United States Department of the Interior

FISH AND WILDLIFE SERVICE

West Virginia Field Office
6263 Appalachian Highway
Davis, West Virginia 26260

May 30, 2024

Rebecca Rutherford
Chief of the Environmental Analysis Section
U.S. Army Corps of Engineers
502 Eighth Street
Huntington, West Virginia 25701

Re: Elk Valley Public Service District Section 14 Streambank Protection Project, Kanawha County, West Virginia (FWS File Number: 2023-0060882)

Dear Rebecca Rutherford:

Thank you for the opportunity to review the biological assessment (BA) provided by the U.S. Army Corps of Engineers (Corps) for the proposed Elk Valley Public Service District (PSD) Section 14 Streambank Protection Project, in Kanawha County, West Virginia. This document transmits the U.S. Fish and Wildlife Service's (Service) West Virginia Field Office (WVFO) biological opinion (Opinion) based on our review of the BA and initiation of formal consultation on February 26, 2024. This project has been assigned the Service File number 2023-0060882; all future correspondence should reference this file number.

In accordance with Section 7 of the Endangered Species Act (ESA; 16 U.S.C. 1531-1544, 87 Stat. 884), as amended, the Corps requested the Service's concurrence with a "likely to adversely affect" determination for the federally endangered diamond darter (*Crystallaria cincotta*), clubshell (*Pleurobema clava*), fanshell (*Cyprogenia stegaria*), northern riffleshell (*Epioblasma rangiana*), pink mucket (*Lampsilis abrupta*), rayed bean (*Villosa fabalis*), snuffbox (*Epioblasma triquetra*), and the threatened longsolid (*Fusconaia subrotunda*) and round hickorynut (*Obovaria subrotunda*). The Corps also requested concurrence with a "likely to adversely affect" determination for diamond darter, longsolid, and round hickorynut critical habitat. Additionally, the Corps requested the Service's concurrence with a "not likely to adversely affect" determination for the federally endangered Indiana bat (*Myotis sodalis*), northern long-eared bat (*Myotis septentrionalis*), and gray bat (*Myotis grisescens*). The Corps made a no effect determination for the federally endangered sheepnose (*Plethobasus cyphyus*), and spectaclecase (*Cumberlandia monodonta*).

The Service's WVFO concurs with the Corp's determination, this project is not likely to adversely affect Indiana bat, northern long-eared bat, and gray bat, in part because of the implementation of the conservation measures outlined in the BA (i.e., seasonal tree clearing restrictions [November 15th to March 31st] and erosion and sedimentation best management practices). This Opinion only addresses the potential effects of the project on the diamond darter, clubshell, fanshell, northern riffleshell, pink mucket, rayed bean, snuffbox, longsolid, and round hickorynut, as well as the potential effects of the project on critical habitat for diamond darter, longsolid, and round hickorynut. Species that are not likely to be adversely affected will not be discussed further within this Opinion. Additionally, those components of the proposed action determined to result in "no effect" or "not likely to adversely affect" to listed species will not be further discussed in this Opinion.

Consultation History

The Corps provided a request for formal consultation on February 26, 2024. The Service's WVFO accepted this BA and initiated formal consultation with the Corps on February 26, 2024. This Opinion is based on information provided in this BA, telephone conversations, email communication, and other sources of information. The consultation history is located in Appendix A. Additionally, a complete administrative record of this consultation is on file in this office.

BIOLOGICAL OPINION

DESCRIPTION OF PROPOSED ACTION

As defined in the ESA Section 7 regulations (50 CFR 402.02), "action" means "all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by federal agencies in the United States or upon the high seas."

The purpose of the proposed action is to stabilize and protect areas of streambank along the Elk River to prevent additional failures to sewer lines damaged during prior flooding events. Below we provide some of the details of the action, however the BA provides a thorough description of the action area (pages 6 through 15).

Following a flood event in June 2016, sewer lines along the Elk River became comprised because of a bank failure and increased bank erosion. Unfortunately, this led to sewer lines failing completely which caused raw sewage discharge into the Elk River.

The proposed project is located on US Route 119 between the town of Big Chimney and Elk Hills approximately 2,296 feet downstream of the confluence of Coopers Creek with the Elk River. Construction limits begin approximately 1,397 feet downstream from to the US Route 119 bridge and extend 3,510 feet downstream. Land use surrounding the action area is predominantly residential lawns transitioning to trees and wooded areas along the river. The proposed project encompasses installation of streambank stabilization and protection measures along 1,949 linear feet along the right descending bank of the Elk River at two separate locations. The first site (Rolling Smoke) extends along 722 feet of the right descending bank and will include areas approximately 25 feet below the ordinary high-water mark (Figure 1). Of this 722-foot area, only 459 feet of impacts are at or below the ordinary high-water mark. The total area of impact at

Rolling Smoke, including the salvage area, is 1.46 acres; this includes 0.679 acres of aquatic impact and 0.781 acres of upland impact. The second site (Crede) extends along 1,227 feet of the right descending bank and will include areas approximately 25 feet below the ordinary high-water mark; all impacts occur at or below the ordinary high-water mark (Figure 2). The total area of impact at Crede, including the salvage area, is 3.01 acres; this includes 1.189 acres of aquatic impacts and 1.821 acres of upland impact.

A combination of a full height stone buttress and longitudinal dike will be used to stabilize and protect the streambank at these locations. The application of these methods will be determined by site conditions at the start of construction because the sites are in a constantly changing condition due to their composition of substrates that are easily destabilized from high water events. Both methods involve similar steps to prep and reclaim the sites. The main difference between the construction of a longitudinal dike and a stone buttress involves the placement of the stone. The former involves creation of a stone wall within the channel parallel to the direction of flow to protect the streambank behind it. The latter involves armoring the slope of the streambank itself. Project completion will require approximately 255 working days including approximately 150 days of in-stream work with a contingency of an additional 60 days of in-stream work to account for unpredictable flows from weather events. All project construction activities are anticipated to be completed from the stream bank and will be completed during daylight hours.

Regardless of stabilization method, each site will be cleared of trees and grubbed of vegetation. Staging areas will be constructed (two at each site), existing access roads will be upgraded, and a new access road will be constructed at the Crede site. Areas where equipment maintenance and refueling will be within controlled areas to prevent any fluids entering the Elk River. Erosion and sedimentation control measures will be placed proximate to access roads, staging areas, and construction reaches will be in both upland areas and areas below the ordinary high-water mark. Anticipated construction equipment will include tandem dump trucks, track-hoe, dozer, 250-ton crawler crane with vibrating hammer, concrete trucks, concrete pumper truck, hydroseeding machine, chainsaws, and various hand tools.

The full height stone buttress will require excavation and spoiling of all unsuitable vegetation, soils, drift, rubble, stone, and debris to form a suitable placement surface for a granular filter. Up and downriver stone transition areas will be necessary to prevent the Elk River outflanking the stabilization treatment. Along the riverbank, stone protection will be placed up and down slope of the normal pool elevation on slopes of 1.0 vertical to 1.5 horizontal on the riverward out-slope. The buttress will be placed 16 to 20 feet from the normal pool land-water contact; however, it may extend approximately 25 feet riverward depending on site conditions (Figure 3). This structure will be constructed in an upstream to downstream sequence after access roads have been upgraded/constructed (construction of a road is proposed only at the Crede site). Once the slope is excavated to a stable geometry, the keys (excavated area at the toe of the slope to improve stability of the fill material) are excavated and filled with stone, and then filter fabric or filter-compatible bedding stone will be placed along the slope. Rip-rap will then be placed to ensure all stone is “packed” to provide strength to the structure and avoid loss of critical stone. Once the structure has been completed, the final grade will be surveyed, access roads will be removed and reclaimed, and the entire area will be revegetated.

A longitudinal dike is a stone structure oriented parallel to stream flow and has tiebacks on 50-foot intervals along the length of bank where it is applied (722 feet at Rolling Smoke [459 feet at or below the ordinary high-water mark] and 1,227 feet at Crede [all 1,227 feet at or below the ordinary high-water mark]). A tieback is a rock placement design that runs perpendicular to flow to encourage deposition along the eroding streambank to anchor the dike to the bank; it will also create a backwater area between the dike and bank. Construction of the dike and its tiebacks does not involve bank excavation like the stone buttress. Figure 4 shows a diagram of this structure. It will be constructed in an upstream to downstream sequence after access roads have been upgraded/constructed (construction of a road is proposed only at the Crede site as there is an existing access road at the Rolling Smoke site). Heavy equipment will excavate the keys, fill them with stone, and then form the tiebacks and place stone to form them and the dike. Once the structure has been completed, the final grade will be surveyed, access roads will be removed and reclaimed, and the entire area will be revegetated.

Figure 1. Overview of project impacts to Rolling Smoke/Site 2

Figure 2. Overview of project impacts to Crede/Site 1

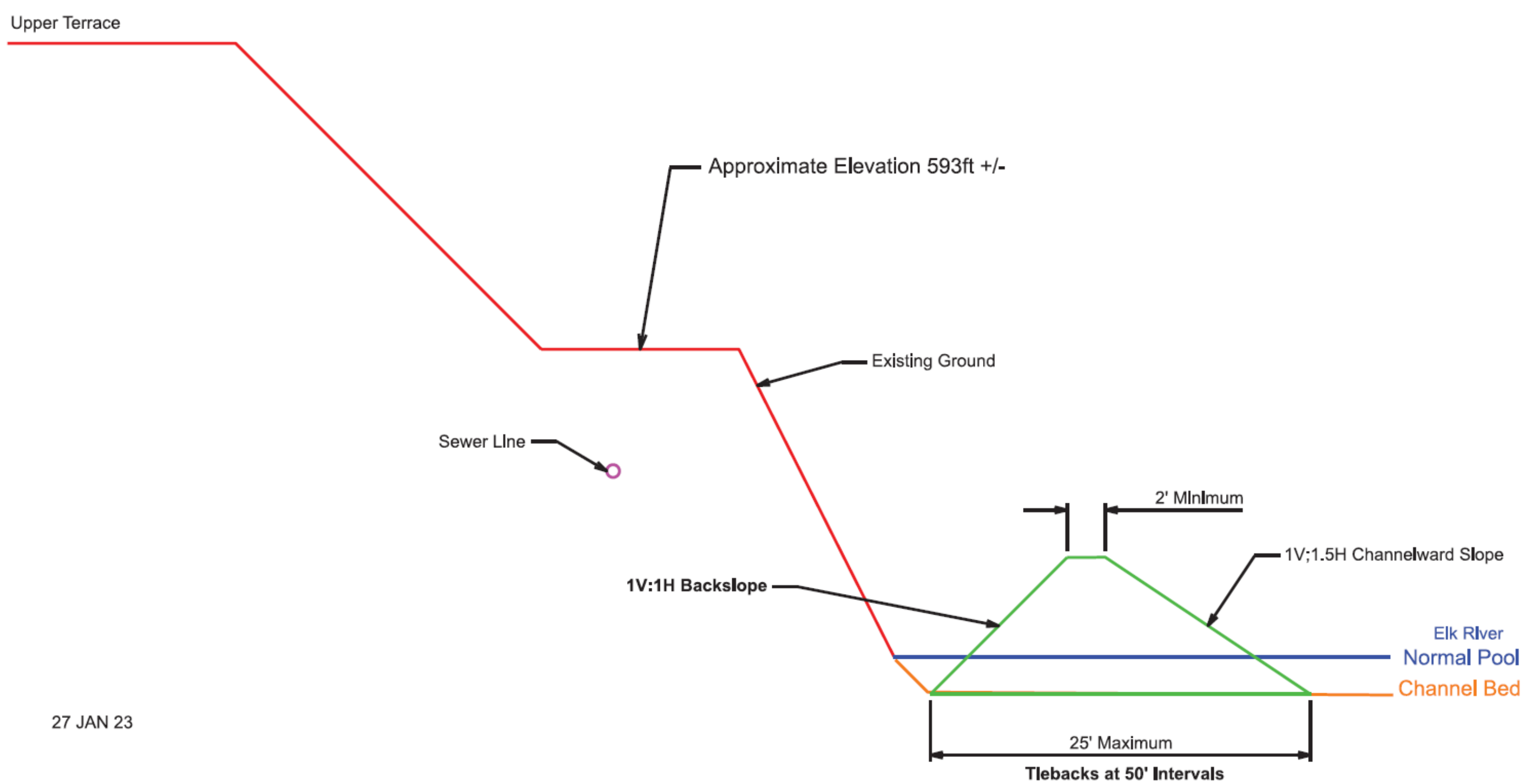

Figure 3. Conceptual drawing of longitudinal dike structure

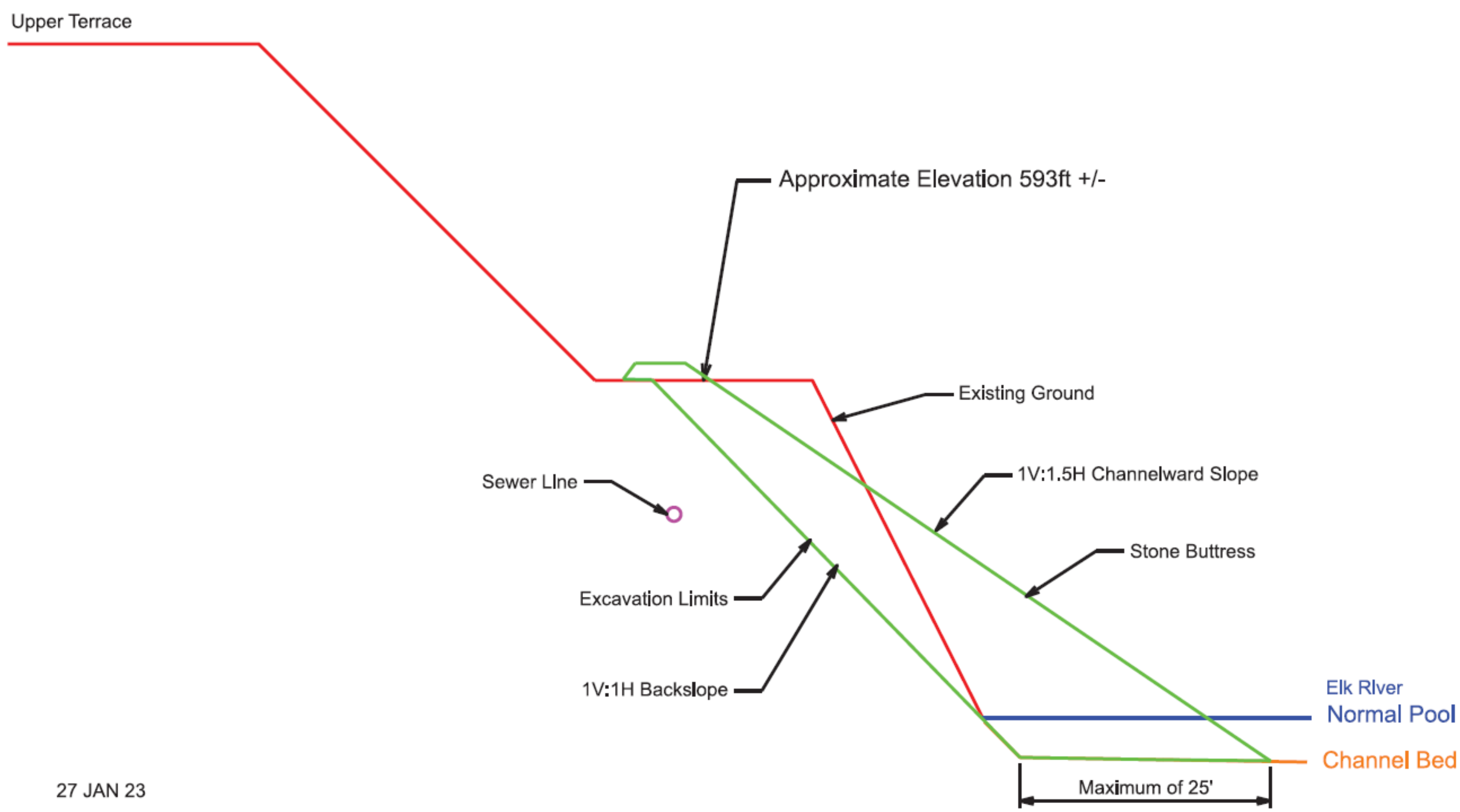

Figure 4. Conceptual drawing of stone buttress

Conservation Measures

Conservation measures are those actions taken to benefit or promote the recovery of the species and are included as an integral portion of the proposed action. These actions will be taken by the Federal agency or the project proponent and serve to minimize or compensate for project effects on the species under review. The Corps have committed to completing the conservation measures listed below and will be included into the project proponent's permit requirements. Additionally, details of these conservation measures are in the BA (pages 26 -32).

1. Vehicle access and equipment management: The number of vehicles and equipment will minimized to what is necessary, all drivable surfaces will be graveled, and speeds will be reduced to maximize control of erosion and sediment.
2. Vegetation removal: Seasonal clearing of trees and vegetation will be conducted between November 15 and March 31.
3. Design conservation: Existing access roads and previously disturbed areas will be utilized as much as possible to reduce impacts to the project area. Additionally, all work will be constructed from the bank without use of barges or in-stream equipment.
4. Avoidance of diamond darter spawning: In-stream construction will avoid the spawning period for the diamond darter (April 1 through June 30).
5. Environmental monitoring: An environmental monitor will be on site to document/confirm areas to be cleared of vegetation, confirm avoidance and minimization measures, best management practices, and emergency plans with the contractor, for in-stream work activities.
6. Mussel salvage, relocation, and post-construction monitoring: Prior to the start of in-stream work, freshwater mussels will be salvaged from the area of direct impact and will be relocated to the nearest suitable upstream habitat following the Mussel Salvage and Relocation Plan (Attachment A of the BA). Mussels that are relocated will be monitored for survival and growth post-construction to determine success of the relocation effort one and three years post-construction.
7. Diamond darter monitoring: A pre-construction diamond darter survey and two post-construction surveys will be completed within the project area to note presence of any fish. The observation plan for these surveys will be provided to the Service for approval prior to fieldwork.
8. Pre- and post-construction habitat monitoring: Cross sections of the river will be established prior to construction to monitor long-term effects of the project to the river channel. Each cross section will record substrates, depth, and qualitative assessment of any darters or mussels observed. Geomorphological monitoring of the established cross sections will occur during years one and three post-construction to document any changes, and a final report will be submitted five years post-construction to describe cumulative effects of the project on in-stream habitats.
9. Erosion and sedimentation controls: Erosion and sediment control devices will be placed throughout the construction site to reduce introduction of sediment to the stream. A turbidity curtain may also be used to reduce sediment travel downstream of the site.
10. Spill response planning: An emergency plan for spill response and removal of equipment in the event of a high-water event will be developed and posted at the site.
11. Establishment of native vegetation: Reseeding of all areas will be completed with native vegetation and any invasive species observed will be removed/controlled.

ACTION AREA

The action area is defined (50 CFR 402.02) as "all areas to be affected directly or indirectly by the federal action and not merely the immediate area involved in the action." The Service has determined that the action area for this project is approximately 4.47 acres of upland and aquatic areas along the Elk River on US Route 119 between the town of Big Chimney and Elk Hills approximately 2,296 feet downstream of the confluence of Coopers Creek with the Elk River. This area covers both direct and indirect effects (e.g., water quality) associated with bank stabilization activities. In addition to this area, the aquatic action area includes the site where salvaged mussels will be relocated and monitored. The relocation site for the salvaged freshwater mussels will be upstream of the project site in the Elk River.

STATUS OF THE SPECIES

Per ESA Section 7 regulations (50 CFR 402.14(g)(2)), it is the Service's responsibility to "evaluate the current status of the listed species or critical habitat." Below, we summarize relevant information regarding the species conservation needs and the status in terms of meeting those needs.

Diamond darter

The diamond darter was listed as endangered throughout its entire range on August 26, 2013 (78 FR 45074). The following is a summary of the diamond darter life history drawn from the species listing (78 FR 45074), the draft species status assessment, and peer reviewed literature. For a more detailed account of the species description, life history, population dynamics, threats, and conservation needs, refer to https://ecos.fws.gov/ecp/species/6921

The diamond darter is generally translucent with silvery white coloration on the underside of the body and head, in addition to having four wide olive-brown "saddles" on the back and upper side (Welsh et al. 2008). Between the saddles, olive-brown colored pigments on the scale margins produce a fragmented crosshatch pattern. A blotch under and in front of each eye is dark and distinctly separated from the front margin of the orbital rim around the eye. The side coloration includes 12 to 14 oblong olive-brown blotches overlain by an iridescent olive-green stripe. Fins are translucent apart from sparse pigmentation on the tail fin. Documented standard lengths measured from the tip of the snout to near the beginning of the tail fin range from 2.9 to 3.0 inches (for adults; Welsh and Wood 2008).

Due to its rarity, limited natural history information is available for this species (Osier 2005). Some general life history characteristics can be inferred, however, from the closely related crystal darter, as noted in the relevant sections below. When maintained in captivity, females showed signs of being gravid from late March to May and exhibited large variations in spawning periods relative to water temperatures (Ruble 2013). Ruble (2013) observed that captive diamond darters typically spawned from late March to early July at temperatures ranging from 58 degrees to 74 degrees Fahrenheit. Larvae hatched within seven to nine days of spawning (Ruble et al. 2010). Given morphological similarities with other darter species, including the crystal darter, diamond darter larvae likely drift within the water column for an unknown length of time after hatching (Osier 2005; Simon and Wallus 2006). Other darter larvae adapted to larger rivers may drift for 15 to 30 days before settling to the river bottom (Rakes pers. comm. 2013), and it is assumed that diamond darter larvae may drift for a similar period. Ruble et al. (2014) suggested that diamond darter larvae go through a pelagic (open water) stage where they feed on objects in the water column or on the water's surface. During this stage, the larvae may drift semi-passively downstream for an unknown period until they arrive in slack water habitats (e.g., pools, backwaters, or eddies). In these low velocity environments, they are likely able to maintain their position and continue to mature before they transition into the benthic stage typified by juveniles and adults. Juveniles and/or adults may then migrate upstream, as has been observed in other darter species with similar life history characteristics. Diamond darter life expectancy in the wild is unknown; however, it may be four years or more based on diamond darters held in captivity (Ruble 2011).

Similar to other darter species, adult diamond darters are believed to feed on benthic invertebrates, primarily stream- bottom-dwelling and drifting invertebrates (NatureServe 2008). When feeding on drifting invertebrates, they may use a lie-in-wait foraging strategy by lying motionless on the stream bottom (Welsh pers. comm. 2022). Diamond darter larvae have unusually large teeth that are not present in the adults (Ruble et al. 2014). Captive diamond darter larvae cannibalize conspecific larvae and did not feed on a variety of other foods (i.e., rotifers, instant algae, newly hatched brine shrimp, *Ceriodaphina dubia* neonates, artificial plankton, and spirulina; Ruble et al. 2014). This suggests that diamond darter larvae may be piscivorous and that their food choice differs from other darter species.

Diamond darter is known predominantly from riffle-pool complexes in moderate to large-sized geomorphically stable streams and rivers (fourth to eighth order) within the Ohio River watershed. Welsh et al. (2013) found the species primarily occupied upstream (glide) and downstream (run) transitional areas between riffle and pool habitats in the Elk River (West Virginia). These areas are characterized by shallow water, typically less than 3.3 feet, and current velocities of less than 1.6 feet/second. During high flow conditions, diamond darters may remain in glide habitats, but bury into the sand (Rizzo et al. 2017a). However, pool habitats may become temporarily suitable depending on the timing and velocity of different flows. As water depth and current velocity increases in glide habitats during high flows, diamond darters may temporarily move into pools if habitat conditions are favorable or remain in the glide habitat and bury into the sand (Rizzo et al. 2017a).

Conservation Needs

There is no recovery plan for the diamond darter, however, the 5-year review (Service 2020b) listed these recommendations for future action:

- Conduct research to further understand the life history needs of the species, including reproduction and juvenile survival, larval prey preferences, habitat use, and movement, as well as developing techniques to more accurately detect the species and estimate population size and trends.
- Evaluate the species' sensitivity to water quality parameters (such as salinity, conductivity, etc.) to determine conditions needed to support all life stages of the species.
- Evaluate diamond darter genetics to identify any factors that would affect their viability and implement measures to manage for these factors both in the wild and during any captive propagation or restoration efforts.

- Establish protocols to survey and monitor population status and trends within the Elk River and implement monitoring on a regularly established schedule. This should include monitoring water quality and habitat conditions.
- Protect and restore water quality and habitat conditions within the Elk River watershed.
- Coordinate with partners to reduce threats to the diamond darter within the Elk River watershed.
- Control invasive species such as didymo and Japanese knotweed within the Elk River watershed.
- Evaluate streams within the historical range of the species to determine whether conditions are suitable to support the species.
- Implement habitat restoration efforts in streams within the historical range of the species to make them suitable to support the species.
- Develop captive propagation and holding techniques that would allow for the establishment of additional diamond darter populations, or restoration efforts within the Elk River if necessary.
- Establish additional populations within the historical range of the species.

Current Condition
At the time of listing, the diamond darter's known occurrences were restricted to the lower 23 miles (mi) of the Elk River, in West Virginia. However, assessments suggested similar habitat conditions existed upstream to King Shoals for a total of 31.7 mi of suitable habitat (Welsh et al. 2012). Surveys conducted on the Elk River since listing confirm that diamond darters are present at two upstream sites near Porter Creek and the mouth of King Shoals Creek, located 28.8 mi and 31.4 mi above the mouth of the Elk River, respectively. This result is consistent with extent of the species' range as reflected in the critical habitat designation (Welsh et al. 2014). The species is believed to have been extirpated from the remainder of its historical range in the Ohio River basin (78 FR 45075). Since the species was listed, surveys conducted in rivers within the species' historical range have not detected diamond darter, though comprehensive surveys using optimal species-specific techniques (i.e., nocturnal spotlight surveys) have not been conducted to date. It is therefore possible, although unlikely, a small number of additional undiscovered populations may remain.

Information on diamond darter abundance, population trends, and demographics is limited because the species' small size, cryptic coloration, nocturnal behavior, tendency to burrow into the substrate, and limitations on sampling techniques make its detection difficult.

Rizzo et al. (2017b) reported diamond darter detection probabilities of 0.11 to 0.19 at three known occupied sites in glide habitats in the Elk River. Because of low detection probability and limited sampling, there are still insufficient data to determine an overall population estimate of the diamond darter within the Elk River. In all cases, the observed number of diamond darters was less than 50 individuals per site.

Severe disturbance events, like the flooding event experienced on the Elk River in 2016, can cause high mortality of vulnerable life stages (e.g., egg and larval), leading to low recruitment and subsequent poor year-class strength[1]. During June 2016, the lower section of the Elk River experienced extreme flooding (greater than a 200-year flood event), which allowed for comparison of diamond darter abundance immediately before and after the event. Combining data across three sites, Rizzo et al. (2018) estimated a pre-flood population of 250 adult diamond darters (95% Confidence Interval [CI]: 175 to 436), which was not significantly different than the post-flood population of 190 (95% CI: 131 to 340) immediately after the event. Thus, this life stage of diamond darters in glide/run habitat appeared to resist short-term displacement and greater mortality following a major flood. The results of the study suggested, however, that there were substantial variations in year-class strength at the three sites sampled during 2015 and 2016, with a decline in abundance at all three sites in 2016. This study was unable to provide specific conclusions about the cause of these observed declines. There are several abiotic and biotic factors that could explain why year-class strength of a fish population might vary substantially among years. Successive years of poor year-class strength could result in local population extirpations (Rizzo et al. 2018).

During surveys in July 2021, the West Virginia Division of Natural Resources (WVDNR) recorded 59 diamond darter observations among four sites in the lower section of the Elk River (WVDNR 2021). These sites consisted of three previous monitoring sites (Reamer, Walgrove, and Clendenin), which have been sampled with some regularity since 2015 following the development of the nocturnal spotlight methodology, and an additional monitoring site at Mink Shoals. Mink Shoals is the current downstream extent of known diamond darter occurrences and had not been sampled since 2012 (Owens pers. comm. 2021). In 2021, the largest number of individual detections (i.e., "naïve abundance") during a single night was at the Reamer site (24), while Walgrove had the fewest detections (two). Sampling was repeated on the next night and yielded 18 and two detections, respectively. Surveys at the most downstream site (Mink Shoals) yielded eight individuals, confirming persistence at the current downstream extent of the species (WVDNR 2021). Four juveniles were detected at the Mink Shoals site, indicating that recruitment is occurring. In 2023 surveys were conducted at 11 sites, eight of which had confirmed occupancy of diamond darter. A total of 20 individuals were detected overall. The largest number of individual detections at one site was nine (Silvis pers. comm. 2023).

Threats

Ongoing threats to diamond darter include sedimentation. Increased sedimentation has been shown to abrade and suffocate bottom-dwelling organisms, reduce aquatic insect diversity and abundance, and ultimately negatively impact fish growth, survival, and reproduction (Berkman and Rabeni 1987). Siltation directly affects the availability of food for the diamond darter by reducing diversity and abundance of aquatic invertebrates on which juvenile and adult diamond darters feed (Powell 1999), and by increasing turbidity, which reduces foraging efficiency (Berkman and Rabeni 1987). Consequently, the amount of suitable microhabitat for species such as the diamond darter is reduced (Bhowmik and Adams 1989, Kessler and Thorp 1993, Waters 1995, and Osier and Welsh 2007 all *in* Service 2011). Excessive sediments can also cover the stream bottom and fill the interstitial spaces between bottom substrate particles (i.e., sand, gravel, and cobble). This could affect diamond darter by limiting sheltering or breeding habitat (Berkman and Rabeni 1987; Messinger and Chambers 2001; Sutherland et al. 2002; McGinley et

[1] The number of fish spawned or hatched in a given year (Ricker 1975).

al. 2013).

This species is also susceptible to changes in water quality. Large numbers of oil and gas wells as well as surface and underground mines occur within the range of the species and may degrade water quality. Water quality degradation relative to diamond darter comes from acid mine drainage, elevated levels of fecal coliform from poorly treated sewage, and high levels of iron from disturbance to iron-rich soils associated with mining, urban/industrial development, roads, oil and gas operations, timbering, agriculture, and streambank erosion. Acid mine drainage changes stream pH and conductivity, which can impair the ability of fish, such as the diamond darter, to extract energy from food, regulate internal pH and water volume, and excrete metabolic wastes. Increased conductivity can also adversely affect egg fertilization, embryonic development, and nerve and muscle activation in fish and other aquatic organisms (Pond et al. 2008; USEPA 2011). Elevated levels of fecal coliform bacteria can cause spawning, breeding, and foraging problems for fish, such as the diamond darter. Moreover, discharge of poorly treated sewage into streams and rivers contributes a variety of contaminants that can decrease dissolved oxygen levels needed for respiration, food availability, and egg development (WVDEP 1997; Whitman and Clark 1982; Keckeis et al. 1996; Chu-Fa Tsai 1973; Wynes and Wissing 1981).

Habitat modification is also considered a threat to diamond darter habitat. The primary contributors to habitat modification in occupied diamond darter habitat are impoundments and pipeline stream crossings. Impoundments permanently altered habitat suitability in the affected reaches and fragmented stream habitats, blocking fish immigration and emigration between river systems, and preventing recolonization (Grandmaison et al. 2003). Pipeline crossings could also kill or injure diamond darter adults, young, or eggs. Pipeline construction that involves direct trenching through the diamond darter's habitat could destabilize the substrates, leading to increased sedimentation or erosion. Placement of fill in the river could result in the overall reduction of habitat that could support the species, and it could alter flows and substrate conditions, making the area less suitable for the species (Welsh pers. comm. 2009). Pipeline stream crossings can also affect fish habitat; food availability; and fish behavior, health, reproduction, and survival. The most immediate effect of instream construction is the creation of short-term pulses of highly turbid water and total suspended solids (TSS) downstream of construction (Levesque and Dube 2007). Studies have found decreased abundance of fish downstream of crossings, as well as signs of physiological stress such as increased oxygen consumption and loss of equilibrium (Reid and Anderson 1999; Levesque and Dube 2007). Increased sediment deposition and substrate compaction from pipeline crossing construction can degrade spawning habitat, result in the production of fewer and smaller fish eggs, impair egg and larvae development, limit food availability for young-of-the-year fish, and increase stress and reduce disease resistance of fish (Reid and Anderson 1999; Levesque and Dube 2007).

<u>Summary</u>
The diamond darter's current range continues to be limited to a single population in the lower portions of the Elk River in West Virginia. The final listing rule described threats to the diamond darter as a result of sedimentation and siltation from development; water quality degradation; habitat changes and isolation caused by impoundments; and direct habitat disturbance (78 FR 45083-45089). All threats to this population identified during listing are ongoing and are

affecting the entire range of the species, and are expected to continue into the future. These threats are primarily related to the present or threatened destruction, modification or curtailment of the species' habitat or range, but the species is also vulnerable to spills and invasive species. The scope and extent of these threats have not substantially changed since listing. However, ESA protections have been effective at avoiding and minimizing many threats from projects that have a federal consultation nexus. These threats would not be avoided and minimized if ESA protections were removed. Overutilization and disease/predation do not appear to be significant threats at this time.

In summary, as a whole, the rangewide status of the species is declining and the Service recommended maintaining the current classification as an endangered species in its 5-year review (Service 2019a). For additional documents related to the species (e.g., recovery plan, Federal Register notices, biological opinions) refer to https://ecos.fws.gov/ecp/species/3789.

Clubshell

The Service listed clubshell as endangered on January 22, 1993 (58 FR 5638). The following is a summary of clubshell general life history drawn from the clubshell recovery plan (Service 1994), the clubshell 5-year reviews (Service 2008a, 2019a), and peer-reviewed literature.

The clubshell is a small to medium-size mussel, up to three inches long. The shell exterior is yellow to brown with bright green blotchy rays. The shell interior is typically white. The shell is wedge-shaped and solid, with a pointed and fairly high umbo. This species does not have sexually dimorphic shells.

Reproduction is likely similar to other freshwater mussels. Males release sperm into the water column and females take in the sperm during normal siphoning activity. Females retain fertilized eggs in specially modified gills (marsupia) until the larvae (glochidia) are fully developed. Once released, the glochidia must attach to the gills or fins of an appropriate fish host. They encyst and metamorphose into juvenile mussels. Fully developed juveniles drop from the fish host and settle to the river bottom. Males of the genus *Pleurobema* release sperm into the water in April, May, and June, and downstream females uptake the sperm with incoming water (Weaver et al. 1991). *Pleurobema* are short-term brooding species that release glochidia shortly after fertilization, generally from June to August. Clubshell have low juvenile annual survival rates. Additionally, clubshells are relatively long-lived with life spans of 20 years or more.

Freshwater mussels feed by siphoning food items that drift in the water column. The clubshell likely feeds on items similar to other mussel species including algae, zooplankton, diatoms, and detritus.

The clubshell has been found in a variety of stream and river conditions, but is most often observed in clean, stable, coarse sand and gravel runs, often just downstream of riffle areas, in medium to small rivers and streams (Service 1994). It typically burrows completely beneath the substrate to a depth of two to four inches, relying on water to percolate between the sediment particles (Watters 1990 *in* Service 2008a). More than 70 percent of a population may be hidden below the substrate surface (Smith et al. 2001). As a fluvial organism, the clubshell can tolerate a range of water velocities, and although often considered to be intolerant of permanently slack water conditions (Service 1994), it has been found living and reproducing in Navigation Pools 7, 8, and 9 in the Allegheny River at depths of 10 to 15 feet. These navigation pools have some flow during higher discharge periods but may accumulate several inches of fine sediment during low flow periods.

Conservation Needs
The Service finalized a recovery plan for the clubshell in 1994 (Service 1994). The recovery objectives for clubshell are to maintain and restore viable populations to a significant portion of their historical range. The Service outlined the following conditions that we believed would result in the species no longer meeting the definition of an endangered species (Service 1994): viable populations must be established in ten drainages; these populations should include both peripheral and central populations to maintain whatever fraction of original genetic variability is left. To delist, each of the above ten populations must be extensive and abundant enough to survive a single adverse ecological event, and the populations and their drainages must be permanently protected from all foreseeable threats.

The primary actions to address these criteria include: (1) initiate and participate in ecosystem conservation efforts; (2) protect and manage mussel populations and their habitat on a site-specific basis; (3) collect data on the species that are necessary for its recovery; (4) as needed, restore habitats and reintroduce the species to suitable areas; and (5) enlist public support for the recovery process through an outreach program and incentives.

Current Condition
Although population numbers are relatively high in a few localized areas, the remaining clubshell populations are now sparsely distributed across the range of the species in Illinois, Indiana, Kentucky, Michigan, New York, Ohio, Pennsylvania, and West Virginia (Service 2019a). Clubshell remains extirpated from Alabama and Tennessee. Of 100 streams once known to be occupied by clubshell, the species is now limited to 11 extant populations occupying 19 streams in the Ohio River and Lake Erie basins, including those where the species has been reintroduced or augmented between 2014 and 2018 in New York, Pennsylvania, West Virginia, Ohio, Kentucky, Indiana, and Illinois. The clubshell has expanded its range to Big Darby Creek, Ohio, as a result of habitat management and reintroductions. Eight populations show signs of successful recruitment. Augmentation and reintroduction sites have not shown evidence of successful reproduction as of 2018; however, clubshell takes a number of years to reach a size likely to be detected. Impoundments and degraded habitat separate most populations from each other, eliminating the potential for natural recolonization if a catastrophic event temporarily degrades habitat (e.g., toxic spill event, flood). In multiple streams, clubshell populations appear to be comprised of only older adults, and the populations are in decline.

Threats
Ongoing threats to the clubshell include water quality degradation from point and non-point sources, particularly in small tributaries that have limited capability to dilute and assimilate sewage, agricultural runoff, and other pollutants (Service 2019a). In addition, the species is affected by hydrologic and water quality alterations resulting from the operation of impoundments. A variety of in-stream activities continue to threaten clubshell populations, including sand and gravel dredging, gravel bar removal, bridge construction, and pipeline construction. The indirect effects of altering the streambed configuration following in-stream

disturbance can result in long-lasting alteration of streamflow patterns, which may result in head-cutting and channel reconfiguration, thereby eliminating previously suitable habitat some distance from the disturbance. Coal, oil, and natural gas resources are present in a number of the watersheds known to support clubshell. Exploration and extraction of these energy resources can result in increased siltation, a changed hydrograph, and altered water quality even at a distance from the mine or well field. Land-based development near streams of occurrence, including residential development and agriculture, often results in loss of riparian habitat, increased storm water runoff due to increased impervious surfaces, increased sedimentation due to loss of streamside vegetation, and subsequent degradation of streambanks. Development has also resulted in an increased number of sewage treatment plants in drainages that support clubshell, as well as an increase in the amount of sewage discharged from existing plants. Increased turbidity and sedimentation from the activities described above irritate or clog the gills of mussels and can even physically smother the animal. Mussel life cycles can be affected indirectly from increased turbidity and sedimentation by affecting host fish populations (e.g., smothering fish eggs or larvae, reducing food availability). Mounting evidence indicates that freshwater mussels are more sensitive to several components of treated sewage effluent (e.g., ammonia, chloride, and copper) than are the typical organisms used to establish criteria protective of aquatic life (Augspurger et al. 2003, Patnode et al. 2015). Several animals prey on this species, including muskrats, raccoons, otters, molluscivous fish, and some invertebrates (Service 2019a).

Mussel die-offs have been documented in clubshell streams, and some researchers believe that disease may be a factor contributing to the die-offs (Haag 2012 *in* Service 2019a). Since listing, mussel die-offs have occurred in two clubshell streams (Elk River [West Virginia] and Big Darby Creek [Ohio]). The causes of these recent die-offs are not known. It is also not known if any clubshells were affected during these events.

This species is also susceptible to habitat loss and competition from zebra mussel (*Dreissena polymorpha*), a highly invasive bivalve native to Europe and western Asia. The zebra mussel has been documented in headwater lakes and reservoirs of a number of streams supporting clubshell populations. These lakes and reservoirs supply a source for zebra mussel veligers (larvae) to colonize downstream reaches. The presence of zebra mussel populations may also cause increased use of molluscides to treat zebra mussel infestations in the watershed. Nearly all remaining reproducing clubshell populations are downstream of lakes or reservoirs that support, or could support, zebra mussels. Zebra mussels in the Ohio River could possibly impact clubshell populations introduced at three sites in the Ohio River between 2013 to 2016. When they reach high population densities, the zebra mussel populations compete for food, oxygen, and space with native mussels causing mortality and population declines. Other invasive species that may be possible threats are the round goby (*Neogobius elanostomus*), which prey on mollusks and small fish that may serve as clubshell hostfish, and the black carp (*Mylopharyngodon piceus*), a molluscivore and present in the lower Ohio, Cumberland, and Tennessee river systems.

The ultimate results of climate change remain unknown, but increased periods of drought are a possibility in some areas, as are changes in precipitation and water temperature cycles (Strayer and Dudgeon 2010, Service 2019a). Physiological tolerances (e.g., temperature, dissolved oxygen) of most mussel species are largely unknown but changes that cross critical thresholds could disrupt life stages or host availability. The isolated nature of remaining clubshell populations combined with life history traits (e.g., slow growth, low dispersal potential) means that natural recolonization is unlikely in the event of a natural or manmade catastrophic event. Many of the remaining populations appear to be limited to relatively short stream reaches or single sites. These small, isolated populations are particularly vulnerable to extirpation due to losses resulting from stochastic events such as droughts, floods, and toxicant spills.

Summary
Historically, the clubshell was once abundant and appeared to have been a highly successful species occupying a range of riverine habitats throughout the Ohio River basin and tributaries of western Lake Erie. It had been documented in over 100 streams throughout its historical range, but now appears to be limited to eleven extant populations in 19 streams. Only eight clubshell populations show evidence of recent reproductive success. As a result, there are few (redundancy) populations in each state and these populations are not evenly distributed across the geographic range (representation). There appear to be reproducing populations in eight of the eleven populations (resiliency). Few extant clubshell populations occupy habitats that are protected from the threats affecting this species. For unknown reasons, many of the remaining clubshell populations do not appear to be reproducing in locations where many other species of freshwater mussels show evidence of recent recruitment.

In summary, as a whole, the rangewide status of the species is declining and the Service recommended maintaining the current classification as an endangered species in its 5-year review (Service 2019a). For additional documents related to the species (e.g., recovery plan, Federal Register notices, biological opinions) refer to https://ecos.fws.gov/ecp/species/3789.

Fanshell
The Service listed fanshell as endangered on June 21, 1990 (55 FR 25591). The following is a summary of fanshell general life history drawn from the fanshell recovery plan (Service 1991), the fanshell 5-year review (Service 2019b), and peer-reviewed literature.

The fanshell is a small to medium-size mussel, seldom exceeding 3.2 inches long (Service 1991). The shell exterior has green rays on a light green or yellow surface ornamented with green mottling. The shell interior is usually silvery white. The shell is subcircular in outline. Specific life history information is based on research of fanshells in the Clinch River in Virginia and Tennessee (Jones and Neves 2002). Ages of fanshell collected from the Clinch River ranged from 6 to 26 years with the mean age being younger than 8 to 10 years. Annual growth averaged 0.16 inches per year through age 10 and decreased approximately 0.03 inches/year thereafter. The smallest gravid females had a length of 1.1 to 1.3 inches, implying that most individuals are mature at 5 to 9 years. The mean age at death of fanshell was determined to be approximately 12 to 13 years.

Reproduction and feeding are likely similar to other freshwater mussels, as described for clubshell. The fanshell is a long-term breeder. Fertilization takes place in late summer/fall, and the glochidia overwinter in the female and are discharged into the water column in spring (March to May). Jones and Neves (2002) collected gravid female fanshells in the Clinch River from late October to late May.

The fanshell occurs in medium to large rivers. It is typically found in stable stream channels where a diversity of other mussel species are concentrated (i.e. a mussel bed). The fanshell is typically found in flowing water and stable substrate, which contains a relatively firm and clean gravel, sand, and silt mixture. However, they can occupy a wide range of currents and water depths. Fanshell mussels are difficult to detect, because a portion of the population can occur below the top of a stream's substrate. Therefore, population estimates should take into account the possibility that individuals are buried. Qualitative and quantitative estimates may underestimate the number of individuals.

Conservation Needs
The Service finalized a recovery plan for the fanshell in 1994 (Service 1991). The recovery objectives for fanshell are to restore viable populations of the fanshell to a significant portion of its historic range in the Ohio River. The Service outlined the following conditions that we suggested would result in the species no longer meeting the definition of an endangered species: (1) through protection of existing populations and through successful establishment of reintroduced populations or the discovery of additional populations, a total of nine distinct viable populations exist; (2) one naturally reproduced year class exists within each of the nine populations; and (3) biological and ecological studies have been completed, and the recovery measures developed and implemented from these studies are beginning to be successful, as evidenced by an increase in population density and/or an increase in the length of the river reach inhabited by each of the nine populations (Service 1991). To delist this species the Service suggested: (1) a total of 12 distinct viable populations exist and they must be separated to the extent that it is unlikely that a single event would eliminate or significantly reduce more than one of these populations; (2) two distinct naturally reproduced year classes exist within each of the twelve populations; (3) studies of the mussel's biological and ecological requirements have been completed, and recovery measures developed and implemented from these studies have been successful, as evidenced by an increase in population density and/or an increase in the length of the river reach inhabited by each of the twelve populations; (4) no foreseeable threats exist that would likely threaten the survival of any of these eight populations; and (5) where habitat had been degraded, noticeable improvements in water and substratum quality have occurred.

The primary actions specified in the recovery plan (Service 1991) to address these criteria include: (1) utilize existing legislation/regulations to protect species; (2) search for new populations and monitor existing populations; (3) develop and utilize an information/education program; (4) determine species' life history requirements; (5) determine threats and alleviate those that threaten species' existence; (6) through reintroduction and protection, establish eight viable populations; and (7) develop and implement cryopreservation protection of species.

Current Condition
Historically, the fanshell was widely distributed in the Ohio, Wabash, Cumberland, and Tennessee rivers and their larger tributaries in Alabama, Illinois, Indiana, Kentucky, Ohio, Pennsylvania, Tennessee, Virginia, and West Virginia (Service 1991). Currently, extant populations of the fanshell mussel currently exist in portions of ten rivers, which are the Muskingum, Kanawha, Ohio, Wabash, East Fork White, Tippecanoe, Tennessee, Green, Licking, and Rolling Fork rivers in Indiana, Kentucky, Ohio, Tennesee, Virginia, and West Virginia (Service 2019b). Each of these populations is susceptible to single, catastrophic events.

This includes both natural stochastic events, such as floods, and anthropogenic events, such as toxic spills. The best populations of the fanshell occur in the Licking, Green, and Rolling Fork rivers in Kentucky, and in the Clinch River in Tennessee and Virginia. These populations are considered healthy with evidence of recruitment over several years or even decades and multiple year classes present. The Rolling Fork River population adds one more known reproducing population since the recovery plan was written, but it is a relatively small population compared to the Licking, Green and Clinch rivers' populations. Other locations (e.g., East Fork White, Tippecanoe, Kanawha, Ohio rivers) appear to have small and restricted, extant populations with limited evidence of recruitment. Adult fanshells obtained from the Licking River, have been stocked in the lower Muskingum River in Ohio (2010), Kanawha River in West Virginia (2010), Ohio River in West Virginia (2010), Ohio River in Ohio/West Virginia (2016), and lower Tennessee River in Kentucky (2015). Monitoring of these stockings have indicated overall excellent survival (except the status is currently unknown in the lower Muskingum River); however, it is not known if any of these stockings have resulted in new recruitment.

Threats
The fanshell has threats similar to the clubshell (see above; Service 2019b). The following is additional information about one of these threats to this species. Enigmatic declines or die-offs have been documented in several streams in Kentucky (e.g., Horselick Creek, Marsh Creek) where strong mussel populations were previously documented but recent surveys have found near total extirpation of listed and common mussel species. Testing of the water and stream sediments have not identified a likely culprit for these die-offs.

Summary
Historically, the fanshell was widely distributed in the Ohio River basin in nine states but is now sparsely distributed within most of its highly restricted range. This species appears to be limited to 10 rivers in six states (Indiana, Kentucky, Ohio, Tennessee, Virginia, and West Virginia), thus extirpated from Alabama, Illinois, and Pennsylvania. Each of these populations is susceptible to single, catastrophic events. As a result, there are few (redundancy) populations in each state and these populations are not evenly distributed across the geographic range (representation). There appear to be reproducing and healthy populations in four of the ten populations (resiliency).

In summary, as a whole, the rangewide status of the species is declining and the Service recommended maintaining the current classification as an endangered species in its 5-year review (Service 2019b). For additional documents related to the species (e.g., recovery plan, Federal Register notices, biological opinions) refer to https://ecos.fws.gov/ecp/species/4822.

Northern riffleshell
The Service listed northern riffleshell as endangered on January 22, 1993 (58FR5638). The following is a summary of northern riffleshell general life history drawn from the northern riffleshell recovery plan (Service 1994), the northern riffleshell 5-year reviews (Service 2008b, 2019c), and peer-reviewed literature.

The northern riffleshell is a small to medium-size mussel, up to three inches long (Service 1994). The shell exterior is brownish-yellow to yellowish-green with fine green rays. The shell interior is typically white. The species is sexually dimorphic. Male shells are irregular ovate in outline, with a wide shallow sulcus just anterior to the posterior ridge. Female shells are obovate in outline, and greatly expanded post-ventrally. The expanded shell shape of the female northern riffleshell results from shell growth around the expanded marsupial region. Northern riffleshells appear to have a relatively short life-span for a freshwater mussel. Sexual maturity can be reached in as little as three years, and most individuals probably live for only seven to 15 years (Rodgers et al. 2001, Crabtree and Smith 2007 *in* Service 2019c). Like other mussels, the northern riffleshell probably experiences very low annual juvenile survival. The combination of short life span and low fecundity indicates that populations depend on a large annual cohort produced by a large population (Musick 1999). Species following this reproductive strategy are susceptible to loss of individuals from predation and stochastic events and are slow to recover from such losses (Rodgers et al. 2001). However, these species may be well suited to exploit dynamic micro-habitat shifts characteristic of free-flowing rivers.

Reproduction and feeding are likely similar to other freshwater mussels, as described for clubshell. The northern riffleshell is a long-term breeder (bradytictic), with fertilization in the late summer and glochidial release the following spring or summer (Ortmann 1919 *in* Service 1994). Individuals within a population exhibit a range of behaviors and may release glochidia from spring through late summer. With the exception of displaying females during breeding season, northern riffleshell are cryptic, with an estimated 48 percent of a population occurring below the substrate surface (Smith et al. 2001); therefore, qualitative population estimates must take into account undetected individuals.

The common name 'riffleshell' implies that riffle habitat often associated with the genus is required; however, the habitat requirement of the northern riffleshell may not be as narrowing constrained as the name implies. The northern riffleshell is also known to occur in relatively slow-flowing, more lentic, or deep run habitats. The species also occurred in Lake Erie, where wave action likely provided needed water flow. Northern riffleshells have also been found in the Allegheny River in run-of-the-river navigation pools 8 and 9 that are impounded to facilitate navigation and may only experience water flow during high river discharge periods. It is not clear if specimens living in more typical riffle/run areas can adapt to slower water should conditions change. Use of low-flow areas may also be limited in more turbid waters, where concomitant silt deposition may limit survival or successful reproduction.

Conservation Needs
The Service finalized a recovery plan for the in 1994 (Service 1994). The plan was written for both clubshell and northern riffleshell together and northern riffleshell has the same recovery objectives and primary actions as clubshell above, therefore, are not provided here.

Current Condition
Now that we have described the species basic needs, we can assess its current condition. Of 54 streams once known to be occupied by this species, the northern riffleshell is known to currently occur in 13 populations in 23 streams in the Ohio and St. Lawrence River basins of Ontario, Canada, Illinois, Indiana, Kentucky, New York, Ohio, Pennsylvania, and West Virginia (Service 2019c). These populations and streams include those where adult northern riffleshells have been relocated between 2010 and 2018 to augment or reintroduce the species to increase redundancy and species recovery, including in New York, Pennsylvania, West Virginia, Ohio, Kentucy, Indiana, and Illinois. Four populations are stable and recruiting. Three of the reproducing

populations are apparently large and occur in the Allegheny River (Pennsylvania), French Creek (Pennsylvania), and East Branch Sydenham River (Ontario). A fourth, smaller population occurs, as of 2006, in the Ausable River (Ontario). The Elk River population (West Virginia) is probably extant and has been augmented, but recruitment has not been documented since 2018. Since the species was listed as endangered, five populations, which are Fish Creek (Ohio), Detroit River (Michigan/Ontario), Green River (Kentucky), Big Darby Creek (Ohio), and Tippecanoe River (Ohio), have undergone severe declines and recent surveys failed to locate living specimens. Although additional surveys are ongoing, northern riffleshells may have been extirpated from these systems. However, translocations have occurred to Big Darby Creek and the Tippecanoe River. There is no evidence of successful reproduction in these augmented or reintroduced populations yet, but natural reproduction and growth may not be observed for several years.

Threats

The northern riffleshell has threats similar to the clubshell (see above; Service 2019c). The following is additional information about some of these threats and different threats to this species. The presence of impoundments may have ameliorated the effects of downstream siltation on northern riffleshell, but these structures also control river discharges (and the many environmental parameters influenced by discharge), which may profoundly affect the ability of these populations to occupy or successfully reproduce in downstream habitats. *Epioblasma*, including northern riffleshell, appear to be exceptionally sensitive to the increased siltation and associated turbidity caused by changing land use (Peacock et al. 2005).

We do not know the northern riffleshell's effective population size, however, several populations appear to be declining, small, or both. These populations may become extirpated if they are below an as-yet-undetermined population density and mortality exceeds reproductive potential.

Zebra mussels are also a threat to northern riffleshell. When they reach high population densities, the zebra mussel populations compete for food, oxygen, and space with native mussels, including the northern riffleshell, causing mortality and population declines. Large zebra mussel populations in Lake St. Clair, the Detroit River, and Lake Erie appear to have eliminated most native mussels from the areas colonized, including northern riffleshell, although the species may persist in refugia where habitat is less suitable for zebra mussels. In much of the remaining northern riffleshell's range, zebra mussels have not developed large populations outside of lakes and impoundments. The effect of large zebra mussel populations developing in headwater impoundments and lakes, upstream of northern riffleshell populations, is not known, but could influence food availability or result in periodic zebra mussel population spikes downstream.

Summary

The northern riffleshell was historically widespread in the lower Great Lake (Lake Huron and Lake Erie) and upper Ohio River drainages but now has a restricted range, although population numbers can be high in localized areas. The best available information indicates that the northern riffleshell is known to currently occur in 13 populations in 23 streams, four of which are stable and recruiting. As a result, there are few (redundancy) populations in each state and these populations are not evenly distributed across the geographic range (representation). There appear to be reproducing populations in four of the 13 populations (resiliency). Three of these populations are apparently large and occur in the Allegheny River, French Creek, and East Branch Sydenham River. A fourth, smaller population occurs, as of 2006, in the Ausable River.

Each of these populations is susceptible to both natural stochastic events, such as floods, and anthropogenic threats, such as toxic spills. In several streams, including the Green River, Big Darby Creek, Detroit River, and Elk River, extant northern riffleshell populations appear highly limited (a single stream reach and a small number of individuals), except for translocated individuals, as in the case of Big Darby Creek. Five northern riffleshell populations have declined since the species was listed as endangered in 1994, and some of these may be extirpated. Translocations may bolster populations in some streams.

In summary, as a whole, the rangewide status of the species is declining and the Service recommended maintaining the current classification as an endangered species in its 5-year review (Service 2019c). For additional documents related to the species (e.g., recovery plan, Federal Register notices, biological opinions) refer to https://ecos.fws.gov/ecp/species/527.

Pink mucket

The Service listed pink mucket as endangered on June 14, 1976 (41 FR 24062). The following is a summary of pink mucket general life history drawn from the pink mucket recovery plan (Service 1985), the pink mucket 5-year review (Service 2019d), and peer-reviewed literature.

The pink mucket is a medium-sized mussel, growing to a length of approximately 4.5 - 5.0 inches. The shell exterior color varies from light yellow or yellowish-brown to dark brown, occasionally marked with broken, fine to wide dark-green rays. The pink mucket has a sub-quadrate or circular shell and becomes thick and heavy in mature individuals. The species is sexually dimorphic. The posterior margins of the shells in females are slightly rounded to straight, while shells of male individuals are rounded or bluntly pointed. A well-defined posterior ridge is present in the males. Using the growth ring method from 36 individuals suggests that the pink mucket has a lifespan of at least 36 years (Ecological Services, Inc. 2003 *in* Service 2020a). It is probable the species lives several years longer considering that the growth ring method typically underestimates age compared to quantitative age determinations (thin sectioning shells).

Reproduction and feeding are likely similar to other freshwater mussels, as described for clubshell. The pink mucket is a long-term brooder. Females become gravid by age three and brood larvae (glochidia) from August through June of the following year (Hubbs 2010, pers. comm. *in* Service 2020a).

The pink mucket inhabits areas in large rivers with swift currents, depths of 1.6 feet to 26.2 feet, and mixed sand, gravel, and cobble substrate (Service 1985). Notwithstanding this, the pink mucket appears to have adapted to reservoir-type conditions in the upper reaches of some impoundments, where it is often found in tailwaters having good riverine-quality habitat (generally rocky substrates swept free of excessive fine sediment deposits by adequate currents; Service 2019d). The mobility of its hosts and/or host fish tolerance for habitats unsuitable for the pink mucket may partially account for sometimes seemingly disjunct records of the mussel in streams like the Paint Rock River in Alabama, the Bourbeuse River in Missouri, and Bear Creek in Alabama. It is possible that these highly sporadic occurrences in otherwise well-sampled streams do not actually represent populations but are merely occurrences of low-probability events (e.g., having a highly mobile host fish carry juveniles spawned from a nearby source population shed post-metamorphosed pink mucket into suitable habitat). Without a readily accessible source population (Tennessee River, Guntersville Dam tailwaters for Paint Rock River; Tennessee River, Wilson Dam tailwaters for Bear Creek; and Meramec River for Bourbeuse and Big Rivers), the pink mucket might not exist in these streams (USFWS 2019d).

Conservation Needs
The Service finalized a recovery plan for the pink mucket in 1995 (Service 1985). The recovery objectives for pink mucket are to maintain and restore viable populations of pink mucket to a significant portion of its historic range. The Service outlined the following conditions that we believed would result in delisting the species (Service 1985): (1) when two additional viable populations of pink mucket are found in any two rivers except the Tennessee, Cumberland, and Meramec rivers. Both of these rivers will contain viable populations that are distributed such that a single event would be unlikely to eliminate pink mucket from the river system; (2) additional mussel sanctuaries are established or expanded in river systems which contain known concentrations of pink mucket; (3) an education program is established for the public with major emphasis towards commercial mussel fishermen; and (4) the species and its habitat are protected from present and foreseeable human-related and natural threats that may interfere with the survival of any of the populations.

The primary actions to address these criteria include: (1) conduct population and habitat surveys; (2) preserve populations and presently used habitat of pink mucket; and (3) develop education programs.

Current Condition
Now that we have described the species basic needs, we can assess its current condition. The recovery plan (Service 1985) stated that pink mucket was historically known from at least 25 streams. Recent sampling efforts and a more-thorough search of historical data from the literature and museum records bring this total to at least 48 streams in 12 states (Alabama, Arkansas, Illinois, Indiana, Kentucky, Louisiana, Missouri, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia; Service 2019d). Pink mucket generally occurred in large streams in the Ohio River drainage and in some tributaries of the lower Missouri and Mississippi rivers that drain the Ozark Plateaus and Ouachita Highlands physiographic provinces. Presently, known populations occur in 29 rivers in 9 states (Alabama, Arkansas, Illinois, Indiana, Kentucky, Louisiana, Missouri, Ohio, Tennessee, West Virginia), with over half of them occupying less than 16 river miles each. Of these extant populations, only a few have shown recent evidence of recruitment. Coupled with losses in the 20 streams of historical occurrence of approximately 1000 river miles, it is likely that approximately 5400 river miles of the historical distribution of pink mucket have collectively been lost over the past century. This represents an 80 percent decline of the approximately 6700 river miles of total historical linear range for the species. Some taxonomists have recently postulated that the reproducing populations west of the Mississippi River are not pink mucket, but rather are more closely related to another endangered species, the Higgins eye pearly mussel (*Lampsilis higginsi*; Service 2019d). If this is true, then there are fewer known reproducing populations of pink mucket than originally thought. Although it has a relatively wide distribution and is apparently more tolerant of reservoir-type habitat conditions than other listed mussel species, the pink mucket is reported to occur in low numbers where it occurs.

Threats

The pink mucket has threats similar to the clubshell (see above; Service 2019d). The following is additional information about some of these threats and different threats to this species. Impoundments alter flow, temperature regimes, and water quality and habitat conditions creating conditions unsuitable for riverine mussels and/or their host fish. Navigational channel activities, including channel maintenance activities, barging facilities, potential for chemical spills, are a threat to pink mucket. Stochastic events associated with navigation (e.g., chemical spills from barges) or other sources (e.g., chemical releases from industrial facilities or transportation arteries) are ever present uncontrollable threats that routinely occur in pink mucket habitat.

Given the sporadic distribution and low population size of most pink mucket populations, habitat fragmentation and population isolation are especially major concerns for this species (Service 2019d). Species that are restricted in range and population size are 1) susceptible to loss of genetic diversity due to genetic drift, 2) increasingly susceptible to inbreeding depression, and 3) less likely to adapt to environmental changes (Allendorf et al. 2012 *in* Service 2019d).

In addition to the negative effects of zebra mussel to clubshell and northern riffleshell, as described above, they can colonize the shells of native mussels. It has been observed attached to native mussels in the Ohio River. It can restrict the ability of a mussel to move, feed, respire, and reproduce, especially if large numbers are present on the shell of the native mussel. High zebra mussel populations in the upper Ohio River are thought to have negatively impacted its pink mucket population (P.A. Morrison, Service, pers. comm., 2004 *in* Service 2019d). Mussel mortality rates of up to 30 percent were attributed to zebra mussel invasions in the upper Ohio River in 2000 (Ecological Specialists, Inc. 2002 *in* Service 2019d). Currently, the threat from zebra mussels to native mussels in the Ohio River has largely abated since densities have continued to decline markedly in recent years. Due to extremely low densities in other pink mucket streams, zebra mussels do not appear to have been a significant threat to any other population.

Climate change effects of drought conditions and warming stream waters may have sub-lethal effects on the wellbeing of pink mucket populations. Laboratory experiments determined that dewatered conditions (a surrogate for drought) significantly reduced burrowing in pink mucket, and that increasing temperature diminished both burrowing and byssal thread production in the species (Archambault et al. 2013 and Archambault et al. 2014).

Summary

Pink mucket is a relatively rare big river mussel that was widely distributed historically in at least 48 streams in the lower half of the Mississippi River basin. At present, 29 streams continue to support populations of this species. At least two of the 16 populations considered extant in the Recovery Plan are now deemed extirpated. Despite the relatively large number of extant populations for a federally listed mussel, the total population size for pink mucket, although undetermined, appears to be relatively small based on significant loss of total range, infrequent occurrence in otherwise suitable habitat, very low relative abundance compared to other mussels, and overall rarity of the species (redundancy). Representation is low with an approximate 80 percent loss of the approximately 6700 river miles total known historical distribution of pink mucket over the past century. With many disjunct populations and its overall scarcity (resiliency), the species is highly susceptible to localized extirpations from the genetic implications of extremely low population size and because of threats that are extremely difficult if not impossible to control.

In summary, as a whole, the rangewide status of the species is declining and the Service recommended maintaining the current classification as an endangered species in its 5-year review (Service 2019d). For additional documents related to the species (e.g., recovery plan, Federal Register notices, biological opinions) refer to https://ecos.fws.gov/ecp/species/527.

Rayed bean

The Service listed the rayed bean as endangered on March 15, 2012 (77 FR 8632). The following is a summary of rayed bean general life history drawn from species status assessment report (SSA) for rayed bean (Service 2022s), and peer-reviewed literature. For a more detailed account of the species description, life history, population dynamics, threats, and conservation needs, refer to https://ecos.fws.gov/ecp/species/5862.

The rayed bean is a small mussel, usually less than 1.5 inches (3.8 centimeters) in length (Cummings and Mayer 1992; Parmalee and Bogan 1998; West et al. 2000). The rayed bean is sexually dimorphic. The shell outline is elongate or ovate in males and elliptical in females, and moderately inflated in both sexes, but more so in females (Parmalee and Bogan 1998). Key characters useful for distinguishing the rayed bean from other mussels are its small size, thick valves, unusually heavy teeth for a small mussel, and color pattern (Cummings and Mayer 1992).

Reproduction and feeding are likely similar to other freshwater mussels, as described for clubshell. The rayed bean is thought to be a long-term brooder as the developing glochidia remain in the gill chamber from May through October until they mature and are ready for release (Parmalee and Bogan 1998; Woolnough 2002).

The rayed bean is generally known from smaller, headwater creeks, but occurrence records exist from larger rivers (Cummings and Mayer 1992; Parmalee and Bogan 1998). They are usually found in or near shoal or riffle (short, shallow length of stream where the stream flows more rapidly) areas, and in the shallow, wave-washed areas of glacial lakes, including Lake Erie (West et al. 2000). In Lake Erie, the species was generally associated with islands in the western portion of the lake. Preferred substrates typically include gravel and sand. The rayed bean is oftentimes found among vegetation (water willow [*Justicia americana*] and water milfoil [*Myriophyllum spp.*]) in and adjacent to riffles and shoals (Watters 1988; West et al. 2000). Specimens are typically buried among the roots of the vegetation (Parmalee and Bogan 1998). Adults and juveniles appear to produce byssal threads (thin, protein-based fibers; Woolnough 2002), apparently to attach themselves to substrate particles.

Conservation Needs

There is no recovery plan for the rayed bean, however, the 5-year review (Service 2018a) listed these recommendations for future action:

- Develop a recovery plan for the species.

- Maintain and increase vegetated riparian buffers of streams throughout the range of the species.
- Initiate more watershed-level, community based riparian habitat restoration projects in streams harboring the rayed bean.
- Investigate the U.S. Environmental Protection Agency's water quality criteria for pollutants to determine levels that would be protective of the rayed bean and other mussels.
- Work with the U.S. Environmental Protection Agency's to adjust the water quality to levels needed to protect the rayed bean (and other mussels; see previous action).
- Perform surveys in known streams to assess the status of known populations and to locate additional populations.
- Rear juveniles in captivity using host fish and in-vitro techniques for future augmentation and reintroductions and develop a captive propagation and genetics management plan.
- Investigate potential sites for future augmentation or reintroduction of captivity reared juveniles and/or adults.
- Develop and implement a monitoring program to evaluate conservation efforts, monitor population levels and habitat conditions, and assess the long-term viability of extant, newly discovered, augmented, and reintroduced rayed bean populations.

Current Condition
The rayed bean currently occupies 19 HUC (Hydrologic Unit Code) 8 watersheds. Currently, the species is considered extant in 28 streams and one lake in seven states and two streams in one Canadian province: Indiana, Michigan, New York, Ohio, Pennsylvania, Tennessee, and West Virginia; and Ontario, Canada (total of 31 streams and lakes; Service 2022a). The rayed bean historically occurred in at least 115 streams, lakes, and some human-made canals in 10 states: Illinois, Indiana, Kentucky, Michigan, New York, Ohio, Pennsylvania, Tennessee, Virginia, and West Virginia; and Ontario, Canada. The rayed bean's range within the Great Lakes basin includes a portion of Canada, Indiana, Michigan, and Ohio. Nine populations are considered extant in the Great Lakes basin. The demographic condition of four populations is categorized as high and the other five populations are categorized as low. The rayed bean's range within the Ohio basin includes a portion of Indiana, Pennsylvania, New York, Ohio, and West Virginia. Nine populations are considered extant in the Ohio basin. The demographic condition of three populations is categorized as high, two populations are categorized as moderate, and four populations are categorized as low. The Tennessee basin has one rayed bean population in Tennessee. This single extant population is the result of a 2008 reintroduction effort and has been categorized as having a low demographic condition.

Threats
The rayed bean has threats similar to the clubshell (see above; Service 2018a, 2022). The following is additional information about some of these threats and different threats to this species.

The SSA (Service 2022a) identified five primary risk factors to assess the current condition of each rayed bean population: contaminants, hydrological regime, landscape alteration, lack of connectivity, and invasive species. Water quality/contaminants include three categories of contaminants and are more thoroughly described in the SSA (i.e., metals, nutrients, and major ions; organic compounds; invasive species control chemicals). Effects of contaminants include mortality and changes to biological processes. Threats due to changes to hydrological regime include drought, prolonged stream drying, inundation, and increased flashiness. Changes to hydrological regimes can ultimately lead to direct mortality or altered habitat conditions. Landscape alteration can result in increased sediment which can lead to smothering, reduced reproduction due to reduced host fish abundance, and declines in feeding and respiration. Additionally, sedimentation can result in habitat alteration through aggradation and degradation (Service 2022a). Connectivity poses a threat to rayed bean through both direct effects (i.e., alterations to water temperatures, flow changes, and habitat alteration) and indirect effects (i.e., changes to food base and host fish availability.) Threats from invasive species include habitat alteration, competition for resources, and direct predation.

Summary
The rayed bean is a federally listed endangered species that, at the time of listing, was known from 31 streams and 1 lake in Indiana, Michigan, New York, Ohio, Pennsylvania, Tennessee, West Virginia, and Ontario, Canada. Three new populations have been discovered since 2012, two in New York and one in Michigan. All of these discoveries were the result of surveys for proposed projects including several pipeline crossings and a bridge maintenance project. Currently the species is known to exist in 34 streams and 1 lake. Records indicate that the species historically occurred in over 115 streams and lakes and also historically occurred in Illinois, Kentucky, and Virginia. The species has been extirpated from the Upper Great Lakes sub-basin and now occurs in 13 streams in the Lower Great Lakes sub-basin, 20 streams and 1 lake in the Ohio River System, and 1 stream in the Tennessee River System. Of the remaining populations, 5 (14 percent) are considered to be large and stable.

In summary, as a whole, the rangewide status of the species has not improved since listing and the Service recommended maintaining the current classification as an endangered species in its 5-year review (Service 2018a). For additional documents related to the species (e.g., Federal Register notices, biological opinions) refer to https://ecos.fws.gov/ecp/species/5862.

Snuffbox
The Service listed the snuffbox as endangered on February 14, 2012 (77 FR 8632). The following is a summary of snuffbox general life history drawn from the snuffbox 5-year review (Service 2018a), species status assessment report (SSA) for snuffbox (Service 2022b), and peer-reviewed literature.

The snuffbox is a small- to medium-sized mussel, with males reaching up to 2.8 inches in length. The maximum length of females is about 1.8 inches (Service 2022b). The shape of the shell is somewhat triangular (females), oblong, or ovate (males) with the valves solid, thick, and very inflated (Parmalee and Bogan 1998 *in* Service 2022b). The shell is generally smooth and yellowish or yellowish-green in young individuals, becoming darker with age. Green squarish, triangular, or chevron-shaped marks cover the umbone but become poorly delineated stripes with age. The life span of snuffbox is estimated to be approximately 20 years (Service 2022b).

Reproduction and feeding are likely similar to other freshwater mussels, as described for clubshell. Snuffbox are long-term brooders; females brood glochidia from September to May

(Ortmann 1912, 1919 *in* Service 2022b). In Virginia, spawning and fertilization occurred from mid-July to August when water levels were low, facilitating sperm transfer to female mussels (Zale and Neves 1982). In Michigan, glochidial release (from drift samples) occurred from mid-May through mid-July (Sherman 1994).

The snuffbox is found in small to medium-sized creeks, to larger rivers and in lakes (Parmalee and Bogan 1998 *in* Service 2022b). It occurs in swift currents of riffles and shoals and wave-washed lakeshores over gravel and sand with occasional cobble and boulders, and generally burrows deep into the substrate except when spawning or attracting a host. Adult snuffbox are usually deeply burrowed into substrate, showing only the truncated posterior slope (Parmalee and Bogan 1998 *in* Service 2022b). This makes the species particularly difficult to locate during surveys.

Conservation Needs
There is no recovery plan for the snuffbox, however, the 5-year review (Service 2018b) listed these recommendations for future action:

- Maintain and increase vegetated riparian buffers of streams throughout the range of the species.
- Initiate more watershed-level, community based riparian habitat restoration projects in streams harboring the snuffbox.
- Investigate the USEPA's water quality criteria for pollutants to determine levels that would be protective of the snuffbox and other mussels.
- Work with the USEPA to adjust the water quality to levels needed to protect the snuffbox (and other mussels; see previous action).
- Perform surveys in known streams to assess the status of known populations and to locate additional populations.
- Rear juveniles in captivity using host fish and in-vitro techniques for future augmentation and reintroductions and develop a captive propagation and genetics management plan.
- Investigate potential sites for future augmentation or reintroduction of captivity reared juveniles and/or adults.
- Develop and implement a monitoring program to evaluate conservation efforts, monitor population levels and habitat conditions, and assess the long-term viability of extant, newly discovered, augmented, and reintroduced snuffbox populations.

Current Condition
Historically, the snuffbox was widespread and occurred in portions of the Great Lakes, Ohio, Tennessee, Upper Mississippi, Lower Mississippi, and Arkansas-White-Red basins in at least 211 streams and lakes and 18 states (Alabama, Arkansas, Iowa, Illinois, Indiana, Kansas, Kentucky, Michigan, Minnesota, Missouri, Mississippi, New York, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia, and Wisconsin) and Ontario, Canada (Service 2022b). Currently the species is considered extant in 83 streams in 14 states and Ontario, Canada and extirpated from 4 states (Iowa, Kansas, Mississippi, and New York). The SSA for snuffbox further defined populations at the subbasin scale using HUC8. The snuffbox currently occupies 55 HUC8 watersheds, thus, there are 55 extant populations. The following is the current condition of populations by basin:

- The Great Lakes basin has 11 extant populations; of these, four populations are in high condition, three are in moderate condition, and four are in low condition. Four populations are at high risk, five are at moderate risk, and one is at low risk (one population in Canada was not able to be fully analyzed).
- The Ohio basin has 30 extant populations; of these, only one is in high condition, three are in moderate condition, 21 are in low condition, and five are in very low condition (functionally extirpated). Thirteen populations are at high risk, 15 are at moderate risk, and two are at low risk.
- The Tennessee basin has five populations; of these, three populations are in moderate condition and two are in low condition. Three populations are at high risk and two at moderate risk.
- The Upper Mississippi basin has four populations; two populations are in high condition and two populations are in low condition. All four populations are at high risk.
- The Lower Mississippi basin has one population that is in low condition and at high risk.
- The Arkansas-White-Red basin has four populations; of these, one is in high condition, two are in low condition, and one is in very low condition. Two populations are at high risk, one is at moderate risk, and one is at low risk.

Threats
The snuffbox has threats similar to the clubshell (see above; Service 2018b, 2022b). The following is additional information about some of these threats and different threats to this species.

The SSA (Service 2022b) identified five primary risk factors to assess the current condition of each snuffbox population: contaminants, hydrological regime, landscape alteration, lack of connectivity, and invasive species. Water quality/contaminants include four primary contaminants (ammonia, chloride, nitrate, and copper) and six secondary contaminants (lead, potassium, sulfate, zinc, aluminum, and cadmium). To evaluate the effects of various land use activities, we assessed a suite of landscape metrics derived from the 2016 National Landcover Dataset (Jin et al. 2019). Specific metrics include percent imperviousness mean within the population; percent vegetative cover remaining within a 254 foot riparian buffer; and percent urban, percent agriculture, and canopy cover within a 254 foot meter riparian buffer. The Service used U.S. Drought Monitoring Data to assess drought risk for the hydrological regime and the number of dams and density of unpaved roads to evaluate connectivity. The invasive species assessment included twelve species known to impact native freshwater mussels: zebra mussel, Asian clam (*Corbicula fluminea*), five species of invasive carps (silver, bighead, black, grass, common), rusty crayfish, spiny waterflea, brown trout, quagga mussel, and hydrilla.

Summary
The species is considered extant in 83 of 211 historically occupied streams and lakes (39.3 percent) in 14 states and Ontario, Canada; the species is extirpated from 4 states (Iowa, Kansas, Mississippi, and New York). The 55 currently extant snuffbox populations are spread across all six representation units or basins but are unevenly distributed in the units (representation). The Great Lakes basin contains 11 populations; the Ohio basin contains 30 populations; the Tennessee basin contains 5 populations; the Upper Mississippi basin contains four populations; the Lower Mississippi basin contains 1 population; and the Arkansas-White-Red basin contains

four populations (redundancy). Of the 55 populations, 32 (57 percent) have a low condition and six (11 percent) have a very low/functionally extirpated condition (resiliency). Only eight (14 percent) have a high current condition while nine (16 percent) have a moderate condition. Of the 55 populations, 27 (49 percent) are at a high overall risk with contaminants and connectivity being the most predominant risk factors. Twenty-three (42 percent) of the populations are at a moderate risk with only four populations (seven percent) currently experiencing a low overall risk.

In summary, as a whole, the rangewide status of the species has not improved since listing and the Service recommended maintaining the current classification as an endangered species in its 5-year review (Service 2018a). For additional documents related to the species (e.g., Federal Register notices, biological opinions) refer to https://ecos.fws.gov/ecp/species/4135.

Round hickorynut

The Service listed the round hickorynut as threatened on March 9, 2023 (88 FR 14794). The following is a summary of round hickorynut general life history drawn from the Federal Register notice for the final listing, SSA for round hickorynut (Service 2019e), and peer-reviewed literature.

The round hickorynut is a small- to medium-sized mussel up to three inches in length, but usually is less than 2.4 inches, and round in shape (Williams et al. 2008 and Watters et al. 2009 *in* Service 2019e). Round hickorynut adult mussels are greenish-olive to dark or chestnut brown, sometimes blackish in older individuals, and may have a yellowish band dorsally (Parmalee and Bogan 1998 *in* Service 2019e). There is variability in the inflation of the shell depending on population and latitudinal location (Ortmann 1920 and Williams et al. 2008 *in* Service 2019e). The species is sexually dimorphic, with character traits visible to differentiate individuals within one to five years, and males average slightly longer maximum ages (Shepard 2006 and Watters et al. 2009 *in* Service 2019e; Ehlo and Layzer 2014). Round hickorynut live up to 15 years.

Reproduction and feeding are likely similar to other freshwater mussels, as described for clubshell. The round hickorynut is a long-term brooder, gravid year-round in some southern populations in the Tennessee River basin, but with gravid period potentially more contracted in the northernmost portions of its range (Service 2019e).

Round hickorynut is found in small streams to large rivers, and prefers a mixture of sand, gravel, and cobble substrates, but may be found in sandy mud (Service 2019e). They can be found in shallow habitat with gentle flows at less than one foot, but in larger rivers up to depths of 6.5 feet.

Conservation Needs

There is no recovery plan for the round hickorynut, but the final listing (88 FR 14794) and SSA (Service 2019e) indicate that the species requires clean, flowing water with appropriate water quality and temperate conditions, natural flow regimes, predominantly silt-free, stable sand, gravel, and cobble substrates, suspended food and nutrients, and availability of sufficient host fish numbers to provide for glochidia infestation and dispersal. The final listing also included a final 4(d) Rule (88 FR 14794), which would provide for the conservation of the species by allowing exceptions to actions and activities that, while they may have some minimal level of disturbance to the round hickorynut, are not expected to negatively impact the species conservation and recovery efforts. The proposed exceptions to these prohibitions include (1) conservation and restoration efforts by the Service or state wildlife agencies, (2) channel and bank restoration projects, (3) bank stabilization projects, and (4) forest management activities that implement state-approved best management practices. The first exception is for conservation and restoration efforts for listed species by the Service or state wildlife agencies, and include, but not limited to, collection of broodstock, tissue collection for genetic analysis, captive propagation, and subsequent stocking into unoccupied areas within the historical range of the species. The second and third exceptions are for channel and bank restoration projects for creation of natural, physically stable, ecologically functioning streams, taking into consideration connectivity with floodplain and groundwater aquifers. The fourth exception is for forest management activities that implement state-approved best management practices because forest landowners who properly implement these best management practices are helping conserve the round hickorynut.

Current Condition
The round hickorynut is wide-ranging, and historically known from the Lower Mississippi, Tennessee, Cumberland, Ohio River, and Great Lakes basins. It is currently known from Alabama, Indiana, Kentucky, Michigan, Mississippi, Ohio, Pennsylvania, Tennessee, and West Virginia, and is extirpated from Georgia, Illinois, and New York (Service 2019e). The results of surveys conducted since 2000, suggest the currently occupied range of the round hickorynut includes 69 rivers and streams. Given the round hickorynut's range includes lengthy rivers, such as the Ohio, Allegheny, Cumberland, and Tennessee rivers, all of which include populations fragmented primarily by dams, the Service (2019e) identified separate populations for each HUC8 watershed and identified them as a "management unit." A management unit could harbor one or more populations. Overall, the round hickorynut has lost an approximate 232 of 301 known populations (i.e., river or streams; 77 percent), and 102 of 138 management units (74 percent). This includes a loss of 25 populations in the Great Lakes basin, 146 populations in the Ohio River basin, 23 populations in the Cumberland River basin, 29 populations in the Tennessee River basin, and nine populations in the Lower Mississippi River basin. The following is the current condition of populations by basin.

- The Great Lakes basin has seven extant populations; of these, one population is in high condition, one is in medium condition, and five are in low condition. There are four extant management units.
- The Ohio River basin has 54 extant populations; two populations are in high condition, 14 are in medium condition, and 38 are in low condition. There are 24 extant management units.
- The Cumberland River basin has two extant populations, both of which are in low condition. There are two extant management units.
- The Tennessee River basin has five extant populations; of these, one population is in high condition, one is in moderate condition, and three are in low condition. There are five extant management units.
- The Lower Mississippi River basin has one extant population and is in low condition. There is one extant management unit.

Threats

The round hickorynut has threats similar to the clubshell (see above; Service 2019e, 88 FR 14794). The following is additional information about these threats and different threats to this species. Across all basins in which the round hickorynut currently occurs, there are one or more threats to the species, which results in effects to individuals and populations at a more rapid rate. The combined impacts of dams and barriers, resource extraction, agricultural activities, and nonnative species have led to localized extirpations of the round hickorynut. Overall, the greatest threats currently to the round hickorynut are habitat alteration and loss, water quality degradation, nonnative species, and genetic isolation.

Invasive, nonnative species are pervasive across the round hickorynut's range (88 FR 14794). Examples of invasive, nonnative species that affect freshwater mussels are the Asian clam, zebra mussel, quagga mussel, black carp, didymo (also known as rock snot; *Didymosphenia geminata*), and hydrilla (also known as water-thyme; *Hydrilla verticillata*). Examples of their potential impacts on freshwater mussels include benthic substrates alteration, filtration of mussel sperm or glochidia, competition for limited food and habitat resources, ammonia spikes in surrounding water when they die off in mass, direct colonization, nutrient cycling alteration, predation. The two nonnative plant species that are most problematic for the round hickorynut (i.e., impacting the species throughout their ranges) are hydrilla and didymo. They are aquatic plants that alters stream habitat, decreases flows, and contributes to sediment buildup in streams (National Invasive Species Council Management Plan 2016, Jackson et al. 2016).

Effects associated with small population are a threat to round hickorynut (88 FR 14794). Without the level of population connectedness that the species experienced historically (i.e., without barriers such as reservoirs), small, isolated populations that may now be comprised predominantly of adult individuals could be slowly dying out. Even given the very improbable absence of other anthropogenic threats, these disjunct populations could be lost simply due to the consequences of below-threshold effective population sizes. The round hickorynut exhibit several traits that influence population viability, including relatively small population size and low fecundity at many locations compared to other mussels. Small, isolated population size puts the species at greater risk of extirpation from stochastic events (e.g., drought) or anthropomorphic changes and management activities that affect habitat.

Summary

The current range of the round hickorynut extends over nine states and the species is now considered extirpated in three states. This range encompasses five major river basins (Great Lakes, Ohio River, Cumberland River, Tennessee River, and Lower Mississippi River). Overall, the species has decreased redundancy across its range compared to its historical levels due to extirpation of an estimated 77 percent of populations (232 of 301 populations in the U.S.) and 74 percent of management units (104 of 138 management units). Of the current populations (69 total), four (six percent) are estimated to be highly resilient, 16 (23 percent) are estimated to be moderately resilient, and 49 (71 percent) are estimated to have low resiliency. While the species currently maintains representation in all five major basins from historical conditions, it is at immediate risk of losing 40 percent (two of five basins) of its representation due to small, isolated populations under a high degree of threats that have resulted from habitat loss and water quality degradation. Given the current status encompasses 69 populations and 36 management units throughout its range in the U.S., the species currently retains adequate redundancy for withstanding and surviving potential catastrophic events. However, it is important to note that a high percentage (71 percent) are currently in low condition (i.e., very small and restricted in linear extent with no evidence of recruitment).

In summary, as a whole, the round hickorynut's abundance has been reduced across its range and threats currently acting upon the species are expected to continue into the foreseeable future. The Service finalized the listing of round hickorynut as threatened on March 9, 2023 (88 FR 14794). For additional documents related to the species (e.g., Federal Register notices, biological opinions) refer to https://ecos.fws.gov/ecp/species/9879.

Longsolid

The Service listed the longsolid as threatened on March 9, 2023 (88 FR 14794). The following is a summary of longsolid general life history drawn from the Federal Register notice for the final listing, SSA for longsolid (Service 2018c), and peer-reviewed literature.

The longsolid is a medium-sized mussel (up to five inches) and are light brown in color, darkening with age (Williams et al. 2008 *in* Service 2018c). The shell is thick and typically has a dull sheen. There is variability in the inflation of the shell depending on population and latitudinal location (Ortmann 1920 and Watters et al. 2009 *in* Service 2018c). The longsolid is a slow growing species that is believed to live on average 25 to 35 year and possibly up to 50 years depending on environmental conditions (Service 2018c).

Reproduction and feeding are likely similar to other freshwater mussels, as described for clubshell. The longsolid is a short-term brooder, with females gravid from June through August (Gordon and Layzer 1989 *in* Service 2018c).

It is found in small streams to large rivers (such as the Ohio River mainstem), and prefers a mixture of sand, gravel, and cobble substrates (Service 2018c). They can be found in shallow habitat less than two feet and in large rivers in excess of 20 feet.

Conservation Needs

There is no recovery plan for the longsolid, but the longsolid was listed with the round hickorynut and they have the same conservation needs and 4(d) Rule (see above; 88 FR 14794, Service 2018b).

Current Condition

The longsolid is historically known from 12 states in the Great Lakes, Ohio, Cumberland, and Tennessee River basins (Service 2018c). It is current known from nine states, including Alabama, Kentucky, North Carolina, New York, Ohio, Pennsylvania, Tennessee, Virginia, and West Virginia and is considered extirpated from Georgia, Illinois, and Indiana. It is currently found in three major river basins: the Ohio (where is most prevalent), Cumberland (where it is rarest), and Tennessee, it is considered extirpated from the Great Lakes basin. The results of surveys conducted since 2000 indicate the currently occupied range of the longsolid includes 60 rivers and streams. Given the longsolid's range includes lengthy rivers, such as the Ohio, Allegheny, Cumberland, and Tennessee rivers, all of which include populations fragmented primarily by dams, the Service (2018c) identified separate populations for each HUC8 watershed and identified them as a "management unit." A management unit could harbor one or more populations. Overall, the longsolid has lost an approximate 100 of 160 known populations (i.e., river or streams) (63 percent) and 60 of 105 management units (57 percent). The total number of extirpated populations and management units by river basin are: 62 populations (36 management units) in the Ohio, eight populations (eight management units) in the Cumberland, 24 populations (12 management units) in the Tennessee, and six populations (four management units) in the Great Lakes. The following is the current condition of populations by basin:

- The Ohio River basin has 39 extant populations; two populations are in high condition, seven are in medium condition, and 30 are in low condition. There are 30 extant management units.
- The Cumberland River basin only has one population, which is in low condition. There is one extant management unit.
- The Tennessee River basin has 20 extant populations; of these, one population is in high condition, two are in moderate condition, and 18 are in low condition. There are 14 extant management units.

Threats
The longsolid has threats similar to the clubshell and round hickorynut (see above; Service 2018c; 88 FR 14794).

Summary
The current range of the longsolid extends over nine states and the species is now considered extirpated in three states (Service 2018c, 88 FR 14794). This range encompasses three major river basins (Ohio River, Cumberland River, Tennessee River) and no longer occurs in the Great lakes basin (representation). Overall, the species has decreased redundancy across its range compared to its historical levels due to extirpation of an estimated 63 percent of populations (100 of 160 populations) and 57 percent of management units (60 of 105 management units). Of the current populations (60 total), three (five percent) are estimated to be highly resilient, nine (15 percent) are estimated to be moderately resilient, and 48 (80 percent) are estimated to have low resiliency. Given the current status encompasses 60 populations and 45 management units throughout its range, the species currently retains adequate redundancy for withstanding and surviving potential catastrophic events. However, it is important to note that a high percentage (80 percent are currently in low condition).

In summary, as a whole, the longsolid's distribution and abundance have been reduced across its range and threats currently acting upon the species are expected to continue into the foreseeable future. The Service finalized the listing of longsolid as threatened on March 9, 2023 (88 FR 14794). For additional documents related to the species (e.g., Federal Register notices, biological opinions) refer to https://ecos.fws.gov/ecp/species/9880.

STATUS OF CRITICAL HABITAT
The Corps also requested concurrence with a "adverse modification" determination for diamond darter, longsolid, and round hickorynut critical habitat.

Diamond darter

Critical habitat for this species also was designated and became effective on September 23, 2013 (78 FR 52363-52387). Critical habitat consists of two units: an occupied unit within the Elk River in West Virginia, and an unoccupied unit within the Green River in Kentucky. The proposed action occurs in the Elk River unit.

Clubshell, fanshell, Northern riffleshell, pink mucket, rayed bean and snuff box.

No critical habitat has been designated for clubshell, fanshell, Northern riffleshell, pink mucket, rayed bean and snuff box.

Longsolid

When the Service listed the longsolid as threatened on March 9, 2023, they also designated critical habitat for the longsolid (88 FR 14794). Critical habitat for longsolid was designated in 12 units in approximately 1,115 river mi (1,794 km), all of which is occupied by the species in the following streams and rivers: French Creek (Pennsylvania), Allegheny River (Pennsylvania), Shenango River (Pennsylvania), Middle Island Creek (West Virginia), Little Kanawha River (West Virginia), Elk River (West Virginia), Kanawha River (West Virginia), Licking River (Kentucky), Green River (Kentucky), Cumberland River (Tennessee), Clinch River (Virginia andTennessee), and Paint Rock River (Alabama). The proposed action occurs in the Elk River unit.

Round hickorynut

When the Service listed the round hickorynut as threatened on March 9, 2023, they also designated critical habitat for the round hickorynut (88 FR 14794). Critical habitat for round hickorynut was designated in 14 units in approximately 921 river mi (1,482 km), all of which is occupied by the species in the following streams and rivers: Shenango River (Pennsylvania), Grand River (Ohio), Tippecanoe River (Indiana), Middle Island Creek (West Virginia), Little Kanawha River (West Virginia), Elk River (West Virginia), Kanawha River (West Virginia), Licking River (Kentucky), Rockcastle River (Kentucky), Buck Creek (Kentucky), Green River (Kentucky), Paint Rock River (Alabama), Duck River (Tennessee), and Big Black River (Mississippi). The proposed action occurs in the Elk River unit.

ENVIRONMENTAL BASELINE

Regulations implementing the ESA (50 CFR 402.02) define the environmental baseline as the past and present effects of all federal, state, or private actions and other human activities in the action area. Also included in the environmental baseline are the anticipated and/or ongoing effects of all proposed federal projects in the action area that have undergone Section 7 consultation, and the effects of state and private actions which are contemporaneous with the consultation in progress.

Status of the Species within the Action Area

Diamond darter

Diamond darter have not been documented directly within the action area. However, it is likely that the species is present within the action area given that 2021 surveys conducted by the WVDNR (WVDNR 2021) documented the species at both upstream and downstream locations in close proximity to the action area. In fact, the action area is in the lower section of the Elk

River, and during surveys in July 2021, the WVDNR recorded 59 diamond darter observations among four sites in the lower section of the Elk River (WVDNR 2021). Furthermore, 2023 surveys within the Elk River were conducted at 11 sites, and diamond darter was confirmed to occupy eight of those sites. A total of 20 individuals were detected during 2023 surveys within the Elk River.

Freshwater mussels
Surveys within the action area were conducted September 17, 2021. A total of 281 cells were surveyed between both of the sites (98 cells at Site 1 and 183 cells at Site 2). The survey documented 720 live individuals between the two sites; 473 mussels of 17 different species were observed at Site 1 and 247 mussels of 16 species were observed at Site 2. Two snuffbox and three round hickorynut, in addition to a relic shell of each of these species, were observed at Site 1. Two snuffbox and one round hickorynut were observed at Site 2, in addition to a relic longsolid shell. All of the snuffbox were found outside the project's area of direct impact. Two round hickorynut at Site 1 were found within the area of direct impact, and the two round hickorynut observed (one at Site 1 and one at Site 2) were outside of the area of direct impact.

Average depth within the project survey sites ranged from one foot on the shoreward side within the project area to eight feet at the river inward extent of the project. Habitats were dominated by a heterogeneous mix of gravel and cobble river inward, and boulder and large woody debris shoreward.

No live individuals of clubshell*,* fanshell, northern riffleshell, pink mucket, rayed bean, or longsolid were found within the project area. However, because these species have the potential to occur within the Elk River, they were included within the BA.

EFFECTS OF THE ACTION

In accordance with 50 CFR 402.02, effects of the action are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (see § 402.17). Prior to analyzing the effects of the action on listed species, we must determine whether there are activities that are not part of the proposed action itself but are nevertheless consequences of the proposed action (i.e., activities that would not occur but for the proposed action and are reasonably certain to occur; 50 CFR 402.02, 402.17).

Diamond darter
Expected adverse effects to diamond darters include injury or death resulting from temporary habitat and water quality degradation due to sedimentation/turbidity, and temporary loss of in-stream habitat during work below the ordinary high-water mark. Changes to hydrology are not anticipated to rise to a level that would adversely affect diamond darter due to the relatively small area that is being impacted by the action (i.e., 1.9 acres) and the fact that the action is restoring the streambank to its pre-flood condition. While there may be injury and mortality to diamond darters during project implementation, effects to habitat and water quality from project

activities are expected to be short-term. Long-term beneficial effects are expected for diamond darters due to reduced bank erosion from improved bank stability.

Impacts from Sedimentation
Increased sedimentation and turbidity in the Elk River caused by construction of the longitudinal dike and/or stone buttress are expected to affect the diamond darter population in the action area. In this Opinion, sedimentation and turbidity are combined to refer to both sediment accumulation on the stream substrate and sediments suspended in the water column.

Excessive sedimentation/turbidity in aquatic systems can cause multiple adverse effects on all life stages of benthic fish. These effects include: loss or degradation of stream habitat essential for sheltering, foraging, and spawning; increased mortality of eggs, young-of-the-year, juveniles, and adults; increased predation on eggs by sediment-dwelling invertebrates; avoidance of previously occupied habitat; increased vulnerability of adults to predation; reduced reproductive success; induced physiological stress; reduced feeding and weight loss; reduced prey availability; increased parasitism; reduced disease resistance; and clogging, abrasion, and necrosis of gills (Berkman and Rabeni 1987; Wood and Armitage 1997; Kundell and Rasmussen 1995; Newcombe and Jensen 1996; Reid and Anderson 1999; Levesque and Dube 2007; Sutherland et al. 2002).

A commonly documented effect of in-water work includes silt deposition that fills interstitial spaces in gravel and cobble substrates and reduces water flow through the substrate in the direct effects area, as well as in areas downstream of the disturbance; the resulting increase in substrate embeddedness is expected to reduce spawning, foraging, and sheltering habitat quality for the diamond darter. Sediment deposition can also reduce pool depth and decrease substrate complexity (Berkman and Rabeni 1987; Wood and Armitage 1997). Physiological stress from damage to gills caused by increased turbidity is also possible; studies have found signs of physiological stress, such as increased oxygen consumption and loss of equilibrium, in remaining fish downstream of disturbed areas, as well as decreased abundance of fish downstream of in-stream work sites (Reid and Anderson 1999; Levesque and Dube 2007). In particular, fish species that require clean cobble and gravel for spawning had decreased abundance in sediment-impaired streams (Sutherland et al. 2002) and typical riffle-dwelling fish species declined in the presence of increased siltation (Berkman and Rabeni 1987), indicating that diamond darter numbers may be reduced by increased sedimentation in the sediment affected areas. Increased sediment deposition and substrate compaction from in-stream construction can degrade spawning habitat, resulting in the production of fewer and smaller fish eggs, impaired egg and larvae development, and limited food availability for young-of-year (Reid and Anderson 1999; Levesque and Dube 2007). Increased sedimentation can be expected to not only affect the suitability of in-stream habitat, but also to affect the availability and quality of prey items by altering the composition and reducing the density of the benthic invertebrate communities within and downstream of in-water work areas (Berkman and Rabeni 1987; Kundell and Rasmussen 1995). These effects on the benthic invertebrate community can persist after construction has been completed, and various studies have documented adverse effects to the benthic community that have been apparent for between six months and four years post-construction (Reid and Anderson 1999; Levesque and Dube 2007; Penkal and Phillips 2011).

Behavioral changes in fish species have been linked to increased sedimentation. These behavioral changes are most likely the result of decreased vision in turbid waters. Fountain darters exhibited impaired anti-predation movements in increased turbidity conditions (Swanbrow Becker and Gabor 2012). Other darter species, which are largely dependent on visual cues when feeding, have been found to exhibit depressed feeding rates and total prey consumption with increased turbidity (Hazelton and Grossman 2009; Swanbrow Becker and Gabor 2012; Swanbrow Becker et al. 2016); similar effects are expected to diamond darters. Collectively, research indicates that in habitat with increased turbidity, darter species expend more energy foraging, which reduces the amount of energy that is devoted to other essential behaviors (summarized in Potoka et al. 2016). Avoidance or abandonment of sediment-affected disturbed areas have been observed (Burkhead and Williams 1992), which further affects fish, as they expend extra energy seeking out new habitat, and competing for resources in new areas; fish are also likely to experience an increased risk of predation in the new habitat. The avoidance or abandonment of previously suitable habitat can result in decreased growth rates, decreased reproductive success, and decreased survivorship of individuals. Furthermore, avoidance can also lead to a reduction in distribution or an alteration in distribution of some fish species (summarized in Kellogg and Leipzig-Scott 2017).

The manner in which the Elk River will be exposed to disturbed sediments will mostly be via many, moderate-intensity sediment plumes (or pulses), that are generated as the existing streambed is disturbed during construction of bank stabilization features. While each pulse may contain only moderate amounts of sediment, the effect of multiple pulses in one area will increase the total duration of exposure. The duration of work varies considerably, depending on the size of the repair area and the activity being conducted. Streambank repairs are scheduled to last up to 210 days, with repeated sediment pulses expected daily. The sediment pulses are expected to have a more intense effect in the immediate vicinity of the work, but then become diluted with increasing distance from the disturbance, until effects are ameliorated outside of the in-stream erosion and sediment control measures.

Sediment pulses that are generated during construction are expected to cause a temporary increase in turbidity and cause sediment accumulation in the substrate. The effects on the health of diamond darters from increased turbidity are referenced above. Most diamond darters are expected to move away from disturbance and to less turbid areas, at least until the water clears. While this will limit their exposure to some of the adverse effects from sedimentation/turbidity, individual diamond darters will also expend extra energy, have increased stress, and have reduced feeding efficiency associated with avoidance of the turbid water. Sedimentation will also reduce the quality of habitat present for use by diamond darters in the action area. Some cobble within the action area will have increased embeddedness, while other cobble areas will have a reduction in embeddedness due to the disturbance, suspension, and resettling of riverbed sediments. Diamond darter prey may also decline as a result of the shifting deposition of sediments. However, the adverse effects from project-induced sedimentation on diamond darters should be relatively limited, as very little new sediment (i.e., from outside the channel) is anticipated to be introduced to the river, due to the use of erosion and sediment best management practices. Thus, the effects of sedimentation and increased turbidity on water quality and habitat suitability will largely be limited to the suspension and redistribution of sediment that is already present in the action area. Furthermore, sedimentation is expected to be temporary and limited to pulses, rather than chronic or long-lasting, as discussed above. Thus, diamond darter exposure to this stressor within the action area is expected to be short-term, and the action area will not be permanently degraded by excess sedimentation. In fact, the action will ultimately result in less sediment in the Elk River by stabilizing and eroding stream banks.

Impacts from Direct Habitat Disturbance
Construction of the longitudinal dike and/or stone buttress will result in the permanent loss of 1.13 acres of aquatic habitat for the diamond darter. Because longitudinal dike and/or stone buttress structures will occupy 1.13 acres of habitat below the ordinary high-water mark permanently, the area occupied by each structure will be unavailable for feeding, sheltering, and dispersing individuals. Areas immediately around the structures may experience increased or new scouring and areas of sediment deposition; this may cause some portions of the riverbed to become less suitable for diamond darter use. However, the permanent loss of habitat will only be within a small area (i.e., 1.13 acres), and negative effects related to changes in flow pattern are not anticipated to occur, as flow conditions after construction are anticipated to be the same as the flow conditions were prior to the bank eroding and becoming destabilized. This suggests an overall improvement in flow conditions due to the action.

Impacts to Diamond Darter Critical Habitat
The adverse effects, direct or indirect, expected to affect diamond darter critical habitat are associated with sedimentation. We anticipate immediate and long-term beneficial effects to the diamond darter critical habitat in the Elk River from reduction in new sediment inputs associated with the streambank stabilization. However, project construction activities will first result in increased sedimentation associated with the disturbance, suspension, and redistribution of substrate sediments that is expected to negatively affect the critical habitat within the action area.

Most stressors that are expected to have an adverse effect on critical habitat during the action stem from the increased water turbidity and siltation that is likely to occur during work activities. While the conservation measures implemented as part of the proposed action are expected to limit the amount of additional sediment input to the river during construction activities, this type of activity involves manipulation of rocks and boulders already present in the river, as well as the placement of additional materials into the water, which will result in substantial disturbance of the stream substrate. Sediments already present in the river channel will be disturbed as rocks that are located at or below the existing water level are manipulated out of the bank, then replaced or moved to a different location in the bank. Sediment disturbed during work below the ordinary high-water mark will be suspended in the water column and/or be flushed from the local work area and deposit elsewhere. This type of work will likely result in the generation of many short-term pulses of turbid water from the work site. Although these types of sediment plumes, or pulses, are usually of relatively short duration and there is typically a rapid return to background conditions after activities cease, in-stream work can have considerable effects on aquatic ecosystems. Additionally, the effects of sedimentation from this action are limited in scope (i.e., approximately one percent of the total length of the Elk River proposed critical habitat unit).

Placement of additional materials in the river during the action is also expected to cause alterations in the stream substrate of the Elk River and cause short-term increases in turbidity (or suspended sediments) in the water column. It is expected that the same degree of total embeddedness will be present before and after the activity, although areas of higher embeddedness will likely have a different distribution pattern throughout the reach after disturbance. Within this sediment effect area there may be localized increased embeddedness in some gravel, cobble, and boulder micro-habitats within the substrate of the shallow pools and runs inhabited by the species. Imported rocks of varying sizes will be placed in the river. The rocks are not anticipated to erode or leach any minerals into the water, leaving the water chemistry unchanged.

This action will result in 1,686 linear feet of permanent loss of diamond darter critical habitat. However, this only constitutes approximately one percent of the total critical habitat in the Elk River, and the effects of will be long-term beneficial to other portions of critical habitat that are in the Elk River Unit by reducing sediment inputs and restoring more natural flow conditions (see below for more detail).

The immediate beneficial effect of bank stabilization after construction of the structure will be the reduction in continued sediment input from the eroding banks. However, in-water construction can also directly alter the stream channel, bed, and banks, and may result in changes in cover, channel morphology, and sediment transport dynamics. While these changes can produce adverse effects to aquatic resources in some circumstances, the effects of in-stream structure placement on the Elk River channel morphology are expected to produce desirable effects. The 2016 flood event caused alterations to the Elk River streambank and channel, which resulted increased erosion and sediment inputs into the system. The creation of in-water streambank stabilization will be a re-construction of areas that were eroded away during the flood event or have been continually eroding since they were destabilized during the flood. Rock placement during streambank stabilization will re-occupy a portion of the footprint that the natural dirt and rock bank once occupied in and along the Elk River prior to the 2016 flood. In summary, stabilizing the streambank is expected to reduce the risk for bank erosion at these locations in the future and contribute to the long-term recovery of a river channel in a state of channel dynamic equilibrium.

<u>Freshwater mussels</u>
Expected adverse effects to freshwater mussels include stress from handling during salvage and relocation, injury or death resulting from temporary habitat and water quality degradation due to sedimentation/turbidity, and temporary loss of in-stream habitat during work below the ordinary high-water mark. Changes to hydrology are not anticipated to rise to a level that would adversely affect freshwater mussels due to the relatively small area that is being impacted by the action (i.e., 1.9 acres) and the fact that the action is restoring the streambank to its pre-flood condition. While there may be stress, injury, and mortality to freshwater mussels during project implementation, effects to habitat and water quality from project activities are expected to be short-term. Long-term beneficial effects are expected for diamond darters due to reduced bank erosion from improved bank stability.

Impacts from Mussel Salvage and Relocation
The mussel salvage and relocation will take place prior to any other site preparation or construction activities. While salvage and relocation will result in the reduction of direct take,

and will thus significantly minimize adverse effects, there can also be some adverse effects associated with salvage/relocations. When conducted properly, relocations can be an effective tool to minimize mussel mortality. Studies have documented survival of up to 99 percent of relocated mussels after one year (Cope et al. 2003). However, handling and relocation of mussels can also cause direct mortality, or stress to mussels resulting in reduced growth and reproduction (Cope and Waller 1995; Dunn et al. 1999; Strayer and Smith, 2003). The rate of survival during relocations and handling is influenced by water and air temperatures, handling and transport methods, and substrate suitability in relocation area. Most relocation projects are conducted from July to September when reproductive stress is relatively low and metabolic rates are sufficient for active reburrowing in the substrate (Cope and Waller 1995). Relocations conducted during active reproduction periods or during low temperatures when metabolic rates are low will likely result in increased mortality and reduced reproductive success. For example, one relocation project conducted during fall with rapidly declining temperatures resulted in greater than 30 percent mortality for most relocated species (Dunn et al. 1999).

Based on previous experiences with relocation efforts in West Virginia, it is estimated that relocations may find approximately 60 percent of the mussels in typical mussel habitat such as sand and gravel (EnviroScience Inc., 2013, 2004, 2002, and 2001; Clayton, J. WVDNR, personal comm.). Some individuals may not be detected and would be crushed or killed by construction of the longitudinal dike or stone buttress. Because they are small and difficult to locate, juvenile mussels are less likely to be located during surveys and thus may have an increased risk of being crushed, killed, or smothered. This could result in the disproportionate loss of younger individuals and could alter the age-class distribution of the population. In addition, because the snuffbox is usually found entirely buried in the substrate or with only the posterior slope exposed to view (Buchanan 1980, Ortmann 1919), they are more difficult to locate during surveys than other species and thus may have an increased risk of being crushed, killed, or smothered.

The mussel relocations for this project will precede project construction and will take place within one year of construction between May 1 and October 1 when reproductive stress is relatively low and metabolic rates are sufficient for active reburrowing in the substrate. Mussels gathered throughout the salvage area will be collected in such a way that spatial location and relative density of mussels can be recorded. Salvaged mussels will then be translocated to the nearest optimal upstream habitat that harbors an existing mussel community, which will be approved by the WVDNR. A report describing the salvage and translocation results will be provided to the WVDNR and the Service.

Impacts from Sedimentation

Sedimentation to mussel habitats within the direct and indirect areas of impact will occur during the construction of the longitudinal dike or stone buttresses. These activities are expected to result in sedimentation and increased turbidity. Both deposited and suspended sediment can negatively affect the survival and fitness of freshwater mussels causing impaired feeding which may result in reduced physiological function and depressed rates of growth, reproduction, and recruitment (Henley et al. 2000).

High levels of suspended sediments will reduce dissolved oxygen levels in the water, while heavy sediment deposition will fill interstitial spaces in the substrates, both of which can suffocate mussels particularly if sufficient accumulation occurs (Ellis 1936, Marking and Bills 1980). Mussels close their valves during periods of heavy siltation to avoid irritation and clogging of feeding structures (Loar et al. 1980). Mussel gills can become overwhelmed with excessive suspended sediment, causing a mussel to either reduce its water and food intake rate or close altogether.

Excessive siltation also degrades water and substrate quality. Sedimentation may permanently alter and degrade habitat through siltation such that conditions are no longer favorable for clubshell and snuffbox. Additionally, increased turbidity due to sedimentation may impede sight-feeding host fishes and disrupt attractant mechanisms mussels use to lure fish hosts (Hartfield and Hartfield, 1996). As a result of decreased water quality and degraded and altered habitat, we anticipate that freshwater mussels will experience impaired feeding resulting in sub-lethal effects on growth and reproduction or starvation with long-term exposure.

It is difficult to determine how far downstream these types of effects will occur, what level of excess sedimentation will be generated by the project, or how long these effects will persist. Factors such as stream channel morphology, flow rates during and post-construction, the composition of excavated sediments, and the effectiveness of sediment and erosion control measures, can affect the duration and severity of in-stream sedimentation. Sedimentation and increased turbidity from construction could cause deleterious effects to mussels downstream of the project area.

The manner in which the Elk River will be exposed to disturbed sediments will mostly be via many, moderate-intensity sediment plumes (or pulses), that are generated as the existing streambed is disturbed during construction of bank stabilization features. While each pulse may contain only moderate amounts of sediment, the effect of multiple pulses in one area will increase the total duration of exposure. The duration of work varies considerably, depending on the size of the repair area and the activity being conducted. Streambank repairs are scheduled to last up to 210 days, with repeated sediment pulses expected daily. The sediment pulses are expected to have a more intense effect in the immediate vicinity of the work, but then become diluted with increasing distance from the disturbance, until effects are ameliorated outside of the in-stream erosion and sediment control measures. Sediment pulses that are generated during construction are expected to cause a temporary increase in turbidity and cause sediment accumulation in the substrate.

The Corps have incorporated a number of conservation measures into the project that may ameliorate the extent and duration of sedimentation that will occur within the action area and areas downstream. These measures include construction of in-stream features from the bank without use of in-stream equipment, presence of an environmental monitor to confirm work is implemented as outlined in this Opinion, use of erosion and sedimentation control devices throughout the project sites and locating staging areas in upland areas away from receiving waters that are protected through sedimentation and erosion control best management practices. Additionally, post-construction monitoring will include habitat and depth monitoring one year and three years post-construction; a report will be submitted five years following construction. The incorporation of these conservation measures will limit the duration and scope of effects to mussels and their habitat from sedimentation. However, not all sediment will be prevented from entering waterways. As a result, we expect habitat degradation and loss will occur and some individual freshwater mussels may experience impaired feeding and reduced reproduction rates while others may suffocate and die. While stabilization and protection of the banks will introduce some sediment to the Elk River, it will prevent further degradation of this habitat from occurring due to erosion of material from the bank into the stream, which will benefit freshwater mussels and their habitats.

Impacts from Direct Habitat Disturbance
The project will disrupt and alter mussel habitat in the action area during construction of the longitudinal dike or stone buttress. As described in the Description of the Proposed Action and the Status of the Species sections above, habitat within area where slopes will be stabilized and protected with a longitudinal dike and/or stone buttress will be directly disturbed. Mussels present within the direct impact area as well as in substrates adjacent to these areas may be crushed, smothered, dislodged, or killed during construction. Those mussels not killed or injured during this process may still suffer death, injury, or increased predation risk if they are unable to right themselves and re-burrow into suitable habitat. These activities will change substrate composition or compaction in and around the construction area and make it less suitable for mussels to live and burrow in. As described above, a total of 1.9 acres of habitat may be affected from these types of effects and there will be 1.13 acres of permanent habitat loss.

The Corps have incorporated a number of conservation measures into the project that should minimize the extent and significance of the direct habitat disturbance on freshwater mussels. These measures include construction of in-stream features from the bank without use of in-stream equipment, presence of an environmental monitor to confirm work is implemented as outlined in this Opinion, use of erosion and sedimentation control devices throughout the project sites, and completion of a mussel salvage prior to in-stream work. Additionally, post-construction monitoring will include habitat and depth monitoring one year and three years post-construction; a report will be submitted five years following construction. As a result of the incorporation of these conservation measures, we expect that the impact to freshwater mussels from direct disturbance will be minimal. While this stabilization and protection will remove some suitable habitat permanently, it will also prevent further degradation of this habitat from occurring due to erosion of material from the bank into the stream, which will benefit freshwater mussels and their habitats over time.

Impacts to Longsolid and Round Hickorynut Critical Habitat
The adverse effects, direct or indirect, expected to affect longsolid and round hickorynut critical habitat are associated with sedimentation. We anticipate immediate and long-term beneficial effects to longsolid and round hickorynut critical habitat in the Elk River as a result of a reduction in new sediment inputs associated with the streambank stabilization. However, project construction activities will first result in increased sedimentation associated with the disturbance, suspension, and redistribution of substrate sediments that is expected to negatively affect the critical habitat within the action area.

Most of the stressors that are expected to have an adverse effect on critical habitat during the action stem from the increased water turbidity and siltation that is likely to occur during work activities. While the conservation measures implemented as part of the proposed action are expected to limit the amount of additional sediment input to the river during construction activities, this type of activity involves manipulation of rocks and boulders already present in the river, as well as the placement of additional materials into the water, which will result in substantial disturbance of the stream substrate. Sediments already present in the river channel will be disturbed as rocks that are located at or below the existing water level are manipulated out of the bank, then replaced or moved to a different location in the bank. Sediment disturbed during work below the ordinary high-water mark will be suspended in the water column and/or be flushed from the local work area and deposit elsewhere. This type of work will likely result in the generation of many short-term pulses of turbid water from the work site. Although these types of sediment plumes, or pulses, are usually of relatively short duration and there is typically a rapid return to background conditions after activities cease, in-stream work can have considerable effects on aquatic ecosystems. Additionally, the effects of sedimentation from this action are limited in scope (i.e., less than one percent of the total length of the Elk River containing critical habitat).

Placement of additional materials in the river during the action is also expected to cause alterations in the stream substrate of the Elk River and cause short-term increases in turbidity (or suspended sediments) in the water column. It is expected that the same degree of total embeddedness will be present before and after the activity, although areas of higher embeddedness will likely have a different distribution pattern throughout the reach after disturbance. Within this sediment effect area there may be localized increased embeddedness in some gravel, cobble, and boulder micro-habitats within the substrate of the habitat inhabited by the species. Imported rocks of varying sizes will be placed in the river. The rocks are not anticipated to erode or leach any minerals into the water, leaving the water chemistry unchanged.

This action will result in 1,686 linear feet of permanent loss of longsolid and round hickorynut critical habitat. However, this only constitutes less than one percent of the total critical habitat in the Elk River Unit, and the effects of will be long-term beneficial to other portions of critical habitat that are in the Elk River Unit by reducing sediment inputs and restoring more natural flow conditions (see below for more detail).

The immediate beneficial effect of bank stabilization after construction of the structure will be the reduction in continued sediment input from the eroding banks. However, in-water construction can also directly alter the stream channel, bed, and banks, and may result in changes in cover, channel morphology, and sediment transport dynamics. While these changes can produce adverse effects to aquatic resources in some circumstances, the effects of in-stream structure placement on the Elk River channel morphology are expected to produce desirable effects. The 2016 flood event caused alterations to the Elk River streambank and channel, which resulted in increased erosion and sediment inputs into the system. The creation of in-water streambank stabilization will be a re-construction of areas that were eroded away during the flood event or have been continually eroding since they were destabilized during the flood. Rock placement during streambank stabilization will re-occupy a portion of the footprint that the natural dirt and rock bank once occupied in and along the Elk River prior to the 2016 flood. In summary, stabilizing the streambank is expected to reduce the risk for bank erosion at these locations in the future and contribute to the long-term recovery of a river channel in a state of channel dynamic equilibrium.

CUMULATIVE EFFECTS

Cumulative effects are those "effects of future State or private activities, not involving federal activities, that are reasonably certain to occur within the action area" considered in this Opinion (50 CFR 402.02). No cumulative effects are expected to occur.

The Service is not aware of any future State, tribal, local, or private actions that are reasonably certain to occur within the action area at this time; therefore, no cumulative effects are anticipated.

JEOPARDY ANALYSIS

Section 7(a)(2) of the ESA requires that federal agencies ensure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of designated critical habitat.

Jeopardy Analysis Framework

"Jeopardize the continued existence of" means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species (50 CFR 402.02). The following analysis relies on four components: (1) Status of the Species, (2) Environmental Baseline, (3) Effects of the Action, and (4) Cumulative Effects. The jeopardy analysis in this Opinion emphasizes the range-wide survival and recovery needs of the listed species and the role of the action area in providing for those needs. It is within this context that we evaluate the significance of the proposed federal action, taken together with cumulative effects, for purposes of making the jeopardy determination (see 50 CFR 402.14(g)).

Analysis for Jeopardy

<u>Diamond darter</u>

Effects to Individuals –The proposed action includes tree clearing and grubbing, construction of access roads, construction of the longitudinal dike and/or stone buttress, and the removal and revegetation of access roads. As discussed in the Effects of the Action, potential effects of the action include adverse effects to adult and juvenile diamond darters present within the action area during the construction period and to young-of-the-year and eggs from nests that were hatched or laid late in the spawning period, which is typically estimated to be from April 1 through June 30, in West Virginia. Effects generally stem from increased sedimentation and include localized loss or degradation of stream habitat essential for sheltering, foraging, and spawning; increased mortality of eggs, young-of-the-year, juveniles, and adults; increased vulnerability of adults to predation; reduced reproductive success; induced physiological stress; reduced feeding and weight loss; reduced prey availability; and reduced survivorship. Effects of sedimentation are not expected to occur outside of the salvage areas surrounding in-water work areas due to the implementation of erosion and sediment controls. Additional adverse effects include direct mortality or injury of adults, juveniles, young-of-the-year, and nests laid late in the spawning season in areas of in-stream rock placement; direct mortality of adults, juveniles, and young-of-the-year when in-water work is occurring.

The adverse effects of sedimentation to individuals are expected to be limited, both in scope and severity, due to the implementation of several project conservation measures, and the limited area of in-water work. The commitment to work with from shore rather than bring equipment below the ordinary high-water mark (except for the installation of best management practices) allows for a decrease in the impact of in-water work. Other conservation measures, such as enhanced erosion and sediment controls (e.g., a turbidity curtain and in-stream water quality monitoring) should further reduce both streambed disturbance and new sediment inputs to aquatic resources. Reductions in sedimentation and disturbance are expected to lessen adverse effects to all life stages of the diamond darter.

Individual adult and juvenile diamond darters are expected to move away from areas of active in-water work. Although young-of-the-year and eggs have limited mobility/are immobile and are too small to be captured during dewatering procedures, adherence to the proposed conservation measure restricting work during the spring spawning period reduces their exposure to sediment deposition and direct crushing during project activities.

Beneficial Effects to the Species - Repair of continually eroding banks along the Elk River is expected to have a long-term beneficial effect on the diamond darter and its habitats within the action area by reducing or eliminating some of the sources of continued sediment input into the Elk River. Given the Conservation Measures that will be implemented during project activities as well as the relatively short duration of much of the in-stream work (210 days), much of the project effects are expected to be sub-lethal to individual diamond darters. Furthermore, the streambank repairs are expected to improve long-term habitat conditions for the diamond darter in the action area. Additionally, turbidity in the Elk River is expected to decrease as a result of stabilization of the continually eroding banks. After a possible initial decline in benthic invertebrates, populations are expected to rebound, and macroinvertebrates that require clean water, such as mayflies, which are a preferred prey items of the diamond darter, may even increase.

In summary, we anticipate effects to individual diamond darter in either their annual survival or reproductive rate.

Effects to Populations – As we have concluded that individual diamond darters are likely to experience effects to their annual survival or reproductive rates, we need to assess the aggregated consequences of the anticipated effects on the population to which these individuals belong.

Diamond darters present in the project action area are part of the Elk River population, which is the only extant population of the species. Most of the effects of sedimentation on individual diamond darters in the project area are expected to be sub-lethal; therefore, we do not expect the Elk River population to be affected by a large reduction in numbers. Currently, a population estimate for the Elk River population of diamond darter is unavailable. However, we do not anticipate a long-term reduction in this population's fitness because diamond darters are likely to be present in suitable habitat located upstream and downstream of the action area that will not be affected by project activities. Additionally, although this project will have long-term beneficial effects for the population by stabilizing an eroding bank. The impact area for the project is also relatively small (i.e., 1.9 acres) compared to the entire portion of the Elk River known to be inhabited by diamond darter.

Finally, we expect the long-term distribution of the diamond darter population in the Elk River to be unchanged. The Elk River diamond darter population in the action area will be adversely affected at different times during the 255-day project implementation timeline; however, not all portions of the population will be affected at once, or for the same length of time. As we are considering the majority of the Elk River to be suitable habitat, it is expected that many adult and juvenile diamond darters will move away from effected areas and return to their current (or an extended) distribution in the river over time, after project completion. Individuals are expected to redistribute throughout the action area post-construction, given the expected beneficial reductions of sediment inputs into the river due to the bank stabilization within the action area. Therefore, only a small portion of the overall population will experience reduced survival or reproductive rates, and these effects are anticipated to be short-term in nature. The proposed action is not expected to cause any long-term adverse effects to the Elk River diamond darter population.

Effects to Species- As we have concluded that Elk River population of diamond darters is unlikely to experience reduction in fitness, there will be no harmful effects (i.e., there will be no long-term reduction in reproduction, numbers, or distribution [RND]) on the species as a whole.

Effects to Critical Habitat- The action area includes 1,686 linear feet of proposed critical habitat within the Elk River, which constitutes a minimal amount (i.e., one percent) of the total amount of critical habitat within the Elk River.

As discussed in the Effects of the Action, potential effects of the action to the critical habitat in the Elk River include increased embeddedness of cobble and gravel substrate, increased water turbidity, and possible alterations in the macroinvertebrate prey base and availability. However, these effects are expected to be limited in relative severity, as most of the sediment disturbance in the proposed habitat will come from sediments already present in the watershed. Very few new sediment inputs are expected to be added to the system. While there may be some short-term and immediate changes in critical habitat conditions due to suspension and then re-deposition of substrate sediments disturbed during streambank repairs, there will be very little net change in sediment accumulation within the sediment effect areas. Because of the conservation measures of within the action area, we anticipate that measurable amounts of sediment will not continue downstream of the action area. Only a small portion of critical habitat (i.e., one percent) of the available critical habitat in the Elk River will be modified as a result of this action. Additionally, this action will improve all critical habitat downstream of the action area by permanently removing sediment inputs into the Elk River caused by the failing bank in the action area. Therefore, we conclude there will be no reduction in the conservation role of individual critical habitat subunits or the conservation role of critical habitat as a whole.

<u>Freshwater mussels</u>

Effects to Individuals –The proposed action includes tree clearing and grubbing, construction of access roads, longitudinal dike and/or stone buttress construction, and the removal and revegetation of access roads. As discussed in the Effects of the Action, potential effects of the action include adverse effects to listed mussels present within the action area during the construction period. Effects generally stem from increased sedimentation and include localized loss or degradation of stream habitat essential for sheltering, feeding, and spawning; increased mortality of individuals; reduced reproductive success; induced physiological stress; reduced feeding and weight loss; reduced prey availability; and reduced survivorship. Effects of sedimentation are not expected to occur outside of salvage areas surrounding in-water work areas due to the implementation of erosion and sediment controls. Additional adverse effects include direct mortality or injury when in-water work is occurring.

The adverse effects of sedimentation to individuals are expected to be limited, both in scope and severity, due to the implementation of several project conservation measures, and the limited area of in-water work. The commitment to work with from shore rather than bring equipment below the ordinary high-water mark (except for the installation of best management practices) allows for a decrease in the impact of in-water work. Other conservation measures, such as enhanced erosion and sediment controls (e.g., a turbidity curtain and in-stream water quality monitoring) should further reduce both streambed disturbance and new sediment inputs to aquatic resources. Reductions in sedimentation and disturbance are expected to lessen adverse effects to all life stages of the diamond darter. Additionally, the mussel salvage prior to construction is anticipated to reduce the number of individuals exposed to the action. This will also will reduce the mussels exposure to sediment deposition and direct crushing during project activities.

Beneficial Effects to the Species - Repair of the continually eroding banks along the Elk River is expected to have a long-term beneficial effect on listed mussels and their habitats within the action area by reducing or eliminating some of the sources of continued sediment input into the Elk River. Given the Conservation Measures that will be implemented during project activities as well as the relatively short duration of much of the in-stream work (210 days), much of the project effects are expected to be sub-lethal to individual listed mussels. Furthermore, the streambank repairs are expected to improve long-term habitat conditions for the listed mussels in the action area. Additionally, turbidity in the Elk River is expected to decrease as a result of stabilization of the continually eroding banks. After a possible initial decline in food availability, availability may rebound due the presence of lower sediment loads in the water column.

In summary, we anticipate effects to individual listed mussels in either their annual survival or reproductive rate.

Effects to Populations – As we have concluded that individual listed mussels are likely to experience effects to their annual survival or reproductive rates, we need to assess the aggregated consequences of the anticipated effects on the population to which these individuals belong.

Most of the effects of sedimentation on individual listed mussels in the project area are expected to be sub-lethal; therefore, we do not expect the Elk River population to be affected by a large reduction in numbers. Currently, population estimates for the Elk River populations of listed mussels are unavailable. However, we do not anticipate a long-term reduction in any population’s fitness because listed mussels are likely to be present in suitable habitat located upstream and downstream of the action area that will not be affected by project activities.

Additionally, although this project will have long-term beneficial effects for the population by stabilizing an eroding bank. The impact area for the project is also relatively small (i.e., 1.9 acres) compared to the entire portion of the Elk River known to be inhabited by listed mussels.

Finally, we expect the long-term distribution of the listed mussel populations in the Elk River to be unchanged. The Elk River listed mussel populations in the action area will be adversely affected at different times during the 255-day project implementation timeline; however, not all portions of those populations will be affected at once, or for the same length of time. As the project proponent is conducting a relocation of listed mussels prior to any construction activities, we anticipate that many of the mussels currently present within the action area will not be exposed to the sedimentation and direct crushing as a result of the action. Therefore, only a small portion of the overall populations will experience reduced survival or reproductive rates, and these effects are anticipated to be short-term in nature. The proposed action is not expected to cause any long-term adverse effects to the Elk River listed mussel populations.

Effects to Species- As we have concluded that Elk River populations of listed mussels are unlikely to experience reductions in fitness, there will be no harmful effects (i.e., there will be no reduction in RND) on the species as a whole.

Effects to Critical Habitat- The action area includes 1,686 linear feet of proposed critical habitat within the Elk River for both longsolid and round hickorynut, which constitutes a minimal amount of the total amount of critical habitat within the Elk River (i.e., less than one percent).

As discussed in the Effects of the Action, potential effects of the action to the critical habitat in the Elk River include increased embeddedness of cobble and gravel substrate, increased water turbidity, and possible alterations in the food availability. However, these effects are expected to be limited in relative severity, as most of the sediment disturbance in the proposed habitat will come from sediments already present in the watershed; and very few new sediment inputs are expected to be added to the system. While there may be some short-term and immediate changes in critical habitat conditions due to suspension and then re-deposition of substrate sediments disturbed during streambank repairs, there will be very little net change in sediment accumulation within the sediment effect areas. Because of the conservation measures of within the action area, we anticipated that measurable amounts of sediment will not continue downstream of the salvage areas surrounding the area of direct impact. Only a small portion of critical habitat (i.e., less than one percent) of the available critical habitat in the Elk River will be modified as a result of this action. Additionally, this action will improve all critical habitat downstream of the action area by permanently removing sediment inputs into the Elk River caused by the failing bank in the action area. Therefore, we conclude there will be no reduction in the conservation role of individual critical habitat subunits or the conservation role of critical habitat as a whole.

CONCLUSION

<u>Diamond darter</u>

We considered the current overall declining status of diamond darter in the Elk River (i.e., the only extant population of the species). We then assessed the effects of the proposed action and the potential for cumulative effects in the action area on individuals, populations, and the species as a whole. As stated in the Jeopardy Analysis, we do not anticipate any reductions in the overall RND of the diamond darter. It is the Service's Opinion that the Elk Valley PSD Section 14 streambank protection project, as proposed, is not likely to jeopardize the continued existence of the diamond darter and is not likely to adversely modify critical habitat. The Service expects long-term beneficial effects to the Elk River diamond darter critical habitat, due to the restorative nature of project activities on the Elk River.

Freshwater mussels

We considered the current overall declining status of listed mussels. We then assessed the effects of the proposed action and the potential for cumulative effects in the action area on individuals, populations, and the species as a whole. As stated in the Jeopardy Analysis, we do not anticipate any reductions in the overall RND of the listed mussels. It is the Service's Opinion that the Elk Valley PSD Section 14 streambank protection project, as proposed, is not likely to jeopardize the continued existence of the listed mussels inhabiting the Elk River and is not likely to adversely modify critical habitat. The Service expects long-term beneficial effects to the Elk River longsolid and round hickorynut critical habitat, due to the restorative nature of project activities on the Elk River.

INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and federal regulation pursuant to Section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. Take is defined in Section 3 of the ESA as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by the Service to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns including breeding, feeding, or sheltering (50 CFR § 17.3). Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of Section 7(b)(4) and Section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the ESA provided that such taking is in compliance with the terms and conditions of this incidental take statement (ITS).

The measures described below are nondiscretionary and must be undertaken by the Corps so that they become binding conditions of any grant or permit issued to the applicant, as appropriate, for the exemption in Section 7(o)(2) to apply. The Corps has a continuing duty to regulate the activity covered by this incidental take statement. If the Corps: (1) fails to assume and implement the terms and conditions or (2) fails to require the applicant to adhere to the terms and conditions of the ITS through enforceable terms that are added to the permit or grant document, the protective coverage of Section 7(o)(2) may lapse. To monitor the impact of incidental take, the applicant must report the progress of the action and its impact on the species to the Service as specified in the incidental take statement [50 CFR 402.14(i)(3)].

AMOUNT OR EXTENT OF TAKE ANTICIPATED

The anticipated take from the proposed action is described in the Tables below.

50 CFR 402.14(i)(1)(i) states that surrogates may be used to express the amount or extent of

anticipated take provided the Opinion or incidental take statement (ITS): (1) describes the causal link between the surrogate and take of the listed species; (2) describes why it is not practical to express the amount of anticipated take or to monitor take-related effects in terms of individuals of the listed species; and (3) sets a clear standard for determining when the amount or extent of the taking has been exceeded.

Diamond darter
It is not practical to monitor take-related impacts in terms of individual diamond darter for the following reasons: 1) the number of individuals within the action area at the time of project implementation will be unknown; 2) encountering dead or injured individuals during or following project implementation is unlikely; 3) diamond darter losses may be masked by annual fluctuations in numbers or other natural causes; 4) loss of young-of-year and eggs, which are small and difficult to detect, would be difficult to quantify; 5) most incidental take is expected to occur as harm, due to sub-lethal levels of sedimentation and water quality degradation, which temporary disrupt movement, breeding, feeding, and sheltering of individuals are likely undetectable and unmeasurable; and 6) incidental take that occurs as harm resulting in injury or death from larger amounts of sedimentation and habitat degradation would be difficult to determine.

Because excavation and stone placement below the ordinary high-water mark is the cause of all forms of take of the diamond darter that are reasonably certain to result from the project, there is a clear causal link between the acres of habitat impacted and take of diamond darter. In addition, because the location, timing, and acreage of habitat impacts can be readily identified, measured, and monitored, this surrogate is the most reasonable means for monitoring the anticipated take, and for detecting when the anticipated level of take may be exceeded, thereby providing a clear trigger for reinitiating consultation. The Service therefore will use the acreage of affected habitat as a surrogate for monitoring the amount and extent of anticipated take (Table 1).

Table 1. Diamond darter amount and type of anticipated incidental take.

Species	Amount of Take Anticipated (Surrogate)	Life Stage when Take is Anticipated	Type of Take	Types of Effects Anticipated
Diamond darter	1.9 acres of habitat loss (of which 1.13 acres is permanent)	All	Harm or Kill	Injury or death during due to crushing during excavation and stone placement. Habitat alteration from excavation and stone placement below ordinary high-water mark, and exposure to elevated suspended sediment and sedimentation from construction activities.

Freshwater mussels
It is not practical to monitor take-related impacts in terms of individual listed freshwater mussels

for the following reasons: 1) listed freshwater mussels have a small body size and can bury themselves in the sediment, which makes encountering dead or injured individuals unlikely; 2) scavengers may consume the shell or it may be swept downstream; 3) listed freshwater mussels losses may be masked by annual fluctuations in numbers or other natural causes; 4) most incidental take is expected to occur as harm, due to sub-lethal levels of sedimentation and water quality degradation, which temporary disrupt movement, breeding, feeding, and sheltering of individuals are likely undetectable and unmeasurable; and 5) incidental take that occurs as harm resulting in injury or death from larger amounts of sedimentation and habitat degradation would be difficult to determine.

Because excavation and stone placement below the ordinary high-water mark is the cause of all forms of take of the listed freshwater mussels that are reasonably certain to result from the project, there is a clear causal link between the acres of habitat impacted and take of listed freshwater mussels. In addition, because the location, timing, and acreage of habitat impacts can be readily identified, measured, and monitored, this surrogate is the most reasonable means for monitoring the anticipated take, and for detecting when the anticipated level of take may be exceeded, thereby providing a clear trigger for reinitiating consultation. The Service therefore will use the acreage of affected habitat as a surrogate for monitoring the amount and extent of anticipated take (Table 2).

Table 2. Listed mussel amount and type of anticipated incidental take.

Species	Amount of Take Anticipated (Surrogate)	Life Stage when Take is Anticipated	Type of Take	Types of Effects Anticipated
Clubshell	1.9 acres of habitat loss (of which 1.13 acres is permanent)	All	Harm or Kill	Injury or death during due to crushing during excavation and stone placement. Habitat alteration from excavation and stone placement below ordinary high-water mark, and exposure to elevated suspended sediment and sedimentation from construction activities.
Fanshell	1.9 acres of habitat loss (of which 1.13 acres is permanent)	All	Harm or Kill	Injury or death during due to crushing during excavation and stone placement. Habitat alteration from excavation and stone placement below ordinary high-water mark, and exposure to elevated suspended sediment and sedimentation from construction activities.
Northern riffleshell	1.9 acres of habitat loss (of which 1.13 acres is permanent)	All	Harm or Kill	Injury or death during due to crushing during excavation and stone placement. Habitat alteration from excavation and stone placement below ordinary high-water mark, and exposure to elevated suspended sediment and sedimentation from construction activities.
Pink mucket	1.9 acres of habitat loss (of which 1.13 acres is permanent)	All	Harm or Kill	Injury or death during due to crushing during excavation and stone placement. Habitat alteration from excavation and stone placement below ordinary high-water mark, and exposure to elevated suspended sediment and sedimentation from construction activities.
Rayed bean	1.9 acres of habitat loss (of which 1.13 acres is permanent)	All	Harm or Kill	Injury or death during due to crushing during excavation and stone placement. Habitat alteration from excavation and stone placement below ordinary high-water mark, and exposure to elevated suspended sediment and sedimentation from construction activities.
Longsolid	1.9 acres of habitat loss (of which 1.13 acres is permanent)	All	Harm or Kill	Injury or death during due to crushing during excavation and stone placement. Habitat alteration from excavation and stone placement below ordinary high-water mark, and exposure to elevated suspended sediment and sedimentation from construction activities.
Round hickorynut	1.9 acres of habitat loss (of which 1.13 acres is permanent)	All	Harm or Kill	Injury or death during due to crushing during excavation and stone placement. Habitat alteration from excavation and stone placement below ordinary high-water mark, and exposure to elevated suspended sediment and sedimentation from construction activities.

REASONABLE AND PRUDENT MEASURES
The Service believes the following reasonable and prudent measures are necessary and appropriate to minimize take of diamond darter and listed mussel species:

- The Corps shall implement all conservation measures as described above to avoid or minimize to the greatest extent possible effects to listed species within the action area.

- The Corps will provide information to individuals involved in project implementation on how to avoid and minimize potential effects to listed species.

- The Corps must ensure that the proposed action will occur as designed, planned, and documented in the BA and this Opinion.

TERMS AND CONDITIONS
To be exempt from the prohibitions of Section 9 of the ESA, the Corps and its contractors must comply with the following terms and conditions, which implement the reasonable and prudent measures described above and outline required reporting/monitoring requirements. These terms and conditions are nondiscretionary in order for the exemption to apply.

- The Corps will have a special condition in the implementation plans stating that the project will occur as designed, planned, and documented in the BA and this Opinion.

- The Corps, their permitted entities, and contractors shall implement all required measures as described in the BA.

- The Corps staff will make site visits prior to, during, and post implementation at all project implementation sites to observe and confirm that all conservation measures are being met. The Corps shall notify the Service of any failures to meet these measures within 24 hours of observation.

MONITORING AND REPORTING REQUIREMENTS
- The Corps shall monitor the number of acres affected by the action on an annual basis. The Corps of Engineers shall provide information on the previous year's activities to the Service no later than January 15 of each year during the implementation of this project, beginning with the first January following the year activities under this project are implemented. The Corps will also provide the Service's WVFO with results of the habitat and the pre-construction diamond darter survey no later than January 15 of the year after the survey occurs. Reports will be sent to the Service's WVFO (6263 Appalachian Highway Davis, West Virginia 26260 or emailed to FW5_WVFO@fws.gov).

- Any dead or injured diamond darter or listed freshwater mussels located in the action area during implementation of the proposed action, regardless of species, shall be immediately reported to the WVFO at fw5_wvfo@fws.gov and the WVDNR at 304-637-0245. The Corps shall record information regarding the date, time, location of any listed species found, the possible cause of injury or death, and then provide this information to the Service. Any dead specimens believed to be federally listed shall be transported on ice to the WVFO or WVDNR. Care must be taken in handling dead specimens to preserve biological material in the best possible state. If needed, staff from the WVFO and/or WVDNR will assist in species determination for any dead or moribund specimens. If a listed species is identified, the WVFO staff will contact the appropriate Service law enforcement office. The Corps will notify the Service, in writing (digital format), regarding the projected and actual start dates, progress, and completion of the project throughout the life of the project.

The contact for these reporting requirements is as follows:
West Virginia Field Office
U.S. Fish and Wildlife Service
Subject Line: ***2023-0060082*** Elk Valley Public Service District (PSD) Section 14 Streambank Protection Project
Attn: FW5_WVFO@fws.gov or 304-866-3858

CONSERVATION RECOMMENDATIONS
Section 7(a)(1) of the ESA directs federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information.

The Service recommends that the Corps consider implementing the following conservation actions:

1. Provide support to the WVDNR or other facilities to facilitate activities for captive husbandry techniques suitable for propagation and augmentation of clubshell and snuffbox populations in the Elk River.

2. Provide support to facilitate eDNA research in the Elk River.

REINITIATION NOTICE
This concludes formal consultation on the actions outlined in the request. As provided in 50 CFR 402.16, reinitiation of formal consultation is required where discretionary federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this Opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species not considered in this Opinion; or (4) a new species is listed

or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, any operations causing such take must cease pending reinitiation.

If you have any questions regarding this Opinion, or our shared responsibilities under the ESA, please contact Curtis Roth on the WVFO Team at Curtis_roth@fws.gov or our general email at FW5_WVFO@fws.gov.

Sincerely,

JENNIFER NORRIS

Digitally signed by JENNIFER NORRIS
Date: 2024.05.30 18:54:00 -04'00'

Jennifer L. Norris
Field Supervisor
West Virginia Field Office

LITERATURE CITED

Archambault, J.M., W.G. Cope, and T.J. Kwak. 2013. Burrowing, byssus, and biomarkers: behavioral and physiological indicators of sublethal thermal stress in freshwater mussels (Unionidae). Marine and Freshwater Behaviour and Physiology 46(4):229-250.

Archambault, J.M., W.G. Cope, and T.J. Kwak. 2014. Survival and behaviour of juvenile unionid mussels exposed to thermal stress and dewatering in the presence of a sediment temperature gradient. Freshwater Biology 59:601-613.

Augspurger, T.J., A.E. Keller, M.C. Black, W.G. Cope, and F.J. Dwyer. 2003. Water quality guidance for protection of freshwater mussels (Unionidae) from ammonia exposure. Environmental Toxicology and Chemistry 22(11):2569-2575.

Berkman, H.E. and C.F. Rabeni. 1987. Effect of siltation on stream fish communities. Environmental Biology of Fishes 18(4): 285–294.

Buchanan, A.C. 1980. Mussels (naiades) of the Meramec River basin. Missouri Department of Conservation Aquatic Series 17, Jefferson City.

Burkhead, N.M., and J.D. Williams. 1992. The Boulder Darter: a Conservation Challenge. Endangered Species Technical Bulletin XVII (3-8):4–6.

Chu-Fa Tsai. 1973. Water Quality and Fish Life below Sewage Outfalls. Transactions of the American Fisheries Society 102(2): 281-292.

Cope, W.G., M.C. Hove, D.I. Waller, D.J. Hornbach, M.R. Bartsch, L.A. Cunningham, H.I. Dunn and A.R. Kapuscinski. 2003. Evaluation of relocation of unionid mussels to in situ refugia. Journal of Molluscan Studies 69:27-34.

Cope, W.G. and D.L. Waller. 1995. Evaluation of freshwater mussel relocation as a conservation and management strategy. Regulated Rivers: Research & Management 11:147-155.

Cummings, K.S., and C.A. Mayer. 1992. Field guide to freshwater mussels of the Midwest. Illinois Natural History Survey Manual No. 5.

Dunn, H.L., B.E. Sietman, and D.E. Kelner. 1999. Evaluation of recent Unionid (Bivalvia) relocations and suggestions for future relocations and reintroductions. Proceedings of the First Freshwater Mollusk Conservation Society Symposium, 1999, pp. 169-183.

Ehlo, C.A. and J.B. Layzer. 2014. Population Demographics and Life History of the Round Hickorynut (Obovaria subrotunda) in the Duck River, Tennessee. American Midland Naturalist. 171:1–15

Ellis, M.M. 1936. Erosion silt as a factor in aquatic environments. Ecology 17(1): 29-42.

EnviroScience Inc. 2001. Braxton County State Route 4 Gassaway Bridge Replacement Project Freshwater Mussel Survey. Report prepared for West Virginia Department of Transportation.

EnviroScience Inc. 2002. Kanawha River Mussel Survey Report River Mile 77.8 to 78.7. Report prepared for American Electric Power.

EnviroScience Inc. 2004. Mussel survey for a proposed barge loading facility at Ohio River mile 194 (Public Notice No. 200300661). Report prepared for D. Skinner, Belpre Sand & Gravel.

EnviroScience Inc. 2013. Biological Assessment and West Virginia Coordination Document for the Proposed 8-Inch Water Pipeline Crossing of the Kanawha River, Kanawha County, West Virginia. Report prepared for Hatch Mott MacDonald, Consulting Engineers and West Virginia American Water.

Grandmaison, D., J. Mayasich, J., and D.A. Etnier. 2003. Crystal darter status assessment report. Report prepared for U. S. Fish and Wildlife Service.

Hartfield, P.W., and E. Hartfield. 1996. Observations on the conglutinates of *Ptychobranchus greeni* (Conrad 1834) (Mollusca: Bivalvia: Unionoidea). American Midland Naturalist 135:370-375.

Hazelton, P.D., and G.D. Grossman. 2009. The effects of turbidity and an invasive species on foraging success of Rosyside Dace (*Clinostomus funduloides*). Freshwater Biology 54:1977–1989.

Henley, W.F., M.A. Patterson, R.J. Neves, and A.D. Lemly. 2000. Effects of sedimentation and turbidity on lotie food webs: A concise review for natural resource managers. *Reviews in Fishery Science* 8:125–139.

Jackson, L.J., L. Corbett, and G. Scrimgeour. 2016. Environmental constraints on Didymosphenia geminata occurrence and bloom formation in Canadian Rocky Mountain lotic systems. Canadian Journal of Fisheries and Aquatic Sciences 73:964–972.

Jones, J.W. and R.J. Neves. 2002. Life history and propagation of the endangered fanshell, pearlymussel, Cyprogenia stegaria Rafinesque (Bivalvia: Unionidae). Journal of the North American Benthological Society 21:76-88.

Keckeis, H., E. Bauer-Nemeschkal, and E. Kamler. 1996. Effects of reduced oxygen level on the mortality and hatching rate on *Chondrostoma nasus* embryos. Journal of Fish Biology 49(3): 430-440.

Kellogg, K.A. and P. Leipzig-Scott. 2017. The Influence of Turbidity on Prey Consumption in the Tessellated Darter. Transactions of the American Fisheries Society 146:508–511.

Kundell, J.E. and T.C. Rasmussen. 1995. Recommendations of the Board of Reagents' Scientific Panel on Evaluating the Erosion and Measurement Standards Defined by the Georgia Erosion and Sedimentation Act. Proceedings of the 1995 Georgia Water Resources Conference, held April 11 and 12, 1995, The University of Georgia, Athens, Georgia.

Levesque, L.M. and M.G. Dube. 2007. Review of the effects of in-stream pipeline crossing construction on aquatic ecosystems and examination of the Canadian methodologies for effect assessment. Environmental Monitoring and Assessment 132:395-409.

Loar, J.M., L.L. Dye, R.R. Turner, and S.G. Hildebrand. 1980. Analysis of environmental issues related to small-scale hydroelectric development. Dredging. ORNL, Environmental Science Division Publication No. 1565, Oak Ridge, Tennessee.

Marking, L.L. and T.D. Bills. 1980. Acute effects of silt and sand sedimentation on freshwater mussels. pp. 204-211 *in* J.L. Rasmussen, ed. Proceedings of the symposium on Upper Mississippi River bivalve mollusks. Upper Mississippi River Conservation Committee, Rock Island, Illinois.

McGinley, E.J, R.L Raesly, and W.L. Seddon. 2013. The effects of embeddedness on the seasonal feeding of mottled sculpin. The American Midland Naturalist, Vol. 170, No. 2.

Messinger, T. and D.B. Chambers. 2001. Fish communities and their relation to environmental factors in the Kanawha River basin, West Virginia, Virginia, and North Carolina, 1997-98. Charleston, West Virginia: U.S. Geological Survey. Water-Resources Investigations Report 01-4048.

Musick, J.A. 1999. Ecology and conservation of long-lived marine animals. American Fisheries Society Symposium 1999. 23:1-10.

National Invasive Species Council. 2016. Management Plan: 2016–2018. Washington, DC. https://www.doi.gov/sites/doi.gov/files/uploads/2016-2018-nisc-management-plan.pdf

NatureServe. 2008. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.0. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: November 24, 2008).

Newcombe, C.P. and J.O.T. Jensen. 1996. Channel Suspended Sediment and Fisheries: A Synthesis for Quantitative Assessment of Risk and Effect. North American Journal of Fisheries Management 16:693-727.

Osier, E.A. 2005. Distribution and habitat use of the crystal darter (Crystallaria asprella) and spotted darter (Etheostoma maculatum) in the Elk River, West Virginia. Masters Thesis, West Virginia University, Morgantown, West Virginia.

Ortmann, A.E. 1919. A monograph of the naiades of Pennsylvania. Part III. Systematic account of the genera and species. Memoirs of the Carnegie Museum 8:1-385.

Owens, N. 2021. West Virginia Division of Natural Resources. Email to Tiernan Ware, U.S. Fish and Wildlife Service, West Virginia Field Office, dated 28 September 2021.

Patnode K.A., E.Hittle, R.M. Anderson, L. Zimmerman, J.W. Fulton. 2015. Effects of high salinity wastewater discharges on unionid mussels in the Allegheny River, Pennsylvania. Journal of Fish and Wildlife Management. 6:55–70.

Peacock, E., W.R. Haag, and M.L. Warren, Jr. 2005. Prehistoric decline in freshwater mussel coincident with the advent of maize agriculture. Conservation Biology 19:547-551.

Penkal, R.F. and G.R. Phillips. 2011. Construction and Operation of Oil and Gas Pipelines. Fisheries 9(3): 6-8.

Parmalee, P.W., and A.E. Bogan. 1998. The freshwater mussels of Tennessee. The University of Tennessee Press, Knoxville, Tennessee.

Pond, G.J., M.E. Passmore, F.A. Borsuk, L. Reynolds, and C.J. Rose. 2008. Downstream effects of mountaintop coal mining: comparing biological conditions using family- and genus-level macroinvertebrate bioassessment tools. Journal of the North American Benthological Society 27:717-737.

Potoka, K.M., C.P. Shea, and P.W. Bettoli. 2016. Multispecies Occupancy Modeling as a Tool for Evaluating the Status and Distribution of Darters in the Elk River, Tennessee. Transactions of the American Fisheries Society 145:1110–1121.

Powell, J.R. 1999. Response of Fish Communities to Cropland Density and Natural Environmental Setting in the Eastern Highland Rim Ecoregion of the Lower Tennessee River Basin, Alabama and Tennessee. U.S. Geological Survey Water-Resources Investigations Report 02-4268. Nashville, Tennessee.

Rakes, P. 2013. Conservation Fisheries. Email to Barbara Douglas, U.S. Fish and Wildlife Service, West Virginia Field Office, dated 22 January 2013.

Reid, S.M. and P.G. Anderson. 1999. Effects of Sediment Released During Open-Cut Pipeline Water Crossings. Canadian Water Resources Journal 24:235-251.

Ricker, W.E. 1975. Computation and Interpretation of Biological Statistics of Fish Populations.

Bulletin of the Fisheries Research Board of Canada, 191.

Rizzo, A.A., S.A. Welsh, and P.A. Thompson. 2017(a). A study of diamond darter macrohabitat use and abundance within the lower Elk River. Report prepared for NiSource.

Rizzo, A.A., D.J. Brown, S.A. Welsh, and P.A. Thompson. 2017(b). Factors influencing detection of the federally endangered Diamond Darter (*Crystallaria cincotta*): Implications for long-term monitoring strategies. American Midland Naturalist 178:123-131.

Rizzo, A.A., C.T. Rota, P.A. Thompson, D.J. Brown, and S.A. Welsh. 2018. Effects of an extreme flood on federally endangered diamond darter abundances. The American Midland Naturalist 180:108-118.

Rodgers, S.O., B.T. Watson, and R.J. Neves. 2001. Life history and population biology of the endangered tan riffleshell *(Epioblasmajlorentina walkeri)* (Bivalvia: Unionidae). Journal of the North American Benthological Society 20:582-594.

Ruble, C., P. Rakes, J.R. Shute, and S.A. Welsh. 2010. Captive propagation, reproductive biology, and early life history of the diamond darter (*Crystallaria cincotta*). Final Report submitted to West Virginia Division of Natural Resources and the U.S. Fish and Wildlife Service 31 December 2010.

Ruble, C.P. 2011. 2011 Diamond darter summary (interim report). Provided by E-mail to Barbara Douglas dated 09 September 2011.

Ruble, C. 2013. Captive propagation, reproductive biology, and early life history of *Crystallaria cincotta* (diamond darter), *Etheostoma wapiti* (boulder darter), *E. vulneratum* (wounded darter), and *E. maculatum* (spotted darter). M.S. thesis, West Virginia University, Morgantown. West Virginia.

Ruble, C.L., P.L. Rakes, J.R. Shute, and S.A. Welsh. 2014. Captive propagation, reproductive biology, and early life history of the diamond darter (*Crystallaria cincotta*). The American Midland Naturalist, 172:107-118.

Sherman, R.A. 1994. Life history information critical to the management of the state endangered snuffbox mussel, *Epioblasma triquetra* (Bivalvia: Unionidae) in Michigan. M.S. thesis, University of Michigan, Ann Arbor.

Silvis, A. 2023. West Virginia Division of Natural Resources. Email to Tiernan Ware, U.S. Fish and Wildlife Service, West Virginia Field Office, dated 15 August 2023.

Simon, T.P. and R. Wallus, 2006. Reproductive Biology and Early Life History of Fishes in the Ohio River Drainage, Vol. 4: Percidae-Perch, Pikeperch, and Darters. CRC Taylor and

Francis, Boca Raton, Florida.

Smith, D.R., R.F. Villella, and D.P. Lemarie. 2001. Survey protocol for assessment of endangered freshwater mussel in the Allegheny River, Pennsylvania. Journal of the North American Benthological Society 20:118-132.

Strayer, D.L. and D.R. Smith. 2003. A guide to sampling freshwater mussel populations. American Fisheries Society, Mongraph 8, Bethesda, Maryland.

Strayer, D.L. and D. Dudgeon. 2010. Freshwater biodiversity conservation: recent progress and future challenges. Journal of the North American Benthological Society 29:344-358.

Sutherland A.B., Meyer J.L. & Gardiner E.P. 2002. Effects of land cover on sediment regime and fish assemblage structure in four southern Appalachian streams. Freshwater Biology 47: 1791–1805.

Swanbrow Becker, L.J., and C.R. Gabor. 2012. Effects of turbidity and visual vs. chemical cues on antipredator response in the endangered Fountain Darter (*Etheostoma fonticola*). Ethology 118:994–1000.

Swanbrow Becker, L.J., E.M. Brooks, and C.R. Gabor. 2016. Effects of turbidity on foraging behavior in the endangered Fountain Darter (*Etheostoma fonticola*). American Midland Naturalist 175:55–63.

U.S. Environmental Protection Agency (USEPA). 2011. A Field-Based Aquatic Life Benchmark for Conductivity in Central Appalachian Streams. National Center for Environmental Assessment Office of Research and Development, Cincinnati, Ohio.

U.S. Fish and Wildlife Service (Service). 1985. Recovery Plan [for the] Pink Mucket Pearly Mussel *Lampsilis orbiculata* [=*abrupta*]. Atlanta, GA.

U.S. Fish and Wildlife Service. 1991. Recovery Plan for Fanshell (*(Cyprogenia stegaria (=C. irrorata)*. Atlanta, GA.

U.S. Fish and Wildlife Service. 1994. Clubshell (*Pleurobema clava*) and northern riffleshell (*Epioblasma torulosa rangiana*) Recovery Plan. Hadley, MA.

U.S. Fish and Wildlife Service. 2008a. Clubshell (*Pleurobema clava*): 5 Year Review: Summary and Evaluation. State College, Pennsylvania.

U.S. Fish and Wildlife Service. 2008b. Northern Riffleshell (*Epioblasma torulosa rangiana*): 5 Year Review: Summary and Evaluation. Columbus, Ohio.

U.S. Fish and Wildlife Service. 2011. Species Assessment and Listing Priority Assignment Form: Spotted Darter (*Etheostoma maculatum*). U.S. Fish and Wildlife Service, Great

Lakes Region, Ohio Field Office.

U.S. Fish and Wildlife Service. 2018a. Rayed bean (*Villosa fabalis*): 5 Year Review: Summary and Evaluation. Columbus Ohio.

U.S. Fish and Wildlife Service. 2018b. Snuffbox (*Epioblasma triquetra*): 5 Year Review: Summary and Evaluation. State College, Pennsylvania.

U.S. Fish and Wildlife Service. 2018c. Species Status Assessment Report for the Longsolid Mussel (*Fusconaia subrotunda*), Version 1.4. Asheville Ecological Services Field Office, Asheville, NC.

U.S. Fish and Wildlife Service. 2019a. Clubshell (*Pleurobema clava*): 5 Year Review: Summary and Evaluation. State College, Pennsylvania.

U.S. Fish and Wildlife Service. 2019b. Fanshell (*Cyprogenia stegaria*): 5 Year Review: Summary and Evaluation. Frankfort, Kentucky.

U.S. Fish and Wildlife Service. 2019c. Northern Riffleshell (*Epioblasma torulosa rangiana*): 5 Year Review: Summary and Evaluation. State College, Pennsylvania.

U.S. Fish and Wildlife Service. 2019d. Pink Mucket (*Lampsilis abrupta*): 5 Year Review: Summary and Evaluation. Asheville, North Carolina.

U.S. Fish and Wildlife Service. 2019e. Species Status Assessment Report for the Round Hickorynut Mussel (*Obovaria subrotunda*), Version 1.1. Asheville Ecological Services Field Office, Asheville, NC.

U.S. Fish and Wildlife Service. 2020a. Biological opinion for Ingram Barge Company; Barge Fleeting Facility; Massac County, Illinois and McCracken County, Kentucky. Frankfort, Kentucky.

U.S. Fish and Wildlife Service. 2020b. Diamond Darter (*Crystallaria cincotta*): 5 Year Review: Summary and Evaluation. Davis, West Virginia.

U.S. Fish and Wildlife Service. 2022a. Species Status Assessment Report for the Rayed Bean (*Vilosa fabalis*), Version 1.0. Minneapolis, Minnesota.

U.S. Fish and Wildlife Service. 2022b. Species status assessment report for the snuffbox (Epioblasma triquetra). May 2022 (Version 1.0). Ohio Ecological Services Field Office, Columbus, OH.

Watters, G.T. 1988. A survey of the freshwater mussels of the St. Joseph River system, with emphasis on the federally endangered white cat's paw pearly mussel. Indiana Department of Natural Resources, West Lafayette.

Weaver, L.R., G.B. Pardue, and R.J. Neves. 1991. Reproductive biology and fish hosts of the Tennessee clubshell Pleurobema oviforme (Mollusca: Unionidae) in Virginia. The American Midland Naturalist 126:82-89.

West, E.L., J.L. Metcalfe-Smith, and S.K. Staton. 2000. Status of the rayed bean, *Villosa fabalis* (Bivalvia: Unionidae), in Ontario and Canada. Canadian Field-Naturalist 114:248-258.

Welsh, S.A. and R.M. Wood. 2008. *Cystallaria cincotta*, a new species of darter (Teleostei: Percidae) from the Elk River of the Ohio River drainage, West Virginia. Zootaxa 1680:62-68.

Welsh, S.A., R.M. Wood, and K.R. Sheehan. 2008. Threatened fishes of the world: Crystallaria cincotta. Environmental Biology of Fishes August, 2008.

Welsh, S.A. 2009. U.S. Geological Survey, West Virginia Cooperative Fish and Wildlife Unit. Email to Barbara Douglas, U.S. Fish and Wildlife Service, West Virginia Field Office, dated 15 July 2009.

Welsh, S.A., D.M. Smith, N.D. Taylor. 2012. Habitat use of the diamond darter. Project Report Submitted to West Virginia Division of Natural Resources. Elkins, West Virginia.

Welsh, S.A., D.M. Smith, and N.D. Taylor. 2013. Microhabitat use of the diamond darter. Ecology of Freshwater Fish 22:587–595.

Welsh, S.A., A.A. Rizzo, and P.A. Thompson. 2014. Distribution and abundance of the Diamond Darter in the Elk River, West Virginia. Report prepared for the West Virginia Division of Natural Resources, Elkins, WV.

Welsh, S. 2022. U.S. Geological Survey, West Virginia Cooperative Fish and Wildlife Unit. Email to Tiernan Ware, U.S. Fish and Wildlife Service, West Virginia Field Office, dated 18 January 2022.

West Virginia Department of Environmental Protection (WVDEP). 1997. An Ecological Assessment of the Elk River Watershed. Charleston, WV.

West Virginia Division of Natural Resources (WVDNR). 2021. Follow up and update for Diamond Darter (*Crystallaria cincotta*) nocturnal spotlight surveys. Report to U.S. Fish and Wildlife Service, West Virginia Field Office, Davis, West Virginia.

Whitman, R.L. and W.J. Clark. 1982. Availability of dissolved oxygen in interstitial waters of a sandy creek. Hydrobiologia 92:651-658.

Wood, P.J., and P.D. Armitage. 1997. Biological Effects of Fine Sediment in the Lotic Environment. Environmental Management 21:203-217.

Wynes, D.L. and T.E. Wissing. 1981. Effects of water quality on fish and macroinvertebrate communities of the Little Miami River. Ohio Journal of Science 81:259-267.

Woolnough, D.A. 2002. Life history of endangered freshwater mussels of the Sydenham River, southwestern Ontario, Canada. M.S. thesis, University of Guelph, Guelph, Ontario, Canada.

Zale, A.V. and R..J. Neves. 1982. Reproductive biology of four freshwater mussel species (Mollusca: Unionidae) in Virginia. Freshwater Invertebrate Biology 1:17-28.

Appendix A. CONSULTATION HISTORY

August 23, 2021 – The WVFO received the mussel survey plan for the project.

September 9, 2021 – The WVFO approved the mussel survey plan.

October 6, 2021– Listed freshwater mussels were found during the mussel survey.

October 28, 2021 – The Corps requested biological assessment and biological opinion examples any other relevant resources from the WVFO.

November 10, 2021 – The WVFO responded the Corps October 28, 2021, request via email.

December 12, 2021 – The WVFO received the mussel survey report.

December 8, 2022 – The WVFO received an email confirming that in-stream work was required for this project.

June 1, 2023 – The WVFO, Corps and the WVDNR had a meeting to discuss the project and biological assessment development.

February 26, 2024 – The Corps submitted a request for formal consultation and the biological assessment to the WVFO.