat degradation that disrupts breeding, feeding, and sheltering behaviors. Therefore, the amount of riparian harvest, the number of road crossing structures, and the miles of stream-adjacent roads are used as surrogates for quantifying the adverse affects on Van Dyke's salamanders. Thus, it is estimated that harvest of riparian timber for up to 88,519 acres along Type S streams, 193,530 acres along Type F streams, 81,394 acres along Type Np streams, and 532,021 acres along Type Ns streams could adversely affect Dunn's salamanders over the life of the proposed 50-year Permit term. These numbers represent the maximum amount of habitat that is expected to be affected during the proposed 50-year Permit term and likely overestimate the actual habitat would be affected as habitat surrogates lack precision. These numbers are derived from a GIS analysis described in Appendix G.

It is estimated that culvert and bridge maintenance and installation could result in adverse effects to Dunn's salamanders from up to 962 Type S stream crossings, 9,283 Type F stream crossings, 4,794 Type Np stream crossings, and 62,693 Type Ns stream crossings. Further, it is estimated that road construction and maintenance could result in adverse effects to Dunn's salamanders from up to 793 miles of road along Type S streams, 1,507 miles of road along Type F streams, and 468 miles of road along Type Np streams. These effects would occur over the life of the proposed 50-year Permit term within WRIAs 10, 11, 16, 19, 20, 21, 22, 23, 24, 25, 26, and 27 that intersect FPHCP covered lands. These numbers are derived from a GIS analysis described in Appendix G.

The conservation measures in the FPHCP minimize and mitigate adverse effects to Van Dyke's salamanders described above. These measures include: (1) no-harvest RMZs along Type S, F, and at least 50 percent of Type Np streams; (2) Inner and Outer Zone RMZ restrictions along Type S and F streams; and (3) equipment limitation zones.

8.4.5.4 CUMULATIVE EFFECTS

Cumulative effects are those effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR §402.02). Cumulative effects were addressed in the Comprehensive Cumulative Effects section of this Opinion, with respect to the aquatic and riparian environment in Washington State. It is assumed that most land surrounding and upstream of the headwater habitat used by Van Dyke's salamanders would be forestland since most agricultural and developed land occurs much lower in watersheds. The cumulative effects of future State or private activities in these headwater areas would likely include upland timber harvest under the FPHCP and recreation activities. These reasonably expected future State and private activities are not expected to substantially change the overall effects of the action, described above, on the Van Dyke's salamander.

8.4.5.5 CONCLUSION

The aggregate effects of the factors analyzed under the environmental baseline, the effects of the action, and the cumulative effects in the FPHCP Action Area, when viewed against the status of the species is not likely to jeopardize the continued existence of the Van Dyke's salamander.

8.4.6 COASTAL TAILED FROG (*Ascaphus truei*) and ROCKY MOUNTAIN TAILED FROG (*Ascaphus montanus*)

8.4.6.1 STATUS OF THE SPECIES

Description of Species

Endemic to the Pacific Northwest, tailed frogs are the only species of the family Ascaphidae, and are among the most primitive living frogs. Males are distinguished by a tail-like appendage that is used for internal fertilization, an adaptation to their life in cold, swift streams (Nussbaum et al. 1983). Female frogs have no tail (Werner et al. 2004). Based on an examination of genetic differences, Nielson et al. (2001) recommended that coastal and inland populations of tailed frogs be recognized as distinct species, *Ascaphus truei* (coastal) and *A. montanus* (inland or Rocky Mountain). In general, there are not significant differences in the life histories and habitat associations of these two species, so they will be treated collectively in this discussion. Any major differences between the two species will be noted. Nomenclature follows Crother et al. (2003).

Adult tailed frogs are small, relatively flat, slender frogs that are usually brown to gray in color above, but can also be reddish or black (Blaustien et al. 1995). They can have a yellow to green triangle on the top of their head, as well as a dark stripe between the eyes. The frogs also have a dark stripe from tip of snout to shoulder, that passes through the eye (Smith 1978). The frogs have no external tympanum, smooth to warty skin, and large eyes with vertical pupils (Blaustein et al. 1995; Werner et al. 2004). Tailed frogs are unable to call (Leonard et al. 1993). The body length of adult Coastal tailed frogs range in size from 1.3 to 2.0 inches (34 to 51 millimeters) (Jones et al. 2005; Lannoo 2005). The body length of adult Rocky Mountain tailed frogs range in size from 1.2 - 2.2 inches (31 to 56 millimeters) (Werner et al. 2004). Female tailed frogs are usually larger than the male frogs (Werner et al. 2004). The tadpoles have a very distinctive large sucker-like mouth and the eggs are unpigmented (Werner et al. 2004).

Historical and Current Range

Coastal tailed frogs occur throughout the Pacific Northwest, with a range that extends from southwestern British Columbia south to northwestern California (Leonard et al. 1993). In Washington, Coastal tailed frogs have been found in the Willapa Hills and the Cascade and Olympic Mountains. The frogs have been found as high as 5,250 feet (1,600 meters) in Washington (Leonard et al. 1993).

Rocky Mountain tailed frogs occur in the Rocky Mountains of Idaho, Montana, and extreme southeastern British Columbia, mainly west of the Continental Divide (Werner et al. 2004). There are also small disjunct populations occurring in southeast Washington and northeast Oregon. The frogs have been found as high as 8,390 feet (2,557 meters) in Montana (Werner et al. 2004).

Historical versus current range of the tailed frogs does not appear to have changed much in the past 100 years (Lannoo 2005). There also appears to be no documented change in historical versus current abundance (Lannoo 2005), but this could simply be due to a lack of large scale surveys (Marc Hayes, Personal Communication, 2005). There is no evidence of a population decline (Lannoo 2005).

Essential Habitat Components

Adult tailed frogs are highly associated with aquatic habitats. They are found almost exclusively in cold, rocky streams from sea level to near timberline. The tadpole's sucker-like mouth, used for clinging to rocks and scraping away food, is a sign of this species' adaptation to life in fast-flowing water (Nussbaum

et al. 1983; Leonard et al. 1993). An additional adaptation to stream life is that the adult frogs breathe through their skin due to reduced lung size; which helps in reducing the buoyancy of adult frogs (Jones et al. 2005). Breeding and rearing habitat for the tailed frog generally consists of permanent, cool (usually less than 59° F (15° C)) streams with cobble/boulder substrate and woody debris (de Vlaming and Bury 1970; Welsh et al. 1993). These conditions are typically associated with cold, clear, headwaters to mid-order streams in older forest ecosystems (Welsh et al. 1993). Adults forage mainly on land along stream banks, but also underwater, seeking cover under rocks and woody debris in streams. At night, adult tailed frogs emerge and may forage up to 1,300 feet (396 meters) into adjacent forested areas (McComb et al. 1993). The adult frogs are opportunistic predators feeding on a variety of invertebrates (Lannoo 2005). Older (greater than 200 years), multi-layer forests, downed woody material, ground-level vegetation, ground cover, and canopy closure have been shown to be important in the occurrence of tailed frogs in northwestern California and southern Washington (Aubry and Hall 1991; Welsh et. al. 1993). The presence of tailed frogs in younger-age stands indicates that suitable microhabitat conditions can be found in forests less than 200 years old (Corn and Bury 1989; Aubry and Hall 1991).

In a study of 40 perennial, non-fish-bearing streams in southwestern Washington, Wilkins and Peterson (2000) found Coastal tailed frogs only in streams with basaltic (i.e., bedrock) lithology, but this pattern may result from marine sedimentary streams being more vulnerable to harvest effects (Adams and Bury 2002). Similarly, Jackson et al. (2003) found tailed frogs only at steep basalt sites, and concluded that local geologic and topographic conditions play a large role in determining the presence and abundance of this species. In both studies, all surveyed streams occurred in second-growth forest stands. In contrast, Adams and Bury (2002) studied streams within unmanaged forests in Olympic National Park and found that stream amphibians (including tailed frogs) were common in waters with unconsolidated surface geology. Welsh and Lind (2002) also found Coastal tailed frogs to be common in streams with unconsolidated geologies in the Klamath-Siskiyou region, noting instead that stream temperature and forest age were the strongest predictors of tailed frog presence and abundance. Collectively, these findings tend to support Dupuis and Steventon's (1999) report that the competency of the parent geology had significant effects on tailed frogs, but that these effects were greatly exacerbated by timber harvest.

Reproductive Ecology

Reproduction occurs in aquatic habitats. Tailed frogs typically mate (internal fertilization) during late August and September, females lay eggs during the summer of the year after mating (Leonard et al. 1993). The eggs (28 to 96 per clutch) are laid as strings under large rocks in the stream (Lannoo 2005). The tadpoles feed on diatoms, some filamentous algae and when in season, conifer pollen (Lannoo 2005). The larvae (tadpoles) remain in the water for one to five years (two to four years has been documented in Washington) after hatching (Smith 1978; Nussbaum et al. 1983; Leonard et al. 1993; Welsh et al. 1993). The tailed frog's exceptionally long period of larval and pre-reproductive adult development (estimated seven to nine years) increases the vulnerability of local populations to habitat disturbance (Brown 1975; Daugherty and Sheldon 1982b; Jennings and Hayes 1994). These factors may also increase the amount of time required for recovery following disturbance (Blaustein et al. 1995). Tailed frog larvae are likely to be particularly sensitive to sedimentation following clearcutting along headwater streams. They cannot adhere to rocks that are coated with fine sediment, and may have difficulty moving to find suitable substrate (Jackson et al. 2003). Tadpole populations can also be wiped out by severe floods that scour the stream bed (Lannoo 2005). Tailed frogs reach sexual maturity at 7 to 9 years and may live 15 to 20 years (Jones et al. 2005; Lannoo 2005).

Movements and Habitat Use

Tailed frogs may migrate seasonally by moving to cooler, more-shaded streams during the summer (Lannoo 2005). There is no evidence of breeding migrations of tailed frogs, but there may be post-metamorphic dispersal of juvenile in the fall (Lannoo 2005). There is no evidence of territories, but the frogs appear to be very philopatric (Jones et al. 2005; Lannoo 2005).

Threats to Survival and Conservation Needs of the Species

The Coastal tailed frog is a Federal species of concern and is on the Washington State monitor list. The Rocky Mountain tailed frog is a Federal species of concern and a Washington State candidate species. Compared to other stream-breeding amphibians, tailed frogs appear to be the most-narrowly distributed and the most sensitive to short- and intermediate-term effects from timber harvest (Jackson et al. 2003). Tailed frogs have demonstrated sensitivity to increased levels of fine sediment, which may reduce the availability of algae and other foods important to tadpoles (Welsh and Ollivier 1998). Local populations are susceptible to extirpation for several reasons, including narrow niche requirements combined with isolated population distribution, long generation time, and loss of mature forest along headwater stream habitats (Welsh 1990). Of seven Pacific Northwest frogs and toads associated with old-growth forests, the tailed frog is probably the species most likely to be affected by old-growth habitat loss and degradation (Blaustein et al. 1995).

Nussbaum et al. (1983) reported that tailed frogs disappeared from streams when areas were logged, speculating that increased water temperature and siltation were the cause. Jackson et al. (2003) compared pre- and post-logging populations of Coastal tailed frogs at five streams in southwestern Washington. In the three streams that were clearcut harvested, no Coastal tailed frogs were detected immediately following harvest. Two years later, Coastal tailed frogs were still absent from two of the three streams. Corn and Bury (1989) and Dupuis and Steventon (1999) also found that logging had significant negative effects on densities of tailed frogs. In the redwood forests of northern California, Ashton et al. (2005) documented significantly greater numbers of Coastal tailed frogs in late-seral forests compared to second growth forests 37 to 60 years old. Findings from recent studies have suggested that increased sediment input may be the most-important factor behind tailed frog population declines following logging (Dupuis and Steventon 1999; Ashton et al. 2005). Dupuis and Steventon (1999) also found that buffered creeks had, on average, higher densities of tailed frogs than logged creeks. Several studies have also suggested that riparian buffer strips may be able to protect the streamside microhabitat variables required by tailed frogs, even if the surrounding habitat is not maintained as old-growth forest (Corn and Bury 1989; Bull and Carter 1996). In contrast to the above information, tailed frog tadpoles and adults were found in abundance in several high-gradient streams surrounded by young (less than 20 years old) riparian and upland stands southeast of Mount St. Helens in the Gifford-Pinchot National Forest (Sally Butts, Personal Observation, 2006). In general, potential conservation measures for tailed frogs include: protection of headwater stream habitat, leaving sediment reducing structures in the stream, reducing wind-throw near the stream, and providing a long-term source of downed wood (Jones et al. 2005).

Based on the above information, the conservation needs of the Coastal and Rocky Mountain tailed frog are: (1) to maintain or expand their current distribution; and (2) to avoid and minimize adverse changes to riparian areas and headwater streams.

8.4.6.2 ENVIRONMENTAL BASELINE

Tailed frogs are the most widely distributed of the FPHCP covered amphibian species. Their occurrence spans all types of land ownerships and is likely driven primarily by stream gradient and substrate conditions.

The Coastal tailed frog is known to occur in parts or all of the following Water Resource Inventory Areas (WRIAs): 1, 3, 4, 5, 7, 8, 9, 10, 11, 12, 13, 14, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 38, 39, 45, 46, 47, and 48 (USFWS and NMFS 2006; Appendix A Regional Summaries).

The Rocky Mountain tailed frog is known to occur in parts or all of the following Water Resource Inventory Areas (WRIAs): 32 and 35. Other WRIAs near or adjacent to known sites in British Columbia and Idaho, WRIAs 51 through 62, may also support Rocky Mountain tailed frogs, however, no systematic surveys have been conducted to date to determine occurrence (USFWS and NMFS 2006; Appendix A Regional Summaries).

Conservation Needs of the Species in the FPHCP Action Area

Coastal tailed frogs occur across the Cascade and coastal mountains in British Columbia, Washington, and Oregon, and the coastal range in northern California. They also occur on the Olympic Peninsula of Washington. Rocky Mountain tailed frogs occur in the Blue Mountains in southeast Washington and northeast Oregon, and also much of Idaho, western Montana, and southeastern British Columbia. Because of their occurrence in British Columbia and Idaho, it is suspected that Rocky Mountain tailed frogs also occur in much of northeastern Washington. Both Coastal and Rocky Mountain tailed frogs inhabit riparian areas and headwater streams. They seem to be dependent on cold, clear, fast-moving headwater streams with cobble substrates and associated riparian areas. Because Coastal and Rocky Mountain tailed frogs are endemic to the Pacific Northwest and because the FPHCP Action Area overlaps a large portion of their range in Washington, maintaining the physical and ecological integrity of riparian and headwater stream habitats in the FPHCP Action Area is essential to the long-term conservation of the Coastal and Rocky Mountain tailed frog.

8.4.6.3 EFFECTS OF THE ACTION

The effects from the proposed action are described in detail in the Effects to Guilds – Headwater Guild section in this Opinion. Coastal and Rocky Mountain tailed frogs would be adversely affected by changes in overstory riparian canopy, through timber harvest, that are expected to increase solar radiation along non-buffered portions of Type Np and Ns streams, thus warming the water in shallow stream margins. Direct damage to streambank conditions through yarding timber within riparian yarding corridors is expected on occasion and would also adversely affect tailed frogs. These effects are expected to reduce the quality of habitat, reduce the numbers, and reduce the reproductive potential of tailed frogs at times throughout the proposed 50-year term of the Permit. However, the distribution of tailed frogs is not expected to be altered because the above effects will be localized and temporally and spatially staggered across its range within the FPHCP Action Area during the proposed 50-year term of the Permit.

Riparian timber harvest along Type Np and Ns streams, especially non-buffered portions, is expected to reduce the amount of wood recruited to streams. This would reduce the capacity for sediment storage, reduce substrate for aquatic invertebrate production, and possibly alter stream channel morphology. Increased sedimentation is expected to reduce the habitat quality for tailed frogs by filling interstitial spaces in stream substrate that impairs movement, egg deposition, and larval development. A reduction

in aquatic invertebrate production would reduce food for tailed frogs. Possible changes in stream channel morphology could degrade stream margins and thus tailed frog habitat. Increased sedimentation, decreased invertebrate production, and possibly changes in channel morphology are expected to reduce the quality of habitat, reduce the numbers, and reduce the reproductive potential of tailed frogs at times throughout the proposed 50-year term of the Permit. However, the distribution of tailed frogs is not expected to be altered because the above effects will be localized and temporally and spatially staggered across its range within the FPHCP Action Area during the proposed 50-year term of the Permit.

Increased sediment inputs from hydrologically connected forest roads or from road construction across Type Np and Ns streams would adversely affect tailed frogs by filling interstitial spaces in stream substrate that impairs movement, egg deposition, and larval development. Electrofishing (related to adaptive management research and instream fish salvage for culvert and bridge maintenance and installation) would adversely affect tailed frogs in the form of stress, wounding, or mortality. Also, culvert and bridge maintenance and installation could adversely affect tailed frogs through short-term (i.e., days to weeks) sediment inputs and riparian and instream heavy equipment use. Increased sediment inputs from forest roads, road crossings, and culvert and bridge maintenance and installation is expected to reduce the quality of habitat, reduce the numbers, and reduce the reproductive potential of tailed frogs at times throughout the proposed 50-year term of the Permit. However, the distribution of tailed frogs is not expected to be altered because the above effects will be localized and temporally and spatially staggered across its range within the FPHCP Action Area during the proposed 50-year term of the Permit. Electrofishing is expected to affect few individual tailed frogs through stress, wounding, and direct mortality over the proposed 50-year Permit term for the FPHCP.

The probability of adverse effects to tailed frogs (especially those effects that would directly injure or kill frogs) is low for any particular forest practice activity in a single location. However, the probability that habitat quality, numbers of individuals, and reproductive potential would be reduced across the FPHCP covered lands during the proposed 50-year Permit term is reasonably certain to occur many times in many locations.

The Coastal tailed frog is known to occur in parts or all of the following Water Resource Inventory Areas (WRIAs): 1, 3, 4, 5, 7, 8, 9, 10, 11, 12, 13, 14, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 38, 39, 45, 46, 47, and 48 (USFWS and NMFS 2006; Appendix A Regional Summaries). The Rocky Mountain tailed frog is known to occur in parts or all of the following WRIAs: 32 and 35 (USFWS and NMFS 2006; Appendix A Regional Summaries). However, because of their distribution in British Columbia and Idaho and the lack of surveys in northeast Washington, it is assumed that Rocky Mountain tailed frogs also occur in WRIAs 51 through 62. Because survey information for Coastal and Rocky Mountain tailed frogs is limited in most WRIAs, it is impossible to determine how many individual tailed frogs would be injured, killed, or affected by habitat degradation that disrupts breeding, feeding, and sheltering behaviors. Therefore, the amount of riparian harvest, the number of road crossing structures, and the miles of stream-adjacent roads are used as surrogates for quantifying the adverse affects on tailed frogs.

Coastal Tailed Frogs

It is estimated that harvest of riparian timber for up to 132,907 acres along Type Np streams and 717,686 acres along Type Ns streams could adversely affect Coastal tailed frogs over the life of the proposed 50-year Permit term. These numbers represent the maximum amount of habitat that is expected to be affected during the proposed 50-year Permit term and likely overestimate the actual habitat would be

affected as habitat surrogates lack precision. These numbers are derived from a GIS analysis described in Appendix G.

Further, it is estimated that culvert and bridge maintenance and installation, and sediment from hydrologically-connected roads, could result in adverse effects to Coastal tailed frogs from up to 7,575 Type Np stream crossings and 89,837 Type Ns stream crossings, and 872 miles of Type Np stream-adjacent roads, over the life of the proposed 50-year Permit term within WRIAs 1, 3, 4, 5, 7, 8, 9, 10, 11, 12, 13, 14, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 38, 39, 45, 46, 47, and 48 that intersect FPHCP covered lands. These numbers are derived from a GIS analysis described in Appendix G.

Rocky Mountain Tailed Frogs

It is estimated that harvest of riparian timber for up to 27,111 acres along Type Np streams and 101,768 acres along Type Ns streams could adversely affect Rocky Mountain tailed frogs over the life of the proposed 50-year Permit term. These numbers represent the maximum amount of habitat that is expected to be affected during the proposed 50-year Permit term and likely overestimate the actual habitat would be affected as habitat surrogates lack precision. These numbers are derived from a GIS analysis described in Appendix G.

Further, it is estimated that culvert and bridge maintenance and installation, and sediment from hydrologically-connected roads, could result in adverse effects to Rocky Mountain tailed frogs from up to 1,341 Type Np stream crossings and 15,473 Type Ns stream crossings, and 255 miles of Type Np stream-adjacent roads, over the life of the proposed 50-year Permit term within WRIAs 32, 35, and 51 through 62 that intersect FPHCP covered lands. These numbers are derived from a GIS analysis described in Appendix G.

The conservation measures in the FPHCP minimize and mitigate adverse effects to Coastal and Rocky Mountain tailed frogs described above. These measures include: (1) no-harvest RMZs on at least 50 percent of Type Np streams; (2) sensitive site protections (e.g., seeps, springs, Type Np intersections, perennial initiation points; and (3) unstable slope protections.

8.4.6.4 CUMULATIVE EFFECTS

Cumulative effects are those effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR §402.02). Cumulative effects were addressed in the Comprehensive Cumulative Effects section of this Opinion, with respect to the aquatic and riparian environment in Washington State. It is assumed that most land surrounding and upstream of the headwater habitat of Coastal and Rocky Mountain tailed frogs would be forestland since most agricultural and developed land occurs much lower in watersheds. The cumulative effects of future State or private activities in these headwater areas would likely include upland timber harvest under the FPHCP and recreation activities. These reasonably expected future State and private activities are not expected to substantially change the overall effects of the action, described above, on Coastal and Rocky Mountain tailed frogs.

8.4.6.5 CONCLUSION

The aggregate effects of the factors analyzed under the environmental baseline, the effects of the action, and the cumulative effects in the FPHCP Action Area, when viewed against the status of tailed frog species is not likely to jeopardize the continued existence of the Coastal or Rocky Mountain tailed frog.

8.5 NATIVE FISH

(Note: Due to the large number of native fish described under section 8.5, their distribution in Water Resource Inventory Areas of Washington (WRIAs) is listed in Appendix H, Table 1. The quantification of effects, by native fish species, is also listed in Appendix H, Table 2.)

8.5.1 Dolly Varden (*Salvelinus malma*)

8.5.1.1 Status of Species

Description of Species

Within Washington State there are two types of native char, the bull trout (*Salvelinus confluentus*) and the Dolly Varden (*Salvelinus malma*). Both are similar in appearance and habitat requirements, and for some time were considered to be the same species until morphological analyses, meristic variation, and genetic analysis (Cavender 1978; Robins et al. 1980, Bond 1992; Crane et al. 1994; Leary and Allendorf 1997) confirmed that they were in fact two distinct species.

Biologists had previously identified bull trout as Dolly Varden (*Salvelinus malma*), largely because of the external similarity of appearance and the previous unavailability of adequate specimens of both species to any one taxonomist. Both species occur together in western Washington, for example, with little or no interbreeding (Leary and Allendorf 1997, as cited in USFWS 2004). Dolly Varden do not occur in eastern Washington. Lastly, bull trout and Dolly Varden each appear to be more-closely related genetically to other species of *Salvelinus* than they are to each other (Phillips *et al.* 1989; Greene *et al.* 1990; Pleyte *et al.* 1992, as cited in USFWS 2004). For example, bull trout are most-closely related to Japanese char (*S. leucomaenis*) and Dolly Varden are most-closely related to Arctic char (*S. alpinus*).

The coloration on Dolly Varden can depend on life history and vary from region to region. Generally the overall, non-spawning body color is olive green from their dorsal surface down along their sides to the belly portion, becoming a dirty to bright white on their ventral side. The pectoral and pelvic fins and anal fin remain an olive green with white leading edges on the pelvic and pectoral fins. Dolly Varden also exhibit white or cream colored spots along their sides starting at about their lateral line area to their dorsal surface. The relative sizes of these spots are small, about the size of their pupils (Wydoski and Whitney 2003). These spots, depending on region, can also range from yellow to a light orange. During spawning, char can take on a red coloration along their sides with a darker brown or olive green color on their dorsal surface. The leading edges of their pectoral and pelvic fins will also become a bright white color. Dolly Varden have smaller, shorter heads than bull trout and with eyes smaller and not-so-dorsally placed (Goetz 1989).

Historical and Current Distribution

Char in Washington State were more widely distributed historically than at present. The historic accounts of Dolly Varden in eastern Washington are now known to actually be that of bull trout. In western

Washington, bull trout and Dolly Varden can occur in the same watershed. Historical distribution of Dolly Varden has been difficult to surmise due to the confusion in identifying bull trout and Dolly Varden (USFWS 2004). Current evidence suggests that the Dolly Varden in Washington tend to be located in isolated populations in headwater tributaries above anadromous barriers (USFWS 2004).

Bull trout and Dolly Varden are known to occur together only within the area of the Coastal Puget Sound Bull Trout Distinct Population Segment and in British Columbia, Canada. Currently, genetic analyses can distinguish between the two species (Crane *et al*. 1994; Baxter *et al*. 1997; Leary and Allendorf 1997). Although morphometrics (measurements) and meristic variation (variation in characters that can be counted) can also be used successfully to distinguish the two species (Haas and McPhail 1991), there can be significant error associated with the application of this methodology by improperly trained users (Haas and McPhail 2001). Haas and McPhail (2001) determined that bull trout were much more likely to be misidentified as Dolly Varden (48 percent of the time), than Dolly Varden were to be misidentified as bull trout (2.5 percent of the time) when this methodology was applied.

McPhail and Taylor (1995) noted that upper Skagit River Dolly Varden, which are generally a stream resident, small in size, and drift feeders, predominate in tributary streams. In contrast, bull trout are migrants, much larger in size and piscivorous, and appear to predominate the main river. Other than one exception discussed below, all native char observed in accessible anadromous reaches are believed to be bull trout.

On the Olympic Peninsula, Dolly Varden have been confirmed in the Dungeness and Quinault core areas (Leary and Allendorf 1997; Young, *in litt.* 2001; Spruell and Maxwell 2002, as cited in USFWS 2004)). Dolly Varden have also been confirmed in the Soleduck River above an anadromous barrier and no bull trout have been identified in the Soleduck River. In the Coastal-Puget Sound Distinct Population Segment, Dolly Varden tend to be distributed as isolated tributary populations above natural anadromous barriers (as in the Dungeness core area), while bull trout are distributed below these barriers (WDFW 1998; Spruell and Maxwell 2002, as cited in USFWS 2004). An exception to this is found in the Quinault core area where Dolly Varden and bull trout occur within the same area in the upper Quinault River and are not isolated above a barrier (Leary and Allendorf 1997, as cited in USFWS 2004). Based on this information, we have assumed that all native char observed in accessible anadromous reaches, other than in the Quinault River, are bull trout (USFWS 2004).

Essential Habitat Components

Generally char require four types of habitat during their life cycle; spawning habitat, rearing habitat, adult habitat and overwintering habitat (Behnke 1992). Deficiencies in any one of the four can limit populations (Behnke 1992).

There are four life history forms of char:

Fluvial, in which spawning and early rearing occurs in smaller tributaries with major growth and maturation occurring in mainstem rivers.

Adfluvial, in which spawning and early rearing occurs in streams, but most growth and maturation occurs in lakes or reservoirs.

Anadromous, in which early rearing occurs in streams with major growth and maturation occurring in salt water.

Resident, in which all life stages (spawning, rearing, growth, maturation) occurs in small headwater streams, often upstream of impassable barriers.

In Washington only the bull trout is known to contain anadromous populations and has all four life history forms, whereas the Dolly Varden seem to only occur in fluvial, resident and possibly adfluvial forms.

Depending on location, char generally spawn from late August to late December, with the peak in September (Wydoski and Whitney 2003). In Alaska, Dolly Varden are known to spawn from September to early November, with the peak spawning period in October (Scott and Crossman 1973). Generally all life history forms of char prefer spawning in small, lower order rivers and streams (McPhail and Baxter 1996). Within the Columbia River system, these spawning sites are characterized by low gradients, small gravel (<20 millimeters), low water velocity (0.03-0.8 meters/second), and proximity to cover, such as cutbanks, log jams, pools, and overhanging vegetation (McPhail and Baxter 1996). Char redds are also constructed at the ends of large pools, channel margins and meander bends (Goetz 1989). Char also require specific water temperatures to spawn and are often associated with cold water springs, ground water seeps and the coldest streams in the watershed (Rieman and McIntyre 1993; McPhail and Baxter 1996). Spawning, for bull trout, is associated with falling water temperatures between 5 and 9°C, with optimum incubation temperatures between 2 and 4°C (Goetz 1989; Moyle 2002). Dolly Varden in Alaska tend to prefer spawning temperatures around 7°C (Scott and Crossman 1973).

Dolly Varden appear to have slightly colder water temperature requirements than bull trout, which may partially explain their Washington residency in upper watersheds upstream from anadromous barriers rather than in marine waters (Haas 2001, as cited in USFWS 2004).

Suitable habitat for rearing of fry is also important in all life histories of native char. The period of incubation and time to fry emergence can vary due to temperature and egg size (McPhail and Baxter 1996). Higher incubation temperatures can decrease the amount of time to hatching, whereas lower temperatures will increase the overall time to hatching (McPhail and Baxter 1996). It has been suggested that the optimal temperatures for development of bull trout occurs between 2 and 4°C (McPhail and Baxter 1996). After emerging, in either late winter or spring, char fry will remain close to the bottom and are relatively secretive and hard to find (McPhail and Baxter 1996). Young char are closely associated with substrates, often using substrates for cover (Rieman and McIntyre 1993).

Adult habitat for char varies depending on life history form. Resident populations of char are usually, but not always, separated from other populations by natural barriers (McPhail and Baxter 1996). These resident populations are usually found in the headwaters of streams or rivers where water temperatures are cool year round. The main habitat used by char in these small headwaters are pool habitats. They also utilize large wood, undercut banks, and overhanging vegetation. These resident populations generally tend to be smaller in size and mature earlier than migratory populations (McPhail and Baxter 1996).

Fluvial populations of char spend their entire adult lives, except when spawning, in large rivers (McPhail and Baxter 1996). Within these large rivers char still seek out large deep pools and instream cover (McPhail and Baxter 1996). These deep pools not only provide cover for char, they also provide cover for other types of fish in which char can feed on, such as whitefish (Goetz 1989).

Currently there are no known populations of adfluvial Dolly Varden in Washington State (S. Spalding, Personal Communication, 2004). There is documentation of a Dolly Varden being sampled from Diablo

Lake on the Skagit River (J. Chan, Personal Communication, 2004). This is thought to be an individual that either managed to pass through the dam system on Ross lake or possibly a fluvial individual of one of the small tributaries of Diablo lake. Adfluvial individuals use the lake environment as adult and overwintering habitat. They spawn in tributary streams or in the lake's inlet or outlet (Goetz 1989). Goetz (1989) summarized that bull trout forage in the littoral zone in fall and spring and move to deeper water in the summer, possibly due to temperature preferences. Bull trout have been known to utilize all parts of the lake environment (McPhail and Baxter 1996).

In Washington State, Dolly Varden seem to be restricted to the resident and fluvial life history form, while bull trout populations on the Olympic Peninsula and in the Puget Sound drainage utilize the marine environment. Dolly Varden do not seem to be anadromous in Washington whereas in British Columbia and Alaska they are anadromous and bull trout populations are fluvial, adfluvial or resident.

Reproductive Ecology

Native char spawn (depending on location) from late August to late December, when water temperatures start to drop (Wydoski and Whitney 2003). Spawning habitats for bull trout are generally characterized by temperatures that drop below 9° C (USFWS 2004). Dolly Varden in Alaska spawn when temperatures are around 7°C (Scott and Crossman 1973). Dolly Varden appear to have slightly colder water temperature requirements than bull trout, which may partially explain their Washington residency in upper watersheds upstream from anadromous barriers rather than in marine waters (Haas 2001, as cited in USFWS 2004). Preferred spawning habitats consist of low-gradient stream reaches with loose, clean gravel. Redds are often constructed in stream reaches fed by springs or near other sources of cold ground water. Fry normally emerge from early April through May, depending on water temperatures and increasing stream flows (Goetz 1989).

The choice of spawning sites is influenced by a number of physical habitat factors such as stream beds with a low percent of boulders and increased amounts of gravel and rubble, low channel gradients, overhanging vegetation, cool ground water seeps, and maximum stream temperatures of 18°C (Goetz 1989). Habitats that contain many of these factors are tailouts of pools, glide sections of streams, channel margins, and meander bends (Goetz 1989). Char can spawn as soon as four years of age (Moyle 2002). Egg production varies as to location and life history and is correlated with the size of female, with larger fish producing more eggs (Wydoski and Whitney 2003).

Movements and Habitat Use

The temperature requirements of char are very specific and represent a critical habitat characteristic (Rieman and McIntyre 1993). Summer temperatures greater than 15°C are thought to limit char distribution (Rieman and McIntyre 1993). However thermal requirements for char can change depending on life stage (USFWS 2004). Although char can tolerate warmer waters for a short period of time, an overall increase in temperatures can greatly limit their distribution and possibly add to the fragmentation of char populations (Rieman and McIntyre 1993).

The foraging behavior of char also varies as to life history and location. Char are opportunistic and adaptive in their feeding habits (Goetz 1989). As char grow they shift their diets from aquatic and terrestrial insects, and at about 110 millimeters, start feeding on small fish (McPhail and Baxter 1996). Stream dwelling resident char are usually more restricted in their movements, and are often isolated by natural barriers and cut off from migrating to larger rivers, lakes or marine environment. Their diet consists of aquatic and terrestrial insects, and small fish.

After emergence, char fry will concentrate in shallow, low velocity areas, such as side channels and small pools associated with cover to avoid predators (McPhail and Baxter 1996). Depending on life history, most fry will move into larger waters to feed and overwinter. High flow events can sometimes push juvenile char into the mainstems of rivers where predation rates are much higher (Goetz 1989). Although young char are very vulnerable to predation, predation still occurs at all stages of life histories. Adult char are preyed on by bears, otters, ospreys, eagles and man. Complex, connected habitats are vital to char in avoiding all types of predators during all life histories.

Threats to Survival

Char distribution (more notably bull trout), abundance, and habitat quality have declined rangewide (USFWS 2004). Current and past land-use practices have altered their environments in unpredictable ways (Rieman and McIntyre 1993). Within Washington State, these declines have resulted from the combined effects of habitat degradation and fragmentation, the blockage of migratory pathways, degraded water quality, poaching, entrainment into diversion channels and dams, fisheries management, and competition with non-native species (USFWS 2004). Not only have these effects had direct impacts on char populations, but they have also indirectly impacted their prey species (USFWS 2004).

Timber harvest, road building, agriculture, mining, dams, and general urbanization have all altered char habitats. Historical forest management actions that removed riparian vegetation from along streams and rivers, removed in-stream large wood, and constructed roads in sensitive locations, contributed to char habitat degradation. Dams created for generating hydroelectric power, or storing drinking water and irrigation water have cut off migratory routes of char and created unnatural hydrological regimes. Dams with improper or no fish passage ways have isolated populations of char from and have restricted genetic interchange with other populations. Dams also restrict movement of returning salmon that provide char with prey items such as salmon eggs and eventually salmon fry. Impassable culverts have also restricted movements of char.

Water quality is extremely important to native char. Char require cold and clean headwaters for spawning and fry development. Char are particularly sensitive to environmental change (Rieman and McIntyre 1993), and changes in water quality can negatively influence char populations. Agriculture, mining, and general urbanization runoff can all add harmful pollutants to water ways. Pollutants can lead to immunosuppression and increased disease susceptibility in juvenile salmon (Arkoosh et al.1998). Petrochemicals and other pollutants can be washed off of city streets and into road drains that empty into waterways. Roads from mining, timber harvesting, agriculture and urbanization can transport fine sediment into water ways causing increased siltation of spawning sites.

Hatchery stocking of non-native fish species in areas occupied by char have impacted populations through competition and hybridization. The stocking of predatory species, such as walleye (*Sander viterus*), small mouth bass (*Micropterus dolomieu*) and large mouth bass (*Micropterus salmoides*), can affect the survival rates of native salmonids, including char (USFWS 2002). Increased fishing pressure is also a major contributor to char mortality and a factor in the declines of some populations (USFWS 2004). In the early 1900's, char were caught commercially in central and southern Puget Sound, but within 10 years catch rates dropped off (USFWS 2004). Poaching and misidentification of char also impacts local populations (USFWS 2004). Char have also been documented as incidental catch by commercial, recreational and Tribal fisherman. The level of incidental catch of char within commercial fishing areas in Washington State is as yet unknown.

8.5.1.2 Environmental Baseline

The state of knowledge for identifying char as either Dolly Varden or bull trout has improved in recent years. With our current ability to separate the two species, we now have a better understanding of where Dolly Varden currently reside. The following streams are currently known to be inhabited by Dolly Varden: upper Dungeness River (upstream of the barrier at mile 24), upper Soleduck River (upstream of the falls) and the upper Quinault River on the Olympic Peninsula. The known Dolly Varden populations on the Olympic Peninsula all occur within the Olympic National Park or within Olympic National Forest. Abundance data for these streams is currently unknown.

In the North Cascades, Dolly Varden occur in the upper Skagit River; Tributaries of the North Fork Nooksack (upper Canyon and Kidney creeks); and tributaries of the South Fork Nooksack River (Bell and Pine Creeks). Dolly Varden may also be present in the Lower Skagit core area, but this has not been confirmed. Areas of known occupancy are either on National Park or National Forest lands.

With our current ability to separate bull trout from Dolly Varden, and our current occupancy data for the Dolly Varden, our conclusion is that the species is not present in the FPHCP Action Area. They are upstream of lands that could be affected by the proposed action. Abundance data for these streams is currently unknown.

Role of FPHCP Action Area for Conservation of species:

The role of the FPHCP Action Area for conservation of Dolly Varden is minor. Currently, documented occupancy of Dolly Varden is outside of the FPHCP Action Area. There may be some unknown areas in the FPHCP Action Area that are occupied by Dolly Varden, but generally the FPHCP Action Area will provide only a minor role in the long-term survival of Dolly Varden. Federal lands appear to provide the majority of the important habitats for Dolly Varden in Washington.

8.5.1.3 EFFECTS OF THE ACTION

General habitat effects to Dolly Varden resulting from the proposed action have been summarized above for the Steep tributary and Low-gradient Tributary Habitat Associations. Currently there is no documentation of Dolly Varden residing in the FPHCP Action Area. New populations of Dolly Varden may eventually be found and it is possible that new populations could be located in the FPHCP Action Area. However, if the current pattern of their occupancy holds, new populations would likely be found on Federal lands. Effects to Dolly Varden streams are possible where distribution of fish is underestimated and the FPHCP covered activities in presumed Type Np streams affect riparian functions in Type F streams, including large wood recruitment, stream temperature, and sediment delivery. A total of 62,414 riparian acres are potentially available to be managed that could contribute to harm of Dolly Varden.

Riparian prescription effects to Dolly Varden

Full riparian and in-stream function likely would not be provided to all habitats occupied by Dolly Varden. In some stream reaches, the highest quality and most structurally complex habitats may fail to develop due to the potential reduction of large wood recruitment to streams at different time scales and following different riparian management prescriptions. For example, although the FPHCP would provide the majority of available large wood adjacent to fish-bearing streams, the FPHCP allows some trees within these large wood recruitment zones to be harvested. In addition, stream-adjacent parallel roads, unbuffered areas in Type Np streams, yarding corridors, and road crossings would likely reduce potential large wood recruitment. Excessive windthrow could affect some riparian processes. The reduction of

large wood over long time frames may not allow recruitment processes to form some habitats (pools, riffles, hiding cover) that Dolly Varden use. Large wood influences pool formation which is important during certain life-history stages for Dolly Varden. Large wood also provides hiding cover, sorts and releasing spawning gravels, and provides numerous other important biological and physical processes. Less structurally complex habitat may reduce densities of Dolly Varden. Less complex habitat may also affect survival of individual fish through increased competition or predation. Degradation of Type Np riparian areas and stream habitat could also alter the availability of terrestrial and aquatic invertebrates, which are an important food source for Dolly Varden at all life stages.

Dolly Varden require cool water for survival, potentially even cooler than bull trout. When RMZs achieve their Desired Future Condition, streams within the areas covered by the FPHCP, that are occupied by Dolly Varden, will receive most of the potentially available shade. There are physical situations (yarding corridors, stream-adjacent parallel roads, stream crossings, 20-acre exemptions, and windthrow) where stream shading potential will be reduced.

Along unbuffered Type Np streams, reductions in shade are likely to occur and water temperature may increase over limited distances as a result of these unbuffered Type Np streams. In some cases, increases in temperature may be delivered to downstream Type F waters and temperatures could be warmed near the confluence of Type Np and F streams. In these circumstances, there could be negative effects to Dolly Varden due to potentially elevated stream temperatures and loss of thermal refugia resulting in impairment of foraging, rearing, and spawning behaviors. Increased temperatures may result in a competitive advantage for certain species, which could affect individual fish.

Sediment effects to Dolly Varden

Sediment would be delivered to Dolly Varden habitat from road surface erosion. When FPHCP activities affect certain watershed features, such as steep unstable slopes, there may be additional sediment delivered to fish-bearing streams that are above natural background rates. Increased sediment could result in changes to channel morphology, Dolly Varden habitat could be reduced due to shallowing and filling of pools. Feeding behavior may be affected under some circumstances affecting individual fish fitness and survival. Siltation of spawning reaches could reduce egg survival. However, the FPHCP is not expected to significantly contribute to instream sediment loading to the point that Dolly Varden would be impaired at more than a streams reach scale. Often, effects might be limited to a habitat unit (pool, riffle) or several units.

Culvert and bridge replacement or installation projects are expected to provide a chronic source of sediment, at least until vegetation has been re-established. When vegetation on culvert streambanks has been restored, the amounts of sediment from road crossings are expected to decline. Short segments of stream are routinely dewatered for culvert installation or replacement and the chance for localized fish mortality increases with these projects.

Effects from the 20-acre Exemption Rule

Although it is there is uncertainty on how often this rule would be implemented, when it is implemented the 20-acre Exemption Rule would affect Dolly Varden. In watersheds with a high proportion of 20-acre exempt landowners, this rule would increase the likelihood that large wood recruitment would be inadequate to maintain properly functioning habitat (USFWS & NMFS 2006). There is also the potential for increased sedimentation, reduced shade, increased stream temperatures, and an increase in windthrow.

Where these adverse effects occur, essential behaviors associated with foraging, reproduction and growth may be impeded and Dolly Varden may occupy the stream at reduced levels and have reduced survival.

Summary of adverse effects to Dolly Varden

The proposed action will have short- to long-term adverse effects on sediment, large wood, and temperature. These effects would be most severe from unbuffered Type Np streams and their downstream effects that result in disruption of natural riparian and aquatic processes and functions in Type F streams. These effects to the aquatic environment may result in impairment of essential foraging, rearing, and spawning behavior of Dolly Varden. It is difficult to predict the severity of these effects because effects to these fish will vary from activity to activity depending on the specific riparian prescription applied, the location, historical management practices, geological characteristics of the watershed, and the biotic community present.

Activities covered under the FPHCP are expected to have direct and indirect adverse effects to adult and juvenile Dolly Varden ranging from mortality to sublethal effects. Direct injury and death to Dolly Varden would likely occur during some stream crossing construction activities (stream dewatering and fish rescue and relocation, and blockage of upstream migration during construction). Alterations of the riparian and aquatic environment will reduce the ability of streams to support prey species, thus reducing the fish's ability and success at finding forage in these streams. In a degraded environment increased competition with and predation by other species is anticipated. This could affect the growth and survival of juvenile and adult Dolly Varden.

The role of the FPHCP Action Area for conservation of Dolly Varden is minor. Currently, documented occupancy of Dolly Varden is outside of the FPHCP Action Area. There may be some unknown areas in the FPHCP Action Area that are occupied by Dolly Varden, but generally the FPHCP Action Area will provide only a minor role in the long-term survival of Dolly Varden. Federal lands appear to provide the majority of the important habitats for Dolly Varden in Washington.

Summary of beneficial effects

The long-term benefits of the FPHCP for Dolly Varden would occur as riparian areas mature, roads are managed with watershed processes in mind, adaptive management is implemented, and fish passage is maintained and restored. The FPHCP's incorporation of BMPs and RMAPs will substantially reduce road surface erosion to Dolly Varden habitat. Most adverse effects are associated with the downstream effects from RMZs on Type Np streams and the 20-acre exemption rule and not from RMZs directly adjacent to Type F streams. Effects are not expected to significantly decrease the distribution of Dolly Varden in the FPHCP Action Area, because the FPHCP is not expected to significantly contribute to habitat degradation to the point that Dolly Varden would be harmed at more than a stream reach scale. Often, effects might be limited to a habitat unit (pool, riffle) or several units.

8.5.1.4 CUMULATIVE EFFECTS

Cumulative effects were addressed in the **Comprehensive Cumulative Effects**, with respect to the aquatic and riparian environment in Washington State. Additional information regarding cumulative effects for Dolly Varden was presented in the section steep **Tributary and Low-gradient Tributary Guilds: Cumulative Effects.**

8.5.2 Coastal Cutthroat Trout (*Oncorhyncus clarki clarki*) and Westslope Cutthroat Trout (*Onchorhynchus clarki lewisi)*

8.5.2.1 Status of the Species

Description of Species

In Washington State there are two subspecies of native cutthroat trout, the coastal cutthroat trout (*Oncorhynchus clarki clarki)*, and the westslope cutthroat trout (*Onchorhynchus clarki lewisi)* (Wydoski and Whitney 2003). A primary distinguishing physical feature for these species is that the maxillary generally extends beyond the posterior margin of the eye, especially in fish larger than 4 inches. Cutthroat trout also have hyoid teeth behind the tongue between the first and second gill clefts (Wydoski and Whitney 2003). Cutthroat trout usually have the trademark orange "slash" under the lower jaw, but it can be absent in silvery sea-run or anadromous forms. The small spots are similar on both coastal and westslope cutthroat trout, being small and irregular in outline (nonrounded) (Behnke 1992).

Coastal cutthroat trout are distinguished by numerous irregular dark spots over the entire body, including the anterior area below the lateral line (Wydoski and Whitney 2003). There can sometimes be red coloration on the operculum of non-anadromous and on anadromous fish that have been in freshwater for some time (Wydoski and Whitney 2003). Sea-run individuals can be light to dark silver in color, sometimes masking their spots. Resident freshwater fish tend to be darker with a coppery or brassy sheen (Behnke 1992). Pale yellowish colors may appear on the body, and the lower fins may be yellow to orange-red (Behnke 1992).

Westslope cutthroat trout also have small irregular dark spots; however, they are found primarily above the lateral line and are most numerous on the caudal peduncle. The spots are absent from the anal fin (Wydoski and Whitney 2003). The area within an arc extending from the origin of the pectoral fin to a point just above the lateral line and downward to the origin of the anal fin usually has very few or no spots (Behnke 1992). The coloration of the westslope cutthroat trout can be variable, generally silver with yellowish tints, but bright yellow, orange, and especially red colors can be expressed to a much greater extent than on coastal cutthroat trout (Behnke 1992). Behnke (1992) also states that the coloration of westslope cutthroat trout under some circumstances is influenced by the food consumed by the fish due to certain pigments deposited in the skin.

Historic and Current Range

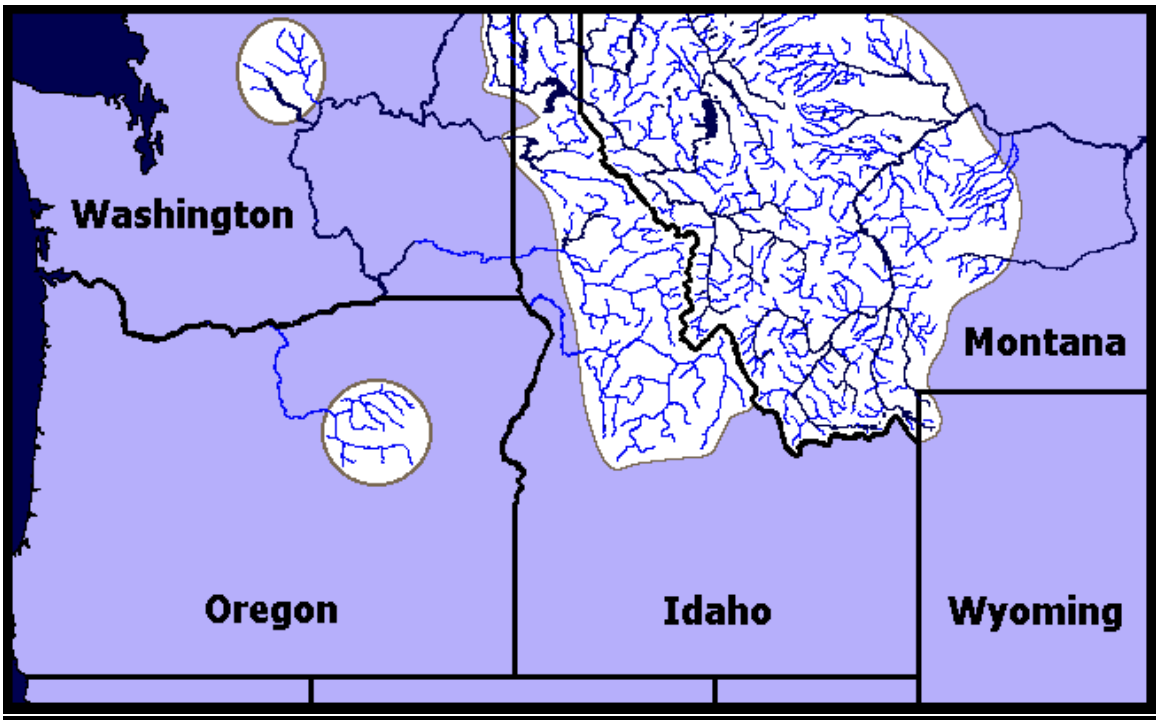
The coastal cutthroat trout occurs from Prince William Sound in Alaska to Humboldt Bay in California (Trotter 1989). In Washington, the historic and current distribution of coastal cutthroat trout includes the coastal watersheds, Puget Sound watersheds, and areas along the Strait of Juan De Fuca. It also occurs in tributaries to the lower Columbia River upstream to approximately the Klickitat River (Wydoski and Whitney 2003).

The historic distribution of westslope cutthroat trout is relatively unknown. West of the Continental Divide, and within Washington State, westslope cutthroat trout are native to the Spokane River above Spokane Falls (Behnke 1992), Methow, and Chelan watersheds (USFWS 1999c) (Figure 8-2). The Methow and Chelan are disjunct populations in the middle Columbia basin (Behnke 1992). Behnke (1992) states that surveys conducted in 1948-1950 contained references to cutthroat trout in the North Fork of the Ahtanum Creek, a tributary of the Yakima River, and in the Wenatchee River watershed. Behnke (1992) also states that cutthroat trout were reported from the Chewack River, which flows to the

Methow River north of Lake Chelan. Behnke (1992) believes that although the Methow drainage has been stocked with both rainbow and cutthroat trout for many years, the widespread occurrence of cutthroat trout indicates that the westslope subspecies is native to the Methow River drainage, and probably also the Wenatchee and Entiat River drainages. Westslope cutthroat trout west of the Cascade crest are believed to be introduced populations (USFWS 1999c).

The range of westslope cutthroat trout increased through years of hatchery stocking. In eastern Washington, westslope cutthroat trout now occur in 1,509 miles of 493 streams and 311 lakes in the Yakima, Wenatchee, Entiat, and Methow Rivers, Lake Chelan drainage, and Pend Oreille River drainages (Wydoski and Whitney 2003). The furthest southern extent of westslope cutthroat trout in eastern Washington occurs in Toppinish Creek, a tributary of the Yakima River (Wydoski and Whitney 2003). This subspecies also occurs on the west slope of the Cascade Mountains, but has not been extensively inventoried (Wydoski and Whitney 2003). The drainages include the Skagit, North Fork Skykomish, South Fork Tolt, Cowlitz, and Cispus Rivers (Wydoski and Whitney 2003). Since the westslope cutthroat trout is native to eastern Washington, there is a high likelihood that the populations west of the Cascade Mountains were introduced.

Figure 8-2. The historic distribution of westslope cutthroat trout in the United States (modified from Behnke 1992). The large region consists primarily of the upper Columbia River and upper Missouri River basins; some waters in the eastern part of this region may not have been occupied historically (MTFWP, *in litt*. 1998). Also shown are the Lake Chelan and Methow River drainages in Washington and the John Day River drainage in Oregon. (USFWS 1999c)



Essential Habitat Components

Generally, trout require four kinds of habitat during their life cycle: spawning habitat, rearing habitat, adult habitat, and overwintering habitat (Behnke 1992). Quantity or quality of these habitat types can influence populations (Behnke 1992). There are four life history forms of cutthroat trout: fluvial, adfluvial, resident, and anadromous. Only the coastal cutthroat trout contains anadromous stocks and has all four life history forms; the westslope cutthroat trout only occurs in three forms (Wydoski and Whitney 2003).

Coastal cutthroat trout generally spawn in small headwater streams and tributaries of small streams and coastal rivers (Trotter 1989). Coastal and westslope cutthroat trout prefer spawning habitat that contains pools, moderate-sized gravel for spawning, overhanging vegetation, submerged rocks and logs, large woody debris (LWD), and undercut banks to use as cover. Both the coastal and westslope cutthroat trout require clean, cool, well oxygenated waters. Cutthroat trout usually prefer the tail-outs of pools in small streams for spawning. In Northern California, spawning of coastal cutthroat trout occurs in water velocities of 0.3-0.9 meters/second, but cutthroat trout have also been observed to spawn in small streams in Oregon with flows as low as 0.01-0.03 meters/second where velocities over the redds were very low (Moyle 2002). Spawning temperatures can range from 9-17°C (Moyle 2002).

Cutthroat trout select spawning areas close to instream cover which provides emerging fry cover. After hatching, cutthroat trout alevins remain in the gravel for several weeks until their yolk sac is absorbed (Moyle 2002). After emerging from the gravel, fry will move into shallow habitats on the edges of streams, where currents are slow, temperatures are warm, and small invertebrates are abundant; the best of these habitats are adjacent to areas with deciduous riparian vegetation, which provides cover, shade, and food (Moyle 2002). Fry typically prefer shallower and slower water velocities (<0.30 meters/second, optimum being 0.08 meters/second) than older life stages (Moyle 2002). Fry can then use the cover to escape from predators and feed on benthic and drift insects, crustaceans and salmon eggs (Moyle 2002).

Adult habitat for coastal cutthroat trout can vary according to life history. Anadromous forms occupy salt water habitats for short periods of time. Some may never move beyond an estuary. Other fish may remain close to the coast, often in low salinity plumes of big rivers (Moyle 2002). Coastal cutthroat trout in Puget Sound move and feed along beaches in water less than 10 feet deep (Wydoski and Whitney 2003). Often, coastal cutthroat trout will move between coastal river systems (Wydoski and Whitney 2003). The time actually spent in the salt water environment varies, but most remain for an average of about 90 days (Wydoski and Whitney 2003). The coastal and westslope cutthroat trout with an adfluvial life history spend from 1 to 4 years as juveniles in tributaries before moving into lakes (Wydoski and Whitney 2003). In lakes where only they occur, cutthroat trout will occupy all habitats, including shallow littoral areas, open limnetic areas, and benthic areas (Wydoski and Whitney 2003). In lakes where rainbow trout and char occur, cutthroat trout will generally use the nearshore littoral areas while the other species occupy the offshore, open-water habitats (Wydoski and Whitney 2003).

The fluvial life history form of the westslope cutthroat trout is similar to that of the coastal cutthroat trout (Wydoski and Whitney 2003). They both occur in pristine headwater streams or alpine lakes, and for the most part exhibit little movement, generally inhabiting lateral shoreline areas of the streams during the summer and moving into pools during the winter (Wydoski and Whitney 2003).

Overwintering habitat is also very crucial to the survival of the coastal and westslope cutthroat trout. Though coastal cutthroat trout have the ability to occupy the marine environment, there are no reports that they overwinter there (Wydoski and Whitney 2003). Coastal cutthroat trout will occupy non natal

streams and rivers during winter and then move to their natal systems to spawn. Adfluvial stocks of coastal cutthroat and westslope cutthroat trout will move into the lake environment to overwinter. Fluvial and resident cutthroat trout, inhabiting a small stream, will both overwinter in deep pools, often with fallen logs or undercut banks. Boulders and scour holes provide alternative forms of cover (Moyle 2002).

Reproductive Ecology

As stated above, the coastal cutthroat trout occurs in four life history forms (anadromous, adfluvial, fluvial, and resident) while the westslope occurs in only three (adfluvial, fluvial and resident) (Wydoski and Whitney 2003). The anadromous form of the coastal cutthroat trout will first spawn at two to four years old, and may return two to five times to overwinter and spawn (Moyle 2002). Coastal cutthroat trout spawn in low gradient reaches of small tributaries, or in the lower regions of streams. The spawning period for coastal cutthroat trout ranges from December to June. The females will use their tails to build redds in clean gravel, from 1.2 to 10 centimeters in diameter (Moyle 2002). Substrates containing finer particles can reduce the survival of embryos. The redds can measure approximately 350 millimeters in diameter by 100 to 120 millimeters in depth (Moyle 2002). After spawning, the female will then cover the redd with about 150 to 200 millimeters of gravel (Moyle 2002). Cutthroat trout prefer the tailouts of pools in small tributaries or headwaters to construct their redds. The fecundity of female cutthroat trout will increase with the size and age (Moyle 2002). After spawning, the embryos will hatch after 6-7 weeks of incubation, depending on temperature (Moyle 2002).

Adfluvial westslope cutthroat trout spawn between March and July in Montana at temperatures of approximately 50°F (Wydoski and Whitney 2003). They also prefer the tailouts of pools to construct their redds. They then move downstream into the lake shortly after spawning (Wydoski and Whitney 2003). Fluvial and resident cutthroat trout spawn in small tributaries or headwaters and migrate very little downstream after spawning is complete. Westslope cutthroat trout in spawning migrations remained within a 219-yard reach in tributaries of the Blackfoot River in Montana (Wydoski and Whitney 2003).

Movements and Habitat Use

Movements and migration, and habitat use of coastal and westslope cutthroat trout, can vary according to region. Some factors that influence the movements of cutthroat trout are: temperatures, oxygen levels, food, spawning habitat, and avoiding predators.

Coastal cutthroat and westslope cutthroat trout both have various life history forms. It is not unusual to have migratory and non-migratory individuals within the same population. Movements of cutthroat trout for locating food or spawning can cover large or relatively small distances. Some headwater stream forms of coastal cutthroat trout may spend their entire lives within a 200-meter stream reach (Wyatt, as cited in Trotter 1989). Anadromous forms of coastal cutthroat trout may migrate long distances to estuaries or large rivers to feed heavily on fish and crustaceans (Moyle 2002). Most sea run populations of coastal cutthroat trout leave their streams only for the summer months and return to overwinter in freshwater streams and rivers, even as nonspawning fish (Moyle 2002). Riverine forms of coastal and westslope cutthroat trout must also move about as river flows and prey availability change, and will often move into rivers and streams to prey on outmigrating salmon (Moyle 2002). The apparent preference of juvenile cutthroat trout for small streams and shallow riffles within larger streams is probably due to interactions with more aggressive coho salmon and steelhead juveniles, which keep small cutthroat trout from occupying pools or larger waters (Moyle 2002).

Cutthroat trout are exposed to a wide range of water temperatures. When changes occur in water temperature or other physical factors, the fish usually respond by seeking refugia. Adult and subadult cutthroat trout will seek cover provided by the shade of large trees, submerged rocks and logs, and undercut banks (Wydoski and Whitney 2003). Cutthroat trout generally prefer stream habitats that are cool (<18°C) and well shaded with an abundance of instream cover (Moyle 2002). Preferred temperatures by adults is 15.5°C (range: 10°C to 21°C) (Wydoski and Whitney 2003). Optimum temperatures for spawning of coastal cutthroat trout ranged from 6.1°C to 17.2°C and for egg incubation from 4.4°C to 12.7°C (Johnson et al. 1999). It has been reported that the lower and upper lethal temperatures of coastal cutthroat trout are 0.5°C and 23°C (Johnson et al. 1999).

Threats to Survival

Both species of cutthroat trout have been petitioned for listing under the ESA. After analyzing the available scientific information for the westslope cutthroat trout, on April 14, 2000, (65 FR 20120) we announced that it was not likely to become threatened or endangered for the foreseeable future. This prompted litigation that stated that hybridization issues were not appropriately analyzed in the listing decision. A new status update was done incorporating new genetic analysis information and we concluded that the initial determination for not listing was warranted (68 FR 46989).

The southwestern Washington/Columbia River Distinct Population Segment of coastal cutthroat trout was proposed as threatened in 1999. After reviewing the available scientific information, we determined that the listing was not warranted (67 FR 44934). Improvements in forest management practices, relatively healthy sized populations of coastal cutthroat trout within much of the DPS, and improved understanding of the ability of freshwater forms to produce anadromous progeny, lead to the conclusion that the species in this area was not threatened.

Limiting factors for both the coastal and westslope cutthroat trout include excessive siltation due to historic and current logging practices, reduced qualities and quantities of large woody debris, urbanization, cattle grazing, water diversions (for agriculture and drinking water) and water pollution. Degraded riparian habitats can increase stream temperatures, and small streams that may have cutthroat trout, are particularly sensitive to incoming radiation, which can increase temperatures and reduce dissolved oxygen levels. Lowered dissolved oxygen levels and increased temperatures can give a competitive edge to pikeminnows and several non-native species that will either prey on juvenile cutthroat trout or out-compete them for resources (Rieman and Apperson 1989). Brook trout tend to replace westslope cutthroat trout where westslope cutthroat trout have declined, whereas rainbow trout (once established and naturally reproducing) can displace westslope cutthroat trout where the two overlap.

Threats to survival of cutthroat trout include: urbanization, agriculture, grazing, passage obstructions, logging, mining, over fishing, hatcheries, poaching, water-withdrawls, loss and degradation of wetlands, loss and degradation of estuaries, and competition with other species (Johnson et al. 1999; USFWS 1999c; SaSI 2000).

Westslope cutthroat trout were considered abundant in the Spokane River drainage, however, the effects of logging activities, road construction, and mineral extraction have degraded habitat, and increased access, over fishing, and the introduction of non-native fish species have combined to reduce the distribution, number of larger fish, and overall abundance of westslope cutthroat trout within the drainage (Hunt and Bjornn 1995, Dunnigan and Bennett 1995; Mauser *et al.* 1988; Lider, *in litt*. 1985). Declines have occurred to all life history forms from tributary streams, mainstem rivers, and lakes (Mauser *et al.* 1988; Behnke 1992).

Many threats, such as road building, timber harvesting, mining, urban development and grazing animals within the Riparian Zone, can increase the amount of sediment transported into a stream or river and increase instream temperatures, which can be fatal to developing fry. Migratory barriers such as diversion dams and poorly constructed or old failing culverts can be impassable to juvenile and adult fish. This can fragment distribution and cut off spawning and rearing habitat need to maintain the population.

The introductions of non-native fish have also had negative affects on the populations of native cutthroat trout. Coastal rainbow trout have been widely stocked throughout the range of both the coastal and westslope cutthroat trout for sport fishing. Rainbow and cutthroat trout have been known to hybridize which complicates the preservation of pure strains of cutthroat trout. In the past, hatchery-reared rainbow trout were also stocked into lakes and streams which changed native fish assemblages living there. Cutthroat trout often were out-competed for resources.

Pollution can also impact the populations of native cutthroat trout. The urbanization of many coastal regions and estuaries located near urban centers receive chemical contaminants via direct pipeline discharges from coastal communities and from ships, rivers, atmospheric deposition, and non-point source runoff (Kennish 1992). Pollution in urban estuaries has the potential to adversely influence the health, and ultimately the survival, of juvenile salmonids in the estuary (Casillas et al. 1998). Over-fishing can result in declines of cutthroat trout. Behnke (1992) states that of cutthroat trout in general, the westslope subspecies is vulnerable to exploitation by anglers, but it can also respond favorably from implementing protective angling regulations.

Threats to the survival of westslope cutthroat were identified and analyzed in the 1999 USFWS status review. This review included threats throughout its entire range by watershed and included Washington State. The threats analyzed were:1) the present or threatened destruction, modification, or curtailment of the species' habitat or range; 2) overutilization for commercial, recreational, scientific, or educational purposes; 3) disease or predation; 4) the inadequacy of existing regulatory mechanisms; and 5) other natural or manmade factors affecting the species' continued existence. We concluded that these threats were not severe enough to warrant listing under the ESA. Further, we determined that the existing regulations pertinent to westslope cutthroat trout and aquatic habitat, large distribution of the species (frequently on Federal lands), numerous and genetically pure westslope cutthroat trout, and that the declines appear to have occurred earlier in the 20th century, did not necessitate the listing of the species as threatened (USFWS 1999c and 2003). Additionally, the 2003 status update determined that the westslope cutthroat trout was not threatened by hybridization (68 FR 46989).

Many of the remaining westslope cutthroat trout stocks are restricted to small, headwater streams in mountainous areas, where the adverse effects of human activities on them and its habitat have often been negligible. This is especially true for many of the remaining, genetically pure westslope cutthroat trout stocks (e.g., Shepard *et al.* 1997, as cited in USFWS 1999c). Such spatial separation precludes natural movement and interbreeding among stocks, however, thereby increasing the likelihood that some stocks will become extinct due to limited genetic variability. In addition, the probable small sizes of these individual westslope cutthroat trout stocks and the short stream reaches that they might inhabit, make individual stocks more vulnerable to extirpation due to natural catastrophes such as floods, landslides, wildfires and other stochastic environmental effects. Remaining westslope cutthroat trout stocks in the Upper Columbia River (Washington) drainage, for example, occupy stream reaches that average 3.4 miles long (USFWS 1999c).

In the anadromous watersheds, coastal cutthroat trout spend more time in freshwater than most of the other salmonids in the Pacific Northwest, and hence are more dependant upon properly functioning watersheds. Degraded habitat has been associated with more than 90 percent of extinctions or declines of Pacific salmonid stocks (Gregory and Bisson 1997, as cited in Johnson et al. 1999). Reeves et al. (1997a) and Behnke (1992) suggest that the cutthroat trout's dependence and sensitivity to their freshwater environment may earn them the metaphor "canary in the coal mine."

Salmonid studies on the relationships of timber harvest and fish response have been ongoing in the Alsea watershed in Oregon for a number of years. Research has investigated the impact of different timber harvest patterns on coastal cutthroat trout and coho salmon response (Reeves et al. 1997a). In a specific study, one basin was clearcut including the riparian zone, another basin received 25 percent patch cuts with intact riparian zones, and the third basin was not harvested and acted as the control. Following logging, the biomass of coastal cutthroat trout declined substantially in the clearcut basin. The patch cut and no harvest basins did not change in cutthroat trout biomass. The population of cutthroat trout remained depressed in the clearcut basin for over 20 years, but has recently shown signs of recovery (Reeves et al. 1997a).

Similar forest harvest studies in Carnation Creek, British Columbia, documents that the effects of forest harvest occurred differently to different species and at different time frames (Hartman et al. 1987). Population changes among young salmonids were positive to some components of forest harvest and negative to others. Streamside clearing along with climatic change reportedly increased cutthroat trout length in upper Carnation Creek (Hartment et al. 1987). A western Washington study (Bisson and Seddell 1984, as cited in Reeves et al. 1997a) found higher percentages of age 0 cutthroat trout, but lower percentages of age 1 and older cutthroat trout in a logged watershed compared to an old growth forest. Reeves et al. (1997a) suggests that pool quality (depth and cover) may decline in watersheds impacted by logging, with cutthroat trout declining in their ability to persist. Shallow pools without large wood may favor juvenile coho salmon over coastal cutthroat trout due to the competitive edge that juvenile coho have over cutthroat trout (Reeves et. al. 1997a). Streams that only had cutthroat trout, and no juvenile coho, did not show the declines associated with the shallowing of pools. Cutthroat trout densities have been shown to increase in winter pool habitats in response to large wood placement (Roni and Quin 2001).

8.5.2.2 ENVIRONMENTAL BASELINE (within the FPHCP Action Area)

Coastal Cutthroat Trout

In 2000, the Washington Department of Fish and Wildlife released its Salmonid Stock Inventory Coastal Cutthroat Trout (SaSI 2000) for Washington State. This inventory identified 40 "stock complexes" within Washington State. A stock complex is a group of stocks typically located within a single watershed, or other relatively limited geographic area, and believed to be closely related to one another (SaSI 2000). Of these 40 stock complexes, one was considered to be healthy, 7 were considered to be depressed and the status of the other 32 complexes was unknown (Table 8-35). The 7 depressed stocks are located in the lower Columbia River area (SaSI 2000). As described above, we determined that the southwest Washington/Columbia River coastal cutthroat trout population was not warranted for listing under the ESA in 2002.

Table 8-35. WDFW SaSI coastal cutthroat trout status.

	Healthy	Depressed	Critical	Unknown	Extinct
Puget Sound					
North Puget Sound	1	0	0	7	0
South Puget Sound	0	0	0	4	0
Hood Canal	0	0	0	2	0
Strait of Juan de Fuca	0	0	0	3	0
Total	1	0	0	16	0
Coastal					
North Coast	0	0	0	6	0
Grays Harbor/Willapa Bay	0	0	0	6	0
Total	0	0	0	12	0
Columbia River					
Lowe Columbia	0	7	0	4	0
Washington State					
40 Total Stock Complexes	1	7	0	32	0
Percent of Total	2%	18%	0%	80%	0%

For coastal cutthroat trout, quantitative estimates of historical abundance generally are lacking (Johnson et al. 1999). Currently, anadromous, fluvial, adfluvial and resident populations of coastal cutthroat trout are present throughout Western Washington, but quantifiable estimates on their population status is relatively unknown.

Westslope cutthroat trout

In eastern Washington, westslope cutthroat trout occur in 1,509 miles of 493 miles of streams and in 311 lakes (Williams 1999 as cited in Wydoski and Whitney 2003). Westslope cutthroat trout are actively reared and stocked in and throughout eastern Washington (Anderson, Personal Communication, 2004). There has been some stocking of westslope cutthroat trout in western Washington (Upper Skagit) but the population is considered small and isolated in the North Cascades. This population was not placed there by WDFW hatchery personal and is not currently supplemented by hatchery stocking. WDFW currently lists the westslope cutthroat trout as a species of concern (2004). Their population status in Washington is for the most part unknown at this time. However, as described above, we determined in 2000 and 2003 that listing of the westslope cutthroat trout under the ESA was not warranted, with the reasons provided in the Federal Register Notices, cited above.

The Spokane, Chelan, and Methow watersheds were analyzed as part of the FWS westslope cutthroat trout status review and are reported below.

Spokane River Drainage

The Spokane River drainage is located in northern Idaho with a very small portion in Washington. The majority of the Spokane watershed is outside of the FPHCP Action Area. The Pend Oreille drainage, Washington (EPA drainage 17010216), is in the northeast corner of Washington State and for these analyses includes the Pend Oreille River and all tributaries below Albeni Falls Dam downstream to the Canada-USA border. The drainage encompasses 1080 square miles of which approximately 60 percent is public land managed by the U.S. Forest Service (Streamnet web site). The Salmo-Priest wilderness area encompasses approximately 30,600 acres (4 percent) within this drainage.

Historically, westslope cutthroat trout were considered abundant in the Spokane River drainage, however, the effects of logging activities, road construction, and mineral extraction have degraded habitat, and increased access, over fishing, and the introduction of non-native fish species have combined to reduce the distribution, number of larger fish, and overall abundance of westslope cutthroat trout within the drainage (Hunt and Bjornn 1995; Dunnigan and Bennett 1995; Mauser *et al.* 1988; Lider, *in litt*. 1985 as cited in USFWS 1999c). The Pend Oreille River was found to lack quality habitat for salmonids and is likely better suited for spiny-rayed predators. In 1986, it was determined that over half of the Pend Oreille River shoreline had been developed or consisted of grass banks (Horner *et al.* 1987).

The percentage of HUCs known or predicted to be inhabited by westslope cutthroat trout stocks that were known or predicted to be depressed was largest in Oregon's John Day River drainage (100 percent), and Idaho and Washington's Pend Oreille River drainage (93.4 percent). The Pend Oreille River stock was considered depressed or predicted depressed (USFWS 1999c).

Methow River Watershed:

The majority of the Methow drainage occurs on Federal lands outside of the FPHCP Action Area. Some portions are within the FPHCP lands, however. Westslope cutthroat trout are native to this drainage, with resident and adfluvial life forms present historically and today.

In portions of the mainstem Methow River, habitat has been and continues to be adversely modified. Channelization or stream alteration has occurred along 35 miles (22 percent) of the Methow River (Mullan *et al.* 1992, as cited in USFWS 1999c). Sediment delivery is estimated to be about 10 percent greater than natural background loading (Mullan *et al.* 1992, as cited in USFWS 1999c). Past fires in the headwaters involving riparian habitat have exposed the stream to isolation and increased water temperatures (WDFW, *in litt.* 1995, as cited in USFWS 1999c). Westslope cutthroat trout of the Methow River watershed are isolated in fragmented habitats created by natural barrier and/or habitat modifications (Molesworth, USFS, Personal Communication, 1999). This presents an elevated risk to their survival in these tributaries in the instance of catastrophic events (USFWS 1999c).

Overutilization of resident westslope cutthroat trout is not considered a notable threat in this drainage. Most westslope cutthroat trout throughout the historic and introduced range occupy habitat that is not easily accessible to anglers and in general, the westslope cutthroat trout are very small and not selected for by anglers (WDFW, *in litt.* 1998b). Predation of westslope cutthroat trout is known to occur by numerous native and introduced species, is an important source of mortality to westslope cutthroat trout, and can act as a destabilizing force when habitat loss and overexploitation are experienced (Rieman and Apperson 1989). Available information does not identify any disease problems in this drainage. Since the early 1900s, stocking programs have introduced non-native trout into the Methow River watershed (WDFW, *in litt.* 1998a). The introduction of rainbow and brook trout has greatly increased the risk of

competition, predation, and hybridization. In addition, the wide distribution and abundance of non-native species increases fishing pressure, which may aggravate the exploitation of westslope cutthroat trout in the same waters (Rieman and Apperson 1989).

Lake Chelan Watershed

Approximately 90 percent of the drainage is public land managed primarily by the U.S. Forest Service and National Park Service. However, there are some lands within the FPHCP. The construction of Lake Chelan Dam in 1928 raised the water level of the lake by 24 feet and inundated potentially important spawning habitat of adfluvial westslope cutthroat trout at the mouths of tributary streams. The westslope cutthroat trout of Lake Chelan (33,104 surface acres) are reproductively isolated and in long-term decline (Brown 1984 in USFS, *in litt.* 1999b, as cited in USFWS 1999c).

Stream surveys of eight north shore tributaries from 1990-1993 indicated that none of the streams conformed to expected pool frequencies or the Forest Plan Standard for pools. Fine-sediment deposition in pools and embeddedness > 35 percent was identified as a problem in many (6 of 8) of these tributaries. The amount of large woody debris (4 of 8 tributaries) and water temperature (3 of 8 tributaries) was also determined to not meet Forest Plan Standards in numerous tributaries (USFS, *in litt.* 1998d, as cited in USFWS 1999c).

Lake trout, first stocked in Lake Chelan in 1980, have established a naturally reproducing population and are known to be a significant predator to westslope cutthroat trout (Mauser *et al.* 1988, as cited in USFWS 1999c). Non-native hatchery stocking programs still continue in Lake Chelan.

Other watersheds occupied by westslope cutthroat trout in FPHCP Action Area

In eastern Washington, westslope cutthroat trout now occur in 1,509 miles of 493 streams and 311 lakes in the Yakima, Wenatchee, Entiat, and Methow Rivers, Lake Chelan drainage, and Pend Oreille River drainages (Wydoski and Whitney 2003). The furthest southern extent of westslope cutthroat trout in eastern Washington occurs in Toppinish Creek, a tributary of the Yakima River (Wydoski and Whitney 2003). This subspecies also occurs on the west slope of the Cascade Mountains, but has not been extensively inventoried (Wydoski and Whitney 2003). The drainages include the Skagit, North Fork Skykomish, South Fork Tolt, Cowlitz and the Cispus Rivers (Wydoski and Whitney 2003). Since the westslope cutthroat trout is native to eastern Washington, there is a high likelihood that the populations west of the Cascade Mountains are introduced. The population status of westslope cutthroat trout in these watersheds is unknown.

Role of the FPHCP Action Area for Conservation of the Species:

The FPHCP Action Area encompasses a significant segment of the cutthroat trout distribution in Washington, especially for coastal cutthroat trout. The majority of the distribution of westslope cutthroat trout (both historic and transplanted) is on Federal land and will not be subject to the proposed action. The exception to this is the Pend Orielle River, which has westslope cutthroat trout. The coastal cutthroat trout distribution, on-the-other hand, is substantially located in the FPHCP Action Area and will be influenced by the FPHCP. Coastal cutthroat trout are normally represented in species assemblages in western Washington, and in small headwater streams, are often the only salmonid present. The FPHCP Action Area provides an important conservation role for cutthroat trout. High quality aquatic habitats within the FPHCP Action Area are necessary for the long-term survival of cutthroat trout in Washington.

8.5.2.3 EFFECTS OF THE ACTION

General habitat effects to cutthroat trout from the proposed action have been summarized above for the Steep Tributary Guild. Coastal and westslope cutthroat trout will occupy habitats found in Mainstem and Low-gradient Guilds.

There are an estimated 23,558 road crossing and 51,061 miles miles of stream-adjacent parallel roads that will deliver sediment to coastal cutthroat trout and 2,809 of road crossing and 664 miles of stream-adjacent parallel roads that will deliver sediment to westslope cutthroat trout habitat for Type S, F, and Np streams.

Riparian prescription effects to cutthroat trout

Full riparian and in-stream function likely would not be provided to all habitats occupied by cutthroat trout. In some stream reaches, the highest quality and most structurally complex habitats may fail to develop due to the potential reduction of large wood recruitment at different time scales and following different riparian management prescriptions. For example, although the FPHCP would provide the majority of available large wood adjacent to fish-bearing streams, the FPHCP allows some trees within these large wood recruitment zones to be harvested. In addition, stream-adjacent parallel roads, unbuffered areas in Type Np streams, yarding corridors, and road crossings would likely reduce potential large wood recruitment. Windthrow could affect some riparian processes. The reduction of large wood over long time frames may not allow processes to form some habitats (pools, riffles, hiding cover) that cutthroat trout use. Large wood influences pool formation which is important during certain life history stages for cutthroat trout. Large wood also provides hiding cover, sorts and releasing spawning gravels, and provides numerous other important biological and physical processes. Less structurally complex habitat may reduce densities of cutthroat trout. Less complex habitat may also affect survival of individual fish through increased competition or predation. For example, coho may displace cutthroat trout when pools are filled or habitat complexity is reduced. Degradation of Type Np stream associated RMZs and stream habitat could also alter the availability of terrestrial and aquatic invertebrates, which are an important food source for cutthroat trout at all life stages.

When RMZs achieve their Desired Future Condition, streams within the areas covered by the FPHCP that are occupied by cutthroat trout will receive most of the potentially available shade. There are physical situations (yarding corridors, stream-adjacent parallel roads, stream crossings, 20-acre exemptions, and windthrow) where stream shading potential will be reduced. Along Type Np streams, reductions in shade are likely to occur and water temperature may increase over limited distances as a result of these unbuffered Type Np streams. In some cases, increases in temperature may be delivered downstream to Type F waters and temperatures could be warmed near the confluence of Type Np and F streams. In these circumstances, there could be negative effects to cutthroat trout due to potentially elevated stream temperatures and loss of thermal refugia resulting in impairment of foraging, rearing, and spawning behaviors. Increased temperatures may result in a competitive advantage for certain other species, which could affect individual fish.

Sediment effects to cutthroat trout

Sediment would be delivered to cutthroat trout habitat from road surface erosion. When FPHCP activities affect certain watershed features, such as steep unstable slopes, there may be additional sediment delivered to fish-bearing streams that are above natural background rates. Increased sediment could result in changes to channel morphology, and cutthroat trout habitat could be reduced due to filling of pools.

When pool depth is reduced this can result in a competitive advantage for other species (Reeves et al. 1997a). Feeding behavior may be affected under some circumstances affecting individual fish fitness and survival. Siltation of spawning reaches could reduce egg survival. However, the FPHCP is not expected to significantly contribute to instream sediment loading to the point that cutthroat trout would be impaired at more than a stream reach scale. Often, effects might be limited to a habitat unit (pool, riffle) or several units.

Culvert and bridge replacement or installation projects are expected to provide a chronic source of sediment, at least until vegetation has been re-established. When vegetation on culvert or bridge streambanks has been restored, the amount of sediment from road crossings is expected to decline. Short segments of stream are routinely dewatered for culvert installation or replacement and the chance for localized fish mortality increases with these projects.

Summary of effects from the 20-acre Exemption Rule

Although it is there is uncertainty about how often this rule would be implemented, when it is implemented the 20-acre Exemption Rule would adversely affect cutthroat trout. In watersheds with a high proportion of small landowners, this rule would increase the likelihood that large wood recruitment would be inadequate to maintain properly functioning habitat (USFWS & NMFS 2006). There is also the potential for increased sedimentation, reduced shade, increased stream temperatures, and increased windthrow. Where these adverse effects occur, essential behaviors associated with foraging, reproduction and growth may be impeded and cutthroat trout may occupy the stream at reduced levels and have reduced survival.

Summary of negative effects to Cutthroat trout

The proposed action will have short- to long-term adverse effects on sediment, large wood, and temperature. These effects would be most severe from unbuffered Type Np streams and their associated downstream effects that result in disruption of natural riparian and aquatic processes and functions. These effects to the aquatic environment may result in impairment of essential foraging, rearing, and spawning behavior of cutthroat trout. It is difficult to predict the severity of these effects because effects to these fish will vary from activity to activity depending on the specific riparian prescriptions applied, the location, historical management practices, geological characteristics of the watershed, and the biotic community present.

Activities covered under the FPHCP are expected to have direct and indirect adverse effects to adult and juvenile cutthroat trout ranging from mortality to sublethal effects. Direct injury and death to cutthroat trout would likely occur during some stream crossing construction activities (stream dewatering and fish rescue and relocation, and blockage of upstream migration during construction). Alterations of the riparian and aquatic environment will reduce the ability of streams to support prey species, thus reducing the fish's ability and success at finding forage in these streams. In a degraded environment, increased competition with and predation by other species is anticipated. This could affect the growth and survival of juvenile and adult cutthroat trout.

Summary of beneficial effects

The long-term benefits of the FPHCP for cutthroat trout will occur as riparian areas mature, roads are managed with watershed processes in mind, adaptive management is implemented, and fish passage is maintained and restored. The FPHCP's incorporation of BMPs and RMAPs would substantially reduce

road surface erosion to cutthroat trout habitat. Most adverse effects are associated with the downstream effects from RMZs on Type Np streams and the 20-acre exemption rule. Effects are not expected to significantly decrease the distribution of the redband or cutthroat trout in the FPHCP Action Area, because the FPHCP is not expected to contribute to habitat degradation to the point that cutthroat trout would be harmed at more than a stream reach scale. Often, effects might be limited to a habitat unit (pool, riffle) or several units.

8.5.2.4 CUMULATIVE EFFECTS

Cumulative effects were addressed in the **Comprehensive Cumulative Effects**, with respect to the aquatic and riparian environment in Washington State. Additional information regarding cumulative effects for the westslope and coastal cutthroat trout was presented in the section **Steep Tributary Guild: Cumulative Effects.**

8.5.3 Coastal Rainbow Trout (*Oncorhynchus mykiss irideus*) and Columbia Redband Trout (*Oncorhynchus mykiss gairdneri)*

8.5.3.1 Status of the Species

Description of Species

In Washington State there are two distinct types of resident native rainbow trout recognized by Behnke (1992): the coastal rainbow trout (*Oncorhynchus mykiss irideus* - including the Beardsley trout *Oncorhynchus mykiss beardslei* of Lake Crescent), and the Columbia redband rainbow trout (*Oncorhynchus mykiss gairdneri*).

Generally rainbow trout of both types can be highly variable in color, body shape, and meristic characters (Moyle 2002). No set of character values distinguishes all coastal rainbow trout from all trout of redband evolutionary lines (Behnke 1992). Considerable genetic interchange between coastal rainbow and interior redband trout in the Columbia River basin has probably occurred during and since the last glacial period (Behnke 1992). In general, adult coastal rainbow trout are recognized by the broad red to pink band (rainbow) that runs laterally from their opercle, on their head, to the end of their caudal peduncle where it meets the tail. Above this red band the coloring of the dorsal surface can be a dark olive to bright green or dark blue to steel blue color. Also covering their dorsal surface and both the dorsal fin and adipose fin are numerous black spots. These spots also cover the tail fin, usually in radiating lines. Below the red lateral band the color of the body can be green or bluish silver turning to white at the belly. This area can sometimes have a few black spots or be completely void of spotting. Typical characters of Columbia redband trout are variable, but generally differentiated from coastal rainbow by larger spots, more-elliptical parr marks that often include dorsal and ventral supplementary rows (as in cutthroat trout), a tendency for yellow and orange tints on the body, a trace of a cutthroat mark, and light-colored tips on dorsal, anal, and pelvic fins (Behnke 1992).

Juvenile rainbow trout exhibit similar colorations to that of adults. Juvenile rainbows, however, have 5-13 widely spaced parr marks centered along their lateral line (Moyle 2002). Juveniles can also posses 5-10 dark marks on their backs between the head and dorsal fin (Moyle 2002). They can also have white to orange tips on their dorsal and anal fins, and few or no black spots on the tail (Moyle 2002).

Historic and Current Range

The coastal rainbow trout's historic range is from the Columbia River, along the coast of Washington including Willapa Bay and Grays Harbor, the Olympic Peninsula and Straight of Juan De Fuca, Hood Canal, Puget Sound, and the San Juan Islands. The redband rainbow trout's range is the Columbia River basin east of the Cascade Coastals to barrier falls including the Okanogan, Pend Oreille, Spokane, and Snake Rivers (Behnke 1992). The coastal rainbow trout's range also extends up the Columbia River and coastal and redband trout overlap in the mid-Columbia River basin (Wydoski and Whitney 2003). The non-migratory coastal strain of rainbow trout is now widely distributed beyond it historical range due to extensive stocking of this popular sportfish into lakes and streams throughout the state (Wydoski and Whitney 2003).

Essential Habitat Components

Generally trout require four kinds of habitat during their life cycle: spawning habitat, rearing habitat, adult habitat, and overwintering habitat (Behnke 1992). Deficiencies in any one of the four will limit populations (Behnke 1992). In general, coastal and redband trout prefer cool water, less than 70°F, containing high amounts of dissolved oxygen, although they can inhabit water with temps ranging from 32°F up to 80°F (Wydoski and Whitney 2003).

Spawning habitat is usually dependent on five criteria: substrate size, stream/river depth, water velocity, upwelling of ground water, and cover. In high gradient systems spawning success can be limited due to higher water velocities which can carry off smaller more suitable substrate and leave behind larger boulders and rubble (Behnke 1992). In lower areas of watersheds, high sediment loads can blanket redds with silt and restrict spawning success. In the Yakima River, rainbow trout redds occurred in substrate that was mostly 0.25 to 6.35 centimeters in diameter at a mean depth of 0.3 to 0.4 meters where water velocity was 0.6 to 0.7 meters/second (Wydoski and Whitney 2003). Areas of upwelling of ground water are also selected for egg incubation due to its constant cool temperature (or warm temperature in the fall and winter months) and flow throughout the year. Cover, such as a log jams or undercut banks, also provides adult spawners and emerging fry a refuge to hide from predators.

Rearing habitat requirements for juvenile rainbow trout can be diverse depending on life history and season. Rearing habitats for rainbow trout incorporate cover to hide from predators, cool temperatures, and a readily accessible food supply. For example, Behnke states that after hatching and during the first months of life, trout need habitat with protective cover and low water velocity. Examples of habitats that contain these factors are found along the margin of the stream or river, in small spring seeps or tributaries, and in side channels, sloughs and braided channels. Whereas after trout start to increase in size, and for the first year or two of life rainbow trout are found in cool, fast-flowing permanent streams and rivers where riffles predominate over pools, where there is ample cover from riparian vegetation or undercut banks, and where invertebrate life is diverse and abundant (Moyle 2002).

Optimal adult habitat provides larger adult fish adequate amounts of cover such as undercut banks, jog jams and ample overhanging vegetation and riparian cover. In a study by Binns and Eiserman (1979) concerning trout biomass in Wyoming streams, the authors found that it is also important that base stream flows don't drop below 25 percent of the average daily flow. A drop below 25 percent would expose and therefore remove much of the desirable cover that trout depend on, such as the undercut banks and preferred shoreline areas.

Overwinter habitat is also very important to the survival of trout. Overwinter survival is related to the amount of deep water with low current velocity and protective cover like deep pools with large boulders and rootwads or areas of beaver ponds (Bjornn 1971; Bustard and Narver 1975). Adult trout in headwater streams with poor overwintering habitat and severe winter conditions have been shown to migrate during the fall to larger streams and rivers in lower elevations to overwinter.

Redband trout appear to have evolved to a variety of environmental conditions, more so than other salmonids, as represented by their diversity of landscapes they are found in. Their persistence in some heavily disturbed basins suggests that they may be less sensitive to habitat degradation than other salmonids (Lee et al. 1997).

Reproductive Ecology

Rainbow trout normally spawn in the spring between February and June, depending on the temperature and location (Wydoski and Whitney 2003). Some wild populations of rainbow trout do spawn in the fall in rivers with unusual thermal characteristics (Behnke 1992). For trout to be able to spawn in the fall they must posses developed gonads and be able to locate warmer spring-fed areas of the river or stream. The disadvantage of fall spawning is that eggs of rainbow trout cannot tolerate several months of near freezing winter conditions and unless they were laid near or in a warmer spring seep they would most likely all die. All native western trout evolved to spawn in flowing waters that circulate dissolved oxygen throughout the redd (Behnke 1992). Embryos need the most oxygen when their development is most rapid, which occurs just before hatching at a time of rising water temperatures (Behnke 1992).

In streams, most western trout first spawn 2-4 years after their parents spawned (Behnke 1992). As with most other salmonids, the female digs a redd in the gravel (gravel size 1 to 13 centimeters in diameter) of a tail out of a pool or in a riffle (Moyle 2002). Water velocities over redds can be 20 to 155 centimeters/second, and at depths of 10 to 150 centimeters (Moyle 2002). During redd construction, male trout will move close to a female in an attempt to establish a territory and spawn with the female. The male will aggressively fend off other males intent on spawning with the female. Spawning takes place when the male trout induces the female to lay her eggs, and as she expels them from her body he fertilizes them. The number of eggs per female in rainbow trout varies from 200 to 9,000 and is dependent on the size of the female and the strain or stock or the fish (Wydoski and Whitney 2003). The fertilized eggs are deposited in the constructed redd and fall into crevices between the larger rocks unable to be moved by the female. Resident rainbow trout can spawn more than once in their life time, and it is not unusual for fish to skip a year between spawns (Moyle 2002). Typically, more females than males are repeat spawners (Behnke 1992).

Time of egg hatching varies greatly with region, and can be anywhere from 3 to 7 weeks, with several more weeks of in-gravel development before they are completely free swimming fry. The fry initially live in quiet waters close to shore and exhibit little aggressive behavior for several weeks (Moyle 2002).

Movements and Habitat Use

Movements, migration, and habitat use of resident rainbow trout may vary according to region. Some factors that can influence the movements of rainbow trout are: locating optimal temperatures, oxygen levels, food, spawning habitat, and avoiding predators. Rainbow trout will move to habitats that contain cool (<20°C, with lethal temps >23°C) well oxygenated waters or areas that contain ample food supply. Predators have a strong effect on microhabitats selected by rainbow trout (Moyle 2002). Small trout

select places to live based largely on proximity to cover in order to hide from both avian predators (kingfishers, herons, mergansers) and predatory fish (Moyle 2002).

In streams, different sizes of rainbow trout show distinct preferences for different microhabitats as defined by depth, velocity, substrate, and cover (Moyle 2002). Fry (<50 millimeters SL) typically concentrate in shallow (<50 centimeters) water along stream edges, where water column velocities are low (1 to 25 centimeters/second) (Moyle 2002). Juveniles (50 to 120 millimeters SL) occur in deeper (50 to100 centimeters) and faster (10 to 30 centimeters/second) water, usually among rocks or other cover (Moyle 2002). Larger fish seek out a wide variety of deeper habitats (often including "pockets" behind rocks, runs, or pools) but typically stay close to fast water capable of delivering drifting invertebrates to them, such as inflowing water at the head of pools (Moyle 2002). Adult trout increase their foraging efficiency by moving into high-velocity water only to feed and then quickly returning to low-velocity areas for holding (Moyle 2002). Habitat used by young of the year rainbow trout in the upper Yakima River basin was water that was 0.1 meter deep with a current of 0.2 meters/second on the bottom (Wydoski and Whitney 2003). Age 1 fish occupied water with similar depth and velocity of 0.12 meters deep with a current of 0.2 meters/second on the bottom (Wydoski and Whitney 2003).

Threats to Survival

Hatchery plantings of coastal rainbow trout have been so widely stocked throughout the state that their present range has now expanded beyond their historic. It can be said that due to the widespread stocking of this popular sport fish, the coastal rainbow trout's population has increased.

Agriculture, dams, over harvest, logging, mining, hybridization, and competition with other trout contributed to the decline of redband trout abundance, distribution, and genetic diversity in the Columbia River Basin (Williams et al. 1989; Behnke 1992). Frequently, redband trout are restricted to isolated headwater streams. The long-term persistence of these populations may be threatened by the loss of migratory life history forms and connectivity with other populations. The redband trout's population status has more recently become a question for Federal, state, and local authorities. The U.S. Forest Service considers the redband trout a sensitive species (Ken MacDonald, Forest Service Fishery Biologist, Wenatchee Office, Personal Communication, 2004). In 2000, the FWS determined that listing the Great Basin redband trout as threatened under the ESA was not warranted (65 FR 14932). The Great Basin redband trout does not occur in Washington.

There is continued concern that the continued widespread stocking of coastal rainbow trout and other non native species within the redband trout's range will result in hybridized populations and displacement of native redband trout. There is a high likelihood that the most substantial threats to the redband trout's population is from introductions of non native species and general habitat loss within its' range. Questions remain on the population status of redband trout.

Threats to rainbow trout survival can be variable depending on species and location. Like most salmonids, rainbow trout need clear, clean, and cold water for proper egg development and fry emergence. As they mature and grow, their habitat requirements change and can vary according to their region. Any change in either part of their ecosystem can have deleterious affects on their survival. Threats to the quality of habitat include increasing water temperatures during egg and fry development, or decreasing dissolved oxygen levels. Providing functional riparian vegetation contributes streamside shade which facilitates keeping fish-bearing waters cool. Riparian vegetation also provides: instream hiding cover for fish; attenuates stream flow; create pools and riffles; and traps sediment. Impoundment by levees or bank armoring with rip rap can constrict the channel and cause it to downcut removing

spawning gravel and redds. Also high flows can be the cause of heavy precipitation which can transport large amounts of sediment from runoff of roads and degraded streambanks which can cover redds and incubating eggs or larval fish.

Competition with non native species has always been a major threat to native rainbow trout. The introduction of non native fish species intro a stream or lake for sport can permanently change the ecosystem for native rainbow trout by removing food from the system, limiting cover to native trout, predation on native trout fry and juveniles, and occupying preferred spawning areas. Hybridization with like species can also disrupt the genetic diversity of native species of rainbow trout. Pollution is also an important factor affecting the populations of native rainbow trout. It has been shown that pollution increases the probability of disease-related impacts on fish populations (Arkoosh 1998).

8.5.3.2 ENVIRONMENTAL BASELINE (within the FPHCP Action Area)

Non-anadromous rainbow trout are distributed across most of the FPHCP Action Area. Both species of rainbow trout occur in the mid-Columbia River basin, and in western Washington, the coastal subspecies occurs. The population of the coastal rainbow trout population appears to be stable. They have a broad distribution across many watersheds in the FPHCP Action Area. Some populations of the anadromous steelhead are listed under the ESA.

The redband rainbow trout, once the most widely distributed salmonid in the Columbia basin (Lee et al. 1997), still appears to be broadly distributed in eastern Washington but their current status is often unknown (Table 8-36). Lee (1997) estimates that redband trout occur in 64 percent of their combined historical range. One reported difficulty was to differentiate juvenile steelhead from sympatric redband trout. Another difficulty for making accurate status determinations is that potential hybridization has occurred for some time due to extensive fish stocking programs which can make classifications difficult.

Table 8-36. Summary of the current status and distribution classifications (number of subwatersheds) for redband trout (sympatric and allopathic) throughout the Columbia Basin. (Lee et al. 1997).

Ecological Unit	Total	Historical	Total Current	Strong*	Depressed*	Status Unknown
Northern Cascades	340	340	253	5	4	244
Columbia Plateau	1089	1050	465	24	156	282
Blue Coastals	695	695	574	48	95	428
Northern Glaciated Mountains	955	456	281	25	13	243

The only Ecological Unit that is specific to Washington is the Northern Cascades, the other units include WA and other states. The * refers to spawning and rearing. Models were used to predict the status of redband trout based on biophysical characteristics of the watershed and patterns of distribution reported for redband trout.

The status estimates from Table 8-36 show that generally, the status of redband trout in these areas is unknown. The Columbia Plateau, Blue Coastals, and Northern Glaciated Coastals Ecological Units are predominately outside of the FPHCP Action Area, but do have some areas that include eastern Washington. The Northern Cascades Unit is primarily on Federal lands.

Role of FPHCP Action Area for Conservation of species:

The FPHCP Action Area encompasses a significant segment of the rainbow trout distribution in Washington. Federal and HCP lands also provide substantial areas that these species occupy. Rainbow trout need high quality streams for their survival. The FPHCP Action Area provides the streams, lakes, and wetlands that the species requires. Rainbow trout are part of the aquatic community and will respond favorably to watersheds managed with natural process in mind. The role of FPHCP covered lands are important to the long-term survival of rainbow trout in Washington.

8.5.3.3 EFFECTS OF THE ACTION

General habitat effects to rainbow and redband trout resulting from the proposed action have been summarized above for the Low-Gradient Tributary Guild. Rainbow trout will also occur in other habitats, particularly in the Mainstem and Steep Tributary Guilds.

Riparian prescription effects to rainbow and redband trout

Full riparian and in-stream function likely would not be provided to all habitats occupied by rainbow trout. In some stream reaches, the highest quality and most structurally complex trout habitats may fail to develop due to the potential reduction of large wood at different time scales and following different riparian management prescriptions. For example, although the FPHCP would provide the majority of available large wood adjacent to fish-bearing streams, the FPHCP allows some trees within these large wood recruitment zones to be harvested. In addition, stream-adjacent parallel roads, unbuffered areas in Type Np streams, yarding corridors, and road crossings would likely reduce potential large wood recruitment. Excessive windthrow could affect some riparian processes. The reduction of large wood over long time frames may not allow recruitment processes to form some habitats (pools, riffles, or hiding cover) that rainbow trout use. Large wood influences pool formation which is important during certain life history stages for trout. Large wood also provides hiding cover, sorts and releases spawning gravels, and provides numerous other important biological and physical processes Less structurally complex habitat may reduce densities of rainbow trout. Less complex habitat may also affect the survival of individual fish through increased competition or predation. Degradation of Type Np riparian areas and stream habitat could also alter the availability of terrestrial and aquatic invertebrates, which are an important food source for rainbow trout at all life stages.

When RMZs achieve their Desired Future Condition, streams within the areas covered by the FPHCP, that are occupied by rainbow and redband trout, will receive most of the potentially available shade. There are physical situations (yarding corridors, stream-adjacent parallel roads, stream crossings, 20 acre exemptions, and windthrow) where stream shading potential will be reduced. Along Type Np streams, reductions in shade are likely to occur and water temperature may increase over limited distances as a result of these unbuffered Type Np streams. In some cases, increases in temperature may be delivered downstream to Type F waters and temperatures could be warmed near the confluence of Type Np and F streams. In these circumstances, there could be negative effects to redband and rainbow trout due to potentially elevated stream temperatures and loss of thermal refugia resulting in impairment of foraging, rearing, and spawning behaviors. Increased temperatures may result in a competitive advantage for certain fish species, which could affect individual fish. For example, redside shiners were found to be competitively superior to steelhead trout when temperatures were above 64° F (Wydoski and Whitney 2003) and in laboratory experiments Sacramento pikeminnow out-competed steelhead in warm water (Reese and Harvey 2002).

Sediment effects to rainbow and redband trout

Sediment would be delivered to rainbow trout habitat from road surface erosion. When FPHCP activities affect certain watershed features, such as steep unstable slopes, there may be additional sediment delivered to fish-bearing streams that are above natural background rates. Increased sediment could result in changes to channel morphology, and rainbow and redband trout habitat could be reduced due to shallowing and filling of pools. Feeding behavior may be affected under some circumstances affecting individual fish fitness and survival. Siltation of spawning reaches could reduce egg survival. However, the FPHCP is not expected to significantly contribute to instream sediment loading to the point that rainbow and redband trout would be impaired at more than a stream reach scale. Often, effects might be limited to a habitat unit (pool, riffle) or several units. There are 22,172 and 4, 921 road crossings in Type S, F, and Np of coastal and redband rainbow trout, respectively.

Culvert and bridge replacement or installation projects are expected to provide a chronic source of sediment, at least until vegetation has been re-established. When vegetation on culvert and bridge streambanks has been restored, the amount of sediment from road crossings are expected to decline. Short segments of stream are routinely dewatered for culvert installation or replacement and the chance for localized fish mortality increases with these projects.

Summary of effects from the 20-acre Exemption Rule

Although it is there is uncertainty regarding how often this rule would be implemented, when it is implemented the 20-acre Exemption Rule would adversely affect rainbow and redband trout. In watersheds with a high proportion of 20-acre exempt landowners, this rule would increase the likelihood that large wood recruitment would be inadequate to maintain properly functioning habitat (USFWS & NMFS 2006). There is also the potential for increased sedimentation, reduced shade, increased stream temperatures, and increased windthrow. Where these adverse effects occur, essential behaviors associated with foraging, reproduction and growth may be impeded and rainbow and redband trout may occupy the stream at reduced levels and have reduced survival.

Summary of negative effects to rainbow and redband trout

The proposed action will have short- to long-term adverse effects on sediment, large wood, and temperature. These effects would be most severe from unbuffered Type Np streams and their associated downstream effects that result in disruption of natural riparian and aquatic processes and functions. These effects to the aquatic environment may result in impairment of essential foraging, rearing, and spawning behavior of rainbow and redband trout. It is difficult to predict the severity of these effects because effects to these trout will vary from activity to activity depending on the specific riparian prescriptions applied, the location, historical management practices, geological characteristics of the watershed, and the biotic community present.

Activities covered under the FPHCP are expected to have direct and indirect adverse effects to adult and juvenile rainbow and redband trout ranging from mortality to sublethal effects. Direct injury and death to these trout would likely occur during some stream crossing construction activities (stream dewatering and fish rescue and relocation, and blockage of upstream migration during construction). Alterations of the riparian and aquatic environment will reduce the ability of streams to support prey species, thus reducing the trout's ability and success at finding forage in these streams. In a degraded environment increased competition with and predation by other species is anticipated. This could affect the growth and survival of juvenile and adult trout.

Summary of beneficial effects to rainbow and redband trout

The long-term benefits of the FPHCP for rainbow and redband trout will occur as riparian areas mature, roads are managed with watershed processes in mind, adaptive management is implemented, and rainbowand redband trout passage is maintained and restored. The FPHCP's incorporation of BMPs and RMAPs would substantially reduce road surface erosion to rainbow trout habitat. Because most adverse effects are associated with the downstream effects from RMZs on Type Np streams and the 20-acre exemption rule the FPHCP is not expected to significantly contribute to habitat degradation to the point that rainbow trout would be harmed at more than a stream reach scale. Often, effects might be limited to a habitat unit (pool, riffle) or several units. Effects are not expected to significantly decrease the distribution of the redband or rainbow trout in the FPHCP Action Area.

8.5.3.4 CUMULATIVE EFFECTS

Cumulative effects were addressed in the **Comprehensive Cumulative Effects**, with respect to the aquatic and riparian environment in Washington State. Additional information regarding cumulative effects for the covered fish species was presented in the section **Mainstem Guild: Cumulative Effects.**

In addition to those cumulative effects discussed earlier in this document, increases in stream temperature from global warming may give a competitive advantage to some species (redside shiner, for instance) that occupy the same streams as rainbow trout.

8.5.4 Kokanee (*Oncorhyncus nerka*)

8.5.4.1 Status of the Species

Description of Species

Kokanee are a non-anadromous, landlocked form of sockeye salmon. Their body is fusiform, streamlined, and laterally compressed (Moyle 2002). Adults lack distinct spots on their backs and caudal fins (Wydoski and Whitney 2003). The dorsal surface of their head and body is usually a steel-blue to green-blue color, and their sides are bright silver. The dorsal fin may sometimes have a few dark spots with the other fins clear or opaque. Kokanee are distinguished from other salmon by having 28-40 long, slender and closely spaced gill rakers on their 1st gill arch (Wydoski and Whitney 2003).

Male kokanee will develop a bright red or a dirty red-gray color over their backs and sides, (including the dorsal, adipose and anal fins) during breeding. Their caudal fin will sometimes be a dark red, black, or dark green color, as can their pelvic and pectoral fins. Their head to lower jaw becomes a bright green to olive-green color, with their lower jaw a dirty white to gray color. Males will also develop a hooked or kyped snout and a small hump anterior to the dorsal fin. Size during breeding can range from 200 to 510 millimeters in length. The largest kokanee recorded in Washington was taken from Lake Roosevelt and weighed 2.6 kilograms and measured 590.5 millimeters (Wydoski and Whitney 2003). Breeding female kokanee also take on a red to red-gray color like that of the male; however, females do not develop a hooked nose or green coloration on the head.

Historical and Current Range

Kokanee are native to British Columbia, Canada, Alaska, Idaho, Washington, Siberia, and Japan (Scott and Crossman 1973; Moyle 2002). The historical range of native kokanee in Washington State is largely unknown or incomplete. Three native stocks of kokanee were found in the Upper Columbia River and its

tributaries prior to the installation of hydroelectric dams: Arrow Lakes, Kootenay Lake, and the Chain Lakes in B.C. (Wydoski and Whitney 2003). In a petition to list the Issaquah Creek native summer run of kokanee (a Lake Sammamish tributary), the petitioners listed 12 lakes in Washington State as having, (or historically having), a native population of kokanee. These lakes included: Baker Lake, Banks Lake, Billy Clapp Lake, Bumping Lake, Cle Elum Lake, Cooper Lake, Crescent Lake, Kachees Lake, Keechelus Lake, Ozette Lake, Whatcom Lake, and Wenatchee Lake.

The range of kokanee in Washington State has been vastly increased due to stocking practices by the Washington Department of Fish and Wildlife. Lakes in eastern and western Washington are continuously stocked with kokanee for sport fishing. According to a Whatcom County Water Resources (WCWR) (2003) fact sheet about kokanee, two-thirds of Washington State's kokanee fisheries are dependent on the stocking of kokanee fry from the Lake Whatcom hatchery on Brannian Creek. Thirty-six lakes in Washington are stocked annually with 14.4 million Lake Whatcom kokanee (WCWR 2003).

Essential Habitat Components

Generally, there are four basic habitat types required by kokanee and salmon during their life cycle: spawning, rearing, adult and overwintering habitat (Behnke 1992). However, for kokanee, rearing, adult and overwintering habitats are all located within the lake environment. While in this environment, kokanee will move seasonally within the water column to locate optimal temperatures, food sources and adequate oxygen levels.

Spawning usually takes place in a small tributary of the lake they inhabit. Spawning may also take place along the lake shore where upwellings of groundwater occur (Garrett et al. 1998). These upwelling sites may enhance embryo survival by providing a more-stable thermal environment and providing a constant flow of water throughout the incubation period (Garrett et al. 1998). Lake spawning also occurs where wave action and storm events have resulted in shoreline areas with clean, well-washed gravel, free of fine sediment (Federicks et al. 1995). For stream spawning, kokanee require cool (6 to 13°C), clean water (Moyle 2002) with adequate substrate to construct a redd. Kokanee generally construct redds in areas of gravel or small cobble with limited amounts of silt or fine substrate material. It has been found that high levels of fine sediment reduce embryo survival (Garrett et al.1998). Generally, riffles or the tail-outs of pools contain clean, uniform-sized gravel to spawn. After hatching and rearing in the gravel for up to six weeks, the kokanee fry will immediately migrate downstream, usually at night, into the lake environment. Studies in Montana have shown that migrating fry have made a 60 mile migration to Low gradient Lake in less than 72 hours (MDFWP 1985).

After entering the lake environment as fry, young kokanee will seek out the well-oxygenated open waters of the lake to rear (Moyle 2002). The growth of kokanee in this open-water zone is directly related to the overall abundance of zooplankton (Clarke and Bennett 2002). Kokanee will inhabit the surface waters (1 to 3 meters in depth), as long as the preferred temperatures (10 C-15 °C) and prey items remain (Moyle 2002). During the summer months when temperatures at the surface increase, kokanee will move to deeper, cooler waters. Kokanee will spend from 2 to 7 years in the lake environment before they return to their natal streams to spawn (Moyle 2002).

Reproductive Ecology

Kokanee remain in fresh water their entire lives. The size and age of spawning kokanee depend in part on growing conditions (food, light, and temperature) and on the origin of the stock. Kokanee usually reach maturity when they are around 200 to 380 millimeters in length (Wydoski and Whitney 2003).

Kokanee spawn in streams and along the shores of lakes. In streams, females construct a redd in which to lay their eggs and in lakes spawning occurs along a shoreline which is characterized by well washed clean gravel free of silt (Federicks et al. 1995), or upwellings of groundwater (Garrett et al. 1998). Female kokanee (254 to 380 millimeters long) can produce from 300 to 1,700 eggs and may spawn up to 3 times or until her eggs have been depleted. Males and females will die a short time (2 to 4 days) after spawning. Like all salmon, their decaying bodies become a source of nutrients for other organisms in the lake or stream.

The fertilized eggs develop in the gravel, which can take from 4 to 9 weeks (WCWR 2003). The emerged alevins will remain in the gravel until they have consumed their yolk sac. They emerge from the gravel during the spring as fry and migrate downstream to the lake at night with the help of high spring runoff (Moyle 2002; Wydoski and Whitney 2003). The fry then begin to feed on plankton upon reaching the lake (Moyle 2002).

Movements (migration) and Habitat Use

Movements of kokanee within the lake environment are influenced by: optimal temperatures and oxygen levels, food sources, and avoiding predators. In lakes, kokanee prefer water temperatures close to 10°C and inhabit surface waters as long as temperatures are around 10°C, or colder (Wydoski and Whitney 2003). As surface waters warm up in the summer, kokanee move to deeper and colder waters. For example, in Lake Tahoe in Northern California, kokanee are found most of the year at depths of less than 4 meters, but in July through September they concentrate at depths of 17 to 40 meters (Moyle 2002). In some lakes, kokanee display daily vertical movements in the water column, moving into warmer waters to feed at night and then down into colder waters during the day to digest their meals (Moyle 2002). Kokanee in the lake environment are also preyed upon by a variety of predators, such as bull trout and other piscivorous fish. Kokanee generally inhabit the pelagic areas of the lake and avoid the shorelines and benthic zones which are occupied by kokanee and bull trout.

When kokanee are ready to spawn they begin to move to the mouths of their natal streams, or specific lake shore areas, and stage for a short time to develop their spawning colors and shape. Optimal habitat for spawning contains cool temperatures, between 6 C and 13°C (Moyle 2002) and suitable gravel absent of fine sediment. Instream cover such as logjams, boulders, and debris piles provide good cover from predators for adults. Redds are placed in suitable gravel usually found at the tail-outs of pools or in shallow riffles. When fry emerge they migrate downstream at night and immediately into the lake. A kokanee study in Idaho documented significantly higher survival of eggs in areas of upwelling versus non-upwelling, although the upwelling sites had a higher percentage of fine sediment (Garret et al. 1998).

Threats to Survival

Historical information on abundance and distribution of kokanee is largely unknown. Past and current stocking of hatchery kokanee has increased their distribution in Washington. Though hatchery stocking of kokanee might have increased their abundance in some watersheds, it is possible this action may have replaced native populations as well. This compounds determinations on the stability of the species in Washington.

Like many native salmon and trout species in Washington State, losses in key habitat areas (e.g., spawning, rearing, and adult habitat) will negatively affect the ability of a native population to persist. In Lake Whatcom, habitat issues include the loss of suitable spawning habitats in major tributaries from timber harvest and overall residential development (WCWR 2003). Threats to survival include habitat

degradation and fragmentation caused by timber harvesting, road building, urbanization, agricultural practices, and general pollution of waterways.

In the Lake Washington basin a number of factors are likely responsible for the historical decline of native kokanee. These factors include: (1) hatchery outplanting programs and resulting genetic introgression; (2) widespread habitat loss and degradation; (3) trapping programs conducted by WDF; (4) blocked upstream passage by artificial barriers and low flows; (5) shifts in zooplankton densities and composition in Lake Washington and Lake Sammamish; (6) disease; (7) predation and competition from non-native fish species, including *O. nerka* from other basins; and (8) sport-fishing pressures (King County 2000).

Kokanee hatchery practices, loss of migration corridors, loss of riparian zones, water withdrawl, urbanization and agriculture can all affect kokanee. The stocking of one strain of kokanee into systems that historically had several can homogenize the overall population. This can reduce the genetic variability and make them more susceptible to diseases. The stocking of non-native piscivorous fish species, such as bass, can reduce native populations and affect the survival rates of kokanee. Also, increased fishing pressure can contribute to mortality of kokanee.

The NMFS listed the Lake Ozette sockeye as threatened under the ESA in 1999 (64 FR 14529). Kokanee and sockeye occur in Lake Ozette but are substantially different genetically. The kokanee are generally a tributary spawner and the sockeye are predominately a beach spawner in the lake. One of the threats identified for the Lake Ozette sockeye was forest practice activities contributing to widespread sedimentation of lake tributaries, lakeshore spawning beaches, and outwash fans. Although past logging practices may not have been directly linked to sockeye declines, those past practices contributed to the failure of sockeye to rebuild after commercial harvest ended (64 FR 14529). Kokanee may also have been affected by past logging practices in this watershed.

8.5.4.2 Environmental Baseline (within the FPHCP Action Area)

Currently, Washington State maintains numerous populations of kokanee by hatchery rearing and stocking throughout the state. Lake Whatcom kokanee are used as an egg source for stocking programs throughout the state (Wydoski and Whitney 2003). There is also concern, however, that some native populations, such as populations within the Lake Washington/ Lake Sammamish Basin, are in need of protection (Berge and Higgins 2003). This watershed, however, is not going to be substantially influenced by the proposed action. We are currently unaware of population trend or abundance figures for the populations of kokanee in Washington.

Role of the FPHCP Action Area for Conservation of the Species:

Kokanee occur throughout much of the FPHCP Action Area and have a high likelihood of being influenced by the FPHCP. The FPHCP Action Area provides an important conservation role for kokanee. High quality aquatic habitats within the FPHCP Action Area will contribute to the long-term survival of kokanee.

8.5.4.3 EFFECTS OF THE ACTION

General habitat effects to kokanee resulting from the proposed action have been summarized above for the Lentic and Low-gradient Guilds.

Riparian prescription effects to Kokanee

Full riparian and in-stream function likely would not be provided to all habitats occupied by kokanee. In some stream reaches, the highest quality and most structurally complex habitats may fail to develop due to the potential reduction of large wood recruitment to streams at different time scales and following different riparian management prescriptions. For example, although the FPHCP would provide the majority of available large wood adjacent to fish-bearing streams, the FPHCP allows some trees within these large wood recruitment zones to be harvested. In addition, stream-adjacent parallel roads, unbuffered areas in Type Np streams, yarding corridors, and road crossings could reduce potential large wood recruitment. Excessive windthrow could affect some riparian processes. The reduction of large wood over long time frames may not allow processes to form some habitats (pools, riffles, and hiding cover) that kokanee use. Large wood influences pool formation which is important during certain life history stages for kokanee. Large wood also provides hiding cover, sorts and releases spawning gravels, and provides numerous other important biological and physical processes. Less structurally complex habitat may reduce densities of kokanee. Less complex habitat may also affect survival of individual fish through increased competition or predation. Degradation of Type Np stream riparian areas and stream habitat could also alter the availability of terrestrial and aquatic invertebrates, which are an important food source for Kokanee at all life stages.

When RMZs achieve their Desired Future Condition, streams on FPHCP covered lands that are occupied by kokanee would receive most of the potentially available shade. There are physical situations (yarding corridors, stream-adjacent parallel roads, stream crossings, 20-acre exemptions, and windthrow) where stream shading potential would reduced. Along Type Np streams, reductions in shade are likely to occur and water temperature may increase over limited distances as a result of these unbuffered Type Np streams. In some cases, increases in temperature may be delivered downstream to Type F waters and temperatures could be warmed near the confluence of Type Np and F streams. In these circumstances, there could be negative effects to Kokanee due to potentially elevated stream temperatures and loss of thermal refugia resulting in impairment of foraging, rearing, and spawning behaviors. Increased temperatures may result in a competitive advantage for certain species, which could affect individual fish.

Sediment effects to kokanee

Sediment would be delivered to kokanee habitat from road surface erosion. When FPHCP activities affect certain watershed features, such as steep unstable slopes, there may be additional sediment delivered to fish- bearing streams that are above natural background rates. Increased sediment could result in changes to channel morphology, and kokanee habitat could be reduced due to shallowing and filling of pools. Feeding behavior may be affected under some circumstances affecting individual fish fitness and survival. Siltation of spawning reaches could reduce egg survival. However, the FPHCP is not expected to significantly contribute to instream sediment loading to the point that Kokanee would be impaired at more than a stream reach scale. Often, effects might be limited to a habitat unit (pool, riffle) or several units.

Culvert and bridge replacement or installation projects are expected to provide a chronic source of sediment, at least until vegetation has been re-established. When vegetation on culvert and bridge streambanks has been restored, the amount of sediment from road crossings are expected to decline. Short segments of stream are routinely dewatered for culvert installation or replacement and the chance for localized fish mortality increases with these projects.

Effects from the 20-acre Exemption Rule

Although there is uncertainty regarding how often this rule would be implemented, when it is implemented the 20-acre Exemption Rule would adversely affect kokanee. In watersheds with a high proportion of 20-acre exempt landowners, this rule would increase the likelihood that large wood recruitment would be inadequate to maintain properly functioning habitat (USFWS & NMFS 2006). There is also the potential for increased sedimentation, reduced shade, increased stream temperatures, and increased windthrow. Where adverse effects occur, essential behaviors associated with foraging, reproduction and growth may be impeded, Kokanee may occupy the stream at reduced levels, and may have reduced survival.

Summary of adverse effects to kokanee

The proposed action could have short- to long-term adverse effects on sediment, large wood, and temperature. These effects would be most severe from unbuffered Type Np streams and their associated downstream effects that result in disruption of natural riparian and aquatic processes and functions. These effects to the aquatic environment may result in impairment of essential foraging, rearing, and spawning behavior of kokanee. It is difficult to predict the severity of these effects because effects to these fish will vary from activity to activity depending on the specific riparian prescriptions applied, the location, historical management practices, geological characteristics of the watershed, and the biotic community present.

Activities covered under the FPHCP are expected to have direct and indirect adverse effects to adult and juvenile kokanee ranging from mortality to sublethal effects. Direct injury and death to kokanee could likely occur during some crossing construction (stream dewatering and fish rescue and relocation, and blockage of upstream migration during construction). Alterations of the riparian and aquatic environment could reduce the ability of streams to support prey species, thus reducing the fish's ability and success at finding forage in these streams. In a degraded environment increased competition with and predation by other species is anticipated. This could affect the growth and survival of juvenile and adult kokanee.

Summary of beneficial effects

The long-term benefits of the FPHCP for kokanee would occur as riparian areas mature, roads are managed with watershed processes in mind, adaptive management is implemented, and kokanee passage is maintained and restored. The FPHCP's incorporation of BMPs and RMAPs would substantially reduce road surface erosion to kokanee habitat. Most adverse effects are associated with the downstream effects from RMZs on Type Np streams and the where the 20-acre exemption rule is implemented. Effects are not expected to significantly decrease the distribution of kokanee in the FPHCP Action Area. The FPHCP is not expected to significantly contribute to habitat degradation to the point that kokanee would be harmed at more than a stream reach scale. Often, effects might be limited to a habitat unit (pool, riffle) or several units.

8.5.4.4 CUMULATIVE EFFECTS

Cumulative effects were addressed in the **Comprehensive Cumulative Effects**, with respect to the aquatic and riparian environment in Washington State. Additional information regarding cumulative effects for the covered fish species was presented in the section **Lentic and Low gradient Tributary Guilds: Cumulative Effects.**

8.5.5 Mountain Whitefish (*Prosopium williamsoni*) and Pygmy Whitefish (*Prosopium coulteri*)

8.5.5.1 Status of the Species

Description of the Species

The mountain whitefish is a slender, silvery (olive green to dusky on back), fish with a forked tail and a short, pointed head (approximately 20 percent of the total length) (Moyle 2002). They have large scales which may have pigmented borders with 74 to 90 scales along the lateral line (Scott and Crossman 1973). It has a small subterminal toothless mouth (Moyle 2002), and has a single nose flap between nostrils (Scott and Crossman 1973). Mountain whitefish can live up to 15 years (McPhail and Troffe 1998). The largest mountain whitefish recorded in Washington was 530 millimeters and weighed 2.3 kilograms (Wydoski and Whitney 2003). Spawning adults will develop nuptial turbercles along their heads, backs, and sides (Moyle 2002). Juvenile mountain whitefish are silver with two or more rows of black spots on their sides (Scott and Crossman 1973). One row is along the lateral line consisting of seven to eleven large parr marks (Moyle 2002), while another row of spots is along their back.

The pygmy whitefish is a small (average size 12 to 15 centimeters, with a maximum size around 280 centimeters), cigar-shaped fish with silvery sides and brown back. Individuals less than 10 to 12 centimeters have 7 to 14 distinct dark parr marks along the lateral line (Mackay 2000). They have relatively large scales, (50 to 70 along the lateral line), and large eyes (Mackay 2000). Their head is longer than the body depth with a mouth posterior to the tip of the snout. Spawning individuals will develop nuptial tubercles on their head, backs, sides and pectoral fins, with the ventral fins becoming orange (Mackay 2000).

Historic and Current Distribution

The mountain whitefish has a broad distribution across the western United States and British Columbia and Alberta, Canada. In Washington, it is currently distributed throughout the Puget Sound Basin, the lower, mid and upper Columbia Basin, Snake River Basin, and the Chehalis and Coastal River Basins (Wydoski and Whitney 2003).

The pygmy whitefish has a distribution across northern North America including Canada and Alaska (Wydoski and Whitney 2003). The pygmy whitefish was historically located in 15 lakes in Washington, but current distribution is now limited to 9 lakes (Table 8-37) (Hallock and Mongillo 1998). Washington is at the southern end of its range. The pygmy whitefish has no sport or commercial value (Hollock and Mongillo 1998).

Table 8-37. Historic and current distribution of pygmy whitefish.

Lake	County	Past	Presence Current
Bead	Pend Oreille	Yes	Yes
Buffalo	Okanogan	Yes	No
Chelan	Chelan	Yes	Yes
Chester Morse	King	Yes	Yes
Cle Elum	Kittitas	Yes	Yes
Crescent	Clallam	Yes	Yes

Table 8-37. Historic and current distribution of pygmy whitefish. (continued)

Diamond	Pend Oreille	Yes	No
Horsehose	Pend Oreille	Yes	No
Kachess	Kittitas	Yes	Yes
Keechelus	Kittitas	Yes	Yes
Little Pend Oreille Lakes	Stevens	Yes	No
Marshall	Pend Oreille	Yes	No
North Twin	Ferry	Yes	No
Osoyoos*	Okanogan	Yes	Yes
Sullivan	Pend Oreille	Yes	Yes

*Partially located in Canada.

Essential Habitat Components

Mountain whitefish

Although mountain whitefish can be quite numerous and range throughout much of the state and occupy lakes, rivers, and streams, very little is known about their essential habitat components. Generally, mountain whitefish require different habitat types during the different stages of their lives, such as spawning, rearing, foraging and over-wintering habitats.

For spawning, mountain whitefish require gravel, cobble, or rocky reaches of streams or lake shoals to lay their eggs (Wydoski and Whitney 2003). Spawning habitats between 4.4 and 7.2°C are chosen (Wydoski and Whitney 2003). As the eggs hatch, mountain whitefish fry will move into shallow, low velocity habitats such as depositional areas to spend their first summer (McPhail and Troffe 1998). Zero age mountain whitefish in the Yakima Basin have been found at depths of 0.37 meters and a current of 0.27 meters/second (Wydoski and Whitney 2003). As they increase in size, juvenile mountain whitefish will move into deeper, faster water (McPhail and Troffe 1998). Adults will occupy riffle habitats in summer feeding on benthic invertebrates (Wydoski and Whitney 2003). They also occupy clear and cool (9 to 11°C) (Wydoski and Whitney 2003) streams with pools deeper than 1 meter and live close to the bottom (Moyle 2002). They are also found in large schools over gravel bars at the mouths of tributary streams.

Pygmy whitefish

Pygmy whitefish occupy deep, unproductive (oligotrophic) lakes where water temperatures are 10°C and below (Wydoski and Whitney 2003). They are considered a glacial relict (Mackay 2000). Adults do not make extensive migrations to spawn, forage, and over-winter (Wydoski and Whitney 2003). They are found at depths of 0.7 to 92 meters in Washington (Hallock and Mongillo 1998), and 50 to 170 meters in Canada (Mackay 2000). Spawning habitats are usually in moderate to swift stream velocities in silty or clear streams (Wydoski and Whitney 2003). Zero-age fish have been found in both open water and nearshore habitats (Hallock and Mongillo 1998).

Reproductive Ecology

Mountain whitefish mature at 3 to 4 years of age (Wydoski and Whitney 2003). Spawning in Washington is usually in the fall from September to December (Wydoski and Whitney 2003). Adults exhibit pre-spawn movements into pools 2 meters deep or deeper (Wydoski and Whitney 2003) as temperatures begin to drop (Moyle 2002). Adults do not prepare gravel like salmon and trout do. Instead they select

course gravel, cobble, or rocks less than 500 millimeters in diameter to scatter their eggs, which are not adhesive (Moyle 2002). Eggs will then fall into the interstitial spaces between the rocks to develop. Preferred spawning temperatures are between 4 and 7°C (Wydoski and Whitney 2003), with high embryo mortality occurring above 9°C (Moyle 2002), and peak spawning occurring at 6°C (McPhail and Troffe 1998). Spawning usually takes place in shallow (less than 3 meters in depth) stream riffles or runs, or possibly along stretches of rocky shoals that have high wave action (Wydoski and Whitney 2003). Spawning often takes place at dusk or at night (Moyle 2002). After spawning, adults migrate to over-wintering areas. Fry emerge after approximately 150 days, usually in late April to early May, often in conjunction with high spring flows (McPhail and Troffe 1998).

Male pygmy whitefish mature at one to two years of age and are between 60 to 80 millimeters in length, and females mature from one to three years and are between 70 to 230 millimeters in length (Mackay 2000). Adults spawn in the riffles of rivers and streams, or the shorelines of lakes (Wydoski and Whitney 2003). Spawning occurs from late summer to early winter depending on location (Wydoski and Whitney 2003). Adults scatter their eggs over coarse gravel (Hallock and Mongillo 1998) in temperatures between 0 and 4°C (Wydoski and Whitney 2003). Lake dwelling populations can usually complete spawning within a three week period (Hallock and Mongillo 1998). Adult female pygmy whitefish have been found to spawn in consecutive years (Hallock and Mongillo 1998). After spawning, adults will move downstream back into the lake to over-winter.

Movements and Habitat Use

Adult mountain whitefish in Alberta, Canada, exhibit extensive and complex movements that are associated with spring and summer feeding, pre-spawning, spawning, and post-spawning activities (Wydoski and Whitney 2003). Adults will migrate from summer foraging habitats to pre-spawning areas (McPhail and Troffe 1998). These pre-spawning migrations can either be upstream or downstream movements into mainstem rivers or into lower reaches of large tributaries (McPhail and Troffe 1998). From large rivers, mountain whitefish may also move upstream into smaller tributaries to spawn (Moyle 2002). The pre-spawning movements are generally made into pools that are approximately 2.0m or greater in depth (Wydoski and Whitney 2003). From there, the adults move into riffles or runs to spawn (Wydoski and Whitney 2003). After spawning, adults will migrate to over-wintering habitats, which can be 4.5 to 10.5 miles from the spawning grounds (Wydoski and Whitney 2003). Within the upper Columbia River Basin in Canada, mountain whitefish have been documented with fidelity to specific foraging sites (McPhail and Troffe 1998). This has also been shown from the McGregor River, Canada, where mountain whitefish were tagged at a summer foraging site and then recaptured the next year at the same site (McPhail and Troffe 1998). This implies a year-to-year site fidelity in adult mountain whitefish with occasional short-term shifts to different environments, for example spawning and over-wintering habitats (McPhail and Troffe 1998).

Mountain whitefish fry must also move to preferred habitat types. After drifting downstream, young-of-year mountain whitefish will select low velocity, shallow depositional areas along the margins of streams (McPhail and Troffe 1998). In the Columbia River in Canada, fry have actually been documented moving upstream to preferred habitats (McPhail and Troffe 1998). As juvenile mountain whitefish increase in size they gradually begin to move into deeper and faster habitats (McPhail and Troffe 1998).

Pygmy whitefish do not make extended migrations to spawning or over-wintering/foraging habitats (Wydoski and Whitney 2003). They primarily make short local movements from the lake into a selected tributary to spawn (Wydoski and Whitney 2003). They require cold water in mountainous regions that

has moderate to swift velocity (Hallock and Mongillo 1998). They are categorized as a cold water stenotherm (narrow temperature range). Within the lake environment, they are generally separated from other whitefish (Mackay 2000), and occupy depths of 30 meters or greater (Wydoski and Whitney 2003).

Threats to Survival

Mountain whitefish

Due to the activities of man in the last 150 years, most native fish populations throughout the state have been substantially reduced. Land use practices, urbanization, pollution, overfishing, and the introduction of exotic species have all had detrimental effects on native fish assemblages throughout the state. Mountain whitefish occur in the same habitats as other native fish, such as salmon, trout, and char, and it is likely they too have been affected by the actions of man. Due to their migration patterns they can have populations fragmented by dams and other man made barriers. Increased sediment into spawning areas can increase embryo mortality. Removing riparian habitat, which influences water temperatures, can create thermal barriers and decrease egg to emergent survival. Many of the native fish populations face similar problems and whitefish are no exception. However, is it unclear to the extent these actions have had on populations of mountain whitefish. We are unaware of historic mountain whitefish population size, and information on current populations is also lacking.

Pygmy whitefish

Pygmy whitefish previously occupied 15 lakes, but are now known to occur only in 9 lakes in Washington State (Hallock and Mongillo 1998). The main reason for their decline has been the use of fish killing piscicides in the 1950's, used to eradicate non-favorable species (Hallock and Mongillo 1998). The introduction of exotic species which prey on the small pygmy whitefish, such as largemouth and smallmouth bass, were also responsible for their decline (Hallock and Mongillo 1998).

Water temperatures greater than 10°C and dissolved oxygen levels less than 5 mg/l may limit pygmy whitefish habitat (Hallock and Mongillo 1998). Poor water quality combined with introduced exotic species may also be responsible for the elimination of pygmy whitefish (Hallock and Mongillo 1998). Two populations of pygmy whitefish in Alberta, Canada, may be potentially affected by warming that has occurred since the last ice age. Warmer water temperatures in these two lakes may eventually force pygmy whitefish to compete with other species (Mackay 2000). Siltation of spawning sites from forest management practices, and increased development, could cause abandonment of spawning areas or disrupt spawning migrations (Hallock and Mongillo 1998).

8.5.5.2 ENVIRONMENTAL BASELINE (within the FPHCP Action Area)

Currently, 9 lakes are known to contain pygmy whitefish and it is currently suspected that there are no other lakes in the state with the species (Hollock and Mongillo 1998). Of the 9 lakes, 4 are predominately surrounded by Federal Lands and are only minimally affected by proposed action: Lake Crescent, Lake Chelan, Lake Sullivan, and Bead Lake. The following 3 lakes are influenced through Federal and private land management activities, some of which will likely be the FPHCP: Cle Elum Lake, Kachess Lake, and Keechelus Lake. Lake Chester Morse is managed under the City of Seattle HCP (2000) and is not subject to the proposed action. Lake Osoyoos is primarily surrounded by lands not managed under the proposed action, although it is within a watershed that has lands that will be managed under the proposed action. Pygmy whitefish population status within these 9 lakes is currently unknown. Lake Osoyoos and its

watershed may be the most prone to development and management activities that are not favorable to the species.

The mountain whitefish has a broad distribution in Washington and is abundant in some areas (Wydoski and Whitney 2003). The WDFW classifies whitefish as a "game fish" and currently allows 15 whitefish to be caught daily of no minimum size. The majority of angling apparently targets mountain whitefish, although there is no discernment between the two species in WDFW fishing regulations (WDFW 2005). The mountain whitefish population appears to be stable in the FPHCP Action Area.

Role of the FPHCP Action Area for the Conservation of the Species:

The FPHCP Action Area encompasses a significant portion of both species distribution in Washington. As described above, a considerable portion of the pygmy whitefish distribution is associated with Federal lands, and as such, is outside of the FPHCP Action Area. The FPHCP Action Area will provide a moderate role in the conservation of the pygmy whitefish. The mountain whitefish, however, has a substantial overlap of its distribution with the FPHCP Action Area. The FPHCP Action Area will provide a substantial role in the conservation of the mountain whitefish.

8.5.5.3 EFFECTS OF THE ACTION

General habitat effects resulting from the proposed action have been summarized above for the mountain whitefish in the Low Gradient and Mainstem Guilds. Effects to the pygmy whitefish are summarized in the Lentic Guild.

Riparian prescription effects to whitefish

Full riparian and in-stream function likely will not be provided to all habitats occupied by whitefish. In some stream reaches, the highest quality and most structurally complex habitats may fail to develop due to the potential reduction of large wood at different time scales and following different riparian management prescriptions. For example, although the FPHCP will be providing the majority of available large wood adjacent to fish-bearing streams, the FPHCP allows some trees within these large wood recruitment zones to be harvested. In addition, stream-adjacent parallel roads, unbuffered areas in Np streams, yarding corridors, and road crossings would likely reduce potential large wood recruitment. Excessive windthrow could affect some riparian processes. The reduced potential of large wood over long time frames may not allow recruitment processes to form some habitats (pools, riffles, or hiding cover) that whitefish use. Large wood influences pool formation which is important during certain life history stages for whitefish. Large wood also provides hiding cover, sorts and releases spawning gravels, and provides numerous other important biological and physical processes. Less structurally complex habitat may reduce densities of whitefish. Less complex habitat may also influence survival of individual fish through increased competition or predation. Degradation of riparian areas and stream habitat could also alter the availability of terrestrial and aquatic invertebrates, which are an important food source for whitefish at all life stages.

Riparian prescription effects to whitefish

Full riparian and in-stream function likely would not be provided to all habitats occupied by whitefish. In some stream reaches, the highest quality and most structurally complex habitats may fail to develop due to the potential reduction of large wood recruitment to streams at different time scales and following different riparian management prescriptions. For example, although the FPHCP would be provide the

majority of available large wood adjacent to fish-bearing streams, the FPHCP allows some trees within these large wood recruitment zones to be harvested. In addition, stream-adjacent parallel roads, unbuffered areas in Type Np streams, yarding corridors, and road crossings would likely reduce potential large wood recruitment. Excessive windthrow could affect some riparian processes. The reduction of large wood over long time frames may not allow recruitment processes to form some habitats (pools, riffles, or hiding cover) that whitefish use. Large wood influences pool formation which is important during certain life history stages of whitefish. Large wood also provides hiding cover, sorts and releases spawning gravels, and provides numerous other important biological and physical processes. Less structurally complex habitat may reduce densities of whitefish. Less complex habitat may also affect survival of individual fish through increased competition or predation. Degradation of Type Np riparian areas and stream habitat could also alter the availability of terrestrial and aquatic invertebrates, which are an important food source for whitefish at all life stages.

Both species of whitefish require cool water for survival. Water temperatures greater than 10º C and dissolved oxygen less than 5 mg/l in deep water zones of lakes may limit pygmy whitefish habitat (Hallock and Mongillo 1998). Water temperatures <7° C are used for spawning by both species in the fall, when air and water temperatures are declining. When RMZs achieve their Desired Future Condition, streams within the areas covered by the FPHCP that are occupied by whitefish will receive most of the potentially available shade. There are physical situations (yarding corridors, stream-adjacent parallel roads, stream crossings, 20-acre exemptions, and windthrow) where stream shading potential may be reduced. Along Type Np streams, reductions in shade are likely to occur and water temperature may increase over limited distances as a result of these unbuffered Type Np streams. In some cases, increases in temperature may be delivered downstream to Type F waters and temperatures could be warmed near the confluence of Type Np and F streams. In these circumstances, there could be negative effects to whitefish due to potentially elevated stream temperatures and loss of thermal refugia resulting in impairment of foraging, rearing, and spawning behaviors. Increased temperatures may result in a competitive advantage for certain species, which could affect individual whitefish.

Sediment effects to whitefish

Sediment would be delivered to whitefish habitat from road surface erosion. When FPHCP activities affect certain watershed features, such as steep unstable slopes, there may be additional sediment delivered to fish-bearing streams that are above natural background rates. Increased sediment could result in changes to channel morphology, and whitefish habitat could be reduced due to filling of pools. Feeding behavior may be affected under some circumstances affecting individual fish fitness and survival. Siltation of spawning reaches could reduce egg survival. However, the FPHCP is not expected to significantly contribute to instream sediment loading to the point that whitefish would be impaired at more than a stream reach scale. Often, effects might be limited to a habitat unit (pool, riffle) or several units.

Culvert and bridge replacement or installation projects are expected to provide a chronic source of sediment, at least until vegetation has been re-established. When vegetation on culvert or bridge streambanks has been restored, the amount of sediment from road crossings are expected to decline. Short segments of stream are routinely dewatered for culvert installation or replacement and the chance for localized fish mortality increases with these projects.

Effects from the 20-acre Exemption Rule

Although there is uncertainty regarding how often this rule would be implemented, when it is implemented the 20-acre Exemption Rule would adversely affect whitefish . In watersheds with a high proportion of 20-acre exempt landowners, this rule would increase the likelihood that large wood recruitment would be inadequate to maintain properly functioning habitat (USFWS & NMFS 2006). There is also the potential for increased sedimentation, reduced shade, increased stream temperatures, and increased windthrow. Where these adverse effects occur, essential behaviors associated with foraging, reproduction and growth may be impeded, and whitefish may occupy the stream at reduced levels and they may have reduced survival.

Summary of adverse effects to whitefish

The proposed action will have short- to long-term adverse effects on sediment, large wood, and temperature. These effects would be most severe from unbuffered Type Np streams and their downstream effects that result in disruption of natural riparian and aquatic processes and functions in Type F streams. These effects to the aquatic environment may result in impairment of essential foraging, rearing, and spawning behavior of whitefish. It is difficult to predict the severity of these effects because effects to these fish will vary from activity to activity depending on the specific riparian prescriptions applied, the location, historical management practices, geological characteristics of the watershed, and the biotic community present.

Activities covered under the FPHCP are expected to have direct and indirect adverse effects to adult and juvenile whitefish ranging from mortality to sublethal effects. Direct injury and death to whitefish would likely occur during some stream crossing construction activities (stream dewatering and fish rescue and relocation, and blockage of upstream migration during construction). Alterations of the riparian and aquatic environment could reduce the ability of streams to support prey species, thus reducing the fish's ability and success at finding forage in these streams. In a degraded environment increased competition with and predation by other species is anticipated. This could affect the growth and survival of juvenile and adult whitefish.

Summary of beneficial effects

The long-term benefits of the FPHCP for whitefish would occur as riparian areas mature, roads are managed with watershed processes in mind, adaptive management is implemented, and whitefish passage is maintained and restored. The FPHCP's incorporation of BMPs and RMAPs will substantially reduce road surface erosion to whitefish habitat. Most adverse effects are associated with the downstream effects from RMZs on Type Np streams and where the 20-acre exempt rule is implemented. Effects are not expected to significantly decrease the distribution of the redband or whitefish in the FPHCP Action Area, because the FPHCP is not expected to significantly contribute to habitat degradation to the point that whitefish would be harmed at more than a reach scale. Often, effects might be limited to a habitat unit (pool, riffle) or several units.

8.5.5.4 CUMULATIVE EFFECTS

Cumulative effects were addressed in the **Comprehensive Cumulative Effects**, with respect to the aquatic and riparian environment in Washington State. Additional information regarding cumulative effects for whitefish was presented in the section steep **Tributary and Low-gradient Tributary Guilds: Cumulative Effects.**

8.5.6 Pacific Lamprey (*Lampetra tridentata*),River Lamprey (*Lampetra ayresi*), Western Brook Lamprey (*Lampetra richardsoni*)

8.5.6.1 Status of the Species

Description of Species

Lampreys are eel-like in shape but lacking jaws and paired fins (Moyle 2002). They have cartilaginous skeletons, a single nostril and two semicircular canals in each side of the head (Moyle 2002). They generally have 7 small round gill openings on either side of their heads. In transformed or adult parasitic individuals, their tongues have sharp horny plates (Moyle 2002) which are used as identifying characteristics. Adult and metamorphed lampreys also have well developed eyes, whereas the larval form, or ammocoetes, has no eyes.

Pacific lamprey, as a spawning adult, is the largest of the three species of native lamprey, growing to over 400 millimeters in total length (Moyle 2002).

The distinguishing characteristic of an adult Pacific lamprey, besides their length, is the arrangement of the teeth in their sucker-like mouth. Their large supra-oral lamina has 3 cusps, the lateral teeth are in 4 pairs, and the posterior teeth are parallel to the margins of the mouth (Wydoski and Whitney 2003). The mid cusp is smaller than the two lateral cusps (Moyle 2002). The tongue also ends in 14-21 small points (Moyle 2002). The two dorsal fins are slightly separated in which the second dorsal fin is continuous with the caudal fin (Moyle 2002). Sexually mature females have a well developed ventral fin fold on the caudal oedema that resembles an anal fin. Male Pacific lamprey, do not develop this fin fold and have no anal fin (Wydoski and Whitney 2003). Adults also have 62-71 body segments (myomeres) (Moyle 2002). The dorsal fin in the male is higher than that of the female (Moyle 2002). The body and the lower half of the oral hood are usually dark in coloration and typically there is a pale area associated with a ridge in the caudal region (Moyle 2002). Spawning adults have dark coloration, sometimes a greenish black, with a pale or gold colored belly (Moyle 2002).

The river lamprey is relatively small as an adult, around 170mm, compared to the Pacific lamprey (Moyle 2002). As an adult, the river lamprey's supra-oral lamina has only two cusps, the lateral teeth are in three pairs, and there are no posterior teeth (Wydoski and Whitney 2003). Their body color is usually darker on their backs and sides with a silver to yellowish color on the belly (Moyle 2002). In spawning adults the two dorsal fins grow closer together and eventually join (Moyle 2002). They have an average of 68 myomeres in adults and 67 in ammocoetes (Moyle 2002). Ammocoetes heads are pale in coloration with a prominent line behind the eye spot (Moyle 2002).

The brook lamprey are also small (180 millimeters in total length) as adults (Moyle 2002). Their tooth plates are poorly developed and are the only native species of lamprey that is not parasitic. Their supra-oral plate has cusps at each end but not in the middle (Moyle 2002). There are 7-10 tooth-like cusps on the infraoral plate and 3 circumolar plates on each side of the mouth, the mid one with 2-3 cusps (Moyle 2002). They have 52-67 myomeres in adults as well as in ammocoetes (Moyle 2002). Their coloration is dark on the back with a yellow to white on the belly (Moyle 2002). Ammocoetes have dark pigmentation on their tail and on the head above the gill openings (Moyle 2002).

Cultural significance:

Pacific lampreys are an important religious food of indigenous people in the mid-Columbia River basin. Pacific lamprey also has medicinal value to tribal peoples. Lampreys continue to be a part of the tribal culture in the Pacific Northwest (Close et al. 2002).

Historic and Current Distribution

The historic distribution of Pacific lamprey encompassed the entire Puget Sound, Strait of Juan de Fuca, coastal areas, as well as the Columbia River Basin upstream to Kettle Falls and the Spokane River to the Spokane Falls (Wydoski and Whitney 2003). The Pacific lamprey has been found from Mexico to Alaska and Japan. It is also found in Idaho. In Washington, it currently is found in tributaries of the Columbia River to Chief Joseph Dam and upstream on the Snake River to Hells Canyon Dam (Wydoski and Whitney 2003). Pacific lamprey are found in most large rivers and streams along the coast and the Strait of Juan De Fuca, throughout Puget Sound, and parts of Hood Canal (Wydoski and Whitney 2003).

Historical distribution of river and western brook lamprey is unknown at this time. They most likely occupied rivers and streams throughout the Puget Sound, Strait of Juan de Fuca, coastal areas, Hood Canal and the Columbia River Basin. However with the construction of dams throughout the Columbia and Snake Rivers, lamprey populations were fragmented and upstream areas of spawning and suitable habitat were cut off, limiting a majority of the populations to the lower reaches of the Columbia and Snake Rivers. The Columbia River dams may not have had as much of an effect on the river lamprey in comparison to the Pacific lamprey because of its apparent preference to use areas closer to the ocean (Lee et al. 1997).

The current distribution of the river lamprey consists of rivers and streams along the coast from the mouth of the Columbia River to the mouth of the Hoh River, and throughout the Puget Sound (Wydoski and Whitney 2003). An adult was found below Easton Lake on the Yakima River in 1959, and several possible ammocoetes of the river lamprey were discovered on the South Fork Touchet River in 1993 (M. Hallock, Personal Communication, 2004).

The western brook lamprey is the only species of native lamprey that does not have an anadromous life form. Western brook lampreys live their entire lives in fresh water. Current distribution of the western brook lamprey is considered as occupying rivers and streams from the Hoh River south along the coast to the mouth of the Columbia River, upstream on the Columbia River to the Yakima River, including the Cowlitz and the Lewis Rivers, the Walla Walla and Touchet Rivers, and throughout the Yakima River (Wydoski and Whitney 2003).

Essential Habitat Components

Essential habitat components of native lampreys vary as to species and stage of development. However, ammocoetes from each of the three species are very difficult to distinguish and therefore life history descriptions and habitat requirements tend to be generalized for all species (Kostow 2002).

Essential to all three species of lamprey is that they require fresh, clean flowing water to spawn in. The Pacific and river lampreys are anadromous and therefore move into the marine environment to feed as developing sub adults (Beamish 1980; Beamish and Levings 1991; Kostow 2002; Moyle 2002; Wydoski and Whitney 2003), whereas the brook lamprey remains in fresh water throughout its entire life cycle (Graham and Brun 2002; Kostow 2002; Moyle 2002; Pirtle et al. 2003; Wydoski and Whitney 2003). All three species of lamprey also require freshwater habitat for rearing and overwintering.

The Pacific, river, and brook lampreys, as ammocoetes, prefer small substrates in coldwater streams for rearing such as mud and fine silt deposits (Kostow 2002; Moyle 2002; Wydoski and Whitney 2003). These conditions are generally located in backwaters and in quiet eddy along the banks of streams and rivers (Wydoski and Whitney 2003). The ammocoetes burrow into the fine silt and mud to hide from predators. The mud and silt also contains detritus, algae and diatoms that the ammocoetes filter feed on (Kostow 2002).

Overwintering has been observed in adult Pacific lamprey returning from the sea. Tagged lamprey were found to hid under rocks and were sedentary in pools for several months until they moved onto the spawning grounds (Kostow 2002).

The Pacific and river lamprey spend part of their life cycle within the marine environment (Beamish 1980; Beamish and Levings 1991). However it is not fully understood what types of habitat are being used during this phase of their life cycle. The Pacific lamprey has been collected at depths of 70 to 250 meters and up to 10 to 100 kilometers off shore (BioAnalysts 2000). In the marine environment, the river lamprey has been found to utilize surface waters in which they feed from, and are not found in mid or deep water areas (Beamish 1980).

Reproductive Ecology

All three species of lamprey require fresh, clean flowing water for spawning. The western brook lamprey is the only species that remains in freshwater its entire life, while the Pacific and river lamprey move into the marine environment during part of their life cycles (Beamish 1980; Beamish and Levings 1991; Kostow 2002; Moyle 2002). All species also spawn around the same time, from April to July. In general, all species seek out spawning areas in riffles or at the tail-outs of pools (Kostow 2002; Larson and Belchik 1998). Lampreys construct a nest which can be from 10 to 30 centimeters in diameter and 2.5 to 8 centimeters deep, by attaching their oral disks onto rocks and debris and moving downstream (Wydoski and Whitney 2003). Pacific lampreys lay from 34,000 to 238,400 eggs, river lampreys lay from approximately 11,000 to 37,000 eggs, and western brook lampreys lay approximately 1,000 to 4,000 eggs (Wydoski and Whitney 2003).

Substrate chosen to construct the nest is usually a composition of gravel and sand (Kostow 2002). Adult Pacific lampreys are the largest of the three and can spawn in larger substrates and faster water velocities than other native lamprey species (Pirtle 2003; Wydoski and Whitney 2003). Spawning takes place when the nest is completed and the female attaches herself to a rock upstream of the nest with her oral disk. The male then attaches his oral disk to her head or a nearby rock and wraps himself around the female and releases milt while the female released her eggs. The sticky fertilized eggs then fall into the nest and stick to rocks and are covered by sand and small sized gravel (Kostow 2002). After spawning the adult lampreys will die a short time after. However, adult Pacific lamprey still containing eggs have been captured in downstream traps, which could suggest the possibility of spawning a second time (Wydoski and Whitney 2003). After the ammocoetes hatch they will remain within the gravel for a few days. They then move into the current and begin a downstream search for suitable rearing habitat. The ammocoetes of all species are filter feeders and burrow tail first into fine sediment areas of sand and silt. Here they remain feeding on detritus and diatoms (Beamish and Levings 1991).

Movements and Habitat Use

Lampreys can exhibit various ranges of movement occupying many types of habitats throughout their lives. However for all species early life history (freshwater phase) descriptions tend to be generalized due to the difficulty in distinguishing each species ammocoetes from one another (Kostow 2002).

Ammocoetes movements can occur throughout the year and can be associated with both discharge patterns and transformation (Pirtle et al. 2003). High discharge events that can cause scouring will often displace ammocoetes from their sand and silt burrows. When lampreys have transformed into adults they actively swim upstream to their spawning grounds. This can often be many kilometers away from their adult feeding habitats, as with the Pacific and river lampreys.

Pacific and River Lamprey

The Pacific and river lampreys have very similar life cycles. Both are anadromous and often occupy the same types of habitat. Pacific and river lamprey ammocoetes both occupy habitats that contain soft substrates within rivers or streams to burrow in. It is unknown how long the river lamprey spends as an ammocoete (Wydoski and Whitney 2003; Moyle 2002). Pacific lamprey will spend between 4 and 7 years in fresh water (Wydoski and Whitney 2003). Both species as newly formed young adults then migrate downstream to the sea. Beamish and Levings (1991) found that migratory activity was closely associated with increases in discharge. Migration was also closely associated with time of day. Young adult Pacific lamprey migrate mainly at night (Wydoski and Whitney 2003; Beamish and Levings 1991). The river lamprey has been documented in moving both day and night with a possible preference for night (Moyle 2002).

In the marine environment Pacific and river lamprey have been documented in occupying different habitats. The Pacific lamprey have been collected from 10 to 100 kilometers offshore along the Oregon coast at depths of 800 meters, but are typically found between 70-250 meters (Wydoski and Whitney 2003). They remain in the ocean from 3-4 years (Beamish 1980). During their time in the ocean the young lamprey will begin their parasitic life phase. As opportunistic feeders, they will feed on many types of rockfish, cod, salmon, low-gradientfish and herring (BioAnalysts 2000). The river lamprey is rarely found at depths >50 meters (Beamish 1980), and only spend 4-5 months in the sea (Wydoski and Whitney 2003). River lamprey are also associated with low salinity, between 26-30 ppt (sea water is 39 ppt) (Wydoski and Whitney 2003). Beamish also found in British Columbia that river lamprey are found in the vicinity of major rivers and their distribution throughout the surface waters may indicate a preference for reduced salinities.

Western Brook Lamprey

The western brook lamprey remains in freshwater its entire life, only moving within the confines of its natal watershed. They tend to occupy smaller streams with lower gradients (Wydoski and Whitney 2003). During their lives western brook lampreys move very little, with most movement occurring during passive downstream movements after they leave their burrows (Kostow 2002). Western brook lamprey ammocoetes live for 3-4 years in Washington State and 4-5 years in British Columbia (Moyle 2002). Brook lamprey have been found to distribute themselves within a creek system according to size (Kostow 2002). The smaller ammocoetes migrate further upstream to finer sediment and shallower water while larger ones move downstream and choose coarser sandy substrates rich in organic matter and in deeper waters (Kostow 2002). After undergoing metamorphism, about 4 months, western brook lampreys enter deep burrows and become dormant (Kostow 2002). Unlike the Pacific and river lamprey, the western

brook lamprey is temperature sensitive and will remain burrowed until the correct temperatures rise above 10°C (Kostow 2002). When temperatures are right the newly metamorphosed adults will emerge from their burrows and migrate short distances to find suitable spawning gravels. Unlike their counterparts, western brook lampreys as adults never feed. After spawning both the male and female die.

Threats to Survival

Pacific lampreys appear to have declined substantially from California to Washington (69 FR 77158). At Ice Harbor Dam on the lower Snake River, almost 50,000 were recorded in 1963. In 2001 the Pacific lamprey count dropped to 203, and in 2003 it was 1700. On the North Umpqua River at the Winchester Dam in Oregon, Pacific lamprey declined from a high of over 46,000 in 1996 to 15 in 1997 (69 FR 77158). Annual counts of Pacific lampreys at the Red Bluff Diversion Dam on the upper Sacramento River have declined from 38,492 in 1972 to 107 or less since 1996.

All lamprey species require cool, clean, connected and complex habitats similar to Pacific salmon and char for survival. Availability and accessibility of suitable spawning and rearing habitat may affect the amount of recruitment that occurs within a basin (Houde 1987, Potter et al. 1986, as cited in Stone et al. 2002). Close et al. (1995) identified four main causes that may account for declines in native lamprey: (1) poor spawning and rearing habitat, (2) pollution, (3) unfavorable ocean conditions which can reduce prey items, and (4) migration barriers (dams). The Fish and Wildlife Service in the recent 90 day finding (69 FR 77158) to not list lampreys in Washington state (and CA, ID, and OR) identified the above threats and also: 1) dewatering habitats occupied by ammocoete; 2) over harvest, 3)introductions of non-native fish.

Pacific lamprey have to survive up to 11 years before they spawn. They can spend to 6 – 7 years as ammocoetes, 1 -3 years in the marine environment, and up to 1 year in freshwater before they spawn. Fecundity is high, but in comparison to most salmonids they have to survive 2 to 3 times as long before they spawn. Western brook and river lamprey probably spawn 2 to 4 years sooner than Pacific lamprey, but must still survive a number of years before spawning.

Quality habitat during any stage of a lamprey's life cycle is critical in its development and maintenance of its population. Throughout Washington State increasing urbanization has impacted vital habitats for lamprey. Agricultural developments in river valleys may have also contributed to a reduction in habitat carrying capacity (BioAnalysts 2000). Lampreys tend to favor lower basin areas, with low gradient reaches (Kostow 2002). These areas generally have high urban, industrial, and agriculture development (Kostow 2002). They are also prone to sedimentation, which may be harmful to the ammocoetes. Removal of riparian vegetation, increased sedimentation, and irrigation withdrawals reducing streamflows and elevating temperature, are all results of increased development within the lower river reaches.

Pollution is also a possible cause in the overall decline in lamprey populations. However there has been some speculation that lampreys can tolerate poor water quality (Kostow 2002). How this tolerance relates to long term survival of populations is unknown. Decreased dissolved oxygen, elevated temperatures, DDT and other man made chemicals, and increased fecal coliform have all had negative affects upon other native fish species. Temperature may be one of the more important factors limiting lamprey success. The Pacific lamprey generally prefer temperatures lower than 20°C, while the western brook lamprey uses temperature to initiate emergence from their burrows (BioAnalysts 2000; Kostow 2002).

Ocean conditions are also a factor that can influence the populations of Pacific and river lamprey. The western brook lamprey does not have an ocean phase of its life cycle and remains within freshwater its

entire life. However, other types of fish that have anadromous life cycles do contribute to the overall production of a watershed in which their bodies function as a nutrient transports. When they die and release their marine-derived nutrients into the system via decay, they provide food for many types of life forms within the watershed. Western brook lamprey as ammocoetes likely feed of the marine-derived nutrients in the forms of algae and detritus. The Pacific and river lamprey spend months to years within the marine environment, feeding and growing on various prey items from salmon to whales (Beamish 1980). If these types of food items are not as available due to unfavorable ocean conditions, then a reduction in the population could occur due to starvation. Ocean fisheries may also reduce prey items (BioAnalysts 2000).

The construction and current operations of dams may more directly impact the populations of native lamprey, as does many other in-water structures such as culverts, tide gates and hatchery weirs. Lamprey are unique among other native fish due to their ability to use their sucker mouths to climb natural barriers and penetrate headwater areas that are not available to other types of fish (Kostow 2002). However, they are unable to negotiate many types of artificial barriers. Lampreys are generally weak swimmers, they lack paired fins and have no jumping ability (Kostow 2002). Although they use fish ladders associated with dams, their passage efficiency is poor. They have difficulty where lips or gratings need to be crossed, areas where water velocity is higher, and areas that are lighted at night (Kostow 2002).

Reservoirs created by dams may also impact lamprey populations. Reservoirs may delay the downstream migration of young adults (BioAnalysts 2000). Longer passage time within a reservoir can increase encounters with native and non-native predators (BioAnalysts 2000). Juvenile lamprey can also get impinged on screens at dams used to bypass anadromous fish (BioAnalysts 2000). Road culverts can also become migration barriers to lampreys. The smooth surfaces of culverts, increased water velocities, and perched downstream ends can inhibit the upstream migration of adult lampreys.

Population dynamics of Pacific lamprey are unknown. Filter-feeding ammocoetes have a long (5-6 year) freshwater residence period that may benefit from increased nutrient input from salmonid carcasses. During this long larval stage, Pacific lamprey fall prey to a wide variety of species including trout, crayfish, and birds (Pacific States Marine Fisheries Commission 2000).

The Idaho Chapter of the American Fisheries Society determined that dams on the Columbia and Snake rivers, alteration of streams, and harvest of ammocoetes for use as bait by fisherman are the most serious threats to the Pacific lamprey in Idaho (IDAFS, as cited in Lee et al. 1997).

The limited amount of ecological information currently available about Pacific lamprey is insufficient to evaluate the species' population status in Washington State. However, in Oregon, this species is considered a species of concern, due primarily to its apparent widespread decline. Although the reasons for this decline are poorly understood, it is likely due to conditions both in oceanic and freshwater habitats; passage at hydroelectric and irrigation dams may also be a contributing factor throughout its range (Oregon Department of Fish and Wildlife 1996; Renaud 1997).

Notably, a related northern species, the Arctic lamprey (*Lampetra japonica*), faces significant mortality in late spring and summer when low stream levels leave burrowed ammocoetes (larvae) stranded in dry stream edges (Scott and Crossman 1973). Degradation of habitat due to scouring of stream bottoms by splash damming, water withdrawls, logging, grazing, and pollutants from urban and agricultural runoff may have contributed to this species' decline. Losses of wetlands, side channels, back eddies, and beaver ponds resulting from agricultural, forestry, or urban development practices or channelization from flood

control affect the juvenile life stages. The lamprey's food supply can be reduced by high stream temperatures and lack of stream cover (Pacific States Marine Fisheries Commission 2000).

Historical practices in Washington of splash damming logs, clearcutting to the streambank, limiting or preventing fish migration, and removing large wood from streams, simplified stream channels to the detriment of aquatic species. While commonly reported as harming salmonid species, in all likelihood these past practices also degraded lamprey habitats. Complex aquatic and riparian habitats create in-stream diversity that larval lamprey and spawning lamprey require for long-term survival.

8.5.6.2 ENVIRONMENTAL BASELINE (within the FPHCP Action Area):

Pacific Lamprey:

Pacific lamprey abundance and distribution data in Washington is extremely limited (69 FR 77158). The following text is from the December 27, 2004, Federal Register for a 90 day finding on a Petition to List Three Species of Lampreys as Threatened or Endangered:

"Substantial declines in the distribution and abundance of Pacific lampreys in Washington have apparently occurred in tributaries of the Columbia and Snake Rivers, and in the Elwha River and Salt Creek on the Olympic Peninsula. R. Fuller (WDFW, in litt. 2004) indicates the species was more common in the 1980s, then declined in the 1990s, and has increased in counts in 2003 and 2004, although not to past levels. WDFW biologists noted this pattern of change in the Stillaguamish, Snohomish, Skagit, Green, Tolt, and Quillayute Rivers, Hood Canal, and the Strait of Juan de Fuca (R. Fuller, in litt. 2004). Pacific lamprey redds (a spawning nest formed by fish in a river bed where their eggs and sperm are deposited) and individuals have been observed less frequently in the past 10 years in streams and rivers of the Strait of Juan de Fuca (B. Vadas, Personal Communication, 2004).

Tribal elders of the Elwha Klallam Tribe report that Pacific lampreys were historically abundant in the Elwha River and other north Olympic Peninsula rivers, including the Pysht, Hoko, and Dungeness Rivers, and Salt Creek (Mike McHenry, Elwha Klallam Tribe, Personal Communication, 2004). Anecdotal information suggests current numbers may represent less than 5 percent of their historical observations (M. McHenry, Personal Communication, 2004). Only one Pacific lamprey (a juvenile in 2003) has been recorded on the Elwha River, below the dam, in the last 20 years (M. McHenry, Personal Communication, 2004).

In southwest Washington, Pacific lampreys are common in Mill Creek and in the Grays, Skamokawa, Elochoman, Abernathy, Germany, Kalama, South Fork Toutle, and Green Rivers (R.Fuller, in litt. 2004). In the 1960s, Pacific lampreys were common in the Chehalis River system (Nawa et al. 2003), and appeared to be more common on the coast than in the Puget Trough (R. Fuller, in litt. 2004). From 1997 to 2000, thousands of lampreys were trapped on the North Fork Toutle River, but numbers have declined from 2000 to 2004 (R. Fuller, in litt. 2004). Pacific lampreys have been documented in Cedar Creek and its tributaries (Pirtle et al. 2003), at the Speelyai Hatchery on the Lewis River (R. Fuller, in litt. 2004), and in streams near Franz Lake National Wildlife Refuge in Skamania County (Nawa et al. 2003).

In eastern Washington, Pacific lampreys historically occurred in numerous other basins, including the Spokane River and Asotin Creek (ACCDLSC 1995; Wydoski and Whitney 2003). The purported historical occurrence of Pacific lampreys in the mainstem Columbia River above Chief Joseph Dam and Grand Coulee Dam prior to their construction (BioAnalysts, Inc. 2000) is supported by historical

documentation of remnant Pacific lamprey at Kettle Falls and in the Spokane River up to Spokane Falls (Wydoski and Whitney 2003).

Where historical information does exist for river basins (Walla Walla, Wenatchee, Tucannon, Asotin), Pacific lampreys were described as ‘‘abundant,’’ ‘‘common,’’ or ‘‘likely had large runs’’ (Service 1959; ACCDLSC 1995; G. Mendel, WDFW, Personal Communication, 1994, cited in Jackson et al. 1996; Lane and Lane cited in Confederated Tribes of the Umatilla Indian Reservation (CTUIR) 2004; Swindell cited in CTUIR 2004). In 1999, surveys found Pacific lamprey ammocoetes were absent from reaches in the Walla Walla River subbasin (Bronson cited in CTUIR 2004). Adult Pacific lampreys have not been documented in the Asotin Creek watershed since at least 1980, although small lampreys of unknown species have been observed (ACCDLSC 1995). A 2002 trapping study designed to capture emigrating Chinook salmon in the Entiat River found Pacific lampreys to be the most numerous species captured during the time of the study. Most outmigration of lampreys occurred during the highest stream flows of the trapping period (Service, in litt. 2002). Although Pacific lampreys are occasionally caught incidentally at a screw trap on the Tucannon River, lamprey production in this subbasin is considered low (Close 2000) because the population has rapidly declined since 1981 (G. Mendel, Personal Communication, 1994, cited in Jackson et al. 1996).

Pacific lampreys occur throughout the mid-Columbia and Snake Rivers and many associated river basins, including the Tucannon, Walla Walla, Yakima, Wenatchee, Entiat, and Methow Rivers. The Pacific lamprey distribution currently extends up to Chief Joseph Dam on the Columbia River, and to Hells Canyon Dam on the Snake River (Nass et al. 2003; CTUIR 2004).

Passage data from numerous mainstem Columbia (McNary, Rock Island, Rocky Reach, and Wells) and Snake River dams (Ice Harbor) suggest that, although annual numbers fluctuate widely at each project, there is a decreasing trend in the number of adult Pacific lampreys counted at each project (BioAnalysts, Inc. 2000). Data indicate that large declines occurred during the late 1960s and 1970s, and that current counts continue to be well below historical levels (Close et al. 1995; BioAnalysts, Inc. 2000; Corps 2003). For example, the number of adult Pacific lampreys counted at the fish ladder at Ice Harbor Dam on the Snake River declined from 50,000 in 1963 to approximately 1,700 in 2003 (Corps 2003).

Although adult lamprey counts have increased at Snake River dams (Ice Harbor, Lower Monumental, Little Goose, and Lower Granite) and Columbia River dams (McNary, Priest Rapids, Rock Island, Rocky Reach, and Wells) in recent years, they are still considered to be well below historical levels (Close et al. 1995; Corps 2003; BioAnalysts, Inc. 2004). For example, counts at Rocky Reach Dam have shown a decline from more than 17,000 adult Pacific lampreys in 1969 to an average of 330 between 1983 and 2001. However, counts increased to 1,842 and 2,521 adult Pacific lampreys in 2002 and 2003, respectively (BioAnalysts, Inc. 2004). Increased numbers of lampreys in recent years may be an artifact of increased sampling or due to increased food abundance in the ocean (BioAnalysts, Inc. 2000).”

Western Brook Lamprey:

Detailed population and distribution data for the western brook lamprey is not available. The following text is from the December 27, 2004, Federal Register for a 90 day finding on a Petition to List Three Species of Lampreys as Threatened or Endangered:

Although western brook lampreys were considered common in Washington in 1936 (Nawa et al. 2003), Morrow (1980) stated, without documentation, that the species ‘‘is not particularly abundant anywhere as far as is known.’’ The species’ known distribution includes parts of the Olympic Peninsula, including

streams on the southern and western boundaries of the Olympic Peninsula, but not streams on the northern and eastern boundaries (Mongillo and Hallock 1997). In surveys conducted during the 1930s, western brook lampreys were collected on the Olympic Peninsula from the Quillayute, Queets, Quinault, Humptulips, Wynoochee, and Satsop Rivers, but not the Hoh River, and from Chimacum Creek (Mongillo and Hallock 1997; Cooper cited in R. Fuller, in litt. 2004). Mongillo and Hallock (1997) include the Hoh River in the distribution of the western brook lamprey because the species is found in the adjacent Quillayute and Queets Rivers. Other observed localities include coastal and Puget Sound streams, including the lower reaches of the Nisqually River (Cook-Tabor 1999), North Creek near Seattle, and Dry Creek in Mason County (Froese and Pauly 2004). This species has also been recently reported from the Nooksack River (R. Fuller, in litt. 2004), the North Fork and South Fork Chelatchie Creeks, and tributaries of Cedar Creek in the Lewis River watershed (Pirtle et al. 2003).

Historically, western brook lampreys were considered abundant in the Walla Walla River subbasin (Lane and Lane cited in CTUIR 2004; Swindell cited in CTUIR 2004). Numerous unidentified lampreys were documented as ‘‘abundant’’ at the Tumwater trap on the Wenatchee River in 1955 (Service 1959).

Western brook lampreys are known to occur in the Yakima and Walla Walla River Basins. While the abundance of the western brook lamprey is unknown, the populations in the Walla Walla River subbasin appear to be self sustaining (CTUIR 2004). In 1998, assessments of the Walla Walla River subbasin indicated that lampreys were present in 8 of 12 subwatersheds inventoried (Mendel cited in CTUIR, in litt. 2004). Although not identified to species, these individuals were assumed to be western brook lampreys because Pacific lampreys have not been documented in recent sampling efforts (Bronson cited in CTUIR 2004). Western brook lampreys are thought to be in the Entiat River (Phil Archibald cited in Service, in litt. 2004b). Small river or western brook lampreys were documented in Asotin Creek by Mendel and others (ACCDLSC 1995).

River Lamprey:

Detailed population and distribution data for the river lamprey is not available. The available data for this species is even less than for the other two species of lamprey in the FPHCP Action Area. The following text is from the December 27, 2004, Federal Register for a 90 day finding on a Petition to List Three Species of Lampreys as Threatened or Endangered:

In Washington, there are no historical distribution records for river lamprey, although the species probably occurred in most major rivers (Wydoski and Whitney 1979). Morrow (1980) stated, without documentation, that the river lamprey ‘‘does not appear to be particularly abundant anywhere within its range.’’ The current distribution of river lamprey includes rivers and streams along the coast from the mouth of the Columbia River to the mouth of the Hoh River, throughout Puget Sound, and in the Lake Washington basin (Wydoski and Whitney 2003), but not on the Olympic Peninsula (Mongillo and Hallock 1997). Two records (1931 and 1959) of river lamprey in Lake Cushman (Mongillo and Hallock 1997; S. Brenkman, Personal Communication, 2004), suggest this lake may have once supported an adfluvial (lake dwelling) population (Mongillo and Hallock 1997). The petition notes specimens were collected from the Bogachiel River in 1897, Lake Pleasant (date unknown), off the coast of Washington in 1999, and 4.0 miles (6.4 kilometers) off La Push, Washington in 2002. River lamprey ammocoetes were trapped in the 1980s in the lower reach of the Nisqually River, but no river lamprey population estimates or in-stream distribution information are available (Cook-Tabor 1999).

WDFW listed the river lamprey as a ‘‘State Candidate’’ in 1998 because of its uncertain status. Surveys are ongoing to determine if the species should be listed as State endangered, threatened, or sensitive (Wydoski and Whitney 2003; WDFW 2004).

River lampreys occur in the Columbia River and have been documented in the Yakima River basin. River lampreys were identified by the Pacific Northwest National Laboratory (2004) in the Hanford Reach of the Columbia River. Numerous unidentified lamprey species were documented as ‘‘abundant’’ at the Tumwater trap on the Wenatchee River in 1955 (Service 1959), but may have been either river or western brook lampreys. Also, small lampreys documented in Asotin Creek by Mendel and others (Mendel cited in ACCDLSC 1995) were not identified to species and may have been either river or western brook lampreys.

None of the three lamprey species in the FPHCP Action Area are listed under the ESA. Although none may currently be listed, there is still considerable cause for concern for the long-term survival for these species. Lampreys are important culturally and ecologically, but lack of public interest, or in some cases outright disdain for lampreys, has been partly responsible for their current status. There currently appears to be an overall population decline for the Pacific lamprey and some of the threats to this species may not be fully understood. There is a substantial lack of knowledge on life history ecology for the river lamprey and even less is known about its population status. Perhaps the population status of the western brook lamprey is the most stable, but yet, there are fundamental questions on its historical distribution, life history, and regional trends. The long-term outlook for lampreys are currently unknown, but a future listing under the ESA is not unlikely.

Role of the FPHCP Action Area in Conservation of the Species:

The FPHCP Action Area encompasses a significant segment of the lamprey distribution in Washington. Many of the aquatic ecosystems these species depends upon are not on Federal or previously approved HCP lands, but are distributed in areas that will be subject to the proposed action. For example, the Fish and Wildlife Service is conducting a lamprey habitat use and population dynamic study in Cedar Creek, a tributary to the Lewis River in southern Washington. Cedar Creek is substantially surrounded by, and potentially influenced by, the proposed action. This stream may be representative of other streams occupied by lampreys in that they may be largely influenced by the FPHCP. The lower gradient portions of many streams, and those that are commonly anticipated to be influenced by the proposed action, appear to encompass a substantial portion of the areas these lamprey species are likely to inhabit. Numerous suitable habitats for lampreys occur in the FPHCP Action Area. The role of the FPHCP Action Area for long-term conservation for lampreys appears to be significant.

8.5.6.3 EFFECTS OF THE ACTION

General habitat effects resulting from the proposed action have been summarized above for the Low-gradient Tributary and Mainstem Guilds. In addition to the effects analyzed above, lampreys may experience effects differently from other aquatic species due to their unique life history characteristics.

Effects of riparian prescriptions to lamprey

Full riparian and in-stream function likely would not be provided to all habitats occupied by Pacific, river and western brook lampreys. In some stream reaches, the highest quality and most structurally complex habitats may fail to develop due to the potential reduction of large wood recruitment to streams at different time scales and following different riparian management prescriptions. For example, although

the FPHCP would provide the majority of available large wood adjacent to fish-bearing streams, the FPHCP allows some trees within these large wood recruitment zones to be harvested. In addition, stream-adjacent parallel roads, unbuffered areas in Type Np streams, yarding corridors, and road crossings will likely reduce potential large wood recruitment. Excessive windthrow could affect some riparian processes. Large wood in freshwater habitats is important for lamprey cover and for storing and releasing the appropriate sediment used for spawning by adults and for burrowing by ammocoetes. Because lamprey ammocetes spend an extensive period of time burrowed into silt, they are vulnerable to changes in stream morphology and hydrology that results in bedload movement. Lamprey habitat use has been positively correlated with pool forming large wood (Roni 2001). Under some circumstances, the FPHCP may not allow the highest quality lamprey habitats to develop and reduced densities of lamprey may result from this.

When RMZs achieve their Desired Future Condition, streams within the areas covered by the FPHCP that are occupied by lamprey will receive most of the potentially available shade. There are situations (yarding corridors, stream-adjacent parallel roads, 20-acre exemptions, and windthrow) where stream shading would be reduced from full ecological potential. Although little is know about the temperature requirements of lamprey, in some circumstances there may be negative effects to lampreys due to elevated stream temperatures. Along Type Np streams, reductions in shade are likely to occur and water temperature may increase over limited distances as a result of these unbuffered Type Np streams. In some cases, increases in temperature may be delivered downstream to Type F waters and temperatures could be warmed near the confluence of Type Np and F streams. In some circumstances, riparian processes associated with production of microscopic plant and animals that provide a forage base for the ammocetes could be affected by effects of the FPHCP to the riparian area.

Sediment effects to lampreys

Due to the long residency time that Pacific lampreys spend in freshwater, they are vulnerable to disturbances that alter natural sediment levels in nursery streams (Lee et al. 1997). Some ammocoetes require quality habitat in freshwater for up to six or seven years before they migrate to the ocean. In contrast, juvenile coho normally reside in freshwater for less than two years. Such an extended time in freshwater increases the chance that sediment causing disturbances, including bedload movement, could adversely affect juvenile lampreys. Water quality consistent with robust diatom production may also be key factor for survival (Lee et al. 1997).

At certain life history stages lamprey are most sensitive to excessive sedimentation of their streams. Ammocoetes in their burrows are filter feeders and depend upon microscopic plant and animal matter. Excessive sedimentation that negatively alters the processes associated with the production and consumption of these food items could negatively influence those individuals. Feeding behaviors may be affected and survival of lamprey could be reduced. Lamprey could be negatively influenced by hillslope erosion and road management related sediment. Although the FPHCP incorporation of BMP's and RMAP's will substantially reduce road surface erosion to lamprey habitats, roads are still expected to deliver sediment to lamprey habitats above natural background rates. Individual lampreys and their habitat could be affected from sediment, resulting in reduced egg and amoretti survival.

Increases in stream flow that cause bed scouring would potentially dislodge ammocoetes from their burrows (Close et al. 2002). In some situations, especially when multiple anthropogenic factors are working synergistically (rip rapped banks, increased road induced runoff, overall changes in hydrology)

there would be increased stream flows, with possible dislodgement of lamprey larva. Dislodged larva have an increased risk of predation.

Implementation of the FPHCP requires fish passage for all fish. Under the FPHCP, roads and their associated crossing structures must be constructed and maintained to provide for fish passage at all life stages. Using steelhead as an indicator in the Columbia River basin, it is estimated that 50 percent of the historic range of the Pacific lamprey is blocked (Lee et al. 1997). While the construction of dams has often been found to limit Pacific lamprey passage (Moser and Close 2003), impassable culverts are also barriers.

Dewatering or reducing stream flow can adversely affect larva survival. Short segments of stream are routinely dewatered for culvert installation or replacement. Dewatering short sections of streams with lamprey ammocoetes present in the substrate will likely harm those in dewatered sections. Ammocoetes that are in their burrows may not be able to survive the extended duration of lack of water during culvert replacement.

Effects from the 20-acre Exemption Rule

Although there is uncertainty regarding how often this rule would be implemented, when it is implemented the 20-acre Exemption Rule would adversely affect lamprey. In watersheds with a high proportion of small landowners, this rule would increase the likelihood that large wood recruitment would be inadequate to maintain properly functioning habitat (USFWS & NMFS 2006). The potential for increased sedimentation and reduced shade also occurs. Frequently, these 20-acre parcels are lower in watersheds and likely would occur adjacent to habitats occupied by lampreys.

Summary of adverse effects

The proposed action will have short- to long-term adverse effects on sediment, large wood, and temperature. These effects would be most severe from unbuffered Type Np streams and their associated downstream effects that result in disruption of natural riparian and aquatic processes and functions. These effects to the aquatic environment may result in impairment of essential foraging, rearing, and spawning behavior of Pacific, river, and brook lamprey. It is difficult to predict the severity of these effects because effects to these fish will vary from activity to activity depending on the specific riparian prescription applied, the location, historical management practices, geological characteristics of the watershed, and the biotic community present. Because of the inherent and expected patchiness of lamprey habitat occupancy, adverse effects to lamprey from the FPHCP will vary in response to the lamprey's location in the watershed. An activity associated with the FPHCP may be detrimental to lampreys in some locations, but the same activity conducted in another location may have less of an impact to lampreys.

Activities covered under the FPHCP are expected to have direct and indirect adverse effects to amulets and adult lamprey ranging from mortality to sublethal effects. Direct injury and death to lamprey would likely occur during some stream crossing construction (stream dewatering and lamprey rescue and relocation, and blockage of upstream migration during construction). Alterations of the riparian and aquatic environment would reduce the ability of streams to support prey species, thus reducing the amulets ability to successfully forage in these streams. In a degraded environment increased predation by other species is anticipated. This could affect the growth and survival of amulets and adult lamprey.

Summary of beneficial effects

The long-term benefits of the FPHCP are expected to outweigh the short-term, negative affects to lamprey. The severity of individual effects to the three species of lamprey will vary from activity to activity depending on the location, past management practices, geological characteristics of the watershed, and the biotic community present. Effects are not expected to significantly decrease distribution of Pacific, river, and brook lamprey in the FPHCP Action Area. Maturation of riparian areas, restoring and maintaining lamprey passage, adaptive management, and improved road management practices are all expected from implementation of the FPHCP.

8.5.6.4 CUMULATIVE EFFECTS

Cumulative effects were addressed in the **Comprehensive Cumulative Effects**, with respect to the aquatic and riparian environment in Washington State. Additional information regarding cumulative effects for the covered fish species was presented in the section **Low-gradient Tributary and Mainstem Guild: Cumulative Effects.**

No additional information is available with respect to cumulative effects for this particular species above those cumulative effects already discussed earlier in this document.

8.5.7 Olympic mudminnow (*Novumbra hubbsi*)

8.5.7.1 Status of the Species

Description of Species

The Olympic mudminnow is found only in Washington State (Wydoski and Whitney 2003), and is the only representative member of the Umbridae (Mudminnow) family. It is a small fish with an average length 52 millimeters (Mongillo and Hallock 1999). It is olive-green or brown in coloration with faint vertical bars along its sides and a light underbelly. During the breeding season, the male becomes a dark brown to almost black color with iridescent blue-green, yellow or white bars along their sides. The Olympic mudminnow's fins are characterized by soft fin rays. Their dorsal and anal fins are approximately equal in size and are both set far back on the body. Their caudal fin is truncated or indented and they lack a lateral line. The upper jaw is nonprotactile and they lack a grove between the upper lip and the snout (Mongillo and Hallock 1999).

Historical and Current Range

Information on the historical distribution of the Olympic mudminnow is sparse. Fossils of the genus *Novumbra* have been unearthed in early-middle Oligocene Era deposits in the Columbia River drainage indicating that Olympic mudminnows may have been more widespread (Mongillo and Hallock 1999).

Currently, Olympic mudminnow are restricted to the southern and western lowlands of the Olympic Peninsula, the Chehalis and lower Deschutes River drainages, and south Puget Sound lowlands west of the Nisqually River (Mongillo and Hallock 1999). This distribution was dictated by the most-recent glacial event during the Pleistocene Era. There is also a population of Olympic mudminnow in the Cherry and Issaquah Creek drainages in Snohomish and King Counties. The WDFW does not consider these populations natural and suspects that these were introduced illegally via aquariums (Mongillo and Hallock 1999).

Essential Habitat Components

Olympic mudminnow are found in slow-moving streams, wetlands, and ponds (Mongillo and Hallock 1999). They require habitats composed of soft mud or silt substrates with little or no water flow and abundant aquatic vegetation (Mongillo and Hallock 1999). Olympic mudminnow can tolerate water temperatures between 0° and 28°C, but have a narrow tolerance for flowing water and salinity (Mongillo and Hallock 1999; Wydoski and Whitney 2003). Olympic mudminnow tend to avoid bright light by hiding under undercut banks and underneath vegetation (Wydoski and Whitney 2003). Olympic mudminnow are also restricted to the lowland areas due to their preference for slow moving streams and wetlands. Overall, Olympic mudminnow must have three main habitat characteristics: fine-silt substrate, wetlands or slow moving streams, and aquatic vegetation. Without these characteristics, their presence is unlikely.

Reproductive Ecology

Starting in late November, spawning often takes place over an extended period of time, with less spawning activity during the colder winter months and picking up again in March and lasting until mid June (Mongillo and Hallock 1999). April and May are peak spawning months for the Olympic mudminnow when water temperatures reach 10-18°C (Mongillo and Hallock 1999).

During the spawning season, males become very dark in coloration and develop thin vertical iridescent blue-green, yellow, or white bars along their bodies (Wydoski and Whitney 2003). The edges of their dorsal and anal fins also turn a light blue to white color (Mongillo and Hallock 1999). Males will set up territories approximately 110 centimeters long by 40 centimeters wide consisting of several clumps of vegetation. These territories are aggressively defended against intruders including young salmon and sticklebacks. When a female enters the territory the male and female display what is called a “wigwag dance”. If the female is receptive after the dance, they will move into one of the clumps of vegetation to spawn. Females will release one or two sticky eggs at a time that are fertilized by the male. The eggs are then deposited in the vegetation near the bottom where they begin to develop. Hatching takes place about 9 days later in water temperatures of 15-17°C. No parental care is provided the developing young. Young Olympic mudminnow seldom move and remain close to, or stuck to, the vegetation. In laboratory studies, fry disperse after about seven days (Mongillo and Hallock 1999).

Movements and Habitat Use

Currently there is no documentation on the movements or migrations of the Olympic mudminnow. Olympic mudminnow occupy ponds, bogs and wetlands that have little to no water flow. Occasional floods of these areas could disperse populations to new areas, but this would only be a passive movement and not an intended migration.

8.5.7.2 ENVIRONMENTAL BASELINE (within the FPHCP Action Area)

Within the FPHCP Action Area, Olympic mudminnow are restricted to the southern and western lowlands of the Olympic Peninsula, the Chehalis and lower Deschutes River drainages, and south Puget Sound lowlands west of the Nisqually River (Mongillo and Hallock 1999). There is also a population of Olympic mudminnow in the Cherry and Issaquah Creek drainages in Snohomish and King Counties, however, it is believed that these populations were introduced illegally via aquariums (Mongillo and Hallock 1999).

Currently 90 percent of the populations of Olympic mudminnow seem to be stable, while the other 10 percent are at some risk (Mongillo and Hallock 1999). Since they depend on healthy wetlands for their survival, and their range is very restricted, they are vulnerable to become threatened or endangered if their habitats are not conserved appropriately.

Role of the FPHCP Action Area for Conservation of the Species

Olympic mudminnow habitat occurs in the FPHCP Action Area. The FPHCP Action Area will contribute to the long-term conservation of the species.

8.5.7.3 EFFECTS OF THE ACTION

General habitat effects to the Olympic mudminnow resulting from the proposed action have been summarized above for the Lentic Guild.

Riparian prescription effects to Olympic mudminnow

No adverse effects to Olympic mudminnow habitat are expected from FPHCP riparian prescriptions.

Sediment effects to Olympic mudminnow

Sediment would be delivered to Olympic mudminnow habitat from road surface erosion. When FPHCP activities affect certain watershed features, such as steep unstable slopes, there may be additional sediment delivered to fish-bearing streams that are above natural background rates. Increased sediment could result in changes to channel morphology, resulting in a reduction in the available slow moving channel habitat preferred by Olympic mudminnow. Increases in sediment levels could smother aquatic vegetation and feeding behavior may be affected resulting in reduced individual fish fitness and survival.

Effects from the 20-acre Exemption Rule

Although there is uncertainty regarding how often this rule would be implemented, when it is implemented the 20-acre Exemption Rule would adversely affect Olympic mudminnow. In watersheds with a high proportion of 20-acre exempt landowners, this rule would increase the likelihood that large wood recruitment would be inadequate to maintain properly functioning habitat (USFWS & NMFS 2006). There is also the potential for increased sedimentation, reduced shade, increased stream temperatures, and increased windthrow. Where these adverse effects occur, essential behaviors associated with foraging, reproduction and growth may be impeded, and Olympic mudminnow may occupy the stream at reduced levels and they may have reduced survival.

Summary of adverse effects to Olympic mudminnow

The proposed action will have short- to long-term adverse effects on sediment, large wood, and temperature. These effects would be most severe from unbuffered Type Np streams and their downstream effects that result in disruption of natural riparian and aquatic processes and functions in Type F streams. These effects to the aquatic environment may result in impairment of essential foraging, rearing, and spawning behavior of Olympic mudminnow. It is difficult to predict the severity of these effects because effects to these fish will vary from activity to activity depending on the specific riparian prescriptions applied, the location, historical management practices, geological characteristics of the watershed, and the biotic community present.

Activities covered under the FPHCP are expected to have direct and indirect adverse effects to adult and juvenile Olympic mudminnow ranging from mortality to sublethal effects. Direct injury and death to Olympic mutinous would likely occur during some stream crossing construction activities (stream dewatering and fish rescue and relocation, and blockage of upstream migration during construction). Alterations of the riparian and aquatic environment would reduce the ability and availability of slow moving streams to provide suitable aquatic vegetation, thus reducing the fish's ability and success at finding forage in these streams. This could affect the growth and survival of juvenile and adult Olympic mudminnow.

Summary of beneficial effects

Any loss of habitat due to the FPHCP is expected to be limited, and not significantly affect the distribution of the species. Maturation of riparian areas, maintaining and restoring Olympic mudminnow passage, adaptive management, and improved road management practices are all expected from implementation of the FPHCP. Protection of aquatic vegetation; protection of associated wetlands, particularly along slow moving streams, and protection from introductions of non-native fish are important for conservation of the Olympic mudminnow. These management prescriptions are expected to contribute to increasing the likelihood of the long-term survival for the Olympic mudminnow in the FPHCP Action Area.

8.5.7.4 CUMULATIVE EFFECTS

Cumulative effects were addressed in the Comprehensive Cumulative Effects, with respect to the aquatic and riparian environment in Washington State. Additional information regarding cumulative effects for the covered fish species was presented in the section Lentic Guild: Cumulative Effects**.**

8.5.8 Chiselmouth (*Acrochelius alutaceus*)

8.5.8.1 Status of the Species

Description of Species

The chiselmouth is a member of the minnow (Cyprinid) family. Overall, it is drab in coloration, with a dark brown dorsal surface, and light brown sides with many black spots. The body is elongate (average size 150 to 180 millimeters), with a slender caudal peduncle (Scott and Crossman 1973). The caudal fin is distinctly forked and the body is composed of small cycloid scales. The head is blunt with a rounded, blunt snout. Its eyes are relatively large. The mouth is inferior with fleshy upper lips that cover a small cartilaginous plate. The lower lip is covered by a hard cartilaginous sheath with an almost straight cutting edge (Scott and Crossman 1973). In young fish, this cartilaginous edge is often rounded (Wydoski and Whitney 2003). The chiselmouth is the only minnow in Washington with a hard sharp plate on the lower jaw (Wydoski and Whitney 2003).

Historical and Current Range

The historic range of the chiselmouth is unknown at this time. Currently, the chiselmouth is found in the upper Columbia River and its tributaries in Eastern Washington, the Snake River and its tributaries, and the Cowlitz and the Wind River in the lower Columbia River (Wydoski and Whitney 2003).

Essential Habitat Components

Chiselmouth are known to inhabit rivers, streams, and lakes throughout their range (Wydoski and Whitney 2003). In Washington, they seem to prefer large, warm streams and rivers with slow currents, rather than lakes (Wydoski and Whitney 2003; Titus 1996). Juveniles have been associated with shallow pools with large substrate such as cobble and boulders, with no other cover (Wydoski and Whitney 2003). Chiselmouth seem better adapted to lotic rather than lentic environments (Titus 1996). Water temperatures in which juveniles were found ranged between 8.9° C to 29° C (Wydoski and Whitney 2003). Titus (1996) found that juvenile chiselmouth inhabited areas with little or no cover and that were unshaded.

Rosenfeld et al. (2001) typically found young-of-the-year and yearling chiselmouth in shallow backwaters with aquatic macrophytes, and often associated with other juvenile fish such as redside shiners, pikeminnows, and peamouth chubs. In general there is very little information and few studies addressing habitat use of chiselmouth (Titus 1996), and very little is known concerning habitat requirements and the factors that influence distribution (Rosenfeld et al. 2001).

Reproductive Ecology

There appears to be very little information on the reproduction of chiselmouth (Scott and Crossman 1973). Generally they begin spawning around late May and into July, with the peak in early June (Wydoski and Whitney 2003). At the time of spawning water temperatures are between 13 to 18°C (Wydoski and Whitney 2003). Both sexes reach maturity between 4 or 5 years of age and are about 250 millimeters in length (Wydoski and Whitney 2003). Eggs are deposited over rock, rubble or gravel substrates (Titus 1996). Chiselmouth eggs that were incubated at 18°C hatched in 6 days (Titus 1996). There is also documentation of hybridization between northern pikeminnows and chiselmouth. Spawning habits of northern pikeminnow may be similar to that of the chiselmouth. Spawning of chiselmouth has not yet been fully documented.

Movements and Habitat Use

There is very little information on the movements and migrations of chiselmouth. In a study on distribution and abundance of chiselmouth in British Columbia, it was found that a population of spawning chiselmouth migrated 1.5 kilometers upstream into tributary streams (Scott and Crossman 1973). Titus (1996) documented segregation of young-of-the-year (YOY) chiselmouth and older juveniles on a temporal scale that resulted in a shift of habitat use. As the YOY appeared, the older 1+ aged juvenile chiselmouth seemed to move out into deep, fast water that could not be sampled effectively (Titus 1996).

Threats to Survival

Overall there is very little information on the life history of chiselmouth in Washington State. Their population status within the State is relatively unknown at this time. However, incidental information suggests that they are abundant throughout their range (Titus 1996; Segler and Segler 1987). There are no currently no known threats to the species.

8.5.8.2 ENVIRONMENTAL BASELINE (within the FPHCP Action Area)

Chiselmouth inhabit both lakes and streams and occur primarily in eastern Washington, but also in the Cowlitz and Lewis Rivers in western Washington. Population trend data is unknown for the species in Washington.

Role of the FPHCP Action Area for Conservation of the Species

The chiselmouth occurs in the FPHCP Action Area. It also occupies large areas outside of the FPHCP Action Area. The FPHCP Action Area will provide a moderate role in the long-term conservation of the species.

8.5.8.3 EFFECTS OF THE ACTION

General habitat effects to chiselmouth resulting from permit issuance have been summarized above for the Mainstem Guild; however the Salish and longnose suckers is also found in the habitats represented by the Lentic and Low-gradient Guilds.

Riparian prescription effects to chiselmouth

No habitat effects, other than those described in its assoicated guilds, are expected for the chiselmouth.

Summary of sediment effects to Chiselmouth

Sediment would be delivered to chiselmouth habitat from road surface erosion and, to a lesser extent, from hillslope erosion. The FPHCP's incorporation of BMPs and RMAPs would substantially reduce delivery of road surface related sediment to chiselmouth habitats, but it would not prevent all sediment from reaching aquatic habitats occupied by the species. Certain watershed features and road related activities may contribute sediment to fish-bearing streams that are above natural background rates. For example, culvert projects may increase siltation until vegetation has recovered to reduce harmful sediment. Juvenile chiselmouth habitat includes shallow pools with large substrate such as cobble and boulders. Excessive siltation may reduce the availability of this habitat and may affect food resources (algae, diatoms, and aquatic insects) of chiselmouth. When feeding behavior is altered by reduced prey, individual fitness and survival could be affected. However the FPHCP is not expected to contribute to instream sediment loading to the point that chiselmouth would be harmed at more than at a stream reach scale.

Effects from the 20-acre Exemption Rule

Although there is uncertainty regarding how often this rule would be implemented, when it is implemented the 20-acre Exemption Rule would likely adversely affect chiselmouth. In watersheds with a high proportion of 20-acre exempt landowners, this rule would increase the likelihood that large wood recruitment would be inadequate to maintain properly functioning habitat (USFWS & NMFS 2006). There is also the potential for increased sedimentation.

Summary of adverse effects to chiselmouth

The proposed action would have short- to long-term adverse effects on sediment. These effects would be most severe from unbuffered Type Np streams and their downstream effects that result in disruption of natural riparian and aquatic processes and functions in Type F streams. These effects to the aquatic environment may result in impairment of essential foraging behavior of chiselmouth. It is difficult to

predict the severity of these effects because little is know about chiselmouth habitat requirements and effects to these fish will vary from activity to activity depending on the specific riparian prescriptions applied, the location, historical management practices, geological characteristics of the watershed, and the biotic community present.

Activities covered under the FPHCP are expected to have direct and indirect adverse effects to adult and juvenile chiselmouth ranging from mortality to sublethal effects. Direct injury and death to chiselmouth would likely occur during some stream crossing construction activities (stream dewatering and fish rescue and relocation, and blockage of upstream migration during construction). Increased sediment levels could reduce available habitat and prey items for chiselmouth. This could affect the growth and survival of juvenile and adult chislemouth.

Summary of beneficial effects

The long-term benefits of the FPHCP are expected to outweigh the short-term, negative affects to chiselmouth. Maturation of riparian areas, maintaining and restoring passage for chiselmouth, adaptive management, and improved road management practices are all expected from implementation of the FPHCP. These management prescriptions are expected to contribute to increasing the likelihood of long-term survival for chiselmouth in the FPHCP Action Area.

8.5.8.4 CUMULATIVE EFFECTS

Cumulative effects were addressed in the **Comprehensive Cumulative Effects**, with respect to the aquatic and riparian environment in Washington State. Additional information regarding cumulative effects for the fish species was presented in the section **Mainstem Guild: Cumulative Effects.**

8.5.9 Redside shiner (*Richardsonius halteatus*)

8.5.9.1 State of the Species

Description of Species

The redside shiner is a rather small and deeply compressed minnow. It has a narrow caudal peduncle that differs from that of the tui chub and it lacks a fleshy keel between the pelvic fins and the anus that differentiates it from the golden shiner (Wydoski and Whitney 2003). Adults are on average 75-130 millimeters in length (Scott and Crossman 1973). They have a relatively long head with a terminal mouth and large eyes. Their caudal fin is deeply forked and they have small rounded pelvic fins and pectoral fins, which are slightly larger than the pelvic (Scott and Crossman 1973). They have small cycloid scales that are steely blue, olive or dark brown to black on the dorsal surface, and have a dark band extending from the snout to the caudal peduncle (Scott and Crossman 1973). During spawning, colors become more vibrant in both sexes. Females turn a golden color above and below the lateral band while males develop a yellow band between the dorsal area and the lateral band.

Historical and Current Range

Historic range is unknown at this time. The range of the redside shiner is found from northern British Columbia eastward into western Alberta, south to western Montana, western Wyoming, and north and northwest Utah, northern Nevada, Oregon, Idaho and Washington. Currently the redside shiner is found in rivers, streams, and lakes throughout Washington State.

Essential Habitat Components

The redside shiner occupies a wide variety of habitats from large rivers to irrigation ditches, ponds, lakes, streams and isolated springs (Wydoski and Whitney 2003). When in rivers or streams, they generally prefer slow to moderate currents (Bond et al. 1988; Wydoski and Whitney 2003). Redside shiners prefer the habitat areas that contain aquatic vegetation (Scott and Crossman 1973; Bond et al. 1988). These areas provide foraging opportunities and refuge from predators.

Reproductive Ecology

Redside shiners begin to spawn in spring or early summer when they are 2 to 3 years old (Wydoski and Whitney 2003). Males arrive on the spawning grounds before the females when water temperatures are 10°C or greater (Scott and Crossman 1973). Males at this time become highly colorful, displaying vibrant orange and yellow colors, where as the female will attain a golden color (Scott and Crossman 1973). Males will also develop nuptial tubercles along their head and upper surface of their paired fins (Scott and Crossman 1973). They apparently have a strong tendency to return to their natal stream. Redside shiners gather in groups of 30-40 individuals to begin spawning. In streams, spawning takes place in riffles less than 102 millimeters deep (Scott and Crossman 1973). Redside shiners are broadcast spawners and do not construct nests. Their eggs are sticky and are deposited over gravel or on vegetation. Eggs are released 10-20 at a time (Scott and Crossman 1973). Spawning can take place in streams or along lakeshores. The length of time to hatching usually depends on water temperature. When water temperatures reach 21°C, hatching can take place in 3 days and, if temperatures are 12°C, hatching can take as long as 15 days (Scott and Crossman 1973). Recently hatched fry will stay along the bottom in the gravel and absorb their egg yolk. If hatched in a stream, fry will drift with the current to a lake or pond or a marginal habitat along the river to rear.

Movements and Habitat Use

Redside shiners are known to exhibit diel and seasonal movements. In lakes during the day, redside shiners are found only in the nearshore areas over shoals that have heavy growth of vegetation (Scott and Crossman 1973). At night, redside shiners move to deeper water but stay close to the surface (Scott and Crossman 1973). The shift of habitat from day to night allows adults to feed on selected items. Adults in the nearshore environment feed on aquatic and terrestrial insects and snails, and at night feed on zooplankton in the deeper pelagic zones of the lake (Wydoski and Whitney 2003). In lakes, the smallest redside shiners are found higher in the water column and closest to the shore, while larger fish are in deeper water and further from the shoreline (Scott and Crossman 1973).

8.5.9.2 ENVIRONMENTAL BASELINE (within the FPHCP Action Area)

The redside shiner occurs throughout eastern and western Washington. Population status for redside shiner in the FPHCP Action Area is unknown. Due to the diversity of habitats it is known to occupy throughout the state, and its ability to outcompete fish in some studies (Wydoski and Whitney 2003), the population may be stable.

Role of the FPHCP Action Area in Conservation of the Species:

The redside shiner has a large distribution in Washington and occurs in the FPHCP Action Area. Suitable habitats for the species occur within the FPHCP Action Area.

8.5.9.3 EFFECTS OF THE ACTION

General habitat effects to redside shiner resulting from the proposed action have been summarized above for the Lentic Guild, although redside shiner are also associated with habitats represented by the Mainstem and Low-gradient Guilds.

Riparian prescription effects to redside shiner

Full riparian and in-stream function likely would not be provided to all habitats occupied by redside shiner. In some stream reaches, the highest quality and most structurally complex habitats may fail to develop due to the potential reduction of large wood recruitment to streams at different time scales and following different riparian management prescriptions. Redside shiners are associated with aquatic vegetation in slow moving water, and, where they are present, modification of these habitats could affect the species. Large wood in freshwater habitats is important for storing and releasing the appropriate sediment for suitable substrate, pool formation and aquatic plant growth.

Sediment effects to redside shiner

Sediment would be delivered to redside shiner habitat from road surface erosion and, to a lesser extent, hillslope erosion. The FPHCP's incorporation of BMPs and RMAPs would substantially reduce road surface erosion to redside shiner habitats, but it would not prevent all sediment from reaching aquatic habitats occupied by the species. Certain watershed features and road use may contribute sediment to fish-bearing streams that are above natural background rates. Culvert projects may increase siltation over short durations, especially until vegetation has recovered. Sediment delivered to streams from roads is likely to have more effects than hillslope erosion due to the magnitude and potentially chronic delivery of road-related sediment to streams. Elevated sediment levels may reduce the availability of aquatic vegetation and prey species for redside shiners and the resulting alteration in food availability could affect individual redside shiner fitness and survival. Los of aquatic vegetation could increase risk of predation for redside shiner. However the FPHCP is not expected to significantly contribute to instream sediment loading to the point that the redside shiner or the aquatic vegetation associated with its habitat would be harmed at more than at a stream reach scale.

Effects from the 20-acre Exemption Rule

Although there is uncertainty regarding how often this rule would be implemented, when it is implemented the 20-acre Exemption Rule would likely adversely affect redside shiner. In watersheds with a high proportion of 20-acre exempt landowners, this rule would increase the likelihood that large wood recruitment would be inadequate to maintain properly functioning habitat (USFWS & NMFS 2006). There is also the potential for increased sedimentation, reduced shade, increased stream temperatures, and increased windthrow. Where these adverse effects occur, essential behaviors associated with foraging, reproduction and growth may be impeded, and redside shiner may occupy the stream at reduced levels and they may have reduced survival.

Summary of adverse effects to redside shiner

The proposed action will have short- to long-term adverse effects on sediment, large wood, and temperature. These effects would be most severe from unbuffered Type Np streams and their downstream effects that result in disruption of natural riparian and aquatic processes and functions in Type F streams. These effects to the aquatic environment may result in impairment of essential foraging,

rearing, and spawning behavior of the redside shiner. It is difficult to predict the severity of these effects because habitat limiting factors for this species are not well understood and effects to their habitat would likely vary from activity to activity depending on the specific riparian prescriptions applied, the location of the activity, historical management practices, geological characteristics of the watershed, and the biotic community present.

Activities covered under the FPHCP are expected to have direct and indirect adverse effects to adult and juvenile redside shiners ranging from mortality to sublethal effects. Direct injury and death to redside shiner would likely occur during some stream crossing construction activities (stream dewatering and fish rescue and relocation, blockage of upstream migration during construction). Increased sediment levels could reduce available habitat and prey items for redside shiner. This could affect the growth and survival of juvenile and adult redside shiners.

Summary of beneficial effects

The long-term benefits of the FPHCP are expected to outweigh the short-term, negative affects to redside shiner. The severity of individual effects to redside shiner will vary from activity to activity depending on the specific riparian prescriptions, location, past management practices, geological characteristics of the watershed, and the biotic community present. However, maturation of riparian areas, maintaining and restoring passage for the redside shiner, adaptive management, and improved road management practices are all expected from implementation of the FPHCP. These management prescriptions are expected to contribute to increasing the likelihood of long-term survival for the redside shiner in the FPHCP Action Area.

8.5.9.4 CUMULATIVE EFFECTS

Cumulative effects were addressed in the Comprehensive Cumulative Effects, with respect to the aquatic and riparian environment in Washington State. Additional information regarding cumulative effects for the covered fish species was presented in the section **Lentic Guild: Cumulative Effects**.

8.5.10 Speckled Dace (*Rhinichthys osculus*)

8.5.10.1 Status of the Sepcies

Description of the Species

The speckled dace is a small (average adult size 51 to76 millimeters), robust fish with a blunt triangular head, a small distinct hump behind the head, and a terminal mouth separated from the snout by a groove between the snout and the upper lip (Wydoski and Whitney 2003). It has a short caudal peduncle with a diffuse dark spot. The pelvic and pectoral fins are small and rounded. The lateral line is usually complete, but in some specimens it terminates before the base of the caudal fin (Scott and Crossman 1979). The color is usually a gray or gray-brown with scattered or vague darker flecks or speckles, usually above the midline. The sides are yellowish, turning off-white at the belly. In fish less than 38.1 millimeters in length, there is a single dark band on the side of the body.

Historic and Current Range

Historic range is currently unknown. Speckled dace occur in much of the western United States and in British Columbia, Canada. Currently the speckled dace is found throughout most of eastern and western

Washington. They are apparently absent in the North Cascades on the west side of the crest. On the Olympic Peninsula, the speckled dace is found only along the southern and western boundaries of the Peninsula (Wydoski and Whitney 2003).

Essential Habitat Components

Speckled dace are known to inhabit a variety of habitat types. They have been found in small springs, rushing brooks, pools in intermittent streams, large rivers, and deep lakes. Generally, they prefer colder waters of streams with slow to swift currents and well-oxygenated water (Wydoski and Whitney 2003). Speckled dace can tolerate a wide range of water temperatures (0° C to 28.0° C) and can tolerate temperatures as high as 31° C (Moyle 2002). In Washington, during the summer, they are generally found in streams with temperatures between 12° C and 21°C (averaging 16° C) and with maximum temperatures of 33° C (Wydoski and Whitney 2003).

In lakes, they seek out beaches that are fairly shallow (less than 1 meter in depth) and that receive abundant wave action. On the Olympic Peninsula, speckled dace occupied pool habitat (70 percent of the time), slow runs (20 percent of the time), and riffles (10 percent of the time) (Wydoski and Whitney 2003). Moyle (2002) found that speckled dace were relatively absent in riffles where sculpins were found; when sculpins were absent, speckled dace occupied riffle habitats. Generally, speckled dace occupy areas with abundant cover, such as rocks or rubble, submerged aquatic vegetation, overhanging vegetation, undercut banks, and woody debris (Moyle 2002). These cover types are used by dace for hiding from predators during the day. Moyle (2002) found that speckled dace are generally diurnal; however, they are nocturnal in areas that have larger populations of fish-eating birds. Speckled dace are rarely found singly, but avoid forming large schools (Sigler 1987). Like other dace, the speckled dace is generally adapted for a benthic life history and consumes a variety of benthic aquatic and terrestrial insects.

Reproductive Ecology

Speckled dace mature at age 2 (Wydoski and Whitney 2003). Spawning takes place from June until August, with the peak spawning period in late June (Wydoski and Whitney 2003). Speckled dace generally spawn over clean gravel substrates along the edges of riffles. The spawning sites are used predominantly by males accompanied by few females. Males develop nuptial tubercles on their heads and pectoral fins along with a red-orange coloration on their lips, cheeks, and fins. Male dace surround the female in a large ball and fertilize the eggs as the female releases them. There is sometimes a high adult mortality after spawning is completed (Wydoski and Whitney 2003). The eggs adhere to the gravel and in the interstitial spaces where they develop. Eggs hatch in about 6 days at 18° C to 19° C (Moyle 2002). Larval fish remain within the gravel for an additional 7 to 8 days (Sigler 1987). Fry then move into warm shallow backwaters with large rocks and emergent vegetation to feed and develop.

Movements and Habitat Use

There is little information on the movements of speckled dace. Most information on speckled dace movement is anecdotal from studies of other fish. Peters (USFWS, Personal Communication, 2005) captured speckled dace moving into off-channel pools in the Queets River drainage during a fall study on native salmon. It is unlikely that speckled dace make lengthy migrations into over-wintering habitats or spawning areas. Moyle (2002) states that speckled dace that inhabit lakes have been observed migrating short distances upstream into small stream inlets to spawn.

Threats to Survival

There are currently no known species specific threats to speckled dace at this time. Speckled dace are fairly abundant throughout the state and are considered habitat generalists. Unlike the Fosket speckled dace *(Rhinichthys osculus spp*.) which occurs in one small area in Lake County, Oregon, the speckled dace (*Rhinichthys osculus*) analyzed for this Opinion occurs throughout many areas of the western United States. Detailed population status is currently unknown but is believed to be secure. Common threats to survival of other species of dace have been loss of habitat, pollution, introduction of non-native species, and population fragmentation by either natural or man-made disturbances. Speckled dace, along with other species of dace, are likely an important link in the food chain, serving as a forage fish for larger game and non-game fish. Specific threats to this species in Washington have not been described.

8.5.10.2 ENVIRONMENTAL BASELINE (within the FPHCP Action Area)

The speckled dace has a broad distribution in the FPHCP Action Area and is considered common in Washington (Wydoski and Whitney 2003). They are found in lakes and streams. Population trend in Washington is currently unknown, but with their distribution and ability to occupy various habitats, they are most likely secure at this time.

Role of FPHCP Action Area in Conservation of the species:

The FPHCP Action Area encompasses a significant segment of the range of speckled dace in Washington. The species is also found on Federal and FPHCP covered lands in Washington. The FPHCP Action Area provides important habitats for speckled dace and will contribute to the long-term survival of the species in Washington.

8.5.10.3 EFFECTS OF THE ACTION

General habitat effects to the speckled dace resulting from the proposed action have been summarized above for the Low-Gradient Tributary and the Lentic Guilds.

Riparian effects to speckled dace

Full riparian and in-stream function likely would not be provided to all habitats occupied by speckled dace. In some stream reaches, the highest quality and most structurally complex habitats may fail to develop due to the potential reduction of large wood recruitment to streams at different time scales and following different riparian management prescriptions. Speckled dace area more often found in pools than in riffles. Reduction in natural recruitment of large wood to streams has resulted in reduced stream habitat complexity, including reduced quantity and quality of pools. In the absence of pools, speckled dace may not occupy streams to the extent that they would if pools were present. Large wood in freshwater habitats is important for storing and releasing the appropriate sediment for suitable substrate and to enable aquatic plants to grow. Speckled dace occupy areas with abundant cover, such as rocks or rubble, submerged aquatic vegetation, overhanging vegetation, undercut banks, and woody debris. Many of these cover types are linked to large wood recruitment and are used by dace for hiding from predators. Speckled dace are benthic fish and feed on algae, aquatic insects, and zooplankton. Alterations of the riparian and aquatic environment could reduce the ability of streams to support forage for speckled dace, thus reducing the fish's ability and success at finding forage in these streams. This could affect the growth and survival of speckled dace.

Along Type Np streams, reductions in shade are likely to occur and water temperature may increase over limited distances as a result of these unbuffered Type Np streams. In some cases, increases in temperature may be delivered downstream to Type F waters and temperatures could be warmed near the confluence of Type Np and F streams.

Sediment effects to speckled dace

Sediment will be delivered to speckled dace habitat from road surface erosion. The FPHCP's incorporation of BMPs and RMAPs will substantially reduce road surface erosion to speckled dace habitat, but it will not prevent all sediment from reaching aquatic habitats occupied by speckled dace. Certain watershed features and road location, design, and use may contribute sediment to fish-bearing streams that are above natural background rates. Sediment delivered to streams from roads is likely to have more effects to speckled dace habitat than hillslope erosion due to the magnitude and potentially chronic delivery of sediment to streams from roads. Primary production processes and benthic habitats may be negatively affected from increased sedimentation, which could affect speckled dace. Individual fitness and survival may be reduced for some fish. Effects are expected at some locations, normally at a stream reach or smaller scale.

Speckled dace are reported to spawn in the summer as late as August. Culvert replacements and installations normally occur in the summer. This work often requires dewatering a short segment of stream, along with work associated with the streambed. Mortality of speckled dace in the vicinity of a culvert project could occur.

Effects from the 20-acre Exemption Rule

Although there is uncertainty regarding how often this rule would be implemented, when it is implemented the 20-acre Exemption Rule would likely adversely affect speckled dace. In watersheds with a high proportion of 20-acre exempt landowners, this rule would increase the likelihood that large wood recruitment would be inadequate to maintain properly functioning habitat (USFWS & NMFS 2006). There is also the potential for increased sedimentation, reduced shade, increased stream temperatures, and increased windthrow. Where these adverse effects occur, essential behaviors associated with foraging, reproduction and growth may be impeded. In situations like these, speckled dace may occupy the stream at reduced levels, which may also affect species which use speckled dace as forage.

Summary of adverse effects to speckled dace

The proposed action will have short- to long-term adverse effects on sediment, large wood, and temperature. These effects to the aquatic environment may result in impairment of essential foraging, rearing, and spawning behavior of speckled dace. It is difficult to predict the severity of these effects because habitat limiting factors for this species are not well understood and effects to their habitat would likely vary from activity to activity depending on the specific riparian prescriptions, the location of the activity, historical management practices, geological characteristics of the watershed, and the biotic community present.

Activities covered under the FPHCP are expected to have direct and indirect adverse effects to adult and juvenile speckled dace ranging from mortality to sublethal effects. Direct injury and death to speckled dace would likely occur during some stream crossing construction activities (stream dewatering, fish rescue and relocation, and blockage of upstream migration during construction). Increased sediment

levels could reduce available habitat and prey items for speckled dace. This could affect the growth and survival of juvenile and adult speckled dace.

Summary of beneficial effects

Speckled dace have a broad distribution in the FPHCP Action Area and effects from the FPHCP are not expected to decrease their distribution. Most disturbances from the proposed action are generally expected to be short-term in nature and at a stream reach or less (habitat unit) scale. Disturbance levels are not expected to cause large scale declines in speckled dace abundance or distribution. Given enough time relative to the magnitude of the disturbance, speckled dace are likely to recover from activities attributable to the FPHCP. Maturation of riparian areas, maintaining and restoring speckled dace passage, adaptive management, and improved road management practices are all expected from implementation of the FPHCP. These management prescriptions are expected to contribute to increasing the likelihood that speckled dace survive in the FPHCP Action Area.

8.5.10.4 CUMULATIVE EFFECTS

Cumulative effects were addressed in the **Comprehensive Cumulative Effects**, with respect to the aquatic and riparian environment in Washington State. Additional information regarding cumulative effects for the covered fish species was presented in the **Low-Gradient Tributary** and **Lentic Guilds**.

No additional information is available with respect to cumulative effects for this particular species above those cumulative effects already discussed earlier in this document.

8.5.11 Longnose dace (*Rhinichthys cataractae*) and Nooksack dace (*Rhinichthys cataractae*)

8.5.11.1 Status of the Species

Description of the Species

The longnose dace has a short (average length for adults is 76mm), slender body with a thick caudal peduncle (Wydoski and Whitney 2003). The head is broad and triangular with a long snout overhanging the mouth (Scott and Crossman 1979). The mouth is inferior and nonprotractile with the upper lip attached to the snout (Wydoski and Whitney 2003). The caudal fin is somewhat forked with rounded lobes. The color of the longnose dace is an olive-green to brown along the dorsal surface, with some mottling on the sides, shading to a cream or slivery white on the belly (Sigler and Sigler 1987; Wydoski and Whitney 2003). The lateral line is dark from the gill cover to the base of the caudal fin. This is more apparent in young longnose dace and may be absent in adults. In breeding, males may display an orange-red coloration along the edges of the mouth and cheeks (Sigler and Sigler 1987). This orange-red coloration can also appear at the bases of the pectoral and pelvic fins.

The Nooksack dace is an evolutionary offshoot of the longnose dace and is very close in body shape, size and coloration. The only true differences in the two species can be determined by scale counts along the lateral line and around the caudal peduncle. The longnose dace has 67 along the lateral line and 31 around the caudal peduncle, where as the Nooksack dace has 54 along the lateral line and 24 around the caudal peduncle.

Historic and Current Range

The longnose dace has a broad distribution in North America. Historic information on these two closely related species is sparse and there are conflicting reports on the current distributions in Western Washington. Wydoski and Whitney (2003) state that the longnose dace is located throughout the State. However in a publication by Inglis (1995) with the British Columbia Ministry of Environment, Lands and Parks, Fisheries Branch (BCMELP) states that the geographic distributions of the longnose and the Nooksack dace do not overlap. The current range of the Nooksack dace is limited to areas west of the Cascade Mountains. They are found from the Canadian border south along the eastern edge of Puget Sound. They also found west to the Willapa Hills area and extend north up though the Grays Harbor area and the Chehalis River to the Quillayute River on the western slopes of the Olympic Mountains (Wydoski and Whitney 2003). The longnose dace is reported to be distributed throughout the state (Wydoski and Whitney 2003). It occurs throughout eastern Washington occupying the Columbia, Snake and Spokane Rivers and their tributaries (Wydoski and Whitney 2003). It is also reported to be located on the Olympic Peninsula, but only the southern and western boundaries (Wydoski and Whitney 2003).

Essential Habitat Components

The longnose and Nooksack are both adapted for a benthic life style. The shape of their bodies and their reduced air bladder help them remain close to the bottom of rivers and streams. The longnose and Nooksack dace both inhabit clean, swift flowing streams with gravel, cobble or boulder substrates (Wydoski and Whitney 2003). They both prefer riffle habitats with water flows from 0.91 to 1.83 meters/second (Wydoski and Whitney 2003). In the Olympic Mountains, the longnose dace is generally found in streams whose width is greater than 43 meters (Wydoski and Whitney 2003). However in B.C., the Nooksack dace is generally found in streams whose width is less than 6 meters (BCMELP 1995). The longnose dace is recorded to inhabit streams whose summer temperatures are between 12.8 and 21°C (Wydoski and Whitney 2003). Scott and Crossman (1973) reported that in Canada the longnose dace sometimes inhabits the inshore waters of lakes that have gravel or boulder substrates.

Dace fry are often found along stream margins (Wydoski and Whitney 2003). The fry feed on drift organisms where as the adults feed in the deeper, faster flowing waters (Sigler and Sigler 1987). Dace are often preyed on by trout or other large game fish and utilize the cobble or boulder substrate to hide in. During fall and into winter, longnose dace leave the riffle habitats and possibly move into pools to over-winter (Wydoski and Whitney 2003).

Reproductive Ecology

There is little information on the reproduction habits of the longnose and Nooksack dace. Both of these species mature between 2 to 3 years of age (Wydoski and Whitney 2003). They begin spawning in the late spring to summer (May to July). The male longnose dace does not build a nest but rather establishes a spawning territory and defends if from other males and sometimes females. Male longnose dace during this time will display orange-red spawning colors along its mouth and at the base of their fins. However the male Nooksack dace does not develop spawning colors and also does not establish and defend at spawning territory. Nooksack dace spawning also takes place at night in 7 to 9°C water temperatures. Spawning sites are located in shallow riffles with gravel bottoms (Wydoski and Whitney 2003). Substrate diameter is generally between 50.8 and 152.4 millimeters and comprises about 75 percent of the overall substrate within the spawning territory (Wydoski and Whitney 2003). Water velocity is between 0.46 and 1.0 meter per second with water temperatures around 11.7°C (Wydoski and Whitney 2003).

Movements and Habitat Use

There is very little information on the movements of longnose or Nooksack dace. Wydoski and Whitney (2003) states that the longnose dace is not found in their preferred habitats in the fall or winter months, and that they possibly move into pools or deeper low velocity habitats to over winter.

Threats to Survival

Currently there is no documentation on population trend of the longnose and Nooksack dace in Washington State. In British Columbia, the Nooksack dace is considered critically imperiled due to a very restricted distribution and habitat loss (Peden 2002).

Common citations for threats to survival of native fish throughout the state include: habitat loss (spawning, rearing, foraging), competition with non-native species, pollution, and habitat fragmentation by man made barriers. Both the longnose and Nooksack dace are susceptible to these factors.

8.5.11.2 ENVIRONMENTAL BASELINE (within the FPHCP Action Area)

These two species of dace have a relatively large distribution in Washington as described above. Their occurrence is expected both within and outside of the FPHCP Action Area. Population trends for the two species within the FPHCP Action Area are unknown.

Role of the FPHCP Action Area for the Conservation of the longnose and Nooksack dace

Areas occupied by these species occur both within and outside of the FPHCP Action Area. The FPHCP Action Area will contribute to the long-term conservation of these species.

8.5.11.3 EFFECTS OF THE ACTION

General habitat effects to the longnose and Nooksack dace resulting from the proposed action have been summarized above for the Low-Gradient Tributary and Mainstem Guilds.

Riparian prescription effects to longnose and Nooksack Dace

Full riparian and in-stream function likely would not be provided to all habitats occupied by the longnose and Nooksack dace. In some stream reaches, the highest quality and most structurally complex habitats may fail to develop due to the potential reduction of large wood recruitment to streams at different time scales and following different riparian management prescriptions. Seasonally longnose and Nooksack Dace inhabit stream margins or deep pools. Reduction in natural recruitment of large wood to streams would likely result in reduced stream habitat complexity, including reduced quantity and quality of pools. Large wood in freshwater habitats is important for storing and releasing the appropriate sediment for suitable substrate and to support aquatic plant growth and macroinvertebrate production. Reductions of large wood in streams could result in reduced forage for longnose and Nooksack dace.

The longnose and Nooksack dace prefer temperatures between 55 and 70º F (Wydoski and Whitney 2003). When RMZs achieve their Desired Future Condition, streams within the areas covered by the FPHCP that are occupied by the longnose and Nooksack dace will receive most of the potentially available shade. Along Type Np streams, reductions in shade are likely to occur and water temperature may increase over limited distances as a result of these unbuffered Type Np streams. In some cases, increases in temperature may be delivered downstream to Type F waters and temperatures could be warmed near the confluence of Type Np and F streams. There are situations (yarding corridors, stream-

adjacent parallel roads, 20-acre exemptions, and windthrow) where stream shading will be reduced from full ecological potential. In some circumstances there may be adverse effects to the longnose and Nooksack dace due to elevated stream temperatures and the behavior and survival of individual fish may be affected. However, under most timber harvest scenarios, adequate levels of shade are expected for the conservation of dace.

Sediment effects to longnose and Nooksack dace

Sediment will be delivered to longnose and Nooksack dace habitat from road surface erosion. The FPHCP's incorporation of BMPs and RMAPs will substantially reduce road surface erosion to speckled dace habitat, but it will not prevent all sediment from reaching aquatic habitats occupied by speckled dace. Certain watershed features and road location, design, and use may contribute sediment to fish-bearing streams that are above natural background rates. Sediment delivered to streams from roads is likely to have more effects to longnose and Nooksack dace habitat than hillslope erosion due to the magnitude and potentially chronic delivery from roads of sediment to streams. Primary stream productivity and benthic habitat may be negatively affected from increased sedimentation, which could affect longnose and Nooksack dace. Individual fitness and survival may be reduced for some fish. Effects are expected at some locations, normally at a reach or smaller scale.

Culvert and bridge replacement projects often require dewatering a short segment of stream. Because capturing all dace prior to culvert and bridge replacement projects is unlikely, mortality to the longnose and Nooksack dace could occur.

Effects from the 20-acre Exemption Rule

Although there is uncertainty regarding how often this rule would be implemented, when it is implemented the 20-acre Exemption Rule would likely adversely affect longnose and Nooksack dace. In watersheds with a high proportion of 20-acre exempt landowners, this rule would increase the likelihood that large wood recruitment would be inadequate to maintain properly functioning habitat (USFWS & NMFS 2006). There is also the potential for increased sedimentation, reduced shade, increased stream temperatures, and increased windthrow. Where these adverse effects occur, essential behaviors associated with foraging, reproduction and growth may be impeded. In situations like these, longnose and Nooksack dace may occupy the stream at reduced levels, which may also affect species which use longnose and Nooksack dace as forage.

Summary of adverse effects to longnose and Nooksack dace

The proposed action will have short- to long-term adverse effects on sediment, large wood, and temperature. These effects to the aquatic environment may result in impairment of essential foraging, rearing, and spawning behavior of longnose and Nooksack dace. It is difficult to predict the severity of these effects because habitat limiting factors for this species are not well understood and effects to their habitat would likely vary from activity to activity depending on the specific riparian prescriptions, the location of the activity, historical management practices, geological characteristics of the watershed, and the biotic community present.

Activities covered under the FPHCP are expected to have direct and indirect adverse effects to adult and juvenile longnose and Nooksack dace ranging from mortality to sublethal effects. Direct injury and death to longnose and Nooksack dace would likely occur during some stream crossing construction activities (stream dewatering and fish rescue and relocation, and blockage of upstream migration during

construction). Increased sediment levels could reduce available habitat and prey items forlongnose and nooksack dace. This could affect the growth and survival of juvenile and adult longnose and Nooksack dace.

Summary of beneficial effects to longnose and Nooksack dace

The FPHCP prescriptions are expected to contribute to increasing the likelihood that longnose and Nooksack dace survive in the FPHCP Action Area. Maturation of riparian areas, maintaining and restoring longnose and Nooksack dace passage, adaptive management, and improved road management practices are all expected from implementation of the FPHCP. Most disturbances from the proposed action are generally expected to be short-term in nature and at a stream reach or less (habitat unit) scale. Disturbance levels are not expected to cause large scale declines in longnose and Nooksack dace abundance or distribution. Given enough time relative to the magnitude of the disturbance, longnose and Nooksack dace are likely to recover from activities attributable to the FPHCP.

8.5.11.4 CUMULATIVE EFFECTS

Cumulative effects were addressed in the **Comprehensive Cumulative Effects**, with respect to the aquatic and riparian environment in Washington State. Additional information regarding cumulative effects for the fish species was presented in the section **Low-Gradient Tributary and Mainstem Guilds: Cumulative Effects.**

8.5.12 Leopard dace (*Rhinichthys falcatus*) and Umatilla dace (*Rhinichthys umitilla*)

8.5.12.1 Status of the Species

Description of the Species

The leopard dace and the Umatilla dace are very similar in appearance. Previously they were considered to be a subspecies of the speckled dace. The Umatilla dace is still not considered a separate species by the American Fisheries Society (Robins et al. 1991), but new evidence supports the separation of the Umatilla dace from the leopard dace (Wydoski and Whitney 2003). For this Opinion, they are considered two separate species.

The leopard dace has a small (average size of adult 75 millimeters), elongate body that is slightly heavy before the dorsal fin (Scott and Crossman 1979). The head is triangular shaped with a bluntly rounded snout and a slightly overhanging small mouth with conspicuous barbels at each corner, which are longer than the barbels on the speckled dace (Scott and Crossman 1979). It has a deeply forked caudal fin, and rounded, small pectoral fins. The leopard dace is generally light in coloration. It has many large irregularly shaped spots on a rather yellowish background along its sides and darker coloration on its dorsal surface (Wydoski and Whitney 2003).

The overall general description of the Umatilla dace is very similar to that of the leopard dace. However there are several distinguishing characteristics that separate the two fish. The leopard dace has conspicuous fleshy attachments to the rays of its pectoral fins, whereas the fleshy attachments in the Umatilla dace are less developed (Wydoski and Whitney 2003). The leopard dace has many irregular dark spots along their sides, whereas the Umatilla dace has dark blotches that are nearly continuous along

their lateral line (Wydoski and Whitney 2003). The mouth of the Umatilla dace is only slightly inferior whereas the leopard dace's mouth is completely inferior (Wydoski and Whitney 2003).

Historic and Current Range

The historic range of the leopard and Umatilla dace is unknown at this time. Currently both species have a very spotty and disjunct distribution which is confined to the Columbia River system (Wydoski and Whitney 2003). The leopard dace has been found in the lower, mid, and upper Columbia River, and in the Snake, Similkameen and Yakima Rivers (Wydoski and Whitney 2003). The Umatilla dace has been found in the Columbia, Similkameen, Kettle, Yakima, Okanogan, Colville and Snake Rivers, along with possible populations in the Methow and Wenatchee Rivers (Wydoski and Whitney 2003).

Essential Habitat Components

The leopard and Umatilla dace share similar habitats throughout their range. They both are primarily found in stream habitats, however the leopard dace has been know to inhabit lakes as well (Wydoski and Whitney 2003). Generally leopard dace have been found to occupy streams with current velocities less than 0.5 meters/second (Scott and Crossman 1979). The Umatilla dace is generally found in current velocities less than that of leopard dace. Both species are benthic in their behaviors. They both occupy relatively productive, low elevation streams with large cobble or rubble substrates with temperatures between 15 and 18°C in late summer (Wydoski and Whitney 2003). Umatilla dace seem to prefer cobble substrates that are clean of sediment whereas leopard dace are associated with cobble covered with fine sediment (Wydoski and Whitney 2003). In British Columbia, 0-age leopard dace have been collected from backwater pools at depths less than 0.50 meters, whereas adults generally occupy habitats 0.90 meters or deeper (Wydoski and Whitney 2003). Umatilla dace have been found along stream banks in shallow water < 1 meter deep where juveniles can forage and hide in dense mats of algae (Wydoski and Whitney 2003). Adult and sub-adult Umatilla dace are found in deeper habitats (Wydoski and Whitney 2003). At night, adult leopard dace move from deep water to shallow water and juveniles move from shallow to deep habitats (Wydoski and Whitney 2003). Young leopard dace feed primarily on dipterous larva and switch to aquatic larva and terrestrial insects as they get older (Scott and Crossman 1979).

Reproductive Ecology

Very little is known about the reproductive ecology of leopard and Umatilla dace, but they are probably similar. Generally, leopard dace spawn in May and July and Umatilla dace are thought to spawn in early to mid July (Wydoski and Whitney 2003). Spawning probably takes place in riffles where several males spawn with one female. Adhesive eggs are then broadcast over a gravel substrate. Males remain at the spawning site possibly to spawn again (Wydoski and Whitney 2003).

Movements and Habitat Use

There is little known about the movements of leopard and Umatilla dace. Wydoski and Whitney (2003) state that some juvenile leopard dace have been known to move at night into deeper water, and that some adults will also move at night into shallow water. There seems to be no information on movements associated with spawning or overwintering.

Threats to Survival

The leopard and Umatilla dace were listed as a "state candidate" species by the Washington State Department of Fish and Wildlife due to their limited range and unknown status. Some frequently cited threats to their continued survival are habitat loss or alterations, pollution, sedimentation of spawning or foraging areas, and reservoir operations which could cause rapid water fluctuations (Wydoski and Whitney 2003).

Leopard dace generally occur in streams with clean substrates of rock, boulders, and cobbles where the water velocity is strong enough to prevent gravel from becoming embedded (Wydoski and Whitney 2003). They are sometimes found in lakes. Sedimentation of streams has been suggested as a potential factor in degrading habitat for leopard dace (Wydoski and Whitney 2003).

In British Columbia, Canada, the Umatilla dace is considered a vulnerable species because of its small range (www.royalbcmuseum.bc.ca). The construction of dams has apparently been partially responsible for declines in British Columbia and may be a threat in Washington. The process of eutrophication may also pose a threat, while the placement of rocks in dike construction may increase available habitat (www.royalbcmuseum.bc.ca).

8.5.12.2 ENVIRONMENTAL BASELINE (within the FPHCP Action Area)

Umatilla dace are confined to the Columbia basin in eastern Washington and are usually associated with low elevation, slow moving streams (Wydoski and Whitney 2003). The distribution of the leopard dace includes the Columbia basin in eastern Washington, and the lower Columbia River downstream to the Cowlitz River system. Leopard dace have been reported from the Hanford reach of the Columbia.

Population trends of the Umatilla and leopard dace are unknown in the FPHCP Action Area. The distribution of both species is considered "spotty" by Wydoski and Whitney (2003). Leopard dace were considered rare in an electrofishing sample the Yakima River.

Role of FPHCP Action Area in Conservation of species:

The FPHCP Action Area encompasses only a moderate portion of the species range within Washington. The species occurs both within and outside of the FPHCP Action Area. The FPHCP Action Area will provide a moderate level of conservation for these two species of dace. However, there are major areas the species occurs that are outside of the FPHCP Action Area and are not influenced by the proposed action.

8.5.12.3 EFFECTS OF THE ACTION

General habitat effects to Umatilla and leopard dace resulting from the proposed action have been summarized above for the Low-Gradient Tributary and Lentic Guilds.

Riparian prescription effects to Umatilla and leopard dace

Full riparian and in-stream function likely would not be provided to all habitats occupied by the Umatilla and leopard dace. In some stream reaches, the highest quality and most structurally complex habitats may fail to develop due to the potential reduction of large wood recruitment to streams at different time scales and following different riparian management prescriptions. Reduction in natural recruitment of large wood to streams would likely result in reduced stream habitat complexity, including reduced quantity and quality of pools. Large wood in freshwater habitats is important for storing and releasing the appropriate

sediment for suitable substrate and to support aquatic plant growth and macroinvertebrate production. Reductions of large wood in streams could result in reduced forage for Umatilla and leopard dace.

Leopard dace have been reported from streams with cool water that ranges from 59 to 64 ° C in late summer. When RMZs achieve their Desired Future Condition, streams within the areas covered by the FPHCP that are occupied by the longnose and Nooksack dace will receive most of the potentially available shade. Along Type Np streams, reductions in shade are likely to occur and water temperature may increase over limited distances as a result of these unbuffered Type Np streams. In some cases, increases in temperature may be delivered downstream to Type F waters and temperatures could be warmed near the confluence of Type Np and F streams. There are situations (yarding corridors, stream-adjacent parallel roads, 20 acre exemptions, and windthrow) where stream shading will be reduced from full ecological potential and in some circumstances there may be adverse effects to the Umatilla and leopard dace due to elevated stream temperatures and the behavior and survival of individual fish may be affected. However, under most timber harvest scenarios, adequate levels of shade are expected for the conservation of dace.

Sediment effects to Umatilla and leopard dace

Sediment will be delivered to Umatilla and leopard dace habitat from road surface erosion. The FPHCP's incorporation of BMPs and RMAPs will substantially reduce road surface erosion to Umatilla and leopard dace, but it will not prevent all sediment from reaching aquatic habitats occupied by speckled dace. Certain watershed features and road location, design, and use may contribute sediment to fish-bearing streams that are above natural background rates. Sediment delivered to streams from roads is likely to have more effects to Umatilla and leopard dace habitat than hillslope erosion due to the magnitude and potentially chronic delivery of sediment from roads to streams. Primary stream productivity and benthic habitat may be negatively affected from increased sedimentation, which could affect Umatilla and leopard dace. Individual fitness and survival may be reduced for some fish. Effects are expected at some locations, normally at a reach or smaller scale.

Culvert and bridge replacement projects often require dewatering a short segment of stream. Mortality of Umatilla and leopard dace in the vicinity of a culvert project could occur.

Effects from the 20-acre Exemption Rule

Although there is uncertainty regarding how often this rule would be implemented, when it is implemented the 20-acre Exemption Rule would likely adversely affect Umatilla and leopard dace. In watersheds with a high proportion of 20-acre exempt landowners, this rule would increase the likelihood that large wood recruitment would be inadequate to maintain properly functioning habitat (USFWS & NMFS 2006). There is also the potential for increased sedimentation, reduced shade, increased stream temperatures, and increased windthrow. Where these adverse effects occur, essential behaviors associated with foraging, reproduction and growth may be impeded. In situations like these, Umatilla and leopard dace may occupy the stream at reduced levels, which may also affect species which use Umatilla and leopard dace as forage.

Because capturing all dace prior to culvert and bridge replacement projects is unlikely mortality to the Umatilla and leopard dace is likely occur during these projects.

Summary of adverse effects to Umatilla and leopard dace

The proposed action will have short- to long-term adverse effects on sediment, large wood, and temperature. These effects to the aquatic environment may result in impairment of essential foraging, rearing, and spawning behavior of Umatilla and leopard dace. It is difficult to predict the severity of these effects because habitat limiting factors for this species are not well understood and effects to their habitat would likely vary from activity to activity depending on the specific riparian prescriptions, the location of the activity, historical management practices, geological characteristics of the watershed, and the biotic community present.

Activities covered under the FPHCP are expected to have direct and indirect adverse effects to adult and juvenile Umatilla and leopard dace ranging from mortality to sublethal effects. Direct injury and death to Umatilla and leopard dace would likely occur during some stream crossing construction activities (stream dewatering, fish rescue and relocation, and blockage of upstream migration during construction). Increased sediment levels could reduce available habitat and prey items for Umatilla and leopard dace. This could affect the growth and survival of juvenile and adult Umatilla and leopard dace.

Summary of beneficial effects to Umatilla and leopard dace

The FPHCP prescriptions are expected to contribute to increasing the likelihood that Umatilla and leopard dace survive in the FPHCP Action Area. Maturation of riparian areas, maintaining and restoring Umatilla and leopard dace passage, adaptive management, and improved road management practices are all expected from implementation of the FPHCP. Most disturbances from the proposed action are generally expected to be short-term in nature and at a stream reach or less (habitat unit) scale. Disturbance levels are not expected to cause large scale declines in Umatilla and leopard dace abundance or distribution. Given enough time relative to the magnitude of the disturbance, Umatilla and leopard dace are likely to recover from activities attributable to the FPHCP.

8.5.12.4 CUMULATIVE EFFECTS

8.5.13 Northern Pikeminnow (*Ptychocheilus oregonensis*)

8.5.13.1 Status of the Species

Description of the Species

The northern pikeminnow is a large (305 millimeters when mature) long- lived, slow growing piscivorous minnow with an elongate and somewhat laterally compressed body (Scott and Crossman 1973). The head between the eyes is somewhat low gradienttened. It has a long snout and a large terminal mouth. Its caudal fin is forked with pointed upper and lower lobes. All the fins are clear or opaque in color except when in breeding. Fins of males during this time will turn a yellow or yellow-orange color. Males can also develop nuptial tubercles on the head, back and on the pelvic and pectoral fins (Scott and Crossman 1973). Their cycloid scales are small and the color is generally a dark green or greenish-brown color on their dorsal surface. This color becomes lighter along the sides turning a white or cream color on their belly.

Historical and Current Range

The historic range of the northern pikeminnow is unknown at this time. Current distribution of northern pikeminnow includes the Columbia and Snake River mainstem and tributaries, the Puget Sound drainage, and scattered lakes and streams along the coastal drainages north to about Lake Ozette (Wydoski and Whitney 2003). The Olympic Peninsulas northern and eastern drainages do not seem to contain populations of northern pikeminnows (Wydoski and Whitney 2003).

Essential Habitat Components

Northern pikeminnows inhabit lakes, rivers and streams and prefer habitats with slow to moderate currents (Wydoski and Whitney 2003). In lakes they inhabit shallow areas during the summer or move to the surface areas of the pelagic zone in order to occupy areas with preferred water temperatures. During winter they also seek out preferred temperatures by moving into the deeper sections of the lake. The larval form of the northern pikeminnow has been found to rear in habitats with low current, low turbidity and warm water. Habitat areas such as shorelines with fine sediment and backwaters both can provide larval pikeminnows with adequate vegetation, warmer water and enhanced food availability (Gadomski et al. 2001a).

In the Columbia River system, northern pikeminnows have adapted to their varied habitat conditions, which has allowed them to flourish despite the operations of the hydropower system. Northern pikeminnows prey heavily on juvenile salmonids and this predation is often highest around dams (Friesen and Ward 1999). Gadomiski et al. (2001) found that although the impoundment of the Columbia River system had decreased the amount of complex side-channel habitats and backwater nurseries, it has increased the availability of possible low-velocity, main-channel shoreline rearing habitats.

Reproductive Ecology

Male pikeminnows mature at age 3 and females at age 4 (Wydoski and Whitney 2003) when they are around 300 millimeters in length. Males are the first to arrive at the spawning areas where they develop a dark lateral line that runs from their snout to their caudal fin. Their fins will also change to an orange or yellow color and nuptial tubercles will develop on the heads and fins of males.

In late May to July, when water temperatures are between 14 and 18°C, males and females will congregate in large schools over gravel, cobble or rubble substrates in lakes, rivers or streams to spawn (Wydoski and Whitney 2003). Optimal spawning areas will contain gravel, cobble or rubble with enough water velocity to keep the area clean but also will add some protection so that the spawning adults can maintain position (Gadomske et al. 2001). Northern pikeminnow have been observed ascending tributaries to get to optimal spawning areas (Gadomske et al. 2001). Nests are not constructed and females quickly release their eggs over the spawning area where as many as a few hundred to several thousand male pikeminnows fertilize them. The adhesive eggs fall to the bottom and stick to the substrate. No parental care is given to the developing eggs. Spawning depends on temperature and may affect the developing larval fish growth and survival. The eggs hatch in about 7 days (Wydoski and Whitney 2003). Larval pikeminnows will then drift downstream into habitats with slow current, ample vegetation, sandy substrate, and warm temperatures (Gadomski et al. 2001a).

Movements and Habitat Use

Although larval pikeminnows are poor swimmers after hatching, they are able to locate suitable rearing habitat during their drift downstream with the current. They feed on invertebrates until they are big

enough to shift to other nearby habitats. In lakes, larval pikeminnows are able to actively seek out suitable habitat. Adults usually select spawning sites that are close to adequate rearing areas. Lakes, rivers, or stream rearing habitats generally contain the same types of conditions need for larval pikeminnows to mature.

The movements of adult northern pikeminnow are also a result of foraging. In summer, adult pikeminnows patrol the shallows or move into the surface waters of the pelagic zone of lakes (Wydoski and Whitney 2003). These areas contain terrestrial insects, small fish species and some plankton (Scott and Crossman 1973). During fall and winter, the northern pikeminnow will move into deeper waters where fish become their primary food item (Scott and Crossman 1973).

Threats to Survival

The northern pikeminnow has been identified as the most abundant predator on outmigrating juvenile salmonids in the mid-Columbia River (West 2001). The northern pikeminnow is widely distributed throughout the Columbia basin (Gadomski et al. 2001a). The impoundment of the Columbia River has created suitable habitat for pikeminnow so that they have become more abundant in these areas.

Factors that can negatively affect the survival of northern pikeminnow are similar to that of all native coldwater species. Destruction of habitat (spawning, rearing, foraging and overwintering), competition with introduced species, predation by introduced species, pollution, habitat and population fragmentation, natural abrupt changes in climate and over-harvesting by man, all play a roll in reducing populations. However, there are no currently known threats that are a risk to the population in Washington.

8.5.13.2 ENVIRONMENTAL BASELINE (within the FPHCP Action Area)

We are unaware of detailed population estimates for the northern pikeminnow in the FPHCP Action Area. An aggressive northern pikeminnow removal program began in 1990's in the lower Columbia River, and yet the population remains productive in that system. The condition of the species in the FPHCP Action Area appears healthy.

Role of the FPHCP Action Area in Conservation of the Species

Suitable habitat for the northern pikeminnow occurs throughout the FPHCP Action Area. The FPHCP Action Area provides an important conservation role for the long-term survival of the species.

8.5.13.3 EFFECTS OF THE ACTION

General habitat effects to northern pikeminnow resulting from the proposed action have been summarized above for the River system Guild. They are also found in habitat associated with Mainstem and Low-Gradient Tributary Guilds.

Riparian prescription effects to northern pikeminnow

Full riparian and in-stream function likely would not be provided to all habitats occupied by the northern pikeminnow. In some stream reaches, the highest quality and most structurally complex habitats may fail to develop due to the potential reduction of large wood recruitment to streams at different time scales and following different riparian management prescriptions. Reduction in natural recruitment of large to streams would likely result in reduced stream habitat complexity, including reduced quantity and quality of pools. Large wood in freshwater habitats is important for storing and releasing the appropriate

sediment for suitable substrate and to support aquatic plant growth and macroinvertebrate production. Reductions of large wood in streams could result in reduced forage for northern pikeminnow.

When RMZs achieve their Desired Future Condition, streams within the areas covered by the FPHCP that are occupied by the northern pikeminnow will receive most of the potentially available shade. Along Type Np streams, reductions in shade are likely to occur and water temperature may increase over limited distances as a result of these unbuffered Type Np. In some cases, increases in temperature may be delivered downstream to Type F waters and temperatures could be warmed near the confluence of Type Np and F streams. There are situations (yarding corridors, stream-adjacent parallel roads, 20 acre exemptions, and windthrow) where stream shading will be reduced from full ecological potential and in some circumstances there may adverse effects to northern pikeminnow due to elevated stream temperatures and the behavior and survival of individual fish may be affected. However, under most timber harvest scenarios, adequate levels of shade are expected for the conservation of northern pikeminnow.

Sediment effects to northern pikeminnow

Sediment will be delivered to northern pikeminnow habitat from road surface erosion. The FPHCP's incorporation of BMPs and RMAPs will substantially reduce road surface erosion to speckled dace habitat, but it will not prevent all sediment from reaching aquatic habitats occupied by northern pikeminnow. Certain watershed features and road location, design, and use may contribute sediment to fish-bearing streams that are above natural background rates. Sediment delivered to streams from roads is likely to have more effects to northern pikeminnow habitat than hillslope erosion due to the magnitude and potentially chronic delivery from roads of sediment to streams. Primary stream productivity and benthic habitat may be negatively affected from increased sedimentation, which could affect northern pikeminnow. Individual fitness and survival may be reduced for some fish. Effects are expected at some locations, normally at a reach or smaller scale.

Culvert and bridge replacement projects often require dewatering a short segment of stream. Mortality of northern pikeminnow in the vicinity of a culvert project would probably occur.

Effects from the 20-acre Exemption Rule

Although there is uncertainty regarding how often this rule would be implemented, when it is implemented the 20-acre Exemption Rule would likely adversely affect northern pikeminnow. In watersheds with a high proportion of 20-acre exempt landowners, this rule would increase the likelihood that large wood recruitment would be inadequate to maintain properly functioning habitat (USFWS & NMFS 2006). There is also the potential for increased sedimentation, reduced shade, increased stream temperatures, and increased windthrow. Where these adverse effects occur, essential behaviors associated with foraging, reproduction and growth may be impeded. In situations like this, northern pikeminnow may occupy the stream at reduced levels.

Because capturing all northern pikeminnow prior to culvert and bridge replacement projects is unlikely, mortality to the northern pikeminnow could occur during these projects.

Summary of adverse effects to northern pikeminnow

The proposed action will have short- to long-term adverse effects on sediment, large wood, and temperature. These effects to the aquatic environment may result in impairment of essential foraging,

rearing, and spawning behavior of northern pikeminnow. It is difficult to predict the severity of these effects because effects to their habitat would likely vary from activity to activity depending on the specific riparian prescriptions, the location of the activity, historical management practices, geological characteristics of the watershed, and the biotic community present.

Activities covered under the FPHCP are expected to have direct and indirect adverse effects to adult and juvenile northern pikeminnow ranging from mortality to sublethal effects. Direct injury and death to northern pikeminnow would likely occur during some stream crossing construction activities (stream dewatering, fish rescue, and relocation, blockage of upstream migration during construction). Increased sediment levels could reduce available habitat and prey items for northern pikeminnow. This could affect the growth and survival of northern pikeminnow. In general the population is well distributed and healthy in Washington, and no further effects to the species, other than those analyzed above, are anticipated.

Summary of beneficial effects to northern pikeminnow

The FPHCP prescriptions are expected to contribute to increasing the likelihood that northern pikeminnow survive in the FPHCP Action Area. Maturation of riparian areas, maintaining and restoring northern pikeminnow passage, adaptive management, and improved road management practices are all expected from implementation of the FPHCP. Most disturbances from the proposed action are generally expected to be short-term in nature and at a reach or less (habitat unit) scale. Disturbance levels are not expected to cause large scale declines in northern pikeminnow abundance or distribution.

8.5.13.4 CUMULATIVE EFFECTS

Cumulative effects were addressed in the **Comprehensive Cumulative Effects** section, with respect to the aquatic and riparian environment in Washington State. Additional information regarding cumulative effects for the covered fish species was presented in the section Mainstem, Lentic and River System Guilds**: Cumulative Effects.**

No Additional information is available with respect to cumulative effects for this particular species above those cumulative effects already discussed earlier in this document.

8.5.14 Lake chub (*Cauesius plumbeus*) and Tui chub (*Gila bicolor*)

8.5.14.1 Status of the Species

Description of the Species

The lake chub is similar in appearance to the speckled dace (Wydoski and Whitney 2003). Lake chub have an elongated body with a long caudal peduncle and have an average length of approximately 100 millimeters (Scott and Crossman 1973). They have a short head with a bluntly rounded snout with a threadlike barbel at the corners of the mouth. Their cycloid scales can be silvery in color. The color of their backs can be a pale olive to olive-brown, brown, dark brown or black with a white belly (Scott and Crossman 1973). Males and females will develop nuptial tubercles on the head and dorsal surface, although female tubercles are less developed. Males will also often develop splashes of red or red-orange coloration on the underside and on the pectoral fins, however this varies with region.

The tui chub has a thick caudle peduncle and is similar in appearance to that of the goldfish or carp, however it lacks the long dorsal fin and spinous rays (Wydoski and Whitney 2003). It has large scales

which can be variable in color, shape and size. It is often a deep olive on its dorsal surface becoming lighter along the sides and white on the belly. The scales can also have a brassy reflection. The fins are olive and tinted with red. The young have a narrow dark stripe along the lateral line (Scott and Crossman 1973). It has a pointed head and rather large eyes with a small terminal and slightly oblique mouth.

Historic and Current Range

Lake chub occupy the northern half of North America (Wydoski and Whitney 2003). In Washington, it is found in the Columbia River system. It was recorded in Twin Lake in Snohomish County in the 1950's, however, it is unknown if they still exist at that location (Wydoski and Whitney 2003).

Tui chub occur in several areas of California, Nevada, Oregon, and Washington. In Washington, they are found in reservoirs, ponds, potholes, and warm, slow-moving reaches of lower Crab Creek about 5 and 10 miles downstream from the Potholes Reservoir (Wydoski and Whitney 2003) in the Columbia River basin.

Essential Habitat Components

Lake chub inhabit lakes and streams, but prefer lakes (Wydoski and Whitney 2003). Lake populations use tributary streams for spawning and spend the majority of the year near the bottom of lakes. Much of what is known about this species is from Canada, where it has a wide distribution, and data available are from widely scattered regions. If lakes are not available they have been known to occupy deep areas of large rivers.

Much of the information on the life history of the tui chub comes from California and Utah where there are several isolated populations of tui chub subspecies. They generally prefer lakes, ponds and slow moving streams. They can tolerate highly alkaline lakes with pH's ranging between 9 to 11, and low dissolved oxygen levels as low as 50 percent saturation, and even lower in cool water (<25 percent saturation) (Moyle 2002). They prefer sandy substrates with beds of aquatic plants (Wydoski and Whitney 2003; Moyle 2002). Young tui chub will form schools and swim parallel to the shore in shallow water or congregate in heavy aquatic vegetation (Sigler and Sigler 1987). Maximum temperature limit of the tui chub was reported to be 33°C from the Klamath River in California (range 32 to 34°C) (Wydoski and Whitney 2003). During the spring, tui chub will migrate to shallow water and then return to deeper water during the fall and winter (Wydoski and Whitney 2003).

Reproductive Ecology

There is very little information on the reproductive ecology of the lake chub and all data is currently known from a few studies conducted in Canadian waters. Lake chub usually begin to spawn in early spring, migrating from lakes into small tributaries (Scott and Crossman 1973). Water temperatures at the beginning of spawning can be between 14 and 19°C. They don't construct nests; eggs are deposited by broadcast spawning over coarse gravel, small rubble, and rocks in shallow water (Wydoski and Whitney 2003). Lake chub are thought to mature by their third or fourth year and probably not survive beyond 5 years (Scott and Crossman 1973).

The reproductive information on the tui chub comes from studies conducted in California, Oregon and Utah. Tui chub spawn from late April to June during their third year of life. Water temperatures at this time are between 13 and 16°C (Wydoski and Whitney 2003). The eggs are deposited in shallow water (less than 1.5 meters deep) over beds of aquatic vegetation or algae-covered rocks and gravel (Moyle

2002). Often, in Lake Tahoe, large swirling aggregations of tui chub, with several males to one female, deposit eggs over sandy substrates (Moyle 2002). Eggs hatch in about 10 to 12 days. Fry are approximately 1.25 centimeters in length and stay close to aquatic vegetation (Wydoski and Whitney 2003).

Movements and Habitat Use

Lake chub migrate from the lake environment to spawn in small tributaries (Scott and Crossman 1973). Length of their migration is unknown. They have also been captured in deeper parts of the lake during summer.

Tui chub in California migrate to shallow waters during spring to spawn. The extent of this migration and habitat used is unknown. Tui chub are known to travel in schools and stay in deeper waters during the winter months (Wydoski and Whitney 2003).

Threats to Survival

Both species of chub appear to have very small, limited distributions in Washington State. Their population status is unknown. The lake chub was listed as a "state candidate" species in 1998 due to its apparent, sparse distribution (Wydoski and Whitney 2003). The tui chub is also confined to small parts of the Columbia Basin, which is its most northern part of its native range (Wydoski and Whitney 2003). Both of these species could be vulnerable to extirpation from introduced warm-water fish. Forest practice activities are expected to have little effect on their abundance and distribution.

8.5.14.3 ENVIRONMENTAL BASELINE (within the FPHCP Action Area)

Tui Chub occur in a small area of the Columbia basin in reservoirs, ponds, potholes, and warm, slow moving reaches of lower Crab Creek. The species does not occur in the FPHCP Action Area.

The lake chub also has a limited distribution in Washington, of which some of it may be in the FPHCP Action Area. It spends much of its life in lakes, but move into streams for spawning (Wydoski and Whitney 2003). Population status of the species is currently unknown in the FPHCP Action Area.

Role of the FPHCP Action Area in Conservation of the species:

The Tui chub does not occur in the FPHCP Action Area and will be unaffected by the FPHCP. The Lake chub may occur in the FPHCP Action Area. The FPHCP Action Area may provide a minor conservation role for long-term conservation of the lake chub.

8.5.14.4 EFFECTS OF THE ACTION

General habitat effects to Tui and lake chub resulting from the proposed action have been summarized above for the Mainstem and Lentic Guilds. They also occur in habitat associated with the River System Guild.

Summary of effects to Tui chub

No effects to the Tui chub are expected from the FPHCP, because they are very limited in distribution and do not occur in an area that would be affected by the FPHCP..

Summary of riparian prescription effects to lake chub

No effects from the riparian prescriptions, other than those described in its assoicated guilds, are anticipated for the lake chub.

Summary of sediment effects to lake chub

Lake chub deposit their eggs by broadcast spawning over coarse gravel, small rubble, and rocks in shallow water. Sediment could be delivered to lake chub spawning habitat from road surface erosion. The FPHCP's incorporation of BMPs and RMAPs will substantially reduce road surface erosion to lake chub habitat, but it will not prevent all sediment from reaching aquatic habitats occupied bylake chub. Certain watershed features and road location, design, and use may contribute sediment to fish-bearing streams that are above natural background rates. Primary stream productivity and benthic habitat may be negatively affected from increased sedimentation, which could affect lake chub. Individual fitness and survival may be reduced for some fish. Effects are expected at some locations, normally at a stream reach or smaller scale.

Culvert and bridge replacement projects often require dewatering a short segment of stream. Mortality of lake chub in the vicinity of a culvert project would probably occur.

Effects from the 20-acre Exemption Rule

Although there is uncertainty regarding how often this rule would be implemented, when it is implemented the 20-acre Exemption Rule would likely adversely affect lake chub.. In watersheds with a high proportion of 20-acre exempt landowners, this rule would increase the likelihood that large wood recruitment would be inadequate to maintain properly functioning habitat (USFWS & NMFS 2006). There is also the potential for increased sedimentation, reduced shade, increased stream temperatures, and increased windthrow. Where these adverse effects occur, essential behaviors associated with foraging, reproduction and growth may be impeded. In situations like this, lake chub may occupy the stream at reduced levels.

Because capturing all lake chub prior to culvert and bridge replacement projects is unlikely mortality to lake chub is likely occur during these projects.

Summary of adverse effects to lake chub

The proposed action will have short- to long-term adverse effects on sediment. These effects to the aquatic environment may result in impairment of essential spawning behavior oflake chub. It is difficult to predict the severity of these effects because effects to their habitat would likely vary from activity to activity depending on the specific riparian prescriptions, the location of the activity, historical management practices, geological characteristics of the watershed, and the biotic community present.

Activities covered under the FPHCP are expected to have direct and indirect adverse effects to adult and juvenile northern lake chub ranging from mortality to sublethal effects. Direct injury and death to lake chub would likely occur during some stream crossing construction activities (stream dewatering and fish rescue and relocation, blockage of upstream migration during construction. Effects are expected to be limited to very short sections of streams, at reach levels or less. Although spawning success may be reduced in some circumstances, but it is not expected to affect populations of the lake chub at the watershed level. Resilience of the lake chub population will remain unaffected by the FPHCP.

Summary of beneficial effects to lake chub

The FPHCP prescriptions are expected to contribute to increasing the likelihood that lake chub survive in the FPHCP Action Area. Maturation of riparian areas, maintaining and restoring lake chub passage, adaptive management, and improved road management practices are all expected from implementation of the FPHCP. Most disturbances from the proposed action are generally expected to be short-term in nature and at a reach or less (habitat unit) scale.

8.5.14.5 CUMULATIVE EFFECTS

Cumulative effects were addressed in the **Comprehensive Cumulative Effects**, with respect to the aquatic and riparian environment in Washington State. Additional information regarding cumulative effects for the covered fish species was presented in the section **Lentic Guild: Cumulative Effects.**

No additional information is available with respect to cumulative effects for these particular species above those cumulative effects already discussed earlier in this document.

8.5.15 Peamouth (*Mylocheilus caurinus*)

8.5.15.1 Status of the Species

Description of the Species

Adult peamouth have an elongate body averaging 100 to 150 millimeters in length (Scott and Crossman 1973). Their mouth is slightly inferior due to a slightly overhanging snout (Scott and Crossman 1973). There is a small barbel at each corner of the mouth and a small axillary process at the origins of the pelvic fins (Wydoski and Whitney 2003). During breeding, males will develop nuptial tubercles on their heads, gill covers, and back. They are red around the mouth, cheeks and operculums back to their pectoral fins and along their sides. Breeding individuals will develop red lower lips and lateral red stripes (Scott and Crossman 1973). Males will often have a green colored back while the females will be brown. Mature individuals can be a silvery color with two dark lateral bands, a dark green or brown back and white underside.

Historic and Current Range

Peamouth occur in British Columbia and Alberta, Canada, Montana, Idaho, Oregon, and Washington. In Washington they occur in coastal and Puget Sound watersheds, Columbia River and it tributaries, and in eastern Washington. However, they are absent along the northern and eastern slopes of the Olympic Peninsula (Wydoski and Whitney 2003).

Essential Habitat Components

Although widespread in Washington, very little is known about the behavior and habitat of peamouth. They are know to occur in both lakes and streams and can even tolerate seawater (Wydoski and Whitney 2003). The young are known to inhabit shallow water in the spring, summer, and fall. Often, peamouth will inhabit shallow areas that are covered in ice during the winter (Nishimoto 1973). Adults tend to be deeper during the day and move to shallow areas at night (Wydoski and Whitney 2003). Peamouth are generally found where the water is the warmest (Wydoski and Whitney 2003). Adults feed primarily on benthic organisms, and juveniles feed on zooplankton (Nishimoto 1973).

Reproductive Ecology

Very little is known about the reproductive behavior of peamouth. Most accounts of peamouth reproductive ecology come from studies done in the Lake Washington basin (Schultz 1935; Nishimoto 1973). Males from Lake Washington reach maturity at age 3, and females at 4 years (Nishimoto 1973). Spawning often takes place along lake shorelines or in tributaries, but neither has been seen or recorded. Large schools of about 60,000 adult peamouth have been seen migrating up the Cedar River, approximately 7.4 and 14.5 kilometers from the mouth (Tabor, Personal Communication, , 2005). Water temperatures during this time in the river and lake were approximately 12.0 °C (Wydoski and Whitney 2003). Eggs are found to be attached to stone and rubble and hatch between 7 and 8 days at 12.2°C (Scott and Crossman 1973; Wydoski and Whitney 2003).

Movements and Habitat Use

Very little is known about the overall movements and habitat use of peamouth. They make migrations to spawning areas during late spring and early summer (Nishimoto 1973; Scott and Crossman 1973); however the extent is still unknown. Their movements during this time are thought to occur during certain moon phases and may only last one or two days (24 to 48 hours) (Tabor 2005). During the early summer newly hatched young have been seen moving in schools along lake shorelines and into bays where there are warmer water temperatures, preferred food, and abundant aquatic vegetation (Nishimoto 1973). As they increase in size they then begin to move into deeper waters in late summer (Scott and Crossman 1973). Adult peamouth spend much of their lives in deeper waters of Lake Washington, only moving off the bottom to feed on mysid shrimp higher in the water column (Wydoski and Whitney 2003). Some populations of peamouth in other parts of their range make greater movements at night and during the day due to lack of predators (Nishimoto 1973).

Threats to Survival

Peamouth have a broad distribution in Washington, but information on their abundance is limited. Specific threats to the species are unknown at this time. Peamouth in Lake Washington have been studied, but their population status remains unknown. Tabor (2005) noted that during a snorkel survey in the spring of 1999 he and other biologists observed approximately 50,000 to 60,000 peamouth adults migrating up the Cedar River, presumably to spawn. Population trends in Washington are unknown.

8.5.15.2 ENVIRONMENTAL BASELINE (within the FPHCP Action Area)

The peamouth occurs throughout much of western and eastern Washington. Population trend for the species is currently unavailable.

Role of the FPHCP Action Area in Conservation of the Species:

The peamouth has a large distribution in Washington and occurs in the FPHCP Action Area in suitable habitats. The FPHCP Action Area provides an important role for long-term conservation of the species.

8.5.15.3 EFFECTS OF THE ACTION

General habitat effects to peamouth resulting from the proposed action have been summarized above for the Lentic Guild.

Summary of sediment effects to peamouth

Sediment would be delivered to peamouth habitat from road surface erosion, and to a lesser extent, hillslope erosion. The FPHCP's incorporation of BMPs and RMAPs will substantially reduce road surface erosion to peamouth habitats, but it will not prevent all sediment from reaching aquatic habitats occupied by the species. Certain watershed features and road use may contribute sediment to fish-bearing streams that are above natural background rates. Culvert projects may increase siltation over short durations. Sediment delivered to streams from roads is likely to have more effects to the species than hillslope erosion due to the magnitude and potentially chronic delivery of sediment to streams. Excessive siltation may affect food resources (zooplankton, aquatic and terrestrial insects) of peamouth. Feeding behavior may be altered under some circumstances, affecting individual fitness and survival. Effects are expected to be limited to a stream reach or smaller scale and not affect the population as a whole. It is unlikely that distribution of the species will be reduced.

Summary of adverse effects to peamouth

The proposed action would have short- to long-term adverse effects on sediment. These effects would be most severe from unbuffered Type Np streams and their downstream effects that result in disruption of natural riparian and aquatic processes and functions in Type F streams. These effects to the aquatic environment may result in impairment of essential foraging behavior of peamouth. It is difficult to predict the severity of these effects because little is know about peamouth habitat requirements and effects to these fish will vary from activity to activity depending on the specific riparian prescriptions applied, the location, historical management practices, geological characteristics of the watershed, and the biotic community present.

Activities covered under the FPHCP are expected to have direct and indirect adverse effects to adult and juvenile peamouth ranging from mortality to sublethal effects. Direct injury and death to peamouth would likely occur during some stream crossing construction activities (stream dewatering and fish rescue and relocation, blockage of upstream migration during construction). Increased sediment levels could reduce available habitat and prey items for chiselmouth. This could affect the growth and survival of juvenile and adult peamouth.

Summary of beneficial effects

The long-term benefits of the FPHCP are expected to outweigh the short-term, negative affects to peamouth. The severity of individual effects to will vary from activity to activity depending on the location, past management practices, geological characteristics of the watershed, and the biotic community present. However, maturation of riparian areas, maintaining and restoring peamouth passage, adaptive management, and improved road management practices are all expected from implementation of the FPHCP. These management prescriptions are expected to contribute to increasing the likelihood of long-term survival for peamouth in the FPHCP Action Area.

The FPHCP is not expected to reduce the chance of long-term survival of the peamouth in the FPHCP Action Area.

8.5.15.4 CUMULATIVE EFFECTS

Cumulative effects were addressed in the **Comprehensive Cumulative Effects** section, with respect to the aquatic and riparian environment in Washington State. Additional information regarding cumulative effects for the covered fish species was presented in the section **Lentic Guild: Cumulative Effects.**

No additional information is available with respect to cumulative effects for this particular species above those cumulative effects already discussed earlier in this document.

8.5.16 Largescale sucker (*Catostomous macrocheilus*)

8.5.16.1 Status of the Species

Description of the Species

The largescale sucker is a long, dark, and noticeably counter-shaded member of the sucker family. The main characteristic that distinguishes it from the other members of the sucker family is that it lacks notches in the corners of the mouth. The mouth is subterminal, protrusible, lacks teeth, and is not overhung by the snout (Wydoski and Whitney 2003). It has large lips, and the lower lip is deeply incised with coarse, oval papillae and has a complete cleft. The caudal fin is moderately long and well forked, and the anal fin is long and pointed. The largescale sucker has large cycloid scales that increase in size from the head to the tail. Its color is blue-gray to olive, beginning just below the lateral line and covering the entire dorsal surface. Below the lateral line, the color is creamy-white. During breeding, the male largescale sucker develops nuptial tubercles along the lower lobe of the caudal and anal fin. The female sometimes develops tubercles that are not as pronounced as in males.

Historic and Current Range

The historic range is currently unknown at this time. The species occurs from British Columbia and Alberta, Canada, Oregon, Idaho, Montana and Washington (Wydoski and Whitney 2003). The largescale sucker is found throughout Washington. On the Olympic Peninsula it is found in a few streams and lakes in the southern and western portions of the Peninsula and is absent from the north and eastern portions of the Peninsula. In the Columbia River basin, it is the predominant species of sucker, comprising 94 percent of sucker species (Wydoski and Whitney 2003).

Essential Habitat Components

The largescale sucker is found in lakes, streams, and large rivers (Wydoski and Whitney 2003). Adults are benthic and generally found in shallow water. They are sometimes found at the mouths of streams that are entering a lake, or in quiet shallow backwaters of rivers. In the spring, lake-dwelling largescale suckers are usually found in shallow bays. Larval largescale suckers are generally pelagic. In the Columbia River near the Hanford Reach, they can also be found along the shoreline in low-velocity water at night. The young are pelagic until they are about 18 millimeters in length (Scott and Crossman 1979). As fry, largescale suckers tend to occupy pools and backwaters with mud and cobble substrates. Fry generally form large schools in weedy shoreline areas of lakes and the backwaters of rivers and streams. They occupy the shallows during the daytime and move to deeper water at night. They inhabit waters with a wide range of temperatures throughout the year. Black (1953) determined the upper lethal water temperature for largescale suckers to be 29° C.

Reproductive Ecology

Spawning takes place from April to June (or possibly early July), depending on location. Males are generally mature at age three, and females can mature at age four or five. Age at maturity can also be dependent upon location. Largescale suckers generally move from lakes and large rivers into smaller streams or tributaries to spawn (Sigler and Sigler 1987). Spawning takes place in shallow-water riffles,

along the edges of streams and rivers, and in the tail-outs of pools (Wydoski and Whitney 2003). Spawning substrate is generally composed of fine gravel, sand, and silt. In the Cedar River at Renton, largescale suckers spawned in 1-meter deep water in low to moderate current (Wydoski and Whitney 2003). Spawning takes place during the day; however, in streams and rivers with little to no cover, spawning often occurs during the night. Water temperatures during spawning vary by location. In the Columbia River at the Hanford Reach, spawning occurs in water temperatures between 12° C and 15° C, while in the Pend Oreille River, spawning occurs between 8° C and 13° C (Wydoski and Whitney 2003). Spawning can take place along lake shores that have adequate substrate and wave action. Females broadcast their eggs as several males fertilize them. The eggs are adhesive and stick to the substrate after they are released, and remain adhered to the substrate for approximately 2 weeks. After hatching, the larval largescale suckers drift for 1 to 3 days in the current until they find a quiet backwater or lake shore in which to rear.

Movements and Habitat Use

Largescale suckers occupy specific habitats at various stages throughout their lives. During the larval stage, largescale suckers exhibit a pelagic life phase and move throughout the surface waters of the Columbia River shoreline at night (Wydoski and Whitney 2003). As they grow in size and become fry, they move to deeper waters and begin their benthic life phase. They then use inshore habitat during the day and move into deeper waters at night. As adults they reverse this behavior and are more abundant along the shallows of the shoreline at night than during the day (Wydoski and Whitney 2003).

Adult largescale suckers tagged in Lake Roosevelt and on the Pend Oreille River were generally recaptured (74 percent to 90 percent) at or near the tagging site (within 9.6 kilometers) (Wydoski and Whitney 2003). However, in a tagging study on the Columbia River in British Columbia, very few (20 percent) were recaptured at the tagging site (Wydoski and Whitney 2003). Some tagged fish moved greater distances (approximately 40 kilometers downstream and 49.6 kilometers upstream) (Wydoski and Whitney 2003).

During the spawning season, adult largescale suckers move from large rivers and lakes into smaller rivers or streams to spawn. In the Lake Washington Basin, groups of largescale suckers are regularly observed moving out of Lake Washington and into the Cedar River to spawn. Similar migrations occur in the Columbia River in early summer. However the extent of these regularly observed seasonal movements of largescale suckers are for the most part unknown.

THREATS TO SPECIES

There are currently no known threats to the largescale sucker in Washington. The species has a broad distribution in Washington and occupies a diversity of habitats. They are likely an important species in the food web of northwest fauna.

8.5.16.2 ENVIRONMENTAL BASELINE (within the FPHCP Action Area)

The largescale sucker is found throughout the FPHCP Action Area and is the most-widely distributed sucker in Washington State. It is the predominant species of sucker within the Columbia River and its tributaries (Wydoski and Whitney 2003). The largescale sucker is found in lakes, streams, and large rivers (Wydoski and Whitney 2003). In 1981, the population of largescale suckers in the Columbia River was estimated to be 9,297 per mile in June, and 7,670 per mile in July (Wydoski and Whitney 2003). Population trends in Washington are currently unknown.

Role of the FPHCP Action Area in Conservation of the Species

The largescale sucker has a broad distribution in Washington and is found both within and outside of the FHPC Action Area. The FPHCP Action Area provides important habitats for the largescale sucker in Washington.

8.5.16.3 EFFECTS OF THE ACTION

General habitat effects for the largescale sucker resulting from the proposed action have been summarized above for the Lentic Guild. The largescale sucker occupies lakes and streams and also uses habitat found in the River System, Mainstem and Low-gradient Guilds.

Summary of sediment effects to largescale sucker

Sediment would be delivered to largescale sucker habitat from road surface erosion, and to a lesser extent, hillslope erosion. The FPHCP's incorporation of BMPs and RMAPs will substantially reduce road surface erosion to sucker habitats, but it will not prevent all sediment from reaching aquatic habitats occupied by the species. Certain watershed features and road use may contribute sediment to fish-bearing streams that are above natural background rates. Culvert projects may increase siltation over short durations, especially until vegetation has recovered to reduce harmful sediment. Some fish may die as a result of dewatering stream segments to replace culverts.

Sediment delivered to streams from roads are likely to have more effects to the species than hillslope erosion due to the magnitude and potentially chronic delivery of sediment to streams. Excessive siltation may affect food resources (algae, diatoms, aquatic insects, crustaceans, and snails) of largescale sucker. Feeding behavior may be altered under some circumstances affecting individual fitness and survival. Effects are expected to be limited to a stream reach or smaller scale.

Summary of adverse effects to largescale sucker

The proposed action will have short- to long-term adverse effects on sediment. These effects to the aquatic environment may result in impairment of essential spawning behavior oflake chub. It is difficult to predict the severity of these effects because effects to their habitat would likely vary from activity to activity depending on the specific riparian prescriptions, the location of the activity, historical management practices, geological characteristics of the watershed, and the biotic community present.

Activities covered under the FPHCP are expected to have direct and indirect adverse effects to adult and juvenile largescale sucker ranging from mortality to sublethal effects. Direct injury and death to largescale sucker would likely occur during some stream crossing construction activities (stream dewatering, fish rescue and relocation, and blockage of upstream migration during construction). Effects are expected to be limited to very short sections of streams, at stream reach levels or less. Although spawning success may be reduced in some circumstances, it is not expected to affect populations of the largescale sucker at the watershed level. Persistence of the largescale sucker population will remain unaffected by the FPHCP.

Summary of beneficial effects

The long-term benefits of the FPHCP are expected to outweigh the short-term, negative affects to largescale sucker. The severity of individual effects will vary from action to action depending on the location, past management practices, geological characteristics of the watershed, and the biotic

community present. However, maturation of riparian areas, maintaining and restoring largescale sucker passage, adaptive management, and improved road management practices are all expected from implementation of the FPHCP. These management prescriptions are expected to contribute to increasing the likelihood of long-term survival for largescale sucker in the FPHCP Action Area.

8.5.16.4 CUMULATIVE EFFECTS

Cumulative effects were addressed in the **Comprehensive Cumulative Effects** section, with respect to the aquatic and riparian environment in Washington State. Additional information regarding cumulative effects for the covered fish species was presented in the section **Lentic Guild: Cumulative Effects.**

No additional information is available with respect to cumulative effects for the largescale sucker above those cumulative effects already discussed earlier in this document.

8.5.17 Longnose Sucker (*Catostomus catostomus*)

8.5.17.1 Status of the Species

Salish Sucker (*Catostomus carli* – species pending)
Note: The longnose and Salish suckers are very similar and were thought to be the same species. The status of the Salish sucker is still in question, but it is most likely an offshoot from the longnose sucker. They are morphologically distinguishable and their distribution does not overlap in Washington.

Description of Species

The longnose sucker is distinguished from other suckers by having a long snout that overhangs a subterminal mouth. The mouth is protrusible, suctorial, moderately small and lacking teeth. The lips are large with coarse, long, oval papillae. The lower lip has a complete cleft and may have one row of papillae crossing at the base. The top of the snout is sometimes concave over the mouth. The body is somewhat elongate and torpedo-shaped, with a long anal fin and moderately forked caudal fin. Small cycloid scales cover the body, becoming more crowded and smaller toward the head and larger on the caudal peduncle. The color of the longnose sucker is dark olive with brassy, gray or black reflections on the dorsal surface, below the eye on the head, and on the upper sides. Ventrally, and along the lower sides, the color becomes a creamy white. During breeding, both the male and female develop a broad mid-lateral band of vivid rose color. Above this band, the color may change to black or green-gold or coppery brown in females. A yellow-orange color on the undersurface of the head and mouth develops. The belly may become bright white to pink. The edges of fins develop a pale red or amber with pink color.

The description of the Salish sucker is very similar to that of the longnose sucker. They do, however, differ in a few morphological characteristics. In the Salish sucker, the snout is slightly shorter than that of the longnose sucker, and the body is somewhat deeper (Wydoski and Whitney 2003). The lateral-line scale count of the Salish sucker ranges between 84 to 86, while the longnose sucker has average scale counts that range between 103 to107 (Wydoski and Whitney 2003).

Historic and Current Range

The longnose sucker occurs across much of North America. In Washington, the longnose sucker is currently found throughout the Columbia River system from about the mouth of the Yakima River

upstream. The historic range of the longnose sucker most likely covered the entire Columbia River system before the construction of dams.

The Salish sucker is currently found in northwest Washington and the Fraser River system in British Columbia, Canada (Pearson 1998). In western Washington it is found in the Nooksack River, Lake Whatcom, Twin Lakes of the Stilliguamish River system, the Green River, and Lake Cushman of the Skokomish River system (Pearson 1998). The historic range of this species is currently unknown.

Essential Habitat Components

The longnose and the Salish suckers occupy similar habitats throughout their range. They both occur in cold water lakes and lowland streams with associated ponds and in major rivers. They are found in a variety of habitats, depths, and velocities. Adults are generally found in deeper water and offshore during the day, while younger fish are in shallow weedy areas of lakes. Juvenile Salish suckers are most often found among in-stream vegetation or along stream banks with overhanging vegetation (Blood 1993). Young-of-the-year suckers are found in habitats similar to adult habitats, but with more overhanging vegetation cover (Pearson 1998). In the Yellowstone system, fry tended to occupy small shallow pools in streams and tended to spend their first summer in streams (Wydoski and Whitney 2003). During the summer, longnose and Salish suckers are found in slow-water, off-channel backwaters, protected lagoons, and bays with silt and sandy substrates, aquatic vegetation and ample riparian cover (Pearson 1998). The Committee on the Status of Endangered Wildlife in Canada (COESWIC) found that, in British Columbia, the Salish sucker was found in deep marshy headwaters with heavy cover and was often caught in waters where temperatures were above 20° C in the summer (COSEWIC 2002). Black (1953) found that lethal temperatures to the longnose sucker were between 26.5° C and 27° C.

Reproductive Ecology

Spawning generally starts during the spring and can last until late summer. Both species have similar spawning behaviors and select similar spawning habitat. The longnose and Salish suckers generally spawn in swift riffles of small streams over gravel substrate (Pearson 1998), although in-lake spawning has also been observed in shallow lakeshore areas (Scott and Crossman 1979). Spawning generally begins when water temperatures reach a specific point, and spawning temperatures and timing can vary as to location. For the Salish sucker in British Columbia, spawning begins when temperatures are between 7° C and 8° C (Pearson 1998), and can last until late August when temperatures are as high as 20° C (Wydoski and Whitney 2003). The longnose sucker was found to begin spawning in British Columbia when water temperatures reached 5° C (Scott and Crossman 1979).

Suckers move upstream out of lakes or larger rivers into small shallow streams to spawn. This movement is often done at night (Scott and Crossman 1979). Spawning takes place as several male suckers accompany a single female to the spawning area. The female broadcasts her eggs as the males fertilize them. The eggs are adhesive and settle onto and between the gravel substrate. Eggs that are on top of the gravel are usually eaten by other fish. After spawning is completed, females return to the slower portions of the stream or back into the lake, while the males remain at the site to possibly spawn again. The eggs hatch in about 2 weeks at water temperatures of 5° C to 10° C (COSEWIC 2002). Fry remain in the gravel for a further 1 to 2 weeks (Pearson 1998).

Movements and Habitat Use

Little is known about the movements and habitat use of the longnose and Salish suckers. Spawning migrations of suckers into smaller headwater streams, from lakes or rivers, has been documented in the longnose sucker (Scott and Crossman 1979), but the extent of this migration and the specific habitat used is unknown at this time.

Observations of local movements of Salish suckers indicate they become more active and have greater movements at night (COSEWIC 2002). This is in contrast to their behavior during the day, where they seek out dense cover in which to hide. Some nightly movements of Salish suckers are extensive, as some fish have been observed moving several hundred meters downstream before returning to their daytime hiding area (COSEWIC 2002).

Threats to Survival

Possible threats to the survival of both species include commonly cited factors, such as pollution of streams, loss of riffle habitat, interactions with non-native species, forest-removal, farming activities, removal of cover elements, alteration of stream flow, and lethal temperature effects. In British Columbia, these factors have caused the Salish sucker to become endangered. The Salish sucker is listed in British Columbia as endangered by COSEWIC due to their restricted distribution and habitat degradation as a result of human land uses (McPhail and Taylor 1999).

8.5.17.2 ENVIRONMENTAL BASELINE (within the FPHCP Action Area)

The Salish and longnose sucker both have significant components of their distribution within the FPHCP Action Area. The longnose sucker is found in coldwater lakes and streams and the Salish sucker inhabits lowland streams and associated ponds (Wydoski and Whitney 2003). These types of aquatic habitats are commonly associated with the proposed action. Population trend of the longnose sucker is unknown.

The Salish sucker in British Columbia, Canada, has declined in abundance, apparently due to impacts from urbanization. In Washington, the Salish sucker was historically reported from Bertrand Creek, Cave, and Fishtrap Creek in the Nooksack watershed. Surveys more recently conducted by the WDFW did not find the fish in these streams (Wydoski and Whitney 2003). These particular streams are substantially influenced by agricultural practices.

Role of FPHCP Action Area in Conservation of species:

Salish and longnose sucker occur throughout the FPHCP Action Area. The FPHCP Action Area provides suitable habitats for these two species and is important for the long-term conservation of these two species.

8.5.17.3 EFFECTS OF THE ACTION

General habitat effects to the Salish sucker resulting from the proposed action have been summarized above for the Lentic and Mainstem Guilds. General habitat effects to the longnose sucker resulting from from the proposed action have been summarized above for the Lentic, Mainstem and Low-Gradient Tributary Guilds.

Riparian prescription effects to Salish and longnose suckers

Full riparian and in-stream function likely would not be provided to all habitats occupied by Salish and longnose suckers. In some stream reaches, the highest quality and most structurally complex habitats may fail to develop due to the potential reduction of large wood recruitment to streams following different riparian management prescriptions. Large wood in freshwater habitats is important for storing and releasing the appropriate sediment for development of suitable substrate, pool formation and aquatic plant growth. Large wood is also used by the Salish and longnose sucker for cover and reduced large wood may result in increased predation.

The longnose sucker has been reported to use coldwater lakes and streams (Wydoski and Whitney 2003). When RMZs achieve their Desired Future Condition, streams within the areas covered by the FPHCP that are occupied by the Salish and longnose suckers will receive most of the potentially available shade. Along Type Np streams, reductions in shade are likely to occur and water temperature may increase over limited distances as a result of these unbuffered Type Np streams. In some cases, increases in temperature may be delivered downstream to Type F waters and temperatures could be warmed near the confluence of Type Np and F streams. There are situations (yarding corridors, stream-adjacent parallel roads, 20 acre exemptions, and windthrow) where stream shading will be reduced from full ecological potential and in some circumstances there may be adverse effects to the Salish and longnose suckers due to elevated stream temperatures and the behavior and survival of individual fish may be affected. However, under most timber harvest scenarios, adequate levels of shade are expected for the conservation of the suckers.

Sediment effects to Salish and longnose suckers

Sediment would be delivered to Salish and longnose suckers habitat from road surface erosion and, to a lesser extent, from hillslope erosion. The FPHCP's incorporation of BMPs and RMAPs would substantially reduce delivery of road surface related sediment to Salish and longnose suckers habitats, but it would not prevent all sediment from reaching aquatic habitats occupied by the species. Certain watershed features and road related activities may contribute sediment to fish-bearing streams that are above natural background rates. For example, culvert projects may increase siltation until vegetation has recovered to reduce harmful sediment. Juvenile Salish and longnose suckers habitat includes shallow pools with large substrate such as cobble and boulders. Excessive siltation may reduce the availability of this habitat and and may affect food resources (algae, diatoms, and aquatic insects) of Salish and longnose suckers. When feeding behavior is altered by reduced prey, individual fitness and survival could be affected. However the FPHCP is not expected to contribute to instream sediment loading to the point that Salish and longnose suckers would be harmed at more than at a stream reach scale.

Effects from the 20-acre Exemption Rule

Although there is uncertainty regarding how often this rule would be implemented, when it is implemented the 20-acre Exemption Rule would likely adversely affect Salish and longnose suckers. In watersheds with a high proportion of 20-acre exempt landowners, this rule would increase the likelihood that large wood recruitment would be inadequate to maintain properly functioning habitat (USFWS & NMFS 2006). There is also the potential for increased sedimentation, reduced shade, increased stream temperatures, and increased windthrow. Where these adverse effects occur, essential behaviors associated with foraging, reproduction and growth may be impeded, and Salish and longnose suckers may occupy the stream at reduced levels and they may have reduced survival.

Summary of adverse effects to Salish and longnose suckers

The proposed action would have short- to long-term adverse effects on sediment, large wood, and temperature. These effects would be most severe from unbuffered Type Np streams and their downstream effects that result in disruption of natural riparian and aquatic processes and functions in Type F streams. These effects to the aquatic environment may result in impairment of essential foraging, rearing, and spawning behavior of Salish and longnose suckers. It is difficult to predict the severity of these effects because little is know about Salish and longnose suckers habitat requirements and effects to these fish will vary from activity to activity depending on the specific riparian prescriptions applied, the location, historical management practices, geological characteristics of the watershed, and the biotic community present.

Activities covered under the FPHCP are expected to have direct and indirect adverse effects to adult and juvenile Salish and longnose suckers ranging from mortality to sublethal effects. Direct injury and death to Salish and longnose suckers would likely occur during some stream crossing construction activities (stream dewatering, fish rescue and relocation, and blockage of upstream migration during construction). Increased sediment levels could reduce available habitat and prey items for Salish and longnose suckers. This could affect the growth and survival of juvenile and adult Salish and longnose suckers.

Summary of beneficial effects

The long-term benefits of the FPHCP are expected to outweigh the short-term, negative affects to Salish and longnose suckers. The severity of individual effects to Salish and longnose suckers will vary from activity to activity depending on the specific riparian prescriptions, location, past management practices, geological characteristics of the watershed, and the biotic community present. However, maturation of riparian areas, maintaining and restoring passage for Salish and longnose suckers, adaptive management, and improved road management practices are all expected from implementation of the FPHCP. These management prescriptions are expected to contribute to long-term survival for Salish and longnose suckers in the FPHCP Action Area.

8.5.17.4 CUMULATIVE EFFECTS

Cumulative effects were addressed in the **Comprehensive Cumulative Effects** section, with respect to the aquatic and riparian environment in Washington State. Additional information regarding cumulative effects for the Salish and longnose sucker was presented in the sections **Lentic, Mainstem and Low-Gradient Tributary Guilds: Cumulative Effects.**

No additional information is available with respect to cumulative effects for this particular species above those cumulative effects already discussed earlier in this document.

8.5.18 Bridgelip Sucker (*Catostomus columbianus*) and Mountain Sucker (*Catostomus platyrhynchus*)

8.5.18.1 Status of the Species

Description of the Species

Mountain sucker

The mountain sucker is a relatively small member of the sucker family. It has a short head with a subterminal mouth. The mouth is characterized by fleshy protrusible lips with numerous large papillae on the lower lip, while the upper lip has very few to no papillae. The mouth has deep lateral notches at the juncture of the upper and lower lips and a shallow cleft in the middle of the lower lip. The lower lip has two semicircular bare areas with round cartilaginous plates. The color of the mountain sucker is usually brown to olive-green along the dorsal surface and sides becoming white to yellow ventrally.

Bridgelip sucker

The bridgelip sucker is similar to the mountain sucker. It also has a subterminal mouth with fleshy protrusible lips. There are weak notches at the corners of the mouth rather than the deep lateral notches of the mountain sucker. The upper and lower lips both have numerous papillae. The lower lip is also not completely cleft. The color of the bridgelip is a dark brown to olive along its dorsal surface. The sides are somewhat mottled and paler brown becoming white or pale yellow on its belly. The male will often have a prominent orange lateral band along its side, especially during breeding season.

Historic and Current Range

Both the mountain and bridgelip sucker's historic range is unknown at this time. Currently they are both found mainly within the Columbia River system (Wydoski and Whitney 2003). The Mountain sucker occurs in the Black Hills of South Dakota, Idaho, Nevada and several other western states. The mountain sucker occupies the lower and mid Columbia River. It has also been found in the Cowlitz, Yakima and the Wentachee Rivers. It also occupies the Snake and Palouse Rivers.

The bridgelip sucker's range includes the lower, mid, and upper Columbia River and a majority of its tributaries (Wydoski and Whitney 2003). It has been found in the Cowlitz, Yakima, Snake, Wenatchee, Okanogan, Spokane and Walla Walla Rivers.

Essential Habitat Components

Mountain sucker

Mountain suckers are primarily found in mountain streams less than 12-meters wide with clear, cold water, and moderate gradients (Wydoski and Whitney 2003; Moyle 2002). They are also sometimes found in lakes, reservoirs and large rivers (Wydoski and Whitney 2003). They have been found in water temperatures from 13 to 21°C with a max of 27.8°C during the summer (Wydoski and Whitney 2003). They generally prefer streams that contain a mix of gravel, sand, and rubble, or large boulder substrate (Wydoski and Whitney 2003; Moyle 2002). They often seek out pools with dense cover elements such as large wood and undercut banks (Moyle 2002). In swift water they will occupy areas behind large rocks or logs (Moyle 2002; Hauser 1969). Young mountain suckers are generally found in shallow water with slow to moderate currents and ample cover elements such as aquatic vegetation, logs, undercut banks and

rocks (Wydoski and Whitney 2003). They are sometimes found in intermittent side channels with very little flow and shallow depths (Hauser 1969). They will also seek out areas that have heavy algal growth in which to hide from predators (Sigler 1987). Older juvenile mountain suckers tend to occupy areas adjacent to pools (Wydoski and Whitney 2003). Adult mountain suckers are often found at the margins of runs and will move into deeper water if disturbed (Hauser 1969). Mountain suckers will also segregate from other catostomids forming small isolated schools (Moyle 2002; Scott and Crossman 1979). Mountain suckers eat a variety of diatoms, algae and aquatic insects. Juveniles generally eat more aquatic insects. Adults will seek out deep water habitats, such as pools, to overwinter in (Wydoski and Whitney 2003), and during the spring and early winter adults are usually found adjacent to pools (Hauser 1969).

Bridgelip sucker

Bridgelip suckers occupy small cold streams and large river habitats. Bridgelip sucker fry are found in inshore areas off the main river current and large young-of-the-year suckers occupy shallow pools with mixed mud and rock substrate (Dauble 1980). Adults and sub-adults tend to occupy the tails-outs of pools, at the ends of riffles and above large boulders (Dauble 1980). Bridgelip suckers are often in deep, swifter water during the day and move into slower shallower waters near shore at night (Wydoski and Whitney 2003). Bridgelip suckers are also common in backwater pools (Wydoski and Whitney 2003).

Reproductive Ecology

Mountain suckers spawn in small streams in riffles below pools from June to July in water temperatures from 11 to 19°C (Wydoski and Whitney 2003; Moyle 2002). Females mature at age three and males mature at age two (Wydoski and Whitney 2003). Males are distinguished from females by secondary sexual characteristics such as enlarged anal fin with large, pointed, cone-shaped tubercles, while the anal fin of the female is small and has medium-sized tubercles (Hauser 1969). Females are also larger and live longer than males (Moyle 2002). During spawning, males outnumber the females. Eggs are sticky and are deposited on the gravel (Moyle 2002). Females will then leave the spawning area after laying all their eggs, while the male remains to spawn multiple times (Wydoski and Whitney 2003).

The bridgelip sucker spawns in mid April to mid June with the peak spawning in May in water temperatures between 8 and 13°C (Dauble 1980). Female bridgelip suckers seek out substrate composed of pebbles, gravel, cobble and sand, and construct a redd in flowing water (Wydoski and Whitney 2003). Eggs are deposited in the redd and covered with the surrounding substrate by the female. There can be a 50 percent post spawning mortality in bridgelip suckers (Wydoski and Whitney 2003).

Movements and Habitat Use

Very little is known about the movements and habitat use of the mountain and bridgelip suckers. Both species are known to migrate or move to spawning areas (Wydoski and Whitney 2003; Dauble 1980; Moyle 2002), but it is unclear to what extent. It is know that the mountain sucker will move to and overwinter in areas of deep water and then move from these areas in the spring (Wydoski and Whitney 2003; Hauser 1969). The bridgelip sucker is also known to move from larger rivers into smaller tributaries to spawn and then back again (Wydoski and Whitney 2003). The literature suggests that spawning and locating overwintering habitat is an important factor in determining the extent of movement for both species, however the extent is still unknown.

Threats to Survival

In Washington, the mountain sucker is currently listed as a "state candidate" species listed in 1998 due to its unknown distribution and population status (Wydoski and Whitney 2003). In other western states such as California and Wyoming, the mountain sucker has had a reduction in their historic range. This reduction in the population is due to several commonly cited factors. There has been a loss of essential spawning habitat in streams above reservoirs, degradation of habitat associated with irrigation practices, degradation and loss of riparian habitats, and competition and predation by non-native species (Wydoski and Whitney 2003).

The bridgelip sucker is currently not listed on either State or Federal lists. Its population is somewhat unknown but seems to be abundant throughout its range.

8.5.18.2 ENVIRONMENTAL BASELINE (within the FPHCP Action Area)

Mountain suckers are found in the Columbia River basin in clear, cold water of mountain streams, generally less than 40 feet wide (Wydoski and Whitney 2003). The types of habitats that the mountain sucker are associated with are found in the FPHCP Action Area. Population trends for the species within the FPHCP Action Area are currently unknown at this time.

In Washington, bridgelip suckers are found in tributaries in the upper and mid Columbia River basin (Wydoski and Whitney 2003). The bridgelip sucker is more common than the mountain sucker, and in Oregon, is considered a habitat "generalist". The bridgelip sucker has a broader distribution in Washington than the mountain sucker. It is expected to occur within the FPHCP Action Area. It is considered common in the Yakima River (Wydoski and Whitney 2003). Population trends for the bridgelip sucker in the FPHCP Action Area are currently unknown at this time.

Role of FPHCP Action Area in Conservation of species:

The mountain and bridgelip sucker occur in the FPHCP Action Area. Suitable habitat occurs for both species in the FPHCP Action Area. The FPHCP Action Area provides an important role for conservation for these two species.

8.5.18.3 EFFECTS OF THE ACTION

General habitat effects for the mountain sucker as a result of the proposed action have been summarized above for the Low-Gradient Tributary Guild, but this species is also found in habitat similar to that described for the Mainstem and Steep Guilds. The effects to the bridgelip sucker were described above for the Mainstem Habitat Association, but this species may also be affected as described for the Low-Gradient Tributary Guild.

Riparian prescription effects to mountain and bridgelip suckers

Full riparian and in-stream function likely would not be provided to all habitats occupied by mountain and bridgelip suckers. In some stream reaches, the highest quality and most structurally complex habitats may fail to develop due to the potential reduction of large wood recruitment to streams following different riparian management prescriptions. The mountain and bridgelip suckers prefer streams that contain a mix of gravel, sand, and rubble, or large boulder substrate and often seek out pools with dense cover elements such as large wood and undercut banks. Young mountain suckers are generally found in shallow water with slow to moderate currents and ample cover elements such as aquatic vegetation, logs, undercut banks

and rocks (Wydoski and Whitney 2003). Adult mountain sucker have been reported to use deep pools in winter and smaller fish are observed near obstructions such as logs. Large wood in freshwater habitats is important for storing and releasing the appropriate sediment for development of suitable substrate, pool formation, providing cover, aquatic plant growth, and macroinvertebrate production. Reductions in large wood recruitment to streams may result in habitat modifications that increase risk of predation, reduce forage, and reduce the survival or fitness of individual suckers.

Bridgelip and mountain sucker require cool water for survival. The mountain sucker is associated with cool water of mountain streams and preferred summer temperatures are between 55 and 70° F. Bridgelip suckers have been reported spawning in April and May in 46 to 55 ° F temperatures. When RMZs achieve their Desired Future Condition, streams within the areas covered by the FPHCP that are occupied by the mountain and bridgelip suckers will receive most of the potentially available shade. Along Type Np streams, reductions in shade are likely to occur and water temperature may increase over limited distances as a result of the unbuffered Type Np stream reaches. In some cases, increases in temperature may be delivered downstream to Type F waters and temperatures could be warmed near the confluence of Type Np and F streams. There are situations (yarding corridors, stream-adjacent parallel roads, 20-acre exemptions, and windthrow) where stream shading will be reduced from full ecological potential. In some circumstances there may be adverse effects to the mountain and bridgelip suckers due to elevated stream temperatures and the behavior and survival of individual fish may be affected. Water temperature increases may be a factor in inter-specific competition, and abundance of these sucker species could be reduced in some cases.

Sediment effects to mountain and bridgelip suckers

Sediment would be delivered to mountain and bridgelip sucker habitat from road surface erosion and, to a lesser extent, from hillslope erosion. The FPHCP's incorporation of BMPs and RMAPs would substantially reduce delivery of road surface related sediment to the suckers habitats, but it would not prevent all sediment from reaching aquatic habitats occupied by these species. Certain watershed features and road related activities may contribute sediment to fish-bearing streams that are above natural background rates. For example, culvert projects may increase siltation until vegetation has recovered to reduce harmful sediment. Juvenile mountain and bridgelip sucker habitat includes shallow pools with large substrate such as cobble and boulders. Excessive siltation may reduce the availability of this habitat and and may affect food resources (algae, diatoms, and aquatic insects) of the suckers. When feeding behavior is altered by reduced prey, individual fitness and survival could be affected. However, the FPHCP is not expected to contribute to instream sediment loading to the point that mountain and bridgelip suckers would be harmed at more than at a stream reach scale.

Effects from the 20-acre Exemption Rule

Although there is uncertainty regarding how often this rule would be implemented, when it is implemented the 20-acre Exemption Rule would likely adversely affect mountain and bridgelip suckers. In watersheds with a high proportion of 20-acre exempt landowners, this rule would increase the likelihood that large wood recruitment would be inadequate to maintain properly functioning habitat (USFWS & NMFS 2006). There is also the potential for increased sedimentation, reduced shade, increased stream temperatures, and increased windthrow. Where these adverse effects occur, essential behaviors associated with foraging, reproduction and growth may be impeded, and mountain and bridgelip suckers may occupy the stream at reduced levels and they may have reduced survival.

Summary of adverse effects to mountain and bridgelip suckers

The proposed action would have short- to long-term adverse effects on sediment, large wood, and temperature. These effects would be most severe from unbuffered Type Np streams and their downstream effects that result in disruption of natural riparian and aquatic processes and functions in Type F streams. These effects to the aquatic environment may result in impairment of essential foraging, rearing, and spawning behavior of mountain and bridgelip suckers. Feeding behavior may be altered under some circumstances affecting individual fitness and survival. Pool depth could be reduced, modifying habitat use and ultimately survival. It is difficult to predict the severity of these effects because effects to these fish will vary from activity to activity depending on the specific riparian prescriptions applied, the location, historical management practices, geological characteristics of the watershed, and the biotic community present.

Activities covered under the FPHCP are expected to have direct and indirect adverse effects to adult and juvenile mountain and bridgelip suckers ranging from mortality to sublethal effects. Direct injury and death to suckers would likely occur during some stream crossing construction activities (stream dewatering, fish rescue and relocation, and blockage of upstream migration during construction). Increased sediment levels could reduce available habitat and prey items for mountain and bridgelip suckers. This could affect the growth and survival of juvenile and adult mountain and bridgelip suckers.

Summary of beneficial effects

The long-term benefits of the FPHCP are expected to outweigh the short-term, negative affects to mountain and bridgelip suckers. The severity of individual effects to these suckers will vary from action to action depending on the specific riparian prescriptions, location, past management practices, geological characteristics of the watershed, and the biotic community present. However, maturation of riparian areas, maintaining and restoring passage for mountain and bridgelip suckers, adaptive management, and improved road management practices are all expected from implementation of the FPHCP. These management prescriptions are expected to contribute to long-term survival for mountain and bridgelip suckers in the FPHCP Action Area.

8.5.18.4 CUMULATIVE EFFECTS

Cumulative effects were addressed in the **Comprehensive Cumulative Effects** section, with respect to the aquatic and riparian environment in Washington State. Additional information regarding cumulative effects for the mountain sucker was presented in the section **Low-Gradient Tributary Guild: Cumulative Effects.** Additional information regarding cumulative effects for the bridgelip sucker was presented in the section **Mainstem Guild.**

However, external factors related to global climate change may begin to pose an increasing threat to mountain sucker populations over the next century. Because the temperatures of small mountain streams are affected most strongly by air temperatures, projected global warming could have a profound effect on the distribution of many aquatic species (Issak 2003), including the mountain sucker.

8.5.19 Three-spine stickleback (*Gasterosteus aculeatus*)

8.5.19.1 Status of the Species

Description of Species

One of the most widespread fishes of the world (Wydoski and Whitney 2003), three-spine sticklebacks in Washington are considered abundant throughout their range. They tend to disappear from streams, ponds, lakes, estuaries, wetlands, and rivers that are heavily altered or polluted, or that have been subject to introductions of non-native predatory fish (Moyle 2002).

The three-spine stickleback is a small (average length 50 millimeters), laterally compressed, spindle-shaped fish with several bony plates along the side of its body. It has three prominent and separated spines on its back and sharp pelvic fins which are modified into spines. It has a narrow caudle peduncle, large eyes, and a terminal mouth that slants upward. There are two forms of the three-spine stickleback, an anadromous and freshwater form. The color of the three-spine stickleback can be variable given location. The fresh water form is usually olive to dark green on its back and sides, and has white or golden bellies. During breeding, males usually have blue sides and bright red bellies which extend to the underside of its head. They will also have iridescent blue or green eyes. Females, during breeding, are a pale green or brown along their backs and sides with silvery bellies.

Historic and Current Range

Within Washington State, the three-spine stickleback is found in inland lakes, streams, rivers, bays, ponds, and tidal marshes. It is also found throughout much of the Columbia River drainage and its tributaries up to and including Lake Chelan (Wydoski and Whitney 2003). The most-eastern location occurs in Lake McCoy, which is close to the confluence of the Spokane River with the Columbia River (Wydoski and Whitney 2003). It is also found throughout the Puget Sound drainage, the Chehalis River drainage, along the coast, and the Strait of Juan de Fuca. However, it is absent from the eastern section (Hood Canal) of the Olympic Peninsula (Wydoski and Whitney 2003).

Essential Habitat Components

The three-spine stickleback is a weak swimmer. It inhabits ponds, lakes, and sheltered coastal bays. In streams and rivers, it seeks shallow, weedy pools, and backwaters with little to no flow (Moyle 2002, Wydoski and Whitney 2003). They also occupy areas along the edges of streams and rivers where emergent plants are located and the current is slow. The substrates of these habitats are usually characterized by gravel, sand, and mud (Moyle 2002). Three-spine sticklebacks are visual feeders and require clean, clear water to locate prey, which are various forms of invertebrates. They feed on organisms living on the bottom, in aquatic vegetation, or floating on or near the surface, and will eat almost any type of insect. In the marine environment, the species occurs in the Pacific Ocean, Puget Sound, and brackish waters of coastal streams (Wydoski and Whitney 2003).

Reproductive Ecology

Three-spine sticklebacks spawn in fresh water that has shallow, weedy areas and sandy substrates. The marine form moves into shallow regions of estuaries before it moves into fresh water. Males develop breeding colors shortly before spawning. Spawning begins in May and goes to July and sometimes into August. The marine form begins spawning in early June (Wydoski and Whitney 2003). The male stickleback sets up a territory close to aquatic vegetation that he uses to construct a nest. The nest is in

the shape of a ball with a tunnel through the middle. The nest is kept together by glue-like kidney secretions. Nests are usually 15 to 40 centimeters apart. The male then entices a passing female into the nest to lay her eggs. The freshwater form can lay 100 to 150 eggs, while the marine form can lay 250 to 350 in the nest (Wydoski and Whitney 2003). The male then swims in the nest and fertilizes the eggs. The females usually die a short time after spawning. The male then guards the nest from predators and incubates the eggs by fanning water through the nest with its fins. The eggs hatch in about 7 days at 18°C (Wydoski and Whitney 2003). The fry will remain in the nest for a couple of days while the male guards them. The fry exhibit rapid growth during their first year that slows in their second year (Scott and Crossman 1973). Sexual maturity is reach during their first year. Most males die after defending the young, however some do spawn again in their second year. They can live a maximum of 4 years, however, in Washington, 90 percent only live one year, and the remainder a second year (Wydoski and Whitney 2003).

Movements and Habitat Use

The three-spine stickleback has two basic forms, the marine and the freshwater form. The marine form migrates into freshwater to spawn, but the extent of this migration is unknown. Since sticklebacks are poor swimmers, they can be easily displaced during high waterflows. During such events, they will often move into the slow-water areas of the flood plain to take refuge. When the waters subside, the fish will then move back into their original habitats (Wydoski and Whitney 2003).

Threats to Species

Stickleback appears to be abundant within the FPHCP Action Area. However, the species disappeared quickly after brown bullhead were introduced into lakes on Vancouver Island and in the Frasier valley (Wydoski and Whitney 2003).

8.5.19.2 ENVIRONMENTAL BASELINE (within the FPHCP Action Area)

The three-spine stickleback has a broad distribution in North America. In Washington, three-spine stickleback are found in inland lakes, streams, rivers, bays, ponds, and tidal marshes. It is also found through much of the Columbia River drainage and its tributaries up to and including Lake Chelan (Wydoski and Whitney 2003).

Detailed population data for the species in Washington is unavailable. However, the species is broadly distributed in various habitat types (marine, estuaries, slow moving streams, lakes, and wetlands) across the FPHCP Action Area.

Role of the FPHCP Action Area for Conservation of the Species

The FPHCP Action Area provides suitable habitat for three-spine stickleback. The FPHCP Action Area will contribute to the long-term conservation of the species.

8.5.19.3 EFFECTS OF THE ACTION

General habitat effects to the three-spine stickleback resulting from the proposed action have been summarized above for the Lentic Guild and the nearshore habitat association. The area also found in habitat represented by the Low-Gradient Guild.

Riparian prescription effects to three-spine stickleback

Full riparian and in-stream function likely would not be provided to all habitats occupied by three-spine stickleback. Large wood in freshwater habitats is important for storing and releasing the appropriate sediment to develop and provide suitable substrate, pool formation, instream cover, aquatic plant growth, and macroinvertebrate production. Reductions in large wood recruitment to streams may result in habitat modifications that increase risk of predation, reduce forage, and reduce the survival or fitness of individual three-spine stickleback. Three spine stickleback are visual feeders and require clean, clear water to locate prey, which are various forms of invertebrates.

Sediment effects to three-spine stickleback

Sediment would be delivered to three-spine stickleback habitat from road surface erosion and, to a lesser extent, from hillslope erosion. The FPHCP's incorporation of BMPs and RMAPs would substantially reduce delivery of road surface related sediment to three-spine stickleback habitat, but it would not prevent all sediment from reaching aquatic habitats occupied by the species. Certain watershed features and road related activities may contribute sediment to fish-bearing streams that are above natural background rates. For example, culvert projects may increase siltation until vegetation has recovered to reduce harmful sediment. Excessive sedimentation may increase turbidity and since three-spine sticklebacks are visual feeders their ability to locate food resources may be affected. When feeding behavior is altered, individual fitness and survival could be affected. However the FPHCP is not expected to contribute to instream sediment loading to the point that three-spine sticklebacks would be harmed at more than a stream reach scale.

Effects from the 20-acre Exemption Rule

Although there is uncertainty regarding how often this rule would be implemented, when it is implemented the 20-acre Exemption Rule would likely adversely affect three-spine sticklebacks. In watersheds with a high proportion of 20-acre exempt landowners, this rule would increase the likelihood that large wood recruitment would be inadequate to maintain properly functioning habitat (USFWS & NMFS 2006). There is also the potential for increased sedimentation. Where these adverse effects occur, essential behaviors associated with foraging, and growth may be impeded, and three-spine sticklebacks may occupy the stream at reduced levels.

Summary of adverse effects to three-spine sticklebacks

The proposed action would have short- to long-term adverse effects on sediment, large wood, and temperature. These effects would be most severe from unbuffered Type Np streams and their downstream effects that result in disruption of natural riparian and aquatic processes and functions in Type F streams. These effects to the aquatic environment may result in impairment of essential foraging behavior of three-spine sticklebacks, which may affect individual fitness and survival. It is difficult to predict the severity of these effects because effects to these fish will vary from activity to activity depending on the specific riparian prescriptions applied, the location, historical management practices, geological characteristics of the watershed, and the biotic community present.

Activities covered under the FPHCP are expected to have direct and indirect adverse effects to adult and juvenile three-spine sticklebacks ranging from mortality to sublethal effects. Direct injury and death to three-spine sticklebacks would likely occur during some stream crossing construction activities (stream dewatering, fish rescue and relocation, and blockage of upstream migration during construction).

Increased sediment levels could reduce available habitat, foraging ability, and prey items for three-spine sticklebacks. This could affect the growth and survival of juvenile and adult three-spine sticklebacks.

Summary of beneficial effects

The long-term benefits of the FPHCP are expected to outweigh the short-term, negative affects to three-spine sticklebacks. The severity of individual effects to three-spine sticklebacks will vary from activity to activity depending on the specific riparian prescriptions, location, past management practices, geological characteristics of the watershed, and the biotic community present. However, maturation of riparian areas, maintaining and restoring passage for three-spine sticklebacks, adaptive management, and improved road management practices are all expected from implementation of the FPHCP. These management prescriptions are expected to contribute to long-term survival for three-spine sticklebacks in the FPHCP Action Area.

8.5.19.4 CUMULATIVE EFFECTS

Cumulative effects were addressed in the Comprehensive Cumulative Effects section, with respect to the aquatic and riparian environment in Washington State.

No additional information is available with respect to cumulative effects for this particular species above those cumulative effects already discussed earlier in this document.

8.5.20 Sand Roller (Percopsis transmontana)

8.5.20.1 Status of the Species

Description of the Species

The sand roller is one of two species of the family Percopsidae found only in the Columbia River system. It is a small fish less than 127mm with a relatively large head and a small ventral mouth adapted for bottom feeding (Scott and Crossman 1973). Their body is thicker toward the front then tapering to a narrow caudle peduncle after the dorsal fin. Their fins are relatively small with a distinct forked caudle fin. Sand rollers also have a small opaque adipose fin. They are very cryptic in coloration. They have spots in the margins of their caudle fins and males can turn very dark in coloration during mating season. Overall they have a mottled look with a small lighter underside sometimes a whitish-yellow.

Historical and Current Range

Information on the historic range of the sand roller is unknown at this time. The sand roller is endemic to the Columbia River system below Crescent Bar, which is about 37km upstream from the I-90 bridge (Wydoski and Whitney 2003). It has been collected from the Columbia, Yakima, Cowlitz and the Snake Rivers (Wydoski and Whitney 2003). Sand rollers seem to be more common in the lower Columbia River downstream of the John Day Reservoir (Wydoski and Whitney 2003).

Essential Habitat Components

Little is known about the sand rollers behavior and habitat. Sand rollers are known to inhabit quiet backwater and off channel areas of rivers and large streams (Wydoski and Whitney 2003). They prefer quiet areas that have lots of cover such as undercut banks, tree roots, and small debris jams (Wydoski and Whitney 2003). Substrate is usually a mix of sand and cobble, or large gravel. During the day they

remain hidden within the various cover types. At night, sand rollers will move out onto the sandy substrate areas, and have been observed in shallow sand depressions at depths of 4 meters (Gray and Dauble 1976). Sand rollers have been found in water temperatures from 2.5 to 20.5°C and as deep as 21.7 meters (Gray and Dauble 1976; Wydoski and Whitney 2003).

Reproductive Ecology

Information on the reproductive ecology of sand rollers is limited. Sand rollers mature between ages two to three (Wydoski and Whitney 2003). In the Columbia River, they begin spawning in June and finish in mid July (Wydoski and Whitney 2003). Spawning most likely takes place over sandy gravel substrates when water temperatures are between 14 and 16°C (Gray and Dauble 1976). Sand rollers are also thought to spawn in the reservoirs of the Columbia River (Wydoski and Whitney 2003). Sand rollers in the Snake River in Idaho are thought to spawn in small tributaries streams and then return to larger rivers (Wydoski and Whitney 2003). Emergent fry are between 15 and 18 millimeters and have been collected in mid-August (Gray and Dauble 1976).

Movements and Habitat Use

Little is known about the movements of sand rollers. They are believed to undertake migrations for spawning, moving from larger streams or rivers into smaller tributaries for spawning (Wydoski and Whitney 2003). Sand rollers are known to have diel movements when feeding from daytime cover to open areas of sand or gravel in the tail-out of pools or riffles at night, or move from deeper water in the daytime to shallow areas in search of food at night (Wydoski and Whitney 2003).

Threats to Survival

Little information exists on the current and historic population status of the sand roller. In the Columbia River non-native species (Walleye, smallmouth bass, and catfish) have been documented to prey on sand rollers (Lee et al. 1997). Between 1987 and 1991 sand roller numbers were estimated to be approximately 3,000 fish per square mile in the Columbia River (Wydoski and Whitney 2003). A potential factor influencing sand roller abundance may be stream cover. Studies on the Yakima River by Patten et al. (1970) found sand roller to be absent from sites that once harbored sand roller. The cause was discovered to be that low flows had exposed the cover used by sand roller, such as undercut banks and tree roots. The small sand roller is dependent upon adequate cover elements to escape from predators during the day. They also appear to use cover for their territories (Wydoski and Whitney 2003). Eliminating these cover elements may affect the abundance of sand roller, both due to their territorial nature and the need for cover as protection from predators. Instream cover (LWD, boulders) may be an important habitat component for this species in the Columbia River and the small tributaries the species uses.

8.5.20.2 ENVIRONMENTAL BASELINE (within the FPHCP Action Area)

The sand roller occurs in the Columbia River to depths of 71 feet (Wydoski and Whitney 2003). It also occurs in small streams associated with tree roots and debris and without this cover it may be prone to predation (Wydoski and Whitney 2003).

Population trends are unknown for the species in the Washington. Sand roller are common in the Columbia River downstream of the John Day Reservoir but are less abundant upstream (Wydoski and Whitney 2003). Sand roller density has been shown to be quite variable. For example, in the Dalles pool

of the Columbia River sand roller densities ranged between 10 and 15 fish per square mile during 1988 – 1991 and between 400 to 3,000 fish per square mile from 1989 -1991 for the John Day pool (Wydoski and Whitney 2003). The reason for this variation is unknown.

Role of FPHCP Action Area in Conservation of species:

The FPHCP Action Area appears to be important for the long-term conservation of the species. Although it is highly likely that many of the streams it occupies will not be directly influenced by forest practices, there will be some places it is subject to the proposed action.

8.5.20.3 EFFECTS OF THE ACTION

General habitat effects to the sand roller resulting from the proposed action have been summarized above for the River System and Low gradient Tributary Guilds.

Riparian prescription effects to Sand roller

Full riparian and in-stream function likely would not be provided to all habitats occupied by sand roller. In some stream reaches, the highest quality and most structurally complex habitats may fail to develop due to the potential reduction of large wood recruitment to streams following different riparian management prescriptions. Sand rollers prefer quiet areas that have lots of cover such as undercut banks, tree roots, and small debris jams, and during the day they remain hidden within the various cover types(Wydoski and Whitney 2003). Large wood in freshwater habitats is important for storing and releasing the appropriate sediment for development of suitable substrate, pool formation, providing cover, aquatic plant growth, and macroinvertebrate production. Reductions in large wood recruitment to streams may result in habitat modifications that increase risk of predation, reduce forage, and reduce the survival or fitness of individual sand rollers.

When RMZs achieve their Desired Future Condition, streams within the areas covered by the FPHCP that are occupied by the sand roller will receive most of the potentially available shade. Along Type Np streams, reductions in shade are likely to occur and water temperature may increase over limited distances as a result of the unbuffered Type Np stream reaches. In some cases, increases in temperature may be delivered downstream to Type F waters and temperatures could be warmed near the confluence of Type Np and F streams. There are situations (yarding corridors, stream-adjacent parallel roads, 20-acre exemptions, and windthrow) where stream shading will be reduced from full ecological potential and in some circumstances there may adverse effects to the sand roller due to elevated stream temperatures and the behavior and survival of individual fish may be affected. Water temperature increases may be a factor in inter-specific competition and abundance of the sand roller could be reduced in some cases.

Sediment effects to sand roller

Substrate used by the sand roller is usually a mix of sand and cobble, or large gravel. Sediment would be delivered to sand roller habitat from road surface erosion and, to a lesser extent, from hillslope erosion. The FPHCP's incorporation of BMPs and RMAPs would substantially reduce delivery of road surface related sediment to the sand roller habitat, but it would not prevent all sediment from reaching aquatic habitats occupied by the species. Certain watershed features and road related activities may contribute sediment to fish-bearing streams that are above natural background rates. For example, culvert projects may increase siltation until vegetation has recovered enough to reduce delivery of harmful sediment.

Excessive siltation may reduce the availability of this habitat and and may affect food resources. When feeding behavior is altered due to reduced prey, individual fitness and survival could be affected.

Effects from the 20-acre Exemption Rule

Although there is uncertainty regarding how often this rule would be implemented, when it is implemented the 20-acre Exemption Rule would likely adversely affect the sand roller. In watersheds with a high proportion of 20-acre exempt landowners, this rule would increase the likelihood that large wood recruitment would be inadequate to maintain properly functioning habitat (USFWS & NMFS 2006). There is also the potential for increased sedimentation, reduced shade, increased stream temperatures, and increased windthrow. Where these adverse effects occur, essential behaviors associated with foraging, reproduction and growth may be impeded, and sand roller may occupy the stream at reduced levels and they may have reduced survival.

Summary of adverse effects to sand roller

The proposed action would have short- to long-term adverse effects on sediment, large wood, and temperature. These effects would be most severe from unbuffered Type Np streams and their downstream effects that result in disruption of natural riparian and aquatic processes and functions in Type F streams. These effects to the aquatic environment may result in impairment of essential foraging, rearing, and spawning behavior of sand roller. Feeding behavior may be altered under some circumstances affecting individual fitness and survival. Available suitable substrate could be reduced, modifying habitat use and ultimately survival. It is difficult to predict the severity of these effects because effects to these fish will vary from activity to activity depending on the specific riparian prescriptions applied, the location, historical management practices, geological characteristics of the watershed, and the biotic community present. Many of the aquatic habitats the species resides in will see little to no effect from the proposed action.

Activities covered under the FPHCP are expected to have direct and indirect adverse effects to adult and juvenile sand roller ranging from mortality to sublethal effects. Direct injury and death to sand roller would likely occur during some stream crossing construction activities (stream dewatering, fish rescue and relocation, and blockage of upstream migration during construction). Increased sediment levels could reduce available habitat and prey items for sand roller. This could affect the growth and survival of individual juvenile and adult sand rollers.

Summary of beneficial effects

The long-term benefits of the FPHCP are expected to outweigh the short-term, negative affects to sand rollers. The severity of individual effects to sand rollers will vary from activity to activity depending on the specific riparian prescriptions, location, past management practices, geological characteristics of the watershed, and the biotic community present. However, maturation of riparian areas, maintaining and restoring passage for sand rollers, adaptive management, and improved road management practices are all expected from implementation of the FPHCP. These management prescriptions are expected to contribute to long-term survival for sand rollers in the FPHCP Action Area.

8.5.20.4 CUMULATIVE EFFECTS

Cumulative effects were addressed in the **Comprehensive Cumulative Effects** section, with respect to the aquatic and riparian environment in Washington State. Additional information regarding cumulative

effects for the covered fish species was presented in the section **River System and Low gradient Tributary Guilds: Cumulative Effects.**

No additional information is available with respect to cumulative effects for this particular species above those cumulative effects already discussed earlier in this document.

8.5.21 Native Sculpins (*Cottus spp.*)

Coastrange *C. aleuticus*
Reticulate *C. perplexus*
Riffle *C. gulosus*
Prickly *C. asper*
Shorthead *C. confusus*
Torrent *C. rhotheus*
Margined *C. marginatus*
Mottled *C. bairdi*
Paiute *C. beldingi*
Slimy *C. cognatus*

8.5.21.1 Status of the Species

Description of the Species

The sculpins are the most difficult species of freshwater fish to identify due to their small size and the great variation in morphological characteristics which tend to overlap throughout their family (Wydoski and Whitney 2003). In general, all have a rather large head and mouth with numerous small teeth. Their bodies taper from their head to the caudal peduncle, which may be narrow or thick at the connection of the caudal fin. There is an absence of true scales which makes their bodies smooth, but occasionally, as in the prickly sculpin, they may have rough patches of skin. The coloration of each species depends on physiological state, sexual maturation, and the general color of the substrate (Wydoski and Whitney 2003). Overall they are drab in color and variably mottled. Breeding males are often much darker than females, often having an entirely black body. They are very adapted to living life on the bottom of lakes, and streams due to the absence of an air bladder and dorsally set eyes. They have fanlike pectoral fins and long narrow pelvic fins located between the pectoral fins (Moyle 2002). They have two dorsal fins, the first is generally short in length with soft spines, and the second, is longer with rays (Moyle 2002).

Historical and Current Range

The current distributions of the 10 species of native sculpins are separated into three distinct groups: (1) the western Washington group has three species of sculpin, the coastrange, reticulate, and riffle; these species only occur west of the Cascade crest; (2) the east/west group contains the prickly, shorthead, and torrent sculpins that range on both sides of the Cascade Mountains; (3) the eastern Washington group that contains the margined, mottled, Paiute and slimy sculpins. These species only occur east of the Cascade Mountains.

Coastrange Sculpin: Is found along the entire Olympic Peninsula, throughout the Puget Sound and up the Columbia River to at least the Bonneville Dam (Wydoski and Whitney 2003).

Reticulate Sculpin: Is found in the Willapa Hills, along the southern and western boundaries of the Olympic Peninsula, the Cowlitz and Lewis Rivers, and as far north as the Green River, Washington, which is the limit of its most northern distribution (Wydoski and Whitney 2003).

Riffle Sculpin: Is found in coastal streams of the Willapa Hills northward along the western and northern slopes of the Olympic Mountains and in southern Puget Sound. It is generally uncommon in the Columbia River drainage, but it is found as far inland as the mouths of the Cowlitz and Kalama Rivers (Wydoski and Whitney 2003).

Prickly Sculpin: Is found throughout the Olympic Peninsula, Willapa Hills, and Puget Sound. It also is found throughout the Columbia River, Okanogan River, and Crab Creek systems (Wydoski and Whitney 2003).

Shorthead Sculpin: Is found in Puget Sound and Columbia River drainages. It is known specifically to inhabit the Snoqualmie, Green, and Carbon River drainages, tributary streams of southern Hood Canal, Cedar, Issaquah and Swamp creeks of the Lake Washington drainage (McPhail 1967; Wydoski and Whitney 2003), and several rivers on the Olympic Peninsula. The northern range of the shorthead sculpin in Puget Sound stops abruptly at the Snohomish River, which is probably due to historic glaciation patterns (McPhail 1967).

Torrent Sculpin: Is found along the west slopes of the Olympic Mountain south along the west coast to the mouth and up the Columbia River. It is generally found south of the Skagit River throughout Puget Sound. It is also found in rivers and streams along the east slopes of the Cascade Mountains and in the northern tributaries of the Columbia and Spokane Rivers in northeastern Washington (Wydoski and Whitney 2003).

Margined Sculpin: The margined sculpin has the smallest range of any fish species in the state of Washington, and is confined only to the Tucannon and Walla Walla drainages (Mongillo and Hallock 1998).

Mottled Sculpin: Is found east of the Cascade Mountains in the Columbia, Snake, and Yakima River basins (Wydoski and Whitney 2003).

Piaute Sculpin: Is currently found only in the Yakima, Wenatchee, Walla Walla, and Tucannon Rivers (Wydoski and Whitney 2003).

Slimy Sculpin: Is currently restricted to Lake Chelan and tributaries of the upper Columbia River (the Kettle and Pend Oreille Rivers) (Wydoski and Whitney 2003).

Essential Habitat Components

Coastrange Sculpin: The coastrange sculpin is generally found in medium or large streams with a moderate to rapid current. Usually they inhabit areas with cobble or gravel substrates. In the Cedar River, coastrange sculpin less than 50 millimeters total length (TL) tended to inhabit gravel substrates, and larger fish tended to inhabit cobble substrates (Tabor et al. 1998). Coastrange sculpin also inhabit the shoreline and deeper benthic areas of lakes and are also occasionally found in estuaries. Generally, prickly sculpin inhabit pools and other slow-water habitat, and coastrange sculpin inhabit riffles. However, in upstream reaches where prickly sculpin does not exist, coastrange sculpin are found in both pools and riffles. Some researchers have suggested that coastrange sculpin may directly compete with juvenile coho salmon (*O. kisutch*) (Mason and Machodori 1976). In experimental troughs, Ringstad

(1974) found that at high stream densities, coastrange sculpin could reduce coho salmon growth. However, at natural stream densities, they did not limit juvenile coho salmon growth.

Also a dwarf, pelagic form of coastrange sculpin occurs in Lake Washington, Washington (Larson and Brown 1975), and Cultus Lake, British Columbia (Ricker 1960; Coffie 1998). These fish are morphologically different from coastrange sculpin.

Reticulate Sculpin: The reticulate sculpin is found in pools, riffles, and runs throughout its range. They generally prefer small, coastal headwater streams with slow currents (Moyle 2002). However, this may depend upon the presence or absence of other species of sculpin. Finger (1982) found that in Oregon streams, reticulate sculpin were found to inhabit both pools and riffles and have higher densities near cover. Where they co-existed with other species, they generally occupied pools and had lower densities (Finger 1982). On the Olympic Peninsula, reticulate sculpins were found to occupy 75 percent of pools, 30 percent of runs, and 10 percent of riffles in small coastal streams (Wydoski and Whitney 2003). They are found associated with all types of substrate, such as sand, gravel, boulders and rubble. They were found in water temperatures between 9 and 22°C with a maximum water temperature of 15°C (Mongillo and Hallock 1997). They are known to tolerate water temperatures as high as 30°C, but generally prefer summer temperatures less than 20°C (Moyle 2002). They occurred in streams from 5 to >100 meters wide, with gradient between 1.3 to 3.5 percent (Mongillo and Hallock 1997). Immature reticulate sculpins were often found in run habitats (Mongillo and Hallock 1997). Reticulate sculpins have also been know to tolerate salinities of about 18 parts per thousand, or about half that of pure seawater (Moyle 2002; Mongillo and Hallock 1997).

Riffle Sculpin: The riffle sculpin is commonly found in quiet waters and slow riffles of small streams and backwaters of large rivers. Riffle sculpin also inhabit ponds and small lakes. It prefers water temperatures < 16°C but survived temperatures up to 28°C in the laboratory (Wydoski and Whitney 2003). On the Olympic Peninsula, it was collected at an average elevation of 108 meters (range 11-494 meters), water temperature of 14.6^{o}C (range 11-21°C), and average gradient of 1.3 percent in streams ranging in width from 2.1 to greater than 100 meters (Mongillo and Hallock 1997). It is found in areas having a variety of substrates, but generally in those with sand or gravel bottoms (Wydoski and Whitney 2003). The spectrum of stream habitat riffle sculpin occupy is broadest when other sculpin species are absent (Moyle 2002).

Prickly Sculpin: The prickly sculpin is commonly found in lakes, ponds, and quiet waters of rivers. In Lake Washington, prickly sculpin inhabit all depths, from the shoreline to depths > 60 meters (E. Warner, Muckleshoot Indian Tribe, Personal Communication). Prickly sculpin typically only inhabit the lower reaches of most rivers. For example, in the Cedar River, prickly sculpin only inhabit the lower 9 kilometers (R. Tabor, USFWS, unpublished data). On the Olympic Peninsula, prickly sculpin were collected at an average elevation of 23 meters, the lowest average elevation of all cottid species (Mongillo and Hallock 1997). Prickly sculpin can also be abundant in estuaries, in salinities as high as 24 ppt. Prickly sculpin prefer water temperatures from 10-18°C, but they have been found in water as high as 28°C. However, Black (1953) found that temperatures of 23 to 27°C were lethal for prickly sculpin. In the Cedar River and along the shoreline of Lake Washington, large prickly sculpin (> 125 millimeters in total length) prefer boulder and large cobble substrate. Smaller sculpin tend to inhabit smaller substrates. In offshore benthic areas, large prickly sculpin inhabit open areas with fine sediment. During the day, prickly sculpin are found close to cover, while at night they move into more open areas. Prickly sculpin are more active at night.

Shorthead Sculpin: Shorthead sculpin commonly inhabit small, cool (less than 16°C), headwater streams (generally >450 meters elevation in western Oregon and >760 meters in eastern Oregon) (Wydoski and Whitney 2003), but may also be found in large rivers (e.g., Columbia River and Cedar River). Shorthead sculpin have been found in water temperature as high as 24 ^{o}C (Wydoski and Whitney 2003). In streams on the Olympic Peninsula, shorthead sculpin were observed in areas having an average stream gradient of 3.2 percent, elevation 369 meters (range 171-804 meters), and water temperature 13.2^{o}C (range10-17°C); (Mongillo and Hallock 1997).

Common habitat for shorthead sculpin are high gradient riffles with a rubble or gravel bottom (Wydoski and Whitney 2003), but are also frequently found in runs and pools, especially where other fishes are not present (Finger 1982; Mongillo and Hallock 1997). Above Cedar Falls on the Cedar River, shorthead sculpin are the only cottid present and they inhabit a wide variety of habitat types including the shoreline and deep benthic areas of Chester Morse Reservoir (R. Tabor, USFWS, unpublished data). Shorthead sculpin were collected in water as deep as 30 meters. Below Cedar Falls, shorthead sculpin coexist with four other species of cottids and appear to be spatially segregated. In this river reach, shorthead sculpin were primarily found in riffle habitat. They were rarely found in pool or shoreline habitats. In the Low gradient River in British Columbia, shorthead sculpin appear to be spatially segregated from slimy sculpin (*C. cognate*) (Hughes and Peden 1984). However, unlike in Washington, shorthead sculpin inhabit the downstream reaches of the Low gradient River. This is probably because slimy sculpin inhabit the coldest and most northerly locations of any North American cottid.

Torrent Sculpin: The torrent sculpin is found primarily in streams >2.5 meters, but it also occurs in lakes along the shoreline (Scott and Crossman 1973; Wydoski and Whitney 2003). In streams of the Olympic Peninsula, torrent sculpin were present in all of three habitat types sampled, but preferred riffles and runs over pools, and were observed in areas with stream gradients ranging from 0.1 to 3.5 percent, elevations 5-502 meters (average 100 meters), water temperatures 11-22°C (average 15.9°C), and stream widths 7.5-100.0 meters (Mongillo and Hallock 1997). The torrent sculpin was only found where rock was present in the Marys River, Oregon (Finger 1982).

Margined Sculpin: Preferred margined sculpin habitats include pools and slow moving glides in headwater tributaries at all seasons (Wydoski and Whitney 2003). They generally avoid habitats with high velocities. They are generally found where water temperatures are between 5 and 19°C, with a maximum water temperature of 24°C (Wydoski and Whitney 2003). Adults are often found in deeper and faster waters than juveniles over small gravel and silt substrates. They tend to avoid larger gravel, cobble or boulders. Margined sculpins can be found in streams between 6 and 18 meters wide (Wydoski and Whitney 2003). Overall, these types of habitat selections do not change over seasons (Mongillo and Hallock 1998).

Mottled Sculpin: Mottled sculpin occur in both streams and lakes. They are generally found in clear, cool mountain streams with fast to moderate currents (Sigler and Sigler 1987). They generally prefer coarse gravel, small loose rocks and rubble substrates and tend to avoid sand and silt (Sigler and Sigler 1987). However, when in the lake environment they are often found with sand, clay and mud substrates (Sigler and Sigler 1987; Scott and Crossman 1979). Mottled sculpin are often found where summer water temperatures are between 13 and 18°C, with a maximum temperature of 21.1°C (Sigler and Sigler 1987). They tend to occupy streams with depths of 0.60 meters or less (Sigler and Sigler 1987), but will move to deeper water during the winter (Wydoski and Whitney 2003). Mottled sculpin often use aquatic vegetation as cover along with large rocks. They also feed at night in open areas and return to this cover during the day to hide (Wydoski and Whitney 2003).

Piaute Sculpin: Piaute sculpin are found in both streams and lakes. They tend to prefer streams with slight to moderate gradient (<1.8 percent), wider than 6.1 meters (Wydoski and Whitney 2003), and are generally absent from high-gradient headwaters and low-gradient warm water streams (Moyle 2002). They prefer riffle habitats with rubble or large gravel substrates (Sigler and Sigler 1987), and water temperatures below 20°C. In Lake Tahoe, Paiute sculpin are associated with aquatic macrophyte beds in deep water and also shallow inshore areas (Moyle 2002). They generally are in waters less than 60 meters but have been found as deep as 210 meters (Moyle 2002). Paiute sculpins tend to avoid torrent sculpins if found in the same stream. Paiute sculpins will burrow into the gravel during the day to avoid torrent sculpins and emerge at night to feed (Wydoski and Whitney 2003). During the winter and spring months where water velocities are at there highest in Washington, Paiute sculpin will occupy the riffle habitats where as torrents will move into quieter waters (Wydoski and Whitney 2003).

Slimy Sculpin: There is little information on habitat requirements of the slimy sculpin. They are known to inhabit deep waters of lakes and rocky or gravelly portions of cool streams (Scott and Crossman 1973). When in streams they occupy shallow riffles. Slimy sculpin have been sampled from Lake Pend Oreille in Idaho at depths of 305 meters (Wydoski and Whitney 2003).

Reproductive Ecology

Coastrange Sculpin: In Oregon, coastrange sculpin spawn when they are three years old. In the Cedar River, sculpin less than 60 millimeters in total length have been observed with eggs, suggesting some fish may be sexually mature before age three. Spawning takes place in the spring, sometime between February and June. In Oregon, the peak spawning months are March and April (Bond 1963). Eggs are deposited under rocks and are adhesive, orange, and less than 1.5 millimeters in diameter. A male sculpin protects the nest and may spawn with several females. Egg counts in females range from 260 to 830, depending on the size of the fish. The larval coastrange sculpin are pelagic and do not become bottom-dwelling for 32-35 days after hatching (Scott and Crossman 1973).

Reticulate Sculpin: The reticulate sculpin matures at two years of age and spawns during the spring when water temperatures are in excess of 6 or 7°C (Moyle 2002). Reticulate sculpin spawn in riffles when other species of sculpin are absent or in slower-flowing areas when other species are present in riffles (Moyle 2002). Adhesive eggs are deposited under rocks and the male guards the nest until the eggs have hatched and the fry have left the area (Wydoski and Whitney 2003). Often male sculpins will spawn with more than one female as indicated by several clusters of eggs at various stages of development (Wydoski and Whitney 2003). The average number of eggs for a two year old female is 170 and 280 for a three year old (Wydoski and Whitney 2003). When the fry have hatched they remain close to the nest getting protection from the male sculpin. Only after leaving the nest do they begin a benthic existence.

Riffle Sculpin: The riffle sculpin matures at two years of age and spawns in late February, March and April, with nests made in rotting logs and under rocks in swift riffles (Millikan 1968; Moyle 2002). A male sculpin usually protects the nest. Eggs are 2.5 millimeters in diameter, adhesive and pale yellow to deep orange. Egg counts in females range from 100 to 450, depending on the size of the fish (Bond 1963; Millikan 1976). Moyle (1976) states that more than one female spawns in a nest, as egg counts in nests range from 460 to greater than 1,000. Eggs hatch in 11 to 24 days, depending on water temperature. In summer, juveniles grow about 5 millimeters per month, reaching 30 millimeters by the end of summer. A few weeks after hatching and attaining about 6 millimeters in total length, fry assume a benthic existence (Millikan 1968).

Prickly Sculpin: Some prickly sculpin become sexually mature at age 1 (12 percent in males, 50 percent in females) and by age 2 over 90 percent are sexually mature (Rickard 1980). Spawning takes place in the spring. In Washington, spawning usually occurs in April and May. In other parts of their range, spawning varies depending on latitude. Nests are usually under rocks or logs in areas with slow water velocities. A male sculpin protects the nest and may spawn with several females. Eggs are adhesive and slightly more than 1 millimeter in diameter. Egg counts in females range from 700 to 9,590, depending on the size of the fish (Kresja 1967a; Rickard 1980). Eggs hatch in 11 days at 15°C to 24 days at 10°C. After hatching, the young begin swimming at once and remain pelagic for 30 to 35 days. They may form large schools (Northcote and Hartman 1959). After the pelagic period, juvenile prickly sculpin settle to the bottom. In Lake Washington during their June transition phase from a pelagic to a benthic existence, they appear to be particularly vulnerable to predators, especially yellow perch (*Perca flavescens*) (Tabor and Chan 1996b).

Shorthead Sculpin: In general, shorthead sculpin will spawn during spring after maturing at age 2-3. Egg production in shorthead sculpin is considered low compared to other sculpin (Bond 1963). In Swamp and Boise Creeks, Washington, egg production was reported as 50 in a 60-millimeter female and 220 in a 75-millimeter and 85-millimeter female (Wydoski and Whitney 2003). Like Piute (*C. beldingi*) and torrent sculpin (*C. rhotheus*), shorthead sculpin probably spawn under stones in swift water. A few weeks after hatching, sculpin adapt a generally benthic lifestyle, which is maintained through the remainder of the fish's life history.

Torrent Sculpin: Little is known about the life cycle patterns of torrent sculpin. Wydoski and Whitney (2003) reported the following information on torrent sculpin spawning biology and behavior. Wydoski and Whitney (2003) state that torrent sculpin can reach a size of 150 millimeters in total length and live as long as six years. The torrent sculpin becomes sexually mature after reaching two years of age, and spawns in late spring under stones in swift water. In a tributary to the Columbia River, it was reported to migrate upstream in late January to late April, spawn and then move downstream in May and June. The number of eggs per female appears to vary, depending on locality. In the Yakima River, females of different ages produced 156 eggs at age two, 226 at age three, 221 at age four, and 370 at age five. In the Newaukum Creek, females produced 165 eggs at age two, 258 at age three, and 320 at age four.

Margined Sculpin: Currently there is little known about the breeding behavior of the margined sculpin. They are known to spawn in May and June when water temperatures are between 12.8 and 16.1°C (Mongillo and Hallock 1998). They seem to prefer pools, but will sometimes spawn in glides and low gradient riffles (Mongillo and Hallock 1998). Males undergo a darkening of their color often turning completely black at this time. Eggs are deposited under rocks like most sculpin species, and the male remains to guard the nest, often fanning the egg clusters with his caudal fin (Mongillo and Hallock 1998).

Mottled Sculpin: The mottled sculpin matures at two years of age (Wydoski and Whitney 2003). Male mottled sculpins will turn almost black in color and develop an orange-yellow margin on their first dorsal fin. Females however do not change color during breeding. Spawning season starts around February and can last until June. Water temperatures around this time vary from 3.9 to 11.1°C and can be up to 15°C (Wydoski and Whitney 2003). Males perform a swimming display to female sculpin to initiate them to deposit their eggs. Female mottled sculpin in the Yakima River had an average of 65 eggs for two year olds, 135 for a three year olds, and 176 for four year olds (Wydoski and Whitney 2003). Eggs were deposited in clusters of 20 to 150 under rocks or overhanging ledges in rapid or slow moving clear water. Females leave after spawning while the males remain to spawn again and to protect the eggs. Eggs hatch

in about 20 to 30 days at 10 to 15.6°C water temperature (Wydoski and Whitney 2003). Hatchlings remain close to the nest for a short time before venturing out into other parts of the stream.

Paiute Sculpin: Paiute sculpin mature at two or three years of age. Spawning begins in May and lasts until June, but it largely depends on water temperature. In Lake Tahoe, Paiute sculpin spawn from early May until August, and select wave swept littoral areas just off the mouths of creeks (Moyle 2002). Nesting sites are generally constructed away from bedrock and mud substrates. In streams, the Paiute sculpin selects riffles to spawn in (Sigler and Sigler 1987). During spawning males develop a pale yellow spot on their caudal peduncle near the posterior base of the second dorsal fin (Wydoski and Whitney 2003). Females deposit small (1.5 to 2.0 millimeters) eggs in clusters on the underside of rocks and overhangs where the male guards them, much like other species of sculpins; however, multiple spawning seems to be uncommon since on average only 100 to 200 eggs are found in any one nest site. Female Paiute sculpin in the Yakima River system had an average of 37 eggs for a 38.1-millimeter sculpin, and 181 for a 76.2-millimeter sculpin (Wydoski and Whitney 2003). Generally, the number of eggs per female increases with size and age. Length of incubation is currently unknown. Hatchlings are about 10 millimeters in length and move to the gravel floor of the nest and remain there for one to two weeks before moving out into the current at night and dispersing downstream (Moyle 2002).

Slimy Sculpin: Very little is known about the spawning behavior and habitats of the slimy sculpin (Scott and Crossman 1973). Most accounts come from Koster (1936) who described some of the spawning habits of slimy sculpins in the waters of northern New York (Scot and Crossman 1973). They generally spawn in the spring when water temperatures are between 5 and 10°C (Scott and Crossman 1973). The male slimy sculpin turns dark in coloration and develops a margin of orange along the first dorsal fin (Wydoski and Whitney 2003). Eggs from the female are deposited under a rock and guarded by the male. Often as is with other species of sculpin, there is multiple spawning by the male. A gravid female 101.6 millimeters in length held about 1,400, (2.3-2.6 millimeter) eggs (Scott and Crossman 1973). Eggs hatch in about four weeks at 7.7 °C (Scott and Crossman 1973).

Movements and Habitat Use

Sculpins are well adapted to having a sedentary, benthic life style and are not developed to make long extended movements and migrations. Sculpins do, however, exhibit four basic movements/ migrations which may vary according to species and location. Mostly, the movements of sculpins are restricted to short foraging movements, spawning, the dispersal of larval sculpins after hatching, and moving into overwintering habitats (Moyle 2002; Wydoski and Whitney 2003). In some capacity, sculpins are know to move to overwintering habitats and foraging areas, and some adult species are known to migrate to spawning areas as are the newly hatched larvae to rearing areas.

Coastrange Sculpin: In California, the coastrange sculpin in small streams migrate downstream during winter to spawn close to an estuary where their larvae will live (Moyle 2002). Coastrange sculpin larvae often drift into a lake or estuary where they live a pelagic life before transforming into juveniles and moving to a benthic lifestyle (Moyle 2002; Wydoski and Whitney 2003). The coastrange along with the slimy sculpin have also been observed in Alaska moving to forage on the eggs of spawning sockeye salmon. The sculpins in this area seem to predict the arrival of the sockeye salmon rather than just reacting to their presence (Foote and Brown 1998). It also seems likely that they must be arriving from relatively large distances, given the high peak in sculpin densities (Foote and Brown 1998).

Reticulate Sculpin: Currently there is no information on the movements of the reticulate sculpin.

Riffle Sculpin: Little is know about the movements and migrations of the riffle sculpin. They are generally considered to have poor dispersal abilities, given their narrow habitat requirements, benthic larvae that do not move far after hatching, and scattered distribution (Moyle 2002).

Prickly Sculpin: The prickly sculpin is known to make downstream migrations to spawning areas which are usually close to an estuary, pool or lake, where the hatched larvae and juveniles can rear. Some populations of prickly sculpin migrate from freshwater to brackish water to spawn (Wydoski and Whitney 2003). After spawning the adults move back upstream. Larval prickly are usually washed downstream where they transform into juvenile sculpins and settle onto the bottom and move into areas with plenty of food and cover, in some cases making extensive upstream migrations (Moyle 2002). This downstream migration of adults and upstream migration of juveniles is typical of coastal populations (Moyle 2002). At night, prickly sculpin move into open areas away from their daytime cover to forage (Wydoski and Whitney 2003). Prickly sculpin also move into deeper water to overwinter.

Shorthead Sculpin: Currently there is no information on the movements of the shorthead sculpin.

Torrent Sculpin: In Washington State, the torrent sculpin is known to move upstream on spawning migrations from late January to late April, and downstream after spawning, in May and June (Wydoski and Whitney 2003). The extent of these migrations is currently unknown.

Margined Sculpin: Currently there is no information on the movements of margined sculpin.

Mottled Sculpin: During the summer months, the mottled sculpin inhabits shallow water that is 0.15 to 0.9 meters deep, but moves to deeper water during the winter (Wydoski and Whitney 2003).

Paiute Sculpin: The Paiute sculpin is generally a sedentary sculpin. During the day it occupies habitats that contain rubble and large gravel substrates to hide or burrow in (Wydoski and Whitney 2003). At night it emerges and begins to forage. In Lake Tahoe, California, Paiute sculpin were found in shallow inshore areas and to depths of 122 to 213.4 meters (Moyle 2002).

Slimy Sculpin: There is no information on the movements of slimy sculpin in Washington State. In Alaska's Lake Iliamna, slimy sculpin were found with coastrange sculpin feeding on the eggs of spawning sockeye salmon. The numbers of sculpin dramatically increased over the course of the salmon spawning run on Woody Island and decreased in a less dramatic fashion after completion of spawning (Foote and Brown 1998).

Threats to Survival

Bond (1963) discusses factors likely influencing the abundance and distribution of sculpin, and reports sculpin numerically dominate the fish fauna in many streams in the northwestern United States. Despite their overall abundance and fairly wide distribution, sculpins are probably less abundant in many areas than they formerly were. They are fairly sensitive indicators of high-quality water and stream habitats (Moyle 2002). Their disappearance from, or low abundance in, a stream reach may be indicative of land use practices, such as water diversions, logging, grazing or general urbanization, that degrade stream environments (Moyle 2002). Harvey (1986) indicated high sedimentation rates could reduce populations of sculpin. This suggests that populations of sculpin may be negatively impacted by some land-use practices. In Washington, coastrange sculpin, prickly sculpin, riffle sculpin, shorthead sculpin, torrent sculpin, reticulate and mottled sculpin are widespread, but there is no information on population trends. The Paiute and slimy sculpin each have limited distribution in eastern Washington and seem to be abundant within that distribution, but there is also no information on population trends. The margined

sculpin also has a limited distribution in an extremely small area of southeastern Washington. Its habitat, however, has been degraded through development, agriculture, logging and channelization (Wydoski and Whitney 2003). The margined sculpin is currently listed as a "sensitive species" in Washington, and as "sensitive" in Oregon (Mongillo and Hallock 1998).

8.5.21.2 ENVIRONMENTAL BASELINE (within the FPHCP Action Area)

The margined sculpin has the smallest range of any fish in Washington. Its current distribution is from the Walla Walla and Tucannon watershed in southeastern Washington (Mongillo and Hallock 1998). The upper watershed of the Tucannon River and upper North Fork of the Touchet River are on the Umatilla National Forest, and are not subject to the proposed action. Stream reaches on National Forest lands are in relatively good condition in comparison to conditions downstream on private lands (Smith, 2005) However, many of the observations of the species come from non-Federal lands and may be subject to the proposed action. Many of these streams are currently in a degraded condition, such as the Walla Walla, Mill Creek, lower Tucannon, and South Fork Touchet watersheds (Mongillo and Hallock 1998). Irrigation, agriculture, urbanization, and logging have been responsible for habitat degradations. High fine sediment loading from agricultural practices and water withdrawls from private lands are causing deleterious effects to salmonids in the Walla Walla basin (Smith, 2005).

The coastrange, prickly, shorthead, riffle, reticulate, and torrent sculpins have relatively large distributions across Washington. However, a substantial part of their ranges occur on Federal lands, including national forests and national parks. These areas will not be subject to the proposed action, but other substantial areas do occur within the FPHCP Action Area.

The mottled and Piute sculpin occur in eastern Washington. The Piute sculpin occurs in the Yakima, Wenatchee, Walla Walla, and Snake Rivers and their tributaries. The mottled sculpin occurs in Columbia, Yakima and Snake River basins. West of the Cascade Mountains, 8 mottled sculpin were found in Lacama Creek, a tributary to the Cowlitz River. Both of these species will have a significant portion of the ranges subject to the proposed action. They also inhabit other watershed that occur on Federal lands and won't be exposed to the proposed action.

The slimly sculpin occurs in eastern Washington in the Lake Chelan and tributaries and the upper Columbia River (Pond Oreille and Kettle Rivers). Federal ownership occurs over significant portions of these areas, but not all. As such, the proposed action will involve many areas where the species occurs.

There is a broad range of ownerships and aquatic conditions within the FPHCP Action Area for the 10 species of sculpin. These conditions have been described above in various areas of the Opinion. Sculpin are likely an important fish in ecosystem health in the FPHCP Action Area. Sculpins provide forage for other fish, including Dolly Varden and bull trout. Sculpins are also known to consume salmon eggs and other fish (Wydoski and Whitney 2003). In suitable habitats, sculpins can be abundant and are important in the food chain and in degraded habitat, sculpins may respond negatively. Many factors beyond aquatic habitat may influence local sculpin abundance.

Sculpins are often reported in fish species assemblages in Washington. However, we are unaware of Cottid population trends across watersheds within the FPHCP Action Area.

Role of the FPHCP Action Area for Conservation of the Species:

The FPHCP Action Area encompasses a significant segment of the range of sculpin in Washington. The FPHCP Action Area provides an important conservation role for these species. High quality aquatic

habitats within the FPHCP Action Area are necessary for the long-term survival of sculpins in Washington.

8.5.21.3 EFFECTS OF THE ACTION

General habitat effects to sculpin resulting from the proposed action have been summarized above for the Guilds that the 10 species of sculpin are assigned. The sculpins are found across the habitat associations that have been analyzed in this Opinion. The following species and their Guilds as follows: Steep Tributary Guild – shorthead sculpin; Low-Gradient Tributary Guild – riffle sculpin; Mainstem Tributary Guild – Paiute sculpin; Lentic Guild – prickly, coastrange, and torrent sculpins; River System Guild – mottled sculpin. Although the sculpins may have been assigned a specific guild, they will occur across different guilds. For example, the coastrange sculpin, although assigned to the Lentic Guild, may also occur in the Mainstem or Low-Gradient tributary habitat associations. The Slimy sculpin has been found in lakes (Lentic association) and in streams.

Summary of Riparian Prescription Effects to Sculpins

Full riparian and in-stream function likely would not be provided to all habitats occupied by sculpins. In some stream reaches, the highest quality and most structurally complex habitats may fail to develop due to the potential reduction of large wood recruitment to streams following different riparian management prescriptions. Some sculpin are found at higher densities near cover. Where they co-existed with other species, some species of sculpin often occupied pools. Large wood in freshwater habitats is important for storing and releasing the appropriate sediment for development of suitable substrate, pool formation, providing cover, aquatic plant growth, and macroinvertebrate production. Reductions in large wood recruitment to streams may result in habitat modifications that increase risk of predation, reduce forage, and reduce the survival or fitness of individual sculpin.

Sculpin generally prefer summer temperatures less than 20°C. When RMZs achieve their Desired Future Condition, streams within the areas covered by the FPHCP that are occupied by the sculpin will receive most of the potentially available shade. Along Type Np streams, reductions in shade are likely to occur and water temperature may increase over limited distances as a result of the unbuffered Type Np stream reaches. In some cases, increases in temperature may be delivered downstream to Type F waters and temperatures could be warmed near the confluence of Type Np and F streams. There are situations (yarding corridors, stream-adjacent parallel roads, 20 acre exemptions, and windthrow) where stream shading will be reduced from full ecological potential and in some circumstances there may adverse effects to the sculpin due to elevated stream temperatures and the behavior and survival of individual fish may be affected. Water temperature increases may be a factor in inter-specific competition and abundance of the sculpin could be reduced in some cases.

Sediment effects to sculpin

Substrate used by the sculpin is usually a mix of sand and cobble, or large gravel. Some species tended to inhabit gravel substrates, and larger fish tended to inhabit cobble substrates. For example, Paiute sculpins will burrow into the gravel during the day to avoid torrent sculpins and emerge at night to feed. Sediment would be delivered to sculpin habitat from road surface erosion and, to a lesser extent, from hillslope erosion. The FPHCP's incorporation of BMPs and RMAPs would substantially reduce delivery of road surface related sediment to the sculpin habitat, but it would not prevent all sediment from reaching aquatic habitats occupied by the species. Certain watershed features and road related activities may contribute sediment to fish-bearing streams that are above natural background rates. For example, culvert

projects may increase siltation until vegetation has recovered enough to reduce delivery of harmful sediment. Excessive siltation may reduce the availability of this habitat and and may affect food resources. When feeding behavior is altered by reduced prey, individual fitness and survival could be affected.

Effects from the 20-acre Exemption Rule

Although there is uncertainty regarding how often this rule would be implemented, when it is implemented the 20-acre Exemption Rule would likely adversely affect the sculpin. In watersheds with a high proportion of 20-acre exempt landowners, this rule would increase the likelihood that large wood recruitment would be inadequate to maintain properly functioning habitat (USFWS & NMFS 2006). There is also the potential for increased sedimentation, reduced shade, increased stream temperatures, and increased windthrow. Where these adverse effects occur, essential behaviors associated with foraging, reproduction and growth may be impeded, and sculpin may occupy the stream at reduced levels and have reduced survival.

Summary of adverse effects to sculpin

The proposed action would have short- to long-term adverse effects on sediment, large wood, and temperature. These effects would be most severe from unbuffered Type Np streams and their downstream effects that result in disruption of natural riparian and aquatic processes and functions in Type F streams. These effects to the aquatic environment may result in impairment of essential foraging, rearing, and spawning behavior of sculpin. Feeding behavior may be altered under some circumstances affecting individual fitness and survival. Available suitable substrate could be reduced, modifying habitat use and ultimately survival. It is difficult to predict the severity of these effects because effects to these fish will vary from activity to activity depending on the specific riparian prescriptions applied, the location, historical management practices, geological characteristics of the watershed, and the biotic community present.

Activities covered under the FPHCP are expected to have direct and indirect adverse effects to adult and juvenile sculpin ranging from mortality to sublethal effects. Direct injury and death to sculpin would likely occur during some stream crossing construction activities (stream dewatering, fish rescue and relocation, and blockage of upstream migration during construction). Increased sediment levels could reduce available habitat and prey items for sculpin. This could affect the growth and survival of juvenile and adult sculpins.

Summary of beneficial effects

The long-term benefits of the FPHCP are expected to outweigh the short-term, negative affects to sculpins. Maturation of riparian areas, maintaining and restoring passage for sculpins, adaptive management, and improved road management practices are all expected from implementation of the FPHCP. These management prescriptions are expected to contribute to long-term survival for sculpins in the FPHCP Action Area.

8.5.21.4 CUMULATIVE EFFECTS

Cumulative effects were addressed in the Comprehensive Cumulative Effects section, with respect to the aquatic and riparian environment in Washington State. Additional information regarding cumulative effects for the covered fish species was presented in the sections: Steep tributary association, Low-

Gradient tributary association, Mainstem association, Lentic association, River system association, and Isolated populations.

No additional information is available with respect to cumulative effects for the following sculpin species: shorthead sculpin, riffle sculpin, Paiute sculpin, prickly sculpin, reticulate sculpin, coastrange sculpin, torrent sculpin, mottled sculpin, slimy sculpin, and margined sculpin.

8.5.22 Longfin Smelt (*Spirinchus thaleichthys*)

8.5.22.1 Status of the Species

Description of the Species

The longfin smelt has a laterally compressed, elongate body which is rarely over 150 millimeters in length as an adult (Scott and Crossman 1979). It has a rather large oblique mouth, no axillary processes at the base of its pelvic fins, long pectoral fins, and a rounded adipose fin (Wydoski and Whitney 2003). Its scales are moderately large cycloid scales. Its color can be dusky color to olive-brown along its dorsal surface becoming silvery along its sides and below. Young longfin smelt are translucent with two rows of large black spots (Scott and Crossman 1979).

Historic and Current Range

The longfin smelt is generally an anadromous species of smelt living most of its life in salt water, only moving into freshwater streams and rivers to spawn. In Washington State, the anadromous form of the longfin smelt is found along the coast, in the Strait of Juan de Fuca and within Puget Sound. However, there is a single landlocked population of longfin smelt that resides within Lake Washington. This population completes its entire life cycle within this freshwater system.

The following information applies to that of the landlocked, Lake Washington form only of longfin smelt.

Essential Habitat Components

In Lake Washington, longfin smelt live predominately in open waters of the lake, only moving into a few of the tributaries during spawning. They generally occupy areas where the temperature is below 18°C (Wydoski and Whitney 2003). Juveniles tend to occur between 11 and 22 meters below the surface from July to December. From January to June, juveniles are often found near the bottom below 18 meters during the day and move at night to depths between 11 to 22 meters (Wydoski and Whitney 2003). Adults occur between 11 and 22 m below the surface at night and move to deeper waters during the day, occupying depths between 18 and 37 meters (Wydoski and Whitney 2003).

Reproductive Ecology

The longfin smelt has a strong spawning run on even years and weak spawning runs on odd years (Wydoski and Whitney 2003). Spawning begins by mid January and lasts until mid April. There are at least five tributaries in which the longfin smelt spawns, the Cedar River being the largest and most important. The others are Coal Creek, Juanita, May and McAleer Creeks (Wydoski and Whitney 2003). Spawning almost always takes place at night in water temperatures between 4.4 and 7.2°C. Migrating smelt go as far as 1.6 kilometers upstream in the Cedar River but mostly stay within 0.6 kilometers of the mouth to spawn. Female smelt only spawn once, whereas males may return to spawn again. Females produce an average of 1,550 eggs, 0.65 to 1.0 millimeters in size (Chigbu and Sibley 1994). Spawning

generally takes place in fairly shallow water (0.1 to 0.8 meters deep) with most spawning being between 0.4 and 0.6 meters deep with 0.3 to 0.6 meters/second water velocity. Eggs are deposited on sandy or grave substrates or rocks and aquatic plants (Scott and Crossman 1979). Time until eggs hatch largely depends on water temperature. Eggs hatch in approximately 40 days in water 7°C, 29 days between 8 and 9°C, and 25 days between 9 and 11°C. After hatching, the larval fish move into the main current and are transported downstream to the lake.

Movements and Habitat Use

The longfin smelt in Lake Washington exhibit both diel and seasonal movements. Diel movements are dependant on two factors: age and season. As stated previously, between July and December, juvenile longfin smelt occur between 11 and 22 meters below the surface. Adults are also at this depth at night, but move to deeper water (18 to 37 meters) during the day (Wydoski and Whitney 2003). From January to June, juveniles are near the bottom (below 18 meters) during the day and move upward at night to depths between 11 and 22 meters below the surface, as do the adults (Wydoski and Whitney 2003). During their second year of life, longfin smelt have well defined patterns of migration, using deeper waters during the day and shallower waters at night. This pattern also follows that of their prey, the mysid shrimp.

Threats to Survival

Since the late 1960's the biomass of the longfin smelt in Lake Washington has increased. Chigbu (2000) found that longfin smelt in Lake Washington made up less than 12 percent of planktivorous species sampled in the late 1960's. Twenty years later, longfin smelt made up 58 to 84 percent of planktivorous species in the lake. This overall increase in the smelt biomass is thought be a product of reduced flows in the Cedar River (the smelt's main spawning site) that have enabled a greater number of spawned smelt eggs to hatch and survive. High flows in the Cedar River have been linked to lower numbers of smelt for the odd-year class, which is four times lower in population than that of the even-year class. Evidence has shown a negative relationship with high flows in the Cedar River during spawning that resulted in decreased survival of spawned eggs (Chigbu 2000). Chigbu (2000) found that Cedar River discharge greater than 28-cubic meters/second occurred more frequently during odd years than even years. An increase in discharge during both even and odd years in the Cedar River, coupled with the fact that the longfin smelt is only found within Lake Washington, may be a factor influencing long-term abundance.

8.5.22.2 ENVIRONMENTAL BASELINE (within the FPHCP Action Area)

The landlocked longfin smelt resides in Lake Washington. Lake Washington is primarily surrounded by city parks and urban development and not within the FPHCP Action Area. The fish spawn in tributaries within 0.7-mile of the lake (Wydoski and Whitney 2003). There are very few lands covered by the proposed action within this close proximity to the lake. However, there are lands upstream in the Cedar River watershed that are part of the FPHCP Action Area. The Lake Washington population appears healthy.

Role of the FPHCP Action Area for conservation of the species:

The FPHCP Action Area provides a very limited role in the long-term conservation for this species. These fish occur in an urbanized landscape and the FPHCP will have very little influence over their survival.

8.5.22.3 EFFECTS OF THE ACTION

As described above, the longfin smelt occurs in Lake Washington and spawns in tributaries very close to the lake. For this Opinion, longfin smelt are assigned to the Isolated Population Guild. However, the most relevant effects to this species may be in the Lentic Guild.

Riparian prescription effects to longfin smelt

It is not anticipated that riparian prescriptions, other than as described in the Isolated Population and Lentic Guilds, will adversely affect longfin smelt.

Sediment effects to longfin smelt

Sediment could potentially be delivered to longfin smelt habitats from road surface erosion. Installing culverts may contribute sediment to habitats occupied by longfin smelt, especially until vegetation has re-established to minimize it. Certain watershed features and road use may contribute sediment to spawning habitats. Excessive siltation may affect egg survival.

Summary of adverse effects to longfin smelt

The longfin smelt is an isolated population. Isolated populations of species are prone to extirpation from catastrophic events, both natural or man-caused. Frequent and severe disturbances could also affect the lake Washington longfin smelt population. Implementation of the FPHCP will not increase the risk of a catastrophic event to the Lake Washington longfin smelt population. Effects from the FFHCP will not be of the duration or magnitude to reduce the chance of this species persisting.

Summary of beneficial effects to longfin smelt

The benefits of the FPHCP are expected to contribute to the long-term survival of the longfin smelt. As riparian areas mature, roads are managed with watershed processes in mind, adaptive management is applied, and fish blockages are removed, longfin smelt should benefit from improvements in watershed functions. The FPHCP will have little influence on the species long-term survival.

8.5.22.4 CUMULATIVE EFFECTS

Cumulative effects were addressed in the **Comprehensive Cumulative Effects** section, with respect to the aquatic and riparian environment in Washington State. Additional information regarding cumulative effects for the covered fish species was presented in the section **Lentic Guild: Cumulative Effects.**

No additional information is available with respect to cumulative effects for this particular species above those cumulative effects already discussed earlier in this document.

8.5.23 Burbot (*Lota lota*)

8.5.23.1 Status of the Species

Description of the Species

The burbot is the only freshwater member of the cod family (Gadidae) (Wydoski and Whitney 2003). The burbot has an elongated body with a single barbel on the chin and a long second dorsal fin, which can be 6-times longer than the first dorsal fin (Morrow 1980). The burbot has a low gradienttened head with a

long snout, a terminal mouth, and prominent tubes extending from each nostril (Morrow 1980). The burbot has short, rounded pectoral fins and a rounded caudal fin. The burbot has small cycloid scales embedded in the skin. The color can be yellowish to brown to dark olive green on the dorsal and sides of the body. The sides tend to be mottled or blotchy with a dark line along the anal fin margin. The ventral surface can be a pale yellow to white. Pelvic fins tend to be pale in color while the other fins tend to be dark or mottled. In Washington State, burbot have been known to live up to 10 years and have an average length of 50 centimeters (Wydoski and Whitney 2003). The oldest burbot recorded was captured in Keechelus Lake and was 19 years old and over 74 centimeters in total length (Bonar et al. 1997).

Historical and Current Range

In North America burbot are found from Alaska to Oregon and east to Connecticut, and in Canada (Wydoski and Whitney 2003). Information on the historical distribution of burbot in Washington State is sparse. Populations of burbot likely originated from the southern unglaciated portion of the Columbia River following the last glaciation (Bonar et al. 1997). The current distribution consists of 11 deepwater lakes of the Columbia River system: Banks, Bead, Chelan, Cle Elum, Franklin D. Roosevelt, Kachess, Keechelus, Osoyoos, Plamer, Rufus Woods, and Sullivan Lakes (Bonar et al. 1997, as cited in Wydoski and Whitney 2003). There seems to be no evidence of burbot populations west of the Cascade crest. The western-most population of burbot occurs in Lake Keechelus in the Cascade Mountains.

Essential Habitat Components

Burbot inhabit large (290 ha to 32,000 ha), deep, oligotrophic or mesotrophic lakes and reservoirs, and portions of the Spokane and Columbia Rivers (Wydoski and Whitney 2003). These habitats are generally located at higher elevations or are in the northeastern portion of the State. The elevations of lakes that burbot inhabit range from 280 to 877 meters above sea level (Bonar et al. 1997). Burbot are photo-negative and prefer to be near the bottom, especially during the summer (Bonar et al. 1997). During the winter, when water temperatures are low, burbot move into shallower waters, but only during the night (Bonar et al. 1997). Burbot forage nocturnally at various depths, depending on the time of year. Optimum water temperatures are reported to be between 16° C and 18° C (Scott and Crossman 1973).

Reproductive Ecology

Burbot spawn in lakes or slow-moving sections of rivers. Spawning begins in winter and can last until early spring (Bonar et al. 1997). Burbot spawn at night when water temperatures are between 0.6° C and 2° C (Scott and Crossman 1973). Spawning takes place in shallow sections of lakes or rivers often under the ice, although there is some evidence that deep-water spawning can occur (Scott and Crossman 1973). Males are the first to arrive on the spawning sites (Wydoski and Whitney 2003). Mature individuals, depending on location, are usually between two and six years of age (Bonar et al. 1997). In the presence of a female, male burbots swim around her, forming a large “ball” with the female in the center (Bonar et al. 1997). The female broadcasts her eggs (sometimes up to 1.4 million depending on length of the female), over the substrate, and the males then fertilize them. The fertilized eggs are not sticky but are demersal and contain an oil globule (Morrow 1980). After spawning, the parents do not care for the eggs, and return to the deeper portions of the lake or river. The fertilized eggs settle onto the substrate where they develop for up to 71 days at water temperatures between 0° C and 4° C and hatch at temperatures of 6° C to 6.5° C (Morrow 1980; Scott and Crossman 1973).

Movements and Habitat Use

The migratory patterns of burbot are somewhat unknown (Morrow 1980). They do migrate into spawning areas during the winter, remaining through spring, and post-spawning movement into tributaries and upstream in rivers in late winter or early spring has been documented (Scott and Crossman 1973). The migrations that burbot make, pre- and post-spawning, are not believed to be of any great distance.

Overall burbot are sedentary, only moving to forage or to seek optimal temperatures or light conditions. Burbot generally remain within the deep portions of lakes and rivers (Mecklenburg et al. 2002; Scott and Crossman 1973). During the summer months, burbot usually remain in the hypolimnetic region of lakes (Scott and Crossman 1973). The optimal water temperatures for burbot are between 16° C to 18° C, with 23° C being their upper temperature limit (Scott and Crossman 1973). During the summer, burbot move into shallower water at night to feed. Burbot are photo-negative and prefer low light conditions (Wydoski and Whitney 2003). They are inactive during the day and only begin to move around dusk. Depending on the season, burbot may move throughout the night to forage (Wydoski and Whitney 2003). Overall, burbot use a small foraging area which changes little from year-to-year.

Threats to Survival

There is very little information to suggest that the original distribution of burbot is different than the present, and it is therefore difficult to make an assessment of decline in their populations (Bonar et al. 1997). Burbot are subject to similar threats as other native fish, such as overharvest, pollution, man-made barriers and habitat fragmentation, competition with non-native species for resources, and climate change (Bonar et al. 1997). Forest practices may not provide a substantial risk to survival of burbot.

8.5.23.2 ENVIRONMENTAL BASELINE (within the FPHCP Action Area)

There are 11 known burbot populations in Washington State, of which one is considered healthy (Lake Roosevelt), one is considered critical (Banks Lake), and the status of the remaining nine populations are unknown (Bonar et al. 1997). They are unknown to occur in western Washington.

Role of the FPHCP Action Area for Conservation of the Species

Some of the lakes that are occupied by burbot are slightly influenced by the FPHCP. Generally, the FPHCP will have little influence to burbot. The FPHCP Action Area provides a minor role in the long-term conservation of burbot.

8.5.23.3 EFFECTS OF THE ACTION

General habitat effects to burbot from the proposed action have been summarized above for the Lentic and River System Guilds. No additional effects from riparian prescriptions or sediment are expected for this species.

Summary of adverse effects to burbot

There may be some sediment effects from the FPHCP to habitats occupied by burbot. Sediment that may affect burbot is most likely to come from road crossings of Type S and F streams. These effects are expected to be very minor and not influence the population or distribution in the FPHCP Action Area.

8.5.23.4 CUMULATIVE EFFECTS

Cumulative effects were addressed in the **Comprehensive Cumulative Effects**, with respect to the aquatic and riparian environment in Washington State. Additional information regarding cumulative effects for the fish species was presented in the section **Lentic Guild: Cumulative Effects.**

No Additional information is available with respect to cumulative effects for this particular species above those cumulative effects already discussed earlier in this document.

8.5.24 White Sturgeon (*Acipenser transmontanus*)

8.5.24.1 Status of the Species

Description of the Species

The white sturgeon is the largest sturgeon in North America; specimens have measured up to 6.1 meters long (Scott and Crossman 1973). It has a short rounded snout with four barbels which are closer to the end of the snout than the mouth. Male white sturgeons have longer pointed snouts than females, which have smaller more rounded snouts (Wydoski and Whitney 2003). Their mouths have highly protrusible lips that lack teeth (Moyle 2002). White sturgeons have no scales and are covered with very minute dermal denticles and isolated rows of large, diamond-shaped bony plates or scutes (Scott and Crossman 1973). The white sturgeon have 4 to 8 scutes between the pelvic and anal fin in two rows, and lateral scutes number between 38 and 48 (Wydoski and Whitney 2003). They have a heterocercal caudal fin, a dorsal fin with one spine that is far back over the anal fin, and large rounded pectoral fins. Their dorsal body surface color above the lateral scutes is light grey, grey-brown or pale olive color, while the ventral body color below the lateral scutes is pale grey to white. The fins tend to be dusky to opaque grey in color.

Historic and Current Range

White sturgeon are found in marine and fresh waters from California to Alaska. Historically, the white sturgeon inhabited the entire Columbia River from the mouth upstream into Canada, the Snake River upstream to Shoshone Falls, and the Kootenai River upstream to Kootenai Falls. Currently in Washington State, the white sturgeon is found in the Columbia River, Snake River, Grays Harbor, Willapa Bay, Puget Sound and Lake Washington (Wydoski and Whitney 2003). In the Columbia River system, five separate stocks of white sturgeon exist: the lower Columbia stock, the mid Columbia stock, the Lake Roosevelt stock, the Snake River stock, and the Kootenai River stock (Wydoski and Whitney 2003). The populations within the Columbia River Basin are considered the largest and most studied in the state.

Essential Habitat Components

Habitat use of white sturgeon varies according to life-history stage and location. Adult white sturgeon seems to prefer large deep pools and eddies in the main channels of the Columbia and Snake Rivers (Wydoski and Whitney 2003). They generally prefer water deeper than 15 meters with low velocities where they rest on the bottom to feed on drifting items (Wydoski and Whitney 2003). In California, adults spend most of their lives in estuaries of large rivers only moving into upper reaches to spawn (Moyle 2002). White sturgeon adults in the Fraser River, British Columbia, prefer deep, near-shore areas adjacent to fast flowing sections with sand and gravel substrates (Ptolemy and Vennesland 2003).

Juveniles and sub-adults tend to occupy sloughs off the main channel during the summer months (Wydoski and Whitney 2003). Young-of-the-year are often found over hard clay, mud, silt, sand, grave and cobble at depths of 12 to 27 meters, with water velocities around 1.4 meters/second (Wydoski and Whitney 2003). Juveniles in the lower reaches of tributaries of the Fraser River, British Columbia, utilized large backwaters, side channels and sloughs, and were often found at depths greater than 5 meters, in low velocities and variable current direction, and preferred high turbidity and relatively warm water. Juveniles were also seen moving from sloughs and backwaters to mainstem areas as summer progressed (Ptolemy and Vennesland 2003).

Generally water temperature, depth, velocity and substrate types are the main factors in determining spawning and rearing habitat by white sturgeon adults. Spawning substrates selected by adult white sturgeon in the lower Columbia River below the tailraces of dams were generally composed of cobble, boulder and bedrock (Parsley et al. 1993). Spawning and subsequently egg incubation occurred in the swiftest water available (mean water column velocity, 0.8 to 2.8 meters/second) (Parsley et al. 1993). In the Fraser River, which is unregulated and largely unaltered, white sturgeon spawning areas were mainly in shallow side channels as opposed to mainstem reaches (Perrin et al. 2003).

Reproductive Ecology

Most studies on the reproductive ecology of white sturgeon have been done on the Columbia and Snake Rivers (Wydoski and Whitney 2003; Parsley et al. 1993; Parsley and Beckman 1994), the Fraser River in British Columbia (Perrin et al. 2003) and the Sacramento River in California (Moyle 2002). A recent study by Perrin et al. (2003) indicates that spawning habitat may vary between natural systems, like the Fraser River, and those that are impounded such as the Columbia and Snake Rivers. In regulated flow systems, sturgeon utilize fast, turbulent mainstem water over clean, large rocky substrate, whereas in unregulated systems, sturgeon selected side-channel habitats to spawn (Perrin et al. 1993; Ptolemy and Vennesland 2003). In the Fraser River, Perrin et al. (2003) found evidence that spawning occurred only in side-channels, rather than within mainstem reaches, with substrates comprised of gravel, cobble and sand, and flows that were mainly laminar with near-bed velocities averaging 1.7 meters/second.

When ready to spawn, white sturgeons migrate upstream. Males in the lower Columbia River mature at 1.2 meters in length and females at 1.8 meters (Wydoski and Whitney 2003). In some areas males mature at 9 years of age and females mature between 13 and 16 years of age (Wydoski and Whitney 2003). Sturgeon tend to spawn in alternating years, with only a small percentage of adults spawning in any one giver year. Sometimes there can be spawning intervals of 3 to 11 years (Wydoski and Whitney 2003). Spawning in the lower Columbia River starts in April and goes through July in water temperatures from 10° to 18°C (Parsley et al. 1993). Males and females spawn in the swiftest water possible (0.8 to 2.8 meters/second at 4 to 20 meters in depth) in mainstem reaches below the dams, over cobble, boulder and bedrock substrate (Wydoski and Whitney 2003). Water released from the dams during this time becomes extremely important to the success of spawning sturgeon. Parsley and Beckman (1994) found that lowering spring and summer discharges reduces the availability of spawning habitats. Survival to hatch is also expected to be greatest under these conditions, as high velocities in egg deposition areas may exclude some predators and provide high turbidity, improving juvenile survival (Gadomski et al. 2001b). Based on limited data, spawning intensity is greatest when discharges are high and steady (Ptolemy and Vennesland 2003).

Mature females in the lower Columbia can produce 98,000 to 700,000, 3-millimeter diameter eggs (Wydoski and Whitney 2003). A 43.3 kg female contained 1.7 million eggs and larger fish may produce

as many as 3 million eggs (Wydoski and Whitney 2003). White sturgeon are broadcast spawners with adhesive eggs. Eggs hatch in about 7 days at 15°C (Wydoski and Whitney 2003). The hatched sac-fry are then transported by the river currents from spawning areas into deeper areas with lower water velocities and finer substrates, where they begin to feed (Parsley et al. 1993).

Movements and Habitat Use

Movements and habitat use of white sturgeon vary according to location and life history state. Sturgeons have been known to make relatively small movements and also extensive migrations of many hundreds to over 1,000 kilometers (Wydoski and Whitney 2003; Moyle 2002). With the construction of the dams on the Columbia and Snake Rivers in the last century, sturgeon populations have generally become isolated from historic migratory routes. The dams have formed migratory barriers that have limited the movement of migratory populations and confined them to relatively short sections of river, often with little essential habitat.

In the lower Columbia River, movements associated with spawning typically occur during the fall months, when adults begin to move upstream to spawning areas. They move back down in late winter and spring after spawning (Wydoski and Whitney 2003). Anadromous adults begin to move into larger rivers such as the Columbia and Fraser Rivers in early spring (Scott and Crossman 1973).

The population of white sturgeon below Bonneville Dam is one of the healthiest in the Columbia River, in part because of its ability to move into the marine environment to feed and overwinter. Little is known about the movements of white sturgeon in the marine environment. Tagged individuals have been captured at sea as far as 1,062 kilometers from the tagging site (Scott and Crossman 1973). An adult sturgeon tagged in San Francisco Bay was captured in the lower Columbia River (Moyle 2002). Other populations in the Columbia and Snake Rivers remain entirely in fresh water throughout their lives in part due to the system of dams and natural barriers. Non-anadromous individuals may travel long distances over short periods of time within an impounded reach (Haynes et al. 1978). One tagged adult was captured more than 1,000 kilometers up the Columbia River after navigating the system of dams (Moyle 2002).

Adults and juveniles move into overwintering habitats in the fall where they remain until water temperatures increase. During this time they are relatively inactive, remaining close to or lying on the bottom of deep pools. In the Hanford Reach, Haynes et al. (1978), found that movement of tagged sturgeon ceased in mid-October when water temperatures were about 15°C, not exceeding 0.2 kilometers from November through May, a period which seemed to be a dormant season.

Sturgeon are also known to make movements to feeding areas. These movements depend on food availability and are not well understood. In San Francisco Bay, sturgeon moved to intertidal areas to feed at high tides (Moyle 2002). Sturgeon in the Fraser River, British Columbia, have been reported traveling more than 30 kilometers to overwintering and feeding areas (Ptolemy and Vennesland 2003). In the upper Columbia River, white sturgeon moved to shallow foraging areas during the spring and summer (Ptolemy and Vennesland 2003).

Threats to Survival

White sturgeon in the Columbia River have declined due to dams, altered streamflows, altered temperature regimes, and overharvest (Wydoski and Whitney 2003). Information suggests that white sturgeon populations are less productive than they were before 1885 (Rieman and Beamesderfer 1990).

This is primarily due to two main factors: overfishing; and habitat loss/alterations due to the constructions of dams in the Columbia and Snake Rivers.

White sturgeon are long lived, slow growing, mature later in life than most fish, and spawn every 2 to 11 years. These life history traits make them susceptible to over exploitation (Miller et al. 1996). In the Columbia River, commercial fisheries for white sturgeon began in the 1880's, peaking in 1892 with a harvest of 2.5 million kg. By 1899 the population of white sturgeon in the Columbia River had been severely depleted and populations remained very low until the late 1940's, when the population appeared to recover enough to expand the fisheries. Restrictions were enacted, which have been subsequently modified over the years, and currently the harvest of white sturgeon has reached on average 42,000 individuals per year for the last ten years (DeVore et al. 1999). Currently, the abundance of white sturgeon below the Bonneville Dam is considered the greatest in the Columbia River system, mainly due to access to the marine environment, abundant food resources, and favorable hydrologic conditions during spawning. Although this population is abundant, it could collapse if not properly managed (Rieman and Beamesderfer 1990).

The construction of dams throughout the Columbia and Snake Rivers has created wide ranging effects on the white sturgeon. First constructed in the 1930's, the dams restricted and eliminated migratory paths, altered seasonal fluctuation of water flows and temperatures, fragmented populations, and eliminated some habitats all together. White sturgeons trapped behind the dams were unable to move into lower river habitats and the ocean. Population fragmentation represents a critical threat to the survival of the white sturgeon.

Altered daily and seasonal river flows and water temperatures from dam operations may also limit migration, habitat availability, and affect timing, location and success of reproduction. Dams have altered the magnitude and timing of discharge, as well as depths, turbidities and channel substrates. Dams have been found to negatively affect spawning habitat and some populations of white sturgeon have shown reduced production potential as a result of dam construction (Perrin 2003).

The construction of dams has also been shown to have an effect on water quality and pollution. Feist et al. (In Press) found that fish residing in the reservoir behind the oldest dam in the study (Bonneville) had the highest contaminant loads, incidence of gonadal abnormalities, and the lowest gonad size. Chemicals are most likely accumulating behind dams over time, and exposure to these contaminants may be affecting both growth and reproductive physiology of sturgeon in some areas of the Columbia River (Feist et al. 2005). Dissolved gases created by dams have also been shown to negatively affect larval sturgeon. One to two day old yolk-sac larvae exposed to gas supersaturation exhibited bubble trauma, where bubbles accumulated in the buccal cavity and forced the larvae to the surface of the water (Counihan et al. 1998).

8.5.24.2 ENVIRONMENTAL BASELINE (within the FPHCP Action Area)

White sturgeon are found in marine and freshwaters. In Washington, they occur in the Columbia River, Snake River, Grays Harbor, Willapa Harbor, Puget Sound, and Lake Washington (Wydoski and Whitney 2003). The largest population of white sturgeon occurs in the Columbia River between the mouth upstream to the Bonneville Dam. The average annual abundance was estimated to be 895,000 fish 21.3" or longer (Wydoski and Whitney 2003). In the Dalles pool, 73,382 white sturgeon were estimated in 1997. In 1994 in Lake Roosevelt, 5,702 white sturgeon were estimated from Grand Coulee dam upstream to the Canada border.

Role of FPHCP Action Area in Conservation of species:

The role of the FPHCP Action Area for the white sturgeon is minor. Due to the habitats the species occupies relative to the threats to it, the FPHCP will only have a minimal influence on the long-term survival of the white sturgeon.

8.5.24.3 EFFECTS OF THE ACTION

Effects resulting from permit issuance have been summarized above for the River System Guild and Nearshore Habitat Association. The FPHCP is expected to have minimal influence on the long-term survival of the white sturgeon.

Summary of sediment effects to white sturgeon

Sediment may be delivered to white sturgeon habitat from road surface erosion as a result of the FPHCP. Certain watershed features and road use may contribute sediment to fish-bearing streams that are above natural background rates. Culvert projects may increase siltation over short durations, especially until vegetation has recovered to reduce harmful sediment.

Summary of adverse effects to white sturgeon

It is not anticipated that there will be effects to large wood or temperature that would affect sturgeon habitat. Any effects from increased sediment to white sturgeon habitat as a result of the FPHCP are expected to be negligible and are not expected to affect the distribution, abundance or survival of the species.

Summary of beneficial effects

The long-term benefits of the FPHCP are expected to outweigh the short-term, negative affects to white sturgeon. Maturation of riparian areas, restoring fish passage, adaptive management, and improved road management practices are all expected from implementation of the FPHCP. These management prescriptions are expected to contribute to increasing the likelihood of long-term survival for white sturgeon in the FPHCP Action Area.

8.5.24.4 CUMULATIVE EFFECTS

Cumulative effects were addressed in the **Comprehensive Cumulative Effects**, with respect to the aquatic and riparian environment in Washington State. Additional information regarding cumulative effects for the covered fish species was presented in the section **River System Guild: Cumulative Effects.**

No additional information is available with respect to cumulative effects for this particular species above those cumulative effects already discussed earlier in this document.

8.6 BULL TROUT

8.6.1 STATUS OF THE SPECIES

(Note that terminology related to bull trout population groupings are further defined in Appendix E)

8.6.1.1 Listing Status

The coterminous United States population of the bull trout (Salvelinus confluentus) was listed as threatened on November 1, 1999 (64 FR 58910). The threatened bull trout occurs in the Klamath River Basin of south-central Oregon and in the Jarbidge River in Nevada, in the Willamette River Basin in Oregon, in the Pacific Coast drainages of Washington, including the Puget Sound; throughout major rivers in Idaho, Oregon, Washington, and Montana within the Columbia River Basin, and in the St. Mary-Belly River, east of the Continental Divide in northwestern Montana (Cavender 1978; Bond 1992; Brewin and Brewin 1997; Leary and Allendorf 1997).

Throughout its range, the bull trout is threatened by the combined effects of habitat degradation, fragmentation and alterations associated with: dewatering, road construction and maintenance, mining, and grazing; the blockage of migratory corridors by dams or other diversion structures; poor water quality; entrainment (a process by which aquatic organisms are pulled through a diversion or other device) into diversion channels; and introduced non-native species (64 FR 58910). Poaching and incidental mortality of bull trout during other targeted fisheries are additional threats.

The bull trout was initially listed as three separate Distinct Population Units (DPSs) (63 FR 31647, 64 FR 17110). The preamble to the final listing rule for the United States coterminous population of the bull trout discusses the consolidation of these DPSs, plus two other population segments, into one listed taxon and the application of the jeopardy standard under section 7 of the ESA relative to this species (64 FR 58930):

> Although this rule consolidates the five bull trout DPSs into one listed taxon, based on conformance with the DPS policy for purposes of consultation under section 7 of the ESA, we intend to retain recognition of each DPS in light of available scientific information relating to their uniqueness and significance. Under this approach, these DPSs will be treated as interim recovery units with respect to application of the jeopardy standard until an approved recovery plan is developed. Formal establishment of bull trout recovery units will occur during the recovery planning process.

8.6.1.2 Current Status and Conservation Needs

As noted above, in recognition of available scientific information relating to their uniqueness and significance, five segments of the coterminous United States population of the bull trout are considered essential to the survival and recovery of this species and are identified as interim recovery units: (1) Jarbidge River; (2) Klamath River; (3) Columbia River; (4) Coastal-Puget Sound; and (5) St. Mary-Belly River (USFWS 2002c; 2004a, b). Each of these segments is necessary to maintain the bull trout's distribution, as well as its genetic and phenotypic diversity, all of which are important to ensure the species' resilience to changing environmental conditions.

A summary of the current status and conservation needs of the bull trout within these units is provided below. A comprehensive discussion of these topics is found in the FWS's draft Bull Trout Recovery Plan for the bull trout (USFWS 2002b; 2004a,b).

The conservation needs of the bull trout are often generally expressed as the four "Cs": cold, clean, complex, and connected habitat. Cold stream temperatures, clean water quality that is relatively free of sediment and contaminants, complex channel characteristics (including abundant large wood and undercut banks), and large patches of such habitat that are well connected by unobstructed migratory pathways are all needed to promote conservation of bull trout at multiple scales ranging from the coterminus to local populations. The recovery planning process for the bull trout (USFWS 2002b; 2004a,b) has also identified the following conservation needs: (1) maintenance and restoration multiple, interconnected populations in diverse habitats across the range of each interim recovery unit; (2) preservation of the diversity of life-history strategies; (3) maintenance genetic and phenotypic diversity across the range of each interim recovery unit; and (4) establishment of a positive population trend. Recently, it has also been recognized that bull trout populations need to be protected from catastrophic fires across the range of each interim recovery unit.

Central to the survival and recovery of the bull trout is the maintenance of viable core areas (USFWS 2002b, 2004a, b). A core area is defined as a geographic area occupied by one or more local bull trout populations that overlap in their use of rearing, foraging, migratory, and overwintering habitat. Each of the interim recovery units listed above consists of one or more core areas. There are 121 core areas are recognized across the United States range of the bull trout (USFWS 2002b; 2004a, b).

Jarbidge River

This interim recovery unit currently contains a single core area with six local populations. Less than 500 resident and migratory adult bull trout, representing about 50 to 125 spawners, are estimated to occur within the core area. The current condition of the bull trout in this interim recovery unit is attributed to the effects of livestock grazing, roads, angler harvest, timber harvest, and the introduction of non-native fishes (USFWS 2004a). The draft Bull Trout Recovery Plan (USFWS 2004a) identifies the following conservation needs for this unit: maintain the current distribution of the bull trout within the core area; maintain stable or increasing trends in abundance of both resident and migratory bull trout in the core area; restore and maintain suitable habitat conditions for all life history stages and forms; and conserve genetic diversity and increase natural opportunities for genetic exchange between resident and migratory forms of the bull trout. An estimated 270 to 1,000 spawning fish per year are needed to provide for the persistence and viability of the core area and to support both resident and migratory adult bull trout (USFWS 2004a).

Klamath River

This interim recovery unit currently contains 3 core areas and 12 local populations. The current abundance, distribution, and range of the bull trout in the Klamath River Basin are greatly reduced from historical levels due to habitat loss and degradation caused by reduced water quality, timber harvest, livestock grazing, water diversions, roads, and the introduction of non-native fishes (USFWS 2002c). Bull trout populations in this unit face a high risk of extirpation (USFWS 2002c). The draft Bull Trout Recovery Plan (USFWS 2002c) identifies the following conservation needs for this unit: maintain the current distribution of the bull trout and restore distribution in previously occupied areas; maintain stable or increasing trends in bull trout abundance; restore and maintain suitable habitat conditions for all life

history stages and strategies; and conserve genetic diversity and provide the opportunity for genetic exchange among appropriate core area populations. Eight to 15 new local populations and an increase in population size from about 3,250 adults currently to 8,250 adults are needed to provide for the persistence and viability of the 3 core areas (USFWS 2002c).

Columbia River

This interim recovery unit currently contains about 90 core areas and 500 local populations. About 62 percent of these core areas and local populations occur in central Idaho and northwestern Montana. The condition of the bull trout within these core areas varies from poor to good, but generally all have been subject to the combined effects of habitat degradation, fragmentation, fisheries management, and alterations associated with one or more of the following activities: dewatering; road construction and maintenance; mining, and grazing; the blockage of migratory corridors by dams or other diversion structures; poor water quality; poaching and incidental mortality from other targeted fisheries; entrainment into diversion channels; and introduced non-native species. The draft Bull Trout Recovery Plan (USFWS 2002c) identifies the following conservation needs for this unit: maintain or expand the current distribution of the bull trout within core areas; maintain stable or increasing trends in bull trout abundance; maintain/restore suitable habitat conditions for all bull trout life history stages and strategies; and conserve genetic diversity and provide opportunities for genetic exchange.

Coastal-Puget Sound

Bull trout in the Coastal-Puget Sound interim recovery unit exhibit anadromous, adfluvial, fluvial, and resident life history patterns. The anadromous life history form is unique to this unit. This interim recovery unit currently contains 14 core areas and 67 local populations (USFWS 2004b). Bull trout are distributed throughout most of the large rivers and associated tributary systems within this unit. With only a few exceptions, bull trout continue to be present in nearly all major watersheds where they likely occurred historically within this unit. Generally, bull trout distribution has contracted and abundance has declined especially in the southeastern part of the unit. The current condition of the bull trout in this interim recovery unit is attributed to the adverse effects of dams, forest management practices (e.g., timber harvest and associated road building activities), agricultural practices (e.g., diking, water control structures, draining of wetlands, channelization, and the removal of riparian vegetation), livestock grazing, roads, mining, urbanization, poaching and incidental mortality from other targeted fisheries, and the introduction of non-native species. The draft Bull Trout Recovery Plan (USFWS 2004b) identifies the following conservation needs for this unit: maintain or expand the current distribution of bull trout within existing core areas; increase bull trout abundance to about 16,500 adults across all core areas; and maintain or increase connectivity between local populations within each core area.

St. Mary-Belly River

This interim recovery unit currently contains 6 core areas and 9 local populations (USFWS 2002c). Currently, the bull trout is widely distributed in the St. Mary River drainage and occurs in nearly all of the waters that it inhabited historically. Bull trout are found only in a 1.2-mile reach of the North Fork Belly River within the United States. Redd count surveys of the North Fork Belly River documented an increase from 27 redds in 1995 to 119 redds in 1999. This increase was attributed primarily to protection from angler harvest (USFWS 2002c). The current condition of the bull trout in this interim recovery unit is primarily attributed to the effects of dams, water diversions, roads, mining, and the introduction of non-native fishes (USFWS 2002c). The draft Bull Trout Recovery Plan (USFWS 2002c) identifies the

following conservation needs for this unit: maintain the current distribution of the bull trout and restore distribution in previously occupied areas; maintain stable or increasing trends in bull trout abundance; restore and maintain suitable habitat conditions for all life history stages and forms; conserve genetic diversity and provide the opportunity for genetic exchange; and establish good working relations with Canadian interests because local bull trout populations in this unit are comprised mostly of migratory fish, whose habitat is mostly in Canada.

8.6.1.3 Life History

Bull trout exhibit both resident and migratory life history strategies. Both resident and migratory forms may be found together, and either form may produce offspring exhibiting either resident or migratory behavior (Rieman and McIntyre 1993). Resident bull trout complete their entire life cycle in the tributary (or nearby) streams in which they spawn and rear. The resident form tends to be smaller than the migratory form at maturity and also produces fewer eggs (Fraley and Shepard 1989, Goetz 1989). Migratory bull trout spawn in tributary streams where juvenile fish rear 1 to 4 years before migrating to either a lake (adfluvial form), river (fluvial form) (Fraley and Shepard 1989; Goetz 1989), or saltwater (anadromous) to rear as sub-adults or to live as adults (Cavender 1978; McPhail and Baxter 1996; WDFW 1997c). Bull trout normally reach sexual maturity in 4 to 7 years and may live longer than 12 years. They are iteroparous (they spawn more than once in a lifetime), and both repeat- and alternate-year spawning has been reported, although repeat-spawning frequency and post-spawning mortality are not well documented (Leathe and Graham 1982; Fraley and Shepard 1989; Pratt 1992; Rieman and McIntyre 1996).

The iteroparous reproductive strategy of bull trout has important repercussions for the management of this species. Bull trout require two-way passage both upstream and downstream, not only for repeat spawning but also for foraging. Most fish ladders, however, were designed specifically for anadromous semelparous salmonids (fishes that spawn once and then die, and therefore require only one-way passage upstream). Therefore even dams or other barriers with fish passage facilities may be a factor in isolating bull trout populations if they do not provide a downstream passage route.

Growth varies depending upon life-history strategy. Resident adults range from 6 to 12 inches total length, and migratory adults commonly reach 24 inches or more (Pratt 1985; Goetz 1989). The largest verified bull trout is a 32-pound specimen caught in Lake Pend Oreille, Idaho, in 1949 (Simpson and Wallace 1982).

8.6.1.4 Habitat Characteristics

Bull trout have more specific habitat requirements than most other salmonids (Rieman and McIntyre 1993). Habitat components that influence bull trout distribution and abundance include water temperature, cover, channel form and stability, valley form, spawning and rearing substrate, and migratory corridors (Fraley and Shepard 1989; Goetz 1989; Hoelscher and Bjornn 1989; Sedell and Everest 1991; Howell and Buchanan 1992; Pratt 1992; Rieman and McIntyre 1993, 1995; Rich 1996; Watson and Hillman 1997). Watson and Hillman (1997) concluded that watersheds must have specific physical characteristics to provide the habitat requirements necessary for bull trout to successfully spawn and rear and that these specific characteristics are not necessarily present throughout these watersheds. Because bull trout exhibit a patchy distribution, even in pristine habitats (Rieman and McIntyre 1993), fish should not be expected to simultaneously occupy all available habitats (Rieman et al.1997).

Migratory corridors link seasonal habitats for all bull trout life histories. The ability to migrate is important to the persistence of bull trout (Rieman and McIntyre 1993; Gilpin, *in litt.* 1997; Rieman et al. 1997). Migrations facilitate gene flow among local populations when individuals from different local populations interbreed, or stray, to non-natal streams. Local populations that are extirpated by catastrophic events may also become reestablished by bull trout migrants. However, it is important to note that the genetic structuring of bull trout indicates that there is limited gene flow among bull trout populations, which may encourage local adaptation within individual populations, and that reestablishment of extirpated populations may take a very long time (Spruell et al. 1999, Rieman and McIntyre 1993).

Cold water temperatures play an important role in determining bull trout habitat, as these fish are primarily found in colder streams (below 59 degrees Fahrenheit), and spawning habitats are generally characterized by temperatures that drop below 48 degrees Fahrenheit in the fall (Fraley and Shepard 1989; Pratt 1992; Rieman and McIntyre 1993).

Thermal requirements for bull trout appear to differ at different life stages. Spawning areas are often associated with cold-water springs, groundwater infiltration, and the coldest streams in a given watershed (Pratt 1992; Rieman and McIntyre 1993; Baxter et al. 1997; Rieman et al. 1997). Optimum incubation temperatures for bull trout eggs range from 35 to 39 degrees Fahrenheit whereas optimum water temperatures for rearing range from about 46 to 50 degrees Fahrenheit (McPhail and Murray 1979; Goetz 1989; Buchanan and Gregory 1997). In Granite Creek, Idaho, Bonneau and Scarnecchia (1996) observed that juvenile bull trout selected the coldest water available in a plunge pool, 46 to 48 degrees Fahrenheit, within a temperature gradient of 46 to 60 degrees Fahrenheit. In a landscape study relating bull trout distribution to maximum water temperatures, Dunham et al. (2003) found that the probability of juvenile bull trout occurrence does not become high (i.e., greater than 0.75) until maximum temperatures decline to 52 to 54 degrees Fahrenheit.

Although bull trout are found primarily in cold streams, occasionally these fish are found in larger, warmer river systems throughout the Columbia River basin (Fraley and Shepard 1989; Rieman and McIntyre 1993, 1995; Buchanan and Gregory 1997; Rieman et al. 1997). Factors that can influence bull trout ability to survive in warmer rivers include availability and proximity of cold water patches and food productivity (Myrick et al. 2002). In the Little Lost River, Idaho, bull trout have been collected in water having temperatures up to 68 degrees Fahrenheit; however, bull trout made up less than 50 percent of all salmonids when maximum summer water temperature exceeded 59 degrees Fahrenheit and less than 10 percent of all salmonids when temperature exceeded 63 degrees Fahrenheit (Gamett 1999). In the Little Lost River study, most sites that had high densities of bull trout were in an area where primary productivity increased in the streams following a fire (B. Gamett, U. S. Forest Service, Personal Communication, 2002).

All life history stages of bull trout are associated with complex forms of cover, including large woody debris, undercut banks, boulders, and pools (Fraley and Shepard 1989; Goetz 1989; Hoelscher and Bjornn 1989; Sedell and Everest 1991; Pratt 1992; Thomas 1992; Rich 1996; Sexauer and James 1997; Watson and Hillman 1997). Maintaining bull trout habitat requires stability of stream channels and maintenance of natural flow patterns (Rieman and McIntyre 1993). Juvenile and adult bull trout frequently inhabit side channels, stream margins, and pools with suitable cover (Sexauer and James 1997). These areas are sensitive to activities that directly or indirectly affect stream channel stability and alter natural flow patterns. For example, altered stream flow in the fall may disrupt bull trout during the spawning period, and channel instability may decrease survival of eggs and young juveniles in the gravel from winter

through spring (Fraley and Shepard 1989; Pratt 1992; Pratt and Huston 1993). Pratt (1992) indicated that increases in fine sediment reduce egg survival and emergence.

Bull trout typically spawn from August through November during periods of increasing flows and decreasing water temperatures. Preferred spawning habitat consists of low-gradient stream reaches with loose, clean gravel (Fraley and Shepard 1989). Redds are often constructed in stream reaches fed by springs or near other sources of cold groundwater (Goetz 1989; Pratt 1992; Rieman and McIntyre 1996). Depending on water temperature, incubation is normally 100 to 145 days (Pratt 1992). After hatching, juveniles remain in the substrate, and time from egg deposition to emergence of fry may surpass 200 days. Fry normally emerge from early April through May, depending on water temperatures and increasing stream flows (Pratt 1992; Ratliff and Howell 1992).

Migratory forms of the bull trout appear to develop when habitat conditions allow movement between spawning and rearing streams and larger rivers, lakes or nearshore marine habitat where foraging opportunities may be enhanced (Frissell 1993; Goetz et al. 2004; Brenkman and Corbett 2005). For example, multiple life history forms (e.g., resident and fluvial) and multiple migration patterns have been noted in the Grande Ronde River (Baxter 2002). Parts of this river system have retained habitat conditions that allow free movement between spawning and rearing areas and the mainstem Snake River. Such multiple life history strategies help to maintain the stability and persistence of bull trout populations to environmental changes. Benefits to migratory bull trout include greater growth in the more productive waters of larger streams, lakes and marine waters, greater fecundity resulting in increased reproductive potential, and dispersing the population across space and time so that spawning streams may be recolonized should local populations suffer a catastrophic loss (Rieman and McIntyre 1993; MBTSG 1998; Frissell 1999). In the absence of the migratory bull trout life form, isolated populations cannot be replenished when disturbance makes local habitats temporarily unsuitable, the range of the species is diminished, and the potential for enhanced reproductive capabilities are lost (Rieman and McIntyre 1993).

8.6.1.5 Diet

Bull trout are opportunistic feeders, with food habits primarily a function of size and life-history strategy. A single optimal foraging strategy is not necessarily a consistent feature in the life of a fish, but this foraging strategy can change from one life stage to another. Fish growth depends on the quantity and quality of food that is eaten (Gerking 1994) and as fish grow their foraging strategy changes as their food changes in quantity, size, or other characteristics. Resident and juvenile migratory bull trout prey on terrestrial and aquatic insects, macrozooplankton, and small fish (Boag 1987; Goetz 1989; Donald and Alger 1993). Adult migratory bull trout feed on various fish species (Leathe and Graham 1982; Fraley and Shepard 1989; Brown 1994; Donald and Alger 1993). Bull trout of all sizes other than fry have been found to eat fish half their length (Beauchamp and Van Tassell 2001). In nearshore marine areas of western Washington, bull trout feed on Pacific herring (*Clupea pallasi*), Pacific sand lance (*Ammodytes hexapterus*), and surf smelt (*Hypomesus pretiosus*) in the ocean (WDFW 1997c; Goetz et al. 2004).

Bull trout migration and life history strategies are closely related to their feeding and foraging strategies. Migration allows bull trout to access optimal foraging areas and exploit a wider variety of prey resources. Optimal foraging theory can be used to describe strategies fish use to choose between alternative sources of food by weighing the benefits and costs of capturing one choice of food over another. For example, prey often occur in concentrated patches of abundance ("patch model"; Gerking 1998). As the predator feeds in one patch, the prey population is reduced, and it becomes more profitable for the predator to seek a new patch rather than continue feeding on the original one. This can be explained in terms of balancing

energy acquired versus energy expended. For example, in the Skagit River system, anadromous bull trout make migrations as long as 121 miles between marine foraging areas in Puget Sound and headwater spawning grounds, foraging on salmon eggs and juvenile salmon along their migration route (WDFW 1997c). Anadromous bull trout also use marine waters as migration corridors to reach seasonal habitats in non-natal watersheds to forage and possibly overwinter (Brenkman, in litt. 2003; Brenkman and Corbett, in litt. 2003; Goetz, in litt., 2003a,b).

8.6.1.6 Changes in Status of the Coastal-Puget Sound Population Segment

Although the status of bull trout in Coastal-Puget Sound population segment has been improved by certain actions, it continues to be degraded by other actions, and it is likely that the overall status of the bull trout in this population segment has not improved since its listing on November 1, 1999. Improvement has occurred largely through changes in fishing regulations and habitat-restoration projects. Fishing regulations enacted in 1994 either eliminated harvest of bull trout or restricted the amount of harvest allowed, and this likely has had a positive influence on the abundance of bull trout. Improvement in habitat has occurred following restoration projects intended to benefit either bull trout or salmon, although monitoring the effectiveness of these projects seldom occurs. On the other hand, the status of this population segment has been affected by a number of Federal and non-Federal actions, some of which are addressed under section 7 of the ESA. Most of these actions degraded the environmental baseline; all of those addressed through formal consultation under section 7 of the ESA permitted the incidental take of bull trout.

Three recent section 10(a)(1)(B) permits have been issued for Habitat Conservation Plans (HCPs) completed in the Coastal-Puget Sound population segment: 1) the City of Seattle's Cedar River Watershed HCP; 2) the Simpson Timber HCP; and 3) the Tacoma Public Utilities Green River HCP. In addition, the Plum Creek Cascades HCP, the Washington State Department of Natural Resources (WDNR) HCP, and the West Fork Timber HCP (Nisqually River) addressed the Coastal-Puget Sound population segment of bull trout. Following listing, consultation was reinitiated for these HCPs regarding their incidental take permits. These HCPs provide landscape-scale conservation for fish, including bull trout. Many of the covered activities associated with these HCPs will contribute to conserving bull trout over the long-term; however, some covered activities (albeit minimized by the conservation measures) may result in short-term degradation of the baseline. All HCPs permit the incidental take of bull trout.

8.6.1.7 Changes in Status of the Columbia River Population Segment

The overall status of the Columbia River population segment has not changed appreciably since its listing on June 10, 1998. Populations of bull trout and their habitat in this area have been affected by a number of actions addressed under Section 7 of the ESA. Most of these actions resulted in degradation of the environmental baseline of bull trout habitat, and all permitted or analyzed the potential for incidental take of bull trout.

In addition, the Plum Creek Cascades HCP addressed portions of the Columbia River population segment of bull trout. Immediately following listing, consultation was reinitiated regarding addition of the population segment to Plum Creek's incidental take permit.

In general, trends since listing have been improving slightly for many of the factors considered to be threats to bull trout due to implementation of conservation measures described in the draft Bull Trout Recovery Plan (USFWS 2002a). Although we have refined our understanding of some aspects of the bull trout's life history, distribution, and abundance, substantial gaps in our knowledge remain.

8.6.2 ENVIRONMENTAL BASELINE: Bull Trout

8.6.2.1 Status of the Species in the FPHCP Action Area

Regulations implementing the ESA (50 CFR § 402.02) define the environmental baseline as the past and present impacts of all Federal, State, or private actions and other human activities in the FPHCP Action Area. Also included in the environmental baseline are the anticipated impacts of all proposed Federal projects in the FPHCP Action Area that have undergone section 7 consultation, and the impacts of State and private actions that are contemporaneous with the consultation in progress.

8.6.2.2 Consulted on Effects

The status of bull trout in each population segment is being affected by a number of ongoing activities that have been addressed through previous biological opinions prepared under section 7 of the ESA, including several Habitat Conservation Plans (section 10(a)(1)(B) permits). A number of biological opinions addressing bull trout have been issued for Federal actions within the Coastal-Puget Sound and Columbia River population segments since listing. Many of these biological opinions have permitted the incidental take of bull trout. Habitat Conservation Plans are also discussed in the following section because they have the potential to have large-scale influences over a long period of time. In addition, numerous recovery permits (section 10(a)(1)(A) permits) have been issued to aid the recovery of bull trout in each population segment. Additionally, a discussion of section 7 analyse can be found in each of the core area narratives.

Coastal-Puget Sound Population Segment

Biological Opinions

Since being listed in 1999, the FWS has issued biological opinions that exempted incidental take in the Coastal–Puget Sound population segment. These incidental take exemptions were in the form of harm and harassment, primarily from temporary sediment increases during in-water work, loss or alteration of habitat, and the capturing and handling of fish. None of these projects were determined to result in jeopardy to the bull trout. The combined effects of actions evaluated under these biological opinions have resulted in short-term and long-term adverse effects to bull trout and degradation of bull trout habitat within the population segment.

Habitat Conservation Plans

The West Fork Timber Company (previously Murray Pacific Corporation), Washington Department of Natural Resources, and Plum Creek Timber Company added the Coastal-Puget Sound population segment of bull trout to their ITPs consistent with their respective HCPs and IAs. The West Fork Timber Company's HCP ensures that sufficient amounts of habitat types will be maintained or enhanced for bull trout on their land for a term of 100 years. The Washington Department of Natural Resources' Permit was updated in 1998 to include an exemption for the incidental taking of bull trout associated with their annual road construction and maintenance program and their annual timber management program. The Coastal-Puget Sound population segment of bull trout was added to the Plum Creek Cascades Permit in 2004 for forest-related activities on their lands. The Permit allows for the incidental take of bull trout associated with habitat degradation/loss due to selective and thinning/restoration-oriented silvicultural harvest, stream restoration, and road construction, maintenance, and removal per year. The term of the Plum Creek HCP and Permit is 50 to 100 years.

Three other HCPs have been completed in the Coastal-Puget Sound population segment. The City of Seattle's Cedar River Watershed HCP, completed in April 2000, covers municipal water supply and includes 1) Chester Morse reservoir operations and activities associated with restoration planting; 2) restoration thinning; 3) ecological thinning; 4) instream habitat restoration projects; 5) road removal; 6) road maintenance; and 7) road improvement. This HCP completely encompasses a single core area, the Chester Morse Lake core area. The term of the City of Seattle HCP and incidental take permit is 50 years.

The Green Diamond (formerly Simpson Timber) HCP, completed in October 2000, encompasses 261,575 acres with approximately 354 miles of fish-bearing stream habitat in the Chehalis and Skokomish River drainages in western Washington. Bull trout currently reside in the South Fork Skokomish River watershed, but they also may be found in low numbers within the Wynoochee and Satsop River watersheds (Chehalis River basin). The FWS authorized the incidental take of bull trout as a result of timber harvest and experimental thinning associated with stream habitats over the 50-year permit term. In addition, the FWS authorized incidental take of bull trout associated with habitat adjacent to new road construction, and road remediation. By year 15 of the HCP, effects to bull trout habitat resulting from road remediation should be eliminated.

The Tacoma Public Utilities Green River HCP, completed in July 2001, addresses effects to listed species from the management of 15,000 acres of forest in the upper Green River watershed, including approximately 110 stream miles, and Tacoma's municipal water withdrawal from Green River at river mile 61.0. Bull trout have not been documented to occur in the upper watershed and only a few individuals have been found in the FMO habitat of the lower Green River and Duwamish Waterway (USFWS 2001). In this HCP, we permitted the incidental take of bull trout resulting from water withdrawal activities affecting the middle and lower Green River, even-aged harvest, uneven-aged harvest, and the construction, maintenance, and decommissioning of forest road. The term of the Tacoma HCP and incidental take permit is 50 years.

Scientific Permits

The FWS may also issues recovery permits that would be in effect during the implementation period of this proposed action within the Coastal-Puget Sound population segment. Pursuant to these permits, bull trout may be injured or killed for research purposes. These permits usually are issued for five years and then would need to be renewed, if necessary. Although actual numbers of fish handled or killed due to fish handling procedures have not been recently summarized, based upon past experience we anticipate that the actual number of fish injured or killed will be significantly less than that issued. Prior years (2000-2002) indicate there have typically been no adult mortalities in almost all core areas, except one, South Fork Skokomish. Juvenile mortality is low as well, with only eight individuals lethally sampled across all core areas in three years (2000-2002).

Columbia River Population Segment

Biological Opinions

Since the bull trout listing, the FWS has issued biological opinions that exempted incidental take in the Columbia River population segment. These incidental take exemptions were in the form of harm and harassment, primarily from temporary sediment increases during in-water work, loss or alteration of habitat, and the capturing and handling of fish. None of these projects were determined to result in jeopardy to the bull trout. The combined effects of actions evaluated under these biological opinions have

resulted in short-term and long-term adverse effects to bull trout and degradation of bull trout habitat within the Columbia River population segment.

Habitat Conservation Plans

The Plum Creek Timber Company's Permit amendment (USDI 1998d) added the Columbia River population segment of bull trout to their Permit consistent with the HCP and IA. The Permit allows for the incidental take of bull trout associated with habitat degradation/loss due to selective and thinning and silvicultural harvest, stream restoration, and road construction, maintenance, and removal per year. The term of the Plum Creek HCP and Permit is 50 to 100 years.

The Washington Department of Natural Resources' HCP incidental take Permit was updated (USDI 1998c) to allow for incidental take of bull trout in the lower Columbia River downstream from Greenleaf and Hamilton creeks. This Permit update was connected with the same effort discussed in the Coastal-Puget Sound population segment for the annual habitat degradation/loss due to road construction and maintenance and selective and thinning harvest.

Scientific Permits

The FWS may also issues recovery permits that would be in effect during the implementation period of this proposed action within the Columbia River population segment. Pursuant to these permits, bull trout may be injured or killed for research purposes. These permits usually are issued for five years and then would need to be renewed, if necessary. Although the actual numbers of fish handled or killed due to fish handling procedures have not yet been summarized, based upon past experience we anticipate that the actual number of fish injured or killed will be significantly less than that issued.

8.6.2.3 Core Areas

The FPHCP Action Area is comprised of almost the entire Coastal-Puget Sound population segment and that portion of the Columbia River population segment encompassed by the State of Washington. The Coastal-Puget Sound population segment is comprised of two management units: the Olympic Peninsula Management Unit and the Puget Sound Management Unit. A management unit is a subset of a listed entity that is defined by USFWS for administrative and management purposes, usually to manage recovery for a species that is broadly distributed and that may experience a wide range of threats and management authorities across its distribution. In the case of bull trout, the population segment was further subdivided into management units based on several factors, including biological and genetic considerations, political boundaries, and ongoing conservation efforts. Within the Olympic Peninsula Management Unit there are six core areas: the Quinault, Queets, Hoh, Elwha, Dungeness, and Skokomish. All six of these core areas are at least partially within the FPHCP Action Area. The Puget Sound Management Unit consists of eight core areas: Chester Morse Lake, Chilliwack, Lower Skagit, Nooksack, Puyallup, Snohomish/Skykomish, Stillaquamish, and the Upper Skagit. Portions of the FPHCP Action Area are within all of these core areas except Chester Morse Lake. Chester Morse Lake is not included in the description of the environmental baseline within the FPHCP Action Area because the entire watershed where bull trout occur is owned and managed under an approved HCP by the City of Seattle. Core areas consist of habitat that could supply all the necessary elements for every life-stage of bull trout (e.g., spawning, rearing, migration, overwintering, foraging), and have one or more local populations of bull trout. Core areas constitute the basic unit on which to gauge recovery.

That portion of the Columbia River population segment that falls within the boundaries of Washington State is made up of all or portions of nine management units (MUs). These recovery units are in the Lower Columbia River Basin, Middle Columbia River Basin, Upper Columbia River Basin, Northeast Washington River Basin, Umatilla-Walla Walla River Basins, Snake River Basin in Washington, Grande Ronde River Basin, Clark Fork River Basin, and the Coeur d'Alene Lake Basin. The Lower Columbia River Basin MU consists of the Klickitat and Lewis core areas. The Middle Columbia River Basin MU consists of the Yakima core area. The Upper Columbia River Basin MU consists of the Entiat, Wenatchee, and Methow core areas. The Northeast Washington River Basin MU contains the Pend Oreille core area. The Umatilla-Walla Walla River Basin MU (portion in Washington) contains the Walla-Walla and Touchet core areas. The Snake River Basin in Washington MU contains the Tucannon and Asotin Creek core areas. The Grande Ronde River Basin MU (portion in Washington) contains the Grande Ronde core area. The Clark Fork River Basin MU (portion in Washington) contains the Priest Lakes and Pend Oreille Lake core area. The Coeur d'Alene Lake Basin MU contains the Coeur d'Alene Lake Basin core area. Portions of each of these core areas are within the FPHCP Action Area.

Recovery objectives are similar for all core areas and are focused on maintaining current bull trout distributions and restoring distribution in previously occupied areas, maintaining stable or increasing trends in abundance of bull trout, restoring and maintaining suitable habitat for all life-history stages, conserving genetic diversity, and providing opportunity for genetic exchange. This can be achieved by correcting prevailing threats in each core area. In addition, the establishment of fisheries management goals and objectives, research and monitoring programs, adaptive-management approaches, and use of available conservation programs and regulations are recommended to achieve recovery objectives, and monitor progress in reaching recovery goals.

Coastal-Puget Sound Population Segment

Olympic Peninsula Management Unit

Queets Core Area

The Queets Core Area comprises the Queets River, all of its tributaries, and the estuary. The Queets mainstem, except for the lower eight miles, is contained entirely within a narrow corridor of the Olympic National Park. The tributaries flow through the Quinault Indian Reservation, Olympic National Forest, and State and private landholdings.

Fluvial, resident, and anadromous life history forms of bull trout occur in the Queets Core Area.

The status of the bull trout Core Area population is based on four key elements necessary for long-term viability: (1) number and distribution of local populations; (2) adult abundance; (3) productivity; and (4) connectivity (USFWS 2004b).

NUMBER AND DISTRIBUTION OF LOCAL POPULATIONS

One local population has been identified: Queets River and associated tributaries upstream from the confluence with Tshletshy Creek. Bull trout occur in the Queets River up to river mile 46; in the Salmon, Sams, and Clearwater Rivers; and in Matheny Creek. The Queets River mainstem and tributaries are designated as mixed use (i.e., rearing, foraging, migration, overwintering). Spawning occurs in the mainstem river between river miles 45 and 48. With only one local population, bull trout in this Core

Area are considered at increased risk of extirpation and adverse effects from random naturally occurring events (see "Life History").

ADULT ABUNDANCE

The Queets Core Area probably supports at least 500 but fewer than 1,000 adults. With fewer than 1,000 adults, the bull trout population in this Core Area is considered at increased risk of genetic drift.

PRODUCTIVITY

The bull trout population in the Queets Core Area is considered to be at risk of extirpation until sufficient information is collected to properly assess productivity.

CONNECTIVITY

Bull trout occur in the Queets River from the marine waters of the anadromous zone up to the headwater spawning sites. Although there are barriers to movement (e.g., impassable culverts) in some tributaries, there are no barriers to movement in the mainstem Queets River. This migratory corridor is relatively pristine and intact.

CHANGES IN ENVIRONMENTAL CONDITIONS AND POPULATION STATUS

Since the bull trout listing, several Federal actions occurring in the Queets Core Area have resulted in harm to, or harassment of, bull trout. These actions include forest management activities and culvert replacements outside of the local population. The culvert replacements are designed to provide long-term benefits to the watershed and bull trout. The more recent forest management activities that are consistent with the Quinault Indian Reservation 10-year Forest Management Plan incorporate riparian buffers and conservation measures designed to reduce adverse effects to bull trout. No section 6 or section 10(a)(1)(A) permits have been issued in the Queets Core Area for effects to bull trout through capture and handling.

The number of non-Federal actions occurring in the Queets Core Area since the bull trout listing is unknown. Activities currently conducted on an infrequent basis, such as emergeny flood control, development, and infrastructure maintenance, affect riparian and instream habitat and probably negatively affect bull trout.

THREATS

Threats to bull trout in the Queets Core Area include:

- Past logging and logging-related activities, such as roads, degraded habitat conditions in the Clearwater, Sams, and Salmon Rivers and Matheny Creek.
- Road densities in the Clearwater River basin are high, and roads throughout the Queets Core Area are in need of repair.
- Bull trout are susceptible to incidental mortality associated with fisheries that target salmon and steelhead at the mouth of the Queets River and incidental hooking mortality from recreational fishers.

Skokomish Core Area

The Skokomish Core Area comprises the South Fork Skokomish River, North Fork Skokomish River (above Cushman Dam), Vance Creek, and their tributaries. Mainstem rivers in the area provide important

foraging, migration, and overwintering habitat for sub-adult and adult bull trout. Available spawning and early rearing habitat is limited and fragmented. One reservoir in the core area, Lake Cushman, supports a typical adfluvial population.

Fluvial, adfluvial and, possibly, anadromous and resident life history forms of bull trout occur in the Skokomish Core Area.

The status the bull trout core area population is based on four key elements necessary for long-term viability: (1) number and distribution of local populations; (2) adult abundance; (3) productivity; and (4) connectivity (USFWS 2004b).

NUMBER AND DISTRIBUTION OF LOCAL POPULATIONS

Two local populations have been identified: (1) North Fork Skokomish River (including Elk and Slate Creeks); and (2) South Fork Skokomish River (including Church Creek). Bull trout are distributed throughout the Skokomish core area, mainly downstream of barriers to migration in the South Fork Skokomish River and upstream of Cushman Dam in the North Fork Skokomish River. A third potential local population may occur in Brown Creek. With only two known local populations, the bull trout in this core area is at increased risk of local extirpation and adverse effects from random naturally occurring events.

ADULT ABUNDANCE

The Skokomish Core Area likely supports fewer than 200 adult bull trout. Olympic National Forest estimates 60 adults occupy the South Fork Skokomish (WSCC 2003b). In the North Fork Skokomish River bull trout numbers remained relatively stable from 1990 to 1996. Counts during this period averaged 302 adults, ranging from 250 to 413. More recent counts from 1998 to 2004 indicate a decline to an average of 100 adults, ranging from 89 to 133 (S. Brenkman, Olympic National Park, *in litt.* 2003; S. Brenkman, Personal Communication, 2004). With fewer than 1,000 adults, the bull trout population in this core area is considered at risk of genetic drift. With fewer than 100 adults, the South Fork Skokomish River local population is considered at risk from inbreeding depression.

The bull trout population in this core area is one of the most depressed in the Olympic Peninsula Management Unit. The decline in numbers of adult bull trout in the North Fork Skokomish River and the low number of spawning adults in the South Fork Skokomish River indicate that the bull trout in this core area is at increased risk of extirpation and adverse effects from random naturally occurring events.

PRODUCTIVITY

The Olympic National Forest completed intensive redd surveys in the core area over a 3-year period. In 2000 in the South Fork Skokomish River, 20 redds were located in 5 spawning areas between river mile 19 and river mile 23.4, and 2 reds were located in the lower 0.5 mile of Church Creek. One questionable redd was observed in Brown Creek. There were 18 redds in the South Fork Skokomish River and 2 Church Creek in 2001. In 2002, there were 13 redds in the South Fork Skokomish River and 1 in Church Creek.

The bull trout in the Skokomish Core Area is considered at risk of extirpation until sufficient information is collected to properly assess productivity.

CONNECTIVITY

Migratory bull trout likely are present in the South Fork Skokomish River local population. Bull trout in the North Fork Skokomish River local population occur in Lake Cushman and the river upstream from the reservoir to the confluence of Four Streams in Olympic National Park. Adfluvial bull trout occur in Lake Cushman, the North Fork Skokomish River, and Elk and Slate Creeks. Restoration of the migratory corridor between the two local populations and between the local populations and Hood Canal will be required to allow full expression of the bull trout's migratory life history form.

CHANGES IN ENVIRONMENTAL CONDITIONS AND POPULATION STATUS

The FWS, NMFS, and the EPA assisted the Simpson Timber Company (now Green Diamond Resources) in completing a habitat conservation plan in 2000. The principle area of the HCP overlaps bull trout distribution in the South Fork Skokomish River and the accessible reaches of its major tributaries. The HCP includes management prescriptions designed to address wetlands, unstable slopes, road construction, road maintenance and decommissioning, certain harvest limitations to moderate snowmelt runoff, and riparian buffers that vary from 5 to 65 meters. The HCP also includes provisions for research and monitoring and a scientific committee of stakeholders.

Capture and handling during implementation of section 6 and section 10(a)(1)(A) permits have directly affected bull trout in the Skokomish Core Area.

The number of non-Federal actions occurring in the Skokomish Core Area since the bull trout listing is unknown. Activities conducted on a regular basis, such as emergency flood control, development, and infrastructure maintenance, affect riparian and instream habitat and probably negatively affect bull trout.

THREATS

Threats to bull trout in the Skokomish Core Area include:

- Past timber harvest and harvest-related activities, such as roads, have degraded habitat conditions, including water quality, in the upper Skokomish River.
- Road densities in the Skokomish River basin represent some of the highest found west of the Cascades Mountains in Washington, and roads throughout the core area are in need of repair.
- Agricultural and livestock practices affect foraging, migration, and overwintering habitat in the lower watershed. Significant effects to the floodplain bull trout habitat, are caused by blocking fish passage, altering stream morphology, and degrading water quality.
- Diversion of water for hydropower production has eliminated connectivity between bull trout habitat upstream from the dams and habitat in the lower North Fork Skokomish River, the mainstem Skokomish River, the South Fork Skokomish River, and Hood Canal.
- The reduction of flows in the North Fork Skokomish River by diversion of water has reduced sediment transport capabilities and caused additional aggradation of the river.
- Incidental mortality of migrating bull trout caused by tribal gill-net fisheries, and recreational and tribal fisheries, poses a threat in the North Fork Skokomish River because of the low numbers of bull trout documented in recent years.
- Rural development in the lower watershed habitat has degraded water quality.

Elwha Core Area

The Elwha Core Area comprises the Elwha River and its tributaries including Boulder, Cat, Prescott, Stony, Hayes Godkin, Buckinghorse, and Delabarre Creeks; Lake Mills and Lake Aldwell; and the estuary of the Elwha River. There is no upstream passage at either the Elwha Dam or Glines Canyon Dam, which fragment the Core Area.

Anadromous, fluvial, adfluvial, and resident life history forms probably occupy the Elwha Core Area, although there is no available information. No spawning sites have been identified above the two dams, and there probably is little habitat suitable for bull trout spawning and incubation downstream from the dams. Elevated stream temperatures due to the two dams likely limit reproducing populations of bull trout in both the lower and middle reaches of the Elwha River.

The status of a bull trout Core Area population is based on four key elements necessary for long-term viability: (1) number and distribution of local populations; (2) adult abundance; (3) productivity; and (4) connectivity (USFWS 2004b).

Number and Distribution of Local Populations

Only one local population has been identified in the Elwha Core Area. However, future surveys may identify additional local populations. Although no spawning areas have been identified, the presence of multiple age classes of bull trout in the Elwha River and accessible tributaries upstream from Glines Canyon Dam indicates spawning and juvenile rearing occur in the area. Many of the tributaries have limited accessible habitat. The Little River has been identified as a potential local population, based on the availability of suitable habitat and the likelihood that spawning will occur when the Elwha and Glines Canyon Dams are removed. With only one local population, bull trout in the Elwha Core Area are considered at increased risk of extirpation and adverse effects from random naturally occurring events.

Adult Abundance

Bull trout occur in moderately low numbers between the two dams. Both juvenile and adult bull trout have been captured in the upper and middle Elwha River and in Lake Aldwell below Glines Canyon Dam. At the time of listing, bull trout were rare (i.e., one or two fish per year) in the Elwha River below the Elwha dam. Thirty-one bull trout, ranging in size from 250 to 620 millimeters, were documented in this section of the river during snorkel surveys in 2003 (G. Pess, NMFS, *in litt*. 2003).

There is no information on trends in abundance of Elwha River bull trout, and the status of Elwha River bull trout is unknown. Consequently, the bull trout population in the Elwha Core Area is considered at risk of genetic drift.

Productivity

Bull trout in the Elwha Core Area are considered at risk of extirpation until sufficient information is collected to properly assess productivity.

Connectivity

The Elwha and Glines Canyon Dams in the Elwha River fragment the populations of bull trout in the Elwha Core Area. Restoration of connectivity in the Elwha River will be required to allow full expression of the bull trout's migratory life history form, including anadromy.

CHANGES IN ENVIRONMENTAL CONDITIONS AND POPULATION STATUS

Since the bull trout listing, Federal actions occurring in the Elwha River Core Area have resulted in harm to, or harassment of, bull trout. These actions include statewide Federal restoration programs that include riparian restoration, replacement of fish passage barriers, and fish habitat improvement projects; federally funded transportation projects involving repair and protection of roads and bridges; and section 10(a)(1)(B) permits for HCPs addressing forest management practices. Capture and handling during implementation of section 6 and section 10(a)(1)(A) permits have directly affected bull trout in the Elwha Core Area.

The number of non-Federal actions occurring in the Elwha River Core Area since the bull trout listing is unknown. However, because most of the Core Area is in Federal ownership, few non-Federal actions likely have occurred in this Core Area.

THREATS

Threats to bull trout in the Elwha Core Area include:

- Two dams in the Elwha River prevent connectivity, increase injury and mortality of bull trout attempting to navigate through the dams, reduce spawning gravel recruitment, prevent recruitment of fluvially transported sediment to the estuary, affect the beach and eelgrass beds in the estuary, and increase water temperatures below the dams.
- Past logging on private lands in the Elwha Core Area, outside of the Olympic National Park, has affected water quality through the release of fine sediment, which potentially affects bull trout egg incubation success and juvenile rearing.
- Impacts from residential and urban development occur mainly in the lower Elwha River. Dike construction has constricted the channel and severely affected nearshore and estuary habitat and processes.
- Bull trout are susceptible to incidental mortality associated with fisheries that target commercially desirable species such as coho and steelhead.

Dungeness River Core Area

The Dungeness River Core Area comprises the Dungeness and Grey Wolf Rivers, associated tributaries, and estuary. The Dungeness River Core Area is one of two Core Areas in the Olympic Peninsula Management Unit that are connected to the Strait of Juan de Fuca.

Bull trout occur throughout the Dungeness and Gray Wolf Rivers downstream of impassable barriers, which are present on both rivers. They also occur in the Dungeness River estuary and Gold Creek, a Dungeness River tributary. Twenty-five char sampled in the Dungeness River were all bull trout (Spruell and Maxwell 2002). However, 50 char sampled upstream of the barrier at river mile 24 were all Dolly Varden (S. Young, WDFW, *in litt.* 2001).

Fluvial and anadromous life history forms of bull trout occur in the Dungeness River Core Area. Mainstem rivers within the Core Area provide spawning, rearing, foraging, migration, and overwintering habitats.

The status of the bull trout Core Area population is based on four key elements necessary for long-term viability: (1) number and distribution of local populations; (2) adult abundance; (3) productivity; and (4) connectivity (USFWS 2004b).

NUMBER AND DISTRIBUTION OF LOCAL POPULATIONS

Two local populations have been identified: (1) middle Dungeness River up to river mile 24 and tributaries, including Silver, Gold, and Canyon Creeks; and (2) Gray Wolf River to confluence with Cameron, Grand, and Cedar Creeks. With only two local populations, bull trout in this Core Area are considered to be at increased risk of extirpation and adverse effects from random naturally occurring events.

ADULT ABUNDANCE

Little is known about adult abundance in the Dungeness River Core Area, mainly due to lack of survey effort and difficult access to the upper watershed. However, the Dungeness River Core Area probably supports at least 500 but fewer than 1,000 adults. With fewer than 1,000 adults, this population is considered to be at increased risk of genetic drift.

From late August through November 1984, comprehensive redd surveys were conducted in the Gray Wolf and middle Dungeness Rivers. These surveys combined walking surveys with radio telemetry tracking. Eight redds were observed in the middle Dungeness, above the confluence with the Gray Wolf River and below the impassable barrier, and 32 redds were observed in the Gray Wolf River local population area. This probably represents approximately 90 percent of the redds in the two local populations (L. Ogg, USFS, Personal Communication, 2004b). There appear to be two spawning peaks during the year, with large (27- to 30-inch) bull trout observed during the second peak.

PRODUCTIVITY

Bull trout in the Dungeness Core Area are considered at risk of extirpation until sufficient information is collected to properly assess productivity.

CONNECTIVITY

Barriers to fish movement and migration in the Dungeness River Core Area include improperly sized or installed culverts throughout the Core Area. Connectivity between the Dungeness River and its floodplain has been eliminated by diking to prevent flooding. Migration during late summer and early fall can be blocked by reduced flows from water diversions for irrigation in the lower Dungeness watershed. Migration at certain times of the year may be blocked by the WDFW fish hatchery collection rack on the lower Dungeness River. In addition, the hatchery water intake is a complete barrier to upstream fish passage in Canyon Creek. Despite these alterations, migratory bull trout persist in both local populations. Bull trout in this Core Area have diminished risk of extirpation from habitat isolation and fragmentation.

CHANGES IN ENVIRONMENTAL CONDITIONS AND POPULATION STATUS

Since the bull trout listing, Federal actions occurring in the Dungeness River Core Area have caused harm to, or harassment of, bull trout. These actions include statewide Federal restoration programs that include riparian restoration, replacement of fish passage barriers, and fish habitat improvement projects; federally funded transportation projects involving repair and protection of roads and bridges; and section 10(a)(1)(B) permits for HCPs addressing forest management practices. Capture and handling during implementation of section 6 and section 10(a)(1)(A) permits have directly affected bull trout in the Dungeness Core Area.

The number of non-Federal actions occurring in the Dungeness River Core Area since the bull trout listing is unknown. Activities conducted on a regular basis, such as emergency flood control, development, and infrastructure maintenance, affect riparian and instream habitat and probably negatively affect bull trout.

One of the greatest causes of bull trout habitat degradation in the upper Dungeness River watershed is the presence of forest roads in an area having naturally unstable geology and steep slopes. Mass wasting and sediment delivery to streams are common problems. The lower watershed has been permanently modified by timber harvest and development into farming and housing areas. Water rights are over appropriated in the Dungeness River. Consequently, water diversions have altered stream flows, resulting in increased water temperatures, seasonal migration barriers, and false attractions of bull trout to other streams. Stormwater runoff from urban and residential development and agricultural practices also affect water quality. Incidental mortality of bull trout due to tribal and recreational fishing are likely affecting bull trout.

THREATS

Threats to bull trout in the Dungeness River Core Area include:

- Past logging and logging-related activities, such as roads, have degraded habitat conditions (e.g., fisheries, water quality, and connectivity) in the upper watershed, which has a naturally unstable geology with steep slopes that are susceptible to mass wasting.
- Past and current agricultural practices and the over appropriation of water rights negatively affect instream flow, increase water temperatures, and increase sediment deposition in the streambed. Other impacts include blocked migration, decreased juvenile rearing areas, false attractions of bull trout to other streams, transportation of pollutants in irrigation flows, reduced amounts of LWD, and loss of estuarine rearing and foraging habitat.
- Water quality has been degraded by municipal, agricultural, and industrial effluent discharges and development.
- Residential and urban development along the shore that include intertidal filling, bank armoring, and shoreline modifications have caused the loss of extensive eelgrass meadows in the nearshore.
- Bull trout are susceptible to incidental mortality associated with fisheries that target coho and steelhead at the mouth of the Dungeness River for approximately 74 days per year. Although recreational fishing for bull trout has been closed in the Dungeness River Core Area since 1994, incidental catch does occur, particularly during the early portion of the winter steelhead fisheries (NMFS, *in litt*. 2004).
- Predation by eagles and ospreys has caused the mortality of several fish in the Dungeness River (L. Ogg, USFS, Personal Communication, 2004a).

Quinault Core Area

The Quinault Core Area comprises the mainstem Quinault (East Fork) and North Fork Quinault Rivers, associated tributaries, the estuary of the river, and Lake Quinault. Fifty-one percent of the core area lies within the Olympic National Park, 32 percent is owned by the Quinault Indian Nation, and 13 percent is managed by the Olympic National Forest. The remaining 4 percent are private landholdings; Rayonier Timberlands Company is the largest private landowner.

Fluvial, adfluvial, anadromous and, possibly, resident life history forms of bull trout occur in the Quinault Core Area. The Cook Creek watershed provides foraging and overwintering habitat.

The status of the bull trout core area population is based on four key elements necessary for long-term viability: (1) number and distribution of local populations; (2) adult abundance; (3) productivity; and (4) connectivity (USFWS 2004b).

NUMBER AND DISTRIBUTION OF LOCAL POPULATIONS

Two local populations have been identified: (1) North Fork Quinault River and its associated tributaries; and (2) upper mainstem Quinault River, upstream from the confluence with the North Fork Quinault River. These two local populations occur entirely within the Olympic National Park. Although there may be more than two local populations, there is insufficient information at this time to identify additional local populations. Dolly Varden occur with bull trout in the upper mainstem Quinault River. There is no evidence of hybridization or introgression between the two species (Leary and Allendorf 1997).

Bull trout occur from the headwaters to the estuary and in numerous tributaries above the lake. Although spawning sites have not been located in the Quinault Core Area, the presence of multiple age classes of bull trout in both local populations indicates spawning and rearing does occur. With only two local populations, bull trout in this core area are considered at increased risk of extirpation and adverse effects from random naturally occurring events.

ADULT ABUNDANCE

Currently there is insufficient information for a precise estimate of adult bull trout abundance. However, the Quinault Core Area probably supports at least 500 but fewer than 1,000 adults. With fewer than 1,000 adults, this population is considered at increased risk of genetic drift.

PRODUCTIVITY

Bull trout in the Quinault Core Area are considered at risk of extirpation until sufficient information is collected to properly assess productivity.

CONNECTIVITY

Migratory bull trout occur in both local populations in the Quinault Core Area. Adequate connectivity between the two local populations, and throughout the core area, diminishes the risk of extirpation of bull trout in the core area from habitat isolation and fragmentation.

CHANGES IN ENVIRONMENTAL CONDITIONS AND POPULATION STATUS

Since the bull trout listing, several Federal actions occurring in the Quinault Core Area have resulted in harm to, or harassment of, bull trout. These actions primarily consist of forest management activities and road repair outside of the local populations. Capture and handling during implementation of section 6 and section 10(a)(1)(A) permits have directly affected bull trout in the Quinault Core Area. The only known Federal action occurring in a local population was a road reconstruction adjacent to the upper mainstem Quinault River. In general, the road repair actions were designed to provide long-term benefits to the watershed and bull trout. The more recent forest management activities that are consistent with the Quinault Indian Reservation 10-year Forest Management Plan incorporate riparian buffers and conservation measures designed to reduce adverse effects to bull trout from timber harvest activities and road construction and maintenance.

The number of non-Federal actions occurring in the Quinault Core Area since the bull trout listing is unknown. Activities conducted on a regular basis, such as emergeny flood control, development, and infrastructure maintenance, affect riparian and instream habitat and probably negatively affect bull trout.

THREATS

Threats to bull trout in the Quinault Core Area include:

- Tributaries and rivers outside of the Olympic National Park have been affected by past logging.
- Current and long-term historical impacts from roads and transportation networks affect fisheries, water quality, and connectivity. The core area below Lake Quinault has been modified by extensive road construction and timber harvest activities.
- Bull trout are susceptible to incidental mortality associated with fisheries that target salmon and steelhead at the mouth of the Quinault River and to incidental hooking mortality from recreational anglers.
- Physical reductions of stream channel depths and cover habitat, along with flow regime changes in the mid-to-lower subbasins, have altered migratory corridors.

Hoh River Core Area

The Hoh River Core Area comprises the Hoh and South Fork Hoh Rivers and associated tributaries. Active glaciers at the headwaters of the Hoh River watershed deliver both cold water and "glacial flour" to the mainstem.

Bull trout occur throughout the mainstem Hoh and South Fork Hoh Rivers. However, bull trout were not detected in 17 of 18 tributaries surveyed in the upper Hoh River. A series of cascades at river mile 48.5 in the upper Hoh River may be a barrier to upstream fish passage. There is a potential barrier to upstream fish passage in the South Fork Hoh River at river mile14.

Resident and migratory life history forms of bull trout, including anadromous forms, likely occur in the Hoh River Core Area. Genetic analysis has identified only bull trout (no Dolly Varden) in the Hoh River Core Area (Spruell and Maxwell 2002).

The status of the bull trout core area population is based on four key elements necessary for long-term viability: (1) number and distribution of local populations; (2) adult abundance; (3) productivity; and (4) connectivity (USFWS 2004b).

NUMBER AND DISTRIBUTION OF LOCAL POPULATIONS

Two local populations have been identified: (1) the Hoh River above the confluence with the South Fork Hoh River and (2) the South Fork Hoh River. With only two local populations, the bull trout in this core area is considered at increased risk of extirpation and adverse effects from random naturally occurring events.

ADULT ABUNDANCE

Historically the Hoh River Core Area likely comprised the largest population of bull trout on the Washington coast (Mongillo 1993). Currently there is insufficient information for a precise estimate of adult bull trout abundance, but the Hoh core area probably supports at least 500 but fewer than 1,000 adults. With fewer than 1,000 adults, this population is considered at increased risk of genetic drift.

PRODUCTIVITY

Bull trout in the Hoh River Core Area are considered at risk of extirpation until sufficient information is collected to properly assess productivity.

CONNECTIVITY

Barriers to fish movement and migration in the Hoh River Core Area include improperly sized or installed culverts in several locations. The mainstem is disconnected from off-channel habitats and adjacent riparian forest by riprap for bank armoring along the Upper Hoh Road. Impassable barriers of cedar spalt debris have formed in coastal rivers and streams in the core area. Holding and rearing areas for adult bull trout during spawning migration, and for juveniles during rearing movements among different stream reaches, are reduced due to reduction of instream large woody debris. Despite these habitat alterations, migratory bull trout persist in the Hoh River Core Area. Recent studies have shown that bull trout in the Hoh River Core Area move into adjacent independent coastal tributaries (Brenkman and Corbett 2003). Bull trout in this core area have diminished risk of extirpation from habitat isolation and fragmentation.

CHANGES IN ENVIRONMENTAL CONDITIONS AND POPULATION STATUS

Since the bull trout listing, Federal actions occurring in the Hoh River Core Area have resulted in harm to, or harassment of, bull trout. These actions include statewide Federal restoration programs that include riparian restoration, replacement of fish passage barriers, and fish habitat improvement projects; federally funded transportation projects involving repair and protection of roads and bridges; and section 10(a)(1)(B) permits for HCPs addressing forest management practices. Capture and handling during implementation of section 6 and section 10(a)(1)(A) permits have directly affected bull trout in the Hoh River Core Area.

The number of non-Federal actions occurring in the Hoh River Core Area since the bull trout listing is unknown. Activities conducted on a regular basis, such as emergency flood control, development, and infrastructure maintenance, affect riparian and instream habitat and probably negatively affect bull trout.

THREATS

Threats to bull trout in the Hoh River Core Area include:

- Past logging and logging-related activities, such as roads, have degraded habitat conditions (e.g., fisheries, water quality, and connectivity) in the lower and middle watershed. Numerous steep slopes are susceptible to mass wasting and channelized landslides. The resulting substantial increase in the number of debris flows has reduced macroinvertebrate populations in the Hoh River. Riparian roads have increased fine sediments and peak flows.
- Other impacts from past logging include reduced amounts of LWD, altered stream morphologies (especially reduced pool area and quality), and loss of riparian vegetation leading to increased water temperatures. Cedar spalts in several tributaries block fish passage, impede water flows, increase water temperature, leach tannins into the water, inhibit plant growth in the riparian area, and form dams that carve stream banks and increase fine sediments.
- Riprap for bank armoring along the Upper Hoh Road has prevented channel migration and formation of new habitats, created unnatural meander patterns, and disconnected the mainstem from off-channel habitats and adjacent riparian forest.
- Fisheries targeting other salmonids cause incidental mortality of bull trout via by-catch and are likely affecting the local populations.

- Black spot disease may be a factor in the decline of bull trout in the Hoh River.

Puget Sound Management Unit

Lower Skagit Core Area

The Lower Skagit Core Area comprises the Skagit basin downstream of Seattle City Light's Diablo Dam, including the mainstem Skagit River and the Cascade, Sauk, Suiattle, White Chuck, and Baker Rivers, and the lake systems above Shannon and Baker Dams.

Bull trout, which occur throughout the Lower Skagit Core Area, include fluvial, adfluvial, resident, and anadromous life-history forms. Resident life-history forms, found in a number of locations in the Core Area, often occur with migratory life-history forms. Adfluvial bull trout occur in Baker and Gorge Lakes. Fluvial bull trout forage and overwinter in the larger pools of the upper portion of the mainstem Skagit River and, to a lesser degree, in the Sauk River (WDFW 1997c; Kraemer, *in litt* 2003).

Many bull trout extensively use the lower estuary and nearshore marine areas for extended rearing and sub-adult and adult foraging. Key spawning and early rearing habitat, found in the upper portion of much of the basin, is generally on federally protected lands, including North Cascades National Park, North Cascades Recreation Area, Glacier Peak Wilderness, and Henry M. Jackson Wilderness Area.

The status of the bull trout Core Area population is based on four key elements necessary for long-term viability: (1) number and distribution of local populations, (2) adult abundance, (3) productivity, and (4) connectivity (USFWS 2004b).

NUMBER AND DISTRIBUTION OF LOCAL POPULATIONS

Nineteen local populations were identified initially: (1) Bacon Creek, (2) Baker Lake, (3) Buck Creek, (4) Cascade River, (5) Downey Creek, (6) Forks of Sauk River, (7) Goodell Creek, (8) Illabot Creek, (9) Lime Creek, (10) Lower White Chuck River, (11) Milk Creek, (12) Newhalem Creek, (13) South Fork Cascade River, (14) Straight Creek, (15) Sulphur Creek, (16) Tenas Creek, (17) Upper South Fork Sauk River, (18) Upper Suiattle River, and (19) Upper White Chuck River. Although initially identified as potential local populations, Stetattle Creek and Sulphur Creek (Lake Shannon), each now meets the definition of local population based on subsequent observations of juvenile bull trout and prespawn migratory adult bull trout (R2 Resource Consultants and Puget Sound Energy 2005; J. Shannon, *in litt*. 2004). With 21 local populations, the bull trout in the Lower Skagit Core Area is at diminished risk of extirpation and adverse effects from random naturally occurring events.

ADULT ABUNDANCE

The Lower Skagit Core Area, with a spawning population of migratory bull trout that numbers in the thousands, is probably the largest population in Washington (C. Kraemer, *in litt*. 2001). Consequently, the bull trout population in this Core Area is not considered to be at risk from genetic drift. Fewer than 100 migratory adults and a limited number of resident fish use the Forks of the Sauk River; however, the migratory component appears abundant and is increasing (C. Kraemer, *in litt*. 2003). Fewer than 100 adults probably occur in Tenas Creek, but this local population is presumed to be increasing. The Straight Creek population includes fewer than 100 migratory adults and an unknown number of resident fish (C. Kraemer, *in litt*. 2001), but the migratory component appears stable. The Lime Creek local population probably has fewer than 100 migratory adults, but resident and migratory components are considered

abundant. The South Fork Cascade River local population probably has fewer than 100 migratory adults (C. Kraemer, *in litt*. 2001); however, resident and migratory components are considered stable. Adult abundances in Newhalem and Stettatle Creeks and Baker Lake are unknown. The majority of local populations in the Core Area include 100 adults or more. However, some local populations probably have fewer than 100 adults and are considered to be risk from inbreeding depression.

PRODUCTIVITY

Long-term redd counts in the index areas of the Lower Skagit Core Area generally indicate stable to increasing population trends.

CONNECTIVITY

The presence of migratory bull trout in most of the local populations indicates the bull trout in the Lower Skagit Core Area has a diminished risk of extirpation from habitat isolation and fragmentation. However, the lack of connectivity of the Baker Lake system and Stetattle Creek in the Gorge Lake system with other occupied sites in the Core Area is a concern.

CHANGES IN ENVIRONMENTAL CONDITIONS AND POPULATION STATUS

Since the bull trout listing, Federal actions occurring in the Lower Skagit Core Area have caused harm to, or harassment of, bull trout. These actions include statewide Federal restoration programs that include riparian restoration, replacement of fish passage at barriers, and fish habitat improvement projects; federally funded transportation projects involving repair and protection of roads and bridges; and section 10(a)(1)(B) permits for HCPs addressing forest management practices. Capture and handling, and indirect mortality, during implementation of section 6 and section 10(a)(1)(A) permits have directly affected bull trout in the Lower Skagit Core Area.

The number of non-Federal actions occurring in the Lower Skagit Core Area since the bull trout listing is unknown. Activities conducted on a regular basis, such as emergency flood control, development, and infrastructure maintenance, affect riparian and instream habitat and probably have negatively affected bull trout.

THREATS

Threats to bull trout in the Lower Skagit Core Area include:

- Gorge and Baker Dams restrict connectivity of the Stetattle Creek and Baker Lake bull trout populations with the majority of other populations in the Core Area.
- Operations of the Lower Baker Dam occasionally have substantially affected water quantity in the lower Baker and Skagit Rivers.
- Agricultural practices, residential development, and the transportation network, with related stream channel and bank modifications, have caused the loss and degradation of foraging, migration, and overwintering habitats in mainstem reaches of the major forks and in a number of the tributaries.
- Marine nearshore foraging habitats have been, and continue to be, affected by agricultural practices and development activities.

Nooksack Core Area

The Nooksack Core Area comprises the Nooksack River and its tributaries, including the North, Middle, and South Fork Nooksack Rivers. Fluvial, anadromous and, possibly, resident life-history forms of bull trout occur in the Nooksack Core Area. Bull trout spawning occurs in the North, Middle, and South Fork Nooksack Rivers and their tributaries. Post-dispersal rearing and sub-adult and adult foraging probably occur throughout accessible reaches below barriers to anadromous fish. Overwintering likely occurs primarily in the lower mainstem reaches of the three forks and in the mainstem Nooksack River.

Bull trout and Dolly Varden co-occur in the Nooksack Core Area, but the level of interaction between the two species and degree of overlap in their distributions is unknown. However, limited genetic analysis and observational data suggest Dolly Varden in this Core Area inhabit stream reaches above barriers to anadromous fish, while bull trout primarily occupy the accessible stream reaches below the barriers.

The status of the bull trout Core Area population is based on four key elements necessary for long-term viability: (1) number and distribution of local populations; (2) adult abundance; (3) productivity; and (4) connectivity (USFWS 2004b).

Number and Distribution of Local Populations

Ten local populations have been identified: (1) Lower Canyon Creek, (2) Glacier Creek, (3) Lower Middle Fork Nooksack River, (4) Upper Middle Fork Nooksack River, (5) Lower North Fork Nooksack River, (6) Middle North Fork Nooksack River, (7) Upper North Fork Nooksack River, (8) Lower South Fork Nooksack River, (9) Upper South Fork Nooksack River, and (10) Wanlick Creek. Spawning areas in the local populations apparently are small and dispersed. With 10 local populations, the bull trout in this Core Area are considered to be at intermediate risk of local extirpation and adverse effects from random naturally occurring events.

Adult Abundance

The Nooksack Core Area probably supports fewer than 1,000 adults. Eight of the local populations likely have fewer than 100 adults each, based on the relatively low number of migratory adults observed returning to the Core Area. The Glacier Creek local population has approximately 100 adults, based on incidental redd counts and available spawning habitats. The Upper North Fork Nooksack River local population may support 100 adults, based on the number of persistent, small numbers of spawning adults observed in tributaries and available side channel habitat. The Nooksack Core Area bull trout population is considered to be at risk of genetic drift. Although the deleterious effects of inbreeding are minimized in these two local populations, the other eight local populations with few adults are considered at risk of inbreeding depression.

Productivity

The bull trout in the Nooksack Core Area are considered to be at increased risk of extirpation until sufficient information is collected to properly assess productivity

Connectivity

There is connectivity among most of the local populations, except for the Middle Fork Nooksack River, which has poor fish passage. There are road culvert barriers in several local populations. Consequently, the bull trout in the Nooksack Core Area is considered to be at intermediate risk of extirpation from habitat isolation and fragmentation.

CHANGES IN ENVIRONMENTAL CONDITIONS AND POPULATION STATUS

Since the bull trout listing, Federal actions occurring in the Nooksack Core Area have resulted in harm to, or harassment of, bull trout. These actions include statewide Federal restoration programs that include riparian restoration, restoration of fish passage at barriers, and fish habitat improvement projects; federally funded transportation projects involving repair and protection of roads and bridges; and section 10(a)(1)(B) permits for HCPs addressing forest management practices. Capture and handling and indirect mortality during implementation of section 6 and section 10(a)(1)(A) permits have directly affected bull trout in the Nooksack Core Area.

The number of non-Federal actions occurring in the Nooksack Core Area since the bull trout listing is unknown. Activities conducted on a regular basis, such as emergency flood control, development, and infrastructure maintenance, affect riparian and instream habitat and probably negatively affect bull trout.

THREATS

Threats to bull trout in the Nooksack Core Area include:

- Past logging and logging-related activities, such as roads, have caused the loss or degradation of a number of spawning and rearing areas within local populations, as well as foraging, migration, and overwintering habitats.
- The Bellingham Diversion has significantly reduced, if not precluded, connectivity of the Upper Middle Fork Nooksack River local population with the rest of the Core Area.
- Agricultural practices, residential development, the transportation network and related stream channel and bank modifications have caused the loss and degradation of foraging, migration, and overwintering habitat in mainstem reaches of the major forks of the Nooksack River and in a number of tributaries.
- Marine foraging habitats have been, and continue to be, greatly affected by urbanization along nearshore habitats in Bellingham Bay and the Strait of Georgia.
- The potential for brook trout and brook trout/Dolly Varden hybrids, detected in many parts of the Nooksack Core Area, to increase their distributions is a significant concern.

Puyallup Core Area

The Puyallup Core Area comprises the Puyallup, Mowich, and Carbon Rivers; the White River, which includes the Clearwater, Greenwater, and the West Fork White Rivers; and Huckleberry Creek. Glacial sources in several watersheds drain the north and west sides of Mount Rainier and significantly influence both water and substrate conditions in the mainstem reaches. The location of many of the headwater reaches of the basin in either Mount Rainier National Park or designated wilderness areas (Clearwater Wilderness, Norse Peak Wilderness) provides pristine habitat conditions.

Anadromous and fluvial/resident bull trout local populations occur in the White River and Puyallup River systems. The Puyallup Core Area has the southernmost, anadromous bull trout population in the Puget Sound Management Unit. Consequently, maintaining the bull trout population in this Core Area is critical to maintaining the overall distribution of migratory bull trout in the management unit.

The status of the bull trout Core Area population is based on four key elements necessary for long-term viability: (1) number and distribution of local populations; (2) adult abundance; (3) productivity; and (4) connectivity (USFWS 2004b).

NUMBER AND DISTRIBUTION OF LOCAL POPULATIONS

Five local populations occur in the Puyallup Core Area: (1) upper Puyallup and Mowich Rivers, (2) Carbon River, (3) upper White River, (4) West Fork White River, and (5) Greenwater River. The Clearwater River is identified as a potential local population, but the occurrence of reproduction there is unknown (USFWS 2004b).

Information about the distribution and abundance of bull trout in this Core Area is limited because observations have generally been incidental to other fish survey work. The anadromous life-history form in the Puyallup Core Area probably uses Commencement Bay and other marine nearshore habitats along Puget Sound. Both anadromous and fluvial/resident bull trout local populations occur in the White River and Puyallup River systems.

Spawning occurs in the upper reaches of this basin where higher elevations produce cool temperatures required by bull trout. Based on current survey data, bull trout spawning in this Core Area occurs earlier (September) than typically observed in other Puget Sound Core Areas (Marks et al. 2002). The known spawning areas in local populations are few in number and not widespread.

Rearing likely occurs throughout the upper Puyallup, Mowich, Carbon, upper White, West Fork White, and Greenwater Rivers. However, sampling indicates most rearing is confined to the upper reaches of the basin. The mainstem reaches of the White, Carbon, and Puyallup Rivers probably provide the primary foraging, migration, and overwintering habitat for migratory bull trout.

With fewer than 10 local populations, the Puyallup Core Area is considered to be at intermediate risk of extirpation and adverse effects from random naturally occurring events.

ADULT ABUNDANCE

Abundance estimates are not available for most local populations in the Puyallup Core Area. Fewer than 100 adults probably occur in local populations in the White River system, based on adult counts at the Buckley fish trap. Although these counts may not adequately account for fluvial migrants that might not migrate below the facility, these counts do indicate a few anadromous bull trout return to local populations in the White River system.

PRODUCTIVITY

The bull trout in the Puyallup Core Area is considered to be at increased risk of extirpation until sufficient information is collected to properly assess productivity.

CONNECTIVITY

Migratory bull trout are present in some local populations in the Puyallup Core Area. Although connectivity between the upper Puyallup and Mowich Rivers local populations and other local populations have been improved recently, very low numbers of migratory fish pass at the Buckley Diversion on the White River. The low abundance of migratory life-history forms limits the possibility for genetic exchange and local population reestablishment. Consequently, bull trout in the Puyallup Core Area are considered to be at intermediate risk of extirpation from habitat isolation and fragmentation.

CHANGES IN ENVIRONMENTAL CONDITIONS AND POPULATION STATUS

Since the bull trout listing, the FWS has issued biological opinions that exempted incidental take in the Puyallup River Core Area. These incidental take exemptions were in the form of harm and harassment,

primarily from temporary sediment increases during in-water work, loss or alteration of habitat, and handling of fish. None of these projects were determined to result in jeopardy to the bull trout. The combined effects of actions evaluated under these Opinions have resulted in short-term and long-term adverse effects to bull trout and degradation of bull trout habitat within the Core Area.

Implementation of section 6 and 10(a)(1)(A) permits have directly affected bull trout. As of May 2005, four juvenile bull trout were reported captured and handled in the Puyallup Core Area.

DNR's HCP (USFWS 1998) allows for the incidental take from associated forest practices and other covered activities of bull trout from the Coastal-Puget Sound population segment and the Columbia River population segment in the lower Columbia River downstream from Greenleaf and Hamilton Creeks.

THREATS

Threats to bull trout in the Puyallup Core Area include:

- Past logging harvest and associated road construction continue to affect bull trout spawning and rearing areas in the upper watershed.
- Agricultural practices continue to affect foraging, migration, and overwintering habitats for bull trout in the lower watershed.
- Dams and diversions have significantly affected migratory bull trout in the Core Area. Until passage was recently restored, the Electron Diversion Dam isolated bull trout in the upper Puyallup and Mowich Rivers for nearly 100 years and drastically reduced the abundance of migratory life-history forms in the Puyallup River. Buckley Diversion and Mud Mountain Dam have significantly affected the White River system in the past by impeding or precluding adult and juvenile migration and degrading foraging, migration, and overwintering habitats in the mainstem. Despite improvements, some of these effects continue, but to a lesser degree.
- Urbanization and residential development and the marine port at Tacoma have significantly reduced habitat complexity and quality in the lower mainstem rivers and associated tributaries and largely eliminated intact nearshore foraging habitats for anadromous bull trout in Commencement Bay.
- The presence of brook trout in many portions of the Puyallup Core Area and their potential to increase in distribution, including Mount Rainer National Park waters, are considered substantial threats to bull trout. Brook trout in the upper Puyallup and Mowich Rivers local populations are of highest concern because of past isolation and the level of habitat degradation.
- Until the early 1990s, bull trout fisheries probably significantly reduced the overall bull trout population. Current legal and illegal fisheries in the Puyallup Core Area may significantly limit recovery of the local population because of low numbers of migratory adults.
- Water quality has been degraded due to municipal and industrial effluent discharges resulting from development, particularly in Commencement Bay.

Snohomish-Skykomish Core Area

The Snohomish-Skykomish Core Area comprises the Snohomish, Skykomish, and Snoqualmie Rivers and their tributaries. Bull trout occur throughout the Snohomish River system downstream of barriers to anadromous fish. Bull trout are not known to occur upstream of Snoqualmie Falls, upstream of Spada Lake on the Sultan River, in the upper forks of the Tolt River, above Deer Falls on the North Fork Skykomish River, or above Alpine Falls on the Tye River.

Fluvial, resident, and anadromous life-history forms of bull trout occur in the Snohomish River/Skykomish Core Area. A large portion of the migratory segment of this population is anadromous. There are no lake systems within the basin that support an adfluvial population. However, anadromous and fluvial forms occasionally forage in a number of lowland lakes connected to mainstem rivers.

The mainstems of the Snohomish, Skykomish, North Skykomish, and South Fork Skykomish Rivers provide important FMO habitat for sub-adult and adult bull trout. The amount of key spawning and early rearing habitat is more limited, in comparison with many other Core Areas, because of the topography of the basin. Rearing bull trout occur throughout most of the accessible reaches of the basin and extensively use the lower estuary, nearshore marine areas, and Puget Sound for extended rearing.

The status of the bull trout Core Area population is based on four key elements necessary for long-term viability: (1) number and distribution of local populations; (2) adult abundance; (3) productivity; and (4) connectivity (USFWS 2004b).

Number and Distribution of Local Populations

Four local populations have been identified: (1) North Fork Skykomish River (including Goblin and West Cady Creeks); (2) Troublesome Creek (resident form only); (3) Salmon Creek; and (4) South Fork Skykomish River. With only four local populations, bull trout in this Core Area are considered to be at increased risk of extirpation and adverse effects from random, naturally occurring events.

Adult Abundance

The Snohomish-Skykomish Core Area probably supports between 500 and 1,000 adults. However, this Core Area remains at risk of genetic drift. About half of the spawners in the Core Area occur in the North Fork Skykomish local population. This is one of two local populations in the Core Area (the other is South Fork Skykomish River) that support more than 100 adults, which minimizes the deleterious effects of inbreeding. The Troublesome Creek population is mainly a resident population with few migratory fish. Although adult abundance is unknown in this local population, it is probably stable due to intact habitat conditions. The Salmon Creek local population likely has fewer than 100 adults. Although spawning and early rearing habitat in the Salmon Creek area is in good to excellent condition, this local population is considered to be at risk of inbreeding depression because of the low number of adults. Monitoring of the South Fork Skykomish local population indicates increasing numbers of adult migrants. This local population recently exceeded 100 adults and is not considered to be at risk of inbreeding depression (C. Jackson, Washington Department of Fish and Wildlife, Personal Communication, 2004). Fishing is allowed in this system.

Productivity

Long-term redd counts for the North Fork Skykomish local population indicate increasing population trends. Productivity of the Troublesome Creek and Salmon Creek local populations is unknown but presumed stable, as the available spawning and early rearing habitats are considered to be in good to excellent condition. In the South Fork Skykomish local population, new spawning and rearing areas are being colonized, resulting in increasing numbers of spawners. Sampling of the North Fork and South Fork Skykomish local population areas indicates the overall productivity of bull trout in the Snohomish-Skykomish Core Area is increasing.

CONNECTIVITY

Migratory bull trout occur in three of the four local populations in the Snohomish-Skykomish Core Area (North Fork Skykomish, Salmon Creek, and South Fork Skykomish). The lack of connectivity with the Troublesome Creek local population is a natural condition. The connectivity between the other three local populations diminishes the risk of extirpation of the bull trout in the Core Area from habitat isolation and fragmentation.

CHANGES IN ENVIRONMENTAL CONDITIONS AND POPULATION STATUS

Since the bull trout listing, Federal actions occurring in the Snohomish-Skykomish Core Area have caused harm to, or harassment of, bull trout. These actions include statewide Federal restoration programs that include riparian restoration, restoration of fish passage at barriers, and fish habitat improvement projects; federally funded transportation projects involving repair and protection of roads and bridges; and section 10(a)(1)(B) permits for HCPs addressing forest management practices. Capture and handling during implementation of section 6 and section 10(a)(1)(A) permits have directly affected bull trout in the Snohomish-Skykomish Core Area.

The number of non-Federal actions occurring in the Snohomish-Skykomish Core Area since the bull trout listing is unknown. However, activities conducted on a regular basis, such as emergency flood control, development, and infrastructure maintenance, affect riparian and instream habitat and probably negatively affect bull trout.

THREATS

Threats to bull trout in the Snohomish-Skykomish Core Area include:

- Past logging and logging-related activities, such as roads, have degraded habitat conditions in the upper watershed.
- Agricultural and livestock practices, including blocking fish passage, altering stream morphology, and degrading water quality in the lower watershed (FMO habitat), have significantly affected the floodplain and bull trout habitat.
- Illegal harvest or incidental hooking mortality may occur where recreational fishing is allowed by WDFW.
- Water quality has been degraded by municipal and industrial effluent discharges and development.
- Nearshore foraging habitat has been, and continues to be, affected by development activities.

Stillaguamish Core Area

The Stillaguamish Core Area comprises the Stillaguamish River basin, including the North Fork and South Fork Stillaguamish Rivers and their tributaries. Major tributaries to the North Fork Stillaguamish River include the Boulder River and Deer, Little Deer, and Higgins Creeks. Canyon Creek, the only major tributary to the South Fork Stillaguamish River, has minor tributaries including Millardy, Deer, Coal, Palmer, Perry, and Beaver Creeks.

Bull trout occur throughout the Stillaguamish River basin and, in the Stillaguamish Core Area, primarily include anadromous and fluvial life-history forms (USFWS 2004b). There are no known populations in the North Fork Stillaguamish River above the barrier to migration at river mile 37.5 (C. Kraemer, WDFW, *in litt*. 1999). No resident populations have been found above any of the natural migratory

barriers on Deer or Higgins Creeks. No exclusively resident populations have been identified in this Core Area, but the South Fork Stillaguamish River population has a strong resident component coexisting with migratory forms.

The South Fork Stillaguamish River upstream of Granite Falls has supported anadromous bull trout since the construction of a fishway in the 1950s. Previously the falls were impassable to anadromous fish. Anecdotal information from fish surveys in the 1920s and 1930s, however, suggest that native char likely were present above Granite Falls prior to construction of the fishway (WDFW 1998).

Spawning habitat is generally limited in the Stillaguamish Core Area, and apparently, only the upper reaches provide adequate spawning conditions. Bull trout spawn in the upper reaches of the accessible portions of the upper North Fork Stillaguamish River and its tributaries, including Deer and Higgins Creeks. There have been no extensive juvenile sampling or evaluation of spawning success in the North Fork Stillaguamish River. Bull trout in the Upper Deer Creek local population spawn in Higgins Creek, and spawning also may occur in upper Little Deer Creek. Bull trout spawn in the Boulder River below the impassible falls at river mile 3. Although unconfirmed, spawning and rearing probably occur in the Squire Creek system, which is similar in size to Boulder River and also influenced by snowmelt. Boulder River may be identified as an additional local population when more distribution information is available.

Spawning areas in the South Fork Stillaguamish River and its tributaries include Canyon Creek and upper South Fork Stillaguamish. Bull trout are known to spawn and rear in Palmer, Perry, and Buck Creeks and the upper South Fork mainstem above Palmer Creek. Recent spawning surveys identified a major spawning area above the Palmer Creek confluence. Between 50 and 100 bull trout spawn in this reach. Electrofishing surveys also documented high densities of juveniles (D. Downen, WDFW, *in litt*. 2003). Spawning and early rearing habitat in the South Fork Stillaguamish River is considered to be in fair condition. Although bull trout spawn in the upper South Fork Stillaguamish River and other tributaries, available habitat is partially limited by gradient and competition with coho salmon. Upstream movement of bull trout from the lower river depends on proper functioning of the fish ladder at Granite Falls. Migratory and resident fish coexist on the spawning grounds.

Bull trout in the Canyon Creek local population use the upper South Fork Stillaguamish River for spawning and rearing. Although there have been isolated and incidental observations of spawning by migratory-size bull trout, electrofishing surveys have been unable to locate any juvenile or resident bull trout from this population. Despite repeated survey efforts, very few bull trout have been located in this population because of the difficulty in locating individuals.

The status of the bull trout Core Area population is based on four key elements necessary for long-term viability: (1) number and distribution of local populations; (2) adult abundance; (3) productivity; and (4) connectivity (USFWS 2004b).

NUMBER AND DISTRIBUTION OF LOCAL POPULATIONS

Four local populations have been identified in the Stillaguamish Core Area: (1) Upper Deer Creek, (2) North Fork Stillaguamish River, (3) South Fork Stillaguamish, and (4) Canyon Creek. The scarcity and spatial isolation of available spawning habitat limits the number of local populations in the Stillaguamish Core Area. With only four local populations, the bull trout in this Core Area is considered to be at increased risk of extirpation and adverse effects from random naturally occurring events.

ADULT ABUNDANCE

The bull trout population in the Stillaguamish River basin is estimated at fewer than 1,000 adults. In the North Fork Stillaguamish River, as many as 100 adult bull trout have been observed holding near the mouth of the Boulder River. Surveys documented nearly 300 adult char between river miles 21 and 25 during fall 2001; fewer than 100 adults were counted in the remaining sample years between 1996 and 2003 (G. Pess, NMFS, *in litt*. 2003). Other limited snorkel surveys had similar results (M. Downen, Personal Communication, 2003). These staging adult bull trout are assumed to spawn somewhere in the North Fork Stillaguamish River. Adult abundance in the Upper Deer Creek and Canyon Creek local populations is considered low. The Boulder River population probably has fewer than 100 adults. Approximately 50 to 100 adults are present in the South Fork Stillaguamish River, based on conservative estimates from spawning and electrofishing surveys (D. Downen, *in litt*. 2003). Although accurate counts are unavailable, current estimates of adult abundance suggest that Upper Deer Creek and Canuyon Creek local populations have fewer than 100 adults and are considered at risk of inbreeding depression.

CONNECTIVITY

Primary foraging, migration, and overwintering areas in the Stillaguamish River basin include the mainstems of the North Fork and South Fork Stillaguamish Rivers and the Stillaguamish River to the estuary. Foraging sub-adults and adults may be found in nearly all reaches of the basin below migratory barriers to the basin. Rearing individuals may use nearly all accessible reaches in higher elevation and coldwater portions of the basin. Anadromous forms in the Stillaguamish Core Area are presumed to use nearshore marine areas in Skagit Bay, Port Susan, and Possession Sound, but may also use areas even farther from their natal basin.

All native char habitat within the Stillaguamish River Basin generally has good connectvity. However, because the local populations are somewhat isolated from one another, maintaining connectivity among them will be critical to support life-hsitory diversity, refounding, and genetic exchange.

CHANGES IN ENVIRONMENTAL CONDITIONS AND POPULATION STATUS

Since the bull trout listing, Federal actions occurring in the Stillaguamish Core Area have caused harm to or harassment of bull trout. These actions include five statewide Federal restoration programs that include riparian restoration, restoration of fish passage at barriers, and habitat-improvement projects. In addition, two federally funded transportation projects involving repair and protection of roads and bridges have been completed. One (WDNR) section 10(a)(1)(B) permits has been issued for HCPs that address bull trout in this Core Area.

The number of non-Federal actions occurring in the Stillaguamish Core Area since the bull trout listing is unknown. However, activities conducted on a regular basis, such as emergency flood control, development, and infrastructure maintenance, affect riparian and instream habitat and probably negatively affect bull trout.

THREATS

Threats to bull trout in the Stillaguamish Core Area include:

- Channel widening and a significant reduction in primary pool abundance have seriously degraded habitat conditions in the North Fork and lower South Fork Stillaguamish Rivers.
- Spawning habitats in Deer and Canyon Creeks have been extremely degraded.

- Past logging and logging-related activities, such as roads, have degraded habitat in the Stillaguamish River basin. The loss of riparian cover, slope failures, stream sedimentation, increased stream temperatures, flooding, and loss of LWD have adversely affected bull trout in Deer Creek and in the South Fork Stillaguamish River (WDFW 1997b; USFWS 2004b). Deer and Higgins Creeks currently violate State water-quality standards for temperature.
- Agricultural and residential development have contributed to poor water quality in the lower Stillaguamish River basin. Excessive siltation caused by mud and clay slides on the North Fork Stillaguamish River near Hazel, Washington, and on the South Fork above Robe, contribute to poor water quality (Williams et al. 1975).
- Other limiting factors in the North Fork Stillaguamish River include loss of deep holding pools for adults and low summer flows (USFWS 2004b).
- Low flows and high temperatures during the summer affect holding habitat for anadromous migrants in the mainstem Stillaguamish River, especially in the lower river sloughs that have slow-moving water without significant riparian cover (WDFW 1997b).

Upper Skagit Core Area

The Upper Skagit Core Area comprises the Skagit River basin upstream of Diablo Dam, including Diablo Lake and most of Ross Lake. The upper Skagit River is a transboundary system that flows south from British Columbia into the United States. A significant portion of the upper Skagit River drainage lies within Canada. Much of the habitat in the Core Area is undisturbed because large portions of the watershed are located in North Cascades National Park, Pasayten Wilderness Area, and Skagit Valley Provincial Park.

Adfluvial, fluvial and, possibly, resident life-history forms of bull trout occur in the Upper Skagit Core Area. This Core Area supports both bull trout and Dolly Varden.

The status of the bull trout Core Area population is based on four key elements necessary for long-term viability: (1) number and distribution of local populations; (2) adult abundance; (3) productivity; and (4) connectivity (USFWS 2004b).

Number and Distribution of Local Populations

Thirteen local populations occur in the upper Skagit River. Having more than 10 local populations diminishes the risk of extirpation of the bull trout in this Core Area. Seven of the local populations occur in the United States. Bull trout spawn and rear in at least eight streams in the United States: Ruby (including Canyon and Granite Creeks), Panther, Lightning, Big Beaver, Little Beaver, Silver, Pierce, and Thunder Creeks.

Adult Abundance

Adult abundance probably exceeds 1,000 adults in the Upper Skagit Core Area, including those portions of the drainage in British Columbia. Therefore, the bull trout population in this Core Area is not considered at risk from genetic drift. Each of the Ruby Creek and Lighting Creek local populations probably has at least 100 adults. Adult abundance and the risk of inbreeding in the remaining local populations are unknown.

PRODUCTIVITY

The bull trout in the Upper Skagit Core Area are considered to be at increased risk of extipation until sufficient information is collected to properly assess productivity.

CONNECTIVITY

The presence of migratory bull trout in the majority of the local populations indicates the bull trout in the Upper Skagit Core Area has a diminished risk of extirpation from habitat isolation and fragmentation. However, Diablo Lake supports only a single population of migratory bull trout and remains a concern. If connectivity between the Diablo Lake system and the rest of the Upper Skagit Core Area cannot be adequately restored at Ross Dam, establishment of additional local populations probably will be necessary to ensure persistence of bull trout in the Diablo Lake system.

CHANGES IN ENVIRONMENTAL CONDITIONS AND POPULATION STATUS

Since the bull trout listing, Federal actions occurring in the Upper Skagit Core Area have caused harm to, or harassment of, bull trout. These actions include statewide Federal restoration programs that include riparian restoration, restoration of fish passage barriers, and habitat-improvement projects, and federally funded transportation projects involving repair and protection of roads and bridges. No section 6, section 10(a)(1)(A), or 10(a)(1)(B) permits have been issued in the Upper Skagit Core Area for effects to bull trout from capture and handling.

The number of non-Federal actions occurring in the Upper Skagit Core Area since the bull trout listing is unknown. Because most of the Core Area is in Federal ownership, few non-Federal actions likely have occurred in this Core Area.

THREATS

Threats to bull trout in the Upper Skagit Core Area include:

- Ross Dam restricts connectivity between the Thunder Creek local population and most of the Core Area.
- Past logging practices have some residual effects on bull trout populations in the United States, and past and ongoing forest practices remain a significant threat to some local populations in Canada.
- Brook trout are established in a number of tributaries to Ross Lake that are also used by bull trout. Brook trout apparently have replaced or displaced bull trout in some tributaries (e.g., Hozemeen Creek).

Columbia River Population Segment

Lower Columbia River Basin Management Unit

Klickitat Core Area

Based on recent surveys, bull trout are known to occur in the West Fork Klickitat River. Tributaries of the West Fork Klickitat River which currently support bull trout include: Trappers Creek, Clearwater Creek, Two Lakes Stream, Little Muddy Creek, and an unnamed tributary of Fish Lake Stream. The West Fork Klickitat population is currently the only population identified in the Klickitat Core Area. This Core Area likely supports only the resident life-history form based on recent trapping efforts (USFWS 2002). Although a migratory size bull trout was observed in the Klickitat River in the early 1990's,

surveys conducted in 2001 did not find bull trout in the mainstem Klickitat River upstream of the confluence with the West Fork (Byrne et al. 2001; Thiesfeld et al. 2001; J. Byrne, Washington Department of Fish and Wildlife, Personal Communication, 2005).

The status of a bull trout core population can be described based on four key elements: 1) number and distribution of local populations; 2) adult abundance; 3) productivity; and 4) connectivity.

NUMBER AND DISTRIBUTION OF LOCAL POPULATIONS

Only one local population is known to occur in the Klickitat Core Area. In additional to the West Fork Klickitat River, bull trout are also found in Trappers Creek, Clearwater Creek, Two Lakes Stream, Little Muddy Creek, and an unnamed tributary of Fish Lake Stream.

ADULT ABUNDANCE

Bull trout in the West Fork Klickitat local population are thought to be primarily resident. Low numbers indicate that this local population is at risk from the deleterious effects of inbreeding depression. If fluvial bull trout persist in the Klickitat Core Area, their abundance is most likely below 100 spawning adults and, therefore, should be considered at risk from inbreeding depression. Abundance of both resident and migratory (if present) in the Klickitat Core Area is likely below a 1,000 spawning individuals and, as a result, the Klickitat Core Area is considered to be at risk from genetic drift.

PRODUCTIVITY

For a population to contribute to recovery, its growth rate must indicate that the population is stable or increasing for a period of time. Given the overall lack of long-term population-census information in the Klickitat Core Area, this Core Area is considered to be at increased risk of extirpation.

CONNECTIVITY

Currently, bull trout in the Klickitat Core Area are most likely represented by resident forms, and consequently are considered to be at an increased risk of extirpation.

THREATS

Threats to bull trout in the Klickitat Core Area include:

- Increased sediment loads associated with logging roads near tributary streams has been identified as problem in several basins within the Klickitat Core Area.
- Some cattle grazing has occurred in the Klickitat River basin which has lead to eroded stream banks, increased sedimentation, and incised channels.
- Warm temperatures due to natural low flows within in the Klickitat drainage my be a concern for adult bull trout that spawn in the mainstem or lower reaches of tributary streams as well as for juveniles that may rear in those locations. Any agricultural diversions would only exacerbate an already tenuous flow conditions.
- Introduction of non-native species has affected bull trout populations through a combination of hybridization, competition, and predation.

Lewis River Core Area

Currently, reproducing populations of bull trout within the Lewis River Core Area are found in Lake Merwin, Yale, and Swift Creek reservoirs. Bull trout in the Lewis River are considered to be predominately adfluvial. The number of bull trout inhabiting the Lewis River Core Area is estimated to be low. Spawning and juvenile rearing occur in Cougar Creek, Rush Creek, and Pine Creek.

The status of a bull trout core population can be described based on four key elements: 1) number and distribution of local populations; 2) adult abundance; 3) productivity; and 4) connectivity.

Number and Distribution of Local Populations

Two local populations are known to occur in the Lewis River Core Area. Spawning adfluvial bull trout in Yale Lake migrate into Cougar Creek from the middle of August through early September and spawn from late September through early October. The other population occurs in Swift Creek Reservoir and spawns in Rush and Pine Creeks.

Adult Abundance

The estimated Cougar Creek spawner population ranges from 0 to 40 individuals based on annual estimates taken between 1979 and 2001. Due to low spawner numbers this population is consider at risk of inbreeding depression. The annual spawner population estimates from Rush and Pine creeks (Swift Creek Reservoir) between 1994 and 2001, range from 101 to 542 fish. The majority of spawning occurs in Rush Creek and the 8-year average for both creeks is 309 fish. Bull trout in this population are not at risk of inbreeding depression. Additional escapement estimates, based on “mark and recapture” counts are also available for Swift Creek Reservoir (Pine and Rush Creeks) since the time of listing. Estimated escapement was variable during the 1990’s (ranging between 101 and 437 adults), but has increased since 1999, with a 2004 population estimate of 1,287 adults (USFWS 2002; WDFW 2005). Overall the population is probably below 1,000 spawning adults and, therefore, is considered to be at risk of genetic drift.

Productivity

Recent genetic analyses suggest that only one genetically distinct group (Pine and Rush Creek local populations) exists within the Lewis River system (Neraas and Spruell 2004). Previous analyses indicated that two genetically distinct groups (Pine and Rush Creeks, and Cougar Creek) were present in the Core Area (Spruell et al. 1998). Increased sample size and samples collected from known spawning sites indicate that the Cougar Creek local population, which represents the only spawning tributary in Yale Reservoir, likely represents a mixture of spawners from the two upstream local populations in Swift Creek Reservoir.

For a population to contribute to recovery, its growth rate must indicate that the population is stable or increasing for a period of time. Given the overall lack of long-term population census information in the Lewis River Core Area and the variability in the Cougar Creek population, this Core Area is considered to be at increased risk of extirpation.

Connectivity

Lack of passage at hydroelectric facilities with in the Lewis River Core Area has fragmented populations and prevented bull trout from using foraging and overwintering habitats in the mainstem Columbia River. Migratory bull trout persist at low levels by virtue of adopting an adfluvial life-history form in Swift

Creek and Yale Lake reservoirs. Lack of passage and the low abundance of the migratory life-history strategy, limit the possibility for genetic exchange and local-population refounding, placing the Lewis River Core Area at increased risk of extirpation.

CHANGES IN ENVIRONMENTAL CONDITIONS AND POPULATION STATUS

A settlement agreement for the relicensing of the Yale, Merwin, Swift No. 1 and Swift No. 2 hydroelectric projects was signed in 2004 (PacifiCorp et al. 2004). Conservation measures are incorporated in the project description to minimize or compensate for the effects of the projects on listed species, including bull trout. Conservation measures for bull trout include: perpetual conservation easements on PacifiCorp's lands in the Cougar/Panamaker Creek area and PacifiCorp's and Cowlitz Public Utility District's lands along the Swift Creek arm of Swift Creek Reservoir; upstream and downstream fish passage improvements at all reservoirs; limiting factors analysis for bull trout to determine additional enhancement measures; public-information program to protect bull trout; and monitoring and evaluation efforts for bull trout conservation measures. This agreement will also restore anadromous salmon to the upper Lewis River system, restoring a substantial part of the historic forage base for bull trout.

THREATS

Threats to bull trout in the Lewis River Core Area include:

- Construction of three hydropower dams on the Lewis River have fragmented habitat, isolated local populations, and prevented access to foraging and overwintering habitat.
- Past logging practices in the Lewis River basin have altered flow regimes, riparian conditions, and instream habitat.
- Introduction of non-native species including brook trout, lake trout, rainbow trout, kokanee, largemouth bass, and tiger musky have affected bull trout populations through a combination of hybridization, competition, and predation.
- Harvest has played a role in the decline of local populations, but fishing for bull trout in the Lewis River Core Area closed only as recently as 1992. Misidentification of bull trout by anglers may remain a threat.

Middle Columbia River Basin Management Unit

Yakima Core Area

The Yakima River has bull trout dispersed throughout the basin. Resident and migratory (both fluvial and adfluvial) bull trout are all found within the Yakima Core Area. Bull trout in the Yakima Core Area are currently found in 16 local populations. These populations are included within habitat in the mainstem Yakima River (Keechelus to Easton Reach for spawning some migration/overwintering in lower Yakima); Ahtanum Creek (North, South, and Middle Forks); Naches River tributaries (American River, Bumping River; Bumping Lake and Deep Creek, Rattlesnake Creek, and Little Naches River and Crow Creek); Tieton River (North Fork Tieton River); Rimrock Lake tributaries (South Fork Tieton River and Indian Creek; Teanaway River and tributaries (North Fork Teanaway); Kachess Lake tributaries (Box Canyon Creek, upper Kachess River - including Mineral Creek); Keechelus Lake (Gold Creek); the Cle Elum River (including its tributaries); Waptus River and Waptus Lake, and Cooper River and Cooper

Lake. Taneum Creek, in the upper Yakima River, is the location where the one population is expected to be reintroduced.

The status of a bull trout core population can be described based on four key elements: 1) number and distribution of local populations; 2) adult abundance; 3) productivity; and 4) connectivity.

NUMBER AND DISTRIBUTION OF LOCAL POPULATIONS

Historically, bull trout occurred throughout the Yakima River basin, but are now fractured into isolated populations. Bull trout in the Yakima Core Area are currently found in 16 local populations including: the mainstem Yakima River (Keechelus to Easton Reach); Ahtanum Creek (North, South, and Middle Forks); Naches River tributaries (American River, Rattlesnake Creek, and Crow Creek); Rimrock Lake tributaries (South Fork Tieton River and Indian Creek); Teanaway River; Kaches Lake tributaries (Box Canyon Creek and upper Kachess River); Keechelus Lake (Gold Creek); the upper Cle Elum River; and the North Fork Tieton River.

Although bull trout are present in the mainstem Ahtanum Creek they are probably more abundant in the upper portion of the drainage, particularly in the North, Middle and South Forks where habitat conditions are more favorable.

U.S. Forest Service surveys found one bull trout in Oak Creek, and one in Milk Creek. WDFW telemetry information shows that much of the mainstem Naches and portions of the lower tributaries are used for overwintering habitat. The radio-tagged bull trout were seen below the mouth of the Naches River in the mainstem Yakima River.

In the Tieton drainage above the Rimrock Dam, local populations of bull trout are found in the South Fork Tieton River (including Bear Creek) and Indian Creek. Juvenile bull trout have been observed in several other South Fork Tieton tributaries including Short, Dirty, Grey, Spruce, and Corral Creeks. These fish most likely originated from native fluvial fish in the Tieton River. Construction of the Tieton Dam in 1925 forced bull trout to adopt an adfluvial life-history pattern. WDFW catch records for Clear Lake on the North Fork Tieton documented bull trout presence in the 1950's. In 1993, U.S. Forest Service staff reported capturing one 75 to 100 millimeter (3 to 4 inch) bull trout from a minnow trap in Clear Lake. In addition, biologists from Central Washington University observed an adult bull trout in the upper North Fork Tieton River in 1996 and interagency surveys located both a redd and adult migratory bull trout in 2004. Bull trout have been found in the Tieton River (below Rimrock Lake).

Within the Naches system, other bull trout local populations have been identified in Rattlesnake Creek (including Little Wildcat Creek), American River (including Union and Kettle creeks), and in the Little Naches River in Crow Creek. Larger bull trout have been observed spawning in the American River.

In the Bumping River, adfluvial bull trout inhabit Bumping Lake and are part of the local population in Deep Creek. The local population in Deep Creek probably originated from a native adfluvial life-history form, which was present even before the construction of the dam in 1910. Construction of the dam enlarged the natural lake and forced any fluvial bull trout to adopt an adfluvial life-history. While Deep Creek is the only identified local population above Bumping Lake, the U.S. Forest Service reported a single redd with three bull trout in the upper Bumping River in 1994. A bull trout redd was seen in the Bumping River during a U.S. Forest Service snorkel survey in September 2003 and juveniles were seen in another snorkel survey in September 2002. Bull trout have been found in the Bumping River (below Bumping Lake).

Within the upper Yakima River and in the Teanaway River, the bull trout local population uses habitat within the North Fork Teanaway River and the mainstem and DeRoux Creek. Limited spawning occurs, and most recently two redds were observed by FWS in 2005 in the North Fork Teanaway River just upstream of DeRoux Creek. Bull trout have also been observed in Jungle and Jack Creeks. Although the habitat appears to be suitable for bull trout in the West and Middle Forks, no bull trout have been found in these streams. Bull trout in the North Fork Teanaway River are likely a mix of both small resident forms and larger fluvial forms.

Bull trout local populations above Kachess Dam probably originated from a native adfluvial life-history form, which was present in the existing lake before the construction of the dam in 1905. Local populations identified by the Middle Columbia Bull Trout Recovery Team in this area include Box Canyon Creek and the upper Kachess River. However, some spawning may occur in Mineral Creek when adequate flows are available.

Similar to Kachess Lake, bull trout in Keechelus Lake include the Gold Creek local population which most likely originated from a native adfluvial life-history form which was present before the construction of the dam and irrigation reservoir in 1914 (which modified the natural lake). Anecdotal reports indicate that bull trout may have been present in Rocky Run Creek in the early 1980's. However, surveys to confirm their presence have not been conducted. In 2005, a bull trout was located in Cold Creek, below the barrier culvert.

The Middle Columbia Bull Trout Recovery Team has identified two local populations above Cle Elum Dam; one using Cle Elum mainstem and its tributaries and the other associated with Waptus Lake and River system. It is thought that due to distance and geologic landform and/or thermal barriers, that these populations may be separate. A waterfall located on the lower Waptus River between Waptus and Cle Elum lakes may act as a barrier to bull trout migration between the two systems. Additional surveys are needed to determine if additional local populations exist in the Waptus River system. However, similar to other areas within the Yakima Core Area, these bull trout most likely originated from a native adfluvial life-history form which were present even before the construction of the dam in 1931. Construction of the Cle Ulum Dam enlarged the natural lake and forced any fluvial bull trout stock to adopt an adfluvial life-history pattern. WDFW catch records indicate that bull trout were present in Waptus Lake in the 1940's and early 1950's. WDFW biologists confirmed the presence of bull trout in Waptus Lake by capturing a single juvenile fish in a gill net in 1996 and a large adult bull trout in 1997.

ADULT ABUNDANCE

Overall, bull trout in the Yakima Core Area persist at low numbers in fragmented, local populations. The strongest bull trout populations are represented by local populations in the South Fork Tieton River and Indian Creek. There has been a large degree of variability in redd numbers since listing. Directly comparable data from redd surveys for all the local populations only occurs between 1999 and 2004 and only data from the main spawning tributary in Ahtanum are used (North Fork Ahutanum) because it had complete surveys. Within this data set, the range of the number of redds in the Yakima Core Area varies from 687 in 2000 to 460 in 2004. Since 1999 there are an average of 548 redds in the Yakima Core Area. The average number of redds (548) is less than in 1998 when redds numbered 593. This is a lower number of adults than the Recovery Team thought could be obtained (USFWS 2002). This is low in comparison to the amount of habitat available. There are the only four populations (Rattlesnake, South Fork Tieton, Indian, and Deep Creek) with greater than 50 redds or 100 spawning adults and three of them (South Fork Tieton, Indian, and Deep Creek) are fragmented from the rest of the populations in the

Yakima basin because of Bureau of Reclamation (BOR) dams, and no populations are located in the upper Yakima River portion of the basin. There is a concern about the variability within the redd counts for all populations except the South Fork Tieton River which has the highest number of redds in the Yakima Core Area.

Recent radio-telemetry studies have shown that bull trout tagged in the mainstem Columbia River move into tributaries to spawn. The FWS draft Bull Trout Recovery Plan identifies that it could be possible for the bull trout in the Yakima Core Area to use the lower portion of the river and migrate to the Columbia River, but that further research is needed. A new WDFW telemetry study in the Yakima basin has identified bull trout tagged in the Tieton River, Naches River, and Bumping River are overwinter in sections of the mainstem lower/middle Naches and in the Yakima River mainstem to Ahtanum Creek. One bull trout even went up into Wenas Creek, above the Naches River in the Yakima River mainstem. In the Yakima River mainstem, a bull trout was caught by a WDFW biologist doing surveys near Toppenish in 2003. During a telemetry study, a bull trout was tagged at Rosa Dam upstream on the Naches River near the canyon reach in 2004, and a gravid female was tagged just below Kachess Dam in Jan 2005.

There is new information describing the estimated number of entrained bull trout in Rimrock Reservoir on the Tieton River (James 2001; Heibert et al. 2003). Bull trout entrainment was most recently estimated at 145 (range 60 to 90) during the August through October 2002 sampling period (Heibert et al. 2003). In a previous effort by James (2001), over 80 percent of the fish entrained through the dams were mortalities. This may be an example of entrainment that is occurring at the other four BOR dams.

Bull trout in the South Fork Tieton River, Indian Creek, and Deep Creek are not considered to be at risk from inbreeding depression. However, the recent decrease in numbers in Indian Creek may be a concern and for the other two populations there is a concern that BOR dams do not provide adequate connectivity within the Core Area. All other populations were either at risk due to low abundance levels or classified as unknown due to lack of information. Because of the lack of interconnectivity, the Yakima Core Area is currently considered to be at intermediate risk from the deleterious effects of genetic drift.

PRODUCTIVITY

Since estimates of the total population size are rarely available, the productivity or population growth rate is usually estimated from temporal trends in indices of abundance at a particular life stage. For example, redd counts are often used as an index of a spawning adult population. The direction and magnitude of a trend in the index can be used as a surrogate for the growth rate of the entire population. For a population to contribute to recovery, its growth rate must indicate that the population is stable or increasing for a period of time.

In the Yakima Core Area, there are less than 10 years of consistent data collected in the same stream reaches between all populations in the Core Area. When you consider the two largest populations in the Yakima system, the South Fork Tieton River, the trend looks stable, but when consider Indian Creek (the longest data set) the trend is decreasing. These populations are disconnected from the rest of the populations and not long ago Indian Creek was considered the largest population in the Yakima basin. Based on the data set from 1986 to 2004, Indian Creek numbers are unstable and more recently decreasing. This is of special concern because this population is located above a barrier (Rimrock Dam) and it has decreased in redd numbers from a high of 226 to only 50 in the last four years. The redd number are variable within and among populations. Redd data have been collected similarly since 1994 in only the South Fork Tieton and numbers have increased and remained somewhat stable.

Because four of the local populations have connectivity issues and low abundances and the other populations (13 as currently defined by the FWS Recovery Team) are fragmented and located above five BOR irrigation reservoirs with no passage, or are considered resident (Ahtanum), the Yakima Core Area continues to be at risk for genetic drift and inbreeding. Research needs to further look at the genetics of these populations for this reason. Of further concern, is that with low abundances and reduced connectivity in the Yakima Core Areas due to the BOR dams and manipulations of downstream habitats, populations could be lost should a catastrophic event such as fire or flood occur.

Given the lack of consistent, population-census information in the record of redd count surveys, the low numbers of adult spawning bull trout in most of the local populations, the continued lack of connectivity, and decreases in one of the largest populations, bull trout in the Yakima Core Area are considered to be at increased risk of extirpation.

CONNECTIVITY

The Yakima Basin continues to be one of the most highly fragmented Core Areas with five total passage barriers at irrigation reservoirs, and numerous inchannel irrigation diversion structures and diversions that reduce flow up to approximately 80 percent (Van Stralen, Personal Communication, 2005) in the mainstem. Low flows, high temperatures, and chemical contaminants cause other barriers. Killing and entrainment of bull trout at the dam at Rimrock Reservoir in the Naches River has been documented. There is the potential for this to be occurring at the other reservoirs. Fish (salmonids) have been stranded at Rosa Dam in the canal and one of the radio-tagged bull trout was located in a diversion in lower Rattlesnake Creek.

A recent assessment indicated some connectivity between the Yakima River populations with the Upper Columbia River units and the Snake River units and that some populations in the Yakima also have their own assignment or a unique genetic characteristic (USFS 2004b). This continues to be a new research need for this management unit. Samples taken from Early Winters Creek and Goat Creek in the Methow River were compared to samples taken in the Yakima River and identified to be genetically different (Spruell and Maxwell, 2002).

Lack of passage within the Yakima Core Area has fragmented bull trout populations and prevented migration to foraging and overwintering habitat. Connectivity to high quality spawning habitat continues to be a problem since the listing of bull trout. This is still a highly fragmented population and entrainment is documented at least one of the five BOR dams, and may occur at all. Low numbers of migratory bull trout accompanied by a lack of passage, limits the possibility for genetic exchange and the reestablishment of local populations. Because four of the local populations have connectivity issues and low adult abundance, and the other populations are either fragmented and located above five BOR irrigation reservoirs with no passage, or are considered resident (Ahtanum), the Yakima Core Area continues to be at risk for genetic drift and inbreeding. Of further concern, is that with low adult abundance and reduced connectivity in the Yakima Core Area, populations could be lost should a catastrophic event such as fire or flood occur.

CHANGES IN ENVIRONMENTAL CONDITIONS AND POPULATION STATUS

Statewide Federal restoration programs which include riparian restoration, restoration of fish passage at barriers, and habitat improvement projects have been authorized in the Yakima Core Area. The Yakima River watershed groups have coordinated to apply for monies to complete stream habitat work along the mainstem Yakima River and its tributaries and are working with the U.S. Forest Service to complete

culvert repairs. Most large fish passage culverts on the national forest land have been replaced with open bottom arches or bridges. The Plum Creek Timber Company Cascades HCP was developed on lands in the I-90 Corridor. The HCP has provisions for timber harvesting and other land management that benefited bull trout. Grazing problems in Ahtanum Creek on WDNR lands and Ahtanum Irrigation District lands have been reduced with the placement of a fence in 2004 along riparian areas adjacent to most of the spawning habitat. Grazing problems on national forest lands in the South Fork Tieton have been reduced with the special use permit changes to preclude cows from areas with redds during/after spawning and to reduce effects to riparian areas.

Available information indicates implementation of section 6 and/or section 10(a)(1)(A) permits have resulted in direct effects to bull trout due to capture and handling and indirect mortality (BOR, WDFW, EPA, CWU, Yakama Nation, and FWS fisheries studies). Although projects associated with the restoration programs may result in long-term benefits for bull trout and their habitat, all projects included above resulted in take of this species.

It is unknown how many non-Federal actions have occurred in the Yakima Core Area since the listing of bull trout. Activities such as emergency flood control, development, and infrastructure maintenance are conducted on a regular basis and affect riparian and instream habitat. Hydraulic Permits issued by the State also affect bull trout and bull trout habitat. Recent land-use changes from agriculture to urban development along the riparian areas may also be affect bull trout and bull trout habitat. County permits have likely increased for construction of homes in floodplain and riparian areas.

THREATS

Threats to bull trout in the Yakima Core Area include:

- Of the five major storage reservoirs in the Yakima Core Area, four were historically natural lakes. Potential effects from each facility include: fragmentation of populations; entrainment; altered water temperatures; reservoir passage; altered basin flow regimes; affected prey base; and habitat characteristics such as cover, holding pools, and diversity.
- Genetic bottlenecks are a concern above the diversion dams especially with the numbers of redds rapidly declining in Indian Creek, a tributary above Rimrock Dam on the Tieton River.
- Past timber logging, and logging-related activities (such as roads), have degraded habitat conditions in the Yakima Core Area, especially in the upper Yakima River, Cle Elum River, Taneum River, Ahtanum Creek, Teanaway River, Naches River, and the Tieton River.
- Livestock practices have degraded bull trout habitat in the Yakima Core Area, especially in Ahtanum Creek, Teanaway River, and the Tieton River.
- There may be increased concerns for stream habitat within the drawdown zone in the irrigation reservoirs, to sloughing of streambank during draw down and predation by birds (i.e., Gold Creek). Gold Creek and Box Canyon Creek recently have needed temporary salvage/restoration operations in the channel within the drawdown zone to allow enough water to get bull trout to move up stream during spawning.
- Irrigation diversions and water withdrawals associated with agricultural practices result in low flow conditions, seasonal dewatering, entrainment, and water-quality problems. Specific areas of concern include: Lower Rattlesnake Creek; Big Creek; Lower Taneum Creek; Teanaway River; Gold Creek; and Ahtanum Creek.

- Placer suction dredging, and hard rock mining occurs on a limited scale in several watersheds including the Little Naches and Cle Elum.
- Effects from residential development and urbanization are likely to increase as the population increases. Development in the upper Yakima Basin along the river is occurring at record levels. Water rights are changing and wells are being developed that can directly affect water levels for migrating fish in the Yakima River.
- The combination of hatchery-stocked rainbow trout, large catch limits, use of bait, and easy public access to mainstem and tributaries has generated high angling pressures that have probably negatively affected bull trout. In addition, poaching has been identified as a serious concern in Gold Creek, Box Canyon Creek, Deep Creek, South Fork Tieton River, and Indian Creek.
- Introduction of non-native species including brook trout, brown trout, lake trout, bass, catfish, bluegill, sunfish, and crappie have affected bull trout populations through a combination of hybridization, competition, and predation. Brook trout F2 hybrids have been observed in upper Cle Elum River where brook trout are numerous.
- Fire regimes in eastern Washington have shifted from historically frequent, low-intensity ground fires to low-frequency, high-intensity crown fires due to past fire suppression. Fire severity has also increased in recent years due to grazing, fire suppression, silvicultural practices, and timber harvest practices.
- Chemical contamination in the Yakima River from pesticides and other chemicals has been noted recently by EPA in the Yakima Basin.
- Habitat variables identified by the U.S. Forest Service, BOR, FWS, and Corp. of Engineers in the habitat condition baselines of biological assessments identifies that habitat and watershed variables are still functioning at risk or not properly functioning for some indicators identified in the Bull Trout Matrix of Pathways and Indicators.
- Concern exists that the instream-work windows for Hydraulic Permits may require adjustments because bull trout are using lower portions of the rivers at different times of the year than previously thought.

Upper Columbia River Basin Management Unit

Entiat Core Area

Bull trout in the Entiat River Core Area are presumed to be primarily fluvial, rearing there, and in the Columbia River (USFWS 2002). Currently two local populations of bull trout are found in the Entiat Core Area (mainstem Entiat River and Mad River). The two local populations are thought to be isolated from each other due to a natural thermal barrier. Recent telemetry studies by the Public Utility District in 2000-2004 and by the FWS in 2003 indicated that most tagged fish in the Mad and Entiat River are using the mainstem Columbia River for overwintering and feeding. In the draft Bull Trout Recovery Plan (USFWS 2002), the U.S. Forest Service expressed concern for the long-term persistence of bull trout in the Entiat Core Area due to the low number of spawning fish, restricted spawning distribution, and limited opportunities for refounding. Spawning habitat is mostly in the Mad River. Some recent spawning has been observed in the Entiat River mainstem, below the Entiat Falls, which is an artifact of increased survey effort. Habitat may be a potentially limiting factor for bull trout in tributaries to the Entiat. The tributaries are either low in the drainage where thermal regimes are not presumed to be suitable for bull trout, or the streams are blocked by natural falls. There is no lake habitat for bull trout use. Spawning habitat for migratory fish the Mad River has been reduced by 4.2 miles due to a log jam.

Spawning habitat for migratory fish is currently located downstream of this log jam. Resident/sub-adult sized bull trout were found upstream of this log jam in 2005 by the U.S. Forest Service. Additional tributary surveys are needed to identify other potential spawning habitat.

The status of a bull trout core population can be described based on four key elements: 1) number and distribution of local populations; 2) adult abundance; 3) productivity; and 4) connectivity.

NUMBER AND DISTRIBUTION OF LOCAL POPULATIONS

Currently two local populations of bull trout are found in the Entiat Core Area. The FWS Proposed Critical Habitat Rule including the Columbia River Distinct Population Segment (50 CFR 17, Vol 67, No. 230, 11-29-02) describes a total of 48.8 miles of stream which are used by the bull trout in the Entiat River. Bull trout have been found in small numbers throughout the Entiat River mainstem up to Entiat Falls, during spawning migrations and some were caught in salmon smolt traps downstream of the Mad River. A small amount of spawning has been observed below the Entiat falls and redd surveys currently document use of this area. The other local population found in Mad River, a tributary to the Entiat River, continues to be the major spawning area for the Core Area. Historically, spawning on the Mad River occurred over a 7.7 mile reach between Young Creek and Jimmy Creek. Currently, spawning habitat of migratory bull trout is blocked by a log jam and this habitat is reduced by approximately 4.2 miles.

Bull trout may also spawn in Tillicum Creek, a tributary to the lower Mad River, but additional survey information is needed to characterize the use of this stream by bull trout. Bull trout were also observed in Stormy Creek, a tributary to the Entiat River, about 7.0 miles upstream of the mouth of the Mad River, in 2004. Recent radio-telemetry studies have shown that bull trout tagged by the Public Utility Districts in the mainstem Columbia River at Rock Island, Rocky Reach, and Wells Dams as well as those tagged by the FWS in the Mad River and Entiat River use the Entiat and Mad Rivers mainly for migrating, holding, and spawning for half the year and the Columbia River mainstem for overwintering, migrating, and foraging for the other part of the year. Sub-adults/juveniles have also been located within the Columbia River upstream and downstream of the Entiat Core Area. A screw trap operated by the FWS in the lower Entiat River mainstem has collected juvenile bull trout moving downstream during the outmigration of smolting salmon.

ADULT ABUNDANCE

Bull trout in the Entiat Core Area persist at a very low abundance. The majority of bull trout spawning in this Core Area occurs in the Mad River between Young Creek and Jimmy Creek. Redd numbers range from 33 (66 spawning adults) in 2002 to 57 (114 spawning adults) in 2003 for the entire Core Area for similarly collected data. Since 2000, there is an average of approximately 43 redds (86 spawning adults) for the Core Area, this is the same as the number of redds found in 1998. However, if we look at only the Mad River data which is directly comparable since 1989, (in 1999 this river lost a substantial portion of spawning habitat because of the formation of a log jam), the trend seems to be increasing with a high of 52 (104 spawning adults) redds observed in 2003.

Only a few bull trout redds have been found the Entiat River mainstem from 1994 to 2001. In most years no redds were observed. The most redds observed during 1994 to 2000 was six, while in three different years three redds were observed. Recently there were 40 redds (80 spawning adults) identified in 2004 in a newly identified spawning section of the Entiat River mainstem. None-the-less, there is currently only one strong spawning area for this Core Area, the Mad River, and it has only had 52 redds on one occasion and numbers for the Entiat have averaged less than 10 redds. Bull trout redd surveys have been

conducted annually between 1989 and 2005 in this Core Area. Data from redd counts for the entire Core Area could only be used from 2000 to 2004, because the Mad River Spawning reach changed in length and the Entiat River reach was added. Overall, the trend for the Entiat Core Area looks stable and is slightly increasing due to the Mad River data. Although, because of the overall low adult abundance, the Entiat Core Area is still considered to be at risk of both genetic drift and inbreeding depression today as it was in 2002 (USFWS 2002)

PRODUCTIVITY

The Entiat Core Area redd counts seem to be stable with slightly increasing redd numbers, but still low in abundance. Because of the low number of adults and the fact that there are only two local populations, there is a risk of inbreeding and genetic drift. Between 1998 and 2002, the redd numbers for the Mad River have remained stable. Since the development of the FWS draft Bull Trout Recovery Plan in 2002, the average number of redds has decreased slightly. However, there is less than ten years of consistent data collected in the same stream reaches between both the Entiat and the Mad River and data variability is a concern.

There is concern about the substantial reduction in spawning habitat in the portion of the Mad River, essentially the majority of spawning habitat before 1999. Finding an area in the Entiat River mainstem with 40 redds in 2004 is, at the same time, encouraging. The spawning habitat is not as high of quality as the Mad River so the number of fish making it to adulthood or returning to spawn may be lower. Genetic baselines are not completed. Connectivity remains the same as in 1998 with a few culverts replaced. Data also shows that the populations in the Core Area uses the mainstem Columbia River for more time than originally thought and potentially increasing the effect of mainstem dams.

For a population to contribute to recovery, its growth rate must indicate that the population is stable or increasing for a period of time. Given the overall lack of long-term, consistent, population census information of redd count survey and the low numbers of adult spawners, this Core Area is considered to be at increased risk.

CONNECTIVITY

Within the Entiat Core Area, the migratory life-history form is predominant within the existing local populations. Resident forms were observed above the log jam in 2005 after blockage created a barrier to the migratory form since 1999. The FWS's draft Bull Trout Recovery Plan describes that the Entiat Core Area is considered at a diminished risk due to the presence of the migratory life-history form. Current telemetry information and observation show the migratory form using the mainstem Columbia River as its major overwintering/migratory/and feeding habitat. Also, in the Mad River, the loss of 4.2 miles of spawning habitat due to the log jam which is a migration barrier currently increases the risk of extirpation, especially while numbers of spawning adults are low. There may be some positive prey benefits in the mainstem Columbia River provided from increased smolts releases due to hatcheries in the Columbia River. However, the dams also adversely affect the mobility of bull trout (i.e., lack of passage during winter maintenance and lack of downstream passage). Currently the Enitat Core Areas is considered to be at an intermediate risk of extirpation due to connectivity issues.

CHANGES IN ENVIRONMENTAL CONDITIONS AND POPULATION STATUS

Statewide Federal restoration programs which include riparian restoration, restoration of fish passage barriers, and fish habitat improvement projects have been authorized in the Entiat Core Area. The Entiat

watershed groups have coordinated to apply for monies to complete stream habitat work along the mainstem Entiat River and are working with the U.S. Forest Service to complete culvert repairs (i.e., the Stormy Creek culvert replacement). The Mid Columbia HCP developed for salmon with NMFS and the local Public Utility Districts is the only HCP in effect in this Core Area. Bull trout are not a covered species but an Opinion (FWS Reference Number: 04-W0203) has been completed for bull trout between the FWS and Federal Energy Regulatory Commission (USFWS 2004b) and included conservation measures that should benefit bull trout.

Available information indicates implementation of section 6 and/or section 10(a)(1)(A) permits have resulted in direct effects to bull trout due to capture and handling and indirect mortality (PUD, WDFW, and FWS fisheries studies). Although projects associated with the restoration programs may result in long-term benefits for bull trout and their habitat, all projects included above resulted in take of this species.

It is unknown how many non-Federal actions have occurred in the Entiat Core Area since the listing of the bull trout. Activities such as emergency flood control, development, and infrastructure maintenance are conducted on a regular basis and impact riparian and instream habitat that likely adversely affects this species. State issued Hydraulic Permit Approvals (HPAs) have also affect bull trout and their habitat. Recent land use changes from agriculture to urban development along riparian areas has also be affected the species.

THREATS

Threats to bull trout in the Entiat Core Area include:

- Historically, dams on the major tributaries in the Upper Columbia Management Unit probably contributed to the decline in bull trout by blocking migratory corridors and restricting connectivity to upstream spawning areas and downstream overwintering areas.
- Past logging practices (such as roads), have diminished natural channel complexity, streambank stability, and riparian conditions to a greater extent in the lower Entiat River but the Mad River has been affected as well.
- The Entiat River has some of the highest road miles identified in the baselines of biological assessments from U.S. Forest Service activities (USFS 1998 and USFS 2003). Most of these are legacy roads but as large fire disturbance comes in closer intervals these roads either remain open or are considered closed but get used during fire emergencies.
- Irrigation diversions and water withdrawals associated with agricultural practices may have exacerbated natural low flow conditions in the Entiat River.
- Effects from residential development and urbanization, like the degradation of water quality, instream habitats, and riparian areas, are a concern as the Entiat Core Area continues to experience socio-economic shifts away from agriculture to industry.
- Effects from recreational developments such as campgrounds, trails, etc., include a reduction in LWD, loss of riparian habitat, alterations of streambanks, and an increase in poaching.
- The presence of non-native brook trout in the Entiat Core Area is a concern, particularly upstream of the falls on the Entiat River mainstem.
- The loss of 4.2 miles of spawning habitat in the upper most portion of the Mad River spawning reach, which historically was the most productive, is a threat to productivity in the Entiat Core Area.

- Large fires during 1994 in the upper Mad River spread across upper spawning reaches and suppression activities resulted in the reduction of large woody debris and the removal of key pieces of wood in some pool habitat (USFS 2003).
- Fire regimes in eastern Washington have shifted from historically frequent, low-intensity ground fires to low frequency, high-intensity crown fires due to past fire suppression. Fire severity has also increased in recent years due to grazing, fire suppression, silvicultural practices, and timber harvest practices.
- Habitat and passage at dams produce impacts to juvenile, sub-adult, and adult life history stages of bull trout.
- Habitat variables identified by the U.S. Forest Service in the habitat condition baselines of biological assessments identifies that habitat and watershed variables are still functioning at risk or not properly functioning for many indicators identified in the Bull Trout Matrix of Pathways and Indicators.
- Genetic baselines are not completed.

Methow Core Area

Bull trout are dispersed through out the Methow River basin. Adfluvial, fluvial and resident life-history forms are present. Bull trout are know to occur in habitat within Gold, Beaver, Wolf, Goat, and Early Winters Creeks, the Twisp River (including Buttermilk, North, War Creeks) the Chewuch River (including Lake Creek), and in the Upper Methow River (including the West Fork and Trout Creek). Resident life-history forms are found above passage barriers and suspected in areas where habitat connectivity has been degraded, such as Gold Creek, Beaver Creek, Goat Creek, etc. Adults overwinter in pools throughout the Methow River mainstem. Recent telemetry studies by the Public Utility District in 2000-2005 and by the FWS in 2000-2004 indicated that tagged fish in the Methow Core Area are also using the mainstem Columbia River for overwintering, feeding, and year round use. The studies also show that fish tagged in the Columbia River travel down to Rock Island Dam below the mouth of the Wenatchee River. The studies also show that a bull trout tagged in the Wenachee River was located near the mouth of the Methow River. Juveniles have been captured in smolt traps in the lower Methow and Twisp Rivers. Additional tributary surveys are needed to identify other potential spawning habitat.

The status of a bull trout core population can be described based on four key elements: 1) number and distribution of local populations; 2) adult abundance; 3) productivity; and 4) connectivity.

NUMBER AND DISTRIBUTION OF LOCAL POPULATIONS

Currently 10 local populations of bull trout are found in tributaries or the upper mainstem within the Methow Core Area. The Recovery Team has identified eight local populations since listing: Gold Creek, Twisp River, Chewuch River, Wolf Creek, Early Winters Creek, Upper Methow River, Lost River, and Goat Creek. There are two other local populations: Lake Creek and Beaver Creek identified by the Recovery Team, since the draft Bull Trout Recovery Plan was released, for a total of 10 local populations. The lower Methow River and mainstem Columbia River are used as a migratory corridor. Spawning occurs in tributary streams and in the mainstem upper Methow River. Carter Creek, a tributary to Gold Creek, has the only documented fluvial spawning population within the Gold Creek basin. A population also occurs in Blue Buck Creek within Beaver Creek. Bull trout in the Twisp River local population are comprised of migratory and resident forms and spawning occurs in the mainstem Twisp River, Buttermilk Creek, Bridge Creek, Reynolds Creek, North Creek and War Creek. Wolf Creek is an important spawning and rearing stream for migratory bull trout and resident bull trout also contribute to this local

population. In the Chewuck River local population spawning occurs in the mainstem Chewuck and Lake Creek, while overwintering, rearing, and foraging likely occur in Black Lake. Spawning in the Upper Methow population occurs within the West Fork of the Methow River, Trout Creek, Robinson Creek, and Rattlesnake Creek. Spawning has bee observed in the upper reaches of Goat Creek. Early Winters Creek included both resident and migratory forms and thus, spawning occurs both upstream and downstream of the barrier fall. The Lost River local population may be represented by resident, fluvial, and adfluvial forms. Bull trout in the Lost River have been located in Cougar Lake, First Hidden Lake, and Middle Hidden Lake, as well as downstream of the gorge. Spawning in the Lost River has been documented both upstream and downstream of the gorge area in the river. Some spawning may occur in the lakes and small tributaries to the lakes due to the glacial moraine and springs/upwellings within the lakes near the shorelines.

Bull trout have been located in and upstream of the reaches of the mainstem Twisp River and Methow Rivers which go subsurface in the summer. Bull trout have been killed by the freezing water when trapped upstream in the Twisp after spawning, and they have been found trapped within ponds of water as the mainstem Methow River goes subsurface upstream of Wolf Creek.

Radio-telemetry studies have located bull trout tagged in the Columbia River in Libby Creek, Wolf Creek, lower Lost River, the Twisp River and Buttermilk Creek, and in the lower Methow River. There was one radio-tagged bull trout that moved into the lower Okanogan River for a short period but moved back out and into the Methow River and one that moved into Libby Creek. Juveniles/sub-adults have been trapped in smolt traps in the lower Methow River mainstem and in the Twisp River.

ADULT ABUNDANCE

There was a large variability in redd numbers between 1998 and 2004. Redd numbers within the local populations remain variable. Directly comparable data from redd surveys are only available between 2000 and 2004 because of differences in survey techniques and changes in surveyed areas. Redd numbers range from 117 in 2001 to 174 in 2003 for the entire Core Area where data were collected similarly. The number of redds in 2004 is 148. Since 2000, there have been an average of 144 redds in the Methow Core Area, which is lower than the number cited in the draft Bull Trout Recovery Plan in 2002 of 174. The average number of redds (144) is slightly higher than numbers in 1998, at the time of listing, when redds numbered 127. If we look just at the Twisp River redd data which are directly comparable since 1998, the numbers were 89 in 1998, as high as 105 in 2000, as low as 55 in 2001, and are currently at 74 in 2004. The upper Methow population also seems to be stable since 1998. The low number of redds in the entire Methow Core Area is less than the Recovery Team thought the system could support (USFWS 2002a). There are only two of the 10 local populations that have had greater than 50 redds or 100 adults. There are larger numbers of fish in the Lost River but no new data on spawning or population estimates are available and the degree of connectivity is unknown. Overall, the trend for the Methow Core Area seems to show that since 2000 the numbers of redds are not stable and slightly decreasing. The Methow River population may be at risk of inbreeding and genetic drift due to the large distances between populations (i.e., the Lost River and the rest of the populations) and small numbers of spawning adults in most of the other populations as it was in 2002.

There is a concern about the variability within the redd counts particularly for the largest spawning populations (Twisp River, Upper Methow River); even comparable data are variable. Recent annual averages for adult abundance (174) in the Twisp River indicate that this local population may not be at risk of inbreeding depression. This is caveated by high variability in redd counts. Several other local

populations in the Methow Core Area are mostly under 100 adults annually and are at risk of inbreeding depression. Overall, adult spawning abundance in the Methow Core Area is probably less that 1,000 individuals and therefore the Core Area is considered to be at risk of deleterious effects of genetic drift.

PRODUCTIVITY

Since estimates of the total population size are rarely available, the productivity or population growth rate is usually estimated from temporal trends in indices of abundance at a particular life-history stage. For example, redd counts are often used as an index of a spawning adult population. The direction and magnitude of a trend in the index can be used as a surrogate for the growth rate of the entire population. For a population to contribute to recovery, its growth rate must indicate that the population is stable or increasing for a period of time.

Overall, the trend for the Core Area seems to show that, since 2000, the numbers of redds are not stable and slightly decreasing. Numbers are still low for the amount of habitat available in the Methow Core Area. There is a lower number of redds than the Recovery Team anticipated. There are only two of the 10 local populations that have had greater than 50 redds or 100 adults. The Methow may be at risk of inbreeding and genetic drift due to the large distances between populations (i.e., the Lost River and the rest of the populations) and small numbers of spawning adults in most of the populations.

Irrigation and connectivity continue to be a problem in the Methow Core Area, however culverts and diversions are being addressed. Genetic baselines are not completed. Connectivity remains the same as in 1998, with a few culverts replaced. However, since 1998 data shows that the populations in the Core Area uses the mainstem Columbia River for more time than originally thought and effects of mainstem dams may have increased in magnitude of effect.

CONNECTIVITY

There is information about the migratory patterns of radio-tagged fish to show some connectivity between multiple local populations and with the Columbia River. Recent radio-telemetry studies have shown that bull trout tagged by the Public Utility Districts in the mainstem Columbia River at Rock Island, Rocky Reach, and Wells Dams migrate and use tributaries in the Methow River. The radio-tagged fish were found in the Twisp River during spawning and overwintering in the Twisp, Lower Methow River, and the Columbia River mainstem. Very little tributary tracking occurred with this project; however, some single other observations of some of the radio-tagged fish occurred in Libby Creek, Wolf Creek, Twisp River including Buttermilk Creek, Lost River, Upper Methow River, and Chewuch River. Some radio-tagged and non-radio-tagged bull trout that moved into the Twisp River were stranded above an intermittent natural channel and died when they could not move downstream post spawning. The lack of fall freshets prevented water from coming to the surface in the upper Twisp River. (M. Nelson, Personal Communication, 2004). Juveniles and sub-adults have been trapped in smolt traps in the lower Methow River mainstem and in the Twisp River

Early Winters Creek has a barrier falls with a population of bull trout above the falls. Genetic samples have been collected from above the falls and below the falls to determine if the population above the falls has unique genetics in comparison to other populations.

More is known today about habitat conditions such as irrigation-diversion structures and the levels of in-stream flows. Some of the barriers and flow levels that are man caused are now identified and beginning to be addressed but many still are not addressed. The diversion structures and private land management

practices such as grazing and agriculture activities near the lower reaches of these kinds of streams continues to degrade bull trout habitat and minimize connectivity. Lack of connectivity may disrupt mixing of genes which may inhibit long-term, self-sustaining, complex, interacting groups of bull trout in the Methow Core Area.

It is thought that the population in the Lost River may be two different local populations. The Lost River population is thought to be fragmented in most years due to a natural rock slide downstream of the gorge area which may preclude migration in most years, in turn, precluding gene flow and mixing with other populations in the basin. However, the upper Lost River population is somewhat removed from the rest of the Methow River populations; although it does provide for downstream migration and it may serve as a source population to reduce inbreeding and refounding of downstream populations in the Core Area. With the rock slide acting as a barrier occurring in some years, bull trout are fragmented from the upper habitat which includes many lakes. This local population contains both adfluvial (above the gorge) and fluvial (below the gorge) life-history forms.

The Twisp River local population is affected by a section of the upper river that goes subsurface and in some years may not allow downstream passage of post-spawn bull trout due the low levels of in stream flows. The low instream flows are viewed as natural and the lack of fall precipitation in recent years does not allow the water to resurface to allow downstream movement (M. Nelson, Personal Communication, 2004) especially before the onset of freezing temperatures. This same concern exists for the upper Methow River population where the upper Methow River, below the spawning reach, goes subsurface. It is thought that this is a natural condition but is not well understood how it impacts post-spawn migrations or rearing juveniles.

There is also some new information about bull trout being found in lower Beaver Creek since the culvert has been fixed allowing passage and connectivity for migratory fish back into the system. Last fish surveys in 2003 identified bull trout in this lower reach.

Within the Methow Core Area, habitat degradation has fragmented bull trout populations. Reductions in habitat quality resulting from irrigation water withdrawals, diversion dams, grazing, and passage barriers have collectively contributed to the decline of bull trout in the basin. Bull trout in the Methow Core Area are considered to be at an increased risk of extirpation.

CHANGES IN ENVIRONMENTAL CONDITIONS AND POPULATION STATUS

Statewide Federal restoration programs which include riparian restoration, restoration of fish passage at barriers, and habitat improvement projects have been authorized in the Methow Core Area. The Methow watershed groups have coordinated to apply for monies to complete stream habitat work along the mainstem Methow River and its tributaries and are working with the U.S. Forest Service to complete culvert repairs. Most large, blocking culverts on national forest lands have been replaced with open-bottom arches or bridges. The Mid-Columbia HCP developed for salmon with NMFS and the local Public Utilities Districts is the only HCP in effect for salmonids in this area. Bull trout are not a covered species under the Mid-Columbia HCP, but a biological opinion (FWS Reference Number: 04-W0203) has been completed for bull trout between the FWS and Federal Energy Regulatory Commission (USFWS 2004b) and conservation measures should benefit bull trout. There have been several attempts to develop HCPs with the irrigation districts in the Methow Basin (i.e., Skyline Ditch, the upper Methow irrigation districts, and Wolf Creek). The Wolf Creek HCP work is the furthest along and the Wolf Creek Irrigation District and Sun Mountain Lodge are the proponents. However, this has not been finalized at this time.

Available information indicates implementation of section 6 and/or section 10(a)(1)(A) permits have resulted in direct effects to bull trout due to capture and handling and indirect mortality (PUD, WDFW, EPA, and FWS fisheries studies). Although projects associated with the restoration programs may have affected bull trout and their habitat, all projects included above resulted in take of this species.

It is unknown how many non-Federal actions have occurred in the Methow Core Area since the listing of bull trout. Activities such as emergency flood control, development, and infrastructure maintenance are conducted on a regular basis and affect riparian and instream habitat that likely adversely affect this species. There have been Hydraulic Permits issued by the State which also has affected bull trout and bull trout habitat. Recent land-use changes from agriculture to urban development along the riparian areas may also be an impact to the species. County permits have likely increased for construction of homes in floodplain and riparian areas, where there use to be orchards.

THREATS

Threats to bull trout in the Methow Core Area include:

- Historically, dams on the major tributaries have contributed to the decline in bull trout by blocking migratory corridors and restricting connectivity to upstream spawning areas and downstream overwintering areas.
- Past logging and logging-related activities (such as roads), have diminished natural channel complexity, streambank stability, and riparian conditions. Forest roads that access timberlands are often located in the narrow floodplains including sensitive bull trout areas. This is particularly true for the Twisp River, Chewuck River, and Lake Creek basins.
- Over 60 percent of the private bottom lands in the Methow River area have erosion problems related to grazing. Of specific concerns are riparian areas adjacent to the Twisp River, lower Wolf Creek, Upper Methow River, Chewuck River, Buttermilk Creek, Gold Creek, and Goat Creek.
- Irrigation diversions and water withdrawals associated with agricultural practices may have resulted in partial or complete barriers on many of the systems that support bull trout.
- Effects from residential development and urbanization on water quality, instream habitats, and riparian areas are a concern as this area continues to experience socio-economic shifts away from agriculture to industry.
- Effects from recreational developments, especially on the Twisp River, such as campgrounds, trails, etc., include a reduction in LWD, loss of riparian habitat, alteration of streambanks, and increased poaching.
- Brook trout are widespread within the Methow River and the potential for genetic introgression to bull trout is a concern.
- Instream flow in the Chewuch River, Twisp River, Methow River, Wolf Creek, Goat Creek, and Beaver Creek, continue to be a concern and may be a large affect to bull trout. Irrigation water continues to be diverted in these areas while populations are low or unknown.
- The Lost River fishery may continue to have negative effects on the population as it continues to be the only open fishery on bull trout in eastern Washington.
- Fire regimes in eastern Washington have shifted from historically frequent, low-intensity ground fires to low-frequency, high-intensity crown fires due to past fire suppression. Fire severity has also increased in recent years due to grazing, fire suppression, silvicultural practices, and timber harvest practices.

- Subsurface reaches in the Twisp and Upper Methow Rivers, within spawning and rearing reaches, may continue to fragment populations. This will occur as drought continues to be a problem in the northwest and it will continue to cause a reduction in area of habitat and quality of habitat in the stream. It will continue to strand fish and fragment the populations of fish as instream flows are reduced.
- Habitat variables identified by the U.S. Forest Service in the habitat condition baselines of biological assessments identifies that habitat and watershed variables are still functioning at risk or not properly functioning for many indicators identified in the Bull Trout Matrix of Pathways and Indicators.
- Genetic baselines are not completed.

Wenatchee Core Area

The Wenatchee River has bull trout dispersed throughout the basin. Resident and migratory (both fluvial and adfluvial) bull trout are all found within the Wenatchee Core Area, which includes habitat within the Chiwawa River, White River, Little Wenatchee River, Nason Creek, Chiwaukum Creek, Icicle Creek, and Peshastin Creek. The strongest populations are centered on Lake Wenatchee and the Chiwawa River. The majority of spawning and fry rearing habitat are within national forest lands including Glacier Peak and Alpine Wilderness areas, while the majority of overwinter habitat is adjacent to multiple landownerships between Lake Wentchee and the Columbia River. Resident and migratory bull trout occur in Icicle Creek above the boulder cascades near the Snow Creek trailhead. Adults, sub-adults/resident sized fish have been found in Mill Creek and Nason Creek in the Nason Creek drainage, the Little Wenatchee River, Panther and Canyon Creeks in the White River drainage, Alder, Chikamin, Rock, Phelps, Buck, James, and Alpine Creeks in the Chiwawa River drainage, in Chiwaukum Creek, in Jack, French, and Icicle Creeks in the Icicle Creek drainage, and in Ingall's and Negro Creeks in the Peshastin drainage. Migratory bull trout frequent habitat in Icicle Creek below the Leavenworth National Fish Hatchery, most likely for foraging year round. Adults overwinter in pools throughout the Wenatchee River mainstem. Recent telemetry studies by the Public Utility District in 2000-2004 and by the FWS in 2000-2004 indicated that tagged fish in the Wenatchee Core Area are using the mainstem Columbia River for overwintering, feeding, and year-round use. The studies also show that fish tagged in the Wenatchee River travel at least as far as Pateros near the mouth of the Methow River in the Columbia River. Juveniles have been captured in smolt traps located in Nason, Chiwawa, and Peshastin Creeks, at the head of the Wenachee River, and in the lower Wenatchee River. Additional tributary surveys are needed to identify other potential spawning habitat.

The status of a bull trout core population can be described based on four key elements: 1) number and distribution of local populations; 2) adult abundance; 3) productivity; and 4) connectivity.

NUMBER AND DISTRIBUTION OF LOCAL POPULATIONS

Seven local populations are currently known for the Wenatchee Core Area. They reside in the following tributaries to the Wenatchee River: the Chiwawa, White, and Little Wenatchee Rivers; and Nason, Chiwaukum, Icicle, and Peshastin Creeks. The Chiwawa River local population complex is a strong-hold for bull trout in the upper Wenatchee River. Spawning has been documented in Rock Creek, Chikamin Creek, Phelps Creek, Buck Creek, and the Chiwawa River mainstem. Rock Creek supports the strongest population of bull trout in the Wenatchee Core Area. Bull trout have also been observed in Alpine, James, and Alder Creeks, tributaries to the Chiwawa River. The White River local population is known to spawn in the White River mainstem and Panther Creek a tributary to the White River. Bull trout have been observed in other tributaries to the White River (Napeequa River, Canyon Creek and Sears Creek),

but no spawning has been documented. The Little Wenatchee River local population spawns in the Little Wenatchee River (tributary to Lake Wenatchee) up to Little Wenatchee Falls at river mile 6.8. The Nason Creek originates at Steven's Pass and flows into the Wenatchee River just below the outlet of Lake Wenatchee. Redd surveys indicate that spawning for the local population occurs in Nason Creek and Mill Creek. These populations are in Chiwaukum Creek which enters the Wenatchee River just above Tumwater Canyon and spawning occurs in the mainstem. Icicle Creek is located at the Town of Leavenworth and spawning areas have not been located. Migratory adults have been located upstream of a boulder cascade previously thought to be a migration barrier. Resident-sized fish have been seen in the upper reaches of the mainstem Icicle Creek, and in Jack Creek and French Creek, tributaries to Icicle Creek just below Rock Island Campground. Peshastin Creek is the lowest tributary with bull trout in the Wenatchee Core Area, located near the town of Dryden. Spawning is known to occur in Ingall's Creek and sub-adults/resident sized bull trout and hybrids were located in Negro Creek in 2005.

Recent radio-telemetry studies have shown that bull trout tagged by the Public Utility Districts in the mainstem Columbia River at Rock Island, Rocky Reach, and Wells Dams, and tagged by the FWS in the Wenatchee Core Area use the tributaries for holding, foraging, and spawning for half the year and Lake Wenatchee and the Wenatchee and Columbia River mainstems for overwintering, migrating, and foraging for half the year or more. Some of the tagged bull trout moved between tributaries within the same year, in multiple years, and resided in migratory habitat in these areas for a year or more before migrating to spawning grounds.

Juvenile bull trout have been captured in smolt traps located in Nason, Chiwawa, and Peshastin Creeks, at the head of the Wenachee River. Bull trout in the lower Wenatchee River also have been located year-round in many of the tributary habitats of the local populations. Sub-adults/juveniles have also been located within the Columbia River upstream and downstream of the Wenatchee Core Area.

ADULT ABUNDANCE

There is a large variability in redd numbers between 1998 and 2004. Directly comparable data from redd surveys for all the local populations only occurs between 2000 and 2004 due to added area and different methods. The range of redds in the Wenatchee Core Area varies from 283 in 2001 to 538 in 2002. The number of redds in 2004 was 440. Since 2002, there are an average of 443 redds in the Wenatchee Core Area which is within the range previously portrayed in the draft Bull Trout Recovery Plan in 2002 of 246-462 for the Core Area.

The strongest population in the Wenatchee Core Area is in the Chiwawa River. The Chiwawa River has the longest data set and largest redd counts that are directly comparable; it ranged from 93 redds in 1990 to 436 in 1999 and was at 292 in 2004. However, there is concern about the variability within the redd numbers, even the directly comparable data. This is a lower number of adults than the FWS Recovery Team thought would be found in the system (USFWS 2002a), but it is not that different from the lower abundance number in the range. The Chiwawa River, which has the highest number of redds in the whole management unit, is still one of the most prolific populations in the Columbia River Distinct Population Segment. However, numbers of redds/adults for the Core Area are still slightly below the lowest number in the range that the Recovery Team wants to reach as discussed at the most recent recovery meetings and identified in recovered abundance tables.

The Chiwawa River local population itself is not at risk of inbreeding, but other local populations in the Wenatchee Core Area persist in low numbers and are considered to be at risk of extirpation because these

other local populations have generally less than 50 redds. Due to the lack of baseline genetic information and inconsistent data collection, the Core Area continues to be at risk for genetic drift and inbreeding.

Recent radio-telemetry studies have shown that bull trout tagged by the Public Utility Districts in the mainstem Columbia River at Rock Island, Rocky Reach, and Wells Dams migrate and use tributaries in the Methow River. These radio-tagged fish were found in the Chiwawa River, Wenatchee River, Icicle Creek, and Peshastin Creek spawning areas and tracked back to the Columbia River mainstem where they overwintered. Another radio-telemetry study conducted by the FWS found bull trout tagged in the Wenatchee River, Lake Wenatchee, the Chiwawa River, and at Icicle Creek used Lake Wenatchee, the Wenatchee River, and the Columbia River for overwintering for at least six months of the year. These tagged fish moved into new spawning areas, migrated multiple years to the same tributaries, upstream into wilderness and downstream to the Columbia River, and in some cases they migrated into two rivers during the spawning period.

Also, bull trout are being observed in smolt traps in Nason Creek, at the head of the Wenatchee River, the Chiwawa River, and Peshastin Creek. A few redds have been identified in Ingalls Creek but the spawning area and timing has not yet been determined.

PRODUCTIVITY

Overall, the trend for the Wenatchee Core Area seems to be stable and increasing due to data from the Chiwawa population. However, numbers of redds/adults for this Core Area are still slightly below the lowest number in the range that FWS Recovery Team wants to reach as discussed at the most recent recovery meetings and identified in recovered abundance tables. Since listing in 1998, the redd numbers have remained stable with only one year when redds were below 300 (2001). Since the development of the FWS's draft Bull Trout Recovery Plan in 2002 average redd numbers are lower. There is less than 10 years of consistent data collected in the same stream reaches between all populations in the Core Area. There is a concern with the variability in the data. Redd data has been collected since 1989 in the Chiwawa and was as low as 93 redds. Since then, new spawning reaches have been identified in the mainstem. It is difficult to attribute all increases to a trend. There is still a risk of inbreeding and genetic drift due to the low number of adults, compounded by the fact that there are only two local populations that have had numbers greater than 50 redds or 100 adults. One of those populations has limited information. Connectivity still does not exist for the Icicle Creek population and there is still a partial barrier during low flows in Peshastin Creek. In both Icicle and the Peshastin system, low flows exist and may continue to minimize connectivity. Tumwater Dam and the Chiwawa Dam weirs are maintained only for fish monitoring. There is a concern that trying to pass bull trout though these structures may cause injury to some bull trout.

For a population to contribute to recovery, its growth rate must indicate that the population is stable or increasing for a period of time. Given the lack of consistent, population census information in the record of redd count surveys and the low numbers of adult spawning bull trout in most of the local populations, this Core Area is considered to be at intermediate risk of extirpation.

CONNECTIVITY

There is information about the migratory patterns of radio-tagged fish to show some connectivity between multiple local populations and with the Columbia River. The Wenatchee Core Area is unique in that it has most of its connectivity to the Columbia River and to a natural large lake in the upper basin. As telemetry has indicated, bull trout are able to exhibit resident, fluvial, and adfluvial patterns and mix

between local populations. Bull trout were documented overwintering in areas of the Wenatchee River near the Icicle Creek, in Icicle Creek near the Hatchery, in upper portions of the Wenatchee River, in Lake Wenatchee River, and in the Columbia River. The Chiwawa, Nason Creek, Icicle Creek, and Chiwaukum Creek are used by fish that use the Columbia River. Fish that overwinter in Lake Wenatchee and the Columbia also use at least the Chiwawa Creek and Nason Creek. Fish use Chiwaukum Creek for spawning and seem to overwinter in the Wenatchee River and in the Columbia River. New spawning areas in the mainstem Chiwawa Creek and White Rivers were confirmed in 2000. Approximately 30-32 large fluvial bull trout were observed in a pool in upper Nason Creek just below the spawning tributary (Mill Creek) in 2004.

Bull trout that were fluvial in size have been observed above the anadromous barrier on Icicle Creek. Snorkel surveys in Jack Creek on the upper Icicle show bull trout further up than previously known. One radio-tagged bull trout that was with Chinook at the Leavenworth National Fish Hatchery ascended into the boulder cascade in Icicle Creek (anadromous barrier), but it was thought not to have moved much further above it. The head gate at the Leavenworth National Fish Hatchery continues to block bull trout passage into Icicle Creek even though there has been work done for the past five years to restore the channel. Bull trout are continuing to pool up at the large pool below the hatchery weirs and head gate (Kelly Ringel 2004). It is unknown if bull trout currently still exist above the barrier cascade on the Little Wenatchee River. A few bull trout were identified by the U.S. Forest Service in 1998 and previously, but no surveys have been completed since then, however, brook trout are abundant in this area.

A total fish barrier still exists on the Icicle Creek and a partial barrier still exists on Peshastin Creek. The Tumwater Dam and Chiwawa Dam fish weirs operate only for fish-monitoring purposes. Trapping and telemetry data indicate that some delay may be occurring at these dams, causing a concern with stress, particularly when water temperatures increase.

Within the Wenatchee Core Area, the migratory life-history form is the dominate life-history form within the existing local populations, and therefore, this Core Area was considered to be at a diminished risk of extirpation. While localized habitat problems currently exist that may impede connectivity and affect bull trout migration, there are no large scale, man-made migration barriers that block access to known critical habitat in this Core Area.

CHANGES IN ENVIRONMENTAL CONDITIONS AND POPULATION STATUS

Statewide Federal restoration programs which include riparian restoration, restoration of fish passage at barriers, and habitat-improvement projects have been authorized in the Wenatchee Core Area. The Wenatchee watershed groups have coordinated to apply for monies to complete stream habitat work along the mainstem Wenatchee and its tributaries and are working with the U.S. Forest Service to complete culvert repairs. Most large fish passage barriers on the national forest lands have been replaced with open-bottom arches or bridges. The Mid-Columbia HCP developed for salmon with NMFS and the local Public Utilities Districts is the only HCP in effect for salmonids in this area. Bull trout are not a covered species under the Mid-Columbia HCP, but a biological opinion (FWS Reference Number: 04-W0203) has been completed for bull trout between the FWS and Federal Energy Regulatory Commission (USFWS 2004b) and conservation measures should benefit bull trout.

Available information indicates implementation of section 6 and/or section 10(a)(1)(A) permits have resulted in direct effects to bull trout due to capture and handling and indirect mortality (PUD, WDFW, EPA, and USFWS fisheries studies). Although projects associated with the restoration programs may

result in long-term benefits for bull trout and their habitat, all projects included above resulted in take of this species.

It is unknown how many non-Federal actions have occurred in the Wenatchee Core Area since the listing of bull trout. Activities such as emergency flood control, development, and infrastructure maintenance are conducted on a regular basis and impact riparian and instream habitat that likely adversely affects this species. Hydraulic Permits issued by the State also affect bull trout habitat and bull trout habitat. Recent land-use changes from agriculture to urban development along the riparian areas may also affect bull trout. County permits have likely increased for construction of homes in floodplain and riparian areas.

THREATS

Threats to bull trout in the Wenatchee Core Area include:

- Historically, dams have contributed to the decline in bull trout by blocking migratory corridors and restricting connectivity to upstream spawning areas and downstream overwintering areas.
- Past logging, and logging-related activities (such as roads), have diminished natural channel complexity and riparian conditions in many of the drainages that support bull trout.
- Irrigation diversions and water withdrawals associated with agricultural practices result in low flow conditions, seasonal dewatering, entrainment, and water-quality problems in many of the drainages that support bull trout especially Peshastin Creek, Mill Creek, Icicle Creek, Chiwaukum Creek, Chiwawa River, and Phelps Creek.
- Small-scale gold mining on Peshastin and Chiwawa River could have effects to water quality.
- Effects from residential development and urbanization on water quality, instream habitats, and riparian areas are a concern as this area continues to experience socio-economic shifts away from agriculture to industry.
- Effects from recreational developments, especially on the Wenatchee River, such as campgrounds, trails, etc., include a reduction in LWD, loss of riparian habitat, alteration of streambanks, and increased poaching.
- The presence of non-native brook trout in many of the drainages is a concern due to possible competition and inbreeding.
- Prior to harvest restrictions, large numbers of adult bull trout were harvested in Lake Wenatchee potentially depleting the number of spawning fish.
- Effects from activities in the mainstem Columbia River on populations that spawn in the Wenatchee Core Area (i.e., Nason Creek, Icicle Creek, Chiwaukum Creek and the Chiwawa River). Degraded habitat and passage at dams affect juvenile, sub-adult, and adult life-history stages of bull trout.
- Instream flow in Icicle Creek and Peshastin Creek continue to be a concern and may be a larger affect to bull trout than we know. Irrigation water continues to be diverted in these areas while populations are low or unknown.
- Potential delay or stress caused to bull trout when passing through the Tumwater and the Chiwawa Dam weirs.
- The Lake Wenatchee Sockeye fishery continues to have detrimental effects on the bull trout population in the lake.
- Fire regimes in eastern Washington have shifted from historically frequent, low-intensity ground fires to low-frequency, high-intensity crown fires due to past fire suppression. Fire severity has also

increased in recent years due to grazing, fire suppression, silvicultural practices, and timber harvest practices.

- Chemical contamination in the Wenatchee River from pesticides and other chemicals has been noted recently by EPA in the Wenatchee River and Icicle Creek.
- Habitat variables identified by the U.S. Forest Service in the habitat condition baselines of biological assessments identifies that habitat and watershed variables are still functioning at risk or not properly functioning for some indicators identified in the Bull Trout Matrix of Pathways and Indicators.
- Genetic baselines are not completed.

Northeast Washington River Basins Management Unit

Pend Oreille Core Area

Migratory and resident life-history forms of bull trout are found within the Pend Oreille Core Area, which includes Pend Oreille River and tributaries from the Canadian border upstream to the Albeni Falls Dam. The adfluvial life-history form which historically returned to Lake Pend Oreille was eliminated with the construction and operation of the Albeni Falls Dam and other dams on the river and within tributary streams. However, in recent years, approximately one dozen large migratory bull trout have been captured within the Pend Oreille River, and on a single occasion documented within a tributary stream on a redd. Recent sightings in the Core Area include LeClerc Creek, Mill Creek, Cedar Creek, Indian Creek, Sullivan Creek, Sweet Creek, and the Box Canyon and Boundary reservoirs, and at the mouths of Marshall Creek and Slate Creek.

At the time of listing, it was assumed that adfluvial bull trout from Lake Pend Oreille utilized this portion of the Pend Oreille River and associated tributaries. Several recent studies have confirmed that a downstream adfluvial migration strategy still exists in the Pend Oreille River (above Albeni Falls Dam) and was likely the more prominent life-history form found in this Core Area (DuPont and Horner 2002; Geist et al. 2004). Geist (et al. 2004) tracked six radio-tagged bull trout from below Albeni Falls Dam making repeated movements to the base of the dam in 2003. In 2004, several additional bull trout were tagged and placed above the dam (Geist in litt. 2004). Subsequent tracking documented that they migrated to Pend Oreille Lake and that one individual migrated to a known spawning stream, presumably to spawn. Albeni Falls Dam presents a substantial threat to the continued existence of bull trout in this Core Area as long as there is no fish passage.

The status of a bull trout core population can be described based on four key elements: 1) number and distribution of local populations; 2) adult abundance; 3) productivity; and 4) connectivity.

NUMBER AND DISTRIBUTION OF LOCAL POPULATIONS

While sighting of individual bull trout have occurred in several tributaries to the Pend Oreille River Core Area, only one extant local population has been identified: the LeClerc Creek complex. With only one local population, this Core Area is considered to be at an increased risk of extirpation.

ADULT ABUNDANCE

Population estimates in the Pend Oreille Core Area are not currently available. However, due to relatively few numbers of bull trout documented recently, abundance of bull trout in LeClerc is probably below 100 adult spawning individuals and should be considered at risk from inbreeding. Similarly, bull

trout in the entire Core Area most likely number fewer than 1,000, and should be considered at risk from genetic drift.

PRODUCTIVITY

For a population to contribute to recovery, its growth rate must indicate that the population is stable or increasing for a period of time. In the Pend Oreille Core Area, bull trout are considered to be at an increased risk of extirpation, due to the lack of long-term census information.

CONNECTIVITY

The downstream migration of bull trout was presumed to occur in the Pend Oreille River basin. Adult bull trout would migrate out of Pend Oreille Lake, down the Pend Oreille River and into tributary streams to spawn. This migration pattern was eliminated with the construction and operation of the Albeni Falls Dam. Fragmentation of the mainstem by this dam and Boundary Dam as well as tributary dams places the Pend Oreille Core Area at an increased risk of extirpation.

CHANGES IN ENVIRONMENTAL CONDITIONS AND POPULATION STATUS

The FWS's Opinion on the operations of the Federal Columbia River Power System (USFWS 2000c) assesses effects of system operations at Albeni Falls Dam on bull trout. The operations of the dam are reviewed on a regular basis and the FWS is routinely consulted on operational changes that are constantly needed in an attempt to balance species needs against other downstream ESA concerns (salmon and steelhead), hydropower demand, flood control and storage, and other factors. Management strategies and operational scenarios are in a constant state of flux. Multiple aspects of bull trout recovery are incorporated into (and funded through) the Bonneville Power Administration Fish and Wildlife Program guided by the Northwest Power and Conservation Council.

Idaho Department of Fish and Game (2001) published a statewide fisheries management plan for 2001-2006 that included the specific objective of “Restoring a fishable population of bull trout in Pend Oreille Lake” with a program which will evaluate creating fish passage at Albeni Falls Dam on the Pend Oreille River. Management strategies to achieve that objective that were identified included angler regulation and education, increased law enforcement, habitat protection, and removal of non-native fishes that compete directly with bull trout (e.g., lake trout). Some of those strategies are being implemented, though the State of Idaho has largely abandoned a formal role in the implementation of their Bull Trout Conservation Plan. An experimental trap-net program with potential to remove lake trout has been at least temporarily halted, due primarily to public resistance.

In May 2004, the Department of the Interior filed with the Federal Energy Regulatory Commission, their modified mandatory terms and conditions prepared by the FWS and the Bureau of Indian Affairs (Bureau) pursuant to sections 18 and 4(e) of the Federal Power Act for the Box Canyon Hydroelectric Project (Project) in the Pend Oreille River and tributary waters. The Department of the Interior fully expects that the Federal Energy Regulatory Commission license will be issued with the FWS’s and Bureau’s mandatory prescriptions and conditions.

Fish Passage (Section 18 FPA Fishway Prescription) - The Project consists of two major facilities; Box Canyon Dam and the Calispell Creek Pumping Plant, both of which presently preclude fish passage under most flow and operational conditions. The FWS has prescribed upstream and downstream fishways at both project facilities to accommodate upstream and downstream movement of bull trout, westslope cutthroat trout, and mountain whitefish. These native salmonids will eventually have access restored to

about 73 miles of contiguous barrier-free habitat in the Pend Oreille River, and access to over 100 miles of barrier-free tributary streams upstream and downstream from the dam. In addition, fish passage at the Calispell Creek Pumping Plant would open an additional 21 miles of barrier-free habitat to migratory salmonids.

Trout Restoration (Section 4[e] Conditions) - While the FWS's fishway prescription focuses on the restoration of fish passage in the Pend Oreille River and its largest tributary (Calispell Creek) in the project area, the Bureau's Trout Assessment and Restoration Plan (TARP) provides for the increase of bull trout and westslope cutthroat trout populations in streams tributary to the Pend Oreille River in the project area. The TARP includes strategies to achieve naturally sustainable trout populations in about 328 tributary miles through instream and riparian restoration, conservation and maintenance, removal of fish passage barriers, and the purchase of land or conservation easements, exotic species control, and other measures. The Pend Oreille River would function primarily as a migratory corridor under the TARP.

THREATS

Threats to bull trout in the Pend Oreille Core Area include:

- Past logging, and logging-related activities (such as roads), have degraded habitat conditions in the especially in portions of Sullivan, Mill, Cedar, Ruby, Tacoma, Calispell, and LeClerc Creeks.
- Livestock grazing practices on both public and private lands has affected upland and riparian areas of most tributaries in the Pend Oreille Core Area. Specific areas of concern where grazing has affected stream habitat include the middle and east branches of LeClerc Creek, Ruby Creek, and Calispell Creek.
- Agriculture, although limited in scope, has contributed to effects through stream channelization, sediment inputs, and water quality problems.
- Mining is limited, but dredging and sluicing occurs primarily on Sullivan Creek and may affect fry and juveniles if present in the system.
- Effects from residential development and urbanization are likely to increase as the local, human population increases.
- Introduction of non-native species including brook trout, brown trout, bass, and walleye and the migration of northern pike from the Clark Fork River, Montana, have affected bull trout populations through a combination of hybridization, competition, and predation.
- The role harvest played in the decline of local populations is unknown, but fishing for bull trout in the Pend Oreille Core Area closed only as recently as 1992. Misidentification of bull trout by anglers may remain a threat.
- Road culverts pose a barrier to upstream passage especially on U.S. Forest Service roads in Sullivan Creek, Saucon Creek, and LeClerc Creek basins.

Snake River Basin in Washington Management Unit

Asotin Creek Core Area

Resident bull trout are the primary life-history form found in the Asotin Creek Core Area. Fluvial bull trout may still exist as evidenced by the capture of four sub-adult fish in a smolt trap in the lower reaches of Asotin Creek in 2004. Historically, migratory bull trout were likely much more prevalent and likely used the mainstem of Asotin Creek and the Snake River. Bull trout currently inhabit portions of the upper

mainstem Asotin Creek, North Fork Asotin Creek, Cougar Creek, the Middle Branch and South Fork of North Fork Asotin Creek, and South Fork Asotin Creek. Bull trout were also documented in Charlie and George Creeks in the 1990's. Subsequent fish surveys in these portions of the Core Area have failed to document bull trout in recent years, which may indicate a loss in distribution. North Fork Asotin Creek and Cougar Creek are the only streams where spawning has been documented. Juvenile and sub-adult bull trout are known to rear in Asotin Creek from Charley Creek to the confluences of the North and South Fork Asotin Creeks as well as lower North Fork Asotin Creek and the Middle Branch and South Fork of North Fork Asotin Creek.

The status of a bull trout core population can be described based on four key elements: 1) number and distribution of local populations; 2) adult abundance; 3) productivity; and 4) connectivity.

NUMBER AND DISTRIBUTION OF LOCAL POPULATIONS

There are currently two known local populations distributed in the Asotin Creek Core Area. These local populations occur in North Fork Asotin Creek and Cougar Creek. Both populations were presumed to consist of isolated groups of resident fish because seasonal water temperatures and poor habitat conditions (riparian zone, channel embeddednesss) were thought to exclude bull trout use of the mainstem Asotin Creek below the confluence of Charley Creek. However, with the recent capture of sub-adult bull trout in the lower mainstem of Asotin Creek, a remnant fluvial population may still exist. Nonetheless, with only two potentially isolated local populations, the Asotin Creek Core Area is considered to be at increased risk of extirpation.

ADULT ABUNDANCE

Adult abundance in the Asotin Core Area was estimated at less than 300 individuals total in the two known local populations based on the results of bull trout surveys. Bull trout in this Core Area are considered to be at increased risk of inbreeding depression.

PRODUCTIVITY

For a population to contribute to recovery, its growth rate must indicate that the population is stable or increasing for a period of time. Because of the depressed and probably declining population trend and the loss of range with in the basin, bull trout in the Asotin Creek Core Area are currently considered to be at increased risk of extirpation.

CONNECTIVITY

Migratory forms of bull trout in the Asotin Creek Core Area are presumed to be extremely limited in both local populations. Based on the extremely low numbers of the migratory life history form and the poor connectivity between populations and with the mainstem Snake River, the Asotin Creek Core Area is considered to be at increased risk of extirpation.

CHANGES IN ENVIRONMENTAL CONDITIONS AND POPULATION STATUS

The FWS's Opinion on the operations of the Federal Columbia River Power System (USFWS 2000c) assesses effects of system operations at Snake River dams on threatened bull trout, a protected species under the ESA. The operations of the dams are reviewed on a regular basis and the FWS is routinely consulted on operational changes that are constantly needed in an attempt to balance species needs against other downstream ESA concerns (salmon and steelhead), hydropower demand, flood control and storage,

and other factors. Management strategies and operational scenarios are in a constant state of flux. Multiple aspects of bull trout recovery are incorporated into (and funded through) the Bonneville Power Administration Fish and Wildlife Program guided by the Northwest Power and Conservation Council. The most recent effort in that regard includes the current subbasin planning for the Asotin subbasin (NPPC 2004).

Critical habitat was formally designated in Asotin Creek and all or part of the following watersheds: Charley Creek, George Creek, and the North Fork Asotin Creek (USDI 2005). There are a variety of programmatic activities that have been recently completed or are ongoing in this Core Area, of which have the potential to improve aquatic habitat (NPPC 2004). These include but are not limited to: Conservation Reserve Program; Continuous Conservation Reserve Program; Conservation Reserve Enhancement Program; Wildlife Habitat Incentives Program; Wetland Reserve Program; Environmental Quality Incentives Program; and Total Maximum Daily Load programs. In addition to these programmatic activities, a wide range of Federal, State, tribal, and local agencies and organizations are involved in protecting and restoring aquatic habitat in this area.

THREATS

Threats to bull trout in the Asotin Creek Core Area include:

- Several small concrete and earthen dams impede passage of bull trout on Asotin Creek and Charley Creek. Silt behind these structures also effect downstream habitats.
- The two local populations in the Asotin Creek Core Area exist in tributaries completely surround by U.S. Forest Service lands. Past logging practices have resulted in elevated water temperatures, degraded pool habitats, and sediment deposition in spawning areas.
- Livestock practices have degraded bull trout habitat in the Asotin Creek Core Area.
- Crop production is the second largest land use in the Asotin Creek Core Area. Agricultural development has removed native vegetation, fragmented riparian habitats, increased sediment loads, and diverted water for irrigation.
- Expanding residential development in the lower reaches of Asotin Creek have degraded stream habitat.
- Rainbow trout were heavily planted in Asotin Creek and Charley Creek to support a recreation fishery. In addition to direct competition by rainbow trout and incidental harvest of bull trout, small dams created to enhance the rainbow trout fishery, have impeded bull trout passage on Charley Creek.

Tucannon River Core Area

Both resident and migratory forms of bull trout occur in the Tucannon River Core Area. Migratory bull trout probably also use the mainstem Snake River on a seasonal basis. Spawning occurs in the upper Tucannon River and at least seven tributary streams. Bull trout spawn in Sheep, Cold, Bear, and Panjab Creeks, all tributaries to the upper Tucannon River. Spawning also occurs in three tributaries to Panjab Creek: Turkey Creek, Meadow Creek, and Little Turkey Creek, a tributary to Meadow Creek. Multiple age classes of bull trout have been sampled within the Cummings Creek watershed on several occasions. However, spawning activity has yet to be documented, but surveys have been limited.

The status of a bull trout core population can be described based on four key elements: 1) number and distribution of local populations; 2) adult abundance; 3) productivity; and 4) connectivity.

NUMBER AND DISTRIBUTION OF LOCAL POPULATIONS

There are currently eight known local populations distributed in the Tucannon River Core Area. These populations coincide with the mainstem and tributary streams where spawning is known to occur. Genetic work has been initiated to determine population structuring within these streams, but results are not yet available. Some spawning streams are very close to one another, which may promote free movement of adults among spawning areas from one year to the next. Such a situation could result in a single population of fish with a common genetic make-up using more than one stream for spawning and rearing. With eight interconnected local populations, bull trout in the Tucannon River Core Area are at intermediate risk of extirpation.

ADULT ABUNDANCE

Bull trout redd surveys have been occurring in portions of this Core Area since 1990. However, they have not been done consistently year-to-year and index reaches have not been established. From the data set obtained from WDFW (2004), there are four areas that have been surveyed on a fairly consistent basis. An average number of redds per stream over all the years surveyed for these streams resulted in an adjusted estimate for each stream per year and finally for the Core Area. For the years 1990-1997, the adjusted estimate resulted in an average of 200 redds/year, and for the years 1998-2004 an estimate of 197 redds/year. Therefore the trend in this Core Area appears to be stable.

Adult abundance in the Tucannon River Core Area is estimated (based on redd counts) at 600 to 700 adult spawners for the eight known local populations. Other spawning areas in the Tucannon River watershed have not been surveyed. Bull trout in this Core Area were considered at intermediate risk of extirpation.

PRODUCTIVITY

For a population to contribute to recovery, its growth rate must indicate that the population is stable or increasing for a period of time. The Tucannon River Core Area is considered to be at intermediate risk of extirpation because of an apparent population trend that is not declining and has low to moderate annual variability.

CONNECTIVITY

There is some evidence that Tucannon River bull trout use the Snake River as habitat for foraging and overwintering. Additional evidence suggests that some Tucannon River bull trout also encounter dams on the Snake River. At least two dams on the Tucannon River had documented effects on bull trout from the early 1900's until recently. The De Ruwe Dam no longer exists and, therefore, is no longer a barrier to bull trout. The Starbuck Dam has been only partially removed and whether it interferes with bull trout migration is unknown. Recreational dams in numerous tributary streams in recent years have been known to kill bull trout or severely limit their ability to reach spawning areas. Migratory bull trout persist in most local populations in the Tucannon River Core Area and, therefore, it was considered to be at intermediate risk.

CHANGES IN ENVIRONMENTAL CONDITIONS AND POPULATION STATUS

The FWS's Opinion on the operations of the Federal Columbia River Power System (USFWS 2000c) assesses effects of system operations at Snake River dams on bull trout. The operations of the dam are reviewed on a regular basis and the FWS is routinely consulted on operational changes that are constantly needed in an attempt to balance species needs against other downstream ESA concerns (salmon and

steelhead), hydropower demand, flood control and storage, and other factors. Management strategies and operational scenarios are in a constant state of flux. Multiple aspects of bull trout recovery are incorporated into (and funded through) the Bonneville Power Administration Fish and Wildlife Program guided by the Northwest Power and Conservation Council. The most recent effort in that regard includes the current subbasin planning for the Tucannon subbasin (NPPC 2004).

Critical habitat was formally designated in the Tucannon River and all or part of the following watersheds: Cummings Creek, Hixon Creek, and the Little Tucannon River (USDI 2005). There are a variety of programmatic activities that have been recently completed or are ongoing in this Core Area which have the potential to improve aquatic habitat (NPPC 2004). These may include but are not limited to: Conservation Reserve Program; Conservation Reserve Enhancement Program; Wildlife Habitat Incentives Program; Wetland Reserve Program; Environmental Quality Incentives Program; and Total Maximum Daily Load programs. In addition to these programmatic activities, a wide range of Federal, State, tribal, and local agencies and organizations are involved in protecting and restoring aquatic habitat in this area.

THREATS

Threats to bull trout in the Tucannon River Core Area include:

- Dams on the mainstem Snake River and two dams on the Tucannon River have had an effect on bull trout since their construction. One of the smaller dams has been completely removed, while the other still presents as a partial barrier. Dams on the Snake River remain and present a passage issue.
- In the Tucannon watershed, the majority of the legacy effects from roads and past logging activities occurred prior to the listing of spring Chinook in 1992. Most national forest lands in the watershed have been harvested and 50 to 75 percent have been cut two to three times. Forestry continues to be a predominant land use in the Tucannon Watershed.
- Livestock practices have degraded bull trout habitat in the Tucannon River Core Area. Grazing on pasture and rangeland is one of the three predominant land uses in the Tucannon Watershed.
- Agricultural practices in the Tucannon watershed have resulted in high erosion rates, and low seasonal water levels can in part be attributed to irrigation diversion.
- Expanding residential subdivisions, numerous individual homes, and associated infrastructure are located primarily in floodplain areas of the Tucannon River.
- The Tucannon River and it tributaries receive substantial fishing pressure all year, that probably has a corresponding effect on adult bull trout escapement.
- Road densities and locations in the Tucannon River Core Area are described as “functionally at risk”. Culverts impede passage and roads funnel sediment into the creeks.

Umatilla-Walla Walla Basins Management Unit

Touchet River Core Area

Resident and migratory (both fluvial and adfluvial) bull trout are all found within the Touchet River Core Area which includes the mainstem Touchet River, North Fork Touchet River, Wolf Fork Touchet River, and South Fork Touchet River.

The status of a bull trout core population can be described based on four key elements: 1) number and distribution of local populations; 2) adult abundance; 3) productivity; and 4) connectivity.

NUMBER AND DISTRIBUTION OF LOCAL POPULATIONS

The currently known spawning distribution in the Touchet River population occurs in the North Fork Touchet River from Bluewood Creek to Spangler Creek, in Sprangler Creek, Wolf Fork Touchet River from Whitney Creek upstream of the U.S. Forest Service boundary, and in Burnt Fork of the South Fork Touchet River. Bull trout in the Touchet River Core Area are primarily restricted to upper portions of the Wolf Fork and North Fork Touchet Rivers (Mendel et al. 2003a). An additional local population was discovered in the South Fork Touchet River, but it appears to be very small and tenuous. Water flows and temperature in lower and middle sections of the South Fork Touchet River have been identified as potential limiting factors (Kuttel 2001). Habitat conditions are relatively good in the North Fork and Wolf Fork Touchet Rivers and the local populations in these drainages appear to be holding their own. Annual variability in redd count totals is high, so it is difficult to make reliable inferences on long-term population trends.

ADULT ABUNDANCE

Redd counts have been done annually on the Wolf Fork Touchet River (from 1990-2004), North Fork Touchet River (1994-2004), and South Fork Touchet River (2000-2004) (annual redd count results up to 2003 are summarized in Mendel et al. 2004; unpublished 2004 results obtained from Glen Mendel, WDFW, Dayton, WA). The Wolf Fork Touchet River continues to support the largest population, although redd totals on that stream have fluctuated a great deal (from 71 in 1994, down to 4 in 1997, then up to 101 in 2003). Despite the high variability, the overall trend in redds per year has been upward in Wolf Fork Touchet River since 1998. On the North Fork Touchet River, redd totals hovered in the 40s from 1998 to 2001, but have dropped each year since to a low of 22 in 2004, which is approximately at levels from the mid-1990s. It is unclear if this represents natural fluctuations or a steady decline. A local population was discovered in the South Fork Touchet River in 2000. However, after 16 redds were observed in the South Fork Touchet River in 2001, the count dropped to one in 2002, and no redds were seen in 2003 and 2004 surveys.

PRODUCTIVITY

For a population to contribute to recovery, its growth rate must indicate that the population is stable or increasing for a period of time. Based on the depressed or variable population trends, bull trout in the Touchet River Core Area were considered to be at increasing risk of extirpation.

CONNECTIVITY

Migratory bull trout persist in some local populations in the Touchet River Core Area. Physiological barriers and impediments to bull trout passage and rearing were extensive in terms of stream miles affected. Water temperature appears to be the most critical physiological barrier, particularly for passage or rearing. Seasonal temperature related barriers for bull trout generally occur in lower areas of the Touchet River.

CHANGES IN ENVIRONMENTAL CONDITIONS AND POPULATION STATUS

A number of barriers or impediments to bull trout passage and rearing have been identified since 1998 (Mendel et. al. 1999, 2000, 2002, 2003b; Coyle et al. 2001). Some of the barriers are physical conditions (e.g., structures or dewatered streambeds) that block movement (see Mendel et al. 2003a); others are physiological barriers (e.g., temperature, sediment, lack of pools). Physiological barriers and impediments to bull trout passage and rearing were extensive in terms of stream miles affected. Water

temperature appears to be the most critical physiological barrier, particularly for passage or rearing. Seasonal temperature-related barriers for bull trout generally occur in lower areas of the Touchet River.

Progress has been made with screening irrigation ditches and eliminating barriers to fish passage along the Touchet River

THREATS

Threats to bull trout in the Touchet River Core Area include:

- Numerous dams, physiological barriers and impediments to bull trout passage and rearing are extensive in terms of stream miles affected.
- Increased sediment loads associated with logging roads and recreation trails, loss of future large wood, and passage barriers associated with road culverts are problems that have result from past and logging practices in Touchet River Core Area.
- Multiple reaches of the mainstem Touchet River are dewatered as a result of agricultural irrigation practices.
- Foraging and overwintering habitat in the mainstem Walla Walla from the Little Walla Walla River downstream to the mouth contains numerous non-native species, but at this time the effects are not well know.
- Angling effects have adversely affected and continue to affect bull trout through direct harvest and incidental harvest. Poaching is a threat to bull trout in the Touchet River upstream of Dayton and the North Fork Touchet River.

Walla Walla Core Area

Bull trout in the Walla Walla Core Area exhibit both fluvial and resident life-history forms. Both forms spawn in headwater tributaries. After spawning, fluvial bull trout return to overwintering areas in the mainstem Walla Walla River until upstream migration begins. They spend the summer through fall in lower order tributaries or the upper mainstem Walla Walla River.

The status of a bull trout core population can be described based on four key elements: 1) number and distribution of local populations; 2) adult abundance; 3) productivity; and 4) connectivity.

NUMBER AND DISTRIBUTION OF LOCAL POPULATIONS

The Walla Walla Core Area currently has two known local populations: upper Walla Walla complex, which includes the North and South Forks of the Walla Walla River; and Mill Creek and its tributaries. Fish in the upper Walla Walla local complex spawn mainly in the North and South Forks of the Walla Walla River between Table Creek and the second major tributary above Reser Creek with the majority of spawning fish found in Bear Creek. Fish from the Mill Creek local population spawn in Mill Creek and its tributaries upstream of the national forest boundary.

ADULT ABUNDANCE

Due to the lack of abundance data, bull trout local populations in the Walla Walla Core Area could not be evaluated relative to the risk of inbreeding depression. Abundance estimates for the Walla Walla Core Area were conservatively estimated by doubling the number of redds counted in 1999 and 2000 and taking the average of both years for an adult abundance estimate of 1,437 individuals. Based on this adult abundance estimate, the Walla Walla Core Area is not at risk from genetic drift.

PRODUCTIVITY

For a population to contribute to recovery, its growth rate must indicate that the population is stable or increasing for a period of time. Based on depressed or variable population trend in the two local populations, bull trout in the Walla Walla Core Area are considered to be at increasing risk of extirpation.

CONNECTIVITY

Migratory bull trout continue to persist in some local populations. Connectivity among populations is limited by numerous dams and diversion structures on the mainstem Walla Walla River and many of its tributaries creating physical and thermal barriers at certain times of the year. Because of these factors, the Walla Walla Core Area is considered to be at an intermediate risk of extirpation.

CHANGES IN ENVIRONMENTAL CONDITIONS AND POPULATION STATUS

In June 2000, the Walla Walla settlement agreement was signed by three local irrigation districts and the FWS. This agreement provided for the maintenance of instream flows in a stretch of the Walla Walla River that had been seasonally dewatered by irrigation diversions (Mendel et al. 2002, 2003). In 1999, over 6,500 fish, including 108 bull trout, were salvaged after being stranded in this dewatered reach. In 2000, a total of 3,887 fish, including 15 bull trout, were salvaged from the area. In 2001, for the first summer in nearly a century, the increased flows resulted in a watered stretch of the Walla Walla River between Milton-Freewater, Oregon, and the Washington/Oregon State line. Since implementation of the agreement, there has not been a fish-stranding problem in this area. The settlement agreement has been amended several times since 2000 to accommodate increased flow requirements; a new 3-year agreement was signed on June 28, 2004.

In 2001, a major new fish ladder was installed at Nursery Bridge near Milton-Freewater to facilitate passage of large salmon, steelhead, and bull trout. Considerable progress has been made in eliminating barriers to fish passage on the Walla Walla River and Mill Creek through screening irrigation ditches, consolidating ditches, and modifying diversion structures.

THREATS AND RECOVERY OBJECTIVES

Threats to bull trout in the Walla Walla Core Area include:

- Numerous dams and diversion structures have been constructed on the mainstem Walla Walla and tributaries for agriculture and flood control.
- Increased sediment loads associated with logging roads and recreation trails, loss of future large wood, and passage barriers associated with road culverts are problems that have resulted from past logging practices in several basins within the Walla Walla Core Area.
- Past livestock grazing on U.S. Forest Service lands has contributed to the degradation of aquatic habitats and present day livestock grazing on private lands continues to degrade habitats.
- Flood control and agricultural practices have simplified aquatic habitats and dewatered others. Poorly maintained diversions also strand bull trout.
- Residential development has meant the loss of floodplain habitats as well as low flow conditions due to municipal water withdrawals.
- The mainstem Walla Walla from the Little Walla Walla River downstream to the mouth contains numerous non-native species, but at this time the effects are not well know.

- Angling effects past and present have adversely affected and continue to affect bull trout through direct harvest and incidental harvest. Poaching is a threat to bull trout in the Walla Walla River and some tributaries.

Grande Ronde River Basin Management Unit

Grand Ronde Core Area

The Grande Ronde Core Area is one of two Core Areas located within the Grande Ronde River Basin. Oregon Department of Fish and Wildlife and the FWS have identified eight distinct local populations of bull trout within this Core Area (Buchanan et al. 1997, Service 2002). Both resident and fluvial life-history forms are known to occur in the Grande Ronde Core Area.

The status of a bull trout core population can be described based on four key elements: 1) number and distribution of local populations; 2) adult abundance; 3) productivity; and 4) connectivity.

NUMBER AND DISTRIBUTION OF LOCAL POPULATIONS

The Grand Ronde Core Area eight distinct bull trout local populations include: the Upper Grande Ronde River (where the headwaters of the Grande Ronde River begins); Catherine Creek; Indian Creek; Minam River/Deer Creek; Lostine River/Bear Creek; Upper Hurricane Creek; Wenaha River; and Lookingglass Creek. Only a portion of one of those populations (Wenaha River) is found in Washington. Bull trout have been observed throughout the mainstem Wenaha River, South Fork Wenaha River, North Fork Wenaha River, Butte Creek, Crooked Creek and Mill Creek, a tributary the South Fork Wenaha River. Wenatchee Creek, a Washington tributary to the Grande Ronde, historically supported fluvial bull trout. However, a barrier water fall that formed in the 1960's, has impeded migration since. A survey in the mid 1980's documented one resident bull trout. More-recent surveys have not been able to confirm bull trout presence. The Grande Ronde Core Area also includes Wallowa Lake and the Wallowa River above the lake where bull trout have been extirpated.

Bull trout have been observed throughout the mainstem Wenaha River, South Fork Wenaha River, North Fork Wenaha River, Butte Creek, Crooked Creek, and Mill Creek, a tributary to the South Fork Wenaha River. Spawning occurs in the headwaters of Wenaha River and many of its tributaries. All known summer rearing and holding areas in the Wenaha River or its tributaries are on national forest land. This population is considered to be at low risk of extirpation. Wenatchee Creek is not considered a local population, but is identified as a research need.

ADULT ABUNDANCE

Bull trout in the Grand Ronde Core Area persist at moderate levels and best estimates are that approximately 4,000 bull trout spawned in each of the past few years. The majority of spawning likely occurs in the Wenaha River and its tributaries.

The extent to which local populations within the Grande Ronde Core Area are genetically distinct is unknown; they were delineated based primarily on known geographic, physical, and thermal barriers between spawning populations. Genetic information on bull trout metapopulation structure in the Grande Ronde Core Area has recently been collected and the University of Montana is currently analyzing the data. (Howell, USFS, Personal Communication, 2005).

PRODUCTIVITY

For a population to contribute to recovery, its growth rate must indicate that the population is stable or increasing for a period of time. Given the overall lack of long-term population-census information in the Grande Ronde Core Area and the variability in abundance estimates, the Grande Ronde Core Area is considered at risk of extirpation. The Wenaha River local population is one of the strongholds as it has multiple age classes, contains fluvial fish, has an anadromous prey base, has connectivity with the Grande Ronde and Snake Rivers, and contains pristine habitat. The status for the Wenaha bull trout population appears to be stable with a low risk of extirpation (although, consistent redd count data is not available for this population).

CONNECTIVITY

There are many physical or thermal barriers obstructing connectivity and migratory forms are present in only four of the eight local populations within the Grande Ronde Core Area. Specific passage barriers identified in the draft Bull Trout Recovery Plan include fish weirs (e.g., upper Grande Ronde River, Lookingglass Creek, and Lostine River) and hatchery intakes (e.g., Wallowa and Lookingglass fish hatcheries, Big Canyon satellite facility, and satellite facilities in the Lostine River, and upper Grande Ronde River). The draft Bull Trout Recovery Plan also identified several possible thermal barriers from warm water temperatures (e.g., upper Grande Ronde River, Bear Creek watershed, Lostine River, and Hurricane Creek below the Consolidated/Moonshine Ditch diversion dam).

CHANGES IN ENVIRONMENTAL CONDITIONS AND POPULATION STATUS

Since the bull trout listing, Federal actions occurring in the Grande Ronde Core Area may have caused harm to, or harassment of bull trout. These actions include riparian restoration, grazing activities, federally funded weed-treatment activities in riparian areas, restoration of fish-passage barriers, fish-habitat-improvement projects, and federally funded transportation projects involving repair and protection of roads and bridges. Several scientific permits have been issued in the Grande Ronde Core Area for effects to bull trout from capture and handing (including Catherine Creek, Lostine River, and Wenaha River, among others).

The U.S. Forest Service has conducted an extensive culvert inventory to determine fish-passage concerns and limited replacements have been conducted for bull trout in the Grande Ronde River Core Area to date. The Oregon Department of Environmental Quality Total Maximum Daily Load and Water Quality Management Plan for the Upper Grande Ronde River Management Plan have recently been completed. Wallowa County is currently conducting a Total Maximum Daily Load and Water Quality Management Plan for the Lower Grande Ronde River. (ODEQ 2000).

The number of non-Federal actions occurring in the Grande Ronde Core Area since the bull trout listing is unknown. Fifty-four percent of the land is in private ownership within the Grande Ronde River Basin. Primary uses of private land are forest, range, and cropland.

THREATS

Threats to bull trout in the Grand Ronde Core Area include:

- Ratliff and Howell (1992) listed habitat degradation, passage barriers, over harvest, and hybridization and competition with non-native brook trout as possible suppressing factors for bull trout populations in the Grande Ronde River Basin.

- Agricultural practices, mining, logging practices, and past road construction in the upper Grande Ronde River watershed have resulted in the alteration and degradation of instream habitats, and have been implicated in stream channel simplification and reduced frequency of large, deep pools (McIntosh *et al.*1994).
- Irrigation diversions and water withdrawals have created passage barriers and reduced stream flows, which often results in elevated water temperatures. Brook trout are present in a number of upper elevation streams where bull trout spawn and rear.
- Gunckel *et al*. (2002) studied two eastern Oregon streams and documented the ability of brook trout to out-compete bull trout and to replace bull trout through hybridization. Furthermore, once brook trout are introduced, they are difficult to eradicate from a watershed and will likely impact bull trout well into the future.

Coeur d'Alene Lake Basin Management Unit

Coeur d'Alene Lake Basin Core Area

The majority of the Coeur d'Alene Lake Basin Core Area resides in northern Idaho. Only a small portion of the Core Area is within Washington and no local populations reside in the State.

The status of a bull trout core population can be described based on four key elements: 1) number and distribution of local populations; 2) adult abundance; 3) productivity; and 4) connectivity.

NUMBER AND DISTRIBUTION OF LOCAL POPULATIONS

Three local populations are currently identified in the Coeur d'Alene Lake Basin Core Area. They are Medicine Creek; Wisdom Creek; and St. Joe River between Heller Creek and St. Joe Lake. Juvenile bull trout as well as bull trout redds have been documented in many other tributary streams of the St. Joe River over the last decade, but because these documentations are infrequent and of limited numbers, fish from these tributaries have not been classified as local populations.

Distribution within the Core Area appears to have become increasingly fragmented since 1992, and even more so since 1998. Since 1992, bull trout redds have been observed in 19 tributary streams. Since 1998, bull trout redds have only been observed in 11 tributary streams. Furthermore, in 6 of these streams, only a single redd has been observed over the seven years since listing.

With fewer than five local populations, the Coeur d'Alene Lake Basin Core Area is considered to be at an increased risk of extirpation. No populations from this Core Area occur in Washington.

ADULT ABUNDANCE

Overall, bull trout in the Coeur d'Alene Lake Basin Core Area persist at low numbers in fragmented and relatively isolated local populations. Adult abundance was previously estimated at 119 to 166 adult spawners per year in the 3 known local populations. However, adult abundance over the last few years is estimated to be increasing, since redd counts in 2004 and 2005, 72 and 91 respectively, have roughly doubled over the previous 12 year (1992–2003) with an average of approximately 42 redds. The adult abundance is now likely greater than 250 adult individuals. None-the-less, based on this low adult abundance, the Core Area is considered to be at increased risk of inbreeding depression.

PRODUCTIVITY

For a population to contribute to recovery, its growth rate must indicate that the population is stable or increasing for a period of time. Data obtained from Idaho Department of Fish and Game annual redd surveys since 1992 indicate an increasing trend for three index streams since the surveys began. However, prior to listing, there was a downward trend with less than 20 redds reported in 1997, and an average of 37 redds annually between 1992 and 1997. Since 1997, greater than 40 redds have been report for most years (only 15 in 1998), with highs of 72 in 2004, and 91 in 2005 for the three index areas. Furthermore, there appears to an increasing trend in one additional stream, Heller Creek. In previous years, redds were rarely documented, but in 2004, seven redds were found, resulting in 79 documented redds for the Core Area. Given the 14 years of population information from annual redd surveys, with only the last few years having a marked increase for a few local populations, bull trout in the Coeur d'Alene Lake Basin Core Area are still considered to be at an increased risk of extirpation.

CONNECTIVITY

Bull trout spatial distribution in the main basin of Coeur d'Alene Lake Basin Core Area and its' direct tributaries is fragmented. Seasonally, unsuitable habitat along with barriers such as water diversions, road crossings, and culverts on smaller streams are known to impede connectivity between local populations and previously occupied suitable habitats.

CHANGES IN ENVIRONMENTAL CONDITIONS AND POPULATION STATUS

The Idaho Panhandle National Forest has implemented many habitat-restoration and enhancement activities in this Core Area. The types of restoration projects that have been implemented include: construction of pool habitat using both large woody debris and/or boulders; placement of large woody debris as cover; placement of boulders to diversify habitat; planting of shrubs and trees within the riparian zone; replacement of culverts which were migration barriers; riparian fencing; and the removal of a small dam. While these activities are expected to improve overall habitat conditions in the Core Area as well as benefit bull trout, only a small number of these activities have occurred in areas currently inhabited by the species.

A Conservation Partnership consisting of the local Soil and Water Conservation Districts, the Idaho Soil Conservation Commission, and the Natural Resources Conservation Service has been established to assist private landowners with the management of their natural resources. As a whole, the focus of the Conservation Partnership is to reduce non-point source pollution from agricultural lands by increasing the voluntary implementation of agricultural best management practices on various agricultural lands.

Critical habitat has formally been designated in Coeur d'Alene Lake, the Coeur d'Alene River, the North Fork Coeur d'Alene River, the St. Joe River, Beaver Creek, Eagle Creek, Fly Creek, Prichard Creek, Ruby Creek, Steamboat Creek, and Timber Creek (USFWS 2005).

Idaho Department of Fish and Game (2001) published a statewide fisheries management plan for 2001-2006. While the management plan emphasizes that wild native populations of resident and anadromous fish species will receive priority consideration in management decisions, there are no specific objectives or programs identified within the Spokane River drainage section of the management plan for bull trout. Management direction identified in the plan for bull trout in this area includes: maintain harvest closure; better define life-history patterns in the lake; and investigate distribution, status, and critical habitat needs to better guide conservation efforts.

The ongoing State and Federal management programs have identified opportunities that have not yet translated into meaningful recovery efforts in this Core Area. The population status of bull trout in this Core Area remains well below that deemed necessary for long-term persistence and remains at risk because of their isolation and other associated risks to the few remaining local populations

THREATS

Threats to bull trout in the Coeur d'Alene Lake Basin Core Area include:

- Post Falls Dam and its operation, and other smaller barriers that block fish passage.
- Effects related to past logging have degraded habitat including loss of riparian habitat, sedimentation, poorly designed and located roads, and blocking culverts.
- Non-native, invasive species including brook, lake, and brown trout.
- Residential development and urbanization leading to poor water quality

Clark Fork Rover Basin Management Unit

Priest Lakes Core Area

The majority of the Priest Lakes basin is in the northwest corner of Idaho. About 2.5 percent extends into Canada where the upper Priest River originates in the Nelson Mountain Range. Headwaters of the major tributaries on the western side of the basin originate in the Kaniksu National Forest and the Salmo-Priest Wilderness in northeast Washington. Recent redd surveys and fish sampling have failed to document use by bull trout in several of these streams, perhaps indicating a further decline in their distribution within this Core Area. Bull trout spatial distribution in the main basin of Priest Lake and its' direct tributaries is increasingly fragmented (IDFG 2004). The strongest remaining bull trout populations are found in Upper Priest Lake.

The status of a bull trout core population can be described based on four key elements: 1) number and distribution of local populations; 2) adult abundance; 3) productivity; and 4) connectivity.

NUMBER AND DISTRIBUTION OF LOCAL POPULATIONS

Twelve populations are currently identified in the Priest Lakes Core Area. They include the upper Priest River, Hughes Fork, Gold Creek, Trapper Creek, Lion Creek, Two Mouth Creek, Granite Creek, North Fork Granite, South Fork Granite, Indian Creek, Kalispell Creek, and Soldier Creek. Hughes Fork, Gold Creek, North Fork Granite Creek, South Fork Granite Creek, and Kalispell Creek originate in Washington.

ADULT ABUNDANCE

Based on recent analysis, there are fewer than 100 adult bull trout in this Core Area and the recent trend is considered stable at best, more probably declining. Bull trout in this Core Area are considered to be at an increased risk of extirpation.

PRODUCTIVITY

For a population to contribute to recovery, its growth rate must indicate that the population is stable or increasing for a period of time. Based on the depressed or variable population trend, bull trout in the Priest Lakes Core Area are considered to be at risk of extirpation.

CONNECTIVITY

Bull trout spatial distribution in the main basin of Priest Lake and its direct tributaries is becoming increasingly fragmented (IDFG 2004). Fish passage at Priest Lake dams needs to be addressed to provide year-round fish passage. Barriers on smaller streams such as water diversions, road crossings, and culverts also impede connectivity between populations.

CHANGES IN ENVIRONMENTAL CONDITIONS AND POPULATION STATUS

Idaho Department of Fish and Game (2001) published a statewide fisheries management plan for 2001-2006 that included the specific objectives of "restoring a fishable population of bull trout in Upper Priest Lake" and "examining the potential to shift management emphasis in Priest Lake from lake trout to cutthroat, bull trout, and kokanee." Identified management strategies to achieve those objectives included angler regulation and education along with active removal of non-native lake trout by intensive gill-netting in Upper Priest Lake.

The ongoing State and Federal management programs have identified opportunities that when fully implemented will promote recovery in this Core Area. Bull trout population response as a result of lake trout control activities is not certain, but there do not appear to be other viable options.

THREATS

Threats to bull trout in the Priest Lakes Core Area include:

- Fish passage at Priest Lake dams needs to be addressed to provide year-round fish passage. Barriers on smaller streams such as water diversions, road crossings, and culverts also impede connectivity between populations.
- Impacts related to past logging practices have degrade habitat including loss of riparian habitat, sedimentation, poorly designed and located roads, and blocking culverts.
- Non-native, invasive species including brook, lake, and brown trout.
- Dewatering occurs regularly on portions of Kalispell Creek.

8.6.3 EFFECTS OF THE ACTION ON THE INDIVIDUAL

The "effects of the action" is defined in the ESA section 7 implementing regulations as:

> "the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline. Indirect effects are those that occur later in time, but that are reasonably likely to occur. Interrelated actions are those that are part of a larger action and depend on the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration." (50 CFR §402.02).

The activities addressed in this Opinion have been previously described in the Project Description section and Description of Activities that are Effects of the Permit.

Bull trout have specific habitat requirements that appear to influence their distribution and abundance (Rieman and McIntyre 1993). All life-history stages are associated with complex forms of cover including large woody debris, undercut banks, boulders, and pools. Other habitat characteristic important

to bull trout include: channel and hydrologic stability, substrate, and the presence of migration corridors (Rieman and McIntyre 1993). Stream temperatures are also an important habitat feature that can affect bull trout distribution, as they prefer cold water. In Alberta, Canada, bull trout occurrence and abundance was found to be inversely related to the percentage of commercial forest harvesting and road density in subbasins (Ripley 2005). Activities related to timber harvest and the development of forest road networks can influence bull trout occurrence through a variety of pathways. Forest practices that would be conducted under the FPHCP have the potential to both negatively and positively influence many of the components known to be associated with suitable, productive bull trout habitat.

8.6.3.1 Large Wood

Large wood serves several important roles in buffering small- and moderate-sized streams against temperature changes. The role of large wood in affecting stream temperatures is covered in the Temperature Effects section of this Bull Trout Effects analysis. This analysis will discuss the effects of large wood on channel hydrology and complexity.

Reduction of wood in stream channels, either from present or past activities, generally reduces pool frequency and quality, and channel complexity (Bisson et al. 1987, House and Boehne 1987, Spence et al. 1996). Large wood in streams enhances the quality of habitat for salmonids and contributes to channel stability (Bisson et al. 1987). It creates pools and undercut banks, deflects stream flow, retains sediment, stabilizes the stream channel, increases hydraulic complexity, and improves foraging opportunities (Murphy 1995). By forming pools and retaining sediment, large wood also helps maintain water levels in small streams during periods of low stream flow (Lisle 1986b). Large pools consisting of a wide range of water depths, velocities, substrates, and cover are characteristic of high-quality, aquatic habitat and an important component of channel complexity.

Research into wood recruitment from stream-adjacent areas helped shape the recruitment-distance relationships for large wood in the FPHCP, as is illustrated in Figure 4.9 (page 215) of the FPHCP. In a study of first- through third-order streams in western Washington and Oregon, McDade et al. (1990) found that for pieces whose source of origin could be determined, 70 percent of wood pieces recruited from mature conifer forests, and 90 percent of the wood from mature hardwood forests, originated from within 15 meters (50 feet) of the stream bank. Source distances of 20 meters (66 feet) and 30 meters (100 feet) correspond with 80 and 90 percent of the total recruitment, respectively, for woody debris from mature conifer forests (McDade et al. 1990). In a similar study, Murphy and Koski (1989) found that 90 percent of the in-stream woody debris recruited from old growth forests in southeast Alaska had source distances of 50 feet or less from the stream edge (Figure 4.10 of WDNR 2005) and almost all (99 percent) identified sources of large wood were within 30 meters (100 feet) of the stream bank (Murphy and Koski 1989). McKinley (1997) found that 95 percent of woody debris originated within 15 meters (50 feet) of the stream bank for small streams bordered by second growth forests in northwest Washington (Figure 4.11 of WDNR 2005).

Although McDade and others (1990) were able to estimate the point of origin of much of the large wood in the studied streams, they could not determine the source of a significant percent of the pieces. Earlier studies (such as McDade and others 1990, Murphy and Koski 1989) focused primarily on chronic inputs of wood from stream-adjacent riparian zones. More recent research suggest that these earlier studies (such as McDade and others 1990) did not sample study reaches influenced by upstream and upslope sources (Reeves et al. 2003). Other studies suggest that half, or more, of large wood inputs may come from upstream and upslope sources (Pollock and Kennard 1998, Reeves et al. 2003, May and Gresswell

2003, McGarry 1994 as cited in Pollack and Kennard 1998). As discussed by Fox (2003), McDade et al. (1990) included greater minimum piece size and included channel-straddling pieces whereas his study did not. Both of these factors would favor counting more pieces that are in proximity to their recruitment source, and undersestimate the contribution of large wood from upstream and upslope sources.

One study (McGarry 1994 as cited in Pollack and Kennard 1998) determined that 48 percent of the large wood in a mainstem creek came from upstream sources, primarily debris flows. In steep terrain, landslides and debris flows are potentially important mechanisms for delivering large wood from hillslopes and small headwaters to valley-bottom streams (Reeves 2006). Another study in a pristine watershed in coastal Oregon shows that the contribution of large wood to fish streams from upslope areas can be as much 65 percent of the total number of pieces and 46 percent of the estimated volume of wood (Reeves et al. 2003). More than 80 percent of the total number of pieces of wood in a western Washington stream were from upslope sources (Benda and others 2003; as cited in Reeves 2006); and large amounts of wood were recruited from upslope sources in the Oregon Coast Range (May and Gresswell 2003). These findings indicate that a substantial proportion of wood in the studied streams came from upslope sources and suggests that studies such as McDade et al. (1990) may have limited applicability for developing and evaluating riparian management policies for landslide-prone areas. Steeper, more highly dissected watersheds will likely have a greater proportion of wood coming from upslope sources than will watersheds with lower gradients (Reeves 2006). Murphy and Koski (1989) and Martin and Benda (2003) found that upslope sources of wood composed a relatively small portion of the total volume of wood in low gradient streams they studied in Alaska (Reeves 2006). In the steep forested terrain of the Pacific Northwest the contribution of large wood delivered by landslides or debris flow from the upslope may account for more than half of the wood in a stream (Reeves et al. 2003; May and Gresswell 2003). Stream size and geographic setting strongly influences processes that recruit wood and redistribute wood in the channel (May and Gresswell 2003). Therefore, it is expected that sources of large wood contribute differently in different areas, and that research results vary according to the location of the study.

It is important to note that pieces of large wood delivered from upslope areas are generally smaller than those originating from riparian zones along fish-bearing streams (Reeves 2006). The mean volume of a piece of wood from upslope areas was one-third the mean size of pieces from stream-adjacent riparian areas in a coastal Oregon stream (Reeves et al. 2003). Differences in mean size are likely attributed to fire history and other stand-resetting events (Reeves 2006). Hillslopes are more susceptible to fire and burn more frequently than riparian zones (Agee 1993 as cited in Reeves 2006). Thus, trees in riparian zones may be disturbed less frequently and achieve large sizes than upslope areas (Reeves 2006). Upslope sources are also more sporadic sources of wood and rely on stochastic events (landslides, slope failure, etc.) as the delivery mechanism.

Expressing wood-recruitment ratios for wood recruited from stream-adjacent riparian areas as a proportion of tree height rather than distance from a stream enables source-distance relationships to be compared across sites and between studies. McDade et al. (1990) reported average tree heights for mature and old-growth conifer forests of 48 meters (157 feet) and 57.6 meters (189 feet), respectively. Using these values to express wood recruitment as a function of tree height indicates that more than 80 percent of the stream-adjacent woody debris in mature and old-growth conifer forests is recruited within half of a tree height while over 90 percent originates from within three-quarters of a tree height. Murphy and Koski (1989) found that 99 percent of large woody debris in streams in southeast Alaska was recruited within three-quarters of a tree height from the stream bank. The generalized wood recruitment

curve presented in FEMAT (1993) and shown in Figure 4.8 of WDNR (2005) suggests that at least 80 percent of woody debris originates from within three-quarters of a tree height.

The effective buffer width needed to deliver a high proportion of the wood sufficiently large enough to be considered functional or key-piece sized to the adjacent stream or river is generally narrower than the buffer width needed to deliver a similar proportion of all available wood. Model predictions by Van Sickle and Gregory (1990 as cited in May and Gresswell 2003) suggest that wood entering a stream from trees growing close to the channel should contribute longer and larger pieces of wood than wood delivered from a greater distance. May and Gresswell (2003) found that along a low-elevation floodplain of an alluvial channel that the majority of wood pieces within a distance of less than 10 meters were young hardwoods. Larger conifers were located beyond the floodplain and terrace surfaces. They also found that along colluvial channels riparian areas were more representative of upland areas and large conifers were dominant in the near-stream area. These two studies emphasize again that stream size and geographic setting strongly influences processes that recruit wood and redistribute wood in the channel (May and Gresswell 2003).

FPHCP Effects on Large Wood

Riparian buffer widths in the FPHCP would vary dependent on site class, size of the stream, whether the stream is fish-bearing or not, and where the stream is located (east or west of the cascade crest). For fish-bearing streams, the FPHCP would also divide the riparian buffer into three distinct zones: the Core, Inner, and Outer Zones. Riparian management zones are measured from the edge of the bankfull width or the CMZ which ever is greater. The widths of the riparian buffers and the amount of harvest that can occur within identified zones are described in **Description of Washington Forest Practices Rules under the Proposed FPHCP** as well as within the rules themselves (i.e., Title 222 WAC).

Tree removal in riparian corridors reduces the potential for the input of large wood, small woody debris, and organic matter to the stream and can reduce bank stability if trees too close to the stream bank are removed (Swanson et al. 1987, MBTSG 1998). These changes have the potential to alter the channel morphology and reduce habitat complexity and the input of organic matter to the stream. In Washington, large wood in streams has been greatly reduced in nearly all streams due to not only historic logging practices, but via agriculture and urbanization as well (USFWS and NMFS 2005). As a result, current riparian habitat conditions have become simplified, both in species composition and structure. Presently, for example, it is thought that red alder dominates more riparian areas in western Washington than was typical under natural disturbance regimes (WFPB 2001a, McHenry et al. 1998). It is also estimated that approximately 78 percent of western Washington stream miles and 61 percent of eastern Washington stream miles flow through early-seral stage riparian stands. Early-seral stage was defined as "reproduction, conifer pole, hardwood pole, and mixed pole stands less than 12 inches in diameter at breast height (dbh)(WFPB 2001a).

In contrast, only 1 percent and 5 percent of the stream miles in western and eastern Washington, respectively, flows through riparian stands considered to be late-seral stands of trees greater that 24 dbh. This is significant, at least in the near-term, as a large percentage of large wood can be a result of bank erosion, windthrow, and near-bank tree mortality, and most riparian stands in Washington currently lack sufficient numbers of large trees. As noted earlier, in steep terrain in the Pacific Northwest, the contribution of large wood delivered by landslides or debris flow from the upslope may account for more than half of the wood in a stream (Reeves et al. 2003; May and Gresswell 2003). However, other studies have found that topographic features of a watershed influence the relative contribution of riparian-

adjacent and upslope sources of large wood. In less steep terrain and in U-shaped valleys, a proportionally lower amount of large wood will be delivered from debris flows. In the near-term, sources of large wood from both near-bank and upslope areas are in early seral condition in many cases and therefore will not be a source of large functional wood for likely decades.

Under the FPHCP, the conditions of riparian areas adjacent to fish-bearing streams are expected to improve as trees are left to mature in the no-harvest core zone, the inner zone, and, to a lesser extent, the outer zone. For both the eastside and westside, the intensity of harvest and RMZ management increases with the distance from the stream. The proportion of the stream-adjacent large wood source area affected by FPHCP prescriptions also increases with distance from the stream (CH2MHill 2000). More specifically, the CH2MHill (2000) review of the scientific foundations of the Forest and Fish plan concluded that the 50-foot, no-harvest core zone on the westside would maintain an unmanaged stand supplying 62 to 79 percent of the potential stream-adjacent large wood depending on stream size and site class. The limited-harvest options for the inner zone in some cases may supply an additional 14 to 34 percent of the potential large wood. On the eastside, numbers are similar. The 30-foot core zone would maintain an unmanaged stand predicted to provide 66 to 82 percent of the potential stream-adjacent large wood, and the inner zone would supply an additional 12 to 30 percent (CH2MHill 2000). Again, these percentages depend on stream size and site class. According to the CH2MHill (2000) study, only five percent or less of the potential stream-adjacent large wood supply would be affected by the more-aggressive harvest prescriptions permitted in the outer zone.

Depending on the stream type and bankfull width, WDNR (2005; Appendix J, part 2) it was estimated that RMZs on 20-acre exempt parcels would provide between 45 and 95 percent of the potential wood recruitment from mature conifer forest. However, in situations where CMZs are present, the amount of the potential large-wood recruitment provided by such buffers may be substantially less. The WDNR estimate was based upon observed buffers on 20-acre exempt parcels and included additional trees retained, ostensibly, to meet shade requirements.

For Type Np streams on the westside, the prescriptions are designed to protect sensitive sites (e.g., headwall seeps, springs, alluvial fans, and stream junctions) by requiring 50-foot-wide buffers along at least 50 percent of the unit length. Where tree-retention buffers are located, the prescriptions would maintain unmanaged timber stands predicted to supply 62 to 79 percent of the potential large wood (CH2MHill 2000). Where buffers are not required, all of the harvestable timber could be removed. Because smaller Type N streams have less power than larger streams, smaller wood will often remain in place and function in sediment storage and channel morphology (Bilby 1995). However, larger wood is expected to be more persistent and form deeper steps and sediment wedges.

For Type Ns streams on the westside, timber harvest would not be restricted except where potentially unstable slopes occur near the channel. In reaches with stable side slopes, all timber could be removed which would eliminate any large wood recruitment in these areas. In reaches with potentially unstable side slopes, a portion of the timber would be retained, and therefore so would a portion of the potential large wood recruitment.

In Type Np streams on the eastside, the effectiveness for maintaining timber in the source area is dependent on the management option used. In partially cut units, a 50-foot-wide buffer with a basal area (BA) equivalent to the BA required for Type F stream would be required along the entire unit. In clear-cut units, a 50-foot-wide no-harvest buffer would be retained along 30 to 70 percent of the unit length. No more than 30 percent of the stream length within a harvest unit would be left without a buffer. The

no-harvest reaches of the partial harvest and clear-cut units are predicted to supply 81 to 95 percent of the potential large wood (CH2MHill 2000). Where buffers are not required, all of the harvestable timber could be removed.

In summary, stream size and topographic setting strongly influence processes that deliver wood to the channel network (May and Gresswell 2003). In larger alluvial channels, the majority of the functional large wood along fish-bearing streams comes from near-stream processes (streambank erosion, wind throw, and near-bank tree mortality), with the remainder coming from channelized landslides or debris flows, and stream-adjacent hillslope landslides (Pollack and Kennard 1998; Murphy and Koski 1989). Riparian buffers adjacent to fish-bearing streams prescribed in the FPHCP are expected to maintain 91 to 100 percent of the potential large wood that originates adjacent to these streams (CH2MHill 2000). This percentage would be substantially less along 20-acre exempt parcels bordering fish-bearing streams. In small colluvial channels draining steep hillslopes, processes associated with slope instability dominate large-wood recruitment.

Due to the portions of many of Type Np or Ns streams without buffers, there will be some reduction in large-wood recruitment to fish-bearing streams. The portions of Type Np and Ns streams that are left unbuffered will result in a more-acute reduction in large-wood recruitment to fish-bearing streams, especially fish-bearing streams nearer headwaters. When debris flows occur, we expect initiation points to provide some wood in most cases. Debris flows will entrain additional wood as they travel downstream. Due to the presence of harvested reaches, a lesser amount of wood would be entrained. Additional wood may also be delivered in the run-out reach in lower segments. Not all debris flows will deliver to fish-bearing streams. When debris flows do deliver to fish-bearing streams, a lesser amount of wood may be delivered due to riparian timber harvest along Type Np and Ns streams. However, wood delivered through debris flows may be damaged and broken as a result of the transport mechanism and may not be as effective at retaining sediment as larger whole pieces recruited lower in the stream reaches affected by these processes. For instance, wood recruited by debris flows or other mechanisms within the 300 to 500 foot sensitive site at the confluence of Type F and Np streams may be longer and less broken, less transportable by fluvial processes, and may be more important for retaining sediment. Regardless of these considerations, the FWS expects that some negative effects will result from the incremental difference in wood delivered at these points. As a result, at these delivery points and in downstream reaches, there may be fewer deep pools, reduced stability of streambanks, channel widening, and additional bedload movement.

Effects of the Reduction of Large Wood on Bull Trout

Bull trout are strongly associated with various components of habitat complexity, including cover, large wood, side channels, undercut banks, boulders, pools, and interstitial spaces in coarse substrate (Rieman and McIntyre 1993; Jakober 1995; MBTSG 1998). Several life-history features of bull trout make them particularly sensitive to activities that reduce the quantity, quality, and distribution of large wood that directly or indirectly affects stream-channel integrity and natural flow patterns (MBTSG 1998). Examples of these life-history features and their association with habitat complexity are:

- An extremely long period from egg deposition to fry emergence from the gravel (220 days or more during winter and early spring);
- Strong association of juvenile bull trout with streambed cobble and substrates low in fine sediments;

- Extensive spawning and overwintering migrations of adult bull trout, which require a large network of suitable freshwater habitat with migratory corridors;
- Use of deep pools by both adults and juveniles for cover and thermal refuge;
- Selection of redd sites by adults in low-gradient reaches and in areas of groundwater influence;
- The lower-gradient sites are sometimes located adjacent to channel roughness elements (large wood and boulders) within stream reaches having overall moderate to steep grades;
- Use by both adults and juveniles of areas with reduced water velocity, such as side channels, stream margins, and pools (Watson and Hillman 1997; MBTSG 1998).

Bull trout of all age classes are closely associated with cover, especially during the day (Baxter and McPhail 1997, Fraley and Shepard 1989). Bull trout distribution and abundance is positively correlated with pools; complex forms of cover such as large or complex woody debris and undercut banks; and coarse substrates (cobble and boulder) (Rieman and McIntyre 1993, Jakober 1995, MBTSG 1998). Studies of Dolly Varden show that population density declined with the loss of woody debris associated with clear-cut harvest or the removal of logging debris from streams (Bryant 1983, Dolloff 1986, Elliott 1986, Murphy et al. 1986). Dolloff (1986) also found that the larger size classes of fish declined the most.

Loss of large-wood recruitment potential relative to 20-acre exempt parcels and Type Np and Ns streams draining steep hillslopes may negatively affect bull trout through bedload movement, lack of cover, lack of protection for undercut banks, and other factors. A reduction in large wood to bull trout streams also has the potential to result in reduced pool formation. These effects could affect bull trout at all life stages. At locations where Type Np and Ns streams occur above bull trout spawning reaches, effects from the loss of potential large wood could be more substantial. Embryos and juvenile bull trout are especially vulnerable to bedload movement and increased sediment and could experience mortality as well as injury. Indirect effects include increased risk of predation and reduced ability to forage. Migratory bull trout require complex habitat and large wood as they forage, migrate, and overwinter, and spawning sites are usually in proximity to large wood and other cover. Potential effects to adult and sub-adult bull trout include reduced ability to forage, loss of suitable habitat patches, reduced carrying capacity, and loss of available spawning habitat. A study by Hauer et al. (1999) suggests that land use practices, and specifically practices that result in changes in the frequency, character, and distribution of instream wood, may play a role in the decline in bull trout. We expect adverse affects associated with the loss of large-wood recruitment to occur in a number of bull trout streams. These effects are anticipated to be typically sub-lethal in nature since they will affect bull trout through the reduction of overall habitat complexity. This reduction in overall habitat complexity would contribute to the impairment of bull trout foraging, rearing, and spawning behaviors. Such adverse effects are not anticipated to occur in all streams that support bull trout, especially streams that derive most of their large wood from near-stream sources.

8.6.3.2 Stream Temperature

Stream temperature is the result of complex, interacting environmental factors. Human activities primarily influence stream temperature by affecting four major components of the physical environment: riparian vegetation, channel morphology, hydrology, and surface/subsurface interactions (IMST 2004).

There are numerous mechanisms that can result in temperature increases in streams. These mechanisms include 1) reduction in canopy cover, 2) increased coarse and fine sediment delivery to stream channels, which can lead to channel widening and loss of pools, 3) reduction in large wood, which result in

reduction of pools, reduced channel capacity, and loss of thermal buffering and coldwater refugia, 4) increased heating of riparian soils, 5) interception of shallow groundwater by road systems, 6) increased air temperature over streams by loss of microclimate buffering, 7) riparian roads, which reduce the interaction of the floodplain with the channel, 8) loss of off-channel wetlands due to reduction in shading, 9) loss of streambank stability due to streamside harvest, leading to increased sediment delivery and channel widening, and 10) increase in basin-wide sediment delivery due to forest-related road systems, leading to pool loss and channel widening (Beschta et al. 1987; Brosofske et al. 1997; Johnson and Jones 2000; IMST 2004).

At the point of stream initiation, the temperature of water entering a forested stream system typically resembles that of the watershed's subsoil environment. Conduction between water and alluvial substrates is an important mechanism influencing stream temperatures (Beschta et al. 1987; Johnson and Jones 2000). In streams where a large amount of water is in contact with substrates, especially during subsurface and hyporheic flow, conduction may be second only to solar radiation in affecting stream temperatures (Johnson and Jones 2000).

As water continues to flow down the stream system, seasonal and diurnal variations in water temperatures are strongly influenced by solar radiation (Beschta et al. 1987). A loss or decrease in riparian vegetation diminishes the amount of shade available to block incoming solar radiation. In several studies the largest increases in stream temperature after riparian removal occurred not in the late summer, the usual time of maximum stream temperatures, but in early summer, which coincides with the timing of maximum solar inputs (Johnson and Jones 2000). Measured increases in maximum daily stream temperatures following canopy removal have ranged from 2 degrees to 12.7 degrees celscius (Beschta et al. 1987; Johnson and Jones 2000; IMST 2004; Story et al. 2003).

Riparian forests and the shade they provide are key factors affecting the thermal regimes of aquatic ecosystems (Brown et al. 1989). Although solar radiation is not the only factor affecting the thermal environment of streams, it is thought to be the primary driver of stream temperatures on FPHCP covered lands (WDNR 2005). Riparian canopy removal can lead to increased maximum water temperatures during summer and lower minimum water temperatures in the winter, thus resulting in increased diel fluctuations in both seasons. Streamside vegetation reduces incoming solar radiation thereby limiting stream heating, particularly during the summer months. In winter, riparian canopy cover may help moderate water temperatures by inhibiting energy losses through evaporation, convection, and long-wave radiation (Beschta et al. 1987).

The amount of influence riparian vegetation may have on stream temperatures is dependant on multiple factors including the size of the stream, water depth, groundwater inputs, riparian vegetative community, length of stream channel shaded, slope, aspect, and region. By altering the thermal regime of streams, reductions in streamside shade may also cause undesirable changes in primary production and fish metabolism, development, and behavior (Beschta et al. 1987). The loss of riparian vegetation and cover can also indirectly influence the thermal environment (local wind patterns, local air temperatures, humidity, conductive and convective heat transfer, outgoing or long-wave radiation), soil temperature, sediment delivery, base flow (and possibly hyporheic exchange), and large wood recruitment (IMST 2004).

Over the long-term, the FPHCP is expected to reduce the amount of water temperature increases from harvest activities from baseline conditions mainly through improved riparian management. Because relatively young stands provide shade for smaller streams (those most-easily warmed by solar radiation),

the temperature regimes in these smaller streams has likely improved over the course of the last 5 years of operations under the current Washington Forest Practices Rules. Although the magnitude of changes in stream temperatures for any given stream is difficult to predict, improved canopy cover, an increase in stream bank stability and the amount of large wood, and the reduction of sediment delivery to the stream is anticipated to result in long-term improvements to the temperature regime of most waters supporting bull trout. Sediment reduction as a result of improved road management is also expected to maintain or improve water temperatures over the long-term.

In the short-term, some riparian timber harvest on FPHCP covered lands may likely result in some adverse effects to bull trout from additional increases in temperature along unbuffered portions of Type Np and Ns streams and potentially reaches of Type F streams that occur immediate downstream. This would primarily occur on FPHCP covered lands with currently mature stands.

The Role of Large Wood and Sediment in Maintaining Stream Temperatures

This section addresses the mechanisms by which losses of large wood and increases in sediments can affect stream temperatures. There are other sections within this analysis of effects to bull trout that present a more-detailed description of the effects of large wood and sediment on stream-channel complexity and hydrology, the effects of this HCP on these processes, and the resulting effects to bull trout from alterations in sediment and large wood.

Large wood also plays an important, but indirect role in buffering small streams against temperature changes by increasing the storage capacity of the alluvial aquifer and by contributing to streambed complexity that drives streambed-scale hyporheic flow (Poole and Berman 2000). In headwater streams where bull trout spawn and rear, large wood is important in helping buffer stream temperatures.

In moderate-sized streams buffering against temperature changes occurs through hydraulic forces associated with large wood (Poole and Berman 2000). Aggregates of large wood act as roughness elements that redirect flow, causing avulsions and creating pools, bars, and side channels (Abbe and Montgomery 1996). These hydraulic forces in the proximity of large wood contribute to streambed complexity, including formation of deep pools that can provide cold water refuges and to streambed-scale hyporheic flow, which provides an important source of cold water to maintain or decrease stream temperatures. Several studies have shown that water near the bottom of pools is sometimes 5 to 10 degrees C cooler than water near the surface (Beschta et al. 1987).

It is unlikely that large wood plays a similar role in large streams. Because large streams are generally subject to increased amounts of solar radiation, they exhibit more- substantive diel variation in temperature than do smaller headwater streams which are more-easily shaded (S. Johnson, Personal Communication, 2006).

Increased coarse and fine sediment delivery to streams can lead to increases in stream temperatures through channel widening and loss of pools. For example, decreased amounts of mature riparian vegetation can result in less large wood that falls into the stream; without large wood, sediments can be mobilized and deposited. A decrease or loss in riparian vegetation can also destabilize the streambank, resulting not only in a loss of shade but in an increase in sediments being deposited downstream. In both instances, an increase in sediments deposited in the channel can cause the channel to widen and increase the amount of solar radiation reaching the surface water of the stream. Sediment can also reduce the size and number of deep pools, not only reducing stream complexity but also the availability of cold-water refugia.

Fine sediments can also clog the streambed, leading to a decrease in base flow of cold water by disconnecting subsurface flow paths and diminishing groundwater and hyporheic discharge. In turn, the assimilative capacity of the stream is diminished and an important source of stream cooling is diminished, resulting in an increase in stream temperature (IMST 2004).

In summary, the loss of large wood and streamside vegetation and large increases in sediment, can directly and indirectly affect stream temperatures. For example, pools which allow for habitat partitioning by various species as well as providing cold water refugia, may be altered either by shallowing (increased sediment) or by decrease in complexity (loss of large wood) (Reeves et al. 1997b). Aggregates of large wood can act as roughness elements that redirect flow, causing avulsions and creating pools, bars, and side channels (Abbe and Montgomery 1996). Hydraulic forces in the proximity of large wood continues to contribute to streambed complexity and streambed-scale hyporheic flow in moderate sized streams buffering against temperature changes (Poole and Berman 2000). Large wood also plays a role in capturing and storing sediment. If adequate amounts are not available to capture and store sediment, sediments can clog the streambed disconnecting subsurface flow paths and diminishing groundwater discharge leading to a decrease in base flow. In turn, the assimilative capacity of the stream is diminished resulting in an increase in stream temperature. A decrease or loss in riparian vegetation also destabilizes the streambank resulting in an increase in sediments being deposited downstream. In turn, the deposition of sediments causes the channel to widen increasing the amount of solar radiation reaching the stream.

The potential reduction of large wood from 20-acre exempt parcels and Type Np and Ns streams has the potential to affect the amount of instream large wood in fish-bearing streams. This could decrease habitat complexity, potentially de-stabilize streambanks, and facilitate stream-channel widening. These habitat effects may result in subsequent stream warming near the confluences of Type Np or Ns streams with fish-bearing streams or adjacent to 20-acre exempt parcels. Where fish-bearing streams immediately downstream of these confluences or adjacent to these 20-acre exempt parcels contain bull trout, this stream warming would likely result in some sub-lethal effects. Severity of effects will vary based on available habitat and existing baseline habitat conditions

FPHCP Effects on Riparian Shade

Riparian management zone (RMZ) prescriptions in the FPHCP protect most shade along Type S and F streams by requiring the retention of shade-providing trees within a certain distance of the bankfull width or the channel migration zone. The size of the RMZ needed to meet the shade requirements varies depending on whether the RMZ is located in western or eastern Washington.

In eastern Washington, within the bull trout habitat overlay, all available shade must be retained within 75 feet from the edge of the bankfull width or outer edge of the CMZ (whichever is greater) along Type S or F waters. The “bull trout habitat overlay” includes those portions of eastern Washington streams containing bull trout as identified on the WDFW bull trout map. RMZ’s for Type S and F streams on 20-acre exempt parcels must also meet the 1998 shade requirements which are measured from the bankfull width.

In western Washington, a temperature prediction method is used to determine appropriate shade levels to prevent excessive water temperatures. The temperature prediction method is based on a nomograph that uses elevation, location (eastside or westside), and the water-quality stream temperature standard, either 16 degrees C or 18 degrees C, to predict the amount of shade beyond the no-harvest 50-foot Core Zone that is necessary to achieve those temperature standards. When using the nomograph to predict the

amount of shade necessary, no tree within an area as much as 75 feet from the stream can be removed if, according to the nomograph, it provides shade necessary to maintain compliance with state water-quality standards. These water-temperature-specific shade requirements must be met regardless of harvest opportunities provided in the Inner Zone RMZ rules; however, meeting the "Shade Rule" does not mean that all shade is retained, nor does it guarantee obtaining any specific water temperature (e.g., 16 or 18 degrees C) or obtaining water temperatures protective of bull trout.

Washington Department of Ecology has recently revised their water quality standards. Although these standards are more protective of bull trout than the previous Class A/ Class AA standards of 16 degree C and 18 degree C, they have not yet received approval from EPA nor have they been adopted into the Forest Practices Board Manual. In Schedule L-1 of the FFR, the shade requirement on the westside for Type F & S streams is described as that produced by the shade model (nomograph) or, "if model not used, virtually all available shade" (WDNR 2004). As new data becomes available and is reviewed by CMER, or water quality standards change, the nomograph should be updated and modified by the Board. A high priority of adaptive management is to improve the shade model to better predict relationships between shade and temperature at a regional level and at different spatial scales, and update it to reflect current research and any updated water quality standards.

Landowners that meet the requirements of the 20-acre exemption are not required to leave the same riparian buffers as described in the FPHCP for larger private forest lands. In addition to smaller riparian buffer widths and fewer trees, RMZs and calculations regarding the shade requirements for 20-acre exempt parcels begin at the bankfull width. Also, under the rules for 20-acre exempt parcels, the shade rule only applies to the RMZs and not out to 75 feet. Therefore, on Type F streams, the shade rule would only provide additional shade within 29-58 feet of the stream, depending on stream size. Under the standard rules, the RMZs and shade requirements begin at the CMZ and the shade requirements extend out to 75 feet. Implementation of the 20-acre exemption may lead to an increased risk of blowdown and diminishing shade on some streams, especially as streams migrate across their historical channel and may re-occupy areas within or outside the RMZ. The estimate of 20-acre exempt parcels based on the available information ranges from 0.5 percent to 5.8 percent of watersheds, but is likely an underestimate (Rogers 2003). The report acknowledges that the percentages of 20-acre exempt parcels are likely underestimated due to lack of adequate data for statewide analysis. In spite of application of the "Shade Rule", reduced shade associated with harvest on 20-acre exempt parcels has the potential to affect stream temperatures in Type F as well as Type N streams.

For segments of Type Np streams in western Washington, a 50-foot, no-harvest riparian buffer is required along each side of the stream for the first 500 feet if the Type Np streem is 1,000 feet or greater; or at least 50 percent of its length or 300 feet, whichever is longer, if the Type Np stream is less than 1,000 feet. This buffer will start at the confluence of the Type Np stream to the Type F or S stream. This theoretical upstream distance above a water temperature site where factors, such as temperature and canopy, influence water temperature is known as a "thermal reach" (Sullivan 1993). A thermal reach is a reach with relatively similar riparian and channel conditions for a sufficient distance in order to allow the stream to reach equilibrium with those conditions (Lewis et al. 2000). The length of stream reach required to reach equilibrium will depend on stream size (especially water depth) and morphology (Sullivan 1993). In one study, the distance of similar riparian and channel conditions required to establish equilibrium with those conditions in fish-bearing streams was estimated to be approximately 1,000 feet (Lewis et al. 2000). As described in the **General Effects of the Action – Water Temperature (Heat)** section, the distance needed to reach equilibrium is variable and depends on the substrate, size of the

stream, groundwater influences, and other factors. Small streams can equilibrate more quickly (Adams and Sullivan 1990; Caldwell et al. 1991; Sugden et al. 1998; Cristea 2005), especially small streams with alluvial substrate (Johnson 2003, 2004). Equilibration does not mean that these streams attain the same temperature as prior to entering a harvest unit. It means that they reach the temperature they would have been in the absence of such a harvest unit. This will occur as thermal inputs and losses approach a balance.

Buffers are also required around sensitive sites including soil zones permanently saturated from headwall seeps, side-slope seeps, headwater springs that indicate the initiation point of perennial flow of Type Np streams, alluvial fans, or intersection of two or more Type Np streams. If these sensitive sites do not add up to 50 percent of the Type Np stream, then the landowner must buffer additional stream reaches in specified priority areas to ensure at least 50 percent of the Type Np stream length is buffered. In some areas, protection measures for sensitive sites and unstable slope protections will complement Type Np stream RMZ prescriptions and are expected to result in buffers along Type Np streams to range between 50 and 100 percent of their lengths. Given the large degree of variability in the occurrence of sensitive sites and unstable slopes throughout the State, it is difficult to quantify the degree of protection that would result from these features, or the degree of adverse effects.

Within 50 feet of the Type Np streams in eastern Washington the landowner may use either a partial cut or clear-cut management strategy. Once approved, the management strategy implemented will remain in effect until July 1, 2051, regardless of changes in ownership.

For the partial-harvest strategy, the basal-area requirements for a 50-foot RMZ on Type Np streams are the same as those for Type S and F streams and must be met regardless of stream-adjacent parallel roads. This strategy does not provide complete protection of shade. Implementation of the clear-cut strategy requires that the landowner designate a two-sided no-harvest 50-foot buffer along each side of a portion of the stream reach in the harvest unit. The buffer length must be equal to the clear-cut portion of the stream in the harvest unit and must meet the upper end of the basal area requirement of the RMZ inner zone for Type S and F streams in the corresponding timber habitat type. As with the westside Type Np stream strategy, stream temperatures may be increased due to removal of riparian vegetation adjacent to portions of the stream.

The FPHCP assumes that stream temperature increases in these Type Np streams will be attenuated when the water flows through a 300- to 500-foot long, 50-foot wide, no-harvest RMZ at the confluence with Type F streams. However, there is uncertainty as to the actual distance required to achieve that goal, due to variation in the many factors that could affect stream heating. In several studies, cold groundwater, hyporheic exchanges, or tributary inputs have been identified as a factor in daytime cooling in forested reaches downstream of clearings (Brown et al. 1971; Beschta et al. 1987; Story et al. 2003). In other studies, alluvium has been identified as a substantial factor in daytime cooling (Brown 1969; Johnson and Jones 2000; Johnson 2003; and Johnson 2004). An expanded discussion of thermal dynamics involved in stream heating and cooling is contained in the section **General Effects of the Action – Water Temperature (Heat)**.

Although shade does not physically cool a stream down, it can help reduce further heating of the stream and therefore it can maintain the cool temperature associated with groundwater inputs and tributaries. In addition, shade is more effective in controlling the rate of heating in cooler water than in cooling warmer water, and therefore it is more efficient ecologically to use shade to protect cool water from warming than to attempt to cool water that has already been warmed (IMST 2004).

For both the eastside and westside, water that may be warmed as it flows through unbuffered reaches of Type Np streams could affect stream temperatures in fish-bearing streams especially near the confluences of these streams with fish-bearing, headwater streams. Because there would be low to moderate protection of stream shade along Type Np streams, this would likely affect temperature in these Type Np streams. The degree to which temperature increases in Type N streams would affect downstream fish-bearing streams is uncertain and could be influenced by a number of factors, such as distance of harvest unit from fish-bearing streams; previous impacts to the thermal recovery zone including past harvest, debris flows, blowdown, fire, or conversion to other uses; hyporheic and groundwater input; volume of water in both the Type Np streams and the receiving fish-bearing waters; shade provided within harvest unit; and type of substrate.

Water from unbuffered Type Ns streams is likely to adversely affect temperatures in receiving Type Ns, Np, and F streams during the summer months. It is uncertain how shrubs and debris will provide shade to these waters, and therefore, there is a high probability of water temperature increases in Type Ns streams with flowing water in the summer. Where these Type Ns streams flow directly into Type F stream reaches containing spawning and rearing habitat for bull trout, this stream warming will likely result in some sub-lethal effects. Severity of effects will vary based on available habitat and existing baseline habitat conditions

Under the 20-acre exemption rule, minimal buffers are required on streams both with and without fish. Reliance upon the "Shade Rule" along Type F and S streams will not ensure that adverse effects from stream warming are avoided, especially along streams with the potential for channel migration. When 20-acre exempt buffers are required along Type Np streams, they are narrow and subject to a high percentage of harvest and, potentially, windthrow. Many of the trees retained can be deciduous, damaged, and/or small. In fact, only a small portion must be undamaged conifer. The lack of RMZs on both Type Ns streams and certain Type Np streams would produce a high probability of diminished shade and increased water temperatures. These effects could be transferred to downstream fish-bearing waters more easily than the effects on Type Np streams managed under the standard rules because standard rules require additional trees and also require sensitive site protection and a thermal-recovery zone.

Effect of Increases in Stream Temperature on Bull Trout

A well-documented facet of bull trout biology is the species' requirement for cold water (Rieman and McIntyre 1993). Bull trout require a narrow range of cold temperature conditions to reproduce and survive and are regarded as having one of the lowest temperature tolerances among North American salmonids (Selong et al. 2001; Bonneau and Scarnecchia 1996; Goetz 1977).

Species, such as bull trout, that have a narrow thermal "niche" are likely to be affected by even small increases in stream temperatures, particularly summer maximum temperatures (McPhail and Baxter 1996; Dunham et al. 2003). As temperatures increase, the following effects to bull trout may occur: 1) an increased rate of physiological damage, including sub-lethal impacts; 2) changes in the relative abundance of bull trout in relation to other salmonids; 3) reduction in overall abundance; and 4) behavioral adjustments (Saffel and Scarnecchia 1995; Myrick, *in litt.* 2002).

Temperature can influence the abundance and well-being of fish by controlling their metabolic processes. Fish and other aquatic species have optimal metabolic ranges. Increasing stream temperatures result in changes in metabolism because higher temperatures require more energy to sustain increased rates and processes (Johnson and Jones 2000). When stream temperatures are warmed over optimal, the increase in energy required for basic life processes can deplete the energy reserves of individual fish. Conversely, as

food availability decreases, optimal temperature for bull trout decreases (lower temperatures require less energy to sustain metabolic rates and processes) (McMahon et al. 2001). The importance of understanding peak-growth temperature at less than satiation rations is related to evidence that bull trout tend to spawn and rear in headwater streams and that these streams in the Pacific Northwest are characterized by low levels of primary and secondary productivity (Gregory et al. 1987). Throughout the entire stream network of the Pacific Northwest salmon fry, eggs, and decomposing carcasses historically were an important source of food and nutrients in streams. With the recent decline of Pacific salmon, productivity of Northwest streams has been further diminished (Cederholm et al. 2000). See **General Effects – Aquatic Community** for additional discussion**.**

As species experience temperatures outside their physiological optimum range, sub-lethal and indirect effects may occur. For example, the composition of species present in a waterbody can change. These changes in composition can result in sub-lethal effects such as increased competition, predation, and disease, and reduced access to coldwater refugia (McCullough et al. 2001; Ebersole et al. 2001). Brook trout are an exotic species that is more thermally tolerant than bull trout. In a study by McMahon and others (1999), bull trout growth declined significantly when brook trout were present, especially at temperatures greater than 12 degrees C. Hybridization and competition with brook trout has been identified as a threat to bull trout populations and are implicated in reducing abundance within bull trout populations throughout their southern range (Dambacher et al. 1992).

Throughout the southern range of bull trout (e.g., within the coterminous United States), there is a consistent relationship between water temperature and the distribution of small bull trout (Dunham et al. 2003). The probability of occurrence for bull trout does not become high (e.g., >0.75) until the maximum daily temperature declines to between 11 and 12 degrees C. As stream temperatures warm there is less suitable habitat available for bull trout, which can result in populations becoming more fragmented as connectivity is disrupted by temperature increases (Dunham et al. 2003; Myrick, *in litt.* 2002).

The temperature requirements of bull trout vary by life-cycle stage, with the young generally being most sensitive to increases in the temperature of their environment (Buchanan and Gregory 1997; Johnson and Jones 2000), while adults are more sensitive to changes in the amount and distribution of thermal refugia as a result of changes in stream temperatures. Thermal refugia is primarily found at the confluence of small or moderate tributaries with larger, more-productive streams, in deep pools, or in areas of hyporheic or groundwater upwelling.

Spawning areas are often associated with cold-water springs, groundwater-infiltration sites, and streams with the coldest summer temperatures (Pratt 1992; Rieman and McIntyre 1993; Rieman et al. 1997; Baxter and Hauer 2000). It is well-documented that spawning is initiated as temperatures drop to 9 degrees C or lower, and increases in temperature during that period can interrupt or postpone spawning activity (Ratliffe and Howell 1992; Sexauer and James 1993; Brenkman 1998; Kraemer 1994). In areas where streams freeze in winter, spawning in groundwater-infiltration areas may actually ensure that the incubating eggs in the gravel remain in relatively constant cold water with little diel fluctuation and are not affected by anchor ice. Survival of bull trout eggs incubated at 2, 4, 6, 8, and 10 degrees C varies and is highest at 2 and 4 degrees C with mortality sharply increasing above 6 degrees C (McPhail and Murray 1979).

Juvenile bull trout survival, growth, and distribution are strongly influenced by water temperature. Numerous studies indicate that juvenile bull trout are associated with cold water and this relationship is most likely a very critical one (McPhail and Baxter 1996). Juvenile fish move far less than sub-adult or

adult fish and tend to reside in the same stream segments or local stream networks for several years. Because juvenile bull trout tend to reside in the same area for a number of years, usually in headwater streams, increases in temperature could decrease the amount of thermally suitable habitat within their limited home range (McPhail and Baxter 1996; Rieman and Chandler 1999). Juvenile bull trout are rarely found at temperatures exceeding 15 degrees C (Rieman and McIntyre 1993; Buchanan and Gregory 1997). In their study, Saffel and Scarnecchia (1995) suggest that high water temperatures may be physically constraining to bull trout. This is supported by the findings of McPhail and Murray (1979) where bull trout fry grew larger and had better survival at low water temperatures (4 degrees C).

Although currently there is little information on temperature requirements of sub-adult and adult bull trout, adult fish are generally physiologically less tolerant of elevated temperatures than smaller fish of the same species (Myrick et al. 2002). As bull trout mature, they move to larger rivers, lakes, or marine waters in order to exploit the availability of larger prey items. Although temperatures in these habitats may be elevated during periods of low flow or during the warmest months, these fish are able to exploit the spatial variation of temperatures within a stream and can behaviorally thermoregulate by periodically moving to more-suitable, cooler thermal environments. For example, when water temperatures in the Blackfoot River were unfavorably warm during the summer, non-spawning migratory bull trout used confluences with cold water tributaries, which provided thermal refugia (Swanberg 1997). The purpose of the migrations to these confluence areas was unlikely to be feeding because prey fish densities in tributaries were lower than in the Blackfoot River. When the Blackfoot River cooled, these migrating fish returned to the Blackfoot River. In this case, the larger migratory bull trout were only able to use some habitats (i.e., the Blackfoot River) seasonally. Loss of coldwater habitat can reduce spatial variation within a stream. This loss of spatial variation can reduce the ability of bull trout and other salmonids to escape high temperatures or avoid other detrimental physiological and ecological conditions (Poole et al. 2001). This reliance upon access to patches of cooler stream temperature tends to make migratory bull trout sensitive to changes in the amount and distribution of thermal refugia.

Conclusion

In conclusion, the no-harvest portions of RMZs, the shade rule, and the bull trout overlay will provide a higher level of protection than previous forest practice rules, because shade will be increased in areas where these RMZ practices are applied. However, potential increases in water temperature along unbuffered Type Np and Ns streams might increase the water temperature on some Type S and F streams. Over the permit term, as riparian vegetation in previously or recently harvested areas in the core zone matures and portions of the inner zone are retained after harvest, improvements (further decreases) in the temperature regimes of fish-bearing streams are anticipated.

When reaches of a channel have become exposed to clear-cut harvest, they may warm, in some cases substantially. Temperature increases from harvests along small streams without fish may, in some cases, be transferred downstream to occupied fish habitat. Not all harvests will occur immediately above the sensitive site at the confluence of Type Np and F streams; some harvests will be located further upstream. Across the large FPHCP Action Area, it is likely that some Type Np streams will have the ability to route the additional heat energy to downstream waters. In some cases, the sensitive site at the confluence of Type Np and F streams may be degraded from past harvests, windthrow, fire, debris flows, or forest conversion to other land uses. Additionally, there may be some streams where the extent of fish use is underestimated and fish occur within or closer to harvest units. There is also significant variation in the characteristics of small streams; and the temperatures of some streams will adjust more rapidly than others.

Harvest on 20-acre exempt parcels adjacent to streams can increase the temperature regime in downstream reaches. Typically, 20-acre exempt parcels are located in the rural-urban interface on lower-elevation land. Because bull trout on the westside spawn in fairly low elevation streams (500 foot elevation or greater) some 20-acre exempt parcels may occur adjacent to or above spawning and rearing reaches. Where a number of 20-acre exempt harvests occur adjacent to or upstream of spawning and rearing habitat, especially where they occur within 300 to 500 feet of occupied streams, there is a high likelihood of additional stream warming. This stream warming could interfere with spawning, incubation, rearing, and feeding by young fish. These disruptions would have the potential to reduce the reproduction and survival of individual bull trout. Where 20-acre exempt parcels occur adjacent to foraging, migrating, and overwintering habitat in lower elevation mainstem rivers, these larger rivers are unlikely to be as affected by changes in shade as the smaller streams are. Where the 20-acre parcels are located on Type Np streams that flow directly into foraging, migration, and overwintering habitat, especially where they occur within 300 to 500 feet of occupied streams, the reduction in riparian canopy and associated stream warming may reduce the effectiveness of coldwater refugia within the occupied habitats. Disruption of cold water refugia may interfere with resting, foraging, and other essential functions.

The effects of these temperature increases from the FPHCP would be difficult to measure or quantify, but could be especially important in bull trout watersheds with a high degree of past harvest, where elevated stream temperatures already exist, or where there are a high proportion of Type Np and Ns streams occurring directly above spawning and rearing habitat or adjacent to 20-acre exempt parcels. These temperature increases are expected to be localized in nature and their effects to bull trout are expected to be mainly limited to headwater portions of occupied streams and areas providing coldwater refugia. These adverse effects to the habitat will range from short-term impairment to long-term temperature changes. However, long-term temperature changes are likely to be infrequent and to be associated with changes in channel morphology and hydrology, rather than associated with reduced shade.

Temperature increases from activities covered under the FPHCP are expected to have direct and indirect adverse effects to bull trout ranging from mortality to sub-lethal effects. In cases where temperature increases resulting from forest practices along Type Np streams or adjacent 20-acre exempt parcels can result in increase in the temperature downstream, and these increases are within a local population area where spawning and early rearing occurs, there is a risk that these temperature increases will adversely affect spawning, incubation, and early rearing. Life stages affected by these temperature increases are eggs, juveniles, and spawning adults. Where temperature increases occur in spawning habitats, reduced incubation success could occur (i.e., eggs or embryos killed). If increases in temperature on Type Np streams or adjacent 20-acre exempt parcels occur, and the temperature increases affect the downstream foraging, migration, and overwintering areas, there is the potential to alter the effectiveness of thermal refugia. The life stages most likely affected by this alteration are adult and sub-adult. Temperature increases would likely reduce the reproduction, feeding, and sheltering of individuals in some cases, but would be most severe when it occurs in bull trout spawning and rearing streams that exceed optimal temperature requirements for bull trout.

Increased stream temperature or alterations in cold-water refugia could also reduce the ability of some streams or stream reaches to support bull trout prey species, but would more likely reduce bull trout access to those prey species. Reducing the bull trout's ability and success at accessing forage in these streams could significantly affect the growth and survival of adult and sub-adult bull trout. Increased temperatures may result in a competitive advantage for certain non-native species, which could reduce

reproduction, feeding, and sheltering of individual fish in some stream reaches across FPHCP covered lands.

8.6.3.3 Sediment

FPHCP activities that are expected to generate sediment that could directly and indirectly affect bull trout can be grouped into one of the following two categories: 1) riparian timber harvest and 2) road system management (consisting of construction, reconstruction, relocation, realignment, culvert replacement, maintenance, abandonment, and similar activities).

Riparian Buffers and Stream Bank Stability

Timber harvest, if conducted in close proximity to the streambank can cause the stream bank to fail. Riparian vegetation aids in maintaining stream channel dimensions and bank stability, and affects where erosion and sedimentation of channels and floodplains occurs (IMST 2004). The loss of riparian vegetation along portions of Type Np and Ns streams can lead to the instability and eventual failure of the streambank, thereby delivering sediment to the stream channel. Sediment from streambank erosion is more likely to originate from the unbuffered portions of Type Np streams and the unbuffered Type Ns streams than buffered sections. Although these stream segments have a 30-foot equipment-limitation zone and harvest activities must avoid disturbing stumps, root systems, and any logs embedded in the stream bank, as well as brush and similar understory vegetation, where no riparian buffers are required, harvest can occur up to the edge of the stream. As a result, some habitat impairment within the unbuffered stream segments from sedimentation is expected to occur. In addition, the routing of sediment through streams without fish into fish-bearing waters may also occur, circumventing the effectiveness of riparian buffers on other typed waters (Rashin et al. 1999). Sediment from Type N streams could, in some cases, lead to aggradation and resultant channel widening in Type F streams that are immediately downstream. However, this would ultimately depend on how chronic and abundant the Type N stream sediment sources are that flow into a particular Type F stream.

Riparian prescriptions on Type S and F streams are anticipated to be adequate to prevent excessive (above natural levels) amounts of streambank erosion that could increase the amount of sediment delivery downstream. Downstream delivery of very large amounts of sediment could lead to substantial habitat modification sufficient to increase water temperatures. However, given the riparian prescriptions on Type S and F streams, delivery of that magnitude would require road failures or mass wasting. Riparian buffer widths in the FPHCP vary dependent on site class, size of the stream, whether the stream is fish-bearing or not, and where the stream is located (east or west of the cascade crest). For fish-bearing streams, the FPHCP also divides the riparian buffer into three distinct zones, the core, inner, and outer zones. Riparian management zones are measured from the edge of the bankfull width or the channel migration zone. The degree of riparian influence on the aquatic environment decreases with increasing distances from the stream (FEMAT 1993). Trees closer to the water generally provide greater direct ecological benefits to streams than those further away. Trees in the 50-foot (westside) and the 30-foot (eastside), no-harvest core zone of Type S and F streams and along the buffered portions of Type Np streams are intended to provide the majority of stability to stream banks. According to FEMAT (1993), trees within one-third of a tree height from the channel provide the rooting strength important for maintaining the integrity of the streambank. In most instances, all buffered portions of typed waters meet or exceed this criterion.

Riparian Timber Harvest

Timber harvest and associated activities can be a significant source of sediment if improperly conducted. Rashin et al. (1999) identified several timber harvest activities permitted by the State of Washington's forest practices rules in affect between 1992 and 1995 that contributed significant amounts of sediment to adjacent streams. The study evaluated those selected timber harvest activities to determine their effectiveness at achieving state water-quality standards pertaining to sediment. In summary, the study found that streamside buffers were generally effective at preventing sediment delivery and direct physical disturbance to the stream. Ground-based harvest and cable yarding in the vicinity of streams without buffers was generally found to be ineffective or only partially effective at preventing sediment-related water-quality effects.

The FPHCP has benefited from the study conducted by Rashin et al. (1999) and includes protective measures that regulate the methods of harvest in and near harvest units adjacent to water bodies. The measures include limitations on felling and bucking of timber, use of ground-based equipment, yarding, cable yarding, clearing of slash and debris, and site preparation. These measures are designed to minimize soil disturbance and compaction, reduce the potential for erosion, and minimize the amount of sediments reaching typed waters and wetlands where it could be harmful to bull trout and bull trout habitat. Generally, the amount of sediment generated from timber harvest activities is related to the amount of bare and compacted soils exposed to rainfall and runoff. Measures in the FPHCP that regulate aforementioned timber harvest practices are designed to minimize the amount of exposed and compacted soils close to the stream channel.

Felling and bucking

Limited felling and bucking as described in General Effects section are usually not expected to occur within riparian buffers of fish-bearing streams, and as such, the need for equipment to penetrate these areas will be very limited. Trees that need to be felled within the core zone must be left on the ground, and under most harvest scenarios, only a few trees are expected to be removed from the inner zone. However, in some cases, up to 70 percent of inner zone trees may be removed, so long as retention meets or exceeds stand-level guidelines. Felling and bucking within the outer zone and landward of riparian buffers should result in minimal effects due to the use of directional felling and the distance this activity will occur from typed water bodies. The required directional feeling away from the stream is not expected to contribute much if any sediment to the stream. Sediment generated from felling and bucking adjacent to buffered portions of Type Np streams, although in closer proximity to the stream channel, is also expected to be minor. Felling and bucking along unbuffered portions of Type Np streams and Type Ns streams is likely to result in the delivery of minor amounts of sediment to non-fish-bearing waters. In these situations harvest can occur up to the streambank, although rules prevent activities that would disturb stumps, root systems, logs embedded in the bank, and understory vegetation. A 30-foot ELZ is required along Type Np and Ns streams.

Ground-based Equipment Use

Modest amounts of sediment may be mobilized during yarding by ground-based and cable equipment. Rutting and soil compaction from skidding of logs within riparian zones may result in increased run-off and erosion rates, and thus may result in modest amounts of sediment being delivered to fish-bearing streams. Buffers on fish-bearing streams are expected to be adequate to intercept almost all sediment originating from timber harvest activities on timber harvest units. Where yarding is permitted across streams or equipment enters the 30-foot ELZ, delivery of sediment becomes more problematic. Rashin et

al. (1999) in evaluating timber harvest best management practices in place during the summers of 1992 to 1995 in Washington, found that, based on the extent of exposed soil associated with erosion features that delivered sediment to streams, the main causes of erosion at harvest sites were skid trails and other yarding activities.

Cable Yarding

According to Rashin et al. (1999), cable yarding, although a less-frequently used yarding technique, actually produces more relative amounts of erosion than ground-based yarding. This may be due to the steeper terrain in which cable yarding is used. Erosion features at cable-yarding sites had a higher frequency of delivery to streams. Under previous forest practices rules, cable yarding without buffers resulted in sediment routing to the stream. Substantial disturbance of stream channels, valley walls, and steep inner gorge areas by cable yarding practices were observed resulting in chronic sediment delivery and extensive fine-sediment deposition on streambeds.

Under the FPHCP, limitations on cable yarding in and across typed waters and wetlands are intended to minimize soil disturbance and effects to their beds and banks. Cable yarding in or across Type S and F streams is not allowed, except where logs will not materially damage the stream bed, banks, sensitive sites, or the riparian management zones. If permitted, yarding is limited to cable or other aerial logging methods that suspend or partially suspend the logs above the riparian zones. Yarding in or above Type F and S streams also requires a HPA from WDFW that may carry additional restrictions to protect fish and fish habitat, such as limited corridors, specific placement of corridors, bank protection, and large wood placement. Such an HPA would also consider potential soil damage to slopes outside the RMZ that would have potential to deliver sediment. Cable yarding in or across Type A and B wetlands is not allowed without written approval from WDNR and a HPA from WDFW, if required.

When it is necessary to create yarding corridors through the RMZ of Type S or F waters, the corridors must be no wider than or more numerous than necessary to accommodate safe and efficient transport of logs. Generally, this means that yarding corridors should be located at least 150 feet apart and should be no wider than 30 feet. Total openings resulting from yarding corridors must not exceed 20 percent of the stream length associated with the forest practices application. Where logs are yarded from or across RMZs, WMZs, and sensitive sites, reasonable care must be taken to minimize damage to vegetation that provides shade and to understory vegetation, stumps, and root systems. When practical and safe, logs must be yarded uphill, in the direction in which they lay, and away from RMZs, WMZs, and sensitive sites. Where downhill yarding is necessary, reasonable care must be taken to lift the leading end of the log to minimize downhill movement of slash and soils. When yarding is parallel to Type S or F waters, below the 100-year flood level, or within the RMZ, reasonable care must be taken to minimize soil disturbance and to prevent logs from rolling into the water or RMZ. Limiting the use, location, widths, and frequency of yarding corridors is intended to minimize the amount of sediment delivered to typed waters.

Site Preparation

Unbuffered areas may be subject to even-aged harvesting (clear cutting). Uneven-aged harvest techniques utilized within and adjacent to some buffers may also require some site preparation and slash disposal or management before replanting. Various forms of site preparation are conducted to control competing vegetation, reduce fuel levels, and ensure seedling establishment and survival.

No site preparation will occur in the core zone. We expect that only minor site preparation will occur within the inner zone, because many areas will be retained with stocking levels that are not conducive to under-planting and would not provide access for mechanized equipment. What site preparation would occur would likely occur outside the core and inner zone approximately 80 to 100 feet from the stream.

Where scarification does occur, minor amounts of soil compaction and rutting may occur as a result of use of heavy equipment to scarify planting sites. Understory disturbance and disturbance of duff and debris layer would be expected as a direct result of scarification. Small amounts of sediment could be generated as a result of site preparation especially along unbuffered reaches of perennial and seasonal non-fish-bearing streams.

Clearing of Slash and Debris

Large accumulations of slash may contribute to the initiation or exacerbation of mass wasting events (e.g., debris slides and debris torrents), however, these events are expect to be rare occurrences under forest practices rules and FPHCP. Forest practices rules prohibit the machine piling of slash and debris within the 30-foot ELZ of unbuffered stream banks. In addition, limbing and bucking (activities that usually generate slash) are prohibited within the bankfull channel of Type S, F, Np streams, in RMZ core zones, sensitive sites, or open water areas of Type A wetlands. Where slash and debris is expected to plug culverts on Type Np and Ns streams, it must be cleared from the channel for a distance of 50 feet upstream.

There are some benefits to retaining slash and debris. Small woody debris provides cover for juvenile fish (bull trout and bull trout prey species) and may trap leaf litter and other detritus important to aquatic insects. Slash and debris left on flood plains also traps leaf litter and detritus, which subsequently decomposes and enriches the soil. Accumulations of small woody debris and slash may also help moderate fine sediment transport from the forest floor to downstream habitats. To prevent the removal of beneficial woody debris, forest practices rules limit the type and amount of material that can be removed. HPAs are required to remove harvest related slash or debris from Type S and F streams; and, depending on the circumstances, HPAs may be required for slash removal from Type Np and Ns streams. Material removed upstream of culverts to prevent culverts from plugging must be immediately placed downstream or as otherwise required by an HPA. Slash and debris that are excluded from removal include logs that are embedded along their length or at least substantially at one end, and slash buried under stable deposits of soil, rocks, and woody debris. Forest practices rules also prevent the limbing, notching, or removal of logs and trees that are to be left in the stream channel or ones that are firmly embedded.

In most instances, clearing slash and debris will not generate sediment. RMZs are expected to prevent sediment from entering typed waters and prevent the operation of equipment immediately adjacent to typed waters. The 30-foot ELZ under FPHCP does not exclude equipment from operating with in this area, but only limits the amount of soil disturbance to no more than 10 percent of the area. Some soil disturbance, therefore sediment, can be expected when equipment operates along unbuffered Type Np streams and Type Ns streams. Where slash is not required to be removed upstream of culverts (unbuffered portions of Type Np streams and Type Ns streams), culverts could become plugged with debris resulting in culvert failure. Under these circumstances, significant amounts of sediment could be delivered to Type Np and Ns streams. A portion of those sediments may eventually be routed to fish-bearing waters. Requiring that all culverts be capable of accommodating the 100-year flood flow should allow for the transport of most small wood, debris, and slash resulting in fewer culvert failures.

Log Placement

While large wood placement in streams is generally done to benefit the aquatic system as well as the fish species which depend upon those habitats, such actions may have localized adverse effects to bull trout and bull trout habitat. Occasionally, riparian restoration in the form of placement of large woody debris will be proposed as part of an FPA. Placement of large wood requires approval from the WDNR to work in the core zone and an HPA from WDFW to work within the wetted portion of the stream. Board Manual section 26 contains guidelines including limiting log placement to fish-bearing streams, minimum length and width criteria, and specifications for solid wood. Root wads must be placed entirely within the bankfull width. Log jams are encouraged, but are limited regarding their spacing and the number of pieces per jam. HPAs are required for all in-channel placements and may result in additional restrictions and guidelines. For instance, public-safety issues such as downstream bridge or culvert crossings that could reasonably be assumed to be endangered by stream-borne logs may necessitate anchoring of placed wood. Where unavoidable, anchoring is generally accomplished either by placing large boulders on top of the log, burying one end of the log in the bank (sometimes in conjunction with boulder placement), or cabling the log to an anchor (such as a boulder, buried ecology block, screw anchor, or driven anchor bar).

Placement would generally be accomplished in one of two ways: (1) Equipment would be used to place the bole with attached root wad into the stream; and/or (2) the bole would be adequately secured to the bank or bed. Placement of a bole without an attached root-wad will generally require (through HPA restrictions) other methods to secure the piece within the stream as described above. Work using heavy equipment may take 1 or more days and may result in some soil exposure. It is only expected that such placement activities would occur once per rotation, and most likely only once. Power tools and heavy equipment would be used in log placement. Ground disturbance must be less than 5 percent of the reach within the harvest unit. Crawler tractors and rubber-tired skidders are discouraged.

While placement of wood with attached root-wad will provide better stability of large wood, it will also increase the probability of sediment delivery and may generate a short-term sediment pulse or turbidity. Placement of a bole without an attached root-wad will generally require other methods to secure the piece within the stream, is less desirable from a stream-dynamics standpoint, but may result in less short-term sediment delivery.

Within the stream, the substrate may be disrupted by movement and positioning of logs. Following placement, large wood may not remain in place and may migrate downstream, having positive and/or negative effects lower down in the stream system. This potential for movement is especially true for large wood placed without attached root wad, and may be true even if secured in other ways. Large wood that remains in place is expected to alter the dynamics between predatory and prey fish, increase the amount of local sediment deposition and result in a temporary storage of that sediment, and act as a host site for aquatic invertebrates.

Effects regarding sediment from log placement are expected to occur to foraging, migrating, incubating, or rearing bull trout and their habitat, and to the forage species supporting these life stages. The effects are anticipated to be short-term and occur mostly during and immediately following log placement, with some additional effects becoming manifest with the first rains following placement.

Summary of Riparian Timber Harvest

In summary, activities associated with riparian timber harvest under the FPHCP have the potential to generate sediment that could enter fish-bearing streams directly or when routed through streams without fish. Sediment generated during timber harvest can generally be prevented from entering typed waters when riparian buffers of adequate widths are used. Based on observations of erosion and sediment routing from several different harvest practices (including skid trails) over a range of topographic conditions in both eastern and western Washington, Rashin et al. (1999) suggested that a 10–meter equipment-exclusion zone for ground-disturbance activities would prevent sediment delivery to streams from about 95 percent of harvest-related erosion features. Gomi et al. (2005) found that streams with buffers ranging from 10 to 30 meters wide had relatively small increases in sediment yield from physical disturbances (i.e., tractor yarding).

The 30- to 50-foot, no-harvest core zone along fish-bearing waters is expected to be adequate to prevent sediment from entering typed waters and prevent soil compaction adjacent to typed waters (CH2MHill 2000). Similarly, 50-foot buffers when required along Type Np streams should also be adequate to filter sediment from riparian timber harvest activities and prevent soil compaction within 50 feet of the stream. Only a 30-foot ELZ is require along unbuffered reaches of Type Np and Ns streams. The 30-foot foot ELZ in the FPHCP does not exclude equipment from operating within this area, but only limits the amount of soil disturbance that can occur without mitigation to no more than 10 percent of the harvest area adjacent to unbuffered Type Np and Ns streams. Washington Forest Practices Rules do prevent activities that would disturb stumps, root systems, logs embedded in the bank, and understory vegetation. Some soil disturbance can be expected when equipment is operated along unbuffered Type Np streams and Type Ns streams; therefore, some level of sediment would also be generated, especially in circumstances where less than 10 percent soil disturbance occurs and goes unmitigated. If the 10 percent criteria is exceeded, erosion-control mitigation measures are required, and we anticipate that they will attempt to address the total amount of ground disturbance.

Where sediment generated immediately upstream enters Type F streams containing bull trout, we anticipate a range of sub-lethal to lethal adverse effects to individual bull trout depending on life stage using the area and baseline habitat conditions.

Road System Management

Roads

Logging roads are particularly important factors affecting surface erosion and subsequent stream sedimentation. Surface drainage concentrated within roadside ditches, that is not dissipated or redirected to reduce its effects can lead to erosive cuts (resulting in soil erosion and stream sedimentation) and concentrated water flow onto slopes that may exceed a slope's capacity to hold the weight (resulting in mass soil movements or landslides). Surface erosion on gravel roads also can lead to high levels of suspended sediment moved into streams. Inadequate road designs, such as inappropriate placement of backfill, undersized culverts, and other factors, can lead to mass-wasting events such as land slides or debris torrents. During periods of heavy rainfall, roads and ditches can become temporary stream systems, speeding water runoff into streams and reducing water absorption into forest soils.

Roads modify natural drainage networks and accelerate erosion processes. These changes can alter physical processes in streams, leading to changes in stream flow regimes, sediment transport and storage, channel bank and bed configurations, substrate composition, and stability of slopes adjacent to streams.

These changes can have important biological consequences, and they can affect all stream-ecosystem components (Furniss et al. 1991). Road construction can also causes the stream-channel network to increase, because the roads act as tributaries, creating a more efficient sediment delivery system (Castro and Reckendorf 1995). McCashion and Rice (1983) found that logging roads were responsible for 61 percent of the soil volume displaced by erosion in northwestern California. Forest roads are considered the most-detrimental forest-management operation to forest soil and water quality, perhaps accounting for 90% of sediment yield for forest lands (Megahan 1972b, 1974).

Severe erosion is almost inevitable if roads are not properly constructed and regularly maintained. Road construction and maintenance associated with timber harvest typically increases the amount of sediment delivered to streams through surface erosion, as compared to natural delivery rates. Roads can rarely be constructed that do not have adverse effects to streams (Furniss et al. 1991). Roads constructed within riparian areas and parallel to streams typically have pronounced adverse effects to aquatic systems, compared to roads built in other locations. In particular, stream crossings pose the greatest risk to fish habitats of any road feature. When culverts are plugged by debris or overtopped by high flows, road damage, channel realignment, and severe sedimentation can occur (Furniss et al. 1991). Failure to properly maintain road drainage can also result in large sediment inputs to streams (Furniss et al. 1991). "Roads, which are the major source of management-related sedimentation in streams associated with logging regionally, continue to have adverse effects to stream communities even when not actively utilized"; they continue to contribute high sediment loads until they are stabilized and/or abandoned (Cederholm and Reid 1987).

Existing and future roads are expected to be the single greatest source of sediment input from covered lands. Upgrading the existing road network, constructing new roads to higher standards, and abandoning old roads are not expected to completely eliminate the road network as a significant source of sediment in the near-term or long-term, but implementation of these measures should result in substantial reductions in sedimentation. A selection of watershed analyses from Washington State indicate that 70 to 85 percent of the road mileage does not contribute sediment to streams (Anderson 1996; McGreer 1997; Toth 1998). A similar study of State and private lands in western Oregon indicated that 61 to 71 percent of roads did not directly contribute sediment to streams (ODF 1996). The results of these studies show that roughly only 15 to 40 percent of the roads in a basin deliver sediment to streams. Developing and implementing RMAPs to address roads, especially those that contribute sediment to streams, will reduce the amount of sediment being delivered to streams.

CH2MHill (2000) modeled sediment production and delivery from three surface-erosion assessments conducted before and 5 years after developing and implementing road maintenance and abandonment plans. Results show that sediment delivery in the Chehalis, Stillman, and Taneum watersheds was reduced by 48, 34, and 44 percent, respectively, within 5 years after applying newly adopted road standards. Although each watershed is unique and road maintenance and abandonment plans varied, the results provide a reasonable indication of the expected benefits from implementing such road plans.

Regular road use can cause chronic sediment inputs to streams. Heavily used roads caused up to 130 times more sediment production that abandoned roads (Ried and Dunn 1984), and even unused roads can cause some sediment delivery. Reid and Dunne (1984) found that gravel forest roads generated up to 300 tons of sediment/mile/year from surface erosion in the Olympic Mountains of Washington. They also found sediment loss was found to be related to traffic intensity and was highest on heavy-use gravel roads compared to unused roads or paved roads. Sediment yield from cutbanks and ditches alongside paved roads was less than 1 percent of that from gravel roads in their study. Heavily used roads were calculated

to produce up to 300 tons of sediment/mile/year over the period of study, compared to lightly used roads with 2.6 tons/mile/year and paved roads with 1.4 tons/mile/year. Therefore, it can be concluded that steps to manage traffic volume can substantially reduce sediment generation and subsequent delivery.

Roads generally accelerate soil-erosion rates due to surface erosion and mass soil movement such as slumps and earth flows, debris avalanches, debris flows, and debris torrents. High rates of stream sedimentation result from this increased erosion. Furniss et al. (1991) found soil erosion rates were 30 to 300 times higher on forests with roads than undisturbed forest. Roads can also alter stream flow rates and volumes, which along with increased sedimentation, resulted in altered stream channel geometry (Furniss et al. 1991). Acting as new flow paths for water, roads increased the channel network over watersheds, increasing the drainage density. By increasing the frequency, magnitude, and altering the composition of debris flows, road-caused erosion and delivery can affect the long-term potential for developing complex channel morphology and aquatic habitat (Jones et al. 2000).

Road abandonment adjacent to streams can also result in adverse effects to bull trout and their habitat through sedimentation of spawning and rearing habitat, degraded water quality (turbidity/contaminants), and direct injury to fish from heavy equipment used for instream work (e.g., culvert removal). Adverse habitat effects associated with these activities are generally short-term (i.e., periodic sediment inputs for up to 12 to 18 months, before vegetation becomes established on disturbed sites). Road abandonment or full decommissioning if properly done, however, will ultimately reduce the potential for excess sediment delivery to streams from roads and would eliminate further impacts of road use. On that basis, road abandonment or full decommissioning is generally considered to have long-term beneficial effects to bull trout habitat. Road abandonment is one option for addressing road-related sediment impacts. Road abandonment is not required by FPHCP. Although, it is likely that when it is used, road abandonment will address roads within the riparian zone of typed waters that are chronic sources of sediment. These roads are more likely to deliver sediment to streams and would be the roads that are more difficult to address using road maintenance BMPs. It should also be noted that the FPHCP and associated Permit will allow abandonment to occur in situations where avoidance of take might have precluded abandonment activities.

The condition of roads on FPHCP covered lands is a concern when public resources, including bull trout and bull trout habitat, are affected. Forest roads have been identified as a major source of sediments being delivered to streams and wetlands in Washington's forests (WDNR 2005). The draft Bull Trout Recovery Plans for both the Coastal-Puget Sound and Columbia River population segments cite existing logging roads as a significant source of sediment that has contributed to declining bull trout populations and the loss or degradation of suitable bull trout habitat in most of the core areas throughout Washington (USFWS 2002).

Implementation of the FPHCP is expected to substantially reduce road-related erosion and sediment delivery from current and future roads relative to current levels of sediment delivery, both in the near-term (< 10 years) and over the long-term (10-50 years). Near-term reductions from existing sources are expected to result largely from implementation of RMAPs on large forest landowner lands. All roads owned and managed by large forest landowners must be improved to meet forest practices standards by the end of 2016. These standards require that roads be disconnected from the stream network through the installation of drainage structures, that road fills susceptible to mass wasting be removed, and that stream-adjacent parallel roads be repaired and maintained, or abandoned. Sediment reductions from small forest landowner lands will occur at a different rate. Therefore, sediment reductions accrued from small landowner lands will likely be distributed over a longer timeframe.

In cases where roads on small forest landowners' lands, or on 20-acre exempt parcels, are causing or have the potential to cause damage to public resources, WDNR can, at any time, require the landowner to take corrective actions to minimize and mitigate the effects. We expect WDNR will be using this authority to significantly reduce the period of time that ongoing, chronic effects remain uncorrected. Approximately 40 percent of covered lands are owned by small forest landsowners. Timberlands owned and managed by many of the small forest landowners (including those who meet the 20-acre exception) are less likely to be adjacent to the headwater streams that support much of the known bull trout spawning and rearing habitat. Large forest landowners are more likely to own and manage timber lands in areas where bull trout spawn and rear.

Under the FPHCP, a series of Best Management Practices (BMPs) (Washington Forest Practices Board 2002) are intended to guide the forest landowner in meeting road-related construction and maintenance obligations via the implementation of the Washington Forest Practices Rules. The primary focus of the BMPs is to protect water quality; to protect aquatic, wildlife, and riparian resources; and to help prevent potential and actual road-related resource damage. To ensure that resources are being adequately protected, landowners are required to apply the appropriate road-related BMPs necessary to address water and sediment delivery, fish passage, sub-surface flow, and natural drainage characteristics when constructing, reconstructing, and/or maintaining roads on their ownerships. BMPs have been specifically developed for road location and design; road construction and reconstruction; compacting and stabilizing embankment and waste materials; landing location and construction; road use; general road maintenance; and road abandonment. Although these BMPs will significantly reduce and minimize impacts to bull trout and their habitat, they will not avoid or eliminate all impacts. For a complete description of road-related construction activities refer to section on **Description of Activities that are Effects of the Permit -- Road Management,** or refer to Title 222WAC or the Forest Practices Board Manual.

The premise behind the road construction and maintenance program in the forest practices rules and the FPHCP is that a well-designed, located, constructed, and maintained system of forest roads is essential to forest management as well as the protection of public resources. To protect public resources such as fish habitat and water quality, roads must be constructed and maintained in a manner that will prevent potential and actual damage. This will be accomplished by constructing and maintaining roads so as not to result in the delivery of sediment and surface water to any typed water in amounts, at times, or by means that preclude achieving desired fish habitat and water quality goals. These goals are to be achieved through the following objectives: 1) providing for fish passage at all life stages; 2) preventing mass wasting; 3) limiting delivery of sediment and surface runoff to all typed waters; 4) avoiding capture and redirection of surface or ground waters; 5) diverting most road runoff to the forest floor; 6) providing for the passage of some woody debris; 7) protecting streambank stability; 8) minimizing the construction of new roads; and 9) abandoning old roads.

Although, the FPHCP is expected to substantially reduce road-related sediment inputs over the near term (10 years) and the long-term (10-50 years), the overall effect may be difficult to quantify in individual watersheds. The effects of decreasing the amount of sediment being delivered to typed waters via improving the existing road network, constructing new roads to higher standards, and abandoning unnecessary roads may not be readily apparent in watersheds where streams have already been substantially degraded by historic road management. In other, less degraded watersheds, these same actions are expected to lead to the recovery of aquatic habitat from the effects of historic road management more quickly.

In summary, the FPHCP area currently has over 60,000 miles of mapped roads, which yields an average road density of 4.1 miles per square miles on FPHCP covered lands. According to our GIS analysis, about 9 percent of these roads occur within a distance equal to a 100-year site-index tree height (averaged for Site Classes 2 and 3) of Type S, F, or Np streams. In addition, there are over 130,000 road-stream crossings in the FPHCP, including over 18,000 crossings on fish-bearing streams. Of these 18,000 road crossings, approximately 570 cross known bull trout spawning and rearing habitat (190) or bull trout FMO habitat (380). An additional ten crossings are unknown. Stream-adjacent parallel roads (those roads within a 100-year site-index tree height) and stream crossings are the two features on FPHCP covered lands that are most likely to deliver sediment to streams. Where sediment generated at these locations enters Type F streams containing bull trout, we anticipate a range of sub-lethal to lethal adverse effects to individual bull trout depending on life stage using the area and baseline habitat conditions.

The implementation of RMAP's on large forest landowners' lands through 2004 has resulted in 1,217 structures being removed or replaced and 705 miles of fish habitat being opened to fish passage. During the same time period, 40 passage barriers on small forest landowner parcels have been replaced under the Family Forest Fish Passage Program opening up 60 miles of fish habitat (Washington Forest Protection Association 2005). Short-term sediment releases will likely be associated with the replacement of road-crossing structures. These sediment releases could have short-term adverse effects to aquatic organisms including bull trout (if located in bull trout habitat), but new structures properly sized and correctly installed and maintained are expected to help minimize sediment delivery to streams over the term of the FPHCP and open up new stream habitat. Short-term adverse effects from sediment to bull trout will be reduced due to timing restrictions for construction and fish relocation efforts prior to replacement.

Road-generated sediment could adversely affect eggs and alevins in the gravel. The effects of suspended sediment deposited in a redd may include reduction in water flow, smothering of eggs or alevins, and/or impeding fry emergence. Additional effects may occur to foraging, migrating, and rearing bull trout and their habitat, and to the forage species supporting these life stages. Reducing the amount of sediment being delivered via the road network will minimize these adverse effects and lead to improved habitat condition over time.

Stream Crossings

Fish-passage barriers located at culverted crossings are typically created by one or a combination of several conditions. Improperly designed or placed culverts do not have the roughness and natural variability of stream channels and therefore do not dissipate energy as readily. In many instances high water velocities amplified by undersized culverts have created large scour pools at the culvert discharge point, altering the stream elevation below the natural gradient (i.e., downcutting). Over time, culverts become elevated or perched above the stream and create a physical barrier to fish passage. In other cases, water also drains under and around culverts, and migrating fish attempting to follow these flow paths can become stranded or impinged against the culvert or road fill.

In addition to allowing for fish passage for all age classes of bull trout, the replacement or removal of fish-blocking culverts should result in more-naturally maintained stream hydraulics, including bedload movement, sediment transport, and passage of moderately-sized woody debris, leading to more-natural stream dynamics and stream geometry. The overall impact of this requirement of the FPHCP on bull trout and bull trout habitat is expected to be beneficial because it will restore spatial and temporal connectivity of waterways within and between watersheds where movement of fish and habitat elements are currently obstructed. This will allow bull trout to access areas critical for fulfilling their life-history

requirements, especially foraging, migration, spawning, and rearing, and help restore natural habitat-forming processes.

Although the overall effect of restoring fish passage and more of the natural stream dynamics to stream systems statewide is beneficial, the on-the-ground construction activities employed to correct fish-passage barriers can result in adverse effects to all life-history stages of bull trout. Sedimentation and turbidity will occur from heavy-equipment operation on access roads, excavation areas, and fill locations by exposing, destabilizing, and/or compacting streambanks, streambeds, and riparian soils. Additional sedimentation may occur from excavating the roadfill, backfilling, bank armoring, clearing and restoring the riparian area, culvert maintenance, and restoration of streambeds following high-flow events, as needed. Sediment can be expected to be generated as the existing culvert is excavated, the work area is enlarged, and the new structure is installed and buried.

Sediment inputs into aquatic systems may result from a variety of actions associated with removing and replacing fish barriers caused by culverts. These include the initial redirection of a stream back into its channel, disturbance of the bank and riparian area by construction and restoration activities, operation of heavy equipment at the work site, and the re-mobilization of sediments accumulated upstream of previous fish barriers during post-construction flows. In addition, sediment may be generated during the installation of large wood, boulders, spawning gravels, or other mitigation as required by the FPHCP or other permits.

The effects of sediment to the aquatic environment and bull trout during construction are expected to be minimal when the construction occurs in dewatered streams and when other best management practices (BMPs) are being implemented at each construction site. However, rain events during and after the construction period will likely mobilize sediment into the stream, even with sediment-control measures in place, as sediment-control measures are not always effective at precluding sediment deposition into streams (Rashin et al. 1999). As a result of changes in gradient, sediment stored behind the old culvert may also be mobilized and transported downstream. Several rain events may be necessary before all the sediment is mobilized and redistributed downstream of the culvert. The removal or replacement of culverts may also, in some cases, result in head cutting upstream of the project. Culverts may be acting as a stable nick point or gradient control, preventing the upstream migration of reach-scale channel incision. Should headcutting occur, this could result in loss of instream and riparian habitat due to channel instability, accelerated streambank failure, and increased sedimentation. Such impacts are likely to occur until equilibrium is reached. In most cases, we do not anticipate that headcutting will occur and, when it does occur, the extent of such headcutting is expected to be localized. However, where it does occur in spawning and rearing reaches for bull trout, we anticipate that spawning and rearing habitat may either be permenantly lost or made unsuitable for a period of time until naturally restored after a new channel equilibrium is reached.

The WDNR in consultation with WDFW, incorporates work-timing windows into forest practices applications to minimize impacts to salmonids. Work-timing windows are considered to be time periods when in-water work can be conducted because salmonids are at a stage in their life cycle when they are least sensitive to disturbances such as sediment or are least likely to be present at or near the work site. This is typically outside of the spawning or egg incubating period. Work-timing windows allow the fish to either move away from impacts or to better cope with short-term, minimal changes to the habitat and/or decreased water quality. The work-timing windows are usually between July and September, but can be further adjusted to meet site-specific circumstances. Timing windows may reduce adverse effects to

spawning fish and egg incubating periods, but there still may be some adverse effects to juveniles, sub-adults, and adults. Not all adverse effects can be avoided via timing windows.

Effects to Bull Trout from Increased Sediment

Bull trout have spatially restrictive biological requirements at the individual and population levels (USFWS 1998b). Even though migratory life-history forms of bull trout may use much of a river basin or inhabit salt water throughout much of their adult life; spawning, rearing, and resident fish often live only in smaller watersheds or their tributaries (second- to fourth-order streams)(Rieman and McIntyre 1993). Resident bull trout inhabit the same streams or nearby tributaries in which they were hatched. Fluvial bull trout spawn in tributary streams where the young rear from 1 to 4 years before migrating to a river where they grow to maturity. Adfluvial bull trout spawn in tributary streams, and after rearing, migrate to a lake (Fraley and Shepard 1989). Anadromous bull trout spawn in tributary streams, but major growth and maturation occurs after migration to salt water. Their affinity to spend vulnerable life stages in headwater or tributary streams may make bull trout particularly susceptible to environmental changes such as sediment deposition. Under natural conditions, headwater streams tend to be less turbid than mainstems and estuaries (faster-flowing water transports suspended sediments downstream more quickly) (Bash et al. 2001). Headwater streams respond more quickly to changes in sediment loading because small streams have limited energy to transport the sediment and the distance from the sediment source to the stream is short (USFWS Native Fish biological opinion). Additionally, the patchiness of turbidity, both spatially and temporally, influences how salmonids, including bull trout, use a river system at various life stages (Sedell et al. 1990).

There is limited information on effects of suspended sediment specific to bull trout. There is generally more information of effects of suspended sediment on other salmonids; however, the body of this information is mainly restricted to effects to spawning and early-rearing stages. Increases in suspended sediment can affect salmonids in several ways (Rhodes et al. 1994). The effect of sediment beyond natural background conditions can be fatal at high levels. Noggle (1978) reported that extremely high concentrations of suspended sediments can cause fish mortality through gill abrasion. Fish may avoid high concentrations of suspended sediments altogether (Hicks et al. 1991). Coho salmon were observed avoiding excessive turbidity levels when less turbid water was easily accessible (Bisson and Bilby 1982). Harvey and Lisle (1998) disclosed that high concentrations of suspended sediment can affect survival, growth, and behavior of stream biota. Slight elevations in suspended sediment may reduce feeding efficiency and growth rates of some salmonids. At lower concentrations of suspended sediment fish may decrease feeding and at higher concentrations may cease feeding completely (Sigler et al. 1984). Noggle (1978) observed that feeding rates of coho salmon decreased when turbidity levels reached certain thresholds. Suspended sediment may alter food supply by decreasing abundance and availability of aquatic insects; however, the precise thresholds of fine sediment in suspension or in deposits that result in harmful effects to benthic invertebrates are difficult to characterize (Chapman and McLeod 1987). Sigler and Bjornn (1980) observed an inability of smaller coho fry reared in turbid water to compete for food and space with their larger cohorts reared in clear water.

Everest et al. (1987) indicated that the effects of deposited fine sediments on salmonid production in a given stream are a complex relationship among many variables that precludes generalization about effects of sediment on salmonid production. It has been well-established that high levels of deposited sediments in spawning gravels (12 - 20 percent typically) can increase mortality of salmonid eggs and alevins by reducing water flow through spawning gravel. Eggs can be suffocated and fry prevented from emerging from the gravel. Levels of fine sediment in streambed gravels have been negatively correlated with

salmonid embryo survival (Cedarholm et al. 1981; Tappel and Bjornn 1983) and the quality of juvenile rearing habitat (Bjornn et al. 1977). Although bull trout generally have a narrow, specific spawning habitat requirement and, therefore, spawn in only a small percentage of the stream habitat available to them (MBTSG 1998), they seem to be slightly more tolerant of sedimentation during development and emergence than other salmonids. It has been reported that survival of bull trout embryos through emergence appears to be unaffected when the percentage of fines comprise up to 30 percent of the streambed. However, at levels above 30 percent, embryo survival through emergence drops off sharply with survival below 20 percent for substrates with 40 percent fine material (Shepard et al. 1984). Weaver and White (1985) found 50 percent survival to emergence in substrates that contained 10 percent fines, compared to 80 percent survival when no fines were present. Weaver and Fraley (1991) also observed an inverse relationship between the percentage of fine sediment in substrates and survival to emergence of bull trout embryos. They found that any increases in fine sediments within spawning areas over natural background concentrations could significantly reduce the emergence success of bull trout fry. Entombment was the major mortality factor in these tests. Densities of juvenile bull trout were found to be lower in areas of high sediment levels and embeddedness (MBTSG 1998). Because of their close association with the substrate, juvenile bull trout distribution and rearing capacity are affected by sediment accumulations (Baxter and McPhail 1997).

Bull trout are apex predators that prey on a variety of species including terrestrial and aquatic insects and fish (Rieman and McIntyre 1993). Fish are common in the diet of individual bull trout that are 4.3 inches (110 millimeters) or longer. Large bull trout may feed almost exclusively on fish. Therefore, when analyzing effects of sediment on bull trout, it is very important to consider other fish species. While sediment may not directly affect bull trout, the increased sediment input may affect the spawning habitat and population levels of species such as Chinook and coho salmon, coastal cutthroat and steelhead trout, mountain whitefish, and various sculpin (cottid) species, which are potential prey species for bull trout.

Distance of prey capture and prey capture success both were found to decrease significantly when turbidity was increased (Berg and Northcote 1985). Waters (1995) states that the loss of visual capability leading to reduced feeding, is one of the major sub-lethal effects of high suspended-sediment levels. Increases in turbidity was reported to decrease the percentage of prey captured (Bash et al. 2001). At 0 NTUs, 100% of the prey items were consumed; at 10 NTUs, fish frequently were unable to capture prey species; at 60 NTUs, only 35% of the prey items were captured. At 20 to 60 NTUs, significant delay in the response of fish to prey was observed. Loss of visual capability and the ability to capture prey leads to depressed growth and reproductive capability.

Downstream migration by bull trout provides access to more prey, better protection from avian and terrestrial predators, and alleviates potential intraspecific competition or cannibalism in rearing areas (MBTSG 1998). One of the benefits of migration from tributary rearing areas to larger rivers or estuaries is increased growth potential. However, increased sedimentation may result in premature or early migration of both juveniles and adults, avoidance of habitat, and migration of non-migratory, resident bull trout. Migration exposes fish to many new hazards, including passage of sometimes difficult and unpredictable physical barriers, increased vulnerability to predators, exposure to introduced species, exposure to pathogens, and the challenges of new and unfamiliar habitats (MBTSG 1998). High turbidity may delay migration back to spawning sites by interfering with cues necessary for orientation, although turbidity alone does not seem to affect homing. Delays in spawning migration and associated energy expenditure may reduce spawning success and, therefore, population size (Bash et al. 2001).

Conclusion

The major source of sediment from riparian timber harvest activities can be expected to occur when sediment that enters unbuffered portions of Type Np streams and Type Ns streams is subsequently routed to fish-bearing streams. Effects from sediment generated by riparian timber harvest activities may occur to foraging, migrating, and rearing bull trout and their habitat, and to the forage species supporting these life stages. This sediment could also adversely affect survival of eggs and alevins in the gravel. The potential sub-lethal and lethal effects of suspended sediment deposited in redds may include reduction in water flow, smothering of eggs or alevins, and/or impeding fry emergence.

Generally, there is a low probability of direct mortality to bull trout from sediment due to restoring fish barriers. Outside of an emergency, the work will most likely be performed when bull trout are least likely to be present based on in-water timing restrictions. However, bull trout are found in some locations at all times of the year and therefore, in some situations bull trout could be directly affected by an increase in suspended sediments.

Due to in-water timing restrictions, any major input of sediment generated during in-water construction activities such as log placement or culvert removal would generally not occur during the bull trout spawning period. Although this will typically avoid direct impacts to spawning adults and incubating eggs, spawning habitat may still be degraded as a result of sediment generated during construction activities. Spawning habitat and potentially redds could also be adversely affected by post-construction sediment releases that could enter the stream during subsequent high flows from either areas disturbed during construction or from sediment that has accumulated behind the fish barrier. As disturbed areas and the channel itself begin to stabilize, the amount of sediment generated during high flow events is expected to subside to background levels. With most sites, this is expected to occur within the first year or two following construction. Where suitable spawning habitat exists downstream of a fish barrier, sediment mobilized as a result of removal and/or restoration of the fish passage barrier could be deposited on bull trout redds and result in egg and alevin mortality. It is more likely that only spawning habitat would be degraded as timing restrictions would prevent construction during spawning or egg incubation, but subsequent erosion of exposed surfaces could affect redds and alevins. An emergency replacement could be an exception to this general rule. Sediment from roads, especially stream-adjacent parallel roads could adversely affect all life stages. Sediment entering bull trout streams, generated from road construction and use, could be deposited on spawning or juvenile rearing areas. Increased sediment could result in changes to channel morphology, and habitat could be reduced due to shallowing and filling of pools, and filling of streambed interstitial spaces. Feeding and rearing behaviors may be significantly affected under some circumstances, affecting individual fish fitness and survival. Siltation of spawning reaches could reduce egg and embryo survival. However, the FPHCP is not expected to significantly contribute to instream sediment loading to the point that bull trout would be impaired at more than a stream reach scale.

In FMO habitats, the potential effects from sediment are to sub-adult and adult life stages and their habitat, and to the forage species supporting these life stages. Fish movement may also be obstructed temporarily by increases in the amount of suspended sediment. However, depending on the location of the activity, the likelihood and the number of bull trout being present will be reduced by the use of restrictive timing windows used for in-water activities. Until stabilized, sediments from a construction site may enter a stream following the first rains (post-construction) when bull trout are more likely to be present. In some locations, bull trout are likely to be present at all times. It is also possible that newly installed and properly designed culverts can still fail during heavy rainfall events. This is expected to be

less likely under the FPHCP and once old culverts are replaced using the new fish-passage standards. Regardless, culvert failure is still expected to occur on a limited basis and the results of such failure can have significant localized effects on bull trout and bull trout habitat. Depending on the timing and location of a culvert failure, which cannot be predicted, bull trout individuals and/or redds could be adversely affected, resulting in mortality of eggs, aelvins, and juveniles. Spawning and rearing habitat could also be affected by excess amounts of sediment with such effects lasting one or more spawning seasons.

In the absence of detailed local information on population dynamics and habitat use, any increase in the proportion of fines in substrates should be considered a risk to the productivity of habitat and to the persistence of associated bull trout populations (Suttle et al. 2005; Rieman and McIntyre 1993). For a general and more complete discussion of the effects of sediment on fish and fish habitat including bull trout and bull trout habitat, the reader should refer to **General Effects -- Sediment Effects** section of this Opinion.

8.6.3.4 Detritus

Detritus or organic litter includes leaves, needles, cones, twigs, bark, propagules, and other small plant materials. Leaves and other organic matter entering streams contribute to nutrient cycling and support food chains and aquatic community structures. Stream microbial communities, algae, and invertebrates encrust fallen litter, and then the litter is slowly decomposed. These processes provide nutrient and energy sources to fish and other animals that ingest them. Terrestrial sources of organic matter compose the largest proportion of the energy base for many smaller streams. In addition to providing energy and nutrients to streams, fallen organic litter and partially decomposed humus in riparian areas may intercept muddied waters and catch silt, and may provide food and cover for aquatic insects.

Organic litter inputs to streams are important food and energy sources for a variety of organisms that, in turn, provide food and energy for fish and other aquatic organisms. Also, organic litter influences water quality and habitat quality in riparian areas. Forest practices have the potential to affect organic-litter generation and transport from riparian forests to aquatic areas.

Although streamside litterfall is highly localized, stream transport systems readily move litter within streams from source areas to sink areas (Newton et al. 1996). Richardson (1992) estimated that 70 to 94 percent of all leaves that enter a stream segment are transported downstream until stored in a large pool or lake. Gregory et al. (1987) indicated that the greater the roughness elements (e.g., boulders, gravels, wood, roots) of a stream and the lower the hydraulic energy, the greater the retention of litter input. Thus, areas having large amounts of existing woody debris may retain more of the additional litter input.

Conclusion

These findings suggest that some litter input to upstream headwater reaches may contribute to downstream segments that support fish. Within watersheds, upstream litter source areas tend to compensate for areas where litter inputs are low. The overall importance and magnitude of this upstream contribution to litter input is not known, but they probably vary among watersheds with varying physiographic and biological conditions. Because it is expected that detrital inputs to fish-bearing streams would come from areas both adjacent to fish-bearing streams as well as upstream of fish-bearing streams, the change in inputs along individual stream segments without fish should not have a substantial effect on the quantity and quality of detritus in fish-bearing streams.

8.6.3.5 Habitat Access

Fish-passage barriers

Some fish habitat on FPHCP covered lands is currently inaccessible due to human-caused blockages at road crossings. Constricted flows at culverts or bridges resulting in fish blockages are largely due to poor installation, undersized structures, or neglected maintenance. In many instances, high water velocities amplified by undersized culverts have created large scour pools at the culvert discharge point, altering the stream elevation below the natural gradient. Over time, culverts become elevated above the stream and create a physical barrier to fish passage. In other cases, water also drains under and around culverts, and migrating fish attempting to follow these flows can become stranded or impinged against the culvert or road fill.

Migratory corridors allow individual fish access to unoccupied but suitable habitats, foraging areas, and refugia from disturbances (Saunders et al. 1991). Maintenance of migratory corridors for bull trout is essential to provide connectivity among local populations, and enables the re-establishment of extirpated populations (FWS 2004). Where migratory bull trout are not present, isolated populations cannot be replenished when a disturbance makes local habitats unsuitable (Rieman and McIntyre 1993; USDA and USDI 1997). Limited downstream movement was observed for resident bull trout in the Bitterroot River basin in Montana (Nelson 1999), suggesting that re-establishment of migratory fish and potential refounding of extirpated bull trout populations may be a slow process, if it occurs at all (FWS 2004). Migratory barriers such as culverted-road crossings can result in isolated populations and habitat fragmentation negatively affecting bull trout in several ways. These may include: (1) reducing geographic distribution, (2) increasing the probability of losing individual local populations, (3) increasing the probability of hybridization with introduced brook trout, and (4) reducing reproduction by eliminating the larger, more fecund migratory life-history form from local populations (FWS 2004).

Fish passage has been an important issue since it was first addressed by forest practices in 1975. With recent listings of various fish species as threatened and endangered including bull trout, it is now required in the FPHCP, that landowners review roads to determine if they have fish blockages. Large forest landowners are required to prioritize road maintenance and abandonment plans (RMAP) which are required to include the identification of fish blockages (culverts, bridges, other road crossings) under the "worst first" principle. This means that road-crossing structures will be inventoried and evaluated, and those acting as fish barriers are to be prioritized as to the amount of potential fish-bearing stream affected. Culverts affecting the most stream miles would be fixed first. The RMAP process is intended to bring all roads owned by large forest landowners into compliance with forest-practices standards including removing all fish barriers by the end of calendar year 2016. Small forest landowners are not held to the same schedule. See **Description of Activities that are Effects of the Permit** for additional information about small landowner requirements and fish-passage programs.

The effects of FPHCP implementation on bull trout habitat is to restore access to stream reaches that have otherwise been blocked to fish passage from a few years to decades (WDNR 2006). The goal of the FPHCP is to remove most if not all such passage barriers by 2016. Species most likely to benefit during the first several years of implementation are thought to be those inhabiting reaches lower in a system, as those barriers are more likely to be corrected first. Conversely though, it is likely that fish-passage blockages are more numerous in the headwater streams where the forest-road network is more concentrated. These barriers are generally expected to be replaced in later years as technology improves making such replacement options more economical (WDNR 2004). In the near-term this may

disproportionately affect bull trout as they are more likely to spawn and rear in headwater streams as compared to other salmonids. However, culvert blockages that affect listed fish are ranked highest in the prioritization scheme established in the FPHCP. This means that many of the culverts that currently act as barriers in known bull trout habitat would actually be addressed sooner. The actual schedules for large landowners are landowner specific and much of the work under these RMAPs has already been completed.

The overall effect of the FPHCP on bull trout and bull trout habitat is expected to be beneficial. Removing fish-passage blockages will restore spatial and temporal connectivity of streams within and between watersheds where fish movement is currently obstructed. This, in turn, will permit bull trout to access areas critical for fulfilling their life-history requirements, especially foraging, spawning, and rearing. Since 2001, approximately 705 miles of previously blocked streams have been opened to fish passage and over 1,200 structures have been removed or replaced under the RMAP process (WFPA 2005). Approximately 58 of those stream miles resulted from the repair of just 36 barriers on small landowners' lands by the Family Forest Fish Passage Program. It is not known how many of the actions directly benefited bull trout and bull trout habitat, but the overall effect is an increase in amount of fish habitat. Sediment effects from these actions are discussed in another section of this Opinion.

In addition to allowing for fish passage for all age classes of bull trout, the replacement or removal of fish-blocking culverts should result in more-naturally maintained stream hydraulics, including bedload movement, sediment transport, and passage of moderately-sized woody debris. This will lead to more-natural stream dynamics, geometry, and improved habitat conditions both in quality and quantity. We also expect the new structures will result in fewer maintenance needs and better performance during high-precipitation events, resulting in near-normal sediment and bedload movement and debris conveyance and less sediment delivery to the stream system. Over time, this should result in improvements in the quality and quantity of suitable foraging, migrating, spawning, and rearing habitat for bull trout and improved reliability that new culverts will provide for fish passage.

This action will also address population and habitat fragmentation/isolation factors that have contributed to the Federal listing of bull trout in the Coastal-Puget Sound and Columbia River population segments. Connectivity has been identified by the FWS as a critical need for enhancing the likelihood of survival and recovery of bull trout (USFWS 2002, 2003). Restoring fish passage will provide access to historically important habitat, which could result in immediate expansions in the distribution of bull trout in some instances. In other cases, this action will restore connectivity between existing bull trout populations. We expect this action to improve the number, distribution, and reproductive potential of bull trout in all core areas despite anticipated short-term adverse effects to bull trout and bull trout habitat (see Sediment Effects). Short-term effects are expected to persist for up to 12 to 18 months after each project, with many projects occurring between 2006 and 2016.

Conclusion

Our GIS analysis identified over 130,000 road-stream crossings on FPHCP covered lands, including over 18,000 crossings on known fish-bearing streams. Of these 18,000 road crossings, approximately 570 cross known bull trout spawning and rearing habitat (190) or bull trout FMO habitat (380). An additional ten crossings are unknown. It is not known how many of these crossings may actual prevent or impede fish passage, but barriers are to be replaced by 2016 with priority emphasis placed on those barriers that occur in areas with federally listed fish. Fourteen of the twenty-eight core areas included in this analysis have at least one road crossing on FPHCP covered lands that intersects designated spawning and rearing

habitat. The Nooksack core area has the most road crossings (43) of known spawning and rearing habitat. The Yakima (36), Walla Walla (20), Puyallup (14), and Stillaguamish (12) core areas all have greater than 10 road crossings that could be potential sources of sediment. The remaining ten core areas (Asotin, Pend Oreille, Lewis, Wenatchee, Snohomish /Skykomish, Lower Skagit, Elwha, Entiat, Hoh, and Tucannon) all have fewer than 10 road crossings on known bull trout spawning and rearing habitat.

Our GIS analysis did not identify road crossings of spawning and rearing habitat in any other core areas in Washington. Bull trout FMO habitat has nearly twice as many road crossings than spawning and rearing habitat, but since these habitats are larger streams and are identified as migration corridors it is more likely that these crossings are bridges and do not act as barriers under most flow regimes. Also since these crossings are lower in the watershed and are in areas of other listed fish, these road crossings are most likely to be replaced first during implementation (WDNR 2005). All FMO areas outside of core areas, and FMO habitat within core areas, have at least one identified crossing on FPHCP covered lands.

Only some of the identified crossings are barriers. According to WDFW (2003), approximately 25 percent of examined potential barriers require full replacement. A number of those culverts requiring replacement have already been replaced.

Fish Salvage and Handling

The salvage and handling of bull trout would not always occur in conjunction with the removal of a fish barrier. A site-specific assessment usually informs decisions about when a diversion of stream flow and fish salvage are necessary. During the diversion and prior to work commencing, bull trout (if present) along with other fish would be removed from the work area according to FWS-developed or FWS-adopted protocol Capture and handling of bull trout for these purposes by landowners or their contractors would require authorization such as a section 10(a)(1)(A) permit.

In an effort to reduce lethal impacts on bull trout from dewatering the stream, capture and relocation of bull trout from project construction sites would be attempted prior to the initiation of construction activities. Seines, dip nets, block nets, and electrofishing would be used. Although this effort would reduce the overall impact to bull trout, bull trout may in some cases experience immediate or delayed injury or death from the use of nets and/or electrofishing techniques. We expect bull trout injuries and death could occur from block nets and electrofishing, while mortality associated with handling stress, seines, and dip nets is less likely based upon our experience with these capture techniques. All captured fish and aquatic organisms would be released upstream from the dewatered stream.

Stream Reach Isolation

Prior to dewatering a stream section, block nets, sand bags, or other obstructions would be placed upstream and downstream from the culvert to prevent fish entering the stream segment that would be dewatered. The use of block nets poses a mortality risk to bull trout, even when monitored on a daily basis. The stream reach would usually be isolated on the same day that fish would be captured and relocated. The stream flow would be completely diverted around the project area in the same day. On rare occasions, block nets or obstructions may remain in the stream overnight when the fish capture and diversion activities require additional time to complete.

Seines, Dip Nets, and Traps

Seines and dip nets would be used as the first method of capture to remove any fish which may be trapped in the isolated reach. We anticipate that in most cases, bull trout would not be injured using this method, although it may disrupt foraging temporarily. Minnow traps, used in conjunction with seining, involve the use of wire-mesh traps placed in key instream fry habitat overnight prior to dewatering. Captured fish are removed and relocated upstream above the project area. Fry would be transported in large buckets (minimum 5 gallon) filled with stream water. The fish and water temperature would be monitored to ensure the health and condition of the fish until they are released. Given the low impact of these capture and relocation techniques, bull trout are not expected to be injured using these capture methods. Nonetheless, bull trout would be temporarily disrupted from their normal behavior during the capture and relocation activities.

In most cases, bull trout are unlikely to be present due to the timing and location of most projects. However, bull trout may in some cases be present as the allowable work windows primarily only limit the work to when bull trout are least likely to be present.

Electrofishing

Electrofishing for fish salvage has the potential to harm and kill bull trout even under FWS-approved protocols. In most, if not all circumstances, electrofishing would be attempted only after less harmful methods of fish removal have been used. In previous biological opinions, we have estimated that up to 25 percent of the fish within a project reach would not be removed by seining and dip-netting. These remaining fish could be affected by electrofishing. Based on studies conducted by Nielson (1998), we estimated in previous biological opinions that death and injury due to electrofishing would result in up to 25 percent of the bull trout remaining in the stream following the use of other removal methods. We judge this estimate may be conservative, yet reasonable given the wide range of water bodies and habitats where projects could occur. The actual effect of the capture and handling of bull trout using electrofishing is short-term in nature, occurring intermittently over one to several days. However, it may result in permanent, adverse effects. Not all flow diversions are likely to result in electrofishing effects as it may be used only when bull trout are least likely to be present in the affected area. This analysis also assumes that most if not all the bull trout subjected to electrofishing would be juveniles. It is expected that most if not all the adult bull trout would be removed using other methods of capture and release, because they are easier to see and capture than juveniles. This may not always be a correct assumption, as resident adult bull trout can be relatively small and, therefore, not readily seen or captured.

Stream Dewatering

During stream dewatering, including when sandbags are used to focus stream flows, there is a potential that a small number (up to 5 percent) of juvenile bull trout that are present may avoid being captured and relocated, and thus may die because they remain undetected in stream margins under vegetation or gravels. A gradual dewatering approach should enhance the efficacy of fish removal and thus reduce, but not eliminate this risk. We estimate the proposed capture methods would remove approximately 95 percent of the fish prior to dewatering. Stranding is only anticipated to affect fish which are less than 120 millimeters in length. In addition, due to the proposed timing of the activities, the risk to bull trout should be minimized because of the reduced likelihood of migratory and/or spawning bull trout being present in the stream reach during the construction period.

Expansion of Non-native Fish

Although the removal of fish-passage barriers are expected to benefit bull trout by re-opening suitable migrating, foraging, spawning, and rearing habitat; where non-native fish such as brook trout currently coexist with bull trout, there is the potential risk of introducing these species along with bull trout into habitat previously blocked by barriers. The effects of this action on bull trout are not easy to identify or quantify (see **Comprehensive Cumulative Effects – Invasive Species**). Because bull trout are associated with headwater streams, they may have a competitive advantage over other species when additional headwater habitat is opened to fish passage. Conversely, non-native fish are known to be a threat to bull trout in relatively secure, unaltered habitats, including roadless areas, wilderness, and national parks (USFWS 2004b). Since, in these situations, bull trout and one or more non-native species previously coexisted below the fish barrier, opening up additional habitat may not fundamentally change that relationship. If a particular bull trout population was healthy in the presence of a non-native species, adding additional habitat may not change that status. If a particular bull trout population was depressed because of the presence of one or more non-native species, reopening additional habitat is not necessarily going to improve the status of bull trout in those subpopulations unless the newly available habitat contains more-favorable (e.g., colder) conditions.

In some circumstances, restoring fish passage to a particular stream system may unintentionally expose a previously isolated population of bull trout to a non-native population of fish that resides below a barrier. In these situations, the removal of a fish barrier may have a more-profound effect on a local population of bull trout. Although the magnitude of threats from non-native fishes is highest for resident bull trout because they are typically isolated, have smaller body size than migratory forms, and usually exist in low abundance, we expect such situations to be extremely rare. In such rare events, we maintain the ability to request that the State not address fish-passage blockages where such projects would negatively affect bull trout (i.e., make additional habitat available to deleterious species or introduce a deleterious species to an isolated bull trout population).

8.6.3.6 CMER Research and Monitoring

Implementation of the FPHCP is expected to include several CMER-approved monitoring, evaluation, survey, and research efforts over the Permit term. A couple of these studies are currently on going and others are awaiting development. These activities are intended to support the monitoring and adaptive management components of the FPHCP and attendant reporting requirements. The monitoring of stream conditions, riparian conditions, performance and efficacy of road standards, baseline condition monitoring, and compliance monitoring are not expected to result in effects to covered species. Some general categories of monitoring and research may have the potential for adverse effects to bull trout and their habitat. Such effects are expected to occur over very limited stream reaches and could result in manipulations of riparian conditions below FPHCP standards.

Habitat Manipulation

In selected reaches, research could result in reduced canopy coverage negatively affecting the amount of shade coving the experimental stream reach. Less shade could, in turn, result in temperature increases in the studied stream. Where experimental stream reaches overlap with bull trout streams, adverse affects to bull trout may occur. Experimental reductions in shade would also result in less trees growing in the riparian buffer. Over time, fewer trees would result in less large wood available for recruitment to the affected reach. A reduction in large wood in bull trout streams has the potential to result in reduced pool formation, increased sediment loads, the loss of cover, and a reduction in stream diversity and

complexity. With regard to the studied stream, we anticipate effects to stream temperatures and wood recruitment originating from the affected reaches to have limited affect on downstream habitat conditions.

Capture and Handling for Research Purposes

Species capture and handling under the proposed Permit may occur during studies proposed as part of the CMER process, as well as for validation of water-typing models. A variety of methods may be used to capture and handle fish for research purposes. Such studies may require repeated sampling to determine habitat use, growth rates, or other response variables. In general, we would expect seines, dip nets, blocknets, and electrofishing to be the more-common methods employed to capture fish. Where such research overlaps bull trout habitat, bull trout may be collected by one or more of these methods. In these circumstances, bull trout may be subject to handling stress, injury, and/or mortality as well as directly or indirectly contributing to disease transmission and increased susceptibility. Research proposals are anticipated to affect a very limited amount of stream habitat and only a fraction of this may coincide with bull trout streams. In addition, we would continue to participate in CMER and guide such studies to reduce unnecessary effects to listed and at-risk species including bull trout.

Summary

FWS participates with other stakeholders in the CMER process and would participate in the development and/or review of individual research proposals. Where impacts may occur to bull trout and bull trout spawning and rearing habitat, the FWS would review such proposals as to their potential to affect bull trout. If such research is independent of bull trout, we would work with other CMER members and researchers to help ensure that such research does not occur in bull trout streams. Should it be necessary to conduct such research in bull trout streams, we would work with other CMER members and researchers to minimize the effects to bull trout and bull trout habitat. In summary, we do not anticipate that research conducted under CMER will have significant effects to bull trout and bull trout habitat, and such effects would be further minimized by FWS continued participation on the CMER committee.

8.6.3.7 Summary of Effects to Bull Trout at the Individual Level

Within covered lands subjected to timber-related activities and road construction and maintenance over the term of the FPHCP, sub-lethal and lethal adverse effects to bull trout and adverse effects to bull trout habitat are likely to occur, as implementation of the FPHCP is not expected to eliminate all adverse effects associated with covered activities. Adverse effects would likely be limited to periodic and temporary increases in sediment and water temperatures and decreases in the availability of large woody in the affected stream miles. We expect that adverse effects from increases in sediment and water temperatures, and decreases in the availability of large wood, would result in some bull trout behaviors being significantly impaired or disrupted, and some bull trout being killed on some covered lands during the proposed 50-year permit term. The actual levels of impact that are likely to occur under the FPHCP are difficult to quantify because the point at which incremental increases in sediment and temperature and decreases in the amount of large woody debris actually lead to death, injury, or harm of individual fish in affected stream miles is extremely difficult to predict. It can also be difficult to determine the extent to which certain habitat modifications can be attributed to such activities due to site specific variables. The extent or contribution of FPHCP effects to a particular habitat modification leading to death, injury, or harm of individual fish is often further confounded by the presence of non-FPHCP activities occurring within a watershed.

We do expect some direct mortality to occur from capture and handling of bull trout when road crossing structures are being replaced. We do not expect all road-crossing structures in spawning and rearing habitat or FMO habitat to require the capturing and handling of bull trout and we do not anticipate that all capturing and handling of bull trout will lead to death or injury. We also expect that in some circumstances the capturing and handling of bull is appropriate and necessary as it will minimize the extent of death or injury that would otherwise occur from stranding or construction following stream dewatering.

On the Westside, potential ramification of adverse effects on individual bull trout discussed previously are expected to be reduced and/or minimized for the following reasons:

1. The FPHCP will reduce road-generated sediment as a result of improved maintenance, construction, and abandonment practices. Although sediment will continue to be generated by FPHCP road activities, the implementation of the FPHCP is intended to substantially reduce road-related erosion and sediment delivery to streams from current and future roads relative to current levels of sediment delivery, both in the near-term (< 10 years) and over the long-term (10-50 years).

2. The FPHCP will result in the restoration of previously inaccessible but suitable bull trout spawning, rearing and foraging habitat through the removal of all fish passage barriers on covered lands. One goal of FPHCP implementation on bull trout habitat is to restore access to stream reaches that have otherwise been blocked to fish passage from a few years to decades (WDNR 2006), with replacement of most if not all such barriers by 2016. This will expand the current amount of available spawning and rearing and FMO habitat for bull trout and potential forage species.

3. The no-harvest portions of RMZs and the shade rule will provide a higher level of protection than previous forest practice rules, because shade will be increased in areas where these RMZ practices are applied. However, potential increases in water temperature along Type Np and Ns streams may temporarily increase water temperatures on some Type S and F streams. Over the permit term, as riparian vegetation in previously or recently harvested areas in the core zone on all Typed waters matures, and portions of the inner zone are retained after harvest, improvements (further decreases) in the temperature regimes of fish-bearing streams are anticipated.

4. Riparian buffers along fish-bearing streams and buffered portions of non-fish-bearing streams will provide, over time, greater amounts of large wood than the previous forest practice rules. The predicted long-term reduction in “natural” recruitment of large wood to Typed streams will primarily be related to the current buffer strategies on Type Np and Ns streams and 20-acre exempt parcels. Overall, riparian buffers adjacent to fish-bearing streams prescribed in the FPHCP are predicted to maintain 91 to 100 percent (CH2MHill 2000) of the potential large wood that originates from FPHCP covered lands adjacent to fish-bearing streams. Where tree-retention buffers are located on Type Np streams, the current prescriptions would maintain unmanaged timber stands within the 50-foot no-harvest zone that are predicted to supply 62 to 79 percent of the potential large wood.

On the eastside, potential ramifications of adverse effects on individual bull trout, as discussed previously, are expected to be reduced and/or minimized for the following reasons:

1. The FPHCP will result in the reduction of sediment coming from existing roads and future roads as a result of improved maintenance, construction, and abandonment practices. Although sediment will continue to be generated by FPHCP road activities, the implementation of the FPHCP is intended to substantially reduce road-related erosion and sediment delivery to streams from current and future roads relative to current levels of sediment delivery, both in the near-term (< 10 years) and over the long-term (10-50 years).

2. The FPHCP will result in the restoration of previously inaccessible but suitable bull trout spawning, rearing and foraging habitat through the removal of all fish passage barriers on covered lands. The effects of FPHCP implementation on bull trout habitat are to restore access to stream reaches that have otherwise been blocked to fish passage from a few years to decades (WDNR 2006). The goal of the FPHCP is to replace most if not all such barriers by 2016. This will expand the current amount of available spawning and rearing and FMO habitat for bull trout and their potential forage species.

3. The no-harvest portions of RMZs, the shade rule, and the bull trout overlay will provide a higher level of protection than previous forest practice rules, because shade will be increased in areas where these RMZ practices are applied. However, potential increases in water temperature along Type Np and Ns streams may temporarily increase water temperatures on some Type S and F streams. Over the permit term, as riparian vegetation in previously or recently harvested areas in the core zone of all typed waters matures, and portions of the inner zone are retained after harvest, improvements (further decreases) in the temperature regimes of fish-bearing streams are anticipated. This shade rule includes streams adjacent to 20-acre exempt parcels.

4. Riparian buffers along fish-bearing streams and buffered portions of non-fish-bearing streams will provide, over time, greater amounts of large wood than the previous forest practice rules. The predicted long-term reduction in "natural" recruitment of large wood to Typed streams will primarily be related to the current buffer strategies on Type Np and Ns streams and 20-acre exempt parcels. The 30-foot core zone would maintain an unmanaged stand providing 66 to 82 percent of the potential stream-adjacent large wood, and the inner zone in some cases may supply an additional 12 to 30 percent. Core buffers when combined with inner zone tree retention on fish-bearing streams on the eastside are expected to retain 91 to 100 percent of the potential stream-adjacent large wood. The no-harvest reaches of the partial harvest and clear-cut units on Type Np streams are expected to supply 81 to 95 percent of the potential large wood (CH2MHill 2000).

8.6.4 GEOGRAPHIC RISK ANALYSIS: Analysis of Risk to Bull Trout Populations from FPHCP Effects

8.6.4.1 Overview

To assess overall risk to bull trout from potential effects of the FPHCP, a risk analysis integrating both spatial and non-spatial information was conducted. In this way we could evaluate where the effects could occur in relation to bull trout core areas and local populations within Washington, and what level of risk those potential effects presented to bull trout and their habitat given baseline conditions. This is a multi-scale analysis, focusing on the local population scale (i.e., smallest group of fish that is known to represent an interacting reproductive unit) and on the core area scale (i.e., the combination of one or more

local populations and their associated foraging, migration, and overwintering habitat - FMO). Core areas require both habitat and bull trout to function, and the number (replication) and characteristics of local populations inhabiting a core area provide a relative indication of the core area's likelihood to persist. Local populations represent the bull trout spawning and early juvenile rearing habitat for a core area and are generally depicted as an area polygon (typically a subwatershed), while FMO habitat is all other habitat used by bull trout within the core area polygon.

This risk analysis can be summarized into four basic steps:

1. Evaluate core area (local population and FMO habitat) exposure risk.
2. Evaluate baseline habitat risk of exposed core areas.
3. Evaluate baseline population risk (i.e., at local population scale and core area scale) of exposed core areas.
4. Integrate all three risk evaluations to reach conclusion about the overall risk to core areas.

A spatial analysis using GIS was conducted on all bull trout core areas in Washington to help facilitate the risk analysis, and was used to identify the following information:

1. The location of FPHCP covered lands in relation to bull trout habitat and populations within core areas;
2. Both the percentage of FPHCP covered lands, and the percentage of FPHCP covered lands adjacent to bull trout streams, within these core areas' local populations (i.e., spawning and rearing habitat) and foraging, migration, and overwintering (FMO) habitat to help estimate and compare relative levels of "exposure risk" (i.e., low, medium, high) from FPHCP activities;
3. The potential degree of effect from existing and future roads to bull trout local populations and FMO habitats using key features (i.e., road crossings and road density) that are or will most likely be the primary sources of some of the adverse effects to bull trout and their habitat; and
4. The presence and underlying risk of existing stressors (e.g., brook trout, 303d impairments) to bull trout habitat within local populations and FMO habitat containing FPHCP covered lands to determine the "baseline habitat risk" (i.e., low, medium, high) to bull trout. As part of this determination, we integrated non-spatial information about the current condition of bull trout habitat within core areas and local populations. This ranking helps us understand the context of the potential effects from FPHCP on baseline bull trout habitat conditions.

As part of the risk analysis, the non-spatial population status parameters (i.e., adult spawner abundance and trend in abundance) of the local populations were evaluated to determine the "baseline population risk" ranking (i.e., low, medium, high). The analysis also evaluated similar population status parameters at the core area scale. This ranking helps one understand the resiliency of a local population and of a core area.

Exposure risk was used to narrow down the risk analysis and focus only on those bull trout core areas within Washington that could potentially be exposed to the majority of effects from the FPHCP activities. The risk analysis then integrated the two remaining risk categories (i.e., baseline habitat risk and baseline

population risk) to estimate an overall relative risk to specific local populations and their core areas. From this analysis, it could be determined which local populations may be at risk, and of those, which were at highest risk from the effects from FPHCP activities. To summarize the overall risk at a core area level, the exposure risk and baseline habitat risk rankings of the corresponding FMO habitat were integrated with that core area's baseline population risk ranking.

Assumptions

The following major assumptions were used in this bull trout risk analysis:

1. Type N streams are generally distributed in a uniform manner within local populations, and some adverse effects to bull trout in Type S and F streams are likely to occur from FPHCP activities on Type N streams;
2. FPHCP covered lands will be harvested at approximately an average of 0.7 percent per year for areas east of the Cascade Crest and 1.3 percent for areas west of the Cascade Crest;
3. Harvest will be generally distributed in a uniform manner amongst core areas (i.e., all harvest in a given year will not all occur within an individual core area);
4. Spawning and rearing habitat is more sensitive to effects from FPHCP activities than FMO habitat; therefore a lower threshold for the percentage (i.e., >10 percent versus >20 percent) of bull trout streams on FPHCP covered lands is appropriate for assessing risk to local populations (i.e., spawning and rearing habitat);
5. Marine areas used by some bull trout populations are assumed to be insignificantly affected (i.e., any effects from FPHCP activities are not anticipated to significantly affect marine nearshore habitats for bull trout), and therefore are not included in the analysis; and
6. The effects of global climate change may have an effect on aquatic resources over the life of the FPHCP. Although the manifestations of global climate change on bull trout on FPHCP covered lands are reasonable to anticipate, the magnitude of effects cannot be specifically predicted. Therefore, this analysis may underestimate the long-term risk of some FPHCP covered activities to bull trout local populations and core areas.

Where additional assumptions were used, but were specific to a particular part of the analysis, they were stated and discussed in those specific sections of the document.

It should be noted that there are three core areas in Washington that are transboundary in nature. The Priest Lake core area spans Washington and Idaho, with only portions of two local populations lying within Washington. The Grande Ronde core area spans Washington and Oregon, with four local populations and a portion of its FMO habitat within Washington. The Umatilla-Walla Walla core area spans Washington and Oregon, with five local populations and a portion of its FMO habitat lying within Washington. We included the portions of habitat in Idaho and Oregon where necessary to complete our analysis (i.e., evaluation of baseline habitat risk and baseline population risk), since these habitats are functionally part of the respective core area.

8.6.4.2 Analysis of Exposure Risk

Using a spatial analysis of FPHCP covered lands in relationship to bull trout habitat, we were able to identify which of the core areas (n = 28) within or partially within Washington had relatively high

percentages, ≥10 percent and ≥ 20 percent, of stream miles on FPHCP covered lands in "spawning and rearing" and "foraging, migration, and overwintering (FMO)" habitats, respectively.

Local Population Exposure

Core areas with less than 10 percent spawning and rearing stream miles on FPHCP covered lands were visually assessed to determine if the FPHCP covered lands encompassed critical spawning reaches, that may have been overlooked by the coarse percentage analysis. Because of the importance and sensitivity of spawning habitat, this additional level of evaluation was considered warranted. These determinations were made by visually reviewing the GIS map (*Washington Bull Trout Local Populations and Key Recovery Habitat with Forest Practices Lands*) and determining the location of FPHCP covered lands.

Ten core areas were identified as containing greater than 10 percent spawning and rearing streams miles on FPHCP covered lands (Appendix A1 "*Summary of Bull Trout Habitat on FPHCP Covered Lands by Bull Trout Core Area or Recovery Planning Unit"*). The core areas with greater than 10 percent spawning and rearing stream miles on FPHCP covered lands are listed below in descending order of percentage.

1. Lewis
2. Nooksack
3. Walla Walla
4. Entiat
5. Pend Oreille
6. Stillaguamish
7. Puyallup
8. Yakima
9. Snohomish/Skykomish
10. Wenatchee

Within these ten core areas (55 local populations), 11 local populations were determined to contain between 30 and 70 percent FPHCP covered lands (Appendix A2 *Acres of FP Lands by Local Population and FMO Areas in Washington*).

Two additional core areas, Priest Lake and Methow, had been overlooked by the coarse percentage analysis. Although these two core areas had less than 10 percent spawning and rearing stream miles on FPHCP covered lands, they were visually determined to have FPHCP covered lands encompassing critical spawning reaches within at least one of their local populations. These two additional core areas were added to the risk analysis.

FMO Habitat Exposure

Fourteen core areas were identified as containing greater than 20 percent FMO stream habitat on FPHCP covered lands (Appendix A1 "*Summary of Bull Trout Habitat on FPHCP Covered Lands by Bull Trout Core Area or Recovery Planning Unit"*). It should be noted that for some core areas, the amount of FMO

stream habitat may be naturally limited, so although the percentage of stream habitat encompassed by FPHCP covered lands may appear large, the actual amount may be lower than a core area having less than 20 percent FMO stream habitat on FPHCP covered lands. For this risk analysis, it was judged that the percentage of stream habitat on FPHCP covered lands is the appropriate metric to evaluate. It is reasonable to assume the overall influence of FPHCP activities on the character/condition of available FMO habitat within an individual core area is generally based on the percent of the FMO stream habitat that FPHCP covered lands encompass.

Core areas containing greater than 20 percent FMO stream habitat miles on FPHCP covered lands are listed below in descending order of percentage:

1. Hoh
2. Lewis
3. Puyallup
4. Stillaguamish
5. Dungeness
6. Elwha
7. Snohomish/Skykomish
8. Klickitat
9. Nooksack
10. Walla Walla
11. Lower Skagit
12. Skokomish
13. Yakima
14. Wenatchee

Local population(s) with low or no exposure risk, but within a core area with greater than 20 percent FMO stream habitat (listed above) on FPHCP covered lands, were also evaluated in the latter steps of the risk analysis (i.e., baseline habitat risk and baseline population risk) if generally known to be in a depressed or severely declining status. Because core areas containing local populations with impaired habitat and/or population baselines will generally be less resilient to adverse effects to their FMO habitat, this additional level of assessment was considered warranted. The rationale for this premise is that a depressed migratory bull trout population must sufficiently sustain effects at two locations, their spawning and rearing habitat (i.e., local populations) and their FMO habitat (regardless if those effects are considered less than what might occur within spawning and rearing habitat).

It should be noted that evaluating only the percent of bull trout FMO stream habitat directly affected may underestimate the actual overall effect to bull trout from activities on FPHCP covered lands within FMO areas (i.e., the greater area of watershed or hydrologic network within which the actual FMO stream habitat is located). This approach does not look at the actual percent acreage of FPHCP covered lands

within an FMO area. For contrast, if the amount of "FMO area" actually covered by FPHCP covered lands is calculated, we find some similarities to the 14 core areas listed above but also some differences (Appendix A2 *Acres of FP Lands by Local Population and FMO Areas in Washington*).

Core areas containing greater than 20 percent "FMO area" on FPHCP covered lands, but having only local populations with either low or no exposure risk, are listed below in descending order of percentage (ranges from 22 to 83 percent):

1. Coeur d'Alene Lake
2. Klickitat
3. Puyallup
4. Snohomish/Skykomish
5. Stillaguamish
6. Lake Pend Orielle
7. Pend Oreille
8. Lewis

Those core areas that had less than 20 percent FMO stream habitat on FPHCP covered lands and less than 10 percent spawning and rearing stream habitat on FPHCP covered lands (with low or no direct exposure) were removed from further analysis. These included the Grande Ronde, Tucannon, Chilliwack, Upper Skagit, Chester Morse Lake, Queets, and Quinault core areas.

It should be noted that freshwater FMO habitats "outside" of core areas (e.g., Chehalis River, Kalaloch Creek, Columbia River, Snake River) were not explicitly evaluated in this risk analysis due to the nature of these habitats and the limited information on their relationship to specific core areas. Bull trout from multiple core areas may use these habitats, making it extremely difficult to evaluate the overall effect to individual core areas. It is recognized that these FMO habitats outside of core areas are an important component of the overall habitat network for migratory populations of bull trout to complete their life history. However, given the limited information on specific relationships to core areas, all that can be stated is that some unknown amount of additional risk will likely be incurred for at least some unknown number of core areas, where these FMO habitats have moderate to high exposure to activities on FPHCP covered lands (see Appendix A1 "*Summary of Bull Trout Habitat on FPHCP Covered Lands by Bull Trout Core Area or Recovery Planning Unit*").

Summary or Exposure Risk

Exposure risk was estimated using the quantity and location of bull trout stream habitat on FPHCP covered lands within a core area's local populations (i.e., spawning and rearing habitats) and FMO areas. This determination addressed the amount of bull trout stream habitat potentially exposed to the effects of FPHCP activities. It also helped weight the importance of the location of those FPHCP covered lands in relationship to spawning and rearing or FMO habitats. In those cases where the specific locations of spawning sites were unknown within the local population, the draft Bull Trout Recovery Plan or a bull trout biologist familiar with the area were consulted to identify/approximate the potential spawning locations.

The spatial analysis of all local populations partially or completely within Washington (n=124), determined that 35 local populations contained no FPHCP covered lands (i.e., no direct risk), while 49 local populations had a small percentage (< 3 percent) of FPHCP covered lands that encompassed or were adjacent to a low risk area (e.g., non-spawning reach) of the local population. Within six core areas, a total of 17 local populations contained less than 10 percent of FPHCP covered lands, however, these lands were located within increased risk areas (e.g., spawning reach) of the local population. The remaining local populations had greater than 10 percent FPHCP covered lands adjacent to portions of spawning and rearing habitat.

Exposure risk for local populations and FMO habitats are summarized for the relevant core areas in Table 8-38. For detailed assessment of exposure risk to local populations and FMO habitats see Appendix B1 (*Supporting Materials for Risk Analysis: Bull Trout Exposure Risk Analysis*).

Table 8-38. Exposure risk rankings for local populations and FMO habitats within the 12 core areas determined to have significant exposure risk (local populations containing no FPHCP lands are not displayed); and for the FMO habitats within core areas having greater than 20 percent bull trout FMO stream habitat on FPHCP covered lands (FMO habitats having "Low" exposure risk, and no associated at risk local populations, are not displayed).

Core Area	Local Population or FMO	Exposure Risk
	Columbia River Population Segment	
Lewis	Cougar Creek	L
	Pine Creek	H
	Lewis FMO	L
Walla-Walla	Mill Creek	H
	NF Touchet	H
	SF Touchet	H
	Wolf Fork Touchet	H
	Walla-Walla FMO	M
Pend Oreille	LeClerc Creek	H
	Pend Oreille FMO	L
Priest Lake	Gold Creek	L
	Granite Creek	M
	Kalispell Creek	L
	Priest Lake FMO	L
Yakima	Ahtanum Creek	H
	American River	M
	Bumping River	L
	Cle Elum River	M
	Gold Creek	H
	Kachess River	L
	NF Teanaway River	H
	NF Tieton	L
	Rattlesnake Creek	M

Table 8-38. Exposure risk rankings for local populations and FMO habitats within the 12 core areas determined to have significant exposure risk (local populations containing no FPHCP lands are not displayed); and for the FMO habitats within core areas having greater than 20 percent bull trout FMO stream habitat on FPHCP covered lands (FMO habitats having "Low" exposure risk, and no associated at risk local populations, are not displayed). (continued)

Core Area	Local Population or FMO	Exposure Risk
	South Fork Tieton	H
	Upper Yakima River	H
	Yakima River Mainstem FMO	H
Wenatchee	Chiwaukum Creek	H
	Chiwawa River	H
	Icicle Creek	M
	Little Wenatchee River	M
	Nason Creek	H
	Peshastin Creek	M
	White River	H
	Wenatchee FMO	H
Entiat	Entiat River	H
	Mad River	H
	Entiat FMO	H
Methow	Beaver Creek	L
	Chewuch River	L
	Early Winters Creek	M
	Goat Creek	M
	Gold Creek	M
	Lost River	M
	Twisp River	M
	Upper Methow River	L
	Wolf Creek	M
	Methow FMO	H
	Coastal-Puget Sound Population Segment	
Nooksack	Middle NF Nooksack River	H
	Glacier Creek	H
	Lower NF Nooksack River	H
	Lower MF Nooksack River	M
	Lower SF Nooksack River	H
	Nooksack FMO	M
Stillaguamish	NF Stillaguamish River	M
	Upper Deer Creek	M
	Canyon Creek	L
	Stillaguamish FMO	H
Snohomish-Skykokmish	NF Skykomish River	L
	SF Skykomish River	M
	Snohomish/Skykomish FMO	M

Table 8-38. Exposure risk rankings for local populations and FMO habitats within the 12 core areas determined to have significant exposure risk (local populations containing no FPHCP lands are not displayed); and for the FMO habitats within core areas having greater than 20 percent bull trout FMO stream habitat on FPHCP covered lands (FMO habitats having "Low" exposure risk, and no associated at risk local populations, are not displayed). (continued)

Core Area	Local Population or FMO	Exposure Risk
Puyallup	Upper White River	L
	WF White River	L
	Carbon River	H
	Upper Puyallup and Mowich Rivers	H
	Puyallup FMO	H
Dungeness	Dungeness River	L
	Dungeness FMO	M
Foraging, Migration, and Overwintering Habitats (>20% FPHCP covered lands, but not listed above)		
Hoh	Hoh FMO	H
	South Fork Hoh River	n/a
	Hoh River	n/a
Elwha	Elwha FMO	M
	Elwha River	n/a
Klickitat	Klickitat FMO	M
	West Fork Klickitat	n/a
Lower Skagit	Lower Skagit FMO	M
	19 local populations	n/a
Skokomish	Skokomish River FMO	M
	NF Skokomish River	n/a
	SF Skokomish River	n/a

The exposure risk for local populations was ranked based on the following criteria:

Low Risk: FPHCP covered lands encompass or are adjacent to a minor amount of juvenile rearing habitat within the local population.

Moderate Risk: FPHCP covered lands encompass or are adjacent to significant amounts of juvenile rearing habitat within the local population, or a small amount of known spawning habitat within the local population.

High Risk: FPHCP covered lands encompass or are adjacent to significant amounts of known spawning habitat within the local population.

Exposure risk for FMO habitat was ranked based on the following criteria:

Low Risk: FPHCP covered lands encompass or are adjacent to less than 20 percent of FMO stream habitat within the core area.

Moderate Risk: FPHCP covered lands encompass or are adjacent to greater than 20 percent but less than 40 percent of FMO stream habitat within the core area.

High Risk: FPHCP covered lands encompass or are adjacent to greater than 40 percent of FMO stream habitat within the core area.

It should be noted that although some FMO habitat may be ranked at high exposure risk, this does not equate with the same level of risk to local populations (i.e., spawning and rearing habitat). FPHCP activities are not expected to affect FMO habitat to the same degree as spawning and rearing habitat when FPHCP covered lands overlap or are adjacent to these areas. Bull trout FMO habitats are 1) typically larger bodies of water, 2) generally contain streams with warmer water temperatures, and 3) typically used seasonally by bull trout life stages that have less sensitive or restrictive habitat requirements. Therefore, the effects of FPHCP activities on tributaries or stream reaches feeding into FMO streams will more likely be reduced to acceptable levels before reaching many, if not most, FMO streams, and will correspondingly have less impact to bull trout.

At this point in the risk analysis, local populations that were determined to have a low exposure risk (see Table 8-38) were eliminated from further analysis of risk. It was concluded that a low exposure risk indicated the population and its habitat would sufficiently avoid any significant effects generated from FPHCP covered lands within that local population. Those local populations that were determined to have moderate or high exposure risk were further analyzed for baseline habitat risk and baseline population risk described below.

8.6.4.3 Analysis of Baseline Habitat Risk

The 9.3 million acres of FPHCP covered lands and its associated infrastructure (e.g., roads, stream crossings, etc.) are not evenly distributed across core areas and local populations. About 18 percent of the mapped bull trout habitat (spawning and rearing [14%] and FMO [19%]) in Washington occurs on FPHCP covered lands. In some core areas, the percentage of covered lands can be as high as 40 percent. In other core areas, no covered lands occur. Even at the local population scale, the percentage of covered lands can vary widely.

Road densities and crossings vary at the core area and local population scales. Some local population areas have no crossings, while some have more than 1,000 crossings (Appendix A3 *Road Density, Stream Crossings, Stream Adjacent Road Summaries by Local Population and Core Area*). Road densities range from 0.0 miles per square mile (mi/mi^2) up to 5.4 mi/mi^2 at the local population scale. FPHCP covered lands currently have over 60,000 miles of mapped roads yielding an average road density of 4.1 mi/mi^2. Road densities on FPHCP covered lands are typically below 9 miles per square mile, but in one case it was 25 miles per square mile. About 9 percent of these roads occur within the riparian zone of Type S, F, and Np streams as determine by a site potential tree height (variable between west and east sides of the Cascade Crest). This road network also has over 130,000 road/stream crossings. The majority of these crossings are over Type Np and Ns streams. Approximately 18,000 road/stream crossing transect Type S and F (fish-bearing) streams. See Appendix A3 (*Road Density, Stream Crossings, Stream Adjacent Road Summaries by Local Population and Core Area*) for details on road density, stream crossings, and other spatial information by local population and FMO habitat.

Given this variability across local populations it was deemed warranted to individually assess and rank each local population and their corresponding FMO habitat. Baseline habitat risk was estimated (ranked) using spatial analysis of road density, number of road crossings on bull trout streams, 303d listings, and additional qualitative information on local population and FMO habitat condition. These rankings rate the condition of existing habitats within local populations that were determined to have moderate to high exposure risk, and their corresponding FMO habitat. FMO habitats that had moderate to high exposure

risk, but no local populations with either moderate or high exposure risk, were also ranked but their rankings are not displayed in Table 8-39. Spatial and non-spatial information was assessed through the bull trout "Matrix of Pathways and Indicators" (Matrix) (USFWS 1998) to arrive at the baseline habitat risk ranking. Risk categories (i.e., low, medium, high) were essentially equated to the Matrix categories (i.e., functioning appropriately, functioning at risk, functioning at unacceptable risk). The draft Bull Trout Recovery Plan (USFWS 2002, 2004a, 2004b), Washington State limiting factors analyses, subbasin plans, other biological opinions, and/or a bull trout biologist familiar with the area were consulted in assessing the baseline habitat risk for local populations. Baseline habitat risk for local populations and FMO habitats is summarized in Table 8-39 below. See Appendix B2 (*Supporting Materials for Risk Analysis: Bull Trout Baseline Habitat Risk Analysis)* for complete analysis of baseline habitat risk.

Table 8-39. Baseline habitat risk ranking for local populations with moderate to high exposure risk, and for their corresponding FMO habitats.

Core Area	Local Population	Baseline Habitat Risk
	Columbia River Population Segment	
Lewis	Pine Creek	L
	Lewis FMO	L
Walla-Walla	Mill Creek	H
	NF Touchet	M
	SF Touchet	H
	Wolf Fork Touchet	M
	Walla-Walla FMO	H
Pend Oreille	LeClerc Creek	M
	Pend Oreille FMO	H
Priest Lake	Granite Creek	M
	Priest Lake FMO	H
Yakima	Ahtanum Creek	H
	American River	M
	Cle Elum River	H
	Gold Creek	M
	NF Teanaway River	H
	Rattlesnake Creek	M
	SF Tieton	M
	Upper Yakima River	H
	Yakima River Mainstem FMO	H
Wenatchee	Chiwaukum Creek	M
	Chiwawa River	L
	Icicle Creek	H
	Little Wenatchee River	H
	Nason Creek	H
	Peshastin Creek	H
	White River	M
	Wenatchee FMO	H

Table 8-39. Baseline habitat risk ranking for local populations with moderate to high exposure risk, and for their corresponding FMO habitats. (continued)

Core Area	Local Population	Baseline Habitat Risk
Entiat	Entiat River	H
	Mad River	M
	Entiat FMO	H
Methow	Early Winters Creek	M
	Goat Creek	H
	Gold Creek	H
	Lost River	M
	Twisp River	M
	Wolf Creek	M
	Methow FMO	H
	Coastal-Puget Sound Population Segment	
Nooksack	Middle NF Nooksack River	H
	Glacier Creek	L
	Lower NF Nooksack River	M
	Lower MF Nooksack River	M
	Lower SF Nooksack River	H
	Nooksack FMO	M
Stillaguamish	NF Stillaguamish River	M
	Upper Deer Creek	H
	Stillaguamish FMO	M
Snohomish/Skykomish	SF Skykomish River	M
	Snohomish/Skykomish FMO	M
Puyallup	Carbon River	L
	Upper Puyallup and Mowich Rivers	H
	Puyallup FMO	H

The baseline habitat risk analysis determined that only four of the local populations with moderate to high exposure risk (n = 40) had low (L) baseline habitat risk. A total of 17 local populations were determined to have high (H) baseline habitat risk within the Columbia River population (n = 13) and the Coastal-Puget Sound population (n = 4) segments; and the remaining 19 local populations were determined to have moderate (M) baseline habitat risk within the Columbia River population (n = 15) and the Coastal-Puget Sound population (n = 4) segments.

Although FMO habitat is critical for supporting migratory life history forms of bull trout, it is less sensitive to potential effects from FPHCP activities. In determining overall core area risk, FMO baseline habitat risk was integrated into the risk analysis for those core areas with local populations at moderate to high overall potential risk (see Summary of Overall Potential Risk section below). We judged that FMO baseline habitat risk becomes a much more relevant factor in these cases, since it is an indicator of what additional pressures are being placed upon a population already at a level of increased risk. By integrating baseline habitat risk for FMO habitat in these cases, it provides a more holistic and reliable risk condition of a core area with a local population(s) at moderate to high overall risk.

8.6.4.4 Analysis of Baseline Population Risk

Local Population Scale

Baseline population risk was estimated using the number of adult spawners and trend status within a local population. This determination addressed the current condition of population status parameters within local populations, which are an indicator of the potential sensitivity of a local population to adverse effects from activities on FPHCP covered lands. In those cases where population parameters were unknown, we ranked these as moderate risk by default. A moderate or intermediate risk ranking seemed reasonable to assume in these cases, although this could mischaracterize the true status of an unknown local population as either better or worse. Population data from the draft Bull Trout Recovery Plans (USFWS 2002, 2004a, 2004b) in conjunction with updated information from the core area templates (USFWS 2005) were used in ranking local populations. Baseline population risk for local populations is summarized in Table 8-40.

Table 8-40. Baseline population risk rankings for local populations with moderate to high exposure risk.

Core Area	Local Population	Baseline Population Risk
	Columbia River Population Segment	
Lewis	Pine Creek	L
Walla-Walla	Mill Creek	M
	NF Touchet	H
	SF Touchet	H
	Wolf Fork Touchet	H
Pend Oreille	LeClerc Creek	H
Priest Lake	Granite Creek	H
Yakima	Ahtanum Creek	H
	American River	H
	Cle Elum River	H
	Gold Creek	H
	NF Teanaway River	H
	Rattlesnake Creek	H
	SF Tieton	L
	Upper Yakima River	H
Wenatchee	Chiwaukum Creek	M
	Chiwawa River	L
	Icicle Creek	M
	Little Wenatchee River	H
	Nason Creek	H
	Peshastin Creek	H
	White River	H
Entiat	Entiat River	H
	Mad River	H
Methow	Early Winters Creek	H
	Goat Creek	H

Table 8-40. Baseline population risk rankings for local populations with moderate to high exposure risk. (continued)

Core Area	Local Population	Baseline Population Risk
	Gold Creek	H
	Lost River	M
	Twisp River	M
	Wolf Creek	H
	Coastal-Puget Sound Population Segment	
Nooksack	Middle NF Nooksack River	M
	Glacier Creek	L
	Lower NF Nooksack River	M
	Lower MF Nooksack River	M
	Lower SF Nooksack River	M
Stillaguamish	NF Stillaguamish River	L
	Upper Deer Creek	H
Snohomish/Skykomish	SF Skykomish River	M
Puyallup	Carbon River	M
	Upper Puyallup and Mowich Rivers	M

Baseline population risk for local populations was ranked using the following criteria, which was based on the bull trout population guidance and information from Rieman and Allendorf (2001):

> *Low Risk*: Average, annual spawner abundance in the local population is greater than 100, and is stable or increasing (5-10 years data).
>
> *Moderate Risk*: Average, annual spawner abundance in the local population is greater than 100, and population trend is declining; or average, annual spawner abundance in the local population is between between 50 and 100 and is stable or increasing; or population parameters are currently unknown.
>
> *High Risk*: Average, annual spawner abundance in the local population is between between 50 and 100 and is declining; or average, annual spawner abundance in the local population is less than 50; or migratory form is or nearly absent.

Core Area Scale

Different parameter values are used to assess baseline population condition or risk at the core area scale. The ranking criteria reflect this, and are generally based on values described in the current bull trout literature and draft recovery plans (USFWS 2002, 2004a, 2004b). Analysis of baseline population risk at this scale also includes assessment of an additional parameter, the number of local populations. Because we did not necessarily evaluate all local populations (i.e., only those with moderate to high exposure risk) within a core area in the earlier parts of our analysis, we could not simply “sum up” the baseline population risk rankings for local populations and equate that with the baseline population risk ranking for the core area, nor would that have been necessarily appropriate. Population data from the draft Bull Trout Recovery Plans (USFWS 2002, 2004a, 2004b) in conjunction with updated information from the core area templates (USFWS 2005) were used in ranking core areas. Baseline population risk for core areas with local populations with moderate to high exposure risk is summarized in Table 8-41.

Table 8-41. Baseline population risk rankings for core areas with a least one local population at moderate to high exposure risk.

Core Area	Baseline Population Risk
Columbia River Population Segment	
Lewis	M
Walla-Walla	M
Pend Oreille	H
Priest Lake	H
Yakima	H
Wenatchee	M
Entiat	H
Methow	H
Coastal-Puget Sound Population Segment	
Nooksack	M
Stillaguamish	M
Snohomish/Skykomish	M
Puyallup	M

Baseline population risk for affected core areas was ranked using the following criteria which was based on the bull trout population guidance and information from Rieman and McIntyre (1993), and Rieman and Allendorf (2001):

> *Low Risk*: Average, annual spawner abundance in the core area is estimated to be greater than 1,000 and is stable or increasing (5-10 years data), and core area contains more than 5 local populations.
>
> *Moderate Risk*: Average, annual spawner abundance in the core area is estimated to be greater than 1,000 and is stable or increasing (5-10 years data), and core area contains less than 5 local populations; or average, annual spawner abundance in the core area is estimated to be at least 500 and is stable or increasing (5-10 years data); or population parameters are currently unknown.
>
> *High Risk*: Average, annual spawner abundance in the core area is estimated to be between 500 and 1,000 and is declining and has less than 5 local populations; or average, annual spawner abundance in the core area is less than 500.

8.6.4.5 Summary of Overall Potential Risk

Overall potential risk is presented at two scales, the local population and core area. Although the ranking results can be used independently to assess relative risk at the two scales, they should also be examined together to more fully assess the ultimate risk to a particular core area from FPHCP activities.

Local Population Scale

Integration of the two risk rankings (i.e., baseline habitat and baseline population) developed from the spatial analysis and non-spatial threat/stressor information indicated that over half of the local populations with moderate to high exposure risk were at an increased (moderate to high) level of overall potential risk from the effects of the FPHCP. Overall local population risk was ranked using a simple scoring system in

the following matrix. A “high” ranking received a value of 3 points, a “moderate” ranking a value of 2 points, and a “low” ranking a value of 1 point (i.e., H=3, M=2, L=1). For each local population, its three resulting ranking values were summed together and then divided by three to determine its final score and its overall potential risk category. Since all local populations with low exposure risk were removed from further analysis by this point, the remaining local populations that were analyzed must either have a moderate or high exposure risk. This removal accordingly eliminated most of the potential “low” scores in the final rankings. We assumed that both habitat and population risk rankings were equally weighted/important to bull trout, and therefore, only a finite number of combinations are possible. These combinations are displayed in Table 8-42.

Table 8-42. Potential individual risk combinations and resultant overall risk ranking for a local population (i.e., spawning and rearing habitat).

Exposure Risk		Risk 1		Risk 2		Overall Potential Risk	
Ranking	**Pt value**	**Ranking**	**Pt value**	**Ranking**	**Pt value**	**Ranking**	**Score**
H	3	H	3	H	3	H	3
H	3	H	3	M	2	MH	2.7
H	3	H	3	L	1	M	2.3
H	3	M	2	M	2	M	2.3
H	3	L	1	M	2	M	2
H	3	L	1	L	1	ML	1.7
M	2	L	1	L	1	L	1.3
M	2	L	1	M	2	ML	1.7
M	2	M	2	M	2	M	2
M	2	H	3	L	1	M	2
M	2	H	3	M	2	M	2.3
M	2	H	3	H	3	MH	2.7

The overall potential risk rankings for local populations with a moderate to high exposure risk are summarized below in Table 8-43. Out of the 40 local populations analyzed to this point, a total of six local populations were scored in the high (H) risk category, all located on the eastside of the Cascade Crest within the Columbia River population segment. An additional 16 local populations were scored in the moderate-high (MH), or next highest risk category. Ten of these local populations where ranked as having a high (H) exposure risk. Four of the 16 local populations were located in the Coastal-Puget Sound population segment, with the remainder in the Columbia River population segment. The remaining 18 local populations ranked, were scored in the moderate (M) to moderate-low (ML) risk category. None of the local populations scored a low (L) overall potential risk.

Two additional “habitat” factors not explicitly integrated into the Matrix analysis and therefore not integrated into the overall baseline habitat risk results were the amounts of stream adjacent roads (Appendix A3) and the presence of brook trout (Appendix B2). The analysis results for these two additional factors can be overlayed with the results of the overall potential risk rankings to provide an even more comprehensive picture of relative risk for individual local populations.

Table 8-43. Overall potential risk rankings for local populations with moderate to high exposure risk. Rankings are in descending order, with high (H) exposure risk local populations listed first in each final ranking (rank 4) category.

		Exposure Risk		Habitat Risk		Population Risk		Overall Potential Risk	
Core Area	**Local Population**	**rank 1**	**score 1**	**rank 2**	**score 2**	**rank 3**	**score 3**	**rank 4**	**score 4**
Walla-Walla	SF Touchet	H	3	H	3	H	3	H	3.0
Yakima	Ahtanum Creek	H	3	H	3	H	3	H	3.0
Yakima	NF Teanaway River	H	3	H	3	H	3	H	3.0
Yakima	Upper Yakima River	H	3	H	3	H	3	H	3.0
Wenatchee	Nason Creek	H	3	H	3	H	3	H	3.0
Entiat	Entiat River	H	3	H	3	H	3	H	3.0
Nooksack	Middle NF Nooksack River	H	3	H	3	M	2	MH	2.7
Nooksack	Lower SF Nooksack River	H	3	H	3	M	2	MH	2.7
Puyallup	Upper Puyallup and Mowich Rivers	H	3	H	3	M	2	MH	2.7
Walla-Walla	Mill Creek	H	3	H	3	M	2	MH	2.7
Walla-Walla	NF Touchet	H	3	M	2	H	3	MH	2.7
Walla-Walla	Wolf Fork Touchet	H	3	M	2	H	3	MH	2.7
Pend Oreille	LeClerc Creek	H	3	M	2	H	3	MH	2.7
Yakima	Gold Creek	H	3	M	2	H	3	MH	2.7
Wenatchee	White River	H	3	M	2	H	3	MH	2.7
Entiat	Mad River	H	3	M	2	H	3	MH	2.7
Stillaguamish	Upper Deer Creek	M	2	H	3	H	3	MH	2.7
Yakima	Cle Elum River	M	2	H	3	H	3	MH	2.7
Wenatchee	Little Wenatchee River	M	2	H	3	H	3	MH	2.7
Wenatchee	Peshastin Creek	M	2	H	3	H	3	MH	2.7
Methow	Goat Creek	M	2	H	3	H	3	MH	2.7
Methow	Gold Creek	M	2	H	3	H	3	MH	2.7
Nooksack	Lower NF Nooksack River	H	3	M	2	M	2	M	2.3
Wenatchee	Chiwaukum Creek	H	3	M	2	M	2	M	2.3
Priest Lake	Granite Creek	M	2	M	2	H	3	M	2.3

Table 8-43. Overall potential risk rankings for local populations with moderate to high exposure risk. Rankings are in descending order, with high (H) exposure risk local populations listed first in each final ranking (rank 4) category (continued)

		Exposure Risk		Habitat Risk		Population Risk		Overall Potential Risk	
Core Area	**Local Population**	**rank 1**	**score 1**	**rank 2**	**score 2**	**rank 3**	**score 3**	**rank 4**	**score 4**
Yakima	American River	M	2	M	2	H	3	M	2.3
Yakima	Rattlesnake Creek	M	2	M	2	H	3	M	2.3
Wenatchee	Icicle Creek	M	2	H	3	M	2	M	2.3
Methow	Early Winters Creek	M	2	M	2	H	3	M	2.3
Methow	Wolf Creek	M	2	M	2	H	3	M	2.3
Puyallup	Carbon River	H	3	L	1	M	2	M	2.0
Yakima	SF Tieton	H	3	M	2	L	1	M	2.0
Nooksack	Lower MF Nooksack River	M	2	M	2	M	2	M	2.0
Methow	Lost River	M	2	M	2	M	2	M	2.0
Methow	Twisp River	M	2	M	2	M	2	M	2.0
Snohomish/ Skykomish	SF Skykomish River	M	2	M	2	M	2	M	2.0
Nooksack	Glacier Creek	H	3	L	1	L	1	ML	1.7
Lewis	Pine Creek	H	3	L	1	L	1	ML	1.7
Wenatchee	Chiwawa River	H	3	L	1	L	1	ML	1.7
Stillaguamish	NF Stillaguamish River	M	2	M	2	L	1	ML	1.7

Four local populations (Lower South Fork Nooksack River, Ahtanum Creek, Upper Puyallup and Mowich Rivers, and North Fork Teanaway River) have greater than 10 miles of stream adjacent roads on FPHCP covered lands. These four local populations were all scored at either moderate-high (MH) or high (H) overall potential risk. Another 11 local populations have between 5 and 10 miles of stream adjacent roads on FPHCP covered lands. Three of these (South Fork Touchet, Nason Creek, and Entiat River) were scored at high (H) overall potential risk, three (North Fork Touchet, LeClerc Creek, and Cle Elum River) were scored at moderate-high (MH) overall potential risk, and the remaining 5 at moderate (M) overall potential risk (Lower North Fork Nooksack River, Lower Middle Fork Nooksack River, and South Fork Skykomish River) to moderate-low (ML) overall potential risk (Pine Creek and North Fork Stillaguamish). Unlike the local population road density analysis, the stream adjacent roads analysis only accounted for those roads within riparian management zones of stream segments on FPHCP covered lands. Therefore, the results should generally be considered an underestimate of the actual extent of the effects of stream adjacent roads from FPHCP activities. For example, stream adjacent haul roads used for FPHCP activities generally extend beyond FPHCP covered lands, especially in fragmented or "checkerboard" ownerships.

Three (Ahtanum Creek, Upper Yakima River, and Entiat River) of the 6 local populations that scored a high (H) overall potential risk, also have a high risk ranking associated with the presence of brook trout, and the remaining three local populations (South Fork Touchet River, North Fork Teanaway River and Nason Creek) have a moderate risk ranking associated with the presence of brook trout. Of the 16 local populations that scored a moderate-high (MH) overall potential risk ranking, six (LeClerc Creek, White River, Cle Elum River, Peshastin Creek, and Gold Creek-Methow) have a high risk ranking associated with the presence of brook trout, eight (Lower South Fork Nooksack River, Upper Puyallup and Mowich Rivers, Mill Creek, North Fork Touchet River, Wolf Fork Touchet River, Gold Creek-Yakima River, Upper Deer Creek, and Goat Creek) have a moderate risk ranking associated with the presence of brook trout, and only two (Middle North Fork Nooksack River and Mad River) have a low risk ranking because of the general absence of brook trout.

Core Area Scale

To estimate the overall potential risk for the core area containing local population(s) with moderate to high exposure risk, we integrated the baseline habitat risk ranking for corresponding FMOs (Table 8-39) with the baseline population risk for core areas (Table 8-41). We also integrated FMO exposure risk into this final ranking. However, since the exposure risk can be variable between local populations and FMO habitat within a core area, the results of this combined ranking should be evaluated with some degree of caution. In addition, baseline habitat conditions may also vary between local populations and FMO habitat within a core area, so bias may lean toward the FMO baseline habitat conditions in the core area ranking. However, bias is minimized by the fact that only those core areas with local populations with moderate to high exposure risk were evaluated, and that FMO habitat is typically an equal or greater portion of a core area's landscape when compared to its local populations.

The overall potential risk rankings for the core areas with local populations with a moderate to high exposure risk are summarized in Table 8-44. The three core areas determined to be at high (H) overall potential risk were the Yakima, Entiat, and Methow. The Wenatchee and Puyallup core areas were determined to be at a moderate-high (MH) overall potential risk, or the next highest risk category. The remaining seven core areas had a moderate (M) or moderate-low (ML) overall potential risk ranking.

Integrating the results of the core area and local population overall potential risk rankings would indicate that the Yakima and Entiat core areas are at greatest risk from FPHCP activities, with the Wenatchee, Puyallup, and Methow core areas also at high risk, but with that risk being more variable across their core areas.

Table 8-44. Overall potential risk rankings for core areas with at least one local population at moderate to high exposure risk.

	FMO Exposure Risk		FMO Habitat Risk		Core Area Population Risk		Overall Potential Risk	
Core Area	**rank 1**	**score 1**	**rank 2**	**score 2**	**rank 3**	**score 3**	**rank 4**	**score 4**
Yakima	H	3	H	3	H	3	H	3.0
Entiat	H	3	H	3	H	3	H	3.0
Methow	H	3	H	3	H	3	H	3.0
Wenatchee	H	3	H	3	M	2	MH	2.7
Puyallup	H	3	H	3	M	2	MH	2.7
Walla-Walla	M	2	H	3	M	2	M	2.3
Pend Oreille	L	1	H	3	H	3	M	2.3
Priest Lake	L	1	H	3	H	3	M	2.3
Stillaguamish	H	3	M	2	M	2	M	2.3
Nooksack	M	2	M	2	M	2	M	2.0
Snohomish/ Skykomish	M	2	M	2	M	2	M	2.0
Lewis	L	1	L	1	M	2	ML	1.3

8.6.4.6 Overall Risk for Core Areas Not Included in Overall Potential Risk Ranking

In the analysis of exposure risk, FMO habitats within six core areas were identified as having moderate to high exposure (i.e., containing greater than 20 percent FMO stream habitat on FPHCP covered lands), but no or low exposure risk to their corresponding local populations (Table 8-38). These areas were located within the Hoh, Dungeness, Elwha, Klickitat, Lower Skagit, and Skokomish core areas. These core area populations can still have risk from FPHCP activities on covered lands, especially for those core areas currently in a significantly impaired condition.

To evaluate the risk to the six core areas containing these FMO habitats, their exposure to FPHCP activities, baseline habitat condition, and core area baseline population condition were evaluated. The overall risk to these six core areas from FPHCP activities is considered to be generally less compared to the core areas ranked above in Table 8-44 due to the lack of exposure to their associated local populations. Because none of their local populations are directly affected, the primary risk to these six core populations is from potential impacts to their FMO habitats. As stated earlier, these habitats are generally less sensitive to the effects from activities on FPHCP covered lands. This does not mean that adverse effects from FPCHP activities will not occur to habitat in these FMO areas or that adverse effects will not occur to bull trout within these areas, but rather the adverse effects to a core population's more sensitive spawning and rearing habitats and more sensitive life stages will largely be avoided.

The overall potential risk rankings for these core areas with local populations with low to no exposure risk are summarized in Table 8-45. None of the six core areas were determined to be at a high (H) overall potential risk. Two core areas, Klickitat and Skokomish, were determined to be at moderate-high (MH) overall potential risk. The Hoh, Dungeness, and Elwha core areas were determined to be at a moderate (M) overall potential risk, and the Lower Skagit core area was determined to have a moderate-low (ML) overall potential risk ranking. The Klickitat core area and Skokomish core area risk rankings are driven by their poor baseline habitat conditions and depressed population status. The Klickitat core area primarily consists of a resident population of bull trout with apparently only a few remnant fluvial migrants. The Skokomish core area, while still containing a primarily migratory population, has been fragmented and suffers from low and declining abundances.

Table 8-45. Overall potential risk rankings for core areas with FMO habitats with moderate to high exposure, with local populations with low or no exposure risk.

	FMO Exposure Risk		FMO Habitat Risk		Core Area Population Risk		Overall Potential Risk	
Core Area	**rank 1**	**score 1**	**rank 2**	**score 2**	**rank 3**	**score 3**	**rank 4**	**score 4**
Klickitat	M	2	H	3	H	3	MH	2.7
Skokomish	M	2	H	3	H	3	MH	2.7
Hoh	H	3	M	2	M	2	M	2.3
Dungeness	M	2	M	2	M	2	M	2.0
Elwha	M	2	M	2	M	2	M	2.0
Lower Skagit	M	2	M	2	L	1	ML	1.7

8.6.4.7 Potential Local Population Risk

"Potential local populations" were identified in the draft Bull Trout Recovery Plan as important for recovery. Potential local population is defined in the draft recovery plan as, "A local population that does not currently exist, but that could exist, if spawning and rearing habitat or connectivity were restored in that area, and contribute to recovery in a known or suspected unoccupied area. Alternatively, a potential local population may be a population that is suspected to exist, but that has not yet been adequately documented (USFWS 2002, 2004a, 2004b)." In some cases, bull trout may have been observed in the potential local population area, but it is unknown whether they represent a spawning population due to the current lack of data demonstrating spawning and juvenile rearing, or due to the limited observations of individuals in the area. In other cases, these areas were identified as necessary for recovery because they were historically occupied by bull trout, but they are now either extirpated or presumed extirpated.

According to Rieman and McIntyre (1993), core areas with multiple local populations (ideally 5 or more) have a lower risk of local extirpation from stochastic events. They ultimately advise that it will be necessary to maintain multiple local populations within a core area to ensure conservation of bull trout populations. In some cases, habitats that could sustain local populations may require more intensive management and monitoring to ensure that their desirable characteristics are protected, enhanced, or restored (Rieman and McIntyre 1993).

Potential local populations were not included in the initial risk rankings because specific location of spawning sites is basically unknown and no population parameters (i.e., adult abundance and trend) are available for these populations. However, a coarse analysis of exposure risk can be conducted, especially if substantial amounts of the available habitat within a potential local population are encompassed by FPHCP covered lands or there are rough estimates of where spawning could likely occur. General baseline habitat risk can be evaluated for these areas since it looks at the potential local population as a whole (i.e., subwatershed scale). There are a total of nine potential local populations that contain FPHCP covered lands. We combined the two available risk categories (i.e., exposure risk and baseline habitat risk) to get a coarse estimate of the overall potential risk ranking for these potential local populations. These rankings are summarized below in Table 8-46.

Table 8-46. Combined exposure and baseline habitat risk rankings for potential local populations.

		Exposure Risk		Habitat Risk		Overall Potential Risk	
Core Area	**Potential LP**	**rank 1**	**score 1**	**rank 2**	**score 2**	**rank 4**	**score 4**
Asotin	Wormell Gulch	M	2	H	3	MH	2.5
Pend Oreille	Indian Creek	H	3	M	2	MH	2.5
Yakima	Taneum Creek	M	2	H	3	MH	2.5
Puyallup	Clearwater River	H	3	M	2	MH	2.5
Pend Oreille	Cedar Creek	M	2	M	2	M	2.0
Pend Oreille	Harvey Creek	M	2	M	2	M	2.0
Pend Oreille	SF Tacoma Creek	M	2	M	2	M	2.0
Pend Oreille	Small Creek	M	2	M	2	M	2.0
Elwha	Little River	L	1	M	2	ML	1.5

The results of the potential local population risk rankings suggest that with respect to recovery risk, the Yakima and Puyallup core areas incur an additional increment of risk to their overall potential core area risk ranking. It should be noted that the Pend Orielle core area is in an unusual situation. It currently contains only one known local population, LeClerc Creek, which was ranked at moderate-high (MH) overall potential risk. This fact, combined with the significant number of Pend Oreille potential local populations ranked at moderate (M) to moderate-high (MH) risk, places this core area at a more elevated risk from the perspective of recovery than its overall potential risk ranking might initially indicate.

8.6.5 MEASURE OF ADVERSE EFFECTS TO BULL TROUT

Tables 8-47 8-48, and 8-49 below display the measure of adverse effects to bull trout at the core area level in both their spawning and rearing habitat and FMO habitat. The tables also display the measure of adverse effects to bull trout FMO habitats located outside of core areas. Adverse effects may range from sub-lethal to lethal. In spawning and rearing habitats, egg, alevin, juvenile, and potentially sub-adult and adult life stages may be adversely affected, while in FMO habitats only sub-adult and adult life stages are anticipated to be affected. Actual effects to individual bull trout will vary from activity to activity depending on the specific riparian prescription applied, the location, historic management practices, geological characteristics of the watershed, and the biotic community present.

Table 8-47. Quantification of effects in bull trout core areas.

Core Area	Number of Stream Crossings	Miles of Stream Adjacent Roads Type S Streams	Miles of Stream Adjacent Roads Type F Streams	Miles of Stream Adjacent Roads Type Np Streams	Spawning and Rearing Stream Miles Adjacent to FPHCP Lands (equivalent acres of RMZs)
Columbia River DPS					
Asotin Creek	0	.10	.06	.92	0.8 (11.64)
Entiat	2	.56	1.56	2.48	7.3 (106.18)
Grande Ronde	0	0	0	0	0
Klickitat	0	0	0	0	0
Lewis	15	.60	4.75	4.39	15.4 (326.67)
Methow	0	1.07	.30	0	0
Pend Oreille	26	1.87	3.13	1.16	35.5 (516.36)
Priest Lakes	0	0	0	.10	0.9 (14.18)
Tucannon	1	0	.34	.06	1.5 (21.82)
Walla Walla	20	2.55	10.8	4.07	19.8 (288.00)
Wenatchee	7	8.99	6.63	5.22	12.9 (187.64)
Yakima	36	10.28	23.98	20.21	55.2 (802.91)
Coastal-Puget Sound DPS					
Chester Morse	0	0	0	0	0
Chilliwack	0	0	0	0	0
Dungeness	0	0	.81	.07	1.6 (33.94)
Elwha	3	0	0	0	0
Hoh	1	.86	0	0	2.7 (57.27)
Lower Skagit	5	1.19	1.42	4.72	7.7 (163.33)
Nooksack	44	16.84	14.41	25.46	57.1 (1211.21)
Puyallup	14	8.84	8.66	13.18	40 (848.49)
Queets	0	0	0	0	0
Quinault	0	0	0	0	0
Skokomish	0	0	.05	0	0.3 (6.36)
Snohomish/Skykomish	5	4.25	3.56	2.19	8.3 (176.01)
Stillaguamish	12	5.74	3.45	1.95	22.2 (470.91)
Upper Skagit	0	0	0.55	0	0.5 (10.61)

Table 8-48 Quantification of effects inside bull trout FMO habitat.

FMO inside of Core Area	Number of Stream Crossings of FMO	Miles of Stream Adjacent Roads Type S and F Streams	Miles of Stream Adjacent Roads Type F Streams	Miles of Stream Adjacent Roads Type Np Streams	Acres of RMZs adjacent to FMO habitat
			Columbia River DPS		
Asotin Creek	0	0.53	1.25	1.09	878.00
Entiat	4	7.26	1.11	5.39	1807.42
Grande Ronde	0	.07	1.87	1.53	524.80
Klicitat	2	18.01	21.60	44.28	13996.80
Lewis	2	17.76	55.22	18.86	16351.73
Methow	7	4.38	4.00	3.68	2502.4
Pend Oreille	3	9.18	26.01	17.27	12078.84
Priest Lakes	0	0.0	0.0	0	197.02
Tucannon	0	0.17	9.23	1.40	502.98
Walla Walla	29	2.29	26.70	13.70	4601.6
Wenatchee	17	9.96	12.46	28.35	2749.96
Yakima	22	28.58	38.88	63.77	22569.89
			Coastal-Puget Sound DPS		
Chester Morse	0	0	0	0	0
Chilliwack	5	3.06	6.19	2.25	2323.20
Dungeness	10	4.8	5.25	0.11	1553.26
Elwha	5	3.24	2.73	1.03	1273.60
Hoh	18	5.83	13.54	6.2	8441.93
Lower Skagit	42	40.57	90.53	43.1	32252.67
Nooksack	23	8.00	23.23	6.88	20471.99
Puyallup	22	35.6	58.92	35.48	33026.71
Queets	2	3.19	7.82	1.10	4716.80
Quinault	3	0.35	4.38	0.57	1958.40
Skokomish	4	2.45	5.25	0.18	1913.64
Snohomish/Skykomish	44	80.02	142.35	58.11	52534.39
Stillaguamish	22	21.13	50.86	18.92	21890.69
Upper Skagit	1	0.16	54.5	0.0	277.39

Table 8-49. Quantification of effects outside bull trout FMO habitat.

FMO outside of Core Areas	Number of Stream crossing	Miles of Stream Adjacent Roads Type S Streams	Miles of Stream Adjacent Roads Type F Streams	Miles of Stream Adjacent Roads Type Np Streams	Acres of RMZ adjacent to FMO habitat
Bell	1	0.0	4.9	179.24	512
Cedar/Steamboat	9	0.01	2.53	1.71	957.2
Chehalis	0	29.95	85.56	7.71	8249.6
Goodman	5	2.02	7.63	1.11	3136
Humtulips	8	9.97	26.41	4.40	6675.2
Kalalock	3	0.80	3.20	0.56	1075.20
Moclips/Copalis	13	5.47	20.03	2.85	8332.8
Morse	6	1.88	8.81	1.85	3667.20
Satsop	1	9.74	15.32	2.53	4051.20
Wishkah	9	7.73	113.09	3.60	4902.40
Wynoochee	2	9.29	8.85	1.58	3264.00
Lake Washington	4	23.09	55.05	6.98	11430.40
Lower Green	3	22.32	22.02	5.83	7571.20
Lower Nisqually	3	28.97	43.12	18.74	18745.60
Samamish	23	9.31	15.66	4.80	4563.20

8.6.6 EFFECTS OF THE ACTION ON POPULATIONS

8.6.6.1 Framework of Analysis

As discussed in the status of the species section for bull trout, the core areas assist in developing the basis for our conclusions in this analysis. Draft Bull Trout Recovery Plans have been developed for the Klamath and Columbia River population segments (USFWS 2002) and the Coastal-Puget Sound population segment (USFWS 2004a, 2004b), defined as interim recovery units, and we have grouped core areas into a series of Management Units to facilitate their management and recovery. Within the Coastal-Puget Sound population segment, we identified the Puget Sound and the Olympic Peninsula Management Units, and within the Columbia River population segment, we identified the Lower Columbia River, Middle Columbia River, Upper Columbia River, Clark Fork River, Umatilla-Walla Walla River, Grande Ronde River, Northeast Washington, and Snake River Management Units.

In general, core areas meet a set of biological criteria proposed by Rieman and McIntyre (1993) (see Lohr et al. 2001). A core area is defined as the combination of suitable habitat and one or more local populations (the smallest group of fish that are known to represent an interacting, reproductive unit) that function as one demographic unit with occasional gene flow between them. Generally, these groups of local populations are presumed to function as a metapopulation at the core area scale. The criteria have been expanded by the bull trout recovery planning team to focus on restoration of conditions and activities that are necessary for recovery. A core area represents the closest approximation of a biologically functioning unit for bull trout, and is the basic unit for measuring recovery.

The intent of the FWS's draft Bull Trout Recovery Plan was to protect the metapopulation structure. Bull trout in local populations have the chance to mate with individuals outside an individual local population but within a group of local populations (core area) (Whitesel et al. 2004). The basic unit for ensuring

long-term sustainability is the aggregation of local populations into core areas (Whitesel et al. 2004). Therefore, to facilitate and more accurately analyze effects to core areas our analysis focused on evaluating those primary elements that make up a core area, local populations (spawning and rearing habitat) and foraging, migration and overwintering habitats.

As previously described, we consider each bull trout local population an important phenotypic, genetic, and distributional component of its respective population segment. Adverse effects that impact the integrity of a bull trout local population and/or its habitat may appreciably reduce the likelihood of survival and recovery of the entire population segment (i.e., may contribute to jeopardy to the species, as defined by the ESA). This is determined through a multi-scale analysis, with the primary emphasis on the local population to discern impacts to the overall metapopulation (i.e., the core area scale). Generally, impacts to one or more local populations that result in a measurable metapopulation effect (i.e., in terms of numbers, reproduction, or distribution), may correspond to an impact at the core area scale. If core area-scale impacts are sufficiently severe, they may contribute to an appreciable reduction in the likelihood of survival and recovery of the population segment and the coterminus listed entity.

8.6.6.2 Summary of Geographic Risk Analysis Results

The geographic risk analysis evaluated the 25 core areas and their 124 local populations that are within or partially within Washington State. The geographic risk analysis determined that there were seven of 25 core areas that had less than 20 percnet FMO stream habitat and less than 10 percent spawning and rearing stream habitat (with low or no direct exposure) on FPHCP covered lands. These included the Grande Ronde, Tucannon, Chilliwack, Upper Skagit, Chester Morse Lake, Queets, and Quinault core areas. These core area's local populations (spawning and rearing habitats) and FMO habitats were determined to have no risk or extremely low risk of any adverse affects from the action. Therefore, it was determined that there were no resultant effects in these core areas that would contribute to an appreciable reduction in the likelihood of survival and recovery of either the entire Coastal-Puget Sound or entire Columbia River population segments.

The geographic risk analysis further determined that the remaining 18 core areas had either spawning and rearing stream habitat (12 core areas) or FMO stream habitat (6 core areas) on FPHCP covered lands that warranted further analysis. Our geographic risk analysis focused particularly on local populations (spawning and rearing habitats) given the greater sensitivity and greater relative value of these areas. Our coarse exposure analysis of the 124 local populations, determined 35 local populations contained no FPHCP covered lands (i.e., no direct risk), while 49 local populations had a small percentage (<3 %) of FPHCP covered lands that encompassed or were adjacent to a low risk area (e.g., non-spawning reach) of the local population. This determination further reduced the core areas of concern to 12 (40 local populations). Within these 12 core areas, the local populations that ranked with moderate to high exposure of FPCHP activities were further evaluated for baseline habitat risk and baseline population risk. We determined that three of the core areas only had local populations at low to moderate overall risk rankings, while the remaining nine core areas had some local populations at moderate-high to high overall potential risk rankings (see Table 8-43 under Bull Trout Geographic Risk Analysis section). We further concluded that of the local populations with a moderate-high overall potential risk ranking, the local populations with a high population risk ranking were of greatest relative concern. A total of 18 local populations meeting these criteria were identified in seven of the nine core areas (Table 8-50). These nine core areas are the Entiat, Methow, Pend Oreille, Walla-Walla, Wenatchee, and Yakima core areas in the Columbia River population segment, and the Nooksack, Puyallup, and Stillaguamish core areas in the Coastal-Puget Sound population segment.

Table 8-50. Risk rankings for local populations with moderate-high to high overall potential risk.

		Exposure Risk		Habitat Risk		Population Risk		Overall Potential Risk	
Core Area	**Local Population**	**rank 1**	**score 1**	**rank 2**	**score 2**	**rank 3**	**score 3**	**rank 4**	**score 4**
Walla-Walla	SF Touchet	H	3	H	3	H	3	H	3.0
Yakima	Ahtanum Creek	H	3	H	3	H	3	H	3.0
Yakima	NF Teanaway River	H	3	H	3	H	3	H	3.0
Yakima	Upper Yakima River	H	3	H	3	H	3	H	3.0
Wenatchee	Nason Creek	H	3	H	3	H	3	H	3.0
Entiat	Entiat River	H	3	H	3	H	3	H	3.0
Walla-Walla	NF Touchet	H	3	M	2	H	3	MH	2.7
Walla-Walla	Wolf Fork Touchet	H	3	M	2	H	3	MH	2.7
Pend Oreille	LeClerc Creek	H	3	M	2	H	3	MH	2.7
Yakima	Gold Creek	H	3	M	2	H	3	MH	2.7
Wenatchee	White River	H	3	M	2	H	3	MH	2.7
Entiat	Mad River	H	3	M	2	H	3	MH	2.7
Stillaguamish	Upper Deer Creek	M	2	H	3	H	3	MH	2.7
Yakima	Cle Elum River	M	2	H	3	H	3	MH	2.7
Wenatchee	Little Wenatchee River	M	2	H	3	H	3	MH	2.7
Wenatchee	Peshastin Creek	M	2	H	3	H	3	MH	2.7
Methow	Goat Creek	M	2	H	3	H	3	MH	2.7
Methow	Gold Creek	M	2	H	3	H	3	MH	2.7
Nooksack	Middle NF Nooksack River	H	3	H	3	M	2	MH	2.7
Nooksack	Lower SF Nooksack River	H	3	H	3	M	2	MH	2.7
Puyallup	Upper Puyallup and Mowich Rivers	H	3	H	3	M	2	MH	2.7
Walla-Walla	Mill Creek	H	3	H	3	M	2	MH	2.7

The geographic risk analysis also identified five core areas (Klickitat, Skokomish, Hoh, Dungeness, Elwha, and Lower Skagit) with significant risk of exposure to their FMO habitats from FPHCP activities, however, they had no to low exposure risk to their corresponding local populations. These FMO areas were further evaluated based on their baseline habitat risk and core area population risk.

8.6.6.3 FPHCP Conservation Measures that Minimize and Mitigate Effects

As discussed previously, the FPHCP has a number of conservation measures that help to reduce, minimize, and mitigate the potential and anticipated adverse effects from FPHCP activities. These features include the riparian buffers, ELZs, RMAPs, best management practices (BMPs) for roads, LHZ/RLIP and FPA screening, FFFPP, and SEPA Class 4 Special evaluations. Riparian buffer strategies strive to conserve adequate wood recruitment, and to minimize temperature increases and sediment inputs. RMAPS, road BMPs, and FFFPP strive to minimize sediment inputs directly related to roads and failing culverts. LHZ/RLIP and FPA screening and SEPA Class 4 Special evaluations strive to prevent FPHCP activity triggered slope failures and mass wasting, which will help conserve LWD recruitment and minimize temperature increases and sediment inputs to bull trout habitats. These conservation measures work collectively to reduce and/or minimize potential and anticipated adverse effects from sediment, loss of LWD, and increases in temperature to bull trout and their habitats. For more information about these conservation measures, refer to **Description of the Rule**.

The Section 10(a)(1)(A) recovery permit conditions for direct take associated with the capture and handling of bull trout during culvert replacements will minimize the level of direct injury or death of individuals related to this FPHCP activity. In addition, issuance of HPAs by WDFW for these particular activities may include project-specific permit conditions that are designed to further reduce the risk of direct injury or death.

8.6.6.4 Effects of the Action on Foraging, Migration, and Overwintering Habitat (FMO)

As stated in the geographic risk analysis, some FMO habitat may be ranked at high exposure risk; however, this does not equate with the same level of risk to local populations (i.e., spawning and rearing habitat). FPHCP activities are not expected to affect FMO habitat to the same degree as spawning and rearing habitat when FPHCP covered lands overlap or are adjacent to these areas. Bull trout FMO habitats are 1) typically larger bodies of water, 2) generally contain streams with warmer water temperatures, and 3) typically used seasonally by bull trout life stages that have less sensitive or restrictive habitat requirements. Therefore, the effects of FPHCP activities on tributaries or stream reaches feeding into FMO streams will more likely be reduced to acceptable levels before reaching many, if not most, FMO streams, and will correspondingly have more limited impacts to bull trout.

There were six core areas with FMO habitats ranked at moderate to high exposure risk, but they had no corresponding local populations with moderate to high exposure risk. Because none of their local populations are directly affected, the primary risk to populations in these six core areas is from potential impacts to their FMO habitats. As stated earlier, these habitats are generally less sensitive to the effects from activities on FPHCP covered lands. This does not mean that adverse effects from FPCHP activities would not occur to habitat in these FMO areas or that adverse effects would not occur to bull trout within these areas, but rather the adverse effects to the core population's more sensitive spawning and rearing habitats and more sensitive life stages are largely avoided. The geographic risk analysis, ultimately determined that none of the six core areas were at a high (H) overall potential risk from FPHCP activities.

Given the less sensitive nature of FMO stream habitat and the less sensitive or restrictive habitat requirements of the life stages at the time they are using this habitat, and because there are more limited effects of FPHCP activities to FMO stream habitat expected, we expect no resultant effects to any of the core areas that would contribute to an appreciable reduction in the likelihood of survival and recovery of bull trout.

8.6.6.5 Effects of the Action on Local Populations/Core Areas

In general, effects of the action to local populations (and consequently core areas) are anticipated to deliver sediment, increase temperature, and decrease large woody debris. This will likely correspond to a variety of sub-lethal effects, and in some cases (i.e., sediment in particular) may lead to lethal effects to individual bull trout. In addition, sediment, temperature, and large woody debris will likely be impacted irrespective of species presence. However, the severity of these effects will depend on the level of exposure to FPHCP activities, on site-specific conditions, and on the frequency, timing, duration, and intensity of forest practices in these local population areas.

Low to Moderate Overall Potential Risk Local Populations

The geographic risk analysis determined that 18 of the 40 local populations determined to be at moderate to high exposure risk from FPHCP activities were at a low to moderate overall potential risk relative to the other local populations (see Table 8-43 under Bull Trout Geographic Risk Analysis section). Four additional local populations were determined to be at a moderate-high overall potential risk, however, they only had a moderate baseline population risk.

Two key factors that determine the resiliency of local populations (and core areas) to potential adverse effects are population and habitat conditions. Local populations with either low to moderate baseline population and/or habitat risk were considered resilient enough to withstand any short-term adverse effects from FPHCP activities. Having low or moderate baseline risk for both conditions is not necessarily required to ensure resiliency, but this can substantially increase it. In addition, the level of exposure to FPHCP activities (as described by the exposure risk ranking) also informs the degree of potential effect that the local population must be resilient against. Through the results of the geographic risk analysis and after evalutating the effects of the FPHCP conservation measures, we do not anticipate the effects of the action to contribute to an appreciable reduction in the likelihood of survival and recovery at the local population scale for these 22 local populations. However, at the core area scale, we need to further evaluate the local populations that were ranked at higher risks. This analysis is presented below.

With respect to the Nooksack and Puyallup core areas, they were determined to have no other local populations with a high baseline population risk ranking and therefore we do not anticipate any appreciable reduction in the likelihood of survival and recovery from effects of FPHCP activities in these two core areas.

Moderate-High to High Overall Potential Risk Local Populations (w/High Population Risk)

Columbia River Population Segment

Entiat

The Entiat River core area is comprised of the Entiat and Mad Rivers local populations, both of which were characterized by a high risk rating in the geographic risk analysis. As previously described, the effects of the action are anticipated to result in varying amounts of increased sedimentation, increased stream temperature, and decreased large woody debris. The severity of these effects depends on the site-specific baseline conditions and the resiliency of the local population.

The Entiat River local population was ranked as high risk due to low numbers and few years of redd survey data to determine a trend. Although fairly long-term data were available in the core area for the Mad River local population, they were not directly comparable because the Mad River survey reach was shortened due to a log jam that may be a barrier, and the Entiat River local population was not discovered until 2000. Spawning is known to occur in the mainstem Entiat River with annual redd counts numbering from 1 to 7 redds, averaging about 4 redds since 2000. In addition, the habitat risk analysis suggests sediment, temperature, and large woody debris indicators are all at high risk. Generally, the population has low resiliency and the overall habitat conditions suggest a low resiliency to the effects of the action.

The Mad River local population was ranked as high risk due to low numbers in redd survey data (1989-2004). Annual redd counts have ranged from 37 to 52, exceeding 50 only once since 1989, but overall suggesting a fairly stable trend. In addition, the habitat risk analysis suggests sediment, temperature, and large woody debris indicators are all at moderate risk. Generally, the population has low resiliency and the overall habitat conditions suggest a moderate resiliency to the effects of the action.

Effects of the action to these two local populations are anticipated to deliver more sediment, and to a lesser degree increase temperature, and decrease large woody debris in some locations across the local population area. This will likely correspond to a variety of sub-lethal effects and in some cases (i.e., sediment in particular) lethal effects to individual bull trout. In addition, sediment, temperature, and large woody debris will likely be adversely affected irrespective of species presence. The severity of these effects will depend on site-specific factors and the frequency, timing, duration, and intensity of forest practices in these local population areas.

At the core area scale, the effects of the action to the aforementioned habitat indicators are generally anticipated to be moderate, depending on site-specific factors and the frequency, timing, duration, and intensity of forest practices. This suggests habitat conditions and processes are generally resilient enough to sustain the effects of the proposed action. However, population resiliency to the effects of the action is low for both local populations, and having only two local populations suggests an elevated risk to stochastic events. In addition, FMO habitats are also at high risk and these local populations spend at least six months in that FMO; this has the effect of subjecting bull trout to adverse effects in both their migratory and spawning and rearing habitats, potentially year-round. The population trend for the core area is not clear, but may be slightly decreasing based on redds counts (1989-2004). Currently, the size of these local populations is far below goals developed by the recovery team. Overall, this suggests that the Entiat core area is generally at high risk and is anticipated to experience varying amounts of adverse effects due to FPHCP activities over the next 50 years. However, FPHCP conservation measures and the conservation measures in Section 10(a)(1)(A) recovery permits required for any activity involving capture and handling of fish in association with fish salvage in these local populations, should reduce or minimize

the likelihood of lethal effects and reduce the uncertainty associated with the unknown site-specific conditions.

Methow

The Methow core area is comprised of 10 local populations and is the most upstream core area on the Columbia River basin below Grand Coulee Dam. Two of the local populations, Gold Creek and Goat Creek, were characterized by a high risk rating in the geographic risk analysis. As previously described, the effects of the action are anticipated to result in varying amounts of increased sedimentation, increased stream temperature, and decreased large woody debris. The severity of this effect depends on the site-specific baseline conditions and the resiliency of the local population.

The Gold Creek local population was ranked as high risk due to very low numbers of redds in survey data (1996-2003), poor habitat, and moderate exposure adjacent to the spawning and rearing area. The Gold Creek local population is located lowest in the Methow basin and has recently had a large fire burn in its upper watershed. Spawning is known to occur in the upper portion of Gold Creek with an average of only one redd a year. In addition, the habitat risk analysis indicates temperature and large woody debris indicators are at high risk while sediment is at moderate risk. Generally, the population and the habitat has low resiliency to the effects of the action.

The Goat Creek local population was ranked as high risk due to low numbers of redds in survey data (2000-2004), poor habitat conditions, and moderate exposure adjacent to the spawning and rearing area. Goat Creek is located further up in the Methow but is subjected to limited access during summer low flows with some reaches of the Methow completely dewatering. Spawning was not identified until 2000 and annual redd counts have ranged between 0 and 12, with an average of 6. In addition, the habitat risk analysis suggests sediment, temperature, and large woody debris indicators are all at moderate risk. Generally, the population has very low resiliency and the overall habitat conditions suggests moderate resiliency to the effects of the action.

Effects of the action to these two local populations are anticipated to deliver more sediment, and to a lesser degree increase temperature, and decrease large woody debris in some locations across the local population areas. This will likely correspond to a variety of sub-lethal effects and in some cases (i.e., sediment in particular) lethal effects to individual bull trout. In addition, sediment, temperature, and large woody debris habitat indicators will likely be adversely affected irrespective of species presence. The locations of project activities within the local populations are uncertain. The severity of these effects will depend on site-specific factors and the frequency, timing, duration, and intensity of forest practices in these local population areas.

At the core area scale, the effects of the action to the aforementioned habitat indicators are anticipated to range from moderate to high, depending on site-specific factors and the frequency, timing, duration, and intensity of forest practices. Additionally, there are four other local populations at moderate risk and FMO habitat which is at high risk due to exposure and habitat conditions, but are considered to be more resilient or less sensitive to the effects of the activities. When combined with the local populations that are at high risk, the core area will likely experience adverse effects in over half of the local populations and in much of the FMO habitat. Population resiliency to the effects of the action is very low in two of the local populations. Additionally, in the other four local populations discussed earlier there is a moderate to high resiliency, however, the exposure to the activities is also moderate. In addition, FMO habitats are also at high risk and these local populations spend at least six months in that FMO; this has the effect of subjecting bull trout to adverse effects in both migratory and spawning and rearing habitats,

potentially year-round. The population trend for the core area is not clear, but may be slightly decreasing based on redds counts (1995-2004). Currently, the size of these local populations is far below goals developed by the recovery team. Overall, this suggests that the Methow core area is generally at high risk and is anticipated to experience varying amounts of adverse effects due to FPHCP activities over the next 50 years. However, FPHCP conservation measures and the conservation measures in Section 10(a)(1)(A) recovery permits required for any activity involving capture and handling of fish in association with fish salvage in these local populations, should reduce or minimize the likelihood of lethal effects and reduce the uncertainty associated with the unknown site-specific conditions.

Pend Oreille

The Pend Oreille core area is comprised of 1 local population and 10 potential local populations; only the LeClerc Creek local population was characterized by a high risk rating in the geographic risk analysis. The mainstem Pend Oreille has three major dams in the U.S. portion and two more in Canada; none provide fish passage suggesting poor connectivity between local and potential local populations. As previously described, the effects of the action are anticipated to result in varying amounts of increased sedimentation, increased stream temperature, and decreased large woody debris. The severity of these effects depends on the site-specific baseline conditions and the resiliency of the local population.

The LeClerc Creek local population is characterized as a small, remnant population with very few recent documented observations. Although spawning is presumed to occur based on past observations of juvenile bull trout in LeClerc Creek, the location and extent of spawning and rearing is unknown. In addition, the habitat risk analysis suggests sediment, temperature, and large woody debris indicators are at high, moderate, and high risk, respectively. Generally, the population has very low resiliency but the overall habitat conditions suggest moderate resiliency to the effects of the action.

Effects of the action to the LeClerc local population are anticipated to deliver more sediment, and to a lesser degree increase temperature, and decrease large woody debris in some locations across the local population area. This will likely correspond to a variety of sub-lethal effects and in some cases (i.e., sediment in particular) lethal effects to individual bull trout. In addition, sediment, temperature, and large woody debris will likely be adversedly affected irrespective of species presence. The severity of these effects will depend on site-specific factors and the frequency, timing, duration, and intensity of forest practices in the local population area.

The Pend Oreille core area also has 10 potential local populations, including Cedar, Harvey, Indian, Mill, Ruby, Slate, Small, South Fork Tacoma, Sullivan, and Tacoma Creeks. However, none of these areas ranked as high risk due to their low to moderate exposure and habitat risk ratings. As a result, they are generally anticipated to be resilient to habitat effects of the proposed action. However, bull trout presence in these potential local populations is not well understood, and may vary from extremely low numbers to absent. As a result, these potential local population areas, if occupied, are anticipated to have very low resiliency to the effects of the action.

At the core area scale, the effects of the action to the aforementioned habitat indicators are anticipated to be moderate, depending on site-specific factors and the frequency, timing, duration, and intensity of forest practices. This suggests habitat conditions and processes are generally resilient enough to sustain the effects of the proposed action. However, population resiliency to the effects of the action is very limited and relies on a single, remnant population. By its very nature, the risk of impact or extirpation of this local population from stochastic events is also high. Loss of the LeClerc Creek local population would likely shrink the distribution of bull trout in Northeast Washington. In addition, FMO habitats are also at

high risk and these local populations spend at least six months in that FMO; this has the effect of subjecting bull trout to adverse effects in both their migratory and spawning and rearing habitats, potentially year-round. Currently, the size of these local populations is far below goals developed by the recovery team. Overall, this suggests that the Pend Oreille core area is generally at very high risk and is anticipated to experience varying amounts of adverse effects due to FPHCP activities over the next 50 years. However, FPCHP conservation measures and the conservation measures in Section 10(a)(1)(A) recovery permits required for any activity involving capture and handling of fish in association with fish salvage in these local populations, should reduce or minimize the likelihood of lethal effects and reduce the uncertainty associated with the unknown site-specific conditions.

Walla Walla

The Walla Walla core area is comprised of 4 local populations, but only the North Fork Touchet, South Fork Touchet, and Wolf Fork Touchet Rivers were characterized by a high risk rating in the geographic risk analysis. The Mill Creek population, a tributary of the Walla Walla River, is disjunct from the other three local populations of the Touchet River in the core area. As previously described, the effects of the action are anticipated to result in varying amounts of increased sedimentation, increased stream temperature, and decreased large woody debris. The severity of these effects depends on the site-specific baseline conditions and the resiliency of the local population.

The North Fork Touchet River local population was ranked as high risk due to low numbers and high variability in redd survey data (1994-2004). Spawning is known to occur in the upper portions of the North Fork Touchet River, with redd counts numbering from the mid-40's in the 1990's through 2001, but has since declined to a low of 22 in 2004. In addition, the habitat risk analysis suggests sediment, temperature, and large woody debris indicators are all at moderate risk. Generally, the population has low resiliency but the overall habitat conditions suggest a moderate resiliency to the effects of the action.

The South Fork Touchet River local population was ranked as high risk due to very low numbers and high variability in redd survey data (2000-2004). Spawning is known to occur in a single tributary and was not identified until 2000. After 16 redds were observed in the South Fork Touchet River in 2001, the redd count dropped to one in 2002, and no redds were seen in 2003 and 2004 surveys. In addition, the habitat risk analysis suggests sediment, temperature, and large woody debris indicators are all at high to moderate risk. Generally, the population has very low resiliency and the overall habitat conditions suggest a low to moderate resiliency to the effects of the action.

The Wolf Fork Touchet River local population was ranked as high risk due to low numbers and high variability in redd survey data (1994-2004). Spawning is known to occur in the upper potions of the Wolf Fork Touchet River and supports the largest population in Touchet River. However, annual redd counts have fluctuated widely, from 71 in 1994, down to 4 in 1997, then as high as 101 in 2003. Despite the high variability, the overall trend in redds have been upward in the Wolf Fork since 1998. In addition, the habitat risk analysis suggests sediment, temperature, and large woody debris indicators are all at moderate risk. Generally, the population has low resiliency but the overall habitat conditions suggest a low to moderate resiliency to the effects of the action.

Effects of the action to these three local populations are anticipated to deliver more sediment, and to a lesser degree increase temperature, and decrease large woody debris in some locations across the local population areas. This will likely correspond to a variety of sub-lethal effects and in some cases (i.e., sediment in particular) lethal effects to individual bull trout. In addition, sediment, temperature, and large woody debris will likely be adversely affected irrespective of species presence. The severity of these

effects will depend on site-specific factors and the frequency, timing, duration, and intensity of forest practices in these local population areas.

The Mill Creek local population is the remaining local population in the core area, but was not determined to be at high risk by the geographic risk analysis. The available data suggest a moderate population risk rating. Despite some annual variability, redd totals have generally been stable in Mill Creek since 1994. Annual redd counts have ranged between 118 and 220, with an average of 170, and with no discernible trend. As a result, the Mill Creek local population is generally anticipated to be resilient to the effects of the proposed action. Habitat effects, however, may be a more sensitive pathway due to the high exposure risk and high habitat risk of the local population. Overall, the population may have moderate resiliency but habitat conditions suggest low to moderate resiliency to the effects of the action.

At the core area scale, the effects of the action to the aforementioned habitat indicators are generally anticipated to be moderate, depending on site-specific factors and the frequency, timing, duration, and intensity of forest practices. This suggests habitat conditions and processes are generally resilient enough to sustain the effects of the proposed action. However, population resiliency to the effects of the action is low to very low in three of four local populations. In addition, FMO habitats are also at high risk and these local populations spend at least six months in that FMO; this has the effect of subjecting bull trout to adverse effects in both their migratory and spawning and rearing habitats, potentially year-round. Currently, the size of these local populations is far below goals developed by the recovery team. Overall, this suggests that the Walla Walla core area is generally at high risk and is anticipated to experience varing amounts of adverse effects due to FPHCP activities over the next 50 years. However, FPCHP conservation measures and the conservation measures in Section 10(a)(1)(A) recovery permits required for any activity involving capture and handling of fish in association with fish salvage in these local populations, should reduce or minimize the likelihood of lethal effect and reduce the uncertainty associated with the unknown site-specific conditions.

Wenatchee

The Wenatchee core area is comprised of 7 local populations. Four of the local populations, Nason Creek, White River, Little Wenatchee River, and Peshastin Creek were characterized by a high risk rating in the geographic risk analysis. As previously described, the effects of the action are anticipated to result in varying amounts of increased sedimentation, increased stream temperature, and decreased large woody debris. The severity of these effects depends on the site-specific baseline conditions and the resiliency of the local population.

The Nason Creek local population was ranked as high risk due to very low numbers of redds in the survey data (1999-2004), poor habitat, and high exposure adjacent spawning and rearing areas. The Nason Creek local population is the most upstream tributary to the Wenatchee River. It has been subjected to two large scale rain on snow events in the size of >100 year floods. It has been extensively harvested and several wildfires have occurred in the last 15 years. Spawning is known to occur in the upper portion of Nason Creek with annual redd count data showing 0 to 15 redds, with an overall average of 7 redds. In addition, the habitat risk analysis indicates sediment, temperature, and large woody debris indicators are at high risk. Generally, the population and the habitat has low resiliency to the effects of the action.

The White River local population was ranked as high risk due to low numbers and unstable or variable redd counts from 1986-2004, moderate habitat conditions, and high exposure of spawning and rearing areas. The White River local population is located in the only all glacial fed river and flows into Lake Wenatchee. Annual redd counts range from 2 to 90, with an average of 39. In addition, the habitat risk

analysis suggests sediment, temperature, and large woody debris indicators are at moderate to low risk from project activities. Generally, the population has low resiliency but the overall habitat conditions suggests a moderate to high resiliency to the effects of the action.

The Little Wenatchee local population was ranked as high risk due to very low numbers in spawning data from 1999-2004, poor habitat, and moderate exposure of spawning and rearing areas. Spawning was not identified until 1999 and annual redd counts have ranged between 0 and 5, with an average of 3. In addition, the habitat risk analysis suggests sediment, temperature, and large woody debris indicators are all at high risk. Generally, the population and habitat conditions have very low resiliency to the effects of the action.

The Peshastin Creek local population was ranked as high risk due to very low numbers in the spawning data from 2000-2004, poor habitat, and moderate exposure of spawning and rearing areas. Spawning was not identified until 2000 and annual redd counts have ranged between 0 and 9, with an average of 4. In addition, the habitat risk analysis suggests sediment, temperature, and large woody debris indicators are all at high risk. Generally, the population has very low resiliency and the overall habitat conditions suggests low resiliency to the effects of the action.

Effects of the action to these four local populations are anticipated to deliver more sediment, and to a lesser degree increase temperature, and decrease large woody debris in some locations across the local population areas. This will likely correspond to a variety of sub-lethal effects and in some cases (i.e., sediment in particular) lethal effects to individual bull trout. In addition, sediment, temperature, and large woody debris habitat indicators will likely be adversely affected irrespective of species presence. The locations of project activities within the local populations are uncertain. The severity of these effects will depend on site-specific factors and the frequency, timing, duration, and intensity of forest practices in these local population areas.

At the core area scale, the effects of the action to the aforementioned habitat indicators are anticipated to range from moderate to high, depending on site-specific factors and the frequency, timing, duration, and intensity of forest practices over the course of 50 years. Additionally, there are two other local populations at moderate risk and one other at a low risk to adverse effects, and FMO habitat is also at high risk to adverse effects due to exposure and habitat conditions, but these are thought to be more resilient and less sensitive to the effects of the activities. When combined with the local populations that are at high risk, the core area is anticipated to experience moderate to high levels of adverse effects in over half of the local populations and in much of the FMO habitat. Population resiliency to the effects of the action is very low in four of the local populations, but is moderate to high for the other three local populations. In addition, FMO habitats are also at high risk and these local populations spend at least six months in that FMO; this has the effect of subjecting bull trout to adverse effects in both their migratory and spawning and rearing habitats, potentially year-round. The core area population trend appears to be stable based on redd counts, but is heavily weighted on a single, large local population in the Chiwawa River. However, redd counts are highly variable and low in the other 6 local populations. Currently, the counts in all but one of the local populations are far below expected recovery numbers developed by the recovery team, and only the Chiwawa River local population is rated at low risk to adverse effects from project activities. Overall, this suggests that the Wenatchee core area is generally at high risk and is anticipated to experience varying amounts of adverse effects due to FPHCP activities. However, FPCHP conservation measures and the conservation measures in Section 10(a)(1)(A) recovery permits required for any activity involving capture and handling of fish in association with fish salvage in these local

populations, should reduce or minimize the likelihood of lethal effects and reduce the uncertainty associated with the unknown site-specific conditions.

Yakima

The Yakima core area is comprised of 15 local populations and 1 potential local population. However, only the Ahtanum Creek, Cle Elum River, Gold Creek, Teanaway River, and Upper Yakima River local populations were characterized as having a high risk rating in the geographic risk analysis. The Yakima may also represent a unique and distinct genotype and life history forms. Preliminary data suggest Yakima bull trout have few similarities between upper and lower Columbia bull trout. The Yakima basin is highly modified and has numerous partial and absolute fish-passage barriers. Five major water storage dams (for irrigation) fragment the metapopulation and prevent demographic and genetic exchange between local populations. In addition, numerous in channel irrigation diversion structures and diversions reduce instream flows by up to 80 percent. High temperatures and chemical contaminants are severe and prevalent enough to constitute barriers to passage. As previously described, the effects of the action are anticipated to result in varying amounts of increased sedimentation, increased stream temperature, and decreased large woody debris. The severity of this effect depends on the site-specific baseline conditions and the resiliency of the local population.

The Ahtanum Creek local population was ranked as high risk due to very low numbers, variability in redd counts (comparable data exists from 1999-2004), and a lack of a migratory life form. Spawning of resident fish is known to occur in the upper portions of the watershed, but annual redd counts number as few as 8 redds. In addition, the habitat risk analysis suggests sediment, temperature, and large woody debris indicators are all at high risk. It is also noteworthy that the Ahtanum has a very high exposure risk, with as much as 59 percent of the local population within or adjacent to FPHCP covered lands. Generally, the population has very low resiliency and the overall habitat conditions also suggest a low resiliency to the effects of the action.

The Cle Elum River local population was ranked as high risk due to very low numbers and high variability in redd survey data (1994-2004). Spawning is presumed to occur in the watershed but data has not been reliably collected to provide numbers or locations of key habitats. Generally, population size is thought to be very small. Evidence of hybridization with brook trout is also of concern in terms of population effects, with F2 hybrids documented in the mainstem Cle Elum. In addition, the habitat risk analysis suggests sediment, temperature, and large woody debris indicators are at high, high, and moderate risk, respectively. Generally, the population has low resiliency but the overall habitat conditions suggest a low to moderate resiliency to the effects of the action.

The Gold Creek local population was ranked as high risk due to very low numbers and high variability in redd survey data (1984-2004). Redd counts are variable but numbers have ranged from 20 to 52, with an average of 20 over the last 20 years. Spawning is known to occur in Gold Creek, but seasonal passage barriers due to stream dewatering from low flows restricts and isolates the spawning distribution above and below these barriers. In addition, the habitat risk analysis suggests sediment, temperature, and large woody debris indicators are all at moderate risk. Generally, the population has low resiliency but the overall habitat conditions suggest a moderate resiliency to the effects of the action.

The Teanaway River local population was ranked as high risk due to extremely low population numbers. Spawning is known to occur in the North Fork Teanaway, but the data are incomplete. Only six years of redd data have been reported in the last ten years, and never more than two redds have been reported. In addition, the habitat risk analysis suggests sediment, temperature, and large woody debris indicators are

all at high risk. Generally, the population has very low resiliency and the overall habitat conditions suggest a low resiliency to the effects of the action.

The Upper Yakima River local population was ranked as high risk due to very low numbers. Spawning is known to occur in the watershed, but redd counts data are limited to four years (2000 through 2003). Two redds were identified in 2000, 1 in 2001, but none were observed in 2002 or 2003. In addition, the habitat risk analysis suggests sediment, temperature, and large woody debris indicators are all at high risk. Generally, the population has low resiliency and the overall habitat conditions suggest a low resiliency to the effects of the action.

Effects of the action to these five local populations are anticipated to deliver more sediment, and to a lesser degree increase temperature, and decrease large woody debris in some locations across the local population areas. This will likely correspond to a variety of sub-lethal effects and in some cases (i.e., sediment in particular) lethal effects to individual bull trout. In addition, sediment, temperature, and large woody debris will likely be adversely affected irrespective of species presence. The severity of these effects will depend on site-specific factors and the frequency, timing, duration, and intensity of forest practices in these local population areas.

Beyond these five local populations above, 10 additional local populations and one potential local population are located in the Yakima core area, but these were not determined to be at high risk by the geographic risk analysis. These include the American River, Box Canyon Creek, Bumping River, Crow Creek, Deep Creek, Indian Creek, Kachess River, North Fork Tieton, Rattlesnake Creek, and South Fork Tieton local populations and the Tanuem Creek potential local populations. Nonetheless, the available data suggest a moderate population risk rating. Overall, the redd counts at the core area scale are relatively stable at about 525 since 1998, but are strongly influenced by the Indian Creek and South Fork Tieton local populations. As a result, these local populations and potential local population are generally anticipated to be resilient to the effects of the proposed action. Overall, the population may have moderate resiliency but habitat conditions suggest low to moderate resiliency to the effects of the action.

Impacts to the Taneum potential local population is anticipated to be moderate due to its low exposure risk rating. As a result, this potential local population is generally anticipated to be resilient to habitat effects of the proposed action. Bull trout distribution in the Taneum potential local population however, is not well understood, and the species may be absent. As a result, this potential local population area, if occupied, is anticipated to have very low resiliency to the effects of the action.

At the core area scale, the effects of the action to the aforementioned habitat indicators are anticipated to be moderate, depending on site-specific factors and the frequency, timing, duration, and intensity of forest practices. This suggests habitat conditions and processes are generally resilient enough to sustain the effects of the proposed action. However, population resiliency to the effects of the action is low to very low in 7 of 15 local populations, is moderate in 7, and is high in only 1. In addition, FMO habitats are also at high risk and these local populations spend at least six months in that FMO; this has the effect of subjecting bull trout to adverse effects in both migratory and spawning and rearing habitats, potentially year-round. The population trend for the core area appears to be declining based on redds counts (1984-2004). Currently, the size of these local populations is far below goals developed by the recovery team. Overall, this suggests that the Yakima core area is generally at high risk and is anticipated to experience varying amounts of adverse effects due to FPHCP activities. However, FPCHP conservation measures and the conservation measures in Section 10(a)(1)(A) recovery permits required for any activity involving capture and handling of fish in association with fish salvage in these local populations, should reduce or

minimize the likelihood of lethal effect and reduce the uncertainty associated with the unknown site-specific conditions.

Coastal-Puget Sound Population Segment

Stillaguamish Core Area

The Stillaguamish core area is comprised of 4 local populations, but only the Upper Deer Creek local population was characterized by a high risk rating in the geographic risk analysis. The Upper Deer Creek local population is one of two within the North Fork of the Stillaguamish River system. As previously described, the effects of the action are anticipated to result in varying amounts of increased sedimentation, increased stream temperature, and decreased large woody debris. The potential for and severity of these effects depends on the site-specific baseline conditions and the resiliency of the local population.

The Upper Deer Creek local population was ranked as high risk due to low numbers of adult spawners. Although no accurate counts have been made, current adult spawner abundance is estimated to be well below 100 individuals. In addition, the baseline habitat risk analysis suggests temperature and large woody debris indicators are at high risk, and sediment at a moderate risk. However, the habitat within this local population is considered to be recovering. Generally the population has low resiliency, but exposure risk to the effects is considered to be only moderate.

Effects of the action to this local population are anticipated to deliver additional sediment, and to a lesser degree increase temperature, and decrease large woody debris in primarily the most downstream portion of the local population. This will likely correspond to a variety of sub-lethal effects and in some cases (i.e., sediment in particular) may lead to lethal effects to individual bull trout. In addition, sediment, temperature, and large woody debris will likely be adversely affected irrespective of species presence. However, the severity of these effects will depend on site-specific conditions, and on the frequency, timing, duration, and intensity of forest practices in these local population areas.

At the core area scale, the effects of the action to the aforementioned habitat indicators are generally anticipated to be moderate, depending on site-specific factors and the frequency, timing, duration, and intensity of forest practices. This suggests habitat conditions and processes are generally resilient enough to sustain the effects of the proposed action. However, population resiliency to the effects of the action is likely low in the affected local population. In addition, FMO habitats are at moderate risk and this local population may spend at least six months in that FMO habitat depending on life history; this has the effect of subjecting bull trout to adverse effects in both their migratory and spawning and rearing habitats, potentially year-round. Overall, this suggests that the Stillaguamish core area is generally at moderate risk and is anticipated to experience varying amounts of adverse effects due to FPHCP activities. However, FPCHP conservation measures and the conservation measures in Section 10(a)(1)(A) recovery permits required for any activity involving capture and handling of fish in association with fish salvage in these local populations, should reduce or minimize the likelihood of lethal effects and reduce the uncertainty associated with the unknown site-specific conditions.

8.6.7 CUMULATIVE EFFECTS

Cumulative effects include the effects of future State, tribal, local or private actions that are reasonably certain to occur in the FPHCP Action Area considered in this Opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA. Numerous non-Federal actions that could affect listed

species are reasonably certain to occur within the FPHCP Action Area. These will typically include mining, agricultural activities, grazing, wildfire, and rural and residential development. Each of these future activities could contribute to cumulative effects on listed species or their habitat in the FPHCP Action Area.

In western Washington, 83 percent of the land is presently forested, 5 percent is in agriculture, 4 percent is urban and industrial lands, and the remaining 8 percent are comprised of water and wetlands, ice, snow and bare rock, shrubland, and grassland. Most of the development has occurred along Puget Sound and along major river systems.

In contrast, eastern Washington is 36 percent forested, 35 percent shrubland/grassland, 26 percent agriculture, 1 percent industrial and urban, and the remaining 3 percent water, wetlands, ice, snow, and bare rock. Major hydroelectric and irrigation developments along the Columbia River system have resulted in the greatest change to the eastern Washington landscape, particularly in the non-forested areas.

8.6.7.1 Population and Development

A rapidly expanding urban and industrial footprint will continue to impact bull trout and bull trout habitat. In western Washington, most of the growth is not only projected to continue to occur in and around Puget Sound, but also along major river systems. As development increases, aquatic habitats outside of protected areas will probably continue to decline. The rate of decline will depend on the amount of growth occurring in a particular area. Anadromous bull trout will continue to be affected by growth-induced impacts to habitat and water quality in Puget Sound and the lower reaches of many of the river systems entering Puget Sound. As growth continues to spread up these rivers, growth-associated impacts are also expected to move further upstream. These impacts are more likely to affect foraging, overwintering, and migration habitat within major river systems than spawning and rearing habitat nearer to the headwaters. Future growth in eastern Washington will probably occur near existing population centers, such as Spokane, Wenatchee, Yakima, and the Tri-cities area. While limited developable space is available within the cities themselves, growth around their peripheries is likely to be high.

8.6.7.2 Transportation

Major transportation projects including highway expansion and upgrades, new highways, and port expansions likely will have a Federal nexus and, therefore, are not part of this cumulative effects discussion. Smaller transportation networks may not fall under the same purview. These projects although on a smaller scale, could have a cumulative effect on bull trout habitat when the two intersect.

8.6.7.3 Forest Activities

Outside of tribal forestlands, federally owned and managed forest lands, and forest lands covered by an existing HCP, there is little forested acreage that is not part of this proposed action. The negative effects from activities associated with timber harvest on bull trout have been reduced over time through the implementation of the Northwest Forest Plan on Federal lands and landscape-scale HCPs on State and private lands. The remaining threats to bull trout and bull trout habitat related to forest activities includes the conversion of forested lands to other uses such as industrial and urban development, agriculture, and highway infrastructure. In addition to conversion, other activities may occur with or without the consent of the landowner. These activities include off-road-vehicle use, harvest of plant materials, dumping of trash, and other activities. As the population of Washington continues to grow, the rate of forestland conversion is likely to increase. More people also tend to place a greater demand on forested lands for the

other activities listed above. In the near-term, forestland conversion would likely continue to occur more rapidly along existing transportation corridors and major river systems and in those counties with the major population centers. Rural counties with relatively small populations are less likely to experience substantial growth in the near future and the need to convert forestlands will be somewhat less. However, improved communications and other technologies make it possible for many people to conduct business across broad geographic areas from relatively remote areas. These people draw development of support services to rural areas.

8.6.7.4 Mining

Mining will have localized impacts to bull trout and bull trout habitat. Continued growth will result in an increasing demand for materials such as sand, gravel, and rock. Although instream mining for these resources was the norm, extraction of these materials has occurred more recently in the floodplain of rivers or upland areas. The impacts associated with these methods of mineral-resource extractions may not be as direct, but they still can result in adverse effects to aquatic habitats. Outside where known mining operations occur, predicting where new mining might occur is speculative. It is likely that the majority of such mining will occur in somewhat close proximity to the ongoing development that forms the demand for sand, rock, and gravel. Floodplain mines within the active channel migration zone are at risk of capture by the river. Run-off from uplands mines can affect water quality and spawning and rearing habitat. In addition, recreational gold mining occurs in Washington especially in parts of eastern Washington. Impacts from such activities are expected to occur at some rate, but such activities are not likely to increase over time. Recreational gold mining can be localized, but with potential negative effects on spawning and rearing bull trout and habitat.

8.6.7.5 Agriculture and Grazing

Agricultural and grazing practices in riparian areas are generally less regulated than forest practices and, like unregulated forest practices, can have a profound effect on bull trout and bull trout habitat. Agricultural and grazing practices can degrade riparian conditions, destabilize streambanks, introduce sediment leading to increased water temperatures, streambed embeddedness, and the loss of cover including pools, woody debris, and overhanging vegetation. Water diversion and irrigation activities associated with agricultural activities are expected to continue, contributing to water quality and water quantity impacts. Diversions can also create barriers to bull trout migration by physically blocking the stream, by drying up portions of the stream, or creating a temperature barrier. Agriculture and grazing tend to be a greater threat to bull trout on the eastside of the Cascades where it accounts for over 25 percent of the land use. Only 5 percent of the land use in western Washington is attributed to agriculture.

8.6.7.6 Fire

Bull trout evolved under historic fire regimes in which disturbance to streams from forest fires resulted in a mosaic of diverse habitats. However, forest management and fire suppression over the past century have increased tree stocking levels, off-site species, moisture stress, and ladder and other fuels within terrestrial and riparian forests, increasing the likelihood of large, intense forest fires in some areas. The most-severe effects of fire on native fish populations can be expected where populations have become fragmented by human activities or natural events (Gresswell 1999).

Rieman and Clayton (1997) discussed relations among the effects of fire and timber harvest, aquatic habitats, and sensitive species. They noted that spatial diversity and complexity of aquatic habitats strongly influence the effects of large disturbances on salmonids. For example, Rieman et al. (1997b)

studied bull trout and redband trout responses to large, intense fires that burned three watersheds in the Boise National Forest in Idaho. Although the fires were the most intense on record, there was a mix of severely burned to unburned areas left after the fires. Fish were apparently eliminated in some stream reaches, whereas others contained relatively high densities of fish. Within a few years after the fires and after areas within the watersheds experienced debris flows, fish had become reestablished in many reaches, and densities increased. In some instances, fish densities were higher than those present before the fires or in streams that were not burned (Rieman et al. 1997b). These responses were attributed to spatial habitat diversity that supplied refuge areas for fish during the fires, and the ability of bull trout and the redband trout to move among stream reaches. For bull trout, the presence of migratory fish within the system was also important (Rieman and Clayton 1997, Rieman et al.1997b).

The risk of fires on bull trout habitat will vary based on current trajectories of forest conditions. In core areas where emphasis has been on the restoration of watershed processes that create and maintain habitat diversity, provide bull trout access to habitats, and protect or restore migratory life-history forms of bull trout, the effects of fire are expected to become less severe to these populations over time. Both passive (e.g., encouraging natural riparian vegetation and floodplain processes to function appropriately) and active (e.g., reducing road-related effects, removing barriers to fish movement, and improving habitat complexity) management responses would offer the best approaches to protect bull trout from the effects of large fires.

8.6.7.7 Other Activities

Other activities, including those described earlier in the **Comprehensive Environmental Baseline** section, will continue to degrade Washington's ecosystems. Some of these activities are more pertinent to bull trout and/or bull trout forage species. The accidental or purposeful introduction of non-native species will continue to occur and these species will continue to expand their ranges. These species will directly compete with bull trout for space and forage, prey upon bull trout, or will alter the habitats on which bull trout depend. Of these, brook trout may pose the biggest threat to bull trout. Brook trout are in the char family and are known to interbreed with bull trout. There are also more aggressive and tend to grow faster. Brook trout compete with bull trout for food and habitat and are more tolerant of warm water temperatures. And like bull trout, they thrive in cold water.

Recreational activities will increase as the population expands placing additional demands on the forested landscape where bull trout occur. Such demands can lead to habitat alteration or direct effects to bull trout via poaching or incidental catching of bull trout.

Habitat restoration and/or enhancement projects designed to improve habitat conditions may continue to increase in number, complexity, and scale. Although the effectiveness of some of these projects is not well known, monitoring of others continues to improve the science. Such projects have been effective and can have localized benefits for bull trout by improving habitat or connectivity between habitats. Many enhancement and restoration projects, and other corrective activities, are in the planning and/or implementation process. The success of those projects that have already been implemented is not always accurately known, but some monitoring is occurring. With continuing advances in understanding natural watershed processes and anticipated improvements to restoration science, we anticipate that future restoration projects will be better designed, provide more quality habitat, and be a better fit for the environment in which they are placed. As a whole, these restoration actions are expected to improve natural-resource conditions in the future, even in consideration of some short-term adverse effects.

8.6.7.8 Conclusion

Many of the existing activities described in the environmental baseline are expected to continue in Washington in the future and where such activities intersect bull trout and bull trout habitat, adverse effects can still be expected. Certain timber harvest, mining, and agricultural practices have improved over time, and are not anticipated to result in the extreme effects that occurred in the more-distant past. Ongoing, incremental adverse effects from these activities may be most severe to high risk populations, where habitats are still recovering from the legacy of more extreme adverse effects and bull trout abundances are currently depressed. Non-native, invasive species will continue to compete with bull trout and under some circumstances out-compete bull trout for forage and space. This will most likely occur where bull trout habitats are currently degraded or recovering, and where the migratory life history form of bull trout has been lost or is currently low in numbers. The increased human population growth and development within bull trout watersheds is likely to result in adverse effects to bull trout foraging, migratory, and spawning behaviors through degraded water quality, reduced flows, habitat changes, and migratory blockages. In turn, the degradation of the water quality and quantity and habitat alterations can make conditions more favorable for exotic species. The most severe development impacts to bull trout would be where development intersects with their local populations (i.e., spawning and rearing habitats).

8.6.8 CONCLUSION

We have reviewed the current status of the bull trout, the environmental baseline, the effects of the proposed FPHCP, and cumulative effects. Based on this review, it is our biological opinion that the FPHCP, as proposed, is not likely to jeopardize the continued existence of bull trout in the coterminous range.

The environmental baseline indicates that although bull trout are widely distributed within Washington, abundance is generally low to moderate within core areas of the Columbia River population segment and Coastal-Puget Sound population segment with some exceptions, and productivity is highly variable across core areas. Fragmentation and reduced distribution of the migratory life history form is generally more prevalent within core areas in the Columbia River population segment than within core areas in the Coastal-Puget Sound population segment. Baseline habitat conditions are generally poorer in spawning and rearing habitats of core areas within the Washington portion of the Columbia River population segment compared to the Coastal-Puget Sound population segment. At the core area scale, numerous historical and ongoing factors continue to limit the potential for population recovery within many of the core areas across the two population segments; however, there are a number of core areas with substantial bull trout habitat within relatively protected areas (e.g., wilderness areas and national parks). In some core areas, habitat is largely protected (e.g., Wilderness Areas and National Parks) and the presence of non-native fish species (i.e., brook trout and lake trout) may be the only significant factor of concern.

The proposed action will have short- to long-term adverse effects on bull trout through sediment, large woody debris, and temperature habitat indicators, but overall baseline habitat conditions should generally improve over the life of the FPHCP. The potential for severe short-term adverse effects is likely highest in core areas with local populations with low abundances and baseline habitat conditions that are currently poor. Where baseline habitat conditions are at low to moderate risk, the potential for severe short-term adverse effects is significantly reduced. Direct injury and death to bull trout may occur during some road crossing construction (e.g., stream dewatering and fish rescue and relocation, blockage of upstream migration during construction). The FPCHP conservation measures reduce the extent of such impacts, and Section 10(a)(1)(A) recovery permits required for any activity involving eletrofishing and

handling of fish in association with fish salvage in high risk local populations, should reduce or minimize the likelihood of lethal effects in these cases. Beneficial effects of the FPHCP, especially improved access to spawning and rearing habitat, overall improved riparian conditions, and overall reduction of sediment impacts to streams, should continue through the life of the HCP.

8.7 BULL TROUT CRITICAL HABITAT

8.7.1 STATUS OF BULL TROUT CRITICAL HABITAT (Rangewide)

8.7.1.1 Legal Status

The FWS published a final critical habitat designation for the coterminous United States population of the bull trout on September 26, 2005 (70 FR 56212); the rule became effective on October 26, 2005. The scope of the designation involved the Klamath River, Columbia River, Coastal-Puget Sound, and St. Mary-Belly River population segments (also considered as interim recovery units). Rangewide, the FWS designated 143,218 acres of reservoirs or lakes and 4,813 stream or shoreline iles as bull trout critical habitat (Table 8-51).

Table 8-51. Stream/shoreline distance and acres of reservoir or lakes designated as bull trout critical habitat by state.

	Stream/shoreline Miles	Stream/shoreline kilometers	Acres	Hectares
Idaho	294	474	50,627	20,488
Montana	1,058	1,703	31,916	12,916
Oregon	27,322	11,057	27,322	11.057
Oregon/Idaho	17	27		
Washington	1,519	2,445	33,353	13,497
Washington (marine)	985	1,585		

Although critical habitat has been designated across a wide area, some critical habitat segments were excluded in the final designation based on a careful balancing of the benefits of inclusion versus the benefits of exclusion (see Section 3(5)(A) and Exclusions under Section 4(b)(2) in the final rule). This balancing process resulted in all proposed critical habitat being excluded in 9 proposed critical habitat units: Unit 7 (Odell Lake), Unit 8 (John Day River Basin), Unit 15 (Clearwater River Basin), Unit 16 (Salmon River Basin), Unit 17 (Southwest Idaho River Basins), Unit 18 (Little Lost River), Unit 21 (Upper Columbia River), Unit 24 (Columbia River), and Unit 26 (Jarbidge River Basin). The remaining 20 proposed critical habitat units were designated in the final rule. It is important to note that the exclusion of waterbodies from designated critical habitat does not negate or diminish their importance for bull trout conservation.

8.7.1.2 Conservation Role and Description of Critical Habitat

The conservation role of bull trout critical habitat is to support viable core area populations (70 FR 56212). The core areas reflect the metapopulation structure of bull trout and are the closest approximation of a biologically functioning unit for the purposes of recovery planning and risk analyses.

Critical habitat units generally encompass one or more core areas and may include foraging, migration, and overwintering areas, outside of core areas, that are important to the survival and recovery of bull trout.

Because there are numerous exclusions that reflect land ownership, designated critical habitat is often fragmented and interspersed with excluded stream segments. These individual critical habitat segments are expected to contribute to the ability of the stream to support bull trout within local populations and core areas in each critical habitat unit.

The primary function of individual critical habitat units is to maintain and support core areas which (1) contain bull trout populations with the demographic characteristics needed to ensure their persistence and contain the habitat needed to sustain those characteristics (Rieman and McIntyre 1993); (2) provide for persistence of strong local populations, in part, by providing habitat conditions that encourage movement of migratory fish (Rieman and McIntyre 1993; MBTSG 1998); (3) are large enough to incorporate genetic and phenotypic diversity, but small enough to ensure connectivity between populations (Rieman and McIntyre 1993; Hard 1995; Healey and Prince 1995; MBTSG 1998); and (4) are distributed throughout the historical range of the species to preserve both genetic and phenotypic adaptations (Rieman and McIntyre 1993; Hard 1995; MBTSG 1998; Rieman and Allendorf 2001).

The Olympic Peninsula and Puget Sound Critical Habitat Units are essential to the conservation of amphidromous bull trout, which are unique to the Coastal-Puget Sound bull trout population. These critical habitat units contain marine nearshore and freshwater habitats, outside of core areas, that are used by bull trout from one or more core areas. These habitats, outside of core areas, contain PCEs that are critical to adult and sub-adult overwintering, migration, and foraging.

Within the designated critical habitat areas, the PCEs for bull trout are those habitat components that are essential for the primary biological needs of foraging, reproducing, rearing of young, dispersal, genetic exchange, and sheltering. Note that only the PCEs described in paragraphs (1), (2), (3), and (4) apply to marine nearshore waters identified as critical habitat; and all except PCE (3) apply to foraging, migration, and overwintering habitat identified as critical habitat.

The PCEs are as follows:

1. Water temperatures that support bull trout use. Bull trout have been documented in streams with temperatures from 32 to 72 ºF (0 to 22 ºC) but are found more frequently in temperatures ranging from 36 to 59 ºF (2 to 15 ºC). These temperature ranges may vary depending on bull trout life-history stage and form, geography, elevation, diurnal and seasonal variation, shade, such as that provided by riparian habitat, and local groundwater influence. Stream reaches with temperatures that preclude bull trout use are specifically excluded from designation;

2. Complex stream channels with features such as woody debris, side channels, pools, and undercut banks to provide a variety of depths, velocities, and instream structures;

3. Substrates of sufficient amount, size, and composition to ensure success of egg and embryo overwinter survival, fry emergence, and young-of-the-year and juvenile survival. This should include a minimal amount of fine substrate less than 0.25 inch (0.63 centimeter) in diameter;

4. A natural hydrograph, including peak, high, low, and base flows within historic ranges or, if regulated, currently operate under a biological opinion that addresses bull trout, or a hydrograph that demonstrates the ability to support bull trout populations by minimizing daily and day-to-day

fluctuations and minimizing departures from the natural cycle of flow levels corresponding with seasonal variation. This rule finds that reservoirs currently operating under a biological opinion that addresses bull trout provides management for PCEs as currently operated;

5. Springs, seeps, groundwater sources, and subsurface water to contribute to water quality and quantity as a cold water source;
6. Migratory corridors with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and foraging habitats, including intermittent or seasonal barriers induced by high water temperatures or low flows;
7. An abundant food base including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish; and
8. Permanent water of sufficient quantity and quality such that normal reproduction, growth, and survival are not inhibited.

Critical habitat includes the stream channels within the designated stream reaches, the shoreline of designated lakes, and the inshore extent of marine nearshore areas, including tidally influenced freshwater heads of estuaries.

In freshwater habitat, critical habitat includes the stream channels within the designated stream reaches, and includes a lateral extent as defined by the ordinary high-water line. In areas where ordinary high-water line has not been defined, the lateral extent would be defined by the bankfull elevation. Bankfull elevation is the level at which water begins to leave the channel and move into the floodplain and is reached at a discharge that generally has a recurrence interval of 1 to 2 years on the annual flood series. For designated lakes, the lateral extent of critical habitat is defined by the perimeter of the water body as mapped on standard 1:24,000 scale topographic maps.

In marine habitat, critical habitat includes the inshore extent of marine nearshore areas between mean lower low-water (MLLW) and minus 33 feet (10 meters) mean higher high-water (MHHW), including tidally influenced freshwater heads of estuaries. This refers to the area between the average of all lower low-water heights and all the higher high-water heights of the two daily tidal levels. The offshore extent of critical habitat for marine nearshore areas is based on the extent of the photic zone, which is the layer of water in which organisms are exposed to light. Critical habitat extends offshore to the depth of 33 feet (10 meters) relative to the MLLW.

Adjacent stream, lake, and shoreline riparian areas, bluffs, and uplands are not designated as critical habitat. However, it should be recognized that the quality of marine and freshwater habitat along streams, lakes, and shorelines is intrinsically related to the character of these adjacent features, and that human activities that occur outside of the designated critical habitat can have major effects on physical and biological features of the marine environment.

Activities that cause adverse effects to critical habitat are evaluated to determine if they are likely to "destroy or adversely modify" critical habitat by altering the PCEs to such an extent that critical habitat would not remain functional to serve the intended conservation role for the species (70 FR 56212; FWS 2004). Our evaluation must be conducted at the scale of the entire critical habitat area designated, unless otherwise stated in the final critical habitat rule (USFWS and NMFS 1998). Therefore, adverse modification of bull trout critical habitat is evaluated at the scale of the final designation, which includes

the critical habitat designated for the Klamath River, Columbia River, Coastal-Puget Sound, and St. Mary-Belly River population segments.

8.7.1.3 Current Condition Rangewide

The condition of bull trout critical habitat varies across its range from poor to good. Although still relatively distributed across its historic range, the bull trout occurs in low numbers in many areas, and populations are considered depressed or declining across much of its range (67 FR 71240). This condition reflects the condition of bull trout habitat.

There is widespread agreement in the scientific literature that many factors related to human activities have impacted bull trout and their habitat, and continue to do so. Among the many factors that contribute to degraded PCEs, those which appear to be particularly significant and have resulted in a legacy of degraded habitat conditions are as follows: (1) Fragmentation and isolation of local populations due to the proliferation of dams and water diversions that have eliminated habitat, altered water flow and temperature regimes, and impeded migratory movements (Rieman and McIntyre 1993; Dunham and Rieman 1999); (2) degradation of spawning and rearing habitat and upper watershed areas, particularly alterations in sedimentation rates and water temperature, resulting from forest and rangeland practices and intensive development of roads (Fraley and Shepard 1989; MBTSG 1998); (3) the introduction and spread of non-native species as a result of fish stocking and facilitated by degraded habitat conditions, particularly for brook trout and lake trout, which compete with bull trout for limited resources and, in the case of brook trout, hybridize with bull trout (Leary et al. 1993; Rieman et al. 2006); (4) in the Coastal-Puget Sound region where amphidromous bull trout occur, degradation of mainstem river FMO habitat, and the degradation and loss of marine nearshore foraging and migration habitat due to urban and residential development; and (5) degradation of foraging, migration, and overwintering habitat resulting from reduced prey base, roads, agriculture, development, and dams.

8.7.2 ENVIRONMENTAL BASELINE

Regulations implementing the ESA (50 CFR § 402.02) define the environmental baseline as the past and present impacts of all Federal, State, or private actions and other human activities in the FPHCP Action Area (see **Action Area** description). Also included in the environmental baseline are the anticipated impacts of all proposed Federal projects in the FPHCP Action Area that have undergone section 7 consultation, and the impacts of State and private actions which are contemporaneous with the consultation in progress.

Common to all the critical habitat units are past logging operations and the infrastructure necessary to carry out these activities. Such operations were mostly unregulated until the 1970's, although reforestation has been required since 1946. In 1974, the Washington Forest Practices Act was passed into law providing the start of comprehensive regulations on State and private forestry operations. Federal management on national forest lands incorporated the aquatic conservation strategy of Northwest Forest Plan, PACFISH, and INFISH beginning in 1993 through 1995. These management strategies have improved management on national forest lands in Washington and reduced the impact of forest management, which has resulted in a reduced rate of degradation within the FPHCP Action Area. Legacy effects from past logging and road building on Federal and non-Federal lands will likely continue for decades. Habitat conditions needed for bull trout recovery will require additional habitat restoration and threat abatement from land- and water-management practices affecting freshwater, estuarine, and/or

marine habitats. The descriptions below describe the condition of designated critical habitat within individual critical habitat units within the FPHCP Action Area of this Opinion.

8.7.2.1 Status of Coastal-Puget Sound and Columbia River Critical Habitat Units in the FPHCP Action Area

Critical habitat was excluded in waterbodies adjacent to lands subject to the current Washington Forest Practices Rules. These are the same lands now being assessed with respect to the proposed FPHCP (absent conversion of non-forestlands to forestlands). However, stream segments within the FPHCP Action Area, that were not adjacent to FPHCP covered lands, were designated as critical habitat. Critical habitat is interspersed with and immediately downstream of FPHCP covered lands and could be affected by FPHCP implementation. Even though riparian and upland areas may not be within a stream's bankfull width, and therefore were not included in the critical habitat designation, actions affecting these riparian and upland areas may affect PCEs within bull trout critical habitat.

This environmental baseline analysis is based on information provided in the proposed and final critical habitat rules, and the Washington Bull Trout Critical Habitat map dated January, 2006, which uses a scale of 1:100,000 (see Administrative Record for this Opinion). It is important to note that there are excluded stream segments within waterbodies designated as critical habitat on this map. Interspersed, excluded stream segments are not consistently identifiable on this map due to limitations related to scale and land ownership information. Therefore, this map should be considered a coarse approximation of final critical habitat locations. Exclusions can be more accurately identified using a finer resolution analysis.

We evaluated the exposure risk to bull trout critical habitat from the potential effects of the FPHCP, and current habitat baseline conditions in the FPHCP Action Area, by integrating both spatial and non-spatial information included in the bull trout Geographic Risk Analysis. Because areas designated as critical habitat are occupied by bull trout, we also used the species' exposure analysis to identify areas of critical habitat most likely to be affected by the FPHCP covered activities.

Where the information was available, the condition of PCEs were further described using our Bull Trout Matrix of Pathways and Indicators (Matrix), which includes the following habitat parameters: water quality, habitat access, habitat elements, channel conditions and dynamics, flow/hydrology, and watershed conditions. The bull trout baseline habitat assessment in the Geographic Risk Analysis summarized information from multiple indicators or similar information when describing each pathway in the Matrix. An additional evaluation of forage base was included in the critical habitat analysis, since this element was not specifically addressed by the baseline habitat assessment in the Geographic Risk Analysis. See Table I in Appendix C (Critical Habitat) for the crosswalk between the Matrix pathways and the PCEs to further understand how the habitat baseline for critical habitat was developed. For more detailed information describing the relationship between the Matrix pathways and indicators and the PCEs, see Appendix D (Critical Habitat). Table J and K summarize the exposure analysis of critical habitat segments to potential effects downstream of FPHCP covered lands.

In summary, PCE #1 (temperature) is addressed primarily by the Matrix water quality pathway; PCE #2 (complex stream channels) is addressed primarily by the Matrix habitat elements and channel conditions and dynamics pathways; PCE #3 (substrate) is addressed primarily by the Matrix water quality and habitat elements pathways; PCE #4 (natural hydrograph) is addressed primarily by the Matrix flow/hydrology and watershed conditions pathways; PCE #5 (springs, seeps, groundwater) is addressed primarily by the Matrix flow/hydrology and watershed conditions pathways; PCE #6 (migratory corridors) is addressed primarily by the Matrix habitat access pathway; PCE #7 (abundant food base) is

addressed by assessing all pathways together and evaluating the capacity for adequate forage to be present; and PCE #8 (permanent water) is addressed primarily by the flow/hydrology pathway. In addition, PCE #7 (abundant food base) may also be assessed by looking at connectivity, presence of productive foraging areas (e.g., lake or estuary), presence of anadromous fish, and presence of non-native fish.

8.7.2.2 Summary of Critical Habitat Unit Status

Columbia River Interim Recovery Unit

Clark Fork: Unit 2

Although no critical habitat in the Clark Fork Critical Habitat Unit has been designated within the FPHCP Action Area (State of Washington), there are FPHCP covered lands within this Critical Habitat Unit. Designated critical habitat segments within the Priest Lake and Lake Pend Oreille core areas in the State of Idaho are located a significant distance downstream of FPHCP covered lands, and beyond where effects are expected. In addition, these FPHCP covered lands are located outside of the riparian zone and are not adjacent to streams that flow into bull trout occupied habitat. Therefore, FPHCP forest management activities on these lands are not anticipated to have any affect on the PCEs in the designated critical habitat in Idaho, and the status of that critical habitat unit does not need to be further addressed.

Umatilla-Walla Walla: Unit 9

The Umatilla-Walla Walla Critical Habitat Unit covers lands in both Washington and Oregon. Within this Critical Habitat Unit, the Walla Walla River is the only tributary to the Columbia River Basin in Washington. It is also the only core area within this Critical Habitat Unit in Washington. Critical habitat in the Walla Walla core area supports four local populations. FPHCP covered lands are generally interspersed and upslope of critical habitat areas used by bull trout for both spawning and rearing habitat and FMO habitat. The majority of designated critical habitat lies within areas where non-FPHCP covered lands occur in lower portions of the larger river systems. Critical habitat has been designated within the Mill Creek, North Fork Touchet, and South Fork Touchet local populations. It is also designated in FMO habitat in Mill Creek, Yellowhawk Creek, North Fork Touchet, South Fork Touchet, Wolf Fork Touchet, and the Walla Walla mainstem.

Within the Walla Walla Critical Habitat Unit, historical and current land-use practices have affected critical habitat in bull trout local populations and FMO areas. Such practices include construction and operation of dams, construction and maintenance of roads, logging, agricultural development and associated water withdrawals, and mining. Some of these historical activities that caused passage barriers may have significantly reduced abundance of important fluvial populations. Lasting effects of some of these activities may still limit bull trout abundance and distribution in the Walla Walla Critical Habitat Unit. Existing activities that continue to contribute to fish-habitat problems, such as increased temperatures and elevated sediment levels, include the operation and maintenance of dams, riparian road construction and use, riparian grazing, agricultural and residential development, recreational use of riparian areas, illegal harvest, and the introduction of non-native species. It is likely that within critical habitat segments in the Walla Walla River Critical Habitat Unit, PCEs 1, 2, 4, 5, 6, and 7 have been degraded, although the severity of degradation varies on a site-specific basis.

In the Walla Walla Critical Habitat Unit, spawning and rearing critical habitat segments were ranked at high risk of becoming non-functional in the following local populations: Mill Creek and South Fork

Touchet. Segments of critical habitat were ranked at moderate risk of becoming non-functional in the Wolf Fork Touchet and North Fork Touchet. Segments of FMO critical habitat in the Walla Walla core area are ranked at high risk of becoming non-functional. Table I in Appendix C (Critical Habitat) displays the PCEs overlaid with the habitat analysis and the additional forage base category. The exposure risk summary indicates spawning and rearing critical habitat is at high risk of exposure to the potential effects from activities on FPHCP covered lands in North Fork Touchet and at a moderate risk of exposure in Mill Creek and Sorth Fork Touchet. In addition, FMO critical habitat is at high risk of exposure for Mill Creek and South Fork Touchet, and at a moderate risk of exposure for North Fork Touchet and Wolf Fork Touchet. There are no FPHCP covered lands interspersed or upslope of FMO critical habitat in Yellowhawk Creek and the Walla Walla mainstem. No critical habitat was designated in spawning and rearing streams in the Wolf Fork Touchet local populations. See Table J and K in Appendix C (Critical Habitat) for summaries of the exposure rankings.

Grande Ronde River: Unit 10

Designated critical habitat segments within this Critical Habitat Unit, and in the FPHCP Action Area, are located within FMO areas of the lower Grande Ronde River and extends to its confluence with the Snake River. Based on exclusions described in the final critical habitat rule, there are no critical habitat segments located in local populations within the Washington portion of this Critical Habitat Unit. Spawning and rearing streams have all been excluded. Only stream habitats within one of the two core areas, the Grande Ronde core area, are located in Washington. The Grande Ronde River, extending from its confluence with the Snake River upstream to Meadow Brook Creek, provides key foraging, migration, and overwintering habitat for sub-adult and adult fluvial bull trout (67 FR 71235). It is the primary migration corridor that supports and links eight local populations in the Grande Ronde River and Wallowa River basins.

Within the Grand Ronde Critical Habitat Unit, historical and current land-use practices have affected bull trout critical habitat in local populations and FMO areas. Such practices include construction and operation of dams, construction and maintenance of roads, logging, agricultural development and associated water withdrawals, and mining. These have resulted in reduced connectivity, altered flows, elevated stream temperatures, and increased sediment levels. Some of these historical activities that have caused passage barriers may have significantly reduced abundance of important fluvial populations. Lasting effects of some of these activities may still limit bull trout abundance and distribution in the Grande Ronde Critical Habitat Unit. Existing activities that continue to contribute to fish-habitat problems include the operation and maintenance of dams, riparian road construction and use, riparian grazing, agricultural and residential development, recreational use of riparian areas, and the introduction of non-native species. It is likely that within critical habitat segments in the Grande Ronde River Critical Habitat Unit, PCEs 1, 2, 4, 5, 6, and 7 have been degraded, although the severity of degradation varies on a site-specific basis. The Wenaha River may be the only low elevation watershed in the Columbia Basin that is almost completely protected by designated wilderness and is virtually unaltered by human activity (Baxter 2002), and therefore all the PCEs are functional.

In the Grande Ronde Critical Habitat Unit, FMO critical habitat segments were ranked at a moderate to high risk of becoming non-functional. Because the designated FMO critical habitat stream segments are not directly adjacent to FPHCP covered lands or are located within Oregon, risk of exposure to the potential effects from activities on FPHCP covered lands is expected to be low.

Coeur d'Alene Lake Basin: Unit 14

For the portion of this Critical Habitat Unit within the FPHCP Action Area, there are no stream segments that are designated as critical habitat or that flow into designated critical habitat stream segments. Streams within the FPHCP Action Area that originate in Washington flow into Idaho's Lake Pend Oreille, which is designated as critical habitat. Due to the long downstream distance between FPHCP covered lands and designated critical habitat in Lake Pend Oreille, FPHCP activities are not anticipated to affect the PCEs in this designated critical habitat, and the status of this critical habitat unit does not need to be further addressed.

Lower Columbia River Basin: Unit 19

Critical habitat has been designated in Lewis and Klickitat core areas, and White Salmon core habitat. In the Lower Columbia River Critical Habitat Unit, all spawning and rearing habitat was excluded in the final designation, except for within the Klickitat core area. In the Lewis River core area, critical habitat has been designated in the lower Lewis River upstream from its confluence with the Columbia River. This segment of the Lewis River is anticipated to provide important FMO habitat and connectivity to the Columbia River once fish passage is restored at Merwin, Yale, and Swift Dams. In the White Salmon core habitat, critical habitat has been designated in the mainstem White Salmon River. Once passage is fully restored at Condit Dam, this section of the river will provide an important migratory corridor to and from the Columbia River and provide important FMO habitat for migratory bull trout. In the Klickitat core area, critical habitat has been designated in the Klickitat River, Clearwater Creek, Fish Lake Stream, Little Muddy Creek, Trappers Creek, Two Lakes Stream, an unnamed tributary to Fish Lake Stream, and the WF Klickitat River. The WF Klickitat River and the above-named tributaries support the only known bull trout local population in the Klickitat core area. However, spawning and rearing critical habitat within the Klickitat core area is located upstream of FPHCP covered lands and therefore has no exposure to FPHCP activities. FMO critical habitat within the Klickitat River provides habitat essential for maintaining connectivity between the Kickitat core area and the Columbia River FMO habitat. FPHCP covered lands are located upstream of and are interspersed with FMO critical habitat segments in the Klickitat River.

Within the Lower Columbia River Critical Habitat Unit, historic and current land-use activities have affected bull trout habitat critical habitat. Dams have fragmented bull trout habitat, isolated local populations, and prevented access to historical foraging and overwintering habitat. Recent settlement agreements for hydropower projects on the Lewis River will reduce the magnitude of the threat posed by dams in this Critical Habitat Unit. Past forest-management activities have also altered habitat conditions in portions of the Critical Habitat Unit. The effects to bull trout habitat result from impassable culverts, excessive erosion and sedimentation, reduced recruitment of large wood, channel changes, and altered water temperatures, instream flows, and runoff patterns. Grazing in the Klickitat core area has resulted in eroded streambanks, increased sedimentation, and incised stream channels. Water withdrawals for agriculture have reduced instream flows and resulted in increased water temperatures. The known bull trout spawning and rearing streams (portions of Cougar, Pine, Rush Creeks, and WF Klickitat River) within this Critical Habitat Unit are impacted by a variety of land-management activities associated with a mosaic of land ownership including Federal, State, tribal, private residential and forestry, and PacifiCorp lands. Portions of the bull trout habitat in the Pine Creek were also impacted by the eruption of Mt. St. Helens. It is likely that within critical habitat segments in the Lower Columbia Critical Habitat Unit all of the PCEs except three have experienced some degradation, with PCEs 1, 2, and 6 being most severely impacted.

In the Lower Columbia River Critical Habitat Unit, FMO critical habitat segments in the Klickitat core area were ranked at high risk of becoming non-functional. This core area also has a high risk of exposure to potential effects from activities on FPHCP covered lands. FMO critical habitat segments on the Lewis and White Salmon Rivers were ranked at moderate risk of becoming non-functional, but have a low risk of exposure to the potential effects from activities on FPHCP covered lands.

Middle Columbia River Basin: Unit 20

Critical habitat has been designated in streams and rivers both upstream and downstream of FPHCP covered lands throughout the Yakima River basin, which is the only core area within this Critical Habitat Unit. Critical habitat in the Yakima River core area supports 16 local populations, one potential local population, and FMO habitat throughout the core area. The majority of designated critical habitat lies within the lower portions of the larger river systems where non-FPHCP covered lands occur. Spawning and rearing critical habitat has been designated within the following local populations: Ahtanum Creek, Box Canyon Creek, Bumping River, Cle Elum River, Gold Creek, Kachess River, Naches River, North Fork Tieton River, Rattlesnake Creek, Teanaway River, Tieton River, and the mainstem Yakima River. It has also been designated in FMO habitat in the mainstem Ahtanum Creek, Naches River, Tieton River, Teanaway River, Cle Elum River, Kachess River, and mainstem Yakima River. FPHCP covered lands are upstream of and interspersed with the designated segments of critical habitat.

Bull trout in the Middle Columbia Critical Habitat Unit may have been extirpated from some former habitats and remaining populations are fragmented and isolated due to a variety of factors. Critical habitat is degraded due to isolation by dams, agricultural practices, and associated water withdrawals that have affected stream temperatures, passage, sediment, and flows. Multiple Bureau of Reclamation irrigation reservoirs currently lack fish passage and block access to most spawning and rearing habitat. Additional activities affecting critical habitat in the basin include forestry practices, grazing, roads, mining, non-native species, contaminants, and residential development. In addition, drought conditions have increased the potential for fire impacts within most forested areas. The updated State Forest Practice Rules and the Northwest Forest Plan are expected to reduce the level of future timber harvest impacts to bull trout streams on private and public lands. However, most legacy threats from past forest practices will likely continue to be a threat for decades. Within the Yakima Critical Habitat Unit, PCEs 1, 2, 4, 5, 6, 7, and 8 have experienced some degree of degradation.

In the Middle Columbia River Basin Critical Habitat Unit, spawning and rearing critical habitat segments were ranked at high risk of becoming non-functional in the following local populations: Ahtanum Creek, Teanaway River, the Mainstem Yakima River, and Cle Elum River. Critical habitat segments in the following local populations were ranked at moderate risk of becoming non-functional: Gold Creek, Rattlesnake Creek, and North Fork Tieton. All FMO critical habitat segments in this core area were ranked at high risk of becoming non-functional (see Table I in Appendix C (Critical Habitat)). The exposure risk summary in Appendix C, Table B indicates spawning and rearing critical habitat is at high risk of exposure to potential effects from activities on FPHCP covered lands in Ahtanum Creek, Teanaway River, and upper Yakima River mainstem; is at moderate risk of exposure in Gold Creek and Rattlesnake Creek areas; and at low risk of exposure in Cle Elum River and North Fork Tieton. In addition, FMO critical habitat is at high risk of exposure in Ahtanum Creek, Teanaway River, upper Yakima River mainstem, Cle Elum River, Kachess River, Tieton River, and Naches River; and is at a low risk of exposure in Bumping River. See Table J and K in Appendix C (Critical Habitat) for summaries of the exposure rankings.

Northeast Washington River Basins: Unit 22

Critical habitat has been designated in streams and rivers either upstream or downstream from FPHCP covered lands throughout the Northeast Washington River Basins Critical Habitat Unit. The Pend Oreille River is the only tributary to the Columbia River basin and the only core area within this Critical Habitat Unit. Critical habitat in the Pend Oreille core area supports one local population and 10 potential local populations. The majority of designated segments of critical habitat lie within areas where non-FPHCP covered lands occur in lower portions of the larger river systems. FPHCP covered lands are generally interspersed and upslope of critical habitat stream segments used by bull trout for spawning and rearing, or for foraging, migration and overwintering. The majority of designated critical habitat lies within areas where non-FPHCP covered lands occur in lower portions of the larger river systems. Critical habitat has been designated within the LeClerc Creek local population and the following potential local populations: Cedar Creek, Indian Creek, Mill Creek, Ruby Creek, Slate Creek, Small Creek, Sorth Fork Tacoma Creek, and Tacoma Creek. It has also been designated in FMO habitat in Calispell Creek, LeClerc Creek, Sorth Fork Tacoma Creek, Small Creek, Sullivan Creek, and Tacoma Creek.

Within the Northeast Washington Critical Habitat Unit, historical and current land-use activities have impacted the habitat in local populations and foraging, migration and overwintering areas. The construction and operation of Albeni Falls, Box Canyon, and Boundary dams on the Pend Oreille River have fragmented habitat and negatively affected bull trout. Other dams and diversions without fish-passage facilities in tributaries to the Pend Oreille River have further fragmented habitat and reduced connectivity. Effects from past logging have altered habitat conditions in portions of the Critical Habitat Unit. The legacy of these activities still persists where poorly constructed roads, impassible culverts, and channel changes remain. Livestock grazing has degraded both upland and riparian areas of most tributaries in the watershed on public and private land. In addition, drought conditions have increased the potential for fire impacts within most forested areas. The introduction of non-native species has continued to effect bull trout populations through predation, competition, and hybridization. PCEs 1, 2, 4, 5, 6, 7, and 8 have experienced varying degrees of degradation.

In the Northeast Washington River Basins Critical Habitat Unit, spawning and rearing critical habitat segments in the LeClerc Creek local population, and Mill Creek and Tacoma Creek potential local populations were ranked at high risk of becoming non-functional. Spawning and rearing critical habitat segments in Indian Creek, Small Creek, East Fork Small Creek, South Fork Tacoma Creek, and Cedar Creek potential local populations were ranked at moderate risk of becoming non-functional. FMO critical habitat segments were ranked at high risk of becoming non-functional within this core area. Table I in Appendix C (Critical Habitat) displays the PCEs overlaid with the habitat analysis and the additional forage base category. The exposure risk summary indicates spawning and rearing critical habitat is at high risk of exposure to potential effects from activities on FPHCP covered lands in Tacoma Creek, at low risk of exposure in Mill Creek, and is at moderate risk of exposure in all other spawning and rearing areas. In addition, FMO critical habitat segments are at high risk of exposure in Calispell Creek, and Small Creek, and are at a moderate risk of exposure in all other FMO habitat. See Table J and K in Appendix C (Critical Habitat) for summaries of the exposure rankings.

Snake River Washington: Unit 23

FPHCP covered lands are located in the upper portion of George Creek in the Wormell Gulch potential local population in the Asotin core area and in the Cummings Creek local population in the Tucannon River core area. George Creek has been identified as a priority stream in the Wormell Gulch potential

local population in the Asotin Creek core area and is considered essential to the recovery of bull trout. The Cummings Creek and North Fork Asotin Creek local populations contains spawning and rearing critical habitat.

Within the Snake River Washington Critical Habitat Unit, historical and current land-use practices have degraded bull trout critical habitat designated in spawning and rearing, and FMO areas. Some historical activities, especially the construction of low-head dams in the early 1900's, may have significantly reduced connectivity for important fluvial populations of bull trout. A combination of human-induced factors have degraded bull trout critical habitat, including till-crop production and irrigation withdrawals, livestock grazing, logging, hydropower production, introduction and management of non-native species, urbanization, and transportation networks. Lasting effects from some of these early land and water developments still limit bull trout habitat in both the Tucannon and Asotin Creek core areas. Three flood events have occurred in these core areas since 1964. The degraded conditions of the stream corridors prior to the floods, especially the conversion of floodplains into agricultural lands and road networks, resulted in even greater flood-related damage than otherwise would have been expected. This reduced the ability of the streams to recover their natural fluvial processes. Due to historical and current land use practices PCEs 1, 2, 4, 5, and 6 have experienced varying degrees of degradation in Wormell Gulch.

In the Snake River Washington Critical Habitat Unit, there are no FPHCP covered lands interspersed with or directly upstream of critical habitat segments in the Wormell Gulch potential local population; therefore, there is no risk of exposure. Information about critical habitat conditions in Cummings Creek local population was not available and by default, the habitat condition was ranked at low-moderate. It is at low risk of exposure to potential effects from activities on FPHCP covered lands. See Table J and K in Appendix C (Critical Habitat) for summaries of the exposure rankings.

Coastal-Puget Sound Interim Recovery Units

Olympic Peninsula: Unit 27

Critical habitat has been designated in streams and rivers in all core areas within this unit. In all core areas except for the Dungeness, FPHCP covered lands are downstream of local populations and interspersed throughout or upstream from designated FMO critical habitat segments. In the Elwha core area, critical habitat has also been designated in the Little River potential local population. In the Dungeness River core area, a small amount of FPHCP covered lands are located within one local population. All designated critical habitat in this core area is located downstream of or interspersed with areas in FMO habitat. Critical habitat has also been designated in the following FMO habitat outside of core areas where FPHCP covered lands are either interspersed, upstream, or immediately adjacent: Bell, Cedar, Ennis, Goodman, Joe, Kalaloch, Morse, Mosquito, and Steamboat Creeks; Canyon, Chehalis, Copalis, Humptulips, Moclips, Satsop, and WF Satsop Rivers; and Grays Harbor, Hood Canal, Pacific Coast, and Strait of Juan de Fuca marine FMO habitats.

On the Olympic Peninsula, a significant portion of the major river basins, particularly the upper river portions where most bull trout spawning and rearing occurs, lie within the Olympic National Park. Spawning and rearing critical habitat has been designated in these areas within the Park. However, FMO critical habitat conditions are degraded downstream of the park boundary (WSCC 2000a, 2001c). In the largely rural setting of the Olympic Peninsula, habitat effects are primarily related to past logging and associated roading and, to a lesser degree, dams and agricultural practices. Habitat conditions have improved to some extent over the past decade with more-protective forest practices and declining timber

harvest on public lands. Although migratory corridors are still functional, especially on the westside of the Olympic Peninsula, critical habitat conditions related to suitable temperatures, floodplain connectivity, substrate, timing and magnitude of flows, and habitat complexity related to large woody material have been degraded by historical land-management practices. PCEs 1, 2, 4, 5, 6, and 7 within the designated critical habitat have likely been degraded, although the severity of degradation varies on site specific basis.

Spawning and rearing critical habitat in the Quinault, Queets, Hoh, and Elwha Rivers core areas is located within the Olympic National Park boundary, and habitat is functioning appropriately. There is no critical habitat designated within spawning and rearing areas in the Skokomish and Dungeness River core areas. In the Olympic Peninsula Critical Habitat Unit, FMO critical habitat segments were ranked at high risk of becoming non-functional in the Skokomish core area, and at moderate risk of becoming non-functional in the Hoh, Dungeness, and Elwha Rivers core areas. Most spawning and rearing critical habitat is located upstream within Olympic National Park, and FMO critical habitat is generally not directly adjacent to FPHCP covered lands. Therefore, exposure to potential effects from activities on FPHCP covered lands is expected to be low in this Critical Habitat Unit.

Puget Sound: Unit 28

Critical habitat has been designated in streams and rivers both upstream and downstream from FPHCP covered lands throughout the Puget Sound Critical Habitat Unit. Most FPHCP covered lands are downstream of local populations and interspersed throughout designated segments of FMO critical habitat. The majority of designated critical habitat is FMO stream segments on non-FPHCP covered lands in lower mainstem river segments that flow into the estuarine/nearshore waters of Puget Sound. In the Nooksack, Lower Skagit, Stillaguamish, Snohomish-Skykomish, and Puyallup core areas, FPHCP covered lands fall within the Lower North Fork Nooksack, Lower Middle Fork Nooksack, Upper Middle Fork Nooksack, Lower South Fork Nooksack, Upper Deer Creek, North Fork Stillaguamish, Canyon Creek, South Fork Skykomish, Carbon, and Upper White River local populations, and the mainstem Nooksack, Skagit, Stillaguamish, Snohomish, Skykomish, Snoqualmie, and White River FMO habitats. FPHCP covered lands have the potential to affect designated critical habitat stream segments within these local populations and within these mainstem segments. Critical habitat has also been designated in the following FMO habitat outside of core areas where FPHCP covered lands are either interspersed or upstream: Lower Nisqually, Lower Green, and Samish Rivers.

The urban rivers of Puget Sound have effects comparable to those on the Olympic Peninsula from past logging and logging roads in the upper reaches, but critical habitat has been further degraded in the lower floodplains. Intensive channelization to protect urban development and agricultural areas has resulted in permanent loss of floodplain functions in most of the lower rivers. The loss of riparian vegetation, increasing discharge of municipal and industrial wastewater and urban stormwater runoff, has resulted in degraded water quality. The Washington Department of Ecology (WDOE) has placed a large number of waterways throughout Puget Sound on the 303(d) list of impaired waters. In addition to affecting water quality through flow alterations, hydroelectric dams block migration and have isolated bull trout populations in several core areas while water-control structures in the floodplains have effectively eliminated most of the estuaries and wetlands that historically provided rearing and foraging areas. PCEs 1, 2, 3, 4, 5, 6 and 7 within the designated critical habitat have likely been degraded, although the severity of degradation varies on a site specific basis.

In the Puget Sound Critical Habitat Unit, spawning and rearing critical habitat segments were ranked at high risk of becoming non-functional in the Lower South Fork Nooksack River, Upper Puyallup and Mowich Rivers, and Upper Deer Creek local populations. Spawning and rearing critical habitat segments were ranked at moderate risk of becoming non-functional in the following local populations: Lower North Fork Nooksack River, Upper and Lower Middle Fork Nooksack River, North Fork Stillaguamish River and South Fork Skykomish River. Critical habitat segments were also ranked at moderate risk of becoming non-functional in the Clearwater River potential local population, and ranked a low risk of becoming non-functional in the Glacier Creek and Carbon River local populations. FMO critical habitat segments were ranked at high risk of becoming non-functional in the Puyallup core area (Puyallup and Carbon Rivers), and ranked at moderate risk of becoming non-functional in the Puyallup (White River), Nooksack, Lower Skagit, Stillaguamish, and Snohomish/Skykomish Rivers core areas. FMO critical habitat segments outside of core areas, within the Lower Nisqually, Lower Green, and Samish Rivers FMO areas, were ranked at moderate risk of becoming non-functional. Table I in Appendix C (Critical Habitat) displays the PCEs overlaid with the habitat analysis and the additional forage base category. The exposure risk summary indicates spawning and rearing critical habitat segments are at high risk of exposure to potential effects of activities on FPHCP covered lands within the Lower South Fork Nooksack River, North Fork Stillaguamish River, and Lower Middle Fork Nooksack River local populations; and are at moderate risk of exposure in the Lower North Fork Nooksack River, Upper Middle Fork Nooksack River, and South Fork Skykomish River local populations; and are at low risk of exposure in the Carbon River local population. Segments in upper Deer Creek were ultimately determined to be at very low risk of exposure because nearly all lands adjacent to the stream are covered under the FPHCP, and therefore are excluded from critical habitat designation. FMO critical habitat segments are at high risk of exposure in the Nooksack, Stillaguamish, and Puyallup FMO; and at a moderate risk of exposure in Kendell Creek, Deer Creek, Canyon Creek, and Snohomish/Skykomish Rivers FMO areas. Critical habitat segments in the Lower Nisqually, Lower Green, Samish, and Skagit Rivers are likely at moderate exposure. See Table J and K in Appendix C (Critical Habitat) for summaries of the exposure rankings.

8.7.3 EFFECTS OF THE ACTION ON CRITICAL HABITAT

Issuance of an incidental take permit for the FPHCP is based on continued application of the current Washington Forest Practices Rules. In some situations, these forest practices are expected to result in effects to bull trout critical habitat. Activities covered by the FPHCP that have the potential to generate effects which may reach sections of streams designated as critical habitat include activities in the riparian area, operation of heavy equipment, construction and maintenance of roads (including stream crossings), and upgrading and abandonment of roads on covered lands. This analysis assesses the effects of the proposed FPHCP on those interspersed and downstream waters that are designated as critical habitat. For additional discussion on the effects to bull trout habitat from forest management activities on FPHCP covered lands, please refer to the section titled "**Effects of the Action on the Individual.**"

The PCEs apply to areas designated as either foraging, migrating, and overwintering habitat or spawning and rearing habitat. The only exception is that PCE #3 (substrate) addresses substrates needed for spawning and rearing habitat and does not address or is not applicable to bull trout foraging, migrating, and overwintering habitat requirements. Only the PCEs described in paragraphs (1), (6), (7), and (8) of the final rule (70 FR 56212) apply to marine nearshore waters identified as critical habitat.

Implementation of the proposed action has the potential to adversely affect up to seven PCEs, depending on the location of the critical habitat and its relation to the location of the FPHCP covered lands. Although effects are likely to be site specific, the PCEs most likely to be directly affected by the FPHCP are PCEs 1, 2, 3, 4, 5, and 6, with a likelihood of indirect affects to PCE 7. Referring to the **Effects of the Action on the Individual** section, the effects to PCE 1 are similar or equivalent to the analysis of effects to stream temperature; effects to PCE 2 are similar or equivalent to the analysis of effects to large wood; effects to PCE 3 are similar or equivalent to the analysis of effects of elevated sediment; effects to PCEs 4 and 5 are related to combined or interrelated effects from elevated sediment and reductions in large wood; effects to PCE 6 and 7 are similar or equivalent to the interrelated and combined effects of temperature increases, reduction of large wood, and elevated sediment levels. No additional impacts to PCE 8 are aniticapted beyond those addressed in our analysis of PCEs 1, 3, 4, and 5.

To determine the "overall risk" to critical habitat from FPHCP covered activities analyzed in this Opinion, we combined the estimates of (1) critical habitat exposure risk and (2) critical habitat function risk, both of which are described in the critical habitat Environmental Baseline section above. Anticipated downstream effects were evaluated in light of the overall risk to determine the likelihood and severity of adverse effects to critical habitat. A range of effects are expected to occur over the 50-year term of the Permit on a variable and site specific basis. The FPHCP covered activities are anticipated to result in elevated sediment delivery, increased temperatures, and reduced large wood recruitment in some areas.

Baseline habitat condition was used to estimate the resiliency of critical habitat segments to support viable core area populations and to appreciably contribute to the conservation value of all critical habitat. The reslience of critical habitat to adverse effects from the action is assumed to be inversely proportional to the overall risk. For example, in Critical Habitat Units where critical habitat segments were ranked at a high or moderate-high overall risk, there is less resilience and greater potential for downstream effects to severely alter PCE function. We conducted a more extensive analysis of baseline habitat conditions in Critical Habitat Units with moderate-high and high overall risks. It is important to note that critical habitat exposure risk is related to downstream effects of FPHCP covered activities. These effects are assumed to be less in magnitude than effects to streams directly adjacent to the activities because fish-bearing streams have wider RMZs than non-fish-bearing streams.

All FMO areas, with critical habitat segments are downstream of or interspersed with FPHCP covered lands, are ranked at moderate-high or high overall risk due to generally poor habitat conditions and/or moderate or high risk of exposure. However, critical habitat segments in these FMO areas are expected to be more resilient than spawning and rearing habitats due to different physical features that include larger stream channels, greater channel/habitat depths, larger volumes of water.

8.7.3.1 Clark Fork: Unit 2

In this Critical Habitat Unit, the FPHCP covered lands are located beyond a distance that could affect designated critical habitat segments within the Priest Lake and Lake Pend Oreille core areas in Idaho or Washington. FPHCP covered lands are located outside of the Riparian Zone and are not adjacent to streams that flow into bull trout occupied habitat, and the potential effects of FPHCP covered activities on these lands are not anticipated to affect the PCEs in the designated critical habitat in Idaho.

8.7.3.2 Umatilla - Walla Walla: Unit 9

FPHCP covered lands are upstream of or interspersed with critical habitat segments designated for the North Fork Touchet, South Fork Touchet, Wolf Fork Touchet Rivers, and Mill Creek. The FPHCP includes covered lands adjacent to many non-fish-bearing streams, fish-bearing tributaries, and mainstem rivers, which have the potential to adversely affect downstream critical habitat. Although critical habitat segments were designated in Yellowhawk Creek and the Walla Walla River mainstem FMO, there are no FPHCP covered lands directly adjacent or interspersed with these segments and exposure to potential effects of covered activities is expected to be minimal. Spawning and rearing habitat in the Wolf Fork Touchet River local population was excluded from the critical habitat designation.

Spawning and rearing critical habitat segments in Mill Creek and the North Fork Touchet River are at a moderate-high overall potential risk to potential adverse effects from the FPHCP, and the South Fork Touchet is at a moderate risk. In terms of FMO critical habitat's overall potential risk from adverse effects, all areas are at moderate-high or high risk (see Appendix C Table F for the overall scoring of these segments). Potential adverse effects to critical habitat in this Critical Habitat Unit include reduced connectivity, reduced quality or quantity of cold water refugia, diminished large wood recruitment, and elevated sediment. Indirect effects from activities on FPHCP covered lands may also result in a decrease in forage or prey base, because adverse effects to habitat also reduce available prey.

In the local populations and FMO areas that were at an overall moderate-high risk or high risk of being adversely affected, a more extensive analysis of the baseline habitat conditions is presented below.

Critical habitat in local populations at moderate to high risk:

In the South Fork Touchet River local population, where there is a moderate overall potential risk to critical habitat segments, the habitat conditions or PCEs are expected to have some resiliency to adverse effects resulting from the FPHCP covered activities.

The overall risk for critical habitat in the Mill Creek and North Fork Touchet River local populations was moderate-high and high, respectively. The baseline habitat assessment indicates that sediment, temperature, and large wood in Mill Creek are functioning at a moderate risk while in the North Fork Touchet River they are functioning at a high risk. Generally, the critical habitat segments in these local populations have low resiliency to potential adverse effects.

Critical habitat in FMO habitat at moderate-high to high risk:

Most FMO critical habitat segments designated in the upper Walla Walla River River core area may experience adverse affects. Potential adverse effects to FMO critical habitat segments in this unit include reduced quality or quantity of cold water refugia, diminished large wood recruitment, and elevated sediment. Indirect effects from forest management activities on FPHCP covered lands may also result in a decrease in forage or prey base, because adverse effects to habitat can also reduce prey availability.

Additional analysis for critical habitat in local populations and FMO habitat:

Because there is a moderate-high or high overall potential risk to critical habitat in the Mill Creek and North Fork Touchet River local populations and in all FMO areas in this Critical Habitat Unit, additional analysis was conducted to evaluate more site-specific watershed conditions related to rain-on-snow, soils, slope steepness and slope hazards, geology, and roads using additional GIS analysis (see Appendix C, Table H). Based on this analysis, it is anticipated that the severity of potential effects from activities on

FPHCP covered lands would likely be higher due to these watershed conditions. The baseline habitat conditions in conjunction with these watershed conditions tend to increase the likelihood that potential downstream adverse effects would be severe. These effects may contribute to the alteration of riparian and channel conditions, including changes in stream temperatures, sediment routing, and large wood recruitment.

Summary of effects at the Critical Habitat Unit scale:

In the Umatilla-Walla Walla Critical Habitat Unit, all critical habitat segments downstream or interspersed with FPHCP covered lands are at an overall risk that ranges from moderate to high. Potential downstream effects of the action may result in variable delivery of sediment, increases in temperatures, and decreases in recruitment of large wood to critical habitat segments. It is likely that PCEs in the critical habitat unit and core area would be adversely affected due to the the proposed action. Although the location of project activities is uncertain, moderate to high baseline habitat conditions suggest potential adverse effects are likely to be severe to several PCEs on a site-specific basis. The magnitude of effects to PCEs 1, 2, 3, 4, 5, and 6 would be variable and site-specific. Indirect effects from activities on FPHCP covered lands may result in a decrease in forage base (PCE 7). Although site-specific effects to PCEs could be severe, it is important to note that downstream effects are likely to be less in magnitude than effects to streams directly adjacent to the activities. We do not expect that the proposed action would alter the function and conservation role of the Critical Habitat Unit. The FPHCP conservation measures are expected to reduce and minimize the likelihood of adverse effects and reduce the risks associated with the unknown site-specific conditions in the moderate-high and high risk local populations.

8.7.3.3 Grande Ronde River: Unit 10

FPHCP covered lands are adjacent to tributary streams that flow into the lower Grande Ronde River, which is designated as FMO critical habitat. At the confluence of these tributaries, there is the potential for effects from activities on FPHCP covered lands on both fish-bearing and non-fish-bearing streams to adversely affect designated critical habitat segments. Potential adverse effects to critical habitat in this unit could include reduced quality and quantity of cold water refugia, diminished large wood recruitment, and elevated sediment. Although effects are likely to be site specific and related to the proximity of the FPHCP covered lands to the critical habitat, it is likely that PCEs 1, 2, 5, and 6 may be adversely affected to some extent, while PCE 4 could also be affected. Indirect effects from activities on FPHCP covered lands may include a decrease in forage base (PCE 7). Because all spawning and rearing segments within local populations are excluded from critical habitat designation, and FMO critical habitat is not directly adjacent to FPHCP covered lands, exposure risk would be low. All PCEs in FMO critical habitat may be affected to some extent on a site-specific basis, but the low exposure risk indicates these effects would be minimal and would not affect the function and conservation role of the Critical Habitat Unit.

8.7.3.4 Coeur d'Alene Lake Basin: Unit 14

Only a minor portion of the Critical Habitat Unit is in Washington. No bull trout spawning and rearing habitat is within this portion of the Critical Habitat Unit. Due to the long downstream distance between FPHCP covered lands and designated critical habitat in Lake Pend Oreille, Idaho, the potential effects from activities on FPHCP covered lands are not anticipated to affect the PCEs in this designated critical habitat.

8.7.3.5 Lower Columbia River Basin: Unit 19

All FPHCP covered lands within this Critical Habitat Unit are located below local populations; therefore, activities on FPHCP covered lands are not anticipated to affect spawning and rearing critical habitat segments in this Critical Habitat Unit. However, FPHCP covered lands are adjacent to and interspersed with many non-fish-bearing streams, fish-bearing tributaries, and the mainstem Lewis, White Salmon, and Klickitat Rivers, and have the potential to affect designated critical habitat segments downstream of covered lands. Critical habitat segments in the Critical Habitat Unit are important for the conservation of FMO habitat. Potential adverse effects to critical habitat in this Critical Habitat Unit include reduced quality or quantity of cold water refugia, diminished large wood recruitment, and elevated sediment.

Critical habitat in FMO habitat at moderate-high to high risk:

Klickitat River FMO habitat has a high overall potential risk due to the high exposure to FPHCP covered lands. Adverse effects to PCEs in the FMO habitat are anticipated. Potential adverse effects to FMO critical habitat segments in this unit include reduced quality or quantity of cold water refugia, diminished large wood recruitment, and elevated sediment. Indirect effects from forest management activities on FPHCP covered lands may also result in a decrease in forage or prey base, because adverse effects to habitat can also reduce prey availability.

Summary of effects at the Critical Habitat Unit scale:

In the Lower Columbia Critical Habitat Unit, FMO critical habitat segments within the Klickitat River that are downstream or interspersed with FPHCP covered lands are at a high overall potential risk. Potential downstream effects of the action may result in variable delivery of sediment, increases in temperatures, and decreases in recruitment of large wood to critical habitat segments. This suggests that habitat conditions and processes in the critical habitat unit and core area could be adversely affected due to the potential effects of the proposed action, which may affect the functional suitability of the PCEs. Although the location of project activities is uncertain, moderate to high baseline habitat conditions suggest potential adverse effects are likely to result in severe effects to several PCEs. Effects are likely to be site specific, and it is likely that PCEs 1, 2, 3, 5, and 6 would be adversely affected to some extent, while PCE 4 could also be affected. Indirect effects from activities on FPHCP covered lands may result in a decrease in forage base (PCE 7). Although site-specific effects to PCEs could be severe, it is important to note that downstream effects are likely to be less in magnitude than effects to streams directly adjacent to the covered activities. We do not expect that the proposed action would alter the function and conservation role of the Critical Habitat Unit. The FPHCP conservation measures are expected to reduce and minimize the likelihood of adverse effects and reduce the risks associated with the unknown site-specific conditions in the moderate-high and high risk local populations.

8.7.3.6 Middle Columbia River Basin: Unit 20

FPHCP covered lands are upstream or interspersed with critical habitat segments designated in the Ahtanum Creek, Teanaway River, and Upper Yakima River, Rattlesnake Creek, Gold Creek, Cle Elum River, and North Fork Tieton River local populations. The FPHCP includes covered lands adjacent to many non-fish-bearing streams, fish-bearing tributaries, and mainstem rivers, which have the potential to adversely affect downstream critical habitat. All spawning and rearing segments in the Bumping River were excluded and all FMO habitat segments in Rattlesnake Creek were excluded from critical habitat designation.

Critical habitat segments designated in the Ahtanum Creek, Teanaway River, and Upper Yakima River local populations are at a high overall potential risk; Rattlesnake Creek, Gold Creek, and Cle Elum River local populations are at a moderate risk; and North Fork Tieton River is at a low risk. The analysis showed that in Box Canyon Creek and Kachess River local populations, spawning and rearing critical habitat segments did not have FPHCP covered lands that were directly adjacent or interspersed so exposure to effects of the activities is expected to be minimal. Potential adverse effects to critical habitat in this Critical Habitat Unit include reduced connectivity, reduced quality and quantity of cold water refugia, diminished large wood recruitment, and elevated sediment. Indirect effects from forest management activities on FPHCP covered lands may also result in a decrease in forage or prey base, because adverse effects to habitat also reduce available prey.

Critical habitat in local populations at moderate to high risk:

In Rattlesnake and Gold Creeks, and Cle Elum River, local populations where there is an overall moderate risk to critical habitat, adverse effects are expected to occur. However, habitat conditions or PCEs are expected to have some resiliency to adverse effects resulting from the FPHCP covered activities.

The overall potential risk is high for critical habitat segments in the Ahtanum Creek, the Teanaway River, and the upper Yakima River local populations. The Geographic Risk Analysis indicates that sediment, temperature, and large wood in these areas are functioning at high risk. Generally critical habitat in these locations has low resiliency to any potential adverse effects.

Critical habitat in FMO habitat at moderate to high risk:

In terms of the overall potential risk to adverse effects, the Bumping River FMO critical habitat is at a moderate risk and the FMO critical habitat in Ahtanum Creek, Cle Elum, Kachess, Naches, Teanaway, Tieton, and upper Mainstem Yakima Rivers are at high risk. Potential adverse effects to FMO critical habitat segments in this unit include reduced quality or quantity of cold water refugia, diminished large wood recruitment, and elevated sediment. Indirect effects from forest management activities on FPHCP covered lands may also result in a decrease in forage or prey base, because adverse effects to habitat can also reduce prey availability.

Additional analysis for critical habitat in local populations and FMO habitat:

Because there is a high overall potential risk to critical habitat in the Ahtanum Creek, Teanaway River, and upper Mainstem Yakima local populations, and FMO areas in this Critical Habitat Unit, additional analysis was conducted to evaluate more site specific watershed conditions related to rain-on-snow, soils, slope steepness and slope hazards, geology, and roads using additional GIS analysis (see Appendix C, Table H). Based on this analysis, it is anticipated that the severity of potential effects from activities on FPHCP covered lands would likely be higher due to these watershed conditions. The baseline habitat conditions in conjunction with these watershed conditions tend to increase the likelihood that potential adverse effects would be severe. These effects may contribute to the alteration of riparian and channel conditions, including changes in stream temperatures, sediment routing, and large wood recruitment.

Summary of effects at the Critical Habitat Unit scale:

In the Middle Columbia River Critical Habitat Unit, the effects of the action to the habitat conditions or PCEs are anticipated to range from low to high, depending on site-specific factors and the frequency,

timing, duration, and intensity of forest practices over the course of 50 years. There are critical habitat segments in two local populations that are at minimal or low risk; three local populations at moderate risk; and all FMO areas are at a high risk to adverse effects due to exposure and habitat conditions, but as discussed earlier they are anticipated to be more resilient to potential effects from FPHCP activities. However, when combined with the critical habitat segments that are at moderate-high and high risk, the Critical Habitat Unit may experience adverse effects in eight (or half) of the local populations and in almost all FMO areas designated in the Yakima River core area. The best functioning habitat within the Yakima core area is upstream of five dams which have significantly reduced connectivity among local populations. Spawning and rearing critical habitat segments functioning at high risk, and that are at high risk of exposure within the local populations, are located downstream of these dams. These critical habitat segments are necessary in supporting the function of the core areas below these dams. This suggests that habitat conditions and processes in the Critical Habitat Unit and core area may be more severely affected by potential downstream effects of the proposed action, or that the functional suitability of the PCEs at the Critical Habitat Unit scale may be affected. Although effects are likely to be site-specific, it is likely that PCEs 1, 2, 3, 5, and 6 would be adversely affected to some extent, while PCE 4 could also be affected. Indirect effects from forest management activities on FPHCP covered lands may result in a decrease in forage base (PCE 7). As noted above, all FPHCP covered lands were excluded from critical habitat designation and effects to critical habitat from the FPHCP would only occur downstream of the FPHCP covered lands. Although site-specific effects to PCEs could be severe, the magnitude of these downstream effects is anticipated to be less than effects to streams directly adjacent to the FPHCP covered activities. In addition, the FPHCP conservation measures are expected to reduce and minimize the likelihood of adverse effects and reduce the risks associated with the unknown site-specific conditions in the moderate-high and high risk local populations. We do not expect that the proosed action would alter the function and conservation role of the Critical Habitat Unit.

8.7.3.7 Northeast Washington: Unit 22

FPHCP covered lands are upstream or interspersed with critical habitat segments designated in the LeClerc Creek local population and the Tacoma, Cedar, Indian, Mill, Ruby, Slate, Small and South Fork Tacoma Creek potential local populations. The FPHCP includes covered lands adjacent to many non-fish-bearing streams, fish-bearing tributaries, and mainstem rivers, which have the potential to adversely affect downstream critical habitat. All spawning and rearing habitat in Sullivan Creek potential local populations were excluded.

Critical habitat segments designated in the Tacoma Creek potential local population are at high overall potential risk and LeClerc Creek local population is at a moderate-high risk, while Cedar, Indian, Mill, Ruby, Slate, Small and South Fork Tacoma Creeks potential local populations are all at a moderate overall potential risk.

Potential adverse effects to critical habitat in this Critical Habitat Unit include reduced connectivity, reduced quality and quantity of cold water refugia, diminished large wood recruitment, and elevated sediment. Indirect effects from forest management activities on FPHCP covered lands may also result in a decrease in forage or prey base, because adverse effects to habitat also reduce prey availability.

Critical habitat in local populations at moderate to high risk:

There were no critical habitat segments in local populations or FMO habitats ranked at an overall low risk for effects. However, in Cedar, Indian, Mill, Ruby, Small and South Fork Tacoma Creeks, potential local

populations with an overall moderate risk, adverse effects are expected to occur. However, habitat conditions or PCEs are expected to have some resiliency to adverse effects resulting from the FPHCP covered activities.

The overall potential risk for critical habitat segments in the LeClerc Creek local population and the Tacoma Creek local population is moderate-high and high, respectively, to adverse effects. The Geographic Risk Analysis indicates that sediment, temperature, and large wood in LeClerc Creek and Tacoma Creek are functioning at moderate to high risk. Generally, the critical habitat in these local populations has the lowest resiliency to any potential adverse effects.

Critical habitat in FMO habitat at moderate-high to high risk:

In terms of the overall potential risk to adverse effects, FMO critical habitat in Calispell Creek and Small Creek is at a high risk, and LeClerc, Sullivan, and Tacoma Creeks are at a moderate-high risk. Further review of South Fork Tacoma Creek and Ruby Creek indicated there was no FMO critical habitat segments contained within these potential local populations.

Additional analysis for critical habitat in local populations and FMO habitat:

Because there is a moderate-high or high overall potential risk to critical habitat in the LeClerc Creek and Tacoma Creek local populations and FMO areas in this Critical Habitat Unit, additional analysis was conducted to evaluate more site specific watershed conditions related to rain on snow, soils, slope steepness and slope hazards, geology, and roads using additional GIS analysis (see Appendix C, Table H). Based on this analysis, it is anticipated that the severity of potential effects from activities on FPHCP covered lands would likely be higher due to these watershed conditions. The baseline habitat conditions in conjunction with these watershed conditions tend to increase the likelihood that potential adverse effects would be severe. These effects may contribute to the alteration of riparian and channel conditions, including changes in stream temperatures, sediment routing, and large wood recruitment.

Summary of effects at the Critical Habitat Unit scale:

In the Northeast Washington Critical Habitat Unit, the effects of the action to the habitat conditions or PCEs are anticipated to range from moderate to high, depending on site specific factors and the frequency, timing, duration, and intensity of forest practices over the course of 50 years. There are critical habitat segments in six potential local populations ranked at moderate overall potential risk; and all FMO areas are ranked at a moderate-high or high overall risk to adverse effects due to exposure and baeline habitat conditions. Moderate risk populations are anticipated to be more resilient to potential effects from FPHCP activities. However, when combined with the critical habitat segments that are at moderate-high and high risk, the Critical Habitat Unit may experience adverse effects in the only known local population (LeClerc Creek), all seven potential local populations with critical habitat segments, and in all FMO areas designated in the Pend Oreille core area.

The critical habitat in the Pend Orielle core area is designated for recovery of the potential local populations. Bull trout are in low abundance and habitat in the core area is in poor condition, has fish passage barriers, and contains non-native predatory fish. Critical habitat segments that are functioning at moderate-high or high risk and are at high risk of exposure within the local populations or potential local populations, are necessary in supporting the function of the core areas. This suggests that habitat conditions and process in the Critical Habitat Unit and core area may be more severely affected by potential downstream effects of the proposed action, or that the functional suitability of the PCEs at the

critical habitat unit scale may be affected. Although effects are likely to be site specific, it is likely that PCEs 1, 2, 3, 5, and 7 would be adversely affected, while PCE 4 could also be affected. Indirect effects from forest management activities on FPHCP covered lands may result in a decrease in prey base (PCE 7). Although effects are likely to be site specific, it is likely that PCEs 1, 2, 3, 5, and 6 would be adversely affected to some extent, while PCE 4 could also be affected. Indirect effects from forest management activities on FPHCP covered lands may result in a decrease in forage base (PCE 7). As noted above, all FPHCP covered lands were excluded from critical habitat designation and effects to critical habitat from the FPHCP would only occur downstream of the FPHCP covered lands. Although site-specific effects to PCEs could be severe, the magnitude of these downstream effects is anticipated to be less than effects to streams directly adjacent to the FPHCP covered activities. In addition, the FPHCP conservation measures are expected to minimize the likelihood of adverse effects and reduce the risks associated with the unknown site-specific conditions in the moderate-high and high risk local populations. We do not expect that the proosed action would alter the function and conservation role of the Critical Habitat Unit.

8.7.3.8 Snake River Washington: Unit 23

There is a small amount of FPHCP covered lands interspersed with or directly upstream of critical habitat in the Cummings Creek local population in the Tucannon core area. The FPHCP includes covered lands adjacent to many non-fish-bearing streams, adjacent to fish-bearing tributaries, and adjacent to the streams and mainstem rivers, which have the potential to adversely affect FMO critical habitat segments that are present downstream. Adverse effects to critical habitat in this Critical Habitat Unit could include reduced quality and quantity of cold water refugia, diminished large wood recruitment, and elevated sediment. Although effects are likely to be site specific, it is likely that PCEs 1, 2, 5, and 6 may be adversely affected, while PCE 4 could also be affected. Indirect effects from forest management activities on FPHCP covered lands may result in a decrease in forage base (PCE 7). There are few FPHCP covered lands located within the Cummings Creek local population and, therefore, there is a very low exposure risk. This low exposure risk indicates that effects from the FHPCP would be minimal and would not affect the function and conservation role of the Critical Habitat Unit.

8.7.3.9 Olympic Peninsula: Unit 27

FPHCP covered lands are located in FMO habitat in all core areas and in the lower portion of the Dungeness River local population. All designated FMO critical habitat in the Critical Habitat Unit is located downstream of FPHCP covered lands and has the potential to be impacted by activities carried out on FPHCP covered lands. The FPHCP includes covered lands adjacent to and interspersed with many non-fish-bearing streams, and fish-bearing tributaries, which have the potential to affect designated critical habitat segments that are present downstream. Adverse effects to critical habitat in this Critical Habitat Unit include reduced quality and quantity of cold water refugia, diminished large wood recruitment, and elevated sediment. Although effects are likely to be site-specific, it is likely that PCEs 1, 2, 5, and 6 may be adversely affected, while PCE 4 could be affected. Indirect effects from forest management activities on FPHCP covered lands may result in a decrease in forage base (PCE 7). Most spawning and rearing critical habitat segments are located upstream within Olympic National Park, and FMO habitat is generally not directly adjacent to FPHCP covered lands. All PCEs may be affected to some extent on a site specific basis. Therefore, due to low exposure to FPHCP covered activities and moderate risk baseline habitat conditions in spawning and rearing and FMO critical habitat segments in the Hoh, Dungeness, and Elwha Rivers, the overall effects are expected to be low. In the Skokomish

FMO, where the exposure is low and the habitat baseline conditions are functioning at high risk, effects are expected to be moderate. Even with the potential of low to moderate downstream effects from FPHCP covered activities, they are expected to be minimal and would not affect the functional suitability of the PCEs. All spawning and rearing segments within local populations are excluded, and FMO critical habitat exposure risk is low. Although PCEs in FMO critical habitat may be affected to some extent on a site-specific basis, the low exposure risk indicates these effects would be minimal and would not affect the function and conservation role of the Critical Habitat Unit.

8.7.3.10 Puget Sound: Unit 28

FPHCP covered lands have the potential to affect spawning, rearing, foraging, migration and overwintering habitat in this Critical Habitat Unit. FPHCP covered lands are adjacent and interspersed with spawning and rearing critical habitat segments in four of the six core areas in this Critical Habitat Unit including the Nooksack, Stillaguamish, Snohomish-Skykomish, and Puyallup Rivers core areas. The remaining FPHCP covered lands within this Critical Habitat Unit are located in FMO areas outside of these core areas including the Lower Nisqually, Lower Green, and Samish Rivers. In these FMO areas, activities on FPHCP covered lands would not affect spawning and rearing critical habitat segments. Except in the four core areas described above, the remaining FPHCP covered lands within this Critical Habitat Unit are located below local populations (i.e., Lower Skagit River core area). Potential effects from activities on FPHCP covered lands were therefore determined to have no affect on spawning and rearing habitat in these areas. However, the FPHCP does include lands adjacent to many non-fish-bearing streams, adjacent to fish-bearing tributaries, and adjacent to the streams and mainstem rivers, which have the potential to adversely affect downstream critical habitat.

There were no FPHCP covered lands adjacent or interspersed with critical habitat designated as spawning and rearing in the White River (including West Fork White River), the Carbon River (including Ipsut and Ranger Creeks), and Mowich River. Most critical habitat in these local populations is located in Mount Rainier National Park so effects would be minimal. All spawning and rearing habitat segments in the Upper Puyallup, Upper Deer Creek, Canyon Creek, and South Fork Stillaguamish River were excluded.

Critical habitat in local populations at moderate to high risk:

The overall potential risk for spawning and rearing critical habitat segments in Lower South Fork Nooksack River local population is high and North Fork Stillaguamish River local population is moderate-high to adverse effects. The Geographic Risk Analysis indicates that sediment, temperature, and large wood in are functioning at moderate to high risk. Generally, the critical habitat in these local populations has low resiliency to effects. The Lower North Fork Nooksack River including Maple Creek, Upper Middle Fork Nooksack River, Lower Middle Fork Nooksack, South Fork Stillaguamish River, and South Fork Skykomish River local populations are at an overall moderate risk.

In the Lower North Fork Nooksack (including Maple Creek), Upper Middle Fork Nooksack, South Fork Stillaguamish, and South Fork Skykomish Rivers local populations where there is an overall moderate risk to critical habitat, adverse effects are expected to occur. However, we expect that the habitat conditions or PCEs have some resiliency to recover.

Critical habitat in FMO habitat at moderate-high to high risk:

FMO habitat in the Puyallup River is at an overall high risk; FMO in the Carbon, Nooksack, Middle Fork Nooksack, South Fork Nooksack, Stillaguamish, and North Fork Stillaguamish Rivers are at a moderate-

high overall risk; while FMO in the core areas in the Lower North Fork Nooksack (including Kendall Creek, Deer and Canyon Creek), the South Fork Stillaguamish, Snohomish/Skykomish, and White Rivers are at overall moderate risk. Additionally, FMO critical habitat segments in the Lower Nisqually, Lower Green, Samish FMO areas, and the Lower Skagit River core area are at an overall moderate risk to adverse effects. Potential adverse effects to FMO critical habitat segments in this Critical Habitat Unit include reduced quality and quantity of cold water refugia, diminished large wood recruitment, and elevated sediment. Indirect effects from forest management activities on FPHCP covered lands may also result in a decrease in forage or prey base, because adverse effects to habitat also reduce prey availability.

Additional analysis for critical habitat in local populations and FMO habitat:

Because there is a moderate-high or high overall potential risk to critical habitat in the Lower South Fork Nooksack, Lower Middle Fork Nooksack, and North Fork Stillaguamish local populations, and in FMO habitats in the Puyallup, Carbon, Nooksack, Middle Fork Nooksack, South Fork Nooksack, Stillaguamish, and North Fork Stillaguamish Rivers in this Critical Habitat Unit, additional analysis was conducted to evaluate more site-specific watershed conditions related to rain-on-snow, soils, slope steepness and slope hazards, geology, and roads using additional GIS analysis (see Appendix C, Table H). Based on this analysis, it is anticipated that the severity of potential effects from activities on FPHCP covered lands would likely be high due to these watershed conditions. The baseline habitat conditions in conjunction with these watershed conditions tend to increase the likelihood that potential adverse effects would be severe. These effects may contribute to the alteration of riparian and channel conditions, including changes in stream temperatures, sediment routing, and large wood recruitment.

Summary of effects at the Critical Habitat Unit scale:

In the Puget Sound Critical Habitat Unit, the effects of the action on the habitat conditions or PCEs are anticipated to range from moderate to high, depending on site-specific factors and the frequency, timing, duration, and intensity of forest practices over the course of 50 years. There are critical habitat segments in four of the six core areas in this Critical Habitat Unit that are potentially affected. Three local populations are at moderate risk, and FMO areas are at a moderate, moderate-high, or high risk to potential adverse effects due to exposure and habitat conditions, but as discussed earlier they are anticipated to be resilient to the effects of the activities. However, when combined with the critical habitat segments that are at moderate-high and high risk, the Critical Habitat Unit may experience adverse effects in many of the local populations with designated critical habitat, and in all FMO areas designated in four core areas in this Critical Habitat Unit. The critical habitat in these core areas is designated for maintenance and recovery of the local populations. Spawning and rearing critical habitat segments functioning at moderate-high or high risk and that are at high risk of exposure within the local populations, are necessary in supporting the function of the core areas. This suggests that habitat conditions and process in the Critical Habitat Unit and core area may be more severely affected by potential downstream effects of the proposed action, or that the functional suitability of the PCEs at the Critical Habitat Unit scale may be affected. Although effects are likely to be site-specific, it is likely that within FMO habitat PCEs 1, 2, 5, and 6 would be adversely affected, while PCE 4 could be affected. Indirect effects from forest management activities on FPHCP covered lands may result in a decrease in prey base (PCE 7). As noted above, all FPHCP covered lands were excluded from critical habitat designation and effects to critical habitat from the FPHCP would only occur downstream of the FPHCP covered lands. Although site-specific effects to PCEs could be severe, the magnitude of these downstream effects is anticipated to be less than effects to streams directly adjacent to the FPHCP

covered activities. In addition, the FPHCP conservation measures are expected to minimize the likelihood of adverse effects and reduce the risks associated with the unknown site-specific conditions in the moderate-high and high risk local populations. We do not expect that the proosed action would alter the function and conservation role of the Critical Habitat Unit.

8.7.3.11 Summary of Effects of the Action on Bull Trout Critical Habitat

Within designated critical habitat throughout the FPHCP Action Area, there is significant uncertainty about the location and timing of activities and the range of adverse effects. Potential effects to critical habitat segments would vary in type and severity; however, in some areas exposure would be reduced due to the location and proximity of critical habitat segments relative to FPHCP covered lands. In some instances there may be no overlap of FPHCP covered lands with segments of critical habitat. Within approximately half of the local populations, there is a moderate-high and high risk of exposure (see Appendix C, Tables J and K for summary of exposure analysis).

In areas where FPHCP covered lands are upstream of or interspersed with critical habitat, adverse effects include an increase in stream temperatures, a reduction in large wood, and/or elevated sediment levels. These effects would likely vary from watershed to watershed, depending primarily on proximity of the critical habitat to FPHCP covered lands, current habitat conditions, site-specific FPHCP prescriptions, geomorphology, and climate. All PCEs may be affected to some extent on a site-specific basis.

Based on the bull trout Geographic Risk Analysis, Critical Habitat Unit GIS analysis, and other exposure information, no critical habitat would be affected in the Priest Lake or Lake Pend Orielle Core Areas, or the Clark Fork and Coeur D'Alene Critical Habitat Unit, respectively. Core areas with only a low potential risk for adverse effects to critical habitat include: Lewis and White Salmon, and Hoh, Dungeness, and Elwha core areas. These are located in the Lower Columbia River Basin, and Olympic Peninsula Critical Habitat Units, respectively. Core areas with only a moderate potential risk for adverse effects include: Grande Ronde, Asotin and Tucannon, and Snohomish/Skykomish core areas. These are located in the Grande Ronde River, Snake River, and Puget Sound Basins Critical Habitat Units, respectively. In these core areas, due to less degraded habitat conditions and/or the proximity of FPHCP covered lands, effects are not anticipated to reduce the function or conservation role of the PCEs.

In general, FMO habitat that is at low or moderate risk is likely to be resilient to adverse affects due to current habitat conditions, or have a low likelihood of exposure to potential adverse effects. Critical habitat segments in these FMO areas have more resiliency to adverse effects than spawning and rearing habitat due to larger stream channels, greater channel/habitat depth, larger volumes of water, and their location further downstream from FPHCP covered activities in most cases. For these reasons, adverse effects to PCEs within FMO habitats are not anticipated to reduce the function or conservation role of PCEs.

Core areas with moderate-high and high risk for adverse effects have a high likelihood that PCEs in spawning and rearing and FMO critical habitat segments would be degraded. The core areas with the highest risk to spawning and rearing critical habitat segments include the Nooksack, Stillaguamish and Puyallup; Yakima; Walla Walla; and Pend Orielle. They are located in the Puget Sound, Middle Columbia River, Umatilla-Walla Walla River, and Northeast Washington Critical Habitat Units, respectively. The core areas with the highest potential for FPCHP covered activities to degrade PCEs in FMO critical habitat segments include the Puyallup, White, Stillaguamish, Nooksack, and Snohomish/Skykomish; Klickitat; Yakima; Walla Walla; and Pend Orielle. They are located in the Puget Sound, Lower Columbia, Middle Columbia, Umatilla-Walla Walla, and Northeast Washington Critical

Habitat Units, respectively. Potential adverse effects to PCEs would likely affect the function and conservation role of the Critical Habitat Units. Additionally, core areas where both the spawning and rearing and FMO critical habitats are at moderate-high or high risk of adverse effects to critical habitat, adverse affects would be the greatest. These core areas include the Stillaguamish, Yakima, Walla Walla, and Pend Orielle. They are located in the Puget Sound, Middle Columbia, Umatilla-Walla Walla, and Northeast Washington Critical Habitat Units, respectively.

The FPHCP has a number of conservation features that help to reduce, minimize, and mitigate the potential and anticipated adverse effects from FPHCP covered activities. These features include the riparian buffers, equipment limitation zones, RMAPs, best management practices (BMPs) for roads, the Landslide Hazard Zonation and Regional Landform Identification Projects, forest practices application screening, the Family Forest Fish Passage Program, and SEPA Class IV-Special evaluations. Riparian buffer strategies are designed to provide adequate wood recruitment, and to minimize temperature increases and sediment inputs. RMAPS, road BMPs, and the Family Forest Fish Passage Program are designed to minimize sediment inputs directly related to roads and failing culverts. The Landslide Hazard Zonation and Regional Landform Identification Projects, forest practices application screening, and SEPA Class IV-Special evaluations are designed to prevent FPHCP covered activities from triggering slope failures and mass wasting, which would help conserve LWD recruitment and minimize temperature increases and sediment inputs to bull trout habitats. These conservation measures work collectively to minimize potential and anticipated adverse effects from sediment, loss of LWD, and increases in temperature PCEs in each critical habitat unit.

8.7.4 CUMULATIVE EFFECTS

Cumulative effects include the effects of future State, tribal, local, or private actions that are reasonably certain to occur in the FPHCP Action Area considered in this Opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA. Numerous non-Federal actions that could affect critical habitat are reasonably certain to occur within the FPHCP Action Area. These future actions could contribute to cumulative effects on critical habitat in the FPHCP Action Area.

Cumulative effects from a variety of activities are likely to adversely affect the PCEs of bull trout critical habitat. These actions include, but are not limited to, industrial and residential development, road construction and maintenance, mining, forest activities, agriculture and grazing, and fire management. Impacts from these activities have the potential to degrade PCEs 1, 2, 3, 4, 5, 6, and 7 within the FPHCP Action Area. Water storage facilities and future dams for irrigation are likely to adversely affect PCE 8.

In western Washington, 83 percent of the land is presently forested, 5 percent is in agriculture, 4 percent is urban and industrial lands, and the remaining 8 percent are comprised of water and wetlands, ice, snow and bare rock, shrubland, and grassland. Most of the development has occurred along Puget Sound and along major river systems.

In contrast, eastern Washington is 36 percent forested, 35 percent shrubland/grassland, 26 percent agriculture, 1 percent industrial and urban, and the remaining 3 percent water, wetlands, ice, snow, and bare rock. Major hydroelectric dams and irrigation developments, and agriculture along the Columbia River system have resulted in the greatest change to the eastern Washington landscape, particularly in the non-forested areas.

For additional discussion on the cumulative effects from various actions see the **Cumulative Effects** section immediately following **Effects of the Action on Populations**.

8.7.5 CONCLUSION

The environmental baseline indicates that PCEs in critical habitat in the FPHCP Action Area ranges from functioning at low risk to high risk and that they are variable across core areas. The conservation role of bull trout critical habitat in the FPHCP Action Area is to provide bull trout foraging, migration, over-wintering, spawning, and rearing habitat of sufficient quality and quantity to support viable core area populations.

Compared to the Coastal-Puget Sound population segment, baseline critical habitat conditions are generally more degraded in spawning and rearing habitats within the Columbia River population segment. At the core area scale, numerous historic and ongoing factors continue to contribute to already degraded critical habitat conditions. An exception to this occurs for those core areas with local populations (spawning and rearing habitat) and/or FMO habitats located largely within relatively protected areas (e.g., Wilderness Areas and National Parks).

The proposed action would have short- to long-term adverse effects on sediment, large wood, and temperature. The FPHCP covered activities, when added to the baseline and considering future cumulative effects in the FPHCP Action Area, are likely to influence the ability of PCEs 1 (water temperature), 2 (complex stream channels), 3 (substrate), 4 (natural hydrograph), 5 (springs, seeps, and groundwater), 6 (migratory corridors), and 7 (food base) to function properly. However, these adverse effects from the FPHCP would be temporally, spatially, and situationally (i.e., site-specific conditions) dispersed over the 50-year Permit term across the FPHCP covered lands.

The FPHCP conservation measures are expected to reduce or minimize the likelihood of adverse effects to critical habitat and reduce the risks and uncertainty associated with the site-specific conditions. We do not anticipate the magnitude of these effects to significantly impair the ability of the PCEs to function, and we conclude that the FPHCP is not likely to affect these Critical Habitat Units to the extent that the PCEs would no longer contribute to the conservation value of designated critical habitat. On this basis, the FPHCP covered activities would not destroy or adversely modify designated critical habitat for bull trout in the Critical Habitat Units located completely or partially in Washington.

Bull trout generally have a broad distribution in the FPHCP Action Area and effects from the FPHCP are not expected to decrease their distribution. Most disturbances from the proposed action are generally expected to be short-term in nature and at a reach or less (habitat unit) scale. Disturbance levels are not expected to cause large-scale declines in bull trout abundance or distribution. Maturation of riparian areas, maintaining and restoring fish passage both for bull trout and their prey species, adaptive management, and improved road management practices are all expected from implementation of the FPHCP. These management prescriptions are expected to contribute to increasing the likelihood that bull trout habitat significantly improves in the FPHCP Action Area over the current conditions. However, because designated critical habitat segments are not located immediately adjacent to FPHCP covered lands, any improvements to critical habitat stream segments would be indirect in nature. Management on FPHCP covered lands typically has a limited ability to directly improve channel and especially riparian and streambank conditions in the designated critical habitat stream segments.

8.8 OVERVIEW AND INTEGRATION OF EFFECTS ON COVERED SPECIES

The provisions of the FPHCP were derived through a multi-stakeholder effort to consider the adverse and beneficial environmental effects of conducting forest practices activities under the Washington Forest Practices Rules. The condition of the comprehensive environmental baseline for the FPHCP Action Area is a reflection of historical forest practices and other non-forestry related activities. The FPHCP provisions reduce, minimize, and/or mitigate the effects of forest practices to improve riparian and aquatic conditions in the FPHCP Action Area. These provisions include: (1) riparian buffers on all fish-bearing streams and at least 50 percent of perennial non-fish-bearing streams; (2) equipment limitation zones; (3) RMAPs; (4) road BMPs; (5) regulations governing the identification and protection of potentially unstable slopes including the Landslide Hazard Zonation and Regional Landform Identification Projects; (6) the Family Forest Fish Passage Program, Riparian Open Space Program, and Forestry Riparian Easement Program for small forest landowners; and (7) Class IV-Special SEPA review. These provisions are designed to provide adequate wood recruitment and to reduce and minimize temperature changes and sediment inputs. RMAPs, road BMPs, and the small forest landowner programs are designed to reduce and minimize sediment inputs directly related to roads and culverts. Unstable slope identification and protection and Class IV-Special SEPA review are expected to reduce and minimize slope failures and mass wasting as a result of forest practices activities. These provisions of the FPHCP work collectively to reduce and/or minimize adverse effects from reduced LWD recruitment and increases in sediment and stream temperatures.

In addition, adverse effects from FPHCP implementation are expected to be spatially and temporally dispersed within riparian areas on over 9.3 million acres of forest land over a 50-year Permit term. However, even if individual forest practices in some areas are not spatially or temporally dispersed, adverse effects would continue to be minimized. Also, adverse effects are expected, in some cases, to be minimized for individual forest practice activities because of site-specific conditions and based on the type of forest practice activity conducted. Many forest practices are expected to provide benefits to FPHCP covered species. For example, the requirement that all fish passage barriers on FPHCP covered lands be removed by July 1, 2016, provides substantial benefits to covered fish species. These long-term benefits are expected to far outweigh the short-term adverse effects from the construction and repair work to upgrade or replace these barriers. Another example is the provision of the Desired Future Conditions for both westside and eastside riparian stands on fish-bearing streams. The long-term benefits from achieving these desired future conditions are expected to outweigh the short-term adverse effects from harvesting in the Inner Zone of riparian stands on fish-bearing streams.

There are some adverse effects from forest practices that do pose risks to covered species. In areas where there is greater exposure to adverse effects from forest practices, such as the upper portions of non-fish-bearing streams that may not receive buffers, there is risk to covered amphibian species that occur in these areas. These same forest practices also pose some risk to the upper portions of some fish-bearing streams due to the expected reduction of LWD recruitment and some increases in stream temperature and sediment input in these areas. However, in our weighing of the benefits of the FPHCP, that are expected to grow over the life of the 50-year Permit term and beyond, the risks are reduced and minimized. All covered species are expected to be sufficiently resilient to these adverse effects, with no appreciable reduction in their likelihood of survival and recovery resulting from this action. Even in areas where there is high risk, such as certain local populations of bull trout, the benefits of full fish passage on all streams on FPHCP covered lands and highly functional riparian buffers on all fish-bearing streams, at least 50 percent of perennial non-fish-bearing streams, and the protection of sensitive sites and unstable slopes outweighs the adverse effects of up to the remaining 50 percent of perennial non-fish-bearing

streams not receiving buffers, and the short-term effects of construction and repair to remove fish-passage barriers.

Overall, as a result of the FPHCP, we expect improvements in riparian and aquatic habitat quality and function, that would provide conservation benefits to covered species, when compared to current baseline conditions. Over the next 50 years, we expect increases in the quality and quantity of pools, reductions in embedded stream substrates, improvements to stream shade, and improvements to in-channel habitat conditions, compared to current baseline conditions.

9. INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by the FWS as an act which actually kills or injures wildlife and may include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Harass is defined by the FWS as intentional or negligent actions or omissions which create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the ESA provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

The proposed FPHCP and its associated documents clearly identify anticipated adverse effects to covered species likely to result from the proposed action and the measures that are necessary and appropriate to minimize those adverse effects. All conservation measures described in the FPHCP, together with the provisions described in the associated Implementation Agreement and section 10(a)(1)(B) Permit, are hereby incorporated by reference as reasonable and prudent measures and terms and conditions within this Incidental Take Statement pursuant to 50 CFR §402.14(i). Such terms and conditions are non-discretionary and must be undertaken for the exemptions under section 10(a)(1)(B) and section 7(o)(2) of the ESA to apply. If the Permittee fails to adhere to the section 10(a)(1)(B) permit conditions, the protective coverage of the Permit and section 7(o)(2) may lapse. The amount or extent of incidental take anticipated under the proposed FPHCP and associated reporting requirements are as described in the FPHCP and its accompanying section 10(a)(1)(B) permit.

Note that 47 of the species addressed in this Biological/Conference Opinion are not currently listed or proposed. Therefore, no take prohibition is in place for these species as of the date of this Opinion. The incidental take statements below, and the section 10(a)(1)(B) Permit as it pertains to these species, do not become effective unless (and until) the currently unlisted species are listed under the ESA.

The FWS anticipates that the proposed action is likely to result in the incidental take of covered species in the form of capture, harm, and harass. We anticipate incidental take of individuals of these species would typically be difficult to detect for the following reasons: (1) there is a low likelihood of finding injured or dead individuals of affected species due to one or more of the following factors: relatively low population density, secretive behavior (such as fossorial or log-dwelling species), concealing habitat (e.g., aquatic species), small size, and sporadic distribution; (2) the large area associated with implementation of the proposed activities covered by the FPHCP Permit; (3) the delayed effects of many of the activities that could take species; (4) the rapid rate of decomposition of some of the species after death; (5) the high probability of scavenging of dead individuals by predators; and (6) the transport of affected individuals to downstream areas. For these reasons, we have used the amount of habitat destroyed or degraded as a surrogate for expressing the anticipated amount of incidental take in the form of harm or harass. Changes in habitat conditions are a reasonably good indicator of those forms of take because impacts to habitat occupied by covered species from permit-related activities are the cause of the incidental take.

Most take of all covered species is expected to be in the form of harass as a result of habitat degradation caused by permit-covered activities that create the likelihood of sub-lethal injury by significantly disrupting their breeding, feeding, or sheltering behavior. A lesser amount of take of all covered species is expected to be in the form of sub-lethal harm as a result of habitat degradation caused by permit-covered activities that actually injures covered species by significantly disrupting their breeding, feeding, or sheltering behavior. The least amount of take is expected to be in the form of harm as a result of habitat degradation caused by permit-covered activities that actually kills covered species by significantly disrupting their breeding, feeding, or sheltering behavior. Direct take from capture, dewatering, instream large wood placement, and instream use of heavy equipment related to culvert and bridge repair, maintenance, and installation is expected to be in the form of sub-lethal or lethal "harm" take.

We estimate that about 2.5 percent of all habitat degradation in riparian management areas caused by permit-covered activities is expected to occur in association with 20-acre exempt parcels (Appendix F). This degradation is expected to cause incidental take of covered species in the form of harm.

9.1 INDIVIDUAL SPECIES INCIDENTAL TAKE STATEMENTS

9.1.1 Amphibians

9.1.1.1 Cascade Torrent Salamander

Amount and Extent of Take

The Cascade torrent salamander is known to occur in parts or all of the following Water Resource Inventory Areas (WRIAs): 11, 23, 26, 27, 28, and 29 (USFWS and NMFS 2006; Appendix A Regional Summaries). We anticipate that take of Cascade torrent salamanders would occur within Type Np and Ns streams on covered lands within these WRIAs over the 50-year Permit term. The conservation measures in the FPHCP provide protection for the highest quality habitat for Cascade torrent salamanders. However, up to 50 percent of Type Np streams and up to 100 percent of Type Ns streams may not receive riparian buffers.

Most take of Cascade torrent salamanders would be from habitat degradation from non-buffered stream margin habitat of Type Np and Ns streams that would impair breeding, feeding, and sheltering behaviors. It is estimated that harvest of riparian timber for up to 42,170 acres along Type Np streams and 275,140 acres along Type Ns streams would result in take of Cascade torrent salamanders over the life of the proposed 50-year Permit term.

A limited amount of take from stress, wounding, or actually killing salamanders is expected as a result of: (1) electrofishing related to adaptive management research and stream type model validation, (2) culvert and bridge maintenance and installation, and (3) heavy equipment use related to harvesting timber in riparian areas or emergency road repairs. Take from electrofishing and heavy equipment use is expected to be minimal. However, take from culvert and bridge maintenance and installation is expected to result during and immediately following instream work as sediment from the work site may degrade downstream habitat for Cascade torrent salamanders impairing breeding, feeding, and sheltering behavioral patterns; upstream habitat could also be degraded from erosional-headcutting as the upstream channel adjusts to the new stream crossing. Also, sediment from hydrologically-connected roads would also occur at culvert and bridge crossings on Type Np and Ns streams causing further degradation of habitat. Therefore, it is estimated that culvert and bridge maintenance and installation, and sediment from

hydrologically-connected roads, would result in take of Cascade torrent salamanders for up to 2,829 Type Np stream crossings and 41,174 Type Ns stream crossings, and 289 miles of Type Np stream-adjacent roads, over the life of the proposed 50-year Permit term.

Effect of Take

For the reasons discussed in the "conclusion" section of this Opinion, we determined that the level of anticipated take from the action is not likely to result in jeopardy to the Cascade torrent salamander.

9.1.1.2 Columbia Torrent Salamander

Amount and Extent of Take

The Columbia torrent salamander is known to occur in parts or all of the following Water Resource Inventory Areas (WRIAs): 22, 23, 24, 25, and 26 (USFWS and NMFS 2006; Appendix A Regional Summaries). We anticipate that take of Columbia torrent salamanders would occur within Type Np and Ns streams on covered lands within these WRIAs over the 50-year Permit term. The conservation measures in the FPHCP provide protection for the highest-quality habitat for Columbia torrent salamanders. However, up to 50 percent of Type Np streams and up to 100 percent of Type Ns streams may not receive riparian buffers.

Most take of Columbia torrent salamanders would be from habitat degradation from non-buffered stream margin habitat of Type Np and Ns streams that would impair breeding, feeding, and sheltering behaviors. It is estimated that harvest of riparian timber for up to 49,881 acres along Type Np streams and 399,843 acres along Type Ns streams would result in take of Columbia torrent salamanders over the life of the proposed 50-year Permit term.

A limited amount of take from stress, wounding, or actually killing salamanders is expected as a result of: (1) electrofishing related to adaptive management research and stream type model validation, (2) culvert and bridge maintenance and installation, and (3) heavy equipment use related to harvesting timber in riparian areas or emergency road repairs. Take from electrofishing and heavy equipment use is expected to be minimal. However, take from culvert and bridge maintenance and installation is expected to result during and immediately following instream work as sediment from the work site may degrade downstream habitat for Columbia torrent salamanders impairing breeding, feeding, and sheltering behavioral patterns; upstream habitat could also be degraded from erosional-headcutting as the upstream channel adjusts to the new stream crossing. Also, sediment from hydrologically-connected roads would also occur at culvert and bridge crossings on Type Np and Ns streams causing further degradation of habitat. Therefore, it is estimated that culvert and bridge maintenance and installation, and sediment from hydrologically-connected roads, would result in take of Columbia torrent salamanders for up to 2,673 Type Np stream crossings and 44,994 Type Ns stream crossings, and 265 miles of Type Np stream-adjacent roads, over the life of the proposed 50-year Permit term.

Effect of Take

For the reasons discussed in the "conclusion" section of this Opinion, we determined that the level of anticipated take from the action is not likely to result in jeopardy to the Columbia torrent salamander.

9.1.1.3 Olympic Torrent Salamander

Amount and Extent of Take

The Olympic torrent salamander is known to occur in parts or all of the following Water Resource Inventory Areas (WRIAs): 16, 17, 18, 19, 20, 21, 22, 23, and 24 (USFWS and NMFS 2006; Appendix A Regional Summaries). We anticipate that take of Olympic torrent salamanders would occur within Type Np and Ns streams on covered lands within these WRIAs over the 50-year Permit term. The conservation measures in the FPHCP provide protection for the highest quality habitat for Olympic torrent salamanders. However, up to 50 percent of Type Np streams and up to 100 percent of Type Ns streams may not receive riparian buffers.

Most take of Olympic torrent salamanders would be from habitat degradation from non-buffered stream margin habitat of Type Np and Ns streams that would impair breeding, feeding, and sheltering behaviors. It is estimated that harvest of riparian timber for up to 41,002 acres along Type Np streams and 317,720 acres along Type Ns streams would result in take of Olympic torrent salamanders over the life of the proposed 50-year Permit term.

A limited amount of take from stress, wounding, or actually killing salamanders is expected as a result of: (1) electrofishing related to adaptive management research and stream type model validation, (2) culvert and bridge maintenance and installation, and (3) heavy equipment use related to harvesting timber in riparian areas or emergency road repairs. Take from electrofishing and heavy equipment use is expected to be minimal. However, take from culvert and bridge maintenance and installation is expected to result during and immediately following instream work as sediment from the work site may degrade downstream habitat for Olympic torrent salamanders impairing breeding, feeding, and sheltering behavioral patterns; upstream habitat could also be degraded from erosional-headcutting as the upstream channel adjusts to the new stream crossing. Also, sediment from hydrologically-connected roads would also occur at culvert and bridge crossings on Type Np and Ns streams causing further degradation of habitat. Therefore, it is estimated that culvert and bridge maintenance and installation, and sediment from hydrologically-connected roads, would result in take of Olympic torrent salamanders for up to 1,938 Type Np stream crossings and 29,107 Type Ns stream crossings, and 187 miles of Type Np stream-adjacent roads, over the life of the proposed 50-year Permit term.

Effect of Take

For the reasons discussed in the “conclusion” section of this Opinion, we determined that the level of anticipated take from the action is not likely to result in jeopardy to the Olympic torrent salamander.

9.1.1.4 Dunn’s Salamander

Amount and Extent of Take

The Dunn’s salamander is known to occur in parts or all of the following Water Resource Inventory Areas (WRIAs): 22, 23, 24, 25, and 26 (USFWS and NMFS 2006; Appendix A Regional Summaries). We anticipate that take of Dunn’s salamanders would occur adjacent to Type S, F, Np, and Ns streams on covered lands within these WRIAs over the 50-year Permit term. The conservation measures in the FPHCP provide protection for the highest quality habitat for Dunn’s salamanders. However, up to 50 percent of Type Np streams and up to 100 percent of Type Ns streams may not receive riparian buffers.

Most take of Dunn's salamanders would be from habitat degradation from non-buffered riparian habitat of Type Np and Ns streams that would impair breeding, feeding, and sheltering behaviors. Direct mortality take is also possible from heavy equipment operation in these non-buffered areas. Therefore, it is estimated that harvest of riparian timber for up to 49,881 acres along Type Np streams and 399,843 acres along Type Ns streams would result in take of Dunn's salamanders over the life of the proposed 50-year Permit term.

A limited amount of take from stress, wounding, or actually killing salamanders is expected with culvert and bridge maintenance and installation, as these activities can degrade riparian habitat immediately adjacent to work sites during the maintenance and installation operations. Therefore, it is estimated that culvert and bridge maintenance and installation would result in take of Dunn's salamanders for up to 2,673 Type Np stream crossings and 29,107 Type Ns stream crossings over the life of the proposed 50-year Permit term. Because Dunn's salamanders may also occur along Type S or F waters, up to 665 stream crossings on Type S waters and 6,137 stream crossings on Type F waters would also cause a limited amount of take during culvert and bridge maintenance and installation operations. Further, it is estimated that road construction and maintenance would result in take of Dunn's salamanders from up to 552 miles of road along Type S streams, 1,033 miles of road along Type F streams, and 265 miles of road along Type Np streams.

Although riparian prescriptions along Type S and F waters are expected to adequately protect habitat for Dunn's salamanders that may occur within these riparian areas, the operation of heavy equipment to harvest riparian timber may cause a limited amount of take from stress, wounding, or actually killing salamanders. Therefore, up to 55,053 acres of Type S riparian harvest and up to 133,453 acres of Type F riparian harvest may take Dunn's salamanders.

Effect of Take

For the reasons discussed in the "conclusion" section of this Opinion, we determined that the level of anticipated take from the action is not likely to result in jeopardy to the Dunn's salamander.

9.1.1.5 Van Dyke's Salamander

Amount and Extent of Take

The Van Dyke's salamander is known to occur in parts or all of the following Water Resource Inventory Areas (WRIAs): 10, 11, 16, 19, 20, 21, 22, 23, 24, 25, 26, and 27 (USFWS and NMFS 2006; Appendix A Regional Summaries). We anticipate that take of Van Dyke's salamanders would occur adjacent to Type S, F, Np, and Ns streams on covered lands within these WRIAs over the 50-year Permit term. The conservation measures in the FPHCP provide protection for the highest quality habitat for Van Dyke's salamanders. However, up to 50 percent of Type Np streams and up to 100 percent of Type Ns streams may not receive riparian buffers.

Most take of Van Dyke's salamanders would from habitat degradation from non-buffered riparian habitat of Type Np and Ns streams that would impair breeding, feeding, and sheltering behaviors. Direct mortality take is also possible from heavy equipment operation in these non-buffered areas. Therefore, it is estimated that harvest of riparian timber for up to 81,394 acres along Type Np streams and 532,021 acres along Type Ns streams would result in take of Van Dyke's salamanders over the life of the proposed 50-year Permit term.

A limited amount of take from stress, wounding, or actually killing salamanders is expected with culvert and bridge maintenance and installation, as these activities can degrade riparian habitat immediately adjacent to work sites during the maintenance and installation operations. Therefore, it is estimated that culvert and bridge maintenance and installation would result in take of Van Dyke's salamanders for up to 4,794 Type Np stream crossings and 62,693 Type Ns stream crossings over the life of the proposed 50-year Permit term. Because Van Dyke's salamanders may also occur along Type S or F waters, up to 962 stream crossings on Type S waters and 9,283 stream crossings on Type F waters would also cause a limited amount of take during culvert and bridge maintenance and installation operations. Further, it is estimated that road construction and maintenance would result in take of Dunn's salamanders from up to 793 miles of road along Type S streams, 1,507 miles of road along Type F streams, and 468 miles of road along Type Np streams.

Although riparian prescriptions along Type S and F waters are expected to adequately protect habitat for Van Dyke's salamanders that may occur within these riparian areas, the operation of heavy equipment to harvest riparian timber may cause a limited amount of take from stress, wounding, or actually killing salamanders. Therefore, up to 88,519 acres of Type S riparian harvest and up to 193,530 acres of Type F riparian harvest may take Van Dyke's salamanders.

Effect of Take

For the reasons discussed in the "conclusion" section of this Opinion, we determined that the level of anticipated take from the action is not likely to result in jeopardy to the Van Dyke's salamander.

9.1.1.6 Coastal Tailed Frog

Amount and Extent of Take

The Coastal tailed frog is known to occur in parts or all of the following Water Resource Inventory Areas (WRIAs): 1, 3, 4, 5, 7, 8, 9, 10, 11, 12, 13, 14, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 38, 39, 45, 46, 47, and 48 (USFWS and NMFS 2006; Appendix A Regional Summaries). We anticipate that take of Coastal tailed frog would occur within Type Np and Ns streams on covered lands within these WRIAs over the 50-year Permit term. The conservation measures in the FPHCP provide protection for the highest quality habitat for Coastal tailed frogs. However, up to 50 percent of Type Np streams and up to 100 percent of Type Ns streams may not receive riparian buffers.

Most take of Coastal tailed frogs would be from habitat degradation from non-buffered riparian habitat that would impair breeding, feeding, and sheltering behaviors. It is estimated that harvest of riparian timber for up to 132,907 acres along Type Np streams and 717,686 acres along Type Ns streams would result in take of Coastal tailed frogs over the life of the proposed 50-year Permit term.

A limited amount of take from stress, wounding, or actually killing frogs is expected with: (1) electrofishing related to adaptive management research and stream typing; (2) culvert and bridge maintenance and installation; and (3) instream heavy equipment use related to harvesting timber in riparian areas. Take from electrofishing and instream heavy equipment use is expected to be minimal. However, take from culvert and bridge maintenance and installation may also cause take during and immediately following instream work as sediment from the work site may degrade downstream habitat for Coastal tailed frogs impairing essential breeding, feeding, and sheltering behaviors; upstream habitat could also be degraded from erosional-headcutting as the upstream channel adjusts to the new stream crossing. Also, sediment from hydrologically-connected roads could also occur at culvert and bridge

crossings on Type Np and Ns streams causing further degradation of habitat. Therefore, it is estimated that culvert and bridge maintenance and installation, and sediment from hydrologically-connected roads, would result in take of Coastal tailed frogs for up to 7,575 Type Np stream crossings and 89,837 Type Ns stream crossings, and 872 miles of Type Np stream-adjacent roads, over the life of the proposed 50-year Permit term.

Effect of Take

For the reasons discussed in the "conclusion" section of this Opinion, we determined that the level of anticipated take from the action is not likely to result in jeopardy to the Coastal tailed frog.

9.1.1.7 Rocky Mountain Tailed Frog

Amount and Extent of Take

The Rocky Mountain tailed frog is known to occur in parts or all of the following Water Resource Inventory Areas (WRIAs): 32 and 35 (USFWS and NMFS 2006; Appendix A Regional Summaries). Additionally, they are suspected to occur in other WRIAs because of their adjacent occupancy in British Columbia and Idaho. Therefore, it is assumed that Rocky Mountain tailed frogs may also occur in WRIAs 51 to 62 (USFWS and NMFS 2006; Appendix A Regional Summaries). The following estimates for take include all known and suspected WRIAs with Rocky Mountain tailed frog occurrence. We anticipate that take of Rocky Mountain tailed frog would occur within Type Np and Ns streams on covered lands within these WRIAs over the 50-year Permit term. The conservation measures in the FPHCP provide protection for the highest quality habitat for Rocky Mountain tailed frogs. However, up to 50 percent of Type Np streams and up to 100 percent of Type Ns streams may not receive riparian buffers.

Most take of Rocky Mountain tailed frogs would be from habitat degradation from non-buffered riparian habitat degrading Type Np and Ns instream habitat that would impair breeding, feeding, and sheltering behaviors. It is estimated that harvest of riparian timber for up to 27,111 acres along Type Np streams and 101,768 acres along Type Ns streams would result in take of Rocky Mountain tailed frogs over the life of the proposed 50-year Permit term.

A limited amount of take from stress, wounding, or actually killing frogs is expected with: (1) electrofishing related to adaptive management research and stream typing; (2) culvert and bridge maintenance and installation; and (3) instream heavy equipment use related to harvesting timber in riparian areas. Take from electrofishing and instream heavy equipment use is expected to be minimal. However, take from culvert and bridge maintenance and installation may also cause take during and immediately following instream work as sediment from the work site may degrade downstream habitat for Rocky Mountain tailed frogs impairing breeding, feeding, and sheltering behaviors; upstream habitat could also be degraded from erosional-headcutting as the upstream channel adjusts to the new stream crossing. Also, sediment from hydrologically-connected roads would also occur at culvert and bridge crossings on Type Np and Ns streams causing further degradation of habitat. Therefore, it is estimated that culvert and bridge maintenance and installation, and sediment from hydrologically-connected roads, would result in take of Rocky Mountain tailed frogs for up to 1,341 Type Np stream crossings and 15,473 Type Ns stream crossings, and 255 miles of Type Np stream-adjacent roads, over the life of the proposed 50-year Permit term.

Effect of Take

For the reasons discussed in the "conclusion" section of this Opinion, we determined that the level of anticipated take from the action is not likely to result in jeopardy to the Rocky Mountain tailed frog.

9.1.2 Native Fish

9.1.2.1 Dolly Varden

Our current understanding of known Dolly Varden occurrence in Washington indicates that the species occupies habitats that are not expected to be affected by the FPHCP because Dolly Varden are upstream of FPHCP lands. However, future stream surveys may determine presence of Dolly Varden in streams associated with the FPHCP. Considering the conservation measures that would be implemented under the FPHCP, we have determined that authorizing a limited amount of take would not affect its habitat, or this species. As such, an analysis of incidental take has been done for Dolly Varden.

There may be minor effects to Dolly Varden, from the FPHCP that would lead to take of Dolly Varden. These affects have been analyzed in three areas of this Opinion: 1) General Effects; 2) Effects to Guilds; 3) and Effects to Species. The effects we have determined that could contribute to take of Dolly Varden are: 1) excessive sediment to fish-bearing streams from roads, riparian timber harvest, and stream crossing projects (culvert, bridge installation, and potentially other approved crossing methods); 2) increases in stream temperature due to riparian tree removal that provides shade; 3) the prevention of riparian trees from growing that could provide shade – primarily by riparian roads; 4) removal of riparian trees that could potentially provide LWD, 5) the prevention of riparian trees from growing that could ultimately provide LWD – primarily by riparian roads; and 6) capture and handling of Dolly Varden for instream projects, primarily road crossings. Dolly Varden that spend the majority of their life in lakes would not be exposed to some of these effects that contribute to take to the degree that some other salmonids may be.

Process for determining Incidental Take of Dolly Varden

We assessed the activities associated with the FPHCP to determine which activities had the highest chance of contributing to take of Dolly Varden. The activities needed to be measurable, have a likelihood of contributing to take, and be an activity directly associated with the FPHCP. The FPHCP activities that best meet these criteria for and Dolly Varden were: 1) riparian timber harvest in Type F, and Np streams, 2) stream crossings of Type F and Np streams, and 3) roads located in Type F, and Np riparian zones. Type S streams were not included in the analysis because of the current understanding of the species habitat association with upper reaches of streams. We determined that these three primary activities could be estimated with available information. See Appendix G for a description of the GIS process for determining these estimates.

Estimates were made of the WRIA's that Dolly Varden occupy in the FPHCP Action Area. The information for determining Dolly Varden occupancy came primarily from the Recovery Plans for Bull Trout in Washington and consultations with FWS bull trout biologists. The several streams where they occur are in the upper portions of their respective watersheds.

As described above, while we can develop quantifiable estimates of take for this Opinion, fish respond to environmental disturbances differently depending upon a variety of factors. Factors that may affect fish response to perturbations are size and species of fish, age of fish, condition of fish, complexity of habitat,

season, inter-specific and intra-specific competition, dissolved oxygen and water temperatures, turbidity, and other physical and biological processes. In addition to the various possible responses of fish to disturbances, fish are often distributed in a stream network at different scales. Fish occupy their environment from a small scale such as a pool, to a large scale, such as the watershed. Because of this often patchy fish distribution within a stream, FPHCP activities that have been determined to contribute to take would not always cause the same fish response. An activity that may cause an adverse fish response in one stream, may not have the same result in another stream because the fish are not in proximity to the disturbance. The same activity could influence adult fish substantially differently than juvenile fish. As such, the incidental take estimates are used to judge the negative activities implemented under the FPHCP, but they are not always a reliable tool for accurately measuring incidental take due to the complexity of biological systems.

We estimate a total of 62,414 riparian acres is potentially available to be managed that could contribute to take of Dolly Varden. The actual reduction in recruitable LWD that occurs because of riparian timber harvest over the 50-year permit term is relatively small, but there would be trees that are harvested that would otherwise have recruited to the stream and formed habitat. The reduction of recruitable LWD becomes more noticeable over longer time frames, such as 100 and 250 years. Sediment delivery from riparian harvest is likely to occur in some situations, but is expected to be much less than sediment delivery from roads. However, there would be some circumstances that sediment delivery is a product of riparian harvest. Temperature effects may also result in take of Dolly Varden.

Incidental take of Dolly Varden from riparian timber harvest over the 50-year permit term is estimated in acres as follows:

- Type F riparian management acres: 40,735
- Type Np riparian management acres: 21,679

Road stream crossings are an activity that would be a primary mechanism for sediment delivery to Dolly Varden habitat. A total of 3,578 stream crossing are estimated on FPHCP lands that could take Dolly Varden. These stream crossings would deliver sediment to Dolly Varden habitat. Intensity of road use and road design influence sediment delivery to Dolly Varden habitat. In addition to sediment delivery from road crossings, loss of LWD and reduced shading can occur at road crossings. An average width of opening through the riparian zone associated with a crossing is approximately 40 feet. This area could lose the potential to deliver LWD and could also cause increased sunlight to reach the stream.

Incidental take of Dolly Varden is estimated in number of stream crossings, over a 50-year permit term as follows:

- Type F stream crossings: 2,308
- Type Np stream crossings: 1,270

The third activity that can be estimated, and could also cause take, are roads located within the Riparian Zone. Most of these riparian roads have been in place for a considerable time and their presence reduces the effectiveness of the riparian area. Roads within the riparian zone have several effects, most notably reduction of recruitable LWD, reduction in shade (especially if close to the stream), and sediment delivery to Dolly Varden habitats. A total of 457 miles of road occurs within the riparian areas of Type F, and Np streams that could cause take. Approximately 2,215 acres (using a 40’ wide road opening) are reduced in providing full riparian functions. Over time these figures should be reduced due to implementation of the FPHCP.

Incidental take of Dolly Varden is estimated from roads in the Riparian Zone of Type F and Np streams. Estimates are in miles and acres as follows:

- Type F riparian roads: 317 miles (1,536acres)
- Type Np riparian roads: 140 miles (678 acres)

Conclusion

In this Opinion, we have determined that this level of anticipated take is not likely to result in jeopardy to the Dolly Varden. The effects to the species are not at a scale or magnitude that would affect the overall abundance or distribution of the species in the FPHCP Action Area.

9.1.2.2 Westslope Cutthroat Trout & Coastal Cutthroat Trout

We anticipate that take of cutthroat trout would occur within cutthroat habitat adjacent to FPHCP covered lands over the 50-year permit term. The conservation measures in the FPHCP provide riparian protections that address stream shade, LWD recruitment, leaf and needle litter production, microclimate, bank stability, and minimization measures for sediment to aquatic habitats on FPHCP covered lands. Implementation of the FPHCP is expected to provide adequate functionality of these factors that would contribute to cutthroat trout long-term survival.

However, there would be effects from the FPHCP that are expected to take cutthroat trout. These affects have been analyzed in three areas of this Opinion: 1) General Effects; 2) Effects to Guilds; 3) and Effects to Species.

The effects we have determined that could contribute to take to cutthroat trout are: 1) excessive sediment to fish-bearing streams from roads, timber harvest, and stream crossing projects (culvert, bridge installation, and potentially other approved crossing methods); 2) increases in stream temperature due to riparian tree removal that provide shade; 3) the prevention of riparian trees from growing that could provide shade (primarily by riparian roads); 4) removal of riparian trees that could potentially provide LWD; 5) the prevention of riparian trees from growing that could ultimately provide LWD – primarily by riparian roads and 20 acre exemptions; and 6) capture and handling of cutthroat trout for instream projects, primarily road crossing activities.

Process for determining Incidental Take of Cutthroat Trout

We assessed the activities associated with the FPHCP to determine which activities had the highest chance of contributing to take of coastal and westslope cutthroat trout. The activities needed to be measurable, have a likelihood of contributing to take, and be an activity directly associated with the FPHCP. The FPHCP activities that best meet these criteria for westslope and coastal cutthroat trout were: 1) riparian timber harvest in Type S, F, and Np streams, 2) stream crossings of Type S, F and Np streams, and 3) roads located in Type S, F, and Np riparian zones. We determined that these three primary activities could be estimated with available information. See Appendix G for a description of the GIS process for determining these estimates.

Estimates were then made of the WRIA's that coastal and westslope cutthroat trout occupy in the FPHCP Action Area. The information for determining occupancy came primarily from the following two sources: Inland Fishes of Washington, by Wydoski and Whitney, 2003, and the Final Environment Impact Statement for the FPHCP, 2006.

As described above, while we can develop quantifiable estimates of take for this Opinion, fish respond to environmental disturbances differently depending upon a variety of factors. Factors that may affect fish response to perturbations are size and species of fish, age of fish, condition of fish, complexity of habitat, season, inter-specific and intra-specific competition, dissolved oxygen and water temperatures, turbidity, and other physical and biological processes. In addition to the various possible responses of fish to disturbances, fish are often distributed in a stream network at different scales. Fish occupy their environment from a small scale such as a pool, to a large scale, such as the watershed. Because of this often patchy fish distribution within a stream, FPHCP activities that have been determined to contribute to take would not always cause the same fish response. An activity that may cause an adverse fish response in one stream, may not have the same result in another stream because the fish are not in proximity to the disturbance. The same activity could influence adult fish substantially differently than juvenile fish. As such, the incidental take estimates are used to judge the negative activities implemented under the FPHCP, but they are not always a reliable tool for accurately measuring incidental take due to the complexity of biological systems.

Coastal cutthroat trout

We estimate a total of 551,747 riparian acres are potentially available to be managed that could contribute to take of coastal cutthroat trout. The actual reduction in recruitable LWD that occurs because of riparian timber harvest over the 50 year permit term is relatively small, but there would be trees that are harvested that would otherwise have recruited to the stream and formed habitats. The reduction of recruitable LWD becomes more noticeable over longer time frames, such as 100 and 250 years. Sediment delivery from riparian harvest would occur in some situations, but is expected to be much less than sediment delivery from roads. However, there would be some circumstances that sediment delivery is a product of riparian harvest.

Incidental take of coastal cutthroat trout from riparian harvest over the 50 year permit term is estimated in acres as follows:

- Type S riparian management acres: 138,429
- Type F riparian management acres: 286,862
- Type Np riparian management acres: 126,456

Road stream crossings are an activity that would be a primary mechanism for sediment delivery to coastal cutthroat trout habitat. A total of 23,558 stream crossing are estimated on FPHCP lands that could affect coastal cutthroat trout. These stream crossing would deliver sediment to trout habitats that contribute to take. Intensity of road use and road design influence sediment delivery to coastal cutthroat trout habitats. In addition to sediment delivery from road crossings, loss of LWD and reduced shading can occur at road crossings. An average width of opening through the riparian zone associated with a crossing is approximately 40 feet. This area would lose the potential to deliver LWD and would also increase sunlight reaching the stream.

Incidental take of coastal cutthroat trout is estimated in number of stream crossings over a 50 year permit term as follows:

- Type S stream crossings: 1,462
- Type F stream crossings: 14,970

- Type Np stream crossings: 7,126

The third activity that can be estimated, and could also cause take, are roads located within the Riparian Zone. Most of these riparian roads have been in place for a considerable time and their presence reduces the effectiveness of the riparian area. Roads within the Riparian Zone have several effects, most notably reduction of recruitable LWD, reduction in shade (especially if close to the stream), and sediment delivery to trout habitats. A total of 4,374 miles of road occurs within the riparian areas of Type S, F, and Np streams that could cause take. This equals approximately 21,206 (using a 40' wide road opening) acres not capable of providing full riparian functions. Over time these figures should be reduced due to implementation of the FPHCP.

Incidental take of coastal cutthroat trout is estimated from roads in the Riparian Zone of Type S, F, and Np streams. Estimates are in miles and acres as follows:

- Type S riparian roads: 1,197 miles (5,803 acres)
- Type F riparian roads: 2,400 miles (11,636 acres)
- Type Np riparian roads: 777 miles (3,767 acres)

Westslope Cutthroat Trout

Riparian timber harvest is expected to contribute to take to westslope cutthroat trout in the following two ways: removal of recruitable LWD and increases in sediment that reach trout habitats. A third way that riparian harvest may influence westslope cutthroat trout are in areas outside of the Bull Trout Habitat Overlay. Riparian harvest along these streams may, in some circumstances, allow increased sunlight to increase stream temperatures. A total of 68,343 riparian acres are potentially available to be managed that could contribute to take of westslope cutthroat trout. The actual reduction in recruitable LWD that occurs because of timber harvest over the 50 year permit term is relatively small, but there would be trees that are harvested that would otherwise have recruited to the stream and formed habitats. The reduction of recruitable LWD becomes more noticeable over longer time frames, such as 100 and 250 years. Sediment delivery from riparian harvest would occur in some situations, but is expected to be much less than sediment delivery from roads. However, there would be some circumstances that sediment delivery is a product of riparian harvest. In addition, some site specific conditions of riparian harvest - when outside of the Bull Trout Habitat Overlay - may allow increases in sunlight to streams.

Incidental take of westslope cutthroat trout over the 50 year permit term as estimated in acres of riparian harvest as follows:

- Type S riparian management acres: 17,373
- Type F riparian management acres: 21,590
- Type Np riparian management acres: 29,380

Road stream crossings are an activity that would be a primary mechanism for sediment delivery to westslope cutthroat trout habitats. A total of 2,809 stream crossing on Type S, F and Np are estimated on FPHCP lands that could take westslope cutthroat trout. These stream crossing would deliver sediment to trout habitats that could cause take. Intensity of road use and road design influence sediment delivery to westslope cutthroat trout habitats. In addition to sediment delivery from road crossings, loss of LWD and reduced shading can occur at road crossings. An average width of opening through the riparian zone

associated with a crossing is approximately 40 feet. This area would lose the potential to deliver LWD and would also increase sunlight reaching the stream.

Incidental take of westslope cutthroat trout is estimated in number of stream crossings over a 50 year permit term as follows:

- Type S stream crossings: 240
- Type F stream crossings: 918
- Type Np stream crossings: 1,651

The third activity that can be estimated, and would also contribute to take, are roads located within the Riparian Zone. Most of these riparian roads have been in place for a considerable time and their presence reduces the effectiveness of the Riparian Zone. Roads within the Riparian Zone have several effects, most notably reduction of recruitable LWD, reduction in shade (especially if close to the stream), and sediment delivery to trout habitats. A total of 664 miles of road occurs within the riparian areas of Type S, F, and Np streams that could cause take. This equals approximately 3,226 acres not capable of providing full riparian functions. Over time these figures should be reduced due to implementation of the FPHCP.

Incidental take of westslope cutthroat trout is estimated from roads in the riparian areas of Type S, F, and Np streams. Estimates are in miles and acres as follows:

- Type S riparian roads: 131 miles (636 acres)
- Type F riparian roads: 252 miles (1,221 acres)
- Type Np riparian roads: 281 miles (1,362 acres)

Conclusion

In this Opinion, we determined that this level of anticipated take is not likely to result in jeopardy to the coastal and westslope cutthroat trout. The effects to the species are not at a scale or magnitude that would affect the overall abundance or distribution of the species in the FPHCP Action Area.

9.1.2.3 Coastal Rainbow Trout and Redband Trout

We anticipate that take of rainbow trout would occur within habitat adjacent to covered lands over the 50-year permit term. The conservation measures in the FPHCP provide riparian protections that address stream shade, LWD recruitment, leaf and needle litter production, microclimate, bank stability, and minimization measures for sediment to aquatic habitats on FPHCP lands. Implementation of the FPHCP is expected to provide adequate functionality of these factors that would contribute to the long-term survival of rainbow trout in the FPHCP Action Area.

There would be adverse effects, however, from the FPHCP that would lead to take of redband coastal rainbow trout. These affects have been analyzed in three areas of this Opinion: 1) General Effects, 2) Effects to Guilds, 3) and Effects to Species.

The effects we determined that could contribute to take of rainbow trout are: 1) excessive sediment to fish-bearing streams from roads, timber harvest, and stream crossing projects (culvert, bridge installation, and potentially other approved crossing methods); 2) increases in stream temperature due to riparian tree removal that provide shade; 3) the prevention of riparian trees from growing that could provide shade –

primarily by riparian roads; 4) removal of riparian trees that could potentially provide LWD; 5) the prevention of riparian trees from growing that could ultimately provide LWD – primarily by riparian roads and 20 acre exemptions; and 6) capture and removal of rainbow trout for instream projects, primarily road crossing activities.

Process for determining Incidental Take of Rainbow trout

We assessed the activities associated with the FPHCP to determine which activities had the highest chance of contributing to take of rainbow trout. The activities needed to be measurable, have a likelihood of contributing to take, and be an activity directly associated with the FPHCP. The FPHCP activities that best meet these criteria for rainbow trout were: 1) riparian timber harvest in Type S, F, and Np streams, 2) stream crossings of Type S, F and Np streams, and 3) roads located in Type S, F, and Np riparian zones. We determined that these three primary activities could be estimated with available information. See Appendix G for a description of the GIS process for determining these estimates.

Estimates were made of the WRIA's that rainbow trout occupy in the FPHCP Action Area. The information for determining fish occupancy came primarily from the following two sources: Inland Fishes of Washington, by Wydoski and Whitney, 2003, and the Final Environment Impact Statement for the FPHCP, 2006.

As described above, while we can develop quantifiable estimates of take for this Opinion, fish respond to environmental disturbances differently depending upon a variety of factors. Factors that may affect fish response to perturbations are size and species of fish, age of fish, condition of fish, complexity of habitat, season, inter-specific and intra-specific competition, dissolved oxygen and water temperatures, turbidity, and other physical and biological processes. In addition to the various possible responses of fish to disturbances, fish are often distributed in a stream network at different scales. Fish occupy their environment from a small scale such as a pool, to a large scale, such as the watershed. Because of this often patchy fish distribution within a stream, FPHCP activities that have been determined to contribute to take would not always cause the same fish response. An activity that may cause a harmful fish response in one stream may not have the same result in another stream because the fish are not in proximity to the disturbance. The same activity could influence adult fish substantially different than juvenile fish. As such, the incidental take estimates are used to judge the negative activities implemented under the FPHCP, but they are not always a reliable tool for accurately measuring incidental take due to the complexity of biological systems.

In some circumstances it is important to recognize the temporal nature of incidental take. Replacing a culvert that is currently preventing fish passage with a culvert that allows fish passage, has both short-term consequences and long-term benefits. While there may be some short-term take associated with a culvert replacement, and individual fish may die as a result of the project, over a longer time frame the availability of new habitats would most likely outweigh the take that occurred with the actual installation of the culvert. In a contrasting temporal situation, the removal of trees in the Outer Zone that may have eventually recruited to the stream may not be incidental take in the short-term, but at longer time frames when the chance of tree recruitment increased and the tree was unavailable, take may have been realized. Because of the temporal variability of incidental take, and the diversity of aquatic systems, the relationship between incidental take and fish response is not absolute.

There are two outcomes of measuring incidental take of rainbow trout using the WRIA distribution data and the three activities for measuring take: 1) fish occupancy aligns precisely with the activities identified as contributing to take and fish respond to that take, 2) fish presence not aligned with activities

identified as contributing to take and take is an overestimate. For the scale of analysis required for the Opinion, we think that incidental take for most species analyzed under this Opinion is an overestimate. It would not be uncommon for some activities to occur without any contribution to take. In another situation the same activity would contribute to take. We consider this approach for evaluating incidental take appropriate for this Opinion.

Coastal rainbow trout

We estimate a total of 517,462 of Type S, F, and Np riparian acres are potentially available to be managed that could contribute to take of coastal rainbow trout. The actual reduction in recruitable LWD that occurs because of riparian timber harvest over the 50 year permit term is relatively small, but there would be trees that are harvested that would otherwise have recruited to the stream and formed habitats. The reduction of recruitable LWD becomes more noticeable over longer time frames, such as 100 and 250 years. Sediment delivery from riparian harvest would occur in some situations, but is expected to be much less than sediment delivery from roads. However, there would be some circumstances that sediment delivery is a product of riparian harvest.

Incidental take of coastal rainbow trout from riparian harvest over the 50 year permit term is estimated in acres as follows:

- Type S riparian management acres: 129,417
- Type F riparian management acres: 270,542
- Type Np riparian management acres: 117,503

Road stream crossings are an activity that would be a primary mechanism for sediment delivery to coastal rainbow trout habitat. A total of 22,172 stream crossing for Type S, F, and Np streams are estimated on FPHCP lands that could affect coastal rainbow trout. These stream crossing would deliver sediment to habitats that contribute to take. Intensity of road use and road design influence sediment delivery to coastal rainbow trout habitats. In addition to sediment delivery from road crossings, loss of LWD and reduced shading can occur at road crossings. An average width of opening through the Riparian Zone associated with a crossing is approximately 40 feet. This area would lose the potential to deliver LWD and would also increase sunlight reaching the stream.

Incidental take of coastal rainbow trout is estimated in number of stream crossings, over a 50 year permit term as follows:

- Type S stream crossings: 1,342
- Type F stream crossings: 14,116
- Type Np stream crossings: 6,714

The third activity that can be estimated, and could also take, are roads located within the Riparian Zone. Most of these riparian roads have been in place for a considerable time and their presence reduces the effectiveness of the Riparian Zone. Roads within the Riparian Zone have several effects, most notably reduction of recruitable LWD, reduction in shade (especially if close to the stream), and sediment delivery to habitats. A total of 4,054 miles of road occurs within the riparian areas of Type S, F, and Np streams that could cause take. This equals approximately 19,655 (using a 40’ wide road opening) acres not capable of providing full riparian functions. Over time, these figures may be reduced due to implementation of the FPHCP.

Incidental take of coastal rainbow trout is estimated from roads in the riparian areas of Type S, F, and Np streams. Estimates are in miles and acres as follows:

- Type S riparian roads: 1,109 miles (5,376 acres)
- Type F riparian roads: 2,233 miles (10,826 acres)
- Type Np riparian roads: 711 miles (3,447 acres)

Redband rainbow trout

A considerable portion of the redband rainbow trout's habitat is influenced by Federal lands and not by the FPHCP. As such, these take estimates are probably higher than what may actually occur. Riparian timber harvest is expected to contribute to take of rainbow trout in the following two ways: removal of recruitable LWD and increases in sediment that reach habitats. A total of 119,706 Type S, F, and Np riparian acres are potentially available to be managed that could contribute to take of rainbow trout. The actual reduction in recruitable LWD that occurs because of timber harvest over the 50 year permit term is relatively small, but there would be trees that are harvested that may have recruited to the stream and formed habitats. The reduction of recruitable LWD becomes more noticeable over longer time frames, such as 100 and 250 years. Sediment delivery from riparian harvest would occur in some situations, but is expected to be much less than sediment delivery from roads. However, there would be some circumstances that sediment delivery is a product of riparian harvest.

Incidental take of redband rainbow trout over the 50 year permit term as estimated in acres of riparian harvest as follows:

- Type S riparian management acres: 27,364
- Type F riparian management acres: 41,608
- Type Np riparian management acres: 50,734

Road stream crossings are an activity that would be a primary mechanism for sediment delivery to redband rainbow trout habitats. A total of 4,921 stream crossing on Type S, F and Np are estimated on FPHCP lands that could take redband rainbow trout. These stream crossing would deliver sediment to habitats that could cause take. Intensity of road use and road design influence sediment delivery to redband rainbow trout habitats. In addition to sediment delivery from road crossings, loss of LWD and reduced shading can occur at road crossings. An average width of opening through the riparian zone associated with a crossing is approximately 40 feet. This area would lose the potential to deliver LWD and would also increase sunlight reaching the stream.

Incidental take of redband rainbow trout is estimated in number of stream crossings over a 50 year permit term as follows:

- Type S stream crossings: 366
- Type F stream crossings: 1,948
- Type Np stream crossings: 2,607

The third activity that can be estimated, and would also contribute to take, are roads located within the Riparian Zone. Most of these riparian roads have been in place for a considerable time and their presence reduces the effectiveness of the Riparian Zone. Roads within the Riparian Zone have several effects, most notably reduction of recruitable LWD, reduction in shade (especially if close to the stream), and

sediment delivery to habitats. A total of 1,182 miles of road occurs within the riparian areas of Type S, F, and Np streams that could cause take. This equals approximately 5,730 acres not capable of providing full riparian functions. Over time these figures may be reduced due to implementation of the FPHCP.

Incidental take of redband rainbow trout is estimated from roads in the riparian areas of Type S, F, and Np streams. Estimates are in miles and acres as follows:

- Type S riparian roads: 206 miles (998 acres)
- Type F riparian roads: 504 miles (2,443 acres)
- Type Np riparian roads: 471 miles (2,283 acres)

Conclusion

In this Opinion, we determined that this level of anticipated take is not likely to result in jeopardy to the coastal rainbow and redband trout. The effects to the species are not at a scale or magnitude that would affect the overall abundance or distribution of the species in the FPHCP Action Area.

9.1.2.4 Mountain Whitefish and Pygmy Whitefish

We anticipate that take of pygmy and mountain whitefish would occur within habitat adjacent to covered lands over the 50-year permit term. The conservation measures in the FPHCP provide riparian protections that address stream shade, LWD recruitment, leaf and needle litter production, microclimate, bank stability, and minimization measures for sediment to aquatic habitats on FPHCP lands. Implementation of the FPHCP is expected to provide adequate functionality of these factors that would contribute to whitefish long-term survival.

There would be effects, however, from the FPHCP that would lead to take of mountain and pygmy whitefish. These affects have been analyzed in three areas of this Opinion: 1) General Effects, 2) Effects to Guilds, 3) and Effects to Species.

The effects we determined could contribute to take of whitefish are: 1) excessive sediment to fish-bearing streams from roads, timber harvest, and stream crossing projects (culvert, bridge installation, and potentially other approved crossing methods), 2) increases in stream temperature due to riparian tree removal that provide shade, 3) the prevention of riparian trees from growing that could provide shade – primarily by riparian roads, 4) removal of riparian trees that could potentially provide LWD, 5) the prevention of riparian trees from growing that could ultimately provide LWD – primarily by riparian roads and 20 acre exemptions, and 6) capture and removal of whitefish for instream projects, primarily road crossing activities.

Process for determining Incidental Take of Whitefish

We assessed the activities associated with the FPHCP to determine which activities had the highest chance of contributing to take of whitefish. The activities needed to be measurable, have a likelihood of contributing to take, and be an activity directly associated with the FPHCP. The FPHCP activities that best meet these criteria for mountain and pygmy whitefish were: 1) riparian timber harvest in Type S, F, and Np streams, 2) stream crossings of Type S, F and Np streams, and 3) roads located in Type S, F, and Np riparian zones. We determined that these three primary activities could be estimated with the available information. See Appendix G for a description of the GIS process for determining these estimates.

Estimates were made of the WRIA's that pygmy and mountain whitefish occupy in the FPHCP Action Area. The information for determining fish occupancy came primarily from the following two sources: Inland Fishes of Washington, by Wydoski and Whitney, 2003, and the Final Environment Impact Statement for the FPHCP, 2006.

As described above, while we can develop quantifiable estimates of take for this Opinion, fish respond to environmental disturbances differently depending upon a variety of factors. Factors that may affect fish response to perturbations are size and species of fish, age of fish, condition of fish, complexity of habitat, season, inter-specific and intra-specific competition, dissolved oxygen and water temperatures, turbidity, and other physical and biological processes. In addition to the various possible responses of fish to disturbances, fish are often distributed in a stream network at different scales. Fish occupy their environment from a small scale such as a pool, to a large scale, such as the watershed. Because of this often patchy fish distribution within a stream, FPHCP activities that have been determined to contribute to take would not always cause the same fish response. An activity that may cause a harmful fish response in one stream, may not have the same result in another stream because the fish are not in proximity to the disturbance. The same activity could influence adult fish substantially different than juvenile fish. As such, the incidental take estimates are used to judge the negative activities implemented under the FPHCP, but they are not always a reliable tool for accurately measuring incidental take due to the complexity of biological systems.

In some circumstances it is important to recognize the temporal nature of incidental take. Replacing a culvert that is currently preventing fish passage with a culvert that allows fish passage, has both short-term consequences and long-term benefits. While there may be some short-term take associated with a culvert replacement, and individual fish may die as a result of the project, over a longer time frame the availability of new habitats would most likely outweigh the take that occurred with the actual installation of the culvert. In a contrasting temporal situation, the removal of trees in the Outer Zone that may have eventually recruited to the stream may not be incidental take in the short-term, but at longer time frames when the chance of tree recruitment increased and the tree was unavailable, take may have been realized. Because of the temporal variability of incidental take, and the diversity of aquatic systems, the relationship between incidental take and fish response is not absolute.

There are two outcomes of measuring incidental take of whitefish using the WRIA distribution data and the three activities for measuring take: 1) fish occupancy aligns precisely with the activities identified as contributing to take and fish respond to that take, 2) fish presence not aligned with activities identified as contributing to take and take is an overestimate. For the scale of analysis required for this Opinion, we think that incidental take for most species analyzed under this Opinion is an overestimate. It would not be uncommon for some activities to occur without any contribution to take. In another situation the same activity would contribute to take. We consider this approach for evaluating incidental take appropriate for this Opinion.

Mountain whitefish

Riparian timber harvest is expected to contribute to take of mountain whitefish in the following two ways: removal of recruitable LWD and increases in sediment that reach habitats. A total of 369,961 Type S, F, and Np riparian acres are potentially available to be managed that could contribute to take of mountain whitefish. The actual reduction in recruitable LWD that occurs because of timber harvest over the 50 year permit term is relatively small, but there would be trees that are harvested that may have recruited to the stream and formed habitats. The reduction of recruitable LWD becomes more noticeable over longer

time frames, such as 100 and 250 years. Sediment delivery from riparian harvest would occur in some situations, but is expected to be much less than sediment delivery from roads. However, there would be some circumstances that sediment delivery is a product of riparian harvest.

Incidental take of mountain whitefish from riparian harvest over the 50 year permit term is estimated in acres as follows:

- Type S riparian management acres: 97,582
- Type F riparian management acres: 173,745
- Type Np riparian management acres: 98,634

Road stream crossings are an activity that would be a primary mechanism for sediment delivery to mountain whitefish habitats. A total of 16,399 stream crossing for Type S, F, and Np streams are estimated on FPHCP lands that could affect mountain whitefish. These stream crossing would deliver sediment to habitats that contribute to take. Intensity of road use and road design influence sediment delivery to coastal whitefish habitats. In addition to sediment delivery from road crossings, loss of LWD and reduced shading can occur at road crossings. An average width of opening through the Riparian Zone associated with a crossing is approximately 40 feet. This area would lose the potential to deliver LWD and would also increase sunlight reaching the stream.

Incidental take of mountain whitefish is estimated in number of stream crossings over a 50 year permit term as follows:

- Type S stream crossings: 988
- Type F stream crossings: 8,786
- Type Np stream crossings: 6,625

The third activity that can be estimated, and could also cause take, are roads located within the Riparian Zone. Most of these riparian roads have been in place for a considerable time and their presence reduces the effectiveness of the Riparian Zone. Roads within the Riparian Zone have several effects, most notably reduction of recruitable LWD, reduction in shade (especially if close to the stream), and sediment delivery to habitats. A total of 3,127 miles of road occurs within the riparian areas of Type S, F, and Np streams that could cause take. This equals approximately 15,161 (using a 40' wide road opening) acres not capable of providing full riparian functions. Over time, these figures should be reduced due to implementation of the FPHCP.

Incidental take of mountain whitefish is estimated from roads in the riparian areas of Type S, F, and Np streams. Estimates are in miles and acres as follows:

- Type S riparian roads: 713 miles (3,456 acres)
- Type F riparian roads: 1,548 miles (7,505 acres)
- Type Np riparian roads: 866 miles (4,198 acres)

Pygmy whitefish

A considerable portion of the pygmy whitefish's habitat is influenced by Federal lands and not by the FPHCP. As such, these take estimates are probably higher than what may actually occur. Riparian timber harvest is expected to contribute to take of pygmy whitefish in the following two ways: removal of

recruitable LWD and increases in sediment that reach habitats. A total of 27,068 riparian acres are potentially available to be managed that could contribute to take. The actual reduction in recruitable LWD that occurs because of timber harvest over the 50 year permit term is relatively small, but there would be trees that are harvested that may have recruited to the stream and formed habitats. The reduction of recruitable LWD becomes more noticeable over longer time frames, such as 100 and 250 years. Sediment delivery from riparian harvest would occur in some situations, but is expected to be much less than sediment delivery from roads. However, there would be some circumstances that sediment delivery is a product of riparian harvest.

Incidental take of pygmy whitefish over the 50 year permit term as estimated in acres of riparian harvest as follows:

- Type S riparian management acres: 11,222
- Type F riparian management acres: 3,574
- Type Np riparian management acres: 12,272

Road stream crossings are an activity that would be a primary mechanism for sediment delivery to pygmy whitefish habitats. A total of 1,643 stream crossing on Type S, F and Np are estimated on FPHCP lands that could take pygmy whitefish. These stream crossing would deliver sediment to habitats that could cause take. Intensity of road use and road design influence sediment delivery to pygmy whitefish habitats. In addition to sediment delivery from road crossings, loss of LWD and reduced shading can occur at road crossings. An average width of opening through the riparian zone associated with a crossing is approximately 40 feet. This area would lose the potential to deliver LWD and would also increase sunlight reaching the stream.

Incidental take of pygmy whitefish is estimated in number of stream crossings, over a 50 year permit term as follows:

- Type S stream crossings: 127
- Type F stream crossings: 843
- Type Np stream crossings: 673

The third activity that can be estimated, and would also contribute to take, are roads located within the Riparian Zone. Most of these riparian roads have been in place for a considerable time and their presence reduces the effectiveness of the Riparian Zone. Roads within the Riparian Zone have several effects, most notably reduction of recruitable LWD, reduction in shade (especially if close to the stream), and sediment delivery to habitats. A total of 360 miles of road occurs within the riparian areas of Type S, F, and Np streams that could cause take. This equals approximately 1,745 acres not capable of providing full riparian functions. Over time these figures should be reduced due to implementation of the FPHCP.

Incidental take of pygmy whitefish is estimated from roads in the riparian areas of Type S, F, and Np streams. Estimates are in miles and acres as follows:

- Type S riparian roads: 88 miles (426 acres)
- Type F riparian roads: 169 miles (819 acres)
- Type Np riparian roads: 103 miles (499 acres)

Conclusion

In this Opinion, we determined that this level of anticipated take is not likely to result in jeopardy to the mountain and pygmy whitefish. The effects to the species are not at a scale or magnitude that would affect the overall abundance or distribution of the species in the FPHCP Action Area.

9.1.2.5 Western Brook Lamprey, River Lamprey and Pacific Lamprey

Riparian timber harvest is expected to contribute to take of Pacific, river, and western brook lamprey in the following two ways: removal of recruitable LWD and increases in sediment that reach lamprey habitats. The total Type S, F, and Np riparian harvest that may lead to take are as follows: Pacific lamprey – 518,475 acres, river lamprey – 320,429 acres, and western brook lamprey – 513,097 acres. The actual reduction in recruitable LWD that occurs because of timber harvest over the 50 year permit term is relatively small, but there would be trees that are harvested that may have recruited to the stream and formed habitats. The reduction of recruitable LWD becomes more noticeable over longer time frames, such as 100 and 250 years. Sediment delivery from riparian harvest would occur in some situations, but is expected to be much less than sediment delivery from roads. However, there would be some circumstances that sediment delivery is a product of riparian harvest.

Road stream crossings are an activity that would be a primary mechanism for sediment delivery to lamprey habitats. The total Type S, F, and Np stream crossings that may lead to take are as follows: Pacific lamprey – 22,150, river lamprey 13,437, and western brook lamprey – 21, 841. These stream crossing would deliver sediment to lamprey habitats that contribute to take. Intensity of road use and road design influence sediment delivery to lamprey habitats. In addition to sediment delivery from road crossings, loss of LWD and reduced shading can occur at road crossings. An average width of opening through the Riparian Zone associated with a crossing is approximately 40 feet. This area would lose the potential to deliver LWD and would also increase sunlight reaching the stream.

The third activity that can be estimated, and could also cause take, are roads located within the Riparian Zone. Most of these riparian roads have been in place for a considerable time and their presence reduces the effectiveness of the Riparian Zone. Roads within the Riparian Zone have several effects, most notably reduction of recruitable LWD, reduction in shade (especially if close to the stream), and sediment delivery to lamprey habitats. The total of riparian roads in Type S, F, and Np as measured in miles and acres (using a 40’ wide road opening) that would contribute to take are as follows: Pacific lamprey – 4,166 miles (20,247 acres), river lamprey – 2,468 miles (11,964 acre), and western brook lamprey – 4,069 miles (19,727 acres). Over time these figures should be reduced due to implementation of the FPHCP.

Incidental take of Pacific lamprey from riparian harvest over the 50 year permit term is estimated in acres as follows:

- Type S riparian management acres: 128,055
- Type F riparian management acres: 268,585
- Type Np riparian management acres: 121,835

Incidental take of Pacific lamprey is estimated in number of stream crossings, over a 50 year permit term as follows:

- Type S stream crossings: 1,469
- Type F stream crossings: 13,818

- Type Np stream crossings: 6,863

Incidental take of Pacific lamprey is estimated from roads in the riparian areas of Type S, F, and Np streams. Estimates are in miles and acres as follows:

- Type S riparian roads: 1,124 miles (5,449 acres)
- Type F riparian roads: 2,267 miles (10,991 acres)
- Type Np riparian roads: 775 miles (3,757 acres)

Incidental take of river lamprey from riparian harvest over the 50 year permit term is estimated in acres as follows:

- Type S riparian management acres: 85,624
- Type F riparian management acres: 155,353
- Type Np riparian management acres: 79,452

Incidental take of river lamprey is estimated in number of stream crossings, over a 50 year permit term as follows:

- Type S stream crossings: 804
- Type F stream crossings: 8,036
- Type Np stream crossings: 4,597

Incidental take of river lamprey is estimated from roads in the riparian areas of Type S, F, and Np streams. Estimates are in miles and acres as follows:

- Type S riparian roads: 628 miles (3,044 acres)
- Type F riparian roads: 1,304 miles (6,322 acres)
- Type Np riparian roads: 536 miles (2,598 acres)

Incidental take of western brook lamprey from riparian harvest over the 50 year permit term is estimated in acres as follows:

- Type S riparian management acres: 128,532
- Type F riparian management acres: 265,246
- Type Np riparian management acres: 119,309

Incidental take of western brook lamprey is estimated in number of stream crossings, over a 50 year permit term as follows:

- Type S stream crossings: 1,365
- Type F stream crossings: 13,702
- Type Np stream crossings: 6,774

Incidental take of western brook lamprey is estimated from roads in the riparian areas of Type S, F, and Np streams. Estimates are in miles and acres as follows:

- Type S riparian roads: 1,079 miles (5,231 acres)

- Type F riparian roads: 2,224 miles (10,783 acres)
- Type Np riparian roads: 766 miles (3,713 acres)

Conclusion

In this Opinion, we determined that this level of anticipated take is not likely to result in jeopardy to the Pacific, river, and western brook lamprey. The effects to these three species are not at a scale or magnitude that would affect the overall abundance or distribution of these species in the FPHCP Action Area.

9.1.2.6 Kokanee

We anticipate that take of kokanee would occur within habitat adjacent to covered lands over the 50-year permit term. The conservation measures in the FPHCP provide riparian protections that address stream shade, LWD recruitment, leaf and needle liter production, microclimate, bank stability, and minimization measures for sediment to aquatic habitats on FPHCP lands. Implementation of the FPHCP is expected to provide adequate functionality of these factors that would contribute to kokanee long-term survival.

There would be effects, however, from the FPHCP that would lead to take of kokanee. These affects have been analyzed in three areas of this Opinion: 1) General Effects, 2) Effects to Guilds, 3) and Effects to Species. The effects that we have determined could contribute to take of kokanee are: 1) excessive sediment to fish-bearing streams from roads, timber harvest, and stream crossing projects (culvert, bridge installation, and potentially other approved crossing methods), 2) increases in stream temperature due to riparian tree removal that provide shade, 3) preventing riparian trees from growing that could provide shade – primarily by riparian roads, 4) removal of riparian trees that could potentially provide LWD, 5) preventing riparian trees from growing that could ultimately provide LWD – primarily by riparian roads and 20 acre exemptions, and 6) capture and removal of kokanee for instream projects, primarily road crossings. Kokanee spend the majority of their life in lakes and would not be exposed to some of these effects that contribute to take to the degree that some other salmonids may be.

Process for determining Incidental Take of Kokanee

We assessed the activities associated with the FPHCP to determine which activities had the highest chance of contributing to take of kokanee. The activities needed to be measurable, have a likelihood of contributing to take, and be an activity directly associated with the FPHCP. The FPHCP activities that best meet these criteria for kokanee were: 1) riparian timber harvest in Type S, F, and Np streams, 2) stream crossings of Type S, F and Np streams, and 3) roads located in Type S, F, and Np riparian zones. We determined that these three primary activities could be estimated with the currently available information. See Appendix G for a description of the GIS process for determining these estimates.

Estimates were made of the WRIA's that kokanee occupy in the FPHCP Action Area. The information for determining occupancy came primarily from the following two sources: Inland Fishes of Washington, by Wydoski and Whitney, 2003, and the Final Environment Impact Statement for the FPHCP, 2006.

As described above, while we can develop quantifiable estimates of take for this Opinion, fish respond to environmental disturbances differently depending upon a variety of factors. Factors that may affect fish response to perturbations are size and species of fish, age of fish, condition of fish, complexity of habitat, season, inter-specific and intra-specific competition, dissolved oxygen and water temperatures, turbidity, and other physical and biological processes. In addition to the various possible responses of fish to

disturbances, fish are often distributed in a stream network at different scales. For kokanee, lakes are important also. Fish occupy their environment from a small scale such as a pool, to a large scale, such as the watershed. Because of this often patchy fish distribution within a stream, FPHCP activities that have been determined to contribute to take would not always cause the same fish response. An activity that may cause a harmful fish response in one stream, may not have the same result in another stream because the fish are not in proximity to the disturbance. The same activity could influence adult fish substantially differently than juvenile fish. As such, the incidental take estimates are used to judge the negative activities implemented under the FPHCP, but they are not always a reliable tool for accurately measuring incidental take due to the complexity of biological systems.

Riparian timber harvest is expected to contribute to take of kokanee in the following two ways: removal of recruitable LWD and increases in sediment that reach kokanee habitats. We estimate a total of 266,513 riparian acres are potentially available to be managed that could contribute to take of kokanee. The actual reduction in recruitable LWD that occurs because of riparian timber harvest over the 50 year permit term is relatively small, but there would be trees that are harvested that would otherwise have recruited to the stream and formed habitats. The reduction of recruitable LWD becomes more noticeable over longer time frames, such as 100 and 250 years. Sediment delivery from riparian harvest would occur in some situations, but is expected to be much less than sediment delivery from roads. However, there would be some circumstances that sediment delivery is a product of riparian harvest.

Incidental take of kokanee from riparian harvest over the 50 year permit term is estimated in acres.

- Type S riparian management acres: 69,162
- Type F riparian management acres: 124,916
- Type Np riparian management acres: 72,435

Road stream crossings are an activity that would be a primary mechanism for sediment delivery to kokanee habitat. A total of 10,750 stream crossing are estimated on FPHCP lands that could take kokanee. These stream crossings would deliver sediment to kokanee habitat that contribute to take. Intensity of road use and road design influence sediment delivery to kokanee habitat. In addition to sediment delivery from road crossings, loss of LWD and reduced shading can occur at road crossings. Stream temperatures could be increased in some cases. An average width of opening through the riparian zone associated with a crossing is approximately 40 feet. This area would lose the potential to deliver LWD and would also increase sunlight reaching the stream.

Kokanee spend a relatively short time of their life in streams, they normally reside in lakes. As such, they would not be exposed to some of the effects of road crossings that some other salmonids are. However, road crossing still have the ability to contribute to take of kokanee.

Incidental take of kokanee is estimated in number of stream crossings over a 50 year permit term.

- Type S stream crossings: 729
- Type F stream crossings: 5,880
- Type Np stream crossings: 4,144

The third activity that can be estimated, and would also cause take, are roads located within the Riparian Zone. Most of these riparian roads have been in place for a considerable time and their presence reduces the effectiveness of the riparian area. Roads within the riparian zone have several effects, most notably

reduction of recruitable LWD, reduction in shade (especially if close to the stream), and sediment delivery to kokanee habitats. A total of 2,085 miles of road occurs within the riparian areas of Type S, F, and Np streams that could cause take. This equals approximately 10,109 (using a 40' wide road opening) acres not capable of providing full riparian functions. Over time these figures should be reduced due to implementation of the FPHCP.

Kokanee spend a relatively short time of their life in streams, they normally reside in lakes. As such, they would not be exposed to some of the effects of stream adjacent roads that some other salmonids are. However, stream adjacent roads still have the ability to contribute to take of kokanee.

Incidental take of kokanee is estimated from roads in the riparian areas of Type S, F, and Np streams. Estimates are in miles and acres.

- Type S riparian roads: 484 (2,346 acres)
- Type F riparian roads: 1,041 miles (5,047 acres)
- Type Np riparian roads: 560 miles (2,715 acres)

Conclusion

In this Opinion, we determined that this level of anticipated take is not likely to result in jeopardy to kokanee. The effects to the species are not at a scale or magnitude that would affect the overall abundance or distribution of the species in the FPHCP Action Area.

9.1.2.7 Olympic Mudminnow

Process for determining Incidental Take of Olympic Mudminnow

We assessed the activities associated with the FPHCP to determine which activities had the highest chance of contributing to take of Olympic mudminnow. The activities needed to be measurable, have a likelihood of contributing to take, and be an activity directly associated with the FPHCP. The FPHCP activities that best meet these criteria for Olympic mudminnow were: 1) stream crossings of Type S, F and Np streams, and 2) roads located in Type S, F, and Np riparian zones. The FWS determined that these two primary activities could be estimated with the currently available information. See Appendix G for a description of the GIS process for determining these estimates.

Incidental Take of Olympic mudminnow is estimated in number of stream crossings over a 50 year permit term. Additionally, removal of cover (primarily aquatic vegetation) in association with stream crossing projects, would contribute to take as follows.

- Type S stream crossings: 357
- Type F stream crossings: 4,268
- Type Np stream crossings: 1,283

Incidental take of Olympic mudminnow is estimated from roads in the riparian areas of Type S, F, and Np streams. Estimates are in miles and acres as follows.

- Type S riparian roads: 300 miles (1,454 acres)
- Type F riparian roads: 686 miles (3,326 acres)
- Type Np riparian roads: 135 miles (654 acres)

Conclusion

In this Opinion, we determined that this level of anticipated take is not likely to result in jeopardy to Olympic mudminnow. The effects to the species are not at a scale or magnitude that would affect the overall abundance or distribution of the species in the FPHCP Action Area.

9.1.2.8 Chiselmouth

Road stream crossings are an activity that would likely be a mechanism for sediment delivery to chiselmouth habitats. A total of 8,777 stream crossings on Type S, F, and Np streams are estimated on FPHCP lands that could affect chiselmouth. These stream crossings would deliver sediment to habitats that contribute to take. Intensity of road use and road design would influence sediment delivery to chiselmouth habitats. In addition to sediment delivery from road crossings, loss of LWD and reduced shading can occur at road crossings. An average width of opening through the riparian zone associated with a crossing is approximately 40 feet. This area would lose the potential to deliver LWD and would also increase sunlight reaching the stream.

Incidental take of chiselmouth is estimated in number of stream crossings over a 50 year permit term.

- Type S stream crossings: 542
- Type F stream crossings: 3,869
- Type Np stream crossings: 4,366

Conclusion

In this Opinion, we determined that this level of anticipated take is not likely to result in jeopardy to chiselmouth. The effects to the species are not at a scale or magnitude that would affect the overall abundance or distribution of the species in the FPHCP Action Area.

9.1.2.9 Redside shiner

Incidental take of redside shiner is estimated in number of stream crossings over a 50 year permit term. Take is primarily from increase in sediment, and secondarily, from reduction in LWD and shade. Mortality of fish may occur during culvert replacement/installation projects.

Incidental take of redside shiner from riparian harvest over the 50 year permit term is estimated in acres.

- Type S riparian management acres: 134,772
- Type F riparian management acres: 248,698
- Type Np riparian management acres: 148,675

Additionally, removal of cover in association with stream crossing projects, primarily aquatic vegetation for redside shiner, would cause take.

- Type S stream crossings: 1,530
- Type F stream crossings: 12,987
- Type Np stream crossings: 8,500

Incidental take of redside shiner is estimated from roads in the riparian areas of Type S, F, and Np streams. Estimates are in miles and acres. Roads in riparian areas would contribute to take from reduced riparian effectiveness, primarily reduction in LWD, shade, and increases in sediment to habitats.

- Type S riparian roads: 1,179 miles (5,716 acres)
- Type F riparian roads: 2,280 miles (11,054 acres)
- Type Np riparian roads: 1,079 miles (5,231 acres)

Conclusion

In this Opinion, we determined that this level of anticipated take is not likely to result in jeopardy to redsided shiner. The effects to the species are not at a scale or magnitude that would affect the overall abundance or distribution of the species in the FPHCP Action Area.

9.1.2.10 Speckled Dace

Riparian timber harvest is expected to contribute to take of speckled dace in the following two ways: removal of recruitable LWD and increases in sediment that reach habitats. A total of 534,534 of Type S, F, and Np riparian acres are potentially available to be managed that could contribute to take of speckled dace. The actual reduction in recruitable LWD that occurs because of riparian timber harvest over the 50 year permit term is relatively small, but there would be trees that are harvested that would otherwise have recruited to the stream and formed habitats. The reduction of recruitable LWD becomes more noticeable over longer time frames, such as 100 and 250 years. Sediment delivery from riparian harvest would occur in some situations, but is expected to be much less than sediment delivery from roads. However, there would be some circumstances that sediment delivery is a product of riparian harvest.

Incidental take of speckled dace from riparian harvest over the 50 year permit term is estimated in acres.

- Type S riparian management acres: 128,300
- Type F riparian management acres: 266,179
- Type Np riparian management acres: 140,055

Road stream crossings are an activity that would be a primary mechanism for sediment delivery to speckled dace habitats. A total of 22,253 stream crossings for Type S, F, and Np streams are estimated on FPHCP lands that could contribute to take of speckled dace. Intensity of road use and road design influence sediment delivery to speckled dace habitats. In addition to sediment delivery from road crossings, loss of LWD and reduced shading can occur at road crossings. An average width of opening through the Riparian Zone associated with a crossing is approximately 40 feet. This area would lose the potential to deliver LWD and would also increase sunlight reaching the stream.

Incidental take of speckled dace as estimated in number of stream crossings, over a 50 year permit term.

- Type S stream crossings: 1,474
- Type F stream crossings: 13,074
- Type Np stream crossings: 7,705

The third activity that can be estimated, and would contribute to take, are roads located within the riparian management zone. Most of these riparian roads have been in place for a considerable time and their presence reduces the effectiveness of the riparian area. Roads within the riparian zone have several

effects, most notably reduction of recruitable LWD, reduction in shade (especially if close to the stream), and sediment delivery to habitats. A total of 4,409 miles of road occurs within the riparian areas of Type S, F, and Np streams that could cause take. This equals approximately 21,376 (using a 40' wide road opening) acres not capable of providing full riparian functions. Over time, these figures may be reduced due to implementation of the FPHCP.

Incidental take of speckled dace is estimated from roads in the riparian areas of Type S, F, and Np streams. Estimates are in miles and acres.

- Type S riparian roads: 1,121 miles (5,435 acres)
- Type F riparian roads: 2,298 miles (11,141 acres)
- Type Np riparian roads: 989 miles (4,795 acres)

Conclusion

In this Opinion, we determined that this level of anticipated take is not likely to result in jeopardy to speckled dace. The effects to the species are not at a scale or magnitude that would affect the overall abundance or distribution of the species in the FPHCP Action Area.

9.1.2.11 Longnose/Nooksack Dace

Riparian timber harvest is expected to contribute to take of longnose/Nooksack dace in the following two ways: removal of recruitable LWD and increases in sediment that reach dace habitats. A total of 533,052 riparian acres are potentially available to be managed that could contribute to take of dace. The actual reduction in recruitable LWD that occurs because of riparian timber harvest over the 50 year permit term is relatively small, but there would be trees that are harvested that would otherwise have recruited to the stream and formed habitats. The reduction of recruitable LWD becomes more noticeable over longer time frames, such as 100 and 250 years. Sediment delivery from riparian harvest would occur in some situations, but is expected to be much less than sediment delivery from roads. However, there would be some circumstances that sediment delivery is a product of riparian harvest.

Incidental take of longnose/Nooksack dace from riparian harvest over the 50 year permit term is estimated in acres.

- Type S riparian management acres: 133,392
- Type F riparian management acres: 258,204
- Type Np riparian management acres: 141,456

Road stream crossings are an activity that would be a primary mechanism for sediment delivery to dace habitats. A total of 22,106 stream crossings on Type S, F, and Np streams are estimated on FPHCP lands that could affect longnose/Nooksack dace. These stream crossings would deliver sediment to dace habitats that contribute to take. Intensity of road use and road design influence sediment delivery to dace habitats. In addition to sediment delivery from road crossings, loss of LWD and reduced shading can occur at road crossings. An average width of opening through the Riparian Zone associated with a crossing is approximately 40 feet. This area would lose the potential to deliver LWD and would also increase sunlight reaching the stream.

Incidental take of longnose/Nooksack dace, is estimated in number of stream crossings, over a 50 year permit term.

- Type S stream crossings: 1,496
- Type F stream crossings: 12,833
- Type Np stream crossings: 7,777

The third activity that can be estimated, and would also contribute to take, are roads located within the Riparian Zone. Most of these riparian roads have been in place for a considerable time and their presence reduces the effectiveness of the riparian area. Roads within the Riparian Zone have several effects, most notably reduction of recruitable LWD, reduction in shade (especially if close to the stream), and sediment delivery to dace habitats. There are an estimated 4,419 miles of riparian roads in Type S, F, and Np streams affecting these species on FPHCP lands. This equals approximately 21,425 riparian acres (using a 40' wide road opening) not capable of providing full riparian functions for dace. Over time, these figures should be reduced due to implementation of the FPHCP.

Incidental take of longnose/Nooksack dace, is estimated from roads in the riparian areas of Type S, F, and Np streams. Estimates are in miles and acres.

- Type S riparian roads: 1,164 (5,643 acres)
- Type F riparian roads: 2,283 miles (11,064 acres)
- Type Np riparian roads: 972 miles (4,712 acres)

Conclusion

In this Opinion, we determined that this level of anticipated take is not likely to result in jeopardy to the longnose/Nooksack dace. The effects to the species are not at a scale or magnitude that would affect the overall abundance or distribution of the species in the FPHCP Action Area.

9.1.2.12 Leopard and Umatilla Dace

Riparian timber harvest is expected to contribute to take to leopard and Umatilla dace in the following two ways: removal of recruitable LWD and increases in sediment that reach habitats. A total of 118,770 and 32,471 of Type S, F, and Np riparian acres are potentially available to be managed that could contribute to take of leopard and Umatilla dace, respectively. The actual reduction in recruitable LWD that occurs because of timber harvest over the 50 year permit term is relatively small, but there would be trees that are harvested that would otherwise have recruited to the stream and formed habitats. The reduction of recruitable LWD becomes more noticeable over longer time frames, such as 100 and 250 years. Sediment delivery from riparian harvest would occur in some situations, but is expected to be much less than sediment delivery from roads. However, there would be some circumstances that sediment delivery is a product of riparian harvest.

Road stream crossings are an activity that would be a primary mechanism for sediment delivery to leopard and Umatilla dace habitats. A total of 5,971 and 1,568 stream crossings for Type S, F, and Np streams are estimated on FPHCP lands that could affect leopard and Umatilla dace, respectively. These stream crossing would deliver sediment to habitats that contribute to take. Intensity of road use and road design influence sediment delivery to dace habitats. In addition to sediment delivery from road crossings, loss of LWD and reduced shading can occur at road crossings. An average width of opening through the riparian zone associated with a crossing is approximately 40 feet. This area would lose the potential to deliver LWD and would also increase sunlight reaching the stream.

The third activity that can be estimated, and would also cause take, are roads located within the Riparian Zone. Most of these riparian roads have been in place for a considerable time and their presence reduces the effectiveness of the riparian area. Roads within the Riparian Zone have several effects, most notably reduction of recruitable LWD, reduction in shade (especially if close to the stream), and sediment delivery to habitats. A total of 1,123 and 351 miles of road occurs within the riparian areas of Type S, F, and Np streams that could cause take to leopard and Umatilla dace, respectively. This equals approximately 5,489 and 1,701 acres (using a 40' wide road opening) not capable of providing full riparian functions for leopard and Umatilla dace, respectively. Over time, these figures may be reduced due to implementation of the FPHCP.

Leopard dace

Incidental take of leopard dace from riparian harvest over the 50 year permit term is estimated in acres.

- Type S riparian management acres: 29,774
- Type F riparian management acres: 53,584
- Type Np riparian management acres: 35,412

Incidental take of leopard dace is estimated in number of stream crossings over a 50 year permit term.

- Type S stream crossings: 364
- Type F stream crossings: 3,123
- Type Np stream crossings: 2,484

Incidental take of leopard dace is estimated from roads in the riparian areas of Type S, F, and Np streams. Estimates are in miles and acres.

- Type S riparian roads: 281 miles (1,362 acres)
- Type F riparian roads: 567 miles (2,794 acres)
- Type Np riparian roads: 275 miles (1,333 acres)

Umatilla Dace

Incidental take of Umatilla dace over the 50 year permit term as estimated in acres of riparian harvest.

- Type S riparian management acres: 1,483 acres
- Type F riparian management acres: 13,022
- Type Np riparian management acres: 17,966

Incidental take of Umatilla dace is estimated in number of stream crossings over a 50 year permit term.

- Type S stream crossings: 96
- Type F stream crossings: 502
- Type Np stream crossings: 970

Incidental take of Umatilla dace is estimated from roads in the riparian areas of Type S, F, and Np streams. Estimates are in miles and acres.

- Type S riparian roads: 56 miles (271 acres)

- Type F riparian roads: 143 miles (693 acres)
- Type Np riparian roads: 152 miles (736 acres)

Conclusion

In this Opinion, we determined that this level of anticipated take is not likely to result in jeopardy to the leopard and Umatilla dace. The effects to the species are not at a scale or magnitude that would affect the overall abundance or distribution of the species in the FPHCP Action Area.

9.1.2.13 Northern pikeminnow

Riparian timber harvest is expected to cause take to northern pikeminnow in the following two ways: removal of recruitable LWD and increases in sediment that reach habitats. A total of 339,850 riparian acres (of Type S, F, and Np) are potentially available to be managed that could contribute to take. The actual reduction in recruitable LWD that occurs because of timber harvest over the 50 year permit term is relatively small, but there would be trees that are harvested that would otherwise have recruited to the stream and formed habitats. The reduction of recruitable LWD becomes more noticeable over longer time frames, such as 100 and 250 years. Sediment delivery from riparian harvest would occur, but is expected to be much smaller than sediment delivery from roads. However, there would be some circumstances that sediment delivery is a product of riparian harvest.

Incidental take of northern pikeminnow from riparian harvest over the 50 year permit term as estimated in acres.

- Type S riparian management acres: 84,009
- Type F riparian management acres: 162,919
- Type Np riparian management acres: 92,922

Road stream crossings are an activity that would be a primary mechanism for sediment delivery to northern pikeminnow habitats. A total of 14,069 stream crossing on Type S, F, and Np streams are estimated on FPHCP lands that could effect the species. These stream crossing would deliver sediment to habitats that contribute to take. Intensity of road use and road design influence sediment delivery to pikeminnow habitats. In addition to sediment delivery from road crossings, loss of LWD and reduced shading can occur at road crossings. An average width of opening through the Riparian Zone associated with a crossing is approximately 40 feet. This area would lose the potential to deliver LWD and would also increase sunlight reaching the stream.

Incidental take of northern pikeminnow is estimated in number of stream crossings over a 50 year permit term.

- Type S stream crossings: 933
- Type F stream crossings: 7,922
- Type Np stream crossings: 5,214

The third activity that can be estimated, and would also cause take, are roads located within the Riparian Zone. Roads within the riparian zone have several effects, most notably reduction of recruitable LWD, reduction in shade (especially if close to the stream), and sediment delivery to northern pikeminnow habitats. A total of 2,868 miles of road occurs within the riparian areas of Type S, F, and Np streams that could cause take to pikeminnow. This equals approximately 13,899 acres not capable of providing full

riparian functions for the species. Over time, these figures should be reduced due to implementation of the FPHCP.

Incidental take of northern pikeminnow is estimated from roads in the riparian areas of Type S, F, and Np streams. Estimates are in miles and acres.

- Type S riparian roads: 702 (3,403 acres)
- Type F riparian roads: 1,458 (7,069 acres)
- Type Np riparian roads: 707 (3,427 acres)

Conclusion

In this Opinion, we determined that this level of anticipated take is not likely to result in jeopardy to the northern pikeminnow. The effects to the species are not at a scale or magnitude that would affect the overall abundance or distribution of the species in the FPHCP Action Area.

9.1.2.14 Lake and Tui Chub

With our current understanding of the Tui Chub's habitat associations and its distribution in Washington, the likelihood of incidental take from activities with the FPHCP to this species is extremely low. The species occupies habitats that are not expected to be affected by the FPHCP. However, the WDNR requested incidental take coverage under the ESA. Considering the WDNR request in combination with the conservation measures that would be implemented under the FPHCP, we determined that authorizing a limited amount of take would not affect its habitat, or this species. Further stream surveys may document the species in some habitats associated with FPHCP lands. We determined that stream crossings of Type S and F streams had the highest chance of contributing to incidental take of these species.

Incidental take of tui chub is estimated in number of stream crossings over a 50 year permit term.

- Type S stream crossings: 5
- Type F stream crossings: 5

Incidental take of lake chub is estimated in number of stream crossings over a 50 year permit term. Take is primarily from increases in sediment, and secondarily, from reduction in LWD and shade.

- Type S stream crossings: 64
- Type F stream crossings: 630

Conclusion

In this Opinion, we determined that this level of anticipated take is not likely to result in jeopardy to the tui or lake chub. The effects to the species are not at a scale or magnitude that would affect the overall abundance or distribution of the species in the FPHCP Action Area.

9.1.2.15 Peamouth

Road stream crossings are an activity that may be a mechanism for sediment delivery to peamouth habitats. A total of 15,121 stream crossings on Type S, F, and Np streams are estimated on FPHCP lands that could affect peamouth. These stream crossings would deliver sediment to peamouth habitats that

contribute to take. Intensity of road use and road design influence sediment delivery to peamouth habitats. In addition to sediment delivery from road crossings, loss of LWD and reduced shading can occur at road crossings. An average width of opening through the riparian zone associated with a crossing is approximately 40 feet. This area would lose the potential to deliver LWD and would also increase sunlight reaching the stream. We determined that stream crossings of Type S, F, and Np had the highest chance of contributing to incidental take of peamouth. In addition, instream work associated with culvert and other road crossing projects may cause mortality with capture and re-location efforts.

Incidental take of peamouth is estimated in number of stream crossings over a 50 year permit term.

- Type S stream crossings: 956
- Type F stream crossings: 8,359
- Type Np stream crossings: 5,806

Conclusion

In this Opinion, we determined that this level of anticipated take is not likely to result in jeopardy to peamouth. The effects to the species are not at a scale or magnitude that would affect the overall abundance or distribution of the species in the FPHCP Action Area.

9.1.2.16 Largescale Sucker

Road stream crossings are an activity that would be a mechanism for sediment delivery to sucker habitats. A total of 22,534 stream crossings on Type S, F, and Np streams are estimated on FPHCP lands that could affect largescale sucker. These stream crossings would deliver sediment to sucker habitats that contribute to take. Intensity of road use and road design influence sediment delivery to sucker habitats. In addition to sediment delivery from road crossings, loss of LWD and reduced shading can occur at road crossings. An average width of opening through the riparian zone associated with a crossing is approximately 40 feet. This area would lose the potential to deliver LWD and would also increase sunlight to reach the stream.

Incidental take of largescale sucker is estimated in number of stream crossings over a 50 year permit term.

- Type S stream crossings: 1,531
- Type F stream crossings: 13,145
- Type Np stream crossings: 7,858

Conclusion

In this Opinion, we determined that this level of anticipated take is not likely to result in jeopardy to largescale sucker. The effects to the species are not at a scale or magnitude that would affect the overall abundance or distribution of the species in the FPHCP Action Area.

9.1.2.17 Salish and Longnose Sucker

Riparian timber harvest is expected to contribute to incidental take of Salish and longnose and sucker in the following two ways: removal of recruitable LWD and increases in sediment that reach Sucker habitats. A total of 155,883 and 118,546 riparian acres are potentially available to be managed that could contribute incidental take of Salish and longnose sucker, respectively. The actual reduction in recruitable

LWD that occurs because of timber harvest over the 50 year permit term is relatively small, but there would be trees that are harvested that would otherwise have recruited to the stream and formed habitats. The reduction of recruitable LWD becomes more noticeable over longer time frames, such as 100 and 250 years. Sediment delivery from riparian harvest would occur in some situations, but is expected to be much less than sediment delivery from roads. However, there would be some circumstances that sediment delivery is a product of riparian harvest.

Road stream crossings are an activity that would be a primary mechanism for sediment delivery to Salish and longnose and sucker habitats. A total of 6,769 and 3,193 stream crossings on Type S, F, and Np streams are estimated on FPHCP lands that could lead to incidental take of Salish and longnose Sucker, respectively. These stream crossings would deliver sediment to sucker habitats that contribute to take. Intensity of road use and road design influence sediment delivery to sucker habitats. In addition to sediment delivery from road crossings, loss of LWD, and reduced shading can occur at road crossings. An average width of opening through the riparian zone associated with a crossing is approximately 40 feet. This area would lose the potential to deliver LWD and would also increase sunlight reaching the stream.

The third activity that can be estimated, and may lead to incidental take, are roads located within the Riparian Zone. Most of these riparian roads have been in place for a considerable time and their presence reduces the effectiveness of the riparian area. Roads within the Riparian Zone have several effects, most notably reduction of recruitable LWD, reduction in shade (especially if close to the stream), and sediment delivery to Sucker habitats. There are an estimated 1,243 and 731 miles of riparian roads in Type S, F, and Np streams for Salish and longnose sucker on FPHCP lands. This equals approximately 6,025 and 3,543 riparian acres (using a 40’ wide road opening) not capable of providing full riparian functions for Salish and longnose sucker, respectively. Over time these figures should be reduced due to implementation of the FPHCP.

Incidental take of Salish sucker from riparian harvest over the 50 year permit term is estimated in acres.

- Type S riparian management acres: 46,778
- Type F riparian management acres: 65,919
- Type Np riparian management acres: 43,106

Incidental take of Salish sucker is estimated in number of stream crossings over a 50 year permit term.

- Type S stream crossings: 401
- Type F stream crossings: 3,945
- Type Np stream crossings: 2,423

Incidental take of Salish sucker is estimated from roads in the riparian areas of Type S, F, and Np streams. Estimates are in miles and acres.

- Type S riparian roads: 347 (1,682 acres)
- Type F riparian roads: 610 miles (2,957acres)
- Type Np riparian roads: 286 miles (1,386 acres)

Incidental take of longnose sucker from riparian harvest over the 50 year permit term is estimated in acres.

- Type S riparian management acres: 17,333
- Type F riparian management acres: 62,340
- Type Np riparian management acres: 38,873

Incidental take of longnose sucker is estimated in number of stream crossings over a 50 year permit term.

- Type S stream crossings: 200
- Type F stream crossings: 1,164
- Type Np stream crossings: 1,829

Incidental take of longnose sucker is estimated from roads in the riparian areas of Type S, F, and Np streams. Estimates are in miles and acres.

- Type S riparian roads: 117 (567 acres)
- Type F riparian roads: 295 miles (1,430acres)
- Type Np riparian roads: 319 miles (1,546 acres)

Conclusion

In this Opinion, we determined that this level of anticipated take is not likely to result in jeopardy to the Salish and longnose sucker. The effects to the species are not at a scale or magnitude that would affect the overall abundance or distribution of the species in the FPHCP Action Area. The FPHCP is expected to support the long-term survival of these species in the FPHCP Action Area.

9.1.2.18 Bridgelip and Mountain Sucker

We anticipate that take of bridgelip and mountain sucker would occur within habitat adjacent to covered lands over the 50-year permit term. The conservation measures in the FPHCP provide riparian protections that address stream shade, LWD recruitment, leaf and needle liter production, microclimate, bank stability and minimization measures for sediment to aquatic habitats on FPHCP lands. Implementation of the FPHCP is expected to provide adequate functionality of these factors that would contribute to sucker long-term survival.

There would be some effects, however, from the FPHCP that would contribute to incidental take of bridgelip and mountain sucker. These affects have been analyzed in three areas of this Opinion: 1) General Effects, 2) Effects to Guilds, 3) and Effects to Species. While a quantitative estimate of individual sucker taken is not possible with this Opinion, effects that could cause take can be estimated from specific elements of the FPHCP. The effects we have determined could lead to take to bridgelip and mountain sucker are: 1) excessive sediment to fish-bearing streams from roads, timber harvest, and stream crossing projects (culvert, bridge installation, and potentially other approved crossing methods), 2) increases in stream temperature due to tree removal that provide shade, 3) preventing trees from growing that could provide shade – primarily by riparian roads, 4) removal of trees that could potentially provide LWD, 5) preventing trees from growing that could ultimately provide LWD – primarily by riparian roads and 20 acre exemptions, and 6) capture and removal of mountain and bridgelip sucker for instream projects, primarily road crossings.

Estimates were made of the WRIA's that bridgelip and mountain sucker occupy. This information for determining occupancy came primarily from the following two sources: Inland Fishes of Washington, by

Wydoski and Whitney, 2003, and the Final Environment Impact Statement for the FPHCP, 2006. To determine the FPHCP activities that had the highest chance of causing take to and bridgelip and mountain sucker, we identified the following three activities for estimating take for these two species: 1) riparian timber harvest in Type S, F, and Np streams, 2) stream crossings of Type S, F and Np streams, and 3) roads located in Type S, F, and Np riparian zones. We determined that these three primary activities could be estimated with the currently available information. See Appendix G for a description of the GIS process for determining these estimates.

Riparian timber harvest is expected to contribute to take of bridgelip sucker in the following two ways: removal of recruitable LWD and increases in sediment that reach habitats. A total of 321,106 and 123,116 riparian acres (of Type S, F, and Np) are potentially available to be managed that could cause take of bridgelip and mountain sucker, respectively. The actual reduction in recruitable LWD that occurs because of timber harvest over the 50 year permit term is relatively small, but there would be trees that are harvested that may have recruited to the stream and formed habitats. The reduction of recruitable LWD becomes more noticeable over longer time frames, such as 100 and 250 years. Sediment delivery from riparian harvest would occur, but is expected to be much smaller than sediment delivery from roads. However, there would be some circumstances that sediment delivery is a product of riparian harvest.

Road stream crossings are an activity that would be a primary mechanism for sediment delivery to bridgelip sucker habitats. A total of 13,053 and 6,244 stream crossing are estimated on FPHCP lands that could affect bridgelip and mountain sucker, respectively. These stream crossing would deliver sediment to habitats that cause take. Intensity of road use and road design influence sediment delivery to bridgelip sucker habitats. In addition to sediment delivery from road crossings, loss of LWD and reduced shading can occur at road crossings. An average width of opening through the riparian zone associated with a crossing is approximately 40 feet. This area would lose the potential to deliver LWD and would also increase sunlight reaching the stream.

The third activity that can be estimated, and would also cause take, are roads located within the riparian management zone. Roads within the riparian zone have several effects, most notably reduction of recruitable LWD, reduction in shade (especially if close to the stream), and sediment delivery to bridgelip sucker habitats. A total of 2,657 and 1,174 miles of road occurs within the riparian areas of Type S, F, and Np streams that could cause take of bridgelip and mountain sucker, respectively. This equals approximately 12,912 and 5,692 acres not capable of providing full riparian functions for bridgelip and mountain sucker, respectively. Over time these figures should be reduced due to implementation of the FPHCP.

Bridgelip Sucker

Incidental take, to bridgelip sucker from riparian harvest over the 50 year permit term as estimated in acres.

- Type S riparian management acres: 76,553
- Type F riparian management acres: 159,439
- Type Np riparian management acres: 85,114

Incidental to bridgelip sucker is estimated in number of stream crossings over a 50 year permit term.

- Type S stream crossings: 947

- Type F stream crossings: 7,417
- Type Np stream crossings: 4,689

Incidental take of bridgelip sucker is estimated from roads in the riparian areas of Type S, F, and Np streams. Estimates are in miles and acres.

- Type S riparian roads: 721 (3,503 acres)
- Type F riparian roads: 1,342 (6,521)
- Type Np riparian roads: 594 (2,866 acres)

Mountain sucker

Incidental take of mountain sucker from riparian harvest over the 50 year permit term as estimated in acres.

- Type S riparian management acres: 30,914
- Type F riparian management acres: 50,499
- Type Np riparian management acres: 41,703

Incidental take of mountain sucker is estimated in number of stream crossings over a 50-year permit term.

- Type S stream crossings: 399
- Type F stream crossings: 3,004
- Type Np stream crossings: 2,841

Incidental take of mountain sucker is estimated from roads in the riparian areas of Type S, F, and Np streams. Estimates are in miles and acres.

- Type S riparian roads: 289 (1,401 acres)
- Type F riparian roads: 533 (2,584 acres)
- Type Np riparian roads: 352 (1,706 acres)

9.1.2.19 Three-spine Stickleback

Estimates were made of the WRIA's that three-spine stickleback occupy. This information for determining occupancy came primarily from the following two sources: Inland Fishes of Washington, by Wydoski and Whitney, 2003, and the Final Environment Impact Statement for the FPHCP, 2006. We identified the following three activities for estimating take for this species: 1) riparian timber harvest in Type S, F, and Np streams; 2) stream crossings of Type S, F and Np streams; and 3) roads located in Type S, F, and Np riparian zones. We determined that these two primary activities could be estimated with the currently available information. These two activities also had the highest chance of contributing to take of three-spine stickleback. See Appendix G for a description of the GIS process for determining these estimates.

Incidental take of three-spine stickleback from riparian harvest over the 50 year permit term as estimated in acres.

- Type S riparian management acres: 126,353

- Type F riparian management acres: 265,989
- Type Np riparian management acres: 120,238

Incidental Take of three-spine stickleback is estimated in number of stream crossings over a 50 year permit term. Take is primarily from increases in sediment, and secondarily, from reduction in LWD and shade. Three-spine stickleback mortality may also occur from culvert installation/replacement projects.

- Type S stream crossings: 1,387
- Type F stream crossings: 13,665
- Type Np stream crossings: 6,679

Incidental Take of three-spine stickleback is estimated from roads in the riparian areas of Type S, F, and Np streams. Estimates are in miles and acres. Roads in riparian areas would contribute to take from reduced riparian effectiveness, primarily reduction in LWD, shade, and increases in sediment to habitats.

- Type S riparian roads: 1,137 miles (5,512 acres)
- Type F riparian roads: 2,248 miles (10,899 acres)
- Type Np riparian roads: 740 miles (3,587 acres)

Conclusion

In this Opinion, we determined that this level of anticipated take is not likely to result in jeopardy to three-spine stickle back. The effects to the species are not at a scale or magnitude that would affect the overall abundance or distribution of the species in the FPHCP Action Area.

9.1.2.20 Sandroller

Estimates were made of the WRIA's that sandroller occupy. This information for determining occupancy came primarily from the following two sources: Inland Fishes of Washington, by Wydoski and Whitney, 2003, and the Final Environment Impact Statement for the FPHCP, 2006. We identified the following three activities for estimating take for this species: 1) riparian timber harvest in Type S, F, and Np streams; 2) stream crossings of Type S, F and Np streams; and 3) roads located in Type S, F, and Np riparian zones. We determined that these three primary activities could be estimated with the currently available information and had the highest chance of contributing to take for this species. See Appendix G for a description of the GIS process for determining these estimates.

Incidental take of sandroller from riparian harvest over the 50 year permit term is estimated in acres. Take is from loss of potential LWD and potential increases in sediment.

- Type S riparian management acres: 35,374
- Type F riparian management acres: 70,463
- Type Np riparian management acres: 41,836

Incidental take of sandroller is estimated in number of stream crossings over a 50 year permit term. Take is primarily from increases in sediment, and secondarily, from reduction in LWD and shade. Sandroller mortality may occur from in-stream projects, primarily from culvert replacement and installations.

- Type S stream crossings: 446

- Type F stream crossings: 4,048
- Type Np stream crossings: 2,744

Incidental take of sandroller is estimated from roads in the riparian areas of Type S, F, and Np streams. Estimates are in miles and acres.

- Type S riparian roads: 364 miles (1,764 acres)
- Type F riparian roads: 714 miles (3,461 acres)
- Type Np riparian roads: 297 miles (1,440 acres)

Conclusion

In this Opinion, we determined that this level of anticipated take is not likely to result in jeopardy to sandroller. The effects to the species are not at a scale or magnitude that would affect the overall abundance or distribution of the species in the FPHCP Action Area.

9.1.2.21 Sculpin: Paiute Sculpin; Prickly Sculpin; Coastrange Sculpin; Torrent Sculpin; Reticulate Sculpin; Riffle Sculpin; Shorthead Sculpin; Mottled Sculpin; Slimy Sculpin; Margined Sculpin

We assessed the activities associated with the FPHCP to determine which activities had the highest chance of contributing to take of the 10 species of sculpins. The activities needed to be measurable, have a likelihood of contributing to take, and be an activity directly associated with the FPHCP. Activities not meeting these criteria were not considered for estimating incidental take. The FPHCP activities that best meet these criteria for sculpins were: 1) riparian timber harvest in Type S, F, and Np streams, 2) stream crossings of Type S, F and Np streams, and 3) roads located in Type S, F, and Np riparian zones. The FWS determined that these three primary activities could be estimated with the currently available information and had the highest chance of contributing to take. FPHCP activities and the watershed processes that contribute to take have been analyzed in detail in other sections of the Opinion. See Appendix G for a description of the GIS process for determining these estimates.

Following the process for determining what activities would be most likely to contribute to incidental take, an estimate needed to be made on watersheds that the 10 species of sculpin occurred. Estimates were made of the WRIA's that the species occupy in the FPHCP Action Area. The information for determining occupancy came primarily from the following two sources: Inland Fishes of Washington, by Wydoski and Whitney, 2003, and the Final Environment Impact Statement for the FPHCP, 2006.

Riparian timber harvest is expected to contribute to take of sculpins in the following two ways: removal of recruitable LWD which reduces stream complexity, and increases in sediment that reach sculpin habitats. The actual reduction in recruitable LWD that occurs because of timber harvest over the 50 year permit term is relatively small, but there would be trees that are harvested that would otherwise have recruited to the stream and formed habitats. The reduction of recruitable LWD becomes more noticeable over longer time frames, such as 100 and 250 years. Sediment delivery from riparian harvest would occur in some situations, but is expected to be much less than sediment delivery from roads. However, there would be some circumstances that sediment delivery is a product of riparian harvest.

Road stream crossings are an activity that would be a primary mechanism for sediment delivery to sculpin habitats. These stream crossing would deliver sediment to sculpin habitats that contribute to take. Intensity of road use and road design influence sediment delivery to habitats. In addition to sediment

delivery from road crossings, loss of LWD and reduced shading can occur at road crossings. An average width of opening through the riparian zone associated with a crossing is approximately 40 feet. This area would lose the potential to deliver LWD and would also increase sunlight reaching the stream. In addition, some sculpin mortality is expected during road crossing structure (most frequently, culverts) installations/replacements. Sculpins are benthic fish, and capturing all sculpins during the construction phase of these projects is difficult. As such, some limited mortality is expected from these types of in-stream projects.

The third activity that can be estimated, and would also cause take, are roads located within the Riparian Zone. Most of these riparian roads have been in place for a considerable time and their presence reduces the effectiveness of the riparian area. Roads within the Riparian Zone have several effects, most notably reduction of recruitable LWD, reduction in shade (especially if close to the stream), and sediment delivery to sculpin habitats. Over time, these figures should be reduced due to implementation of the FPHCP.

Incidental take for the 10 species follows:

Shorthead sculpin

Incidental take of shorthead sculpin from riparian harvest over the 50 year permit term is estimated in acres.

- Type S riparian management acres: 107,875
- Type F riparian management acres: 212,696
- Type Np riparian management acres: 101,481

Incidental take of shorthead sculpin is estimated in number of stream crossings over a 50 year permit term.

- Type S stream crossings: 1,160
- Type F stream crossings: 11,101
- Type Np stream crossings: 6,064

Incidental take of shorthead sculpin is estimated from roads in the Riparian Zones of Type S, F, and Np streams. Estimates are in miles and acres.

- Type S riparian roads: 930 miles (4,509 acres)
- Type F riparian roads: 1,818 miles (8,814 acres)
- Type Np riparian roads: 704 miles (3,413 acres)

Riffle Sculpin

Incidental take of riffle sculpin from riparian harvest over the 50 year permit term is estimated in acres.

- Type S riparian management acres: 91,220
- Type F riparian management acres: 207,671
- Type Np riparian management acres: 81,175

Incidental take of riffle sculpin is estimated in number of stream crossings, over a 50 year permit term.

- Type S stream crossings: 981
- Type F stream crossings: 10,100
- Type Np stream crossings: 4,498

Incidental take of riffle sculpin is estimated from roads in the riparian areas of Type S, F, and Np streams. Estimates are in miles and acres.

- Type S riparian roads: 139 miles (673 acres)
- Type F riparian roads: 276 miles (1,338 acres)
- Type Np riparian roads: 459 miles (2,225 acres)

Paiute Sculpin

Incidental Take of Paiute sculpin from riparian harvest over the 50 year permit term is estimated in acres.

- Type S riparian management acres: 6,928
- Type F riparian management acres: 6,885
- Type Np riparian management acres: 10,860

Incidental take of Paiute sculpin is estimated in number of stream crossings over a 50 year permit term.

- Type S stream crossings: 123
- Type F stream crossings: 427
- Type Np stream crossings: 592

Incidental take of Paiute sculpin is estimated from roads in the riparian areas of Type S, F, and Np streams. Estimates are in miles and acres.

- Type S riparian roads: 52 miles (252 acres)
- Type F riparian roads: 120 miles (581 acres)
- Type Np riparian roads: 127 miles (615 acres)

Prickly Sculpin

Incidental take of prickly sculpin from riparian harvest over the 50 year permit term is estimated in acres.

- Type S riparian management acres: 126,735
- Type F riparian management acres: 255,648
- Type Np riparian management acres: 121,361

Incidental take of prickly sculpin is estimated in number of stream crossings over a 50 year permit term.

- Type S stream crossings: 1,361
- Type F stream crossings: 13,184
- Type Np stream crossings: 6,745

Incidental take of prickly sculpin is estimated from roads in the riparian areas of Type S, F, and Np streams. Estimates are in miles and acres.

- Type S riparian roads: 1,096 miles (5,313 acres)
- Type F riparian roads: 2,185 miles (10,593 acres)
- Type Np riparian roads: 764 miles (3,704 acres)

Coastrange Sculpin

Incidental take of coastrange sculpin from riparian harvest over the 50 year permit term is estimated in acres.

- Type S riparian management acres: 133,404
- Type F riparian management acres: 274,768
- Type Np riparian management acres: 118,710

Incidental take of coastrange sculpin is estimated in number of stream crossings over a 50 year permit term.

- Type S stream crossings: 1,395
- Type F stream crossings: 14,312
- Type Np stream crossings: 6,757

Incidental take of coastrange sculpin is estimated from roads in the riparian areas of Type S, F, and Np streams. Estimates are in miles and acres.

- Type S riparian roads: 1,147 miles (5,561 acres)
- Type F riparian roads: 2,269 miles (11,001 acres)
- Type Np riparian roads: 718 miles (3,481 acres)

Torrent Sculpin

Incidental take of torrent sculpin from riparian harvest over the 50 year permit term is estimated in acres.

- Type S riparian management acres: 127,061
- Type F riparian management acres: 258,504
- Type Np riparian management acres: 132,377

Incidental take of torrent sculpin is estimated in number of stream crossings over a 50 year permit term.

- Type S stream crossings: 1,346
- Type F stream crossings: 12,870
- Type Np stream crossings: 7,416

Incidental take of torrent sculpin is estimated from roads in the riparian areas of Type S, F, and Np streams. Estimates are in miles and acres.

- Type S riparian roads: 1,067 miles (5,713 acres)
- Type F riparian roads: 2,182 miles (10,579 acres)
- Type Np riparian roads: 893 miles (4,329 acres)

Mottled Sculpin

Incidental take of mottled sculpin from riparian harvest over the 50 year permit term is estimated in acres.

- Type S riparian management acres: 11,674
- Type F riparian management acres: 12,877
- Type Np riparian management acres: 20,435

Incidental take of mottled sculpin is estimated in number of stream crossings over a 50 year permit term.

- Type S stream crossings: 165
- Type F stream crossings: 593
- Type Np stream crossings: 1,068

Incidental take of mottled sculpin is estimated from roads in the riparian areas of Type S, F, and Np streams. Estimates are in miles and acres.

- Type S riparian roads: 75 miles (363 acres)
- Type F riparian roads: 156 miles (756 acres)
- Type Np riparian roads: 212 miles (1,027 acres)

Slimy Sculpin

Incidental take of slimy sculpin from riparian harvest over the 50 year permit term is estimated in acres.

- Type S riparian management acres: 6,901
- Type F riparian management acres: 9,412
- Type Np riparian management acres: 10,841

Incidental take of slimy sculpin is estimated in number of stream crossings over a 50 year permit term.

- Type S stream crossings: 67
- Type F stream crossings: 418
- Type Np stream crossings: 609

Incidental take of slimy sculpin is estimated from roads in the riparian areas of Type S, F, and Np streams. Estimates are in miles and acres.

- Type S riparian roads: 41 miles (198 acres)
- Type F riparian roads: 112 miles (543 acres)
- Type Np riparian roads: 102 miles (494 acres)

Margined Sculpin

Incidental take of margined sculpin from riparian harvest over the 50 year permit term is estimated in acres.

- Type S riparian management acres: 687
- Type F riparian management acres: 2,106

- Type Np riparian management acres: 2,293

Incidental take of margined sculpin is estimated in number of stream crossings over a 50 year permit term.

- Type S stream crossings: 15
- Type F stream crossings: 133
- Type Np stream crossings: 75

Incidental take of margined sculpin is estimated from roads in the riparian areas of Type S, F, and Np streams. Estimates are in miles and acres.

- Type S riparian roads: 6 miles (29 acres)
- Type F riparian roads: 50 miles (242 acres)
- Type Np riparian roads: 23 miles (111 acres)

Reticulate Sculpin

Incidental take of reticulated sculpin from riparian harvest over the 50 year permit term is estimated in acres.

- Type S riparian management acres: 101,082
- Type F riparian management acres: 216,295
- Type Np riparian management acres: 87,623

Incidental take of reticulated sculpin is estimated in number of stream crossings over a 50 year permit term.

- Type S stream crossings: 1,112
- Type F stream crossings: 10,601
- Type Np stream crossings: 5,095

Incidental take of reticulate sculpin is estimated from roads in the riparian areas of Type S, F, and Np streams. Estimates are in miles and acres.

- Type S riparian roads: 907 miles (4,397 acres)
- Type F riparian roads: 1,737 miles (8,412 acres)
- Type Np riparian roads: 507 miles (2,458 acres)

Conclusion

In this Opinion, we determined that this level of anticipated take is not likely to result in jeopardy to the 10 species of sculpin. The effects to the species are not at a scale or magnitude that would affect the overall abundance or distribution of the species in the FPHCP Action Area.

9.1.2.22 Longfin Smelt

With our current understanding of landlocked longfin smelt habitat, the likelihood of incidental take from FPHCP activities to this species is relatively low. The species in Lake Washington, and its associated

habitats, are not expected to be substantially influenced by the FPHCP. However, the WDNR requested incidental take coverage under the ESA for this species. Considering the WDNR request, in combination with the conservation measures that would be implemented under the FPHCP, we determined that authorizing a limited amount of take would have little to no consequences to the species.

Some sediment may be delivered to longfin smelt habitat as a result of the FPHCP that may contribute to take. We determined that stream crossings likely had the highest chance of contributing to incidental take.

Incidental take of longfin smelt is estimated in number of stream crossings over a 50 year permit term.

- Type S stream crossings: 19
- Type F stream crossings: 259
- Type Np stream crossings: 27

Conclusion

In this Opinion, we determined that this level of anticipated take is not likely to result in jeopardy to the landlocked longfin smelt. The effects to the species are not at a scale or magnitude that would affect the overall abundance or distribution of the species in the FPHCP Action Area.

9.1.2.23 Burbot

With our current understanding of lakes occupied by burbot, the likelihood of incidental take from activities with the FPHCP to this species is low. The species generally occupies habitats that are not expected to be substantially influenced by the FPHCP. However, the WDNR requested incidental take coverage under the ESA for this species. Considering the WDNR request, in combination with the conservation measures that would be implemented under the FPHCP, we determined that authorizing a limited amount of take would have little to no consequences to the species. However, future surveys may document the species in some habitats associated with FPHCP lands. If that occurs, it is expected that the conservation measures implemented under the FPHCP would provide adequate conservation. Incidental take is authorized under these assumptions.

Road stream crossings are an activity that would be a potential mechanism for sediment delivery to burbot habitats. A total of 267 stream crossing for Type S, and F streams are estimated on FPHCP lands that could affect burbot. These stream crossings may deliver sediment to habitats that contribute to incidental take. Intensity of road use and road design influence sediment delivery to burbot habitats.

Incidental take of burbot is estimated in number of stream crossings over a 50 year permit term.

- Type S stream crossings: 42
- Type F stream crossings: 225

Conclusion

In this Opinion, we determined that this level of anticipated take is not likely to result in jeopardy to the burbot. The effects to the species are not at a scale or magnitude that would affect the overall abundance or distribution of the species in the FPHCP Action Area.

9.1.2.24 White Sturgeon

With our current understanding of white sturgeon habitat, the likelihood of incidental take from FPHCP activities to this species is extremely low. The species generally occupies habitats that are not expected to be substantially influenced by the FPHCP. However, the WDNR requested incidental take coverage under the ESA for this species. Considering the WDNR request, in combination with the conservation measures that would be implemented under the FPHCP, we determined that authorizing a limited amount of incidental take would have little to no consequences to the species.

Road stream crossings are an activity that may be a mechanism for sediment delivery to white sturgeon habitats. A total of 856 Type S stream crossings are estimated on FPHCP lands that could affect white sturgeon.

Incidental take of white sturgeon is estimated in number of stream crossings over a 50 year permit term.

- Type S stream crossings: 856

Conclusion

In this Opinion, we determined that this level of anticipated take is not likely to result in jeopardy to the white sturgeon. The effects to the species are not at a scale or magnitude that would affect the overall abundance or distribution of the species in the FPHCP Action Area.

9.1.2.25 Bull Trout

Amount or Extent of Take

We anticipate that take of bull trout may occur within spawning and rearing streams and foraging, migrating, and overwintering (FMO) habitat adjacent to FPHCP covered lands over the 50-year permit term. The conservation measures in the FPHCP provide riparian protections to minimize temperature and sediment-related effects from timber-harvest activities, and erosion-control measures to minimize sediment delivery to bull trout streams via roads and stream crossings. However, these effects would not be completely eliminated as it is expected that up to 50 percent of Type Np streams and up to 100 percent of Type Ns streams may not receive riparian buffers; that all stream crossings may be replaced during the permit term; and that some amount of sediment may still come from timber-harvest activities in and adjacent to riparian areas as well as the construction, maintenance, use, and decommissioning of roads including the replacement of road crossings.

The direct take of or injury to bull trout may occur as a result of CMER research and capture and handling activities which may include the use of seines, dipnets, blocknets, electrofishing or other similar methods. In addition, the direct and indirect take of bull trout from capture and handling associated with fish salvage is being addressed by this Opinion because these activities are interrelated to the proposed action and support the conservation measures in the FPHCP. We expect fish salvage would minimize the level of incidental take that would otherwise occur if bull trout were not salvaged prior to stream channels being dewatered and stream crossing structures replaced. We also expect that take of bull trout through CMER research may be necessary for the purposes of adaptive management.

We expect incidental take of bull trout may be difficult to detect because the presence and number of bull trout is difficult to determine within the FPHCP Action Area and detecting a dead or impaired specimen is unlikely. While bull trout may be taken as a result of the previously described effects, accurately quantifying these effects is difficult. Therefore, even though we expect incidental take to occur, data are

not available and are not sufficient to enable us to estimate an exact number of individuals which are incidentally taken. However, a quantitative estimate of the anticipated take of bull trout may be made based on habitat surrogates such as stream miles, acres of riparian habitat that influence the aquatic environment, and/or acres of marine nearshore habitat. We expect three types of effects that may result in take due to the implementation of FPHCP over the 50-year Permit term. The types of effects and the authorized take anticipated are related to increases in sediment, increases in water temperature, and decreases in large wood. The direct take of bull trout would occur as a result of capture and handling and the implementation of CMER research. Take associated with capture and handling of bull trout is necessary to further reduce the level of incidental take that would otherwise occur during in-water construction. Take associated with CMER research may be necessary for the purposes of adaptive management. The amount of take associated with CMER research is expected to be minimal. An action may result in more than one type of effect, with the potential for take of individual bull trout for each type of effect.

1. Take of bull trout may occur through the impairment of essential foraging, rearing, and spawning behaviors associated with the direct and indirect effects of sediment in spawning and rearing streams and FMO habitat. Covered activities that are likely to generate sediment include: timber harvest and harvest-related activities adjacent to fish- and nonfish-bearing streams; and construction, maintenance, decommissioning, and use of roads (especially stream-adjacent roads) including the replacement of stream crossing structures. Cumulatively, these covered activities may result in the take of bull trout via sediment inputs to spawning and rearing streams and FMO habitat. Adverse effects from sediment that may lead to the take of bull trout are not anticipated to occur in all streams that support bull trout spawning and rearing. Life-history forms that may be taken by elevated sediment levels in spawning and rearing streams as a result of the implementation of the FPHCP are primarily eggs and alevins, but may also include fry, juveniles and, in some instances, subadult and adult bull trout. Adverse effects from sediment that may lead to the take of bull trout are not anticipated to occur in all streams that support foraging, migrating, and overwintering. Life-history forms that may be taken by elevated sediment levels in FMO habitat as a result of the implementation of the FPHCP consist of only adult and subadult bull trout.

2. Take may occur through the impairment of foraging, rearing, and spawning behaviors associated with increases in stream temperatures. Covered activities that are likely to lead to temperature increases include: timber harvest adjacent to fish- and nonfish-bearing streams (potential increases in sediment and decreases in shade and large wood); and the construction, maintenance, decommissioning, and use of stream-adjacent roads including the replacement of stream crossing structures (potential sediment inputs and reduction of shade due to limited tree clearing). Cumulatively, these covered activities may result in the take of bull trout by increasing stream temperatures via the loss of shade or the delivery of sediment to spawning and rearing habitat. Adverse effects from temperature that may lead to the take of bull trout are not anticipated to occur in all streams that support bull trout spawning and rearing. Life-history forms that may be taken by elevated stream temperatures are expected to be primarily eggs and alevins, but may also include fry and juveniles. Subadult and adult bull trout are less likely to be taken as they are more mobile and have the ability to avoid areas of warm water. Although we anticipate some take, temperature increases s a result of implementation of the FPHCP are not expected to affect bull trout in FMO habitat to the same degree as bull trout in spawning and rearing habitat. This is because FMO habitats are typically larger bodies of water, generally contain streams with warmer

water temperatures, and are used seasonally by bull trout life stages (adult and subadult) that have less sensitive or less restrictive habitat requirements. Life-history forms that may be taken by elevated temperature levels in FMO habitat as a result of the implementation of the FPHCP consist of only adult and subadult bull trout.

3. Take of bull trout may occur through the impairment of foraging, rearing, and spawning behaviors associated with the loss of large wood recruitment potential. Riparian harvest adjacent to fish- and nonfish-bearing streams has the potential to reduce the amount of large wood available over the 50-year permit term. A reduction in large wood in bull trout streams has the potential to result in reduced pool formation, increased sediment loads, the loss of cover, and a reduction in stream diversity and complexity. Take associated with the reduction of large wood would be more acute in headwater (Np and Ns) streams with steep hill slopes adjacent to or immediately upstream of bull trout spawning and rearing habitat. Adverse effects from the reduction of large wood that may lead to the take of bull trout are not anticipated to occur in all streams that support bull trout spawning and rearing, especially streams that derive most of their large wood from near-stream sources. Life-history forms that may be taken by the reduction of large wood are primarily eggs and alevins, but may also include fry, juveniles, and, in some instances, subadult and adult bull trout. Although we anticipate some take, the reduction of large wood as a result of implementation of the FPHCP is not expected to affect bull trout in FMO habitat to the same degree as bull trout in spawning and rearing habitat. Life-history forms that may be taken by reduction in large wood in FMO habitat as a result of the implementation of the FPHPC consist of only adult and subadult bull trout.

   Spawning and rearing streams in Core Areas, FMO habitat within Core Areas and FMO habitat outside of Core Areas vary in the amount of stream-adjacent road miles and adjacent FPHCP covered lands. These stream miles would be subject to adverse effects from covered activities and some of these adverse effects could result in the take of bull trout. Take associated with increases in temperature and sediment, and decreases in amounts of large wood may occur on portions of the 295.7 stream miles of spawning and rearing habitat adjacent to FPHCP covered lands, but we do not expect such take to occur on all 295.7 stream miles. Take associated with effects to FMO habitats both inside and outside of Core Areas is even more difficult to ascertain as FMO habitats typically consist of larger bodies of water; generally contain streams with warmer water temperatures; and are typically used seasonally by bull trout life stages that are more mobile, less sensitive to changes in habitat parameters, and have less restrictive habitat requirements. Twenty Core Areas have some amount of stream-adjacent roads or FPHCP covered lands that are adjacent to spawning and rearing habitat (Table 9-1). All Core Areas expect Chester Morse contain some FMO habitat adjacent to FPHCP covered lands or stream-adjacent roads (Table 9-2). In addition, FPHCP lands and FPHCP stream-adjacent roads are found adjacent to FMO areas outside of Core Areas (Table 9-3).

4. Direct take of bull trout may occur as a result CMER research and fish capture and handling activities including the use of seines, dipnets, blocknets, electrofishing or other methods used to capture bull trout. However, fish-salvage operations (as authorized through future section 10(a)(1)(A) permits or equivalent process), if necessary, would minimize the stranding of fish prior to stream channels being dewatered and stream crossing structures replaced. The capture of bull trout is expected to be minimized by avoiding periods of the year when bull trout are present in significant numbers. While it is possible that adverse effects may be avoided in some instances

Table 9-1. Quantification of take in bull trout core areas.

Core Area	Number of Stream Crossings	Miles of Stream Adjacent Roads Type S Streams	Miles of Stream Adjacent Roads Type F Streams	Miles of Stream Adjacent Roads Type Np Streams	Spawning and Rearing Stream Miles Adjacent to FPHCP Lands (equivalent acres of RMZs)
Columbia River DPS					
Asotin Creek	0	.10	.06	.92	0.8 (11.64)
Entiat	2	.56	1.56	2.48	7.3 (106.18)
Grande Ronde	0	0	0	0	0
Klickitat	0	0	0	0	0
Lewis	15	.60	4.75	4.39	15.4 (326.67)
Methow	0	1.07	.30	0	0
Pend Oreille	26	1.87	3.13	1.16	35.5 (516.36)
Priest Lakes	0	0	0	.10	0.9 (14.18)
Tucannon	1	0	.34	.06	1.5 (21.82)
Walla Walla	20	2.55	10.8	4.07	19.8 (288.00)
Wenatchee	7	8.99	6.63	5.22	12.9 (187.64)
Yakima	36	10.28	23.98	20.21	55.2 (802.91)
Coastal-Puget Sound DPS					
Chester Morse	0	0	0	0	0
Chilliwack	0	0	0	0	0
Dungeness	0	0	.81	.07	1.6 (33.94)
Elwha	3	0	0	0	0
Hoh	1	.86	0	0	2.7 (57.27)
Lower Skagit	5	1.19	1.42	4.72	7.7 (163.33)
Nooksack	44	16.84	14.41	25.46	57.1 (1211.21)
Puyallup	14	8.84	8.66	13.18	40 (848.49)
Queets	0	0	0	0	0
Quinault	0	0	0	0	0
Skokomish	0	0	.05	0	0.3 (6.36)
Snohomish/Skykomish	5	4.25	3.56	2.19	8.3 (176.01)
Stillaguamish	12	5.74	3.45	1.95	22.2 (470.91)
Upper Skagit	0	0	0.55	0	0.5 (10.61)

due to the low likelihood of the species being present during project implementation, bull trout are still being discovered at times and locations where they were not expected to occur. If bull trout are present in the reach of stream being dewatered, they would be captured using the methods described above and placed back into the flowing stream. The actual numbers of fish taken by capture and handling methods is difficult to estimate because bull trout may not be present when the work occurs and most bull trout would not likely be injured and would be released. It is anticipated that less lethal methods of capture would be used first, and if necessary, other methods such as electro fishing may be used. The take authorized by this incidental take statement is for an undeterminable, but small number of bull trout captured during fish-salvage operations prior to the replacement of a stream-crossing structure. Life-history forms that may be directly taken include alevins, fry, juveniles, and, in some instances, subadult and adult bull trout. Fourteen Core Areas have at least one stream crossing structure that crosses known spawning and rearing habitat (Table 9-1). We also expect that

Table 9-2. Quantification of take inside bull trout FMO habitat.

FMO inside of Core Area	Number of Stream Crossings of FMO	Miles of Stream Adjacent Roads Type S and F Streams	Miles of Stream Adjacent Roads Type F Streams	Miles of Stream Adjacent Roads Type Np Streams	Acres of RMZs adjacent to FMO habitat
Columbia River DPS					
Asotin Creek	0	0.53	1.25	1.09	878.00
Entiat	4	7.26	1.11	5.39	1807.42
Grande Ronde	0	.07	1.87	1.53	524.80
Klicitat	2	18.01	21.60	44.28	13996.80
Lewis	2	17.76	55.22	18.86	16351.73
Methow	7	4.38	4.00	3.68	2502.4
Pend Oreille	3	9.18	26.01	17.27	12078.84
Priest Lakes	0	0.0	0.0	0	197.02
Tucannon	0	0.17	9.23	1.40	502.98
Walla Walla	29	2.29	26.70	13.70	4601.6
Wenatchee	17	9.96	12.46	28.35	2749.96
Yakima	22	28.58	38.88	63.77	22569.89
Coastal-Puget Sound DPS					
Chester Morse	0	0	0	0	0
Chilliwack	5	3.06	6.19	2.25	2323.20
Dungeness	10	4.8	5.25	0.11	1553.26
Elwha	5	3.24	2.73	1.03	1273.60
Hoh	18	5.83	13.54	6.2	8441.93
Lower Skagit	42	40.57	90.53	43.1	32252.67
Nooksack	23	8.00	23.23	6.88	20471.99
Puyallup	22	35.6	58.92	35.48	33026.71
Queets	2	3.19	7.82	1.10	4716.80
Quinault	3	0.35	4.38	0.57	1958.40
Skokomish	4	2.45	5.25	0.18	1913.64
Snohomish/Skykomish	44	80.02	142.35	58.11	52534.39
Stillaguamish	22	21.13	50.86	18.92	21890.69
Upper Skagit	1	0.16	54.5	0.0	277.39

direct and indirect take of bull trout through CMER research may be necessary for the purposes of adaptive management. The direct take of bull trout would be permitted only in association with CMER research, monitoring, and model validation. All other direct take of bull trout would need to be authorized through the issuance of a section 10(a)(1)(A) permit or equivalent process by the FWS including capture and handling of bull trout during fish salvage operations associated with stream-crossing replacements, and operational fish presence/absence surveys.

Table 9-3. Quantification of take outside bull trout FMO habitat.

FMO outside of Core Areas	Number of Stream crossing	Miles of Stream Adjacent Roads Type S Streams	Miles of Stream Adjacent Roads Type F Streams	Miles of Stream Adjacent Roads Type Np Streams	Acres of RMZ adjacent to FMO habitat
Bell	1	0.0	4.9	179.24	512
Cedar/Steamboat	9	0.01	2.53	1.71	957.2
Chehalis	0	29.95	85.56	7.71	8249.6
Goodman	5	2.02	7.63	1.11	3136
Humtulips	8	9.97	26.41	4.40	6675.2
Kalalock	3	0.80	3.20	0.56	1075.20
Moclips/Copalis	13	5.47	20.03	2.85	8332.8
Morse	6	1.88	8.81	1.85	3667.20
Satsop	1	9.74	15.32	2.53	4051.20
Wishkah	9	7.73	113.09	3.60	4902.40
Wynoochee	2	9.29	8.85	1.58	3264.00
Lake Washington	4	23.09	55.05	6.98	11430.40
Lower Green	3	22.32	22.02	5.83	7571.20
Lower Nisqually	3	28.97	43.12	18.74	18745.60
Samamish	23	9.31	15.66	4.80	4563.20

Effect of Take

In this Opinion, we determined that the level of anticipated take is not likely to result in jeopardy to the species. Take associated with sediment generated from timber-harvest activities is likely to be short-term as buffers on all fish-bearing streams and buffers and equipment-limitation zones on non-fish-bearing streams would intercept most sediment from such activities. In addition, sediment associated with road construction, maintenance, and use including the replacement stream crossing structures is expected to also be short-term and reduced in scope over the Permit term. Increases in stream temperatures are expected to be situational and are not likely to occur at all locations where Type Np and Ns streams enter fish-bearing waters. Such increase in temperatures from Type Np and Ns streams are also expected to equilibrate to some degree as affected water flows through buffered sections and/or mixes with fish-bearing streams. Buffers along fish-bearing streams are expected to be adequate to protect against temperature increases. The capture and handling of bull trout associated with stream crossings could result in direct and indirect mortality of bull trout. Direct take other than CMER research, monitoring, and model validation would need to be authorized through the issuance of a section 10(a)(1)(A) permit or equivalent process by the FWS including capture and handling during fish salvage operations associated with stream-crossing replacements.

9.2 REASONABLE AND PRUDENT MEASURES

The FWS believes the following reasonable and prudent measure is necessary and appropriate to minimize the impacts of incidental take of covered species:

1. Any incidental take of covered species must comply with all the terms and conditions of the section 10(a)(1)(B) Permit (including the provisions of the Implementation Agreement and the FPHCP).

9.3 TERMS AND CONDITIONS

In order to be exempt from the prohibitions of section 9 of the ESA, the FWS must comply with the following terms and conditions, which implement the reasonable and prudent measure described above and outline required reporting and monitoring requirements. These terms and conditions are nondiscretionary:

1. A section 10(a)(1)(B) permit, as evaluated in this Biological Opinion, must be issued by the FWS. The Implementation Agreement for the FPHCP for the section 10(a)(1)(B) Permit must be agreed to by the FWS, and the Permit conditioned upon implementation of the FPHCP and associated Implementation Agreement.

2. The FWS shall condition the section 10(a)(1)(B) Permit to include the following conditions:

    A. The Forest Practices Habitat Conservation Plan (FPHCP) is generally described in Chapter 4 of the document entitled "Washington State Forest Practices Habitat Conservation Plan," and is approved as constituted on the date of permit issuance. Any changes to the FPHCP shall be subject to the provisions of the implementing agreement for the Final FPHCP, section 11.0 on Modifications and Amendments.

    B. The permittee shall maintain sufficient compliance and enforcement personnel whose responsibilities include conducting on-the-ground inspections of forest operations and documenting and reporting violations. The permittee shall ensure that these personnel are trained in forest practices regulations and enforcement procedures, and that they are equipped with vehicles and other necessary facilities and equipment. The permittee shall ensure that effective procedures are in place to identify operators who commit chronic or significant violations of forest practices regulations. The permittee shall take enforcement actions against violators, including but not limited to notices to comply, stop work orders, corrective action orders, civil penalties, disapproval of forest practices applications, financial assurance requirements, and criminal penalties, as appropriate to deter violations of these regulations.

    C. Under the 20-acre exemption provision (FPHCP section 4b-3.1.3 [WAC 222-30-023(1) for western Washington] and FPHCP section 4b-3.2.3 [WAC 222-30023(2) for eastern Washington]), the Permit shall only apply to the following:

        1. Forestlands owned by a person who affirms in writing on a forest practices application of qualifying as an eligible person under the "20-acre exemption" as of and since the date of Permit issuance.

        2. Forestlands that are purchased, inherited, or otherwise lawfully obtained by a person who affirms in writing on a forest practices application of qualifying at the time that person takes possession of the forestlands under the following provisions:

            a. the forestlands have continually been qualified for the "20-acre exemption" since the date of Permit issuance; or,

b. the forestlands have not been subject to commercial harvest under the jurisdiction of the Washington Forest Practices Act since the date of Permit issuance and are being converted to forestland from another land use.

3. Forestlands subject to a Class IV General Forest Practices Application only when the otherwise-qualifying applicant indicates on the application that he or she is not converting those forestlands to another use within three years.

4. Forestlands in any Wastershed Administrative Unit (WAU) for which the permittee has previously established, with the review and approval by the FWS, an estimate of the length of streams on FPHCP Covered Lands. The permittee shall establish, with review and approval of the FWS, a method to reasonably estimate post-harvest the length of classified streams on a 20-acre exempt site and the proportion of riparian function as measured by recruitable LWD from the site when compared to that which would have been provided under the standard riparian strategies. The permittee shall monitor 20-acre exempt timber harvest activities and maintain a reasonable estimate of the cumulative change in riparian function provided by FPHCP Covered Lands as measured by recruitable LWD in each WAU that results from 20-acre exempt forest practices covered by this Permit.

   a. The Permit shall not apply to forestlands subject to subsequent 20-acre exempt forest practices applications when the permittee anticipates that forest practices on those forestlands will result in a cumulative reduction in riparian function as measured by recruitable LWD greater than 10 percent of what would have been provided under the standard riparian strategies.

   b. The Permit shall not apply to forestlands subject to subsequent 20-acre exempt forest practices applications in a WRIA once the WAUs within the WRIA exceeding the “10 percent limit” (above) represent more than 15 percent of the total stream length on FPHCP Covered Lands in the WRIA.

   c. The Permit shall not apply to 20-acre exempt forestlands in any WAU where there is found the spawning and rearing habitat of bull trout populations identified in Table 3-51 of the Opinion until the permittee has established, with review and approval of the FWS, that forest practices under the 20-acre exempt provisions will not measurably diminish the level of riparian function provided by FPHCP Covered Lands in the WAU as measured by recruitable LWD when compared to that which would have been provided under the standard riparian strategies.

D. The permittee shall require trees to be left along Type Np waters under the 20-acre exemption unless it is determined that such leave trees are not necessary to protect covered species and their habitats. Unless determined by WDNR to be unnecessary, leave at least 29 conifer or deciduous trees, 6 inches in diameter or larger, on each side of every 1,000 feet of stream length within 29 feet of the stream. These leave trees may be arranged to accommodate the forest practices operation.

E. Each year, prior to commencement of electrofishing surveys or other activities involving capture and handling of listed species for adaptive-management research and monitoring (including validation of the water-typing model), the permittee shall submit an estimate

of the amount of stream surveys or electrofishing activities to be conducted and an estimate of the number of listed fish (or miles of listed-species habitat) to be affected by these activities. The permittee shall also provide the names and qualifications of the staff, contractors, or cooperators who will be supervising the field work. The permittee shall provide the FWS with a copy of the operating protocols designed to reduce effects to listed fish while maintaining the efficiency of the surveys and monitoring. This incidental take permit does not apply to operational water typing by individual landowners or to fish-salvage operations; these activities would need incidental take authorization through other means.

Following the conclusion of the field season and prior to the next field season, the permittee shall provide a report to the Project Leader, U.S. Fish and Wildlife Service, Western Washington Fish and Wildlife Office, 510 Desmond Drive SE, Suite 102, Lacey, Washington 98503, documenting the level of stream-survey and electrofishing activity and describing any listed fish encounters. This report shall document any effects that may rise to the level of incidental take (including mortality) and shall include the apparent condition of all listed fish specimens encountered. Results of surveys and monitoring shall be incorporated into the appropriate FPHCP periodic reports. The permittee shall obtain all needed Federal and State permits and shall abide by the conditions of each. This includes following the guidelines provided by NMFS (NMFS 2000). If the NMFS guidelines are subsequently revised, the permittee shall follow the revised guidelines. The permittee shall follow the guidelines unless proposed operating protocols described above are otherwise approved by FWS and NMFS, or additional restrictions are imposed by the FWS.

The reasonable and prudent measures, with their implementing terms and conditions, are designed to minimize the impact of incidental take that might otherwise result from the proposed action. If, during the course of the action, this level of incidental take is exceeded, such incidental take represents new information requiring reinitiation of consultation and review of the reasonable and prudent measures provided. The FWS's Western Washington Fish and Wildlife Office must immediately provide an explanation of the causes of the taking and review the need for possible modification of the reasonable and prudent measures.

9.4 CONSERVATION RECOMMENDATIONS

Sections 2(c) and 7(a)(1) of the ESA direct Federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of listed species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on covered species or critical habitat, to help implement recovery plans, or to develop information. The FWS offers the following conservation recommendations:

1. The FWS should continue to work with WDNR, WDFW, forest landowners, and other TFW/FFR stakeholders to increase awareness regarding listed species associated with forested habitats that are not covered by the FPHCP, and to promote education regarding: (1) recognizing signs of listed species use and important habitat features; (2) utilizing methods to reduce impacts from forest activities; and (3) implementing measures to benefit listed species.

2. The FWS should provide technical assistance, upon request, to WDNR to assist them in working with forest landowners to avoid activities with a high risk of unauthorized take of listed species not covered under the FPHCP.

3. The FWS should provide technical assistance to WDNR, other regulatory agencies, and forest landowners in determining appropriate prescriptions to apply where over-stocking and off-site tree species exist as a result of past management, and where insects, disease, fire, and other stochastic events threaten to reduce the vigor of riparian stands. Large wood recruitment often occurs in an episodic manner, particularly in certain eco-regions; however, catastrophic fires are generally not in the best interest of landowners, wildlife, or the general community. As requested, the FWS should participate in forums focusing on solutions (e.g., working groups developing alternate plan templates) to incorporate sound scientific and ecological principles.

4. When technical assistance is requested from FWS, we should work with WDNR, WDFW, forest landowners, and other TFW/FFR stakeholders in developing guidelines for management of the Core Zone under alternate plans. Where RMZs are composed of overly-stocked, young, dense stands along streams and rivers with substantial flow requiring key piece and functional wood of considerable size, consideration should be given to encouraging the development of alternate plans or guidelines to thin the Core Zone with the objective of hastening the development of large wood that could be recruited to typed waters. We should encourage forest landowners to: (1) retain sub-merchantable trees, shrubs, and other vegetation to provide bank protection, shade, and habitat continuity in situations where riparian buffers are not retained within the equipment-limitation zone (30 feet) of Type Np or Ns streams; and (2) maximize canopy coverage on forested wetlands. Where harvest occurs within forested wetlands, the FWS should encourage landowners to place emphasis on maintaining tree-species composition, but also balance leave tree retention with tree species that are less abundant or of particular wildlife value (e.g., Oregon ash, bitter cherry, hazel nut, cottonwood, aspen, cascara, Pacific yew, western white pine, etc.).

5. The FWS should continue to work with WDNR, WDFW, forest landowners, and other TFW/FFR stakeholders in CMER and the TFW/FFR Policy group. The FWS should provide staff to participate regularly in appropriate Scientific Advisory Groups under CMER.

6. The FWS should continue to work with WDNR, WDFW, forest landowners, and other TFW/FFR stakeholders within CMER to develop and conduct monitoring regarding whether the objectives and rules associated with unstable slopes are being correctly interpreted and implemented in the field.

7. The FWS should work with WDNR, WDFW, forest landowners, and other TFW/FFR stakeholders within CMER to ensure that recharge zones for deep-seated landslides in glacial deposits are consistently and correctly identified, and subsequently protected.

8. The FWS should continue to participate in the development, design, and approval of CMER research. Habitat manipulations and handling of fish and amphibians may be conducted for research purposes and are expected to occur along a very small percentage of streams and have minor impacts at a watershed scale. Localized impacts to listed species (e.g., bull trout spawning and rearing areas) would be further limited due to screening and coordination with the FWS in the site selection process for studies.

9. The FWS should coordinate with WDNR, WDFW, forest landowners, and other TFW/FFR stakeholders to develop local strategies for significant instream work in areas of depressed populations of bull trout. These strategies should ascertain whether multiple repair projects (especially within the same timeframe) could have deleterious effects to depressed local populations, and if so, should address timing and minimization measures.

10. The FWS should continue to work with WDNR, WDFW, forest landowners, and other TFW/FFR stakeholders to inventory and map the presence of brook trout in Washington especially those populations in close proximity to bull trout local populations. Where brook trout are found below passage barriers, and native species such as bull trout are located above such barriers, strategies should be developed to protect native species. Options may include retaining passage barriers, installing precluding devices, or initiating control of brook trout.

11. The FWS should provide technical assistance to WDFW through WDNR on hydraulic project approval (HPA) activities to minimize adverse effects on 18 local populations of bull trout when conducting culvert and bridge repair, maintenance, and installation activities or other instream work.

12. The FWS should participate in CMER to ensure that studies on riparian buffers and roads are prioritized and completed within 10 years to demonstrate the effectiveness of the conservation strategies in the FPHCP to minimize adverse effects on covered species from sediment inputs, loss of wood recruitment, and stream temperature changes.

13. The FWS should participate in the FPHCP compliance monitoring program to prioritize monitoring activities related to riparian buffers and road management.

14. The FWS should prepare a report summarizing the implementation of all conservation recommendations within five years of permit issuance. This report should be made available to affected State and Federal agencies, the Tribes, other TFW/FFR stakeholders, and interested members of the public. This report should also be kept in the implementation file for the FPHCP.

10. REINITIATION - CLOSING STATEMENT

This concludes formal consultation on the actions outlined in this Opinion. As provided in 50 CFR 402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect covered species or critical habitat in a manner or to an extent not considered in this Opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the covered species or critical habitat that was not considered in this Opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action.

The factors enumerated above could include approved deviations from the proposed FPHCP that result from implementation of the adaptive management program under the FPHCP. Adaptive management changes to benefit covered species may have adverse effects to other covered species (or listed species which are not covered by the FPHCP). Should such adjustments occur to the extent that covered or listed species, or critical habitat, are adversely affected in a manner or to an extent not considered in this Opinion, consultation would be reinitiated.

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Appendix A

Supporting GIS Analyses for Bull Trout Geographic Risk Analysis

A.1 SUMMARY OF BULL TROUT HABITAT ON FPHCP LANDS BY BULL TROUT CORE AREA OR RECOVERY PLANNING UNIT

V.Harke, January 9, 2006

Summarized from GIS analysis completed by C. Langston, November 8, 2005.

Stream miles based on bull trout key recovery habitat/proposed critical habitat.
WRIA Totals and Core totals off by 215 miles due to segments of Columbia R, Snake R East WA border, and Pend Orielle (small segment) not in WRIA boundary.
SR = spawning and rearing; **FMO** = foraging, migration, and overwintering habitat

ID#	Management Unit	Core Area Name	Total SR Miles by Core Area	Total SR Miles on FP Lands by Core Area	% of total SR Miles on FP Lands	Total FMO Miles in Core Area	Total FMO Miles on FP Lands by Core Area	% of total FMO Miles on FP Lands	Total Miles Unclass-ified BT Habitat by Core Area	Total Miles Unclass-ified BT Habitat on FP Lands by Core Area	Total Miles of BT Habitat by Core Area	Total Miles of BT Habitat on FP Lands by Core Area	% of Total BT Habitat on FP Lands
6	Lower Columbia River Basin	Lewis River	35.7	15.4	43%	123.9	57.8	47%	2.7	0.0	162.2	73.2	45%
36	Puget Sound	Nooksack	141.9	57.1	40%	139.0	38.9	28%	0.0	0.0	280.9	96.0	34%
45	Umatilla-Walla Walla River Basins	Walla Walla	52.0	19.8	38%	99.4	27.7	28%	0.0	0.0	151.4	47.5	31%
46	Upper Columbia River Basin	Entiat River	24.6	7.3	30%	27.2	4.8	18%	0.0	0.0	51.7	12.0	23%
10	Northeast Washington River Basins	Pend Oreille River	132.4	35.5	27%	105.4	9.7	9%	0.0	0.0	237.8	45.2	19%
40	Puget Sound	Stillaguamish	90.8	22.2	24%	152.9	66.3	43%	0.0	0.0	243.7	88.4	36%
37	Puget Sound	Puyallup	178.7	40.0	22%	147.4	68.6	47%	0.0	0.0	326.2	108.6	33%
9	Middle Columbia River Basin	Yakima	254.4	55.2	22%	335.3	74.8	22%	28.6	8.2	618.3	138.1	22%
39	Puget Sound	Snohomish/Skykomish	67.9	8.3	12%	261.9	83.7	32%	0.0	0.0	329.8	92.0	28%
48	Upper Columbia River Basin	Wenatchee River	129.3	12.9	10%	110.7	23.6	21%	0.0	0.0	240.0	36.5	15%
13	Olympic Peninsula	Dungeness	27.7	1.6	6%	21.7	8.1	37%	0.0	0.0	49.4	9.6	20%

ID#	Management Unit	Core Area Name	Total SR Miles by Core Area	Total SR Miles on FP Lands by Core Area	% of total SR Miles on FP Lands	Total FMO Miles in Core Area	Total FMO Miles on FP Lands by Core Area	% of total FMO Miles on FP Lands	Total Miles Unclass-ified BT Habitat by Core Area	Total Miles Unclass-ified BT Habitat on FP Lands by Core Area	Total Miles of BT Habitat by Core Area	Total Miles of BT Habitat on FP Lands by Core Area	% of Total BT Habitat on FP Lands
16	Olympic Peninsula	Hoh	60.3	2.7	5%	97.2	50.2	52%	0.0	0.0	157.5	53.0	34%
14	Olympic Peninsula	Elwha	69.0	2.7	4%	36.9	13.7	37%	0.0	0.0	106.0	16.4	15%
34	Puget Sound	Lower Skagit	238.9	7.7	3%	353.3	92.3	26%	0.0	0.0	592.2	100.0	17%
1	Clark Fork River Basin	Priest Lakes and River	36.1	0.9	3%	0.0	0.0	0%	0.0	0.0	36.1	0.9	3%
44	Snake River Basin in Washington	Tucannon River	59.9	1.5	3%	44.1	0.2	0%	0.0	0.0	104.0	1.7	2%
47	Upper Columbia River Basin	Methow River	153.3	3.5	2%	163.9	19.3	12%	0.0	0.0	317.2	22.8	7%
43	Snake River Basin in Washington	Asotin Creek	47.7	0.8	2%	15.0	0.0	0%	37.9	16.0	100.6	16.7	17%
26	Olympic Peninsula	Skokomish	25.8	0.3	1%	91.6	21.0	23%	0.0	0.0	117.4	21.4	18%
41	Puget Sound	Upper Skagit	106.2	0.5	0%	111.3	7.4	7%	0.0	0.0	217.5	7.9	4%
2	Columbia River	Added by WWFWO for Key Habitat CBDPS/migratory	0.0	0.0	0%	193.9	0.3	0%	0.0	0.0	193.9	0.3	0%
3	Columbia River	NONE	0.0	0.0	0%	538.2	0.1	0%	0.0	0.0	538.2	0.1	0%
4	Grande Ronde River Basin	Grande Ronde	25.0	0.0	0%	37.4	0.1	0%	0.0	0.0	62.4	0.1	0%
5	Lower Columbia River Basin	Klickitat River	19.8	0.0	0%	64.6	20.3	31%	0.0	0.0	84.3	20.3	24%
7	Lower Columbia River Basin	White Salmon River	0.0	0.0	0%	18.7	12.9	69%	0.0	0.0	18.7	12.9	69%
8	Middle Columbia River Basin	Added by WWFWO for Key Habitat CBDPS/migratory	0.0	0.0	0%	107.8	7.8	7%	0.0	0.0	107.8	7.8	7%
11	Olympic Peninsula	Bell	0.0	0.0	0%	3.8	0.9	25%	0.0	0.0	3.8	0.9	25%
12	Olympic Peninsula	Chehalis	0.0	0.0	0%	48.8	5.3	11%	0.0	0.0	48.8	5.3	11%

ID#	Management Unit	Core Area Name	Total SR Miles by Core Area	Total SR Miles on FP Lands by Core Area	% of total SR Miles on FP Lands	Total FMO Miles in Core Area	Total FMO Miles on FP Lands by Core Area	% of total FMO Miles on FP Lands	Total Miles Unclass-ified BT Habitat by Core Area	Total Miles Unclass-ified BT Habitat on FP Lands by Core Area	Total Miles of BT Habitat by Core Area	Total Miles of BT Habitat on FP Lands by Core Area	% of Total BT Habitat on FP Lands
15	Olympic Peninsula	Goodman	0.0	0.0	0%	21.7	8.6	40%	0.0	0.0	21.7	8.6	40%
17	Olympic Peninsula	Humptulips	0.0	0.0	0%	103.6	45.0	43%	0.0	0.0	103.6	45.0	43%
18	Olympic Peninsula	Kalaloch	0.0	0.0	0%	6.4	4.3	67%	0.0	0.0	6.4	4.3	67%
19	Olympic Peninsula	Marine	0.0	0.0	0%	447.4	29.2	7%	0.0	0.0	447.4	29.2	7%
20	Olympic Peninsula	Moclips/Copalis	0.0	0.0	0%	26.9	16.9	63%	0.0	0.0	26.9	16.9	63%
21	Olympic Peninsula	Morse	0.0	0.0	0%	16.3	11.0	67%	0.0	0.0	16.3	11.0	67%
22	Olympic Peninsula	Queets	29.2	0.0	0%	139.8	13.8	10%	0.0	0.0	169.0	13.8	8%
23	Olympic Peninsula	Quinault	38.3	0.0	0%	119.3	8.0	7%	0.0	0.0	157.5	8.0	5%
24	Olympic Peninsula	Raft	0.0	0.0	0%	9.0	0.0	0%	0.0	0.0	9.0	0.0	0%
25	Olympic Peninsula	Satsop	0.0	0.0	0%	57.5	12.2	21%	0.0	0.0	57.5	12.2	21%
27	Olympic Peninsula	Wishkah	0.0	0.0	0%	56.7	37.3	66%	0.0	0.0	56.7	37.3	66%
28	Olympic Peninsula	Wynoochee	0.0	0.0	0%	50.9	12.2	24%	0.0	0.0	50.9	12.2	24%
29	Puget Sound	Chester Morse Lake	24.9	0.0	0%	21.6	0.0	0%	0.0	0.0	46.5	0.0	0%
30	Puget Sound	Chilliwack	29.8	0.0	0%	15.9	2.9	18%	0.0	0.0	45.7	2.9	6%
31	Puget Sound	Lake Washington	0.0	0.0	0%	99.8	16.3	16%	0.0	0.0	99.8	16.3	16%
32	Puget Sound	Lower Green	0.0	0.0	0%	63.3	12.2	19%	0.0	0.0	63.3	12.2	19%
33	Puget Sound	Lower Nisqually	0.0	0.0	0%	45.3	20.6	45%	0.0	0.0	45.3	20.6	45%
35	Puget Sound	Marine	0.0	0.0	0%	566.1	39.5	7%	0.0	0.0	566.1	39.5	7%
38	Puget Sound	Samish	0.0	0.0	0%	33.2	18.6	56%	0.0	0.0	33.2	18.6	56%
42	Snake River	NONE	0.0	0.0	0%	173.5	0.0	0%	0.0	0.0	173.5	0.0	0%
		Totals	**2099.7**	**295.7**	**14%**	**5525.1**	**1024.3**	**19%**	**69.2**	**24.1**	**7693.9**	**1344.2**	**17%**

A.2 ACRES OF FP LANDS BY LOCAL POPULATION AND FMO AREAS IN WASHINGTON

Item: Acres of FPLands by Local Population (Spawning and Rearing Habitat) in Washington
Forest Practices Lands Union with Local Population Areas then Frequency on WRIA summing updated Area

sources: FPLands US FWS(selected areas from FFRLands.shp)
US FWS Draft Bull Trout Recovery Plans (2004)

Percent FP lands within Local Populations
LP Type: L= Local Population; P= Potential Local Population

DPS	Management Unit	Core Area	Local Population Name	LP Type	FPLP Meters^2	FPLPAcres	Total LP Meters^2	Total LP Acres	% FP Lands in LP
Columbia River	Northeast Washington	Pend Oreille River	Mill Creek PLP	P	34543056.87	8535.74	50296296.66	12428.43	68.7
Coastal-Puget Sound	Puget Sound	Nooksack River	Lower South Fork Nooksack River	L	205272838.50	50723.79	311122442.61	76879.68	66.0
Coastal-Puget Sound	Puget Sound	Nooksack River	Middle North Fork Nooksack River	L	22669863.19	5601.82	36460772.33	9009.61	62.2
Coastal-Puget Sound	Puget Sound	Nooksack River	Lower Middle Fork Nooksack River	L	43152145.28	10663.08	70800112.43	17495.01	60.9
Columbia River	Middle Columbia	Yakima River	Ahtamum Creek	L	165679112.85	40940.01	280707937.30	69364.12	59.0
Coastal-Puget Sound	Puget Sound	Puyallup River	Clearwater River PLP	P	54169976.62	13385.63	100095846.54	24734.11	54.1
Columbia River	Lower Columbia	Lewis River	Pine Creek	L	33127831.88	8186.03	61388772.54	15169.43	54.0
Coastal-Puget Sound	Puget Sound	Nooksack River	Lower North Fork Nooksack River	L	46565441.84	11506.52	88089552.73	21767.30	52.9
Columbia River	Northeast Washington	Pend Oreille River	Indian Creek PLP (2)	P	6372461.12	1574.66	13923670.91	3440.60	45.8
Columbia River	Northeast Washington	Pend Oreille River	Le Clerc Creek	L	87577280.52	21640.72	195927628.42	48414.55	44.7
Columbia River	Umatilla-Walla Walla	Walla Walla River	South Fork Touchet River	L	21990311.83	5433.90	50514723.13	12482.40	43.5
Columbia River	Northeast Washington	Pend Oreille River	SFk Tacoma Creek PLP	P	15513244.18	3833.39	41977175.22	10372.74	37.0
Coastal-Puget Sound	Puget Sound	Puyallup River	Upper Puyallup & Mowich Rivers	L	81558267.01	20153.39	236698629.89	58489.24	34.5
Columbia River	Northeast Washington	Pend Oreille River	Tacoma Creek PLP	P	21686525.76	5358.83	64167465.39	15856.05	33.8
Columbia River	Umatilla-Walla Walla	Walla Walla River	Wolf Fork Touchet River	L	8919405.46	2204.02	26540200.22	6558.20	33.6

DPS	Management Unit	Core Area	Local Population Name	LP Type	FPLP Meters^2	FPLPAcres	Total LP Meters^2	Total LP Acres	% FP Lands in LP
Columbia River	Northeast Washington	Pend Oreille River	Small Creek PLP	P	23285907.61	5754.05	69649989.48	17210.81	33.4
Columbia River	Lower Columbia	Lewis River	Cougar Creek	L	13017206.92	3216.61	42952865.26	10613.84	30.3
Columbia River	Middle Columbia	Yakima River	NFk Teanaway River	L	72079476.65	17811.15	246054831.49	60801.19	29.3
Columbia River	Umatilla-Walla Walla	Walla Walla River	North Fork Touchet River	L	44596104.01	11019.89	155626624.58	38456.00	28.7
Columbia River	Northeast Washington	Pend Oreille River	Harvey Creek PLP	P	22666909.21	5601.09	103225658.43	25507.50	22.0
Coastal-Puget Sound	Puget Sound	Puyallup River	Carbon River	L	45418035.86	11222.99	209613705.18	51796.44	21.7
Columbia River	Middle Columbia	Yakima River	Upper Yakima River	L	33501441.59	8278.35	157379201.13	38889.07	21.3
Columbia River	Upper Columbia	Wenatchee River	Nason Creek	L	58765608.43	14521.23	283565673.94	70070.28	20.7
Coastal-Puget Sound	Puget Sound	Stillaguamish River	Canyon Creek	L	20967258.39	5181.10	116759193.39	28851.69	18.0
Columbia River	Northeast Washington	Pend Oreille River	Cedar Creek PLP	P	6674777.22	1649.37	47167291.28	11655.24	14.2
Columbia River	Snake River Basin in Washington	Asotin Creek	Wormell Gulch PLP	P	27499293.42	6795.19	196793317.26	48628.47	14.0
Coastal-Puget Sound	Puget Sound	Puyallup River	West Fork White River	L	22593180.92	5582.87	169936856.43	41992.12	13.3
Coastal-Puget Sound	Puget Sound	Stillaguamish River	North Fork Stillaguamish River	L	32300844.27	7981.68	248092598.49	61304.74	13.0
Coastal-Puget Sound	Puget Sound	Nooksack River	Glacier Creek	L	10074280.86	2489.40	82231071.52	20319.65	12.3
Coastal-Puget Sound	Puget Sound	Stillaguamish River	Upper Deer Creek	L	10185930.90	2516.99	91455147.49	22598.96	11.1
Coastal-Puget Sound	Olympic Peninsula	Elwha River	Little River PLP	P	6493187.86	1604.49	59253269.39	14641.73	11.0
Coastal-Puget Sound	Puget Sound	Nooksack River	Lower Canyon Creek	L	8685365.08	2146.19	79994770.26	19767.05	10.9
Coastal-Puget Sound	Puget Sound	Puyallup River	Greenwater River	L	14189253.18	3506.22	131555236.55	32507.86	10.8
Coastal-Puget Sound	Puget Sound	Nooksack River	Upper Middle Fork Nooksack River	L	17782573.47	4394.15	186424409.24	46066.26	9.5
Columbia River	Upper Columbia	Wenatchee River	Chiwaukum Creek	L	10887095.80	2690.25	125737814.66	31070.35	8.7
Columbia River	Middle Columbia	Yakima River	Cle Elum River	L	47012911.45	11617.09	573264379.73	141656.06	8.2
Columbia River	Clark Fork	Priest Lake	Granite Creek	L	13220990.31	3266.96	164008632.37	40527.23	8.1
Coastal-Puget Sound	Olympic Peninsula	Dungeness River	Dungeness River	L	7414070.95	1832.05	92001990.16	22734.08	8.1
Columbia River	Middle Columbia	Yakima River	SFk Tieton River	L	18037030.28	4457.03	231892204.83	57301.55	7.8
Columbia River	Middle Columbia	Yakima River	Gold Creek (2)	L	10993212.23	2716.47	146631065.45	36233.16	7.5
Coastal-Puget Sound	Puget Sound	Snohomish/Skykomish River	South Fork Skykomish River	L	51790619.67	12797.68	711690976.17	175861.86	7.3
Coastal-Puget Sound	Puget Sound	Lower Skagit River	Illabot Creek	L	7100592.27	1754.59	111618521.66	27581.41	6.4

DPS	Management Unit	Core Area	Local Population Name	LP Type	FPLP Meters^2	FPLPAcres	Total LP Meters^2	Total LP Acres	% FP Lands in LP
Columbia River	Upper Columbia	Entiat River	Entiat River	L	19996327.68	4941.18	326352377.70	80643.06	6.1
Columbia River	Upper Columbia	Entiat River	Mad River	L	14268452.79	3525.80	236301378.59	58391.07	6.0
Columbia River	Northeast Washington	Pend Oreille River	Ruby Creek PLP (2)	P	4688247.42	1158.49	80168540.18	19809.99	5.8
Columbia River	Middle Columbia	Yakima River	Kachess River	L	6966021.72	1721.33	133793833.00	33061.02	5.2
Columbia River	Snake River Basin in Washington	Tucannon River	Little Tucannon River	P	904629.27	223.54	19445593.21	4805.09	4.7
Coastal-Puget Sound	Puget Sound	Puyallup River	Upper White River	L	16337960.05	4037.18	389023161.91	96129.28	4.2
Columbia River	Umatilla-Walla Walla	Walla Walla River	Mill Creek (2)	L	2207286.86	545.43	54393126.95	13440.77	4.1
Columbia River	Upper Columbia	Wenatchee River	White River	L	17877852.79	4417.69	475399132.66	117473.15	3.8
Coastal-Puget Sound	Puget Sound	Lower Skagit River	Upper South Fork Sauk River	L	1762342.76	435.48	46933641.22	11597.50	3.8
Columbia River	Upper Columbia	Wenatchee River	Chiwawa River	L	16122987.96	3984.06	488898065.55	120808.79	3.3
Coastal-Puget Sound	Puget Sound	Nooksack River	Wanlick Creek	L	800251.59	197.75	25396597.22	6275.61	3.2
Columbia River	Upper Columbia	Wenatchee River	Icicle Creek	L	15398943.82	3805.14	555239804.94	137202.12	2.8
Columbia River	Snake River Basin in Washington	Asotin Creek	NFk Asotin River	L	7385245.36	1824.93	269436328.17	66578.86	2.7
Coastal-Puget Sound	Puget Sound	Snohomish/Skykomish River	North Fork Skykomish River	L	5808846.53	1435.39	214209055.84	52931.97	2.7
Columbia River	Middle Columbia	Yakima River	Rattlesnake Creek	L	7282721.08	1799.59	282061219.95	69698.53	2.6
Columbia River	Middle Columbia	Yakima River	Taneum Creek PLP	P	4045632.29	999.69	161794007.67	39979.99	2.5
Coastal-Puget Sound	Puget Sound	Stillaguamish River	South Fork Stillaguamish River	L	3857836.24	953.29	188211621.8	46507.89	2.0
Coastal-Puget Sound	Olympic Peninsula	Skokomish River	Brown Creek PLP	P	356013.10	87.97	20648589.08	5102.35	1.7
Columbia River	Snake River Basin in Washington	Tucannon River	Cummings Creek	L	855238.82	211.33	51592993.67	12748.85	1.7
Columbia River	Upper Columbia	Methow River	Wolf Creek	L	1537823.80	380.00	104539111.95	25832.06	1.5
Coastal-Puget Sound	Puget Sound	Snohomish/Skykomish River	Troublesome Creek	L	451979.66	111.69	33595484.27	8301.59	1.3
Coastal-Puget Sound	Puget Sound	Lower Skagit River	Tenas Creek	L	342250.80	84.57	27136907.66	6705.65	1.3
Columbia River	Upper Columbia	Methow River	Gold Creek (3)	L	1487478.18	367.56	157497562.68	38918.32	0.9
Columbia River	Upper Columbia	Wenatchee River	Peshastin Creek	L	739881.91	182.83	95285192.17	23545.38	0.8
Coastal-Puget Sound	Puget Sound	Nooksack River	Upper North Fork Nooksack River	L	908134.79	224.40	119013354.02	29408.71	0.8

DPS	Management Unit	Core Area	Local Population Name	LP Type	FPLP Meters^2	FPLPAcres	Total LP Meters^2	Total LP Acres	% FP Lands in LP
Columbia River	Upper Columbia	Methow River	Twisp River	L	3933944.93	972.09	535294369.00	132273.51	0.7
Columbia River	Clark Fork	Priest Lake	Kalispell Creek	L	392375.98	96.96	60538130.26	14959.23	0.6
Columbia River	Snake River Basin in Washington	Tucannon River	Tucannon River	L	724250.16	178.97	116375742.05	28756.94	0.6
Coastal-Puget Sound	Olympic Peninsula	Hoh River	South Fork Hoh River	L	783781.42	193.68	138091398.33	34122.97	0.6
Coastal-Puget Sound	Puget Sound	Lower Skagit River	Bacon Creek	L	702252.86	173.53	132209383.64	32669.50	0.5
Coastal-Puget Sound	Puget Sound	Chilliwack River	Silesia Creek	L	544987.00	134.67	102852739.98	25415.35	0.5
Coastal-Puget Sound	Puget Sound	Upper Skagit River	Ruby Creek	L	2293041.17	566.62	453638382.32	112095.97	0.5
Coastal-Puget Sound	Puget Sound	Upper Skagit River	Thunder Creek	L	1412946.73	349.15	280912893.69	69414.77	0.5
Columbia River	Upper Columbia	Wenatchee River	Little Wenatchee River	L	1185417.29	292.92	262289868.99	64812.94	0.5
Coastal-Puget Sound	Puget Sound	Lower Skagit River	South Fork Cascade River	L	402536.82	99.47	93891158.18	23200.90	0.4
Columbia River	Upper Columbia	Methow River	Goat Creek	L	364145.51	89.98	93182917.42	23025.89	0.4
Coastal-Puget Sound	Puget Sound	Lower Skagit River	Sulphur Creek (Lake Shannon) PLP	P	101171.88	25.00	26073578.45	6442.89	0.4
Coastal-Puget Sound	Puget Sound	Lower Skagit River	Baker Lake	L	2086969.66	515.70	557660481.58	137800.28	0.4
Coastal-Puget Sound	Puget Sound	Lower Skagit River	Forks of Sauk River	L	874294.51	216.04	275909664.86	68178.45	0.3
Coastal-Puget Sound	Puget Sound	Chester Morse	Cedar River	L	345530.28	85.38	111190661.88	27475.69	0.3
Columbia River	Middle Columbia	Yakima River	Bumping River	L	703485.29	173.83	234067543.64	57839.08	0.3
Columbia River	Grande Ronde	Grande Ronde River	Crooked Creek	L	551999.25	136.40	193525775.04	47821.04	0.3
Coastal-Puget Sound	Olympic Peninsula	Skokomish River	North Fork Skokomish River	L	290245.06	71.72	110709761.92	27356.85	0.3
Coastal-Puget Sound	Puget Sound	Snohomish/Skykomish River	Salmon Creek	L	52518.08	12.98	21466154.76	5304.38	0.2
Columbia River	Upper Columbia	Methow River	Early Winters Creek	L	464371.04	114.75	208315024.67	51475.53	0.2
Columbia River	Middle Columbia	Yakima River	American River	L	457643.94	113.09	205663548.53	50820.34	0.2
Coastal-Puget Sound	Olympic Peninsula	Skokomish River	South Fork Skokomish River	L	192050.18	47.46	99585586.53	24608.02	0.2
Columbia River	Middle Columbia	Yakima River	NFk Tieton River	L	510365.78	126.11	296004604.98	73144.00	0.2
Columbia River	Upper Columbia	Methow River	WFk Methow River	L	334429.95	82.64	220965562.31	54601.53	0.2
Columbia River	Northeast Washington	Pend Oreille River	Sullivan Creek PLP	P	242940.07	60.03	184744414.20	45651.13	0.1
Coastal-Puget Sound	Puget Sound	Lower Skagit River	Goodell Creek	L	119107.27	29.43	101342237.76	25042.10	0.1
Columbia River	Upper Columbia	Methow River	Lost River	L	364598.86	90.09	434619951.28	107396.44	0.1

DPS	Management Unit	Core Area	Local Population Name	LP Type	FPLP Meters^2	FPLPAcres	Total LP Meters^2	Total LP Acres	% FP Lands in LP
Coastal-Puget Sound	Puget Sound	Chester Morse	Boulder Creek	L	44347.70	10.96	59438925.24	14687.61	0.1
Columbia River	Upper Columbia	Methow River	Chewack River	L	545788.07	134.87	843465677.47	208423.95	0.1
Coastal-Puget Sound	Puget Sound	Lower Skagit River	Newhalem Creek	L	6348.50	1.57	70782011.48	17490.54	0.0
Coastal-Puget Sound	Puget Sound	Lower Skagit River	Stetattle Creek	L	2234.46	0.55	58498126.91	14455.14	0.0
Columbia River	Middle Columbia	Yakima River	Crow Creek	L	4928.92	1.22	220615085.66	54514.93	0.0
Coastal-Puget Sound	Puget Sound	Upper Skagit River	Little Beaver Creek	L	3003.89	0.74	139328300.20	34428.62	0.0
Coastal-Puget Sound	Puget Sound	Upper Skagit River	Lightning Creek	L	3396.72	0.84	293953034.61	72637.04	0.0
Coastal-Puget Sound	Puget Sound	Upper Skagit River	Big Beaver Creek	L	648.71	0.16	170933161.30	42238.31	0.0
Coastal-Puget Sound	Olympic Peninsula	Queets River	Queets River	L	421.80	0.10	190231817.75	47007.09	0.0
Coastal-Puget Sound	Puget Sound	Upper Skagit River	Silver Creek	L	40.21	0.01	43234003.26	10683.31	0.0
Coastal-Puget Sound	Olympic Peninsula	Dungeness River	Gray Wolf River	L	0.00	0.00	197282841.57	48749.43	0.0
Coastal-Puget Sound	Olympic Peninsula	Elwha River	Elwha River	L	0.00	0.00	634061211.21	156679.22	0.0
Coastal-Puget Sound	Olympic Peninsula	Hoh River	Hoh River	L	0.00	0.00	267591191.41	66122.92	0.0
Coastal-Puget Sound	Olympic Peninsula	Quinault River	North Fork Quinault River	L	0.00	0.00	172172626.81	42544.59	0.0
Coastal-Puget Sound	Olympic Peninsula	Quinault River	Upper Quinault River	L	0.00	0.00	232794043.87	57524.40	0.0
Coastal-Puget Sound	Puget Sound	Chester Morse	Rack Creek	L	0.00	0.00	5699901.34	1408.47	0.0
Coastal-Puget Sound	Puget Sound	Chester Morse	Shotgun Creek PLP	P	0.00	0.00	2083696.34	514.89	0.0
Coastal-Puget Sound	Puget Sound	Chilliwack River	Depot Creek	L	0.00	0.00	32372816.37	7999.46	0.0
Coastal-Puget Sound	Puget Sound	Chilliwack River	Little Chilliwack River	L	0.00	0.00	32994190.11	8153.00	0.0
Coastal-Puget Sound	Puget Sound	Chilliwack River	Upper Chilliwack River	L	0.00	0.00	141938868.12	35073.70	0.0
Coastal-Puget Sound	Puget Sound	Lower Skagit River	Buck Creek	L	0.00	0.00	88080333.50	21765.02	0.0
Coastal-Puget Sound	Puget Sound	Lower Skagit River	Cascade River	L	0.00	0.00	84448347.49	20867.55	0.0
Coastal-Puget Sound	Puget Sound	Lower Skagit River	Downey Creek	L	0.00	0.00	92443834.56	22843.26	0.0
Coastal-Puget Sound	Puget Sound	Lower Skagit River	Lime Creek	L	0.00	0.00	45572082.96	11261.06	0.0
Coastal-Puget Sound	Puget Sound	Lower Skagit River	Lower Whitechuck River	L	0.00	0.00	121148312.20	29936.26	0.0
Coastal-Puget Sound	Puget Sound	Lower Skagit River	Milk Creek	L	0.00	0.00	37596205.82	9290.18	0.0
Coastal-Puget Sound	Puget Sound	Lower Skagit River	Straight Creek	L	0.00	0.00	29191101.50	7213.25	0.0
Coastal-Puget Sound	Puget Sound	Lower Skagit River	Sulphur Creek	L	0.00	0.00	85228584.20	21060.35	0.0
Coastal-Puget Sound	Puget Sound	Lower Skagit River	Upper Suiattle River	L	0.00	0.00	232881665.35	57546.05	0.0

DPS	Management Unit	Core Area	Local Population Name	LP Type	FPLP Meters^2	FPLPAcres	Total LP Meters^2	Total LP Acres	% FP Lands in LP
Coastal-Puget Sound	Puget Sound	Lower Skagit River	Upper Whitechuck River	L	0.00	0.00	99447435.67	24573.88	0.0
Coastal-Puget Sound	Puget Sound	Nooksack River	Upper South Fork Nooksack River	L	0.00	0.00	54017108.85	13347.86	0.0
Coastal-Puget Sound	Puget Sound	Upper Skagit River	Deer Creek PLP	P	0.00	0.00	947633.51	234.16	0.0
Coastal-Puget Sound	Puget Sound	Upper Skagit River	Panther Creek	L	0.00	0.00	95438997.04	23583.38	0.0
Coastal-Puget Sound	Puget Sound	Upper Skagit River	Pierce Creek	L	0.00	0.00	10413525.11	2573.23	0.0
Columbia River	Clark Fork	Priest Lake	Gold Creek	L	0.00	0.00	62184145.09	15365.97	0.0
Columbia River	Grande Ronde	Grande Ronde River	Butte Creek	L	0.00	0.00	107266806.89	26506.08	0.0
Columbia River	Grande Ronde	Grande Ronde River	North Fork Wenaha River	L	0.00	0.00	45695792.13	11291.62	0.0
Columbia River	Lower Columbia	Klickitat River	West Fork Klickitat River	L	0.00	0.00	236487594.04	58437.09	0.0
Columbia River	Lower Columbia	Lewis River	Rush Creek	L	0.00	0.00	68288213.28	16874.31	0.0
Columbia River	Lower Columbia	Lewis River	Upper Lewis River PLP	P	0.00	0.00	298654503.83	73798.80	0.0
Columbia River	Middle Columbia	Yakima River	Box Cayon Creek	L	0.00	0.00	32235965.36	7965.64	0.0
Columbia River	Middle Columbia	Yakima River	Deep Creek	L	0.00	0.00	62707141.83	15495.20	0.0
Columbia River	Middle Columbia	Yakima River	Indian Creek	L	0.00	0.00	42684545.47	10547.53	0.0
Columbia River	Northeast Washington	Pend Oreille River	Slate Creek PLP	P	0.00	0.00	83142842.45	20544.95	0.0
Columbia River	Snake River Basin in Washington	Asotin Creek	Charley Creek	L	0.00	0.00	58500765.98	14455.79	0.0
Columbia River	Snake River Basin in Washington	Tucannon River	Hixon Creek	P	0.00	0.00	8046914.79	1988.43	0.0
Columbia River	Snake River Basin in Washington	Tucannon River	Little Turkey Creek	L	0.00	0.00	6088353.65	1504.46	0.0
Columbia River	Snake River Basin in Washington	Tucannon River	Meadow Creek	L	0.00	0.00	18276718.64	4516.25	0.0
Columbia River	Snake River Basin in Washington	Tucannon River	Panjab Creek	L	0.00	0.00	30034459.97	7421.64	0.0
Columbia River	Snake River Basin in Washington	Tucannon River	Turkey Creek	L	0.00	0.00	11630064.09	2873.84	0.0
Columbia River	Upper Columbia	Methow River	Blue Buck Creek PLP	L	0.00	0.00	21969995.68	5428.88	0.0
					1679463868.96	415002.66	22650998262.43	5597157.94	7.4

Item: Acres of FP Lands by Recovery Plan FMO Areas in Washington (includes FMO Areas in Core Areas)

Copy FMO columns from FPLANDS LP - CORE = FFMO spreadsheet

sources: FPLands US FWS(selected areas from FFRLands.shp)
US FWS Draft Bull Trout Recovery Plans (2004)

Percent FP lands within Core Area FMO

#	DPS	Management Unit	Area Type	Area Name (Core, FMO, RN)	FP Acres for FMO	Total Acres for FMO	% FP Lands in Areas FMO	Total RP Areas Acres	%FP Lands for FMO in entire Core
20	Coastal-Puget Sound	Olympic Peninsula	FMO Marine	Hood Canal	4928.67	95683.64	5.2	95683.64	
38	Coastal-Puget Sound	Puget Sound	FMO Marine	Puget Sound	57980.20	1187643.24	4.9	1187643.24	
19	Coastal-Puget Sound	Olympic Peninsula	FMO Marine	Grays Harbor	441.14	62306.23	0.7	62306.23	
21	Coastal-Puget Sound	Olympic Peninsula	FMO Marine	Pacific Coast	2753.30	515684.37	0.5	515684.37	
22	Coastal-Puget Sound	Olympic Peninsula	FMO Marine	Strait of Juan DeFuca	92.89	562734.10	0.0	562734.10	
17	Coastal-Puget Sound	Olympic Peninsula	FMO	Wishkah	56808.48	65799.08	86.3	65799.08	
36	Coastal-Puget Sound	Puget Sound	FMO	Lower Nisqually	184253.68	301623.34	61.1	301623.34	
11	Coastal-Puget Sound	Olympic Peninsula	FMO	Humptulips	93623.01	157871.53	59.3	157871.53	
14	Coastal-Puget Sound	Olympic Peninsula	FMO	Moclips/Copalis	55902.36	100493.92	55.6	100493.92	
37	Coastal-Puget Sound	Puget Sound	FMO	Samish	44119.49	81375.48	54.2	81375.48	
10	Coastal-Puget Sound	Olympic Peninsula	FMO	Goodman	18838.99	40434.04	46.6	40434.04	
9	Coastal-Puget Sound	Olympic Peninsula	FMO	Chehalis	159203.39	344566.71	46.2	344566.71	
15	Coastal-Puget Sound	Olympic Peninsula	FMO	Morse	31724.25	71823.82	44.2	71823.82	
35	Coastal-Puget Sound	Puget Sound	FMO	Lower Green	74818.36	177880.73	42.1	177880.73	
18	Coastal-Puget Sound	Olympic Peninsula	FMO	Wynoochee	52392.81	125451.34	41.8	125451.34	
12	Coastal-Puget Sound	Olympic Peninsula	FMO	Kalaloch	4905.59	13648.90	35.9	13648.90	
8	Coastal-Puget Sound	Olympic Peninsula	FMO	Cedar/Steamboat	4659.58	13129.58	35.5	13129.58	

#	DPS	Management Unit	Area Type	Area Name (Core, FMO, RN)	FP Acres for FMO	Total Acres for FMO	% FP Lands in Areas FMO	Total RP Areas Acres	%FP Lands for FMO in entire Core
34	Coastal-Puget Sound	Puget Sound	FMO	Lake Washington	103205.31	331958.56	31.1	331958.56	
7	Coastal-Puget Sound	Olympic Peninsula	FMO	Bell	3962.32	12938.02	30.6	12938.02	
16	Coastal-Puget Sound	Olympic Peninsula	FMO	Satsop	43702.36	189525.95	23.1	189525.95	
50	Columbia River	Lower Columbia	FMO	Columbia	1977.67	148141.39	1.3	148141.39	
13	Coastal-Puget Sound	Olympic Peninsula	FMO	Raft	0.00	90344.66	0.0	90344.66	
49	Columbia River	Lower Columbia	Core Habitat	White Salmon	109225.57	217308.69	50.3	217308.69	
44	Columbia River	Coeur d'Alene Lake	Core Area	Coeur d'Alene Lake	7203.58	8690.77	82.9	8690.77	82.9
47	Columbia River	Lower Columbia	Core Area	Klickitat	301728.25	806027.31	37.4	864464.40	34.9
30	Coastal-Puget Sound	Puget Sound	Core Area	Puyallup	226404.13	359021.78	63.1	664670.82	34.1
31	Coastal-Puget Sound	Puget Sound	Core Area	Snohomish/ Skykomish	385865.47	929972.07	41.5	1172371.87	32.9
32	Coastal-Puget Sound	Puget Sound	Core Area	Stillaguamish	144079.64	291683.09	49.4	450946.37	32.0
41	Columbia River	Clark Fork	Core Area	Lake Pend Orielle	21681.78	77322.23	28.0	77322.23	28.0
53	Columbia River	Northeast Washington	Core Area	Pend Oreille	160531.34	433241.29	37.1	664133.27	24.2
48	Columbia River	Lower Columbia	Core Area	Lewis	116414.14	415444.03	28.0	531900.40	21.9
28	Coastal-Puget Sound	Puget Sound	Core Area	Lower Skagit	245365.22	779741.83	31.5	1377263.04	17.8
3	Coastal-Puget Sound	Olympic Peninsula	Core Area	Hoh	31017.00	90841.42	34.1	191087.31	16.2
27	Coastal-Puget Sound	Puget Sound	Core Area	Chilliwack	22557.27	76007.47	29.7	152648.98	14.8
29	Coastal-Puget Sound	Puget Sound	Core Area	Nooksack	70648.90	238486.10	29.6	498822.83	14.2
4	Coastal-Puget Sound	Olympic Peninsula	Core Area	Queets	25127.35	241399.32	10.4	288406.41	8.7
6	Coastal-Puget Sound	Olympic Peninsula	Core Area	Skokomish	13039.36	95922.81	13.6	152990.04	8.5
60	Columbia River	Upper Columbia	Core Area	Wenatchee	65371.71	313478.95	20.9	878461.95	7.4
45	Columbia River	Grande Ronde	Core Area	Grande Ronde	12299.60	100909.67	12.2	186528.42	6.6
1	Coastal-Puget Sound	Olympic Peninsula	Core Area	Dungeness	7959.81	59402.44	13.4	130885.95	6.1
57	Columbia River	Umatilla-Walla Walla	Core Area	Walla Walla	47786.76	750322.22	6.4	821259.59	5.8
52	Columbia River	Middle Columbia	Core Area	Yakima	209317.90	3117057.41	6.7	3934368.83	5.3
5	Coastal-Puget Sound	Olympic Peninsula	Core Area	Quinault	12520.44	179724.75	7.0	279793.74	4.5
58	Columbia River	Upper Columbia	Core Area	Entiat	14181.03	198462.36	7.1	337496.49	4.2

#	DPS	Management Unit	Area Type	Area Name (Core, FMO, RN)	FP Acres for FMO	Total Acres for FMO	% FP Lands in Areas FMO	Total RP Areas Acres	%FP Lands for FMO in entire Core
2	Coastal-Puget Sound	Olympic Peninsula	Core Area	Elwha	7407.76	34343.67	21.6	205664.62	3.6
59	Columbia River	Upper Columbia	Core Area	Methow	34275.11	727230.32	4.7	1374606.43	2.5
56	Columbia River	Snake River Basin in Washington	Core Area	Tucannon	4181.63	258627.39	1.6	323242.89	1.3
55	Columbia River	Snake River Basin in Washington	Core Area	Asotin	3247.83	121593.99	2.7	251257.11	1.3
26	Coastal-Puget Sound	Puget Sound	Core Area	Chester Morse	88.45	8301.74	1.1	52388.40	0.2
33	Coastal-Puget Sound	Puget Sound	Core Area	Upper Skagit	574.04	95989.51	0.6	463878.30	0.1
42	Columbia River	Clark Fork	Core Area	Priest Lake	32.25	3108.66	1.0	73961.09	0.0
43	Columbia River	Clearwater	Core Area	Lower and Middle Fork Clearwater	0.00	2682.43	0.0	2682.43	0.0
0				Not in Area Type, in DPS or MU (not included in sums)	2732237.50			15211199.15	
					3300427.17	15723404.38	21.0	21320562.32	15.5

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A.3 ROAD DENSITY, STREAM CROSSINGS, STREAM ADJACENT ROAD SUMMARIES BY LOCAL POPULATION AND CORE AREA

Item: Transportation in Local Populations & FP Lands

Clip WaTrans2005 with Local Populations
Identify clipped WaTrans2005 with Fplands in Local populations
Frequency by road type & local population to get total road miles in LP
sources: WDNR Transportation 2005 & US FWS FPLands 2005

Road Density by Local Population (Totals and FP lands)

LP Type: L= Local Population; P= Potential Local Population

ID #	Distinct Population Segment	Management Unit	Core Area	Local Population (LP) Name	LP Type	Total Acres in Local Population	Total (10,99) Miles in LP	Road Density in LP	Acres FPL in Local Population	FPL Total (10,99) Miles in LP	Road Density FPL in LP
101	Columbia River	Middle Columbia	Yakima River	Upper Yakima River	L	38889.07	329.76	5.43	8278.35	69.82	5.40
15	Coastal-Puget Sound	Puget Sound	Chester Morse	Rack Creek	L	1408.47	10.62	4.83	0.00	0.00	#DIV/0!
83	Columbia River	Lower Columbia	Lewis River	Pine Creek	L	15169.43	113.74	4.80	8186.03	81.71	6.39
106	Columbia River	Northeast Washington	Pend Oreille River	Mill Creek PLP	P	12428.43	88.93	4.58	8535.74	67.56	5.07
54	Coastal-Puget Sound	Puget Sound	Puyallup River	Greenwater River	L	32507.86	228.87	4.51	3506.22	34.29	6.26
45	Coastal-Puget Sound	Puget Sound	Nooksack River	Lower North Fork Nooksack River	L	21767.30	143.73	4.23	11506.52	87.50	4.87
47	Coastal-Puget Sound	Puget Sound	Nooksack River	Middle North Fork Nooksack River	L	9009.61	59.38	4.22	5601.82	39.69	4.53
129	Columbia River	Upper Columbia	Entiat River	Mad River	L	58391.07	377.47	4.14	3525.80	30.47	5.53
118	Columbia River	Snake River Basin in Washington	Tucannon River	Little Tucannon River	P	4805.09	29.72	3.96	223.54	1.80	5.15
10	Coastal-Puget Sound	Olympic Peninsula	Skokomish River	Brown Creek PLP	P	5102.35	31.55	3.96	87.97	0.41	3.01
46	Coastal-Puget Sound	Puget Sound	Nooksack River	Lower South Fork Nooksack River	L	76879.68	461.89	3.85	50723.79	355.48	4.49
13	Coastal-Puget Sound	Puget Sound	Chester Morse	Boulder Creek	L	14687.61	84.44	3.68	10.96	0.43	25.31
82	Columbia River	Lower Columbia	Lewis River	Cougar Creek	L	10613.84	58.29	3.51	3216.61	34.59	6.88

ID #	Distinct Population Segment	Management Unit	Core Area	Local Population (LP) Name	LP Type	Total Acres in Local Population	Total (10,99) Miles in LP	Road Density in LP	Acres FPL in Local Population	FPL Total (10,99) Miles in LP	Road Density FPL in LP
93	Columbia River	Middle Columbia	Yakima River	Gold Creek (2)	L	36233.16	194.47	3.43	2716.47	20.59	4.85
44	Coastal-Puget Sound	Puget Sound	Nooksack River	Lower Middle Fork Nooksack River	L	17495.01	92.98	3.40	10663.08	58.78	3.53
113	Columbia River	Snake River Basin in Washington	Asotin Creek	Charley Creek	L	14455.79	76.71	3.40	0.00	0.00	#DIV/0!
12	Coastal-Puget Sound	Olympic Peninsula	Skokomish River	South Fork Skokomish River	L	24608.02	127.77	3.32	47.46	0.00	0.00
1	Coastal-Puget Sound	Olympic Peninsula	Dungeness River	Dungeness River	L	22734.08	114.32	3.22	1832.05	15.94	5.57
14	Coastal-Puget Sound	Puget Sound	Chester Morse	Cedar River	L	27475.69	135.76	3.16	85.38	0.42	3.14
86	Columbia River	Middle Columbia	Yakima River	Ahtamum Creek	L	69364.12	318.26	2.94	40940.01	213.63	3.34
128	Columbia River	Upper Columbia	Entiat River	Entiat River	L	80643.06	356.74	2.83	4941.18	30.39	3.94
53	Coastal-Puget Sound	Puget Sound	Puyallup River	Clearwater River PLP	P	24734.11	108.31	2.80	13385.63	98.95	4.73
127	Columbia River	Umatilla-Walla Walla	Walla Walla River	Wolf Fork Touchet River	L	6558.20	28.42	2.77	2204.02	10.56	3.07
100	Columbia River	Middle Columbia	Yakima River	Taneum Creek PLP	P	39979.99	170.95	2.74	999.69	8.14	5.21
110	Columbia River	Northeast Washington	Pend Oreille River	Small Creek PLP	P	17210.81	73.43	2.73	5754.05	26.81	2.98
104	Columbia River	Northeast Washington	Pend Oreille River	Indian Creek PLP (2)	P	3440.60	14.64	2.72	1574.66	8.12	3.30
16	Coastal-Puget Sound	Puget Sound	Chester Morse	Shotgun Creek PLP	P	514.89	2.12	2.64	0.00	0.00	#DIV/0!
120	Columbia River	Snake River Basin in Washington	Tucannon River	Meadow Creek	L	4516.25	17.33	2.46	0.00	0.00	#DIV/0!
95	Columbia River	Middle Columbia	Yakima River	Kachess River	L	33061.02	126.78	2.45	1721.33	20.40	7.59
112	Columbia River	Northeast Washington	Pend Oreille River	Tacoma Creek PLP	P	15856.05	60.01	2.42	5358.83	23.61	2.82
126	Columbia River	Umatilla-Walla Walla	Walla Walla River	South Fork Touchet River	L	12482.40	46.44	2.38	5433.90	32.32	3.81

ID #	Distinct Population Segment	Management Unit	Core Area	Local Population (LP) Name	LP Type	Total Acres in Local Population	Total (10,99) Miles in LP	Road Density in LP	Acres FPL in Local Population	FPL Total (10,99) Miles in LP	Road Density FPL in LP
43	Coastal-Puget Sound	Puget Sound	Nooksack River	Lower Canyon Creek	L	19767.05	70.82	2.29	2146.19	14.22	4.24
143	Columbia River	Upper Columbia	Wenatchee River	Nason Creek	L	70070.28	247.89	2.26	14521.23	131.56	5.80
105	Columbia River	Northeast Washington	Pend Oreille River	Le Clerc Creek	L	48414.55	165.40	2.19	21640.72	107.10	3.17
57	Coastal-Puget Sound	Puget Sound	Puyallup River	West Fork White River	L	41992.12	138.00	2.10	5582.87	47.86	5.49
111	Columbia River	Northeast Washington	Pend Oreille River	Sullivan Creek PLP	P	45651.13	149.31	2.09	60.03	0.02	0.21
55	Coastal-Puget Sound	Puget Sound	Puyallup River	Upper Puyallup & Mowich Rivers	L	58489.24	190.85	2.09	20153.39	152.03	4.83
99	Columbia River	Middle Columbia	Yakima River	SFk Tieton River	L	57301.55	182.04	2.03	4457.03	23.43	3.36
65	Coastal-Puget Sound	Puget Sound	Stillaguamish River	Upper Deer Creek	L	22598.96	68.87	1.95	2516.99	14.53	3.70
84	Columbia River	Lower Columbia	Lewis River	Rush Creek	L	16874.31	51.39	1.95	0.00	0.00	#DIV/0!
63	Coastal-Puget Sound	Puget Sound	Stillaguamish River	North Fork Stillaguamish River	L	61304.74	185.29	1.93	7981.68	52.24	4.19
114	Columbia River	Snake River Basin in Washington	Asotin Creek	NFk Asotin River	L	66578.86	201.03	1.93	1824.93	4.19	1.47
62	Coastal-Puget Sound	Puget Sound	Stillaguamish River	Canyon Creek	L	28851.69	87.11	1.93	5181.10	27.76	3.43
133	Columbia River	Upper Columbia	Methow River	Goat Creek	L	23025.89	68.73	1.91	89.98	0.28	2.02
125	Columbia River	Umatilla-Walla Walla	Walla Walla River	North Fork Touchet River	L	38456.00	114.63	1.91	11019.89	49.16	2.85
103	Columbia River	Northeast Washington	Pend Oreille River	Harvey Creek PLP	P	25507.50	75.85	1.90	5601.09	23.59	2.70
102	Columbia River	Northeast Washington	Pend Oreille River	Cedar Creek PLP	P	11655.24	34.66	1.90	1649.37	11.94	4.63
77	Columbia River	Clark Fork	Priest Lake	Kalispell Creek	L	14959.23	44.05	1.88	96.96	1.31	8.64
119	Columbia River	Snake River Basin in Washington	Tucannon River	Little Turkey Creek	L	1504.46	4.22	1.79	0.00	0.00	#DIV/0!
42	Coastal-Puget Sound	Puget Sound	Nooksack River	Glacier Creek	L	20319.65	56.38	1.78	2489.40	18.69	4.81
48	Coastal-Puget Sound	Puget Sound	Nooksack River	Upper Middle Fork Nooksack River	L	46066.26	126.57	1.76	4394.15	33.54	4.88
115	Columbia River	Snake River Basin in Washington	Asotin Creek	Wormell Gulch PLP	P	48628.47	132.69	1.75	6795.19	19.30	1.82
37	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Sulphur Creek (Lake Shannon) PLP	P	6442.89	17.24	1.71	25.00	0.70	17.94
116	Columbia River	Snake River Basin in	Tucannon River	Cummings Creek	L	12748.85	33.82	1.70	211.33	0.57	1.72

ID #	Distinct Population Segment	Management Unit	Core Area	Local Population (LP) Name	LP Type	Total Acres in Local Population	Total (10,99) Miles in LP	Road Density in LP	Acres FPL in Local Population	FPL Total (10,99) Miles in LP	Road Density FPL in LP
		Washington									
85	Columbia River	Lower Columbia	Lewis River	Upper Lewis River PLP	P	73798.80	192.02	1.67	0.00	0.00	#DIV/0!
91	Columbia River	Middle Columbia	Yakima River	Crow Creek	L	54514.93	141.69	1.66	1.22	0.00	0.00
51	Coastal-Puget Sound	Puget Sound	Nooksack River	Wanlick Creek	L	6275.61	15.74	1.61	197.75	1.36	4.41
49	Coastal-Puget Sound	Puget Sound	Nooksack River	Upper North Fork Nooksack River	L	29408.71	68.35	1.49	224.40	3.19	9.10
140	Columbia River	Upper Columbia	Wenatchee River	Chiwawa River	L	120808.79	268.80	1.42	3984.06	34.30	5.51
52	Coastal-Puget Sound	Puget Sound	Puyallup River	Carbon River	L	51796.44	114.97	1.42	11222.99	54.55	3.11
60	Coastal-Puget Sound	Puget Sound	Snohomish /Skykomish River	South Fork Skykomish River	L	175861.86	382.60	1.39	12797.68	89.83	4.49
107	Columbia River	Northeast Washington	Pend Oreille River	Ruby Creek PLP (2)	P	19809.99	42.79	1.38	1158.49	5.86	3.24
56	Coastal-Puget Sound	Puget Sound	Puyallup River	Upper White River	L	96129.28	206.94	1.38	4037.18	32.18	5.10
97	Columbia River	Middle Columbia	Yakima River	NFk Tieton River	L	73144.00	157.31	1.38	126.11	0.00	0.00
130	Columbia River	Upper Columbia	Methow River	Blue Buck Creek PLP	L	5428.88	11.57	1.36	0.00	0.00	#DIV/0!
90	Columbia River	Middle Columbia	Yakima River	Cle Elum River	L	141656.06	294.35	1.33	11617.09	84.53	4.66
4	Coastal-Puget Sound	Olympic Peninsula	Elwha River	Little River PLP	P	14641.73	29.39	1.28	1604.49	12.98	5.18
96	Columbia River	Middle Columbia	Yakima River	NFk Teanaway River	L	60801.19	118.33	1.25	17811.15	55.98	2.01
109	Columbia River	Northeast Washington	Pend Oreille River	Slate Creek PLP	P	20544.95	38.78	1.21	0.00	0.00	#DIV/0!
64	Coastal-Puget Sound	Puget Sound	Stillaguamish River	South Fork Stillaguamish River	L	46507.89	87.72	1.21	953.29	4.35	2.92
38	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Tenas Creek	L	6705.65	12.30	1.17	84.57	0.91	6.89
142	Columbia River	Upper Columbia	Wenatchee River	Little Wenatchee River	L	64812.94	117.01	1.16	292.92	0.99	2.16
98	Columbia River	Middle Columbia	Yakima River	Rattlesnake Creek	L	69698.53	121.33	1.11	1799.59	9.01	3.20
117	Columbia River	Snake River Basin in Washington	Tucannon River	Hixon Creek	P	1988.43	3.42	1.10	0.00	0.00	#DIV/0!
76	Columbia River	Clark Fork	Priest Lake	Granite Creek	L	40527.23	66.71	1.05	3266.96	4.25	0.83
35	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Straight Creek	L	7213.25	11.40	1.01	0.00	0.00	#DIV/0!
88	Columbia River	Middle Columbia	Yakima River	Box Cayon Creek	L	7965.64	12.25	0.98	0.00	0.00	#DIV/0!
75	Columbia River	Clark Fork	Priest Lake	Gold Creek	L	15365.97	23.32	0.97	0.00	0.00	#DIV/0!

ID #	Distinct Population Segment	Management Unit	Core Area	Local Population (LP) Name	LP Type	Total Acres in Local Population	Total (10,99) Miles in LP	Road Density in LP	Acres FPL in Local Population	FPL Total (10,99) Miles in LP	Road Density FPL in LP
30	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Lower Whitechuck River	L	29936.26	45.06	0.96	0.00	0.00	#DIV/0!
28	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Illabot Creek	L	27581.41	38.94	0.90	1754.59	13.63	4.97
134	Columbia River	Upper Columbia	Methow River	Gold Creek (3)	L	38918.32	54.01	0.89	367.56	2.57	4.48
108	Columbia River	Northeast Washington	Pend Oreille River	SFk Tacoma Creek PLP	P	10372.74	14.34	0.88	3833.39	8.09	1.35
136	Columbia River	Upper Columbia	Methow River	Twisp River	L	132273.51	182.55	0.88	972.09	4.64	3.05
131	Columbia River	Upper Columbia	Methow River	Chewack River	L	208423.95	271.95	0.84	134.87	0.35	1.66
139	Columbia River	Upper Columbia	Wenatchee River	Chiwaukum Creek	L	31070.35	39.44	0.81	2690.25	22.50	5.35
59	Coastal-Puget Sound	Puget Sound	Snohomish /Skykomish River	Salmon Creek	L	5304.38	6.73	0.81	12.98	0.00	0.00
145	Columbia River	Upper Columbia	Wenatchee River	White River	L	117473.15	140.27	0.76	4417.69	43.13	6.25
80	Columbia River	Grande Ronde	Grande Ronde River	North Fork Wenaha River	L	11291.62	12.96	0.73	0.00	0.00	#DIV/0!
6	Coastal-Puget Sound	Olympic Peninsula	Hoh River	South Fork Hoh River	L	34122.97	38.56	0.72	193.68	0.04	0.14
123	Columbia River	Snake River Basin in Washington	Tucannon River	Turkey Creek	L	2873.84	3.22	0.72	0.00	0.00	#DIV/0!
22	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Baker Lake	L	137800.28	134.11	0.62	515.70	4.94	6.14
122	Columbia River	Snake River Basin in Washington	Tucannon River	Tucannon River	L	28756.94	27.90	0.62	178.97	1.07	3.82
89	Columbia River	Middle Columbia	Yakima River	Bumping River	L	57839.08	53.95	0.60	173.83	1.51	5.55
21	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Bacon Creek	L	32669.50	28.94	0.57	173.53	1.13	4.18
26	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Forks of Sauk River	L	68178.45	58.43	0.55	216.04	1.28	3.80
50	Coastal-Puget Sound	Puget Sound	Nooksack River	Upper South Fork Nooksack River	L	13347.86	11.15	0.53	0.00	0.00	#DIV/0!
58	Coastal-Puget Sound	Puget Sound	Snohomish /Skykomish River	North Fork Skykomish River	L	52931.97	43.96	0.53	1435.39	6.55	2.92
81	Columbia River	Lower Columbia	Klickitat River	West Fork Klickitat River	L	58437.09	47.94	0.53	0.00	0.00	#DIV/0!
39	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Upper South Fork Sauk River	L	11597.50	8.98	0.50	435.48	1.11	1.63
87	Columbia River	Middle Columbia	Yakima River	American River	L	50820.34	37.06	0.47	113.09	0.12	0.70
141	Columbia River	Upper Columbia	Wenatchee River	Icicle Creek	L	137202.12	92.67	0.43	3805.14	22.78	3.83
92	Columbia River	Middle Columbia	Yakima River	Deep Creek	L	15495.20	10.41	0.43	0.00	0.00	#DIV/0!

ID #	Distinct Population Segment	Management Unit	Core Area	Local Population (LP) Name	LP Type	Total Acres in Local Population	Total (10,99) Miles in LP	Road Density in LP	Acres FPL in Local Population	FPL Total (10,99) Miles in LP	Road Density FPL in LP
132	Columbia River	Upper Columbia	Methow River	Early Winters Creek	L	51475.53	30.52	0.38	114.75	0.84	4.71
11	Coastal-Puget Sound	Olympic Peninsula	Skokomish River	North Fork Skokomish River	L	27356.85	16.20	0.38	71.72	0.20	1.78
94	Columbia River	Middle Columbia	Yakima River	Indian Creek	L	10547.53	5.78	0.35	0.00	0.00	#DIV/0!
121	Columbia River	Snake River Basin in Washington	Tucannon River	Panjab Creek	L	7421.64	3.87	0.33	0.00	0.00	#DIV/0!
29	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Lime Creek	L	11261.06	4.76	0.27	0.00	0.00	#DIV/0!
138	Columbia River	Upper Columbia	Methow River	Wolf Creek	L	25832.06	10.61	0.26	380.00	1.21	2.04
24	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Cascade River	L	20867.55	7.86	0.24	0.00	0.00	#DIV/0!
72	Coastal-Puget Sound	Puget Sound	Upper Skagit River	Ruby Creek	L	112095.97	38.42	0.22	566.62	1.48	1.67
32	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Newhalem Creek	L	17490.54	5.67	0.21	1.57	0.00	0.00

ID #	Distinct Population Segment	Management Unit	Core Area	Local Population (LP) Name	LP Type	Total Acres in Local Population	Total (10,99) Miles in LP	Road Density in LP	Acres FPL in Local Population	FPL Total (10,99) Miles in LP	Road Density FPL in LP
27	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Goodell Creek	L	25042.10	7.83	0.20	29.43	0.10	2.27
137	Columbia River	Upper Columbia	Methow River	WFk Methow River	L	54601.53	16.54	0.19	82.64	0.00	0.00
2	Coastal-Puget Sound	Olympic Peninsula	Dungeness River	Gray Wolf River	L	48749.43	13.20	0.17	0.00	0.00	#DIV/0!
78	Columbia River	Grande Ronde	Grande Ronde River	Butte Creek	L	26506.08	6.77	0.16	0.00	0.00	#DIV/0!
79	Columbia River	Grande Ronde	Grande Ronde River	Crooked Creek	L	47821.04	9.77	0.13	136.40	0.01	0.06
5	Coastal-Puget Sound	Olympic Peninsula	Hoh River	Hoh River	L	66122.92	11.64	0.11	0.00	0.00	#DIV/0!
124	Columbia River	Umatilla-Walla Walla	Walla Walla River	Mill Creek (2)	L	13440.77	2.28	0.11	545.43	0.59	0.69
23	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Buck Creek	L	21765.02	2.77	0.08	0.00	0.00	#DIV/0!
9	Coastal-Puget Sound	Olympic Peninsula	Quinault River	Upper Quinault River	L	57524.40	6.24	0.07	0.00	0.00	#DIV/0!
144	Columbia River	Upper Columbia	Wenatchee River	Peshastin Creek	L	23545.38	2.34	0.06	182.83	1.90	6.65
33	Coastal-Puget Sound	Puget Sound	Lower Skagit River	South Fork Cascade River	L	23200.90	2.29	0.06	99.47	0.00	0.00
3	Coastal-Puget Sound	Olympic Peninsula	Elwha River	Elwha River	L	156679.22	14.79	0.06	0.00	0.00	#DIV/0!
8	Coastal-Puget Sound	Olympic Peninsula	Quinault River	North Fork Quinault River	L	42544.59	3.28	0.05	0.00	0.00	#DIV/0!
135	Columbia River	Upper Columbia	Methow River	Lost River	L	107396.44	7.34	0.04	90.09	0.32	2.29
20	Coastal-Puget Sound	Puget Sound	Chilliwack River	Upper Chilliwack River	L	35073.70	1.98	0.04	0.00	0.00	#DIV/0!
61	Coastal-Puget Sound	Puget Sound	Snohomish /Skykomish River	Troublesome Creek	L	8301.59	0.29	0.02	111.69	0.00	0.00
25	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Downey Creek	L	22843.26	0.35	0.01	0.00	0.00	#DIV/0!
34	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Stetattle Creek	L	14455.14	0.17	0.01	0.55	0.00	0.00

ID #	Distinct Population Segment	Management Unit	Core Area	Local Population (LP) Name	LP Type	Total Acres in Local Population	Total (10,99) Miles in LP	Road Density in LP	Acres FPL in Local Population	FPL Total (10,99) Miles in LP	Road Density FPL in LP
19	Coastal-Puget Sound	Puget Sound	Chilliwack River	Silesia Creek	L	25415.35	0.15	0.00	134.67	0.00	0.00
36	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Sulphur Creek	L	21060.35	0.06	0.00	0.00	0.00	#DIV/0!
70	Coastal-Puget Sound	Puget Sound	Upper Skagit River	Panther Creek	L	23583.38	0.04	0.00	0.00	0.00	#DIV/0!
7	Coastal-Puget Sound	Olympic Peninsula	Queets River	Queets River	L	47007.09	0.00	0.00	0.10	0.00	0.00
17	Coastal-Puget Sound	Puget Sound	Chilliwack River	Depot Creek	L	7999.46	0.00	0.00	0.00	0.00	#DIV/0!
18	Coastal-Puget Sound	Puget Sound	Chilliwack River	Little Chilliwack River	L	8153.00	0.00	0.00	0.00	0.00	#DIV/0!
31	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Milk Creek	L	9290.18	0.00	0.00	0.00	0.00	#DIV/0!
40	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Upper Suiattle River	L	57546.05	0.00	0.00	0.00	0.00	#DIV/0!
41	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Upper Whitechuck River	L	24573.88	0.00	0.00	0.00	0.00	#DIV/0!
66	Coastal-Puget Sound	Puget Sound	Upper Skagit River	Big Beaver Creek	L	42238.31	0.00	0.00	0.16	0.00	0.00
67	Coastal-Puget Sound	Puget Sound	Upper Skagit River	Deer Creek PLP	P	234.16	0.00	0.00	0.00	0.00	#DIV/0!
68	Coastal-Puget Sound	Puget Sound	Upper Skagit River	Lightning Creek	L	72637.04	0.00	0.00	0.84	0.00	0.00
69	Coastal-Puget Sound	Puget Sound	Upper Skagit River	Little Beaver Creek	L	34428.62	0.00	0.00	0.74	0.00	0.00
71	Coastal-Puget Sound	Puget Sound	Upper Skagit River	Pierce Creek	L	2573.23	0.00	0.00	0.00	0.00	#DIV/0!
73	Coastal-Puget Sound	Puget Sound	Upper Skagit River	Silver Creek	L	10683.31	0.00	0.00	0.01	0.00	0.00
74	Coastal-Puget Sound	Puget Sound	Upper Skagit River	Thunder Creek	L	69414.77	0.00	0.00	349.15	0.00	0.00
						5597157.94	10707.13	1.22	415002.66	2642.87	4.08

]

Item: Transportation in FMO & FP Lands

Take values from Item 10 spreadsheet for FMO Acres
Take values from FMO Roads and FP Roads worksheets to get road desity totals
sources: WDNR Transportation 2005; US FWS FPLands 2005 & US FWS Draft Recovery Plan

Road Density by FMO (Totals and FP lands)

Recovery Plan Area Type: FMO = Foraging, Migration, and Overwintering habitat; RN = Research Need Area

NC = not computed / Research Need Areas

ID #	Distinct Population Segment	Management Unit	Recovery Plan Area Type	Recovery Plan Area Name	Total Acres in FMO of RP Area	Total (10,99) Miles in FMO of RP Area	Road Density in FMO of RP Area	Acres FPL in FMO of RP Area	FPL Total (10,99) Miles in FMO of RP Area	Road Density FPL in FMO of RP Area
23	Coastal-Puget Sound	Olympic Peninsula	RN	Grays Harbor	NC 8301.74242327832	NC	NC	NC 8301.74242327832	0.00	NC
24	Coastal-Puget Sound	Olympic Peninsula	RN	Hood Canal	NC 76007.4651180237	NC	NC	NC 76007.4651180237	0.00	NC
25	Coastal-Puget Sound	Olympic Peninsula	RN	Hoquiam	NC 779741.830877164	NC	NC	NC 779741.830877164	0.00	NC
39	Coastal-Puget Sound	Puget Sound	RN	Upper Green	NC 8690.77156701255	NC	NC	NC 8690.77156701255	NC	NC
40	Coastal-Puget Sound	Puget Sound	RN	Upper Nisqually	NC 100909.673229856	NC	NC	NC 100909.673229856	NC	NC
46	Columbia River	Grande Ronde	RN	Wenatchee	NC 433241.286359542	NC	NC	NC 433241.286359542	NC	NC
51	Columbia River	Lower Columbia	RN	Cowlitz/Kalama	NC 727230.320823129	NC	NC	NC 727230.320823129	NC	NC
54	Columbia River	Northeast Washington	RN	Northeast Washington	NC 4743135.64539057	NC	NC	NC 1560963.37803802	NC	NC
61	Columbia River	Upper Columbia	RN	Lake Chelan	NC 611390.741672225	NC	NC	NC 9095.9255246006	NC	NC

ID #	Distinct Population Segment	Management Unit	Recovery Plan Area Type	Recovery Plan Area Name	Total Acres in FMO of RP Area	Total (10,99) Miles in FMO of RP Area	Road Density in FMO of RP Area	Acres FPL in FMO of RP Area	FPL Total (10,99) Miles in FMO of RP Area	Road Density FPL in FMO of RP Area
62	Columbia River	Upper Columbia	RN	Okanogan	NC 1287166.50060923	NC	NC	NC 259898.383319352	NC	NC
38	Coastal-Puget Sound	Puget Sound	FMO Marine	Puget Sound	2682.43	996.93	237.86	2682.43	488.36	116.52
37	Coastal-Puget Sound	Puget Sound	FMO	Samish	3108.66	540.55	111.29	3108.66	316.81	65.22
34	Coastal-Puget Sound	Puget Sound	FMO	Lake Washington	81375.48	4210.81	33.12	81375.48	706.79	5.56
52	Columbia River	Middle Columbia	Core Area	Yakima	313478.95	12792.12	26.12	313478.95	1031.32	2.11
30	Coastal-Puget Sound	Puget Sound	Core Area	Puyallup	95989.51	2989.16	19.93	95989.51	1446.22	9.64
36	Coastal-Puget Sound	Puget Sound	FMO	Lower Nisqually	77322.23	2392.86	19.81	77322.23	1448.25	11.99
47	Columbia River	Lower Columbia	Core Area	Klickitat	121593.99	3249.53	17.10	121593.99	1535.09	8.08
31	Coastal-Puget Sound	Puget Sound	Core Area	Snohomish/Skykomish	331958.56	4184.88	8.07	331958.56	2484.42	4.79
32	Coastal-Puget Sound	Puget Sound	Core Area	Stillaguamish	177880.73	2111.08	7.60	177880.73	1029.45	3.70
7	Coastal-Puget Sound	Olympic Peninsula	FMO	Bell	12938.02	135.57	6.71	12938.02	40.83	2.02
48	Columbia River	Lower Columbia	Core Area	Lewis	258627.39	2306.46	5.71	258627.39	1027.96	2.54
15	Coastal-Puget Sound	Olympic Peninsula	FMO	Morse	71823.82	541.13	4.82	71823.82	238.06	2.12
9	Coastal-Puget Sound	Olympic Peninsula	FMO	Chehalis	344566.71	2480.64	4.61	344566.71	1098.31	2.04
12	Coastal-Puget Sound	Olympic Peninsula	FMO	Kalaloch	13648.90	85.27	4.00	13648.90	30.09	1.41
8	Coastal-Puget Sound	Olympic Peninsula	FMO	Cedar/Steamboat	13129.58	80.72	3.93	13129.58	31.16	1.52
16	Coastal-Puget Sound	Olympic Peninsula	FMO	Satsop	189525.95	1142.81	3.86	189525.95	244.01	0.82
10	Coastal-Puget Sound	Olympic Peninsula	FMO	Goodman	40434.04	216.36	3.42	40434.04	129.76	2.05
17	Coastal-Puget Sound	Olympic Peninsula	FMO	Wishkah	65799.08	327.76	3.19	65799.08	277.27	2.70
13	Coastal-Puget Sound	Olympic Peninsula	FMO	Raft	90344.66	442.46	3.13	90344.66	0.00	0.00
3	Coastal-Puget Sound	Olympic Peninsula	Core Area	Hoh	90841.42	429.81	3.03	90841.42	149.88	1.06
6	Coastal-Puget Sound	Olympic Peninsula	Core Area	Skokomish	95922.81	445.46	2.97	95922.81	116.36	0.78
4	Coastal-Puget Sound	Olympic Peninsula	Core Area	Queets	241399.32	1120.73	2.97	241399.32	172.92	0.46
18	Coastal-Puget Sound	Olympic Peninsula	FMO	Wynoochee	125451.34	573.23	2.92	125451.34	290.15	1.48
11	Coastal-Puget Sound	Olympic Peninsula	FMO	Humptulips	157871.53	720.05	2.92	157871.53	460.65	1.87

ID #	Distinct Population Segment	Management Unit	Recovery Plan Area Type	Recovery Plan Area Name	Total Acres in FMO of RP Area	Total (10,99) Miles in FMO of RP Area	Road Density in FMO of RP Area	Acres FPL in FMO of RP Area	FPL Total (10,99) Miles in FMO of RP Area	Road Density FPL in FMO of RP Area
28	Coastal-Puget Sound	Puget Sound	Core Area	Lower Skagit	929972.07	3690.03	2.54	929972.07	1823.53	1.25
14	Coastal-Puget Sound	Olympic Peninsula	FMO	Moclips/Copalis	100493.92	390.73	2.49	100493.92	266.67	1.70
29	Coastal-Puget Sound	Puget Sound	Core Area	Nooksack	291683.09	1117.15	2.45	291683.09	390.01	0.86
1	Coastal-Puget Sound	Olympic Peninsula	Core Area	Dungeness	59402.44	220.11	2.37	59402.44	72.98	0.79
2	Coastal-Puget Sound	Olympic Peninsula	Core Area	Elwha	34343.67	124.48	2.32	34343.67	61.62	1.15
53	Columbia River	Northeast Washington	Core Area	Pend Oreille	664133.27	1699.61	1.64	215697.70	409.93	1.22
57	Columbia River	Umatilla-Walla Walla	Core Area	Walla Walla	821259.59	2030.12	1.58	66990.00	209.34	2.00
5	Coastal-Puget Sound	Olympic Peninsula	Core Area	Quinault	179724.75	436.07	1.55	179724.75	44.01	0.16
58	Columbia River	Upper Columbia	Core Area	Entiat	337496.49	802.76	1.52	22648.00	109.16	3.08
56	Columbia River	Snake River Basin in Washington	Core Area	Tucannon	323242.89	643.34	1.27	4795.46	32.14	4.29
60	Columbia River	Upper Columbia	Core Area	Wenatchee	878461.95	1607.78	1.17	95265.84	388.45	2.61
35	Coastal-Puget Sound	Puget Sound	FMO	Lower Green	1187643.24	2156.03	1.16	1187643.24	555.40	0.30
					8825572.51	29461.01	2.14	6206375.33	19157.38	1.98
49	Columbia River	Lower Columbia	Core Habitat	White Salmon	750322.22	1061.48	0.91	750322.22	649.61	0.55
59	Columbia River	Upper Columbia	Core Area	Methow	1374606.43	1477.07	0.69	36507.10	113.33	1.99
55	Columbia River	Snake River Basin in Washington	Core Area	Asotin	251257.11	251.13	0.64	11867.94	12.72	0.69
27	Coastal-Puget Sound	Puget Sound	Core Area	Chilliwack	359021.78	259.03	0.46	359021.78	123.23	0.22
20	Coastal-Puget Sound	Olympic Peninsula	FMO Marine	Hood Canal	95683.64	58.39	0.39	95683.64	43.15	0.29
41	Columbia River	Clark Fork	Core Area	Lake Pend Orielle	806027.31	376.99	0.30	806027.31	99.12	0.08
44	Columbia River	Coeur d'Alene Lake	Core Area	Coeur d'Alene Lake	148141.39	57.95	0.25	148141.39	47.54	0.21
50	Columbia River	Lower Columbia	FMO	Columbia	198462.36	41.12	0.13	198462.36	8.69	0.03
26	Coastal-Puget Sound	Puget Sound	Core Area	Chester Morse	238486.10	43.16	0.12	238486.10	0.52	0.00
21	Coastal-Puget Sound	Olympic Peninsula	FMO Marine	Pacific Coast	515684.37	57.19	0.07	515684.37	19.14	0.02

ID #	Distinct Population Segment	Management Unit	Recovery Plan Area Type	Recovery Plan Area Name	Total Acres in FMO of RP Area	Total (10,99) Miles in FMO of RP Area	Road Density in FMO of RP Area	Acres FPL in FMO of RP Area	FPL Total (10,99) Miles in FMO of RP Area	Road Density FPL in FMO of RP Area
19	Coastal-Puget Sound	Olympic Peninsula	FMO Marine	Grays Harbor	62306.23	4.68	0.05	62306.23	0.51	0.01
45	Columbia River	Grande Ronde	Core Area	Grande Ronde	3117057.41	205.68	0.04	3117057.41	54.82	0.01
33	Coastal-Puget Sound	Puget Sound	Core Area	Upper Skagit	301623.34	16.74	0.04	301623.34	0.04	0.00
42	Columbia River	Clark Fork	Core Area	Priest Lake	415444.03	17.26	0.03	415444.03	-0.44	0.00
43	Columbia River	Clearwater	Core Area	Lower and Middle Fork Clearwater	217308.69	6.17	0.02	217308.69	0.00	0.00
22	Coastal-Puget Sound	Olympic Peninsula	FMO Marine	Strait of Juan DeFuca	562734.10	9.26	0.01	562734.10	0.00	0.00

Item: Number of Stream Road Crossings in Local Populations (Spawning and Rearing Habitat) in Washington

Take stream Road Xings from Item 7 Dec 2005 work and merge East/West and WRIA29 as appropriate
Clip WaStrRoadXing with WaLP; ID clipped file with WaLP
Frequency by LP and Road Type; future analysis could freq by stream type
sources: FPLands US FWS(selected areas from FFRLands.shp)
US FWS Draft Bull Trout Recovery Plans (2004& 2002)

Stream Crossings by Local Population (Road Types and Totals)
LP Type: L= Local Population; P= Potential Local Population
Road Type: 10 = Road; 20 = Trail; 30 = Railroad; 31 = Railroad Grade; 99 = unspecified transportation route

ID #	Distinct Population Segment	Management Unit	Core Area	Local Population Name	LP Type	Road Type = 10	Road Type = 20	Road Type = 30	Road Type = 31	Road Type = 99	Total	LP Acres	Xing Density
129	Columbia River	Upper Columbia	Entiat River	Mad River	L	2524	203	0	0	0	2727	58391	0.03
128	Columbia River	Upper Columbia	Entiat River	Entiat River	L	1953	159	0	0	0	2112	80643	0.06
46	Coastal-Puget Sound	Puget Sound	Nooksack River	Lower South Fork Nooksack River	L	1858	8	0	0	0	1866	76880	0.06
143	Columbia River	Upper Columbia	Wenatchee River	Nason Creek	L	1137	192	99	2	0	1430	70070	0.08
60	Coastal-Puget Sound	Puget Sound	Snohomish/Skykomish River	South Fork Skykomish River	L	1083	131	52	14	0	1280	175862	0.21
140	Columbia River	Upper Columbia	Wenatchee River	Chiwawa River	L	1072	226	0	0	3	1301	120809	0.15
55	Coastal-Puget Sound	Puget Sound	Puyallup River	Upper Puyallup & Mowich Rivers	L	933	241	0	0	0	1174	58489	0.08
101	Columbia River	Middle Columbia	Yakima River	Upper Yakima River	L	765	11	13	3	0	792	38889	0.08
86	Columbia River	Middle Columbia	Yakima River	Ahtamum Creek	L	714	23	0	0	0	737	69364	0.15
90	Columbia River	Middle Columbia	Yakima River	Cle Elum River	L	607	444	3	2	0	1056	141656	0.21
93	Columbia River	Middle Columbia	Yakima River	Gold Creek (2)	L	529	79	0	6	0	614	36233	0.09
141	Columbia River	Upper Columbia	Wenatchee River	Icicle Creek	L	491	529	0	0	0	1020	137202	0.21
96	Columbia River	Middle Columbia	Yakima River	NFk Teanaway River	L	452	409	0	0	0	861	60801	0.11
83	Columbia River	Lower Columbia	Lewis River	Pine Creek	L	449	29	0	0	0	478	15169	0.05

ID #	Distinct Population Segment	Management Unit	Core Area	Local Population Name	LP Type	Road Type = 10	Road Type = 20	Road Type = 30	Road Type = 31	Road Type = 99	Total	LP Acres	Xing Density
114	Columbia River	Snake River Basin in Washington	Asotin Creek	NFk Asotin River	L	441	1	0	0	0	442	66579	0.24
54	Coastal-Puget Sound	Puget Sound	Puyallup River	Greenwater River	L	433	20	0	0	0	453	32508	0.11
48	Coastal-Puget Sound	Puget Sound	Nooksack River	Upper Middle Fork Nooksack River	L	421	8	0	0	0	429	46066	0.17
145	Columbia River	Upper Columbia	Wenatchee River	White River	L	404	123	0	0	0	527	117473	0.35
131	Columbia River	Upper Columbia	Methow River	Chewack River	L	380	221	0	0	0	601	208424	0.54
63	Coastal-Puget Sound	Puget Sound	Stillaguamish River	North Fork Stillaguamish River	L	362	0	7	0	0	369	61305	0.26
45	Coastal-Puget Sound	Puget Sound	Nooksack River	Lower North Fork Nooksack River	L	359	0	0	0	0	359	21767	0.09
52	Coastal-Puget Sound	Puget Sound	Puyallup River	Carbon River	L	358	93	0	0	0	451	51796	0.18
100	Columbia River	Middle Columbia	Yakima River	Taneum Creek PLP	P	353	87	0	0	0	440	39980	0.14
14	Coastal-Puget Sound	Puget Sound	Chester Morse	Cedar River	L	342	1	0	0	0	343	27476	0.13
111	Columbia River	Northeast Washington	Pend Oreille River	Sullivan Creek PLP	P	292	0	0	0	0	292	45651	0.24
105	Columbia River	Northeast Washington	Pend Oreille River	Le Clerc Creek	L	288	0	0	0	0	288	48415	0.26
13	Coastal-Puget Sound	Puget Sound	Chester Morse	Boulder Creek	L	279	0	0	0	0	279	14688	0.08
82	Columbia River	Lower Columbia	Lewis River	Cougar Creek	L	279	8	0	0	0	287	10614	0.06
53	Coastal-Puget Sound	Puget Sound	Puyallup River	Clearwater River PLP	P	274	9	0	0	0	283	24734	0.14
44	Coastal-Puget Sound	Puget Sound	Nooksack River	Lower Middle Fork Nooksack River	L	263	0	0	0	0	263	17495	0.10
99	Columbia River	Middle Columbia	Yakima River	SFk Tieton River	L	252	45	0	0	0	297	57302	0.30
64	Coastal-Puget Sound	Puget Sound	Stillaguamish River	South Fork Stillaguamish River	L	248	73	0	0	0	321	46508	0.23
125	Columbia River	Umatilla-Walla Walla	Walla Walla River	North Fork Touchet River	L	247	3	0	0	0	250	38456	0.24
139	Columbia River	Upper Columbia	Wenatchee River	Chiwaukum Creek	L	233	257	6	0	0	496	31070	0.10
95	Columbia River	Middle Columbia	Yakima River	Kachess River	L	227	24	0	0	0	251	33061	0.21
115	Columbia River	Snake River Basin in Washington	Asotin Creek	Wormell Gulch PLP	P	219	12	0	0	0	231	48628	0.33
65	Coastal-Puget Sound	Puget Sound	Stillaguamish River	Upper Deer Creek	L	216	0	0	0	0	216	22599	0.16
1	Coastal-Puget Sound	Olympic Peninsula	Dungeness River	Dungeness River	L	201	1	0	0	3	205	22734	0.17
113	Columbia River	Snake River Basin in Washington	Asotin Creek	Charley Creek	L	201	0	0	0	0	201	14456	0.11
56	Coastal-Puget Sound	Puget Sound	Puyallup River	Upper White River	L	194	88	0	0	0	282	96129	0.53

ID #	Distinct Population Segment	Management Unit	Core Area	Local Population Name	LP Type	Road Type = 10	Road Type = 20	Road Type = 30	Road Type = 31	Road Type = 99	Total	LP Acres	Xing Density
62	Coastal-Puget Sound	Puget Sound	Stillaguamish River	Canyon Creek	L	184	0	0	0	0	184	28852	0.25
142	Columbia River	Upper Columbia	Wenatchee River	Little Wenatchee River	L	182	41	0	0	0	223	64813	0.45
42	Coastal-Puget Sound	Puget Sound	Nooksack River	Glacier Creek	L	176	2	0	0	0	178	20320	0.18
136	Columbia River	Upper Columbia	Methow River	Twisp River	L	166	121	0	0	0	287	132274	0.72
106	Columbia River	Northeast Washington	Pend Oreille River	Mill Creek PLP	P	160	0	0	0	0	160	12428	0.12
12	Coastal-Puget Sound	Olympic Peninsula	Skokomish River	South Fork Skokomish River	L	158	23	0	0	0	181	24608	0.21
57	Coastal-Puget Sound	Puget Sound	Puyallup River	West Fork White River	L	156	39	0	0	0	195	41992	0.34
47	Coastal-Puget Sound	Puget Sound	Nooksack River	Middle North Fork Nooksack River	L	155	0	0	0	0	155	9010	0.09
10	Coastal-Puget Sound	Olympic Peninsula	Skokomish River	Brown Creek PLP	P	137	0	0	0	0	137	5102	0.06
85	Columbia River	Lower Columbia	Lewis River	Upper Lewis River PLP	P	137	29	0	0	0	166	73799	0.69
58	Coastal-Puget Sound	Puget Sound	Snohomish/Skykomish River	North Fork Skykomish River	L	125	40	0	0	0	165	52932	0.50
110	Columbia River	Northeast Washington	Pend Oreille River	Small Creek PLP	P	118	0	0	0	0	118	17211	0.23
126	Columbia River	Umatilla-Walla Walla	Walla Walla River	South Fork Touchet River	L	118	24	0	0	0	142	12482	0.14
97	Columbia River	Middle Columbia	Yakima River	NFk Tieton River	L	115	37	0	0	0	152	73144	0.75
43	Coastal-Puget Sound	Puget Sound	Nooksack River	Lower Canyon Creek	L	110	2	0	0	0	112	19767	0.28
103	Columbia River	Northeast Washington	Pend Oreille River	Harvey Creek PLP	P	110	0	0	0	0	110	25507	0.36
76	Columbia River	Clark Fork	Priest Lake	Granite Creek	L	103	0	0	0	0	103	40527	0.61
98	Columbia River	Middle Columbia	Yakima River	Rattlesnake Creek	L	103	66	0	0	0	169	69699	0.64
112	Columbia River	Northeast Washington	Pend Oreille River	Tacoma Creek PLP	P	102	0	0	0	0	102	15856	0.24
77	Columbia River	Clark Fork	Priest Lake	Kalispell Creek	L	100	1	0	0	0	101	14959	0.23
133	Columbia River	Upper Columbia	Methow River	Goat Creek	L	96	0	0	0	0	96	23026	0.37
49	Coastal-Puget Sound	Puget Sound	Nooksack River	Upper North Fork Nooksack River	L	92	3	0	0	0	95	29409	0.48
91	Columbia River	Middle Columbia	Yakima River	Crow Creek	L	88	41	0	0	0	129	54515	0.66
107	Columbia River	Northeast Washington	Pend Oreille River	Ruby Creek PLP (2)	P	87	0	1	0	0	88	19810	0.35
26	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Forks of Sauk River	L	78	43	0	0	0	121	68178	0.88
6	Coastal-Puget Sound	Olympic Peninsula	Hoh River	South Fork Hoh River	L	73	5	0	0	3	81	34123	0.66
102	Columbia River	Northeast Washington	Pend Oreille River	Cedar Creek PLP	P	73	0	1	0	0	74	11655	0.25
22	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Baker Lake	L	71	19	0	0	0	90	137800	2.39

ID #	Distinct Population Segment	Management Unit	Core Area	Local Population Name	LP Type	Road Type = 10	Road Type = 20	Road Type = 30	Road Type = 31	Road Type = 99	Total	LP Acres	Xing Density
28	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Illabot Creek	L	71	1	0	0	0	72	27581	0.60
134	Columbia River	Upper Columbia	Methow River	Gold Creek (3)	L	69	38	0	0	0	107	38918	0.57
72	Coastal-Puget Sound	Puget Sound	Upper Skagit River	Ruby Creek	L	60	140	0	0	0	200	112096	0.88
89	Columbia River	Middle Columbia	Yakima River	Bumping River	L	60	39	0	0	0	99	57839	0.91
21	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Bacon Creek	L	57	0	0	0	0	57	32670	0.90
109	Columbia River	Northeast Washington	Pend Oreille River	Slate Creek PLP	P	57	0	0	0	0	57	20545	0.56
4	Coastal-Puget Sound	Olympic Peninsula	Elwha River	Little River PLP	P	54	12	0	0	0	66	14642	0.35
127	Columbia River	Umatilla-Walla Walla	Walla Walla River	Wolf Fork Touchet River	L	54	30	0	0	0	84	6558	0.12
116	Columbia River	Snake River Basin in Washington	Tucannon River	Cummings Creek	L	53	0	0	0	0	53	12749	0.38
38	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Tenas Creek	L	50	0	0	0	0	50	6706	0.21
132	Columbia River	Upper Columbia	Methow River	Early Winters Creek	L	50	50	0	0	0	100	51476	0.80
35	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Straight Creek	L	45	0	0	0	0	45	7213	0.25
15	Coastal-Puget Sound	Puget Sound	Chester Morse	Rack Creek	L	43	0	0	0	0	43	1408	0.05
118	Columbia River	Snake River Basin in Washington	Tucannon River	Little Tucannon River	P	41	0	0	0	0	41	4805	0.18
87	Columbia River	Middle Columbia	Yakima River	American River	L	40	62	0	0	0	102	50820	0.78
79	Columbia River	Grande Ronde	Grande Ronde River	Crooked Creek	L	37	79	0	0	0	116	47821	0.64
75	Columbia River	Clark Fork	Priest Lake	Gold Creek	L	35	0	0	0	0	35	15366	0.69
81	Columbia River	Lower Columbia	Klickitat River	West Fork Klickitat River	L	35	4	0	0	0	39	58437	2.34
122	Columbia River	Snake River Basin in Washington	Tucannon River	Tucannon River	L	34	14	0	0	0	48	28757	0.94
30	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Lower Whitechuck River	L	31	14	0	0	0	45	29936	1.04
24	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Cascade River	L	30	0	0	0	0	30	20868	1.09
11	Coastal-Puget Sound	Olympic Peninsula	Skokomish River	North Fork Skokomish River	L	24	23	0	0	0	47	27357	0.91
137	Columbia River	Upper Columbia	Methow River	WFk Methow River	L	24	54	0	0	0	78	54602	1.09
59	Coastal-Puget Sound	Puget Sound	Snohomish/Skykomish River	Salmon Creek	L	22	0	0	0	0	22	5304	0.38
88	Columbia River	Middle Columbia	Yakima River	Box Cayon Creek	L	22	19	0	0	0	41	7966	0.30
39	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Upper South Fork Sauk River	L	20	3	0	0	0	23	11598	0.79

ID #	Distinct Population Segment	Management Unit	Core Area	Local Population Name	LP Type	Road Type = 10	Road Type = 20	Road Type = 30	Road Type = 31	Road Type = 99	Total	LP Acres	Xing Density
120	Columbia River	Snake River Basin in Washington	Tucannon River	Meadow Creek	L	20	23	0	0	0	43	4516	0.16
84	Columbia River	Lower Columbia	Lewis River	Rush Creek	L	18	26	0	0	0	44	16874	0.60
104	Columbia River	Northeast Washington	Pend Oreille River	Indian Creek PLP (2)	P	18	0	0	0	0	18	3441	0.30
144	Columbia River	Upper Columbia	Wenatchee River	Peshastin Creek	L	15	164	0	0	0	179	23545	0.21
2	Coastal-Puget Sound	Olympic Peninsula	Dungeness River	Gray Wolf River	L	14	78	0	0	0	92	48749	0.83
108	Columbia River	Northeast Washington	Pend Oreille River	SFk Tacoma Creek PLP	P	14	1	0	0	0	15	10373	1.08
9	Coastal-Puget Sound	Olympic Peninsula	Quinault River	Upper Quinault River	L	13	49	0	0	1	63	57524	1.43
130	Columbia River	Upper Columbia	Methow River	Blue Buck Creek	L	13	10	0	0	0	23	5429	0.37
138	Columbia River	Upper Columbia	Methow River	Wolf Creek	L	13	52	0	0	0	65	25832	0.62
5	Coastal-Puget Sound	Olympic Peninsula	Hoh River	Hoh River	L	11	31	0	0	10	52	66123	1.99
51	Coastal-Puget Sound	Puget Sound	Nooksack River	Wanlick Creek	L	11	1	0	0	0	12	6276	0.82
23	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Buck Creek	L	10	5	0	0	0	15	21765	2.27
27	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Goodell Creek	L	10	0	0	0	0	10	25042	3.91
32	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Newhalem Creek	L	10	0	0	0	0	10	17491	2.73
117	Columbia River	Snake River Basin in Washington	Tucannon River	Hixon Creek	P	10	0	0	0	0	10	1988	0.31
16	Coastal-Puget Sound	Puget Sound	Chester Morse	Shotgun Creek PLP	P	8	0	0	0	0	8	515	0.10
50	Coastal-Puget Sound	Puget Sound	Nooksack River	Upper South Fork Nooksack River	L	8	6	0	0	0	14	13348	1.49
3	Coastal-Puget Sound	Olympic Peninsula	Elwha River	Elwha River	L	7	84	0	0	0	91	156679	2.69
37	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Sulphur Creek (Lake Shannon) PLP	P	7	8	0	0	0	15	6443	0.67
92	Columbia River	Middle Columbia	Yakima River	Deep Creek	L	7	12	0	0	0	19	15495	1.27
80	Columbia River	Grande Ronde	Grande Ronde River	North Fork Wenaha River	L	6	0	0	0	0	6	11292	2.94
29	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Lime Creek	L	4	0	0	0	0	4	11261	4.40
33	Coastal-Puget Sound	Puget Sound	Lower Skagit River	South Fork Cascade River	L	4	45	0	0	0	49	23201	0.74
94	Columbia River	Middle Columbia	Yakima River	Indian Creek	L	4	14	0	0	0	18	10548	0.92
135	Columbia River	Upper Columbia	Methow River	Lost River	L	3	99	0	0	0	102	107396	1.65
61	Coastal-Puget Sound	Puget Sound	Snohomish/Skykomish River	Troublesome Creek	L	2	0	0	0	0	2	8302	6.49

ID #	Distinct Population Segment	Management Unit	Core Area	Local Population Name	LP Type	Road Type = 10	Road Type = 20	Road Type = 30	Road Type = 31	Road Type = 99	Total	LP Acres	Xing Density
119	Columbia River	Snake River Basin in Washington	Tucannon River	Little Turkey Creek	L	2	0	0	0	0	2	1504	1.18
121	Columbia River	Snake River Basin in Washington	Tucannon River	Panjab Creek	L	2	11	0	0	0	13	7422	0.89
8	Coastal-Puget Sound	Olympic Peninsula	Quinault River	North Fork Quinault River	L	1	12	0	0	5	18	42545	3.69
25	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Downey Creek	L	1	6	0	0	0	7	22843	5.10
34	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Stetattle Creek	L	1	6	0	0	0	7	14455	3.23
36	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Sulphur Creek	L	1	3	0	0	0	4	21060	8.23
123	Columbia River	Snake River Basin in Washington	Tucannon River	Turkey Creek	L	1	2	0	0	0	3	2874	1.50
7	Coastal-Puget Sound	Olympic Peninsula	Queets River	Queets River	L	0	15	0	0	0	15	47007	4.90
17	Coastal-Puget Sound	Puget Sound	Chilliwack River	Depot Creek	L	0	0	0	0	0	0	7999	#DIV/0!
18	Coastal-Puget Sound	Puget Sound	Chilliwack River	Little Chilliwack River	L	0	0	0	0	0	0	8153	#DIV/0!
19	Coastal-Puget Sound	Puget Sound	Chilliwack River	Silesia Creek	L	0	13	0	0	0	13	25415	3.05
20	Coastal-Puget Sound	Puget Sound	Chilliwack River	Upper Chilliwack River	L	0	48	0	0	9	57	35074	0.96
31	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Milk Creek	L	0	13	0	0	0	13	9290	1.12
40	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Upper Suiattle River	L	0	45	0	0	0	45	57546	2.00
41	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Upper Whitechuck River	L	0	25	0	0	0	25	24574	1.54
66	Coastal-Puget Sound	Puget Sound	Upper Skagit River	Big Beaver Creek	L	0	33	0	0	0	33	42238	2.00
67	Coastal-Puget Sound	Puget Sound	Upper Skagit River	Deer Creek PLP	P	0	1	0	0	0	1	234	0.37
68	Coastal-Puget Sound	Puget Sound	Upper Skagit River	Lightning Creek	L	0	17	0	0	0	17	72637	6.68
69	Coastal-Puget Sound	Puget Sound	Upper Skagit River	Little Beaver Creek	L	0	44	0	0	0	44	34429	1.22
70	Coastal-Puget Sound	Puget Sound	Upper Skagit River	Panther Creek	L	0	15	0	0	0	15	23583	2.46
71	Coastal-Puget Sound	Puget Sound	Upper Skagit River	Pierce Creek	L	0	2	0	0	0	2	2573	2.01
73	Coastal-Puget Sound	Puget Sound	Upper Skagit River	Silver Creek	L	0	0	0	0	0	0	10683	#DIV/0!
74	Coastal-Puget Sound	Puget Sound	Upper Skagit River	Thunder Creek	L	0	39	0	0	0	39	69415	2.78
78	Columbia River	Grande Ronde	Grande Ronde River	Butte Creek	L	0	24	0	0	0	24	26506	1.73
124	Columbia River	Umatilla-Walla Walla	Walla Walla River	Mill Creek (2)	L	0	68	0	0	0	68	13441	0.31
											33362	5597158	

Item: Transportation Miles within RMZ Buffers (on FPLands) by Local Population

Identify WaLP with East RMZ (rows highlighted yellow) and West RMZ buffers (rows highlighted green)
Calculate length for east and west
Select for LP > " and Roadtype = 10 or 99 (10 = Road; 99 = unspecified transportation route)
Frequency east and west on FWSTYPE, LP (&DPS,MU,L_P type), summing Length
Convert to mdb using crystal reports, convert to excel using access, copy paste roadtype 10 + 99 to main xls
sources: FPLands US FWS(selected areas from FFRLands.shp); US FWS WaLP Draft 2006/03;
WDNR Hydro 2005 Eastside & Westside; WDNR transportation 2005
Stream Adjacent Roads by Local Population (FP lands)
LP Type: L= Local Population; P= Potential Local Population

Specific RMZ widths used in analysis

	Western Washington				Eastern Washington			
RMZ Assumptions	**Type S**	**Type F**	**Type Np**	**Type Ns**	**Type S**	**Type F**	**Type Np**	**Type Ns**
Mean riparian tree hieght or other RMZ width	200	155	155	0	130	100	100	0
Assumption: 1/2 mean bankfull width	30	5.25	2.5	0	25	3.75	2.5	0
Mean channel migration zone width	30	10	0	0	5	2	0	0
Total RMZ width:	**260**	**170.25**	**157.5**	**0**	**160**	**105.75**	**102.5**	**0**

ID #	Distinct Population Segment	Management Unit	Core Area	Local Population Name	LP Type	Roads 10&99 RMZ Buffer Type S		Roads 10&99 RMZ Buffer Type F		Roads 10&99 RMZ Buffer Type Np		Total RMZ
						Meters	Miles	Meters	Miles	Meters	Miles	Miles
46	Coastal-Puget Sound	Puget Sound	Nooksack River	Lower South Fork Nooksack River	L	15334.11	9.53	11562.17	7.18	25754.88	16.00	32.72
86	Columbia River	Middle Columbia	Yakima River	Ahtanum Creek	L	6051.17	3.76	18715.61	11.63	15068.52	9.36	24.75
55	Coastal-Puget Sound	Puget Sound	Puyallup River	Upper Puyallup & Mowich Rivers	L	6786.92	4.22	7798.31	4.85	12688.16	7.88	16.95
96	Columbia River	Middle Columbia	Yakima River	NFk Teanaway River	L	2354.40	1.46	11160.58	6.94	9771.44	6.07	14.47

ID #	Distinct Population Segment	Management Unit	Core Area	Local Population Name	LP Type	Roads 10&99 RMZ Buffer Type S		Roads 10&99 RMZ Buffer Type F		Roads 10&99 RMZ Buffer Type Np		Total RMZ
53	Coastal-Puget Sound	Puget Sound	Puyallup River	Clearwater River PLP	P	1911.73	1.19	6682.16	4.15	7455.00	4.63	9.97
45	Coastal-Puget Sound	Puget Sound	Nooksack River	Lower North Fork Nooksack River	L	5780.68	3.59	3443.88	2.14	5618.27	3.49	9.22
143	Columbia River	Upper Columbia	Wenatchee River	Nason Creek	L	4392.42	2.73	5792.25	3.60	4557.23	2.83	9.16
60	Coastal-Puget Sound	Puget Sound	Snohomish/Skykomish River	South Fork Skykomish River	L	6846.17	4.25	4267.88	2.65	3103.50	1.93	8.83
126	Columbia River	Umatilla-Walla Walla	Walla Walla River	South Fork Touchet River	L		0.00	9820.99	6.10	3555.73	2.21	8.31
128	Columbia River	Upper Columbia	Entiat River	Entiat River	L	8447.13	5.25	1895.07	1.18	2444.40	1.52	7.95
125	Columbia River	Umatilla-Walla Walla	Walla Walla River	North Fork Touchet River	L	4111.33	2.55	4128.78	2.57	2917.21	1.81	6.93
44	Coastal-Puget Sound	Puget Sound	Nooksack River	Lower Middle Fork Nooksack River	L	3295.45	2.05	3395.91	2.11	4287.94	2.66	6.82
63	Coastal-Puget Sound	Puget Sound	Stillaguamish River	North Fork Stillaguamish River	L	6238.01	3.88	2824.09	1.75	1836.87	1.14	6.77
83	Columbia River	Lower Columbia	Lewis River	Pine Creek	L	0.00	0.00	6034.08	3.75	4265.80	2.65	6.40
105	Columbia River	Northeast Washington	Pend Oreille River	Le Clerc Creek	L	3005.12	1.87	5031.19	3.13	1868.70	1.16	6.15
90	Columbia River	Middle Columbia	Yakima River	Cle Elum River	L	2575.09	1.60	4025.39	2.50	2307.71	1.43	5.54
141	Columbia River	Upper Columbia	Wenatchee River	Icicle Creek	L	4564.76	2.84	243.42	0.15	2380.59	1.48	4.47
54	Coastal-Puget Sound	Puget Sound	Puyallup River	Greenwater River	L	3723.37	2.31	1956.89	1.22	1397.70	0.87	4.40
145	Columbia River	Upper Columbia	Wenatchee River	White River	L	4261.50	2.65	1675.72	1.04	460.50	0.29	3.98
57	Coastal-Puget Sound	Puget Sound	Puyallup River	West Fork White River	L	1107.81	0.69	2817.41	1.75	2437.52	1.51	3.95
101	Columbia River	Middle Columbia	Yakima River	Upper Yakima River	L	3542.73	2.20	581.96	0.36	1946.99	1.21	3.77
82	Columbia River	Lower Columbia	Lewis River	Cougar Creek	L	962.41	0.60	1603.53	1.00	2806.45	1.74	3.34
52	Coastal-Puget Sound	Puget Sound	Puyallup River	Carbon River	L	1233.93	0.77	1853.79	1.15	2145.31	1.33	3.25
93	Columbia River	Middle Columbia	Yakima River	Gold Creek (2)	L	1117.33	0.69	2588.13	1.61	1204.74	0.75	3.05
56	Coastal-Puget Sound	Puget Sound	Puyallup River	Upper White River	L	1373.84	0.85	474.23	0.29	2552.80	1.59	2.73

ID #	Distinct Population Segment	Management Unit	Core Area	Local Population Name	LP Type	Roads 10&99 RMZ Buffer Type S		Roads 10&99 RMZ Buffer Type F		Roads 10&99 RMZ Buffer Type Np		Total RMZ
48	Coastal-Puget Sound	Puget Sound	Nooksack River	Upper Middle Fork Nooksack River	L	1681.42	1.04	1067.56	0.66	1546.30	0.96	2.67
47	Coastal-Puget Sound	Puget Sound	Nooksack River	Middle North Fork Nooksack River	L	182.07	0.11	2279.99	1.42	1778.18	1.10	2.63
106	Columbia River	Northeast Washington	Pend Oreille River	Mill Creek PLP	P		0.00	1807.51	1.12	2193.60	1.36	2.49
127	Columbia River	Umatilla-Walla Walla	Walla Walla River	Wolf Fork Touchet River	L		0.00	3429.01	2.13	100.16	0.06	2.19
115	Columbia River	Snake River Basin in Washington	Asotin Creek	Wormell Gulch PLP	P		0.00	1971.61	1.23	1469.59	0.91	2.14
64	Coastal-Puget Sound	Puget Sound	Stillaguamish River	South Fork Stillaguamish River	L	2262.41	1.41	931.96	0.58	113.31	0.07	2.06
42	Coastal-Puget Sound	Puget Sound	Nooksack River	Glacier Creek	L	493.33	0.31	1094.37	0.68	1629.71	1.01	2.00
129	Columbia River	Upper Columbia	Entiat River	Mad River	L	560.74	0.35	617.24	0.38	1542.57	0.96	1.69
140	Columbia River	Upper Columbia	Wenatchee River	Chiwawa River	L	799.71	0.50	1327.53	0.82	529.63	0.33	1.65
62	Coastal-Puget Sound	Puget Sound	Stillaguamish River	Canyon Creek	L	0.00	0.00	1777.92	1.10	838.62	0.52	1.63
114	Columbia River	Snake River Basin in Washington	Asotin Creek	NFk Asotin River	L	1010.58	0.63	96.72	0.06	1474.63	0.92	1.60
4	Coastal-Puget Sound	Olympic Peninsula	Elwha River	Little River PLP	P	1541.12	0.96	408.48	0.25	238.32	0.15	1.36
139	Columbia River	Upper Columbia	Wenatchee River	Chiwaukum Creek	L	8.14	0.01	1636.92	1.02	473.00	0.29	1.32
103	Columbia River	Northeast Washington	Pend Oreille River	Harvey Creek PLP	P		0.00	512.11	0.32	1552.78	0.96	1.28
99	Columbia River	Middle Columbia	Yakima River	SFk Tieton River	L	131.32	0.08	1133.52	0.70	683.82	0.42	1.21
58	Coastal-Puget Sound	Puget Sound	Snohomish/Skykomish River	North Fork Skykomish River	L	0.00	0.00	1453.76	0.90	424.01	0.26	1.17
28	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Illabot Creek	L	802.53	0.50	570.53	0.35	361.40	0.22	1.08
102	Columbia River	Northeast Washington	Pend Oreille River	Cedar Creek PLP	P	101.41	0.06	1125.86	0.70	216.25	0.13	0.90
1	Coastal-Puget Sound	Olympic Peninsula	Dungeness River	Dungeness River	L	0.00	0.00	1309.55	0.81	110.11	0.07	0.88

ID #	Distinct Population Segment	Management Unit	Core Area	Local Population Name	LP Type	Roads 10&99 RMZ Buffer Type S		Roads 10&99 RMZ Buffer Type F		Roads 10&99 RMZ Buffer Type Np		Total RMZ
6	Coastal-Puget Sound	Olympic Peninsula	Hoh River	South Fork Hoh River	L	1386.22	0.86	0.00	0.00	0.00	0.00	0.86
95	Columbia River	Middle Columbia	Yakima River	Kachess River	L	158.71	0.10	385.89	0.24	833.50	0.52	0.86
98	Columbia River	Middle Columbia	Yakima River	Rattlesnake Creek	L	609.36	0.38		0.00	706.03	0.44	0.82
136	Columbia River	Upper Columbia	Methow River	Twisp River	L	1247.49	0.78		0.00		0.00	0.78
112	Columbia River	Northeast Washington	Pend Oreille River	Tacoma Creek PLP	P		0.00		0.00	1143.40	0.71	0.71
65	Coastal-Puget Sound	Puget Sound	Stillaguamish River	Upper Deer Creek	L	734.73	0.46	17.37	0.01	355.76	0.22	0.69
134	Columbia River	Upper Columbia	Methow River	Gold Creek (3)	L	447.61	0.28	548.64	0.34		0.00	0.62
110	Columbia River	Northeast Washington	Pend Oreille River	Small Creek PLP	P		0.00	697.95	0.43	280.65	0.17	0.61
21	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Bacon Creek	L	809.85	0.50	0.00	0.00	162.88	0.10	0.60
72	Coastal-Puget Sound	Puget Sound	Upper Skagit River	Ruby Creek	L	0.00	0.00	879.91	0.55	0.00	0.00	0.55
43	Coastal-Puget Sound	Puget Sound	Nooksack River	Lower Canyon Creek	L	236.13	0.15	201.22	0.13	385.57	0.24	0.51
26	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Forks of Sauk River	L	0.00	0.00	761.57	0.47	0.00	0.00	0.47
108	Columbia River	Northeast Washington	Pend Oreille River	SFk Tacoma Creek PLP	P		0.00	744.80	0.46		0.00	0.46
107	Columbia River	Northeast Washington	Pend Oreille River	Ruby Creek PLP (2)	P		0.00	547.98	0.34	165.81	0.10	0.44
104	Columbia River	Northeast Washington	Pend Oreille River	Indian Creek PLP (2)	P	54.29	0.03	215.06	0.13	328.43	0.20	0.37
22	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Baker Lake	L	126.05	0.08	420.71	0.26	0.00	0.00	0.34
39	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Upper South Fork Sauk River	L	0.00	0.00	506.43	0.31	0.00	0.00	0.31
122	Columbia River	Snake River Basin in Washington	Tucannon River	Tucannon River	L		0.00	327.26	0.20	89.55	0.06	0.26
144	Columbia River	Upper Columbia	Wenatchee River	Peshastin Creek	L	397.00	0.25		0.00		0.00	0.25
49	Coastal-Puget Sound	Puget Sound	Nooksack River	Upper North Fork Nooksack River	L	101.87	0.06	139.22	0.09	0.00	0.00	0.15

ID #	Distinct Population Segment	Management Unit	Core Area	Local Population Name	LP Type	Roads 10&99 RMZ Buffer Type S		Roads 10&99 RMZ Buffer Type F		Roads 10&99 RMZ Buffer Type Np		Total RMZ
116	Columbia River	Snake River Basin in Washington	Tucannon River	Cummings Creek	L		0.00	223.37	0.14		0.00	0.14
38	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Tenas Creek	L	173.30	0.11	0.00	0.00	0.00	0.00	0.11
76	Columbia River	Clark Fork	Priest Lake	Granite Creek	L		0.00		0.00	161.41	0.10	0.10
138	Columbia River	Upper Columbia	Methow River	Wolf Creek	L	154.63	0.10		0.00		0.00	0.10
12	Coastal-Puget Sound	Olympic Peninsula	Skokomish River	South Fork Skokomish River	L	0.00	0.00	84.41	0.05	0.00	0.00	0.05
133	Columbia River	Upper Columbia	Methow River	Goat Creek	L		0.00	69.21	0.04		0.00	0.04
27	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Goodell Creek	L	0.00	0.00	29.12	0.02	0.00	0.00	0.02
142	Columbia River	Upper Columbia	Wenatchee River	Little Wenatchee River	L	20.25	0.01		0.00		0.00	0.01
2	Coastal-Puget Sound	Olympic Peninsula	Dungeness River	Gray Wolf River	L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	Coastal-Puget Sound	Olympic Peninsula	Elwha River	Elwha River	L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	Coastal-Puget Sound	Olympic Peninsula	Hoh River	Hoh River	L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	Coastal-Puget Sound	Olympic Peninsula	Queets River	Queets River	L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	Coastal-Puget Sound	Olympic Peninsula	Quinault River	North Fork Quinault River	L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	Coastal-Puget Sound	Olympic Peninsula	Quinault River	Upper Quinault River	L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	Coastal-Puget Sound	Olympic Peninsula	Skokomish River	Brown Creek PLP	P	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	Coastal-Puget Sound	Olympic Peninsula	Skokomish River	North Fork Skokomish River	L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	Coastal-Puget Sound	Puget Sound	Chester Morse	Boulder Creek	L	0.00	0.00	0.00	0.00	0.00	0.00	0.00

ID #	Distinct Population Segment	Management Unit	Core Area	Local Population Name	LP Type	Roads 10&99 RMZ Buffer Type S		Roads 10&99 RMZ Buffer Type F		Roads 10&99 RMZ Buffer Type Np		Total RMZ
14	Coastal-Puget Sound	Puget Sound	Chester Morse	Cedar River	L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	Coastal-Puget Sound	Puget Sound	Chester Morse	Rack Creek	L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	Coastal-Puget Sound	Puget Sound	Chester Morse	Shotgun Creek PLP	P	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	Coastal-Puget Sound	Puget Sound	Chilliwack River	Depot Creek	L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	Coastal-Puget Sound	Puget Sound	Chilliwack River	Little Chilliwack River	L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	Coastal-Puget Sound	Puget Sound	Chilliwack River	Silesia Creek	L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	Coastal-Puget Sound	Puget Sound	Chilliwack River	Upper Chilliwack River	L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Buck Creek	L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Cascade River	L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Downey Creek	L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Lime Creek	L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Lower Whitechuck River	L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Milk Creek	L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
32	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Newhalem Creek	L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33	Coastal-Puget Sound	Puget Sound	Lower Skagit River	South Fork Cascade River	L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
34	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Stetattle Creek	L	0.00	0.00	0.00	0.00	0.00	0.00	0.00

ID #	Distinct Population Segment	Management Unit	Core Area	Local Population Name	LP Type	Roads 10&99 RMZ Buffer Type S		Roads 10&99 RMZ Buffer Type F		Roads 10&99 RMZ Buffer Type Np		Total RMZ
35	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Straight Creek	L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
36	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Sulphur Creek	L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
37	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Sulphur Creek (Lake Shannon) PLP	P	0.00	0.00	0.00	0.00	0.00	0.00	0.00
40	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Upper Suiattle River	L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
41	Coastal-Puget Sound	Puget Sound	Lower Skagit River	Upper Whitechuck River	L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
50	Coastal-Puget Sound	Puget Sound	Nooksack River	Upper South Fork Nooksack River	L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
51	Coastal-Puget Sound	Puget Sound	Nooksack River	Wanlick Creek	L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
59	Coastal-Puget Sound	Puget Sound	Snohomish/Skykomish River	Salmon Creek	L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
61	Coastal-Puget Sound	Puget Sound	Snohomish/Skykomish River	Troublesome Creek	L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
66	Coastal-Puget Sound	Puget Sound	Upper Skagit River	Big Beaver Creek	L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
67	Coastal-Puget Sound	Puget Sound	Upper Skagit River	Deer Creek PLP	P	0.00	0.00	0.00	0.00	0.00	0.00	0.00
68	Coastal-Puget Sound	Puget Sound	Upper Skagit River	Lightning Creek	L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
69	Coastal-Puget Sound	Puget Sound	Upper Skagit River	Little Beaver Creek	L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
70	Coastal-Puget Sound	Puget Sound	Upper Skagit River	Panther Creek	L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
71	Coastal-Puget Sound	Puget Sound	Upper Skagit River	Pierce Creek	L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
73	Coastal-Puget Sound	Puget Sound	Upper Skagit River	Silver Creek	L	0.00	0.00	0.00	0.00	0.00	0.00	0.00

ID #	Distinct Population Segment	Management Unit	Core Area	Local Population Name	LP Type	Roads 10&99 RMZ Buffer Type S		Roads 10&99 RMZ Buffer Type F		Roads 10&99 RMZ Buffer Type Np		Total RMZ
74	Coastal-Puget Sound	Puget Sound	Upper Skagit River	Thunder Creek	L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
75	Columbia River	Clark Fork	Priest Lake	Gold Creek	L		0.00		0.00		0.00	0.00
77	Columbia River	Clark Fork	Priest Lake	Kalispell Creek	L		0.00		0.00		0.00	0.00
78	Columbia River	Grande Ronde	Grande Ronde River	Butte Creek	L		0.00		0.00		0.00	0.00
79	Columbia River	Grande Ronde	Grande Ronde River	Crooked Creek	L		0.00		0.00		0.00	0.00
80	Columbia River	Grande Ronde	Grande Ronde River	North Fork Wenaha River	L		0.00		0.00		0.00	0.00
81	Columbia River	Lower Columbia	Klickitat River	West Fork Klickitat River	L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
84	Columbia River	Lower Columbia	Lewis River	Rush Creek	L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
85	Columbia River	Lower Columbia	Lewis River	Upper Lewis River PLP	P	0.00	0.00	0.00	0.00	0.00	0.00	0.00
87	Columbia River	Middle Columbia	Yakima River	American River	L		0.00		0.00		0.00	0.00
88	Columbia River	Middle Columbia	Yakima River	Box Cayon Creek	L		0.00		0.00		0.00	0.00
89	Columbia River	Middle Columbia	Yakima River	Bumping River	L		0.00		0.00		0.00	0.00
91	Columbia River	Middle Columbia	Yakima River	Crow Creek	L		0.00		0.00		0.00	0.00
92	Columbia River	Middle Columbia	Yakima River	Deep Creek	L		0.00		0.00		0.00	0.00
94	Columbia River	Middle Columbia	Yakima River	Indian Creek	L		0.00		0.00		0.00	0.00
97	Columbia River	Middle Columbia	Yakima River	NFk Tieton River	L		0.00		0.00		0.00	0.00
100	Columbia River	Middle Columbia	Yakima River	Taneum Creek PLP	P		0.00		0.00		0.00	0.00
109	Columbia River	Northeast Washington	Pend Oreille River	Slate Creek PLP	P		0.00		0.00		0.00	0.00
111	Columbia River	Northeast Washington	Pend Oreille River	Sullivan Creek PLP	P		0.00		0.00		0.00	0.00
113	Columbia River	Snake River Basin in Washington	Asotin Creek	Charley Creek	L		0.00		0.00		0.00	0.00
117	Columbia River	Snake River Basin in Washington	Tucannon River	Hixon Creek	P		0.00		0.00		0.00	0.00
118	Columbia River	Snake River Basin in Washington	Tucannon River	Little Tucannon River	P		0.00		0.00		0.00	0.00
119	Columbia River	Snake River Basin in Washington	Tucannon River	Little Turkey Creek	L		0.00		0.00		0.00	0.00

ID #	Distinct Population Segment	Management Unit	Core Area	Local Population Name	LP Type	Roads 10&99 RMZ Buffer Type S		Roads 10&99 RMZ Buffer Type F		Roads 10&99 RMZ Buffer Type Np		Total RMZ
120	Columbia River	Snake River Basin in Washington	Tucannon River	Meadow Creek	L		0.00		0.00		0.00	0.00
121	Columbia River	Snake River Basin in Washington	Tucannon River	Panjab Creek	L		0.00		0.00		0.00	0.00
123	Columbia River	Snake River Basin in Washington	Tucannon River	Turkey Creek	L		0.00		0.00		0.00	0.00
124	Columbia River	Umatilla-Walla Walla	Walla Walla River	Mill Creek (2)	L		0.00		0.00		0.00	0.00
130	Columbia River	Upper Columbia	Methow River	Blue Buck Creek	L		0.00		0.00		0.00	0.00
131	Columbia River	Upper Columbia	Methow River	Chewack River	L		0.00		0.00		0.00	0.00
132	Columbia River	Upper Columbia	Methow River	Early Winters Creek	L		0.00		0.00		0.00	0.00
135	Columbia River	Upper Columbia	Methow River	Lost River	L		0.00		0.00		0.00	0.00
137	Columbia River	Upper Columbia	Methow River	WFk Methow River	L		0.00		0.00		0.00	0.00
Totals						115249.67	71.61	151725.70	94.28	146722.93	91.17	257.07

APPENDIX B

Supporting Materials for Bull Trout Geographic Risk Analysis

B.1 BULL TROUT EXPOSURE RISK ANALYSIS

Lower Columbia (Klickitat core area), Umatilla/Walla-Walla, Grande Ronde, Snake River, Northeast Washington, Clark Fork, Clearwater, Coeur d'Alene, Upper Columbia, and Middle Columbia Management Units

Prepared by Jeff Krupka and Judy De La Vergne, CWFO, 21 Feb 06

Overview

We looked at the percent of bull trout spawning and rearing habitat streams on FPHCP lands in the core areas and developed our first population list to conduct the exposure analysis. Populations that did not have any FPHCP covered lands were not initially included on the list for the exposure analysis. Next we looked and the percent of FPHCP in Spawning and Rearing habitat and developed out next population list. If there were special cases outside of the 10% criteria then it was included for the exposure analysis. If there was >20% FMO it was included for the exposure analysis if it was not already included on the Spawning and Rearing list of populations.

We used GIS, other maps, proposed critical habitat information, and WDFW layers to look at the % exposure or the amount of FFR lands next to or adjacent to spawning, rearing, and FMO habitat.

Methods for Exposure Risk

(Also see "Analysis of Risk to Bull Trout Populations from FPHCP Effects" for detailed writeup about the analysis)

- Estimated by the quantity and location of FPHCP lands
- Risk to local populations (emphasis on spawning and juvenile rearing habitat)
- Modify risk if FMO impacts appear substantial (i.e., >20%)
- Summary of exposure ranking for local populations:
- Low – <10% overlap; typically removed from analysis of baseline habitat and baseline population risk factors (except for some special cases).
- Med – substantial amounts of rearing or small amount of spawning
- High – significant amount of spawning

LOWER COLUMBIA MANAGEMENT UNIT

Klickitat Core Area

The Klickitat core area consists of a single local population, the West Fork Klickitat. It is located entirely on the Yakama Indian Nation, and no known spawning and rearing habitats occur within or adjacent to FPHCP lands.

West Fork Klickitat River Local Population

The West Fork Klickitat River local population is comprised of the West Fork Klickitat, Fish Lake Stream, and Trappers and Little Muddy Creeks. There are no known spawning and rearing habitats on or adjacent to with FPHCP lands, so the exposure risk is low.

Foraging, Migratory, and Overwintering Habitats

About 31 percent of the FMO habitat in the Klickitat Core Area is downstream of the West Fork Klickitat local population and is located on or adjacent to FPHCP lands. This relatively high degree of overlap suggests an elevated risk of exposure for the West Fork Klickitat local population. The exposure risk to the Klickitat FMO habitats is moderate.

UMATILLA/WALLA-WALLA MANAGEMENT UNIT

Walla-Walla Core Area

The Walla-Walla core area is comprised of four local populations; three in the Touchet River and one in Mill Creek. Much of the upper portion of this core area in located within the Umatilla National Forest. About 38 percent of the known spawning and rearing habitats in the core area are located within or adjacent to FPHCP lands.

Mill Creek Local Population

Spawning and rearing in the Mill Creek local population may be restricted to the upper third of the watershed. Although most of this area is managed by the Umatilla National Forest, about 10 percent of known spawning and rearing habitat is located on FPHCP lands. In addition, another 30 percent of known spawning and rearing habitat is located immediately downstream of these FPHCP lands. The substantial amount of spawning and rearing habitat in or within close proximity to FPHCP lands suggests a high exposure risk for this local population.

North Fork Touchet River Local Population

Known spawning and rearing habitat in this local population is primarily in the North Fork, but is also located in Lewis and Spangler Creeks. About 20 of spawning and rearing habitat are located on FPHCP lands, with the remainder upstream on the Umatilla National Forest. This suggests an overall high exposure risk for the North Fork local population.

South Fork Touchet River Local Population

Nearly all known spawning and rearing in the South Fork Touchet River local population is within or adjacent to FPHCP lands. Although the upper portions of the watershed are located on the Umatilla National Forest, the overall exposure risk for the South Fork Touchet River local population is high.

Wolf Fork Touchet River Local Population

About 60 percent of all known spawning and rearing occurs in the Wolf Fork Touchet River on FPHCP lands. The remaining spawning and rearing is located in the uppermost portions of the Wolf Fork on the Umatilla National Forest. The overall exposure risk for the Wolf Fork Touchet River local population is high.

Foraging, Migratory, and Overwintering Habitats

At the core area scale, about 28 percent of the known FMO habitat in the Walla-Walla are within or adjacent to FPHCP lands. Some areas, such as the South Fork Touchet, have substantial overlap with FMO habitat and elevate the overall exposure risk to that local population. This degree of overlap suggests a relatively moderate exposure risk for FMO habitat.

GRANDE RONDE MANAGEMENT UNIT

Grande Ronde River Core Area

The Grande Ronde core area is comprised of three local populations, spanning both Oregon and Washington. These local populations are all tributaries of the Wenaha River, which is located in Oregon, but drain into the Grande Ronde River which occurs in both states. Most of the area occupied by these local populations is on the Umatilla National Forest. Less than 1 percent of the known spawning and rearing habitats in the core area are located within or adjacent to FPHCP lands.

Butte Creek Local Population

The distribution and frequency of spawning and rearing in the Butte Creek local population is unknown, but is suspected in the mainstem and West Fork Butte Creek. About 10 percent of the lower portion of this watershed is in Oregon, but the entire local population is located on the Umatilla National Forest. The lack of FPHCP lands in or adjacent to spawning or rearing habitats suggests a low exposure risk.

Crooked Creek Local Population

The distribution and frequency of spawning and rearing in the Crooked Creek local population is unknown, but is suspected in the mainstem and First Creek. Less than 1 percent of the total area of the local population is comprised of FPHCP lands. These lands are adjacent to the mainstem Crooked Creek near the Oregon/Washington border. The remainder of the local population is within the Umatilla National Forest. The very low amount of FPHCP lands within this local population suggests a low exposure risk.

North Fork Wenaha Local Population

The distribution of spawning and rearing in the North Fork is unknown, but is suspected in the mainstem. The lower half of this watershed is in Oregon, and the upper half is located in Washington. The entire Washington portion of the North Fork is located on the Umatilla National Forest. The lack of FPHCP lands in the Washington portion of this local population suggests a low exposure risk.

Foraging, Migratory, and Overwintering Habitats

Within the Washington portion of the Grande Ronde, less than 1 percent of the FMO habitat is located on FPHCP lands. Almost all of this is located in the mainstem Grande Ronde River, between the confluences of the Wenaha and Snake Rivers. The low degree of overlap suggests a low exposure risk for FMO habitat.

SNAKE RIVER BASIN IN WASHINGTON MANAGEMENT UNIT

Asotin River Core Area

The Asotin River Core Area consists of two local populations and one potential local population. Potential local populations are areas that may be occupied by bull trout, but the distribution and occurrence of spawning and rearing is unknown. The upper portion of this core area is located on the Umatilla National Forest. About 2 percent of the suitable spawning and rearing habitats in the core area are located within or adjacent to FPHCP lands.

Charley Creek Local Population

The distribution of spawning and rearing in the Charley Creek local population is unknown, but is suspected in the mainstem and First Creek. The entire Washington portion of the North Fork is located on the Umatilla National Forest. The lack of FPHCP lands within this local population suggests a low exposure risk.

North Fork Asotin River Local Population

Spawning and rearing in the North Fork are known to occur in the upper mainstem and Cougar Creeks on the Umatilla National Forest. FPHCP lands comprise less than 10 percent of this watershed, primarily in the mainstem North Fork, South Fork of the North Fork Asotin, and Lick Creek. The low proportion of FPHCP lands within this local population and lack of overlap with known spawning and rearing habitats suggests a low exposure risk.

Wormell Gulch Potential Local Population

The distribution and occurrence of spawning and rearing is unknown in the Wormell Gulch potential local population, but this area has been identified as important for the species conservation. About 50 percent of this potential local population overlaps with FPHCP lands. Uncertainty in the distribution and occurrence of spawning and rearing, and the high degree of overlap with FPHCP lands, suggests a moderate exposure risk.

Foraging, Migratory, and Overwintering Habitats

No FMO habitats were identified on or adjacent to FPHCP lands in the Asotin Core area. This suggests a low exposure risk.

Tucannon River Core Area

The Tucannon River core area is comprised of four local populations and two potential local populations. Most of the area above the confluence of Cummings Creek is located on the Umatilla National Forest. About 3 percent of the known spawning and rearing habitats in the core area are located within or adjacent to FPHCP lands.

Cummings Creek Local Population

The distribution of spawning and rearing in the Charley Creek local population is unknown, but is suspected in the mainstem. The degree of overlap with FPHCP lands in the Cummings local population is less than 10 percent. Uncertainty in the distribution and occurrence of spawning and rearing, and the low degree of overlap with FPHCP lands, suggests a low exposure risk.

Hixon Creek Potential Local Population

The distribution and occurrence of spawning and rearing is unknown in the Hixon Creek potential local population, but this area has been identified as important for the species conservation. The entire potential local population is located on the Umatilla National Forest. Uncertainty in the distribution and occurrence of spawning and rearing, and the lack of overlap with FPHCP lands, suggests a low exposure risk.

Little Tucannon River Potential Local Population

The distribution and occurrence of spawning and rearing is unknown in the Little Tucannon potential local population, but this area has been identified as important for the species conservation. A lack of FPHCP lands within or immediately adjacent to the Little Tucannon, and uncertainty in the distribution and occurrence of spawning and rearing, suggests a low exposure risk.

Meadow Creek Local Population

Spawning and rearing are known to occur in the mainstem Meadow Creek on the Umatilla National Forest, but no FCHCP lands are within or adjacent to these areas. The lack of FPHCP lands in or adjacent to spawning and rearing habitats suggests a low exposure risk.

Panjab Creek Local Population

This local population is comprised of Panjab, Little Turkey, and Turkey Creeks. Spawning and rearing are known to all three of these creeks, located on the Umatilla National Forest. However, a lack of FPHCP lands in or adjacent to these areas suggests a low exposure risk.

Tucannon River Local Population

Spawning and rearing are known to occur in the mainstem Tucannon, and Cold, Sheep, and Bear Creeks. Less than 10 percent of spawning and rearing habitat is within or adjacent to FPHCP lands, with the remainder of area within the Umatilla National Forest. This minor degree of overlap with spawning and rearing habitats suggests a moderate exposure risk.

Foraging, Migratory, and Overwintering Habitats

Less than 1 percent of FMO habitat in the Tucannon River core area is within or adjacent to FPHCP lands, most of which is located just downstream of the Cummings Creek local population. This minor degree of overlap suggests a low exposure risk.

NORTHEAST WASHINGTON MANAGEMENT UNIT

Pend Oreille Core Area

The Pend Oreille core area is comprised of one local population and ten potential local populations. Much of the upper portion of this core area are located within Colville and Idaho Panhandle National Forests. About 27 percent of the known spawning and rearing habitats in the core area are located within or adjacent to FPHCP lands.

Cedar Creek Potential Local Population

The distribution and occurrence of spawning and rearing is unknown in the Cedar Creek potential local population, but this area has been identified as important for the species conservation. About 30 percent of the suitable spawning and rearing habitat in this potential local population are within or adjacent to FPHCP lands. This suggests a moderate exposure risk.

Harvey Creek Potential Local Population

The distribution and occurrence of spawning and rearing is unknown in the Harvey Creek potential local population, but this area has been identified as important for the species conservation. About 20 percent of the suitable spawning and rearing habitat in this potential local population are within or adjacent to FPHCP lands. This suggests a moderate exposure risk.

Indian Creek Potential Local Populations

The distribution and occurrence of spawning and rearing is unknown in the Indian Creek potential local population, but this area has been identified as important for the species conservation. This area is considered capable of supporting two potential local populations. About 60 percent of the suitable spawning and rearing habitat in this area are within or adjacent to FPHCP lands. This suggests a high exposure risk.

Le Clerc Creek Local Population

The distribution and frequency of spawning is unknown in this local population, although rearing is known to the East and West Branches of Le Clerc Creek. About 40 percent of rearing overlaps or is adjacent to FPHCP lands. The remaining area within the local population is on the Colville National

Forest. Due to the uncertainty in the location used for spawning and the high degree of overlap with known rearing, the sole local population in the Pend Oreille is considered to have a high exposure risk.

Mill Creek Potential Local Population

The distribution and occurrence of spawning and rearing is unknown in the Mill Creek potential local population, but this area has been identified as important for the species conservation. About 10 percent of the suitable spawning and rearing habitat in this potential local population are within or adjacent to FPHCP lands. This suggests a low exposure risk.

Ruby Creek Potential Local Population

The distribution and occurrence of spawning and rearing is unknown in the Ruby Creek potential local population, but this area has been identified as important for the species conservation. This area is considered capable of supporting two potential local populations. About 10 percent of the suitable spawning and rearing habitat in this potential local population are within or adjacent to FPHCP lands. This suggests a low exposure risk.

South Fork Tacoma Creek Potential Local Population

The distribution and occurrence of spawning and rearing is unknown in the South Fork Tacoma Creek potential local population, but this area has been identified as important for the species conservation. About 30 percent of the suitable spawning and rearing habitat in this potential local population are within or adjacent to FPHCP lands. This suggests a moderate exposure risk.

Slate Creek Potential Local Population

The distribution and occurrence of spawning and rearing is unknown in the Slate Creek potential local population, but this area has been identified as important for the species conservation. About 5 percent of the suitable spawning and rearing habitat in this potential local population are within or adjacent to FPHCP lands. This suggests a low exposure risk.

Small Creek Potential Local Population

The distribution and occurrence of spawning and rearing is unknown in the Small Creek potential local population, but this area has been identified as important for the species conservation. About 30 percent of the suitable spawning and rearing habitat in this potential local population are within or adjacent to FPHCP lands. This suggests a moderate exposure risk.

Sullivan Creek Potential Local Population

The distribution and occurrence of spawning and rearing is unknown in the Sullivan Creek potential local population, but this area has been identified as important for the species conservation. About 10 percent of the suitable spawning and rearing habitat in this potential local population are within or adjacent to FPHCP lands. This suggests a low exposure risk.

Tacoma Creek Potential Local Population

The distribution and occurrence of spawning and rearing is unknown in the Tacoma Creek potential local population, but this area has been identified as important for the species conservation. About 20 percent of the suitable spawning and rearing habitat in this potential local population are within or adjacent to FPHCP lands. This suggests a low exposure risk.

Foraging, Migratory, and Overwintering Habitats

About 9 percent of the FMO habitat in the Pend Oreille core area is within or adjacent to FPHCP lands. Most of this is located along the mainstem Pend Oreille River and lower portions of tributaries. This suggests a low exposure risk.

CLARK FORK MANAGEMENT UNIT

Priest Lake Core Area

The Washington portion of the Priest Lake core area is located primarily in the Idaho Panhandle National Forests. Only about 3 percent of the known spawning and rearing habitats in this core area are located in or adjacent to FPHCP lands. About half of the core area is located in Idaho.

Gold Creek Local Population

The distribution and frequency of spawning and rearing in the Gold Creek local population is unknown. The upper half of Gold Creek is in Washington, the lower half in Idaho, and eventually drains into the Hughes Fork and Upper Priest Lake. No FPHCP lands are within or adjacent to the Washington portion of this local population. This suggests a low exposure risk.

Granite Creek Local Population

Spawning and rearing are known to the North and South Forks of Granite Creek, almost all of which is in Washington; approximately 5 percent of known spawning and rearing is located in Idaho. Although only about 5 percent of the local population area is adjacent to or within FPHCP lands, its proximity to known spawning is significant. The juxtaposition and number of intermittent and perennial streams suggests that sediment from adjacent FPHCP lands could mobilized and deposited downstream into the spawning area. This suggests a moderate exposure risk.

Kalispell Creek Local Population

The distribution and frequency of spawning and rearing in the Kalispell Creek local population is unknown. Less than 5 percent of the suitable spawning and rearing habitats in the local population are adjacent to FPHCP lands. The upper half of Kalispell Creek is in Washington, and it drains into the Upper Priest Lake in Idaho. This suggests a low exposure risk.

Foraging, Migratory, and Overwintering Habitats

Due in part to the high degree of overlap with the Idaho Panhandle National Forests, no FMO habitat is located on FPHCP lands. This suggests a low exposure risk.

CLEARWATER AND COEUR D'ALENE LAKE MANAGEMENT UNITS

Although these management units extend into the state of Washington, most of these areas are centered in Idaho. The distribution of spawning, rearing, and FMO habitats are unknown. In addition, the degree of overlap with Washington is very small, probably less than 1 percent. While the Clearwater Management Unit does not appear to be within or adjacent to FPHCP lands, most of the Coeur d'Alene Management Unit overlaps with FPHCP lands. However, the distribution and occurrence of spawning, rearing, and FMO habitat is unknown. Despite this uncertainty, the low degree of overlap with FPHCP lands suggests a low exposure risk.

MIDDLE COLUMBIA RIVER MANAGEMENT UNIT

Yakima Core Area

Ahtanum Creek local population

The Ahtanum Creek local population includes Ahtanum Creek and its accessible tributaries. Spawning occurs within the N. Fork, Middle Fork and S. Fork Ahtanum Creek. Spawning is also found within Shellneck Creek in the N. Fork. Rearing occurs at least downstream to the confluence of the North and South Forks. FP HCP covered lands completely over lap spawning and rearing habitat. Ahtanum Creek is at High Risk for exposure due to significant overlap of covered lands with spawning and rearing habitat.

The Ahtanum Creek local population uses FMO in Ahtanum Creek mainstem and likely the Columbia River. However there has been a migration barrier until recently blocking the use of the Yakima River and potentially the Columbia by this local population and it is unknown if these fish may use the Columbia. Most of the FMO lands could be considered non-forested in lower Ahtanum Creek. Covered lands are adjacent to minor amounts <10% of FMO in Ahtanum Creek. The lower Yakima River may also provide for the FMO but it is unknown how much. There is 70% of the FMO habitat for the Upper Yakima (upstream of Ahtanum Creek) adjacent to covered lands. There is about 80% of the FMO habitat for the Lower Yakima (downstream of Ahtanum Creek) adjacent to covered lands. Ahtanum Creek is at High exposure due to significant overlap of covered lands with FMO habitat.

American River local population

The American River local population includes the American River and its accessible tributaries. Spawning occurs in Union and Kettle Creeks and in the mainstem American River mainstem. Rearing occurs in the American River downstream to the confluence of the American and Bumping Rivers. FP HCP covered lands are adjacent to 10% of the upper spawning area in the American River, however they are a minor amount but located near tributaries that drain directly into the spawning habitat. The American River is at Moderate Risk for exposure due to overlap of covered lands with minor amounts of spawning and rearing habitat.

FMO habitat exists downstream in the Bumping River and along the Naches River and potentially in the Yakima River mainstem (identified with the WDFW Yakima River Telemetry studies). There is no overlap of covered lands with Bumping River FMO, and 70% of Naches River FMO is adjacent to covered lands. The lower Yakima River may also provide for the FMO but it is unknown how much. There is 70% of the FMO habitat for the Upper Yakima (upstream of Ahtanum Creek) adjacent to covered lands. There is about 80% of the FMO habitat for the Lower Yakima (downstream of Ahtanum Creek) adjacent to covered lands. The American River is at High exposure due to significant overlap of covered lands with FMO.

Box Canyon local population

The Box Canyon Creek includes Box Canyon Creek and its accessible tributaries. Spawning occurs within Box Canyon Creek, tributary to Kachess Lake. There are no FP HCP covered lands adjacent to spawning or rearing habitat. Box Canyon Creek is at no risk for exposure from overlap of covered lands with spawning and rearing habitat.

FMO habitat exists in Kachess Lake and there are covered lands along or adjacent to 90% most of the shoreline of this reservoir. There is a dam and the end of the lake that prevents fish passage. Box Canyon Creek local population is at high risk for exposure from overlap of covered lands with FMO habitat,

however lake habitat is affected differently than stream habitat so this is more likely a Moderate risk for exposure for FMO habitat.

Bumping River local population

The Bumping River local population, tributary to Bumping Lake, includes the Bumping River and its accessible tributaries. Spawning occurs in Deep Creek.But more recently a redd, adults, and juveniles have been located in the upper Bumping R mainstem above the lake indicating spawning and rearing. Deep Creek is discussed separately below. The extent of spawning in the lower Bumping is unknown. There is rearing habitat in the lower Bumping River. FP HCP covered lands occur adjacent to approximately 10% of rearing habitat. The Bumping River is considered at Low Risk of exposure due to the overlap of covered lands with rearing habitat.

FMO habitat exists in Bumping Lake and is 90% surrounded by covered lands along the shoreline. As well, the lower Bumping River is FMO for the American River fish (identified by WDFW using telemetry) and likely others. There is approximately 10% of the FMO in the lower Bumping adjacent to covered lands. The Bumping River local population is at High risk for exposure from overlap of covered lands with FMO habitat, however lake habitat is affected differently than stream habitat so this is more likely a Moderate risk for exposure for FMO habitat.

Cle Elum River local population (includes Waptus River local population)

The Cle Elum River local population, tributary to Cle Elum Lake, has a large area that includes many associated tributaries that qualifies as spawning and rearing habitat. Spawning has not been identified but juveniles have been located upstream of Cle Elum Lake. This local population encompasses Waptus River and Cooper River systems and lakes. Waptus is thought to be possibly its own local population but it will be analyzed together with the Cle Elum local population for this project. FP HCP covered lands are adjacent to some spawning and significant amounts of rearing areas in the Cle Elum River corridor and minimal to none in the Waptus and Cooper systems. The Cle Elum River local population is at Moderate Risk of exposure due to adjacent covered lands overlapping with spawning and rearing habitat.

FMO habitat exists in Cle Elum Lake. There is a fish passage barrier at the dam on the reservoir. There is approximately 90% of FMO adjacent to covered lands. These lands are located along the shoreline of the reservoir and on adjacent slopes next to the lake. The Cle Elum local population is at high risk for exposure from overlap of covered lands with FMO habitat, however lake habitat is affected differently than stream habitat so this is more likely a Moderate risk for exposure for FMO.

Crow Creek local population

The Crow Creek local population includes Crow Creek and its accessible tributaries. Spawning occurs within the mainstem Crow Creek in the Naches River system. FP HCP covered lands are not adjacent to any spawning or rearing habitat in Crow Creek. There is no risk of exposure for spawning and rearing habitat from covered lands.

There is no FMO habitat in Crow Creek. But this local population uses the mainstem Naches River for FMO and potentially the mainstem Yakima River. Approximately 70% of the Naches River is adjacent to covered lands. The lower Yakima River may also provide for the FMO but it is unknown how much. There is 70% of the FMO habitat for the Upper Yakima (upstream of Ahtanum Creek) adjacent to covered lands. There is about 80% of the FMO habitat for the Lower Yakima (downstream of Ahtanum Creek) adjacent to covered lands. The Crow Creek local population is at High exposure of covered lands with FMO habitat.

Deep Creek local population

The Deep Creek local population includes the Deep Creek and its accessible tributaries. Spawning occurs in the Deep Creek mainstem a tributary to the upper Bumping River, above Bumping Lake. FP HCP covered lands are not adjacent to spawning and rearing habitat. The Deep Creek local population spawning and rearing habitat is not at risk of exposure from activities on covered lands.

FMO habitat exists in Bumping Lake and is 90% surrounded by covered lands along the shoreline. The Deep Creek local population is at high risk of exposure due to overlap of covered lands with its FMO habitat, however lake habitat is affected differently than stream habitat so this is more likely a Moderate risk for exposure for FMO.

Gold Creek local population

The Gold Creek local population, tributary to Kecheelus Lake, includes Gold Creek and its accessible tributaries. Spawning occurs within the Gold Creek mainstem. FP HCP lands are adjacent to approximately 75% of the Spawning and rearing habitat. The Gold Creek local population is at High risk of exposure due to the significant amount of covered lands adjacent to spawning and rearing habitat.

The Gold Creek population uses Kecheelus Lake for FMO. There is a dam at the outlet of the Reservoir with out fish passage. There is 80 % of FMO where covered land overlap along the shoreline of the reservoir. The Gold Creek local population is at high exposure of covered lands with FMO habitat, however lake habitat is affected differently, so this more likely a Moderate risk for exposure for FMO.

Indian Creek local population

Indian Creek local population, tributary to Rimrock Lake, includes Indian Creek and its accessible tributaries. Spawning occurs in Indian Creek. FP HCP covered lands adjacent to spawning and rearing habitat are minimal and only occur near the mouth at Rimrock lake and near Clear Lake. The Indian Creek local population is at Low Risk for exposure from covered lands overlapping with spawning and rearing habitat.

FMO habitat exists in Rimrock Lake. There is a dam at the lower end of Rimrock Reservoir with a fish passage barrier. There is about 75% of the FMO habitat adjacent to covered lands along the shoreline of the reservoir. The Indian Creek local population is at High risk of exposure due to covered lands overlapping with FMO habitat.

Kachess River local population

The Kachess River local population, tributary to Kachess Lake, includes the Kachess River and its accessible tributaries. Spawning occurs in Mineral Creek and the Kachess River mainstem. FP HCP covered lands are not located adjacent to spawning habitat and only a minor amount of rearing habitat near the mouth at the Lake. There is a Low risk of exposure due to covered lands overlapping with spawning and rearing habitat.

FMO habitat exists in Kachess Lake and there are covered lands along or adjacent to 90% of the shoreline of this reservoir. There is a dam and the end of the lake that prevents fish passage. The Kachess River local population is at a high risk of exposure due to covered lands overlapping with FMO habitat, however lake habitat is affected differently than stream habitat and this is likely a Moderate risk of exposure for FMO habitat.

NF Teanaway local population

The Teanaway local population includes the Teanaway and its associated tributaries. Spawning and rearing habitat is located in Deroux Creek, the mainstem N. Fork Teanaway, and in Jungle and Jack Creeks. Only two redds have been found recently, in 2005. FP HCP covered lands overlap with significant portions of spawning and rearing habitat in the lower to middle reaches of the N.Fork Teanaway River. The N.Fork Teanaway is at a High risk of exposure due to covered lands overlapping with spawning and rearing habitat.

FMO habitat for the Teanaway exists in the Teanaway mainstem, West Fork Teanaway, Middle Fork Teanaway, and Upper Yakima mainstem. The lower Yakima River may also provide for the FMO but it is unknown how much. There is an 80% overlap with the Teanaway FMO. There is 70% of the FMO habitat for the Upper Yakima (upstream of Ahtanum Creek) adjacent to covered lands. There is about 80% of the FMO habitat for the Lower Yakima (downstream of Ahtanum Creek) adjacent to covered lands. The N.Fork Teanaway is at High risk of exposure due to covered lands overlapping with FMO habitat.

North Fork Tieton River local population

The North Fork Tieton River local population, tributary to Rimrock Lake, includes the N. Fork Tieton River and its accessible tributaries. Spawning and rearing in the mainstem N. Fork Tieton. FP HCP covered lands overlap with minor amounts of rearing habitat. They likely do not overlap with spawning habitat. The North Fork Tieton River local population is at Low risk of exposure due to covered lands overlapping with spawning and rearing habitat.

FMO habitat is downstream in Clear Lake and Rimrock Lake. There is a dam at the lower end of Rimrock Reservoir with a fish passage barrier. There is fish passage between Clear Lake and lower N. Fork Tieton River. There is about 75% of the FMO habitat adjacent to covered lands along the shoreline of the reservoir. The N.Fork Tieton River local population is at a high risk of exposure due to covered lands overlapping with FMO habitat, however lake habitat is affected differently than stream habitat and this is likely a Moderate risk of exposure for FMO habitat.

Rattlesnake Creek local population

The Rattlesnake local population, tributary to the Naches River, includes the Rattlesnake Creek and its accessible tributaries. Spawning includes Rattlesnake Creek mainstem, Wildcat Creek, and the North Fork Rattlesnake Creek mainstem. FP HCP covered lands are adjacent to 30% of the rearing habitat. They do not overlap with known spawning areas. The Rattlesnake local population is at Moderate Risk for exposure due to the overlap of covered lands with rearing habitat.

There is no FMO in Rattlesnake Creek Waterhsed. FMO for the Rattlesnake local population is in the Naches River and potentially downstream in the Yakima River (identified with the WDFW Yakima River Telemetry studies). But this local population uses the mainstem Naches River for FMO and potentially the mainstem Yakima River. Approximately 70 % of the Naches River is adjacent to covered lands. The lower Yakima River may also provide for the FMO but it is unknown how much. There is 70% of the FMO habitat for the Upper Yakima (upstream of Ahtanum Creek) adjacent to covered lands. There is about 80% of the FMO habitat for the Lower Yakima (downstream of Ahtanum Creek) adjacent to covered lands. Rattlesnake Creek is at High risk of exposure due to significant overlap of covered lands with FMO habitat.

South Fork Tieton local population

The South Fork Tieton local population, tributary to Rimrock Lake, includes the S. Fork Tieton River and its accessible tributaries. Spawning includes areas within Bear, Corral, Grey, and Spruce Creeks and the mainstem S. Fork Tieton R. FP HCP lands exist adjacent to ~30% of the spawning habitat along the mainstem S.Fork Tieton upper reach. The S. Fork local population is at High Risk of exposure due to overlap of covered lands with spawning habitat.

FMO for this local population exists downstream in Rimrock Lake. There is a dam at the lower end of Rimrock Reservoir with a fish passage barrier. There is about 75% of the FMO habitat adjacent to covered lands along the shoreline of the reservoir. The S.Fork Tieton River local population is at a high risk of exposure due to covered lands overlapping with FMO habitat, however Lake habitat is affected differently than stream habitat and this is likely a Moderate risk of exposure for FMO habitat.

Taneum Creek potential local population

The Taneum Creek potential local population includes Taneum Creek and its accessible tributaries. This local population is necessary for recovery in the Yakima Core area. Spawning and rearing habitat conditions exist in the upper reaches, particularly in the North and South Forks. Bull trout have not been located here and spawning areas are not determined at this time. FP HCP lands are adjacent to 10% of the rearing habitat. The Taneum Creek potential local population is at Moderate risk for exposure due to overlap of covered lands on this habitat.

FMO habitat for the Taneum Creek potential local population exists in Taneum Creek and the Upper Yakima mainstem. The lower Yakima River may also provide for the FMO but it is unknown how much. There is a 40% overlap of covered lands with Tamuem Creek FMO. There is 70% of the FMO habitat for the Upper Yakima (upstream of Ahtanum Creek) adjacent to covered lands. There is about 80% of the FMO habitat for the Lower Yakima (downstream of Ahtanum Creek) adjacent to covered lands. Taneum Ceek is at High exposure due to significant overlap of covered lands with FMO habitat.

Upper Yakima River local population

The Upper Yakima River local population includes the Upper Yakima River and its accessible tributaries. Spawning includes spawning and rearing in the mainstem Yakima River between Kecheelus Dam and the Easton Dam. FP HCP covered lands are adjacent to 50% of the spawning area in the upper Yakima local population. The upper Yakima is at High Risk of exposure due to the overlap of covered lands with spawning and rearing habitat.

FMO habitat for the upper Yakima local population exists in the Upper Yakima mainstem. Likely the lower portions of Cle Elum and Kachess, and the Teanaway River are also FMO habitat. The lower Yakima River may also provide for the FMO but it is unknown how much. There is an 80% overlap of covered lands with Teanaway R. FMO. There is 70% of the FMO habitat for the Upper Yakima (upstream of Ahtanum Creek) adjacent to covered lands. There is about 80% of the FMO habitat for the Lower Yakima (downstream of Ahtanum Creek) adjacent to covered lands. The upper Yakima is at High risk of exposure due to significant overlap of covered lands with FMO habitat.

Overview of FMO exposure

Naches River FMO-90%
Rimrock Lake FMO-75%
Bumping Lake FMO-90%
Lower Yakima River Mainstem FMO-70%

Upper Yakima River Mainstem FMO-80%
Teanaway FMO- 80%
Taneum Creek FMO-40%
Cle Elum Lake FMO
Kachess Lake FMO-90%
Kecheelus Lake FMO-80%

Wenatchee Core Area

Chiwaukum Creek local population

The Chiwaukum Creek local population includes Chiwaukum Creek and its accessible tributaries. Spawning and rearing occur in its mainstem. No other tributaries are known to have spawning. FP HCP lands overlap with spawning and rearing in the lower 1/3 of the habitat. This local population is at High risk of exposure for spawning and rearing due to this significant overlap of covered lands.

There is no FMO mapped in the Chiwakum Creek watershed. The FMO for this local population is located downstream in the Wenatchee River and in the Columbia River and has been identified with radio telemetry. There is approximately 50% overlap of Wenatchee River FMO with covered lands. These fish could also use the Columbia River mainstem upstream as FMO of which includes approximately 10% of the Columbia River FMO overlaps with covered lands. The Chiwaukum Creek local population is at a High risk of exposure due to the overlap of covered lands with FMO habitat.

Chiwawa River local population

The Chiwawa River local population includes the Chiwawa River and its accessible tributaries. Spawning occurs in the mainstem, Chikamin Creek, Rock Creek, Phelps Creek, and small portions of Buck and Alpine Creeks. FP HCP covered lands overlap with approximately 60% of spawning habitat in Phelps Creek. There is an overlap of about 20% of spawning habitat in Chikamin Creek with the covered lands, however, it is located near the mouth. There are no covered lands adjacent to Rock Creek, Buck Creek, or Alpine Creek. There is an overlap of 15% of the rearing habitat in the Chiwawa River maintem with the covered lands. The Chiwawa River local population is at High risk of exposure for spawning and rearing due to this significant overlap.

There is no FMO mapped in the Chiwawa local population watershed. The FMO for this local population is located downstream in Lake Wenatchee, the Wenatchee River, and in the Columbia River and has been defined with radio telemetry. There is approximately 30% overlap of Lake Wenatchee FMO with covered lands and approximately 50% overlap of Wenatchee River FMO with covered lands. These fish also use the Columbia River mainstem upstream at least as far as the mouth of the Methow River as FMO habitat of which approximately 10% of the Columbia River FMO overlaps with covered lands. The Chiwawa River local population is at High risk of exposure due to the overlap of covered lands with FMO habitat, particularly in the Wenatchee River.

Icicle Creek local population

The Icicle Creek local population includes the Icicle Creek and its tributaries both above and below the barrier at the Leavenworth National Fish Hatchery. Spawning and rearing habitat occur in the mainstem and associated tributaries. However, there have not been any redd surveys to locate actual spawning areas but habitat exists and different sizes classes of fish have been observed within the habitat. Population surveys have identified migratory sized adults upstream of a boulder cascade near Snow Creek and resident sized fish have been identified, close to spawning time, in Jack Creek, the Upper Icicle mainstem,

and in other time periods, in French Creek and in Leland Lake. There is some overlap (5%) with potential spawning areas in Icicle Creek mainstem near Jack Creek. There is a significant amount of overlap with rearing habitat in lower Icicle Creek. The Icicle Creek local population is at Moderate risk of exposure for rearing habitat due to significant overlap of covered lands.

There is no FMO habitat mapped in the local population watershed. However, there is some spawning and rearing habitat used as FMO by migratory fish (located below a fish passage barrier at the Leavenworth National Fish Hatchery down to the mouth of the Wenatchee River). There is 100% overlap in the lower Icicle with FMO habitat. The other FMO for this local population is located and upstream in the Wenatchee River and in the Columbia River and has been identified with radio telemetry. There is approximately a 50% overlap of Wenatchee River FMO with covered lands. These fish could also use the Columbia River mainstem upstream as FMO of which includes approximately 10% overlaps of covered lands with the Columbia River FMO. The Icicle Creek local population is at High risk of exposure due to the overlap of covered lands and FMO habitat.

Little Wenatchee River local population

The Little Wenatchee River local population includes the Little Wenatchee River and its accessible tributaries and the area above the Little Wenatchee Falls. Bull trout have been located in Rainy Creek above those falls. Spawning occurs in the mainstem of the Little Wenatchee River. FP HCP covered lands do not overlap with spawning habitat. They are adjacent to approximately 25% of the rearing habitat. The Little Wenatchee River local population is at Moderate risk of exposure because the proximity of rearing habitat is significant.

There is no FMO mapped in the local population watershed. The FMO for this local population is located downstream in Lake Wenatchee, the Little Wenatchee River, the upper Wenatchee River, and in the Chiwawa River and has been defined with radio telemetry. Rearing habitat identified in other tributaries also has been identified as FMO for the Little Wentchee River local population. There is approximately 30% overlap of Lake Wenatchee FMO with covered lands, approximately 25% overlap with the Little Wentchee River FMO, approximately 15% overlap with the Chiwawa River FMO, and approximately 50% overlap of the Upper Wenatchee River FMO with covered lands. The Little Wenatchee River local population is at High exposure due to the overlap of covered lands with FMO habitat, particularly in the Wenatchee River.

Nason Creek local population

The Nason Creek local population includes Nason Creek and its accessible tributaries. Spawning occurs in Nason Creek mainstem and Mill Creek areas. FP HCP covered lands overlap with significant portions of spawning and rearing habitat. They completely overlap with Mill Creek spawning and rearing habitat which is the main spawning habitat for the local population. There are significant amounts (65%) of covered lands adjacent to the spawning areas within Nason Creek. Portions of rearing habitat in Nason Creek are directly adjacent to these lands between Mill Creek and the mouth. This local population is at High Risk of exposure for Spawning and Rearing due to a significant amount of overlap of covered lands.

There is no FMO mapped in the local population watershed. The FMO for this local population is located downstream in Lake Wenatchee, the Wenatchee River, and in the Columbia River and has been defined with radio telemetry. There is approximately 30% overlap of Lake Wenatchee FMO with covered lands and approximately 50% overlap of Wenatchee River FMO with covered lands. These fish also use the Columbia River mainstem upstream at least as far as the mouth of the Methow River as FMO where covered lands overlap with approximately 10% of the Columbia River FMO habitat. The Nason Creek

local population is at High risk of exposure due to overlap of covered lands with FMO habitat, particularly the Wenatchee River FMO.

Peshastin Creek local population

The Peshastin Creek local population includes Peshastin Creek and its accessible tributaries. Spawning occurs in Ingall's Creek. Juveniles have been located in Peshastin Creek in smolt traps. The FP HCP covered lands overlap with 12% of the spawning and rearing habitat in Ingall's Creek. Most spawning likely occurs upstream of the lowest reach in Wilderness however, spawning can occur downstream of the Wilderness boundary. The lowest reach is also rearing habitat and covered lands overlap it 100%. The Peshastin Creek local population is a Moderate Risk of exposure due to significant overlap of covered lands with rearing habitat.

There is 100% overlap of FMO habitat with covered lands along the Peshastin Creek downstream of Ingall's Creek. The FMO for this local population is also located and upstream and downstream in the Wenatchee River, and in the Columbia River and has been identified with radio telemetry. There is approximately 50% overlap of Wenatchee River FMO with covered lands. These fish could also use the Columbia River mainstem as FMO habitat of which covered lands overlap 100 % of the FMO habitat. The Peshastin Creek local population is at High risk of exposure from the overlap of covered lands with FMO habitat.

White River local population

The White River local population includes the mainstem White River and its accessible tributaries. Spawning is known to occur in Panther Creek and the upper mainstem White River. It is suspected that Canyon Creek and the Nepeequa are other spawning areas. FP HCP covered lands overlap with approximately 15% of the upper White River spawning area and with almost all of the lower reach of the White River below the Napeequa River downstream to the mouth at Lake Wenatchee. There is no overlap with the Panther Creek spawning area. Approximately 60% of rearing habitat is adjacent to covered lands. There is a High Risk of Exposure for both Spawning and Rearing habitat particularly because of the significant amount of overlap with rearing and the lack of spawning area in this local population.

There is no FMO mapped in the local population watershed however, other local populations have been tracking into the lower reaches of the White River using it as FMO. The FMO for this local population is located downstream in Lake Wenatchee, the Little Wenatchee River, the upper Wenatchee River, and in the Chiwawa River and has been defined with radio telemetry. There is approximately a 30% overlap of Lake Wenatchee FMO with covered lands, approximately 25% overlap with the Little Wenatchee FMO, approximately 15% overlap with the Chiwaw River FMO, and approximately 50% overlap of the Upper Wenatchee River FMO with covered lands. The White River local population is at High exposure due to the overlap of covered lands with FMO habitat, particularly in the Wenatchee River.

Overview of FMO

Lake Wenatchee 30%
Wenatchee River FMO 50%
Columbia River FMO 10%

Entiat Core Area

Entiat River

The Entiat local population includes the Entiat River and its accessible tributaries. Spawning occurs in the mainstem Entiat River. FP HCP covered lands overlap with 90% of the spawning and rearing habitat in the mainstem Entiat River, particularly, upstream from the mouth of the Mad River. The Entiat local population is at High risk of exposure due to the overlap of covered lands with spawning and rearing habitat.

FMO for mainstem Entiat occurs in the mainstem Entiat River and the Columbia River and has been identified with radio telemetry. There is approximately a 75% overlap of covered lands with Entiat River FMO habitat and 10% overlap with Columbia River FMO habitat. The Entiat River local population is at High risk of exposure due to the overlap of covered lands with FMO habitat.

Mad River

The Mad River local population includes the Mad River and its accessible tributaries. Spawning occurs in the mainstem Mad River and migratory spawning habitat is currently reduced by a large log jam. FP HCP covered lands overlap with 20% of the spawning and rearing habitat in the mainstem Mad River. The Mad River local population is at High risk of exposure due to the overlap of covered lands with spawning and rearing habitat.

There is no FMO habitat mapped in the Mad River. FMO for mainstem Mad River occurs in the mainstem Entiat River and the Columbia River and has been identified with radio telemetry. There is approximately a 75% overlap of covered lands with the Entiat River FMO habitat and 10% overlap with Columbia River FMO habitat. The Mad River local population is at High risk of exposure due to the overlap of covered lands with FMO habitat.

Overview of FMO

Entiat R.- 75%
Columbia R – 10%

Methow Core Area

Beaver Creek local population

(Blue Buck Creek potential local population is now considered a local population)

The Beaver Creek local population includes the Beaver Creek and its accessible tributaries. Spawning occurs in the Blue Buck Creek. Recently fish barrier culverts have been removed and current spawning is unknown but large migratory adults have been located in the Beaver Creek mainstem. FP HCP covered lands do not overlap with mapped spawning and rearing habitat. Rearing is suspected to be down to the mouth as recently USGS has pit tagged a few juveniles in the lower reaches of Beaver Creek. Currently this area is mapped as FMO. The Beaver Creek local population is at Low risk of exposure due to overlap with rearing habitat.

FMO habitat is located in lower Beaver Creek and likely in the Methow River. It is possible that fish in Beaver Creek used the Columbia River. Radio tagged bull trout in the Columbia River from Wells Dam have been located upstream of Beaver Creek in Wolf Creek. There is approximately a 10% overlap of covered lands with the Beaver Creek FMO habitat, a 90% overlap of covered lands with the Upper Methow FMO (above Chewuch R), a 50% overlap with the Lower Methow FMO (below the Chewuch), a 90% overlap with Twisp River FMO, and 10% overlap with Columbia River FMO habitat. The Beaver Creek local population is at High risk of exposure due to the overlap of covered lands with FMO habitat.

Chewuch River local population (includes Lake Creek)

The Chewuch River local population includes the Chewuch River and its accessible tributaries. Lake Creek is thought that it may be its own local population due to the location of Black Lake in that drainage however, for this project we will cover it as part of the Chewuch local population. Spawning occurs in the mainstem Chewuch River and Lake Creek. FP HCP covered lands do not overlap with any of the spawning habitat and overlap with 15% rearing habitat (downsream of Eightmile Creek). The Chewuch River local population is at Low risk of exposure due to the overlap of covered lands with rearing habitat.

There is FMO habitat in the Chewuch River and in Black Lake. FMO for the Chewuch population likely occurs in the Methow and possibly the Columbia River. There is approximately a 50% overlap of covered lands with the Chewuch River mainstem FMO habitat. There is no overlap with Black Lake FMO habitat. There is approximately a 90% overlap of covered lands with the Upper Methow FMO (above Chewuch R), a 50% overlap with covered lands in the Lower Methow FMO (below the Chewuch), and 10% overlap with Columbia River FMO habitat. The Chewuch local population is at High risk of exposure due to the overlap of covered lands with FMO habitat, particularly in the Chewuch and upper Methow River.

Early Winters Creek local population

The Early Winters Creek local population includes Early Winters Creek, its accessible tributaries, and the area upstream of the falls located adjacent to Highway 20 thought to be a barrier to migratory fish. Spawning occurs in the mainstem Early Winters Creek, both upstream and downstream of the falls, and in Cedar and Huckleberry Creeks. FP HCP covered lands do not overlap with any of the spawning habitat but they do overlap with about 10% of the rearing habitat near the mouth. The Early Winters local population is at Moderate risk of exposure due to the overlap of covered lands with rearing habitat.

There is no FMO habitat mapped in Early Winters Creek. However, it is likely that the Lost River and upper Methow local populations use lower Early Winters as FMO habitat. FMO for the Early Winters population likely occurs in the Methow River and possibly the lower Chewuch and Columbia Rivers. There is approximately a 50% overlap of covered lands with the Chewuch River mainstem FMO habitat. There is approximately a 90% overlap of covered lands with the Upper Methow FMO (above Chewuch R), a 50% overlap with covered lands in the Lower Methow FMO (below the Chewuch), and 10% overlap with Columbia River FMO habitat. The Early Winters local population is at High risk of exposure due to the overlap of covered lands with FMO habitat, particularly in the upper Methow River.

Goat Creek local population

The Goat Creek local population includes Goat Creek, its accessible tributaries. Spawning occurs in the mainstem Goat Creek. FP HCP covered lands do not overlap with any of the spawning habitat but they do overlap with about 20% of the rearing habitat. The Goat Creek local population is at Moderate risk of exposure due to the overlap of covered lands with rearing habitat.

There is no FMO habitat in Goat Creek. FMO for the Goat Creek local population likely occurs in the Methow River and possibly the lower Chewuch and Columbia Rivers. There is approximately a 50% overlap of covered lands with the Chewuch River mainstem FMO habitat. There is approximately a 90% overlap of covered lands with the Upper Methow FMO (above Chewuch R), a 50% overlap with covered lands in the Lower Methow FMO (below the Chewuch), and 10% overlap with Columbia River FMO habitat. The Goat Creek local population is at High risk of exposure due to the overlap of covered lands with FMO habitat, particularly in the upper Methow River.

Gold Creek

The Goat Creek local population includes the Goat Creek and its accessible tributaries. Spawning occurs in Crater Creek. FP HCP covered lands do not overlap with mapped spawning habitat but overlap approximatelhy 30% of the rearing habitat. Rearing is suspected to be down to the mouth as recently USGS has pit tagged a few juveniles in the lower reaches of Gold Creek. The Gold Creek local population is at a Moderate risk of exposure due to overlap with rearing habitat.

There is no FMO habitat mapped in Gold Creek. The Gold Creek local population likely uses FMO habitat in the Methow River and the Twisp River. It is possible that fish in Gold Creek use the Columbia River. Radio tagged bull trout in the Columbia River from Wells Dam have been located upstream of Beaver Creek in Wolf Creek, in the upper Methow, and in the Twisp River. There is approximately a 90% overlap of covered lands with the Upper Methow FMO (above Chewuch R), a 50% overlap with the Lower Methow FMO (below the Chewuch), a 90% overlap with Twisp River FMO, and 10% overlap with Columbia River FMO habitat. The Gold Creek local population is at High risk of exposure due to the overlap of covered lands with FMO habitat.

Lost River local population

The Lost River local population includes the Lost River and its accessible tributaries and all the area within the upper Lost watershed including the Hidden Lakes and Cougar Lake. It is thought that the upper Lost River could be its own local population upstream of a partial barrier in the canyon reach where water goes subsurface and due to the location of lakes within its headwaters. However, for this project we will cover it all as one local population. Spawning occurs in the mainstem Lost River below the canyon reach and upstream of the canyon reach and may occur in the reach of the Hidden Lakes and Ptarmigan Creek. FP HCP covered lands do not overlap with any of the spawning habitat in the upper reaches above the canyon reach and overlaps with 10% of both spawning and rearing habitat in the lower reach. The Lost River local population is at Moderate risk of exposure due to the overlap of covered lands with rearing habitat.

There is FMO habitat in the Lost River, in the upper reach, in the Hidden Lakes and Cougar Lake. FMO for the Lost River population likely occurs in the Methow and possibly the Columbia River. There is no overlap with upper reach FMO in Hidden and Cougar Lakes. There is approximately a 90% overlap of covered lands with the Upper Methow FMO (above Chewuch R), a 50% overlap with covered lands in the Lower Methow FMO (below the Chewuch), and 10% overlap with Columbia River FMO habitat. The Lost River local population is at High risk of exposure due to the overlap of covered lands with FMO habitat, particularly in the upper Methow River.

Twisp River local population

The Twisp River local population includes the Twisp River and its accessible tributaries. Spawning occurs in the Twisp River mainstem, and in North, Buttermilk, Reynolds, and War Creeks. FP HCP covered lands do not overlap with mapped spawning habitat but overlap with approximately 25% of the rearing habitat. The Gold Creek local population is at a Moderate risk of exposure due to overlap with rearing habitat.

There FMO habitat mapped in the Twisp River downstream of Little Bridge Creek. The Twisp River local population is known to also use FMO habitat in the Methow River the Columbia River. Radio tagged bull trout in the Columbia River from Wells Dam have been located upstream of Beaver Creek in Wolf Creek, in the upper Methow, and in the Twisp River. There is approximately a 90% overlap of covered lands with the Upper Methow FMO (above Chewuch R), a 50% overlap with the Lower Methow

FMO (below the Chewuch), a 90% overlap with Twisp River FMO, and 10% overlap with Columbia River FMO habitat. The Twisp River local population is at High risk of exposure due to the overlap of covered lands with Twisp River and Methow River FMO habitat.

Upper Methow River local population (Includes the West.Fork Methow River local population)

The upper Methow local population includes the upper Methow River, its accessible tributaries. Spawning occurs in the mainstem West Fork Methow, Robinson, Rattlesnake, and Trout Creeks. FP HCP covered lands do not overlap with any of the spawning and rearing habitat. The upper Methow River local population is at no risk of exposure due to the overlap of covered lands with spawning and rearing habitat.

There is FMO habitat mapped in the upper Methow. However, it is likely that the upper Methow local populations use the lower reaches of Early Winters and the Lost River spawning and rearing areas as FMO habitat. FMO habitat also occurs in the Methow River and possibly the lower Chewuch and Columbia Rivers. Radio telemetry of bull trout tagged in the Columbia River near Wells Dam has determined they use the upper Methow. There is approximately a 90% overlap of covered lands with the Upper Methow FMO (above Chewuch R), a 50% overlap with covered lands in the Lower Methow FMO (below the Chewuch), a 50% overlap of covered lands with the Chewuch River mainstem FMO habitat, and 10% overlap with Columbia River FMO habitat. The Upper Methow local population is at High risk of exposure due to the overlap of covered lands with FMO habitat, particularly in the upper Methow River.

Wolf Creek local population

The Wolf Creek local population includes Wolf Creek and its accessible tributaries. Spawning occurs in the mainstem Wolf Creek. Bull trout exist above a barrier falls in Wolf Creek. FP HCP covered lands do not overlap with any of the spawning habitat but they do overlap with about 30% of the rearing habitat. The Wolf Creek local population is at Moderate risk of exposure due to the overlap of covered lands with rearing habitat.

There is no FMO habitat mapped in Wolf Creek. FMO for the Wolf Creek local population occurs in the Methow River and possibly the lower Chewuch, Twisp, and Columbia Rivers. There is approximately a 90% overlap of covered lands with the Upper Methow FMO (above Chewuch R), a 50% overlap with covered lands in the Lower Methow FMO (below the Chewuch), a 50% overlap of covered lands with the Chewuch River mainstem FMO habitat, a 90% overlap of covered lands with the Twisp River FMO, and 10% overlap with Columbia River FMO habitat. The Wolf Creek local population is at High risk of exposure due to the overlap of covered lands with FMO habitat, particularly in the upper Methow River

Table B-1. Summary of exposure risk rankings for local populations and FMO habitats.

Core Area or Management Unit	Local Population or FMO	Exposure Risk
Klickitat*	West Fork Klickitat	**
	Klickitat FMO	M
Walla-Walla	Mill Creek	H
	North Fork Touchet	H
	South Fork Touchet	H
	Wolf Fork Touchet	H
	Walla-Walla FMO	M
Grande Ronde*	Butte Creek	**
	Crooked Creek	L
	North Fork Wenaha	**
	Grande Ronde FMO	L
Asotin*	Charley Creek	**
	North Fork Asotin	L
	Wormell Gulch PLP	M
	Asotin FMO	L
Tucannon*	Cummings	L
	Hixon Creek PLP	**
	Little Tucannon PLP	**
	Meadow Creek	**
	Panjab Creek	**
	Turkey Creek	**
	Little Turkey Creek	**
	Tucannon FMO	L
Pend Oreille	Cedar Creek PLP	M
	Harvey Creek PLP	M
	Indian Creek PLP	H
	Le Clerc Creek	H
	Mill Creek PLP	L
	Ruby Creek PLP	L
	South Fork Tacoma Creek PLP	M
	Slate Creek PLP	**
	Small Creek PLP	M
	Sullivan Creek PLP	L
	Tacoma Creek PLP	L
	Pend Oreille FMO	L
Priest Lake*	Gold Creek	L
	Granite Creek	M
	Kalispell Creek	L
	Clark Fork FMO	L
Clearwater MU*	n/a	**
Coeur d'Alene MU*	n/a	**
Yakima	Ahtanum Creek	H

Table B-1. Summary of exposure risk rankings for local populations and FMO habitats. (continued)

Core Area or Management Unit	Local Population or FMO	Exposure Risk
	American River	M
	Box Canyon	**
	Bumping River	L
	Cle Elum River (includes Waptus population)	M
	Crow Creek	**
	Deep Creek	**
	Gold Creek	H
	Indian Creek	**
	Kachess River	L
	Teanaway River (includes N. Fork Teanaway)	H
	N. Fork Tieton	L
	Rattlesnake Creek	M
	S. Fork Tieton	H
	Upper Yakima River	H
	Taneum Creek PLP (Potential local population)	M
	Yakima River Mainstem FMO	H
Wenatchee	Chiwaukum Creek	H
	Chiwawa River	H
	Icicle Creek	M
	Little Wenatchee River	M
	Nason Creek	H
	Peshastin Creek (includes Ingalls Creek)	M
	White River	H
	Wenatchee FMO	H
Entiat	Entiat River	H
	Mad River	H
	Entiat FMO	H
Methow*	Beaver Creek (true local pop)	L
	Chewuch River (includes Lake Creek population)	L
	Early Winters Creek	M
	Goat Creek	M
	Gold Creek	M
	Lost River	M
	Twisp River	M
	Upper Methow River (includes W.Fork Methow local pop)	L
	Wolf Creek	M
	Methow FMO	H

Notes: PLPs are potential local populations. An (*) indicates core areas with less than 10 percent spawning and rearing streams miles on FPHCP covered lands. An (**) indicates local populations (or Management Units with local populations) with no FPHCP lands according to the GIS spatial analysis, and therefore have no direct risk of exposure.

Table B-2. Summary of Moderate and High Exposure Risk Local Populations and FMO habitats.

Core Area	Local Population or FMO	Exposure Risk
Klickitat	Klickitat FMO	M
Walla-Walla	Mill Creek	H
	North Fork Touchet	H
	South Fork Touchet	H
	Wolf Fork Touchet	H
	Walla-Walla FMO	M
Pend Oreille	Le Clerc Creek	H
Priest Lake	Granite Creek	M
Yakima	Ahtanum Creek	H
	American River	M
	Cle Elum River (includes Waptus population)	M
	Deep Creek	M
	Gold Creek	H
	Teanaway River (includes N. Fork Teanaway)	H
	Rattlesnake Creek	M
	S. Fork Tieton	H
	Upper Yakima River	H
	Taneum Creek PLP (Potential local population)	M
	Yakima River Mainstem FMO	H
Wenatchee	Chiwaukum Creek	H
	Chiwawa River	H
	Icicle Creek	M
	Little Wenatchee River	M
	Nason Creek	H
	Peshastin Creek (includes Ingalls Creek)	M
	White River	H
	Wenatchee FMO	H
Entiat	Entiat River	H
	Mad River	H
Methow	Entiat FMO	H
	Early Winters Creek	M
	Goat Creek	M
	Gold Creek	M
	Lost River	M
	Twisp River	M
	Wolf Creek	M
	Methow FMO	H

Table B-3. Summary of Moderate and High Exposure Risk Potential Local Populations.

Core Area	Potential Local Population	Exposure Risk
Asotin	Wormell Gulch PLP	M
Pend Oreille	Cedar Creek PLP	M
	Harvey Creek PLP	M
	Indian Creek PLP	H
	South Fork Tacoma Creek PLP	M
	Small Creek PLP	M
Yakima	Taneum Creek PLP	M

Puget Sound, Olympic Peninsula, and Lower Columbia (Lewis core area) Management Units

Prepared by Jeff Chan and Tim Romanski, WWFWO, 03 Feb 06

*Note that local populations (and in some cases their core areas) with no direct exposure risk (based on Appendix A1 "*Summary of Bull Trout Habitat on FPHCP Lands by Bull Trout Core Area or Recovery Planning Unit*") are not included in the following analysis.

PUGET SOUND MANAGEMENT UNIT

Nooksack Core Area

Middle North Fork Nooksack River local population

The Middle North Fork Nooksack River local population includes the mainstem Nooksack River and associated tributaries between Glacier Creek and Canyon Creek. FPHCP covered lands completely overlap the known bull trout spawning stream "Son of Gallop Creek" and spawning reaches in Gallop Creek. FPHCP covered lands encompass all of Hendrick Creek. Although no spawning has been observed in this creek, adult bull trout have been recorded in this system during the spawn period, therefore spawning is presumed (USFWS 2004). In addition, Cornell Creek is completely encompassed by FPHCP covered lands. Cornell Creek does not have recent records of bull trout, however, native char were historically reported to use this stream (Norgore and Anderson 1921).

Glacier Creek local population

The Glacier Creek local population includes Glacier Creek and its accessible tributaries. FPHCP covered lands completely overlap with Little Creek and Davis Creek which are known bull trout spawning streams, and upper portions of the known spawning reach within Thompson Creek (USFWS 2004). Portions of lower Glacier Creek are also immediately adjacent to FPHCP covered lands. Although spawning has not been currently documented within this portion of Glacier Creek, it could occur due to its close proximity to known spawning reaches in Little and Davis Creeks. Juvenile rearing is known to occur within this portion of Glacier Creek.

Lower North Fork Nooksack River local population

The Lower North Fork Nooksack River local population consists of the North Fork Nooksack River and tributaries between Canyon Creek and Maple Creek (USFWS 2004). FPHCP covered lands overlap with the majority of known spawning reaches within Canyon Creek, and significant portions of known

spawning areas within Boulder Creek. Portions of "McDonald Creek" and Wildcat Creek, which provide rearing habitat and potentially spawning habitat, are also encompassed by FPHCP covered lands.

Lower Middle Fork Nooksack River local population

The Lower Middle Fork Nooksack River local population includes the MF Nooksack River and its accessible tributaries between the Bellingham Diversion Dam and the confluence with the NF Nooksack River (USFWS 2004). FPHCP covered lands overlap a small portion of the known spawning distribution within the MF Nooksack River, and areas adjacent to the MF Nooksack River upstream of this spawning reach (within the downstream portion of the Upper Middle Fork Nooksack River local population). Rearing habitats in the mainstem MF Nooksack River and potential spawning and rearing habitats in Canyon Lake Creek and "Peat Bog Creek" are also encompassed by FPHCP covered lands. Although bull trout spawning and rearing have not recently been documented in Canyon Lake Creek, Norgore and Anderson (1921) reported native char use in this system.

Lower South Fork Nooksack River local population

The Lower South Fork Nooksack River local population includes the mainstem and all tributaries downstream of Wanlick Creek to and including Hutchinson Creek (USFWS 2004). FPHCP covered lands completely encompass the known spawning stream Howard Creek, and significant portions of Hutchinson Creek, Skookum Creek, and the mainstem SF Nooksack River. Although spawning has not yet been confirmed within Hutchinson Creek, it is presumed since rearing juveniles have been documented at least 5 miles into the system (USFWS 2004). While spawning has not been confirmed within Skookum Creek, it is presumed since it is utilized by bull trout and has similar water temperature profiles to Hutchinson Creek (USFWS 2004).

Stillaguamish Core Area

North Fork Stillaguamish River local population

The North Fork Stillaguamish River local population includes the mainstem NF Stillaguamish River and accessible tributaries upstream of, and including, the Boulder River (USFWS 2004). FPHCP covered lands encompass no documented spawning reaches within the North Fork Stillaguamish River local population, however, some areas that overlap with FPHCP covered lands are presumed to be spawning reaches. Based on observations of adult bull trout during the spawn period, it is believed that bull trout likely spawn in the upper reaches of the NF Stillaguamish River and accessible reaches of Squire Creek (USFWS 2004). FPHCP covered lands are adjacent to sections of rearing habitat throughout the local population.

Upper Deer Creek local population

The Upper Deer Creek local population includes Little Deer Creek and Higgins Creek upstream and including the confluence with Deer Creek (USFWS 2004). FPHCP covered lands overlap a small portion of the presumed spawning habitat within Little Deer Creek, and a small portion of juvenile rearing habitat on Higgins Creek.

Canyon Creek local population

The Canyon Creek local population includes accessible reaches of the North and South Forks of Canyon Creek, and the Canyon Creek mainstem downstream to confluence of stream #. FPHCP covered lands overlap a moderate portion of the juvenile rearing and potential spawning habitat in the middle to lower reaches of mainstem Canyon Creek.

Snohomish-Skykomish Core Area

North Fork Skykomish River local population

The North Fork Skykomish River local population includes the NF Skykomish River mainstem and all accessible tributaries (excluding Troublesome Creek and Salmon Creek local populations) from the confluence with Salmon Creek upstream to approximately 0.5 mile above confluence with Goblin Creek. FPHCP covered lands encompass a small portion of potential juvenile rearing habitat in the headwaters of Silver Creek and at the confluence with the NF Skykomish River mainstem.

South Fork Skykomish River local population

The South Fork Skykomish River local population includes the SF Skykomish River mainstem and all accessible tributaries upstream of Index Creek. FPHCP covered lands overlap juvenile rearing habitats within the lower Beckler and Foss Rivers. The reaches of the Beckler River encompassed by FPHCP covered lands may also be potential spawning habitat, since this population is expanding. Current documented spawning areas within the Beckler system are immediately upstream of FPHCP covered lands, between rm 2.0 and 5.0 (USFWS 2004).

Puyallup Core Area

Upper White River local population

The Upper White River local population includes the mainstem White River from the confluence with Greenwater River, and all accessible tributaries upstream (excluding the West Fork White River). FPHCP covered lands encompass juvenile rearing habitat in the lower reach of the Upper White River below Huckleberry Creek.

West Fork White River local population

The West Fork White River local population includes the mainstem West Fork White River from the confluence with the White River and all accessible tributaries upstream. FPHCP covered lands encompass juvenile rearing habitat in the lower reach of the West Fork White River below Huckleberry Creek.

Carbon River local population

The Carbon River local population includes the mainstem Carbon River from the top of the canyon reach (RM 15) upstream to accessible reaches, including all accessible tributaries. FPHCP covered lands encompass or are adjacent to portions of the known spawning habitat along the mainstem Carbon River. FPHCP covered lands also encompass a significant amount of juvenile rearing habitat along the mainstem Carbon River.

Upper Puyallup and Mowich Rivers local population

The Upper Puyallup and Mowich Rivers local population includes the mainstem Puyallup River upstream from Electron Dam, Mowich River, accessible reaches of the North and South Forks of the Puyallup River and Mowich Rivers, and all accessible tributaries. FPHCP covered lands encompass all juvenile rearing habitat on the Puyallup River downstream from the confluence of the North and South Forks Puyallup River. Bull trout spawning is also presumed to occur in some portions of this mainstem reach. FPHCP covered lands encompass almost all juvenile rearing habitat on the Mowich River mainstem. Bull trout spawning is also presumed to occur in some portions of this mainstem reach.

Clearwater River PLP

The Clearwater River potential local population includes the mainstem Clearwater River upstream from its confluence with the White River, and its accessible tributaries. Although bull trout spawning and rearing areas have not been specifically identified within this system, FPHCP covered lands encompass nearly all accessible reaches of the Clearwater River, and therefore, nearly all potential spawning and rearing habitat for bull trout.

OLYMPIC PENINSULA MANAGEMENT UNIT

Dungeness Core Area

Dungeness River local population

The Dungeness River local population includes the middle mainstem Dungeness River upstream, from the confluence with and including Canyon Creek and associated tributaries, to the impassable barrier at river mile 19. FPHCP covered lands are adjacent to only a minor portion of juvenile rearing habitat along the lowest portion of the middle mainstem Dungeness River, and lower portion of Canyon Creek.

Elwha Core Area

Little River PLP

The Little River potential local population includes the mainstem Little River upstream from its confluence with the Elwha River to river mile 7. FPHCP covered lands encompass a small portion of the lower Little River, which likely could support only juvenile rearing.

LOWER COLUMBIA MANAGEMENT UNIT

Lewis River Core Area

Cougar Creek local population

Bull trout spawning and rearing occurs in Cougar Creek which flows into Yale Lake. Although most of the land surrounding Cougar Creek is technically considered covered lands under the FPHCP, an agreement with PacifiCorp is being implemented that further restricts land use in the vicinity of Cougar Creek. A 500-foot easement on both sides of Cougar Creek has been purchased by PacifiCorp and managed to protect bull trout spawning and rearing habitat. The upper portion of Cougar Creek is owned and managed by the USFS.

Pine Creek local population

Bull trout in Swift Reservoir spawn and rear in Rush and Pine Creeks. Rush Creek is encompassed by USFS lands, and therefore, not affected by the FPHCP. More than 50 percent of Pine Creek, on the other hand, is encompassed by FPHCP covered lands and the majority of the spawning and rearing reaches fall within this 50 percent.

**Lewis River FMO*

Lewis River FMO contains just under 22 percent FPHCP lands, and therefore would have technically just received a moderate (M) exposure ranking (i.e., contains between 20 and 40 percent FPHCP covered lands). However, because Lewis River FMO primarily consists of the three reservoirs within the Lewis River system (Swift, Yale, and Merwin), the exposure risk is actually believed to be low (L), which is reflected in the final ranking.

Table B-4. Summary of exposure risk rankings for local populations and their core area's FMO habitat within the Puget Sound, Olympic, and Lower Columbia Management Units. PLPs are potential local populations.

Core Area	Local Population	Exposure Risk (H, M, L)
Nooksack	Middle NF Nooksack River	H
	Glacier Creek	H
	Lower NF Nooksack River	H
	Lower MF Nooksack River	M
	Lower SF Nooksack River	H
	Nooksack FMO	M
Stillaguamish	NF Stillaguamish River	M
	Upper Deer Creek	M
	Canyon Creek	L
	Stillaguamish FMO	H
Snohomish-Skykokmish	NF Skykomish River	L
	SF Skykomish River	M
	Snohomish-Skykokmish	M
Puyallup	Upper White River	L
	WF White River	L
	Carbon River	H
	Upper Puyallup and Mowich Rivers	H
	Clearwater River PLP	H
	Puyallup FMO	H
Dungeness	Dungeness River	L
	Dungeness FMO	M
Elwha	Little River PLP	L
	Elwha FMO	M
Lewis	Pine Creek	H
	Cougar Creek	L
	Lewis FMO	L[1]

[1] See note in Lower Columbia Management Unit narrative above regarding exposure risk.

B.2 BULL TROUT BASELINE HABITAT RISK ANALYSIS

Spatial and non-spatial information was assessed through the bull trout "Matrix of Pathways and Indicators" (Matrix) (USFWS 1998) to arrive at the baseline habitat risk ranking. Risk categories (i.e., low, medium, high) were essentially equated to the Matrix categories (i.e., functioning appropriately, functioning at risk, functioning at unacceptable risk). The draft Bull Trout Recovery Plan (USFWS 2002 and 2004), Washington State limiting factors analyses, subbasin plans, other biological opinions, and/or a bull trout biologist familiar with the area were consulted in assessing the baseline habitat risk for local populations. For the Coastal-Puget Sound population segment's local populations, the "watershed conditions" category was rated by integrating road density and road crossing information (Table B-7), while road density as well as other available information was used to rate the watershed conditions for local populations within the Columbia River population segment.

To calculate the overall baseline habitat risk ranking an average of the six habitat pathways in the Matrix was used. It should be noted that this approach may underestimate the actual overall risk ranking. For example, if either flow/hydrology or habitat access is determined to be high risk (i.e., functioning at unacceptable risk), the condition or ranking of the remaining pathways may in reality have only a minor significance to the overall habitat risk ranking. More simply stated, if bull trout access to habitat is significantly impaired or base flows of a stream are extremely low, the pathways of water quality, habitat elements, and/or channel condition are all secondary in significance in this particular case. However, in many cases pathways work synergistically or are ultimately related in some way. To minimize subjectivity and potential rating errors or biases in weighting any particular pathway, "averaging" was ultimately deemed the most appropriate approach for calculating the baseline habitat risk analysis.

The "brook trout presence" category was added to the matrix to indicate what additional level of risk might be faced by bull trout populations, especially where baseline habitat conditions are in a significantly degraded or impaired condition (i.e., rated at high risk). The level of effect from brook trout on bull trout is sight specific and variable depending on a number of factors (e.g., baseline habitat condition, amount of available habitat, bull trout access to refugia, brook trout densities, water temperature). In addition, the presence of brook trout primarily has population effects to bull trout (e.g., hybridization, competition) as opposed to strictly habitat effects. Therefore, we did not integrate it directly into our overall baseline habitat risk ranking. Because brook trout appear to have a competitive advantage over bull trout in degraded habitats, the brook trout presence ranking is most significant for those local populations determined to have a high (H) overall baseline habitat risk.

Table B-5. Baseline habitat risk ranking matrix by local population and FMO habitat for the Columbia River population segment.

Core Area	Local Population/Potential Local Population	FMO	Water Quality	Habitat Access	Habitat Elements	Channel Condition	Flow/ Hydrology	Watershed Conditions	Brook Trout Presence	Risk Ranking
Yakima	Ahtanum Creek		H	M	H	H	H	H	H	H
	American River		L	L	M	M	M	L	M	M
	Box Canyon		M	H	M	M	H	M	M	M
	Bumping River		H	H	M	H	H	M	H	H
	Cle Elum River (includes Waptus population)		H	H	M	M	H	H	H	H
	Crow Creek		M	L	M	L	L	M	M	M
	Deep Creek		L	H	L	H	L	M	M	M
	Gold Creek		M	H	M	H	H	L	M	M
	Indian Creek		L	H	M	M	L	L	M	M
	Kachess River		M	H	M	H	M	H	M	M
	Teanaway River (includes N. Fork Teanaway)		H	H	H	H	H	H	M	H
	N. Fork Tieton		M	H	M	M	M	M	H	M
	Rattlesnake Creek		M	M	M	M	M	M	M	M
	S. Fork Tieton		M	H	M	M	M	H	M	M
	Upper Yakima River		H	H	H	H	H	H	H	H
	Taneum Creek (Potential local population)		H	H	M	M	M	H	H	H
		Yakima River	H	M	H	H	H	H	H	H
Wenatchee	Chiwaukum Creek		M	L	M	L	L	M	H	M
	Chiwawa River		M	L	L	L	L	L	M	L
	Icicle Creek		H	H	H	M	H	H	H	H
	Little Wenatchee River		H	M	H	M	M	H	H	H
	Nason Creek		H	M	H	H	H	H	M	H
	Peshastin Creek (includes Ingalls Creek)		H	H	H	H	H	H	H	H
	White River		L	M	M	M	L	M	H	M
		Wenatchee River	H	M	H	H	H	H		
Entiat	Entiat River		H	M	H	H	H	H	H	H
	Mad River		M	M	M	M	M	M	L	M
		Entiat River	H	M	H	H	H	H	H	H

Table B-5. Baseline habitat risk ranking matrix by local population and FMO habitat for the Columbia River population segment. (continued)

Core Area	Local Population/Potential Local Population	FMO	Water Quality	Habitat Access	Habitat Elements	Channel Condition	Flow/ Hydrology	Watershed Conditions	Brook Trout Presence	Risk Ranking
Methow	Beaver Creek		H	M	H	H	H	H	H	H
	Chewuch R (includes Lake Creek local population)		H	M	M	M	H	H	H	H
	Early Winters Creek		L	L	M	H	H	M	M	M
	Goat Creek		M	M	M	H	H	H	M	H
	Gold Creek		H	H	H	H	H	H	H	H
	Lost River		L	L	M	H	M	M	M	M
	Twisp River		M	M	M	M	H	M	H	M
	Upper Methow River (includes W. Fork Methow River)		L	L	M	H	H	L	M	M
	Wolf Creek		M	M	M	M	H	M	L	M
		Methow River	H	M	H	H	H	H	H	H
Klickitat		Klickitat	H	H	H	H	H	H		H
Walla Walla	Mill Creek		H	H	H	H	H	H	M	H
	North Fork Touchet		M	M	M	H	M	M	M	M
	South Fork Touchet		H	M	H	M	M	H	M	H
	Wolf Fork Touchet		H	M	M	M	M	M	M	M
		Walla Walla	H	H	H	H	H	H	M	H
Asotin	Wormell Gulch PLP		H	H	H	H	H	H	M	H
Pend Oreille	Cedar Creek PLP		M	H	M	M	M	M	H	M
	Harvey Creek PLP		M	H	M	M	M	M	H	M
	Indian Creek PLP		M	M	M	M	M	M	H	M
	Le Clerc Creek		M	M	H	M	M	H	H	M
	Small Creek PLP		M	M	M	M	M	M	H	M
	South Fork Tacoma Creek PLP		M	M	M	M	M	M	H	M
	Sullivan Creek PLP		M	H	M	M	H	M	H	H
		Pend Oreille	H	H	H	H	H	H	H	H
Priest Lake	Granite Creek		M	M	M	M	M	M	M	M
		Priest Lake	M	H	M	M	H	H	H	H

Functioning Appropriately = L; Functioning at Risk = M; Functioning at Unacceptable Risk = H

Table B-6. Baseline habitat risk ranking matrix by local population and FMO habitat for the Coastal-Puget Sound population segment.

Core Area	Local Population/ Potential Local population	FMO	Water Quality	Habitat Access	Habitat Elements	Channel Condition	Flow/ Hydrology	Watershed Conditions	Brook Trout Presence	Risk Ranking
Nooksack	Middle NF Nooksack River		H	L	M	H	H	M	L	H
	Glacier Creek		L	M	L	M	L	L	L	L
	Lower NF Nooksack River		M	L	M	M	H	H	L	M
	Lower MF Nooksack River		M	L	M	M	M	M	M	M
	Lower SF Nooksack River		H	L	H	H	H	H	M	H
		Nooksack	H	M	M	M	H	M	n/a	M
Stillaguamish	NF Stillaguamish River		M	L	M	M	L	M	M	M
	Upper Deer Creek		H	L	H	H	M	M	M	H
		Stillaguamish	M	L	M	L	L	M	n/a	M
Snohomish/ Skykomish	SF Skykomish River		M	L	H	M	M	H	M	M
		Snohomish/ Skykomish	M	L	M	M	L	H	n/a	M
Puyallup	Carbon River		L	L	L	L	L	L	H	L
	Upper Puyallup and Mowich Rivers		L	M	H	M	H	H	M	H
	Clearwater River PLP		H	L	M	M	L	M	L	M
		Puyallup	M	M	H	H	M	H	n/a	H
Lewis	Pine Creek		L	L	L	M	L	H	L	L
		Lewis	L	M	L	L	L	M	n/a	L
Hoh		Hoh	M	L	M	M	M	H	n/a	M
Elwha		Elwha	M	H	H	H	L	M	n/a	M
Dungeness		Dungeness	M	L	H	H	M	M	n/a	M
Skokomish		Skokomish	M	M	H	H	H	H	n/a	H
Lower Skagit		Lower Skagit	M	L	M	H	M	H	n/a	M

Functioning Appropriately = L; Functioning at Risk = M; Functioning at Unacceptable Risk = H

Table B-7. Matrix for ranking "watershed conditions" for the Coastal-Puget Sound population segment. Crossing categories [1] for Road Type = 10 were based on best professional judgment after reviewing the range of the number of crossings among local populations. It should be noted that the resolution of our road crossing data set used in this analysis could not distinguish between crossing types (i.e., bridges versus culverts), nor did we distinguish crossing location (i.e., over fishbearing versus non-fishbearing stream) (see Appendix A3 *Road Density, Stream Crossings, Stream Adjacent Road Summaries by Local Population and Core Area*). Therefore, we believe our crossing categories represent an adequate compromise given the resolution of the data used, even though we acknowledge that there may be some over or underestimate of the impact from crossings given the uncertainties of crossing types and locations. It should also be noted that the watershed condition ranking was often not affected by the road crossing ranking (i.e., it was consistent with the road density ranking), and in those cases where it was different, it could only shift the ranking by one level.

Core Area	Local Population	FMO	Road Density	Road Crossings	Watershed Conditions
Nooksack	Middle NF Nooksack River		H	L	M
	Glacier Creek		L-M	L	L
	Lower NF Nooksack River		H	M	H
	Lower MF Nooksack River		H	L	M
	Lower SF Nooksack River		H	H	H
		Nooksack	M	n/a	M
Stillaguamish	NF Stillaguamish River		M	M	M
	Upper Deer Creek		M	L	M
		Stillaguamish	H	n/a	H
Snohomish/ Skykomish	SF Skykomish River		H	H	H
		Snohomish/ Skykomish	H	n/a	H
Puyallup	Carbon River		L-M	M	L
	Upper Puyallup and Mowich Rivers		M	H	H
	Clearwater River PLP		M-H	L	M
		Puyallup	H	n/a	H
Lewis	Pine Creek		H	M	H
		Lewis	H	n/a	M[2]
Hoh		Hoh	H	n/a	H
Elwha		Elwha	M	n/a	M
Dungeness		Dungeness	M	n/a	M
Skokomish		Skokomish	H	n/a	H
Lower Skagit		Lower Skagit	H	n/a	H

Functioning Appropriately = L; Functioning at Risk = M; Functioning at Unacceptable Risk = H

1 >600 crossings = H; 300 to 600 crossing = M; <300 crossings = L for Type 10 (roads)

2 The Lewis was rated "moderate" because the majority of FMO habitat in this core area is represented by lakes and not streams, therefore, road density overestimates the level of impact in this case.

Appendix C

Supporting Materials for Bull Trout Critical Habitat Analysis

C.1 FRAMEWORK FOR ANALYSIS

Previously in the bull trout Geographic Risk Analysis, the exposure of the local populations (spawning and rearing habitat) and FMO habitats to activities on FPHCP covered lands was evaluated and ranked as high, moderate, or low risk based on the proximity and amount of overlap. Where a moderate or high exposure risk to local populations or FMO habitats was identified, there could be an increased risk from potential adverse effects from FPHCP activities to downstream or interspersed segments of critical habitat. Table 1 of the bull trout Geographic Risk Analysis displays the exposure risk rankings for bull trout local populations and FMO habitats within relevant core areas. However, all FMO habitat within a particular core area was combined and evaluated in that analysis.

Similar to the bull trout Geographic Risk Analysis, by visually estimating the amount of designated critical habitat in relation to FPHCP lands, a similar exposure risk can be applied to critical habitat. First, a visual comparison between the total amount of spawning, rearing, and FMO habitat and the total final amount of designated critical habitat was made; Second, a visual estimation of the percentage of critical habitat that was interspersed or located downstream of FPHCP lands was made; and finally, the two were combined to come up with an overall exposure risk for each critical habitat segment to potential effects from activities on FPHCP covered lands.

We assumed that all moderate to high exposure risks for critical habitat could also be subjected to an increased risk from adverse affects. Combining the information of the critical habitat exposure risk analysis and the baseline habitat condition, the overall potential risk can be scored similar to how the bull trout local populations and FMO were scored in the Geographic Risk Analysis. Scoring the critical habitat occurred by assigning H = 3, M =2, and L =1, adding them together and dividing by 2 to get the overall score or ranking.

After the initial ranking, additional GIS analysis was conducted on spawning and rearing habitat and on all FMO habitats which were ranked as moderate-high and high. The GIS analysis was at multiple scales using GIS vegetation and USGS quad maps. National Lands Cover data maps at 1:100,000 and USGS quad maps at 1:24,000 were used in a GIS exercise to look at the vegetation types in conjunction with the exclusion rules along the final critical habitat segments. This effort was to more accurately determine what amount of critical habitat actually lies between the legal end points mapped in the final listing rule. For example, if there was a segment in the final rule mapped as designated critical habitat, and the lands were agricultural or non-forested vegetation based on the two maps, then the segment was considered to be critical habitat. However, if a segment was mapped as critical habitat but had forested vegetation, then it should have likely been excluded by at least one of the exclusions in the final designation. Note that some segments of streams that were depicted as excluded in the listing had sections of land that appear to be non-forested based on GIS layers, and therefore, should likely not have been excluded in the final designation. This is likely due to different scale maps and different GIS coverages used to estimate the final designation. Also, this GIS exercise helped to refine what the level of exposure would be, based on how close the FPHCP lands were located to segments of critical habitat. For example, if FPHCP covered lands closely surrounded a critical habitat segment, or were interspersed among segments, these segments were determined to be exposed to FPHCP lands and a percentage of that exposure was estimated.

C.1.1 Item 1: Additional Analysis for Middle Columbia River Basin: Unit 20

C.1.1.1 *Baseline condition*

Spawning and rearing critical habitat is located within the mainstem Yakima River upstream of Easton Lake Dam to Keechelus Dam. FMO critical habitat is located from the mouth up to Easton Dam (just below Kachess River) and there are exclusions applied in portion of both the spawning and rearing and FMO reaches. In the Naches River there are segments of FMO critical habitat identified from the mouth upstream to the confluence of the Bumping River and there are some exclusions that apply in the upper portion of the reach and in a few interspersed segments. Segments of FMO critical habitat are located in the tributaries to the Naches River, Bumping River and Tieton River; and segments of spawning and rearing critical habitat are located within the Tieton River and Rattlesnake Creek, and NF Tieton River. Both have large interspersed segments that are excluded. In Ahtanum Creek, segments of spawning and rearing critical habitat are designated in the mainstem generally upstream from the confluence of the North and South Forks; while there are only segments of FMO critical habitat within the mainstem Ahtanum Creek, and in the North Fork and South Fork where large segments are excluded. In the Teanaway River segments of spawning and rearing and FMO critical habitat are located generally within the mainstem from the confluence with the NF Teanaway and upstream to a barrier falls; spawning and rearing critical habitat is located in Jungle and Jack Creeks; and FMO critical habitat is located in the Teanaway mainstem and the Middle Fork. Exclusions occur in most of the NF Teanaway, segments of Jungle and Jack Creeks, and in a small segment of the mainstem Teanaway. In the Cle Elum River system segments of FMO critical habitat are located within the mainstem both above and below Cle Elum Lake and within the Cooper River system below Cle Elum Lake, with some exclusions interspersed. Segments of spawning and rearing critical habitat are located upstream of Cle Elum Lake and with some small interspersed segments in both the Cle Elum River and Cooper River. In the Kachess River spawning and rearing and FMO critical habitat is located between the mouth and the Dam at Kachess Lake and upstream of the lake in the Kachess River and in Box Canyon Creek. Some FMO critical habitat segments are downstream of the lake, however, most segments have been excluded. In Gold Creek, spawning and rearing critical habitat is almost all excluded. All other areas that contained bull trout habitat were completely excluded in the final rule. See Table I, which shows the BT matrix and the habitat conditions overlapped with the PCEs and the overall critical habitat condition ranking.

C.1.1.2 *Effects Section*

Further FMO analysis of the individual stream systems, reveals that individually the Naches, Tieton, N. Fork Tieton, Kachess, Cle Elum, Teanaway and the N. Forks Teanaway River FMOs, and the mainstem Yakima River rank high because it was estimated that there were greater than 40 percent adjacent FPHCP lands. Bumping River (below the dam) ranked low, having only 10 percent adjacent FPHCP lands.

Our analysis indicates spawning and rearing critical habitat segments in the action area are at high risk of exposure in Ahtanum Creek and its tributaries, mainstem Yakima River, and the Teanaway River and its tributaries; and are at moderate risk of exposure in Rattlesnake Creek and Gold

Creek; but are at low risk in Cle Elum River and its tributaries and NF Tieton Rivers. In addition, FMO critical habitat segments are at high risk of exposure in the Ahtanum Creek, Naches, Tieton, Yakima, Teanaway, Cle Elum, and Kachess Rivers, while the FMO critical habitat segments are at low risk in the Bumping River. There were no FPHCP lands interspersed or upslope of spawning and rearing critical habitat segments in Box Canyon Creek or in upper Kachess River. See Table J for the exposure ranking for the Middle Columbia CHU.

In terms of the preliminary ranking of overall potential risk from potential adverse effects, spawning and rearing critical habitat segments in Ahtanum Creek and its tributaries, the Teanaway River and its tributaries, and the upper mainstem Yakima River are at a high risk; and Gold Creek and Cle Elum and its tributaries are at a moderate risk. The NF Tieton is at a low risk to potential adverse effects to spawning and rearing critical habitat. In terms of the overall potential risk from potential adverse effects to FMO critical habitat segments, Ahtanum Creek, Cle Elum, Kachess, Naches, Teanaway, Tieton, and upper mainstem Yakima Rivers are at high risk; Rattlesnake Creek is at a moderate-high risk; and the Bumping River is at moderate risk for adverse affects. Table A shows a combination of the exposure risk of the local populations and FMO habitat, and the critical habitat baseline condition to give an initial ranking in terms of the overall potential risk of critical habitat from potential adverse affects.

Additional GIS analysis was conducted on Ahtanum, Teanaway, and Upper Yakima spawning and rearing habitat and on all FMO habitats to double check the exposure risk and overall potential risks of these critical habitat segments that were identified above in Table A as moderate-high and high overall potential risks.

Table A. Preliminary Overall Potential Risk for Middle Columbia River Critical Habitat. Moderate and high risk categories are at significant risk to potential adverse effects.

	CHU Exposure Risk		CHU Habitat Rating*		Overall Potential Risk	
CHU Name/function	**rank 1**	**score 1**	**rank 2**	**score 2**	**rank 3**	**score 3**
Spawning/Rearing CH						
Ahtanum (including the NF and SF) S/R	H	3	H	3	HH	3
Teanaway (including NF, Jungle, Jack Cr) S/R	H	3	H	3	HH	3
Upper Yakima S/R	H	3	H	3	HH	3
Gold S/R	M	2	M	2	MM	2
Cle Elum (including Cooper and Waptus R) S/R	L	1	H	3	LH	2
NF Tieton S/R	L	1	M	2	LM	1.5
Foraging Migration and Overwintering CH						
Cle Elum FMO	H	3	H	3	HH	3
Kachess FMO	H	3	H	3	HH	3
Naches FMO	H	3	H	3	HH	3
Teanaway FMO	H	3	H	3	HH	3
Tieton FMO	H	3	H	3	HH	3
Upper Yakima FMO	H	3	H	3	HH	3
Ahtanum FMO	H	3	H	3	MH	3
Rattlesnake FMO	M	2	H	3	MH	2.5
Bumping FMO	L	1	H	3	LH	2

Table B is a summary of the refined final overall potential risk rankings that will be carried forward in the BO. Spawning and rearing segments in the Ahtanum, Teanaway, and Upper Yakima remain at a high risk. Further review of Rattlesnake Creek determined that it was a spawning and rearing segment and not FMO habitat, and that it was at moderate risk along with Gold Creek. All FMO except Bumping River remained at high risk. See Table K for validation of the exposure ranking of these critical habitat segments.

Table B. Final Overall Potential Risk for Middle Columbia River Critical Habitat.

	CHU Exposure Risk		CHU Habitat Rating		Overall Potential Risk	
CHU Name/function	**rank 1**	**score 1**	**rank 2**	**score 2**	**rank 3**	**score 3**
Spawning/Rearing CH						
Ahtanum S/R (including the NF and SF)	H	3	H	3	HH	3
Teanaway S/R (including NF, Jungle, Jack Cr)	H	3	H	3	HH	3
Upper Yakima S/R	H	3	H	3	HH	3
Gold Cr S/R	M	2	M	2	MM	2
RattleSnake Creek S/R	*M*	*2*	*M*	*2*	*MM*	*2*
Cle Elum S/R (including Cooper and Waptus R)	L	1	H	3	LH	2
NF Tieton S/R	L	1	M	2	LM	1.5
Foraging Migration and Overwintering CH						
Cle Elum FMO	H	3	H	3	HH	3
Kachess FMO	H	3	H	3	HH	3
Naches FMO	H	3	H	3	HH	3
Teanaway FMO	H	3	H	3	HH	3
Tieton FMO	H	3	H	3	HH	3
Upper Yakima FMO	H	3	H	3	HH	3
Ahtanum FMO	H	3	H	3	HH	3
~~*Rattlesnake FMO*~~	~~*M*~~	~~*2*~~	~~*H*~~	~~*3*~~	~~*MH*~~	~~*2.5*~~
Bumping FMO	L	1	H	3	LH	2

Moderate-high and high risk categories are at significant risk to potential adverse effects that can affect the functional suitability of PCEs (Italic/italic strikeout is additions/deletions due to the detailed analysis).

C.1.2 Item 2: Additional Analysis for NE Washington River Basins: Unit 22

C.1.2.1 *Baseline condition*

FMO critical habitat is located in Calispell Creek downstream of Small Creek. In Cedar Creek, there are segments of critical habitat located near the mouth and midway upstream, with excluded segments in between and upstream. In Indian Creek, there are critical habitat segments interspersed with excluded segments. In LeClerc Creek, East and West Branch LeClerc Creek, and Fourth of July Creek, there are segments of spawning and rearing critical habitat, with many excluded segments interspersed and

upstream and downstream. No FMO critical habitat segments remain on LeClerc Creek after exclusions. In Mill Creek, segments of spawning and rearing critical habitat are located near the creek mouth, with exclusions upstream. In Ruby Creek, segments of spawning and rearing critical habitat are located in the lower half of the stream, and are interspersed with large excluded segments. In SF Tacoma Creek, segments of spawning and rearing critical habitat are located near the mouth and in its headwaters, with large excluded segments interspersed in between. In Tacoma Creek, segments of spawning and rearing critical habitat and FMO critical habitat are located near the mouth and in its headwaters with large exclusions interspersed in between. In Slate Creek, spawning and rearing critical habitat segments are located near the mouth, with large excluded segments upstream. In Small Creek, segments of spawning and rearing critical habitat and FMO critical habitat are located from the mouth to the EF Small Creek and within the lower portion of the East Fork, with some interspersed excluded segments in the EF Small Creek. In Sullivan Creek, only segments of FMO critical habitat remain, while no spawning and rearing segments appear designated after the exclusions. See Table I, which shows the BT matrix and the habitat conditions overlapped with the PCEs and the overall critical habitat condition ranking. The overall discussion of the crosswalk to the PCEs is located in Appendix D.

C.1.2.2 *Effects Section*

Further FMO analysis, of the individual stream systems, reveals that Calispell, SF Tacoma, Sullivan, and Tacoma FMOs also rank high because of the large amount or high exposure to FPHCP covered lands (estimated at greater than 40 percent adjacent FPHCP lands).

Our analysis indicates spawning and rearing critical habitat segments in the action area are at high risk of exposure in LeClerc, Indian, SF Tacoma, and Small Creeks; and are at moderate risk of exposure in all other spawning and rearing areas, but are at low risk of exposure in Mill Creek. In addition, FMO critical habitat segments are at high risk of exposure in Calispell, SF Tacoma, and Small Creeks; and are at a moderate risk of exposure in Tacoma Creek, and at low risk in Ruby Creek. See Table J for the exposure ranking for critical habitat.

In terms of the preliminary ranking of overall potential risk from potential adverse effects, spawning and rearing critical habitat segments in LeClerc including the East Branch and West Branch LeClerc Creeks and Fourth of July Creeks are at high risk; Indian Creek, Small Creek including EF Small Creek, SF Tacoma Creek, and Tacoma Creek are at moderate-high risk; and Cedar and Mill Creeks are at moderate risk. In terms of the overall potential risk to potential adverse effects to FMO critical habitat, Calispell Creek, SF Tacoma Creek, and Tacoma Creek are at high risk; Sullivan Creek is at moderate-high risk; and Ruby Creek is at moderate risk. Table C shows a combination of the exposure risk of the local populations and FMO habitat, and the critical habitat baseline condition to give an initial ranking in terms of the overall potential risk of critical habitat to potential adverse affects.

Further GIS analysis was conducted on LeClerc, Indian, Small, SF Tacoma, and Tacoma Creek spawning and rearing habitat and on all FMO habitats to double check the exposure risk and overall potential risks of these critical habitat segments that were identified above in Table C as moderate-high and high overall potential risks.

Table C. Preliminary Overall Potential Risk for NE Washington River Basins Critical Habitat.

CHU Name/function	CHU Exposure Risk		CHU Habitat Rating*		Overall Potential Risk	
	rank 1	score 1	rank 2	score 2	rank 3	score 3
Spawning/Rearing CH						
LeClerc Cr S/R (including E. Branch and W. Branch LeClerc Cr, Fourth of July Cr)	H	3	H	3	HH	3
Indian Cr S/R	H	3	M	2	HM	2.5
Small Cr (including EF Small Cr)	H	3	M	2	HM	2.5
SF Tacoma Cr S/R	H	3	M	2	HM	2.5
Tacoma Cr S/R	M	2	H	3	MH	2.5
Cedar Cr S/R	M	2	M	2	MM	2
Mill Cr S/R	L	1	H	3	LH	2
Foraging Migration and Overwintering CH						
Calispell Cr FMO	H	3	H	3	HH	3
SF Tacoma Cr FMO	H	3	H	3	HH	3
Tacoma Cr FMO	H	3	H	3	HH	3
Sullivan Cr FMO	M	2	H	3	MH	2.5
Ruby Cr FMO	L	1	H	3	LH	2

Moderate and high risk categories are at significant risk to potential adverse effects.

Table D summarizes the refined overall rankings from the additional GIS analysis. Spawning and rearing critical habitat segments in Tacoma Creek moved up to a overall high risk; in LeClerc Creek they moved to a moderate-high risk; while Indian, Small, and SF Tacoma Creeks they moved to a moderate risk along with Cedar and Mill Creeks. Further review of Ruby Creek determined that it was a spawning and rearing segment and not a FMO segment, and that it was at moderate risk. Slate Creek was determined to have an exposed segment of spawning and rearing critical habitat, which was at a moderate risk. Segments of FMO critical habitat in Calispell Creek remained at an overall high risk, and Sullivan Creek remained at a moderate-high overall risk. Tacoma Creek FMO critical habitat moved to a moderate-high overall risk. Additionally, Small Creek was determined to have segments of FMO critical habitat at an overall high risk, and LeClerc Creek was determined to have segments of FMO critical habitat at an overall moderate-high risk. Further review of SF Tacoma Creek and Ruby Creek determined there are apparently no FMO critical habitat segments. See Table K for validation of the exposure ranking of these critical habitat segments.

Table D. Final Overall Potential Risk for NE Washington River Basins Critical Habitat.

CHU Name/function	CHU Exposure Risk		CHU Habitat Rating*		Overall Potential Risk	
	rank 1	**score 1**	**rank 2**	**score 2**	**rank 3**	**score 3**
Spawning/Rearing CH						
Tacoma Cr S/R	H	3	H	3	HH	3
LeClerc Cr S/R (including E. Branch and W. Branch LeClerc Cr, Fourth of July Cr)	M	2	H	3	HM	2.5
Indian Cr S/R	M	2	M	2	MM	2
Small Cr S/R (including the EF Small Cr)	M	2	M	2	MM	2
SF Tacoma Cr S/R	M	2	M	2	MM	2
Cedar Cr S/R	M	2	M	2	MM	2
Ruby Cr S/R	*M*	*2*	*M*	*2*	*MM*	*2*
Slate Cr S/R	*M*	*2*	*M*	*2*	*MM*	*2*
Mill Cr S/R	L	1	H	3	LH	2
Foraging Migration and Overwintering CH						
Calispell Cr FMO	H	3	H	3	HH	3
~~*SF Tacoma Cr FMO*~~	~~*H*~~	~~*3*~~	~~*H*~~	~~*3*~~	~~*LM*~~	~~*3*~~
Small Cr FMO	*H*	*3*	*H*	*3*	*HH*	*3*
Tacoma Cr FMO	M	2	H	3	MH	2.5
Sullivan Cr FMO	M	2	H	3	MH	2.5
Le Clerc Cr FMO	*M*	*2*	*H*	*3*	*MH*	*2.5*
~~*Ruby Cr FMO*~~	~~*L*~~	~~*1*~~	~~*H*~~	~~*3*~~	~~*LH*~~	~~*2*~~

Moderate-high and high risk categories are at a significant risk to potential adverse effects that can affect the functional suitability of PCEs (Italic/Italic strikeout is additions/deletions due to the detailed analysis).

C.1.3 Item 3: Additional Analysis for Umatilla -Walla Walla Unit: Unit 9

C.1.3.1 *Baseline condition*

Segments of spawning and rearing critical habitat are located within the Walla Walla River and within its tributary, Mill Creek. Additionally, segments of spawning and rearing critical habitat are located in the Touchet River system within the NF Touchet, Lewis and Spangler Creeks; and within the SF Touchet. Segments of FMO critical habitat are located in the Walla Walla mainstem, Mill Creek mainstem, Yellowhawk Creek off of lower Mill Creek; the Touchet system the mainstem Touchet, North and South Forks of the Touchet; and within the Wolf Fork Touchet. All other areas that contained bull trout habitat were completely excluded in the final rule. See Table I, which shows the BT matrix and the habitat conditions overlapped with the PCEs and the overall critical habitat condition ranking. The overall discussion of the crosswalk to the PCEs is located in Appendix D.

C.1.3.2 *Effects Section*

Further FMO analysis of the individual stream systems, reveals that individually FMO in the Mill Creek, Walla Walla, North and South Forks of the Touchet and the Wolf Fork areas also rank high because there were greater than 40 percent adjacent FPHCP lands. Wolf Fork Touchet ranked out as a moderate with 20 percent adjacent FPHCP lands.

Our analysis indicates spawning and rearing critical habitat segments in the action area are at high risk of exposure in Mill Creek and the NF Touchet and its tributaries. In addition, FMO critical habitat segments are at moderate high to high risk of exposure in all the FMO areas. See Table J for the exposure ranking for the Umatilla-Walla Walla CHU.

In terms of the preliminary ranking of overall potential risk from potential adverse effects, spawning and rearing critical habitat segments in Mill Creek and NF Touchet are at high risk and at moderate risk in the SF Touchet. The overall risk to potential adverse effects to FMO critical habitat segments in Mill Creek and SF Touchet are at high risk and in Wolf Fork and NF Touchet areas are at moderate-high risk. Table E shows a combination of the exposure of the local populations and FMO habitat and the critical habitat baseline condition ratings to give a final ranking in terms the overall condition.

Table E. Preliminary Overall Potential Risk for Umatilla-Walla Walla River Basins Critical Habitat.

	CHU Exposure Risk		CHU Habitat Rating*		Overall Potential Risk	
CHU Name/function	**rank 1**	**score 1**	**rank 2**	**score 2**	**rank 3**	**score 3**
Spawning/Rearing CH						
Mill Cr S/R	M	2	H	3	MH	2.5
NF Touchet S/R	H	3	M	2	MH	2.5
SF Touchet S/R	H	3	M	2	MH	2.5
Foraging Migration and Overwintering CH						
Mill Cr FMO	H	3	H	3	HH	3
SF Touchet FMO	H	3	H	3	HH	3
NF Touchet FMO	M	2	H	3	MH	2.5
Wolf Fork Touchet FMO	M	2	H	3	MH	2.5
Moderate and high risk categories are at significant risk to potential adverse effects.						

Further GIS analysis was conducted on Mill Creek and NF Touchet spawning and rearing habitat and on all FMO habitat to double check the exposure risk and overall potential risks of these critical habitat segments that were identified above in Table E as moderate-high and high overall potential risks.

Table F summarizes the refined overall exposure rankings from the GIS analysis. Spawning and rearing critical habitat segments in Mill Creek and NF Touchet are at an overall moderate-high risk. Further review of the SF Touchet determined that it was a spawning and rearing segment with exposure, and that it was at an overall moderate risk. All FMO critical habitat segments remain at moderate-high or high risk. See Table K for validation of the exposure ranking of these critical habitat segments.

Table F. Final Overall Potential Risk for Umatilla-Walla Walla River Basins Critical Habitat.

CHU Name/function	CHU Exposure Risk		CHU Habitat Rating*		Overall Potential Risk	
	rank 1	score 1	rank 2	score 2	rank 3	score 3
Spawning/Rearing CH						
Mill Cr S/R	M	2	H	3	MH	2.5
NF Touchet S/R	H	3	M	2	MH	2.5
SF Touchet S/R	*M*	*2*	*M*	*2*	*MM*	*2*
Foraging Migration and Overwintering CH						
Mill Cr FMO	H	3	H	3	HH	3
SF Touchet FMO	H	3	H	3	HH	3
NF Touchet FMO	M	2	H	3	MH	2.5
Wolf Fork Touchet FMO	M	2	H	3	MH	2.5

Moderate-high and high risk categories are at a significant risk to potential adverse effects that can affect the functional suitability of PCEs (Italic/Italic strikeout is additions/deletions due to the detailed analysis).

C.1.4 Item 4: Additional analysis for Puget Sound and Lower Columbia Units

C.1.4.1 *Baseline Section*

See Table I, which shows the BT matrix and the habitat conditions overlapped with the PCEs and the overall critical habitat condition ranking. The overall discussion of the crosswalk to the PCEs is located in Appendix D.

C.1.4.2 *Effects Section*

Table 1, of the bull trout Geographic Risk Analysis displays the exposure risk rankings for local populations and FMO habitats within the Puget Sound and Lewis River core area. Further FMO analysis of the individual stream systems, reveals that FMO areas in the Carbon, Puyallup, NF Stillaguamish, Stillaguamish, SF Nooksack, Nooksack, and Klickitat areas also rank high because of poor habitat conditions and moderate-high or high exposure (estimated at 20 to 40 percent adjacent FPHCP lands).

Additional GIS analysis was conducted on spawning and rearing and FMO habitat within the Puyallup, Nooksack, Stillaguamish, Snohomish/Skykomish, and Klickitat core areas to double check the exposure risk and overall potential risks of these critical habitat segments that were identified above in Table A as moderate-high and high overall potential risks.

Our analysis indicates spawning and rearing critical habitat segments in the action area are at high risk of exposure in Lower SF Nooksack and NF Stillaguamish local populations; at moderate risk of exposure in SF Stillaguamish, Lower NF Nooksack (including Maple Creek), and Lower MF Nooksack local populations; but is at low risk of exposure in the Carbon River local population. In addition, FMO critical habitat segments are at high risk of exposure in Carbon River, mainstem Puyallup, NF Stillaguamish, mainstem Stillaguamish, SF Nooksack, mainstem Nooksack, and Klickitat Rivers, and is at a moderate risk of exposure in all other FMO critical habitat stream segments. See Table K for validation of the exposure ranking of these critical habitat segments.

In terms of the of overall potential risk to potential adverse effects, spawning and rearing critical habitat segments in Lower SF Nooksack are at high risk; in the NF Stillaguamish are at moderate-high risk; SF Stillaguamish and Lower NF Nooksack, Lower MF Nooksack, and Upper MF Nooksack are at moderate risk; and Carbon River is at low risk. In terms of the overall potential risk to potential adverse effects to FMO critical habitat segments, Carbon, Puyallup, Klickitat Rivers are at high risk; NF Stillaguamish, Stillaguamish, SF Nooksack, and Nooksack are at moderate-high risk; and Deer Creek, Canyon Creek, White River, SF Stillaguamish River, and Lower NF Nooksack (including Kendall Creek) are at moderate risk. Table G shows a summary of the exposure risk of the local populations and FMO habitat, and the critical habitat baseline condition to give a final ranking in terms of the overall potential risk of critical habitat to adverse affects.

Table G. Final Overall Potential Risk for the Puget Sound Critical Habitat.

	CHU Exposure Risk		CHU Habitat Rating*		Overall Potential Risk	
CHU Name/function	**rank 1**	**score 1**	**rank 2**	**score 2**	**rank 3**	**score 3**
Spawning/Rearing CH						
Lower SF Nooksack S/R	H	3	H	3	HH	3
NF Stillaguamish S/R	H	3	M	2	HM	2.5
SF Stillaguamish S/R	M	2	M	2	MM	2
Lower NF Nooksack S/R (including Maple Cr)	M	2	M	2	MM	2
Lower MF Nooksack S/R	M	2	M	2	MM	2
Upper MF Nooksack S/R	M	2	M	2	MM	2
Carbon S/R	L	1	L	1	LL	1
Foraging Migration and Overwintering CH						
Carbon River FMO	H	3	H	3	HH	3
Puyallup FMO	H	3	H	3	HH	3
Klickitat River FMO	H	3	H	3	HH	3
NF Stilliguamish FMO	H	3	M	2	HM	2.5
Stilliguamish FMO	H	3	M	2	HM	2.5
SF Nooksack FMO	H	3	M	2	HM	2.5
Nooksack FMO	H	3	M	2	HM	2.5
White River FMO	M	2	M	2	MM	2
Deer Cr FMO	M	2	M	2	MM	2
Canyon Cr FMO	M	2	M	2	MM	2
SF Stilliguamish FMO	M	2	M	2	MM	2
Lower NF Nooksack (Kendall Cr) FMO	M	2	M	2	MM	2
Lower Skagit FMO	M	2	M	2	MM	2

Moderate-high and high risk categories are at a significant risk to potential adverse effects that can affect the functional suitability of PCEs.

C.1.5 Item 5: CHU Habitat Analysis for Unstable Slopes, Soils, Rain on Snow Areas, and Roads.

Within areas where we had a moderate high or high overall potential risk we reviewed road density, unstable slopes and high slope hazard areas, soil types, and rain on snow areas using multiple scale maps from WDNR. We anticipated that the magnitude of potential effects may be higher in areas where certain conditions exist that may tend to assist with the movements of sediments, wood, and alter riparian, stream temperature, and channel conditions. A summary of these conditions within areas of moderate-high and high overall potential risks are displayed in Table H.

Table H: Summary of Selected Watershed Characteristics of High and Moderate-High Risk Local populations and Critical Habitat Areas.

Core Area	Local Population or CH	ROS			High Slope Instability		31-49% Slope		Erosion Potential
		% in LP	% CH in LP	% CH in FMO	LP	FMO	LP	FMO	
Walla-Walla	SF Touchet	90	100	20	H	n/a	M	n/a	M
Yakima	Ahtanum Creek and CH[2]	50	70	25	L	L	L	M	M
Yakima	Teanaway River and CH[2]	40	90	25	L	L	M	M	H
Yakima	Upper Yakima and CH[2]	100	100	25	L	L	L	M	M
Wenatchee	Nason Creek	10	0	0	L	n/a	H	n/a	H
Entiat	Entiat River	20	0	0	L	n/a	H	n/a	H
Walla-Walla	NF Touchet and CH[2]	80	90	20	L	M	H	L	M
Walla-Walla	Wolf Fork Touchet	60	0	20	H	n/a	M	n/a	M
Pend Oreille	Le Clerc Creek and CH[2]	30	90	70	M	L	L	L	M
Yakima	Gold Creek	0	0	25	L	n/a	M	n/a	H
Wenatchee	White River	10	0	0	L	n/a	H	n/a	M
Entiat	Mad River	30	0	0	L	n/a	H	n/a	H
Stillaguamish	Upper Deer Creek	80	40	0	H	n/a	M	n/a	M
Yakima	Cle Elum River	60	90	25	M	n/a	M	n/a	H
Wenatchee	Little Wenatchee River	0	0	0	L	n/a	M	n/a	M
Wenatchee	Peshastin Creek	0	0	0	L	n/a	H	n/a	M
Methow	Goat Creek	30	0	0	L	n/a	M	n/a	M
Methow	Gold Creek	30	0	0	L	n/a	M	n/a	H
Pend Oreille	Tacoma Creek CH	10	100	70	L	L	L	M	M
Nooksack	SF Nooksack CH	20	10	30	L	M	M	L	M
Nooksack	MF Nooksack CH	20	100	0	L	n/a	M	n/a	M
Walla-Walla	Mill Creek CH	100	100	10	L	L	M	L	M
Stillaguamish	NF Stillaguamish CH	10	10	0	M	M	M	L	H

Additional watershed condition analysis information for the Umatilla-WallaWalla River Basins CHU

Within the critical habitat areas where we had a moderate-high or high overall risk in Mill Creek and NF Touchet local populations and FMO habitats we looked at more site specific watershed conditions for rain on snow, soils, slope steepness and slope hazards, geology, and roads using additional GIS support. In Mill Creek and NF Touchet there is 80-100% of the local population in a rain on snow zone with 90-100% of the segments of spawning and rearing critical habitat affected; low slope instability and low to high amount of steep slopes in the local population exists, and the geology in the watershed has a moderate potential for soil erosion. Additionally 10-20% of the FMO is in a rain on snow zone; and has low-moderate amounts of slope instability and low amounts of steep slopes. The geology in the watersheds has a moderate potential for soil erosion. Road density on FPHCP lands in the Mill Creek local population is 5.07 miles per square mile with 2.49 miles of riparian road miles on FPHCP lands. In the NF Touchet miles local population there are 2.85 miles per square mile with 6.93 miles of riparian road miles on FPHCP lands. The magnitude of effects of the implementation of the FPHCP will likely be higher in these kinds of areas which tend to assist with the movements of sediments, wood, and alter riparian and channel conditions that cause changes in stream temperatures.

Additional watershed condition analysis information for the Middle Columbia River Basin CHU

Within the critical habitat areas where we had a high overall risk in the local populations (i.e., Ahtanum Creek, Teanaway River, and upper Mainstem Yakima) and FMO habitats, we looked at more site specific watershed conditions for rain on snow, soils, slope steepness and slope hazards, geology, and roads using additional GIS analyses. In Ahtanum Creek, 50% of the local population is in a rain on snow zone with 70% of the segments of spawning and rearing critical habitat affected. Low amounts of unstable slopes and steep slopes exist within the local population, but the geology in the watershed has a moderate potential for soil erosion. In the Teanaway River, 40% of the local population is in a rain on snow zone with 90% of the segments of spawning and rearing critical habitat affected. Low amounts of unstable slopes but moderate amounts of steep slopes exist within the local population, and the geology has a high potential for soil erosion. In the upper Mainstem Yakima local population, 100% of the local population is in a rain on snow zone with 100% of the segments of spawning and rearing critical habitat affected. Low amounts of unstable slopes and steep slopes exist within the local population, but the geology has a moderate erosion potential. Additionally, 25% of the FMO habitat is in a rain on snow zone and has low amounts of unstable slopes with moderate amounts of steep slopes. The geology in the watersheds has a moderate to high potential for soil erosion. Road density on FPHCP lands in the Ahtanum Creek local population is 3.34 miles per square mile with 24.75 miles of riparian road miles on FPHCP lands. In the Teanaway River potential local population, there are 2.01 miles per square mile with 14.47 miles of riparian road miles on FPHCP lands. The magnitude of effects of the implementation of the FPHCP will likely be higher in these types of areas which tend to assist with the movements of sediments, wood, and alter riparian and channel conditions that cause changes in stream temperatures.

Additional watershed condition analysis information for the NE Washington River Basins CHU

Within the critical habitat areas where we had a moderate-high or high overall risk in the local populations (i.e., LeClerc Creek and Tacoma Creek) and FMO habitats, we looked at more site specific watershed conditions for rain on snow, soils, slope steepness and slope hazards, geology, and roads using additional GIS analysis. In LeClerc Creek, 30% of the local population is in a rain on snow zone with 90% of the segments of spawning and rearing critical habitat affected. Moderate slope instability and low

amount of steep slopes exist within the local population, and the geology in the watershed has a moderate potential for soil erosion. In Tacoma Creek, 10% of the local population is in a rain on snow zone with 100% of the segments of spawning and rearing critical habitat affected. Low slope instability and low amounts of steep slopes exist within the local population. Additionally, 70% of the FMO habitat is in a rain on snow zone; and has low amounts of slope instability and steep slopes. The geology in the watersheds has a moderate potential for soil erosion. Road density on FPHCP lands in the LeClerc Creek local population is 3.17 miles per square mile with 6.15 miles of riparian road miles on FPHCP lands. In the Tacoma Creek potential local population, there are 2.82 miles per square mile with 0.72 miles of riparian road miles on FPHCP lands. The magnitude of effects of the implementation of the FPHCP will likely be higher in these types of areas which tend to assist with the movements of sediments, wood, and alter riparian and channel conditions that cause changes in stream temperatures.

Additional watershed condition analysis information for the Puget Sound CHU

Within the critical habitat areas where we had a moderate-high or high overall risk in S.Fork Nooksack, M. Fork Nooksack, and N.Fork Stillaguamish local populations and in FMO habitats in the Puyallup River, Carbon River, Nooksack River, M. Fork Nooksack, S.Fork Nooksack River, Stillaguamish River, and N. Fork Stillaguamish River we looked at more site specific watershed conditions for rain on snow, soils, slope steepness and slope hazards, geology, and roads using additional GIS support. In S. Fork Nooksack there is 20% of the local population in a rain on snow zone with 10% of the critical habitat spawning and rearing segments affected; and it has low amounts of unstable slopes but moderate amounts of steep slopes; and the geology in the watershed has a moderate erosion potential. In the M.Fork Nooksack there is 20% of the local population in a rain on snow zone but with 100% of the spawning and rearing critical habitat segments affected; it has low amounts of unstable slopes but moderate amounts of steep slopes; and the geology has a moderate erosion potential. In the N.Fork Stillaguamish there is 10% of the local population in a rain on snow zone and only 10% of the spawning and rearing critical habitat segments affected; it has moderate amounts of unstable and steep slopes, and a geology with a high potential for soil erosion. Additionally, 30% of the SFork Nooksack FMO is in a rain on snow zone and all FMO is has a moderate amount of unstable and steep slopes; and has a geology of moderate to high potential for soil erosion. Road density on FPHCP lands in the S.Fork Nooksack local population is 4.49 miles per square mile with 32.72 miles of riparian road miles on FPHCP lands. In the M.Fork Nooksack local population there are 3.53 miles per square mile with 6.82 miles of riparian road miles on FPHCP lands. In the N.Fork Stillaguamish local population there are 4.19 miles per square mile of roads on FPHCP lands with 6.77 miles of riparian road miles on FPHCP lands. The magnitude of effects of the implementation of the FPHCP will likely be higher in these kinds of areas which tend to assist with the movements of sediments, wood, and alter riparian and channel conditions that cause changes in stream temperatures.

C.1.6 Item 6: BT habitat matrix with PCE crosswalk

Table I. Bull Trout CHU Matrix Analysis for estimating a baseline condition for designated critical habitat (derived from the bull trout matrix analysis table used for estimating local population and FMO baseline habitat risk). (H; M; L= functioning at unacceptable risk; functioning at risk; and functioning appropriately)

						Bull Trout Habitat Matrix Crosswalk to PCEs for Critical Habitat**								
Core Area	**Local Pop'n/ Potential Local Pop'n**	**FMO**	**CHU Name/ Function**	**BT Local Pop. and FMO Exposure Rating**	**CHU S/R and FMO Exposure Rating**	**PCE 1,4,5,6,8 : Water Quality**	**PCE 1,4,6,8: Habitat Access**	**PCE 2,3,5,8: Habitat Elements**	**PCE 2,4,6,8: Channel Condition**	**PCE 2,4,5,8: Flow/ Hydrology**	**PCE 1,2,3,4,6,8: Watershed Conditions**	**Non-native fish: i.e Brook Trout Presence**	**PCE 2,3,6,7 : Prey Base**	**CHU Habitat Rating**
Yakima	Ahtanum Creek (includes N. and S. Forks)		Ahtanum S/R	H	H	H	M	H	H	H	H	H	H	H
			Ahtanum FMO		H	H	M	H	H	H	H	H	H	H
	~~American River*~~		~~n/a~~	~~M~~	~~n/a~~	~~L~~	~~L~~	~~M~~	~~M~~	~~M~~	~~L~~	~~M~~	~~L~~	~~n/a~~
	Box Canyon		Box Canyon S/R	L	n/a*	M	H	M	M	H	M	M	M	n/aA
	Bumping River		Bumping S/R	L	n/a*	H	H	M	H	H	M	H	H	n/a
			Bumping FMO		L	H	M	H	H	H	H	H	H	H
	Cle Elum River (includes Cooper and Waptus population)		Cle Elum S/R	M	L	H	H	M	M	H	H	H	H	H
			Cle Elum FMO		H	H	M	H	H	H	H	H	H	H
	~~Crow Creek~~		~~n/a~~	~~L~~	~~n/a~~	~~M~~	~~L~~	~~M~~	~~L~~	~~L~~	~~M~~	~~M~~	~~M~~	~~n/a~~

Table I. Bull Trout CHU Matrix Analysis for estimating a baseline condition for designated critical habitat (derived from the bull trout matrix analysis table used for estimating local population and FMO baseline habitat risk). (H; M; L= functioning at unacceptable risk; functioning at risk; and functioning appropriately) (continued)

						Bull Trout Habitat Matrix Crosswalk to PCEs for Critical Habitat**								
Core Area	**Local Pop'n/ Potential Local Pop'n**	**FMO**	**CHU Name/ Function**	**BT Local Pop. and FMO Exposure Rating**	**CHU S/R and FMO Exposure Rating**	**PCE 1,4,5,6,8 : Water Quality**	**PCE 1,4,6,8: Habitat Access**	**PCE 2,3,5,8: Habitat Elements**	**PCE 2,4,6,8: Channel Condition**	**PCE 2,4,5,8: Flow/ Hydrology**	**PCE 1,2,3,4,6,8: Watershed Conditions**	**Non-native fish: i.e Brook Trout Presence**	**PCE 2,3,6,7 : Prey Base**	**CHU Habitat Rating**
Yakima (continued)	~~Deep Creek~~		~~n/a~~	~~L~~	~~n/a~~	~~L~~	~~H~~	~~L~~	~~H~~	~~L~~	~~M~~	~~M~~	~~M~~	~~n/a~~
	Gold Creek		Gold S/R	H	M	M	H	M	H	H	L	M	M	M
	~~Indian Creek~~		~~n/a~~	~~L~~	~~n/a~~	~~L~~	~~H~~	~~M~~	~~M~~	~~L~~	~~L~~	~~M~~	~~M~~	~~n/a~~
	Kachess River		Kachess S/R	L	n/a	M	H	M	H	M	H	M	M	n/a
			Kachess FMO		H	H	M	H	H	H	H	H	H	H
	Teanaway River (includes tribs & NF Teanaway)		Teanaway S/R	H	H	H	H	H	H	H	H	M	H	H
			Teanaway FMO		H	H	M	H	H	H	H	H	H	H
	NF Tieton River		NF Tieton S/R	L	L	M	H	M	M	M	M	H	M	M
	Rattlesnake Creek		Rattlesnake S/R	M	M	M	M	M	M	M	M	M	M	M
			Rattlesnake FMO		n/a									n/a
	~~SF Tieton River~~		~~n/a~~	~~H~~	~~n/a~~	~~M~~	~~H~~	~~M~~	~~M~~	~~M~~	~~H~~	~~M~~	~~M~~	~~n/a~~
	Upper Yakima River		upper mainstem Yakima S/R	H	H	H	H	H	H	H	H	H	H	H
			upper mainstem Yakima FMO		H	H	M	H	H	H	H	H	H	H
			Naches FMO		H	H	M	H	H	H	H	H	H	H

Table I. Bull Trout CHU Matrix Analysis for estimating a baseline condition for designated critical habitat (derived from the bull trout matrix analysis table used for estimating local population and FMO baseline habitat risk). (H; M; L= functioning at unacceptable risk; functioning at risk; and functioning appropriately) (continued)

						Bull Trout Habitat Matrix Crosswalk to PCEs for Critical Habitat**								
Core Area	**Local Pop'n/ Potential Local Pop'n**	**FMO**	**CHU Name/ Function**	**BT Local Pop. and FMO Exposure Rating**	**CHU S/R and FMO Exposure Rating**	**PCE 1,4,5,6,8 : Water Quality**	**PCE 1,4,6,8: Habitat Access**	**PCE 2,3,5,8: Habitat Elements**	**PCE 2,4,6,8: Channel Condition**	**PCE 2,4,5,8: Flow/ Hydrology**	**PCE 1,2,3,4,6,8: Watershed Conditions**	**Non-native fish: i.e Brook Trout Presence**	**PCE 2,3,6,7 : Prey Base**	**CHU Habitat Rating**
Yakima (continued)			Tieton FMO		H	H	M	H	H	H	H	H	H	H
	~~Taneum Creek (Potential local population)~~		~~n/a~~	~~M~~	~~n/a~~	~~H~~	~~H~~	~~M~~	~~M~~	~~M~~	~~H~~	~~H~~	~~H~~	~~n/a~~
		**** Yakima River (sum all FMO for core area)		H	n/a	H	M	H	H	H	H	H	H	n/a
Pend Oreille			Calispell Cr FMO		H	H	H	H	H	H	H	H	H	H
	Cedar Creek PLP		Cedar Cr S/R	M	M	M	H	M	M	M	M	H	H	M
	~~Harvey Creek PLP*~~		~~n/a~~	~~M~~	~~n/a~~	~~M~~	~~H~~	~~M~~	~~M~~	~~M~~	~~M~~	~~H~~	~~H~~	~~n/a~~
	Indian Creek PLP		Indian Cr S/R	H	M	M	M	M	M	M	M	H	H	M
	Le Clerc Creek		Le Clerc Cr S/R (including E. Branch and W. Branch LeClerc Cr, Fourth of July Cr)	H	M	M	M	H	M	M	H	H	H	H
			Le Clerc Cr FMO		M	H	H	H	H	H	H	H	H	H

Table I. Bull Trout CHU Matrix Analysis for estimating a baseline condition for designated critical habitat (derived from the bull trout matrix analysis table used for estimating local population and FMO baseline habitat risk). (H; M; L= functioning at unacceptable risk; functioning at risk; and functioning appropriately) (continued)

						Bull Trout Habitat Matrix Crosswalk to PCEs for Critical Habitat**								
Core Area	**Local Pop'n/ Potential Local Pop'n**	**FMO**	**CHU Name/ Function**	**BT Local Pop. and FMO Exposure Rating**	**CHU S/R and FMO Exposure Rating**	**PCE 1,4,5,6,8 : Water Quality**	**PCE 1,4,6,8: Habitat Access**	**PCE 2,3,5,8: Habitat Elements**	**PCE 2,4,6,8: Channel Condition**	**PCE 2,4,5,8: Flow/ Hydrology**	**PCE 1,2,3,4,6,8: Watershed Conditions**	**Non-native fish: i.e Brook Trout Presence**	**PCE 2,3,6,7 : Prey Base**	**CHU Habitat Rating**
Pend Oreille (continued)	Mill Creek PLP		Mill Cr S/R	L	L	M	H	H	H	H	H	H	H	H
	Ruby Creek PLP		Ruby Cr S/R	L	M	M	M	H	H	M	H	M	M	M
			Ruby Cr FMO		n/a	H	H	H	H	H	H	H	H	n/a
	Slate Creek PLP		Slate Cr S/R	L	M	M	M	H	H	H	M	M	M	M
			Slate Cr FMO		n/a	H	H	H	H	H	H	H	H	n/a
	Small Creek PLP		Small Cr S/R (including EF Small Cr)	M	M	M	M	M	M	M	M	H	H	M
			Small Creek FMO		H	H	H	H	H	H	H	H	H	H
	South Fork Tacoma Creek PLP		SF Tacoma Cr S/R	M	M	M	M	M	M	M	M	H	H	M
			SF Tacoma Cr FMO		n/a	H	H	H	H	H	H	H	H	n/a
	Sullivan Creek PLP		Sullivan Cr S/R	L	n/a	M	H	M	M	H	M	H	H	n/a
			Sullivan Cr FMO		M	H	H	H	H	H	H	H	H	H
	Tacoma Creek PLP		Tacoma Cr S/R	L	H	M	H	H	H	M	H	H	H	H
			Tacoma Cr FMO		M	H	H	H	H	H	H	H	H	H
		****Pend Oreille (all FMO)		L	n/a	H	H	H	H	H	H	H	H	n/a

Table I. Bull Trout CHU Matrix Analysis for estimating a baseline condition for designated critical habitat (derived from the bull trout matrix analysis table used for estimating local population and FMO baseline habitat risk). (H; M; L= functioning at unacceptable risk; functioning at risk; and functioning appropriately) (continued)

						Bull Trout Habitat Matrix Crosswalk to PCEs for Critical Habitat**								
Core Area	**Local Pop'n/ Potential Local Pop'n**	**FMO**	**CHU Name/ Function**	**BT Local Pop. and FMO Exposure Rating**	**CHU S/R and FMO Exposure Rating**	**PCE 1,4,5,6,8 : Water Quality**	**PCE 1,4,6,8: Habitat Access**	**PCE 2,3,5,8: Habitat Elements**	**PCE 2,4,6,8: Channel Condition**	**PCE 2,4,5,8: Flow/ Hydrology**	**PCE 1,2,3,4,6,8: Watershed Conditions**	**Non-native fish: i.e Brook Trout Presence**	**PCE 2,3,6,7 : Prey Base**	**CHU Habitat Rating**
Priest Lake	Granite Creek		Granite Cr S/R	M	n/a	M	M	M	M	M	M	M		n/a
		Priest Lake (all FMO)		L	n/a	M	H	M	M	H	H	H		n/a
Klickitat	WF Klickitat		WF Klickitat S/R		n/a									n/a
		Klickitat (all FMO)	Klickitat FMO	M	M	H	H	H	H	H	H	M	H	H
Walla Walla	Mill Creek		Mill Cr S/R	H	M	H	H	H	H	H	H	M	H	H
			Mill Cr FMO		H	H	H	H	H	H	H	M	H	H
			Yellowhawk Cr		n/a*									n/a
	NF Touchet River		NF Touchet S/R	H	H	M	M	M	H	M	M	M	M	M
			NF Touchet FMO		M	H	H	H	H	H	H	M	H	H
	SF Touchet River		SF Touchet S/R	H	M	H	M	H	M	M	H	M	M	M
			SF Touchet FMO		H	H	H	H	H	H	H	M	H	H
	Wolf Fork Touchet		Wolf Fork Touchet S/R	H	n/a	H	M	M	M	M	M	M	M	n/a

Table I. Bull Trout CHU Matrix Analysis for estimating a baseline condition for designated critical habitat (derived from the bull trout matrix analysis table used for estimating local population and FMO baseline habitat risk). (H; M; L= functioning at unacceptable risk; functioning at risk; and functioning appropriately) (continued)

						Bull Trout Habitat Matrix Crosswalk to PCEs for Critical Habitat**								
Core Area	**Local Pop'n/ Potential Local Pop'n**	**FMO**	**CHU Name/ Function**	**BT Local Pop. and FMO Exposure Rating**	**CHU S/R and FMO Exposure Rating**	**PCE 1,4,5,6,8 : Water Quality**	**PCE 1,4,6,8: Habitat Access**	**PCE 2,3,5,8: Habitat Elements**	**PCE 2,4,6,8: Channel Condition**	**PCE 2,4,5,8: Flow/ Hydrology**	**PCE 1,2,3,4,6,8: Watershed Conditions**	**Non-native fish: i.e Brook Trout Presence**	**PCE 2,3,6,7 : Prey Base**	**CHU Habitat Rating**
Walla Walla (continued)			Wolf Fork Touchet FMO		M	H	H	H	H	H	H	M	H	H
			Walla Walla mainstem FMO		n/a	H	H	H	H	H	H	M	H	H
		****Walla Walla (all FMO)	n/a	M	n/a	H	H	H	H	H	H	M	H	n/a
Asotin	Wormell Gulch PLP		Wormell Gultch S/R	M	n/a	H	H	H	H	H	H	M		n/a
			George Cr S/R		n/a									n/a
	Charley Creek		Charley Cr S/R	L	n/a									n/a
	NF Asotin		NF Asotin S/R	L	L									M (unknwn so used Mod as default)
		Asotin FMO	Asotin FMO	L	n/a									n/a
Tucannon R	Cummings Creek		Cummings Cr S/R	L	L									M (unknwn so used Mod as default)
	Hixon Creek PLP		Hixon Cr S/R	L	n/a									n/a
	Little Tucannon PLP			L	n/a									n/a

Table I. Bull Trout CHU Matrix Analysis for estimating a baseline condition for designated critical habitat (derived from the bull trout matrix analysis table used for estimating local population and FMO baseline habitat risk). (H; M; L= functioning at unacceptable risk; functioning at risk; and functioning appropriately) (continued)

						Bull Trout Habitat Matrix Crosswalk to PCEs for Critical Habitat**								
Core Area	**Local Pop'n/ Potential Local Pop'n**	**FMO**	**CHU Name/ Function**	**BT Local Pop. and FMO Exposure Rating**	**CHU S/R and FMO Exposure Rating**	**PCE 1,4,5,6,8 : Water Quality**	**PCE 1,4,6,8: Habitat Access**	**PCE 2,3,5,8: Habitat Elements**	**PCE 2,4,6,8: Channel Condition**	**PCE 2,4,5,8: Flow/ Hydrology**	**PCE 1,2,3,4,6,8: Watershed Conditions**	**Non-native fish: i.e Brook Trout Presence**	**PCE 2,3,6,7 : Prey Base**	**CHU Habitat Rating**
Tucannon R (continued)	Panjab Creek			L	n/a									n/a
	Meadow Creek			L	n/a									n/a
	Tucannon River		Tucannon R S/R	M	n/a									n/a
		Tucannon FMO	Tucannon R FMO	L	n/a									n/a
Puyallup R	Upper White River		White R S/R (also includes Crystal, Huckleberry, Kickitat, Frying Pan Creeks - all upstream in the park)	L	n/a									n/a
			White R. FMO		M	M	L	M	M		H	n/a	M	M
	WF White River		WF White R S/R (all upstream in the park)	L	n/a									n/a
	Carbon River		Carbon R mainstem S/R (Ipsut and Ranger Creeks are upstream in park)	H	n/a	L	L	L	L	L	L	H	L	n/a
			Carbon R. FMO		H	M	L	M	M		H	n/a	M	M

Table I. Bull Trout CHU Matrix Analysis for estimating a baseline condition for designated critical habitat (derived from the bull trout matrix analysis table used for estimating local population and FMO baseline habitat risk). (H; M; L= functioning at unacceptable risk; functioning at risk; and functioning appropriately) (continued)

						Bull Trout Habitat Matrix Crosswalk to PCEs for Critical Habitat**								
Core Area	**Local Pop'n/ Potential Local Pop'n**	**FMO**	**CHU Name/ Function**	**BT Local Pop. and FMO Exposure Rating**	**CHU S/R and FMO Exposure Rating**	**PCE 1,4,5,6,8 : Water Quality**	**PCE 1,4,6,8: Habitat Access**	**PCE 2,3,5,8: Habitat Elements**	**PCE 2,4,6,8: Channel Condition**	**PCE 2,4,5,8: Flow/ Hydrology**	**PCE 1,2,3,4,6,8: Watershed Conditions**	**Non-native fish: i.e Brook Trout Presence**	**PCE 2,3,6,7 : Prey Base**	**CHU Habitat Rating**
Puyallup R (continued)	Upper Puyallup and Mowich Rivers		Upper Puyallup S/R (all excluded)	H	n/a	L	M	H	M	H	H	M	H	H
			Mowich R S/R (all upstream in park)	H	n/a	L	M	H	M	H	H	M	H	H
		Puyallup FMO	Puyallup FMO	H	H	M	M	H	H	M	H	n/a	M	H
Stillaguamish	NF Stillaguamish River		NF Stillaguamish S/R	M	H	M	L	M	M	L	M	M	M	M
			NF Stillaguamish FMO		H	M	L	M	L	L	M	n/a	M	M
	Upper Deer Creek		Upper Deer Cr S/R	M	n/a	H	L	H	H		M	M	H	n/a
			Deer Cr FMO		M	M	L	M	M			n/a	M	M
	Canyon Creek		Canyon Cr S/R	L	n/a									n/a
			Canyon Cr FMO		M	M	L	M	M			n/a	M	M
	SF Stillaguamish		SF Stillaguamish S/R		n/a									n/a
			SF Stillaguamish FMO		M	M	L	M	L	L	M	n/a	M	M

Table I. Bull Trout CHU Matrix Analysis for estimating a baseline condition for designated critical habitat (derived from the bull trout matrix analysis table used for estimating local population and FMO baseline habitat risk). (H; M; L= functioning at unacceptable risk; functioning at risk; and functioning appropriately) (continued)

						Bull Trout Habitat Matrix Crosswalk to PCEs for Critical Habitat**								
Core Area	**Local Pop'n/ Potential Local Pop'n**	**FMO**	**CHU Name/ Function**	**BT Local Pop. and FMO Exposure Rating**	**CHU S/R and FMO Exposure Rating**	**PCE 1,4,5,6,8 : Water Quality**	**PCE 1,4,6,8: Habitat Access**	**PCE 2,3,5,8: Habitat Elements**	**PCE 2,4,6,8: Channel Condition**	**PCE 2,4,5,8: Flow/ Hydrology**	**PCE 1,2,3,4,6,8: Watershed Conditions**	**Non-native fish: i.e Brook Trout Presence**	**PCE 2,3,6,7 : Prey Base**	**CHU Habitat Rating**
Stillaguamish (continued)		Stillaguamish FMO	Stillaguamish FMO	H	H	M	L	M	L	L	M	n/a	M	M
Nooksack	Lower NF Nooksack R.		Kendell Cr FMO		M	H	M	M	M	H	M	n/a	M	M
			Maple Cr S/R		M	M	L	M	M	H	H	L	M	M
	~~Middle NF Nooksack R.~~		~~n/a~~		~~n/a~~	~~H~~	~~L~~	~~M~~	~~H~~	~~H~~	~~M~~	~~L~~		~~n/a~~
	~~Lower Canyon Creek~~		~~n/a~~		~~n/a~~									~~n/a~~
	~~Upper NF Nooksack R.~~		~~n/a~~		~~n/a~~									~~n/a~~
	~~Glacier Creek~~		~~n/a~~		~~n/a~~	~~L~~	~~M~~	~~L~~	~~M~~	~~L~~	~~L~~	~~L~~		~~n/a~~
	Lower MF Nooksack R.		MF Nooksack R. S/R		H	M	L	M	M	M	M	M	M	M
	Upper.MF Nooksack R.		Upper.MF Nooksack R. S/R		M	M	L	M	M	M	M	M	M	M
	Lower SF Noocksack R.		SF Nooksack S/R		H	H	L	H	H	H	H	M	H	H
			SF Nooksack FMO		H	H	M	M	M	H	M	n/a	M	M

Table I. Bull Trout CHU Matrix Analysis for estimating a baseline condition for designated critical habitat (derived from the bull trout matrix analysis table used for estimating local population and FMO baseline habitat risk). (H; M; L= functioning at unacceptable risk; functioning at risk; and functioning appropriately) (continued)

						Bull Trout Habitat Matrix Crosswalk to PCEs for Critical Habitat**								
Core Area	**Local Pop'n/ Potential Local Pop'n**	**FMO**	**CHU Name/ Function**	**BT Local Pop. and FMO Exposure Rating**	**CHU S/R and FMO Exposure Rating**	**PCE 1,4,5,6,8 : Water Quality**	**PCE 1,4,6,8: Habitat Access**	**PCE 2,3,5,8: Habitat Elements**	**PCE 2,4,6,8: Channel Condition**	**PCE 2,4,5,8: Flow/ Hydrology**	**PCE 1,2,3,4,6,8: Watershed Conditions**	**Non-native fish: i.e Brook Trout Presence**	**PCE 2,3,6,7 : Prey Base**	**CHU Habitat Rating**
Nooksack (continued)	~~Upper SF Nooksack R~~		~~n/a~~											
		Nooksack FMO	Nooksack FMO		H	H	M	M	M	H	M	n/a	M	M
Snoqualmie /Skykomish	SF Skykomish		SF Skykomish S/R	M	M	M	L	H	M	M	H	M	M	M
			NF Skykomish		n/a									n/a
			Snohomish/Skykomish FMO	M	M	M	L	M	M	L	H	n/a	M	M
Lower Skagit	19/1PLP		All S/R habitat		n/a									n/a
		Lower Skagit FMO	Lower River Skagit FMO	M	M	M	L	M	H	M	H	n/a	M	M

* Strikeout lines = no designated Critical Habitat within these local populations; n/a = local population has CH designated but only one of S/R or FMO critical habitat is designated; n/a = no FPHCP lands interspersed or upslope of designated ritical habitat

** Used bull trout habitat conditions to characterize PCEs with addional category of forage base and then recalculated the overal condition rating (see appendix D).

*** Criteria for used For Forage base

H Bull trout habitat is ranked at a high risk for bull trout; OR connectivity is lacking or is not available for migration to a larger river, lake, or estuary to allow forage; OR there are no anadromous fish.

M Bull trout habitat is ranked at moderate risk for bull trout; OR partial connectivity is available for migration to a larger river, lake, or estuary where adequate forage base exists; OR there are few anadromous fish or runs; OR forage base is unknown

L Bull trout habitat is ranked at a low risk for bull trout; OR partial or full connectivity is available for migration to a larger river, lake, or estuary where adequate forage base exists; OR there are strong populations of anadromous fish .

**** Used Core area FMO condition ranking to rank individual FMO for the CH FMO segments located within the stream of the local populations

C.1.7 Item 7: First cut at estimating exposure of critical habitat adjacent to or interspersed with FPHCP lands.

Table J is the output of an analysis where we looked at areas of critical habitat and FP lands that are immediately upslope or interspersed and it generates the estimate of exposure. We did not look at lands outside farther upslope than the immediate area of the critical habitat. We looked at what the percentage of the spawning and rearing or FMO habitats were mapped as critical habitat from a course scale map (1:100,000) and sometimes using more precise scales to help in difficult areas. We also looked at the percent o f FPHCP lands that were upslope or interspersed in these segments of mapped critical habitat. We then ranked the overall exposure based on criteria. For spawning and rearing segments of critical habitat we used minor, moderate, and significant (<10%, 10%, and >10% respectively) for estimating the amount of spawning and rearing segments in comparison to overall spawning and rearing habitat as well as for the estimating the amount of FPHCP lands that were upslope or interspersed with critical habitat segments. For FMO segments of critical habitat we used (<20%, 20%, and >20%) for estimating the amount of FMO segments in comparison to the overall amount of FMO habitat and then (<20, 20-40%, >40%) for the estimating the amount of FPHCP lands that were upslope or interspersed with critical habitat segments. The FMO is generally considered more resilient than spawning and rearing habitat and was given the higher percentage to reflect that.

Table J. Exposure risk ranking for CHUs.

Core Area	Local Population/Potential Local Population	FMO	CH name/use	Visual estimate of the % of all Spawning/ Rearing and FMO	Visual estimate of the % of FPHCP lands Interspersed or upslope of CH	Exposure ranking*
Yakima	Ahtanum Creek (includes N and S Forks)		Ahtanum S/R	60	95	H
			Ahtanum FMO	95	60	H
	Box Canyon		Box Canyon S/R	50	0	n/a**
	Bumping River		n/a			
			Bumping FMO	20 of total; 20 below dam	<10	L
	Cle Elum River (includes Cooper and Waptus population)		Cle Elum S/R	<10	<10	L
			Cle Elum FMO	40 of total but <10 above dam; 80 below dam	95	H
	Gold Creek		Gold S/R	<10	90	M
	Kachess River		Kachess S/R	10	0	n/a
			Kachess FMO	10 of total but <10 above dam; 100 below dam	90	H
	Teanaway River (includes tribs & NF Teanaway)		Teanaway S/R	95	90	H

Table J. Exposure risk ranking for CHUs. (continued)

Core Area	Local Population/Potential Local Population	FMO	CH name/use	Visual estimate of the % of all Spawning/ Rearing and FMO	Visual estimate of the % of FPHCP lands Interspersed or upslope of CH	Exposure ranking*
Yakima (continued)			Teanaway FMO			H
	NF Tieton		NF Tieton S/R	<10	<10	L
	Rattlesnake Creek		Rattlesnake S/R	<1	95	M
	Upper Yakima River		upper mainstem Yakima S/R	10	95	H
		Yakima FMO	upper mainstem Yakima FMO	95	80	H
			Naches FMO	75	90	H
			Tieton FMO	60	90	H
Pend Orielle			Calispell Cr FMO	100	50%	H
	Cedar Creek PLP		Cedar Creek S/R	16%	14%	M
	Indian Creek PLP		Indian Creek S/R	80%	60%	H
	Le Clerc Creek		Le Clerc Cr S/R (including E. Branch and W. Branch LeClerc Cr, Fourth of July Cr)	20%	80%	H
			Le Clerc Cr FMO	n/a		n/a
	Mill Creek PLP		Mill Cr S/R	5%	10%	L
	Ruby PLP		Ruby Cr S/R	<10%	0	n/a
	Slate PLP		Slate Cr S/R	5%	0	n/a
	Small Creek PLP		Small S/R (including EF Small Cr S/R)	70%	50%	H
	SF Tacoma Creek PLP		SF Tacoma Cr S/R	13%	95%	H
			SF Tacoma Cr FMO	~50%	50%	H
	Sullivan Creek PLP		Sullivan Cr S/R	n/a		n/a
			Sullivan Cr FMO	10%	95%	M
	Tacoma Creek PLP		Tacoma Cr S/R	15%	95%	M
			Tacoma Cr FMO	~50%	80%	H
		~~Pend Orielle FMO~~	-	~~n/a~~	-	~~n/a~~
Walla Walla	Mill Creek		Mill Cr S/R (the NF portion in WA)	13% (1/2 in WA)	50%	M
			Mill Cr FMO	100%	90%	H

Table J. Exposure risk ranking for CHUs. (continued)

Core Area	Local Population/Potential Local Population	FMO	CH name/use	Visual estimate of the % of all Spawning/ Rearing and FMO	Visual estimate of the % of FPHCP lands Interspersed or upslope of CH	Exposure ranking*
Walla Wall (continued)			Yellowhawk Cr FMO	100%	0%	n/a
	NF Touchet		NF Touchet S/R (Spangler and Lewis are excluded)	50%	50%	H
			NF Touchet FMO	100%	<1%	M
	SF Touchet		SF Touchet S/R	13%	90%	H
			SF Touchet FMO	90%	30%	H
	Wolf Fork Touchet		Wolf Fork Touchet S/R	n/a		n/a
			Wolf Fork Touchet FMO	30%	15%	M
	Walla Walla (in OR)		Walla Walla FMO (in WA)	100%	0	n/a
		~~Walla Walla (all FMO)~~				

*Exposure criteria

Criteria for S/R:

L=If minor amount of S/R and minor (<10%) amount of interspersed or upslope FPHCP lands

M=If minor amount of S/R and moderate to significant (>10%) amount of interspersed or upslope FPHCP lands

M=If moderate amount of S/R and minor (<10%) or moderate (>10%) amount of interspersed or upslope FPHCP lands

M=If significant amount of S/R and minor (<10%) amount of intersperested or upslope FPHCP lands

H=If significant amount of S/R and moderate (>10%) amount of interspersed or upslope FPHCP lands

H=If moderate or significant amount of S/R and significant (>10%) amount of interspersed or upslope FPHCP lands

Criteria for FMO:

L=If minor amount of FMO and minor (<20%) amount of interspersed or upslope FPHCP lands

M=If minor amount of FMO and moderate (20-40%) or significant (>40%) amount of interspersed or upslope FPHCP lands

M=If moderate amount of FMO and minor (<20%) or moderate (20-40%) amount of interspersed or upslope FPHCP lands

M=If significant amount of FMO and minor (<20%) amount of intersperested or upslope FPHCP lands

H=If significant amount of FMO and moderate (20-40%) amount of interspersed or upslope FPHCP lands

H=If moderate or significant amount of FMO and significant (40%) amount of interspersed or upslope FPHCP lands

**No FPHCP lands interspersed or upslope of these segments of CH

C.1.8 Item 8: Second cut at estimating exposure of critical habitat adjacent to or interspersed with FPHCP lands for the overall moderate-high and high risk segments identified in Table J.

Table K is the output of an analysis where we re-evaluated areas of critical habitat that were identified as a moderate-high or a high or where habitat had ranked out as a high risk in the bull trout geographic risk analysis. The re-evaluation looked site specifically at each area of critical habitat and redefined the exposure rankings and consequently led to some changes in the overall risk scores in Tables B, D, F, and

G. and FP lands that are immediately upslope or interspersed and it generates the estimate of exposure. We did not look at lands outside the immediate vicinity of the critical habitat. We looked at what the percentage of the spawning and rearing or FMO habitats were mapped as critical habitat from a course scale map (1:100,000) and sometimes using more precise scales to help in difficult areas. We also looked at the percent o f FPHCP lands that were upslope or interspersed in these segments of mapped critical habitat. We then ranked the overall exposure based on criteria. For spawning and rearing segments of critical habitat we used minor, moderate, and significant (<10%, 10%, and >10% respectively) for estimating the amount of spawning and rearing segments in comparison to overall spawning and rearing habitat as well as for the estimating the amount of FPHCP lands that were upslope or interspersed with critical habitat segments. For FMO segments of critical habitat we used (<20%, 20%, and >20%)) for estimating the amount of FMO segments in comparison to the overall amount of FMO habitat and then (<20, 20-40%, >40%) for the estimating the amount of FPHCP lands that were upslope or interspersed with critical habitat segments. The FMO is generally considered more resilient than spawning and rearing habitat and was given the higher percentage to reflect that.

Table K. Reevaluation of those CH segments that were High or Mod High in the overall ranking, and other segments that were determined to need further evaluation (3-29-06 JD).

Core Area	Local Population/Potential Local Population	FMO	CH name/use	First cut at visual estimate of the % of all Spawning/ Rearing and FMO	More precise visual estimate of the % of actual CH within redlines****	Second cut at a visual estimate of actual spawning/rearing and FMO of mod-high to high risk CH	Visual estimate of the % of FPHCP lands Interspersed or upslope of CH	Validation Exposure ranking**
Yakima	Ahtanum Creek (includes N. and S. Forks)		Ahtanum S/R (includes N. and S. Forks)	40	20	30	80	H
		Yakima FMO	Ahtanum FMO	100	80	90	90	H
	Teanaway River (includes tribs & NF Teanaway)		Teanaway S/R (includes mainstem,Jungle, and Jack)	40	40	15	35	H
		Yakima FMO	Teanaway FMO	95	50	50	90	H
	Rattlesnake Creek		Rattlesnake S/R	2	50	1	85	M
	Upper Yakima River		upper mainstem Yakima S/R	10	100	10	75	H
		Yakima FMO	upper mainstem Yakima FMO	95	80	75	90	H
	Cle Elum River (includes Cooper and Waptus population)	Yakima FMO	Cle Elum FMO	40 of total but <10 above dam; 80 below dam	20 of total but 80 below dam	20 of total but 80 below dam	95	H
	Kachess River	Yakima FMO	Kachess FMO	10 of total but <10 above dam; 100 below dam	100	10 of total but 100 below dam	90	H
		Yakima FMO	Naches FMO	75	100	75	90	H
		Yakima FMO	Tieton FMO	60	100	60	90	H
NE Washington	Indian Creek PLP		Indian Creek S/R	50	15	7.5	60	M
	Le Clerc Creek		Le Clerc Creek S/R (including E. Branch and W. Branch LeClerc Cr, Fourth of July Cr)	40	10	4	80	M

Table K. Reevaluation of those CH segments that were High or Mod High in the overall ranking, and other segments that were determined to need further evaluation (3-29-06 JD). (continued)

Core Area	Local Population/Potential Local Population	FMO	CH name/use	First cut at visual estimate of the % of all Spawning/ Rearing and FMO	More precise visual estimate of the % of actual CH within redlines****	Second cut at a visual estimate of actual spawning/rearing and FMO of mod-high to high risk CH	Visual estimate of the % of FPHCP lands Interspersed or upslope of CH	Validation Exposure ranking**
NE Washington (continued)			Le Clerc Creek FMO	11	100	11	50	M
	Ruby PLP		Ruby Cr S/R	10	<1	<0.1	95	M
	Slate PLP		Slate Cr S/R	5	60	3	50	M
	Small Creek PLP		Small S/R- including EF Small Cr S/R	20	15	3	95	M
			Small Creek FMO	100	100	100	20	H
	SF Tacoma Creek PLP		SF Tacoma Creek S/R-	13	7	1	95	M
			Sullivan Creek FMO	10	100	10	95	M
	Tacoma Creek PLP		Tacoma Creek S/R	25	60	15	95	H
			Tacoma Creek FMO	100	100	100	10	M
			Calispell Cr FMO	100	100	100	30	H
Walla Walla	Mill Creek		Mill Creek S/R (the NF portion in WA);	10	3	0.3	95	M
			Mill Creek FMO	100	50	50	90	H
	North Fork Touchet		NF Touchet-S/R (Spangler and Lewis are excluded)	50	85	40	50	H
			NF Touchet FMO	100	100	100	<1%	M
	SF Touchet		SF Touchet S/R	13	7	1	90	M
			SF Touchet FMO	75	80	60	40	H
	Wolf Fork Touchet		Wolf Fork Touchet FMO	30	20	6	20	M
Klickitat		Klickitat FMO	Klickitat R FMO	60	30	18	80	M

Table K. Reevaluation of those CH segments that were High or Mod High in the overall ranking, and other segments that were determined to need further evaluation (3-29-06 JD). (continued)

Core Area	Local Population/Potential Local Population	FMO	CH name/use	First cut at visual estimate of the % of all Spawning/ Rearing and FMO	More precise visual estimate of the % of actual CH within redlines****	Second cut at a visual estimate of actual spawning/rearing and FMO of mod-high to high risk CH	Visual estimate of the % of FPHCP lands Interspersed or upslope of CH	Validation Exposure ranking**
Puyallup			White R. FMO	50	10	5	90	M
	Carbon R		Carbon R mainstem S/R (Ipsut and Ranger Creeks are excluded)	25	30	7.5	0	n/a
			Carbon R. FMO	80	40	32	75	H
	Upper Puyallup and Mowich Rivers		Upper Puyallup S/R (all excluded)	0	100	0	n/a	n/a
			Mowich R (all upstream in park)	100	100	100	0	n/a**
			Puyallup FMO	100	40	40	70	H
Stilliguamish	NF Stillaguamish River		NF Stillaguamish S/R	60	50	30	95	H
			NF Stillaguamish FMO	100	40	40	90	H
	Upper Deer Creek		Deer Creek S/R (All should be excluded)	20	0	0		n/a*
			Deer Creek FMO	50	20	10	95	M
	Canyon Creek		Canyon Creek S/R (all should be excluded)	30	0	0		n/a
			Canyon Creek FMO	100	5	5	90	M
			SF Stillaguamish S/R(all is excluded)	n/a				n/a
			SF Stillaguamish FMO (includes Jim Creek)	10	7	1	60	M
		Stillaguamish FMO	Stillaguamish FMO	100	70	70	60	H

Table K. Reevaluation of those CH segments that were High or Mod High in the overall ranking, and other segments that were determined to need further evaluation (3-29-06 JD). (continued)

Core Area	Local Population/Potential Local Population	FMO	CH name/use	First cut at visual estimate of the % of all Spawning/ Rearing and FMO	More precise visual estimate of the % of actual CH within redlines****	Second cut at a visual estimate of actual spawning/rearing and FMO of mod-high to high risk CH	Visual estimate of the % of FPHCP lands Interspersed or upslope of CH	Validation Exposure ranking**
Nooksack	Lower NF Nooksack R.		Kendell Cr FMO	60	100	60	30	M
			Maple Cr S/R	20	85	17	95	M
	~~Middle NF Nooksack R.~~		~~n/a*~~					
	~~L.Canyon Creek~~		~~n/a~~					
	~~Upper NF Nooksack R.~~		~~n/a~~					
	~~Glacier Creek~~		~~n/a~~					
	Lower MF Nooksack R.		Lower MF Nooksack R. S/R (includes Canyon Cr)	25	45	11	95	H
	Upper MF Nooksack R.		Upper MF Nooksack R. S/R	<1	100	<1	50	M
	Lower SF Noocksack R.		SF Nooksack R. S/R	50	50	25	75	H
			SF Nooksack FMO	100	25	25	75	H
	~~Upper SF Nooksack R.~~		~~n/a~~					
		Nooksack FMO	Nooksack FMO	60	100	60	50	H
Snoqualmie/Skykomish	SF Skykomish		SF Skykomish S/R	2	25	2	20	M
			Snohomish/Skykomish FMO	20	70	14	20	M
Lower Skagit	19/1PLP		All S/R habitat	n/a				
		Lower Skagit FMO		70	10	7	20	M
Asotin	Wormell Gulch PLP		Wormell Gulch S/R	n/a				n/a
			George Creek S/R	n/a				n/a
	Charley Creek		Charley Creek S/R	5	1	5	0	n/a
	NF Asotin		NF Asotin S/R	1	5	<5	<1	L

Table K. Reevaluation of those CH segments that were High or Mod High in the overall ranking, and other segments that were determined to need further evaluation (3-29-06 JD). (continued)

Core Area	Local Population/Potential Local Population	FMO	CH name/use	First cut at visual estimate of the % of all Spawning/ Rearing and FMO	More precise visual estimate of the % of actual CH within redlines****	Second cut at a visual estimate of actual spawning/rearing and FMO of mod-high to high risk CH	Visual estimate of the % of FPHCP lands Interspersed or upslope of CH	Validation Exposure ranking**
Asotin (continued)		Asotin FMO	Asotin FMO	100	100	100	0	n/a
Tucannon	Cummings Creek		Cummings Creek S/R	60	5	3	6	L
	Hixon Creek PLP		Hixon Creek S/R	5	<1	<5	0	n/a
	Little Tucannon PLP			n/a				n/a
	Panjab Creek			n/a				n/a
	Meadow Creek			n/a				n/a
	Tucannon River		Tucannon River S/R	3	<1	<3	0	n/a
		Tucannon FMO	Tucannon FMO	80	70	56	0	n/a

* No Critical Habitat in these local populations, all excluded.

** No FPHCP lands interspersed or upslope of these segments of CH

***Criteria used for ranking S/R and FMO exposures

Criteria for S/R

L=If minor amount of S/R (<10%) and minor (<10%) amount of interspersed or upslope FPHCP lands

M=If minor amount of S/R (<10%) and moderate to significant (>10%) amount of interspersed or upslope FPHCP lands

M=If moderate amount of S/R (10%) and minor (<10%) or moderate (>10%) amount of interspersed or upslope FPHCP lands

M=If significant amount of S/R (>10%) and minor (<10%) amount of intersperested or upslope FPHCP lands

H=If significant amount of S/R (>10%) and moderate (>10%) amount of interspersed or upslope FPHCP lands

H=If moderate or significant amount of S/R (≥10%) and significant (>10%) amount of interspersed or upslope FPHCP lands

Criteria for FMO

L=If minor amount of FMO (<20%) and minor (<20%) amount of interspersed or upslope FPHCP lands

M=If minor amount of FMO (<20%) and moderate (20-40%) or significant (>40%) amount of interspersed or upslope FPHCP lands

M=If moderate amount of FMO (20-40%) and minor (<20%) or moderate (20-40%) amount of interspersed or upslope FPHCP lands

M=If significant amount of FMO (>40%) and minor (<20%) amount of intersperested or upslope FPHCP lands

H=If significant amount of FMO (>40%) and moderate (20-40%) amount of interspersed or upslope FPHCP lands

H=If moderate or significant amount of FMO (20-40% or >40%) and significant (40%) amount of interspersed or upslope FPHCP lands

****% of actual CH within the redlines is based on a review of looking and zooming in on a GIS arcmaps to see where fphcp lands were in relation to forested and non forested lands. Where the redlines were in non forest lands it was determined to be actual CH. Non forested lands were determined by looking at quads maps of 1:24,000 scale and a map of National Land Cover Data set classification system of 1:100,000 scale.

APPENDIX D

Information for Crosswalk between the Bull Trout Matrix and the PCEs

This crosswalk information was developed originally for a USFWS BO for a restoration program consultation, however, the thought process is applicable to this effort. Table 1 is a crosswalk summary for the restoration BO. Several additional indicators were evaluated for the FPHCP habitat baseline. Table 2 is a crosswalk summary for the FPHCP analysis.

D.1 CROSSWALK BETWEEN BULL TROUT MATRIX AND CRITICAL HABITAT PCES DEVELOPED FOR DRAFT USFWS RESTORATION BO

The Matrix of Pathway Indicators (Matrix) for bull trout is used to evaluate and document baseline conditions and to aid in determining whether a project is likely to adversely affect or result in the incidental take of bull trout.

The Matrix analysis incorporates 4 biological indicators and 19 physical habitat indicators. The majority of the Matrix analysis consists of specific consideration of the 19 habitat indicators. Analysis of the these indicators should provide a thorough analysis of the existing baseline condition and potential impacts to bull trout habitat. While assessing potential effects to bull trout as a species, biologists can concurrently provide an analysis of effects to the primary constituent elements (PCEs) for bull trout critical habitat. Table 1 shows the relationship between the primary constituent elements (PCE) for bull trout critical habitat and the Matrix habitat indicators. The following information provides the rationale for how the PCEs for bull trout critical habitat can be thoroughly addressed by using the Matrix.

1. ***Water temperatures that support bull trout use. Bull trout have been documented in streams with temperatures from 32 to 72 ºF (0 to 22 ºC) but are found more frequently in temperatures ranging from 36 to 59 ºF (2 to 15 ºC). These temperature ranges may vary depending on bull trout life-history stage and form, geography, elevation, diurnal and seasonal variation, shade, such as that provided by riparian habitat, and local groundwater influence. Stream reaches with temperatures that preclude bull trout use are specifically excluded from designation.***

   This PCE is addressed directly by the analysis of *temperature*. It is also addressed through consideration of *refugia*, which by definition is high quality habitat of appropriate temperature. Availability of refugia is also considered in analysis of *pool frequency and quality* and *large pools*. *Average wetted width/maximum depth ratio* is an indication of water volume, which indirectly indicates water temperature, i.e., low ratios indicate deeper water, which in turn indicates possible refugia. This indicator in conjunction with *change in peak/base flows* is an indicator of potential temperature and refugia concerns particularly during low flow periods. *Streambank condition*, *floodplain connectivity*, r*oad density and location* and *riparian conservation areas* address the components of shade and groundwater influence, both of which are important factors of water temperature. Stable streambanks and intact riparian areas, which include part of the floodplain, typically support adequate vegetation to maintain thermal cover to streams during low flow periods. *Road density and location* addresses the potential contributions of warm water discharges from stormwater ponds.

2. ***Complex stream channels with features such as woody debris, side channels, pools, and undercut banks to provide a variety of depths, velocities, and instream structures.***

   Large woody debris increases channel complexity and creates pools and undercut banks, so the analysis of the current amounts and sources of *large woody debris* available for recruitment is pertinent to this PCE. *Pool frequency and quality* considers the number of pools per mile as well as the amount of cover and temperature of water in the pools. *Average wetted width/maximum*

depth ratio is an indicator of channel shape and pool quality. Low ratios suggest deeper, higher quality pools. *Large pools,* consisting of a wide range of water depths, velocities, substrates and cover, are typical of high quality habitat and are a key component of channel complexity. Analysis of *off-channel habitat* describes side-channels and other off-channel areas. *Streambank condition* analyzes the stability of the banks, including features such as undercut banks. The analysis of both *riparian conservation areas,* and *floodplain connectivity, disturbance history, and disturbance regime* includes the maintenance of habitat and channel complexity, the recruitment of large woody debris, and the connectivity to off-channel habitats or side channels. Complex habitats provide refugia for bull trout and in turn, analysis of *refugia* assesses complex stream channels. All of these habitat indicators consider the numerous characteristics of instream bull trout habitat and quantify critical components that are fundamental to creating and maintaining complex instream habitat over time.

3. ***Substrates of sufficient amount, size, and composition to ensure success of egg and embryo overwinter survival, fry emergence, and young-of-the-year and juvenile survival. This should include a minimal amount of fine substrate less than 0.25 inch (0.63 centimeter) in diameter.***

   The analyses for *sediment* and *substrate embeddedness* assess substrate composition and stability in relation to the various life stages of the bull trout as well as the sediment transportation and deposition. *Large woody debris* and *pool frequency and quality* affect sediment transport and redistribution within a stream and assessment of these indicators will clarify substrate composition and amounts. Analysis of *streambank condition* will provide insight into the amount of fine sediment contribution.

4. ***A natural hydrograph, including peak, high, low, and base flows within historic ranges or, if regulated, currently operate under a biological opinion that addresses bull trout, or a hydrograph that demonstrates the ability to support bull trout populations by minimizing daily and day-to-day fluctuations and minimizing departures from the natural cycle of flow levels corresponding with seasonal variation: This rule finds that reservoirs currently operating under a biological opinion that addresses bull trout provides management for PCEs as currently operated.***

   The analysis of *change in peak/base flows* considers changes in hydrograph amplitude or timing with respect to watershed size, geology, and geography. Analyses of *floodplain connectivity, increase in drainage network, road density and location, disturbance history,* and *riparian conservation areas* provides further information regarding possible interruptions in the natural stream hydrology. *Floodplain connectivity* considers the hydrologic linkage of off-channel areas with the main channel. Roads and vegetation management both have effects strongly linked to a stream's hydrograph. *Disturbance regime* ties this information together to consider how a watershed reacts to disturbance and the time required to recover back to pre-disturbance conditions.

5. ***Springs, seeps, groundwater sources, and subsurface water to contribute to water quality and quantity as a cold water source.***

   The analysis of *floodplain connectivity* considers the hydrologic linkage of off-channel areas with the main channel and overbank-flow maintenance of wetland function and riparian vegetation and succession. Floodplain and riparian areas provide hydrologic connectivity for springs, seeps, groundwater upwelling and wetlands and contribute to the maintenance of the water table. The

analysis of *changes in peak/base flows* addresses subsurface water connectivity and *substrate embeddedness* addresses inter-gravel flows. *Increase in drainage network* and *road density and location* address potential changes to groundwater sources and subsurface water connectivity. *Streambank condition, floodplain connectivity* and *riparian conservation areas* address groundwater influence. C*hemical contamination/nutrients* addresses concerns regarding groundwater water quality.

6. ***Migratory corridors with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and foraging habitats, including intermittent or seasonal barriers induced by high water temperatures or low flows.***

   Physical, biological or chemical barriers to migration are addressed directly through water quality habitat indicators, including *temperature, sediment, chemical contamination/nutrients* and *physical barriers*. The analysis of these indicators assess whether barriers have been created due to impacts such as high temperatures or high concentrations of turbidity or contaminants. Analysis of *change in peak/base flows* and *average wetted width/maximum depth ratio* assess whether changes in flow might create a seasonal barrier to migration. An analysis of *refugia* considers the habitat's ability to support strong, well distributed, and connected populations for all life stages and forms of bull trout.

7. ***An abundant food base including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.***

   Floodplain connectivity and *riparian conservation areas* provide habitat to aquatic invertebrates, which in turn provide a forage base for bull trout. *Pool frequency and quality* and *substrate embeddedness* contributes to the variety and density of aquatic invertebrates and other fish species. Changes in *temperature, sediment,* and *chemical contaminants and nutrients* affect aquatic invertebrate production.floodplain and riparian areas provide habitat to aquatic invertebrates, which in turn provide a forage base for bull trout. The combined analyses of all the Matrix habitat indicators and the other seven PCEs provide information to assess whether there is an abundant food base in the analysis area. Therefore, any impairment to the food base will be addressed by way of summarizing the biological and habitat indicators.

8. ***Permanent water of sufficient quantity and quality such that normal reproduction, growth, and survival are not inhibited.***

   The quantity of permanent water will be considered in the analyses for PCE 4 natural hydrograph and PCE 5 springs, seeps, and groundwater, which include *floodplain connectivity, changes in peak/base flows, drainage network increase, disturbance history,* and *disturbance regime*.

   Analysis of *temperature, sediment, and chemical contaminates and nutrients* consider the quality of permanent water. Current listing under 303(d) and 305(d) status should be considered, as well as the causes for that listing. Analysis pertinent to sediment should address turbidity.

Table 1. Relationship of Matrix habitat indicators to the Primary Constituent Elements of bull trout critical habitat.

Indicator	PCE 1 - Temperature	PCE 2 - Complex Stream Channel	PCE 3 - Substrate	PCE 4 - Natural Hydrograph	PCE 5 - Springs, seeps, groundwater	PCE 6 - Migratory corridors	PCE 7 - Abundant food base	PCE 8 - Permanent water
Water Quality								
Temperature	x					x	x	x
Sediment			x			x	x	x
Chemical Contaminants and Nutrients					x	x	x	x
Habitat Access								
Physical Barriers						x		
Habitat Elements								
Substrate Embeddedness			x		x		x	
Large Woody Debris		x	x					
Pool Frequency and Quality		x	x				x	
Large Pools	x	x						
Off-Channel Habitat		x						
Refugia	x	x				x		
Channel Conditions and Dynamics								
Wetted Width/Maximum Depth Ratio	x	x				x		
Streambank Condition	x	x	x		x			
Floodplain Connectivity	x	x		x	x		x	x
Flow/Hydrology								
Changes in Peak/Base Flows	x			x	x	x		x
Drainage Network Increase				x	x			x
Watershed Conditions								
Road Density and Location	x			x	x			
Disturbance History		x		x				x
Riparian Conservation Areas	x	x		x	x		x	
Disturbance Regime		x		x				x

Table 2. The crosswalk table used for the crosswalk for the PCEs for the FPHCP.

Indicator	PCE 1 - Temperature	PCE 2 - Complex Stream Channel	PCE 3 - Substrate	PCE 4 - Natural Hydrograph	PCE 5 - Springs, seeps, groundwater	PCE 6 - Migratory corridors	PCE 7 - Abundant food base[1]	PCE 8 - Permanent water
Water Quality								
Temperature	x*				x*	x*	x	x*
Sediment	x*		x	x*		x*	x	x*
Chemical Contaminants and Nutrients					x*	x*	x	x*
Habitat Access								
Physical Barriers	x*			x*		x*		x*
Habitat Elements								
Substrate Embeddedness		x*	x*		x*		x	
Large Woody Debris	x	x*	x*			x*	x	
Pool Frequency and Quality		x*	x*			x*	x	
Large Pools	x	x*	x*		x*	x*		
Off-Channel Habitat		x*			x*	x*		
Refugia	x	x*	x*		x*	x*		x
Channel Conditions and Dynamics								
Wetted Width/Maximum Depth Ratio	x	x*	x	x*		x*		x*
Streambank Condition	x	x*	x		x	x*	x	
Floodplain Connectivity	x	x*		x*	x	x*	x	x*
Flow/Hydrology								
Changes in Peak/Base Flows	x	x*	x	x*	x*	x		x
Drainage Network Increase	x	x*	x	x*	x*			x
Watershed Conditions								
Road Density and Location	x*	x*	x*	x*	x	x*	x	x*
Disturbance History	x*	x*	x*	x*	x	x*	x	x*
Riparian Conservation Areas	x*	x*	x*	x*	x	x*	x	x*
Disturbance Regime	x*	x*	x*	x*		x*	x	x*
Prey Base		x*	x*			x*	x	

Notes:

1/ Prey base is affected by changes in most habitat conditions and can be related to Water quality, Habitat elements, Channel conditions, and Watershed condition changes in the matrix. Changes to PCEs 2,3,6,and 7 directly affect amounts of food available in streams. Changes to headwater stream affect the primary production in the stream system or the 1st couple of levels in the trophic food pyramid for fish.

* Asterisks indicate PCEs affected by the associated habitat indicators for the FPHCP crosswalk.

Appendix E

Glossary of Bull Trout Technical Terms

CORE AREA

The combination of core habitat (*i.e.*, habitat that could supply all elements for the long-term security of bull trout) and a core population (a group of one or more local bull trout populations that exist within core habitat) constitutes the basic unit on which to gauge recovery. Core areas require both habitat and bull trout to function, and the number (replication) and characteristics of local populations inhabiting a core area provide a relative indication of the core area's likelihood to persist. In most cases, core areas are presumed to reflect the metapopulation structure of bull trout (see "metapopulation," below).

CORE HABITAT

Habitat that encompasses spawning and rearing habitat (resident populations), with the addition of foraging, migrating, and overwintering habitat if the population includes migratory fish. Core habitat is defined as habitat that contains, or if restored would contain, all of the essential physical elements to provide for the security of and allow for the full expression of life history forms of one or more local populations of bull trout. Core habitat may include currently unoccupied habitat if that habitat contains essential elements for bull trout to persist or is deemed critical to recovery.

CORE POPULATION

A group of one or more bull trout local populations that exist within core habitat.

DISTINCT POPULATION SEGMENT

A distinct population segment is a population subset of a vertebrate species or subspecies that meets the tests of discreteness and significance under the joint policy of the U.S. Fish and Wildlife Service and National Marine Fisheries Service (61 FR 4722). A distinct population segment designated as such under a regulatory rulemaking is a "listable entity" under the Endangered Species Act.

LOCAL POPULATION

A group of bull trout that spawn within a particular stream or portion of a stream system. Multiple local populations may exist within a core area. A local population is considered to be the smallest group of fish that is known to represent an interacting reproductive unit. For most waters where specific information is lacking, a local population may be represented by a single headwater tributary or complex of headwater tributaries. Gene flow may occur between local populations (*e.g.*, those within a core population), but is assumed to be infrequent compared with that among individuals within a local population.

MANAGEMENT UNIT (BULL TROUT)

A subset of a listed entity that is defined by the U.S. Fish and Wildlife Service for administrative and management purposes, usually to manage recovery for a species that is broadly distributed and that may experience a wide range of threats and management authorities across its distribution. In the case of bull trout, the distinct population segment was further subdivided into management units based on several factors, including biological and genetic considerations, political boundaries, and ongoing conservation efforts. In some instances, management unit boundaries were modified to maximize efficiency of established watershed groups, encompass areas of common threats, or accommodate other logistic concerns. Biologically, management units are considered groupings of bull trout for which gene flow was historically or is currently possible. Management units are utilized to more effectively target specific

recovery actions, but management units are not eligible for reclassification or delisting separately from the listed entity.

METAPOPULATION

There are several different models of metapopulation dynamics, but in general a metapopulation refers to a population structure in which subpopulations may be distributed across the landscape in a patchy or semi-isolated pattern, but connectivity between these subpopulations is critical for maintaining the metapopulation as a whole. In the case of bull trout, we assumed that core areas represent the functional equivalent of a metapopulation structure for bull trout, and that the local populations within these core areas are interconnected by occasional dispersal between them and therefore share some genetic characteristics.

POTENTIAL LOCAL POPULATION

A local population that does not currently exist, but that could exist, if spawning and rearing habitat or connectivity were restored in that area, and contribute to recovery in a known or suspected unoccupied area. Alternatively, a potential local population may be a population that is suspected to exist, but that has not yet been adequately documented.

Appendix F

Quantification of incidental take under the 20-acre exemption rule (WAC 222-30-023)

The quantification of incidental take under the 20-acre exemption rule is problematic due to the lack of consistent statewide data on forested parcel ownership to determine precisely who is eligible for the 20-acre exemption rule under WAC 222-30-023. Two analyses were conducted on the eligibility of landowners that would qualify for the 20-acre exemption and on the subsequent effects to aquatic resources. The first analysis is presented in the Final FPHCP, Appendix J (i.e., the RTI analysis). The second analysis was provided to the Services by the Skagit River System Cooperative during the 90-day public comment period on the DEIS[1] (i.e., the Waldo and Wyman analysis). A discussion of these two analyses is presented in the FEIS, Volume II, subsection 3.13, 20-Acre Exemption.

In addition to the two analyses mentioned above, the DNR prepared a paper entitled Exempt 20-Acre Parcel Riparian Management Zones: An Assessment of Riparian Function. This paper constitutes the last 10 pages of Appendix J in the Final FPHCP. This paper presents data from October 25, 2001, through June 30, 2005, on the number of 20-acre exemption forest practices applications that the DNR received and of those applications, the number that were identified as conversions to a use other than forestry. The two analyses and DNR's assessment paper are used to inform the Services' quantification of incidental take under the 20-acre exemption rule.

The Services are using information from Table 3-1 in the FEIS, Volume II, subsection 3.13, 20-Acre Exemption, and the column entitled "RTI Forested Fish-bearing F&F Stream Miles[2]. This column presents the percentage of affected stream miles within the North Puget Sound Region as 1.1 percent under the RTI analysis and 3.9 percent under the Waldo and Wyman analysis. The FEIS, Volume II, subsection 3.13, 20-Acre Exemption, acknowledges that the RTI analysis is likely an underestimate, and the Waldo and Wyman analysis is likely an overestimate, of the actual amount of land eligible for the 20-acre exemption rule. Therefore, the Services are using both analyses and the percentages described above to calculate an average between the two analyses. Therefore, the average percentage is 2.5 percent of the affected stream miles within the North Puget Sound Region. The Services consider the North Puget Sound Region to be one of the highest regions out of all of the 12 FEIS regions with landowners eligible for the 20-acre exemption rule. Therefore, the Services consider that 2.5 percent is a conservative estimate when extrapolated statewide.

The Services also are using the data from Table 1 within the last 10 pages of Appendix J of the Final FPHCP. This table presents the total number of 20-acre exempt forest practices applications received by the DNR between October 25, 2001, and June 30, 2005. A total of 440 forest practices applications were received during this time. Of the 440, 86 were actual conversions to a land use other than forestry and would not be a part of the FPHCP. That leaves 354 forest practices applications that are then multiplied by 20 acres (assuming that each forest practices application included the maximum harvestable amount). That calculates to 7,080 acres harvested during the time period under the 20-acre exemption rule. Then, the 7,080 acres are divided by the time period the forest practices applications were received (i.e., 3.5 years). This calculates to 2,023 acres per year harvested under the 20-acre exemption rule. Using data presented in the Northwest Forest Plan 10-Year Monitoring Report that provides annual harvest estimates within the range of the northern spotted owl from 1992 through 2002, we calculate a 10-year average annual harvest acreage of 79,377 acres of harvest for all FPHCP covered lands. The Services assume this

[1] The Skagit River System Cooperative public comment letter is number 788 and is available at: http://www.fws.gov/westwafwo/consplan/docs.html or the Services' administrative record for the FPHCP Biological Opinion.

[2] This column heading means the total fish-bearing stream miles on forestland regulated under the current Washington Forest Practices Rules in the North Puget Sound Region as reported by the Rural Technology Initiative.

average annual harvest acreage would apply to the covered lands under the FPHCP. So, the Services calculated an annual percentage of FPHCP acres under the 20-acre exemption as a portion of the total annual acres harvested (i.e., 2,023 acres divided by 79,377 acres) as 2.5 percent.

It is mere coincidence that both approaches to estimating the percentage of land subject to the 20-acre exemption resulted in 2.5 percent. However, the Services are using this percentage in attributing take, as represented by the habitat surrogate of riparian management acres, to the 20-acre exemption rule. The Services acknowledge this is an imprecise methodology, but the most practical method given the available data of attributing take to the 20-acre exemption rule. Therefore, the Services use the 2.5 percent to attribute take to the 20-acre exemption rule.

Appendix G

Summary of GIS Analysis Completed in Support of the U.S. Fish and Wildlife Service's Biological Opinion for the Washington Forest Practices Habitat Conservation Plan

The following is a summary of the spatial analysis used to evaluate the environmental baseline and the potential effects of activities analyzed in this Opinion. The objective of this analysis was to estimate the general extent that both aquatic and terrestrial species habitats may be affected by the forest practices activities analyzed in this Opinion. We used a geographic information system (GIS) to estimate the acres of FPHCP covered lands, estimate miles of streams by water-type on the FPHCP covered lands, and estimate the acres of managed riparian area occurring on FPHCP covered lands. The values generated in the GIS analysis are estimates only, and are not meant to be interpreted as absolute values. The software used for the analysis is the ArcGIS 9.1 package developed by ESRI. We obtained GIS data from several different sources to prepare this analysis. Significant data sources and limitations to these data are described below.

G.1 FPHCP COVERED LANDS

The original file displaying the FPHCP covered lands was obtained from Tetra Tech FW, Inc. The file received from Tetra Tech (ffr_lands) contains attributes for non-Federal landownership, forested and non-forested lands, and existing HCPs. Because HCPs and some non-forested lands were included in this original file, there were over 3 million acres of lands included in this file that are not covered by the FPHCP. We modified the ffr_lands file to exclude those areas that are covered by existing HCPs and non-forested areas, except in eastern Washington. East of the Cascade crest, WDNR lands that are covered by an existing HCP for northern spotted owls would also be covered by the FPHCP. Our final selection was saved as FPlands. The total area covered by this file is 9.3 million acres, and excludes all Federal and tribal lands. This is a complex polygon file that includes many small fragments or “micro” polygons that are the result of joining several different data sources. There may be some errors of inclusion or omission associated with this file, but given the size of the area covered, we felt that these errors are minor, and that this file represents the best available GIS data for the FPHCP covered lands.

G.2 STREAM TYPING

We used the 2005 hydrography data for Washington developed by WDNR to analyze water types in the FPHCP area. There were two separate data sets covering eastern and western Washington. These data are mapped at a scale of 1:24,000 and vary in detail depending upon ownership. Generally, we found the hydrography data mapped for non-federal lands to be highly detailed. Stream data for Federal lands was less complete, with fewer small streams mapped. These datasets contained attribute fields for both the forest practices water-typing codes (i.e., Type S, Type F, etc.) and the interim water-typing codes (i.e., Type 1, 2, 3, 4, 5, 9) (Table G-1).

Table G-1. Water-typing values included in the WDNR 2005 hydrography data. Each line segment in the dataset has an assigned value for both attribute fields listed below.

Attribute Field	Attribute Field
FP_WTRTYP_CODE (Forest Practices Types)	FP_WTRTY_1975_Code (Interim Types)
Values	Values
S = Shorelines	Type 1 = "Shorelines of the State"
F= Fish Habitat	Type 2 = High value fish habitat
N = Non-fish Habitat	Type 3 = Fish habitat
U = Unknown	Type 4 = Perennial, non-fish bearing stream
X = No WaterType Designation	Type 5 = Seasonal, intermittent, ephemeral
(e.g., pipelines, flumes)	Type 9 = Unclassified

Because the forest practices water-typing codes did not include a code to identify Type Np or Type Ns waters, we used the following selections to identify Type Np and Type Ns waters:

Np Streams =

FP_WTRTYP_CODE = N and FP_WTRTY_1975_code = 1 or 2 or 3 or 4

Ns Streams =

FP_WTRTYP_CODE = N and FP_WTRTY_1975_code = 5 or 9

In applying the above selections, we classified all non-fish-bearing waters as either Type Np or Type Ns for our stream analysis. All waters typed as "unknown" remained typed as unknown in our analysis dataset. We completed this classification so that we could estimate the miles of each water-type located on the FPHCP covered lands and map riparian areas for each water-type. Miles of lake and wetland shorelines were not calculated separately, but were included in final estimates as stream miles if they were connected to streams. We do not expect that all waters on the FPHCP lands are mapped, or that all mapped waters are typed correctly. However, the WDNR hydrography data is the most comprehensive and detailed dataset available for the analysis area, and therefore represents the best available GIS data for this analysis.

G.3 RIPARIAN MANAGEMENT ZONES

We chose to estimate the area associated with riparian management zones (RMZs) on the FPHCP covered lands by using GIS to map the RMZs and calculate the approximate acres associated with RMZs along each water type. Under the Washington Forest Practices Rules, the width of the RMZ depends upon the stream width, stream type, site class, and whether the site is located on the east or west side of the Cascades. Rather than developing a complex GIS dataset based on each site class and water type, we chose to apply a set of standard assumptions for bankful width, channel migration zones (CMZs), and riparian areas (site potential tree heights) (Table G-2). The assumptions we used to map the RMZs were taken directly from the Appendix B (Riparian Modeling) in the FEIS (USFWS and NMFS 2006).

For each stream in the FPHCP GIS dataset, we used the buffer tool in ArcGIS to map riparian area buffers based on the assumptions listed in Table G-2. We mapped 2 separate riparian buffers for each stream.

One buffer represented the total riparian area width, and the 2nd buffer represented the minimum protected area within the larger RMZ (i.e., bankful width, CMZs, and Core Zones).

Table G-2. Assumptions used to map RMZs on the FPHCP covered lands (all distances are in feet, along each side of a mapped stream in GIS).

Riparian Area Assumptions	Western Washington			Eastern Washington		
	Type S	Type F	Type Np	Type S	Type F	Type Np
Mean riparian tree height	200	155	155	130	100	100
Mean ½ bankful channel width	30	5.25	2.5	25	3.75	2.5
Mean channel migration zone	30	10	0	5	2	0
Total Mean Riparian Area width by Type	260	170.25	157.5	160	105.75	102.5
Protected Area Assumptions	**Western Washington**			**Eastern Washington**		
	Type S	**Type F**	**Type Np**	**Type S**	**Type F**	**Type Np**
½ mean bankful channel width	30	5.25	2.5	25	3.75	2.5
Mean channel migration zone width	30	10	0	5	2	0
Core Zone or other no-harvest area	50	50	50	30	30	30
Total Mean RMZ width by Type	110	65.25	52.5	60	35.75	32.5

Notes: The Type S riparian buffer is based on a Site Class I 100-year site index tree height. The Type F and Type Np riparian buffer width is based on the average of Site Class II and Site Class III 100-year site index tree heights, because these are the most common Site Class types in Washington. Bankful width and CMZ assumptions are from the FEIS, Appendix B (USFWS and NMFS 2006).

For Type Np streams, we chose to map the riparian areas based on the average 100-year site index tree height because we assume that forest practices activities that occur within a site-index tree height have the potential to affect the stream (Table G-2). For calculating the total protected acres along Type Np waters, we assumed that only half of the protected areas mapped along Type Np waters would be protected in Type Np RMZs, and the other half could be harvested. To minimize the overlap in the GIS buffers, we mapped buffers sequentially, starting with Type S, then Type F, and finally Type Np. For example, the portions of Type Np streams that occurred within a Type S or Type F buffer were excluded when we mapped the Type Np buffers (Figure G-1).

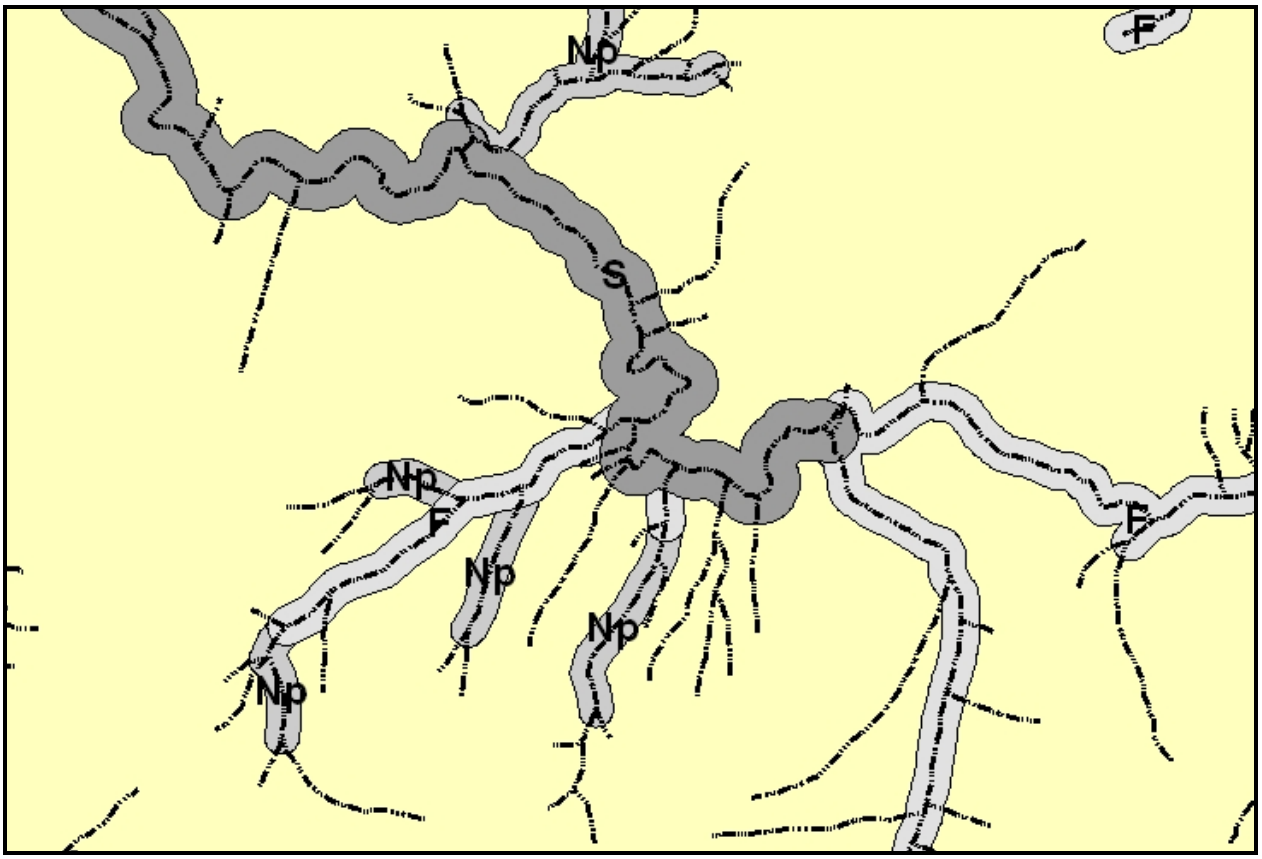

Figure G-1. Example of riparian areas mapped using GIS to create buffers along each side of a mapped stream. Unbuffered streams in this figure were identified as Type Ns waters in our analysis.

G.4 BULL TROUT HABITAT

We used GIS data compiled by the USFWS for bull trout recovery planning and the proposed and final bull trout critical habitat designations for the Coastal-Puget Sound and the Columbia River bull trout distinct populations segments. Bull trout stream data included all areas identified for recovery of the species as determined by the Recovery Plan teams, based on their expertise and knowledge of habitat conditions. The base data source was WDFW 1:100,000 streamnet data, with some local areas digitized from 1:24,000 scale USGS topographic maps where known bull trout spawning and rearing have been documented. Bull trout critical habitat is a subset of the larger bull trout stream data, and is based on individual stream segments identified in the Final Rule (FR 56212-56311). Because these data are mapped at varying scales across the analysis area, we were not always able to make direct comparisons between the WDNR hydrography data and the WDFW streamnet data used to map bull trout habitat. For bull trout analysis areas, we used both data sets – we used the hydrography data to estimate stream density at the local population scale, and overlayed the bull trout stream data to estimate the miles of bull trout habitat within the analysis area. Refer to Appendix A for more information on the GIS analysis for bull trout.

G.5 ROADS AND STREAM CROSSINGS

We used the 2005 transportation data for Washington developed by WDNR to analyze roads and stream crossings on the FPHCP covered lands. This data is mapped at the 1:24,000 scale and includes attributes for roads, trails, railroads, railroad grades, ferry crossings, and unknown. We selected the roads from this data set and created a clip with our FPHCP covered lands data to estimate the miles of roads on the FPHCP covered lands. By intersecting the roads data with the stream data, we were able to estimate the number of road-stream crossings by watertype on the FPHCP covered lands. We also estimated stream-adjacent roads by intersecting our riparian buffer layer with the roads layer.

G.6 ANALYSIS AREAS

We used the Water Resource Inventory Areas (WRIA) boundaries developed by the WDOE to subdivide the FPHCP covered lands into watershed analysis areas. For each dataset that we analyzed, we summarized the information by WRIA as a way to refine our analysis and for comparative purposes. For many of the native fish and amphibian species, we did not have GIS data showing the distribution of those species, so we used WRIA boundaries as a surrogate for species distributions. For example, if a species was known to occur in a WRIA, we assumed that all stream miles (of the type(s) associated with that species) in the WRIA would provide habitat for that species. Based on these assumptions, we were able to estimate potential effects and incidental take for each of the non-listed native fish and amphibian species covered under the FPHCP.

For our bull trout analysis, we used bull trout core areas and recovery planning units as identified in the draft bull trout recovery plans (U.S. Fish and Wildlife Service 2002; 2004) to evaluate the FPHCP. The bull trout core areas are not the same as WRIA boundaries, so the values listed for WRIAs are not directly comparable with bull trout core areas or recovery units.

G.7 SUMMARY TABLES

The following tables display the results of our GIS analysis used in this Opinion. These are summary tables only. More detailed spreadsheets that list data sources and the analysis methods used are filed in the GIS administrative record for this Opinion.

Table G-3. Summary of estimated stream miles and acres on FPHCP covered lands by WRIA.

WRIA Number	WRIA Name	Total WRIA Acres	Acres of FPHCP Covered Lands in WRIA	Percent of WRIA in FPHCP Covered Lands	Total Stream Miles in WRIA	Stream Miles on FPHCP Covered Lands	Percent of Streams in WRIA on FPHCP Covered Lands
1	Nooksack	1,034,637	255,561	24.7%	4,005.8	1,564.9	39.1%
2	San Juan	397,683	77,260	19.4%	226.1	137.1	60.6%
3	Lower Skagit / Samish	472,175	178,808	37.9%	1,843.4	899.7	48.8%
4	Upper Skagit	1,564,949	123,837	7.9%	6,544.8	853.1	13.0%
5	Stillaguamish	460,483	160,616	34.9%	3,108.6	935.5	30.1%
6	Island	332,085	84,107	25.3%	222.7	140.3	63.0%
7	Snohomish	1,221,290	405,197	33.2%	8,183.2	2,374.0	29.0%
8	Cedar-Sammamish	438,857	106,618	24.3%	1,664.7	467.7	28.1%
9	Duwamish-Green	372,162	108,939	29.3%	1,975.6	598.6	30.3%
10	Puyallup-White	672,848	282,638	42.0%	3,516.5	1,919.6	54.6%
11	Nisqually	491,024	229,349	46.7%	3,398.4	1,534.9	45.2%
12	Chambers-Clover	114,850	21,843	19.0%	113.6	32.5	28.6%
13	Deschutes	186,802	113,420	60.7%	1,018.4	884.7	86.9%
14	Kennedy-Goldsborough	243,990	104,515	42.8%	799.0	351.3	44.0%
15	Kitsap	630,646	298,742	47.4%	1,738.9	1,283.8	73.8%
16	Skokomish-Dosewallips	408,660	44,300	10.8%	1,891.3	277.2	14.7%
17	Quilcene-Snow	400,435	130,722	32.6%	1,250.6	664.7	53.1%
18	Elwha-Dungeness	650,267	54,754	8.4%	1,688.5	264.2	15.6%
19	Lyre-Hoko	502,643	124,122	24.7%	1,888.1	1,054.0	55.8%
20	Soleduc	959,550	233,183	24.3%	6,201.5	2,215.1	35.7%
21	Queets-Quinault	862,967	98,487	11.4%	5,042.3	756.5	15.0%
22	Lower Chehalis	938,847	467,582	49.8%	7,359.4	4,836.5	65.7%
23	Upper Chehalis	830,282	537,167	64.7%	9,224.4	6,781.5	73.5%
24	Willapa	814,678	500,868	61.5%	9,383.9	7,778.6	82.9%
25	Grays/Elochoman	322,903	215,115	66.6%	4,348.0	3,165.3	72.8%
26	Cowlitz	1,594,104	674,950	42.3%	13,697.1	6,797.6	49.6%
27	Lewis	836,885	321,838	38.5%	7,399.2	3,367.2	45.5%
28	Salmon-Washougal	316,669	112,316	35.5%	1,575.7	624.8	39.7%
29	Wind-White Salmon	576,696	196,260	34.0%	3,042.9	1,236.4	40.6%
30	Klickitat	922,718	303,867	32.9%	4,087.2	1,542.3	37.7%
31	Rock-Glade	1,059,603	45,407	4.3%	3,897.3	304.1	7.8%
32	Walla Walla	910,153	67,056	7.4%	4,153.3	584.9	14.1%
33	Lower Snake	463,575	33	0.0%	1,484.8	0.0	0.0%
34	Palouse	1,771,481	33,039	1.9%	6,602.6	168.6	2.6%
35	Middle Snake	1,445,485	31,838	2.2%	7,530.4	301.8	4.0%
36	Esquatzel Coulee	1,060,530	105	0.0%	3,745.5	1.8	0.0%
37	Lower Yakima	1,863,300	43,745	2.3%	9,134.6	377.6	4.1%
38	Naches	706,912	49,688	7.0%	3,345.0	422.5	12.6%
39	Upper Yakima	1,368,976	206,649	15.1%	9,383.9	1,686.0	18.0%
40	Alkali-Squilchuck	539,550	28,589	5.3%	2,046.0	262.4	12.8%
41	Lower Crab	1,623,542	340	0.0%	6,083.5	6.9	0.1%
42	Grand Coulee	484,972	30	0.0%	1,364.1	0.7	0.1%
43	Upper Crab-Wilson	1,187,925	12,248	1.0%	3,549.2	76.4	2.2%
44	Moses Coulee	730,482	5,122	0.7%	2,156.5	17.2	0.8%
45	Wenatchee	878,130	95,266	10.8%	10,151.4	1,651.7	16.3%
46	Entiat	305,693	18,948	6.2%	3,489.8	317.7	9.1%
47	Chelan	667,785	14,476	2.2%	3,844.3	227.5	5.9%
48	Methow	1,358,016	34,112	2.5%	8,062.2	340.9	4.2%
49	Okanogan	1,342,170	275,013	20.5%	7,416.1	1,585.1	21.4%
50	Foster	577,595	228	0.0%	1,965.7	1.5	0.1%
51	Nespelem	144,489	0	0.0%	1,068.8	0.0	0.0%
52	Sanpoil	628,920	71,757	11.4%	4,496.2	452.5	10.1%
53	Lower Lake Roosevelt	326,829	29,186	8.9%	2,163.1	240.0	11.1%
54	Lower Spokane	567,683	181,664	32.0%	3,095.5	1,062.2	34.3%
55	Little Spokane	434,759	267,851	61.6%	2,347.0	1,660.5	70.7%
56	Hangman	292,083	38,934	13.3%	1,193.4	179.1	15.0%
57	Middle Spokane	184,110	75,579	41.1%	1,099.8	655.2	59.6%
58	Middle Lake Roosevelt	708,499	127,360	18.0%	4,594.1	726.1	15.8%
59	Colville	653,505	399,342	61.1%	3,294.9	2,018.3	61.3%
60	Kettle	656,718	167,932	25.6%	3,967.3	1,199.8	30.2%
61	Upper Lake Roosevelt	369,352	226,445	61.3%	1,830.6	1,050.3	57.4%
62	Pend Oreille	791,807	222,128	28.1%	5,135.4	1,288.8	25.1%
	Totals	**45,677,416**	**9,337,092**	**20.4%**	**250,131.6**	**74,207.5**	**29.7%**

Table G-4. Summary of total estimated stream miles by water type on FPHCP covered lands.

WRIA Number	WRIA Name	Type S Stream Miles on FPHCP Covered Lands	Type F Stream Miles on FPHCP Covered Lands	Type Np Stream Miles on FPHCP Covered Lands	Type Ns Stream Miles on FPHCP Covered Lands	Unclassified Stream Miles on FPHCP Covered Lands	Total Stream Miles on FPHCP Covered Lands
1	Nooksack	124.2	278.4	227.9	852.2	82.2	1,564.9
2	San Juan	5.2	44.1	8.0	71.9	7.9	137.1
3	Lower Skagit / Samish	66.7	221.8	123.8	444.9	42.5	899.7
4	Upper Skagit	72.7	169.6	94.1	446.5	70.2	853.1
5	Stillaguamish	86.0	260.3	92.8	437.7	58.7	935.5
6	Island	0.6	39.6	7.8	87.5	4.7	140.3
7	Snohomish	209.3	565.6	282.1	1,032.6	284.3	2,374.0
8	Cedar-Sammamish	35.4	162.8	26.5	195.4	47.6	467.7
9	Duwamish-Green	38.5	124.5	62.3	323.8	49.6	598.6
10	Puyallup-White	131.9	318.7	266.2	1,004.1	198.7	1,919.6
11	Nisqually	131.9	249.3	143.0	741.2	269.5	1,534.9
12	Chambers-Clover	5.5	10.8	2.6	7.5	6.1	32.5
13	Deschutes	50.5	141.4	31.5	527.8	133.4	884.7
14	Kennedy-Goldsborough	37.5	119.6	15.1	162.1	17.1	351.3
15	Kitsap	41.4	434.5	90.7	634.5	82.6	1,283.8
16	Skokomish-Dosewallips	20.4	70.3	32.7	134.3	19.5	277.2
17	Quilcene-Snow	14.9	173.7	37.0	431.3	7.7	664.7
18	Elwha-Dungeness	29.9	92.1	15.3	121.3	5.7	264.2
19	Lyre-Hoko	68.6	281.9	101.8	600.1	1.6	1,054.0
20	Soleduc	170.8	630.3	202.0	1,199.1	13.0	2,215.1
21	Queets-Quinault	52.2	253.4	39.4	408.9	2.5	756.5
22	Lower Chehalis	253.0	1,272.0	247.7	2,831.1	232.7	4,836.5
23	Upper Chehalis	243.4	1,071.3	320.4	4,115.9	1,030.6	6,781.5
24	Willapa	354.2	1,319.1	349.7	4,238.6	1,517.0	7,778.6
25	Grays/Elochoman	95.4	468.5	146.1	1,765.3	690.0	3,165.3
26	Cowlitz	313.0	1,069.1	554.7	4,007.7	853.2	6,797.6
27	Lewis	153.0	524.9	246.5	1,971.9	470.8	3,367.2
28	Salmon-Washougal	76.1	179.6	42.1	297.7	29.3	624.8
29	Wind-White Salmon	81.0	260.2	38.3	757.9	99.0	1,236.4
30	Klickitat	76.8	170.5	279.2	514.0	501.8	1,542.3
31	Rock-Glade	0.4	42.1	63.5	114.8	83.3	304.1
32	Walla Walla	28.0	94.4	63.9	369.9	28.8	584.9
33	Lower Snake	0.0	0.0	0.0	0.0	0.0	0.0
34	Palouse	6.8	3.8	0.2	2.0	155.8	168.6
35	Middle Snake	2.5	33.1	35.4	122.7	108.0	301.8
36	Esquatzel Coulee	0.0	0.0	0.0	0.0	1.8	1.8
37	Lower Yakima	9.2	46.4	44.1	113.7	164.2	377.6
38	Naches	42.0	43.2	53.4	172.2	111.8	422.5
39	Upper Yakima	193.7	149.6	238.6	669.7	434.4	1,686.0
40	Alkali-Squilchuck	1.1	31.1	39.4	86.0	104.7	262.4
41	Lower Crab	0.0	0.0	0.0	0.0	6.9	6.9
42	Grand Coulee	0.4	0.0	0.0	0.0	0.3	0.7
43	Upper Crab-Wilson	1.0	1.1	0.7	0.4	73.2	76.4
44	Moses Coulee	0.4	0.7	0.5	4.7	10.9	17.2
45	Wenatchee	90.5	66.0	110.1	490.1	895.0	1,651.7
46	Entiat	33.9	6.3	26.7	105.1	145.7	317.7
47	Chelan	9.3	2.5	2.7	19.4	193.6	227.5
48	Methow	47.3	16.4	18.9	39.1	219.1	340.9
49	Okanogan	20.7	163.7	155.2	432.9	812.6	1,585.1
50	Foster	0.2	0.0	0.0	0.0	1.3	1.5
51	Nespelem	0.0	0.0	0.0	0.0	0.0	0.0
52	Sanpoil	8.2	72.2	64.1	190.3	117.7	452.5
53	Lower Lake Roosevelt	0.1	10.9	24.2	73.1	131.8	240.0
54	Lower Spokane	27.2	86.7	97.1	325.4	525.8	1,062.2
55	Little Spokane	120.3	132.8	146.4	577.9	683.1	1,660.5
56	Hangman	16.4	4.5	16.5	44.5	97.1	179.1
57	Middle Spokane	8.1	30.5	42.5	217.0	357.1	655.2
58	Middle Lake Roosevelt	2.0	53.1	48.2	180.4	442.4	726.1
59	Colville	68.0	269.1	258.5	765.2	657.4	2,018.3
60	Kettle	80.8	144.7	164.5	546.3	263.5	1,199.8
61	Upper Lake Roosevelt	53.9	111.2	153.6	516.9	214.6	1,050.3
62	Pend Oreille	85.7	217.1	147.3	471.5	367.1	1,288.8
	Totals	**3998.3**	**12,810.9**	**6,143.5**	**37,016.1**	**14,238.8**	**74,207.5**
	Percent	**5.4%**	**17.3%**	**8.3%**	**49.9%**	**19.2%**	**100.0%**

Table G-5. Summary of total estimated riparian acres and minimum "protected" riparian acres on FPHCP covered lands.

WRIA Number	WRIA Name	Total Type S Riparian Area Acres	Type S Protected Area Acres	Type S Riparian Management Acres	Total Type F Riparian Area Acres	Type F Protected Area Acres	Type F Riparian Management Acres	Total Type Np Riparian Area Acres (no F or S overlap)	Type NP Protected Area	50% "no cut" area along NP type	Type Np Riparian Management Acres	Total Riparian Acres all stream types	Total Protected Area Acres all stream types	Totals - Riparian Management Acres - All stream types	FPHCP Acres in WRIA	Percent of FPHCP Lands in Riparian Areas
1	Nooksack	10,219	3,980	6,239	12,173	4,552	7,621	8,880	2,925	1,462	7,418	31,272	9,994	21,278	255,561	12.2%
2	San Juan	443	164	279	2,117	750	1,367	338	106	53	285	2,898	967	1,931	77,260	3.8%
3	Lower Skagit / Samish	4,997	1,958	3,039	9,705	3,617	6,088	4,895	1,598	799	4,096	19,596	6,374	13,222	178,808	11.0%
4	Upper Skagit	6,705	2,515	4,189	7,369	2,768	4,601	3,581	1,195	598	2,984	17,654	5,880	11,774	123,837	14.3%
5	Stillaguamish	7,699	2,958	4,741	11,152	4,207	6,945	3,606	1,188	594	3,012	22,456	7,759	14,697	160,616	14.0%
6	Island	51	19	32	1,815	657	1,157	349	106	53	296	2,215	730	1,485	84,107	2.6%
7	Snohomish	17,628	6,785	10,843	24,513	9,211	15,302	10,830	3,605	1,803	9,027	52,971	17,799	35,173	405,197	13.1%
8	Cedar-Sammamish	2,971	1,128	1,843	7,714	2,756	4,957	1,106	349	174	932	11,791	4,059	7,733	106,618	11.1%
9	Duwamish-Green	3,879	1,412	2,467	5,744	2,078	3,665	2,481	805	402	2,079	12,104	3,892	8,211	108,939	11.1%
10	Puyallup-White	10,743	4,224	6,518	13,308	5,099	8,209	9,722	3,340	1,670	8,052	33,772	10,993	22,780	282,638	11.9%
11	Nisqually	9,785	3,961	5,823	10,594	4,020	6,574	5,376	1,812	906	4,470	25,755	8,888	16,868	229,349	11.2%
12	Chambers-Clover	536	189	347	555	191	364	108	34	17	91	1,199	397	802	21,843	5.5%
13	Deschutes	3,407	1,411	1,996	6,097	2,287	3,810	1,194	399	200	994	10,698	3,898	6,800	113,420	9.4%
14	Kennedy-Goldsborough	2,684	1,085	1,599	5,468	1,986	3,483	615	197	98	516	8,767	3,169	5,598	104,515	8.4%
15	Kitsap	3,003	1,198	1,805	19,097	7,080	12,017	3,583	1,167	583	3,000	25,683	8,862	16,822	298,742	8.6%
16	Skokomish-Dosewallips	1,736	661	1,075	3,107	1,151	1,956	1,245	415	208	1,037	6,088	2,019	4,068	44,300	13.7%
17	Quilcene-Snow	1,110	438	673	7,536	2,812	4,724	1,457	475	238	1,219	10,103	3,488	6,616	130,722	7.7%
18	Elwha-Dungeness	2,282	904	1,377	4,144	1,524	2,620	620	199	99	521	7,045	2,527	4,518	54,754	12.9%
19	Lyre-Hoko	4,544	1,899	2,645	11,579	4,457	7,122	3,663	1,262	631	3,032	19,786	6,987	12,799	124,122	15.9%
20	Soleduc	13,308	5,324	7,984	25,907	9,995	15,911	7,215	2,513	1,257	5,959	46,430	16,576	29,854	233,183	19.9%
21	Queets-Quinault	4,029	1,619	2,410	10,549	4,035	6,514	1,471	495	247	1,223	16,048	5,901	10,147	98,487	16.3%
22	Lower Chehalis	19,902	7,849	12,053	52,904	20,250	32,654	9,132	3,090	1,545	7,587	81,938	29,644	52,293	467,582	17.5%
23	Upper Chehalis	17,618	7,109	10,508	45,030	17,122	27,908	11,940	4,022	2,011	9,929	74,587	26,242	48,345	537,167	13.9%
24	Willapa	22,906	9,778	13,129	53,911	20,828	33,084	12,660	4,330	2,165	10,495	89,478	32,770	56,707	500,868	17.9%
25	Grays/Elochoman	6,971	2,786	4,185	19,443	7,452	11,991	5,396	1,836	918	4,478	31,810	11,156	20,654	215,115	14.8%
26	Cowlitz	25,037	9,858	15,178	44,913	17,096	27,817	20,896	7,008	3,504	17,392	90,846	30,458	60,387	674,950	13.5%
27	Lewis	11,735	4,725	7,010	22,212	8,421	13,790	9,298	3,117	1,559	7,740	43,245	14,705	28,540	321,838	13.4%
28	Salmon-Washougal	6,124	2,398	3,726	8,001	2,959	5,042	1,701	547	273	1,428	15,826	5,630	10,196	112,316	14.1%
29	Wind-White Salmon	5,187	2,413	2,774	10,933	4,167	6,766	1,455	486	243	1,211	17,574	6,823	10,751	196,260	9.0%
	Westside subtotals	**227,237**	**90,748**	**136,489**	**457,587**	**173,529**	**284,058**	**144,812**	**48,620**	**24,310**	**120,502**	**829,636**	**288,587**	**541,049**	**6,263,115**	**13.2%**
30	Klickitat	2,771	1,132	1,639	4,166	1,453	2,712	7,059	2,220	1,110	5,949	13,995	3,695	10,301	303,867	4.6%
31	Rock-Glade	25	7	18	1,191	381	809	1,731	520	260	1,470	2,947	649	2,298	45,407	6.5%
32	Walla Walla	936	335	601	2,240	747	1,493	1,715	521	260	1,454	4,890	1,342	3,548	67,056	7.3%
33	Lower Snake	0	0	0	0	0	0	0	0	0	0	0	0	0	33	0.0%
34	Palouse	432	132	301	130	39	91	6	2	1	5	569	172	397	33,039	1.7%
35	Middle Snake	125	38	86	901	288	613	984	292	146	838	2,010	472	1,537	31,838	6.3%
36	Esquatzel Coulee	0	0	0	0	0	0	0	0	0	0	0	0	0	105	0.0%
37	Lower Yakima	426	150	276	1,217	406	811	1,074	344	172	902	2,716	728	1,989	43,745	6.2%
38	Naches	1,319	559	760	1,172	385	787	1,433	434	217	1,216	3,923	1,160	2,763	49,688	7.9%
39	Upper Yakima	6,478	2,639	3,839	4,133	1,341	2,792	6,123	1,899	950	5,174	16,735	4,930	11,805	206,649	8.1%
40	Alkali-Squilchuck	71	22	49	865	280	585	1,028	316	158	870	1,964	461	1,503	28,589	6.9%
41	Lower Crab	2	0	2	0	0	0	0	0	0	0	2	0	2	340	0.7%
42	Grand Coulee	35	9	26	0	0	0	0	0	0	0	35	9	26	30	100.0%
43	Upper Crab-Wilson	77	22	55	34	11	23	19	5	3	16	129	35	93	12,248	1.1%
44	Moses Coulee	41	10	31	19	6	13	15	4	2	13	74	18	57	5,122	1.5%
45	Wenatchee	3,439	1,313	2,125	1,753	577	1,176	2,940	895	447	2,492	8,132	2,338	5,794	95,266	8.5%
46	Entiat	964	404	560	176	57	120	758	223	111	647	1,898	572	1,327	18,948	10.0%
47	Chelan	531	165	366	73	23	50	80	23	11	69	685	199	486	14,476	4.7%
48	Methow	1,490	577	912	475	151	324	516	155	78	439	2,481	805	1,675	34,112	7.3%
49	Okanogan	1,142	372	771	4,286	1,444	2,842	3,777	1,222	611	3,166	9,206	2,427	6,779	275,013	3.3%
50	Foster	21	5	16	0	0	0	0	0	0	0	21	5	16	228	9.4%
51	Nespelem	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
52	Sanpoil	353	127	225	1,891	636	1,255	1,611	510	255	1,356	3,855	1,018	2,837	71,757	5.4%
53	Lower Lake Roosevelt	10	2	8	323	101	223	683	202	101	582	1,016	204	813	29,186	3.5%
54	Lower Spokane	1,922	578	1,344	2,456	789	1,667	2,523	785	392	2,131	6,901	1,759	5,141	181,664	3.8%
55	Little Spokane	3,861	1,576	2,285	3,456	1,176	2,281	3,704	1,168	584	3,121	11,022	3,336	7,687	267,851	4.1%
56	Hangman	734	254	480	156	45	111	499	142	71	428	1,388	369	1,019	38,934	3.6%
57	Middle Spokane	556	173	383	796	265	531	1,091	337	169	922	2,443	607	1,837	75,579	3.2%
58	Middle Lake Roosevelt	118	36	82	1,444	471	973	1,213	381	190	1,023	2,774	697	2,077	127,360	2.2%
59	Colville	2,710	1,000	1,710	6,965	2,353	4,612	6,442	2,044	1,022	5,420	16,117	4,374	11,742	399,342	4.0%
60	Kettle	2,822	1,184	1,639	3,811	1,277	2,534	4,221	1,315	658	3,563	10,854	3,119	7,735	167,932	6.5%
61	Upper Lake Roosevelt	2,401	847	1,554	2,826	963	1,863	3,814	1,213	606	3,208	9,041	2,416	6,625	226,445	4.0%
62	Pend Oreille	3,897	1,367	2,529	5,468	1,894	3,574	3,648	1,165	582	3,066	13,013	3,844	9,169	222,128	5.9%
	Eastside subtotals	**39,708**	**15,035**	**24,673**	**52,422**	**17,557**	**34,865**	**58,706**	**18,336**	**9,168**	**49,539**	**150,837**	**41,760**	**109,076**	**3,073,977**	**4.9%**
	TOTALS	**266,945**	**105,783**	**161,162**	**510,009**	**191,087**	**318,923**	**203,519**	**66,956**	**33,478**	**170,041**	**980,473**	**330,347**	**650,126**	**9,337,092**	**10.5%**

Table G-6. Summary of estimated road miles and stream crossings on FPHCP covered lands.

WRIA Number	WRIA Name	Square Miles of FPHCP Covered Lands in WRIA	Total Road Miles on FPHCP Covered Lands	Road Density on FPHCP Covered Lands (mi./sq.mi.)	Type S stream crossings	Type F Stream Crossings	Type NP Stream Crossings	Type Ns Stream Crossings	Unclassified Stream Crossings	Total Stream Crossings on FPHCP Covered Lands
1	Nooksack	399.3	1,574.5	3.9	56	454	384	1,444	1,054	3,392
2	San Juan	120.7	355.5	2.9	0	95	10	56	57	218
3	Lower Skagit / Samish	279.4	1,234.9	4.4	40	376	224	616	622	1,878
4	Upper Skagit	193.5	985.5	5.1	31	367	176	771	733	2,078
5	Stillaguamish	251.0	1,056.4	4.2	28	410	184	633	479	1,734
6	Island	131.4	503.1	3.8	0	94	9	73	82	258
7	Snohomish	633.1	2,721.4	4.3	102	1,025	523	1,533	1,471	4,654
8	Cedar-Sammamish	166.6	719.3	4.3	19	259	27	172	284	761
9	Duwamish-Green	170.2	781.8	4.6	15	176	88	511	379	1,169
10	Puyallup-White	441.6	1,859.3	4.2	40	393	469	1,630	1,037	3,569
11	Nisqually	358.4	1,842.6	5.1	64	363	285	1,656	1,448	3,816
12	Chambers-Clover	34.1	191.4	5.6	7	16	3	7	35	68
13	Deschutes	177.2	924.2	5.2	23	215	50	1,433	863	2,584
14	Kennedy-Goldsborough	163.3	813.5	5.0	19	269	28	221	171	708
15	Kitsap	466.8	2,202.7	4.7	30	772	123	811	648	2,384
16	Skokomish-Dosewallips	69.2	365.9	5.3	6	122	63	228	194	613
17	Quilcene-Snow	204.3	959.7	4.7	6	292	82	652	389	1,421
18	Elwha-Dungeness	85.6	444.9	5.2	11	124	21	166	149	471
19	Lyre-Hoko	193.9	850.7	4.4	27	283	206	838	210	1,564
20	Soleduc	364.3	1,587.1	4.4	51	842	425	1,507	374	3,199
21	Queets-Quinault	153.9	513.5	3.3	22	269	61	391	99	842
22	Lower Chehalis	730.6	2,662.1	3.6	90	1,052	237	1,500	523	3,402
23	Upper Chehalis	839.3	4,268.2	5.1	133	1,362	455	8,290	4,539	14,779
24	Willapa	782.6	3,718.7	4.8	207	1,372	388	5,394	3,664	11,025
25	Grays/Elochoman	336.1	1,876.3	5.6	74	661	251	3,601	2,761	7,348
26	Cowlitz	1,054.6	5,874.5	5.6	161	1,690	1,342	9,089	5,633	17,915
27	Lewis	502.9	2,895.8	5.8	87	874	612	4,908	3,179	9,660
28	Salmon-Washougal	175.5	712.3	4.1	46	274	50	357	285	1,012
29	Wind-White Salmon	306.7	1,186.6	3.9	47	384	85	932	858	2,306
30	Klickitat	474.8	1,536.7	3.2	19	85	265	555	1,146	2,070
31	Rock-Glade	70.9	154.8	2.2	0	8	42	93	95	238
32	Walla Walla	104.8	302.8	2.9	15	111	56	431	114	727
33	Lower Snake	0.1	0.1	2.4	0	0	0	0	0	0
34	Palouse	51.6	113.4	2.2	1	0	0	3	44	48
35	Middle Snake	49.7	132.0	2.7	0	22	19	137	200	378
36	Esquatzel Coulee	0.2	0.2	1.2	0	0	0	0	1	1
37	Lower Yakima	68.4	223.4	3.3	6	49	71	171	273	570
38	Naches	77.6	245.1	3.2	24	39	86	227	296	672
39	Upper Yakima	322.9	1,069.4	3.3	60	142	266	721	1,257	2,446
40	Alkali-Squilchuck	44.7	174.0	3.9	0	31	57	136	433	657
41	Lower Crab	0.5	1.2	2.2	0	0	0	0	2	2
42	Grand Coulee	0.0	0.2	3.9	0	0	0	0	0	0
43	Upper Crab-Wilson	19.1	48.0	2.5	0	0	1	1	16	18
44	Moses Coulee	8.0	12.4	1.6	0	1	1	2	3	7
45	Wenatchee	148.9	645.3	4.3	42	103	180	984	2,930	4,239
46	Entiat	29.6	151.1	5.1	19	4	25	222	739	1,009
47	Chelan	22.6	85.7	3.8	2	5	3	30	401	441
48	Methow	53.3	115.5	2.2	8	12	31	52	364	467
49	Okanogan	429.7	1,063.0	2.5	7	0	154	467	1,753	2,381
50	Foster	0.4	0.3	0.8	0	108	0	0	0	108
51	Nespelem	0.0	0.0	0.0	0	0	0	0	0	0
52	Sanpoil	112.1	312.0	2.8	5	52	73	231	330	691
53	Lower Lake Roosevelt	45.6	83.1	1.8	0	7	19	42	144	212
54	Lower Spokane	283.9	890.6	3.1	5	37	94	423	1,258	1,817
55	Little Spokane	418.5	1,267.9	3.0	27	95	139	720	1,510	2,491
56	Hangman	60.8	185.8	3.1	6	1	7	46	113	173
57	Middle Spokane	118.1	399.5	3.4	2	35	32	289	803	1,161
58	Middle Lake Roosevelt	199.0	684.6	3.4	0	54	68	273	1,234	1,629
59	Colville	624.0	1,858.8	3.0	13	199	251	949	1,720	3,132
60	Kettle	262.4	651.4	2.5	19	110	228	695	700	1,752
61	Upper Lake Roosevelt	353.8	1,080.1	3.1	20	100	184	679	752	1,735
62	Pend Oreille	347.1	1,187.0	3.4	19	154	171	641	1,039	2,024
	Totals	14,589.2	60,357.7	4.1	**1,761**	**16,449**	**9,384**	**58,640**	**51,890**	**138,124**

Table G-7. Summary of road miles located in riparian areas on FPHCP covered lands.

WRIA Number	WRIA Name	Total Road Miles on FPHCP Covered Lands	Miles of Roads located in Type S Riparian Zones	Miles of Roads located in Type F Riparian Zones	Miles of Roads located in Type Np Riparian Zones	Total Road miles located in Type S, F, or Np Riparian Zones	Percentage of Road Miles located in Type S, F, or Np Riparian Zones
1	Nooksack	1,574.5	39.7	66.3	46.4	152.4	9.7%
2	San Juan	355.5	2.4	12.2	2.1	16.8	4.7%
3	Lower Skagit / Samish	1,234.9	25.1	64.6	32.4	122.1	9.9%
4	Upper Skagit	985.5	26.1	44.5	20.1	90.8	9.2%
5	Stillaguamish	1,056.4	26.9	54.9	20.9	102.7	9.7%
6	Island	503.1	0.3	10.4	2.2	12.9	2.6%
7	Snohomish	2,721.4	88.6	146.0	60.5	295.1	10.8%
8	Cedar-Sammamish	719.3	23.1	54.8	6.9	84.8	11.8%
9	Duwamish-Green	781.8	23.5	31.4	11.7	66.6	8.5%
10	Puyallup-White	1,859.3	44.4	67.5	48.7	160.6	8.6%
11	Nisqually	1,842.6	45.4	59.8	31.6	136.8	7.4%
12	Chambers-Clover	191.4	4.0	4.9	2.0	10.9	5.7%
13	Deschutes	924.2	17.1	36.6	6.1	59.8	6.5%
14	Kennedy-Goldsborough	813.5	12.1	33.7	3.7	49.4	6.1%
15	Kitsap	2,202.7	17.1	108.4	21.0	146.5	6.7%
16	Skokomish-Dosewallips	365.9	4.5	20.2	6.9	31.7	8.7%
17	Quilcene-Snow	959.7	6.5	51.3	7.8	65.6	6.8%
18	Elwha-Dungeness	444.9	9.9	22.5	3.2	35.6	8.0%
19	Lyre-Hoko	850.7	26.1	44.4	15.7	86.2	10.1%
20	Soleduc	1,587.1	38.0	106.3	36.4	180.8	11.4%
21	Queets-Quinault	513.5	9.8	35.5	5.1	50.4	9.8%
22	Lower Chehalis	2,662.1	71.3	161.3	22.0	254.6	9.6%
23	Upper Chehalis	4,268.2	128.8	258.3	54.5	441.6	10.3%
24	Willapa	3,718.7	147.6	216.8	35.7	400.1	10.8%
25	Grays/Elochoman	1,876.3	65.0	120.1	26.5	211.6	11.3%
26	Cowlitz	5,874.5	139.6	276.0	126.0	541.6	9.2%
27	Lewis	2,895.8	72.7	141.0	59.2	272.9	9.4%
28	Salmon-Washougal	712.3	33.6	42.0	6.8	82.5	11.6%
29	Wind-White Salmon	1,186.6	27.9	86.0	10.7	124.5	10.5%
30	Klickitat	1,536.7	18.0	21.6	44.3	83.9	5.5%
31	Rock-Glade	154.8	0.2	3.0	7.0	10.2	6.6%
32	Walla Walla	302.8	4.8	37.5	17.8	60.1	19.8%
33	Lower Snake	0.1	0.0	0.0	0.0	0.0	0.0%
34	Palouse	113.4	2.2	0.1	0.1	2.4	2.1%
35	Middle Snake	132.0	0.9	12.7	5.2	18.8	14.3%
36	Esquatzel Coulee	0.2	0.0	0.0	0.0	0.0	0.0%
37	Lower Yakima	223.4	3.8	11.6	9.4	24.8	11.1%
38	Naches	245.1	11.7	12.6	13.8	38.2	15.6%
39	Upper Yakima	1,069.4	23.4	38.6	60.8	122.7	11.5%
40	Alkali-Squilchuck	174.0	0.4	5.6	6.7	12.7	7.3%
41	Lower Crab	1.2	0.0	0.0	0.0	0.0	2.3%
42	Grand Coulee	0.2	0.0	0.0	0.0	0.0	0
43	Upper Crab-Wilson	48.0	0.2	0.1	0.1	0.4	0.9%
44	Moses Coulee	12.4	0.1	0.1	0.1	0.3	2.2%
45	Wenatchee	645.3	18.9	19.1	33.6	71.6	11.1%
46	Entiat	151.1	7.7	2.7	7.9	18.3	12.1%
47	Chelan	85.7	4.2	1.7	0.5	6.4	7.5%
48	Methow	115.5	5.4	3.8	3.7	12.9	11.2%
49	Okanogan	1,063.0	6.5	27.5	17.0	51.0	4.8%
50	Foster	0.3	0.0	0.0	0.0	0.0	0
51	Nespelem	0.0	0.0	0.0	0.0	0.0	0
52	Sanpoil	312.0	2.3	14.6	12.5	29.4	9.4%
53	Lower Lake Roosevelt	83.1	0.0	2.1	10.8	12.9	15.5%
54	Lower Spokane	890.6	5.4	13.2	23.0	41.6	4.7%
55	Little Spokane	1,267.9	9.1	31.2	30.0	70.3	5.5%
56	Hangman	185.8	2.3	0.4	2.2	4.9	2.6%
57	Middle Spokane	399.5	2.5	7.2	8.1	17.8	4.5%
58	Middle Lake Roosevelt	684.6	1.1	17.2	11.6	30.0	4.4%
59	Colville	1,858.8	9.2	50.0	49.5	108.7	5.8%
60	Kettle	651.4	15.3	32.4	40.9	88.6	13.6%
61	Upper Lake Roosevelt	1,080.1	11.5	22.3	25.2	59.0	5.5%
62	Pend Oreille	1,187.0	11.1	29.5	18.9	59.5	5.0%
	Totals	**60,357.7**	**1,355.5**	**2,796.4**	**1,193.6**	**5,345.5**	**8.9%**

Appendix H

Native Fish Distribution and Quantification of Effects

Table 1. FPHCP native fish covered species and Water Resource Inventory Area (WRIA) distribution. Table does not include bull trout.

Bridgelip Sucker	Burbot	Chiselmouth	Coastrange Sculpin	Cutthroat Trout (Coastal)	Cutthroat Trout (Westslope)	Dolly Varden	Kokanee Salmon	Lake Chub
				WRIA				
22	31	26	1	1	34	1	1	42
23	33	27	3	2	37	3	11	49
24	37	30	4	3	38	4	16	50
26	40	31	5	4	39	20	18	52
27	44	33	7	5	44	21	19	53
28	46	34	8	6	45		20	58
30	47	37	9	7	46		21	59
31	48	38	10	8	47		22	60
32	49	39	11	9	48		27	61
33	50	40	12	10	49		29	
34	51	45	13	11	59		32	
35	53	46	14	12	60		34	
37		49	15	13	61		38	
38		51	16	14	62		39	
39		52	17	15			40	
43		53	18	16			44	
45		54	19	17			45	
47		55	20	18			46	
48		56	21	19			47	
49		57	22	20			48	
53		58	23	21			49	
60		59	24	22			50	
61		60	25	23			51	
		61	26	24			53	
		62	27	25			54	
			28	26			55	
				27			58	
				28			60	
				29			61	
				30			62	
				34				

Table 1. FPHCP native fish covered species and Water Resource Inventory Area (WRIA) distribution. Table does not include bull trout. (continued)

Largescale Sucker	Leopard Dace	Longfin Smelt	Longnose Dace	Longnose Sucker	Margined Sculpin	Mottled Sculpin	Mountain Sucker	Mountain Whitefish
				WRIA				
1	26	8	1	31	32	31	26	3
3	27		3	37	35	33	27	4
4	28		5	40		37	30	5
5	32		7	45		39	33	10
7	33		8	46		45	35	11
8	35		9	47		52	37	16
9	37		10	48		53	38	18
10	45		11	49		54	39	20
11	49		13	50		55	45	21
12			21	51		61		22
13			22	52				26
21			23	53				27
22			24	54				29
23			25	55				30
24			26	56				32
25			27	57				35
26			28	58				37
27			29	59				38
28			30	60				39
29			32	61				40
30			35	62				41
31			37					44
32			38					45
33			39					46
34			48					47
35			48					48
37			49					49
38			52					50
39			55					52
43			58					53
47			59					54
48			60					55
49			61					58
52			62					59
53								60
54								61
55								62
56								
57								
59								
61								
62								

Table 1. FPHCP native fish covered species and Water Resource Inventory Area (WRIA) distribution. Table does not include bull trout. (continued)

Northern Pikeminnow	Olympic Mudminnow	Pacific Lamprey	Paiute Sculpin	Peamouth	Prickly Sculpin	Pygmy Whitefish	Rainbow Trout (Coastal)	Rainbow Trout, (Redband)
				WRIA				
8	8	1	32	5	1	8	1	29
11	13	3	35	7	3	19	3	30
20	14	5	37	8	4	39	4	31
22	20	7	39	14	5	47	5	32
23	21	9	45	20	7	62	6	33
25	22	11		21	8		7	34
26	23	13		25	9		8	35
28		15		26	10		9	37
32		16		27	11		10	38
33		17		28	13		11	39
34		18		29	14		13	40
35		19		30	15		14	44
37		20		32	16		15	45
38		21		34	17		16	46
39		22		35	18		17	47
40		23		38	21		18	48
44		24		39	22		19	49
45		25		45	23		20	50
46		26		46	24		21	51
47		27		47	26		22	52
48		28		48	27		23	53
49		29		49	28		24	54
50		30		50	29		25	55
51		31		51	30		26	56
53		32		52	38		27	57
54		33		53	48		43	58
55		34		55	49			59
56		35		58	58			60
57		37		59	61			61
58		40		60				62
59		45		61				
60		47		62				
61		48						
62								

Table 1. FPHCP native fish covered species and Water Resource Inventory Area (WRIA) distribution. Table does not include bull trout. (continued)

[2]

Redside Shiner	Reticulated Sculpin	Riffle Sculpin	River Lamprey	Salish Sucker	Sandroller	Shorthead Sculpin	Slimy Sculpin	Speckled Dace
				WRIA				
1	9	8	1	1	25	7	47	8
3	10	9	3	3	26	8	55	9
5	11	10	5	4	27	9	58	10
7	13	11	7	5	28	10	60	11
8	14	13	8	7	29	11	62	13
9	16	14	9	8	30	15		14
10	19	15	10	9	31	16		15
11	20	16	16	10	35	19		19
19	21	19	20	11	37	20		20
20	22	20	21	16	56	21		21
21	23	21	22			22		22
23	24	22	26			23		23
24	25	23	28			25		24
25	26	24	29			26		25
26	27	25	31			27		26
27	28	26	32			28		27
28	29		37			38		28
29			39			39		29
30						45		30
32						46		31
33						47		32
34						48		34
35						60		35
37								37
38								38
39								39
40								40
44								43
45								44
46								45
47								46
48								47
49								48
50								49
51								50
52								51
53								52
54								53
55								54
58								55
59								56
60								57
61								58
62								59

Table 1. FPHCP native fish covered species and Water Resource Inventory Area (WRIA) distribution. Table does not include bull trout. (continued)

Three-Spine Stickelback	Torrent Sculpin	Tui Chub	Umatilla Dace	Western Brook Lamprey	White Sturgeon
			WRIA		
1	5	41	31	1	8
3	7		37	3	22
5	8		40	5	24
7	9		45	7	25
8	10		48	8	26
9	11		49	9	27
10	12		59	10	28
11	13		61	11	29
12	14			13	30
13	15			14	31
14	16			15	32
15	19			16	33
16	20			17	34
17	21			18	35
18	22			19	37
19	23			20	38
21	24			21	39
22	26			22	
23	27			23	
24	30			24	
25	32			26	
26	35			27	
27	45			29	
28	46			32	
29	47			35	
30	48			37	
31	49			39	
37	51				
40	52				
47	55				
	58				
	59				
	60				
	61				
	62				

Table 2. Quantification of the Effects of the Action, on FPHCP covered native fish, by FPHCP Covered Activities.

FPHCP Covered Native Fish Species
Dolly Varden
• Type F riparian management acres: 40,735
• Type Np riparian management acres: 21,679
• Type F stream crossings: 2,308
• Type Np stream crossings: 1,270
• Type F riparian roads: 317 miles (1,536acres)
• Type Np riparian roads: 140 miles (678 acres)
Coastal cutthroat trout
• Type S riparian management acres: 138,429
• Type F riparian management acres: 286,862
• Type Np riparian management acres: 126,456
• Type S stream crossings: 1,462
• Type F stream crossings: 14,970
• Type Np stream crossings: 7,126
• Type S riparian roads: 1,197 miles (5,803 acres)
• Type F riparian roads: 2,400 miles (11,636 acres)
• Type Np riparian roads: 777 miles (3,767 acres)
Westslope cutthroat trout
• Type S riparian management acres: 17,373
• Type F riparian management acres: 21,590
• Type Np riparian management acres: 29,380
• Type S stream crossings: 240
• Type F stream crossings: 918
• Type Np stream crossings: 1,651
• Type S riparian roads: 131 miles (636 acres)
• Type F riparian roads: 252 miles (1,221 acres)
• Type Np riparian roads: 281 miles (1,362 acres)
Coastal rainbow trout
• Type S riparian management acres: 129,417
• Type F riparian management acres: 270,542
• Type Np riparian management acres: 117,503
• Type S stream crossings: 1,342
• Type F stream crossings: 14,116
• Type Np stream crossings: 6,714
• Type S riparian roads: 1,109 miles (5,376 acres)
• Type F riparian roads: 2,233 miles (10,826 acres)
• Type Np riparian roads: 711 miles (3,447 acres)

Table 2. Quantification of the Effects of the Action, on FPHCP covered native fish, by FPHCP Covered Activities. (continued)

Redband rainbow trout

- Type S riparian management acres: 27,364
- Type F riparian management acres: 41,608
- Type Np riparian management acres: 50,734
- Type S stream crossings: 366
- Type F stream crossings: 1,948
- Type Np stream crossings: 2,607
- Type S riparian roads: 206 miles (998 acres)
- Type F riparian roads: 504 miles (2,443 acres)
- Type Np riparian roads: 471 miles (2,283 acres)

Mountain whitefish

- Type S riparian management acres: 97,582
- Type F riparian management acres: 173,745
- Type Np riparian management acres: 98,634
- Type S stream crossings: 988
- Type F stream crossings: 8,786
- Type Np stream crossings: 6,625
- Type S riparian roads: 713 miles (3,456 acres)
- Type F riparian roads: 1,548 miles (7,505 acres)
- Type Np riparian roads: 866 miles (4,198 acres)

Pygmy whitefish

- Type S riparian management acres: 11,222
- Type F riparian management acres: 3,574
- Type Np riparian management acres: 12,272
- Type S stream crossings: 127
- Type F stream crossings: 843
- Type Np stream crossings: 673
- Type S riparian roads: 88 miles (426 acres)
- Type F riparian roads: 169 miles (819 acres)
- Type Np riparian roads: 103 miles (499 acres)

Pacific lamprey

- Type S riparian management acres: 128,055
- Type F riparian management acres: 268,585
- Type Np riparian management acres: 121,835
- Type S stream crossings: 1,469
- Type F stream crossings: 13,818
- Type Np stream crossings: 6,863
- Type S riparian roads: 1,124 miles (5,449 acres)
- Type F riparian roads: 2,267 miles (10,991 acres)
- Type Np riparian roads: 775 miles (3,757 acres)

Table 2. Quantification of the Effects of the Action, on FPHCP covered native fish, by FPHCP Covered Activities. (continued)

River lamprey

- Type S riparian management acres: 85,624
- Type F riparian management acres: 155,353
- Type Np riparian management acres: 79,452
- Type S stream crossings: 804
- Type F stream crossings: 8,036
- Type Np stream crossings: 4,597
- Type S riparian roads: 628 miles (3,044 acres)
- Type F riparian roads: 1,304 miles (6,322 acres)
- Type Np riparian roads: 536 miles (2,598 acres)

Western brook lamprey

- Type S riparian management acres: 128,532
- Type F riparian management acres: 265,246
- Type Np riparian management acres: 119,309
- Type S stream crossings: 1,365
- Type F stream crossings: 13,702
- Type Np stream crossings: 6,774
- Type S riparian roads: 1,079 miles (5,231 acres)
- Type F riparian roads: 2,224 miles (10,783 acres)
- Type Np riparian roads: 766 miles (3,713 acres)

Kokanee

- Type S riparian management acres: 69,162
- Type F riparian management acres: 124,916
- Type Np riparian management acres: 72,435
- Type S stream crossings: 729
- Type F stream crossings: 5,880
- Type Np stream crossings: 4,144
- Type S riparian roads: 484 (2,346 acres)
- Type F riparian roads: 1,041 miles (5,047 acres)
- Type Np riparian roads: 560 miles (2,715 acres)

Olympic mudminnow

- Type S stream crossings: 357
- Type F stream crossings: 4,268
- Type Np stream crossings: 1,283
- Type S riparian roads: 300 miles (1,454 acres)
- Type F riparian roads: 686 miles (3,326 acres)
- Type Np riparian roads: 135 miles (654 acres)

Chiselmouth

- Type S stream crossings: 542
- Type F stream crossings: 3,869
- Type Np stream crossings: 4,366

Table 2. Quantification of the Effects of the Action, on FPHCP covered native fish, by FPHCP Covered Activities. (continued)

Redside shiner

- Type S riparian management acres: 134,772
- Type F riparian management acres: 248,698
- Type Np riparian management acres: 148,675
- Type S stream crossings: 1,530
- Type F stream crossings: 12,987
- Type Np stream crossings: 8,500
- Type S riparian roads: 1,179 miles (5,716 acres)
- Type F riparian roads: 2,280 miles (11,054 acres)
- Type Np riparian roads: 1,079 miles (5,231 acres)

Speckled dace

- Type S riparian management acres: 128,300
- Type F riparian management acres: 266,179
- Type Np riparian management acres: 140,055
- Type S stream crossings: 1,474
- Type F stream crossings: 13,074
- Type Np stream crossings: 7,705
- Type S riparian roads: 1,121 miles (5,435 acres)
- Type F riparian roads: 2,298 miles (11,141 acres)
- Type Np riparian roads: 989 miles (4,795 acres)

Longnose/Nooksack dace

- Type S riparian management acres: 133,392
- Type F riparian management acres: 258,204
- Type Np riparian management acres: 141,456
- Type S stream crossings: 1,496
- Type F stream crossings: 12,833
- Type Np stream crossings: 7,777
- Type S riparian roads: 1,164 (5,643 acres)
- Type F riparian roads: 2,283 miles (11,064 acres)
- Type Np riparian roads: 972 miles (4,712 acres)

Leopard dace

- Type S riparian management acres: 29,774
- Type F riparian management acres: 53,584
- Type Np riparian management acres: 35,412
- Type S stream crossings: 364
- Type F stream crossings: 3,123
- Type Np stream crossings: 2,484
- Type S riparian roads: 281 miles (1,362 acres)
- Type F riparian roads: 567 miles (2,794 acres)
- Type Np riparian roads: 275 miles (1,333 acres)

Table 2. Quantification of the Effects of the Action, on FPHCP covered native fish, by FPHCP Covered Activities. (continued)

Umatilla dace

- Type S riparian management acres: 1,483 acres
- Type F riparian management acres: 13,022
- Type Np riparian management acres: 17,966
- Type S stream crossings: 96
- Type F stream crossings: 502
- Type Np stream crossings: 970
- Type S riparian roads: 56 miles (271 acres)
- Type F riparian roads: 143 miles (693 acres)
- Type Np riparian roads: 152 miles (736 acres)

Northern pikeminnow

- Type S riparian management acres: 84,009
- Type F riparian management acres: 162,919
- Type Np riparian management acres: 92,922
- Type S stream crossings: 933
- Type F stream crossings: 7,922
- Type Np stream crossings: 5,214
- Type S riparian roads: 702 (3,403 acres)
- Type F riparian roads: 1,458 (7,069 acres)
- Type Np riparian roads: 707 (3,427 acres)

Tui chub

- Type S stream crossings: 5
- Type F stream crossings: 5

Lake chub

- Type S stream crossings: 64
- Type F stream crossings: 630

Peamouth

- Type S stream crossings: 956
- Type F stream crossings: 8,359
- Type Np stream crossings: 5,806

Largescale sucker

- Type S stream crossings: 1,531
- Type F stream crossings: 13,145
- Type Np stream crossings: 7,858

Salish sucker

- Type S riparian management acres: 46,778
- Type F riparian management acres: 65,919
- Type Np riparian management acres: 43,106
- Type S stream crossings: 401
- Type F stream crossings: 3,945
- Type Np stream crossings: 2,423
- Type S riparian roads: 347 (1,682 acres)
- Type F riparian roads: 610 miles (2,957acres)
- Type Np riparian roads: 286 miles (1,386 acres)

Table 2. Quantification of the Effects of the Action, on FPHCP covered native fish, by FPHCP Covered Activities. (continued)

Longnose sucker

- Type S riparian management acres: 17,333
- Type F riparian management acres: 62,340
- Type Np riparian management acres: 38,873
- Type S stream crossings: 200
- Type F stream crossings: 1,164
- Type Np stream crossings: 1,829
- Type S riparian roads: 117 (567 acres)
- Type F riparian roads: 295 miles (1,430acres)
- Type Np riparian roads: 319 miles (1,546 acres)

Bridgelip sucker

- Type S riparian management acres: 76,553
- Type F riparian management acres: 159,439
- Type Np riparian management acres: 85,114
- Type S stream crossings: 947
- Type F stream crossings: 7,417
- Type Np stream crossings: 4,689
- Type S riparian roads: 721 (3,503 acres)
- Type F riparian roads: 1,342 (6,521)
- Type Np riparian roads: 594 (2,866 acres)

Mountain sucker

- Type S riparian management acres: 30,914
- Type F riparian management acres: 50,499
- Type Np riparian management acres: 41,703
- Type S stream crossings: 399
- Type F stream crossings: 3,004
- Type Np stream crossings: 2,841
- Type S riparian roads: 289 (1,401 acres)
- Type F riparian roads: 533 (2,584 acres)
- Type Np riparian roads: 352 (1,706 acres)

Three-spine stickleback

- Type S riparian management acres: 126,353
- Type F riparian management acres: 265,989
- Type Np riparian management acres: 120,238
- Type S stream crossings: 1,387
- Type F stream crossings: 13,665
- Type Np stream crossings: 6,679
- Type S riparian roads: 1,137 miles (5,512 acres)
- Type F riparian roads: 2,248 miles (10,899 acres)
- Type Np riparian roads: 740 miles (3,587 acres)

Sandroller

- Type S riparian management acres: 35,374
- Type F riparian management acres: 70,463
- Type Np riparian management acres: 41,836
- Type S stream crossings: 446
- Type F stream crossings: 4,048
- Type Np stream crossings: 2,744

Table 2. Quantification of the Effects of the Action, on FPHCP covered native fish, by FPHCP Covered Activities. (continued)

Shorthead sculpin

- Type S riparian management acres: 107,875
- Type F riparian management acres: 212,696
- Type Np riparian management acres: 101,481
- Type S stream crossings: 1,160
- Type F stream crossings: 11,101
- Type Np stream crossings: 6,064
- Type S riparian roads: 930 miles (4,509 acres)
- Type F riparian roads: 1,818 miles (8,814 acres)
- Type Np riparian roads: 704 miles (3,413 acres)

Riffle sculpin

- Type S riparian management acres: 91,220
- Type F riparian management acres: 207,671
- Type Np riparian management acres: 81,175
- Type S stream crossings: 981
- Type F stream crossings: 10,100
- Type Np stream crossings: 4,498
- Type S riparian roads: 139 miles (673 acres)
- Type F riparian roads: 276 miles (1,338 acres)
- Type Np riparian roads: 459 miles (2,225 acres)

Paiute sculpin

- Type S riparian management acres: 6,928
- Type F riparian management acres: 6,885
- Type Np riparian management acres: 10,860
- Type S stream crossings: 123
- Type F stream crossings: 427
- Type Np stream crossings: 592
- Type S riparian roads: 52 miles (252 acres)
- Type F riparian roads: 120 miles (581 acres)
- Type Np riparian roads: 127 miles (615 acres)

Prickly sculpin

- Type S riparian management acres: 126,735
- Type F riparian management acres: 255,648
- Type Np riparian management acres: 121,361
- Type S stream crossings: 1,361
- Type F stream crossings: 13,184
- Type Np stream crossings: 6,745
- Type S riparian roads: 1,096 miles (5,313 acres)
- Type F riparian roads: 2,185 miles (10,593 acres)
- Type Np riparian roads: 764 miles (3,704 acres)

Table 2. Quantification of the Effects of the Action, on FPHCP covered native fish, by FPHCP Covered Activities. (continued)

Coastrange sculpin

- Type S riparian management acres: 133,404
- Type F riparian management acres: 274,768
- Type Np riparian management acres: 118,710
- Type S stream crossings: 1,395
- Type F stream crossings: 14,312
- Type Np stream crossings: 6,757
- Type S riparian roads: 1,147 miles (5,561 acres)
- Type F riparian roads: 2,269 miles (11,001 acres)
- Type Np riparian roads: 718 miles (3,481 acres)

Torrent sculpin

- Type S riparian management acres: 127,061
- Type F riparian management acres: 258,504
- Type Np riparian management acres: 132,377
- Type S stream crossings: 1,346
- Type F stream crossings: 12,870
- Type Np stream crossings: 7,416
- Type S riparian roads: 1,067 miles (5,713 acres)
- Type F riparian roads: 2,182 miles (10,579 acres)
- Type Np riparian roads: 893 miles (4,329 acres)

Mottled sculpin

- Type S riparian management acres: 11,674
- Type F riparian management acres: 12,877
- Type Np riparian management acres: 20,435
- Type S stream crossings: 165
- Type F stream crossings: 593
- Type Np stream crossings: 1,068
- Type S riparian roads: 75 miles (363 acres)
- Type F riparian roads: 156 miles (756 acres)
- Type Np riparian roads: 212 miles (1,027 acres)

Slimy sculpin

- Type S riparian management acres: 6,901
- Type F riparian management acres: 9,412
- Type Np riparian management acres: 10,841
- Type S stream crossings: 67
- Type F stream crossings: 418
- Type Np stream crossings: 609
- Type S riparian roads: 41 miles (198 acres)
- Type F riparian roads: 112 miles (543 acres)
- Type Np riparian roads: 102 miles (494 acres)

Table 2. Quantification of the Effects of the Action, on FPHCP covered native fish, by FPHCP Covered Activities. (continued)

Margined sculpin

- Type S riparian management acres: 687
- Type F riparian management acres: 2,106
- Type Np riparian management acres: 2,293
- Type S stream crossings: 15
- Type F stream crossings: 133
- Type Np stream crossings: 75
- Type S riparian roads: 6 miles (29 acres)
- Type F riparian roads: 50 miles (242 acres)
- Type Np riparian roads: 23 miles (111 acres)

Reticulate sculpin

- Type S riparian management acres: 101,082
- Type F riparian management acres: 216,295
- Type Np riparian management acres: 87,623
- Type S stream crossings: 1,112
- Type F stream crossings: 10,601
- Type Np stream crossings: 5,095
- Type S riparian roads: 907 miles (4,397 acres)
- Type F riparian roads: 1,737 miles (8,412 acres)
- Type Np riparian roads: 507 miles (2,458 acres)

Longfin smelt

- Type S stream crossings: 19
- Type F stream crossings: 259
- Type Np stream crossings: 27

Burbot

- Type S stream crossings: 42
- Type F stream crossings: 225

White sturgeon

- Type S stream crossings: 856