U.S. Fish and Wildlife Service
Recovery Plan for the
Arkansas River Shiner *(Notropis girardi)*

South Canadian River near Roll, Oklahoma (top)
Arkansas River Shiner (*Notropis girardi*) (bottom)
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U.S. Fish and Wildlife Service
Southwest Region

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The Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*), requires the development of recovery plans for listed species, unless such a plan would not promote the conservation of a particular species. Recovery plans define such reasonable actions as may be necessary, based upon the best scientific and commercial data available, for the conservation and survival of listed species. Plans are published by the U.S. Fish and Wildlife Service (USFWS), and sometimes prepared with the assistance of recovery teams, contractors, State agencies and others. Recovery plans do not necessarily represent the views, official positions or approval of any individuals or agencies involved in the plan formulation, other than the USFWS. Specifically, they represent the official position of the USFWS only after the final recovery plan has been signed by the Regional Director. Recovery plans are guidance and planning documents only; identification of an action to be implemented by any public or private party does not create a legal obligation beyond existing legal requirements. Nothing in this plan should be construed as a commitment or requirement that any Federal agency obligate or pay funds in any one fiscal year in excess of appropriations made by Congress for that fiscal year in contravention of the Anti-Deficiency Act, 31 U.S.C. 1341, or any other law or regulation. Approved recovery plans are subject to modification as dictated by new information, changes in species status, and the completion of recovery actions.

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An electronic copy is available at the Arkansas River Shiner ECOS webpage.

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FORWARD

The Southern Great Plains Riverine ecosystem provides resources for a wide array of users, including ranchers and farmers, municipalities, recreational users, industries such as oil and gas and large-scale animal feeding operations, and fish and wildlife. Most of those that depend on resources provided by this ecosystem know of its significant decline. Although these rivers are known for their highly variable flows and temperature extremes, water use changes in the Southern Great Plains since the 1950s have established a contemporary pattern in which natural surface flows and groundwater availability have diminished, resulting in river drying, fragmentation, and channel narrowing. As the ecological function of these rivers has declined, so has the Arkansas River shiner (*Notropis girardi*) and many other fishes native to the Southern Great Plains. Although this recovery plan focuses on a single species, the USFWS recognizes that achieving recovery of the Arkansas River shiner has implications well beyond any single species or water user. Based on a shared concern for the resource and a common interest in its future use, we believe that large collaborative partnerships that consider all user perspectives will be essential to conserving Southern Great Plains rivers into the future.

EXECUTIVE SUMMARY

The Arkansas River shiner (*Notropis girardi*) is an imperiled minnow that historically inhabited wide, shallow, sandy-bottomed rivers and larger streams in western portions of the Arkansas River basin. As flow patterns, channel complexity, and water quality of rivers in the Southern Great Plains have changed over time, so has the status and distribution of the Arkansas River shiner. The species is now restricted to two geographically isolated and separate populations within the South Canadian River: 1) the upper South Canadian River population in eastern New Mexico and the Texas panhandle upstream of Lake Meredith and 2) the lower South Canadian River population downstream of Lake Meredith in the Texas panhandle and into Oklahoma (Figure 1).

On November 23, 1998, the USFWS listed the species as threatened under the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*; hereafter ESA) (63 FR 64772) within the Arkansas River basin (its historical range). A non-native introduced population of the species found in the Pecos River, NM did not meet the requirements of the USFWS 1996 Distinct Population Segment (DPS) policy (61 FR 4722). Therefore, the species is listed as threatened only in the Arkansas River basin, while the Pecos River, NM population does not receive ESA protections. This is due, in part, to the New Mexico population not being essential to the species' recovery and potential conflict with recovery and conservation of the Pecos bluntnose shiner (*Notropis simus pecosensis).*

Primary threats to the Arkansas River shiner include altered flow regimes, impoundments and other sources of stream fragmentation, modified geomorphology, decreased water quality, and the expansion of invasive riparian plant species such as salt cedar and phragmites. The source of

many of these stressors is primarily related to the construction of dams and associated impoundments and water use, which alter stream flows and fragment streams. A final designation of critical habitat for the Arkansas River shiner was published on October 13, 2005 (70 FR 59808), which includes portions of both the Cimarron River in Kansas and Oklahoma and the South Canadian River in Oklahoma (Figure 1). Designated critical habitat includes the river channel itself and 300 feet of adjacent riparian habitat measured laterally from each bank.

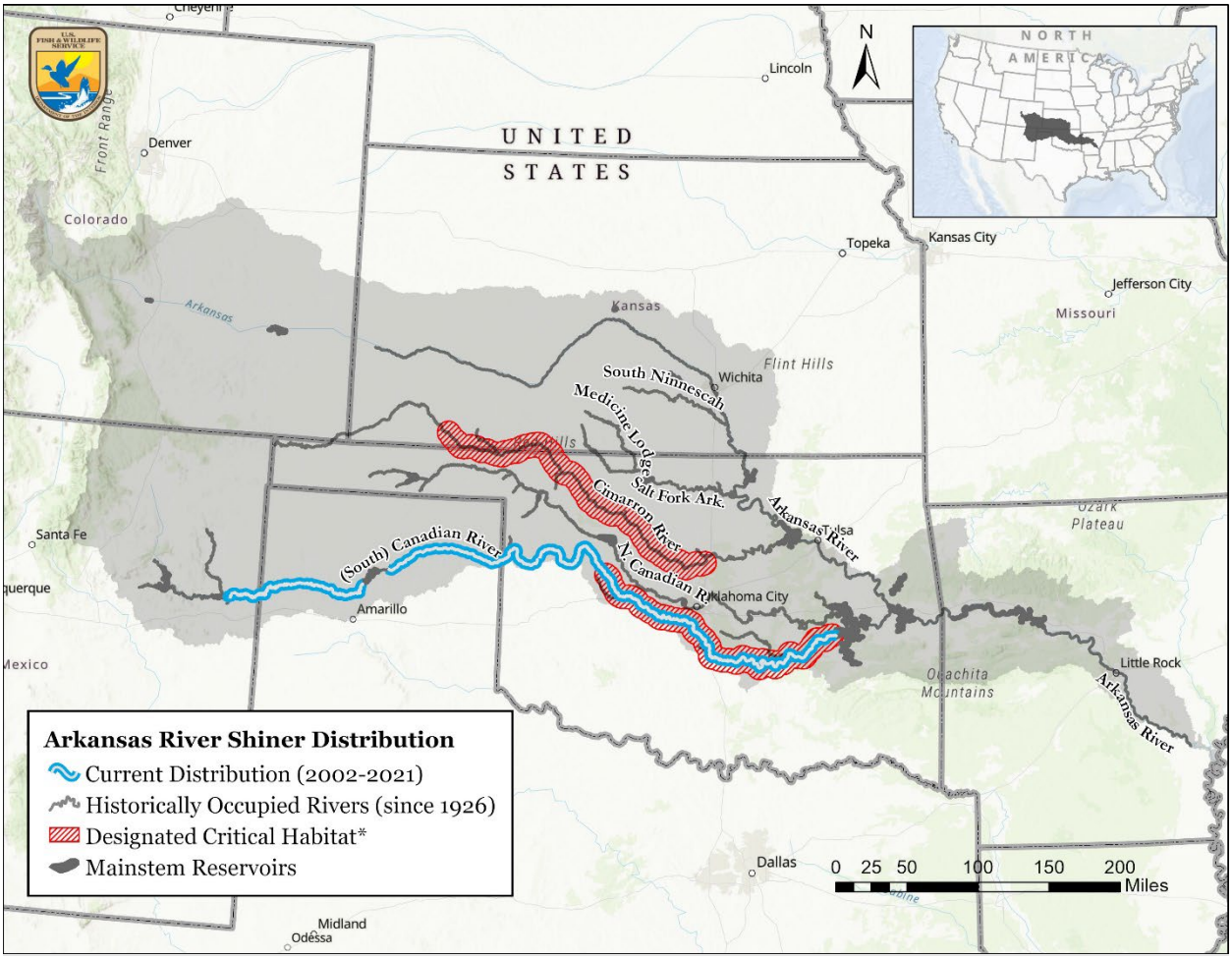

Figure 1. Arkansas River shiner historical and current distributions and designated critical habitat. *Note that the width of critical habitat displayed on this map is not to scale. Designated critical habitat includes the river channel and 300 feet of riparian habitat to each side (left and right) of the riverbank.

We conducted a Species Status Assessment (SSA) of the Arkansas River shiner and peppered chub (*Macrhybopsis tetranema*) (USFWS 2018, entire), which provides a thorough review of the two species' taxonomy, natural history, habitats, ecology, populations, and range. The SSA analyzes individual, population, and species requirements, factors affecting the species' survival, and current conditions to assess the species' current and future viability in terms of resiliency, redundancy, and representation (USFWS 2015, entire). The SSA also includes a brief overview of existing and potential conservation actions for both species.

This recovery plan provides a recovery strategy and recovery criteria thought necessary to recover the Arkansas River shiner. The recovery strategy is based on potential future conditions of the species that are reasonably likely to occur, depending on the level of conservation effort and severity of future threats (USFWS 2018, pp. 123-159). Based on the anticipated future conditions, measurable delisting criteria are provided that are designed to indicate when the threats have been removed or reduced to such an extent that the species may be considered for removal from the Federal List of Endangered and Threatened Wildlife (delisting). Following the delisting criteria are specific recovery actions which further delineate the steps required to achieve delisting. In the final section of the plan, a time and cost estimate for implementation is provided. Recovery of the Arkansas River shiner is largely based on protecting existing populations and establishing a third population within the historical range of the species, along with achievement of the delisting criteria (Table 1). With successful implementation of this plan, recovery is estimated to occur by 2054 and cost approximately $92.2 million.

Table 1. Summary of recovery strategy and delisting criteria for Arkansas River shiner.

Recovery Strategy
Presence of multiple resilient populations across the species' range that represents diversity of habitats in which the species historically occurred. Threats within these resilient populations reduced to a level whereby the species is no longer in danger of extinction into the foreseeable future.
1. Stop decline and improve existing populations and their associated habitats.
2. Stop habitat degradation and improve habitat in historically occupied segments with highest potential to accommodate future populations.
3. Reintroduce Arkansas River shiner into one or more historically occupied rivers.
4. Maintain three or more populations into the foreseeable future.
Delisting Criteria
1. Three wild, self-sustaining populations of Arkansas River shiner exist in the historical range.
2. River connectivity throughout all three populations is sufficient to support the species' life history.
3. Flow patterns throughout all three populations reflect a natural flow regime.

This streamlined recovery plan is derived from the SSA and focuses primarily on the elements required under section 4(f)(1)(B) of the ESA:

1) A description of such site-specific management actions as may be necessary to achieve the plan's goal for the conservation and survival of the species;
2) Objective, measurable criteria which, when met, would result in a determination, in accordance with the provisions of this section, that the species be removed from the list; and,
3) Estimates of the time required and the cost to carry out those measures needed to achieve the recovery plan's goal and to achieve incremental steps toward that goal.

In cooperation with our partners, we also will prepare a Recovery Implementation Strategy (RIS), which serves as an operational plan for stepping down the higher-level recovery actions into specific tasks. The RIS is a separate, collaborative effort from this recovery plan that can be easily updated. The RIS will be available at the Arkansas River Shiner ECOS webpage.

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SPECIES OVERVIEW

The following is a brief overview of the life history and status of the Arkansas River shiner. Please refer to the Arkansas River shiner and peppered chub SSA Report (USFWS 2018, entire) for a more detailed discussion and complete literature citations. The SSA can be found on the Arkansas River shiner ECOS webpage.

Status and Distribution

The Arkansas River shiner is a small minnow once widespread and common in the western portion of the Arkansas River basin in New Mexico, Texas, Kansas, Oklahoma, and Arkansas. The species is no longer found in over 83 percent of its historical range (approximately 3,896 river miles) and now appears to be entirely restricted to two highly regulated portions of the South Canadian River (identified as Canadian River on USGS topographic maps): 1) downstream from Ute Reservoir in eastern New Mexico (including a 10 mile stretch of the downstream portion of Revuelto Creek) to the upstream end of Lake Meredith in the Texas panhandle (171 river miles); and 2) downstream of Lake Meredith in the Texas panhandle to the upstream end of Eufaula Lake in Oklahoma (515 river miles) (Figure 1, above). In the past 10 years, surveys have indicated that the occurrence of Arkansas River shiner downstream from Lake Meredith and into far western portions of Oklahoma has decreased. A non-native introduced population of the Arkansas River shiner occurs in the Pecos River in Chavez, De Baca, and Eddy counties, New Mexico which was likely the result of a bait bucket introduction below Sumner dam in the 1970s. This population is just outside of the species' historical range and is not federally listed under the ESA. However, this population may serve as an important refugia population for future propagation and reintroduction efforts (Osborne *et al.* 2013, p. 644).

Habitat, Flows, and Reproduction

Historically, main channel habitat for the Arkansas River shiner consisted of wide, shallow, sandy-bottomed rivers and larger streams of the Arkansas River basin. Adults prefer shallow channels where currents flow over clean fine sand but may also utilize still pool habitats in response to environmental conditions (Moore 1944, p. 209; Gilbert 1980, entire, Matthews and Hill 1980, entire). The species has adapted to tolerate many adverse conditions present in the drought-prone prairie rivers they inhabit, including a relatively high capacity to endure elevated temperatures and low dissolved oxygen concentrations (Matthews 1987, p. 116) and a wide range of salinity levels (USFWS 2018, p. 111-112).

The Arkansas River shiner is a member of the pelagic broadcast spawning guild, in which females broadcast semi-buoyant eggs that must remain suspended in flowing water until hatching (Platania and Altenbach 1998, entire; Johnston 1999, entire). Historically, pelagic broadcast spawning fishes such as the Arkansas River shiner may have relied more on floodplain access for spawning and widespread retention of eggs and larvae in upstream reaches (Medley and Shirey 2013, entire); however, as channelization has greatly limited floodplain access in prairie rivers, longer stretches of unfragmented rivers have become necessary for egg and larval development. This reproductive strategy appears to be an adaptation to highly variable environments where stream flows are unpredictable and suspended sediments and shifting sand can cover eggs laid in nests or crevices (Bonner 2000, p. 35; Hoagstrom and Turner 2015, entire). After hatching,

adequate stream length provides the extended time and distance needed for larval fish development. During the development period, steady currents help keep larva suspended in the water column until they are capable of independent movement and are strong enough to leave the main channel or move into other habitat with lower velocity flows (Dudley and Platania 1999, entire). Research suggests that with river conditions in their current state (*e.g.*, hydrology, channel width and complexity) at least 135 miles of unfragmented flowing river is needed for egg and larval development (Platania and Altenbach 1998, pp. 565-566; Wilde *et al.* 2000, p. 107; Perkin and Gido 2011, p. 374). Without adequate stream flow and sufficient distance for eggs to freely drift downstream and develop, eggs tend to become covered with silt and likely suffocate or are preyed upon (Platania and Altenbach 1998, p. 565). Additional channel complexity (*i.e.*, wide, shallow, braided channels) and/or floodplain connectivity results in reduced downstream displacement of eggs and larva, which could allow more time and require less stream distance for eggs to develop and larva to reach their free-swimming stage (Worthington *et al.* 2014, entire). Conversely, narrow, single-thread river channels with limited habitat complexity may require more than 135 miles for successful reproduction.

Arkansas River shiners spawn throughout the spring and summer when flows are adequate for egg and larval drift and development; however, moderate to high flows appear to trigger greater reproduction and recruitment for the species (Durham and Wilde 2006, pp. 1647-1649). These natural flow pulses from precipitation events are also critical for sediment transport and establishing or maintaining floodplain connectivity by promoting the formation of more complex habitats where wide, braided channels represent the species' preferred habitat. Arkansas River shiners have been found to spawn in isolated pools, but without flowing water and less than optimal water quality conditions, eggs do not hatch (Wilde *et al.* 2000, p. 96).

Most individual Arkansas River shiners do not live past their second winter (18-20 months), thus most spawn only once in their lifetime (Bestgen *et al.* 1989, pp. 231-232 and Bonner 2000, pp. 63-64). This reproductive strategy produces high numbers of offspring in a single spawning season; however, if spawning conditions are poor in subsequent years, population levels can become drastically reduced, leaving this species particularly vulnerable to extirpation (as demonstrated by its disappearance throughout much of its historical range) and possible extinction.

Influences on Species Viability

Section 4(a) of the ESA describes five factors that may lead to endangered or threatened status for a species. These include A) the present or threatened destruction, modification, or curtailment of its habitat or range; B) overutilization for commercial, recreational, scientific, or educational purposes; C) disease or predation; D) the inadequacy of existing regulatory mechanisms; or E) other natural or manmade factors affecting its continued existence. The greatest threats to the species are from a loss of continuous stream habitat necessary for pelagic spawners and altered hydrology (Factor A). Below, we discuss stressors impacting the species' viability and correlate those to the five listing factors.

Stressors affecting the viability of the Arkansas River shiner, discussed in Chapter 3 of the SSA (USFWS 2018, pp. 22-38), include altered flow regimes, impoundments and other stream fragmentation, modified geomorphology, stream channelization, decreased water quality, the

introduction of invasive plant species (*e.g.,* salt cedar and phragmites) (Factor A), and historic bait fish collections (Factor B). The sources of many of these stressors are primarily related to the construction of dams and associated impoundments and water use, which alter stream flows and fragment streams. Additional sources of stressors include the effects of drought caused by climate change and bank armoring from the establishment of non-native plant communities, in-stream gravel mining and dredging (Factor A), and off-road vehicle use within the species' habitat (Factor D and E).

Altered Flows, Stream Fragmentation, and Modified Geomorphology

Impoundments and surface water diversions have contributed to the decline of wide, shallow sand bed river channels that are characteristic of Arkansas River shiner habitat (Factor A). Their effects on baseflows have resulted in intermittent river drying and fragmentation, which has negatively affected the species' ability to move freely throughout the system. These alterations have also resulted in a reduction in the magnitude and frequency of moderate and high flows necessary for maintaining wide and shallow braided channels. Widespread vegetation encroachment has armored riverbanks, and the active channel has thus narrowed and become more incised. This has led to the river becoming more isolated from its historical floodplain, affecting the species' ability to access important low velocity floodplain habitat during high flow events. Limited floodplain access and river fragmentation has resulted in eggs and larvae being flushed further downstream and formed impediments to upstream movement. Synergy among these physical alterations tends to limit the species' ability to repopulate upstream areas and, in some rivers, has resulted in complete extirpation (USFWS 2018, pp. 22-25).

High demand of groundwater resources (*i.e.,* municipal, industrial, and agriculture) has contributed to a permanent decline in stream flow and the subsequent loss of pelagic broadcast spawning fishes as streams are increasingly decoupled from shallow aquifers (Perkin *et al.* 2017, p. 7374). Groundwater pumping has decreased overall fish habitat availability and, like surface water diversion and impoundments, has promoted encroachment of invasive plant species and armored banks, increased channel incision, and increased river fragmentation through more frequent channel drying (USFWS 2018, pp. 25-29).

Within the Southern Great Plains, average air temperatures have increased, and projections indicate this trend will continue over this century (Shafer *et al.* 2014, pp. 442-445). Precipitation within the southern portion of the Southern Great Plains is expected to decline, with extreme events such as heat waves, sustained droughts, and extreme rainfall events becoming more frequent (Shafer *et al.* 2014, p. 445, Fig. 19.4; Walsh *et al.* 2014, pp. 28-40). These additional environmental stressors negatively affect Arkansas River shiner due to the species' limited range, life history needs related to river flows and distances, and its inability to disperse outside of existing river systems.

Water Quality

Adequate water quality is necessary to maintain suitable conditions for the Arkansas River shiner (Factor A). Impairments can arise from contaminants or the alteration of basic water chemistry and affect nutrient dynamics. Dissolved oxygen levels may be reduced by increased nutrients in the water column from agricultural runoff, wastewater effluent, and livestock operations.

Increased water temperature from climate change and extended low flow conditions can exacerbate low dissolved oxygen levels, especially when reduced flows strand fish in isolated pools. Increasing water temperatures due to climate change could also result in the exceedance of suitable temperatures (known as critical thermal maximum) of several Great Plains fishes, including Arkansas River shiner (Matthews and Manes 1979, entire; Matthews and Zimmerman 1990, entire). Similarly, as flows decline, the species can be subjected to increased salinity which is known to affect Great Plains fish assemblages and distributions (Ostrand and Wilde 2004, entire; Higgins and Wilde 2005, entire; Hoagstrom 2009, pp 36-38; Cheek and Taylor 2016, entire). High relative abundances of adult Arkansas River shiners have been collected from waters with specific conductance over 2000 µS/cm (an indicator of salinity). Conversely, results from Mueller *et al*. 2017 suggested that early life stages of the species may be sensitive to higher salinities, although they did not directly assess mortality rates and suggested that more comprehensive studies are needed (Mueller *et al*. 2017, pp. 84-85; USFWS 2018, p. 15).

Land use activities that affect water quality include irrigated cropland, concentrated animal feeding operations, oil and gas operations, municipal solid waste sites, and stormwater runoff from urban and other developed areas (USFWS 2018, pp. 17, 34-35, and 114) (Factors A and E).

Other Influences

Additional stressors to the Arkansas River shiner as discussed in Chapter 3 of the SSA include the expansion of invasive riparian species such as salt cedar and phragmites (Factor A) and in-stream sand/gravel mining and dredging, and recreational off-road vehicle use within habitat (Factor E). The effects of these stressors are less likely to impact the overall viability of the species but do represent a localized impact that can have a cumulative effect over time. Chapter 3 of the SSA (USFWS 2018, pp. 22-38) also discussed ongoing and potential management actions targeted to improve Arkansas River shiner populations.

RECOVERY STRATEGY

Our strategy is to support at least three self-sustaining Arkansas River shiner populations into the foreseeable future. To accomplish this strategy, our goals are to:

1) Stop the decline and improve existing populations and their associated habitats in the upper and lower South Canadian River.
2) Stop habitat degradation and improve habitat conditions in historically occupied rivers that have the highest potential for future reintroductions of the species.
3) Reintroduce Arkansas River shiner into one or more historically occupied rivers and monitor their status.
4) Maintain three or more self-sustaining populations, within the species' historical range, into the foreseeable future.

Our recovery strategy focuses on habitat preservation, habitat restoration, and establishing favorable, more naturalized riverine hydrology which supports the Arkansas River shiner. This is predicated on an increased understanding of the relationship between the Arkansas River shiners' life history requirements and the physical, chemical, and ecological conditions of its environment. Implementation of this recovery plan will necessitate inclusion of the most up-to-

date information as it becomes available.

Recovery of the Arkansas River shiner will require maintaining and developing watershed scale partnerships among Federal, State, Tribal, and local agencies, private landowners, local industries, commercial agriculture, and other stakeholders. Because the species is currently limited to two extant populations, with multiple stressors affecting their habitat, recovery of the Arkansas River shiner is likely a long-term, challenging process. Therefore, the success of the recovery plan will rely on the implementation of recovery actions conducted by USFWS and those conservation partners identified above, while maintaining partner coordination within and among watersheds.

Management units

We identified five geographically separate management units across the species' current and historical range (Figure 2). Each management unit provides at least some elements needed for Arkansas River shiner survival, and all provide adequate stream length necessary for successful reproduction. These management units are separated into two categories, Priority 1 (occupied) and Priority 2 (unoccupied). We consider each management unit to support, or potentially support, a separate population of Arkansas River shiners. The purpose for identifying separate management units is to:

1) Allow for site-specific recovery actions, and
2) Promote local and targeted watershed partnerships to improve delivery, efficiency, and communication of recovery activities and allow for the flexibility of adaptive management.

Priority 1 management units

The Upper and Lower South Canadian River management units, which are currently both occupied by Arkansas River shiners, are considered two separate Priority 1 management units. Our strategy in these two management units is to curtail the decline of the species and its habitat through effective water conservation and management, control of riparian invasives, restoration of local floodplain dynamics, monitoring of the species to assess its status, population augmentation (if needed) and implementation of research and adaptive management to ensure that recovery actions are effective into the foreseeable future. More information on each unit is provided below:

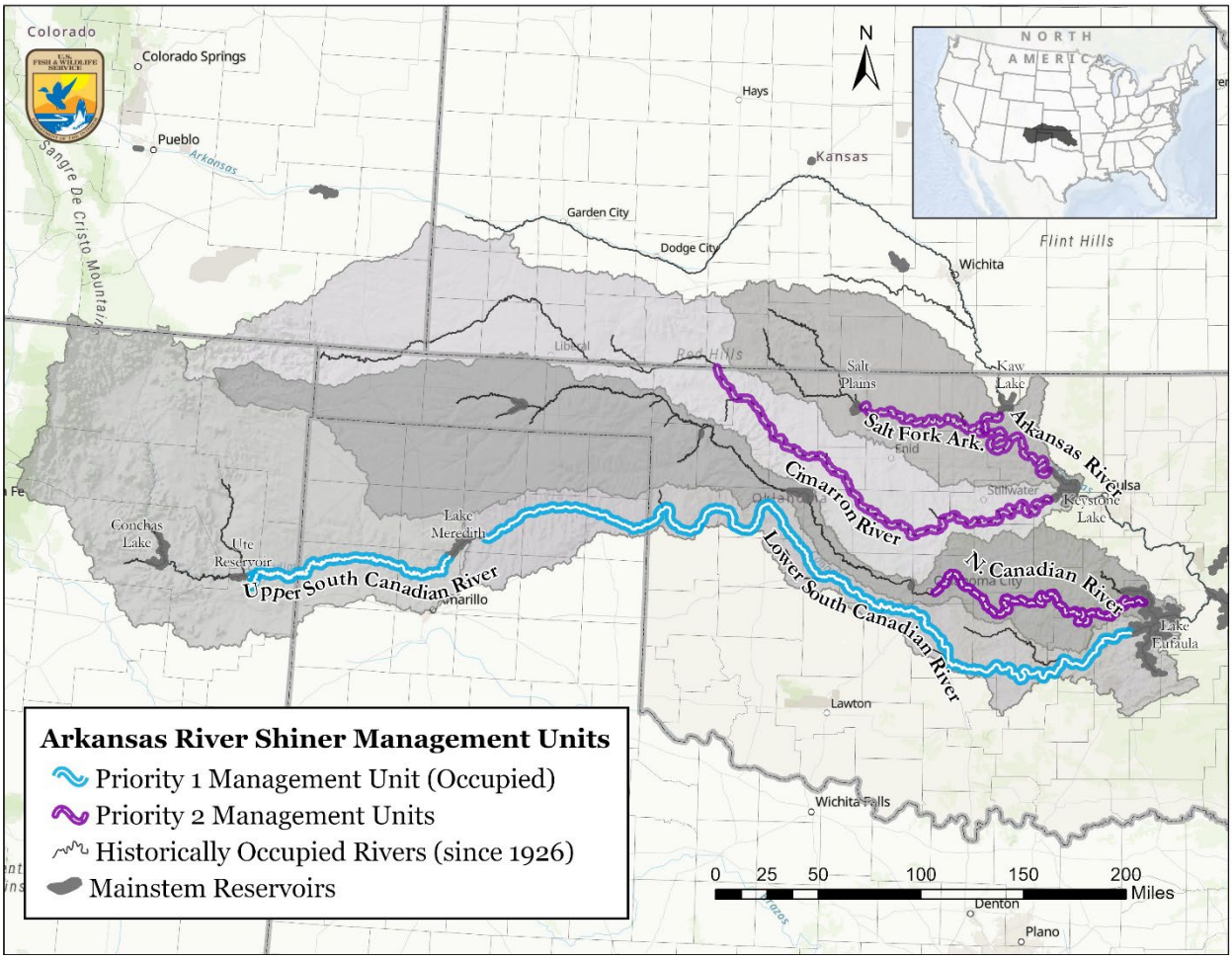

Figure 2. Management units and their associated watersheds for the Arkansas River shiner.

South Canadian River – The South Canadian River flows from west to east, originating in eastern New Mexico. The river is impounded by Conchas Lake, just downstream of its headwaters, and then by Ute Reservoir, approximately 40 river miles upstream of the New Mexico/Texas border. Revuelto Creek is a major tributary to the South Canadian River, entering just downstream of Ute Reservoir dam.

Upper South Canadian River - Once the South Canadian River enters Texas, it travels without obstruction another 131 miles, until it reaches the delta of Lake Meredith 10 miles north of Amarillo, TX. We refer to the 171-mile stretch of river (including the downstream most 10 miles of Revuelto Creek) between Ute Reservoir and Lake Meredith as the Upper South Canadian River management unit, which is known to be entirely occupied by Arkansas River shiner. Natural river flows in this stretch are altered primarily by Ute dam, which provides minimal 'seepage' flows (i.e., water that naturally leaks through the dam's foundation or abutments). Ute Reservoir was created to provide a sustainable supply of water for communities that rely on the declining Ogallala Aquifer. Revuelto Creek, entering the river just downstream of Ute dam, can also provide a significant portion of the flows to the South Canadian River, including high pulse flow events necessary for habitat maintenance and Arkansas River shiner reproduction. Ute dam occasionally releases excess water, according to requirements under the Canadian River

Compact, but these releases are infrequent and not predictable. Projected future demands on water from the reservoir associated with the Eastern New Mexico Rural Water System pipeline and other uses could decrease dam seepage and possibly the magnitude and/or frequency of future releases. There are other viable mechanisms and opportunities to purchase or lease water in order to supplement in-stream flows and foster periodic spawning pulses or, at a minimum, provide supplemental water during extreme low-flow or drought conditions. Additional challenges to maintain adequate surface water flows and habitat to support the Arkansas River shiner in the Upper South Canadian River watershed include groundwater withdrawals for irrigation and potential increases in salinity. The U.S. Bureau of Reclamation's Lake Meredith Salinity Control Project (CRMWA 2018, entire) is estimated to reduce baseflows in the South Canadian River below its confluence with Revuelto Creek by 14 percent (U.S. Bureau of Reclamation 1995, p. 19). As a part of annual fish surveys, the USFWS monitored conductivity at two sites in the Upper South Canadian River (U.S. Hwy 87 crossing north of Amarillo and U.S. Hwy 385 crossing near Tascosa, TX) with values ranging from 1,047 - 4,167 µS/cm (2,577 µS/cm average), all within the suitable range for Arkansas River shiner (USFWS 2018, p. 11).

Lower South Canadian River - We refer to the 515-mile stretch of river from Lake Meredith dam (Texas) downstream to Eufaula Lake (Oklahoma) as the Lower South Canadian River management unit. Lake Meredith (Sanford Dam) does not release water or provide any seepage, resulting in a highly altered hydrology and substrate unsuitable for Arkansas River shiner for several miles downstream of the dam. Numerous downstream tributary and groundwater inputs contribute to riverine flows such that hydrological conditions likely become suitable for Arkansas River shiner again near Canadian, TX (Wilde and Urbanczyk 2017, p. 24). The species was last observed near Canadian, TX in 2011, and more recent surveys downstream from that area do not begin to detect Arkansas River shiner until Camargo, OK, nearly 100 river miles downstream from Canadian, TX. The river within these 100 miles likely goes dry more often than in the past, making upstream movement and repopulation of Arkansas River shiner near Canadian, TX challenging. Additional survey work and hydrologic study within this stretch of river is needed.

As the river moves from west to east in Oklahoma, it widens and becomes more turbid. Arkansas River shiners are known to currently exist from Camargo, OK downstream to the upper end of Eufaula Lake, OK. Water demands, primarily for crop irrigation and livestock in western portions of the Lower South Canadian River, are mostly supplied through groundwater. As the river nears central Oklahoma, water use transitions from groundwater to surface water, primarily for municipal and industrial needs, including a significant portion of surface water used as cooling water for Oklahoma Gas and Electric at Lake Konawa. Nutrient loads in the Lower South Canadian River are relatively low; however, nitrogen and phosphorus have shown increases (Oklahoma Water Resources Board [OWRB] 2012a, entire; OWRB 2012c, entire). Conductivity in the Lower South Canadian River averages 1,684 µS/cm, indicating that salinity levels are relatively low as compared to the Upper South Canadian River or other rivers historically occupied by the Arkansas River shiner.

Priority 2 management units

We have identified three Priority 2 management units: the Cimarron, Salt Fork/Arkansas, and North Canadian River. These management units were historically occupied by Arkansas River

shiner and currently exhibit favorable habitat features, indicating their potential to accommodate future reintroductions.

Our strategy for these Priority 2 management units is to further evaluate each individually and determine which may have the highest likelihood of successful reintroduction and future population resiliency. Our assessment of priority areas for Arkansas River shiner reintroductions will account for current and future habitat conditions, the level of management actions needed (if any) to accommodate reintroduction, and the ability/commitment of partners to ensure success of such reintroductions. Once reintroductions are implemented, our strategy will be to continue to work with partners on implementation of water conservation, monitor the species to assess its status, implement research and adaptive management, and ensure survival into the foreseeable future. If resources allow and corresponding partnerships exist, simultaneous reintroductions into at least two of these unoccupied units could provide an opportunity to monitor the species' response to different environments, help inform future conservation efforts and provide additional population redundancy. More information on each unit is provided below.

Cimarron River - The Cimarron River originates in far northeastern New Mexico, travels northeast into Colorado and then into Kansas for a significant stretch. The river briefly drops into Oklahoma before moving northeast back into Kansas for a short stretch and then back into Oklahoma (Figure 2). Flows become much more significant after it crosses the Oklahoma/Kansas state line for the last time, where it travels over 270 miles before reaching Keystone Lake and its confluence with the Arkansas River. Except for a temporary earthen dam and related canal upstream of Buffalo, OK, there are no impoundments on the Cimarron River, making it one of Oklahoma's longest free flowing rivers. We refer to this 270-mile segment between the Oklahoma/Kansas State line downstream to Keystone Reservoir as the Cimarron River management unit.

Arkansas River shiners were once abundant and widespread in over 570 miles of the Cimarron River. The species experienced significant declines in the 1980s and was last collected in 1992 near the Kansas/Oklahoma state line. Water demands are primarily groundwater used for municipal, industrial, and crop irrigation (OWRB 2012a, entire; OWRB 2012b, entire). As the river nears Guthrie, OK surface water use surpasses groundwater inputs, where municipal and industry demands increase, and crop irrigation lessens. Salinity in the Cimarron River is high, peaking near Freedom, OK. Salinity levels in some stretches of the Cimarron River are likely not suitable for Arkansas River shiner and may act as a movement barrier. However, salinity levels decrease as the river moves downstream from Freedom, OK, and the stretch of river from approximately Cleo Springs, OK to Lake Keystone (approximately 150 river miles) may be suitable for the species. Likely due to a bait bucket introduction, the Red River shiner (*Notropis bairdi*) (endemic to the Red River drainage) has become established in the Cimarron River; however, the level of competition between the two species is uncertain, warranting further research.

Arkansas River and Salt Fork of the Arkansas River - The Arkansas River originates in Colorado, moves through southwestern Kansas, and crosses the Oklahoma/Kansas border in Kay County, just south of Arkansas City, Kansas. Flows in Oklahoma are primarily affected by releases from Kaw Reservoir, which is managed by the U.S. Army Corps of Engineers. Arkansas River shiners were last collected from the Arkansas River in Oklahoma in 1986 near Ralston,

OK and from the Salt Fork in 1987, just downstream of Great Salt Plains Lake.

The free-flowing stretch of river downstream of Kaw Reservoir to the upper end of Keystone Reservoir is approximately 90 river miles, just below the 135-mile threshold necessary for successful Arkansas River shiner reproduction and recruitment. However, the Salt Fork of the Arkansas River from Great Salt Plains Lake to its confluence with the Arkansas River provides an additional 186 river miles. We refer to the 90-mile Arkansas River segment between Kaw and Keystone reservoirs and the 186-mile Salt Fork segment downstream from Great Salt Plains Lake as the Arkansas River and Salt Fork of the Arkansas River management unit. Groundwater is the primary source for water demands in the Salt Fork of the Arkansas River watershed, which is mostly used for crop irrigation (OWRB 2012b, entire). Moving downstream, including the Arkansas River between Kaw and Keystone reservoirs, surface water demands increase, primarily for municipal and industrial uses. Salinity levels in the Salt Fork of the Arkansas are greater than in the Arkansas River mainstem; however, they are still within the range suitable for Arkansas River shiner (USFWS 2018, p. 15)

North Canadian River - The North Canadian River originates in far northeastern New Mexico and is considered Oklahoma's longest river. However, Optima Reservoir in the Oklahoma panhandle, Canton Reservoir in northwestern Oklahoma and multiple smaller reservoirs associated with low head dams and locks in the Oklahoma City area have resulted in the river becoming too fragmented to support Arkansas River shiner reproduction upstream of Oklahoma City, OK. Reservoirs and other water demands such as crop irrigation in the western portion of this river have also resulted in significant narrowing and vegetative encroachment, creating a homogenous, single-thread channel not conducive to Arkansas River shiner reproduction. The Arkansas River shiner was last collected from the North Canadian River in 1993, near Beaver, OK.

We refer to a 237-mile stretch of the North Canadian River from Oklahoma City, OK downstream to Eufaula Lake, OK as the North Canadian River management unit. This stretch of the river provides adequate unimpeded river length to support successful long-term reproduction. Major water demands within this stretch of river are a mix of surface water and groundwater, primarily for municipal and industrial use. The North Canadian River upstream of Oklahoma City was designated in 2006 as a nutrient-limited watershed due to high trophic state index (TSI) values. Nutrient limited watershed designations in Oklahoma are those waters where a designated beneficial use is adversely affected by excess nutrients. Downstream of Oklahoma City, water quality in the North Canadian River and its tributaries is primarily affected by urbanization, runoff, and excess nutrients (OWRB 2012a, entire). The extent of potential water quality concerns and implications for Arkansas River shiner needs further investigation.

RECOVERY CRITERIA

This section delineates objective, measurable delisting criteria. These criteria are designed to be met through implementation of the recovery actions in this recovery plan. Criteria in this recovery plan are divided into two sets: those that meet demographic (population) goals (Criterion 1), and those that address habitat and flow requirements (Criteria 2-3) necessary to support populations into the foreseeable future. The SSA analyzed the projected future condition of the Arkansas River shiner 20 and 50 years into the future (USFWS 2018, p.123). Therefore,

our projections of habitat and flow requirements necessary to support the species are based upon projections 20 years into the future. Demographic (population) goals may require another 10 years to become established once habitat and flow trends are suitable. The Arkansas River shiner may be considered for removal from the List of Endangered and Threatened Wildlife (delisting) when the following criteria are met:

Criterion 1 - Three wild Arkansas River shiner populations are self-sustaining. Each population must be in separate management units (*e.g.,* South Canadian River, Cimmaron, Salt Fork/Arkansas River). Populations are considered self-sustaining when the following demographic conditions are satisfied:

a) In each of at least three management units, annual wild recruitment is occurring as demonstrated by the presence of Age-0 (*i.e.,* young of year wild, not hatchery released) fish measured across six or more survey years within a ten-year period, with presence documented in the most recent three survey years indicating wild recruitment, and;
b) In each of at least three management units, Arkansas River shiners are distributed throughout a river reach of at least 135 river miles, as demonstrated by documentation of wild Arkansas River shiners at a minimum of three sites spanning 135 miles (one near each end and at least one midpoint site) for at least three consecutive survey years.

Additional rationale for this Criterion - Demographic (population) goals may require 10 years in addition to the 20-year SSA projection to establish once habitat and flow trends are suitable (*e.g.,* rearing individuals, repeated stocking efforts, and assessing population viability). Therefore, Criterion 1 includes a 10-year period of species sampling data (Criterion 1a), during which six or more of those years must show presence, with the last three consecutive survey years indicating wild recruitment. This helps to ensure that population viability can be sustained in the wild despite recruitment failures due to poor condition years. Additionally, there will likely be years where survey conditions are less than optimal and detectability, even of a robust population, could be low. The 10-year period, with three consecutive survey years of presence at the end of that period, allows for some flexibility in sampling effectiveness while also ensuring that by the end of that period, there are consecutive survey years of presence. Rather than requiring consecutive years of presence at the end of that 10-year period, we recognize there may be years where, for numerous reasons, surveys cannot be conducted. We use the term 'consecutive survey years' to provide that flexibility.

Current research suggests that with river conditions in their current state (*e.g.*, flow patterns, channel width and complexity), at least 135 miles of unfragmented flowing river is needed for egg and larval development (Platania and Altenbach 1998, pp. 565-566; Wilde *et al*. 2000, p. 107; Perkin and Gido 2011, p. 374). To further support the reproductive needs of the species' pelagic spawning, a minimum stream reach of 135 river miles, with appropriate channel width and complexity, is required. Within this stream reach, documented natural recruitment at a minimum of three sites over three consecutive survey years is required. Although this Criterion requires a minimum of three sites, additional sites could be established through the development of Recovery Action 12, below. Criterion 1b ensures that the population is sufficiently distributed throughout the river and resilient to withstand interannual variations in reproductive output. Again, most Arkansas River shiners do not live past their second winter (18-20 months), thus most spawn only once in their lifetime (Bestgen *et al*. 1989, pp. 231-232 and Bonner 2000, pp.

63-64). Consecutive years of poor recruitment may have detrimental effects to the population overall.

Criterion 2 - River connectivity throughout each of the three occupied management units is sufficient to support Arkansas River shiner movement necessary for successful reproduction and recruitment, as evidenced by meeting criteria a, b, and c:

a) Baseflows (amount and seasonal aspects) necessary to maintain adequate river connectivity for Arkansas River shiner movement, successful reproduction and recruitment have been determined and;
b) Baseflows measured at USGS gauge(s) throughout each of the three management units are stable to increasing over a 20-year trend, and;
c) Criterion 1b (Arkansas River shiners throughout at least a 135-mile stretch of river) is met in years 18-20 of Criterion 2b.

Criterion 3 - Flow patterns throughout each of the three occupied management units reflect a natural flow regime (peak and moderate flows, appropriately timed, and of adequate duration and frequency) and water quality conditions (salinity, water temperature, dissolved oxygen, and pollutant levels) that result in the maintenance and creation of river habitat suitable for the Arkansas River shiner. Additional research and analysis are required to elucidate the specific range of hydrological conditions required to facilitate the creation and maintenance of suitable riverine habitat. Until such information is available, the following criteria may be used to measure flow patterns:

a) Hydrologic patterns necessary to maintain and create suitable Arkansas River shiner habitat have been determined, and;
b) Channel width and complexity is stable to improving for at least 20 years, and;
c) Criterion 1 above (successful recruitment during a 10-year period) is achieved during the second half of this 10-year period or later.

Progress toward meeting delisting criteria should be measured throughout implementation of this recovery plan. Careful planning and consideration of the timing of surveys and ongoing implementation of propagation and introductions will be necessary to ensure that all habitat and recovery criteria have been met at the time delisting is considered. Further, additional scientific research may be necessary, as outlined above, to elucidate the exact suite of environmental conditions (*e.g.,* baseflows, water quality parameters, etc.) required for Arkansas River shiner. Recovery actions in this recovery plan and recovery activities, included in the separate RIS document, will provide additional clarity on the species' needs and ultimately determining when recovery of the species has been met.

RECOVERY ACTIONS

The following is a list of prioritized, site-specific management actions that when fully implemented are expected to result in the recovery of the Arkansas River shiner (Table 2). Implementation of this recovery plan is strictly voluntary and dependent on the cooperation and commitment of numerous partners in conservation. A separate RIS will provide additional detailed, site-specific near-term activities needed to implement the recovery actions identified

below and will identify potential responsible parties. We intend to update the RIS as frequently as needed by incorporating new information, including the findings of future 5-year status reviews. The RIS will provide near-term (*e.g.*, 1–5 years) activities that will be continually updated as recovery implementation progresses. Therefore, we will provide a greater degree of site specificity in the RIS than do the recovery actions in the recovery plan.

As stated in the Disclaimer, recovery plans are advisory documents, not regulatory documents. A recovery plan does not commit any entity to implementing the recommended strategies or actions contained within it for a particular species, but rather provides guidance for ameliorating threats and implementing conservation measures, as well as providing context for implementation of other sections of the ESA, such as section 7(a)(2) consultations on Federal agency actions, development of Habitat Conservation Plans, or the establishment of experimental populations under section 10(j). Priorities for recovery actions are assigned using the following guidelines:

Priority 1 – An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

Priority 2 – An action that must be taken to prevent a substantial decline in species population/habitat quality or some other substantial negative effect short of extinction.

Priority 3 – All other actions necessary to meet the recovery criteria. The assignment of these priorities does not imply that some recovery actions are of low importance, but instead implies that lower priority items may be deferred while higher priority items are being implemented.

Table 2. Recovery actions for the Arkansas River shiner including recovery action number, action theme, description, corresponding recovery criteria, association with five listing factors, and recovery action priority number. The recovery actions in this table are listed and grouped by recovery action type (*e.g.,* habitat conservation, population conservation, etc.), and prioritized via their recovery action priority number.

Recovery Action Number	Action Theme	Action Description	Recovery Criteria	Association with Five Factors	Recovery Action Priority Number
1	Habitat Conservation and Restoration	**Develop and implement water management strategies in both the Upper and Lower South Canadian Priority 1 management units.** Water management strategies will consider base flows and peak/moderate flows that support the Arkansas River shiner's life history, including adequate river length, channel width, and complexity necessary to support Arkansas River shiner populations into the foreseeable future. This will involve supporting and working with stakeholders to implement ground and surface water conservation and restoration to maximize natural flow regimes, as well as implementing water releases from reservoirs where possible.	2, 3	Factor A	1

2	Habitat Conservation and Restoration	**Evaluate the three Priority 2 management units (*e.g.,* Arkansas River, Cimarron, and North Canadian rivers) and develop priorities for Arkansas River shiner reintroductions.** These management units each have the potential to support Arkansas River shiner populations but may first require some level of habitat/flow modification and management. Prioritization will be based on the potential for successful Arkansas River shiner reintroductions and will account for current and future habitat conditions, level of needed management actions (if any) to accommodate reintroductions, and ability and commitment of partners to ensure success of such reintroductions.	1	Factor A	2
3	Habitat Conservation and Restoration	**Develop and implement water management strategies for the Priority 2 management units identified through implementation of Action 2 above.** After priorities from Action 2 above have been developed, management unit(s) will be selected for Arkansas River shiner reintroduction. For reintroductions to be successful, water management strategies will be developed and will consider base flows and peak/moderate flows that accommodate the Arkansas River shiner's life history, including adequate river length and channel width and complexity necessary to support Arkansas River shiner populations into the foreseeable future.	2, 3	Factor A	2

4	Habitat Conservation and Restoration	**Control riparian invasive species range-wide.** Establish and strengthen partnerships to manage and control invasive species encroachment along the riparian corridor of the Upper and Lower South Canadian rivers and the selected Priority 2 management unit(s), as identified by implementation of Action 2 above. Implement riparian restoration to slow vegetative encroachment of salt cedar (*Tamarix ramosissima*), common reed (*Phragmites australis*), ravenna grass (*Saccharum ravennae*) and other invasive plants and maintain wider, complex (braided) channels more suitable for successful reproduction and recruitment. However, until flow events reach a magnitude, frequency, and duration that can maintain or expand channel width and complexity, this action will be necessary to curb further losses to Arkansas River shiner habitat.	2, 3	Factor A	1
5	Habitat Conservation and Restoration	**Restore floodplains throughout the species range.** Establish partnerships to design and implement floodplain restoration in targeted areas to aid in egg and larval development and potentially shorten river length needed for successful recruitment and to promote further upstream movement of Arkansas River shiner populations. For example, if adequate floodplain access were available in the Lower South Canadian River in western Oklahoma during the spawning season, eggs and larvae may not need to move as far downstream. With adequate flow conditions over the following 18 months, natural reproduction could then re-populate upper stretches of the South Canadian River upstream of the Oklahoma/Texas border where they have not been collected since 2011.	2, 3	Factor A	1

6	Habitat Conservation and Restoration	**Develop and implement a plan for fish passage and flow barrier assessment and potential removal of barriers throughout the species range.** Other than existing, large impoundments on the main stem rivers of current and historically occupied rivers, this action is targeted at smaller physical barriers that affect either fish movement or restrict flows to the Upper and Lower South Canadian River and other potential management units. Barriers affecting fish movement in main stem rivers should be given high priority, as even small or partial barriers could have significant consequences for Arkansas River shiner reproduction. Barriers in tributaries of main stem rivers which may affect main stem flows will be prioritized separately, based on the amount of flow being restricted and opportunities with conservation partners for removal or barrier improvements.	2, 3	Factor A	1
7	Habitat Conservation and Restoration	**Preclude the need for new reservoir development within the Upper and Lower South Canadian River and any other occupied management units.** Strengthen work with stakeholders to identify alternatives or modifications to new reservoir construction (on main stem and their larger tributaries) to meet future water demands or flood control needs.	2	Factor A and B	1

8	Habitat Conservation and Restoration	**Long-term management commitments or conservation agreements are implemented across the species range to ensure water quality and quantity sufficient (within >100 miles (161 kilometers) of river length) to support at least three resilient populations of Arkansas River shiner.** Additional research is required to determine the necessary water quality and quantity parameters required by the peppered chub. Therefore, further research to elucidate the specific suite of water quality and quantity parameter ranges sufficient to support long-term populations, and; based on water quality and quantity parameters identified, specific management commitments or conservation agreements to maintain those parameters into the foreseeable future are implemented. These commitments must be robust and with such high certainty of implementation that their continued benefit to the species is reasonably expected to continue for at least 30 years, or more, into the future.	1, 2, 3	Factor A and B	2
9	Habitat Conservation and Restoration	**Develop and implement water quality targets.** Utilize existing information to develop and implement water quality targets for Arkansas River shiner. Information in this subject area is limited, therefore adaptive management based on new information from species-specific studies will be essential to ensure long-term viability of the species.	3	Factor A and B	1

10	Habitat Conservation and Restoration	**Develop and implement best management practices for water quality.** Strengthen work with stakeholders to develop and implement best management practices aimed to meet water quality targets determined by Recovery Action 9, above. This would include best practices to address unsuitable salinity levels, high water temperatures, as well as determine the source of pollution discharges negatively affecting the Arkansas River shiner and take steps to avoid and minimize future surface water contamination. Plans should be developed to avoid, if possible, or contain and remediate catastrophic spills within the watersheds occupied by the species.	3	Factor A and B	1
11	Habitat Conservation and Restoration	**Research and develop hydrologic targets to determine hydrology necessary to support Arkansas River shiner populations.** Utilize existing information and conduct additional research to develop and implement hydrologic regimes range-wide which support Arkansas River shiner. Information in this area is limited, therefore adaptive management based on new information from species-specific studies (see Recovery Action 22 – Adaptive Management below) will be essential to ensure long-term viability of the species.	3	Factor A	1
12	Population Conservation	**Continue to implement a range-wide monitoring program.** In working with State partners, the USFWS will continue to implement a monitoring program for the species. Additional reporting and coordination between the USFWS and State wildlife agencies will be necessary to ensure standard protocols are consistent and being implemented such that results can be used to address Recovery Criterion 1.	1	Factor A	1

13	Population Conservation	**Develop a comprehensive Captive Propagation and Contingency Plan (CPCP) consistent with the USFWS Policy regarding Controlled Propagation of Species Listed Under the Endangered Species Act.** A comprehensive CPCP should be developed to guide captive maintenance and breeding programs and a reintroduction strategy for the Arkansas River shiner. The goal of the captive propagation portion of the CPCP will be to outline the steps necessary to provide a representation of the genetic characteristics of wild populations. The contingency portion of the CPCP will also establish the collection targets and protocols needed to respond to crisis situations. Contingency planning should not be delayed until the completion of genetic, breeding, and reintroduction studies, but should be updated as these studies are completed. The CPCP should be developed in coordination with agencies that would likely be involved with the collection efforts, including the USFWS, State agencies and experts from academic institutions with relevant expertise. The Pecos River population of Arkansas River shiner should be considered as an additional source for propagation or translocation efforts. Identifying facilities suitable for captive propagation and contingency portions of the CPCP is necessary for its success. Institutions involved in collection efforts would need to hold appropriate State and Federal permits. For each facility, a Participation Plan should be developed in coordination with the USFWS that outlines the level of commitment to cooperate (long-term versus short-term holding facilities), qualified personnel to collect and transport animals, research to be conducted, and level of	1	Factor A	1

		information to be collected. The CPCP and Participation Plans should be periodically re-assessed (for example, annually) and altered as necessary.			
14	Population Conservation	**Establish and maintain a captive breeding program.** A captive population of the Arkansas River shiner would serve as refugia population and a source for reintroductions. Captive propagation of Arkansas River shiners and their reintroduction into historically occupied stream reaches will address limited redundancy of the species. The number of individuals in captivity, their genetic structure, and effectiveness of the captive breeding program should be monitored in accordance with a Captive Propagation and Contingency Plan (CPCP; Action 13, above). Captive Arkansas River shiner populations should be monitored closely for disease and other health concerns. When reintroductions are planned, precautions should be taken to ensure individuals to be introduced are free from disease or other harmful agents into the wild. Commitments to long-term monitoring and management of captive and reintroduced populations will be necessary. Biological and genetic information on the species should be collected in captivity, particularly information on reproduction and early life stages, in accordance with the CPCP (Action 13, above).	1	Factor A	1
15	Population Conservation	**Develop and Implement a Reintroduction Plan.** Develop and implement a plan that outlines parameters for the release of captive-bred individuals into currently and historically occupied stream reaches. This plan will be informed by Actions 12, 13, and 14 above.	1	Factor A	2

16	Population Conservation	**Develop and Implement a Biobanking Plan.** Develop and implement a plan that provides for conservation of the species' genetic diversity and ability to recover in the case of a catastrophic event.	1	Factor A	3
17	Research and Adaptive Management	**Continue to develop knowledge of the species' life history, ecology, habitat requirements and behavior and apply that knowledge to restore and protect appropriate habitats.** Perpetuation of the Arkansas River shiner in the wild depends on a thorough knowledge of the species' life history, ecology, habitat requirements and behavior, and application of that knowledge to restore and protect appropriate habitats.	1, 2, 3	Factor A	1
18	Research and Adaptive Management	**Continue genetic studies on all Arkansas River shiner populations.** The ability of a species to persist over the long term is determined in part by the amount of genetic variation that is retained by a species. Baseline studies of Arkansas River shiner genetic variation have been developed, but additional genetic monitoring will be essential to determine changes in genetic diversity and its implications for population viability into the foreseeable future.	1	Factor A	2

19	Research and Adaptive Management	**Improve understanding of the nature, extent, and role of water quality degradation in the decline of the species, as well as the water quality standards necessary for its protection and recovery.** Many land use activities and their resultant discharges (both point and non-point source) have the potential to affect the Arkansas River shiner and its habitat. These include urban runoff and related discharges, discharges from industrial sites, wastewater treatment plants, runoff from concentrated animal feeding operations and grazing land, return flows from agriculture, and other sources. The impacts of these activities and their discharges are not well understood and should be examined further.	3	Factor A	1
20	Research and Adaptive Management	**Improve understanding of climate change effects to river flows, water quality, and species viability.** Continue to learn and utilize new tools as they become available to help better understand future climate projections and related tools on how those projections will affect flows, habitat, water quality, and species viability.	1, 2, 3	Factor A	1

21	Research and Adaptive Management	**Improve understanding of the nature and extent of interaction between other fish species (native and non-native) and Arkansas River shiner, and the possible role of these species in the Arkansas River shiners' decline.** The potential impacts to Arkansas River shiner based on competition with other fish species is not well understood. For example, the Red River shiner (*Notropis bairdi*) became prevalent in the Cimarron River in the 1980s, as the Arkansas River shiner was beginning to decline. There is reasonable uncertainty as to whether the Red River shiner played a role in the Arkansas River shiners' functional extirpation from the Cimarron River, or if that species was instead better adapted to modified stream conditions (higher chloride concentrations and low flows) that was not conducive to the Arkansas River shiner. Determining the level of impact the introduction of Red River shiner, and other non-native species, have on declining Arkansas River shiner populations is crucial to developing effective restoration and management techniques.	1	Factor C	3

22	Research and Management	**Develop and implement an adaptive management program and ensure that appropriate research and management activities are implemented in a timely manner to achieve recovery.** To maintain a flexible management approach for the recovery of the Arkansas River shiner, it will be necessary for the USFWS and its conservation partners to continually analyze new and additional information regarding the biological, physical, and chemical conditions of identified management units for the Arkansas River shiner. This ensures appropriate research and management activities are implemented for the species range-wide. Monitor the effectiveness of these actions such that adaptions can be implemented as necessary.	3	Factor D	2
23	Partnerships and Collaboration	**Identify key partners for each management unit.** Identify key partners in each of the Priority 1 and 2 management units. Partners will include Tribes, landowners, municipalities, non-government organizations, State, and Federal agencies.	1, 2, 3	Factor E	2
24	Partnerships and Collaboration	**Develop and implement a communications plan to enhance collaboration with partners.** Develop a plan that outlines how collaboration among partners identified in Recovery Action 22 will be implemented. The plan will include a process on how to best share information and how frequently that information will be shared.	1, 2, 3	Factor E	2
25	Partnerships and Collaboration	**Integrate existing conservation plans.** Evaluate and integrate existing plans from State, Federal, and non-government organizations to identify common goals and assist with recovery actions.	1, 2, 3	Factor E	2

26	Outreach and Communication	**Develop and implement an outreach and communication plan for the Arkansas River shiner.** A comprehensive outreach and communications plan will be developed jointly by the USFWS and its partners. Some basic considerations and idea for such a plan include identifying key audiences, key messages, and methods of disseminating information such as regular meetings, social media, USFWS webpages, news outlets, etc.	1, 2, 3	Factor E	2

TIME AND COST ESTIMATES

The estimates of the time needed to implement recovery actions (Table 3) are a guide for meeting the recovery criteria discussed in this plan. The initiation and completion of recovery actions are subject to the availability of funds, as well as other constraints affecting the parties involved. The total cost of recovery stated in this plan is a rough estimate and may change substantially as efforts to recover the species continue. Thus, detailed cost breakdowns for each management unit with expected annual costs are not known at this time. While we have the statutory responsibility for developing and implementing this recovery plan, recovery of Arkansas River shiner will necessitate the involvement of Federal, tribal, state, private, and local partners. The continued expertise and contributions of these and additional agencies and interested parties is needed to implement the recovery actions identified in this plan. To enhance the effectiveness of this recovery plan, the USFWS will develop and adopt a RIS as a flexible way to update and revise step-down recovery activities as needed.

With successful implementation of this recovery plan, we expect the status of the Arkansas River shiner to improve such that we can delist the species in approximately 30 years, with a total estimated cost of $92,225,000. These timeframes are based on expectation of full funding, implementation as provided for in the recovery plan and implementation strategy, high degree of success in executed actions, and full cooperation of partners.

Table 3. Estimated time and cost for Arkansas River shiner Recovery Actions.

Recovery Action Number	Recovery Action Description	Estimated Annual Cost	Estimated Time	Total Cost
1	Develop and implement water management strategies in both the Upper and Lower South Canadian Priority 1 management units.	$300,000	20	$6,000,000
2	Evaluate the three Priority 2 management units (Arkansas River, Cimarron, and North Canadian rivers) and develop priorities for Arkansas River shiner reintroductions.	$100,000	5	$500,000
3	Develop and implement water management strategies for the Priority 2 management units identified through implementation of Action 2 above.	$300,000	30	$9,000,000
4	Control riparian invasive species range-wide.	$300,000	15	$4,500,000
5	Restore floodplains throughout the species range.	$600,000	15	$9,000,000
6	Develop and implement a plan for fish passage and flow barrier assessment and potential removal.	$600,000	15	$9,000,000
7	Preclude the need for new reservoir development within the Upper and Lower South Canadian River and the Priority 1 management unit.	$100,000	10	$1,000,000
8	Long-term management commitments or conservation agreements are implemented across the species range.	$100,000	30	$3,000,000
9	Develop and implement water quality targets.	$100,000	10	$1,000,000
10	Develop and implement best management practices for water quality.	$500,000	15	$7,500,000
11	Research and develop hydrologic targets to determine flow patterns necessary to support Arkansas River shiner populations.	$100,000	10	$1,000,000
12	Continue to implement a range-wide monitoring program.	$80,000	30	$24,000,000
13	Develop a comprehensive captive propagation and contingency plan (CPCP) consistent with the USFWS Policy regarding Controlled Propagation of Species Listed Under the Endangered Species Act.	$75,000	3	$225,000
14	Establish and maintain a captive breeding program.	$125,000	30	$3,750,000
15	Develop and Implement a Reintroduction Plan.	$180,000	6	$1,080,000

16	Develop and Implement a Biobanking Plan.	$100,000	6	$600,000
17	Continue to develop knowledge of the species' life history, ecology, habitat requirements and behavior and apply that knowledge to restore and protect appropriate habitats.	$200,000	20	$4,000,000
18	Continue genetic studies on Arkansas River shiner populations.	$60,000	8	$480,000
19	Improve understanding of the nature, extent, and role of water quality degradation in the decline of the species, as well as the water quality standards necessary for its protection and recovery.	$200,000	10	$2,000,000
20	Improve understanding of climate change effects to river flows, water quality, and species viability.	$20,000	20	$400,000
21	Improve understanding of the nature and extent of interaction between other fish species (native and non-native) and Arkansas River shiner, and the possible role of these species in the Arkansas River shiners' decline.	$60,000	4	$240,000
22	Develop and implement a flexible, range-wide management program.	$62,500	20	$1,250,000
23	Identify key partners for each management unit.	$10,000	5	$500,000
24	Develop and implement a communications plan to enhance collaboration with partners.	$10,000	20	$200,000
25	Integrate existing conservation plans.	$250,000	10	$2,500,000
26	Develop and implement an outreach and communication plan for the Arkansas River shiner.	$25,000	20	$500,000
Total				**$92,225,000**

PEER AND PUBLIC REVIEW RESPONSE

We received comments from five commentors (New Mexico Game and Fish Department, New Mexico Interstate Stream Commission, Petroleum Alliance of Oklahoma, Oklahoma Farm Bureau, and an academic researcher) during the public comment period which ended on 30 October 2023. We received one of thirteen requested peer reviews for this recovery plan. State wildlife agencies across the species range (*i.e.,* Kansas, Oklahoma, Texas, and New Mexico), were provided an opportunity to comment on a draft of this recovery plan prior to the public comment period. In general, comments were supportive of the plan. Several commentors requested more specific, measurable details be included in the recovery criteria. There is insufficient scientific information to provide more accurate details. We have noted those additional research needs throughout this recovery plan. We made edits as described below, and in some instances, additional language and/or citations were added to the recovery plan for clarity. Comments and how we addressed them are summarized below.

Comment: Reviewer requested we remove Criteria 4, 5, and 6 from the draft recovery plan.

> Response: We have revised the recovery criteria language in this final plan. Specifically, previous recovery criteria which focused on captive propagation and long-term management commitments have been moved to recovery actions, which support the 3 recovery criteria now included in this final recovery plan. See pages 10-26.

Comment: We received multiple, minor, non-substantive changes and corrections throughout this document (*e.g.,* typos, spelling errors, grammatical revisions) to revise the readability and clarity of the document.

> Response: The USFWS appreciate these comments and have incorporated them as appropriate. A full summary of such changes is not provided.

Comment: We received multiple comments regarding the clarification of terminology regarding water quality and the use of “chlorides”. “salinity”, and “conductivity”.

> Response: Where appropriate we have revised the language to be consistent throughout the text and standardized “salinity” for readability and clarity.

Comment: Peer reviewer noted that we had invasive riparian vegetation incorrectly listed under ESA Listing Factor C (disease or predation) and not Factor A (the present or threatened destruction of habitat).

> Response: The USFWS appreciates this comment. Invasive riparian vegetation has been placed under Factor A throughout this document.

Comment: Multiple reviewers requested we provide an in-depth list of all potential external partnerships necessary for conservation and recovery of the species.

> Response: The USFWS believes it would be quite difficult to compile such a list and could unintentionally alienate any partners not listed. Therefore, we chose to list partners by type (*e.g.,* Federal, State, Tribal, local agencies, private landowners, etc.). In working with

partners and stakeholder, we will develop a detailed list in the species Recovery Implementation Strategy (RIS), an accompanying but separate document.

Comment: Reviewer asked if the Ninnescah River was discussed as a potential management unit for Arkansas River shiner. This river was identified as a potential restoration area for Peppered chub (*Marchybopsis tetranema*) in Pennock *et al*. 2007, which has a similar life history.

Response: Yes, the USFWS reviewed the Ninnescah River for Arkansas River shiner restoration as a potential management unit. However, we believe the Salt Fork, Cimmaron, and North Canadian rivers provide the best opportunity for restoration of Arkansas River Shiner populations. The Ninnescah River may be considered for Peppered chub restoration in its respective recovery plan.

Comment: We received multiple comments and edits to the language describing the function of Ute Dam reservoir, Colorado River Compact, and Eastern New Mexico Rural Water System pipeline.

Response: The USFWS appreciates these clarifications and have incorporated them into the document.

Comment: Peer reviewer requested we include Revuelto Creek as a management unit and raised questions regarding management protections conferred by such designation.

Response: The lowermost 10 miles of Revuelto Creek is included in the Upper South Canadian, Priority 1 Management Unit. Designation of management units in this recovery plan does not provide any legal status or additional protections.

Comment: Reviewer requested we provide additional details regarding what is meant by "seepage" flows from Ute dam.

Response: Language has been added to this document to clarify the terminology.

Comment: Reviewer requested we provide feasible examples to identify where additional groundwater and surface flows may be acquired to improve habitat conditions.

Response: It would be impractical to list all possible scenarios to alleviate low flows. Therefore, we have chosen to identify specific biological needs required by the Arkansas River shiner and its habitat to achieve recovery; however, specifics regarding how these requirements can be accomplished will be provided in the species Recovery Implementation Strategy (RIS), an accompanying but separate document.

Comment: Peer reviewer suggested we add salinity ranges within which Arkansas River shiner are known to persist.

Response: While this information is discussed at length in the Arkansas River and Peppered Chub SSA and cited as such, we have added additional language to this document.

Comment: Reviewer requested we provide additional details and specifications for survey methodology, survey timeframe, etc.

Response: This level of detailed discussion is more appropriately include in the RIS.

Comment: Given the species short lifecycle and singular reproduction event per generation, missing a consecutive year could have dire consequences for the species future condition. Suggest revising Recovery Criterion 1a such that it must be met annually.

Response: We agree that the species' lifecycle lends itself to declines if multiple years of poor, or nonexistent reproduction, occurs within a population. However, to account for our potential inability to conducting fish sampling annually, given a variety of constraints, we have chosen to require frequent, but not explicitly annual survey detection. We developed additional rationale for Recovery Criterion 1 on page 11.

Comment: Peer reviewer expressed concern that in the draft recovery plan's Recovery Criterion 3, n=500 minimum fish in captivity may not be a large enough population to maintain genetic diversity.

Response: This recovery criterion has been removed and is now recovery action 14 (Table 2). This recovery action supports recovery criterion 1 (*i.e.,* three wild, self-sustaining populations of Arkansas River shiner). Further, we no longer specify how many fish are required in the captive population as scientific information to accurately inform this value is currently unknown.

Comment: A reviewer inquired if the Outreach and Communication recovery action (actions 23-26, Table 2), was of less importance/priority because it was listed at the end of the table.

Response: No. The order of the recovery actions in the table itself is not indicative of their importance. The recovery actions are however grouped by type (*e.g.,* habitat restoration, population augmentations, partnerships, etc.) and assigned recovery action priority numbers (*i.e.,* 1, 2, or 3; see page 13). A disclaimer has been added to the Table 2 description to further clarify.

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