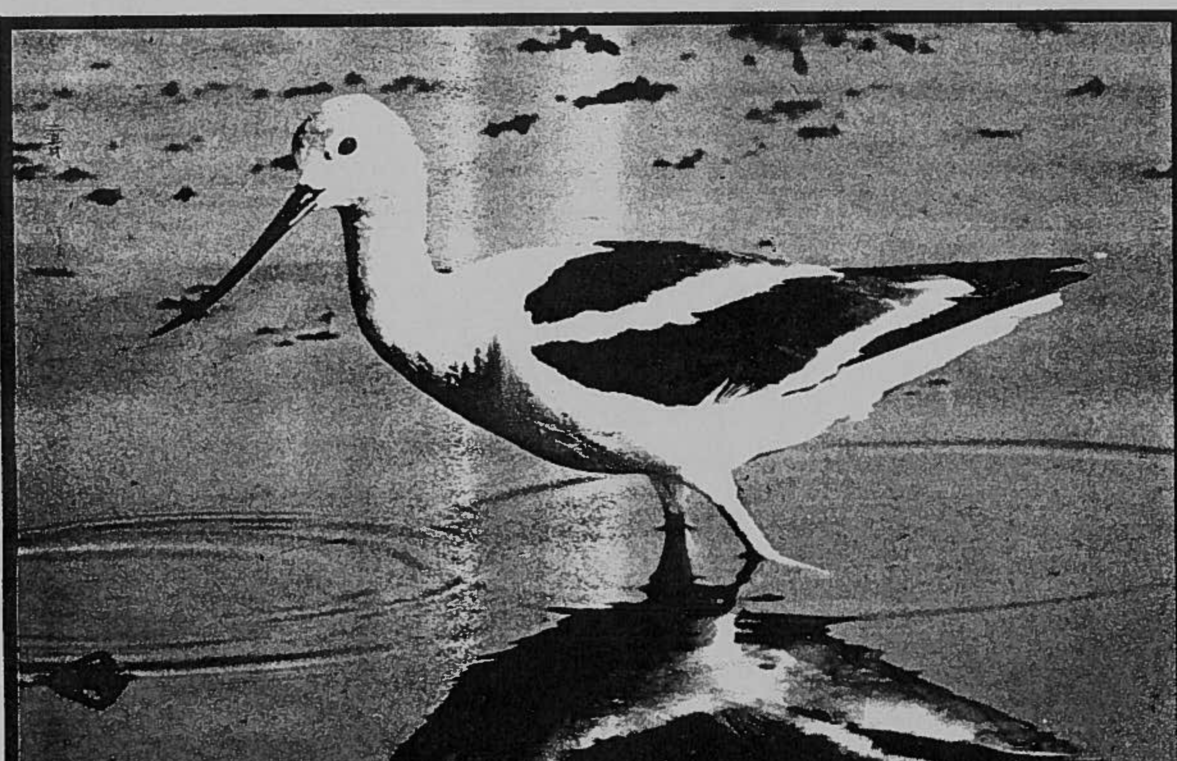
Contaminant Report Number: R6/206H/91

U.S. FISH & WILDLIFE SERVICE
REGION 6
CONTAMINANTS PROGRAM

CALMING TROUBLED WATERS:

Contaminants at Benton Lake National Wildlife Refuge, Montana

A PLAN OF ACTION



U.S. FISH AND WILDLIFE SERVICE
FISH AND WILDLIFE ENHANCEMENT
MONTANA STATE OFFICE
HELENA, MONTANA
1991

CALMING TROUBLED WATERS

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A view of the Benton Lake Refuge marsh in a year of good runoff, looking to the northwest.

Cover photo of avocet by Neal and Mary Mishler

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INTRODUCTION

" Contaminant: A substance that contaminates another substance, the air, water, etc."

"Contaminate: Refers to that which on coming into contact with something will make it impure, unclean or unfit for use"

- Webster's New World Dictionary

When contaminants on National Wildlife Refuges are mentioned, visions of old toxic waste sites, trace elements such as selenium and mercury, and pesticide residues most often come to mind. However, contaminants can be much more. At Benton Lake National Wildlife Refuge, contaminants mean not only the trace elements proven harmful to biotic systems at certain concentrations, but the question of salinity, or salts, that may prove to be a more immediate concern to the continued well-being of the refuge marsh.

The subject of contaminants has been an extremely complex one. To a refuge manager who is often a generalist and pragmatist, the research of contaminants based on complex chemistry and analytical methods can be confusing and frustrating. This complexity is one of the reasons why action to remedy the contaminant problems on many refuges has been slow in coming.

However, when all the studies, all the technical bulletins and all the research papers are set aside, solving contaminant problems on refuges may in the end boil down to implementing sound land management on the refuge, and more importantly, sound land management on private lands surrounding the refuge.

This plan of action for Benton Lake is thus a bridge between the necessary world of research and the practical, down-to-earth methods of land management to solve the contaminant problem. The problem has been studied for years, and study or monitoring will be a necessary part of future work. But now it is time to apply what has been learned and begin cleaning up the problem.

This effort will not be easy or cheap, but to watch a national treasure die a slow death is an unacceptable alternative. This

plan will first provide a background on the refuge environment which includes the refuge proper as well as the components and dynamics of the surrounding area. It will summarize research or contaminant monitoring that has been done to date, set objectives, and finally, list the actions necessary to ensure the long-term health of the refuge. Although actions will be carried out over the next 10 years, budget projections are only through 1995 as plan revisions will no doubt change some actions and thus dollar amounts.

The reader is urged to review Appendices A-1 and A-2 before reviewing this plan. These "fact sheets" on selenium, salinity and units of measure will aid in understanding several plan sections. Finally, credit is due many people whose field work, advice and insight are really the basis for this plan. Special thanks to the staff of the Fish and Wildlife Enhancement Office in Helena, the U.S. Geological Survey, Montana Salinity Control Association and the exceptional staff at Benton Lake Refuge and Wetland Management District.

Don Hultman
Refuge Manager
March, 1991

EXECUTIVE SUMMARY

The contaminant issue on Benton Lake National Wildlife Refuge near Great Falls, Montana involves both salts and trace elements proven toxic at certain concentrations. Salinization of the refuge marsh has been a concern for nearly 20 years, while trace element contamination, namely selenium, was first brought to light in 1985.

Since 1985, studies by the U.S. Fish and Wildlife Service and other agencies have shown that Benton Lake contains concentrations of trace elements that exceed most standards for both wildlife and human health. Salinity levels have shown a trend upward since 1974 and may pose a more immediate threat than trace elements to the refuge wetland environment. Despite the concern over salt and element concentrations on the refuge, no major problems are being exhibited by wildlife to date.

The root causes of undesirable contaminant levels are agricultural practices on private land within the refuge's 150 square mile watershed. The fallow-cropping method of growing small grain has drastically increased the rate of saline seep development. Saline seeps are either directly or indirectly responsible for bringing most salts and trace elements into the refuge.

The basic strategy for cleaning-up contaminants on the refuge is to clean-up the watershed by reclaiming saline seeps and improving water management capabilities by a more stable water supply and an outlet drain. This strategy will be carried out by a series of actions over the next 5-10 years. Total cost for the first five years of clean-up is estimated at $4.5 million. These actions are designed to reach clean-up goals of a tolerable, stable salinity level in the refuge marsh, and a selenium input rate that will not accumulate in the system.

THE REFUGE ENVIRONMENT

This section describes the refuge itself and the various components of the surrounding environment that have a direct affect on the contaminant issue at Benton Lake. Each description is followed by a map or diagram to aid understanding of the "big picture". The last part of the section includes a diagram provided by a hydrologist with the Geological Survey that depicts the probable dynamics of water, salt and trace element movement in and out of Benton Lake.

The Refuge

Benton Lake is a 12,383 acre refuge located on the western edge of the northern Great Plains some 50 miles east of the Rocky Mountains and 12 miles north of Great Falls, Montana. Benton Lake proper is a 5,000 acre glacial lake bed which is the terminus, or sump, of a 150 square mile watershed. Refuge terrain is gently rolling with shortgrass native prairie the predominant vegetation.

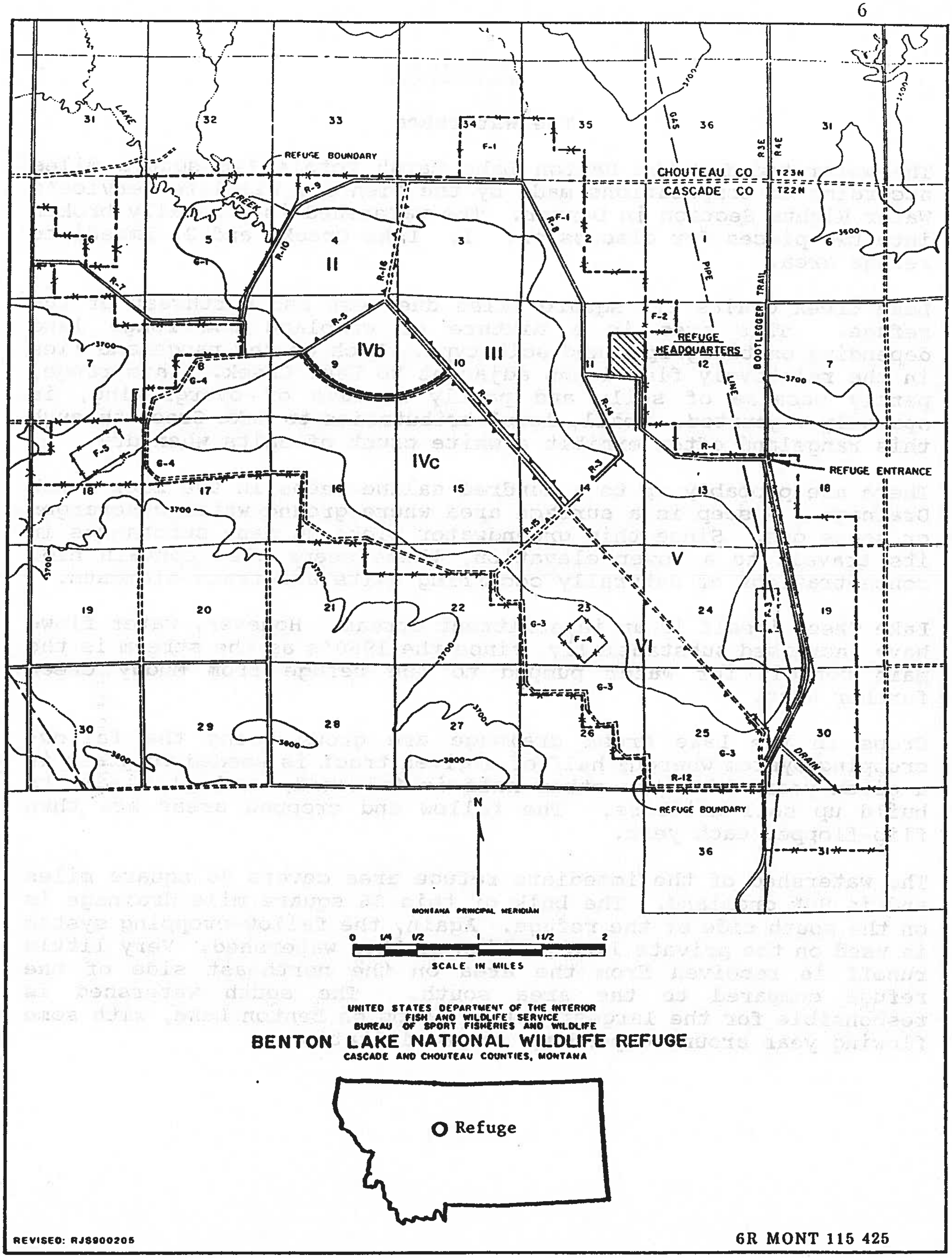
The climate is generally temperate, but wild fluctuations may occur. Summer highs may soar to over 100 degrees while winter lows may plunge to near 50 below zero. Rain and snow are erratic with the area averaging only 12 inches of precipitation a year. Evaporation losses average 42 inches per year. Extremely windy conditions often occur fall through spring due to Chinook winds that develop along the Rocky Mountain Front.

The refuge was established by Executive Order in 1929 as "a refuge and breeding ground for birds." Little development of the refuge occurred until the station was staffed in 1961. At about this same time, a pumping station was built on Muddy Creek 15 miles to the west to bring return irrigation flows to the refuge via a pipeline and Lake Creek. This additional water source has helped eliminate the boom and bust cycle of the refuge marsh, generally assuring some water even in times of severe drought. The refuge is one of the premiere waterfowl production refuges in the country, producing to flight stage an average of 20,000 ducks yearly.

The lake or marsh has been divided into eight marsh units to more efficiently use available water for the enhancement of aquatic vegetation, while allowing water manipulation in the case of a botulism outbreak. Water management between units is generally by gravity flow, although an inter-unit pump system is available for moving water between lower marsh units.

Refuge wildlife is dominated by waterbirds including most major species of ducks, Canada geese, gulls, terns and various shorebirds. The refuge has been nominated for inclusion in the Western Hemisphere Shorebird Preserve Program. Peak one-time migration numbers include 100,000 ducks, 40,000 snow and dark geese, 5,000 tundra swans and upwards of 10,000 shorebirds. Threatened or endangered species such as the bald eagle and peregrine falcon are often sighted spring and fall. Other refuge wildlife includes twenty species of prairie mammals, but only a handful of reptiles and amphibians. No sizeable fish are present due to the shallowness of the marsh.

Land use around the refuge is intensive agriculture with wheat the principal crop grown. The area from Great Falls north to the Canadian border is known as the "Golden Triangle" of Montana due to the sea of grain.


REFUGE BOUNDARY
CHOUTEAU CO
CASCADE CO
T23N
T22N
R3E
R4E
GAS PIPE LINE
BOOTLEGGER TRAIL
LAKE CREEK
REFUGE HEADQUARTERS
REFUGE ENTRANCE
REFUGE BOUNDARY
DRAIN
II
III
IVb
IVc
V
VI
F-1
F-2
F-3
F-4
F-5
G-1
G-3
G-4
R-1
R-3
R-4
R-5
R-7
R-8
R-9
R-10
R-12
R-14
R-15
R-16
3700
3600
3800
N
MONTANA PRINCIPAL MERIDIAN
0 1/4 1/2 1 1 1/2 2
SCALE IN MILES
UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE
BENTON LAKE NATIONAL WILDLIFE REFUGE
CASCADE AND CHOUTEAU COUNTIES, MONTANA
Refuge
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The Watershed

The watershed for the Benton Lake marsh totals 148 square miles according to computations made by the Fish and Wildlife Service's Water Rights Section in Denver. The watershed is generally broken into two pieces for discussion: 1. Lake Creek, and 2. Immediate refuge area.

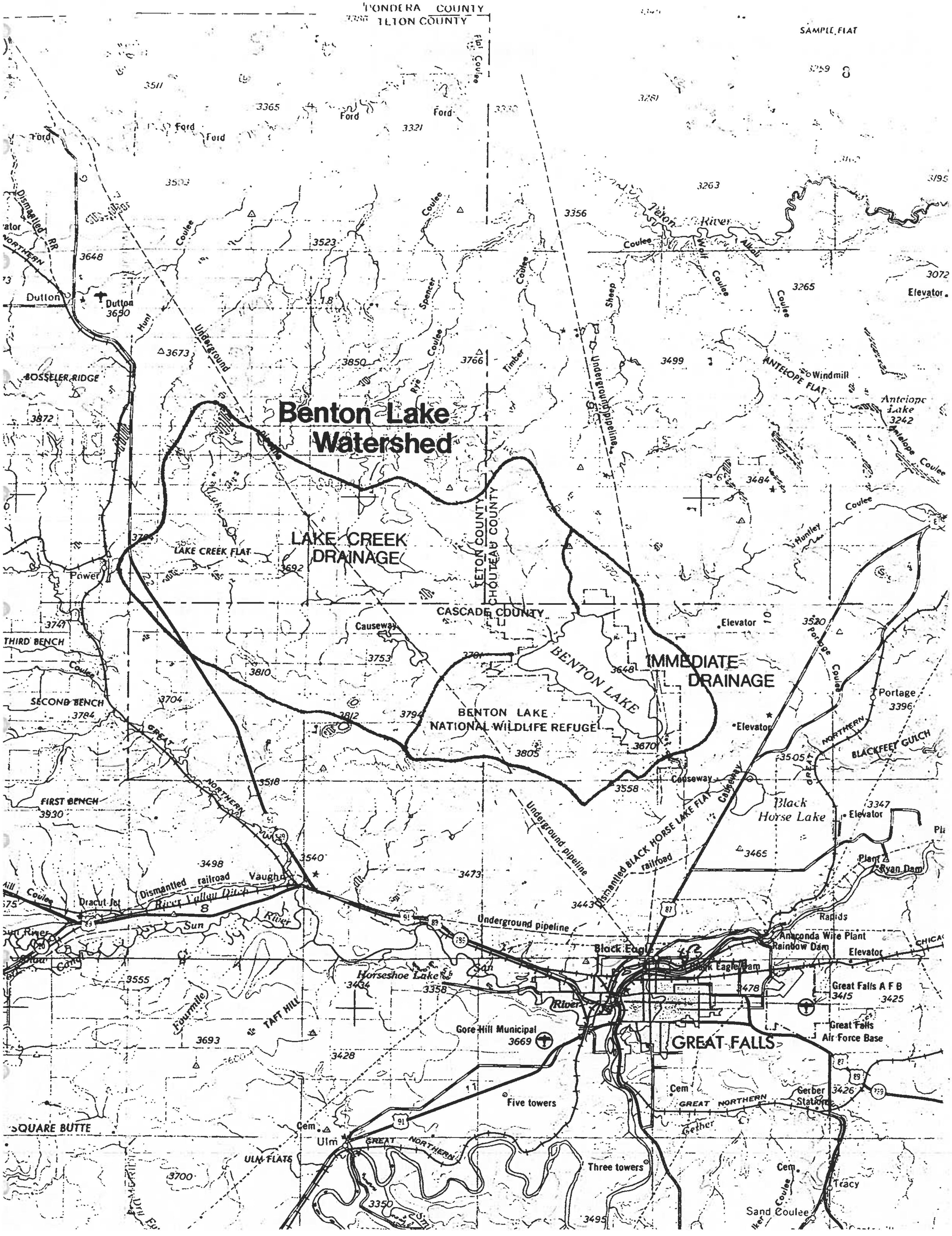
Lake Creek drains 112 square miles due west and northwest of the refuge. This area is a mixture of cropland and range land depending on topography and soil type. Much of the rangeland lies in the relatively flat lands adjacent to Lake Creek. This range, partly because of soils and partly because of overgrazing, is sparsely vegetated. Small, local tributaries to Lake Creek through this rangeland often exhibit a white crust of salts when dry.

There are probably up to a hundred saline seeps in the Lake Creek Drainage. A seep is a surface area where ground water discharges or seeps out. Since this groundwater picks up many substances in its travels to a lower elevation, these seeps also contain high concentrations of naturally occurring salts and trace elements.

Lake Creek itself is an intermittent stream. However, water flows have increased substantially since the 1960's as the stream is the main conduit for water pumped to the refuge from Muddy Creek further west.

Crops in the Lake Creek drainage are grown using the fallow-cropping system whereby half of a given tract is seeded to grain in a given year while the other half is fallowed, or kept black, to build up soil moisture. The fallow and cropped areas are then flip-flopped each year.

The watershed of the immediate refuge area covers 36 square miles and is 90% cropland. The bulk of this 36 square mile drainage is on the south side of the refuge. Again, the fallow-cropping system is used on the private land portion of this watershed. Very little runoff is received from the area on the northeast side of the refuge compared to the area south. The south watershed is responsible for the largest saline seeps on Benton Lake, with some flowing year around depending on precipitation.


Benton Lake Watershed
LAKE CREEK DRAINAGE
IMMEDIATE DRAINAGE
BENTON LAKE
BENTON LAKE NATIONAL WILDLIFE REFUGE
PONDERA COUNTY
TETON COUNTY
CHOUTEAU COUNTY
CASCADE COUNTY
Teton River
SAMPLE FLAT
Dutton
BOSSELER RIDGE
LAKE CREEK FLAT
Power
THIRD BENCH
SECOND BENCH
FIRST BENCH
ANTELOPE FLAT
Antelope Lake
Black Horse Lake
BLACK HORSE LAKE FLAT
Portage
BLACKFEET GULCH
Vaughn
Dracut Jct
Sun River
Sun River
Horseshoe Lake
TAFT HILL
Gore Hill Municipal
Black Eagle
Black Eagle Dam
Rainbow Dam
Ryan Dam
Anaconda Wire Plant
GREAT FALLS
Great Falls A F B
Great Falls Air Force Base
Gerber Station
Five towers
Three towers
SQUARE BUTTE
Ulm
ULM FLATS
Tracy
Sand Coulee
Underground pipeline
Dismantled railroad
GREAT NORTHERN

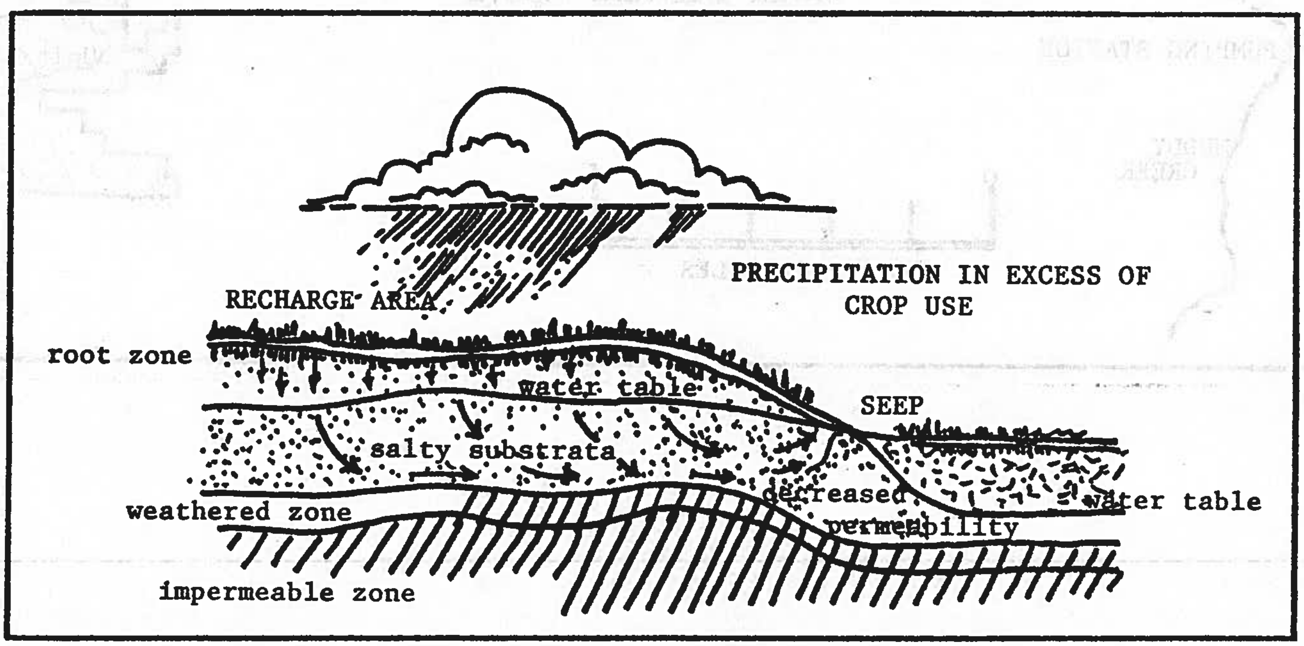
Saline Seeps

To understand the contaminant problem at Benton Lake, it is crucial to understand saline seeps which may directly and indirectly be the main source of contaminant flow to the refuge marsh. The following explanation of seeps is taken from the Soil Conservation Service's soil survey for Cascade County:

Most soils in arid regions contain soluble salts. The salts released by weathering of soil material normally remain in soils of arid regions because not enough rain falls to fully wet the soil profile and leach the salts.

Saline seep results when water moves through a saline soil, commonly formed in glacial till, and collects on top of impermeable underlying shale or dense clay. The problem of excess water occurs mainly in areas of crop-fallow dryland farming. During the fallow periods, more water is stored in the soil than can be used by the crop. This excess water moves downslope over the shale until it reaches the soil surface. The water then evaporates and dissolved salts are precipitated on the soil surface. The water is saline because salts have been leached from the subsoil, the glacial till parent material, and the shale. The predominant dissolved materials are sodium, magnesium, sulfate, and nitrate. The trace metallic elements, generally found in high concentrations, are aluminum, iron, manganese, strontium, lead, copper, zinc, nickel, selenium, chromium, molybdenum, and vanadium. Samples of ground water may contain up to 41,000 mg/l of dissolved solids which is more saline than sea water at 36,000 mg/l.

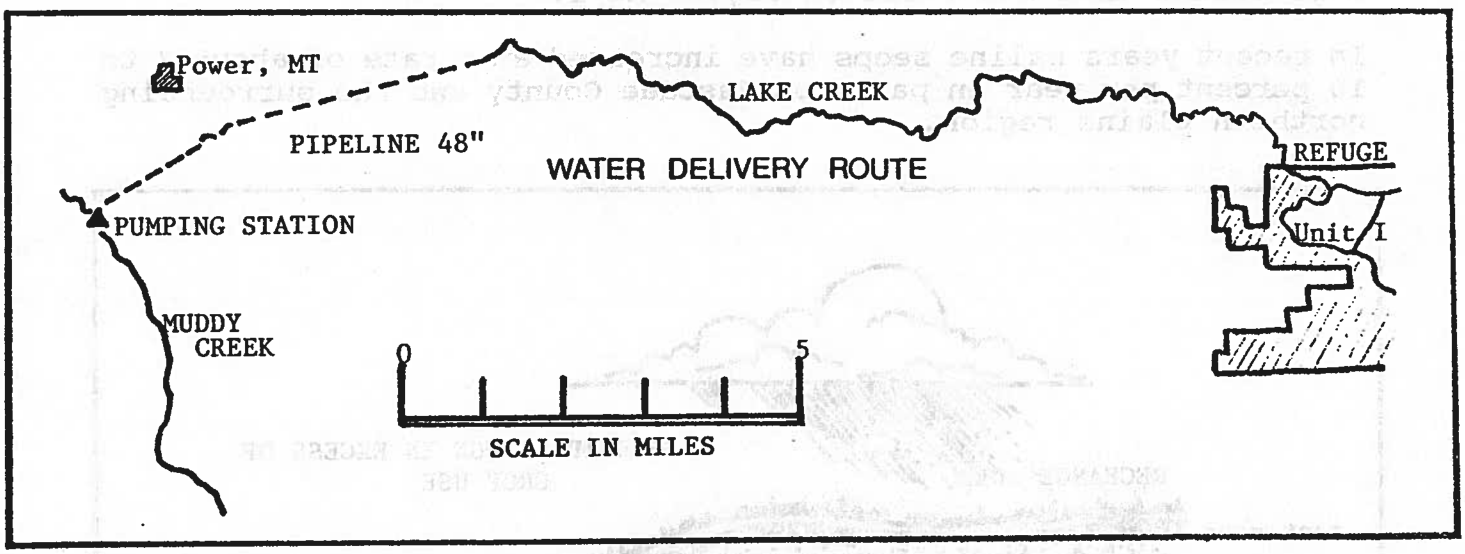
In recent years saline seeps have increased at a rate of about 8 to 10 percent per year in parts of Cascade County and the surrounding northern plains region.



Pumping System

The pumping station at Muddy Creek some 15 miles due west of the refuge was one of the first refuge developments in the late 1950's and early 1960's. During periods of irrigation on the Greenfields Irrigation District, return flows or "excess" water finds its way to Muddy Creek, thus providing enough flow for pumping. The pumping season is generally from May until mid-October. The refuge has rights for up to 14,600 acre feet of Muddy Creek's water each year. This water is free of charge, but electrical costs to run the three pumps (2-350 h.p. and 1-250 h.p.) are high, with each acre-foot of water pumped the past five years costing about $6.50. Since 1974, an average of 3,578 acre-feet of water has been pumped to the refuge each year. During periodic years of high spring runoff no water may be pumped, while in most years the average pumping fund of $30-60,000 is exhausted prior to meeting water needs. Funds for pumping are generally not a line item in the station budget, but gleaned from regular operations and maintenance funds.

Upon leaving the pump station, water passes through an underground pipeline for five miles before emptying into Lake Creek. From this point the water flows by gravity into the northwest corner of the refuge marsh called Unit I. With all three pumps running, approximately 82 acre-feet can be pumped per 24 hour day.

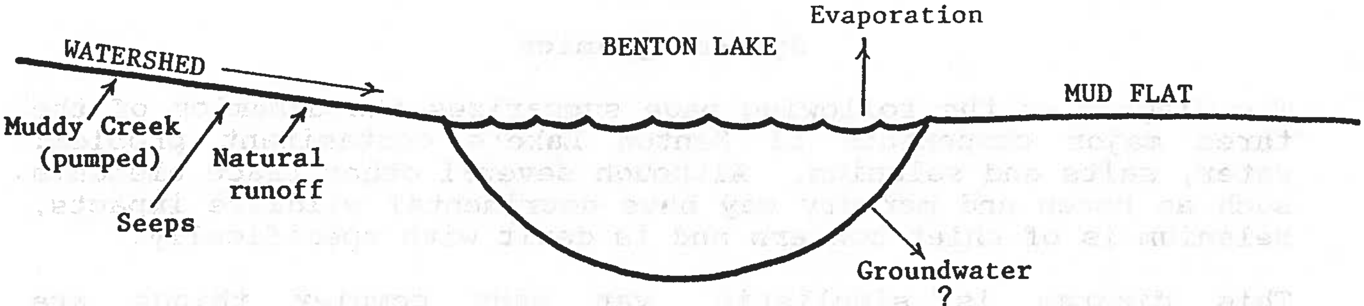


System Dynamics

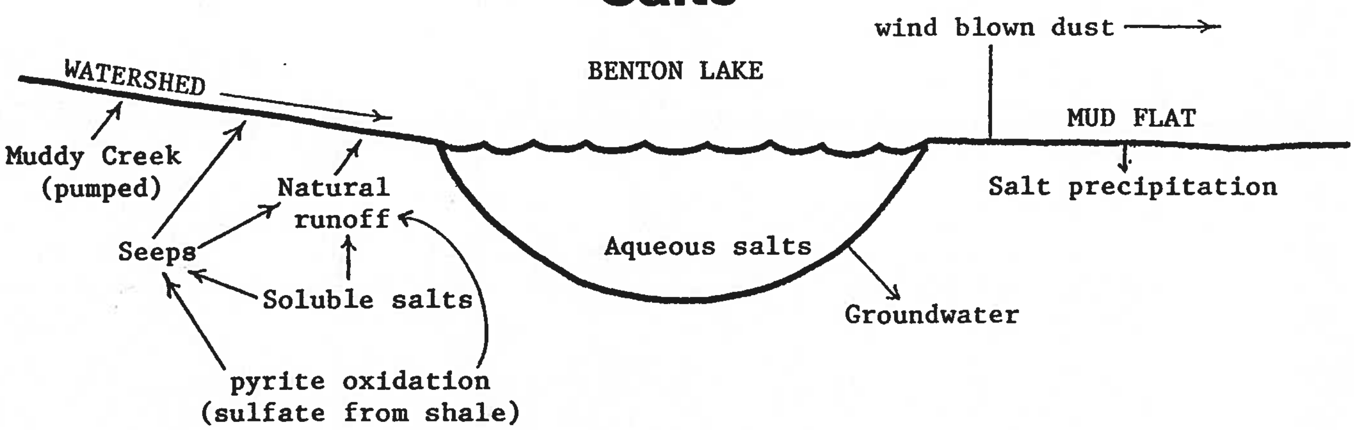
The diagram on the following page summarizes the dynamics of the three major components of Benton Lake's contaminant problem: water, salts and selenium. Although several other trace elements such as boron and mercury may have detrimental wildlife impacts, selenium is of chief concern and is dealt with specifically.

This diagram is simplistic, yet many complex things are represented, as well as questions yet to be answered. For example, what amount, if any, of water in the marsh is leaving the system via groundwater (discharge)? As for selenium, how much is actually leaving the lake via volatilization? How much selenium is being tied-up in deep sediments and thus "out of reach" of the refuge food chain? Those areas of the diagram with question marks are thus some interactions that have yet to be quantified.

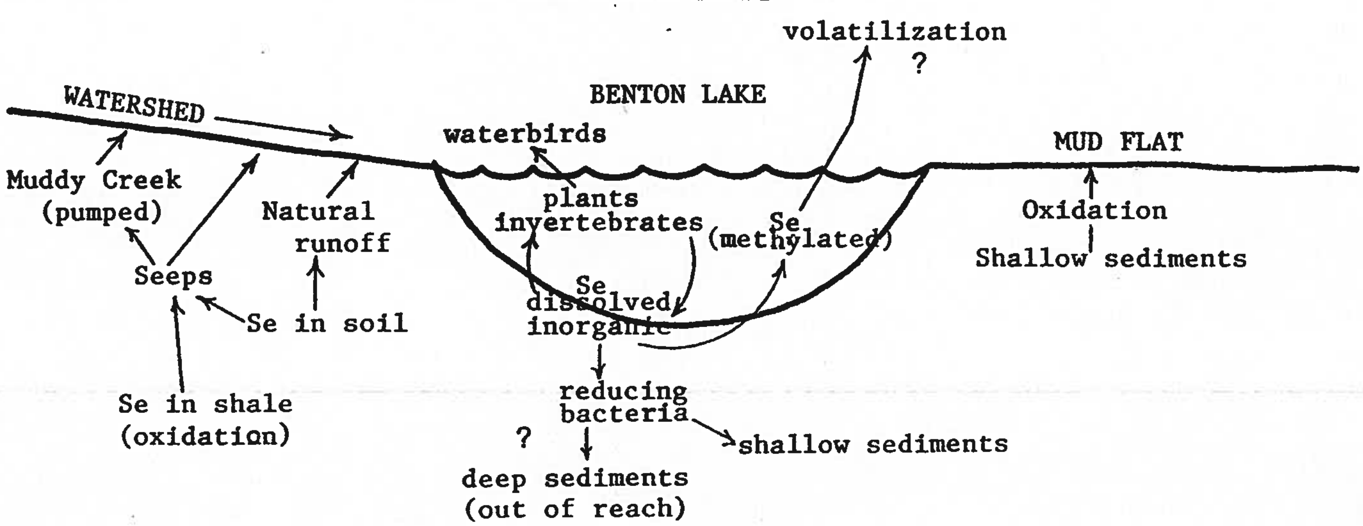
Water



Salts



Selenium



PROBLEM DEFINITION AND BACKGROUND

Contaminant problems at Benton Lake are twofold: 1. The salinization of the refuge marsh, and 2. The accumulation of trace elements such as selenium. Both can cause a marked decline in wildlife use, survivability of wildlife, or affect the reproductive capability of wildlife attracted to the area.

Water quality of the refuge has been a concern for decades. When the refuge was first being developed in the late 1950's and early 1960's, engineers and managers toyed with the idea of digging an outlet channel to improve water quality by flushing the marsh downstream in years of high runoff. The outlet was also desirable from the standpoint of controlling botulism outbreaks and protecting dikes during floods.

In the 1970's, managers began measuring the salt content or salinity of refuge marsh units. In a few years, data showed a trend towards more saline conditions. Also in the 70's, the refuge experienced some of the worse botulism outbreaks since the refuge was established, necessitating a reevaluation of water management practices which eventually led to shallow water impoundments rather than "pump and hold as much water as you can."

In the 1980's, water management was geared towards shallow water regimes which decreased the severity of botulism outbreaks and increased marsh productivity. An inter-unit pumping system was developed which allowed the transfer of water from one unit to another in case of a disease outbreak. These pumps also permitted the use of Unit IV as a saline sump, to keep waters in the remaining areas fresher (discontinued in 1989). Salinity continued to be a concern and monitoring of salt levels continued, again with an upward trend in salt concentrations. An outlet study by a private engineering firm in 1984 predicted that some marsh units would be unfit for waterfowl broods in as few as 16 years or in as many as 50 years. This prediction was based on salinity readings since 1974 and a salt balance formula.

In 1985, reporter Tom Harris from the <u>Sacramento Bee</u> newspaper in California sampled water and sediments from many refuges throughout the west in an attempt to see if they were heading the way of Kesterson NWR in California which had experienced bird deformities due to selenium concentrations. The reporter found elevated levels of selenium in sediment from several refuges including Benton Lake (7.5 $\mu g/g$), prompting the FWS to begin active monitoring of refuge waters, sediments and wildlife to see if a problem did exist. The first sediment sample was taken by refuge staff during the fall of 1985 in response to Harris' findings. This sample showed a selenium concentration of 10 $\mu g/g$.

RESEARCH AND MONITORING SUMMARY

Since the Sacramento Bee story, the U.S. Geological Survey, Bureau of Reclamation and the Fish and Wildlife Service in particular have carried out yearly monitoring programs to find out if a contaminant problem did exist at Benton Lake, and if so, what were the consequences on wildlife. Investigation of salinity levels was rarely looked at specifically, but was often a by-product of water sampling done in most studies.

The summaries that follow are only highlights of the often lengthy and complex documents. It is also important to note that analysis of samples is a long process, with final results not often known until up to two years following collection. This analysis in and of itself can delay final report writing.

To assist the reader, a units of measure table with explanation is included in Appendix A-1, while fact sheets on selenium and salinity are in Appendix A-2.

Feasibility Report on Constructing an Outlet Drain 1984

This report by a private engineering firm dealt mainly with the design of an outlet drain to alleviate flood damage and control salinity levels in the marsh. The firm analyzed past refuge conductivity (salinity) measurements from 1974-1981 and also made a salinity analysis based on calculation of the refuge salt balance. Based on this analysis, the firm concluded that Benton Lake would reach a conductivity level of 16,000 µS/L in 16 to 50 years. At this conductivity level duckling survival is sharply curtailed with mortality up to 30% and a drop in weight gain of up to 84%.

Dept. of Interior Reconnaissance Investigation 1986-87

This study, led by the U.S. Geological Survey, entailed the collection and analyzing of a large number of water, sediment and biota samples from the Sun River Irrigation Project, Freezeout Lake State Game Management Area and Benton Lake NWR. Although selenium was of primary interest, the presence of other trace elements and certain pesticides were also analyzed in the samples.

It was found that concentrations of toxic elements in the water, bottom sediment and biota of Benton Lake were moderately to considerably higher than established criteria. Refuge saline seeps showed the highest concentrations of toxic elements, with one sample showing selenium levels 50 times greater than the established standard for drinking water in Montana. Concentrations of selenium in fish, invertebrates, plants, coot livers, and avocet eggs pointed to the potential for a significant contaminant problem when compared to previous studies on selenium concentrations harmful to waterfowl.

Other conclusions from the reconnaissance investigation were that water being pumped from Muddy Creek to the refuge was relatively clean. Thus, contaminants and salts were being transported to the refuge by natural runoff or pumped water traveling down Lake Creek, saline seeps directly, or during runoff events that flushed seeps into the marsh.

FWS Contaminant Biomonitoring 1987

This study took a closer look at high selenium or "hot spots" on the refuge by examining livers of eared grebes. Eared grebes have been shown to be sensitive to contaminants due to their position in the marsh food chain. Nine out of 10 grebes collected showed selenium levels above 10 μg/g. These selenium levels are greater than the selenium residues detected in the liver of birds collected from uncontaminated areas. One grebe had a highly elevated level of 73.7 μg/g selenium in its liver. It was theorized that the Unit I marsh may have more selenium than other marsh units since the "hottest" grebes came from this area.

Benton Lake Refuge Embryo Study 1987-88

In 1987, duck eggs were collected from upland nests during refuge nest studies. Only eggs remaining in nests following hatching were collected. A total of 129 eggs were examined in the field for signs of infertility, dead embryos and deformed embryos. Some embryos were submitted for trace element analysis. In 1988, eggs were again collected, but this time visually checked in the lab. Any apparent deformed embryos were sent to the Patuxent Wildlife Research Center for visual examination prior to trace element analysis.

When compared to past research elsewhere on duck egg fertility and embryo deformities, it was concluded that Benton Lake was not experiencing embryo abnormalities, or chick and adult mortality from selenium toxicosis. For comparison purposes, the percentage of abnormal embryos found at Benton Lake was 0.1%, compared to 6.3% at Kesterson NWR.

FWS Contaminant Biomonitoring 1988-89

In 1988, extensive samples of refuge sediment, aquatic plants, invertebrates of several species, coot eggs and chicks (livers) and grebe eggs and chicks (livers) were collected. In addition, nine carcasses of several bird species were picked up and submitted for analysis. In 1989, sampling was limited to invertebrates. Samples for both years were submitted for trace element analysis. Results below are mainly for 1988 since a final report on 1989 samples is not yet available.

Results to date showed that many sediment samples had trace elements above the western U.S. geometric mean, but overall the concentrations did not represent unusually elevated levels. For invertebrates and plants, element concentrations showed mixed results depending on element. Selenium, arsenic, cadmium and lead were lower in plants on Benton Lake when compared to plants in the San Joaquin Valley of California, but concentrations of boron, copper, manganese and nickel were higher. Maximum boron concentrations in sago pondweed approached the boron dosage in mallard diets that caused reduced hatching success (laboratory study).

For invertebrates, some elements were lower than that reported in other parts of the country, while some were higher. Selenium levels for example, exceeded the maximum levels found in an uncontaminated site in California. The analysis suggests that bioaccumulation of selenium in invertebrates may be taking place.

Young-of-the-year coot and grebe livers showed concentrations of seven trace elements including selenium. Selenium levels in eared grebe livers exceeded levels found in mallards that experienced reproductive problems in other studies. In several duck and waterbird species eggs, selenium concentrations exceeded levels considered natural in other studies.

Patuxent Research Center Contaminant Study 1989

This study evaluated reproductive success of waterfowl by both field nest searches and incubation of collected eggs. Nests were located along dikes and edges of wetlands on the refuge and the fate of each nest documented. Of 262 nests found, 49% (Mayfield) were successful. Of approximately 300 eggs placed in an incubator, 80% hatched indicating healthy embryos in those nests sampled. Selenium concentrations were determined on 73 eggs and averaged 4.17 ppm. Again, mallards fed a diet of food with 8 ppm (µg/g) of selenium showed reproductive problems. No statistical work or write-up has been done to date.

FWS Contaminant Biomonitoring 1990

In 1990, personnel from the FWS Enhancement Office in Helena looked at avocets. Avocets were chosen since their diet consists primarily of aquatic invertebrates which have been shown to contain elevated levels of trace elements at Benton Lake. A total of 102 avocet nests were located and included in the study. Nest success was very high and few nests showed signs of embryo death. Of thirty-five embryos of sufficient size to examine, none exhibited gross abnormalities typical of selenium toxicosis. The chemical analysis of eggs and a sample of young avocets has yet to be completed.

U.S. Geological Survey 1990

This study, with assistance from FWS and Bureau of Reclamation, was designed to take a more detailed look at contaminants in the Sun River irrigation area. This area had previously been studied in 1986-87, but many specific questions needed answering. Although Benton Lake will be a very minor part of this new research effort, some information will have a bearing on the refuge due to its obvious ties with the irrigation area.

In 1990, an automatic gauging station was installed on Lake Creek just above where it enters the refuge. Besides giving an accurate measurement of water volumes entering the refuge via runoff or pumping, water samples taken at this site in 1990 documented the major flushing of contaminants that takes place in Lake Creek. On July 25 at 10:32 a.m. as the first "wave" of pumped water passed the gauge, the water had a conductance (salinity indicator) of 16,600 μS/L and dissolved selenium concentration of 110 μg/L. Twenty-four hours later the conductance was 1,260 μS/L and selenium 6 μg/L.

Refuge Duck Nesting Studies 1985-1990

Since 1985, a representative sample of refuge habitat has been searched for duck nests using the cable-chain method. To date, the fates of 3000 nests have been followed. In 1985, Mayfield nest success was 19 percent, and since then has averaged over 69 percent. This level of success is due mainly to a reduced predator population, but indicates a reproductive rate which greatly exceeds the average in the Prairie Pothole Region of the U.S. The examination of this large nest sample has not uncovered anything unusual that could lead one to suspect that contaminants are yet affecting nesting by waterfowl on Benton Lake NWR.

Inferences from Research and Monitoring

1. Refuge salinity levels have increased over the past 20 years and it appears this trend will continue.

2. Selenium and other toxic trace elements are present in elevated levels in refuge water, sediment, plants, invertebrates and waterbird tissue.

3. Toxic element concentrations do not appear to be causing any direct mortality to wildlife at this time, neither is reproduction or embryo development being greatly affected.

4. Water being pumped from Muddy Creek is relatively clean in terms of salinity and trace elements.

5. Salts and trace elements are being transported to the refuge by natural runoff and pumped water once it leaves the pipeline at Lake Creek.

6. Saline seeps are numerous in the refuge watersheds and are directly or indirectly bringing massive concentrations of salts and toxic elements into the refuge.

7. Land use in the refuge watershed is responsible for an accelerated accumulation of salts and toxic elements in Benton Lake.

GOAL AND OBJECTIVES OF CLEAN-UP ACTIONS

GOAL

To maintain Benton Lake National Wildlife Refuge as a premiere wetland/prairie complex for waterfowl, shorebirds, and the myriad of other water birds and terrestrial wildlife that thrive there.

OBJECTIVES

1. **Maintain or reduce levels of trace elements such as selenium, boron and mercury at levels which pose no threat to species using Benton Lake. For selenium, the objective is 2 ug/L or less for all waters entering the lake.**

2. **Maintain a salinity level of no greater than 6,000 µS/L in any of the refuge marsh units, and no more than 5,000 µS/L for all units combined, when water is at planned management levels in any given year.**

Note: Objective of 2 µg/L selenium is chosen since above this level selenium begins to bioaccumulate in a system. Salinity above 5,000 µg/L begins to change the aquatic plant community, thus affecting current marsh productivity.

STRATEGY FOR RESOLVING THE CONTAMINANT ISSUE

The actions on the pages to follow describe what is needed to reach the goals and objectives of contaminant abatement on Benton Lake. Some actions are independent, but most will work in concert.

The basic strategy for addressing contaminants is rather simple. First, find out basic information like the refuge's water budget that will guide other land-treatment actions. Secondly, clean-up the refuge watershed as much as possible by identifying seeps and drying them up. This in itself involves several actions. Third, improve water management capabilities by ensuring an adequate water supply and constructing an outlet from the lake. And lastly, develop a system of contaminant monitoring that is easily replicated to see if the actions are working and whether the objectives are being met. Like any major program, personnel will be needed to ensure that actions are carried out and for overall coordination.

Much of this work will involve private landowners upstream, around and downstream of Benton Lake. It is therefore crucial that landowner-refuge communication be a key strategy. Landowners must understand the role their land management practices are playing in the future of the refuge. Without the understanding and support of landowners affected by clean-up actions, reaching the goal of a productive refuge for decades to come will be difficult to achieve.

The Service's land acquisition, easement enforcement and private lands programs have shown repeatedly that communication with landowners is most effective, and sometimes only effective, when it is done one on one. Working with landowners to improve the watershed and thus clean up the contaminant problem will rely heavily on this face to face contact with the refuge's farmer-neighbors. The Agricultural Extension Service and Soil Conservation Service should be enlisted to help with this communication and education.

Lastly, the actions to follow will take funding. Without the support of contaminant specialists and administrators at the Regional and Washington levels, and perhaps Montana's Congressional delegation, the efforts of those on the ground will be for naught. Since all actions are interrelated, funding must be for the package of options.

ACTION SUMMARY AND BUDGET

Action		Funding Needs in $000 1991	1992	1993	1994	1995
	Current Actions	50				
1.	Water Budget Research[1]		40	40	40	
2.	Identify all Seeps[2]					
3.	Systematic Sampling[3]				10	
4.	Expand Refuge			25	400	400
5.	Refuge Biologist Position		40	40	40	40
6.	Seep Reclamation[4]					
	a. Recharge Delineation		20	20	20	20
	b. Extension Agreements		260	260	260	260
7.	Outlet Drain				500	1,500
8.	Water Supply		70	70	70	70
9.	WPA Seep Reclamation		36	36	36	36
	YEARLY TOTALS	50	466	491	1,376	2,326

FIVE YEAR FUNDING TOTAL: $4.7 million

Notes

[1]Data review/research plan in 1991 using $50K funds
[2]Scheduled for 1991 - Hire Bio Tech using $50K funds
[3]Developed in 1991, biologist to do from 1992 on
[4]Reclamation of large seep Unit IV/VI begun 1991 with $50K fund.

NOTE

Total costs for each action above may not match total cost in action pages since the five-year funding projections for some actions start in a later year. For example, refuge expansion will probably not start until 1994 due to NEPA requirements, and it will take up to 10 years to accomplish all acquisition which averages out to the $400K/year as shown above.

CURRENT ACTIONS - 1991

In FY 1991, $50K in FWS contaminant clean-up funds were earmarked for efforts at Benton Lake. Below is a summary of ongoing or planned actions.

Biomonitoring

Monitoring efforts will analyze ducklings on Benton Lake to fill the existing data gap on the affects of the elevated selenium level in invertebrates. Ducklings will be collected just prior to fledging and their liver analyzed for trace elements. If possible, eared grebe nesting will also be studied since grebes are good indicators of selenium bioaccumulation. This should complete baseline biotic data collection which will be important down the road in assessing whether clean-up actions are reducing trace element accumulation at Benton Lake.

USGS - Sun River Study

Since the 1986 Sun River Reconnaissance Study showed that return irrigation flows being pumped to Benton Lake were relatively clean, monitoring work on the refuge by the USGS has been reduced considerably. However, USGS will conduct some monitoring of water in 1991 including: Muddy Creek at the pumpsite, Lake Creek during peak runoff or pumping, two refuge seeps, and Units I and IV. They will also put in test wells east of the refuge to see if water is leaving Benton Lake via the marsh bottom (discharge). Samples will also be taken from saline seep test wells installed in 1990 by Montana Salinity Control.

Seep reclamation pilot project

In 1990, a series of test wells were installed on private land upslope from the refuge's worst seep adjacent to marsh units Ivc and VI. Readings from these wells led to a recharge area plan that will hopefully be implemented in 1991 depending on landowner/refuge negotiations. The plan is to purchase 240 acres from one landowner and enter into an extension agreement on 60 acres with another landowner, with alfalfa being planted on the entire acreage to "dry up" the perched water table and thus the seep.

Other actions

Other actions planned with the $50K fund include hiring a biological technician to map all seeps in the watershed and conduct more systematic salinity testing, as well as monitor existing saline seep test wells. Also, a contract with USGS will analyze past and current water use data and develop a detailed study plan for determining the refuge water budget in regards to salinity and trace elements as a prelude to Action 1.

ACTION 1

Determine the refuge's water budget

Contract with U.S. Geological Survey to determine quantity of water coming from the refuge's watersheds, and amount of salts and contaminants from each source. This would entail a detailed analysis of past water management records, installation of gauging stations on the various drainages, installation of ground water test wells to measure ground water flows, and extensive sampling of water. In 1991, USGS will begin this work by reviewing and analyzing available water information and designing a longer term study to come up with a water budget.

Rationale

Prior to initiating some of the costlier clean-up actions such as land acquisition and an outlet drain, it is crucial to understand the level of contaminants coming from each water source. For example, all the seeps could be reclaimed on the south side of the refuge, but compared to salts and elements coming in from Lake Creek, such reclamation could do little to abate salinity and toxic element accumulation in the lake. In addition, this study would provide a more accurate prediction on the salinity and selenium build-up. If it is found that under current management and watershed conditions Benton Lake will be a viable marsh for another 200 years, this has important ramifications for taking certain actions, such as an outlet drain.

Cost

FY 1991 - $10K FY 1992-94 - $40K per year

Who will do

U.S. Geological Survey due to their expertise

ACTION 2

Identify all seeps in refuge watershed

Through use of aerial photos and seep identification done by the Soil Conservation Service during wetland mapping for the Food Security Act (Farm Bill), produce a detailed map showing the location of all seeps within the 148 square mile Benton Lake Watershed. A cursory review of seep information indicates that at least 50 seeps are present.

Rationale:

Seeps have been shown to be true hot spots for salts and toxic trace elements. Seeps on the refuge are well known. However, seeps in the larger Lake Creek drainage are virtually unknown. No treatment can begin on seeps until they are first identified.

Cost:

Minimal except for staff time.

Who will do:

Biological Technician hired for the purpose of contaminant monitoring in 1991.

ACTION 3

Institute systematic sampling plan

Establish permanent sample sites on the refuge, Lake Creek and the pump station at Muddy Creek for monitoring water salinity. Establish permanent sites for monitoring levels of selenium and other toxic elements. Establish set schedule for taking samples over a period of several years. For salinity testing, this may involve weekly samples each year, while sampling for trace element levels may be done every third, fourth or fifth year depending on recommendations of contaminant experts.

Rationale:

Research and monitoring in the past have not always been systematic enough to provide accurate comparisons between years. For example, the salinity readings taken since 1974 may not have followed proper procedures for instrument calibration, or may have been taken at different locations which makes identification of trends difficult. Development of a systematic sampling plan will provide a measurement of various action effectiveness, as well as serve as a trigger for certain actions to begin.

Cost:

$10K for sample analysis (trace elements) in 1994. Labor provided by Bio. Tech. in 1991 and by Refuge Biologist in 1992 and beyond (see Action 5).

ACTION 4

Expand refuge area

Initiate action to get Migratory Bird Commission approval to expand refuge boundary beyond current limits (see map, next page). Once approved, conduct aggressive acquisition of new lands from willing sellers. Estimate an additional 10,000 acres of fee land added to refuge. Land to be purchased will be prioritized by: 1. identified seep recharge areas, 2. lands which contribute the heaviest surface runoff, and 3. remaining lands that will complete a grassland buffer on the south and west sides of the refuge.

Rationale

The south and west boundary of the refuge is located in relatively steep terrain with private cropland separated from the marsh by just a narrow strip. Cropping on this area has caused large seeps on the refuge, while surface runoff and wind erosion carry huge quantities of soil, fertilizer and pesticides into the refuge and wetlands. Acquisition of this area would put recharge areas in permanent cover, thus drying up the seeps while providing a protective buffer for Benton Lake proper. Besides water quality benefits, this acquisition would add excellent diversity to the refuge since numerous draws, shrubs and small water impoundments are present.

Cost

Planning: Preliminary administrative work for approval process by refuge staff. In 1993, $25K contract for EIS preparation.

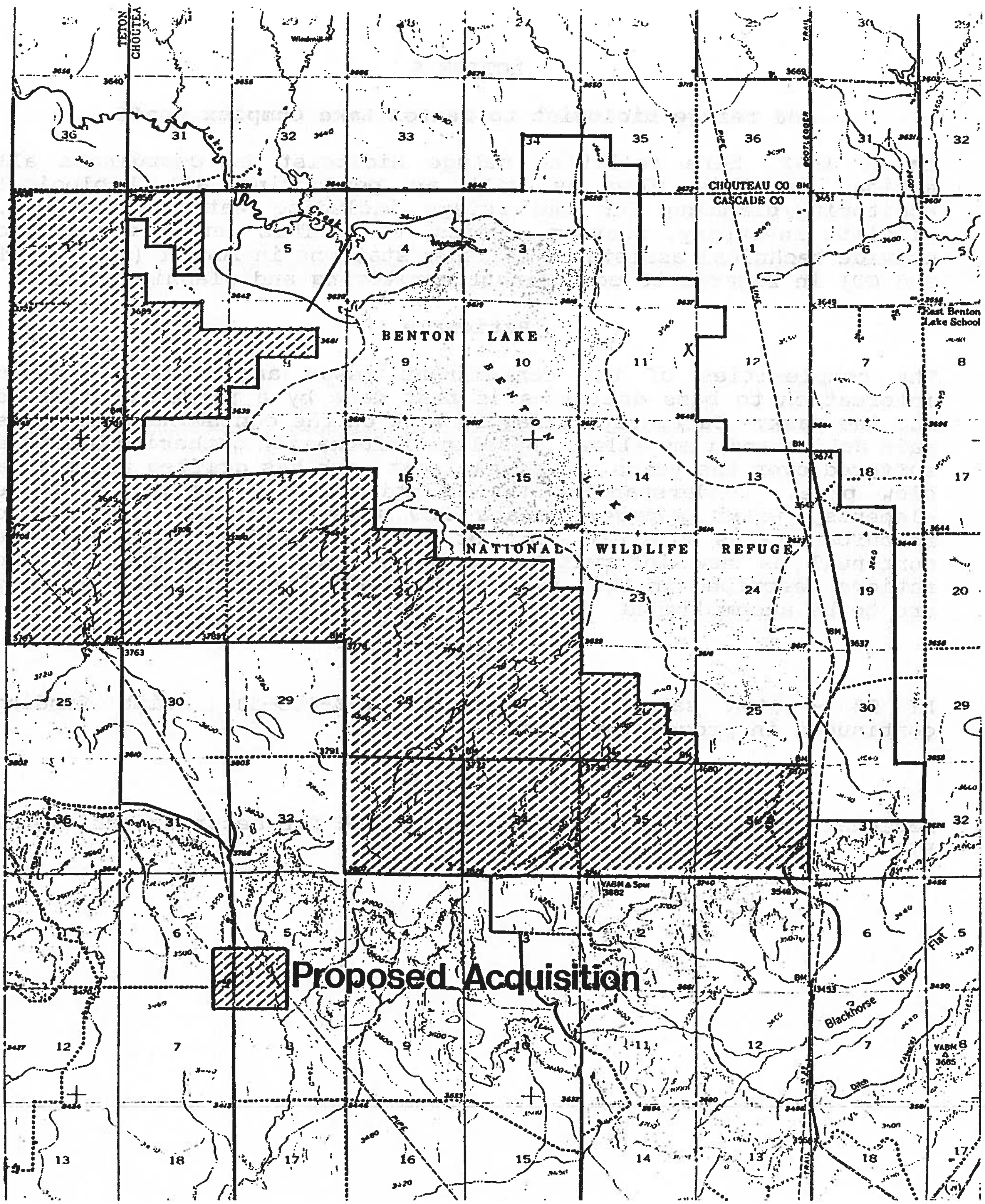
Acquisition: An estimated $4 million beginning in 1994, spread out over 10 years.

Who will do

Refuge staff, Realty Division

Note

This action depends on willing sellers since condemnation is generally not acceptable socially and politically. To encourage "willingness", a premium price per acre of $50 to $100 above appraised price should be approved. In the long term this would be a sound investment since Benton Lake is one of the most productive refuges in the country.


TETON
CHOUTEAU
CHOUTEAU CO
CASCADE CO
BENTON LAKE
NATIONAL WILDLIFE REFUGE
East Benton
Lake School
Windmill
Creek
Blackhorse Lake Flat
Ditch
Proposed Acquisition

ACTION 5

Add refuge biologist to Benton Lake Complex staff

In FY 1992, hire full-time refuge biologist to coordinate all actions in this plan as well as performing all biological monitoring/planning for the refuge including water management, wildlife inventory, nesting studies, etc. This person would also provide technical assistance to other stations in Zone I (MT, WY, UT and CO) in regards to contaminant monitoring and planning.

Rationale

The complexities of the contaminant issue and need for solid information to base decisions is best done by a person designated for the task. Currently, managers work on the contaminant issue as main duties and time allow. Baseline information gathering has thus suffered over the years and contaminant work has drifted along at a slow pace. Understanding the relationship of salinity, trace elements, water management and how they interact with refuge resources takes a great deal of time and effort that must be continual as new information is processed. Also, many of the actions described in this plan will demand full time work if they are to be accomplished.

Cost

FY 92 - $40K salary and benefits (GS-401-11), with funding continuous in proceeding years.

Who will do

Regional and Washington office responsible for securing additional FTE.

ACTION 6

Reclaim saline seeps in Lake Creek Watershed

Once all seeps in the Lake Creek Watershed are identified (Action 2), work can begin on cleaning or drying them up. This clean-up requires two steps: 1. Identify seep recharge area, and 2. establish moisture-using cover on recharge area to dry up perched water table and thus seep. All work will be on private land since all seeps originate on private land in the watershed. Once recharge areas are identified, landowners will be persuaded to enter into a Wildlife Extension Agreement with the FWS whereby they will receive a payment for placing the recharge area in cover for a 5 to 10 year period. Following this drying out phase, incentives/persuasion will be needed for landowners to use either a continuous cropping system or keep the area in grass permanently.

Rationale

All research to date indicates that seeps are a main source of Benton Lake contamination, either directly through seeps on the refuge, or indirectly by dumping salts and trace elements in the watershed which finds its way to the refuge during runoff events and pumping. Salt concentrations and trace element readings on seeps since 1986 exceed all known wildlife and human health standards. Those directly on the refuge are also destroying upland and wetland plant communities.

Cost

Determining the extent of recharge areas by drilling of test wells costs about $10K per seep. It is estimated that nearly 100 seeps are present in the watershed and drilling test wells for each would be cost prohibited and too time consuming. Instead, 10 "test" seep recharge areas would be identified and monitored with wells. The remainder would be mapped based on topography, land use and the experience of seep reclamation experts. Recharge treatment areas estimated at 60 acres per seep or 6,000 acres in watershed. Getting the recharge areas in moisture-using alfalfa/wheatgrasses would be accomplished by 5-10 year Service wildlife extension agreements since the patchwork of recharge areas in the 112 square mile drainage precludes acquisition and effective fee area management.

Seep Identification: $100K over 5 years

Agreement on recharge area: $1.2 million over 5 years*

TOTAL COST: $1.3 million or $260K per year

*Treatment on recharge areas will probably not start until 1993 pending completion of test well installation and recharge mapping.

Who will do

Recharge identification: Contracts with the Montana Salinity Control Association since they are the experts in seep reclamation.

Extension Agreements: Refuge biologist (Action 5), refuge managers and private lands program staff.

Note

Some other options exist that may lower costs. For example, the 1990 Farm Bill included provisions for enrolling land that affected water quality in the Conservation Reserve Program. However, it appears that opportunities will be limited in the first sign-up phase, although this may change in future years. Other USDA programs such as set aside, Water Bank and wildlife practices can be dove-tailed with the Service's agreement. Also, the Montana Dept. of Fish, Wildlife and Parks has some habitat programs that could provide funding. Once an area is in grass, permanency may be achieved by use of the Service's grassland easement.

ACTION 7

Construct an outlet drain from Benton Lake to Missouri River

Plan and construct a gravity flow outlet from Benton Lake following the original glacial outlet path. Water would flow approximately 15 miles and empty into the Missouri River 15 miles northeast of Great Falls, MT. Project would involve securing right-of-way easements since almost entire route is privately owned. Construction would include substantial excavation and installation of nearly two dozen control or drop structures. A detailed engineering report was completed in 1984 by Morrison-Maierle Consulting Engineers. A copy of their report is available at the refuge or Regional Office.

Rationale

The ability to flush the Benton Lake marshes periodically is needed to control the build-up of salinity and trace elements before they become toxic to plant and animal life. Besides these contaminants, the outlet would also safeguard the extensive system of refuge dikes and control structures in times of flood, and allow much greater flexibility in the event of a severe botulism outbreak (outbreaks in the early 70's took over 20,000 birds). Water released through an outlet would also flow through 600-acre Black Horse Lake which has great waterfowl potential but only holds water during years of high runoff (last year of waterfowl use was 1989).

NOTE: This action would only be initiated if salinity and trace element levels showed a definite trend upwards to a level that endangers the refuge (see Actions 1 and 3).

Cost

According to 1984 engineering report, total cost for an outlet would be approximately $1.3 million. Adjusted for inflation, the cost is now probably closer to $2 million. In addition to construction costs, annual operations and maintenance is estimated at $15 thousand. Costs for a 100 foot right-of-way easement would be minimal but would involve substantial realty time due to the number of landowners involved.

Who will do

Fish and Wildlife Service. Other agencies and private groups would perhaps be interested in being partners on the project (Bureau of Reclamation and Ducks Unlimited for example).

Notes

A project of this magnitude has the potential to be quite controversial since it crosses private land and would release lower quality water into the Missouri. Although impacts to the Missouri would be negligible (engineering report), the perception of dumping water with higher salt and trace element concentrations would alarm many if not handled correctly. Also, if not all landowners wish to grant an easement the project hits a snag unless the FWS is willing to use condemnation. The Service may have the right to construct the drainway, even without landowner consent, according to a 1957 Solicitor's opinion (copy on file at Benton Lake).

ACTION 8

Ensure a more stable supply of water for refuge

Provide funding for purchasing (electricity costs) 10,000 acre-feet of water yearly.

Rationale

The refuge has rights to 14,600 acre-feet of water yearly from Muddy Creek. However, electricity costs, especially since large rate increases in the early 1980's, have reduced the amount of water that can be delivered annually due to budget restraints.
In 1990 for example, the refuge needed 7500 acre-feet of water to maintain the marsh in optimum condition. However, funds were available for pumping only 4000 acre-feet. In 1991, needs for the year total 11,000 acre-feet and money available will only allow the transfer of 6500 acre-feet.

Additional water would serve many purposes. In the short term, additional water would dilute the salt and trace element concentrations and thus keep the refuge "cleaner" while other actions in this plan are put into effect. In the long term, the additional water, coupled with an outlet drain, would allow the flushing of Benton Lake to reduce salt and tract element buildups. Lastly, additional water would ensure optimum wildlife use and production at Benton Lake year-in and year-out rather than the boom and bust cycle under current operation.

Compared to dollars spent on other FWS programs on refuges nationwide such as visitor center construction and operation, grazing administration and the like, the dollars spent for water on a refuge that can produce an average of 50,000 waterbirds (20,000 ducks) under good water conditions is a sound investment for wildlife.

Cost

$70,000 per year for FYs 1992 through 1995.

Notes

Explore the possibility of setting up a National Water Bank, whereby interest from a permanent fund established by Congress is used to purchase water for refuges throughout the west. In times of excellent water in a particular year, the money would be left in the "bank" to draw interest for future purchases. Since precipitation and runoff is so variable across the west, some refuges would be drawing on the water bank while others would have no need.

ACTION 9

Address contaminant problems on Waterfowl Production Areas

Stop saline seeps that are dumping contaminants into wetlands on waterfowl production areas in the Benton Lake Wetland Management District.

Rationale

There are 19 Waterfowl Production Areas covering over 12,000 acres managed from Benton Lake Refuge. Ten of these areas are being negatively impacted by surrounding private land use which has accelerated saline seeps. Testing by the FWS in 1987 showed that water flowing into WPA marshes from seeps had concentrations of salts and trace elements as high as those on Benton Lake. This action would address this problem by reclaiming seeps through purchase or lease.

Cost

Ten seeps with treatment area of 60 acres each = 600 acres
1. Purchase 300 acres at 400/acre = $120,000
2. Wildlife Ext. Agreement on 300 acres at $40 an acre = $12,000 per year or $60,000 for five years.

TOTAL $180,000 over five years

Who would do

Wetland District Manager and Realty

PLAN UPDATING AND EVALUATION OF ACTIONS

This plan should be reviewed and updated on an annual basis. This is important since most actions can have a direct bearing on carrying out a subsequent action. For example, construction of an outlet (Action 7) depends on what is found in Actions 1 and 3. Also, monitoring on Benton Lake each year, or research being conducted elsewhere, will bring new information to light which may call for a modification of actions, or at the very least, additions to the research summary section or appendix. Finally, many cost estimates are just that, estimates. In Action 6 (seep reclamation), acreages may change drastically once the work begins, thus changing the funding needs upward or downward.

Evaluating whether plan actions are meeting the stated goals is covered in Action 3, systematic sampling. It will be important to ensure that such monitoring is set-up to indeed measure against the criteria in those objectives.

APPENDIX

A-1 Units of measure used in plan
A-2 Fact sheet on selenium and salinity effects
A-3 Significant and useful reports and space for reader's own references

A-1

UNITS OF MEASURE

Concentration

Measures of concentration based on mass are usually reported as μg/g which is sometimes typed as ug/g or mg/kg. These measures refer to concentrations in sediment or non-liquid tissue. A microgram (μg) is one-millionth of a gram (g), and a milligram (mg) is one-millionth of a kilogram (kg). Both measures express the same concentration as the term "parts per million" (ppm), the difference being that ppm is a dimensionless concentration, while μg/g and mg/kg express the concentration in units of mass.

Measures of concentration based on mass and volume are usually reported as mg/l or μg/L or ug/L. These measures refer to concentrations in water or blood. A concentration expressed in mg/L is also equal to a dimensionless concentration in parts per million. A concentration expressed in μg/L is equal to a dimensionless concentration of "parts per billion" (ppb).

In summary:

(c) = centi = one-hundredth
(m) = milli = one-thousandth
(μ) = micro = one-millionth
(L) = liter

μg = ug = mg/kg or 1 microgram of a gram = 1 milligram of a kilogram

ppt = parts per thousand = g/L
ppm = parts per million = mg/L
ppb = parts per billion = μg/L

Conductivity and Salinity

Specific conductance was formerly reported in mmhos/cm, (micro-"moes" per centimeter) but is now reported in μS/cm (micro-Siemens per centimeter). The two units are the same. Strictly speaking, there is no measurement of salinity. When people speak of salinity, they mean "dissolved solids." Dissolved solids are measured in units of mg/L. Depending on the sulfate content of the water, specific conductance, in units of μS/cm, can be converted to dissolved solids in units mg/L, by multiplying by a conversion factor of from .65 to .80. Modern conductance/salinity meters have this conversion built in, with a salinity reading based on conductance expressed in ppt (parts per thousand).

In summary:

μs/cm = us/cm = mmhos/cm = conductivity level
Conductivity in μS\L x conversion = salinity in PPM, or,
16,000 μS/L x .80 = 12,800 ppm (mg/L) = 12.8 ppt salts

A-2

FACT SHEET ON SELENIUM AND SALINITY EFFECTS

Based on a review of known studies

Selenium

- Selenium is a natural element that is essential or beneficial to many organisms at low levels, but harmful at high levels. The range between being beneficial and harmful is very narrow.

- Selenium chemistry is very complex. The element is found in the forms of hydrogen selenide, elemental selenium, selenium dioxide, selenite and selenate. These forms may have varying effects on plants and animals, complicated further by specific environmental conditions in a given area.

- Selenium can be lost from a system through volitization, conversion by biological or chemical means, or tied-up in deep sediments out of the reach of organisms, as long as input of selenium to the system is reduced.

- The western states geometric mean (i.e. normal level) for selenium in sediment is .23 μg/g dry weight.

- Accumulation of selenium by aquatic organisms is highly variable depending on species, water temperature, age of the organism, organ or tissue specificity, mode of intake and other factors.

- Selenium is often purged from an animals system in rather short order. In various species of marine and freshwater fauna, 50 percent of the accumulated Se was excreted in from 13 to 181 days.

- It is recommended that inorganic selenite concentrations in water should not exceed 35 ppb on a daily average, or 260 ppb at any time, to protect freshwater aquatic life (EPA 1980). In contrast, selenium levels at two seeps feeding into Benton Lake had readings of 500 and 580 ppb in 1987.

- Increased deformities were observed in laboratory studies on embryos with a selenium concentration of 1.3 μg/g wet weight or 5.2 μg/g dry weight.

- Mallards fed a diet containing 10 μg/g selenium had significantly more abnormal embryos and an 80% reduction in the number of young produced. Levels of selenium in livers of these same mallards ranged from 2.6 to 12.0 μg/g (wet).

- Concentrations of selenium greater than 2 to 5 μg/L in water can be bioconcentrated in food chains.

Salinity

- Total soluble salts are commonly measured by the electrical conductivity of the water in mmhos/cm or ·μS/L. This conductance can be converted to salinity for most waters which is usually expressed in ppt or ppm.

- Salinity generally refers to the dissolved materials sodium, magnesium, sulfate, and nitrate.

- Water with a conductance of 10 mmhos contains about 8 to 10 tons of salt per acre-foot, depending on the composition of the salts.

- Germination, growth, and seed and tuber production of important marsh plants decreases as salinity increases.

- When water conductance exceeds 3 mmhos, plant growth reduction is slight. Conductance above 6 mmhos and plant growth is noticeably inhibited, and above 10 mmhos reduction in growth is pronounced.

- Plant communities in a wetland are determined by salinity, which in turn can affect composition of the wildlife community. Benton Lake is currently in the "moderately brackish" plant community which would begin to change to "brackish" at a conductance above 5,000 mmhos/cm.

- Duckling production in water with a conductance above 16,000 mmhos/cm drops off dramatically due to mortality from salts and reduced weight gain.

42 pgs.

...e Manuals

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Salt + Se @ high concentration
– '91 – "no probs seen in wildlife yet"

goal – Se input that won't accumulate in system (≤ 2 ug/L)

2–5 ug/L in H_2O can be bioconc. in chains

western states geomean = for Se in sed = .23 ug/g dw

lab study → deforms embryos w/Se conc of 1.3 ug/g ww or 5.2 ug/g dw
mallards fed 10 ug/g Se → shows # of young reduced
liver levels in mallards w/abn embryos = 2.6–12 ww ug/g

TIM HALLS RPT
[illegible]

L.L. MP.

P:\WP\DOCS\F&W\GIFLOG

Corrected
[illegible] 8/26/97