Boulder Darter
(Etheostoma wapiti)

5-Year Review:
Summary and Evaluation

Boulder darter

Boulder darter habitat in Shoal Creek

U.S. Fish and Wildlife Service
Southeast Region
Cookeville Ecological Services Field Office
Cookeville, Tennessee

5-YEAR REVIEW

Boulder Darter/*Etheostoma wapiti*

Please refer to Appendix B to see our evaluation of new information for our completed second 5-year review for the boulder darter.

I. GENERAL INFORMATION

A. Methodology used to complete the review: In conducting this 5-year review, we relied on available information pertaining to historic and current distribution, life history, and habitat of this species. Our sources include the final rule listing this species under the Endangered Species Act; the Recovery Plan; peer reviewed scientific publications; unpublished field observations by Service, State and other experienced biologists; unpublished survey reports; and notes and communications from other qualified biologists or experts. A *Federal Register* notice announcing the review and requesting information was published on July 28, 2006 (71 FR 42871). Comments received and suggestions from peer reviewers were evaluated and incorporated as appropriate (see Appendix A). No part of this review was contracted to an outside party. This review was completed by the Service's lead Recovery biologist in the Cookeville Field Office, Tennessee.

B. Reviewers

Lead Region – Southeast Region: Kelly Bibb, 404-679-7132

Lead Field Office – Cookeville, Tennessee, Ecological Services Field Office: Stephanie Chance, 931-528-6481

Cooperating Field Office – Daphne, Alabama, Ecological Services Field Office: Jeff Powell, 251-441-5181

C. Background

1. Federal Register Notice citation announcing initiation of this review: July 28, 2006, 71 FR 42871

2. Species status: Uncertain, 2009 Recovery Data Call. In 2007, CFI collected boulder darters below Harms Mill on the Elk River in order to obtain broodstock for Shoal Creek reintroduction efforts. Although this collection was successful, no population estimates were conducted due to difficulties snorkeling in the Elk River. In 2008, CFI failed to locate boulder darters in surveys conducted below the release site in Shoal Creek. After four years of boulder darter reintroduction efforts into Shoal Creek, CFI noted a total of 19 fish of three age-classes, including young-of-year boulder darters in three surveys conducted during 2008 near the release site in Shoal Creek. This would indicate that successful reproduction is occurring. However, it remains too early to draw conclusions regarding the overall success of these reintroduction efforts.

3. Recovery achieved: 2 (2 = 26-50% recovery objectives achieved)

4. Listing history
Original Listing
FR notice: 53 FR 33996
Date listed: September 1, 1988
Entity listed: Species
Classification: Endangered

5. Associated rulemakings:
April 8, 2005. Establishment of a Nonessential Experimental Population for Two Fishes (Boulder Darter and Spotfin Chub) in Shoal Creek, Tennessee and Alabama. 70 FR 17916.

6. Review History:
Recovery Data Call: 2009, 2008, 2007, 2006, 2005, 2004, 2003, 2002, 2001, 2000, 1999, and 1998
Final Recovery Plan: July 27, 1989

7. Species' Recovery Priority Number at start of review (48 FR 43098):
5 (high degree of threat/low recovery potential)

8. Recovery Plan
Name of plan: Recovery Plan for Boulder Darter (Etheostoma sp.)
Date issued: July 27, 1989

II. REVIEW ANALYSIS

A. Application of the 1996 Distinct Population Segment (DPS) policy

1. Is the species under review listed as a DPS? No.

2. Is there relevant new information that would lead you to consider listing this species as a DPS in accordance with the 1996 policy? No

B. Recovery Criteria

1. Does the species have a final, approved recovery plan containing objective, measurable criteria? Yes

2. Adequacy of recovery criteria.

a. Do the recovery criteria reflect the best available and most up-to-date information on the biology of the species and its habitat? Yes

b. **Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria?** Yes
The recovery criteria do take into account the 5 listing factors.

3. **List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information.**

Reclassification to threatened status would be considered when:

1) Through protection of the existing population in the Elk River and its tributaries and successful establishment of a reintroduced population in Shoal Creek or other historic habitat, or by discovery of an additional population, two distinct viable populations exist.

Viable Population – A reproducing population that is large enough to maintain sufficient genetic variation to enable it to evolve and respond to natural habitat changes. The number of individuals needed and the amount and quality of habitat required to meet this criterion will be determined for the species as one of the recovery tasks.

This criterion has not been met.

Elk River
When listed in 1988, boulder darters were known from only about ten isolated localities in some 60 miles (mi) (96 kilometers (km)) of the Elk River in Giles and Lincoln counties, Tennessee, and Limestone County, Alabama, and the extreme lower ends of Richland Creek and Indian Creek, Giles County, Tennessee (USFWS 1989). The historic collections from these localities document fewer than 100 boulder darters in the Elk River system prior to 1990. Conservation Fisheries, Inc. (CFI) collection efforts from 1993 to 1997 produced only 11 additional specimens from Hamilton Mill and a new site, the Interstate 65 Bridge (Rakes and Shute 2001). Between 1998 and 2000, CFI observed boulder darters at two additional sites, below Harms Mill and at Hobbs Bridge (Rakes and Shute 2001).

In 1993, CFI began developing techniques for captive propagation of the boulder darter, using the bloodfin darter (*Etheostoma sanguifluum*) as a surrogate. The Service, Tennessee Wildlife Resources Agency (TWRA), and Tennessee Valley Authority (TVA) cooperated in a project to reintroduce the boulder darter into sections of the Elk River where it was no longer found (Rakes et al. 1999). CFI's methods used for captive breeding, husbandry, and rearing of young boulder darters are described in Rakes et al. (1999) and Rakes and Shute (2005; 2008).

Between 1997 and 2003, CFI released a total of 2,264 propagated boulder darters into 4 sites in the Elk River (Rakes et al. 1998, 2000; Rakes and Shute 2001, 2002a, 2003, and 2004) (see Table 1).

Table 1. Number of propagated boulder darters released by CFI into 4 sites in the Elk River, Tennessee (Rakes et al. 1998, 2000; Rakes and Shute 2001, 2002a, 2003, and 2004).

Year	TWRA/Frito Lay Access	Hamilton Mill	I-65 Bridge	Hwy 231/431 Bridge
2003	280			
2002	219	153	200	157
2001	265	180		300
2000			104	186
1999			100	
1998				
1997		120		
Total	764	453	404	643

Conservation Fisheries, Inc. surveys from 1997 to 2007 indicate that boulder darters are apparently still present at all locations with suitable habitat, in the mainstem Elk River, albeit in low numbers (CFI, field notes). CFI observed boulder darters at three new localities, expanding the distribution known at the time the recovery plan was written: below Harms Mill, at Hobbs Bridge, and at a shoal well above the I-65 Bridge (Rakes and Shute 2001). Between 1997 and 2007, CFI observed only 93 boulder darters in the Elk River (many were propagated individuals found at release sites), with catch rates (fish per person hour) ranging from 0 to 6.5 (CFI, field notes; Rakes and Shute 2004). Surveys from 2000 to the present were only conducted at the 4 sites where propagated individuals were released (see Table 1), except for 1 additional site in 2005 (CFI, field notes). The TWRA/Frito Lay Access, just upstream from Fayetteville, Tennessee, is the upstream extent of the boulder darter's current known range. Shepard et al. (2006) collected boulder darters between Elk River miles 17 and 33 in 2004-2006. These collections included adult specimens that were collected while boat electrofishing along rock bluffs in deepwater habitats with slabrock in the transition area between the Elk River and Wheeler Reservoir (Shepard et al. 2006).

Conservation Fisheries, Inc. did not conduct boulder darter sampling in the Elk River in 2004 due to rain events from hurricanes (Rakes and Shute 2005). Likewise, high water levels prevented sampling in 2006 (Rakes and Shute 2007). In 2007, CFI collected boulder darters below Harms Mill to obtain broodstock with the purpose of propagating individuals for Shoal Creek reintroduction efforts. However, no population estimates were made. Thorough surveys of previously monitored locations in the Elk River are needed to determine the current distribution and population estimates for this species. However, monitoring conditions are less than ideal in the Elk River due to fluctuations in flows from Tims Ford Dam. Snorkel surveys are also difficult to conduct in the Elk River due to low visibility in the water column from high suspended sediment levels (Rakes and Shute 2002b).

Aside from Richland Creek, boulder darters appear to be absent, or present in such low numbers as to be undetectable, in all Elk River tributaries (CFI, field notes). CFI's

propagation efforts suggest that nearly all tributaries to the Elk River are too small to support reproducing populations of this species except in the lowest reaches (Rakes and Shute 2001). Boulder darter larvae are pelagic feeders, which probably require gently flowing pools in sufficiently large streams to provide drifting zooplankton prey. Only the lower few miles of Richland Creek appear to be large enough to provide these gently flowing pools (Rakes and Shute 2001). Boulder darters have not been found during TVA routine monitoring efforts in Indian Creek (Amy Wales, TVA, personal communication, 2008). In 2004, two boulder darters were found at the mouth of Shoal Creek just upstream of the embayment of Wheeler Reservoir, representing a new tributary record for the species (Shepard et al. 2006). Additional specimens were found in 2005 and 2006 (Shepard et al. 2006). Shepard et al. (2006) speculated that these Shoal Creek specimens represent a reproducing population because they are separated by the Elk River by the Wheeler Reservoir embayment.

Shoal Creek (Tennessee River tributary)

In 1999, CFI conducted field assays in Shoal Creek in an effort to locate suitable habitat for possible reintroductions. Habitat that appeared suitable for boulder darters was observed to be relatively common in portions of the middle and lower reaches of Shoal Creek. Water quality, habitat quality and quantity, and lack of sedimentation all appeared to be far superior in Shoal Creek when compared with the Elk River. An even more significant factor is that Shoal Creek, unlike the Elk River, is not subject to the flow and temperature impacts of a tailwater stream below a reservoir. In 2005, the Service designated a portion of Shoal Creek from creek mile 41.7 (66.7 km) downstream to creek mile 14 (22 km) (Lauderdale County, Alabama and Lawrence County, Tennessee) as a nonessential experimental population (NEP) (USFWS 2005). The NEP allows reintroduction of the boulder darter into this portion of its historical range (USFWS 2005). CFI's methods used for captive breeding, husbandry, and rearing of young boulder darters are described in Rakes et al. (1999) and Rakes and Shute (2005; 2008).

Since 2005, CFI has stocked 1,593 propagated boulder darters into Shoal Creek near Iron City, Tennessee (Rakes and Shute 2008). In September 2007, fourteen adult boulder darters were observed in the release area. Seven adult boulder darters were sampled at this location in early August 2009. It is assumed that all or a portion of the fish sampled were wild progeny of previous stocked boulder darters (Pat Rakes, CFI, personal communication, 2009). Additional surveys of Shoal Creek will be conducted to better determine the over-wintering survivorship, downstream dispersal, natural reproduction and recruitment success of these fish.

Recovery Task 1.3.5. Determine number of individuals to maintain a viable population.

This recovery task has not been completed. Given the rarity of this species, and the continued threat from current Tims Ford Reservoir operations, the Elk River boulder darter population is likely not demographically viable. Current status and genetic assessments are needed to determine the species' abundance, genetic viability, and population trends. (See section III.C.2. for further discussion on threats to the Elk River population). The presumed small population size and apparently fragmented distribution

of individuals in the Elk River leaves the boulder darter vulnerable to heightened risk of reductions in genetic variation through the processes of inbreeding and random genetic drift.

2) Studies of the fish's biological and ecological requirements have been completed, and the implementation of management strategies developed from these studies have been or are likely to be successful.

This criterion has been partially met. In a laboratory study, Burkhead and Williams (1992) found that spawning habitat consists of boulders in flowing water with a velocity of about 1 to 2 feet (ft) (0.3 to 0.6 meters (m)) per second. Burkhead and Williams (1992) stated that nesting sites must have the following specific attributes: 1) the space must be between boulders, not between a boulder and gravel or a boulder and pieces of rubble, although a space created between a boulder and bedrock might be acceptable; 2) it must have a wedge-shaped configuration, with the two boulders touching at a relative narrow angle, creating a space into which the female wedges her eggs; 3) the site must have current flowing across it; 4) the cavity must be roughly horizontal (no vertical or nearly vertical spaces were selected); and 5) the boulders must not only be in the correct depth and current ranges, but they must also occur in a certain configuration relative to the current and to each other.

As a result of this research, the TWRA began constructing artificial spawning structures to enhance existing habitat in the Elk River. In September 1996, 54 structures were placed below Hamilton Mill in Lincoln County, Tennessee. The structures were inspected in May 1997, and no boulder darters were observed. In September 1997, 175 more structures were installed at Hamilton Mill for a total of 229; and 98 structures were placed at the I-65 Bridge in Giles County, Tennessee. Many of the structures placed at the site in 1996 could not be relocated, and approximately half of those that were relocated were clogged with sediment and debris (Rakes et al. 1998). While 3 other fish species were found near the structures, the 7 boulder darters located during the 1997 surveys were found in association with natural slabrocks and were not observed near the structures (Rakes et al. 1998). However, according to CFI, the most important habitat requirement for boulder darters is open cavities for cover and spawning sites in areas with at least moderate velocity (Rakes and Shute 1999).

Between 1998 and 2000, CFI conducted surveys to determine the status of existing populations and to locate habitat suitable for reintroduction and augmentation efforts in the Elk River (Rakes and Shute 2002b). Boulder darter populations were found wherever there was available habitat; however, appropriate habitat was sparse in the Elk River (Rakes and Shute 2002b). These efforts supported earlier conclusions that spawning habitat enhancements would benefit the boulder darter; however, CFI hypothesized that natural slabrocks would be more successful (Rakes and Shute 2002b).

In 1999, the Service, TWRA, and CFI placed 3.5 tons of natural limestone slabrock in the Elk River at the I-65 Bridge crossing adjacent to the remaining TWRA artificial spawning structures which did not appear to be providing habitat for the boulder darter.

In 2001, the Service, TWRA, CFI, and International Paper (IP) placed 18 tons of limestone slabrock in the river at the Highway 231/431 Bridge in Fayetteville and 23 tons at Hamilton Mill. In 2000, CFI conducted surveys near the I-65 Bridge site and collected 16 boulder darters, the greatest number seen in a single survey since the late 1980s (Rakes and Shute 2002b). CFI noted that most of these boulder darters were found beneath slabrock that had been placed in the river in 1999 (Rakes and Shute 2002b). Snorkel surveys conducted in 2003 at the Highway 231/431 Bridge revealed that none of the slabrocks added to the river to augment habitat were visible; the rocks were now buried by shifting gravel substrates (Rakes and Shute 2004). However, almost all monitoring attempts from 2001 to 2004 were hindered due to low visibility conditions. (Surveys were only attempted at the 4 sites included in Table 1). Elk River conditions are seldom suitable for snorkeling, the most effective monitoring technique for boulder darters (Rakes and Shute 2003). Late summer and fall are the optimal times of the year for conducting snorkel surveys, as agriculture and livestock impacts decrease and water clarity improves (Rakes and Shute 2002a). Therefore, no conclusions can be made about the effectiveness of adding slabrock habitat to the Elk River. What little monitoring has been done indicates that the slabrock was buried by sediments or washed downstream during flood events and no longer provides habitat for the boulder darters.

Based on laboratory and field observations, CFI determined that water depth is not a critical factor in the boulder darter's preferred habitat (Rakes and Shute 1999). CFI collected adults and sub adults from the Elk River in less than 12 inches (in) (30.5 centimeters (cm)) of water and at low velocities (Rakes and Shute 1999); while others had only observed them in greater than 2 ft (0.61 m) of water (O'Bara and Etnier 1987; Etnier and Williams 1989).

In 2000, CFI determined that elastomer tags were an effective method for tagging boulder darters (Rakes and Shute 2002b). They did not observe mortality with the elastomer tags, but they observed a high mortality rate with acrylic tags.

CFI developed methods currently in use for captive breeding, husbandry, and rearing of young boulder darters; these are described in Rakes et al. (1999) and Rakes and Shute (2005; 2008). Boulder darters exhibit breeding color when water temperatures reach 64.4-73.4 °F (18-23 °C), usually beginning in April (Rakes et al. 1999; Rakes and Shute 2002a). Females cluster eggs in crevices, as described above, and yolk-sac larvae alternate swimming with resting on the bottom for a day or two (Rakes et al. 1999; Pat Rakes, CFI, personal communication, 2009). The larvae become fully pelagic when their yolk-sac is absorbed and they begin feeding (Pat Rakes, CFI, pers. comm., 2009). Larvae feed at the top and in the water column, unlike other darter species. These pelagic larvae eat a variety of plankton (Rakes et al. 2000).

Removal from the endangered species list would be considered when:

1) Through protection of the existing population and successful establishment of reintroduced populations or discovery of additional populations, three distinct viable populations exist. The existing Elk River population, including the two tributary segments, must be secure from river mile 90 downstream to river mile 30.

This criterion has not been met. See reclassification criterion discussions above.

2) Studies of the fish's biological and ecological requirements have been completed, and the implementation of management strategies developed from these studies has been successful.

This criterion has not been met. See reclassification criterion discussions above.

3) No foreseeable threats exist that would likely threaten survival of any of the populations.

This criterion has not been met. See Section III.C.2.

C. Updated Information and Current Species Status

1. Biology and Habitat

a. Abundance, population trends (e.g. increasing, decreasing, stable), demographic features (e.g., age structure, sex ratio, family size, birth rate, age at mortality, mortality rate, etc.), or demographic trends:
Thorough population monitoring has not been conducted since 1999 (Rakes and Shute 2001). Therefore, boulder darter abundance, population trends, and demographic trends are unknown. However, monitoring efforts associated with the release of captive propagated individuals at specific locations in the Elk River have verified the continued existence of the boulder darter at these locations and have resulted in the successful collection of individuals for broodstock (Rakes and Shute 2008, CFI field notes).

b. Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding, etc.):
The phylogeny of the boulder darter, and other species in the subgenus *Nothonotus*, is described in Etnier and Williams (1989). There have been no further genetic analyses conducted on the boulder darter since the Recovery Plan was written in 1989. However, species such as the boulder darter, that are restricted in range and population size, are more likely to suffer loss of genetic diversity due to genetic drift, potentially increasing their susceptibility to inbreeding depression and decreasing their ability to adapt to environmental changes (Allendorf and Luikart 2007).

c. Taxonomic classification or changes in nomenclature:
Etheostoma wapiti Etnier and Williams, 1989 is the recognized classification of the boulder darter (Nelson et al. 2004). The species was recognized as *Etheostoma* sp. at the time the Recovery Plan was written in 1989.

d. Spatial distribution, trends in spatial distribution (e.g. increasingly fragmented, increased numbers of corridors, etc.), or historic range (e.g. corrections to the historical range, change in distribution of the species' within its historic range, etc.):

CFI has identified three new sites within the boulder darter's current range since the recovery plan was written and the Geological Survey of Alabama has found a potentially reproducing population in Shoal Creek (see Reclassification Criterion 1, on pages 5-6).

e. Habitat or ecosystem conditions (e.g., amount, distribution, and suitability of the habitat or ecosystem):

In 2005, TVA initiated formal consultation with the Service regarding routine operation and maintenance of TVA's water control structures. As a result of this consultation, concluded in 2006, TVA agreed to modify operations at Tims Ford Dam in an attempt to more closely simulate natural flow regimes and to warm water temperatures downstream from the dam. TVA is using an adaptive management process to determine which combination of sluicing, spilling, and hydropower generation at Tims Ford Dam will produce the desired flow and temperature conditions for the boulder darter. This process is ongoing, but is expected to improve habitat conditions for the boulder darter in the entire 133 mile tailwater. In addition, the changes in operations at Tims Ford Dam are anticipated to provide 30 miles of additional habitat to the boulder darter by warming temperatures from Fayetteville upstream to Beans Creek, allowing the darter to expand its current range.

2. Five-Factor Analysis (threats, conservation measures, and regulatory mechanisms)

a. Present or threatened destruction, modification or curtailment of its habitat or range:
As indicated in the Recovery Plan (USFWS 1989), toxic chemical spills, siltation, improper pesticide use, and cold water releases from Tims Ford Reservoir remain threats to the boulder darter. Additional threats to the boulder darter include gravel dredging and agricultural practices.

Other threats to the boulder darter include physical habitat destruction resulting from a variety of human-induced impacts such as siltation, disturbance of riparian

corridors, and changes in channel morphology. The most significant of these impacts is siltation caused by excessive releases of sediment from activities such as agriculture, resource extraction (e.g., coal mining, silviculture), road construction, and urban development (Waters 1995). Another possible contributor to sediment in the Elk River is bank sloughing due to hydropower peaking operations at Tims Ford Dam and the resultant wet-dry cycle on stream bank soils. Activities that contribute sediment discharges into a stream system change the erosion or sedimentation pattern, which can lead to the destruction of riparian vegetation, bank collapse, excessive instream sediment deposition, and increased water turbidity and temperatures. Sediment has been shown to abrade and or suffocate bottom-dwelling algae and other organisms by clogging gills; reducing aquatic insect diversity and abundance; impairing fish feeding behavior by altering prey base and reducing visibility of prey; impairing reproduction due to burial of nests; and, ultimately, negatively impacting fish growth, survival, and reproduction (Waters 1995). Wood and Armitage (1997) identified at least five impacts of sedimentation on fish, including (1) reduction of growth rate, disease tolerance, and gill function; (2) reduction of spawning habitat and egg, larvae, and juvenile development; (3) modification of migration patterns; (4) reduction of food availability through the blockage of primary production; and (5) reduction of foraging efficiency. The effects of these types of threats will likely increase as human populations grow in the Elk River and Shoal Creek watersheds in response to human demands for housing, transportation, and places of employment.

Non-point source pollution from land surface runoff can originate from virtually any land use activity and may be correlated with impervious surfaces and storm water runoff. Pollutants may include sediments, fertilizers, herbicides, pesticides, animal wastes, septic tank and gray water leakage, and petroleum products. These pollutants tend to increase concentrations of nutrients and toxins in the water and alter the chemistry of affected streams such that the habitat and food sources for species like the boulder darter are negatively impacted. Construction and road maintenance activities associated with urban development typically involve earth-moving activities that increase sediment loads into nearby streams. Other siltation sources, including timber harvesting, clearing of riparian vegetation, and mining and agricultural practices, allow exposed earth to enter streams during or after precipitation events.

The TVA (John Baxter, TVA, pers. comm., 2009) indicated that they are receiving an increasing number of 26a permit requests for water withdrawals in the Elk River and Richland Creek, Giles and Lincoln counties, Tennessee. Water withdrawals might be an increasing threat in the Elk River if global climate change results in an increase in the occurrence and severity of drought in the Southeast.

b. Overutilization for commercial, recreational, scientific, or educational purposes:
Overutilization is not known to be a factor in the decline of this species.

c. Disease or predation:
Disease and predation are not known to be factors in the decline of this species.

d. Inadequacy of existing regulatory mechanisms:
The boulder darter and its habitats are afforded limited protection from water quality degradation under the Clean Water Act of 1977 (33 U.S.C. 1251 et seq.) and the Tennessee Water Quality Control Act of 1977. These laws focus on point-source discharges, and many water quality problems are the result of non-point source discharges. Therefore, these laws and corresponding regulations have been inadequate to halt population declines and degradation of habitat for the boulder darter.

In addition to the Federal listing, the boulder darter is listed as Endangered by the State of Tennessee. Under the Tennessee Nongame and Endangered or Threatened Wildlife Species Conservation Act of 1974 (Tennessee Code Annotated §§ 70-8-101-112), "...it is unlawful for any person to take, attempt to take, possess, transport, export, process, sell or offer for sale or ship nongame wildlife, or for any common or contract carrier knowingly to transport or receive for shipment nongame wildlife." Further, regulations included in the Tennessee Wildlife Resources Commission Proclamation 00-15 Endangered Or Threatened Species state the following: except as provided for in Tennessee Code Annotated, Section 70-8-106 (d) and (e), it shall be unlawful for any person to take, harass, or destroy wildlife listed as threatened or endangered or otherwise to violate terms of Section 70-8-105 (c) or to destroy knowingly the habitat of such species without due consideration of alternatives for the welfare of the species listed in (1) of this proclamation, or (2) the United States list of Endangered fauna. Potential collectors of this species would be required to have a state collection permit.

Since listing, section 7 of the Act has required Federal agencies to consult with the Service when projects they fund, authorize, or carry out may affect the species. However, the lack of Federal authority over the many actions likely impacting boulder darter habitat has become apparent. Many of the threats (including those identified at the time of listing, during recovery planning, and since development of the Recovery Plan) involve activities that likely do not have a Federal nexus (such as water quality changes resulting from development, water withdrawals, or indiscriminate logging) and, thus, may not result in section 7 consultation. Although the take prohibitions of section 9 of the Act do apply to these types of activities and their effects on the boulder darter, enforcement of the section 9 prohibitions is difficult, at best. The Service is not informed

when many activities are being considered, planned, or implemented; therefore, we have no opportunity to provide input into the design of the project or to inform project proponents of the need for a section 10 permit. Unlike higher profile species, conservation of the boulder darter is not valued by most of the public to the extent that citizens would report to the Service the likelihood of habitat destruction or illegal taking. A non-regulatory approach to providing for conservation of the boulder darter may be most effective in alleviating threats and providing for conservation of the fish.

Portions of the Elk River and its tributaries are listed as impaired by the State of Tennessee due to *Escherichia coli*, siltation, physical substrate alterations, flow alteration, low DO, alteration of stream-side vegetative cover, nutrient levels, and thermal modifications (Tennessee Department of Environment and Conservation (TDEC) 2008a). State and federal water quality laws have not been used to their full potential in preventing pollution from agricultural, municipal, and industrial sources. Major sources of pollution in the Elk River basin include pasture grazing, upstream impoundment, industrial and municipal point-source discharges, sand and gravel mining, nonirrigated crop production, and off-road vehicles (TDEC 2008a). However, TDEC is currently developing nutrient Total Maximum Daily Loads (TMDL) for the Upper and Lower Elk River watersheds. As a part of the TMDL process, TDEC will determine the sources and extent of nutrient impairment, quantify nutrient loadings and source contributions, and develop cause and effect relationships between nutrient loadings and response parameters in the Elk River basin (TDEC 2008b).

In the 1990's, the Service met with TVA to discuss cold-water releases from Tims Ford Dam and their effects on boulder darters in the Elk River. In 1993, TVA installed a liquid oxygen diffuser system into Tims Ford Reservoir to maintain a target DO (dissolved oxygen) level of 6 milligrams per liter (mg/L) (2.7 pounds per acre foot of water (lbs./acre ft)) in Tims Ford tailwater (Scott et al. 1996). Fish diversity did not change from 1993 to 1995 below the dam, and although physical habitat was present along with increased DO levels, fluctuations in flows along with subsequent changes in water velocity and temperature were thought to hinder establishment of a diverse fish community (Scott et al. 1996).

In 2005, TVA initiated formal consultation with the Service regarding routine operation and maintenance of TVA's water control structures. As a result of this consultation, concluded in 2006, TVA agreed to modify operations at Tims Ford Dam in an attempt to more closely simulate natural flow regimes and to warm water temperatures downstream from the dam. TVA is using an adaptive management process to determine which combination of sluicing, spilling, and hydropower generation at Tims Ford Dam will produce the desired flow and temperature conditions for the boulder darter. This process is ongoing, but is expected to improve habitat conditions for the boulder darter in the entire 133 mile tailwater. In addition, the changes in operations at Tims Ford Dam are

anticipated to provide 30 miles of additional habitat to the boulder darter by warming temperatures from Fayetteville upstream to Beans Creek, allowing the darter to expand its current range.

e. Other natural or manmade factors affecting its continued existence: The boulder darter's limited geographic range and apparent small population size leaves the species extremely vulnerable to localized extinctions from accidental toxic chemical spills or other stochastic disturbances and to decreased fitness from reduced genetic diversity. Potential sources of such spills include potential accidents involving vehicles transporting chemicals over road crossings of streams inhabited by boulder darter and accidental or intentional release into streams of chemicals used in agricultural or residential applications. Species that are restricted in range and population size are more likely to suffer loss of genetic diversity due to genetic drift, potentially increasing their susceptibility to inbreeding depression and decreasing their ability to adapt to environmental changes (Allendorf and Luikart 2007).

D. Synthesis

When listed in 1988, boulder darters were known from only about ten isolated localities in some 60 mi (96 km) of the Elk River in Giles and Lincoln counties, Tennessee, and Limestone County, Alabama, and the extreme lower ends of Richland Creek and Indian Creek, Giles County, Tennessee. Between 1998 and 2000, CFI observed boulder darters at three new sites in the Elk River. Recent surveys conducted by CFI and TVA indicate that boulder darters are still present at all locations with suitable habitat in the mainstem Elk River and in Richland Creek; however, there are no recent records of the species in Indian Creek. Since 2005, CFI has conducted annual stocking of captive propagated boulder darters into Shoal Creek. However, overwintering survival is unknown and there has been no evidence of natural reproduction or recruitment. As indicated in the Recovery Plan (USFWS 1989), toxic chemical spills, siltation, improper pesticide use, and cold water releases from Tims Ford Reservoir remain threats to the boulder darter. Additional threats to the boulder darter include gravel dredging and agricultural practices.

Due to its limited distribution, unknown population trends, and continued threats, the boulder darter continues to be in danger of extinction throughout its range. Therefore, the status of the boulder darter listed as endangered remains appropriate.

Although TVA is currently implementing operational changes at Tims Ford Reservoir, the adaptive management process is experimental and the probability of success is uncertain. The boulder darter has been successfully propagated; however, the threat of Tims Ford Reservoir operations has prevented the successful reintroduction and recovery of this species in the Elk River. The recovery priority number for the boulder darter should remain 5, as the degree of threat remains high and the potential for recovery remains low.

III. RESULTS

A. Recommended Classification:

__X__ **No change is needed**

IV. RECOMMENDATIONS FOR FUTURE ACTIONS -

- Develop population monitoring techniques that will be effective in the Elk River. According to Rakes and Shute (2002), late summer and fall are the optimal times of year for conducting snorkel surveys, as agricultural impacts decrease and water clarity improves. Monitoring conditions, especially for snorkeling, are less than ideal in the Elk River due to fluctuations in flows from Tims Ford Dam. Initiate a long-term monitoring program in the Elk River and Shoal Creek to observe population levels/trends and habitat conditions of presently established populations as well as reintroduced and expanding populations.

- Determine demographic viability of the boulder darter in the Elk River and assess the short-term feasibility of continued propagation and reintroduction efforts in the Shoal Creek NEP. Assess need for additional captive propagation and augmentation efforts in the Elk River. Review available population genetics data to determine whether they provide a sufficient basis for developing a broodstock management plan. Conduct additional genetics studies as necessary.

- Continue the adaptive management process of implementing operational changes at Tims Ford Reservoir that TVA initiated in 2008. Monitor progress of boulder darter dispersal upstream of Fayetteville with releases of warmer water temperatures from Tims Ford Dam.

- Assess additional sites in the Elk River within the species' historic range to determine the availability and location of suitable augmentation sites for future recovery efforts (as needed).

- Determine feasibility of additional habitat improvement activities in the Elk River. In the mid- 1990s, the TWRA, Service, CFI, IP, and other partners attempted to augment spawning structures (i.e., man-made structures and natural slabrocks) in the Elk River. However, monitoring conducted after placement in the river, indicates that the slabrock and man-made structures were buried by sediments or washed downstream during flood events and no longer provided habitat for boulder darters.

- Continue to utilize existing legislation and regulations (Federal and State endangered species laws, water quality requirements, stream alteration regulations, etc.) to protect the species and its habitat.

- Continue efforts to reduce non-point pollution from agricultural activities by working through the Partners for Fish and Wildlife, USDA Farm Bill, and other landowner incentive programs to implement best management practices.

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of Boulder Darter (*Etheostoma wapiti*)

Current Classification: Endangered
Recommendation resulting from the 5-Year Review

__X__ **No change is needed**

Review Conducted By Stephanie Chance

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve Mary E. Jennings Date 9-8-09

REGIONAL OFFICE APPROVAL:

Acting
Lead Regional Director, Fish and Wildlife Service

Approve Aaron Valdez Date 9-18-09

Appendix A

Summary of peer review for the 5-year review of the Boulder darter (*Etheostoma wapiti*)

A. Peer Review Method: On August 29, 2008, an email was sent to Conservation Fisheries, Inc. (CFI) and biologists from the Tennessee Valley Authority (TVA) Natural Heritage Program asking for peer review of the draft boulder darter 5 year review. These individuals are considered to be species experts.

B. Peer Review Charge: Peer reviewers were asked for scientific peer review of presented data. Peer reviewers were provided with the conclusion that no change in status was warranted for the species, but were not asked for their review of the legal status recommendation.

C. Summary of Peer Review Comments/Report –TVA did not respond back with comments on the review. Conservation Fisheries, Inc. responded that the yolk-sac larvae of boulder darter are not benthic and inactive, but instead alternate between swimming and resting on the bottom before becoming fully pelagic.

D. Response to Peer Review – Based on the comments received from CFI, the yolk-sac larvae information was corrected on page eight of this review.

FY 2017 APPROVAL*

Current Classification: Endangered

Review conducted by: Todd Shaw, Tennessee ESFO

Lead Field Supervisor, Fish and Wildlife Service

Approve Mary E Jennings Date 10/2/17

*In 2014, Southeast Region Field Supervisors were delegated authority to approve 5-year reviews that do not recommend a status change.

Field Supervisor signature on this document reflects:

1. _____ We have no new information, received no new public comments, and the original five factor analysis remains an accurate reflection of the species' current status.
2. __X__ We have obtained a small amount of new information that we have summarized in Appendix B, received no new public comments, and the original five factor analysis remains an accurate reflection of the species' current status.

Lead Field Offices must ensure that all other Field Offices within the range of the species have been provided an adequate opportunity to review and comment prior to the review's completion. If it is concluded that a change in classification is warranted, written concurrence from other Field Offices is required.

Cooperating Field Supervisor, Fish and Wildlife Service

Concur _____ Date 10/4/2017

Not concur_____Date_____

U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW OF Boulder Darter (*Etheostoma wapiti*)

Appendix B. Summary of new information obtained since the 2009 5-Year Review

We initiated a new five-year review for the boulder darter on August 30, 2016 (81 FR 59650-59652). We received no public comments during the comment period. The new information we have gathered in the time since our last five-year review is outlined below along with our current recommendation of status. This completes our review initiated in 2016.

Distribution/Status

Elk River, Alabama and Tennessee

Currently, boulder darters are scattered throughout small areas of suitable habitat over 64 mi (approximately 103 km) of the Elk River from Limestone County, Alabama, upstream through Giles and Lincoln counties, Tennessee. Geological Survey of Alabama (GSA) collected boulder darters from the mainstem Elk River in Limestone County, Alabama, from Elk river mile (ERM) 28 at Gallus Island (the slackwaters of Wheeler Reservoir; their most downstream documented extent) upstream to ERM 32.5 (Fishtrap Ford) on several occasions between 1993 and 2006 (Shepard et al. 2009); while the 2009 5-Year Review indicated that boulder darters occur in Limestone County, Alabama, this stream reach was not specified. 2010 survey efforts included collection of one individual at ERM 91.8 in the vicinity of the Wells Creek confluence near Fayetteville, in Lincoln County, Tennessee (the furthest recorded upstream extent for the species) (Charlie Saylor, personal communication, 2011). TVA has also encountered boulder darters in recent years when conducting Index of Biological Integrity (IBI) surveys and coordinating sampling efforts with CFI at various known occurrence sites in the vicinity of Harms Mill and Fayetteville (approximately ERM 75 to ERM 90).

GSA collected two boulder darters in Shoal Creek, tributary to the Elk River in Limestone County, Alabama, upstream of the embayment of Wheeler Reservoir in 2004; this represented a new tributary record for this species. One additional specimen was collected in the same shoal in 2005 and another one in 2006 (Shepard et al. 2009); this information was previously not included in the 2009 5-Year Review. Therefore, the species is now known to occupy three Elk River tributaries: (1) approximately the lower 2.1 mi of Richland Creek in Giles County, Tennessee, (2) approximately the lower 0.5-mi of Indian Creek in Giles County, Tennessee, and (3) approximately the lower 0.5-mi of Shoal Creek in Limestone County, Alabama.

Tennessee Technological University (TTU) conducted a 2011-2013 study to assess the current status and distribution of 15 darter species in the Elk River, with particular emphasis on boulder darters, and to identify the predominant factors influencing darter occurrence and detection (Potoka et al. 2016). They determined that large-river obligate fish species, including the boulder darter, were 6.92 times more likely to occur for every 37 km (23 mi) increase in distance downstream from Tims Ford Dam. Their study also found that the probability of occurrence for darter species also had a strong negative relationship with the absence of cobble and boulder

substrates and the presence of high silt levels, particularly for species that require boulder substrates during spawning, such as the boulder darter.

Table 1 below includes all boulder darters observed or collected (removed from the population by CFI for brood stock) in the Elk River drainage since 2009.

Table 1. Boulder Darters Surveyed in the Elk River Drainage 2009 – 2017 (Patrick Rakes, personal communication, 2017; Colin Shea, personal communication 2017; Jeff Simmons, personal communication 2017).

Year	Location (Elk River Mile = ERM)	Surveyor(s)	Boulder Darter #	
			Observed	Collected
2009	No surveys conducted			
2010	ERM 31 (Mason Island, Limestone Co., AL)	TVA	2	---
	ERM 49.2 (at I-65 Bridge)	CFI, TVA	11	11
	ERM 77 (downstream of Harm's Mill Dam)	CFI, TVA	7	---
	ERM 88.4 (old dam, upstream of Bearden Mill Bridge)	CFI, TVA	1	---
	ERM 91.8 (vicinity of Wells Creek confluence)	CFI, TVA	1	---
2011	ERM 32.4 (first shoal in TN [Giles County])	TTU	5	---
	ERM 75 (at Cave Spring, North of Molino)	CFI, TVA	2	1
	ERM 77 (downstream of Harm's Mill Dam)	CFI, TVA	12	12
	ERM 77 (downstream of Harm's Mill Dam)	TTU	2	---
	ERM 88.4 (Bearden Bridge)	TTU	2	---
2012	ERM 36.8 (upstream 0.2-mi Veto Bridge)	TTU	3	---
	ERM 49.2 (I-65 Bridge Crossing)	TTU	7	---
	ERM 58.5 (Stone Bluff Bridge)	TTU	2	---
	ERM 63.9 (Hobbs Bridge)	TTU	1	---
	ERM 78.7 (Skunk Shoal)	TTU	1	---
	ERM 82.1 (Sycamore Island)	TTU	1	---
	ERM 91.7 (vicinity of Wells Creek confluence)	TTU	3	---
	Richland Creek (at Tennessee 273 Bridge)	CFI	5	12
2013	ERM 88.4 (Bearden Bridge)	TTU	3	---

2014	ERM 77 (downstream of Harm's Mill Dam)	CFI	39	12
2015	Richland Creek (at Tennessee 273 Bridge)	CFI	---	10
2016	ERM 41.5 (Poplar Hill)	TVA	1	---
	ERM 75 (at Cave Spring, North of Molino)	TVA	1	---
	ERM 77 (downstream of Harm's Mill Dam)	CFI	3	12

Shoal Creek, Alabama and Tennessee

CFI continued reintroduction of boulder darters into Shoal Creek (Tennessee River tributary, Lauderdale County, Alabama). Although successful reproduction and recruitment have been observed in Shoal Creek over quite a few years, data is still too limited, and reintroductions and observed recruitments are still too early to determine that an established, viable population exists in Shoal Creek without more extensive survey efforts (Patrick Rakes, personal communication, 2017). Table 2 below includes all boulder darters stocked and observed in Shoal Creek since 2009.

Table 2. Boulder Darters Stocked and Surveyed in Shoal Creek 2009 – 2017 (Patrick Rakes, personal communication, 2017).

Year	Location (Shoal Creek River Mile = SCRM; Factory Creek River Mile = FCRM)	Stocked #	Observed #
2009	SCRM 25.5 (at Brewers Branch)	835	24
	SCRM 27.8 (pool, downstream unnamed tributary)	447	---
2010	SCRM 22.55 (820 ft upstream of Iron City Bridge)	80	---
	SCRM 23.25 (0.25-mi downstrem unnamed tributary)	84	1
	SCRM 24.4 (long run, upstream Mackey Bluff)	110	1
	SCRM 25.5 (at Brewers Branch)	52	17
2011	SCRM 22.55 (820 ft upstream of Iron City Bridge)	---	1
	SCRM 24.4 (long run, upstream Mackey Bluff)	---	5
	SCRM 25.1 (riffle/run, downstream Brewers Branch)	---	1
	SCRM 25.5 (at Brewers Branch)	---	7
2012	SCRM 20.5 (approximately 1,150 ft into Alabama)	---	1
	SCRM 23.1 (east of Lawrence/Wayne Co. Line)	37	---
	SCRM 23.25 (0.25-mi downstream unnamed tributary)	75	---
	SCRM 24.4 (long run, upstream Mackey Bluff)	75	---
	SCRM 25 (below tributary downstream Brewers Branch)	38	---
	SCRM 25.5 (at Brewers Branch)	153	7
	SCRM 27.8 (pool, downstream unnamed tributary)	165	---
	FCRM 0.6	90	---

2013	SCRM 22.55 (820 ft upstream of Iron City Bridge)	75	---
	SCRM 23.1 (east of Lawrence/Wayne Co. Line)	75	---
	SCRM 24.4 (long run, upstream Mackey Bluff)	75	---
	SCRM 25.5 (at Brewers Branch)	98	5
	SCRM 27.8 (pool, downstream unnamed tributary)	162	3
	SCRM 28.7 (vicinity of Factory Creek mouth)	85	4
	FCRM 1.2 (at Bromley Ford)	188	---
2014	SCRM 25.5 (at Brewers Branch)	---	10
	SCRM 26.5 (upstream of island above Brewers Branch)	---	1
	SCRM 27.8 (pool, downstream unnamed tributary)	114	---
	SCRM 27.95 (downstream of Factory Creek)	359	2
	SCRM 29.05 (riffle/run, upstream of Hardin Ford)	75	---
	SCRM 30.3 (0.75-mi downstream of Clack Branch)	75	---
	SCRM 31.5 (3,000 ft upstream of Clack Branch)	108	---
	SCRM 32.05 (660 ft downstream of Busby Bridge)	90	---
2015	SCRM 18.75 (downstream of Savannah Ford)	---	1
	SCRM 22.3 (downstream of Iron City Bridge)	18	---
	SCRM 25.5 (at Brewers Branch)	407	---
	SCRM 27.8 (pool, downstream unnamed tributary)	170	---
	SCRM 27.95 (downstream of Factory Creek)	198	3
	SCRM 29.05 (riffle/run, upstream of Hardin Ford)	98	---
	SCRM 30.3 (0.75-mi downstream of Clack Branch)	98	---
	SCRM 31.5 (3,000 ft upstream of Clack Branch)	96	1
	SCRM 32.05 (660 ft downstream of Busby Bridge)	101	---
2016	SCRM 25.5 (at Brewers Branch)	215	---
	SCRM 27.8 (pool, downstream unnamed tributary)	114	2
	SCRM 27.95 (downstream of Factory Creek)	86	6
	SCRM 29.05 (riffle/run, upstream of Hardin Ford)	97	---
	SCRM 30.3 (0.75-mi downstream of Clack Branch)	178	---
	SCRM 31.5 (3,000 ft upstream of Clack Branch)	96	---
	SCRM 32.05 (660 ft downstream of Busby Bridge)	203	---
2017	SCRM 25.5 (at Brewers Branch)	110	---
	SCRM 27.8 (pool, downstream unnamed tributary)	130	---
	SCRM 27.95 (downstream of Factory Creek)	190	---
	SCRM 29.05 (riffle/run, upstream of Hardin Ford)	95	---
	SCRM 30.3 (0.75-mi downstream of Clack Branch)	95	---
	SCRM 31.5 (3,000 ft upstream of Clack Branch)	95	---
	SCRM 32.05 (660 ft downstream of Busby Bridge)	93	---

Structured Decision Modeling

In response to the 2006 formal consultation (FWS #2006-F-0146), TVA agreed to attempt improvement of Elk River flow and temperature conditions for the boulder darter in Tims Ford Dam tailwaters by modifying operations at the dam; TVA has further committed to using an

Adaptive Resource Management (ARM) framework to identify factors influencing native fish and mussel populations in the Elk River and balancing the need to improve habitat for imperiled aquatic species with other dam operations, such as flood protection, water supply, recreation and power production. The federally endangered boulder darter and cracking pearlymussel (*Hemistena lata*) have been affected by operation and maintenance activities at Tims Ford Dam, and have been identified as the primary species upon which structured decision making (SDM) models and ARM techniques will focus.

In 2010, the Service executed an Intra-Agency Agreement (No. F11RG00031) with the U.S. Geological Survey (USGS) via funds provided by TVA to assist with recovery of the boulder darter and cracking pearlymussel; the objectives of the agreement were to: (1) develop and apply SDM models and ARM techniques to improve habitat for imperiled species in the Elk River and, when feasible, maintain the other benefits provide by the operation of Tims Ford Dam, and (2) in cooperation with TVA, TWRA and Service partners, develop sampling protocols and describe habitat use by boulder darters and cracking pearlymussels in the Elk River downstream of Tims Ford Dam. The final deliverables for Objective (1) are currently pending and are expected to be provided to the Service in the near term, fall 2017; Objective (2) has been accomplished and is described under "Distribution/Status", a "2011-2013 study conducted to assess the current status and distribution of 15 darter species in the Elk River, with particular emphasis on boulder darters, and to identify the predominant factors influencing darter occurrence and detection (Potoka et al. 2016)".

Five Factor Analysis:

No new threats are known. However, since the 2009 5-Year Review, damage to TVA's electrical transmission system in areas affected by severe storms and tornados has resulted in TVA implementing emergency hydroelectric generation as needed at Tims Ford Dam to restore electricity to essential services (hospitals, nursing homes, etc.); the Service believes that the boulder darter may have potentially been adversely affected as a result of these actions. The event with the most significant impacts likely occurred from April 28 through May 3, 2011, when TVA initiated emergency hydro-generation at Tims Ford Dam due to a series of severe storms and tornados across the southeastern United States on April 27, 2011. TVA initiated generation by "ramping up" flow releases from approximately 2,000 cubic feet per second (cfs) to approximately 4,000 cfs on April 28, 2011, and continued to operate the hydrogenation turbine at approximately 4,000 cfs on April 28 until May 3, 2011 (Tennessee Valley Authority 2012).

At the time of the April 27, 2011, storm occurrence, Elk River flows had increased from a mean daily discharge of approximately 750 cfs to a peak of 13,600 cfs (U.S. Geological Survey 2013) at Fayetteville, Tennessee, from local rainfall and run-off, prior to TVA ramping up flow releases at Tims Ford Dam. During the week of April 28, 2011, flow releases from Tims Ford Dam added an additional 4,000 cfs to the flood peak at Fayetteville, resulting in a total peak flow of 17,600 cfs at Fayetteville. These releases contributed approximately 23% of the peak flow at Fayetteville and less than 10% of the peak flow (approximately 40,000 cfs) at Prospect, Tennessee. As natural runoff and input from tributaries declined, TVA generation provided a

greater proportion of these flows and was providing the majority of the Elk River flows at Fayetteville by April 29 and at Prospect by April 30 (Tennessee Valley Authority 2012).

TVA had agreed to modify releases at Tims Ford Dam after April 30 (from May 1- October 15) under an Adaptive Management Alternative in *TVA's Final Environmental Assessment - Tims Ford Dam Flow Modification for Habitat Quality Improvements, Franklin County, Tennessee* (Tennessee Valley Authority 2008) to provide appropriate temperatures and more desirable flow conditions for federally endangered aquatic warm-water species, including the boulder darter, which occur throughout Tims Ford Dam tailwaters. TVA varied from this period in 2009 and 2010 and cancelled hydro-generation at Tims Ford Dam around April 15 (Tennessee Valley Authority 2012), out of concern that earlier warming of the Elk River than in previous years could prompt earlier reproduction by listed species, particularly advanced spawning by the boulder darter. The April 28 – May 3, 2011, emergency hydro-generation event at Tims Ford Dam extended beyond the date (April 30) that TVA had committed to curtail hydro-generation. TVA indicated that the hydro-generation event resulted in tailwater temperatures that departed from desired conditions and may have adversely affected boulder darters during their 2011 spawning season (Tennessee Valley Authority 2012).

An after-the-fact, emergency consultation was initiated by TVA in 2012 (Tennessee Valley Authority 2012), addressing the April 28 – May 3, 2011 Emergency Hydroelectric Operations at Tims Ford Dam, and their effects to the endangered boulder darter, cracking pearlymussel, shiny pigtoe (*Fusconaia cor*), fine-rayed pigtoe (*Fusconaia cuneolus*), birdwing pearlymussel (*Lemiox rimosus*) and Cumberland monkeyface (*Quadrula intermedia*). The Service's biological opinion (FWS #2013-F-0059) determined that the action did not jeopardize the continued existence of the boulder darter because: 1) the entire boulder darter population would not have been affected by the action because a small percentage of the population (approximately 5%) would have been residing in Elk River tributaries, such as Richland Creek, Shoal Creek and Indian Creek, when the action occurred and would not have been exposed to the temperature reductions. However, the Service further determined that abrupt temperature reduction in the Elk River caused by the emergency hydro-generation at Tims Ford Dam did result in incidental take of all boulder darters, scattered throughout approximately 64 mi of the Elk River from approximately ERM 28 upstream to approximately ERM 91.8 (based on 1986-2012 occurrence data). The Service estimated that approximately 95% of individuals comprising the only naturally occurring boulder darter population, relative to its range-wide distribution in the Elk River basin, were taken in the action area in the form of lethal or harm; this take estimate was based on the assumption that approximately 95% of the boulder darter population inhabited the mainstem Elk River, where the action's effects occurred, and the remaining 5% of the population resided in Elk River tributaries (Indian, Richland and Shoal creeks), where the effects of the action would not have been felt.

Synthesis

The boulder darter has a limited range, and continues to be exposed to threats which could lead to extinction throughout its range. Therefore, the status of the boulder darter listed as endangered remains appropriate. TVA is continuing to implement operational changes at Tims Ford Dam, however, potential future reservoir releases associated with emergency hydroelectric generation could eradicate the species. A structured decision model is in final stages of

development and adaptive management, associated with the model, will be experimental, long-term and probability of success is uncertain. The boulder darter has been successfully propagated, and an introduced population appears to becoming established within historical habitat in Shoal Creek; however, more extensive surveys are needed before population viability in Shoal Creek can be determined. The recovery priority number for the boulder darter should remain 5, as the degree of threat remains high and the potential for recovery remains low.

Additional Recommendations for Future Actions

- Continue monitoring of boulder darters in the Elk River drainage.
- Implement the structured decision model and adaptive management.
- Conduct an extensive survey(s) of Shoal Creek to determine viability of the introduced boulder darter population.

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