RECOVERY OUTLINE

for the

GUYANDOTTE RIVER CRAYFISH (*Cambarus veteranus*) and

BIG SANDY CRAYFISH (*Cambarus callainus*)

May 2018

INTRODUCTION

This document lays out a preliminary course of action for the survival and recovery of the Guyandotte River (*Cambarus veteranus*) and Big Sandy crayfish (*C. callainus*). It is meant to serve as interim guidance to direct recovery efforts and inform consultation and permitting activities until a recovery plan is completed. Recovery outlines are intended primarily for internal use by the U.S. Fish and Wildlife Service (Service). Although we do not solicit public comments on recovery outlines, we will consider any new information or comments that members of the public may wish to offer in response to this outline during the recovery planning process. We will solicit public comments, however, on the draft recovery plan through publication of a Federal Register notice. For more information on Federal recovery efforts for these species, interested parties may contact the lead biologist for this species listed below.

This recovery outline, all subsequent recovery planning efforts, and all consultations on these species will be based on the best available information at the time. We recognize that some information gaps and uncertainties exist for these species. For example, while we have information about the levels of some water quality parameters (e.g., conductivity) that can affect the species (Loughman *et al.* 2016, Loughman *et al.* 2017), optimal conditions for these species, or appropriate thresholds for most water quality parameters or pollutants (e.g., stream temperature, metals), are not known. Other key information gaps and uncertainties include habitat use for different life stages (juveniles, females with eggs), home range size, limiting factors to population growth, and specific mechanisms by which individual and cumulative land-use activities affect the species. Information gaps and uncertainties will be clarified to the extent possible if new information becomes available during this recovery process. Additional modifications to the recovery plan may also occur as new information to inform recovery strategies and consultation recommendations becomes available.

<u>Listing and Contact Information</u>

Listing Status and Date:

Guyandotte River crayfish: Endangered, April 7, 2016 (81 FR 20450)

Big Sandy crayfish: Threatened, April 7, 2016 (81 FR 20450)

Critical Habitat Designation and Date: N/A

Lead Agency, Region: U.S. Fish and Wildlife Service, Northeast Region

Lead Field Office: West Virginia Ecological Services (ES) Field Office

Lead Field Biologist: Barbara Douglas, 304-636-6586 ext 19, barbara_douglas@fws.gov

Cooperating Service Offices:

Guyandotte River crayfish: White Sulphur Springs National Fish Hatchery
Big Sandy crayfish: Kentucky ES Field Office, Virginia ES Field Office, White Sulphur Springs National Fish Hatchery

RECOVERY STATUS ASSESSMENT

Information on the status of and threats to these species is fully summarized in the final listing rule and will not be repeated here. The final listing rule is available at: https://www.gpo.gov/fdsys/pkg/FR-2016-04-07/pdf/2016-07744.pdf. No significant new information has become available on population distribution or numbers since the time of listing. Additional surveys have been conducted in areas of historical, currently occupied, or potentially occupied habitat. While additional individuals have been documented during surveys within streams known to support the species at the time of listing (particularly in the Tug Fork River), no new populations have been discovered. Threats as described in the listing rule are still ongoing and are described accurately.

However, since the time of listing, some recovery actions have been implemented, and some new information on threats and habitat conditions has been developed. Survey protocols have been developed by the Service, State resource agencies, and the species expert (West Virginia Division of Natural Resources (DNR) and Service 2016). These standardized protocols are being used throughout the ranges of the two species. Both West Virginia and Kentucky have held workshops for surveyors, agencies, and consultants that provided training on the species biology and threats, how to identify listed crayfish, and how to implement the survey protocols. Potential surveyors were given standardized tests to evaluate their ability to correctly implement the protocols and identify crayfish species prior to obtaining any State or Federal collecting permits for these species. This has both increased the number of qualified scientists available to work on the species and helped to ensure that any data gathered are accurate, consistent, and comparable. These protocols may be updated as new information is developed.

The Service, West Virginia DNR, Virginia Department of Game and Inland Fisheries, and West Liberty University are working together to conduct additional research on these species. Research topics include life history, habitat use and activity patterns, maximum entropy modeling, captive holding and propagation, and fish interactions. In addition, genetic samples from both species were gathered during 2015 survey efforts and are being held at the Carnegie Museum until funding to process the samples is available.

New research published since the time of listing has provided information on the physical and physiochemical habitat conditions that are needed to support these species (Loughman *et al.* 2016 entire, Loughman *et al.* 2017 entire). Habitat conditions where the Guyandotte River crayfish are found were consistently large streambed slab boulders, with low embeddedness, open interstitial spaces, and minimal substrate concretion (Loughman *et al.* 2016). Guyandotte River crayfish presence was associated with high overall Qualitative Habitat Evaluation Index (QHEI) scores (mean score of 83.5, with scores ranging from 69.5 to 93.0) (Loughman *et al.* 2016). The QHEI is a commonly accepted method of assessing physical habitat in central Appalachian streams (Rankin 1995, Burskey and Simon 2010, and Gazendam *et al.*, 2011 all in Loughman *et al.* 2016). It evaluates a variety of physical habitat covariates including substrate

type and quality, instream cover type and amount, channel morphology (sinuosity, development, channelization, and stability), riparian zone (width, quality, and bank erosion), pool quality (maximum depth, current, and morphology), riffle quality (depth, substrate stability, and substrate embeddedness), and stream gradient. Sites where Guyandotte River crayfish were present had lower than average conductivity (379 μS), while sites where Guyandotte River crayfish were absent had elevated stream conductivity (>460 μS), indicating that low stream conductivity could be necessary for the persistence of the species (Loughman *et al.* 2016). While the specific biological effect of stream conductivity on the Guyandotte River crayfish is unknown, these results indicate that increased conductivity and sulfate levels could help to explain the decline of the Guyandotte River crayfish over the past century (Loughman *et al.* 2016).

Similar research on the Big Sandy crayfish demonstrated that presence of this species was associated with stream sites containing unembedded boulders and QHEI scores categorized as good (55 to 69) to excellent (≥ 70) (Loughman *et al.* 2017). The species was found at sites containing large rock sizes (i.e., slab boulders), riffles and fast-flowing runs, and low substrate embeddedness. No individuals were observed in stream reaches with heavy sedimentation and embedded substrates (Loughman *et al.* 2017). Mean values for conductivity and sulfates at sites supporting Big Sandy crayfish were similar to sites where the species was not detected, suggesting that these variables were not as influential in determining presence or absence of this species compared to the Guyandotte River crayfish (Loughman *et al.* 2017). These studies also noted that both the spiny stream crayfish (*Orconectes cristavarius*) and the coalfields crayfish (*C. theepiensis*) appeared to have higher ecological tolerances to degraded water and habitat quality parameters than the Big Sandy crayfish and Guyandotte River crayfish (Loughman *et al.* 2017). The differences in results between species, including between the Big Sandy crayfish and Guyandotte River crayfish, emphasize that crayfish species differ in their tolerance to physical habitat quality and water quality, and that interspecies differences must be considered during conservation assessments (Loughman *et al.* 2017).

Recent studies show that cumulative and watershed-level stressors must be considered when planning for recovery of these species. Wide-ranging impacts to aquatic habitats throughout the species' range include sedimentation, elimination of headwater streams, increased inputs of physicochemical pollutants, habitat degradation, and fragmentation of riparian corridors. All of these impacts are due primarily to poor land-use practices (Loughman *et al.* 2016, Bernhardt and Palmer 2011, Merriam *et al.*, 2011). Although most direct effects to streams from coal mining occur in low-order headwater streams, studies have documented that sediment transfer from surface mines has a greater cumulative effect in higher order streams (i.e., those that may contain the crayfish) than previously thought, and that the degradation of instream habitat may be occurring as a result of the interactive effects of surface mining together with residential development (Loughman *et al.* 2016, Bernhardt *et al.* 2012, Bernhardt and Palmer 2011, and Palmer *et al.* 2010). These findings are consistent with Nippgen *et al.* (2017), who evaluated watershed-level effects and found that fills placed in headwater streams had downstream effects on first- and fourth-order streams, including altered hydrologic regimes and degradation of stream water quality (Nippgen *et al.* 2017). Affected first- and fourth-order streams had elevated summer base flows and continuously high concentrations of total dissolved solids (Nippgen *et al.* 2017). This regional impact on water quantity and quality was most extreme and widespread

during low flow periods (Nippgen *et al.* 2017). For example, conductivity in streams was on average 10 times higher in fourth-order watersheds affected by valley fills in their headwaters compared to reference watersheds and was particularly elevated compared to reference conditions during low-flow periods (May-October), reaching values near 1500 µS/cm for the majority of that period (Nippgen *et al.* 2017). The study further concluded that enhanced base flow, even in large, partially disturbed watersheds, can contribute to stream impairment (Nippgen *et al.* 2017).

Finally, recent studies recommended that conservation measures for these species should include stream restoration activities that flush excess bedload sediments from stream channels, create slab boulder clusters, and broadly reduce basin-wide stream degradation (Loughman *et al.* 2016). Stream restoration efforts should target sites with low population numbers, historical streams where the species have been extirpated, and sites that could increase connectivity between disjunct isolated populations (Loughman *et al.* 2016). The development and initiation of a captive rearing program to produce animals that could be released into streams following restoration was also recommended as an imperative conservation action (Loughman *et al.* 2016). Finally, these studies indicate that the Guyandotte River crayfish potentially has the most limited distribution of any large, stream-dwelling, tertiary burrowing crayfish in North America (Loughman *et al.* 2016). The species has increased susceptibility to extinction because a single catastrophic event in either Pinnacle Creek or the Clear/Laurel Fork watershed could eliminate these populations (Loughman *et al.* 2016). The potential for this was highlighted in 2017, when leaks from sediment control structures from a mine discharged sediment that traveled from Knob Fork into Clear Fork to the town of Oceana, West Virginia (at least 14 miles downstream) (Stihler 2017, Vernon 2017). Although this spill occurred in the area upstream of where the Guyandotte River crayfish is known to occur, crayfish surveys were not conducted in the affected area, and it is not known whether any effects occurred further downstream. Therefore, the development of spill prevention and remedial action plans as well as the establishment of a captive "ark" population will be particularly important to the conservation of this species. Ark populations are populations maintained in captivity to avert the threat of extinction when threats in the wild cannot be adequately controlled.

PRELIMINARY RECOVERY STRATEGY

Recovery Priority Number:

The Guyandotte River crayfish is assigned a recovery priority number of 5C on a scale of 1C (highest) to 18 (lowest; the "C" indicates the potential for conflict with human economic activities). This ranking is based on the high degree of threat, a low potential for recovery, and its status as a species (48 FR 43098-43105, 48 FR 51935). There is the potential for a high degree of conflict with existing land uses for the crayfish throughout its range (e.g., ATV trails, residential development, mining). The high degree of threat is based on the fact that threats are pervasive and imminent throughout the current range. The only two remaining populations are threatened by instream disturbance, water and habitat quality degradation, invasive species, and catastrophic events such as spills. Recovery potential is considered low because the species' biological and ecological limiting factors are poorly understood (see the discussion of

uncertainties above), the threats are difficult to alleviate, and mitigating these threats will require intensive management and development of new techniques.

The Big Sandy crayfish is assigned a recovery priority number of 11C, based on the moderate degree of threat, a low potential for recovery, and its status as a species (48 FR 43098-43105, 48 FR 51935). The rationale for this is the same as for the Guyandotte River crayfish except that there is a moderate degree of threat since this species is slightly more widely distributed, has more populations, has less pervasive or imminent threats, and appears to be less sensitive to some types of water quality degradation.

Recovery Vision Statement:

The ultimate goal of recovery efforts are to ensure the long-term survival of the Guyandotte River and Big Sandy crayfishes by controlling or reducing threats to the extent that populations are self-sustaining and protections afforded by the Endangered Species Act (ESA) are no longer required. Although subject to change, full recovery of the Guyandotte River and Big Sandy crayfishes includes the following long-range targets: (1) multiple viable populations are well-distributed throughout the species' historical ranges in sufficiently managed and protected habitats, and (2) threats to the species, primarily modification and degradation of river and stream habitat from localized and watershed impacts, are sufficiently abated. The strategy for meeting these targets will include providing for sufficient representation, resiliency, and redundancy to ensure the high probability of survival for the foreseeable future. What constitutes a viable population will be further defined as recovery planning progresses, but in general, populations should be self-sustaining, have stable or increasing numbers, demonstrate successful reproduction, and have sufficient size and connectivity to withstand foreseeable long-term threats. As the Service works with its partners to prepare a recovery plan for these species, we will refine these objectives and develop criteria that provide specific, measurable standards for recovery.

Initial Recovery Strategy and Action Plan:

The threats to the Guyandotte and Big Sandy crayfishes are present in all watersheds where the species occur. Therefore, it is essential to characterize and monitor aquatic habitats on a watershed scale and respond to changing conditions rapidly, whether through negotiation and partnerships to alleviate threats, through husbandry, or both. Promoting watershed management is the best route to protect surviving populations. This strategy would use nonregulatory approaches to encourage and assist local, State, and Federal agencies, private landowners, nongovernmental organizations, and local communities/businesses to maintain and improve watershed health, while also employing existing State and Federal laws and regulations to protect, enhance, and manage aquatic habitats throughout the watersheds within the range of the species. Stakeholder cooperation will be needed to monitor the extant populations, characterize the current habitat conditions, reduce current threats, and implement recovery actions.

Immediate recovery efforts should focus on avoiding and minimizing disturbances and degradation of streams where each species currently exists; further investigating potential causes of declines; conducting additional research on the species to address key information gaps, such as life history and water quality parameters that are necessary to support viable populations of the species; developing a spill prevention and remedial action plan; and developing captive

holding/propagation techniques. It will be particularly important to avoid actions that could: (1) result in mortality or injury to the species, (2) reduce reproduction or recruitment of young into populations, (3) increase stress to remaining individuals in the wild, and/or (4) alter habitats such that survival or reproduction is reduced. Especially critical is the protection of Guyandotte River crayfish populations within Pinnacle Creek and Clear Fork.

Long-term recovery efforts should focus on habitat restoration efforts to expand current population size and stability; artificial propagation to prevent local extirpation, augmentation of existing populations or establishment of new populations; and implementation of measures to improve water quality, reduce sediment and contaminant input, and address any other threats found to contribute to declines. Because of its extreme rarity, the Guyandotte River crayfish will require more extensive recovery actions, including the establishment of additional populations within its historical range. Overall, the recovery strategy for both species includes four basic components: (1) research and monitoring; (2) maintaining and enhancing resiliency of existing populations; (3) increasing redundancy by establishing connectivity between existing populations and/or establishing additional populations; and (4) communication, outreach and education. More detail on specific actions needed under each of these components is provided below.

Research and Monitoring

Conduct research to better understand the species life history, habitat needs, and threats. As mentioned above, there are some key information gaps and uncertainties regarding these two species. Research should be conducted to address these issues so that more informed conservation recommendations and actions can be made. Little is known about the life history of these species. Having additional information on reproductive biology, home range and movements, interactions with other fishery populations, habitat preferences (e.g., relevant physical, biological, chemical components for all life history stages), and sensitivity to sedimentation and contaminants, would help quantify the vulnerability of these species to various threats.

Research should be conducted to determine the most significant suite of stressors to the crayfish and their habitats, to locate the sites of the various stressors, and to outline management activities to eliminate or at least minimize each stressor. Watershed-level evaluations should be conducted to assess potential interactive and cumulative effects of the stressors to the species and their habitats. Research on the effects of various water quality parameters will be particularly important. Crayfish are known to be more sensitive to contaminants and water quality degradation when molting (Wigginton and Birge 2007, Taylor *et al.* 2007, Loughman and Welsh 2010). Therefore, water quality investigations should consider potential effects to sensitive life stages such as eggs, young, and molting individuals. To the extent possible, upper and lower thresholds and optimal conditions for each species and each suite of contaminants should be identified using ecotoxicological studies or other methods sufficient to detect effects to survival, reproduction, and fitness. The direct and indirect impacts of pollutants and sedimentation on the various life history stages of the crayfish should be studied. The results of these studies should be used to ensure that water quality criteria and aquatic conditions are sufficient to maintain

viable populations of the species. The results of these investigations can also be used to identify and prioritize potential restoration sites and activities.

Research is also needed in conservation genetics. Previously obtained genetic samples from the Big Sandy crayfish and Guyandotte River crayfish are being held at the Carnegie Museum until research funding is available. The number and distribution of these samples should be reviewed to determine if additional samples should be gathered. Once funding is secured, samples should be processed to evaluate genetic diversity and gene flow. The implications of these results on population viability and conservation biology should be assessed. As new information is gathered, or as ecological conditions change, additional research needs may be identified.

Develop and implement captive holding, propagation, and reintroduction techniques.
White Sulphur Springs National Fish Hatchery, in cooperation with other partners, has already initiated efforts to develop captive holding techniques for crayfish. Captive propagation and holding is needed to reduce the threat of extirpation from spills and other catastrophic events, to augment existing populations, and to establish additional populations within the historical range of the species. This should include maintaining an "ark" population of the Guyandotte River crayfish. Efforts to develop and implement technology for maintaining and propagating these two crayfish species in captivity and for reintroducing captive individuals into the wild should be continued and expanded. A captive propagation plan for the species should be developed that assesses the feasibility of augmenting existing populations and reintroducing these species into restored habitats. This plan should establish restoration goals and criteria for measuring success. Potential augmentation or reintroduction sites should be selected based on an analysis of the suitability of biological, ecological, and habitat conditions.

Monitor listed crayfish populations and their associated habitat conditions.
A long-term monitoring program should be developed and implemented to evaluate population and habitat conditions, and assess the long-term viability of extant, newly discovered, augmented, and reintroduced crayfish populations. Monitoring should be designed to evaluate the effectiveness of recovery efforts such as habitat restoration, and to assess effects from actions conducted in crayfish watersheds. The frequency and extent of monitoring should be sufficient to effectively detect statistically and biologically meaningful trends in density and abundance within known populations. When monitoring these populations, data concerning habitat conditions, water quality, and other benthic macroinvertebrate populations should be recorded. Installing continuous water quality monitoring stations to measure conductivity, turbidity, and other key water quality parameters would help assess conditions in streams more effectively than occasional or periodic monitoring. This would also help detect and document the effects of spills or other temporary discharges that might not otherwise be detected. Results of surveys and monitoring should be compiled in a comprehensive Geographic Information System (GIS) database so that status and trends can be easily tracked.

Conduct surveys in streams within the range of the species to determine if suitable habitat or additional occupied habitat is present.
Surveys should be conducted to locate unknown populations. Existing data on the crayfishes, other benthic macroinvertebrate populations, and aquatic habitats within the range of the species, should be reviewed to identify areas where additional survey work should be conducted. Areas

with historical, but extirpated, populations should be periodically resurveyed. Surveys should also be conducted in areas where proposed or ongoing activities may occur that could affect the crayfish or its habitat. Presence and absence survey data should be compiled and periodically reviewed to determine whether and where additional survey efforts are needed. Results of these efforts should be compiled in the same GIS database mentioned above and could be used to help prioritize areas for recovery efforts.

Maintaining and Enhancing Resiliency of Existing Populations

Protect habitat integrity and quality of streams within watersheds that currently support the species.
This should be accomplished by avoiding and minimizing threats to the species including: (1) instream disturbance; (2) sources of sedimentation or erosion; (3) adverse modifications of stream morphology or hydrology; and (4) water quality degradation. Within these watersheds, measures should be implemented to avoid new threats and reduce current threats to the species. Newly proposed activities should be designed to avoid and minimize these threats, and existing activities should implement measures to remediate or alleviate existing threats. If information is available that suggests there are other threats to the species in addition to those listed above, measures should be included to avoid and minimize those threats as well. It will be important to protect habitat integrity of streams that support the species, as well as tributaries to these streams, to ensure that cumulative downstream effects as described in Nippgen *et al.* (2017) are also avoided and minimized. Conservation easements, land purchases from willing sellers, and other land conservation approaches should be used to protect priority habitats for crayfish within these watersheds.

Reduce the potential for spills and develop a spill response plan.
As noted above and in the final listing rule, these crayfishes are threatened by potential spills from various sources including transportation corridors and mining. Given its limited distribution, the Guyandotte River crayfish is particularly susceptible to the effects of potential spills or other catastrophic events (Loughman *et al.* 2016). To reduce the potential for these types of events, a threats assessment for each watershed within the range of the species should be conducted to identify likely sources of spills or other discharges. Federal, State, and local agencies and responders, as well as facility owners, should be provided with information on the presence of crayfish, and action plans should be developed for each potential source so that the potential for spills is reduced and immediate actions are taken to reduce potential effects if a spill occurs. This should include implementation of measures to reduce the potential for spills, such as locating tanks, impoundments, or other storage facilities, away from streams and their tributaries that could support the species, installing barriers or other containment systems so that discharges are directed away from streams, and locating or designing newly proposed facilities so that the potential for spills and discharges are reduced. If a spill occurs, the Service and State wildlife management agency should be immediately notified, and then immediate actions should be taken to assess potential effects to crayfish, including measures to stop contaminants from entering crayfish streams, rescuing or salvaging crayfish from affected areas, restoring affected stream reaches, and monitoring and assessment of the event such as conducting surveys for dead or injured crayfish, collecting and analyzing sediment and/or water quality samples. Followup enforcement or mitigation measures should occur if unauthorized adverse effects occurred.

Protect and restore streams that support the species.
Within watersheds that currently support or could support the species, measures should be implemented to protect and restore the biological, chemical, and physical functions of stream ecosystems. Loughman *et al.* (2016) recommended that stream restoration should be designed to flush excess bedload sediments from stream channels, stabilize streambanks, create slab boulder clusters, and broadly reduce basin-wide stream degradation. This should also include restoring or maintaining suitable flows, natural hydrographs, riffle and pool complexes, and substrates suitable to support crayfish. Studies have noted that restoring physical stream functions alone may not be sufficient to lead to improvements in biological condition, such as increases in invertebrate diversity or presence of pollution-intolerant macroinvertebrate taxa (Palmer *et al.* 2014, Palmer and Hondula 2014). Macroinvertebrates provide an important food source for crayfish, and the best available data indicate these two crayfishes appear to be more intolerant of water quality degradation than other crayfish species. Therefore, these results suggest that stream restoration efforts should also include measures to address chemical and biological functions sufficient to support diverse macroinvertebrate populations including sensitive crayfish species (Palmer *et al.* 2010). These studies note that, to successfully restore stream invertebrate diversity, watershed-level factors must also be addressed. Therefore, they recommend that stream restoration efforts adopt a sequential process of protecting key habitats, improving water quality, restoring watershed processes (e.g., habitat connectivity and hydrology), and improving instream habitat (Palmer *et al.* 2010).

Protect and restore riparian areas within crayfish watersheds.
Healthy, functioning, riparian forests are an essential component of maintaining water and habitat quality in streams that support crayfish and other aquatic organisms (Urgenson 2006; Wenger 1999, Jones *et al.* 1999 entire). Forested riparian buffers remove sediment and other contaminants from runoff, stabilize streambanks, reduce channel erosion, reduce flood damage, and moderate water temperature (Wenger 1999). Removal of trees from the riparian zone can have substantial effects on downstream habitats, including an increase in sediment entering the stream (Jones *et al.* 1999). For example, research has found that, as the length of deforested riparian areas increases, habitat diversity decreases, riffles become filled with sediments, and the number of benthic-dependent, sediment-intolerant species decreases (Jones *et al.* 1999). Therefore, maintaining existing forested riparian areas and restoring degraded riparian areas within crayfish watersheds will be an important component of crayfish recovery efforts. A scientific literature review on riparian buffers determined that, to be most effective at reducing sediment inputs and stabilizing stream channels, riparian vegetation consisting of native woody species with deep root structures that hold soil should extend along all streams including intermittent and ephemeral streams. This study further recommended that riparian buffers of 100 feet on both sides of a stream should be preserved or restored (Wenger 1999). Wider buffers were recommended on steep slopes (Wenger 1999).

Controlling nonnative invasive species is another component of protecting and restoring riparian areas. Japanese knotweed (*Polygonum cuspidatum*) was noted to be a dominant component of many riparian areas of streams known to contain these crayfish species in West Virginia (Douglas, personal observation). Streambanks dominated by Japanese knotweed populations are less stable and more prone to erosion because the plant has shallower roots compared to native

riparian trees and woody shrubs. Because Japanese knotweed becomes dormant and the canes die back in the winter, it also leaves streambanks more exposed to erosive forces during this time period (Urgenson 2006). Thus, knotweed can increase streambank erosion, increase sedimentation in streams, and alter channel morphology.

Increasing Redundancy of the Species

Establish connectivity between existing populations and/or establish additional populations.
For both the Guyandotte River crayfish and the Big Sandy crayfish this objective would be to enhance stream habitats in and around existing populations to improve their abundance and extent. Protection and restoration efforts should target sites with low population numbers or limited extents and sites that could increase connectivity between disjunct isolated populations. For example, for the Guyandotte River crayfish this would include increasing the abundance and extent downstream and upstream of the existing Pinnacle Creek population and/or providing connectivity between the two remaining populations in Clear Fork and Pinnacle Creek. This should include restoration of suitable habitat and water quality conditions in connecting stream reaches.

For the Guyandotte River crayfish, an additional objective would be to restore habitats within watersheds that historically supported populations and reestablish populations in those areas. The Guyandotte River crayfish has been extirpated from the following HUC 12 watersheds: Huff Creek, Little Huff Creek, Indian Creek, Turkey Creek/Guyandotte River, Cabin Creek, and Barkers Creek. The Guyandotte River crayfish was most recently extirpated from Huff Creek and, based on survey efforts in July 2017, it appears that this stream still contains some of the habitat components needed to support the species (Loughman 2014). Therefore, this stream should be prioritized for initial recovery efforts. To determine which other areas should be prioritized for recovery efforts, data on current habitat and water quality conditions within historically occupied watersheds should be gathered and reviewed, and current and potential threats within the watersheds should be assessed. The same measures described under "Maintaining and Enhancing Resiliency of Existing Populations" should then be applied in priority recovery areas to reduce threats and habitat degradation. Where necessary, habitat restoration efforts should be conducted in stream segments that have the greatest potential to support populations in the future. Once habitat conditions are suitable to support the species, captive propagation could be used to reintroduce the species if natural colonization is unlikely.

Communication, Outreach, and Education

Conduct outreach and education to increase understanding of and participation in crayfish conservation efforts.
The support of the local community, including agricultural, silvicultural, mining, construction, and other developmental interests as well as local individuals and landowners, will be essential in meeting crayfish recovery goals. Therefore, it will be important to develop and implement programs to educate the public and private industry about the importance of rare species, such as the crayfish, and to increase participation in conservation efforts. Outreach techniques should include the preparation and distribution of materials, such as fact sheets and brochures, and

utilization of social media. Signs and informational kiosks could be placed near streams important to crayfish recovery. Presentations should be conducted to solicit support for and participation in crayfish recovery efforts. Outreach and education could be developed in cooperation with and/or target State and Federal agencies, government representatives, private organizations, industry, schools, community groups, and citizens. It will be particularly important to target outreach and education to owners or managers of lands in close proximity to crayfish streams as well as organizations, industries, or user-groups that have a high probability of being able to reduce threats to known crayfish streams (e.g., all-terrain vehicle users along Pinnacle Creek). Opportunities should be sought to incorporate aquatic restoration and protection into economic development projects that would improve recreation and tourism, enhance sport fishing, improve quality of human life (such as improve drinking water quality or wastewater management), or other similar mutually beneficial objectives.

Voluntary stewardship, cooperative agreements, joint initiatives, and individual actions with landowners and managers, should be encouraged as a practical and economical means of minimizing adverse effects of private land use and activities within watersheds. Existing legislation and regulations and policies should also be used to the fullest extent practicable to protect crayfish populations and their habitat. This could include using the Partners for Fish and Wildlife Program, Natural Resources Conservation Service programs, and other funding sources to target recovery actions in crayfish watersheds. Enhanced Best Management Practices for forestry and land disturbing activities could also be developed and employed in crayfish watersheds.

Sections 7(a)(1) and 7(a)(2) of the ESA should also be utilized as mechanisms for conservation of the crayfish. Federal regulatory agencies are mandated to use their authorities in furthering the purposes of the ESA under section 7(a)(1). Agencies that have jurisdiction over activities that could affect the crayfish should provide crayfish habitat protection and restoration through section 7(a)(2) consultation with the Service. Section 7 consultation and planning projects should incorporate the recovery actions listed above and should include measures to avoid, minimize, and mitigate for adverse effects to the species.

PREPLANNING DECISIONS

A recovery plan will be prepared for the Guyandotte River and Big Sandy crayfishes. Recovery planning will follow the Service's Recovery Planning and Implementation Approach with the development of a Species Status Assessment (SSA), Recovery Plan, and Recovery Implementation Strategy. Under this approach, SSAs are typically completed as part of the listing process. The two crayfishes were listed prior to development of the SSA process. However, the information in the listing determination about the biology, threats, and status of the species is still current. Therefore, to expedite recovery planning, we will use a modified/transitional process for developing the SSA or Biological Report focusing on information relevant to resiliency, representation, and redundancy of the species. Future conservation scenarios will then be developed and evaluated to determine the most effective implementation strategy to achieve recovery. The recovery plan will include objective and measurable criteria which, when met, will ensure the conservation of the species without the

need for Federal listing. Recovery criteria will address all meaningful threats to the species and estimate the time and the cost to achieve recovery.

The recovery plan will be prepared by the West Virginia Ecological Services Field Office and the cooperating Ecological Services and Fisheries offices. We plan to use working groups or expert elicitation to help determine the recovery vision and criteria and then develop future conservation scenarios that will most effectively achieve those criteria. Groups or experts consulted would include academics or managers who are authorities on the species, aquatic ecology and management, watershed health and restoration, and population/conservation biology. Primary authorship of the Recovery Plan will be the responsibility of Service staff, but State wildlife management agencies will be heavily involved in all phases of the planning and implementation process.

Input and review will be sought from multiple stakeholders within the states of West Virginia, Kentucky, and Virginia, when developing the Recovery Implementation Strategy. This will include State and Federal agencies, local communities, industry, and conservation organizations. This stakeholder input will be focused on developing a suite of recovery actions that could be most effectively implemented to achieve the criteria and vision developed above.

Because the two species are closely related, both biologically and geographically, we anticipate that there will be efficiencies associated with developing a joint recovery plan, at least during the initial planning stages. However, we recognize that there are some differences between the species that may require separate analysis. For example, the Guyandotte River crayfish is endangered and is known to exist in only two small, isolated streams, whereas the Big Sandy crayfish is threatened and has a wider distribution. Therefore, we expect that more concentrated and significant recovery actions will be needed to address the Guyandotte River crayfish. The Service will reassess whether a multispecies approach is appropriate as recovery planning progresses.

Recovery planning is being initiated in fiscal year (FY) 2018 and a draft is expected in FY 2021. This completion date accounts for the need to complete transitional SSAs and a recovery plan for two species. A final recovery plan should be completed 1 year after release of the public review draft. These timelines may be affected by available resources and regional priorities.

Approve: _____ Date: May 31, 2018
Regional Director, ~~Northeast Region~~

LITERATURE CITED

Bernhardt, E. S., and M. A. Palmer. 2011. The environmental costs of mountaintop mining valley fill operations on aquatic ecosystems of the central Appalachians. Annals of the New York Academy of Sciences 1223: 39–57.

Bernhardt, E. S., B. D. Lutz, R. S. King, J. P. Fay, C. E. Carter, A. M. Helton, and J. Amos. 2012. How many mountains can we mine? Assessing the regional degradation of central Appalachian rivers by coal mining. Environmental Science and Technology 46:8115–8122.

Burskey, J. L., and T. P. Simon. 2010. Reach- and watershed-scale associations of crayfish within an area of varying agricultural impact on west-central Indiana. Southeastern Naturalist (special edition 3 ed.) 9:199–216.

Gazendam, E. B., F. C. Gharabaghi, and H. Whiteley. 2011. Evaluation of the Qualitative Habitat Evaluation Index as a planning and design tool for restoration of rural Ontario waterways. Canadian Water Resources Journal 36:149–158.

Jones, E. B. D. III, G. S. Helfman, J. O. Harper, and P. V. Bolstad. 1999. Effects of riparian removal on fish assemblages in southern Appalachian streams. Conservation Biology 13(6): 1454-1465.

Loughman, Z. J., S. A. Welsh, N. M. Sadecky, Z. W. Dillard, and R. K. Scott. 2017. Evaluation of physicochemical and physical habitat associations for *Cambarus callainus* (Big Sandy crayfish), an imperilled crayfish endemic to the Central Appalachians. Aquatic Conservation: Marine and Freshwater Ecosystems 27(4): 755-763.

Loughman, Z. J., S. A. Welsh, N. M. Sadecky, Z. W. Dillard, and R. K. Scott. 2016. Physical habitat and physiochemical covariates associated with in-stream presence of *Cambarus veteranus* (Faxon 1914), an imperiled narrow endemic Appalachian crayfish. Journal of Crustacean Biology 36: 642–648.

Loughman, Z. J., and S. A. Welsh. 2010. Distribution and conservation standing of West Virginia crayfishes. Southeastern Naturalist 9 (Special Issue 3): 63-78.

Loughman, Z. J. 2014. Biological Status Review of *Cambarus veteranus* Faxon 1914 (Big Sandy Crayfish). Report prepared for the U.S. Fish and Wildlife Service.

Merriam, E. R., J. T. Petty, G. T. Merovich, J. B. Fulton, and M. P. Strager. 2011. Additive effects of mining and residential development on stream conditions in a central Appalachian watershed. Journal of the North American Benthological Society 30: 399–418.

Nippgen, F., M. R. V. Ross, E. S. Bernhardt, and B. L. McGlynn. 2017. Creating a More Perennial Problem? Mountaintop Removal Coal Mining Enhances and Sustains Saline Baseflows of Appalachian Watersheds. Environmental Science and Technology 51: 8324–8334.

Palmer, M. A. and K. L. Hondula. 2014. Restoration as mitigation: analysis of stream mitigation for coal mining impacts in southern Appalachia. Environmental Science and Technology 48(18):10552-60.

Palmer, P. A., E. S. Bernhardt, W. H. Schlesinger, K. N. Eshleman, M. S. Foufoula-Georgiou, A. D. Hendryx, and P. R. Wilcock. 2010. Mountaintop mining consequences. Science 327:148–149.

Rankin, E. T. 1995. Habitat indices in water resource quality assessment. In W. S. Davis, and T. P. Simon (Eds.), Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. (pp. 181–208). Boca Raton, FL: Lewis Publishers.

Stihler, C. W. 2017. FW: Wyoming County Spill Report. Email to Kieran O'Malley dated February 8, 2017.

Taylor, C.A., G.A. Schuster, J.E. Cooper, R.J. DiStefano and A.G. Eversole. 2007. A reassessment of the conservation status of crayfishes of the United States and Canada after 10+ years of increased awareness. Fisheries 32: 372-389.

Urgenson, L. S. 2006. The Ecological Consequences of Knotweed Invasion into Riparian Forests. Masters Thesis. University of Washington.

Vernon, J. T. 2017. Rockwell Mining – Knob Fork of Clear. Email to Chase Allred dated August 17, 2017.

Wenger, S. 1999. A review of the scientific literature on riparian buffer, width, extent, and vegetation. Report for the Office of Public Service and Outreach, Institute of Ecology, University of Georgia. Athens, Georgia.

West Virginia Division of Natural Resources and U.S. Fish and Wildlife Service, West Virginia Field Office. 2016. Big Sandy and Guyandotte River Crayfish Survey Protocol.

Wigginton, A. J. and W. J. Birge. 2007. Toxicity of cadmium to six species in two genera of crayfish and the effect of cadmium on molting success. Environmental Toxicology and Chemistry 26(3): 548–554.