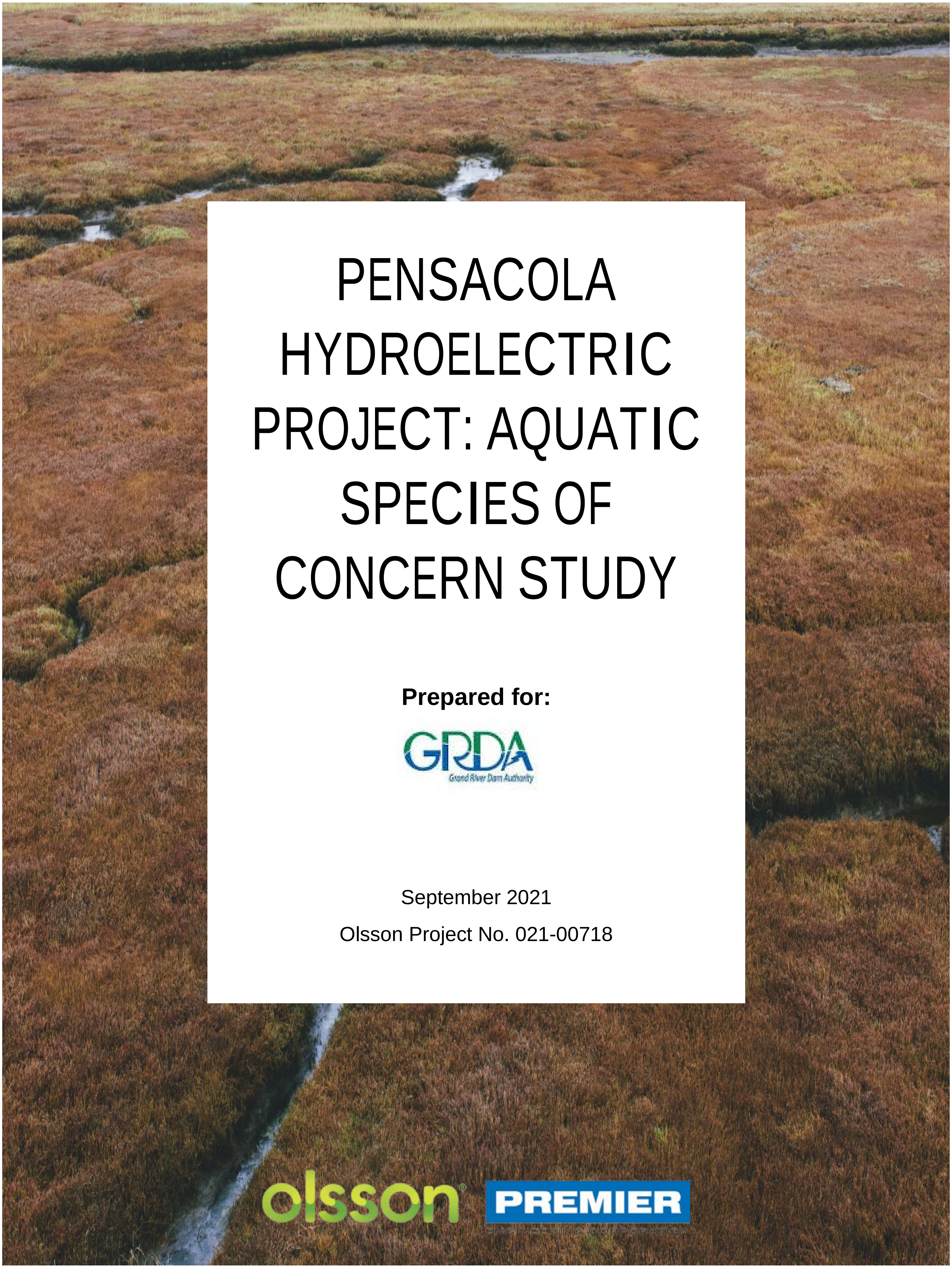

PENSACOLA HYDROELECTRIC PROJECT: AQUATIC SPECIES OF CONCERN STUDY

Prepared for:

GRDA

Grand River Dam Authority

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olsson

PREMIER

ACRONYMS AND ABBREVIATIONS

CHM... Comprehensive Hydraulic Model
GRDA……………………………………………..……………………Grand River Dam Authority
FERC………………………………………………………Federal Energy Regulatory Commission
FPA…………………………………………………………………………….Federal Power Act
NDAA.. National Defense Authorization Act for Fiscal Year 2020
ODWC ....Oklahoma Department of Wildlife Conservation
OWRB…………………………………………………………Oklahoma Water Resource Board
PSP…………………………………………………………………………….. Proposed Study Plan
RTE………………………………………………………………..rare, threatened, and endangered
USFWS...U. S. Fish and Wildlife Service
USGS……………………………………………………………..……..…U. S. Geological Survey
PD………………………………………………………………………………Pensacola Datum
SMP……………………………………………………………………..Shoreline Management Plan
kW…………………………………………………………………………………………kilowatts
USACE……………………………………………..………………U.S. Army Corps of Engineers
NRHP……………………………………………………………National Register of Historic Places
H&H………………………………………………………………Hydrologic and Hydraulic Study

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1. INTRODUCTION

As part of the relicensing of the Pensacola Hydroelectric Project (Project; FERC [Federal Energy Regulatory Commission] No. 1494), the Grand River Dam Authority (GRDA) filed a Pre-Application Document (PAD) with FERC on February 1, 2017 (GRDA 2017). The GRDA filed its Proposed Study Plan (PSP) for the relicensing on April 27, 2018 (GRDA 2018a). Also, on April 27, 2018, FERC released its Scoping Document 2 for the relicensing of the Project (FERC 2018). In its PSP, GRDA did not include a specific study to investigate potential Project effects on aquatic resources. Based on comments received from federal and state resource agencies and other stakeholders, GRDA's Revised Study Plan (RSP), filed on September 24, 2018, proposed an Aquatic Species of Concern Study to provide further details regarding how potential impacts to aquatic resources related to changing water levels due to Project operations will be assessed during the relicensing process.

GRDA's Aquatic Species of Concern Study proposed a phased approach to identify and analyze potential Project effects on aquatic species in the study area and focused on six species: Neosho mucket (*Lampsilis rafinesqueana*); rabbitsfoot mussel (*Quadrula cylindrical cylindrical*); winged mapleleaf mussel (*Quadrula fragosa)*; Neosho madtom (*Noturus placidus*); Neosho smallmouth bass (*Micropterus dolomieu velox*); and paddlefish (*Polyodon spathula*). In the RSP, GRDA's Aquatic Species of Concern Study Plan generally proposed to use existing information and output from the Comprehensive Hydraulic Model (CHM) to assess potential impacts to these aquatic resources. For the three Neosho species (Neosho mucket, Neosho madtom, and Neosho smallmouth bass), GRDA also proposed to conduct field surveys in the second study season to develop rough estimates of species' distribution in relevant reaches, if determined necessary.

FERC issued its Study Plan Determination on November 8, 2018, which recommended the following refinements to GRDA's proposed Aquatic Species of Concern Study:

- For paddlefish, FERC recommended that GRDA include estimating the proportion of paddlefish spawning habitat affected by increasing the reservoir elevation, relative to available spawning habitat in the project vicinity. FERC explained that estimating the proportion of spawning habitat affected by increasing the reservoir elevation could be accomplished using GRDA's proposed data gathering methodology.

- For the three Neosho species, FERC recommended that GRDA address the need for species density information by: (1) including a review of existing density estimates in the Project vicinity for each species (for the first season of studies); and (2) include surveys designed to estimate each species' density (in the second season of studies).

This study report contains the information required by the FERC-approved Aquatic Species of Concern Study for the first season of studies for the relicensing of the Project.

1.1 Purpose of the Study

The GRDA's proposal to continue operating the Project has the potential to affect aquatic species of concern in Grand Lake O' the Cherokees (Grand Lake) and the lower reaches of its tributaries. This study reports on information needed to assess the effects of the Project, if any, on these species relevant species identified in the preceding paragraph as part of FERC's National Environmental Policy Act (NEPA) analysis for the relicensing of the Project. Section 3 summarizes existing information on each of the six species identified above and based on that existing information, identifies the species that are proposed for additional investigation.

1.1.1 Species of Concern

The Neosho mucket, rabbitsfoot, winged mapleleaf, Neosho madtom, and Neosho smallmouth bass have been identified as species of concern that inhabit or have the potential to inhabit the areas affected by the proposed Project operations. While paddlefish is not a species of concern, it is an important resource in Grand Lake. Project operations may influence water levels of the surrounding tributaries of the Pensacola Dam. These water level fluctuations have the potential to alter the habitat of the species of concern and paddlefish. Understanding the spatial and temporal effects, if any, caused by Project operations on the study area will allow for characterization of potential impacts to these species.

The following list details the dates when the above species were listed by the U.S. Fish and Wildlife Service (USFWS) as threatened or endangered under the federal Endangered Species Act (ESA):

- Neosho mucket was listed as endangered effective October 17, 2013 – listed wherever found (ECOS 2021a).
- Rabbitsfoot mussel was listed as endangered effective October 17, 2013 – listed wherever found (ECOS 2021b).
- Winged mapleleaf mussel was listed as endangered effective June 20, 1991, and experimental population, nonessential effective June 14, 2001– Endangered wherever found except where listed as an experimental population (ECOS 2021c).
- Neosho madtom was listed as threatened effective June 22, 1990 – listed wherever found (ECOS 2021d).

Neosho smallmouth bass is not listed under the federal ESA. However, it was identified by Oklahoma Department of Wildlife Conservation (ODWC) in its July 24, 2018, PSP comment letter to FERC as a species of concern in the context of potential changes to water level management in Grand Lake.

Paddlefish is not listed under the federal ESA, nor has it been identified by ODWC as a species of concern. Paddlefish use Grand Lake's two primary headwaters (the Neosho River and Spring River) for spawning. However, stocks in Grand Lake and the Neosho and Spring Rivers support a prominent snag fishery, attracting anglers from throughout the United States during the spring spawning run (Jager and Schooley 2016). Although annual catch rates are variable depending on hydrologic conditions, thousands of mature paddlefish are harvested from Grand Lake stocks during some years (Scarnecchia et al. 2013). Trip expenditures from paddlefish angling in Oklahoma have an estimated economic impact of $18.2 million (Melstrom and Shideler 2017), much of which is focused on the Grand Lake fishery.

1.2 Project Background

Based on the information in the Shoreline Management Plan (SMP; GRDA 2008) the existing Project consists of the following:

1) A main dam, which has a maximum height of 147 feet (ft) and is comprised of (a) a 53.5-ft-long non-overflow abutment section on the western end, (b) a 4,284-ft long multiple-arch section with a crest elevation of 757-ft Pensacola Datum (PD), (c) an 861-ft long main spillway section, which has a crest elevation of 730-ft PD and is controlled by 21 Taintor gates, each of which is 36-ft long by 25-ft high, (d) a 451-ft long non overflow gravity section on the eastern end, and (e) a 300-ft long non overflow abutment section consisting of a concrete core wall

2) Two auxiliary spillways with approximate lengths of 464-ft and 422-ft about 1.0 mile east of the main dam, which consist of concrete gravity overflow type spillways with crest elevations of 740-ft PD controlled by a total of 21 Taintor gates, each of which is 37-ft long by 15-ft high

3) Grand Lake, which has a surface area of 46,500 acres (ac) and a storage volume of 1,680,000 acre-feet at the maximum power pool of 745-ft PD

4) A 27-ft by 246-ft intake structure

5) A powerhouse with dimensions of 87.75-ft by 279.0-ft located immediately downstream of the western end of the dam, which contains seven turbine generator units with a total nameplate capacity of 86,900 kilowatts (kW)

6) Other pertinent equipment and facilities

The GRDA operates the Project according to its existing operating rule curve, established in FERC's April 24, 1992 Order Issuing New License, and amended most recently by FERC's August 15, 2017 Order Amending License and Dismissing Application for Temporary Variance. The existing rule curve for hydro generation and flood control is as seen in Table 1.

Table 1. Curve for Hydro Generation and Approximate Dates for Fill and Release.

Period	Reservoir Elevation
May 1 – May 31	Raise Target elevation from 742 ft to 744-ft PD
Jun 1 – July 30	Target Elevation 744-ft PD
Aug 1 – Aug 14	Lowering Target elevation from 744 to 743-ft
Aug 15 – Sept 15	Target Elevation at 743-ft PD
Sept 16 – Sept 30 1 –	Lowering targe elevation from 743 to 742-ft PD
Oct 1 – April 30	Target Elevation at 742-ft PD

Under the Flood Control Act of 1944, the NDAA (National Defense Authorization Act for Fiscal Year 2020), and other federal legislation and regulations, the U.S. Army Corps of Engineers (USACE) has control of the basinwide system of flood control and navigation projects. Flood storage at the Project is provided between elevations of 745- and 755-ft PD.

1.3 Study Area

Grand Lake is located in portions of Craig, Mayes, Delaware, and Ottawa counties, Oklahoma. The study area for the Aquatic Species of Concern review corresponds to those counties associated with the Hydrologic and Hydraulic (H&H) Study (see Section 3 Methodology of the H&H Study Plan: GRDA 2018b). The study area extends upstream from Pensacola Dam along the Neosho River to within approximately 3 miles of the Kansas state line, upstream along the Spring River to within 6.5 miles of the Kansas state line, upstream along the Elk River to the upstream extent dictated by the H&H model, and along Tar Creek to just upstream of the U.S. Geological Survey (USGS) gage at 22nd Avenue Bridge (Figure 1). The study area also encompasses the bays/coves within Grand Lake associated with tributaries flowing into the lake.

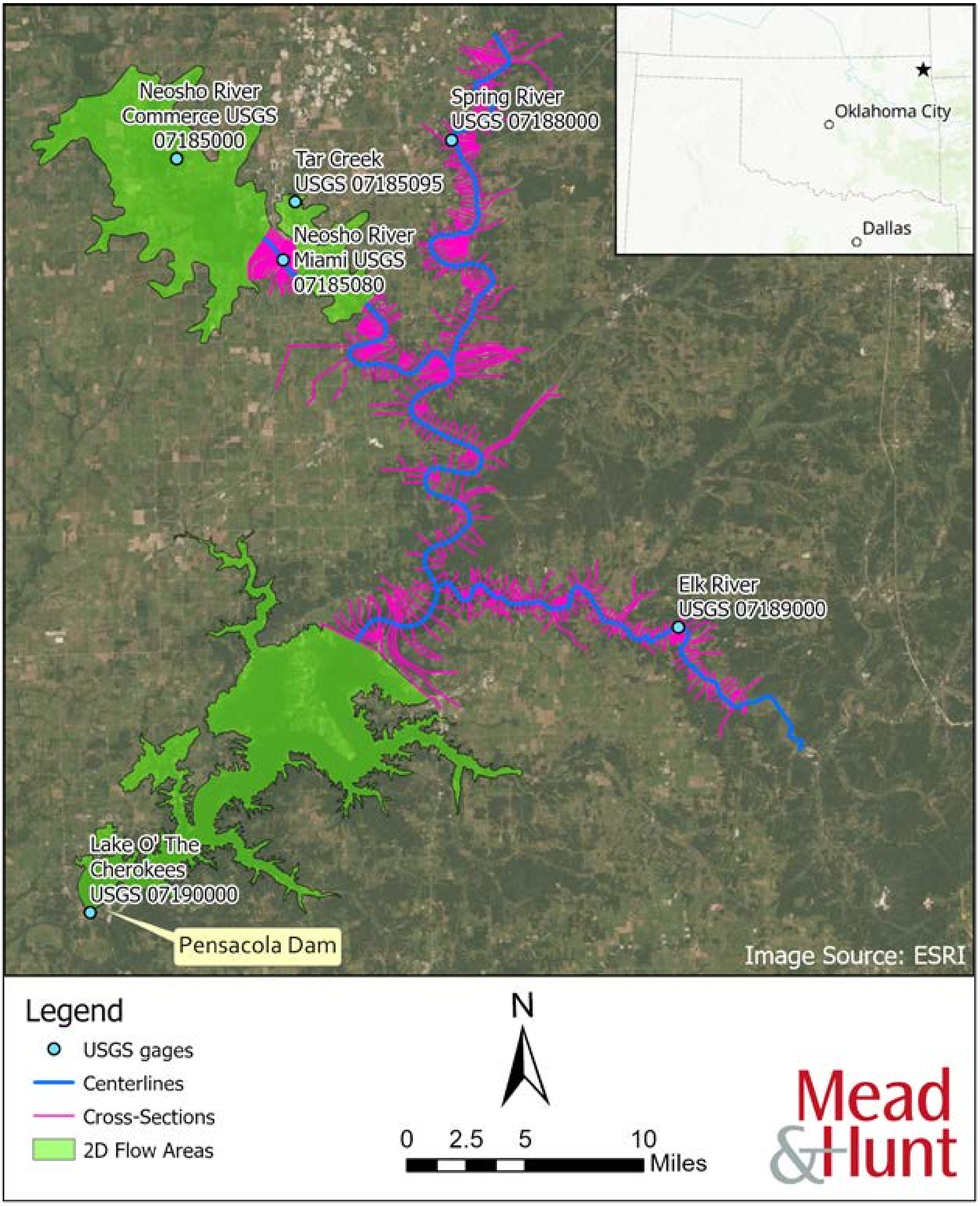

Figure 1. Study Area for the Aquatic Species of Concern

2. REVIEW OF EXISTING INFORMATION

2.1 Phase I: Review of Existing information

Phase I of this study involved a detailed exploration of existing information, including ODWC reports, peer-reviewed scientific publications, and, to the extent possible, unpublished information gathered by researchers from ODWC, Sam Nobel Museum, OSU invertebrate collection, Oklahoma Water Resource Board, academic institutions, and other entities. As part of the Phase I activities, Olsson coordinated with ODWC to obtain verbal feedback (i.e., documented personal communications) regarding the distributions of the species of interest in reaches that have the potential to be affected by Project operations (study area). Reaches within the study area were identified based on maps generated by the CHM as part of the H&H Study. Habitat preferences for each life-history stage of the species of concern identified in this study report are based on literature review and professional judgment.

2.2 Phase II and Phase III: Field Studies to Document Distribution of the Species of Concern

Under GRDA's RSP for the Aquatic Species of Concern Study, if the information gathered during Phase I for any species is of sufficient quality to conduct an effects analysis, then Phase II actions (e.g., fieldwork) would not be undertaken for that species. If existing records are inadequate for estimating a species' distribution, the FERC-approved study plan provides for targeted field surveys to be conducted to develop a rough estimate of the species' distribution in the reaches of concern (i.e., reaches of reservoir inundation identified by the CHM). Phase II fieldwork includes the following:

1) A review of existing density estimates in the project vicinity for each species and
2) Including surveys designed to estimate each species' density.

As stated in the previous section, habitat preferences have been based on information taken from the scientific literature and collaboration with agency experts; no field data will be collected during Phase II to characterize habitat use. After Phase II data has been analyzed, Phase III will incorporate project effects.

3. EXISTING INFORMATION

The following section reviews the habitat preference, distribution, and occurrence of all six species, listed above, that are the subject of this Aquatic Species of Concern Study.

3.1 Neosho Mucket (*Lampsilis rafinesqeana*)

3.1.1 Distribution and Occurrence

The Neosho mucket (*Lampsilis rafinequeana)* is an endemic and federally endangered freshwater mussel species with a distribution found in the Arkansas River System (Gordon 1981; Harris and Gordon 1987; Mather 1990; Obermeyer 1996). Historically, this species of mussel has been observed in seventeen streams within the Neosho, Illinois, and Verdigris River basins (USFWS 2018). With respect to this relicensing project and discrete study area, rivers within the Neosho River basin with known populations of Neosho mucket include the Neosho River, Spring River, and Elk River. In a USFWS 5-year review (2020) of the Neosho mucket, the population status was found the be declining in the Neosho River (Last Observed 2014), and Stable in the Spring and Elk Rivers (Last Observed 2017). While the species is considered endangered wherever found, critical habitat are summarized in table 2 for the Neosho, Spring and Elk Rivers.

Table 2. Critical habitat for Neosho Mucket

Critical Habitat Unit Number	River	Within Study Area
NM7	Neosho	No
NM5	Spring	No
NM4	Spring	No
NM3	Spring	No
NM2	Elk	Yes

Critical Habitat found within project modeling extent is located on the Elk River with the general description as follows:

Unit NM2 includes 12.6 mi of the Elk River from Missouri Highway 59 at Noel, McDonald County, Missouri, to the confluence of Buffalo Creek immediately downstream of the Oklahoma and Missouri State line, Delaware County, Oklahoma (USFWS 2021).

The occurrence of the Neosho mucket within the study area has been described as extremely rare in the Oklahoma portions of the Spring and Neosho Rivers (USFWS Biological Opinion 2015). On the Elk River, species occurrences have been documented primarily on the Missouri side of the state line (USFWS 2018). However, some of these locations appear to fall within the study area. While personal contacts with ODWC suggests no mussel surveys have been conducted within the Neosho, Spring, and Elk Rivers (Curtis Tacket; Personal Communication) data does exist in various agency reports, primary literature, and communications that is germane to this process. These data are summarized in Table 3.

Table 3. Summary of Neosho Mucket Locations within and adjacent to the to the Project Area.

River	Date (Years)	Agency/Tribe/Entity	Location/Result	Citation(s)
Neosho	1990	ODWC	4 Sites from Neosho River 3 Miles WNW of Miami to Kansas State Line/8 Relic Shells Found	Mater, C.M. 1990. Status Survey of the western fanshell and the Neosho Mucket. Report to the Oklahoma Department of Wildlife Conservation.
	1994-1997	ODWC/OU	Neosho River, State Line to Stepp's Ford Bridge (estimate)/No Live Neosho Muckets/29% of sites had Relic Neosho Mucket Shells	Vaughn CC. Determination of the status and habitat preference of the Neosho mucket in Oklahoma. Oklahoma City, OK: Oklahoma Biological Survey; 1998. 17 pp.
	2006-2007	Peoria Tribe	Gravel Bars 4, 7, and 8/ Six Relict Shells	USFWS Neosho Mucket 5-year review: Summary and Evaluation
	2014	Peoria Tribe	Stepp's Ford Bridge/ 1 Live and 1 Relict Shell	USFWS Neosho Mucket 5-year review: Summary and Evaluation USFWS Memorandum, Biological Opinion, May 12, 2015
	2018	EcoAnaysts, Inc.	19.5 km upstream to 1.5 km downstream of the Interstate 44 Bridge near Miami Oklahoma/No live or Relic Neosho Mucket Found	USFWS Neosho Mucket 5-year review: Summary and Evaluation
Spring	1990	ODWC	3 Sites North from Devils Promenade Bridge to the State Line/1 relict shell collected	Mater, C.M. 1990. Status Survey of the western fanshell and the Neosho Mucket.

				Report to the Oklahoma Department of Wildlife Conservation
	1994-1997	ODWC/OU	Spring River, E57 Rd Bridge to State Line, 10 Sites, 60% of sites had relic shells. Authors Note Fresh Shells found at 2 sites and may have come down the river from known/healthy populations in Kansas/Missouri.	Vaughn CC. Determination of the status and habitat preference of the Neosho mucket in Oklahoma. Oklahoma City, OK: Oklahoma Biological Survey; 1998. 17 pp.
	2003/11/05 2006/08/03	KDHE	Spr7: 36.96145, -94.72203, Dead Weathered Neosho Mucket Shell Spr8: 36.93439, -94.74520, Dead (Recent) Neosho Mucket Shell Spr9: 36.87474, -94.76269 None Found	Angelo, R.T., M.S. Cringan, D. L. Chamberlain, A. J. Stahl, S. G. Haslouer, and C. A. Goodrich. 2007. Residual effects of lead and zinc mining on freshwater mussels in the Spring River basin (Kansas, Missouri, and Oklahoma, USA). Science of the Total Environment 384: 467-496.
	2018	EcoAnaysts, Inc.	Found live Neosho Mucket From 8 of 15 sites in Missouri, Kansas, and Oklahoma. They documented changes in in the mussel community since Angelo 2007 with previously inhabited sites uninhabited.	USFWS Neosho Mucket 5-year review: Summary and Evaluation
Elk River	1978-1995		23 Neosho Muckets collected in Missouri from two sites. (Location Undisclosed)	USFWS Neosho Mucket 5-year review: Summary and Evaluation
	1992 & 1998		Reports of Brooding Neosho Mucket Females and	USFWS Neosho Mucket 5-year

			Juveniles present at two sites (Location Undisclosed)	review: Summary and Evaluation
	2016-2017		45 Live Muckets collected from 4 locations near Noel and HWY DD, McDonald County, MO	USFWS Neosho Mucket 5-year review: Summary and Evaluation

3.1.2 Habitat and Conservation Status

The life history for the Neosho mucket, similar to most freshwater mussels in North America, is not fully understood. In general, freshwater mussels siphon water across gills for respiration and food collection. Mussels are known to forage on detritus, algae, dissolved organic carbon, and other microscopic organisms (Strayer et al. 2004). Adult mussels tend to orient themselves on the surfaces of substrate to take in food and oxygen from the water column (The Neosho Mucket Recovery Team 2018). The Neosho mucket reproduces with the release of sperm from male mussels into the water column where females can draw it in through their siphon (Barnhart 2003). Reproductive success is often a function of water flow conditions and species density. Neosho Muckets spawn in late April and May and female brooding of glochidia occurs through the month of August (Barnhart 2003). It's been demonstrated the Neosho mucket glochidia are obligate parasites of black bass species, including the largemouth (Micropterus slmonides), smallmouth (Micropterus dolomieu) and spotted bass (Mocropterus punctulatus) (Barnhart and Roberts 1997; Service 2005).

Habitat requirements for the Neosho mucket are not adequately understood and sometimes contradictory depending on the reporting survey and the drainage where found. Previous research has demonstrated an association of Neosho Muckets and shallow riffles and runs with moderate to swift-moving water. In Shoal Creek and the Illinois River, Oklahoma, it prefers nearshore areas or areas out of the main current (Oesch 1984; Obermeyer 2000). It is believed the Neosho mucket does not occur in reservoirs lacking riverine characteristics (Obermeyer et al. 1997). In the Illinois River, Neosho muckets seem to concentrate in areas outside of the main river channel near the shore (ODWC 2021b), often in mucky and/or slack-water habitats (Olsson 2019).

As of its 5-year status review conducted by USFWS in 2020, the conservation status of the Neosho Mucket remains unchanged and exists in isolated populations with low abundance except in the Spring River critical habitat locations (USFWS 5 Year Review). Threats to conservation vary by river system within the study area. In the Neosho River upstream of Grand Lake, 12 low head dams and 3 federal dams exist, which alter the hydrologic and water quality conditions along the Neosho River North of the project area. Obermeyer 1997 found mussel richness and diversity negatively affected by the presence of low head dams both upstream and downstream on the Neosho River in Kansas. In the Spring River, the historic mining of lead and zinc within the tri-state mining district (TSMD) have caused contamination of waterways within the project area at levels above TSMD sediment quality guidelines in the Spring River (Morrison et. al., 2019).

Angelo et al (2007) noted that unionid mussel species richness declined with increasing sediment metals concentrations within the Spring River and TSMD. Overall, threats to the species include impoundment, sedimentation, chemical contaminants, mining, the inadequacy of existing regulatory mechanisms, population fragmentation and isolation, invasive nonindigenous species, and degradation of water quality. Climate change is also likely to have adverse effects on the species because of the alteration of hydrologic cycles of rivers that support Neosho mucket, but the extent or magnitude of this threat has not been quantified at this time (USFWS 2018).

3.1.3 Phase II and Phase III Recommendations

Based off historical mussel survey data from 1990-2017, and the 5 year species reviews compiled by USFWS for the Neosho mucket a data gap exists in the record regarding the presence or absence of endangered mussel species within the Elk River portion of the GRDA project boundary.

On the Neosho River, the most recent mussel survey completed by Eco Analysts Inc. (2018) in 2017 found no live or relic shells of Neosho mucket within or upstream of the study area. While one live specimen of Neosho mucket was found during a bridge construction project in 2014, the body of available data within the Neosho River arm of the project suggests that the Neosho Mucket and other ESA mussel species are unlikely to occur in the project boundary of the Neosho River arm. On the Spring River, surveys from the Kansas/Oklahoma State line to the project boundary have similarly been unable to locate live Neosho mucket, suggesting that these species are unlikely to occur in this area of the project.

The Elk River portion for the GRDA project boundary was listed in 2015 as critical habitat for the Neosho Mucket. The most recent survey data recounted in the 5 Year Review of the Neosho Mucket status suggests that a population of mussels may exist within the project boundary of Grand Lake as evidenced by recent surveys that recovered live specimens only a few river miles upstream. Per the description in the CFR for critical habitat NM2; a roughly one mile stretch of critical habitat occurs within the current project boundary and no data is available regarding the presence or absence of the Neosho Mucket, ESA or other unionid species in this area. Therefore, we propose a freshwater mussel survey from the Oklahoma/Missouri State line on the Elk River, to the confluence of Buffalo Creek in phase II of this process.

In order to accomplish our objective to collect data on the occurrence and distribution of endangered, threatened and other unioid mussels within the survey area, we will use a phased sampling design incorporating both Qualitative and Quantitative methods. Qualitative surveys will characterize the substrate, identify potential mussel beds, and potential presence of live mussels within the Study Area. A minimum search time of five person-hours (divided into five one person-hour searches) will be conducted within the delineated search area. If no live mussels are encountered after the first three one-person hour searches, surveys within this location will cease and it will be assumed no live mussels are present. At the end of each search period, collected mussels will be identified and enumerated. If no new species of mussels are collected during the fifth search period, the survey is complete. If at least one new mussel species is collected in the fifth search period, additional one person-hour search periods are required until no new species are collected.

Visual, combined with tactile searching (hand-grubbing into the top 1-4 inches of substrate to increase detection of more-deeply buried mussels) will be used. Searchers will select a shoreline and begin searching from downstream to upstream moving back and forth across the stream, ensuring that all the delineated search area is sufficiently covered. If listed mussels are detected, initial surveys will immediately cease, and quantitative methods will commence.

Quantitative surveys will involve sampling on mussel beds identified during qualitative surveys to quantify the mussel populations. Quantitative point sampling will be conducted on mussel beds by randomly selecting 0.25 m2 quadrats plots within each bed. Systematic sampling will incorporate three random starts (Smith et al. 2000) with 2 additional quadrats selected at 1-m intervals (9 quadrats per sample/site). Additional, randomly selected quadrat points will be available to replace locations that do not provide mussel habitat (e.g. too close to shore, water depth, poor substrate).

Quantitative surveys will be performed by visual and tactile searches of randomly placed 0.25 m2 quadrats placed at random locations as outlined above. Substrate within the quadrats will be excavated to a depth of 20 cm and sieved, as this increases the likelihood of detecting juvenile mussels (Smith et al. 2000).

All live individuals will be identified, enumerated, and returned to the approximate location of collection. Shell material will also be collected and quantified during sampling from the stream and classified as fresh dead (FD; intact periostracum and lustrous nacre), weathered dead (WD; intact periostracum, weathered and chalky nacre), or subfossil (SF; shell chalky, no periostracum).

These surveys will be conducted under the supervision of qualified personnel with appropriate licenses and knowledge of mussel survey methods and procedures for handling endangered mussel species.

3.2 Rabbitsfoot (Quadrula cylindrica)

3.2.1 Distribution and Occurrence

The rabbitsfoot was historically found in the Verdigris, Neosho, Spring, Illinois, Blue, and Little rivers in Oklahoma. Populations currently remain in the Verdigris, Illinois, and Little rivers. Though rabbitsfoot still exist in the Spring and Neosho rivers, they are considered very rare or extirpated in the Oklahoma portion (Curtis Tacket; personal communication; USWFS 2020b). Relic shells indicate that rabbitsfoot formerly occurred extensively in the Verdigris, Fall, Cottonwood, Neosho, and Spring rivers in Kansas, and Spring River and Shoal Creek in Missouri, but recent records only identify a few individuals from a handful of sites in the Spring and Neosho rivers (EcoAnalysts 2018, Obermeyer et al. 1997). In 2016 and 2017, biologists surveyed 15 sites extending from 500 meters downstream of the confluence with the North Fork of the Spring River in Jasper County, Missouri, to 7.45 miles upstream of the confluence with the Neosho River in Ottawa County, Oklahoma (USFWS 2020b). Based on the five-year review (USFWC 2020b), two live specimens from two sites in Missouri and two live specimens from two sites in Kansas were reported but no specimens were found in Oklahoma during this survey period. This species is considered endangered wherever found with the closest critical habitat being found in Missouri 25 miles upstream (Table 4).

Table 4. Critical habitat for Rabbitsfoot

Critical Habitat Unit Number	River	Within Study Area
RF1	Spring	No

3.2.2 Habitat and Conservation Status

The rabbitsfoot is a freshwater mussel typically found in small-to-medium-sized rivers that have a moderate current and clear, relatively shallow water. It prefers river bottoms that are a mixture of sand and gravel substrates (Watters 1988). The rabbitsfoot spawns from May to June (Yeager and Neves 1986). Six species of minnows have been determined to be suitable hosts for the rabbitsfoot larval stage: blacktail shiner (*Cyprinella venusta*), red shiner (*Cyprinella lutrensis*), bluntface shiner (*Cyprinella camura*), cardinal shiner (*Luxilus cardinalis*), whitetail shiner (*Cyprinella galctura*), spotfin shiner (*Cyprinella spiloptera*), and bigeyed chub (*Hybopsis amblops*). Based on records received from the OWRB, none of the host species have been present at sampling events in the Neosho, Spring, and Elk rivers draining into the project area from 2003-2018.

As with other headwater-inhabiting species of mussel, the combination of river impoundments and the ecological requirements of the rabbitsfoot predict a series of isolated populations in the headwater streams throughout the species range. Because adults do not typically burrow into sediment but rather lie horizontally on the streambed surface (Watters 1988), flow refuges may decrease the likelihood of displacement into unsuitable habitat. The primary cause of population declines of the rabbitsfoot is the construction of reservoirs and impoundments throughout its range (USFWS 2009). Direct disturbance by human recreational activities also can have a negative impact on the species. Metal pollution in the Spring River was the consequence of metal inputs from the Tri-State Mining District, where extensive mining for Pb and Zn occurred during the mid-1800s through the 1950s (Barks 1986; Wildhaber et al. 1999b; 2000a; Brumbaugh et al. 2005)

3.2.3 Phase II and Phase III Recommendations

Through personal contact and data received from the Sam Nobel Museum, Oklahoma State invertebrate collection department, and ODWC suggest that no mussel surveys have been conducted within the drainages leading up to the reservoir. The closet critical habitat is located 25 miles upstream from the Project Area in Jasper County Missouri on the Spring River. No live specimens have been found in Oklahoma segment of the river (EcoAnalysts 2018). The five year (USFWS 2020b) acknowledges the Oklahoma segment of the river as historic range with no extant population. Therefore, based on the literature and data available it is not likely that a population would occur within the study area and no further studies are recommended.

3.3 Winged Mapleleaf (*Quadrula fragosa*)

3.3.1 Distribution and Occurrence

Historically, the winged mapleleaf is known to occur in the Boggy, Kiamichi, Neosho, and Little rivers of Oklahoma. The only known population to still occur in Oklahoma is found in the Little River, though its status in other river systems is generally unknown (USWFS 2011).

Winged mapleleaf is known to exist in Missouri, Wisconsin, Arkansas, and Oklahoma. Known populations closest to the Project includes the Bourbeuse River in Missouri, the Ouachita River in Arkansas, the Saline River in Arkansas, and the Little River in Arkansas and Oklahoma. In the Little River, the winged mapleleaf has been found in 12 sites since 2005 (Galbraith et al. 2008). In 2008 (Allen and Vaughn 2008), sampled six mussel beds and located winged mapleleaf in four of those beds. No critical habitat is currently available for this species.

3.3.2 Habitat and Conservation Status

The winged mapleleaf is a freshwater mussel found in areas that have high water quality in stream beds varying from sand, cobble, or rubble (USFWS 2011, ODWC 2021c). The winged mapleleaf is often found in dense and diverse mussel beds where the large number of mussel species may stabilize the riverbed and improve the habitat for rare mussel species (Allen et al. 2008).

The winged mapleleaf has been found to be a fall tachytictic or short-term brooder (Heath et al. 2000). Habitat degradation is the primary cause of this species decline. Dams, channelization, and dredging increase siltation, physically alter habitat conditions, and block the movements of fish hosts (ODWC 2021c). Other factors could include narrow range, sparse population and low reproduction, and the probability of inbreeding, which could weaken the species genetically (Hornbach et al.1996). Of the five remaining populations, three are subject to threats from restricted populations and isolation from other populations. The low flows associated with droughts have been found to pose a high degree of threat to the Little River population (Hove et al. 2012).

3.3.3 Phase II and Phase III Recommendations

Personal contact with the Sam Nobel Museum, Oklahoma State invertebrate collection department and ODWC indicate that no specimens have been previously found within the Neosho, Spring, and Elk Rivers or surrounding drainages leading up to the reservoir. The only recognized population in Oklahoma is within the Little River which is 175 miles from the study area. It is not likely that there is a population within the study area and no further studies are recommended.

3.4 Neosho Madtom (*Noturus placidus*)

3.4.1 Distribution and Occurrence

The Neosho madtom is a small catfish commonly 1.75–2.75 inches long; the maximum is about 3 inches long (Wenke 1991). This species is native to the Illinois River in Oklahoma, the Neosho River (Kansas & Oklahoma), the Cottonwood River (Kansas), and the Spring River (Kansas, Oklahoma, and Missouri), where it inhabits riffles and bar habitats with loose pebble and gravel substrate, moderate to high water velocities, and relatively shallow depths (Ernsting et al. 1989; Wilkinson et al. 1996; Wilkinson and Fuselier 1997; Wildhaber et al. 2000) The density of Neosho madtom populations is much greater in the Neosho system (i.e., the Neosho and Cottonwood rivers combined) than in the Spring River (Moss 1983; Wilkinson et al. 1996). The Tar Creek superfund site is located with portions of the range of the Neosho madtom within the Neosho and Spring rivers watersheds and the superfund site is a known source of heavy metal contamination (lead, cadmium, and zinc). Where metals contamination is minimal, Neosho madtom densities seem to be limited primarily by physical and chemical habitat quality and availability. Extant Oklahoma populations of the Neosho madtom are restricted to the Neosho River upstream from Grand Lake. A population documented in 1946 in the lower Illinois River is now presumed to be extirpated (Moss 1981).

3.4.2 Habitat and Conservation Status

Neosho madtoms have been found in the highest numbers during daylight in riffles in late summer and early fall, after young of the year are estimated to have recruited to the population (Moss 1983; Luttrell et al. 1992; Fuselier and Edds 1994). Neosho madtoms prefer the interstitial spaces of unconsolidated pebbles and gravel, moderate-to-slow flows, and depths averaging 0.23 meter (Wildhaber et al. 2000). Adults hide in the interstices of loose gravel riffles during the day and feed nocturnally on the aquatic insects (Cross and Collins 1975). Young of the year are said to inhabit slower flowing waters downstream from riffles and use pools and backwaters as nursery areas (Fuselier and Edds 1994). Where contamination has occurred, Neosho madtoms seem to be limited primarily by the presence of contaminants associated with the Spring River acting directly (via mortality or avoidance) or indirectly (by suppressing and/or contaminating) on the benthic invertebrate food base (Cross and Collins 1975).

3.4.3 Phase II and Phase III Recommendations

Neosho madtoms have been found in the drainages of the study area from 1969-2007; the last sampling attempts near the project area occurred in 2016 and were conducted by the OWRB (Figure 2). The closest collection point within the study area was conducted in 2007. Because of the five-year data gap, it is proposed that sampling efforts take place within the Neosho River branch of the study area including sampling select locations upstream to determine habitat quality. Determining habitat quality outside of the project area will allow for appropriate mitigation if management practices limit suitable habitat within the study area. All previous madtom locations have been within this branch of the river and is the most likely area to have a stable population.

It is recommended that a 20 mile stretch of the river from HWY60 to the Craig/Ottawa county border be assessed in locations that contain riffles and moderate to low-velocity gravel bar habitats. Fish sampling will be conducted between late summer and early fall at selected sites where riffles and gravel bars are identified via review of aerial imagery that are readily accessible public roads, bridges, or access points. Fish sampling will be conducted by kick-seining (4.6 m x 1.8 m seine with 3.2 mm mesh) by one or two individuals thoroughly disturbing the substrate beginning four meters upstream from a stationary seine and then kicking in a downstream direction to the seine's lead line. Kick-seining will start at the downstream end of a habitat and proceeded laterally and then upstream with multiple kick-seine efforts until all habitat less than one meter deep at a site had been sampled. All fishes captured will be identified to species, measured for total length (TL) to the nearest millimeter, counted, and then returned to the stream.

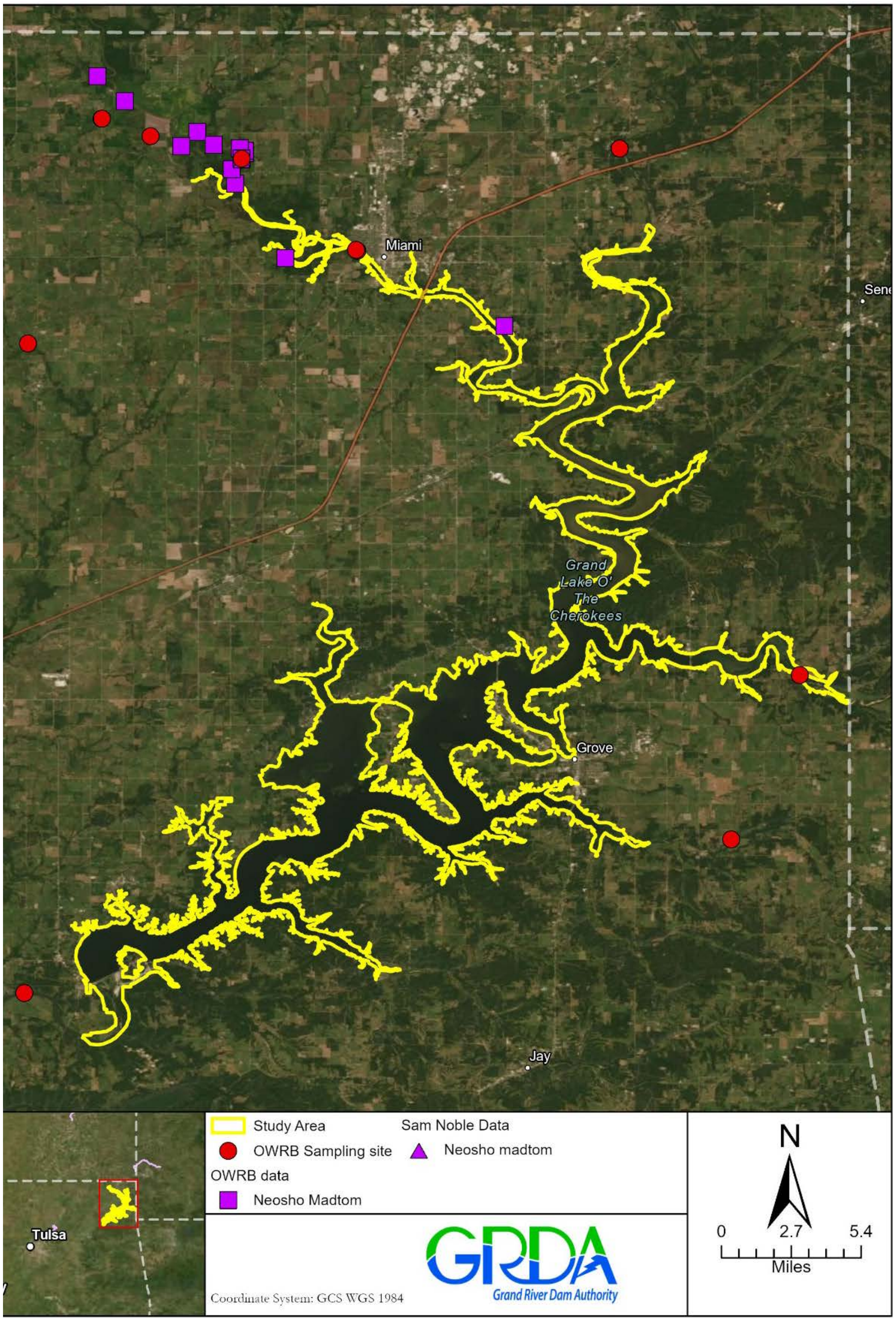

Figure 2. Known Locations of Neosho Madtom – data provided by OWRB and Sam Noble Museum.

3.5 Neosho Smallmouth Bass

3.5.1 Distribution and Occurrence

The Neosho smallmouth bass is a genetically distinct subspecies of smallmouth bass (Stark and Echelle 1998, Tayler et al. 2018. The Neosho smallmouth bass is found in the western extent of the Ozark Highlands ecoregion (Nigh and Schroeder 2002) and is known to occur in the Spring River, the Elk River, the Neosho River, Spavinaw Creek, Spring Creek, the Illinois River, Baron Fork, Sallisaw Creek, Lee Creek, Clear Creek, the Mulberry River, Big Piney Creek, and the Illinois Bayou (Brewer and Long 2015). Taylor et al. (2018) identified Neosho smallmouth bass in Sycamore Creek, the Elk River, and Honey Creek: all of which feed into Grand Lake.

3.5.2 Habitat and Conservation Status

The Neosho smallmouth bass is found in streams that have watersheds with coarse-textured soils (Brewer et al. 2007, Brewer and Long 2015, Dauwalter et al 2007) within the Ozark and Boston Mountain ecoregions. Generally, the smallmouth bass is found in clear streams, but the Neosho smallmouth bass can persist in some streams that are often spring fed and have relatively high sediment loads (Nigh and Shroeder 2002; Brewer and Long 2015). Though Neosho smallmouth bass are found in pool habitats, larger streams that have various channel units, including runs and riffles, are necessary for abundant populations (Dauwalter et al. 2007, Brewer 2013).

Spawning habitat for the Neosho smallmouth bass consists of low-velocity, nearshore waters that are close to cover. The Neosho smallmouth bass also prefers to construct nests in areas that have fine sediment substrates and avoids areas that have thick layers or silts and clays (Dauwalter et al. 2007). In years that have low stream flows, low water velocity at the nest site was found to be important for nest success (Dauwalter et al. 2007). In years that have elevated discharge events, nest success was influenced by streamflow, temperature, and distance to shore (Dauwalter et al. 2007).

However, available biology and ecology data suggest that Neosho Smallmouth Bass possess local adaptations to warmer climates and intermittent stream flows (Brewer and Long 2015). Moreover, the Neosho Smallmouth Bass inhabits stream systems but lack impact to impoundment fisheries (Stark and Echelle 1998; Malloy 2001), underscoring the unique fluvial ecology of this subspecies compared with nonnative Smallmouth Bass that thrive in impoundments following stocking. Conservation of the Neosho Smallmouth Bass subspecies, and the population-level diversity within the subspecies, would thus provide a “diversified portfolio” that would contribute to maintaining the overall adapt-ability of Smallmouth Bass to future climate change or habitat-related stressors (Schindler et al. 2010). Nonnative black bass are typically stocked in impoundments to bolster sportfishing opportunities, and native congeners often experience introgression, widespread admixture, or complete replacement within impoundments (Avise et al. 1997; Barwick et al. 2006).

3.5.3 Phase II and Phase III Recommendations

Several records show that a smallmouth bass population is present within the drainages of the study area (Figure 3), but during the sampling there was no determination that the Neosho subspecies was identified. It is likely that all records of smallmouth bass from OWRB and the Sam Nobel Museum are not of the Neosho strain (Curtis Tacket; personal communication) because the smallmouth bass that may occur within Grand Lake and the stretches of the Neosho, Spring, and Elk rivers in Oklahoma are likely to be reservoir-strain fish. ODWC sampling efforts (locations not disclosed), which looked for both the Neosho and reservoir subspecies, did not detect the Neosho subspecies of the smallmouth bass within this project area or surrounding drainages; the latest surveys occurred in 2019 (Curtis Tacket; personal communication). Based on these data indicating that the Neosho smallmouth does not occur within the study area, Olsson does not recommend any additional surveys for Neosho smallmouth bass.

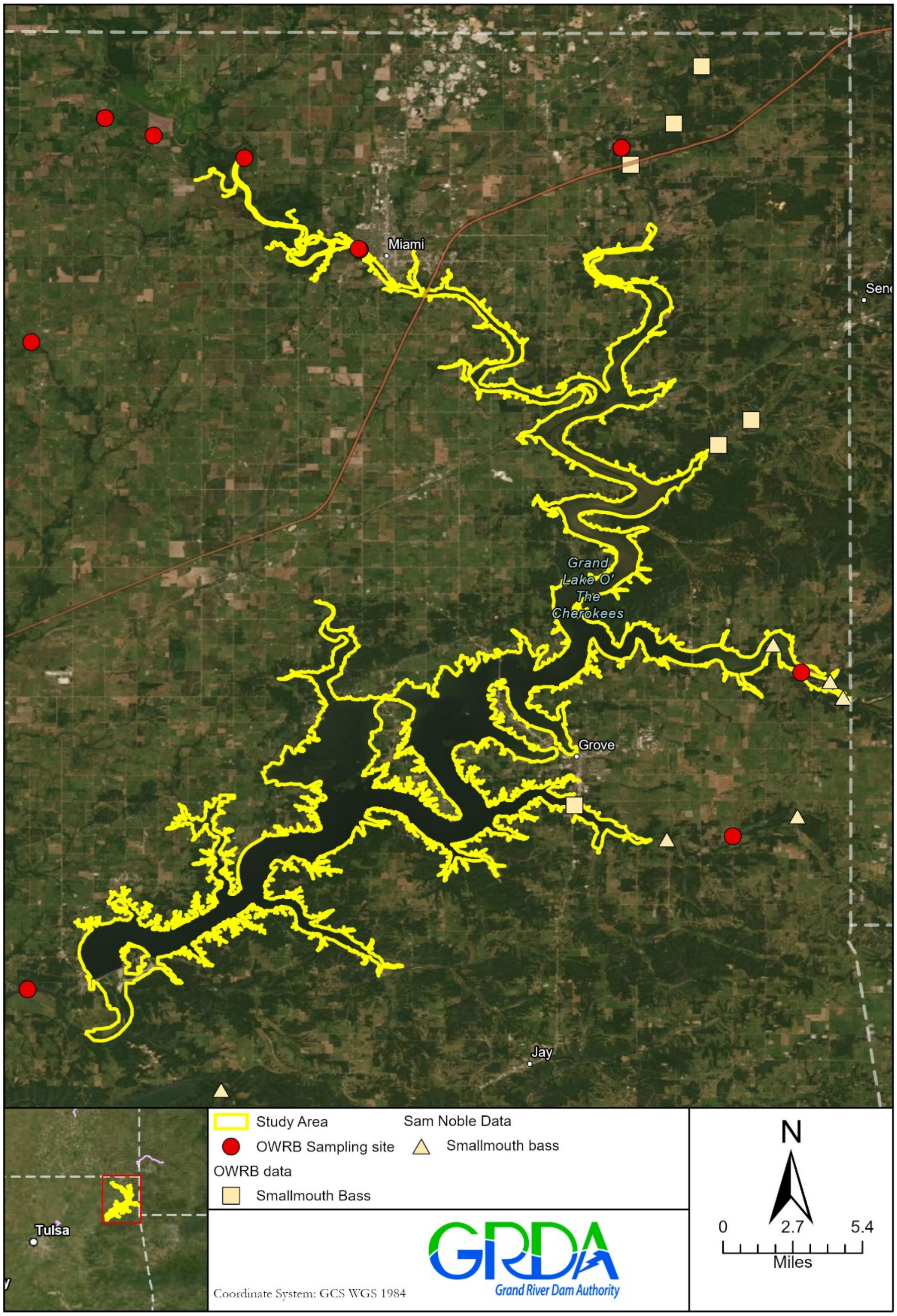

Figure 3. Known Locations of Neosho Smallmouth Bass – data provided by OWRB and Sam Noble Museum.

3.6 Paddlefish

3.6.1 Distribution and Occurrence

Paddlefish are native to large rivers and lakes of the Mississippi River drainage and nearby gulf slope drainages from the San Jacinto River in the southwest to the Tombigbee and Alabama rivers in the southeast. At the northern extent of their range, paddlefish extend as far west as the Missouri and Yellowstone rivers of Montana to the Ohio and Allegheny rivers of the northeast (Jennings and Zigler 2009). In Oklahoma, paddlefish were originally present in most large rivers of the Arkansas system including the Neosho and Grand rivers, the Little River, and the Red River (Miller and Robison 2004).

Paddlefish stocks in Grand Lake and the Neosho and Spring Rivers support a prominent snag fishery, attracting anglers from throughout the United States during the spring spawning run (Jager and Schooley 2016). Although annual catch rates are variable depending on hydrologic conditions, thousands of mature paddlefish are harvested from Grand Lake stocks during some years (Scarnecchia et al. 2013). Trip expenditures from Paddlefish angling in Oklahoma have an estimated economic impact of 18.2 million dollars (Melstrom and Shideler 2017), much of which is focused on the Grand Lake fishery. Since 2015, good water years (years with extended high springtime flows) have resulted in good Paddlefish recruitment in the Neosho watershed. The impacts of a large recruitment event in 2015 are now being realized as the males have reached sexual maturity and the females will in 2022-2023 (personal communication via email on Sep. 13, 2021, Jason Schooley, ODWC Paddlefish Research Center).

3.6.2 Habitat and Conservation Status

Adult paddlefish inhabit deep slow-moving pools of large rivers and associated lakes and reservoirs, where they use special electrical receptors on their rostrum to detect zooplankton that are filtered from the water with specialized gill rakers (Jennings and Zigler 2009). They typically inhabit areas with depths greater than 9.8 ft and current velocities below 1.6 feet per second (ft/s) in reservoirs (Rosen et al. 1982; Zigler et al. 2003). Appropriate spawning habitats are more specific and require riverine habitats. Paddlefish spawning occurs in aggregations over hard substrates such as washed cobble within river environments during March – June, depending on latitude (Jennings and Zigler 2009; Schooley and O’Donnell 2016). In Oklahoma, spawning peaks in late March and early April (Scarnecchia et al. 2013). Spawning appears to be episodic, often initiated by rising water levels and occurring during periods of high flow, and year-class recruitment is often highest in years that have extended high flow conditions during the spring spawning period (O’Keefe et al. 2007; Jennings and Zigler 2009; Scarnecchia et al. 2013). Paddlefish spawn demersal eggs that become adhesive upon fertilization and stick to the substrate (Purkett 1961; Yeager and Wallus 1982). Hard substrates such as gravel and cobble are key to spawning success because eggs that fall on sand or silt may have reduced survival (Schooley and O’Donnell 2016).

Previous research by ODWC biologists has quantified the amount of hard spawning substrates within the Neosho and Spring rivers upstream of Grand Lake to the first migration barriers and evaluated how changes in flows influence the availability of spawning habitat in these rivers (Schooley and O'Donnnel 2016; Schooley and Neely 2018). Because changes to reservoir elevations could potentially influence the availability of spawning substrates, Phase I of this study included compilation of this data and development of maps to evaluate the amount and spatial distribution of paddlefish spawning substrate within the Project area.

To perform this evaluation, spatially explicit depth and hardness data from the above studies provided by Jason Schooley (ODWC Senior Biologist, Paddlefish Research Center) and Ben Neely (Kansas Department of Wildlife, Parks, and Tourism) were compiled and formatted into a geographic information system (GIS) platform. Details on data collection and analysis used to generate this dataset and differentiate substrate types are provided in Schooley and O'Donnell (2016) and Schooley and Neely (2018). The study area for this dataset includes 38.5 miles of the Neosho River upstream to a dam at Chetopa, Kansas, and 22.4 miles of the Spring River upstream to a barrier at Baxter Springs, Kansas. Within this study area, the amount of usable spawning substrate changes with flow in each system because higher flows generally inundate more usable substrate. At the maximum flows evaluated, a total of approximately 2,647 ac of potential habitat occurs, of which 1,701 ac (64 percent) consist of hard substrates presumably suitable for paddlefish spawning (Table 5). Specifically, 997 ac of paddlefish spawning substrates (69 percent of available) were identified within the Neosho River and 704 ac (59 percent of available) were identified in the Spring River. The availability of hard substrates generally increases moving upstream from the river/reservoir interface. Within the project boundary, approximately 696 ac of paddlefish spawning substrate was identified within the Neosho River and 493 ac of spawning substrate was observed within the Spring River (Table 5; figures 4-6). Therefore, 70 percent of the available spawning substrate within both the Neosho River and the Spring River falls within the Project boundary.

Due to hydrology differences between the two river systems, modeling of proportional habitat availability under varying flow rates suggests that the Neosho River has greater value for Paddlefish reproduction than the Spring River (Schooley and Neely 2018). Additionally, studies using dentary bone microchemistry to identify natal river found that 87% of fish analyzed were of Neosho River origin, whereas only 7% were of Spring River origin (Whitledge and Schooley 2019). Taken together, this demonstrates that the Neosho River has much greater value to Paddlefish reproduction than the Spring River.

Table 5. Area of Paddlefish Spawning Substrate in Acres (ac) as Quantified by Schooley and O'Donnell (2016) in Relation to their Study Area and the Project.

	Neosho River	Spring River	Overall
Study Area (ac)	1,444	1,203	2,647
Paddlefish Spawning Habitat (ac)	997	704	1,701
Paddlefish Spawning Habitat within Project (ac)	696	493	1,189
Percent of Paddlefish Spawning Habitat within Project	70%	70%	70%

The area below the confluence of the two rivers, in the Grand River near the river/reservoir interface, was not evaluated for spawning habitat. Spawning activity in this section is unlikely because this area is a transitional zone used by staging paddlefish in the late winter and early spring as they wait for high-flow pulses to move upriver into the Spring or Neosho rivers and begin spawning (Schooley and O'Donnell 2016). Occurrence of such high-flow pulses which stimulate upstream migration within the spring spawning period are the major determinant of Paddlefish spawning success, and likely have a much greater influence on Paddlefish recruitment than reservoir levels.

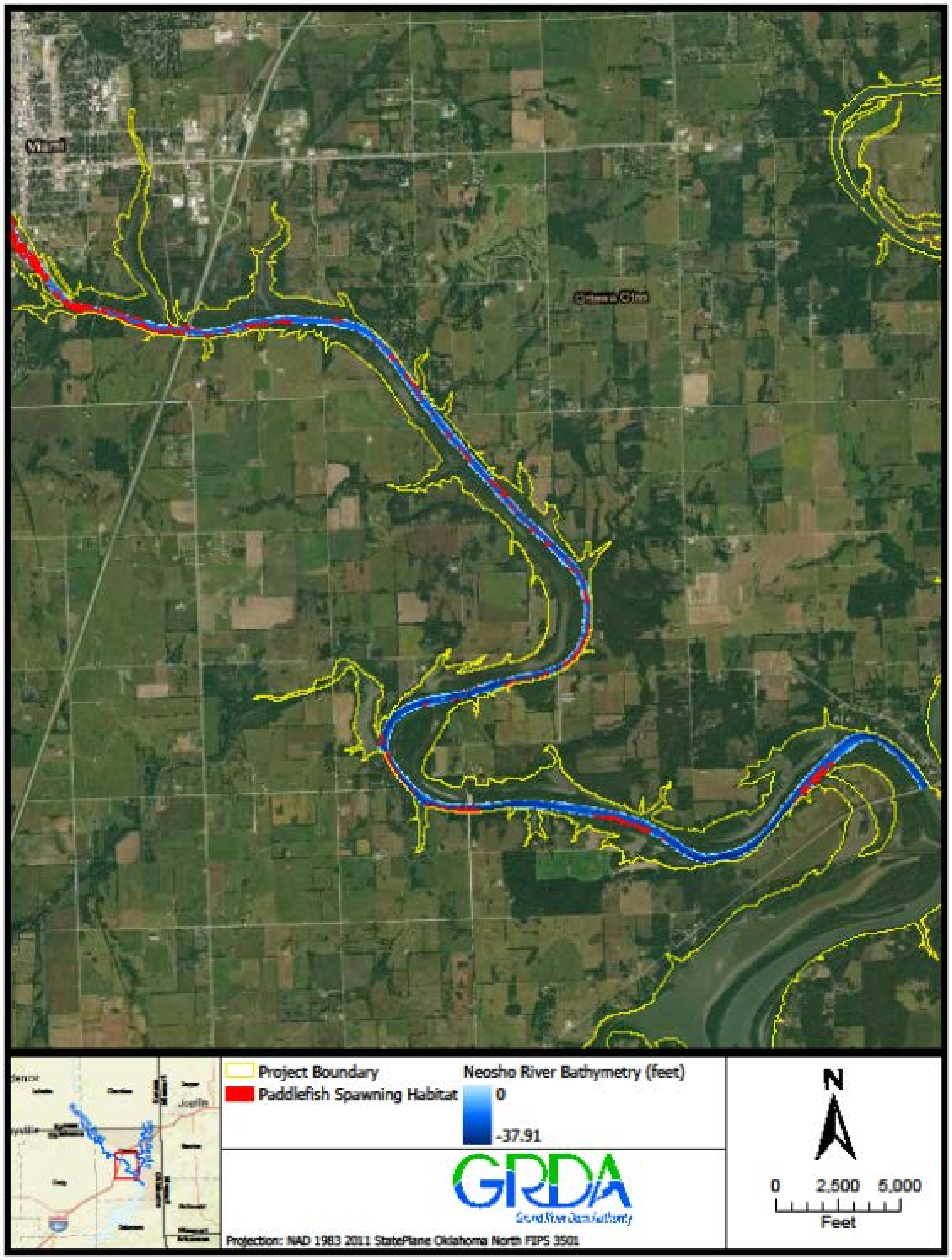

Figure 4. Potential Paddlefish Spawning Substrate as Defined by Schooley and O'Donnell (2016) within the Project Boundary on the Neosho River downstream of Miami, OK.

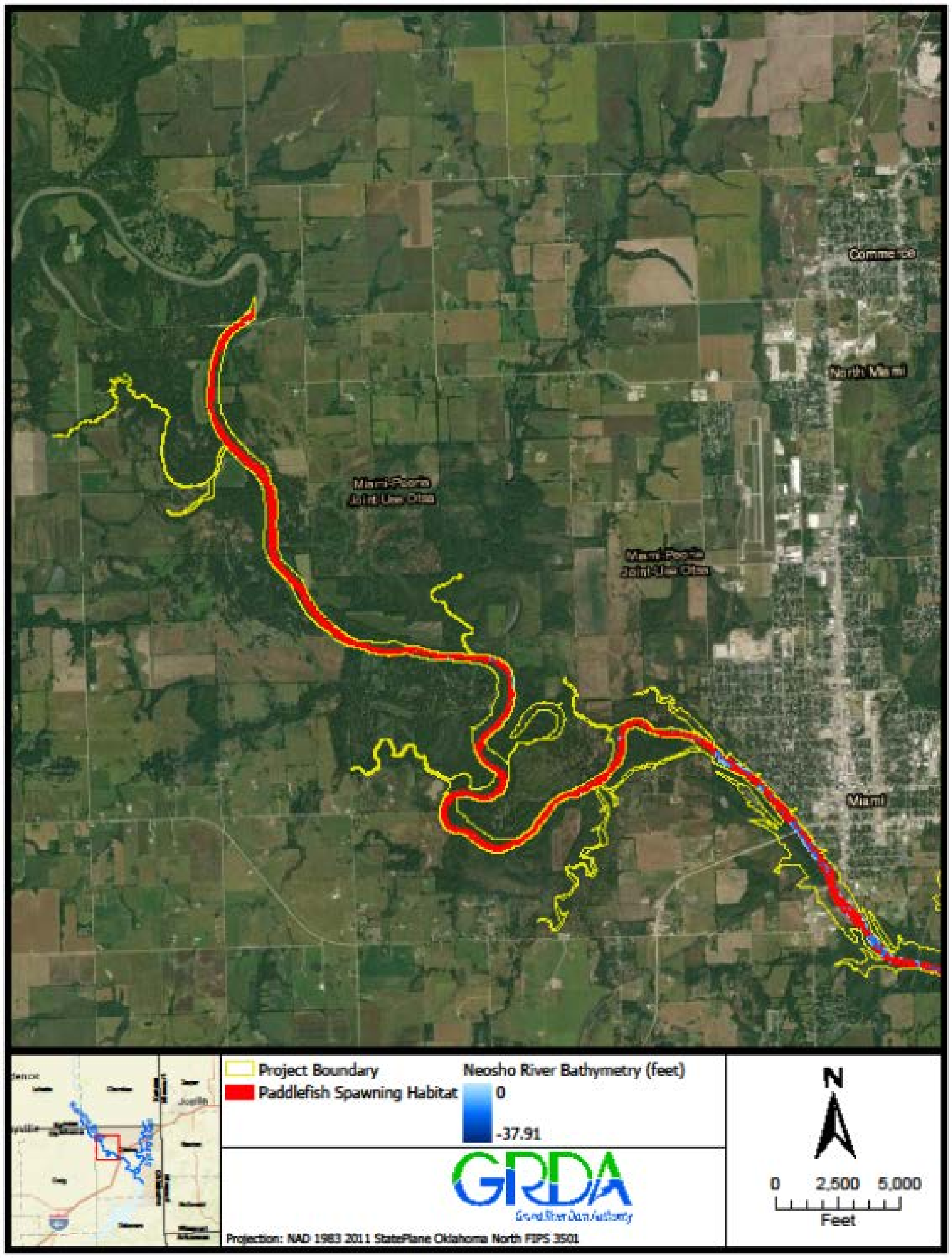

Figure 5. Potential Paddlefish Spawning Substrate as Defined by Schooley and O'Donnell (2016) within the Project Boundary on the Neosho River upstream of Miami, Oklahoma.

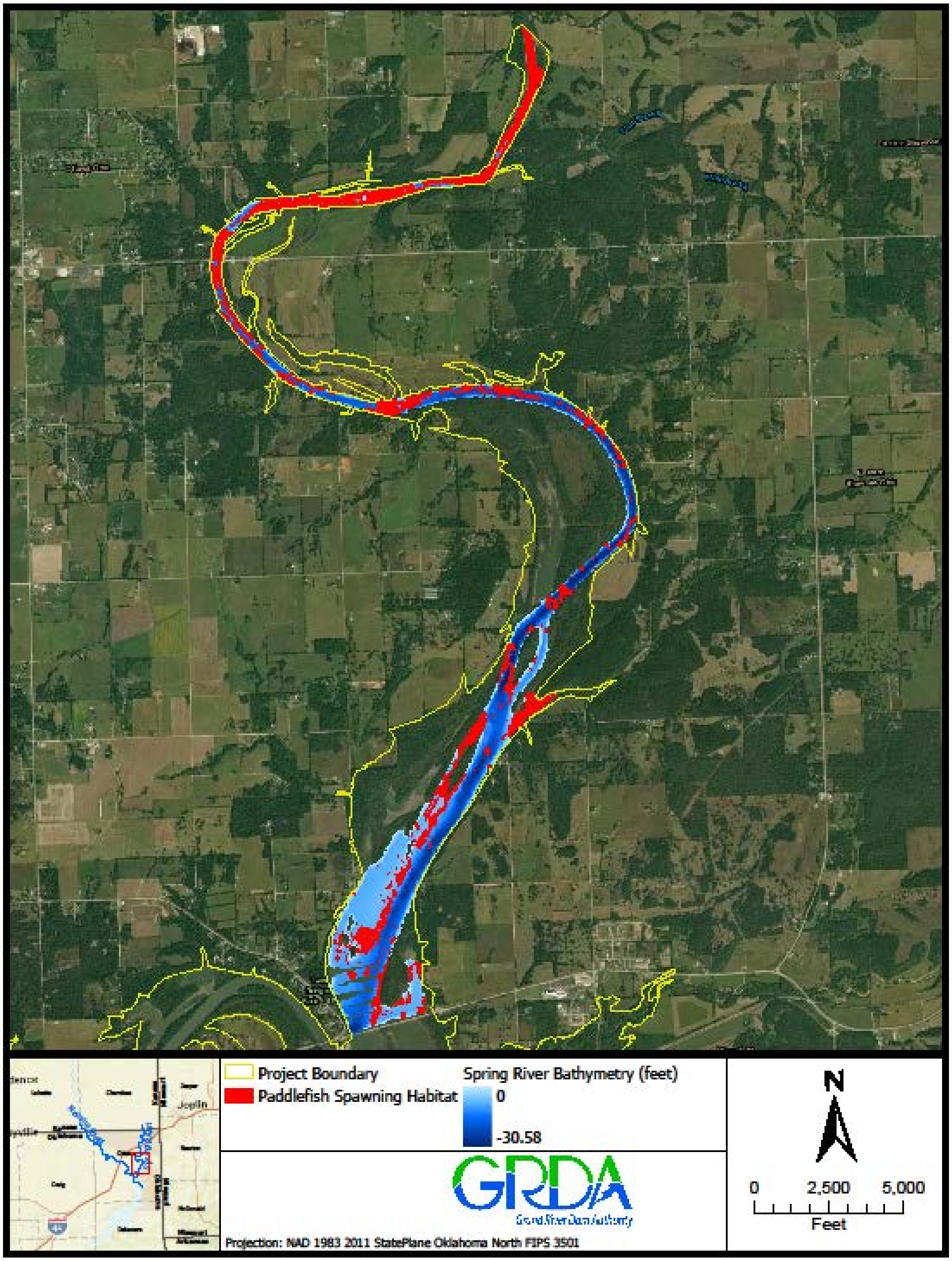

Figure 6. Potential Paddlefish Spawning Substrate as Defined by Schooley and O'Donnell (2016) within the Project Boundary on the Spring River.

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