Pensacola Hydroelectric Project
FERC Project No. 1494

Exhibit E
Environmental Report

Final License Application

Prepared for

GRDA
Grand River Dam Authority

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May 2023

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LIST OF ABBREVIATIONS AND TERMS

1D .... one-dimension
2013 Order .... Order Approving and Modifying Shoreline Management Plan
2015 Order .... Commission's August 14, 2015 Order revising the rule curve
§ .... Section
% .... percent
°C .... degrees Celsius
°F .... degrees Fahrenheit
ABB .... American Burying Beetle (ABB)
ACHP .... Advisory Council on Historic Preservation
anticipated operation .... operation without a rule curve
Applicant .... Grand River Dam Authority
APE .... Area of Potential Effect
BA .... draft biological assessment
baseline operation .... operation under the pre-2015 rule curve
BIA .... Bureau of Indian Affairs
BMPs .... Best Management Practices
Cd .... cadmium
CEQ .... Council for Environmental Quality
CFR .... Code of Federal Regulations
CHM .... Comprehensive Hydraulic Model
cfs .... cubic feet per second
Commission .... Federal Energy Regulatory Commission
Corps .... United States Army Corps of Engineers
CPUE .... catch per unit effort
CRWG .... Cultural Resources Working Group
Cs-137 .... cesium-137
current operation .... operation under current post-2015 rule curve
CWA .... Clean Water Act
CZMA .... Coastal Zone Management Act
dam .... Pensacola Dam
DAMP .... Drought Adaptive Management Plan
dbh .... diameter breast height
DLA .... Draft License Application
DO .... Dissolved Oxygen
E. coli .... *Escherichia coli*
EFH .... Essential Fish Habitat
EJ .... Environmental Justice
EPA .... US Environmental Protection Agency
ESA .... Endangered Species Act
FERC .... Federal Energy Regulatory Commission
FIS .... Flood Insurance Studies
FLA .... Final License Application
FPA .... Federal Power Act
fps .... feet per second
FRM .... Flood Routing Model
FWHMP .... Fish and Waterfowl Habitat Management Plan
FWP .... Fish and Wildlife Propagation

Grand Lake .... Grand Lake O' the Cherokees
GRDA .... Grand River Dam Authority
GWh .... gigawatt hour
H&H .... hydrologic and hydraulic
H&H Study .... Hydrologic and Hydraulic Modeling Study
HEC-RAS .... Hydrologic Engineering Center's River Analysis System
Hg .... mercury
hp .... horsepower
HPMP .... Historic Properties Management Plan
IBI .... Index of Biological Integrity
ILP .... Integrated Licensing Process
IPaC .... Information for Planning and Consultation
ISR .... Initial Study Report
IWB .... Index of Well Being
kV .... kilovolts
kVA .... kilovolt amperes
kW .... kilowatts
LEAD .... Local Environmental Action Demanded Agency
Licensee .... Grand River Dam Authority
LiDAR .... Light Detection and Ranging
MeHG .... methylmercury
µg/L .... micrograms per liter
mg/L .... milligrams per liter
Miami Tribe .... Miami Tribe of Oklahoma
mL .... milliliter
msl .... mean sea level
MVA .... megavolt amperes
MW .... megawatts
n.d. .... no date
NDAA 2020 .... National Defense Authorization Act for Fiscal Year 2020
NEPA .... National Environmental Policy Act
NHPA .... National Historic Preservation Act
NLEB .... northern long-eared bat
NMFS .... National Marine Fisheries Service
NOI .... Notice of Intent
NPS .... National Park Service
NRCS .... Natural Resource Conservation Service
NRHP .... National Register of Historic Places
NSE .... Nash-Sutcliffe Efficiency
NTU .... Nephelometric Turbidity Units
NWI .... National Wetlands Inventory
OAS .... Oklahoma Archaeological Survey
ODEQ .... Oklahoma Department of Environmental Quality
ODWC .... Oklahoma Department of Wildlife Conservation
OK .... Oklahoma
ONHI .... Oklahoma Natural Heritage Inventory
OM .... Operations Model
OMNH .... Sam Noble Oklahoma Museum of Natural History
OPSP .... Open Project Selection Process
OSU .... Oklahoma State University

OTRD .... Oklahoma Department of Tourism and Recreation
OWQS .... Oklahoma Water Quality Standards
OWRB .... Oklahoma Water Resources Board
PAD .... Pre-Application Document
PAL .... provisionally accredited levee
Pb .... Lead
PBIAS .... Percent Bias
PD .... Pensacola Datum
PSP .... Proposed Study Plan
Pensacola Project .... Pensacola Hydroelectric Project
Project .... Pensacola Hydroelectric Project
Qal .... Quaternary alluvial landforms
REA Notice .... Notice of Acceptance and Ready for Environmental Analysis
REAS .... Real Estate Adequacy Study
RM .... river mile
RMP .... Recreation Management Plan
ROI .... Region Of Influence
rpm .... revolutions per minute
RSP .... Revised Study Plan
RSR .... RMSE-Observations Standard Deviation Ratio
RUSLE 2 .... Revised Universal Soil Loss Equation Version 2
RWM .... RiverWare period-of-record model
SAMP .... Storm Adaptive Management Plan
SD2 .... Scoping Document 2
SCORP .... Statewide Outdoor Comprehensive Recreation Plan
SHPO .... State Historic Preservation Officer
SMC .... Shoreline Management Classification
SMP .... Shoreline Management Plan
SSC .... suspended sediment concentration
STM .... Sediment Transport Model
TCP .... Traditional Cultural Property
TE .... Threatened and Endangered (Species)
TSMD .... Tri-State Mining District
TP .... Total Phosphorus
UHM .... Upstream Hydraulic Model
USACE .... United States Army Corps of Engineers
USC .... United States Code
USDA .... United States Department of Agriculture
USFWS .... United States Fish and Wildlife Service
USGS .... United States Geologic Survey
USP .... Updated Study Plan
USR .... Updated Study Report
WMA .... Wildlife Management Area
WSE .... Water Surface Elevation
WWAC .... Warm Water Aquatic Community
Zn .... Zinc

1. Introduction

The Pensacola Hydroelectric Project (Pensacola Project or Project), owned and operated by the Grand River Dam Authority (GRDA or Licensee) is licensed by the Federal Energy Regulatory Commission (FERC or Commission) as Project No. 1494. GRDA is an agency of the state of Oklahoma, created by the Oklahoma Legislature in 1935 to be a "conservation and reclamation district for the waters of the Grand River." GRDA fulfills its statutory responsibilities under state law by operating the Pensacola Project, as well as the downstream Markham Ferry Project (FERC No. 2183), and Salina Pumped Storage Project (FERC No. 2524). In addition, GRDA manages the three lakes formed by the three Project dams, which include Pensacola Project's Grand Lake O' the Cherokees (Grand Lake), Markham Ferry Project's Lake Hudson, and Salina Pumped Storage Project's W.R. Holway Reservoir. GRDA produces and sells electricity that reaches into 75 of the 77 counties in Oklahoma (Grand River Dam Authority, 2017a).

The Pensacola Project was the first hydroelectric project constructed in Oklahoma. Construction began in 1938 and concluded when the spillway gates were closed in March 1940, forming Grand Lake. GRDA has operated and maintained the Project since August 1946 when, pursuant to an act of Congress, the United States returned the Project to GRDA following World War II (Grand River Dam Authority, 2008).

The Pensacola Project is located on the Neosho and Grand Rivers in northeastern Oklahoma, within Craig, Delaware, Mayes, and Ottawa Counties. The Neosho River originates in Kansas and flows into Oklahoma where it joins the Spring River to form the Grand River. Pensacola Dam is located between the towns of Langley and Disney at river mile (RM) 77. The Grand River flows south from the Pensacola Dam past the GRDA's Markham Ferry Project Dam and the United States Army Corps of Engineers' (USACE or Corps) Fort Gibson Dam to its confluence with the Arkansas River near Muskogee, Oklahoma.

Unlike most other FERC-licensed hydropower projects, federal law establishes a Congressionally authorized regulatory structure at Grand Lake. Under Section 7 of the Flood Control Act of 1944[1] and Section 7612 of the National Defense Authorization Act for Fiscal Year 2020 (NDAA 2020).[2] Congress conferred upon the Corps "exclusive jurisdiction and responsibility for management of the flood pool for flood control operations at Grand Lake O' the Cherokees." Pursuant to the Corps' Water Control Manual for Grand Lake, when reservoir elevations are either above elevation 745 feet Pensacola Datum (PD) or projected to rise above 745 feet PD (the flood pool minimum elevation), the Corps directs water releases from the Pensacola Dam. Outside of flood control operations, i.e., when water surface elevations at Grand Lake are within the conservation pool and not projected to rise above 745 feet PD, GRDA controls Project operations with regard to water surface elevations at Grand Lake. NDAA 2020 expressly prohibits any federal or state agency from imposing requirements related to the surface elevations of the conservation pool, except for the Commission's project safety and human health regulations.

The purpose of this Exhibit E is to provide a description of the environmental setting in the Project vicinity. The Licensee prepared this Exhibit to conform to the Commission's regulations under 18 Code of Federal Regulations (CFR) § 5.18(b), as required under the Integrated Licensing Process (ILP) regulations.

1 33 USC § 709.
2 Pub. L. No. 116-92 (2019).

1.1 Application

The existing license for the Pensacola Project was issued on April 24, 1992, effective April 1, 1992, for a term of thirty years, and was originally set to expire on March 31, 2022. On February 1, 2017, GRDA filed a Notice of Intent (NOI) and Pre-Application Document (PAD) to relicense the Project. On February 15, 2017, FERC issued an order holding the ILP in abeyance and waiving the requirement to issue notice of the commencement of the pre-filing process and scoping within 60 days of GRDA's filing of the NOI and PAD. This was done to allow the Commission to take action on a previous application from GRDA to amend the existing Project License. The Commission issued an order amending the Pensacola Project License, lifting the abeyance, and providing an updated process plan and schedule on August 15, 2017 (Federal Energy Regulatory Commission, 2017a).

On September 9, 2019, FERC issued an order extending the license term to May 31, 2025. The order also modified the relicensing process plan and schedule and granted extensions of time for filing an updated Shoreline Management Plan and Exhibit G drawings. According to the revised relicensing process plan and schedule, GRDA must file its Draft License Application (DLA) for the Project on or before January 1, 2023, and its Final License Application (FLA) on or before May 31, 2023 (Federal Energy Regulatory Commission, 2019).

GRDA has prepared this application in accordance with FERC's ILP regulations at 18 CFR § 5.18(b) and pursuant to the guidelines listed in the Commission's *Preparing Environmental Assessments: Guidelines of Applicants, Contractors, and Staff*.

1.2 Purpose and Need for Power

FERC must determine whether to issue a license to GRDA for the Pensacola Project and what conditions should be placed in any license issued. In deciding whether to issue a license, FERC must determine if the Project will be best adapted to a comprehensive plan for improving or developing the waterway. In addition, FERC must give equal consideration to the purposes of energy conservation, fish and wildlife resources, cultural resources, recreational resources, water quality, and other environmental resources.

FERC's issuance of a new license for the continued operation of the Pensacola Project will allow GRDA to continue producing electric power from a renewable resource for the term of the new license, while addressing the affected environmental, land use, public recreation, and cultural resources in accordance with the Commission's public interest and equal consideration mandates under the Federal Power Act (FPA).

This Exhibit E was prepared consistent with the ILP requirements as set forth in 18 CFR § 5.18(b) and designed to support FERC's required analysis under the National Environmental Policy Act (NEPA). In this Exhibit E, GRDA assesses the environmental and economic effects of continuing to operate the Project as proposed herein. GRDA also considers the effects of the baseline operation or current operation alternative which is defined by all measures proposed in this application to be included in the future license.

Power generated at the Project is sold to three customer classes: municipalities, electric cooperatives, and industries. GRDA produces electricity that reaches into 75 of the 77 counties in Oklahoma (Grand River Dam Authority, 2017a). The anticipated operation allows for a more flexible operating regime between the elevations of 742 to 745 feet PD, without the current restrictions of a confined and set rule curve. If relicensed as proposed, additional power from the Project would be generated and would sizably increase the ability of GRDA to meet its customer demand. It would also sizably reduce the need to acquire replacement energy and capacity from fossil-fueled electric generation elsewhere, thereby increasing that environmental benefit under anticipated operations during the new license term.

1.3 Statutory and Regulatory Requirements

FERC's issuance of a new license for the Pensacola Project is subject to numerous requirements under the FPA and other applicable statutes. In addition, on December 20, 2019, Congress enacted NDAA 2020. Importantly, the NDAA 2020 includes special legislation applicable only to the Pensacola Project. The major requirements are described below. The actions GRDA has taken to address these requirements are also described below.

1.3.1 Federal Power Act

1.3.1.1 Section 18 Fishway Prescriptions

Section 18 of the FPA, 16 United States Code (USC) § 811, states FERC is to require the construction, maintenance, and operation of such fishways as may be prescribed by the Secretary of Commerce or the Interior. During the environmental studies phase of this ILP, neither the United States Fish and Wildlife Service (USFWS) nor the National Marine Fisheries Service (NMFS) raised fish passage as a potential relicensing issue. Under the Commission's ILP regulations, 18 CFR § 5.23(a), fishway prescriptions, if any, must be filed within 60 days of FERC's Notice of Acceptance and Ready for Environmental Analysis (REA Notice) following GRDA's filing of the FLA.

1.3.1.2 Section 4(e) Conditions

The first proviso in Section 4(e) of the FPA, 16 USC § 797(e), provides that any license issued by the Commission for a project within a federal reservation shall be subject to and contain such conditions as the Secretary of the responsible federal land management agency deems necessary for the adequate protection and use of the reservation. As explained in Section 6 and Appendix A-5 of Exhibit A, the Project occupies approximately 8.122 acres of land held in legal title by the United States in trust for the benefit of a Native American Tribe or individual members of a Native American Tribe and 57.69 acres in wetland easements.[3] However, Congress in NDAA 2020 removed FPA Section 4(e) mandatory conditioning authority at the Project, as follows:

> (1) FEDERAL LAND.—Notwithstanding Section 3(2) of the Federal Power Act (16 USC § 796(2)), any Federal land within the project boundary, including any right, title, or interest in or to land held by the United States for any purpose, shall not—
>
> > (A) be subject to the first proviso in Section 4(e) of the Federal Power Act (16 USC § 797(e)); or
> >
> > (B) be considered to be—

[3] This acreage figure is based upon the information provided to the BIA on March 9, 2023. As of the writing of this application, the BIA is reviewing the information provided on March 9, 2023 and has not had an opportunity to provide a response. If the figure requires additional updates based upon future discussions with the BIA, the updated information will be filed with the Commission.

> (i) land or other property of the United States for purposes of recompensing the United States for the use, occupancy, or enjoyment of the land under Section 10(e)(1) of that Act (16 USC § 803(e)(1)); or
> (ii) land of the United States for purposes of Section 24 of that Act (16 USC § 818).

Under this special Congressional directive, the 65.75 acres of federal land within the Project boundary are not subject to the Secretary of the Interior's mandatory conditioning authority in the first proviso of FPA Section 4(e).

1.3.1.3 Section 10(j) Recommendations

Under Section 10(j) of the FPA, each hydroelectric license issued by FERC is required to include conditions based on recommendations of federal and state fish and wildlife agencies for the protection, mitigation, or enhancement of fish and wildlife resources affected by the Project. The Commission is required to include these conditions in the license, unless it determines that they are inconsistent with the purpose and requirements of the FPA or other applicable laws. Before rejecting or modifying an agency recommendation, the Commission is required to attempt to resolve any such inconsistency with the agency, giving due weight to the recommendations, expertise, and statutory responsibilities of such agency.

During the pre-filing phase of this relicensing, GRDA consulted with those agencies with authority to submit Section 10(j) recommendations, including USFWS and the Oklahoma Department of Wildlife Conservation (ODWC). Under the Commission's ILP regulations, 18 CFR § 5.23(a), federal and state fish and wildlife agencies will have 60 days following FERC's issuance of the REA Notice to submit Section 10(j) recommendations.

Under the restrictions imposed by Congress under NDAA 2020, as described below in section 1.3.8, no FPA Section 10(j) recommendation adopted by the Commission may contain any requirement relating to surface elevations of the conservation pool at Grand Lake; or the flood pool, except to the extent it references flood control requirements prescribed by the Corps.

1.3.2 Clean Water Act

Under Section 401 of the Clean Water Act (CWA), a license applicant must obtain certification from the appropriate state pollution control agency verifying compliance with the applicable provisions of the CWA, unless the certification is waived. Therefore, a CWA Section 401 water quality certification or waiver is required from the Oklahoma Department of Environmental Quality (ODEQ) as a prerequisite to FERC's issuance of a new license for the Project. Pursuant to 18 CFR § 5.23(b), GRDA will request water quality certification from ODEQ within 60 days of the issuance of FERC's REA Notice.

Under the restrictions imposed by Congress under NDAA 2020, as described below in section 1.3.8, no CWA Section 401 water quality certification from ODEQ may include any condition relating to surface elevations of the conservation pool at Grand Lake; or the flood pool, except to the extent it references flood control requirements prescribed by the Corps.

1.3.3 Endangered Species Act

Section 7 of the Endangered Species Act (ESA) requires federal agencies to ensure that their discretionary actions are not likely to jeopardize the continued existence of any federally listed threatened or endangered (TE) species or result in the destruction or adverse modification of the critical habitat of such species.

GRDA was designated as FERC's non-federal representative for ESA consultation on January 12, 2018. GRDA has consulted with USFWS and determined thirteen federally listed, proposed, or candidate species may occur within the vicinity of the Project. These species include the gray bat (*Myotis grisescens*), Indiana bat (*Myotis sodalis*), northern long-eared bat (*Myotis septentrionalis*), Ozark big-eared bat (*Corynorhinus townsendii ingens*), tricolored bat (*Perimyotis subflavus*), piping plover (*Charadrius melodus*), rufa red knot (*Calidris canutus rufa*), alligator snapping turtle (*Machrochelys temminkii*), Neosho madtom (*Noturus placidus*), Ozark cavefish (*Amblyopsis rosae*), Neosho mucket (*Lampsilis rafinesqueana*), American burying beetle (*Nicrophorus americanus*), and monarch butterfly (*Danaus plxippus*) (US Fish and Wildlife Service, 2022). The Licensee's analysis of Project impacts on threatened and endangered species is presented in Section 3.7. In addition, a draft biological assessment appears in **Appendix E-26**.

If formal consultation is required pursuant to ESA Section 7 is required during this relicensing process, NDAA 2020, as described below in section 1.3.8, precludes any resulting biological opinion from containing any reasonable and prudent measure/alternative, term or condition, or other measure relating to: surface elevations of the conservation pool at Grand Lake; or the flood pool, except to the extent it references flood control requirements prescribed by the Corps.

1.3.4 National Historic Preservation Act

Section 106 of the National Historic Preservation Act (NHPA) requires federal agencies to take into account the effects of any proposed undertaking on historic properties and to afford the Advisory Council on Historic Preservation (ACHP) a reasonable opportunity to comment on the issuance of a new license. Historic properties are districts, sites, buildings, structures, traditional cultural properties, and objects that are listed in or eligible for inclusion in the National Register of Historic Places (NRHP). FERC's issuance of a new license for the Project is considered an undertaking under NHPA Section 106.

GRDA was designated as FERC's non-federal representative for NHPA Section 106 consultation on January 12, 2018. As part of its role as FERC's non-federal representative, GRDA developed and conducted cultural resource studies in consultation with the Oklahoma Historic Preservation Officer (SHPO), Oklahoma Archeological Survey (OAS), and Native American Tribes, as described in Section 3.11 of this FLA. GRDA anticipates the Commission will meet its obligations under NHPA Section 106 through the execution of a programmatic agreement that will require the implementation of an Historic Properties Management Plan (HPMP) that addresses the management and treatment of historic properties identified within the Project's area of potential effects. An updated HPMP, developed in consultation with the Oklahoma SHPO, OAS, and Native American Tribes, included in **Appendix E-34** of this application.

1.3.5 Coastal Zone Management Act

Under Section 307(c)(3)(a) of the Coastal Zone Management Act (CZMA), FERC cannot issue a license for a project within or affecting a state's coastal zone unless the state CZMA agency concurs with the license applicant's certification of consistency with the state's CZMA program, or the agency's concurrence is conclusively presumed by its failure to act within 180 days of its receipt of the applicant's certification. Oklahoma does not have a coastal zone or CZMA program; therefore, the Project is not subject to this act.

1.3.6 Magnuson-Stevens Fishery Conservation and Management Act

The Magnuson-Stevens Fishery Conservation and Management Act (Public Law 94-265) requires federal agencies to consult with NMFS on all actions that may adversely affect Essential Fish Habitat (EFH). EFH is only applicable to federally managed commercial fish species which live at least one component of their lifecycle in marine waters. All fish in the Grand River are freshwater species and are not managed commercially; therefore, no designated EFH is located in the Project vicinity.

1.3.7 Wild and Scenic River and Wilderness Act

Section 7(a) of the Wild and Scenic Rivers Act (Public Law 90-542) requires federal agencies to make a determination as to whether the operation of a project under a new license would unreasonably diminish the scenic, recreational, and fish and wildlife values present within any designated wild or scenic rivers. There are no designated wild or scenic rivers within the state of Oklahoma (National Park Service, n.d.a).

The Wilderness Act (Public Law 88-577) was enacted to establish a National Wilderness Preservation System. There are no nationally designated wilderness areas within the Project vicinity (National Park Service, n.d.b).

1.3.8 National Defense Authorization Act for Fiscal Year 2020

On December 20, 2019, Congress enacted NDAA 2020.[4] NDAA 2020 includes special legislation applicable only to the Pensacola Project, and it confines the scope of the ongoing relicensing for this Project in several important and unique ways.

Lands Necessary and Appropriate for the Project

First, NDAA 2020 resolves a long-standing dispute between GRDA and the City of Miami, Oklahoma, regarding lands that must be licensed as part of the Project, and therefore requiring GRDA to obtain title pursuant to Article 5 of its license.[5] In addressing this matter, Congress in NDAA 2020 forbids any unilateral expansion of the Project to encompass any new lands, as follows:

NDAA 2020 provides that "[t]he licensing jurisdiction of the Commission for the project shall not extend to any land or water outside the project boundary."[6] Thus, NDAA 2020 statutorily prohibits the Commission from imposing any license obligation outside of the Project boundary as it existed as of

4 Pub. L. No. 116-92 (2019).
5 *See, e.g.,* Formal Complaint of the City of Miami, Oklahoma, Project No. 1494-445 (filed Dec. 26, 2018).
6 Pub. L. No. 116-92, § 7612(b)(3)(A).

Congress' enactment of NDAA 2020—including any obligation to purchase lands outside the Project boundary.

Next, NDAA 2020 provides that "[a]ny land, water, or physical infrastructure or other improvement outside the project boundary shall not be considered to be part of the project."[7] This language also confirms that GRDA cannot be required under its license to obtain title to the approximately 13,000 acres identified by the City of Miami,[8] as all of these lands are outside the Project boundary and not part of the licensed Project.

Finally, NDAA 2020 allows FERC to amend the Project boundary "only with the expressed written agreement of" GRDA.[9] If GRDA does not consent to a Project boundary amendment, NDAA 2020 provides that the Commission's responsibilities under the FPA are met without any change to the Project boundary.[10]

Exclusive Flood Control Jurisdiction of the U.S. Army Corps of Engineers

Second, NDAA 2020 confirms—consistent with the Corps' long-standing jurisdiction under Section 7 of the Flood Control Act of 1944—that the Corps has "exclusive jurisdiction and responsibility for management of the flood pool for flood control operations at Grand Lake O' the Cherokees."[11]

Prohibition on Water Surface Elevation Regulation

In addition to confirming the Corps' exclusive jurisdiction for flood control, Congress in NDAA 2020 prohibits the Commission or any other federal or state agency (including FWS) from imposing any license condition related to surface water elevations. NDAA 2020 provides:

> Except as may be required by the Secretary [of the Army] to fulfill responsibilities under Section 7 of the Flood Control Act of 1944 (33 USC 709), the Commission or any other federal or state agency shall not include in any license for the project any condition or other requirement relating to—
>
> (i) surface elevations of the conservation pool; or
>
> (ii) the flood pool (except to the extent it references flood control requirements prescribed by the Secretary).[12]

Although the Commission and other agencies are prohibited under NDAA 2020 from regulating water surface elevations at Grand Lake, NDAA 2020 provides that the Project "shall remain subject to the Commission's rules and regulations for project safety and protection of human health."[13]

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7 *Id.* § 7612(b)(3)(B).
8 *See* 16 USC § 796(11) (defining the "project" to include "lands, or interest in lands the use and occupancy of which are necessary or appropriate in the maintenance and operation of" the unit of development); *compare* Standard Article 5, Form L-3, 54 F.P.C. 1817, 1818–19 (requiring GRDA to acquire lands "necessary or appropriate for the construction, maintenance, and operation of the project").
9 Pub. L. No. 116-92, § 7612(b)(3)(C).
10 *Id.* As provided in the cover to Exhibit G of this FLA, GRDA is consenting to several changes to the Project boundary.
11 Pub. L. No. 116-92, § 7612(c); *see* 33 USC § 709.
12 *Id.* § 7612(b)(2)(A).
13 *Id.* § 7612(b)(2)(B).

Removal of Mandatory Conditioning Authority

Finally, as explained in Section 1.3.1.2 above, NDAA removes FPA Section 4(e) mandatory conditioning authority with respect to any federal reservation occupied by the Project, together with any FPA Section 10(e) annual charges with respect to any such reservation.

1.4 Public Review and Comment

FERC's regulations for the ILP requires GRDA to consult with appropriate resource agencies, Native American Tribes, and other entities before filing an application for a license. This consultation is the first step in complying with federal statutes including the ESA, Fish and Wildlife Coordination Act, and NHPA. Prefiling consultation must be completed and documented according to FERC's regulations.

1.4.1 Scoping

GRDA filed an NOI and PAD for the Project on February 1, 2017. The PAD provided summaries of existing, relevant, and reasonably available information related to the Project that was in GRDA's possession or was obtained with the exercise of due diligence. The purpose of the PAD was to provide participants in the relicensing proceeding with a summary of the information necessary to identify issues and related information needs to assist with the development of study requests and study plans.

In the PAD, GRDA proposed the following studies:

- Cultural Resources Study
- Hydrologic and Hydraulic Modeling Study (H&H Study)
- Recreation Facilities Inventory and Use Survey
- Sedimentation Study
- Socioeconomics Study

FERC published Scoping Document 1 (SD1) for the Project on January 1, 2018. Public scoping meetings were held on February 7, 2018 at the GRDA Ecosystems and Education Center in Langley, Oklahoma; on February 7, 2018 at Grove City Hall, in Grove Oklahoma; on February 8, 2018 at Northeastern Oklahoma A&M College Fine Arts Center Performance Hall in Miami, Oklahoma; and on February 9, 2018 at the GRDA Engineering and Technology Center in Tulsa, Oklahoma. At the scoping meetings, potential issues were identified by agencies, stakeholders, and other interested members of the public. A court reporter was present at all scoping meetings to record all comments and statements; these are part of FERC's public record for the Project. FERC also held a site visit on February 7, 2018. In addition to comments and statements provided at the scoping meetings, several entities provided written comments (Federal Energy Regulatory Commission, 2018a).

Written comments were provided by the following entities:

- Bureau of Indian Affairs (BIA)
- Cherokee Nation
- City of Grove
- City of Miami
- Eastern Shawnee Nation
- FERC

- Grand Riverkeeper
- GRDA
- Larry Bork
- Local Environmental Action Demanded Agency, Inc. (LEAD)
- Miami Tribe of Oklahoma (Miami Tribe)
- Oklahoma Archaeological Survey
- ODWC
- Oklahoma Water Resources Board (OWRB)
- Osage Nation
- Ottawa Tribe of Oklahoma
- Seneca-Cayuga Nation
- Southwestern Power Administration
- US Army Corps of Engineers
- US Environmental Protection Agency (EPA)
- USFWS
- Wyandotte Nation

Written comments were also filed by 41 individual residents or business owners. Following the scoping meetings and applicable comment period, the Commission issued its Scoping Document 2 (SD2) on April 27, 2018 (Federal Energy Regulatory Commission, 2018a).

1.4.2 Studies

Comments on the PAD and requests for additional studies were addressed in GRDA's Proposed Study Plan (PSP). GRDA filed the PSP with FERC on April 27, 2018. Subsequent to the PSP filing, GRDA held PSP meetings on May 30 and 31, 2018 at the GRDA Ecosystems and Education Center. The purpose of the meetings was to inform attendees about the contents of the PSP and provide an opportunity to ask questions related to the proposed studies.

Based on comments received on the PSP, GRDA filed a Revised Study Plan (RSP) with FERC on September 24, 2018. On November 8, 2018, FERC issued a Study Plan Determination approving the following studies:[14]

- Hydrologic and Hydraulic Modeling
- Bathymetric Study
- Sedimentation
- Aquatic Species of Concern
- Terrestrial Species of Concern
- Wetlands and Riparian Habitat
- Recreation Facilities Inventory and Use
- Cultural Resources
- Socioeconomics
- Infrastructure Study

[14] The Terrestrial Species of Concern and the Wetlands and Riparian Habitat Studies were the only studies approved without Commission staff-recommended modifications.

On September 30, 2021, GRDA filed an Initial Study Report (ISR) that described each study's objectives, progress, and remaining activities. The ISR included completed study reports for the Infrastructure, Recreation Facilities Inventory and Use, and Socioeconomic Studies, as well as status reports on the remaining studies with results for the portion of the study completed during the first study season. In the ISR, GRDA requested modifications to the Aquatic Species of Concern, Cultural Resources, Infrastructure, and Terrestrial Species of Concern Studies.

As required by FERC's ILP regulations, GRDA held meetings to discuss the ISR on October 12, 13, and 14, 2021. GRDA prepared an ISR meeting summary, which was filed with FERC and distributed to relicensing participants on October 29, 2021.

The following relicensing participants filed written comments with FERC in response to the ISR:

- BIA
- Cherokee Nation
- City of Miami
- FERC Staff
- OAS
- ODWC
- USFWS

Several stakeholders recommended several study modifications and one new study in their comments on the ISR. In its study plan modification determination letter issued on February 24, 2022, FERC approved the Aquatic Species of Concern, Infrastructure, and Hydrologic and Hydraulic Modeling Studies with modifications. FERC staff did not approve proposed modifications to the Cultural Resources, Socioeconomic, and Terrestrial Species of Concern Studies sought by various stakeholders. In addition, FERC staff did not approve a renewed request for GRDA to complete a Contaminated Sediment Transport Study.

In its February 24 study plan determination, FERC staff deferred its decision on proposed modifications for the Sedimentation Study until additional information could be provided (Federal Energy Regulatory Commission, 2022a). After further comments and proposals submitted by both GRDA and the City of Miami, FERC issued its study plan determination for the Sedimentation Study on May 27, 2022. In this determination, FERC approved the modified Sedimentation Study proposed by GRDA, but with FERC staff-recommended modifications (Federal Energy Regulatory Commission, 2022b).

GRDA completed all studies and filed the Updated Study Report (USR) on September 30, 2022. The USR included reports for all Commission-approved study plans, including Hydrologic and Hydraulic Modeling (included Bathymetry), Sedimentation, Aquatic Species of Concern, Terrestrial Species of Concern, Wetlands and Riparian Habitat, Recreation Facilities Inventory and Use, Cultural Resources, Socioeconomics, and Infrastructure. All studies have been completed, and GRDA has not proposed any study modifications or additional studies. In accordance with FERC's amended ILP process and schedule issued on September 9, 2019, the USR meeting was held on October 12 and 13, 2022.

Comments on the USR were received from the following entities:

- BIA
- Cherokee Nation
- City of Miami
- FERC Staff
- LEAD
- Quapaw Nation
- USFWS

Responses to the USR comments are being filed by GRDA as a separate filing.

1.4.3 Comments on Application

Comments on the DLA were received from FERC Staff, BIA, SHPO, OAS, Miami Tribe of Oklahoma, Cherokee Nation, City of Miami, and LEAD. The comments and response to comments for subjects other than cultural resources are included in **Appendix X-1**. The comments and responses to cultural resources comments are included in **Appendix X-2**. Consultation with the BIA on Federal land mapping is included as **Appendix X-3**.

Numerous other comments that did not provide comments on the specific information or conclusions outlined in the DLA were filed with the Commission. These comments were often received on pre-made post cards, with hand-written additions or were received as personal letters outlining the conditions resulting from floods in the Miami area and experiences with contamination resulting from the Tar Creek Superfund site within the Tri-State Mining District. These types of comments are not individually addressed by GRDA, as they raise similar issues as other local stakeholders, such as the Miami Tribe of Oklahoma, City of Miami, and LEAD.

2. Proposed Action and Alternatives

In accordance with the NEPA review process, the environmental analysis must consider, at a minimum the three alternatives described in the sections below: (1) the no-action alternative, (2) the GRDA's proposed action, and (3) alternatives to the proposed action.

2.1 No-Action Alternative

Under the no-action alternative, current operation, which is defined as current operation (under the current post-2015 rule curve) or as appropriate baseline operation (under the pre-2015 rule curve), the Pensacola Project would continue to operate as required by the current Project License (i.e., there would be no change to the recent condition of the environment).[15] No new environmental protection, mitigation, or enhancement measures would be implemented. This alternative is termed as current operation (under the current post-2015 rule curve) or baseline operation (under the pre-2015 rule curve) for comparison with other alternatives as appropriate depending upon the resource being analyzed. The current operation (under the current post-2015 rule curve) or baseline operation (under the pre-2015 rule curve) are further defined in Section 3.0 of this application.

2.1.1 Existing Project Facilities

The Pensacola Project is located on the Grand (Neosho) River in Craig, Delaware, Mayes and Ottawa Counties, Oklahoma. Project facilities include the dam with a gated main spillway, middle gated spillway, east gated spillway, powerhouse, tailrace, electrical switching station, transmission, Grand Lake, arch toe pump station, and surrounding land extending landward to an approximate elevation of 750 feet PD. From right to left looking downstream, the principal Project works consist of the intake structure for the powerhouse, main gated spillway adjoining to the dam, middle gated spillway, and east gated spillway. The Project has an authorized capacity of 105.176 megawatts (MW).

2.1.1.1 Pensacola Dam

The Pensacola Dam (dam) is a multi-section structure. The different sections, from right to left looking downstream, consist of the west non-overflow section, multiple arch section, main spillway section, east non-overflow section, middle spillway section, and east spillway section. A non-Project highway bridge comprised of two lanes and a pedestrian sidewalk, State Highway 28, runs along the top of the dam. Grade elevation of the lanes is approximately 763.5 feet PD at the multiple arch section and 768.5 feet PD at the middle spillway segments and east spillway segment.

2.1.1.1.1 West Non-Overflow Section

The west abutment is connected to the west end of the west non-overflow section of the dam, which is a concrete gravity section approximately 28 feet long. The east side of the west non-overflow section is connected to the multiple arch section. The cross-sectional width is approximately 43 feet

[15] For the purposes of the studies completed as part of this relicensing process, the analyses and their effects upon the environment use the rule curve ranging from 741 to 744 feet PD that was a part of the license up until the Commission's Order (160 FERC ¶ 61,001) (Accession # 20170815-3044), which amended the rule curve to range between 742 and 744 feet PD. Because of the longevity of the 741 to 744 feet PD rule curve conditions and its influence of Project environmental effects over a long period, the analysis of environmental effects set forth in this Exhibit E generally uses this prior rule curve range of 741 to 744 feet PD as the baseline operation (under the pre-2015 rule curve).

and the height from the base of the section to the top of the roadbed is approximately 75 feet. The width and height measurements are scaled from the Exhibit F drawings.

2.1.1.1.2 Multiple Arch Section

The main portion of the dam is a reinforced concrete multiple-arch structure consisting of 52 buttresses spaced 84 feet apart. The buttresses are hollow except for the first and last. There are 51 free span concrete arches resulting in an approximate length of 4,284 feet. A typical buttress has a length of 84 feet. The dam has a crest elevation of 757 feet PD. An arch section has a cross-sectional width varying from approximately 130 to 185 feet. The height from the base of the section to the top of the roadbed varies from approximately 100 to 155 feet. The width and height measurements are scaled from the Exhibit F drawings.

2.1.1.1.3 Main Spillway Section

The main spillway section is integral to the dam on its west end and connected to the east non-overflow section at the other end. The structure is mass concrete with an ogee-shaped spillway with a crest elevation of 730 feet PD. The spillway is comprised of 21 radial gates that are 36 feet wide by 25 feet tall resulting in a structure length of approximately 861 feet. The top of the gate elevation is 755 feet PD. The approximate cross-sectional width is 90 feet and height from the base of the section to the top of the roadbed of a typical section of the spillway is 100 feet. The width and height measurements are scaled from the Exhibit F drawings. The gates are operated by two traveling gate hoists located above the main spillway. Water flows into the main spillway channel below the spillway. The main spillway channel merges with the east spillway channel and flows into the tailrace further downstream.

2.1.1.1.4 East Non-Overflow Section

The east end of the main spillway is connected to the east non-overflow section of the dam. The structure is a concrete gravity section approximately 451 feet long. The east side of the non-overflow is connected to the east abutment and has a cross-sectional width varying from approximately 40 to 70 feet. The height from the base of the section to the top of the roadbed varies from approximately 55 to 85 feet.

2.1.1.1.5 Middle Spillway Section

The middle spillway section is situated about 0.9 mile east of the dam's east abutment. The structure is mass concrete with an ogee-shaped spillway with a crest elevation of 740 feet PD. The spillway is comprised of 11 radial gates that are 37 feet wide and 15 feet tall resulting in a structure length of approximately 450 feet. The typical cross-sectional width and height of the middle spillway from the base of the section to the top of the roadbed is approximately 45 feet and 40 feet, respectively. The width and height measurements are scaled from the Exhibit F drawings. Gates are operated by a traveling hoist located at the middle spillway section. The water flows for approximately 0.5 miles to where it joins with the east spillway channel.

2.1.1.1.6 East Spillway Section

The east spillway section is located approximately 700 feet east of the middle spillway section. The structure is mass concrete with an ogee-shaped spillway, which has a crest elevation of 740 feet PD.

The east spillway is comprised of ten radial gates that are 37 feet wide and 15 feet tall resulting in structure length of approximately 410 feet. The typical cross-sectional width and height of the middle spillway from the base of the section to the top of the roadbed is approximately 45 feet and 40 feet, respectively. The width and height measurements are scaled from the Exhibit F drawings. Gates are operated by a traveling hoist located at the east spillway section. The water flows into the east spillway channel below the spillway. The east spillway channel is approximately 1.5 miles long and 850 feet wide. The east spillway channel merges with the tailrace further downstream.

2.1.1.2 Bypass Flow Pipe

A 30-inch diameter bypass flow pipe was included in the Project's design to provide a means of releasing water from the Project at all times, even when none of the hydropower units are operating or none of the spillway gates are open. It is not needed for the operation of the Project (Grand River Dam Authority, 2021a).

2.1.1.3 Powerhouse and Intake Structure

The powerhouse is located below Arches 2 through 4 of Pensacola Dam (Arch 1 is the western-most arch). The powerhouse is a multi-story, reinforced concrete building and is 87.75 feet wide in the upstream to downstream direction, 279 feet long in the west to east direction, and approximately 45 feet tall. The elevation of the generator floor is 652.0 feet PD.

The intake structure supplies water to the penstocks that supply flow to the powerhouse's six hydropower units and the house unit. The reinforced concrete structure is located on top of Arches 2 through 4. The intake structure has a length of 246 feet, a cross-sectional width of 23 feet, and a height of 75 feet. The minimum intake elevation is 682 feet PD, and the top deck elevation is 757 feet PD. The intake includes vertical trash racks that are 73 feet high, with 3.75-inch spacing, to catch debris and bulkhead gates that are used to isolate and dewater individual penstocks (Grand River Dam Authority, 2017a) (Grand River Dam Authority, 2021a). The gates are operated by a traveling gantry crane mounted on the top deck on the intake structure.

Six separate steel penstocks transfer flow from the intake structure to the powerhouse hydroelectric units. The length of all seven penstocks is approximately 195 feet long. The six main penstocks have a 15-foot diameter and flow is controlled by wicket gates at the entrance of each turbine. Two (2) draft tubes per hydroelectric unit located below the powerhouse discharge the flow in the tailrace. The draft tubes are 12 feet tall by 14 feet wide with an invert elevation of 602.5 feet PD. Slots in the draft tube opening can be utilized to install stoplogs to dewater a unit using a traveling hoist. A separate 3-foot diameter penstock has been used to transfer flow to one hydroelectric unit known as the house unit.[16]

The draft tubes of the powerhouse discharge in the tailrace located below the powerhouse. The tailrace is approximately 1.5 miles long and 300 feet wide. The tailwater elevations for the Pensacola Project typically range between 620 and 625 feet PD at normal reservoir elevations depending on the conditions at the downstream Lake Hudson Project.

[16] The house unit is currently inoperable but scheduled to return to service in 2025.

A bypass system on the west end of the powerhouse consists of a 30-inch diameter pipe. The system was designed to release water from the lake to meet any minimum release requirements. However, the system has never been used for this purpose and has not been operated in years. It is unknown if any flow could pass through the system due to sediment concerns at the intake.

2.1.1.4 Arch Toe Pump Station

Seepage through the Pensacola Dam and runoff from the surrounding area result in standing water in the ditch at the toe of the dam. The pump station located outside of Arch 6 contains two six-inch submersible pumps and a single twelve-inch vertical turbine pump. The pumps are connected to a 20-inch diameter pipe that discharges into the tailrace below the powerhouse.

2.1.1.5 Reservoir (Grand Lake O' the Cherokees)

Grand Lake O' the Cherokees is impounded by the Pensacola Dam and was created in 1940 with the completion of the Pensacola Project. Under the current operation (under the current post-2015 rule curve), when the reservoir surface elevation is within the conservation pool, below the flood pool elevation of 745 feet PD, and not expected to exceed 745 feet PD, GRDA maintains to the extent practicable, approved seasonal target reservoir surface elevations known as the rule curve, except as necessary for USACE to provide flood control protection. When the reservoir elevation is expected to exceed 745 feet PD, at which time USACE has exclusive jurisdiction over flood control (Section 2.1.3.1). The reservoir contains approximately 1.44 million acre-feet in water storage and has a surface area of approximately 45,056 acres at an elevation of 745 feet PD. The reservoir contains approximately 1.31 million acre-feet in water storage and has a surface area of approximately 41,581 acres at an elevation of 742 feet PD (Hunter, S.L, et. al., 2020). The usable water storage between 742 and 745 feet PD is 130,000 acre-feet.

2.1.1.6 Generating Units

The powerhouse has six main hydroelectric units with Francis-style hydraulic turbines and associated generators. The six main hydroelectric units have an as-built turbine head of 117.5 feet. One additional hydroelectric unit, the house unit, has an as-built turbine head of 115 feet.[17]

Each of the six main turbines has a nameplate capacity of 17,446 kilowatts (kW) or 23,395 horsepower (hp) at a nameplate flow of 1,950 cubic feet per second (cfs). Each turbine operates at 150 revolutions per minute (rpm) and the normal maximum flow for each turbine is 2,317 cfs (Grand River Dam Authority, 2004a). The house unit has a nameplate capacity of 500 kW or 666 hp.[18] It operates at 720 rpm. This results in a combined generation capacity of 105.176 MW because output is turbine-limited for the six main units.

Each of the six main generating units has a generator nameplate rating of 21.640 MW and 24 megavolt Amperes (MVA) at 90 percent (%) nameplate power factor. The generators are Westinghouse A/C, 60-cycle models generating at 13.8 Kilovolts (kV) (Grand River Dam Authority, 2004a).

[17] The house unit is currently inoperable and scheduled to return to service in 2025.
[18] Horsepower is calculated from watts: 750 watts equals 1 hp.

The 500-kW nameplate house unit turbine is operated at 720 rpm. The 500-kW house unit generator has a nameplate rating of 500 kW and 625 kilovolt amperes (kVA) at 80% nameplate power factor. The generator is a Westinghouse A/C, 60-cycle model which operates at 480 volts.

2.1.1.7 Switching Station and Transmission Equipment

The Pensacola Project's switching station is located on the bluff west of the powerhouse downstream of the arch dam. The primary transmission lines vary in length from 450 to 650 feet and terminate at 15 kV breakers at the switching station. The 13.8 kV disconnects are the point of interconnect for the Project.

2.1.2 Dam Safety

Dam safety considerations have been taken into account during the development of the proposed and alternative actions described in this application to ensure that the Project continues to meet the Commissions' dam safety criteria found in Part 12 of the Commissions regulations and engineering guidelines. There are no proposed modifications to the dam structures that could impact their integrity as part of this application.

2.1.3 Existing Project Operation

2.1.3.1 Normal Operations

When the reservoir surface elevation is within the conservation pool and below the flood pool elevation of 745 feet PD, GRDA maintains to the extent practicable, approved seasonal target reservoir surface elevations known as the rule curve, except as necessary for USACE to provide flood control protection. The existing rule curve was approved by FERC in their August 15, 2017 Order Amending License and Dismissing Application for a Temporary Variance. The rule curve is shown in **Table 2.1.3.1-1** and **Figure 2.1.3.1-1**. For the purposes of analysis, this operation scenario is called the current operation.

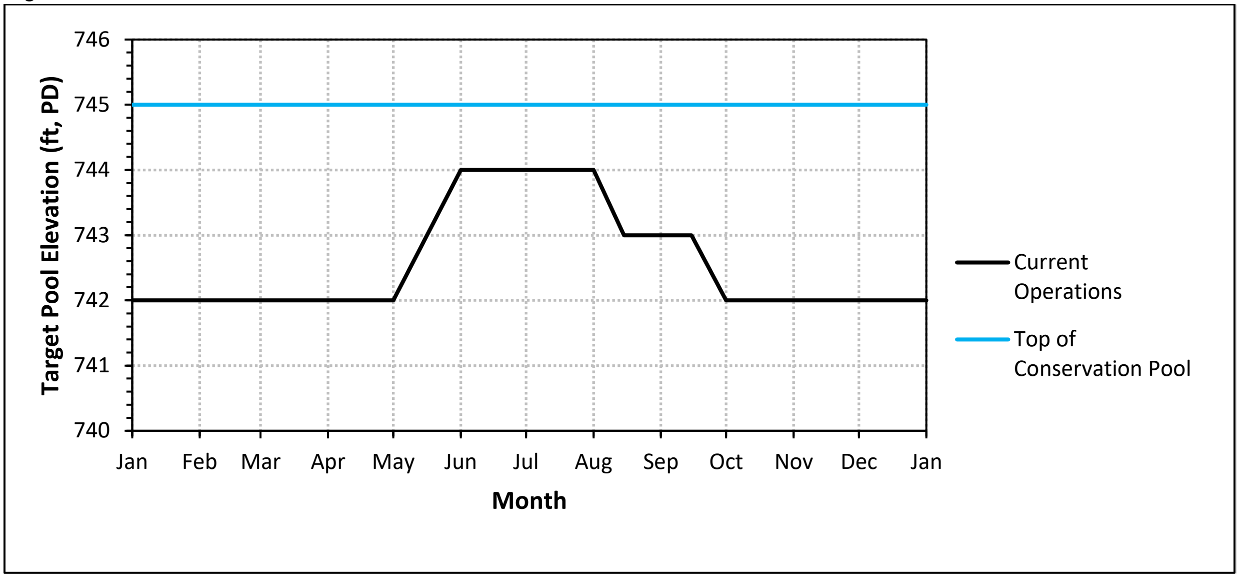
Table 2.1.3.1-1 Pensacola Project Rule Curve[19]

Period	Reservoir Elevation
May 1 through May 31	Raise elevation from 742 to 744 feet PD
June 1 through July 31	Maintain target elevation at 744 feet PD
August 1 through August 15	Lower elevation from 744 to 743 feet PD
August 16 through September 15	Maintain target elevation at 743 feet PD
September 16 through September 30	Lower elevation from 743 to 742 feet PD
October 1 through April 30	Maintain target elevation at 742 feet PD

Source: (Federal Energy Regulatory Commission, 2017c)

19 For the purposes of the studies completed as part of this relicensing process, the analyses and their effects upon the environment use the rule curve ranging from 741 to 744 feet PD that was a part of the license up until the Commission's Order (160 FERC ¶ 61,001) (Accession # 20170815-3044), which amended the rule curve to range between 742 and 744 feet PD. Because of the longevity of the 741 to 744 feet PD rule curve conditions and its influence of Project environmental effects over a long period, the analysis of environmental effects set forth in this Exhibit E generally uses this prior rule curve range of 741 to 744 feet PD as the baseline operation (under the pre-2015 rule curve).

Figure 2.1.3.1-1 Pensacola Rule Curve



Source: (Federal Energy Regulatory Commission, 2017c)

2.1.3.2 Low Flow Operations

Under the current operation (under the current post-2015 rule curve), GRDA implements the Drought Adaptive Management Plan (DAMP) that guides project operations and flow releases in the event of significant drought conditions. The DAMP is in **Appendix E-1**. GRDA is required to maintain dissolved oxygen (DO) concentrations downstream of the Pensacola Project and Markham Ferry Project. During drought conditions it is difficult for GRDA to maintain Grand Lake at elevations within the requirements of the rule curve while still maintaining downstream DO concentration requirements and reservoir elevations at the Markham Ferry Project sufficient to operate the Salina Pumped Storage Project, as well as meeting water supply needs (Federal Energy Regulatory Commission, 2017c).

Under the DAMP, GRDA monitors information from the National Drought Mitigation Center's US Drought Monitor. If drought conditions appear imminent, GRDA begins weekly teleconferences with federal and state resource agencies, local government officials, FERC staff, Native American Tribes, and other interested stakeholders. During these teleconferences, GRDA keeps parties informed of prevailing conditions and any plans to begin additional releases in the event a severe to exceptional drought is declared.

Specifically, the following issues are discussed during the teleconferences:

- Current and forecasted drought conditions and planned operation of the Project,
- Maintenance of water levels and flows sufficient to maintain downstream DO concentrations to maintain water quality and prevent fish kills,
- Maintenance of reservoir elevations at the Markham Ferry Project to operate the Salina Pumped Storage Project, and
- Timeframes for when the severe to exceptional drought period is expected to end (Federal Energy Regulatory Commission, 2017c).

If the US Drought Monitor declares severe to exceptional drought for the Grand/Neosho River basin, GRDA may commence additional releases from the Project regardless of prevailing Grand Lake elevations based on input received during the weekly teleconferences. These releases do not exceed a rate equal to 0.06 feet of reservoir elevation per day, which is equivalent to 837 cfs over a 24-hour period. When severe to exceptional drought conditions end, GRDA ceases releases under the DAMP to return the Project to its normal operating elevations and notifies federal and state resource agencies and other stakeholders (Federal Energy Regulatory Commission, 2017c).

2.1.3.3 High Flow Operations

2.1.3.3.1 Storm Adaptive Management Plan

GRDA implements a year-round Storm Adaptive Management Plan (SAMP) that is used in anticipation of and during major precipitation events within the Grand/Neosho River basin that may result in high water conditions upstream or downstream of Grand Lake. As part of the SAMP, GRDA reviews, at a minimum, on a daily basis the following information:

- Weather forecasts in the watershed,
- Grand Lake surface elevation data,
- Data from United States Geologic Survey (USGS) gages upstream and downstream of the Project,
- Surface elevations at USACE's upstream John Redmond Reservoir and downstream Lake Hudson (part of GRDA's Markham Ferry Project), and
- Other relevant information affecting surface elevations at Grand Lake during the potential flood (Federal Energy Regulatory Commission, 2017c).

If GRDA's daily review of information indicates the probability of high-water conditions in the Grand/Neosho River basin the vicinity of the Project, GRDA immediately provides the information to federal and state resource agencies, local government officials, FERC staff, Native American Tribes, and other interested stakeholders. GRDA also schedules a conference call. Prior to the conference call, GRDA consults with USACE to determine whether any reservoir management action can be taken to avoid, reduce, or minimize high water levels upstream and downstream of the Project. During the conference call, GRDA notifies participants of any decision to take action. GRDA continues regular communication with all participants during each event to keep them informed of prevailing conditions (Federal Energy Regulatory Commission, 2017c).

2.1.3.3.2 USACE Flood Control Operations

Under Section 7 of the Flood Control Act of 1944 (Code of Federal Regulations, 1944), USACE has the responsibility to prescribe releases from Pensacola Dam under active or anticipated flood operations (Code of Federal Regulations, 1945). USACE is also responsible for directing spillway releases in accordance with the procedures for system balancing of flood storage outlined in the Arkansas River Basin Water Control Master Manual (US Army Corps of Engineers, 1980). This authority is reinforced by Section 7612(c) of NDAA 2020 which states: "The Secretary [of the Army] shall have exclusive jurisdiction and responsibility for management of the flood pool for flood control operations at Grand Lake O' the Cherokees" (NDAA, 2020).

The flood storage associated with Grand Lake consists of the storage volume available between the approximate reservoir elevation of 745 and 755 feet PD (US Army Corps of Engineers, 1992). When reservoir elevations are either above or projected to rise above 745 feet PD, USACE directs the water releases from the Pensacola Dam under the terms of Section 7 of the Flood Control Act of 1944.

When directed to make lake releases by USACE, GRDA first discharges as much water as possible through the Project's hydropower units. Once the Project has reached the powerhouse's maximum hydraulic capacity, USACE may direct GRDA to open one or more spillway gates if the reservoir is still rising, but typically not unless the reservoir elevation exceeds or is projected to exceed 745 feet PD. USACE will then determine if additional gates need to be opened. The target discharge rate at any time is based on the current reservoir elevation, the current estimated inflow to Grand Lake, and the amount of projected flooding downstream in the Grand River or Arkansas River basins (Grand River Dam Authority, 2017a).

Operators in the Energy Control Center are contacted by USACE personnel when gate operations are required. When USACE directs GRDA to release water from Grand Lake, the staff at Pensacola Dam decides which specific gate or gates to open. The gate opening order is rotated so each gate is opened about the same number of times. However, a general exception to this rule is GRDA avoids opening the outside gates on all three spillways, when possible, to help limit bank erosion in the discharge channels downstream of the spillways (Grand River Dam Authority, 2021a).

2.1.4 Existing Environmental Measures

Existing environmental measures implemented by GRDA in the current license are described in the following sections.

2.1.4.1 Geologic and Soil Resources

GRDA currently implements a Shoreline Management Plan (SMP) to help control erosion and sedimentation within the Project boundary.

2.1.4.2 Water Resources

GRDA currently implements a SMP to help control erosion and sedimentation within the Project boundary.

GRDA currently implements a Dissolved Oxygen Mitigation Plan to mitigate low DO levels downstream of the Pensacola Dam. When DO levels fall below the action limits set in the plan, which is 6.5 milligram per liter (mg/L) or 5.5 mg/L depending on time of year, one turbine is operated with full aeration until the average DO exceeds the criterion, typically for three to eight hours. If DO levels fall below a second action limit of 4.5 mg/L, the flow of the turbine used for aeration is increased and will continue until the average DO exceeds the criterion, but for no less than two hours (Oklahoma Water Resources Board, 2022).

2.1.4.3 Fish and Aquatic Resources

GRDA currently implements a Fish and Waterfowl Habitat Management Plan (FWHMP) which includes a mitigation fund that funds, designs, implements, and evaluates projects to protect, mitigate and enhance fish and wildlife resources at the Project (Federal Energy Regulatory Commission, 2003).

2.1.4.4 Terrestrial Resources

GRDA currently implements three separate plans that protect terrestrial resources within the Project boundary, which include:

- SMP - helps preserve and protect botanical and terrestrial resources and
- FWHMP - protects terrestrial habitats.

2.1.4.5 Threatened and Endangered Resources

GRDA currently implements the Gray Bat Compliance Plan and cave monitoring to protect the endangered gray bat (*Myotis grisescens*).

2.1.4.6 Recreation Land Use and Aesthetics

GRDA implements a Recreation Management Plan (RMP) for the management of the Project's five formal recreation sites.

2.1.4.7 Land Use

GRDA implements an SMP to manage land use and protect environmental resources within the Project.

2.1.4.8 Cultural Resources

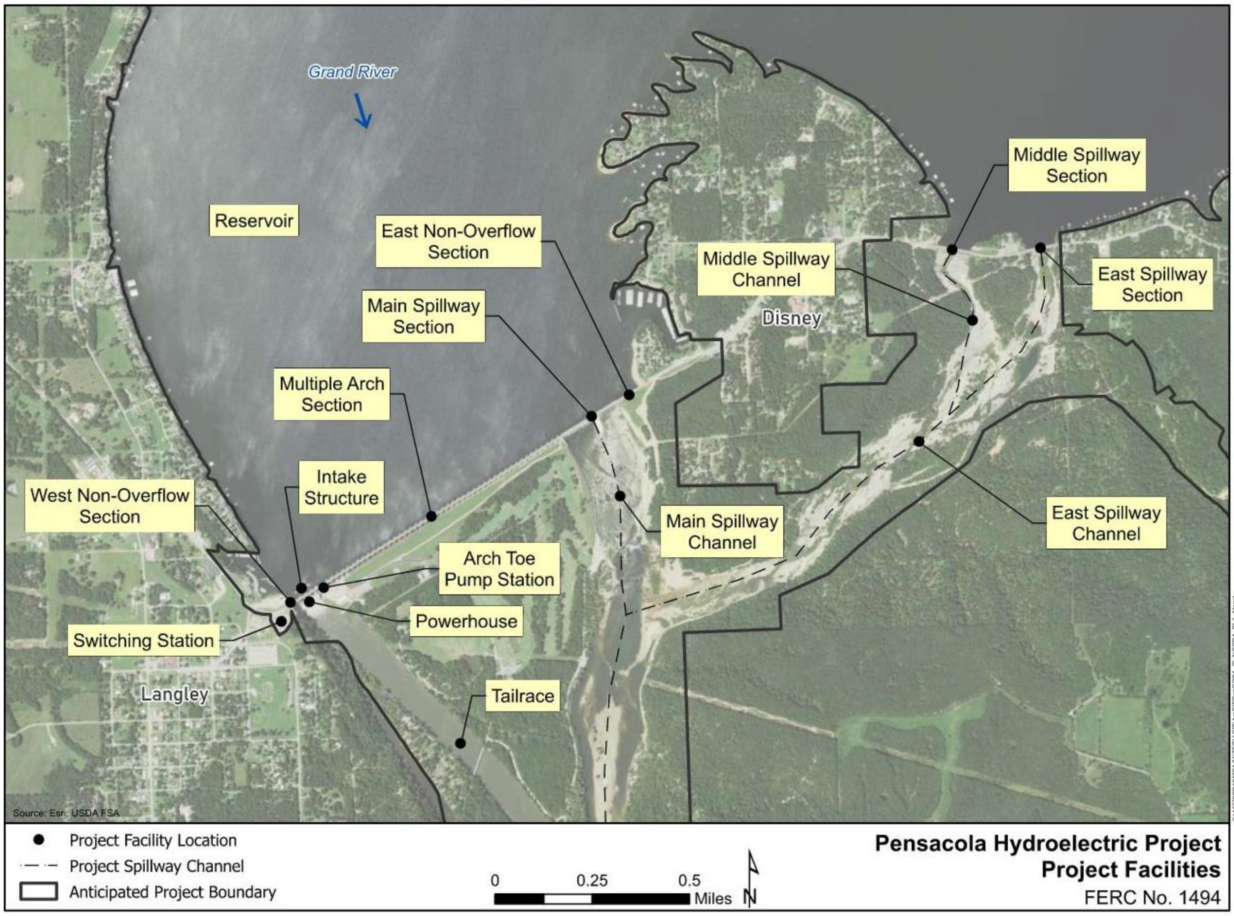
GRDA is currently required to consult with the SHPO before starting any land-clearing or ground-disturbing activities within the Project boundaries, including recreational developments, at the Project.

2.2 Applicant's Proposal

2.2.1 Proposed Project Facilities

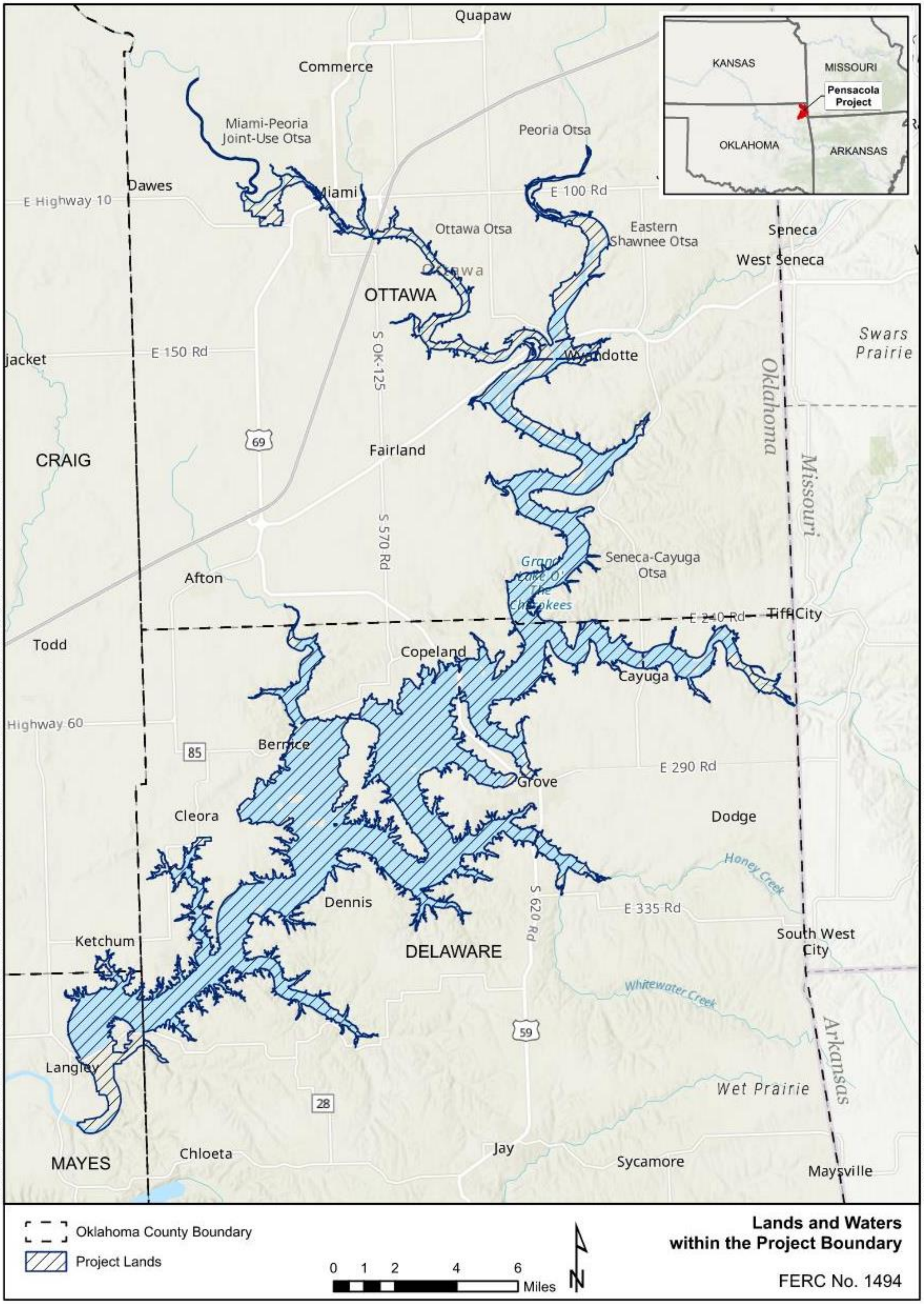
GRDA is not proposing any changes to the existing Project facilities. **Figure 2.2.1-1** depicts the existing Project facilities. **Figure 2.2.1-2** depicts lands and waters within the Project boundary. Further detail on lands and waters within the Project boundary can be found in Section 2.2.4.

Figure 2.2.1-1 Existing Project Facilities[20]



[20] Figure 2.2.1-1 is also depicted as Appendix A-2.

Figure 2.2.1-2 Lands and Waters within the Project Boundary



2.2.2 Proposed (Anticipated) Project Operation

2.2.2.1 Normal Operations

Under NDAA 2020 section 7612, the Commission and other agencies are prohibited from imposing any license conditions or other requirements relating to water surface elevations of Grand Lake's conservation pool.[21] Accordingly, GRDA's Project operations that affect water surface elevations at Grand Lake are not part of the proposed action for purposes of the Commission's review under NEPA—as Congress has removed any discretion for the Commission or other agencies to regulate these operations.

For purposes of analyzing indirect and cumulative effects of the Commission's relicensing order, however, GRDA is anticipating the following operational parameters to apply for the Pensacola Project during the new license term:

- GRDA will no longer utilize a rule curve with seasonal target elevations.[22]
- GRDA will maintain the reservoir between elevations 742 and 745 feet PD for purposes of normal hydropower operations. While hydropower operations may occur when water surface elevations are outside this range (e.g., maintenance drawdowns and high-flow events), GRDA expects to maintain water surface elevations between 742 and 745 feet PD during normal Project operations.
- Instead of managing the Project to target a specified seasonal elevation, GRDA's anticipated operation (without a rule curve) may fluctuate reservoir levels within the elevational range of 742 and 745 feet PD, for purposes of responding to grid demands, market conditions, and the public interest, such as environmental and recreational considerations.
- GRDA will continue to adhere to the USACE's direction on flood control operations in accordance with the Water Control Manual (US Army Corps of Engineers, 1992).

For the purposes of analysis, the operation scenario described above is called the anticipated operation.

2.2.2.1.1 Fluctuation

In an effort to demonstrate the frequency of reservoir elevation occurrences between the elevations of 742 and 745 feet PD and any seasonal differences that may occur, GRDA used the Operations Model (OM) and inflow data from the period April 1, 2004 through December 31, 2019 to simulate the resulting reservoir elevations under the current operation (under the current post-2015 rule curve) and the anticipated operation without a rule curve. The results demonstrate the fluctuations vary by time period.

The minimum range of fluctuation under the anticipated operation is slightly higher in the months of January, February, March, April, June, July, October, November, and December than the current operation (under the current post-2015 rule curve) and slightly less during the months of May, August, and September.

[21] Pub. L. Np. 119-92, § 7612(b)(2).

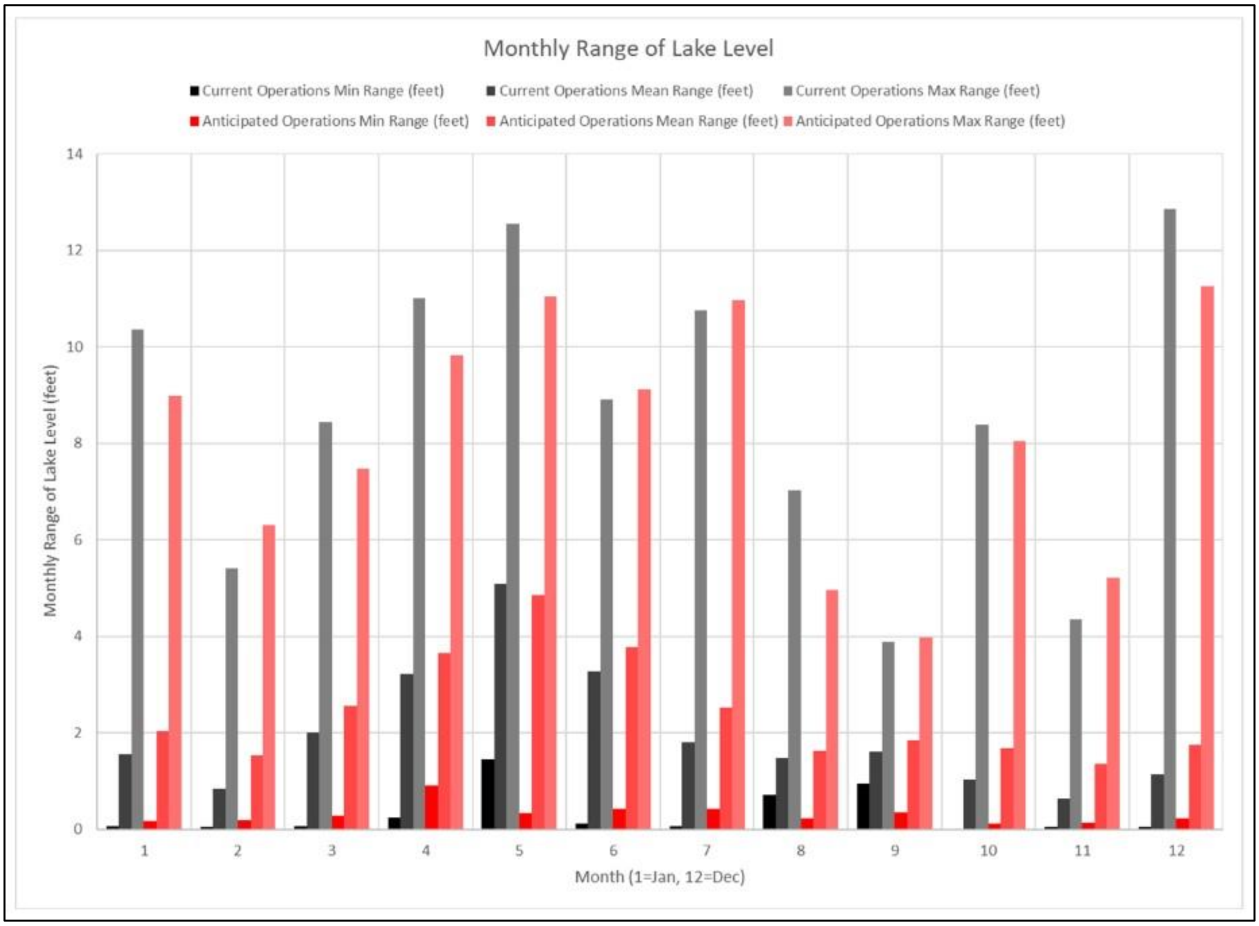
[22] GRDA will no longer follow the rule curve outlined in Section 2.1.3. According to the generation mix by fuel type published by the Southwest Power Pool (https://marketplace.spp.org/pages/generation-mix), over 27% of the fuel mix consists of wind and solar. Therefore, the electricity supply in the region has a significant share of its generation composed of renewable energy sources such as wind and solar where production is intermittent based upon weather conditions. The anticipated operation of the Project that is not restricted to a specific rule curve like the current operation (under the current post-2015 rule curve) will further allow for an immediate response by the Project to increase its generation to support the stability of the grid at all times, even when weather conditions reduce the generation contribution of wind and solar facilities. GRDA often responds to requests from the Southwest Power Pool to increase generation to stabilize the grid in the region due to unexpected significant reductions of generation from intermittent sources such as wind and solar. These requests occur about once every 45 to 60 days. This need for additional generation flexibility to support the grid is also expected to increase as the fuel mix percentages in the Southwest Power Pool trend more towards wind and solar.

The mean range of fluctuation under the anticipated operation is slightly higher in the months of January, February, March, April, June, July, August, September, October, November, and December than the current operation (under the current post-2015 rule curve) and slightly less during the month of May.

The maximum range of fluctuation under the anticipated operation is slightly higher in the months of February, June, July, September, and November than the current operation (under the current post-2015 rule curve) and significantly lower during the months of January, March, April, May, August (over two feet lower), October, and December.

Graphs of the simulation results are shown in **Figure 2.2.2.1.1-1.**

Figure 2.2.2.1.1-1 Monthly Minimum, Mean, and Maximum Range of Lake Level



2.2.2.2 Low Flow Operations

GRDA will continue to implement the DO Mitigation Plan to maintain DO concentrations downstream of the Project during low flow conditions. Because GRDA will no longer be operating under a rule curve during the new license, the DAMP is no longer necessary and is not being proposed by GRDA for continuation in the new license term.

2.2.2.3 High Flow Operations

2.2.2.3.1 Storm Adaptive Management Plan

The extensive suite of studies conducted in this relicensing process demonstrates that GRDA's Project operations between the elevations of 742 and 745 feet PD do not materially influence the water surface elevations, inundation, or duration during high-flow flooding events in areas upstream of the Project, such as within and in the vicinity of the City of Miami, Oklahoma. These findings demonstrate that the SAMP required under the current license does not address Project-related effects. Therefore, GRDA is not proposing to implement the SAMP in the new license.

2.2.2.3.2 USACE Flood Control Operations

GRDA is not proposing any changes to USACE flood control operations. Because the Corps has exclusive jurisdiction for flood control at Grand Lake, such operations are beyond the scope of this relicensing.

2.2.3 Proposed Environmental Measures

1) GRDA will implement an updated SMP with new provisions to address vegetation management and impacts to wetlands, wildlife habitat, and TE species. The updated plans will help control erosion and sedimentation, protect terrestrial resources, TE species, cultural resources, and manage land use resources within the Project.
2) GRDA will continue to implement the DO Mitigation Plan to reduce impacts of low DO on fish and aquatic resources downstream of the Pensacola Dam.
3) GRDA will implement construction stormwater Best Management Practices (BMPs) for erosion and sediment control prior to conducting ground disturbing activities related to operation or maintenance of the Project to minimize or eliminate the impacts of erosion and siltation.
4) GRDA is proposing the following environmental measures regarding recreation resources:
    a) Review Part 8, regulatory, and directional signage at all FERC-approved recreation sites, and install, repair, or replace the signage, as necessary.
    b) Develop a new RMP to address maintenance of FERC-approved recreation sites and include a provision to complete a recreation facilities inventory and use study in year 25 after the license is issued.
5) GRDA will implement the HPMP developed in consultation with the Cultural Resources Working Group (CRWG). The HPMP includes measures to protect, mitigate, or enhance cultural, historical, archaeological, and Traditional Cultural Properties (TCPs) such that the anticipated operation (without a rule curve) of the Project do not adversely impact currently identified properties and properties that may be identified in the future.

2.2.4 Project Boundary

The Project boundary has been included in Exhibit G in Volume 2 of this application. The Project boundary set forth in Exhibit G of this application contains some minor adjustments to the existing Project boundary, to ensure that the boundary encompasses all lands and waters that are necessary for Project purposes, consistent with FERC regulations and governing precedent. As provided in NDAA 2020 section 7612(b)(3)(C), GRDA consents to these proposed adjustments to the Project boundary.

The current Project boundary (2014 boundary) was developed and approved prior to the availability of accurate Light Detection and Ranging (LiDAR) elevation or contour data. The Project boundary presented in Exhibit G utilizes the LiDAR information in the form of the Digital Elevation Model used for the hydrologic and hydraulic (H&H) Model. This information is viewed as the most accurate elevation or contour information readily available for mapping purposes.

The accuracy of the 2014 boundary has been improved to create the Project boundary shown in Exhibit G of this application. The 2014 boundary intended to follow specific contour elevations or parcel lines as defined on the Project boundary maps but did not accurately graphically and spatially depict the actual location of the Project boundary. In areas where there is significant shoreline development or other areas where the 2014 boundary did not accurately encompass the entire reservoir area at the elevations depicted on the 2014 boundary drawings, the Project boundary presented in Exhibit G of this application was created to match the best available data and correct the deficiencies of the 2014 boundary drawings.

Accuracy improvements were made to the create the Project boundary maps enclosed as Exhibit G of this application. The improvements are generally organized according to the following categories that are also explained as map notes on the enclosed Exhibit G and the explanation maps contained in **Appendix E-2**.

The following accuracy improvements were made, and their locations are shown on the explanation maps contained in **Appendix E-2**:

- Parcel line accuracy improvements were made when the 2014 boundary intended to follow parcel lines,
- Metes and bounds/ROW accuracy improvements were made when the 2014 boundary included land that is not needed for the operation of the Project,
- Contour elevation accuracy improvements were made when the 2014 boundary intended to follow a specific contour elevation and the 2014 boundary did not accurately graphically or spatially represent the location of the contour line, or
- Extension/interpolation accuracy improvements are very short in distance and were made to transition among accuracy improvements or between accuracy improvements and the 2014 boundary where it is mapped accurately enough to leave the boundary unchanged for the anticipated Project boundary included in Exhibit G.

2.3 Alternatives To the Proposed Action

The Commission will consider and assess alternative recommendations for operational or facility modifications as well as protection, mitigation, and enhancement measures identified by the Commission, resource agencies, Native American Tribes, Non-governmental organizations, and the public.

2.4 Alternatives Considered but Eliminated from Detailed Study

FERC proposed eliminating the alternatives in the following sections from detailed study in SD2.

2.4.1 Federal Government Takeover of the Project

In accordance with Section 16.14 of the Commission's regulations, a federal department or agency may file a recommendation that the United States exercise its rights to take over a hydroelectric project with a license that is subject to Sections 14 and 15 of the FPA.[23] In SD2, the Commission indicated federal takeover was not a reasonable alternative. Federal takeover of the Project would require congressional approval. No parties suggested federal takeover is appropriate, and no federal agencies have expressed interest in operating the Project. There is no evidence showing federal takeover should be recommended to Congress (Federal Energy Regulatory Commission, 2018a).

2.4.2 Issuing a Nonpower License

The Commission may issue a non-power license temporarily that is terminated when it determines another governmental agency is authorized and willing to assume the regulatory authority and supervision over the lands and facilities covered by the non-power license. No governmental agencies have indicated they have a willingness or ability to take over the Project. No parties have sought a non-power license, and there is no information to conclude the Project should no longer be used for power production. The Commission has concluded that consideration of a non-power license was not a reasonable alternative to relicensing the Project (Federal Energy Regulatory Commission, 2018a).

2.4.3 Decommissioning the Project

Decommissioning of the Project could be accomplished with or without dam removal. Both alternatives would require the Commission to deny the relicensing application and require GRDA to file an application to surrender the existing license. Decommissioning the Project and/or removing Project facilities would involve significant costs. The Project provides a clean, safe, and viable source of renewable energy in the region. If the Project were decommissioned, it would no longer be authorized to generate electricity. No entities have requested decommissioning or indicated that it is appropriate. The Commission has concluded that Project decommissioning was not a reasonable alternative to relicensing the Project (Federal Energy Regulatory Commission, 2018a).

[23] 16 USC §§ 791(a)-825(r).

3. Environmental Analysis

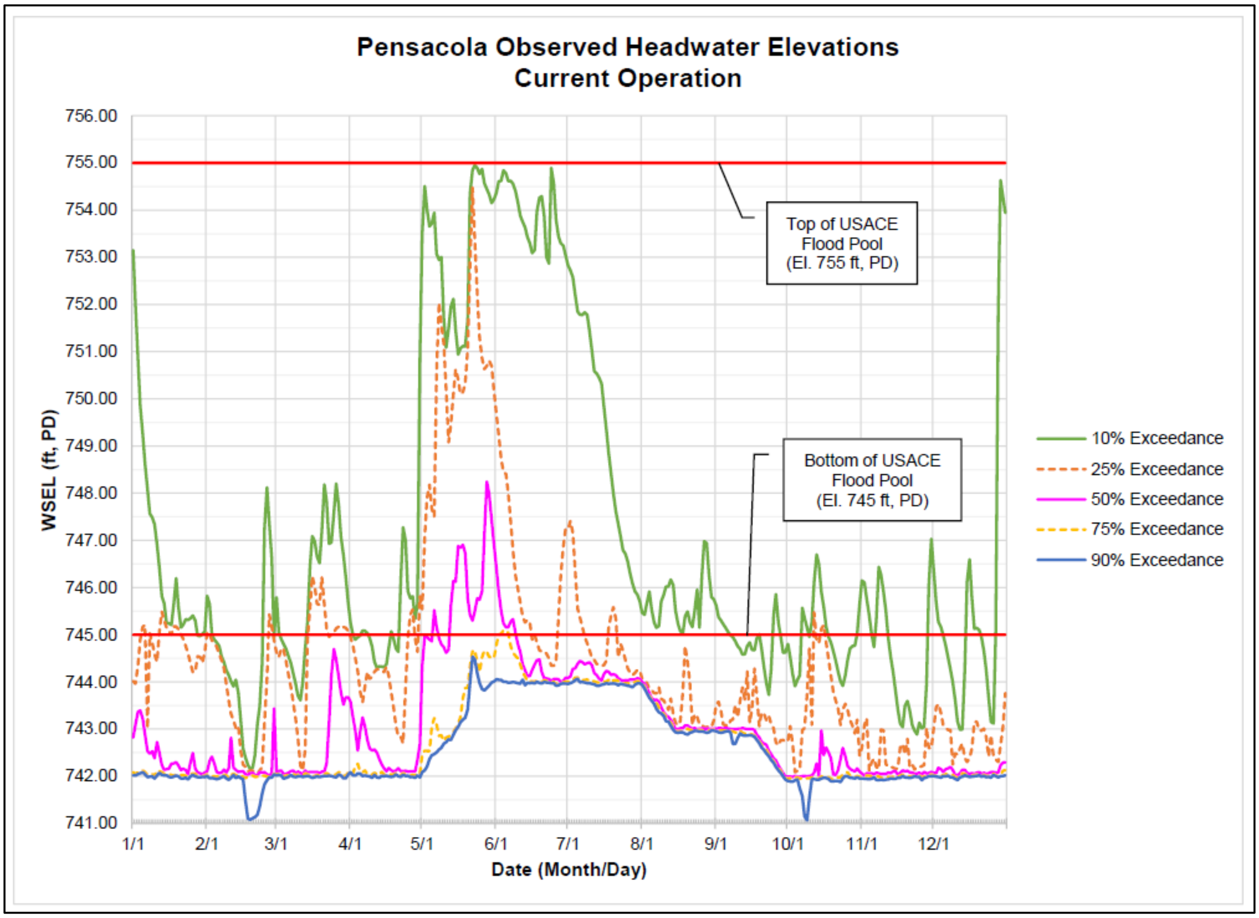
This analysis was prepared by GRDA and includes a description of the affected environment and the environmental effects, as appropriate, of continued current operation (under the current post-2015 rule curve) or baseline operation (under the pre-2015 rule curve) as appropriate versus the anticipated operation (without a rule curve) of the Project. The information provided is based on existing sources of information including the results of studies conducted during the relicensing process.

To predict reservoir elevations that may occur in the future under the anticipated operation (without a rule curve) and to replicate reservoir elevations under the current operation (under the current post-2015 rule curve) and baseline operation under rule curves, GRDA used the OM and inflow data from the period April 1, 2004 through December 31, 2019, which were provided by the USACE RiverWare Model to simulate the resulting reservoir elevations under the current operation (under the current post-2015 rule curve) and baseline operation (under the pre-2015 rule curve) and the anticipated operation. The OM is further explained in Section 3.4.1.3.10.

Current Operation (under the current post-2015 rule curve)

Simulated results for the current operation (under the current post-2015 rule curve) from the OM utilize the rule curve implemented following the Commission's August 14, 2015 Order (2015 Order) that revised the rule curve to guide operations for the entire inflow data period of April 1, 2004 through December 31, 2019. Graphs showing the computed 10%, 25%, 50%, 75%, and 90% exceedance values for the observed and modeled Grand Lake elevations each day under current operation (under the current post-2015 rule curve) are provided as **Appendix B-8.1.** The graph for the observed Grand Lake elevations is reproduced as **Figure 3-1**. The hourly headwater elevations from the OM used for development of the observed graph spans a time period from August 14, 2015 through December 31, 2022.

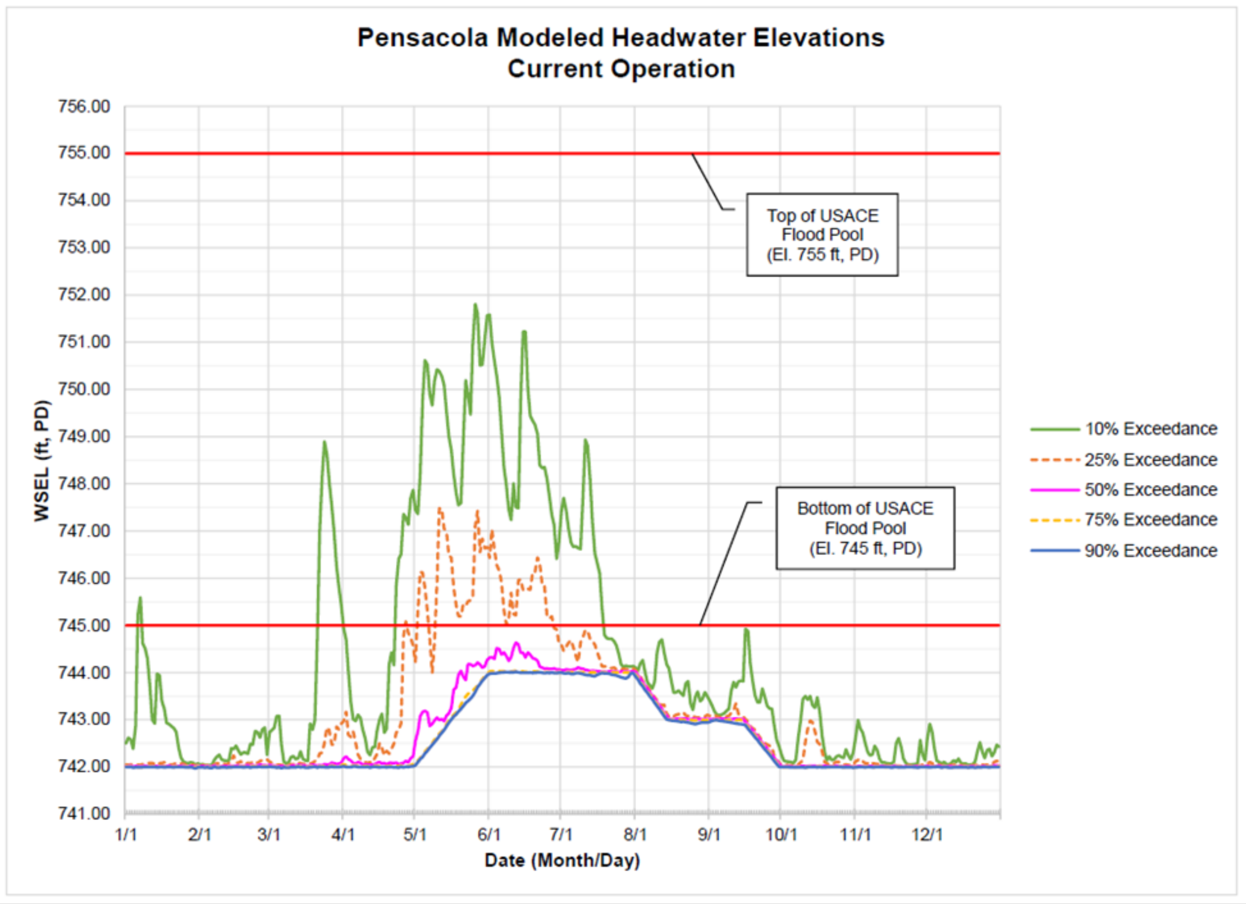
Figure 3-1 Observed Headwater Elevation Exceedance Curves for Current Operation



Source: Appendix B-8.1

The graph for the modeled Grand Lake elevations is reproduced as **Figure 3-2**. The hourly headwater elevations from the OM used for development of the modeled graphs span a time period from April 1, 2004 through December 31, 2019.

Figure 3-2 Modeled Headwater Elevation Exceedance Curves for Current Operation



Source: Appendix B-8.1

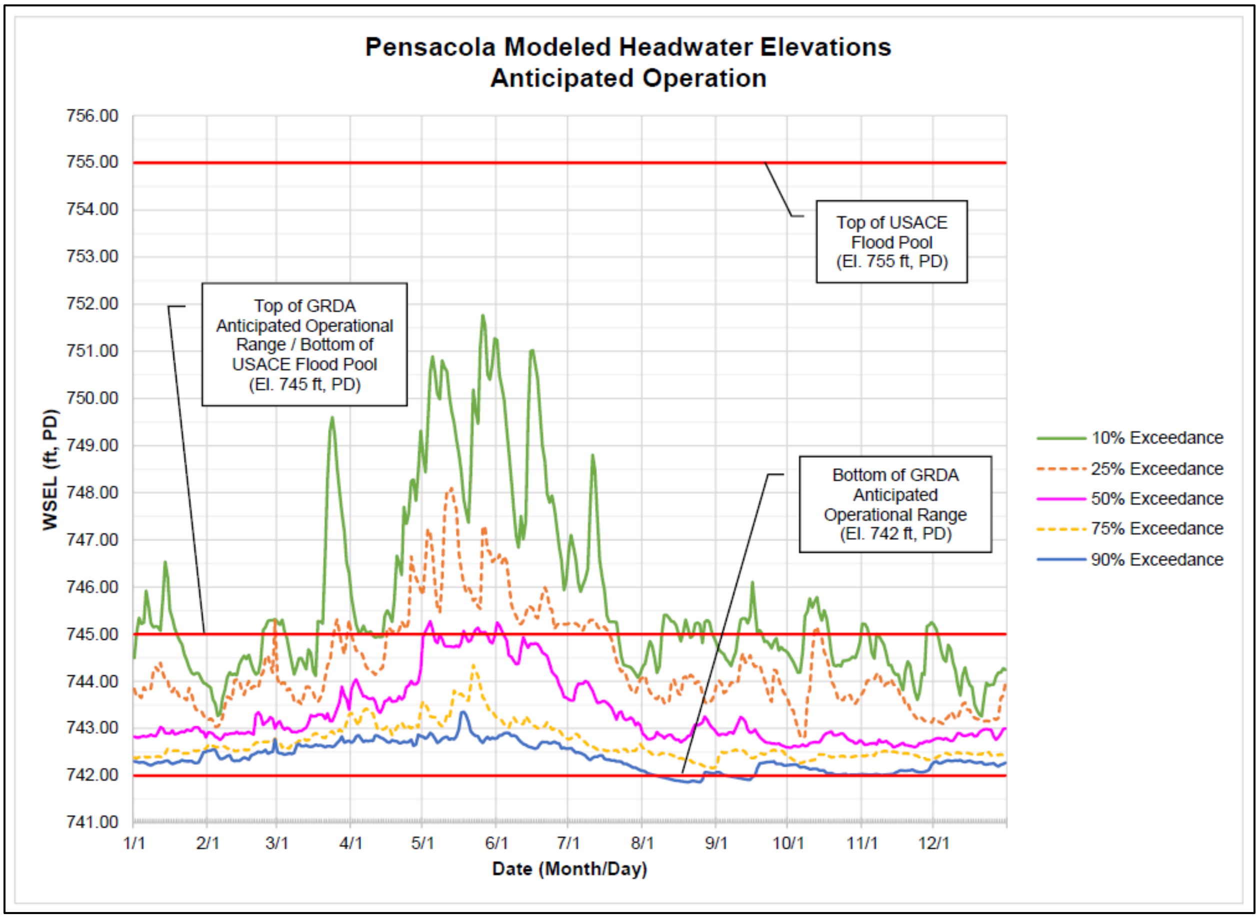
Baseline Operation (under the pre-2015 rule curve)

Simulated results for the baseline operation (under the pre-2015 rule curve) from the OM utilize the rule curve that was in place just prior to the 2015 Order to guide operations for the inflow data period of April 1, 2004 through December 31, 2019.

Anticipated Operation (without a rule curve)

Simulated results for the anticipated operation from the OM utilize the anticipated operation as outlined in Section 2.2.2 to guide operations for the entire inflow data period of April 1, 2004 through December 31, 2019. A graph showing the computed 10%, 25%, 50%, 75%, and 90% exceedance values for modeled Grand Lake elevations each day under anticipated operation is provided as **Appendix B-1**. The graph for the modeled Grand Lake elevations is reproduced as **Figure 3-3**. The hourly headwater elevations from the OM used for development of the modeled graph spans a time period from April 1, 2004 through December 31, 2019.

Figure 3-3 Modeled Headwater Elevation Exceedance Curves for Anticipated Operation



Source: Appendix B-1

Figure 3-4 provides median reservoir elevations by month for both the current operation (under the current post-2015 rule curve) and the anticipated operation without a rule curve. These values along with many other values generated by the OM will be used in the environmental analyses contained in this section to discuss environmental effects of the current operation (under the current post-2015 rule curve) versus the anticipated operation without a rule curve.

Figure 3-4 Median Reservoir Elevations by Month for Current and Anticipated Operations

Median Values (feet PD)			Anticipated Operations											
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
			742.89	742.92	743.23	743.72	744.99	744.72	743.26	742.85	742.88	742.74	742.62	742.84
Current Operations	Jan	742.02	0.87	0.91	1.21	1.71	2.98	2.70	1.24	0.83	0.87	0.72	0.61	0.82
	Feb	742.02	0.87	0.90	1.21	1.70	2.97	2.70	1.24	0.83	0.86	0.72	0.60	0.82
	Mar	742.03	0.86	0.89	1.20	1.69	2.96	2.69	1.22	0.82	0.85	0.71	0.59	0.81
	Apr	742.08	0.81	0.84	1.15	1.64	2.91	2.64	1.18	0.77	0.80	0.66	0.54	0.76
	May	743.82	-0.93	-0.90	-0.59	-0.09	1.17	0.90	-0.56	-0.97	-0.93	-1.08	-1.19	-0.98
	Jun	744.21	-1.32	-1.29	-0.98	-0.49	0.78	0.51	-0.96	-1.36	-1.33	-1.47	-1.59	-1.37
	Jul	744.03	-1.14	-1.10	-0.80	-0.30	0.97	0.69	-0.77	-1.17	-1.14	-1.28	-1.40	-1.18
	Aug	743.18	-0.29	-0.25	0.05	0.55	1.82	1.54	0.08	-0.32	-0.29	-0.43	-0.55	-0.33
	Sep	742.98	-0.09	-0.05	0.25	0.75	2.02	1.74	0.28	-0.13	-0.09	-0.24	-0.35	-0.14
	Oct	742.02	0.87	0.91	1.21	1.71	2.98	2.70	1.24	0.83	0.87	0.73	0.61	0.82
	Nov	742.01	0.88	0.91	1.22	1.71	2.98	2.71	1.25	0.84	0.87	0.73	0.61	0.83
	Dec	742.01	0.88	0.91	1.22	1.71	2.98	2.71	1.24	0.84	0.87	0.73	0.61	0.83

It is important to utilize the current operation under the current rule curve and the baseline operation under the pre-2015 rule curve for a proper analysis on a case-by-case basis for each type of resource. This is important because some resources are sensitive to reservoir level changes and the current occurrence of that resource may have already adapted to the current operation conditions that have been in place since the 2015 Order. However, other more resilient resources are only sensitive to reservoir level changes over the long-term. Therefore, the baseline analysis that simulates the operating requirements that were in place prior to or prior to and after the 2015 Order can both be appropriate comparisons depending upon the specific resource being analyzed.

3.1 General Description of the River Basin

3.1.1 Grand River Basin

The Pensacola Project is located on the Grand River, a tributary of the Arkansas River. The Grand River begins as the Neosho River in east central Kansas, just north of the city of Council Grove. The Neosho River generally flows southeast through Kansas for approximately 300 miles into Oklahoma. The Grand River begins at the Neosho's confluence with the Spring River, southeast of Miami, Oklahoma. Pensacola Dam is located at RM 77 and impounds water upstream approximately 66 miles, extending upstream of the confluence of the Neosho River and Spring River approximately 14 miles up the Neosho River and 10 miles up the Spring River (Federal Energy Regulatory Commission, 1991). At flood pool, when the river is under USACE jurisdiction, the water is impounded further upstream into the tributaries (Grand River Dam Authority, 2008).

The river basin covers a total area of 12,520 square miles in four states, including Kansas with approximately 6,220 square miles, Missouri with approximately 2,960 square miles, Oklahoma with approximately 2,930 square miles, and Arkansas with approximately 410 square miles. The river basin ranges in elevation from approximately 1,500 feet mean sea level (msl) in the upper basin in Kansas to about 500 feet msl in the lower basin in Oklahoma (Federal Energy Regulatory Commission, 1991).

3.1.2 Major Land Uses

Land use in the Grand River Basin is devoted primarily to agriculture, mining, and recreational development. Corn, small grains, sorghum, alfalfa, fruits, and vegetables are the principal crops produced. Coal, clay, lead, zinc, lime, petroleum, and natural gas are mined in the basin (Federal Energy Regulatory Commission, 1991). A more detailed description of current land use in the Project vicinity is found in Section 3.9.

3.1.3 Major Water Uses

Water from the Pensacola Project serves multiple purposes including hydropower generation, water supply, public recreation, fish and wildlife enhancement, and flood control. A more detailed description of water use in the Project vicinity is found in Section 3.4.

3.1.4 Grand River Basin Flow Management

The Arkansas River watershed, and the Grand/Neosho subbasin in particular, has a well-established history of significant flooding, which predates the original construction of the Project (Section 3.4.1.3.1). One of the purposes of the Pensacola Dam, and USACE reservoirs both upstream and downstream of Pensacola Dam, in fact, is to provide flood control. For purposes of flood control in the Grand River Basin and overall Arkansas River Basin System, the Tulsa USACE office manages an elaborate and complex system of eleven large reservoirs, including Grand Lake. Within the Grand/Neosho subbasin, USACE manages three federal reservoirs upstream of the Pensacola Project, which consist of the Marion Reservoir, Council Grove Reservoir, and John Redmond Reservoir. These three federal reservoirs have a combined storage capacity of approximately 465,000 acre-feet. Downstream of Grand Lake and GRDA's Lake Hudson (Markham Ferry), USACE manages Fort Gibson Reservoir (919,000 acre-feet) on the Grand River prior to its confluence with the Arkansas River.

Within this large system, USACE must provide the safe passage of flows to municipalities and lands as far upstream as Emporia, Kansas, as well as downstream to Muskogee, Oklahoma and further down the Arkansas River system, including Fort Smith, Russellville, Van Buren, and even Little Rock, Arkansas (Grand River Dam Authority, 2017a).

Pensacola, Markham Ferry, and Fort Gibson reservoirs are regulated as a subsystem of the Arkansas River Basin System, with similar percentages of the total flood control storage in each project utilized during periods of high flow. The system is also balanced by percentage of flood control storage utilized during evacuation (US Army Corps of Engineers, 1992). Under Section 7 of the Flood Control Act of 1944 and the NDAA 2020, USACE has the exclusive jurisdiction to prescribe releases from Pensacola Dam under active or anticipated flood operations.[24] A map showing the dams on the Grand River and Arkansas River is in **Appendix E-3**.

3.1.5 Tributary Streams

Principal tributaries of the Grand River include the Cottonwood, Elk, and Spring Rivers and Big Cabin, Labette, Lightning, and Spavinaw Creeks (Federal Energy Regulatory Commission, 1991).

[24] 33 USC § 709.

3.1.6 Climate

The climate in Delaware County and Ottawa County, Oklahoma, where the majority of the Project is located, is temperate with average annual temperatures of 58.9 degrees Fahrenheit (°F) and 57.8°F, respectively and an average annual precipitation of 46.68 inches and 46.02 inches, respectively (Oklahoma Climatological Survey, n.d.a). Warm, moist air moving northward from the Gulf of Mexico often influences weather, especially in the southern and eastern portion of the state resulting in increased humidity, cloudiness, and precipitation (Oklahoma Climatological Survey, n.d.b).

3.2 Scope of Cumulative Effects Analysis

According to the Council on Environmental Quality's (CEQ) regulations for implementing NEPA, a cumulative effect is defined as, *"… the effect on the environment that results from the incremental effect of the Action when added to other past, present, or reasonably foreseeable future actions, regardless of what agency (federal or non-federal) or person undertakes such other actions. Cumulative effects can result from individually minor but collectively significant actions taking place over a period of time, including hydropower and other land and water development activities*" (Federal Energy Regulatory Commission, 2018a).

In SD2, the Commission stated it received analysis and comments from staff during the scoping process, which indicated geology and soils, water quantity, land use, socioeconomics, and cultural resources have the potential to be cumulatively affected by the proposed continued operation and maintenance of the Project in combination with other hydroelectric projects and other activities within the Grand River Basin.

3.2.1 Geographic Scope

3.2.1.1 Geology and Soils

In SD2, the Commission identified the geographic scope for geology and soils to include the Grand River Basin, which extends approximately 66 miles upstream from the Pensacola Dam and downstream to the Markham Ferry Project Dam. The collective operation and maintenance of the Project, in combination with other developmental and non-developmental uses of the Grand River Basin have the potential to affect geology and soils in the Grand River (Federal Energy Regulatory Commission, 2018a). The geology and soil resources that could potentially be cumulatively affected by continued operation of the Project are discussed in Section 3.3.

3.2.1.2 Water Quantity

The Commission identified the geographic scope for water quantity to include the system of 11 dams managed by USACE for the purposes of flood control. This system extends upstream from the Pensacola Project, including the Marion, Council Grove, and John Redmond Reservoirs, and downstream from Grand Lake to include GRDA's Markham Ferry Reservoir (Lake Hudson) and the Fort Gibson Reservoir on the Grand River prior to its confluence with the Arkansas River. This geographic scope was chosen because it includes the entire Grand River Basin that is managed for flood control purposes. USACE flood control operations in the Grand River Basin have the potential to affect water quantity directly and cumulatively at Grand Lake (Federal Energy Regulatory Commission, 2018a). The water quantity resources that could potentially be cumulatively affected by continued operations are discussed in Section 3.4.

3.2.1.3 Land Use and Cultural Resources

The Commission identified the geographic scope for land use and cultural resources as Grand Lake to elevation 750 feet PD, as well as any adjacent upland areas that are periodically inundated by Grand Lake. The existing operation and maintenance of the Project, in combination with other developmental and non-developmental activities within the Grand River Basin, have the potential to cumulatively affect land use adjacent to the reservoir or cultural resources located on lands adjacent to the reservoir, including by flooding of adjacent lands (Federal Energy Regulatory Commission, 2018a). The land use and cultural resources that could potentially be cumulatively affected by continued operation of the Project are discussed in Section 3.9 and Section 3.11, respectively.

3.2.1.4 Socioeconomic Resources

The Commission identified Craig, Delaware, Mayes, and Ottawa Counties, Oklahoma as the geographic scope of analysis for socioeconomic resources. These counties contain the communities that are most closely associated with Grand Lake and have the potential to be economically affected by the Project's operations (Federal Energy Regulatory Commission, 2018a). The socioeconomic resources that could potentially be cumulatively affected by continued operations are discussed in Section 3.12.

3.2.2 Temporal Scope

The temporal scope of the cumulative effects analysis addresses past, present, and reasonably foreseeable future actions and their effects on each affected resource. Based on the expected term of a new license, the temporal scope of analysis will reasonably address foreseeable actions for 30 to 50 years into the future (Federal Energy Regulatory Commission, 2018a). It is reasonable to expect the existing laws and regulations that are used to protect and manage resources within the Grand River Basin that have the potential to be cumulatively affected by continued operation of the Project will remain in place for the term of a new FERC license and will continue to balance human uses with the protection of potentially impacted resources.

3.3 Geology and Soils

3.3.1 Affected Environment

3.3.1.1 Topography

The Pensacola Project spans two geomorphic provinces, which include the Ozark Plateau and Neosho Lowland. Maps showing the geomorphic provinces of Oklahoma and general topography of the Pensacola Project vicinity are in **Appendix E-4** and **Appendix E-5**, respectively.

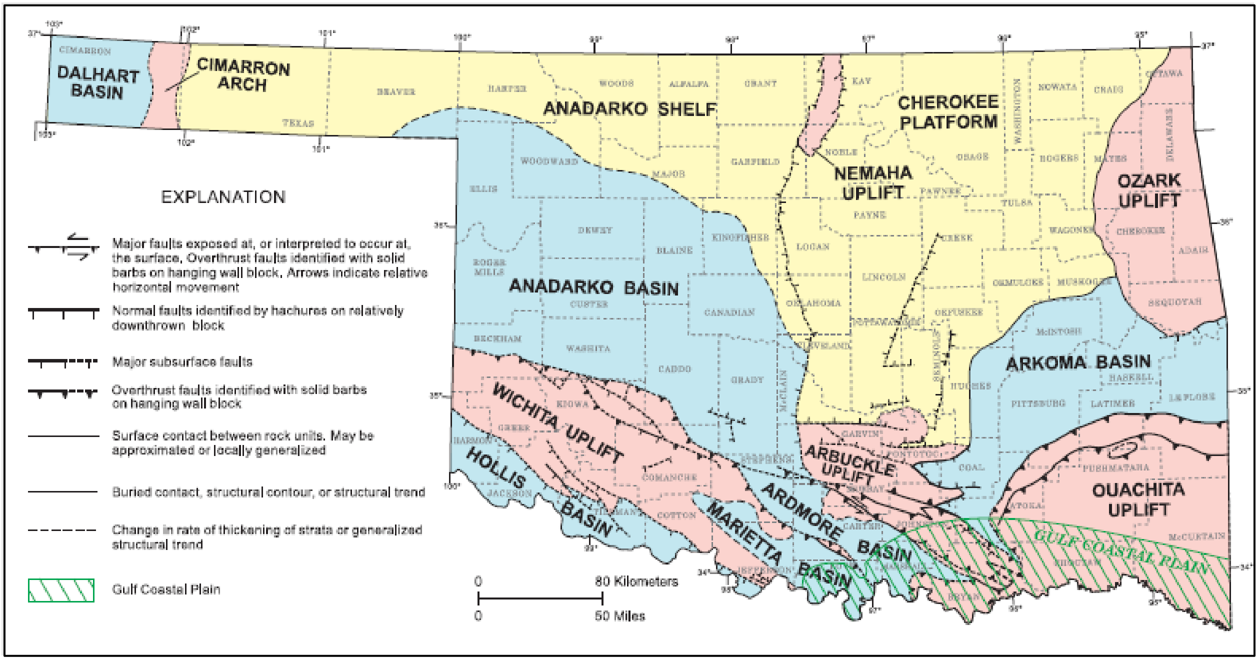
The eastern portion of the Project vicinity lies within the Ozark Plateau geomorphic province. Its landscape is typified by locally rugged topography of deeply dissected limestones and cherts from the Mississippian subperiod. Deep ravines and narrow stream valleys with branched systems transition into gently rolling uplands (Grand River Dam Authority, 2017a). Hilltops adjacent to the Project in this province range in elevation from 850 to over 1,000 feet.

The western portion of the Project vicinity lies within the Neosho Lowland geomorphic province. Its landscape is typified by gently rolling plains with occasional hills and ridges. Generally, shorelines surrounding the Project reservoir in this geomorphic province have gentler slopes as compared to those in the Ozark Plateaus. The Neosho Lowland geomorphic province was formed on shales from the Pennsylvanian subperiod and is marked by occasion low escarpments and buttes capped by Pennsylvanian sandstones and Mississippian limestones (Grand River Dam Authority, 2017a). Hilltops adjacent to the Project in this province range in elevation from 800 to about 850 feet.

3.3.1.2 Geology

The major geologic provinces in Oklahoma are shown in **Figure 3.3.1.2-1**. The Pensacola Project is almost entirely within the Ozark Uplift geologic province; the northwestern-most portion of the Project is in the Cherokee Platform geologic province, which bounds the Ozark Uplift to the west.

Figure 3.3.1.2-1 Geologic Provinces of Oklahoma



Source: (Johnson, K.S. and K.V. Luza, 2008)

3.3.1.2.1 Regional Geology

The Ozark Uplift is a broad dome that covers large portions of northeastern Oklahoma, southern Missouri, and northeast Arkansas. The western boundary of the Ozark Uplift with the Cherokee Platform generally parallels the alignment of the Grand River and Spring River (Grand River Dam Authority, 2021a). A majority of the Grand River upstream of its confluence with the Elk River is incised into the very western portion of the Ozark Uplift and the Neosho River formed primarily in the Cherokee Platform.

The Ozark Uplift is divided into three portions, which include the Salem Platform, Springfield Structural Plain, and Boston Mountains. The Pensacola Project is located within the Springfield Structural Plain. It is underlain largely by rocks of Mississippian age and slopes generally outward from the center of the uplift to the west, southwest, and south (Grand River Dam Authority, 2021a).

Structural features in the Project vicinity include the Horse Creek Anticline, Seneca Fault, and Locust Grove Fault, all of which trend southwest to northeast. The Horse Creek Anticline is located about five to six miles northwest of the Pensacola Dam. The Seneca Fault is approximately 100 miles in length and extends from Pryor, Oklahoma to southwestern Missouri. The Seneca Fault is inactive and passes approximately 1,700 feet downstream of the Pensacola Dam and is visible where it crosses the main spillway channel. This fault also passes very close to the middle spillway and continues to the northeast through Grand Lake. The Locust Grove Fault is approximately 10 miles long and is also an inactive fault. This fault is located approximately 18 to 19 miles south-southwest of the Pensacola Dam at its closest point (Grand River Dam Authority, 2021a).

3.3.1.2.2 Local Geology

Bedrock in the vicinity of the Pensacola Project consists of Mississippian-age rocks, which include the Keokuk and Reed Spring Formations and underlying St. Joe Group. At greater depths, the St Joe Group is underlain by Devonian-Mississippian Rocks (Grand River Dam Authority, 2021a).

The Keokuk Formation consists of massive, white to buff- and gray-mottled, fossiliferous chert and irregular masses of blue-gray, dense, fine grain limestone. The thickness of this formation ranges up to 250 feet with an average thickness of 60 to 80 feet. The formation is exposed primarily in the steep slope at the west abutment of the Pensacola Dam (Grand River Dam Authority, 2021a).

The Reeds Spring Formation comprises the majority of the Pensacola Dam foundation and consists of alternating gray, thin-bedded, fine-grained, dense limestone and dark gray to blue gray and tan chert in nearly equal parts. This formation has a maximum thickness of 175 feet in the Project vicinity (Grand River Dam Authority, 2021a).

The St. Joe Group comprises three distinct subdivisions in northeast Oklahoma. The upper Pierson Formation includes up to 25 feet of gray, thick bedded, fine-crystalline limestone. Locally, this formation passes into a thick crinoidal reef that may exceed 50 feet in thickness. The middle Northview Formation consists of 3 to 5 feet of gray-green, calcareous shale or marlstone. The lower Compton Formation includes up to ten feet of gray, nodular-weathering, heavy-bedded limestone (Grand River Dam Authority, 2021a).

The Devonian-Mississippian age Chattanooga Formation underlies the St. Joe Group and consists of a dark gray to black, thinly bedded shale with minor amounts of sandstone (Grand River Dam Authority, 2021a).

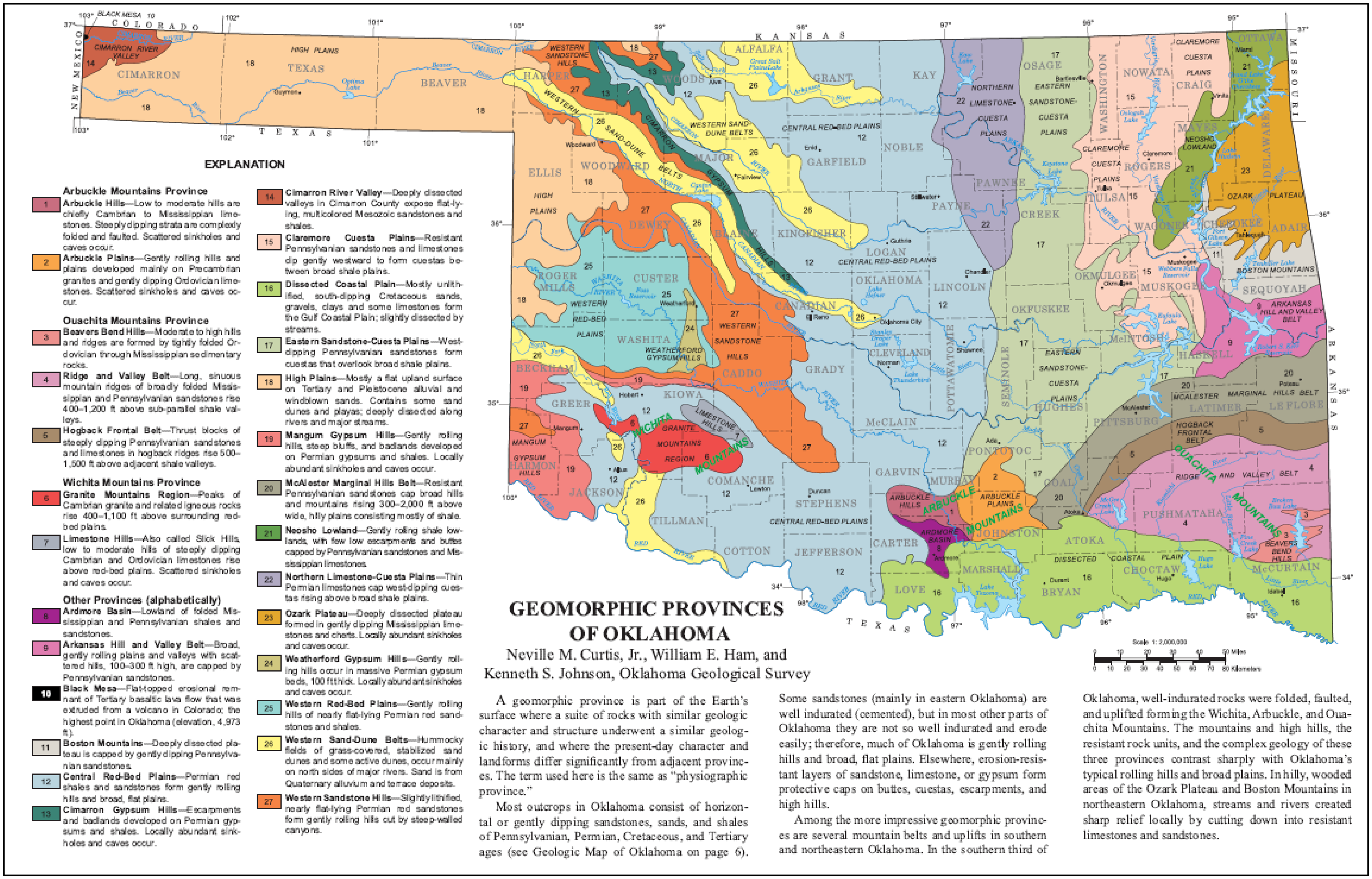
3.3.1.3 Local Geomorphology

Geomorphic provinces are areas where the current character of the landforms differs significantly from the landforms of the adjacent areas (Johnson, K.S. and K.V. Luza, 2008). As shown in **Figure 3.3.1.3-1**, the major tributaries which form the northern and western areas of the reservoir as the Neosho River and Spring River, were formed in the Neosho Lowland province, which is characterized by gently rolling shale lowlands with few escarpments. The main tributaries that come together to form the eastern and southern portions of the reservoir were formed in the Ozark Plateau province characterized by a deeply dissected plateau of Mississippian limestones and Cherts.

The differences in geomorphic province characteristics are evident in the river valleys forming the reservoir and on its shorelines. The Neosho River Valley upstream of its confluence with the Spring River typically has gradual slopes with mud substrates, silt deposits, and wetlands at confluences with small tributaries (Grand River Dam Authority, 2017a). The other southern and eastern shorelines of the reservoir typically have limestone bluffs and steep, rocky beaches (Grand River Dam Authority, 2017a).

Such as occurs in the Pensacola Project and its riverine system, changes due transitions from one geomorphic province to another cause changes from upstream to downstream fluvial geomorphic properties. Therefore, such fluvial geomorphic properties such as soil type, valley and thalweg slope, valley and thalweg orientation, erodibility and sediment transport are generally different in the northern and western portions of the Project compared to the southern and eastern portions of the Project.

Figure 3.3.1.3-1 Geomorphic Provinces of Oklahoma



Source: (Johnson, K.S. and K.V. Luza, 2008)

3.3.1.4 Soils

Soil development is complex within the Project vicinity and is dependent on and varies with the underlying geologic material, local topography, climate, land use, and habitat. In general, dominant soils of the Ozark Plateau are ultisols, while those of the Neosho Lowlands are mollisols (Grand River Dam Authority, 2017a).

Ultisols of the Ozark Plateau are brown to light brown, silty soils with reddish clay subsoils on cherty limestones. They are typically found under forests and are identified by intense leaching, a clay horizon, and a low supply of bases below the surface level. Ultisols are generally well suited for shifting cultivation, although they can be highly productive if used with fertilizers. Most soils in the Ozark Plateau will not readily absorb ionic constituents found in infiltrating water (Grand River Dam Authority, 2017a).

The mollisols found under grasses in the Neosho Lowlands, are steppe soils with a relatively thick, dark, and humus-rich surface layer. The mollisols in the Project vicinity are deep, dark-colored soils mostly with clay subsoils developed on shales, sandstones, and limestones under tall grass prairies. These soils often have distinct layers rich in clay, sodium, calcium, and other materials (Grand River Dam Authority, 2017a). Mollisols are well suited for agricultural use.

A review of the Natural Resource Conservation Service (NRCS) Web Soil Survey was completed on October 20, 2022 and the resulting custom soil report for the Project vicinity is in **Appendix E-6**. The five most prevalent soil series identified in the Project vicinity include Clarksville (49.0%), Osage (9.1%), Verdigris (5.7%), Britewater (5.2%), and Choteau (3.9%). The general characteristics of each of these soil series are shown in **Table 3.3.1.4-1**.

Table 3.3.1.4-1 Prevalent Soil Characteristics in the Pensacola Project Vicinity

Soil Series	Drainage Classification	Formation	Water Transmittal Capacity	Runoff Class
Clarksville silt loams	Somewhat excessively drained	Steep side slopes of hills and narrow ridge tops	Moderately low to high	Medium to very high
Osage silty clays	Poorly drained	Flood plains	Very low to moderately low	Very low
Verdigris silt loams	Well drained	Flood plains	Moderately high to high	Very low
Britewater silt loams	Well drained	Stream terraces	Moderately high to high	Low
Choteau silt loams	Somewhat poorly drained	High terraces or foot slopes of uplands	Moderately low to moderately high	Low to medium

Source: (USDA Natural Resources Conservation Service, n.d.)

3.3.1.5 Erosion

The NRCS uses a computer software model called the Revised Universal Soil Loss Equation Version 2 (RUSLE 2) to estimate soil loss from erosion caused by rainfall on cropland. Several factors are viewed in RUSLE 2 to estimate soil erosion based on the soil type’s inherent erodibility; factors include hydrologic group, T factor, Kf factor, and soil texture.

The hydrologic group for each soil is based upon runoff potential for saturated and bare soils and range from Group A to Group D, with Group A having the lowest runoff potential and Group D having the highest. The T factor is an estimate of the maximum average rate of soil erosion in tons per acre that can occur without affecting crop productivity over a sustained period. T factor values range from 1 to 5 tons per acre, with higher values being less subject to damage from erosion. The T factor also relates to the ability of the soil to revegetate once it is disturbed. The Kf factor gives an indication of how susceptible a soil type is to sheet and rill erosion. Kf factor values range from 0.02 to 0.69, with 0.69 having the highest susceptibility to erosion. NRCS also provides representative values of the amounts of sand, silt, and clay to describe the representative soil texture in each soil type (USDA Natural Resources Conservation Service, 2001).

A summary of the RUSLE 2 related attributes for the five most prevalent soil series in the Project vicinity are shown in **Table 3.3.1.5-1**.

Except for moderate slumping of an area downstream of the dam following the 2015 flood of record, no instances of mass soil movement, slumping, or other forms of instability are present within the Project boundary (Grand River Dam Authority, 2017a).

Table 3.3.1.5-1 RUSLE 2 Related Attributes for the Five Most Prevalent Soil Series in Project Vicinity

Soil name	Percent of Project Vicinity	Hydrologic Group	T Factor	Kf Factor	Soil Texture Representative Values		
					% Sand	% Silt	% Clay
Clarksville							
gravelly silt loam	0.84	A	2.0	0.37	26.5	53.5	20.0
very gravelly silt loam 1-8% slopes	14.73	A	5.0	0.37	29.3	53.7	17.0
very gravelly silt loam 5-20% and 20-50% slopes	21.38	B	3.0	0.32	21.2	67.5	11.3
stony silt loams	12.03	A	2.0	0.32	26.3	52.7	21.0
Osage							
silty clay	9.12	D	5.0	0.20	2.0	45.0	53.0
Verdigris							
silt loam	4.21	B	5.0	0.37	11.3	67.7	21.0
silty clay loam	1.49	C	5.0	0.32	7.0	62.0	31.0
Choteau							
silt loam	5.18	C	5.0	0.32	25.0	53.0	22.0

Source: (USDA Natural Resources Conservation Service, n.d.)

3.3.1.6 Reservoir Shoreline

The Grand Lake shoreline ranges from forested areas with a variety of different vegetative cover types to areas largely developed for commercial and residential uses. The overall vegetation in the Project vicinity is dominated by deciduous forests.

Soils along the Grand Lake shoreline can be cherty and have developed from carbonate rocks or interbedded chert, sandstone, and shale. The primarily soils consist of stony, silt-loam soils on slopes ranging from 5-20%. Timbered upland ridges in cherty limestone areas are also characterized by this soil type. Within the Ozark Plateau, the Ozark highlands ecoregion is largely underlain by highly soluble and fractured limestone and chert. Caves, sinkholes, and underground drainage occur, heavily influencing surface water availability, water temperature, and the potential for surface and groundwater contamination. Numerous sinkholes allow surface water to rapidly infiltrate into the subsurface and recharge the underlying shallow aquifers. Clear, cold perennial spring-fed streams with bedrock bottoms are common. Numerous small, dry valleys occur where overland flow is entirely driven by runoff. Losing streams are common, permitting the flow of water directly into the groundwater system through streambeds. During the summer dry period, springs and groundwater recharge help sustain stream flows (Grand River Dam Authority, 2017a).

The shoreline of upper Grand Lake along the northern and western portions is generally typified by gentler slopes, while the shoreline of the southern and eastern portions is steep rocky beaches and bluffs. Upper Grand Lake has large sections of primarily undeveloped shoreline. However, the lower reservoir shoreline areas consist of limestone bluffs that are mainly developed for commercial and residential use (Grand River Dam Authority, 2017a).

3.3.1.7 Sedimentation

3.3.1.7.1 Sedimentation Study Background

Sediment transport, erosion, and deposition are natural processes that can have impacts to hydroelectric projects. Rivers carry sediment downstream, and as flow conditions change, they erode or deposit that load. Where tributaries meet, streambed gradients change, floodplains widen, near bridge and channel constrictions, and other places where flow velocities decrease, sediment tends to drop out of the flow and create depositional features that have the potential to affect upstream flows.

During the relicensing process of the Pensacola Project, stakeholders expressed interest in a Sedimentation Study to evaluate future impacts of sediment deposition in the system. The study had two primary goals:

- Determine potential effect of Project operations on sediment transport, erosion, and deposition in the lower reaches of tributaries to Grand Lake upstream of Pensacola Dam.
- Provide an understanding of sediment transport processes and patterns upstream of Grand Lake on the Neosho River, Spring River, and Elk River, as well as on Tar Creek.

To complete the Updated Study Plan (USP) submitted to FERC in April 2022 and incorporate FERC's requested modifications as provided in the May 2022 Study Modification Determination, GRDA has used a "three-legged-stool" methodology to evaluate sedimentation in the study area (Anchor QEA, LLC, et. al., 2022) (Federal Energy Regulatory Commission, 2022b). GRDA completed extensive fieldwork to collect data on the existing system to support three different analyses. They performed a Qualitative Analysis of the system, then a Quantitative Analysis, and finally developed a Sediment Transport Model (STM) using Hydrologic Engineering Center's River Analysis System (HEC-RAS). Findings from each leg supported the others and helped validate results. The culmination of the study allowed GRDA to evaluate impacts to upstream water levels and reservoir storage due to expected future sediment deposition.

3.3.1.7.2 Field Data

GRDA used a variety of field data to complete the Sedimentation Study, which included both existing datasets provided by USACE, USGS, OWRB, and other sources, as well as data collected by GRDA during the study. Major datasets are described in the sections below and include bathymetry and topography, inflow volumes and water levels, sediment loading, and sediment properties.

<u>Bathymetry and Topography</u>

Bathymetry and topography data were available from multiple dates for use in STM development. This allowed GRDA to create a starting terrain for use in the STM, then simulate sedimentation in the study area and compare to later terrain measurements for calibration and validation.

Bathymetric and topographic data are available from a range of sources. Grand Lake was surveyed by OWRB in 2009, then again by USGS in 2019 (Oklahoma Water Resources Board, 2009); (Hunter, S.L, et. al., 2020). Upstream surveys of the Neosho River, Spring River, and Elk River were performed as part of the 1998 *Grand Lake, Oklahoma Real Estate Adequacy Study* (REAS) (US Army Corps of Engineers, 1998). USGS surveyed those reaches again in 2017 (Smith S., et. al., 2017). Topographic information was available from surveys performed in support of the 1998 REAS and LiDAR flights conducted in 2011 (Dewberry, 2011). Other topographic information was obtained from the USGS National Elevation Dataset one-third, arc-second datasets where LiDAR information was unavailable. Circa-1940 topographic maps and cross-sectional survey information were digitized for analysis of conditions at the time of dam construction (US Army Corps of Engineers, 1938) (US Army Corps of Engineers, 1941) (US Army Corps of Engineers, 1942). Additionally, stage storage- curves were available from circa-1940 USACE as-built drawings, as well as the more recent Grand Lake bathymetry surveys.

Several of these datasets have significant uncertainties. This is especially true of the circa-1940 data and has been discussed at length in GRDA's USP (Anchor QEA, LLC, et. al., 2022) and USR (**Appendix E-7**). Models and study results can only be as good as the data upon which they rely. The circa-1940 data is based on low-resolution scans of topographic maps with 5-foot contour intervals and non-georeferenced cross-sectional survey data. Limited resolution of the topographic maps meant many contour labels were illegible. However, GRDA also recognizes these are the best available information with known collection dates and, therefore, chose to use them in this study. Because of the large uncertainties associated with the data, they included sensitivity analyses in their modeling efforts as discussed in Section 3.3.1.7.5.

<u>Inflow Volumes and Water Levels</u>

Daily stream discharge information is available from USGS gaging stations along the Neosho River, Spring River, and Elk River, as well as on Tar Creek (US Geological Survey, 2021a) (US Geological Survey, 2021b) (US Geological Survey, 2021c) (US Geological Survey, 2021d) (US Geological Survey, 2021e) (US Geological Survey, 2021f). There are also daily storage records at Pensacola Dam that were converted to water levels based on USGS stage-storage curves (US Geological Survey, 2022g). These records date back to approximately 1940. Continuous water surface elevation (WSE) data are also available at these locations beginning in 2007.

Data gaps existed within the period of record for USGS gaging stations within the Grand Lake watershed, and the gaging network lacked spatial density. As a result, the study team developed a field monitoring system to track WSE throughout the study area and fill data gaps. A set of 16 monitoring locations were selected, and pressure loggers were installed at each site in December 2016. Over the last 4.5 years, pressure and temperature were recorded at 30-minute intervals. The record provided a detailed dataset of water levels used for model development and calibration.

The relevant datasets were used for STM development in several ways. They provided the hydraulic calibration information for the model to ensure it was performing adequately. They also served as input hydrographs for historical calibration and validation efforts, as well as a basis for future simulations. For future simulations, they were randomized as proposed in GRDA's USP (Anchor QEA, LLC, et. al., 2022).

<u>Sediment Loading</u>

USGS gaging stations also provide sediment transport data in the form of suspended sediment concentration (SSC) measurements taken throughout the period of record at each gage (US Geological Survey, 2021a) (US Geological Survey, 2021b) (US Geological Survey, 2021c) (US Geological Survey, 2021d) (US Geological Survey, 2021e) (US Geological Survey, 2021f). These are sporadic measurements, rather than the continuous monitoring available for discharge and stage at the USGS gages.

GRDA collected SSC and bedload transport measurements on the Neosho River, Spring River, and Elk River, as well as Tar Creek. These sampling efforts targeted high-flow events to fill in data gaps present in USGS datasets. Each sample was collected according to USGS standards (US Geological Survey, 2006).

Samples indicated most of the sediment moving through the system was fine silts and clays. Bedload sampling showed no significant volume of coarse material moving through the system. These data were used to create sediment loading files in the STM.

<u>Sediment Properties</u>

Sediment properties in the study area were defined by additional fieldwork. GRDA collected grab and core samples on multiple occasions to parameterize sediment inputs. These included 62 grab samples, 14 core samples for SEDflume analysis, and 24 cores using a vibracore sampler.

All grab samples and 22 of the vibracore samples were evaluated for grain size. Findings showed significant portions of fine sediments in the silt and clay size range through much of the lacustrine areas and higher proportions of coarse sand and gravel material in the upper reaches.

The SEDflume core samples were used to evaluate critical shear stress of the cohesive sediments in the study area (Integral Consulting, 2020). The critical shear stress is the hydraulic shear stress (fluid drag), at which sediment begins moving downstream. For non-cohesive materials like sand and gravel, this can be approximated based on grain size and density. For cohesive materials, it is far more complex and a function of depth in the soil column, degree of compaction, and other variables.

SEDflume is used to measure critical shear stress for these sediments (McNeil, J.C. and Lick, W., 1996). It uses a specialized hydraulic flume to pump water across a sediment core and measures the erosion rate at different hydraulic shear stresses. Data can then be analyzed to determine critical shear stress and erosion rates of cohesive material.

Vibracore sampling was used as a part of subsurface investigations. Vibracoring involves using a vibratory machine to drive core tubes into the bed. Samples were used for two primary purposes: grain size analysis and sediment layer dating. Sediment dating relied on cesium-137 (Cs-137) activity evaluation at a specialized laboratory (Section 3.3.1.7.6).

This information was used to parameterize the sediment bed throughout the STM domain. The importance of cohesive material in the study area complicated STM development. HEC-RAS is an excellent tool for evaluating hydraulics and non-cohesive sediment transport but is more limited in its ability to simulate cohesive sediment transport. As a result, it was necessary to model only the upper portions of the system, rather than extending the model to Pensacola Dam, where cohesive materials reduce the reliability of predictive HEC-RAS models. Calibration required more comprehensive inputs to evaluate critical shear stress, erosion rates, and mobility parameters with the cohesive sediments.

This increased relevance of cohesive materials also introduced uncertainty to the model. Spatial variations in erosive parameters are present in all sedimentation studies, but cohesive material introduces significant temporal variability as well. As cohesive material accumulates, it compresses and consolidates, increasing density and critical shear stress over time.

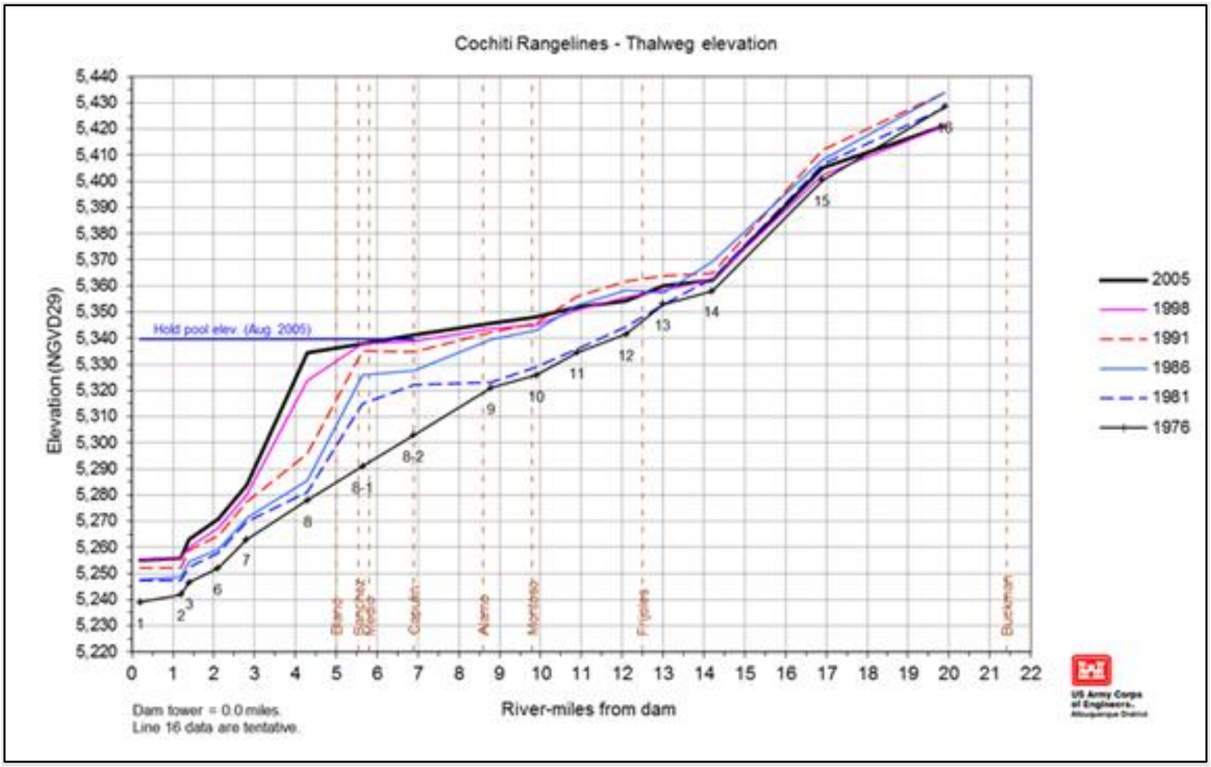
3.3.1.7.3 Qualitative Analysis

Qualitative analysis evaluated several features of the study area and included assessing the Project itself, as well as geomorphic features over time.

Pensacola Dam

Like any impounded fluvial system, there is some amount of deposition near the headwaters which is expected behavior and well-documented in the scientific literature (Fan, J. and G.L Morris, 1992) (US Army Corps of Engineers, 1995) (Huang, J, et. al,, 2006) (Vanoni, V.A., 2006). Typical evolution of such features shows under low flows, material is deposited on the top, then washed downstream during higher flows. The net result is that most material is transported to the downstream face of the delta feature; after an initial growth period, it does not increase appreciably in height. This is illustrated in the evolution of the Cochiti Reservoir delta on the Rio Grande (**Figure 3.3.1.7.3-1**) and is generally applicable to reservoir delta features. Recent surveys of the delta feature in Grand Lake indicate it is currently at its maximum expected height and is in dynamic equilibrium.

Figure 3.3.1.7.3-1 Typical Reservoir Delta Formation and Evolution - Progressive Bathymetric Surveys of the Cochiti Reservoir Delta, Rio Grande River, New Mexico



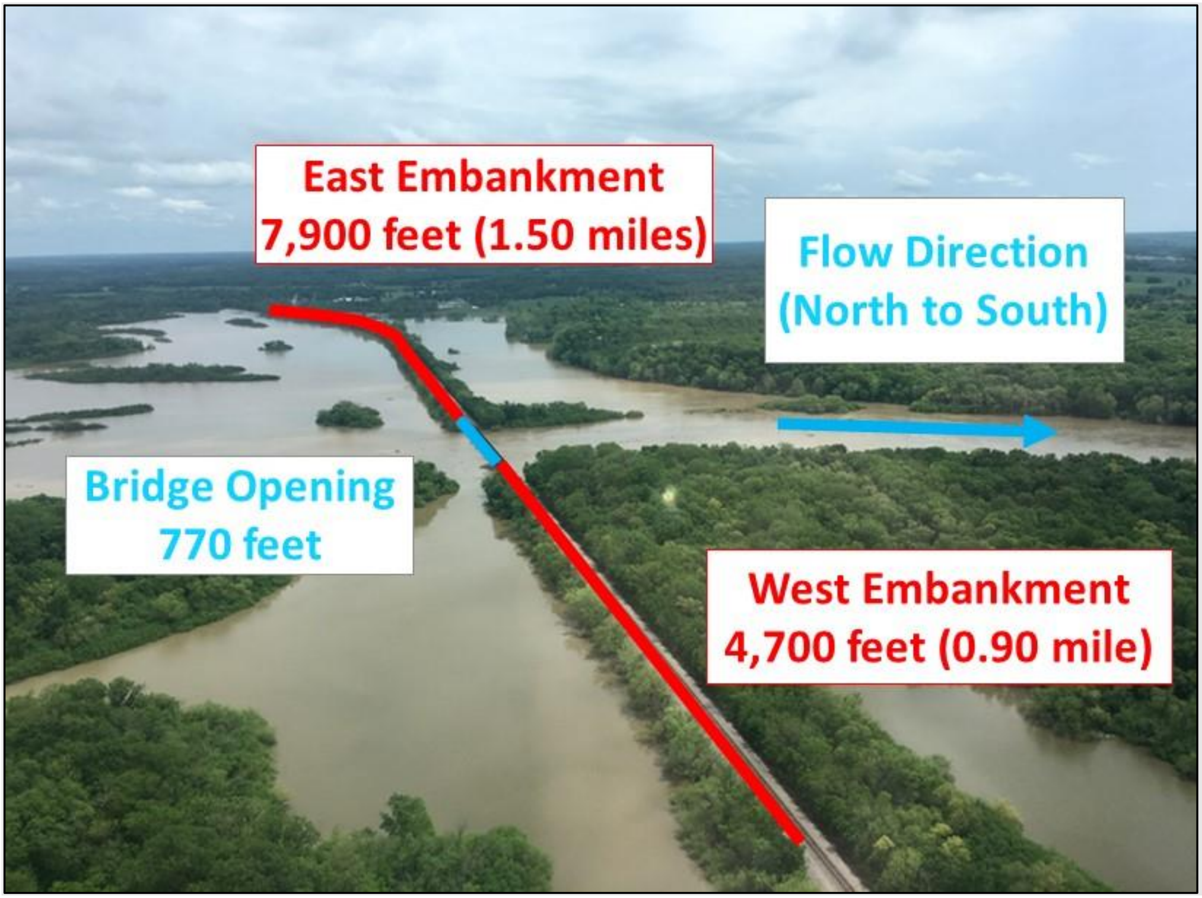
Source: (WEST, 2012)

Bathymetric data review indicates the head of the Grand Lake delta feature is located at approximately RM 122, which is more than 20 miles downstream of where the WSE of 745 feet PD at the top of the conservation pool intersects the river thalweg at approximately 0.5 mile downstream of USGS Commerce gage at East 60th Road Bridge. Data also suggested complex cohesive sedimentation processes significantly impact deposition in the reservoir. Processes include density currents, fluid mud flows, and changes in time of density, critical shear stress, and erosion rates.

<u>Bridges</u>

Bridges in the system also impact the volume and location of sediment deposition, particularly where debris is caught on support piles. Support piles create hydraulic constrictions and backwater effects that increase the likelihood of sediment deposition. The Burlington Northern Railroad Bridge and associated embankment is an extreme example on the Grand River. This bridge features approximately 12,600 feet of embankment, which forces flow through an opening just 770 feet wide (**Figure 3.3.1.7.3-2**).

Figure 3.3.1.7.3-2 Burlington Northern Railroad Bridge and Embankment at Twin Bridges Looking East



<u>Geologic Features</u>

Vertical rock embankments and other features confine the stream at various locations in the Neosho River. These cliffs eliminate the floodplain and confine flow to a relatively narrow cross section, potentially creating upstream backwater and increasing deposition.

A now-submerged bioherm (ridge) composed of erosion-resistant limestone and chert was also discovered by McKnight and Fischer (1970) at RM 108. This and other similar features are likely part of the Ozark Uplift, specifically the Springfield Plateau. Their erosion resistance resulted in a change in bank line grade as documented in the 1938 USACE topographic maps beginning at RM 108 and extending upstream to approximately RM 115. These stable points affect sediment transport patterns and increase the likelihood of deposition at the location of the delta feature.

<u>Riverine Features</u>

The rivers themselves also impact sediment transport. The confluences of the Neosho River with the Spring River and Elk River provide opportunities for development of tributary bars. These form when a steeper tributary flows into a stream with a shallower slope. The higher slopes of the Spring River and Elk River allow them to carry more and coarser sediment than the Neosho River. When the two rivers flow into the Neosho River, that decreased sediment carrying capacity results in deposition and the formation of tributary bars. The Spring River is approximately 7% steeper than the Neosho River, and the Elk River is approximately 56% steeper.

Further upstream, there are flood-protection levees that disconnect the river from the floodplain. Water is confined to the narrowed channels, raising water levels. During large flood events, this can increase risk to communities not protected by levees.

3.3.1.7.4 Quantitative Analysis

The Quantitative Analysis was the second leg of the stool and was completed to help support the other parts of GRDA's three-legged-stool approach. It relied on a basis of the Qualitative Analysis and helped validate the results of the STM (Section 3.3.1.7.3).

This analysis was developed in part because HEC-RAS was not purpose-built to accurately model cohesive sediment transport in lacustrine systems. It is an effective tool for non-cohesive material in streams, but the nature of Grand Lake and the type of sediment moving through the system meant an alternative approach was recommended.

The Quantitative Analysis used sediment data, bathymetric information, and the hydraulically calibrated STM to estimate deposition patterns in the study area. Historical bathymetry and sediment data allowed quantification of deposition, as well as evaluation of sediment critical shear stress. The STM hydraulic bed shear results allowed estimates of future deposition.

Sediment inflow rates were developed using the HEC-RAS "Sediment Rating Curve Analysis Tool" (US Army Corps of Engineers, 2022), which uses USGS and user-entered SSC data to create rating curves for modeling. It also removes mathematical bias from log transformation of the SSC data and allows evaluation of changes to sediment loading over time.

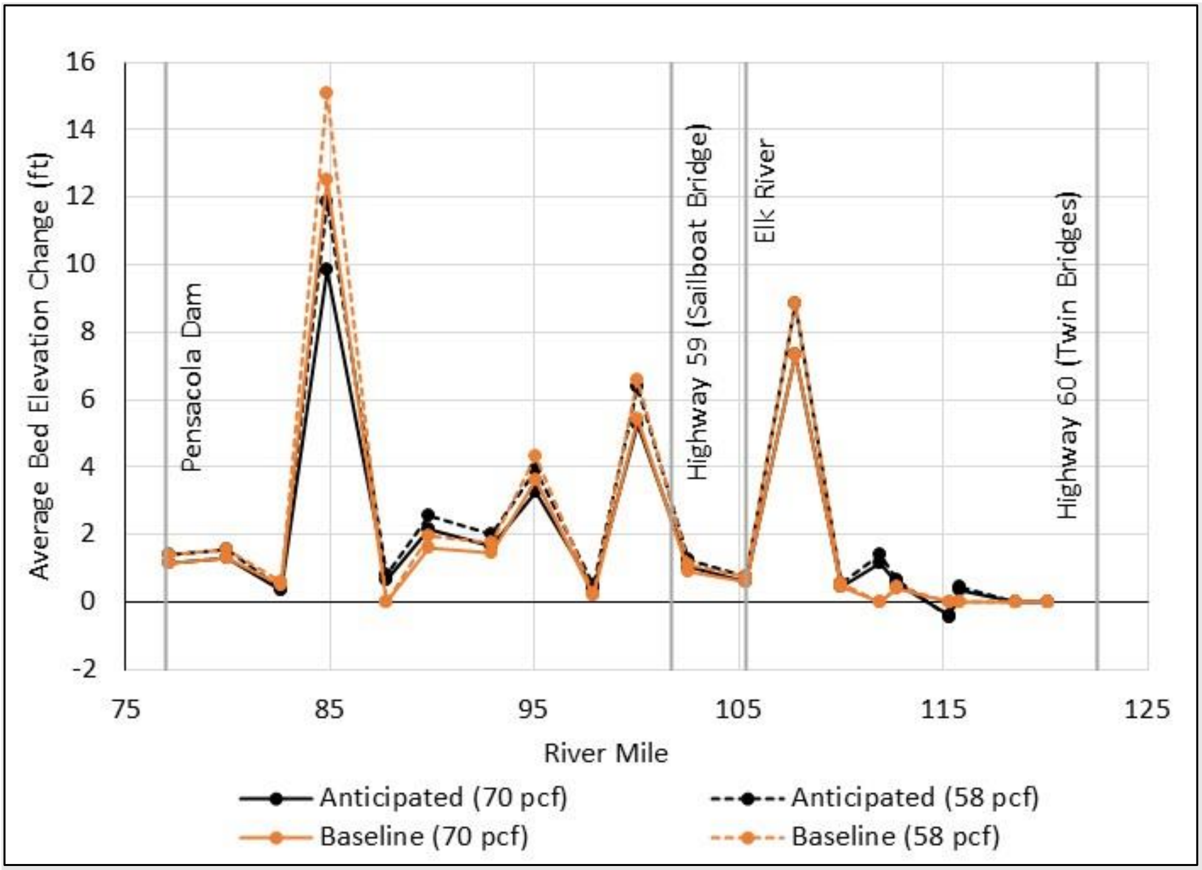
Sediment density was estimated using both core sampling (Integral Consulting, 2020) and grain size distribution information (Lane, E.W. and V.A Koelzer, 1943). The analyses resulted in values of 58 pounds per cubic foot and 70 pounds per cubic foot, respectively.

The bathymetry was then evaluated to determine the percentage of sediment passing each analyzed location through a given river location. That percentage was related to hydraulic shear stresses at those locations, which showed a significant trend.

Future scenarios were then evaluated with a randomized 50-year hydrograph based on past hydrology. The predicted STM bed shear stresses at the various river locations were used to estimate the amount of deposition based on the shear stress versus percentage passing relationship found previously. This allowed for prediction of the volume of deposition and increase in channel elevation.

The results showed greater than 95% of the sediment was transported downstream of RM 115, which is the crest of the delta feature. Changes to average bed elevations predicted by this method are shown in **Figure 3.3.1.7.4-1**.

Figure 3.3.1.7.4-1 Average Bed Elevation Change 2020-2069 from Quantitative Analysis



This analysis also included an evaluation of sediment loading throughout the period of record. Findings indicated most of the sediment enters the system during flooding events. Flooding events generally occur in just 20% of the record, yet approximately 76% of the total sediment moving into the study area entered during this time. Sediment loading is not under GRDA's control, and the bulk of it enters the system during flood events when GRDA does not have operational control of the Project.

3.3.1.7.5 Sediment Transport Model

The STM and computer modeling was the final component of the three-legged-stool approach. The STM results were validated by the Qualitative Analysis and Quantitative Analysis discussed in Section 3.3.1.7.3 and Section 3.3.1.7.4, respectively.

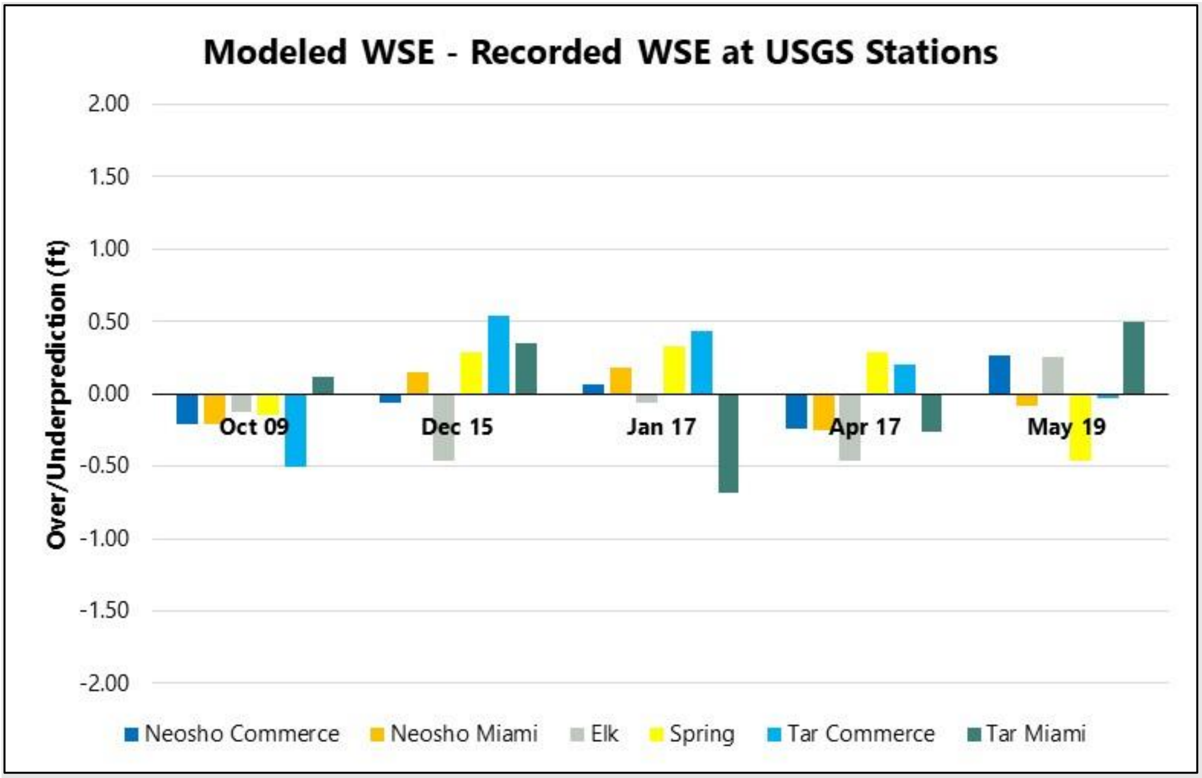
Development

The STM was developed as a quasi-unsteady one-dimension (1D) model in HEC-RAS. GRDA created the circa-1940 geometry as a starting point for calibration and validation efforts, then used the most recent surveys (USGS 2017 tributaries and 2019 Grand Lake) to create a modern terrain (hereafter referred to as the "2019 terrain") as a starting point for future scenarios.

Hydraulic calibration of the circa-1940 data relied on land-use information because water level data was not available from USGS gaging stations.

Hydraulic calibration of the 2019 terrain used a combination of USGS gage station data, high water marks, and GRDA water level monitoring data. Six events were modeled, and flow roughness factors were adjusted to improve hydraulic calibration. The final model calibration showed good agreement with field measurements. A comparison of USGS WSE records (US Geological Survey, 2021a) (US Geological Survey, 2021b) (US Geological Survey, 2021c) (US Geological Survey, 2021d) (US Geological Survey, 2021e) (US Geological Survey, 2021f) (US Geological Survey, 2021f) and model results are shown in **Figure 3.3.1.7.5-1**.

Figure 3.3.1.7.5-1 Overprediction and Underprediction of Simulated WSE at USGS Gages



It should be emphasized that several of the datasets used in developing the model come with significant uncertainty. Specifically, the circa-1940 data are based on low-resolution scans of the original contour maps and un-georeferenced cross-sectional survey information. There are also questions about the 2009 OWRB survey of Grand Lake as discussed in Section 2.1.1 of the Sedimentation Study Report (**Appendix E-8**). The calibration is only as good as the accuracy of those datasets; while they are imperfect, they are also the best available data.

Sediment calibration used the circa-1940 terrain as the starting point and ran simulations from October 1942 at the beginning of continuous daily records for the Project water levels until 2019. Sediment properties and loading rates were determined through the analyses described above. Deposition calibration volumes were derived from changes between measured circa-1940 cross sections and more modern geometry. Validation volumes were collected using the same method.

The model predicted sediment deposition throughout the study area, and results were compared to measured changes. Statistical analyses including the Nash-Sutcliffe Efficiency (NSE), Percent Bias

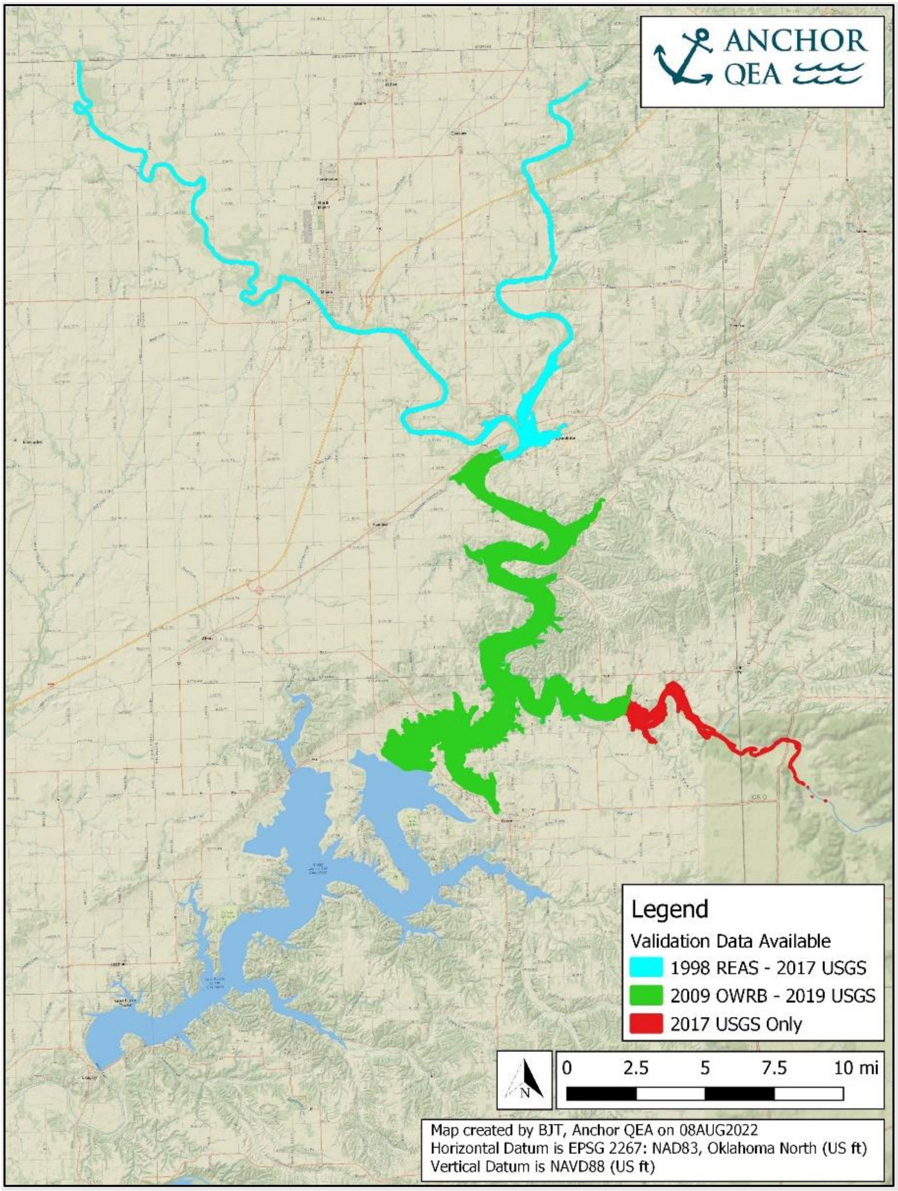
(PBIAS), and RMSE-Observations Standard Deviation Ratio (RSR) were used following the methodology of (Moriasi, D.N, et. al., 2007) to evaluate model predictions. The model was calibrated and validated according to **Table 3.3.1.7.5-1** and **Figure 3.3.1.7.5-2**.

Table 3.3.1.7.5-1 Model Reaches and Available Survey Data for STM Development

Reach	Starting Survey	Calibration Survey	Validation Survey
Upper (above RM 120.1)	Circa-1940 USACE	Circa-1998 REAS	2017 USGS
Lower (RM 120.1–RM 100)	Circa-1940 USACE	2009 OWRB	2019 USGS
Elk River (above RM 5.47)	Circa-1940 USACE	2017 USGS	N/A
Reservoir (below RM 100)	Circa-1940 USACE	2009 OWRB*	2019 USGS

*2009 OWRB data were not used for long-term analysis downstream of RM 100 (Section 2.1.1.5.1 of Sedimentation Study USR in **Appendix E-7**). Sedimentation rates from 1940 to 2009 were implausibly different than those from 2009 to 2019, so an assessment of deposition from 1940 to 2019 was used instead.

Figure 3.3.1.7.5-2 Modeled Reaches Used for Calibration and Validation by Available Survey Data (All Starting Geometry was Based on Circa-1940 Data)



Model results on the Neosho River were generally reasonable. The model overpredicted deposition on the downstream face of the delta feature, below RM 105, where the system becomes lacustrine and cohesive material plays a major role in deposition. Uncertainty in the RM 130.01 topographic data led to significant uncertainty in the measured deposition at that location (**Figure 3.3.1.7.5-3**). Excluding those cross sections, the model performed adequately on the Neosho River (**Table 3.3.1.7.5-2**).

Figure 3.3.1.7.5-3 Neosho River Volume Change from Circa 1940

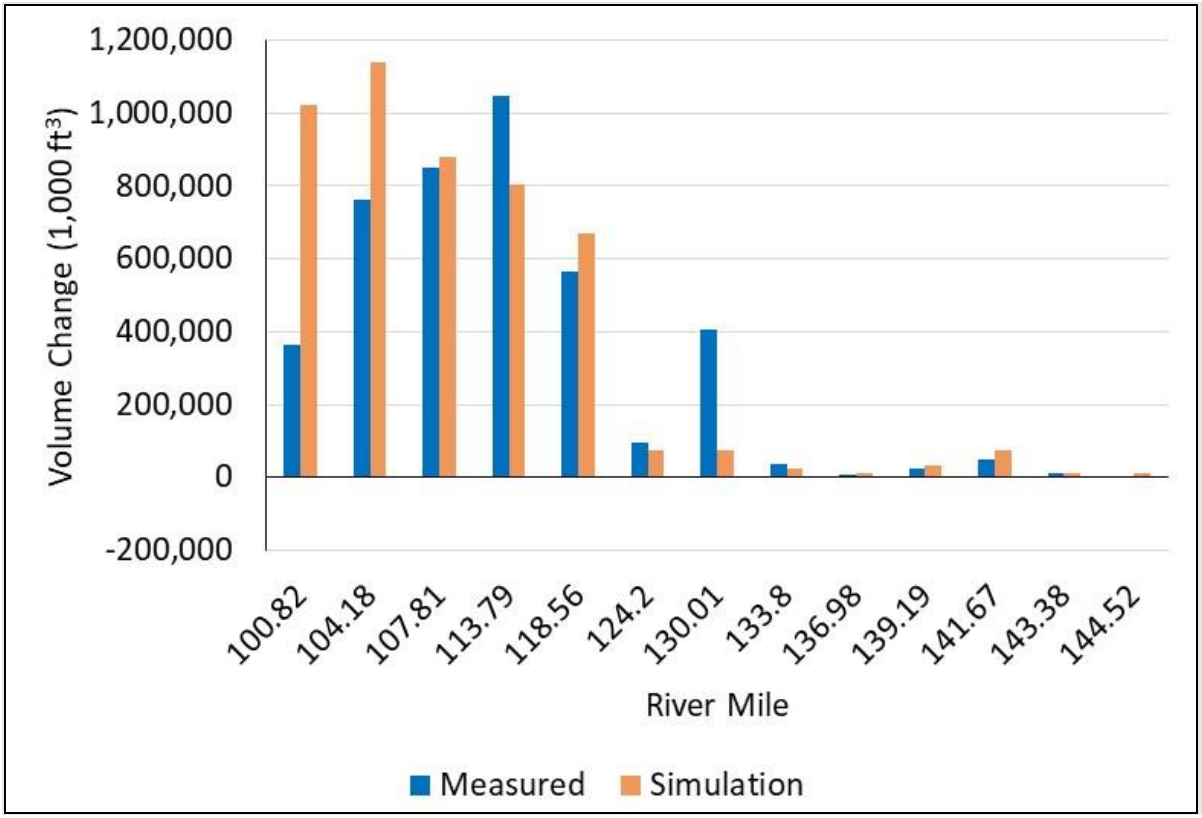


Table 3.3.1.7.5-2 Statistical Calibration Evaluation Parameters of STM on the Neosho River

Reach	NSE (Target: > 0.5)	PBIAS (|Target|: < 0.55)	RSR (Target: < 0.70)
All Locations	-0.94	0.19	0.69
Excluding RM 130.01, 104.18, 100.82	0.95	0.01	0.22

The model did not perform as well on the Spring River and Elk River. This is largely due to the difficulty georeferencing the circa-1940 surveyed cross sections on these streams. The information available for the Neosho River included measurements on and near bridges, making it easy to locate those sections; the Spring River and Elk River cross sections did not offer such reference points and as a result are less reliable.

Validation results for each river were comparable to the calibration data. More detailed information regarding calibration and validation of the STM is available in Section 6.2.2 of the Sedimentation Study Report (**Appendix E-8**).

Calibration was also evaluated using the average channel and average section profiles of the datasets. These are similar to thalweg profiles but use the entire dataset for analysis, rather than a single point, and, therefore, offer a more complete picture of model performance. The Neosho River results showed a mean error of -1.2 feet in the channel (**Figure 3.3.1.7.5-4**) and -1.8 feet in the average section (**Figure 3.3.1.7.5-5**). Given the original 5-foot contour maps the starting data was based on, this is a good result.

Figure 3.3.1.7.5-4 Neosho River Comparison of Measured and Modeled Average Channel Profiles

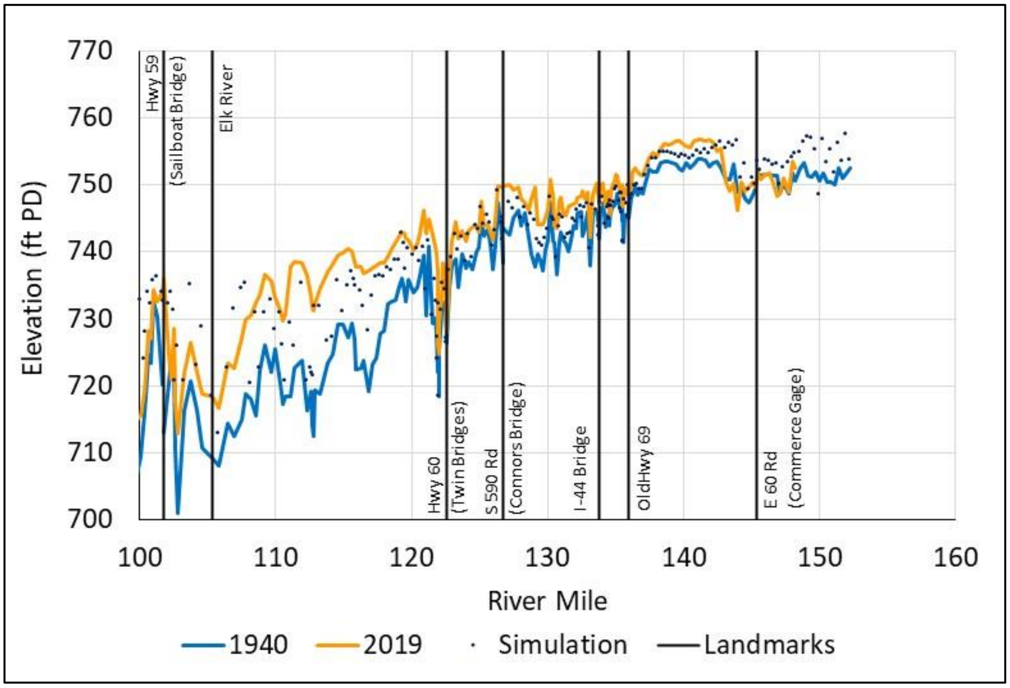
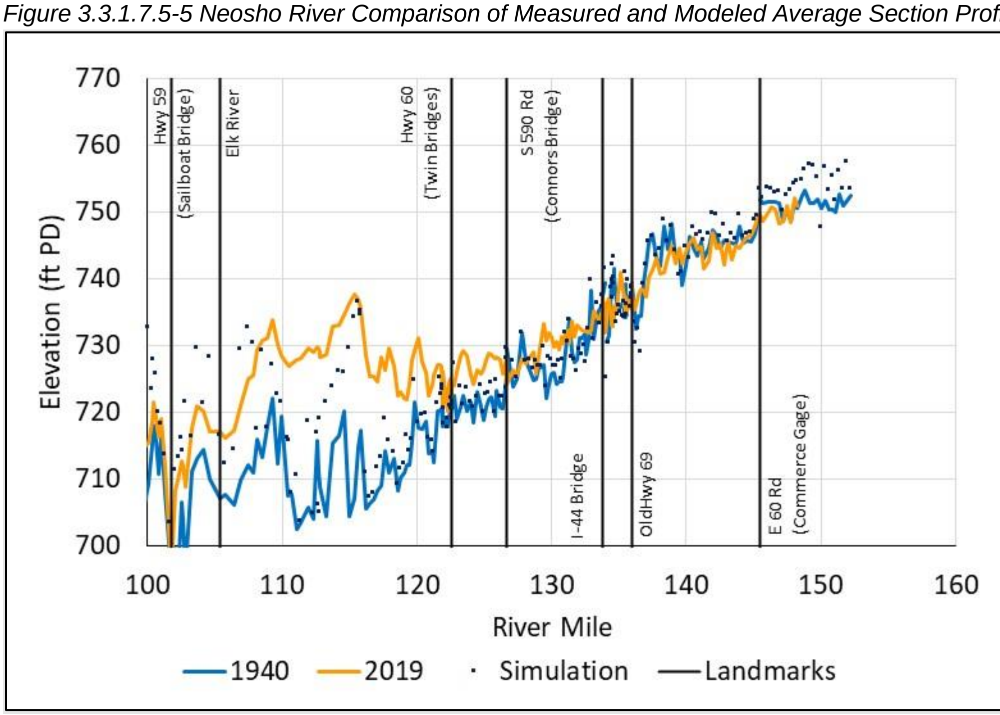


Figure 3.3.1.7.5-5 Neosho River Comparison of Measured and Modeled Average Section Profiles

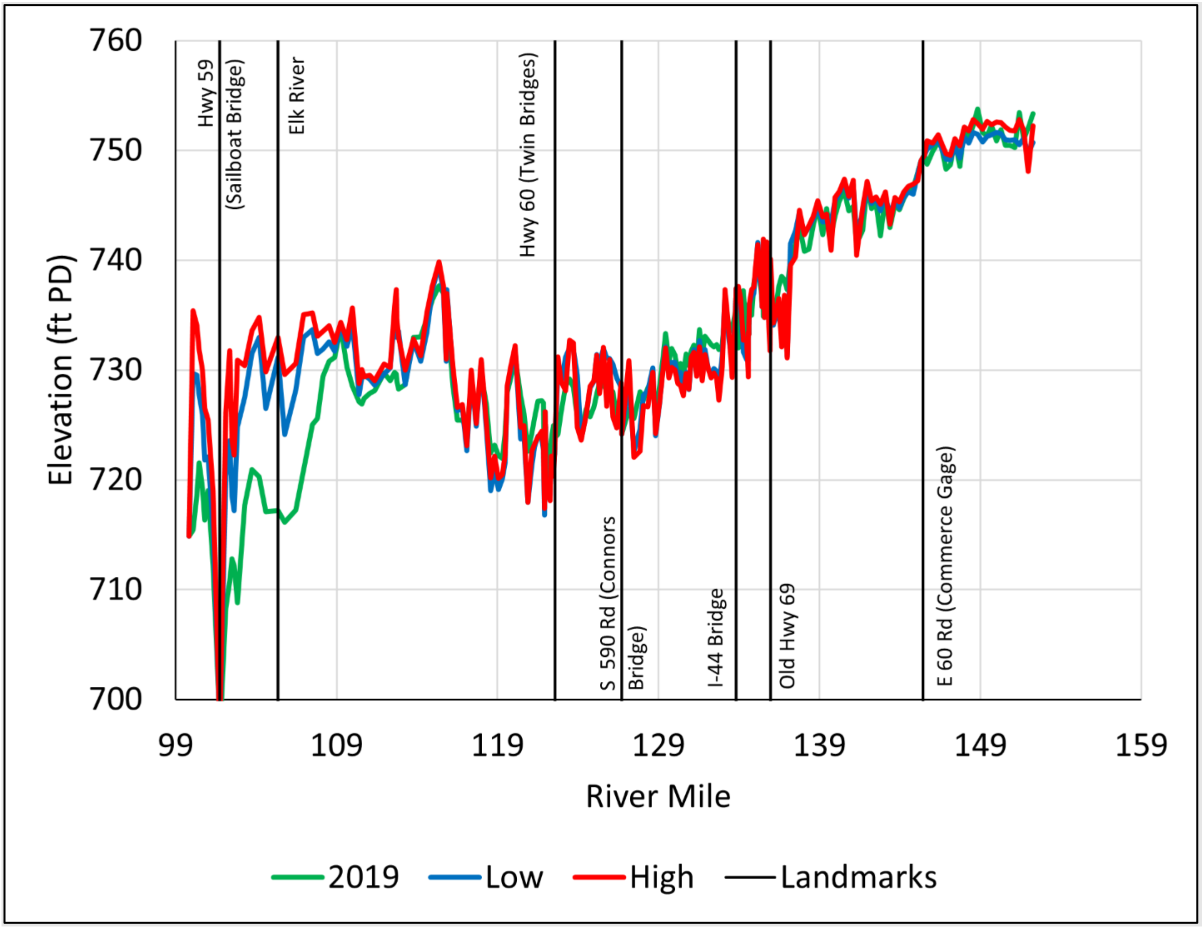


Future Predictions

The STM was then used to evaluate future sediment deposition in the study area. This included a sensitivity analysis for sediment loading, as well as analysis of the impact of Project operations.

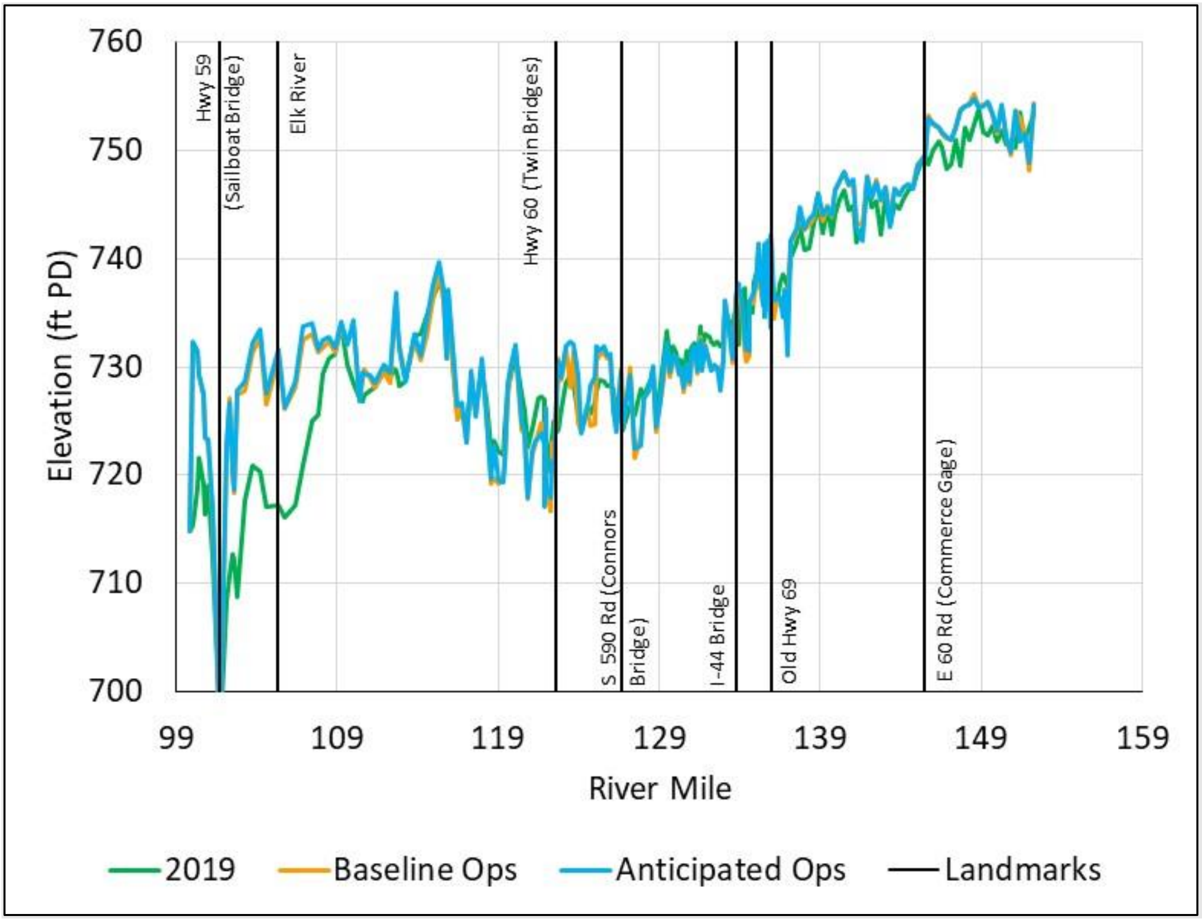
Initial comparisons were between predicted bed geometries from the simulations. **Figure 3.3.1.7.5-6** shows the difference in average channel profiles between the current geometry (2019), High Sedimentation, and Low Sedimentation modeling. Most deposition occurs downstream of RM 109, meaning there is little growth to the vertical height of the delta feature.

Figure 3.3.1.7.5-6 Neosho River Average Channel Showing Predicted Effects of Sediment Loading



The comparison between Project operations scenarios (**Figure 3.3.1.7.5-7**) showed similar results. The differences between average channels are more sensitive to sediment loading than to Project operations. The mean difference between *High Sedimentation* and *Low Sedimentation* is 0.47 foot, while the mean difference between *Baseline Operations* and *Anticipated Operations* is 0.24 feet below RM 115.35 (crest of delta feature). Sediment loading scenarios differ by 2.09 feet, and Project operations differ by only 0.45 feet, indicating sediment loading, which is not controlled by GRDA, has approximately 3.76 times the impact of Project operations.

Figure 3.3.1.7.5-7 Neosho River Average Channel Showing Predicted Effects of Operations



Future scenarios were based on a randomization of the inflow hydrology and coordination with the OM to predict future water levels at Pensacola Dam. Because analysis of the historical record did not indicate significant trends in discharge, the record was simply randomized with no adjustment. The basic process was as follows:

- The initial stage-storage curve was extracted from the 2019 HEC-RAS terrain.
- This initial curve with the synthetic hydrographs was run in the OM to determine the downstream WSE hydrograph. STM was then run with the downstream WSE boundary computed by the OM.
- Upon completion of the HEC-RAS sediment simulation, the resulting geometry was processed and stage-storage upstream of RM 100 was extracted from the model. This method does not provide information about the impacts on storage downstream of the model domain. Adjustments to account for the loss of storage below RM 100 are provided below.
- The OM was re-run with a dynamic stage-storage curve based on a temporal linear interpolation between the starting 2019 curve and the curve output from Step 3.
- The STM was then re-run with the downstream WSE boundary computed by the second storage-interpolated iteration of the OM. The stage-storage output from this second STM run was compared to the initial output to determine if storage values changed significantly, which would indicate the need for another iteration.

To estimate stage-storage impacts on the downstream portion of the study area, the measured historical vertical accumulation rate at the dam was projected forward in time to estimate the minimum storage elevation at the dam. **Table 3.3.1.7.5-3** provides the estimated minimum storage elevation at the dam and total change in storage estimated from measured stage-storage curves (US Army Corps of Engineers, 1941) (Smith S., et. al., 2017) for the various future conditions.

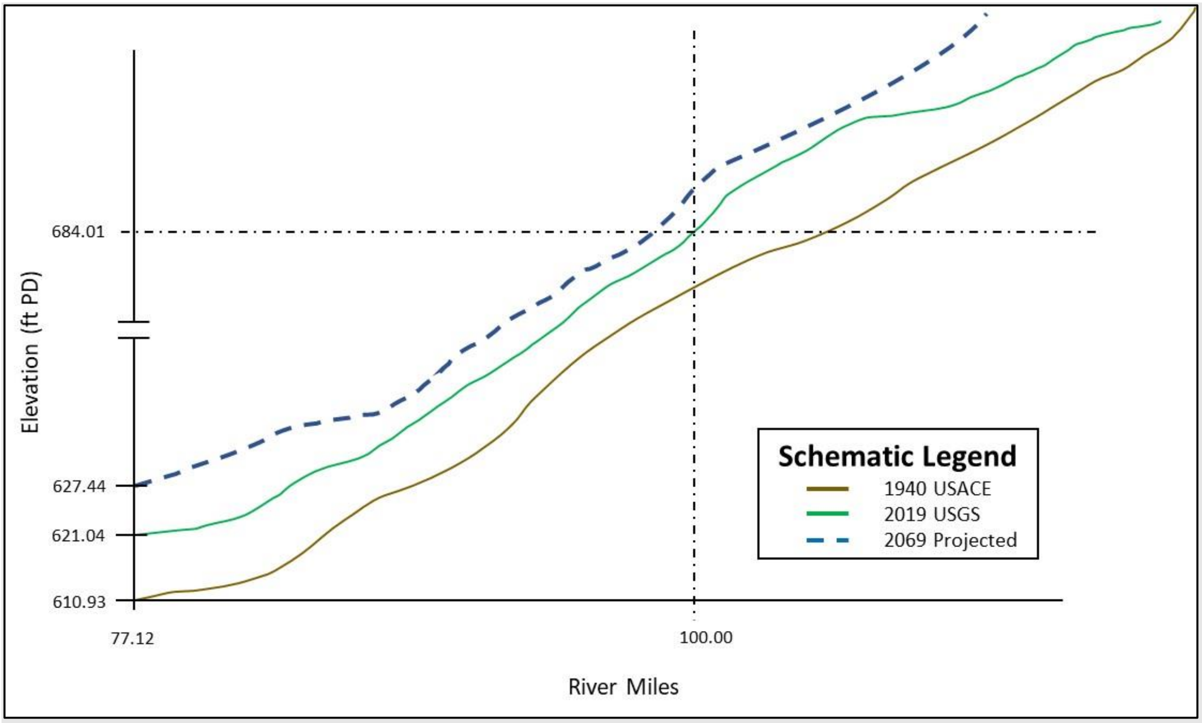
Table 3.3.1.7.5-3 Historical Stage-Storage Information Used to Develop Future Stage-Storage Curves Downstream of RM 100

Stage-Storage Curve	Lowest Storage Elevation (feet PD)	Total Change in Storage (acre-feet)
1940 USACE	610.93	--
2019 USGS	621.04	319,473
2069 (Baseline Operations)	627.44	224,332
2069 (Anticipated Operations)	627.44	224,332
2069 (High Sedimentation)	627.44	269,258
2069 (Low Sedimentation)	627.44	179,505

Based on the change in storage between 1940 and 2019, the long-term sediment deposition at the base of Pensacola Dam is approximately 0.13 foot per year. Projecting that rate into the future provides an estimated low point of approximately 627.44 feet. Because dam operations depend on storage changes, but not the specific location of sediment deposition near the dam, the low point is relatively unimportant to overall storage volume change and was therefore held constant for all predictive simulations.

To determine approximate storage volume change downstream of RM 100, the thalweg elevation at RM 100 was used as a reference point (**Figure 3.3.1.7.5-8**). This elevation was 684.01 feet PD at the time of the 2019 USGS survey.

Figure 3.3.1.7.5-8 Schematic Representation of Neosho River Thalweg for Illustration Purposes



All material deposited below elevation 684.01 feet PD was therefore necessarily deposited downstream of RM 100. Material deposited upstream of RM 100 is modeled directly in the STM simulations. The remaining volume was accounted for using trap efficiencies and relative sediment loading.

The volume of sediment entering, depositing in, and leaving the model domain in each simulation is summarized in **Table 3.3.1.7.5-4**.

Table 3.3.1.7.5-4 Modeled Sediment Loading

Simulation	Modeled Incoming Load (acre-feet)	Modeled Outgoing Load (acre-feet)	Deposited in Modeled Reach (acre-feet)	Deposited Below RM 100 (acre-feet)	Total Storage Volume Change (acre-feet)
1942–2019	402,733	236,242	166,491	152,982	319,473 (measured)
2020–2069 (Baseline Operations)	280,481	173,978	106,503	117,882	224,385
2020–2069 (Anticipated Operations)	280,481	166,282	114,200	110,185	224,385
2020–2069 (High Sediment)	336,573	202,377	134,196	135,062	269,258
2020–2069 (Low Sediment)	224,382	127,682	96,700	82,806	179,506

Note: Values are approximated by converting to volume using a sediment density of 58 pounds per cubic foot.

Total change in storage within the reservoir between 1940 and 2019 can be evaluated based on published stage-storage curves from USACE and USGS. For this period, the total sediment inflow as modeled was approximately 402,733 acre-feet, and total measured storage volume change was approximately 319,473 acre-feet. This corresponds to a trap efficiency of approximately 0.8.

Trap efficiency of the entire system is not expected to change drastically from one simulation to the next, so the same study-area-wide trap efficiency of 0.8 was used for all analyses. It should be noted this may differ from trap efficiencies calculated by other methods; it relies on measured data and model results to ensure consistency through the analysis. It is not the trap efficiency for the unmodeled area alone; it includes deposition and erosion upstream of RM 100.

For the Baseline Operations and Anticipated Operations simulations, the total inflow volume of sediment was identical and the expected trapping efficiency is the same. Therefore, the total expected change in storage volume is also expected to match (**Table 3.3.1.6.5-4**).

Relative sediment loading rates were used to calculate the storage volume change in the lower left quadrant of the schematic in Figure 3.3.1.7.5-9. The volume lost in that quadrant between 1940 and 2019 was measured to be 69,926 acre-feet. Storage volume change was assumed to scale with inflow volumes and adjusted accordingly (**Table 3.3.1.7.5-5**).

Table 3.3.1.7.5-5 Sediment Loading Compared to Storage Volume Change Below Elevation 684.01 feet PD and Storage Total Volume Change Downstream of RM 100

Simulation	Modeled Incoming Load (acre-feet)	Total Storage Change Below 684.01 feet PD (acre-feet)	Total Storage Change Downstream of RM 100 (acre-feet)
1942–2019	402,733	69,926 (measured)	--
2020–2069 (Baseline Operations)	280,481	48,668	132,450
2020–2069 (Anticipated Operations)	280,481	48,668	123,926
2020–2069 (High Sediment)	336,573	58,038	141,973
2020–2069 (Low Sediment)	224,382	38,949	87,389

Note: *Loss downstream of RM 100 includes both the upper and lower quadrants of Figure 3.3.1.7.5-8 and cannot be precisely determined through available rating curves.

This storage volume change was applied to elevations below 684.01 feet PD at a rate proportional to the additional storage volume increment at each elevation step.

Accounting for additional storage changes in the upper left quadrant of **Figure 3.3.1.7.5-8** used a similar approach. The difference between modeled deposition calculated by the method above was assumed to have been in the upper left quadrant. It was assumed to also apply at a rate proportional to the incremental change in storage volume at each elevation step.

The change in total storage below 684.01 feet PD was assumed to be identical under *Baseline Operations* and *Anticipated Operations* scenarios. There is no information to determine the exact location of deposition downstream of RM 99.82, but the expected total change in volume is identical between the scenarios as discussed above. No changes were made to storage change below 684.01 feet PD, but the expected storage change was accounted for when calculating deposition in the upper left quadrant of **Figure 3.3.1.7.5-8**.

This resulted in the stage-storage curves for projected future bathymetry discussed below.

The STM was used to evaluate deposition for several scenarios. The first was a comparison between operation effects, analyzing the differences between *Baseline Operations* and *Anticipated Operations*. The next was done to help account for uncertainty associated with terrain and sediment loading datasets and was a comparison of *High Sedimentation* and *Low Sedimentation* rates.

High Sedimentation and *Low Sedimentation* simulations used the results of the rating curves from model calibration. However, analysis of sediment loading over time indicates future loading is expected to be **lower** than in the past. Construction of John Redmond Dam upstream of Grand Lake, changes in land use, and improved agricultural practices have all decreased sediment loading over time.

The *High Sedimentation* and *Low Sedimentation* scenarios increased and decreased sediment loading by 20% from baseline, respectively. These relatively conservative values (i.e., they introduce **more** sediment than would be expected for future loading ±20%) should result in higher deposition than would be predicted by current trends in sediment loading.

The results produced the following important findings:

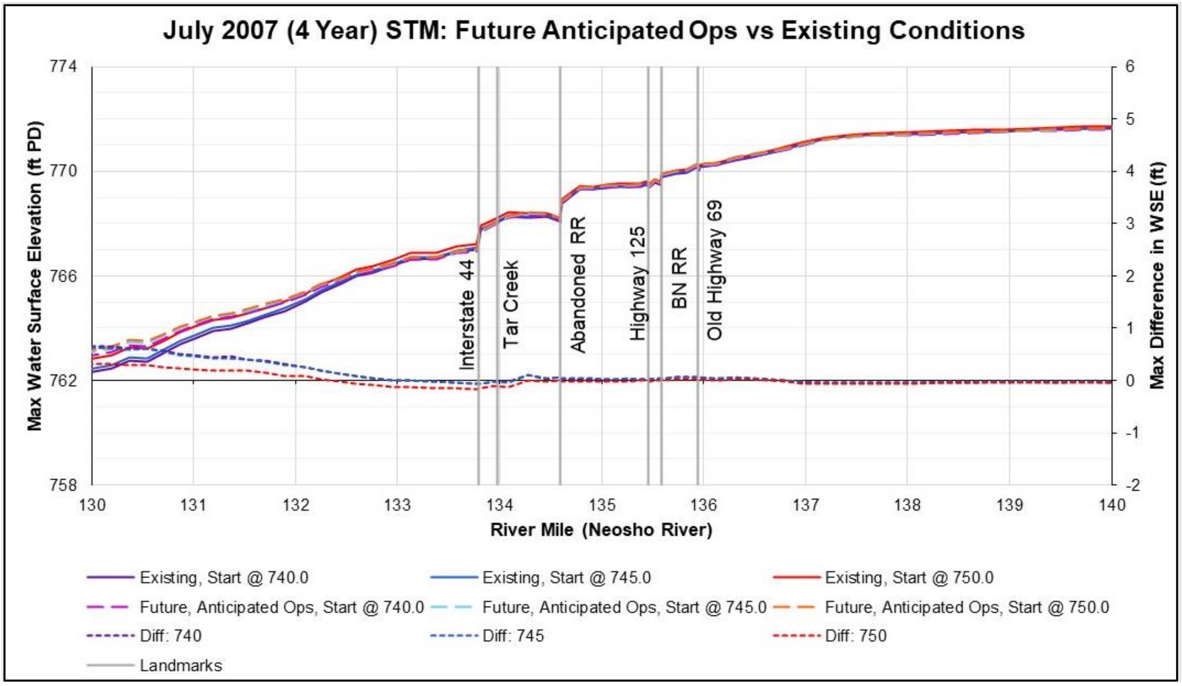
- Sediment tends to deposit primarily on the downstream face of the delta feature, which matches expected patterns found in literature (Vanoni, V.A., 2006) and in the Quantitative Analysis in Section 3.3.1.7.4.
- Differences in sediment deposition due to changes in Project operations are generally smaller than differences in deposition due to changes in sediment loading rates.

1D Upstream Hydraulic Model Evaluations

After simulations of future sediment loading, the final STM geometry was imported to a 1D Upstream Hydraulic Model (1D UHM) for hydraulic analysis. This model is distinct from both the STM and the Upstream Hydraulic Model (UHM) that was developed for the hydrologic and hydraulic study. The 1D UHM was used to simulate the fully unsteady July 2007 (4-year) and synthetic 100-year flow events with starting pool elevations of 740, 745, and 750 feet PD for a total of six simulations. The results allow comparison of different sedimentation parameters on upstream water levels.

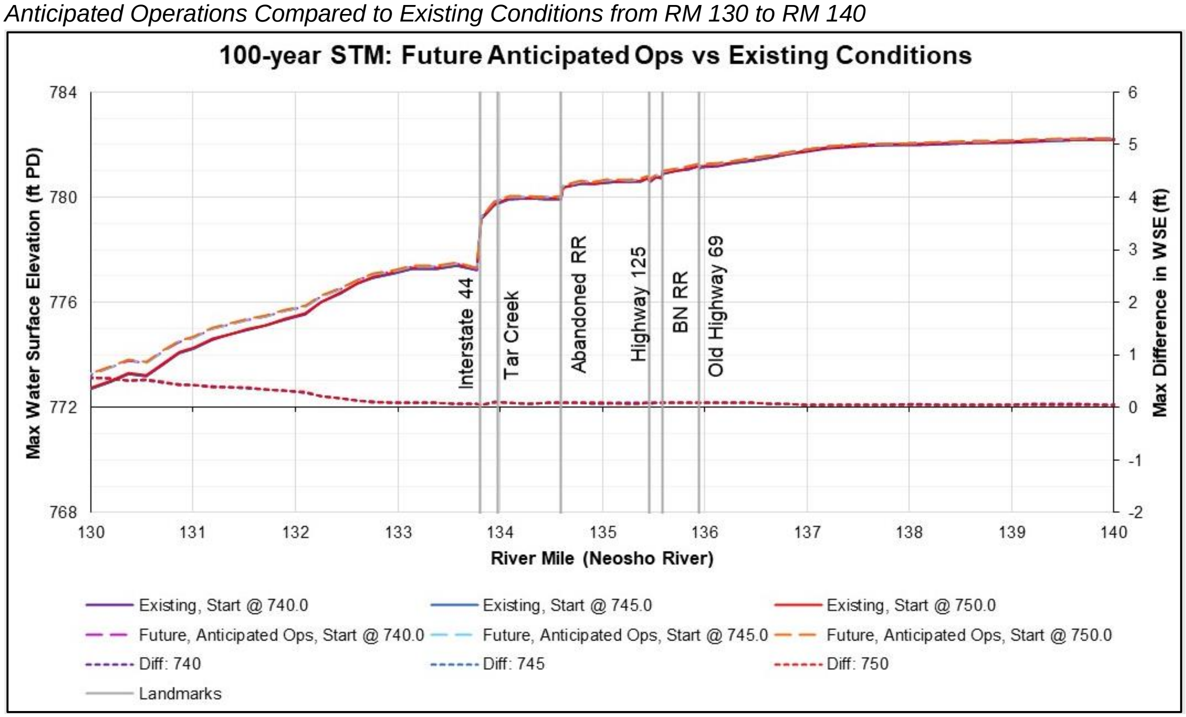
Comparisons were made between the current 2019 geometry and projected 2069 geometry under Anticipated Operations. For the July 2007 event, the largest increase in WSE near Miami between RM 133 and RM 137 occurs with a starting pool elevation of 740 or 745 feet PD. The maximum increase (i.e., projected 2069 geometry results are higher than the current 2019 results) is upstream of the Tar Creek confluence and is 0.11 foot (**Figure 3.3.1.7.5-9**).

Figure 3.3.1.7.5-9 Changes in July 2007 Event WSE Due to 50 Years of Expected Sedimentation under Anticipated Operations Compared to Existing Conditions from RM 130 to RM 140



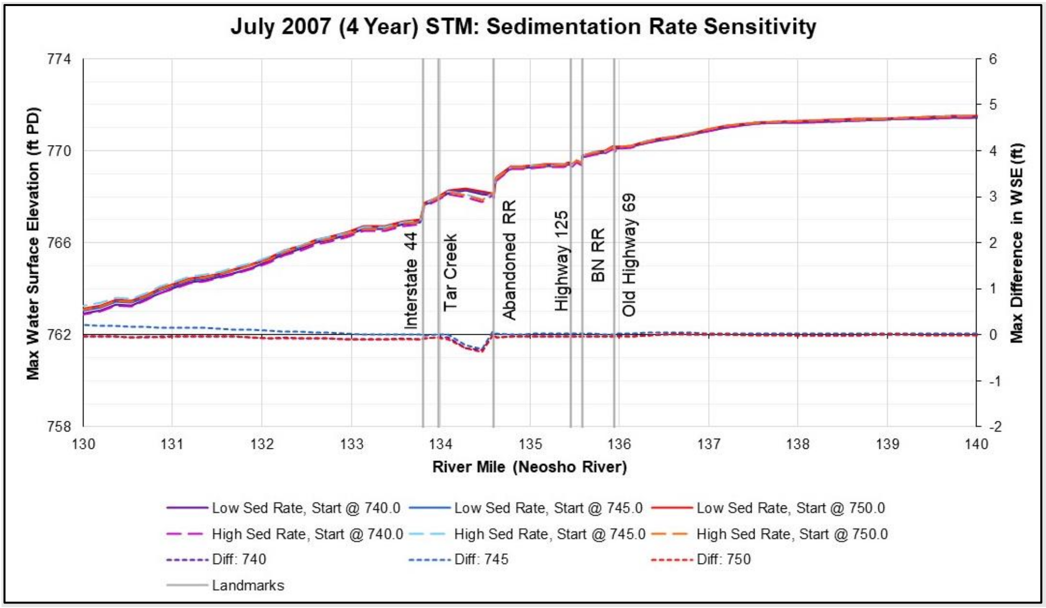
For the 100-year event, the largest increase in WSE near Miami occurs with a starting pool elevation of 740 or 745 feet PD. This maximum increase is located upstream of the Tar Creek confluence and is also 0.11 foot (**Figure 3.3.1.7.5-10**). This change is immaterial to urbanized areas despite 50 years of sedimentation.

Figure 3.3.1.7.5-10 Changes in 100-Year Event WSE Due to 50 Years of Expected Sedimentation under Anticipated Operations Compared to Existing Conditions from RM 130 to RM 140



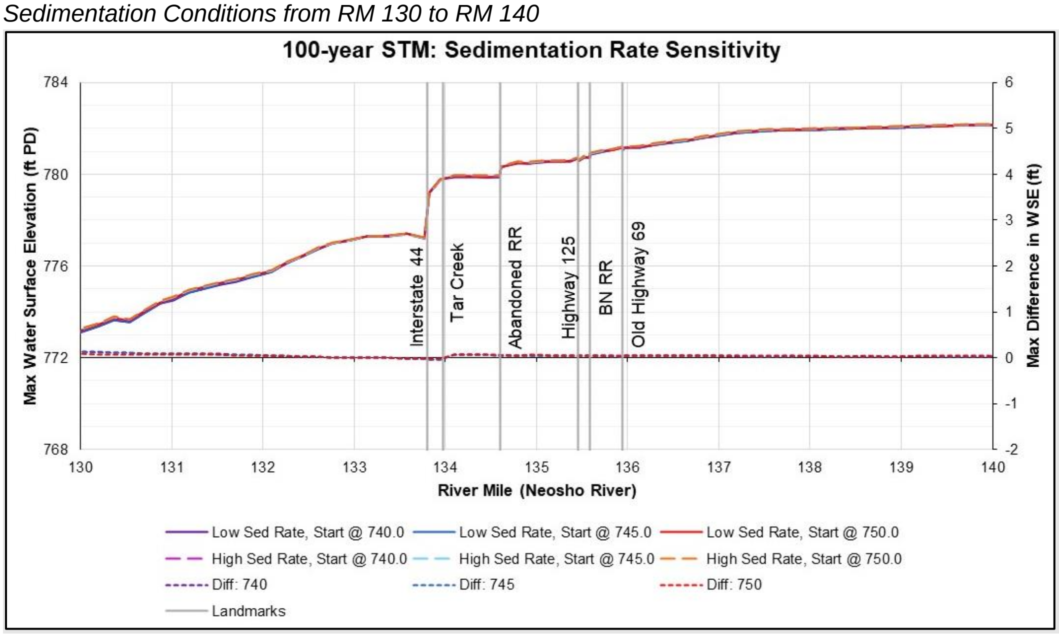
Comparisons between sediment loading scenarios showed similar results. For the July 2007 event, the largest increase in WSE near Miami occurs with a starting pool elevation of 745 feet PD. The maximum increase (i.e., the *High Sedimentation* results are higher than the *Low Sedimentation* results) is near the abandoned railroad bridge and is 0.06 foot (**Figure 3.3.1.7.5-11**).

Figure 3.3.1.7.5-11 Changes in July 2007 Event WSE Due to 50 Years of Sedimentation under High and Low Sedimentation Conditions from RM 130 to RM 140



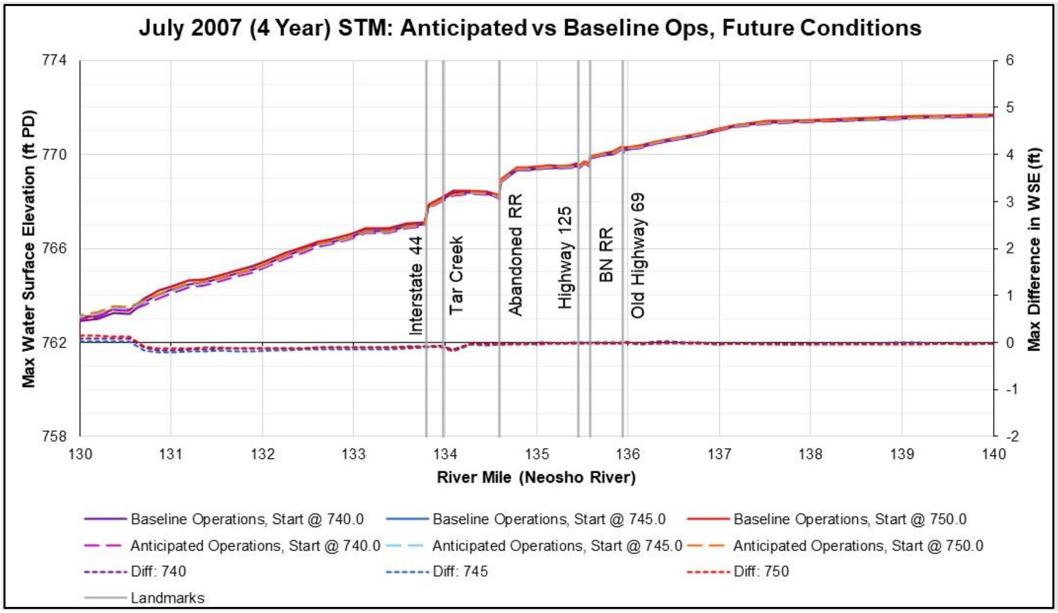
For the 100-year event, the largest increase in WSE near Miami occurs with a starting pool elevation of 750 feet PD. This maximum increase is located upstream of the Tar Creek confluence and is 0.07 foot (**Figure 3.3.1.7.5-12**). This change is immaterial to urbanized areas, regardless of the range of sediment loading evaluated.

Figure 3.3.1.7.5-12 Changes in 100-Year Event WSE Due to 50 Years of Sedimentation under High and Low Sedimentation Conditions from RM 130 to RM 140



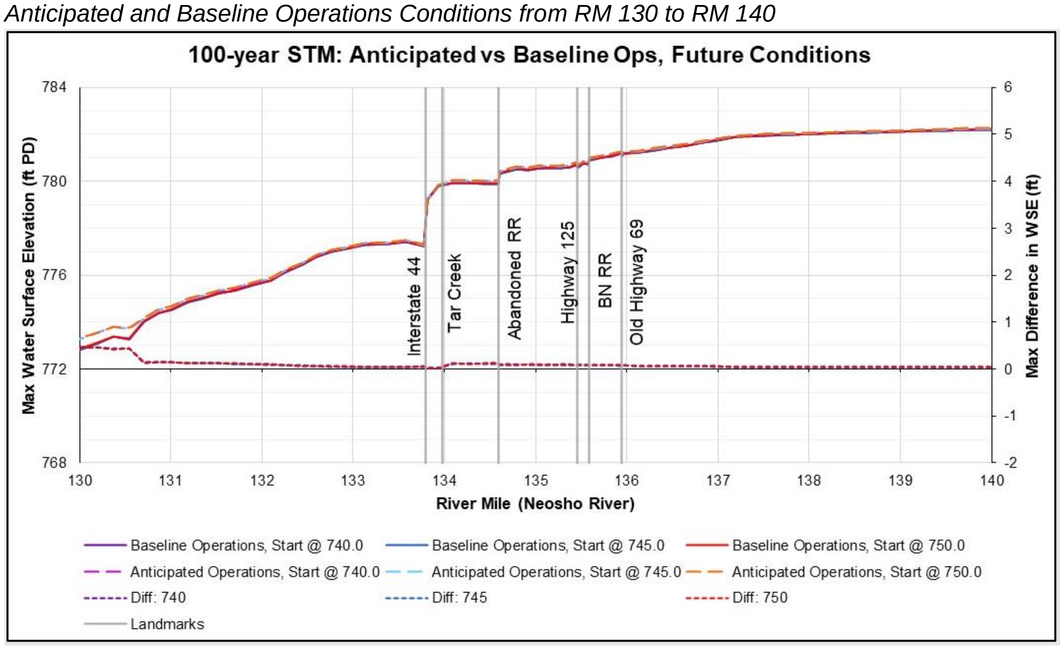
Comparisons between Project operation scenarios showed similar results. For the July 2007 event, the largest increase in WSE near Miami occurs with a starting pool elevation of 740 feet PD. The maximum increase (i.e., the *Anticipated Operations* results are higher than the *Baseline Operations* results) is near the Highway 69 Bridge and is 0.03 foot (**Figure 3.3.1.7.5-13**).

Figure 3.3.1.7.5-13 Changes in July 2007 Event WSE Due to 50 Years of Expected Sedimentation under Anticipated and Baseline Operations Conditions from RM 130 to RM 140



For the 100-year event, the largest increase in WSE near Miami occurs with a starting pool elevation of 750 feet PD. This maximum increase is located upstream of the Tar Creek confluence and is 0.12 foot (**Figure 3.3.1.7.5-14**). This change is immaterial to urbanized areas, regardless of the range of Project operations evaluated.

Figure 3.3.1.7.5-14 Changes in 100-Year Event WSE Due to 50 Years of Expected Sedimentation under Anticipated and Baseline Operations Conditions from RM 130 to RM 140

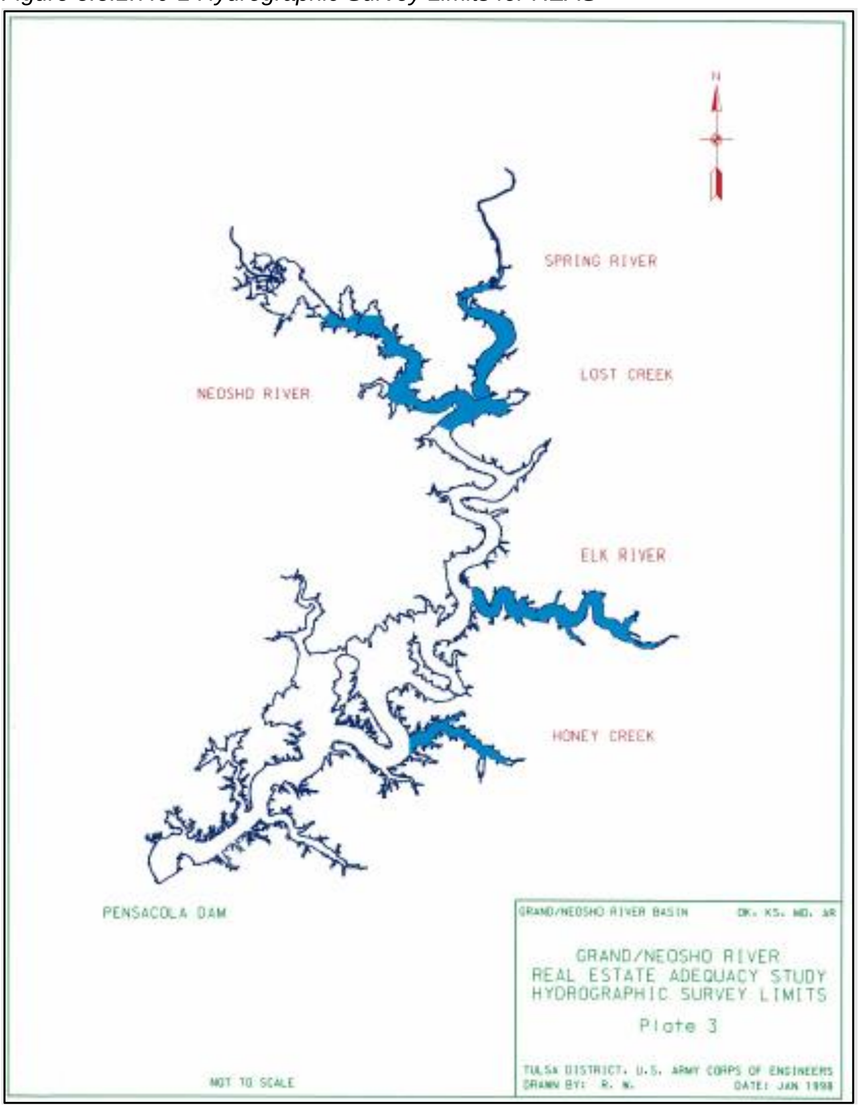


3.3.1.7.6 Delta Feature

Bathymetry information indicates the presence of a delta feature between Twin Bridges at approximately RM 122 and the Elk River at RM 105. This is an area of historical deposition; comparisons of bed elevations between the circa-1940 data and more recent surveys indicate there have been accretion in this reach. Stakeholders indicated concern Project operations created the delta feature and the deposit would continue to grow in height and increase flood risk in upstream communities.

This argument was based in part on the claim the delta feature had formed between the 1998 REAS data collection and 2009 OWRB survey of Grand Lake. As covered in more detail in Section 2.2.1 of the Sedimentation Study Report (**Appendix E-8**), that claim is not supported by the evidence. The USACE REAS documentation showed there were no surveys below RM 120.1 on the Neosho River (US Army Corps of Engineers, 1998) and the remaining portions of the data were based on unknown data likely collected circa 1940. Therefore, the lack of a delta feature in that dataset does not conclusively show a lack of a delta feature in 1998 (**Figure 3.3.1.7.6-1**).

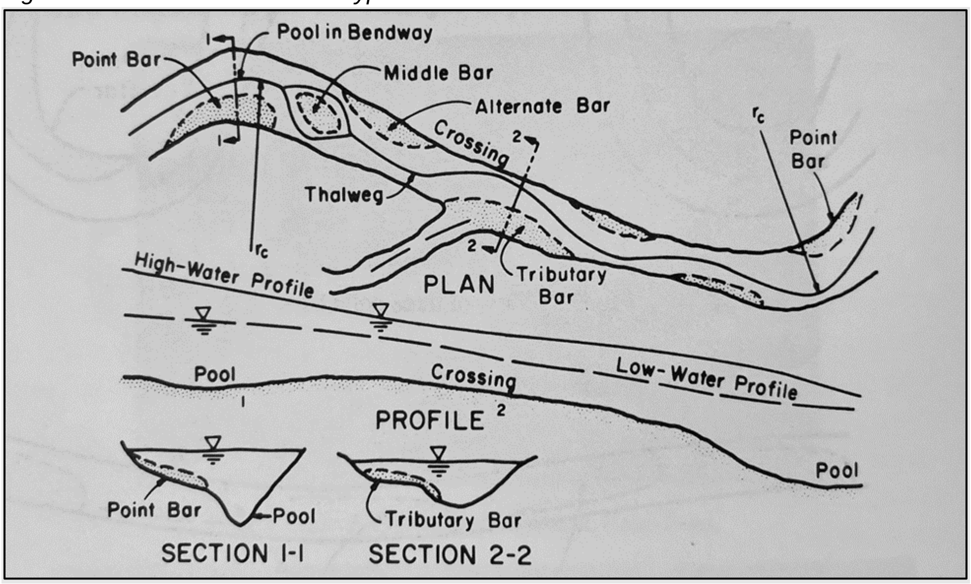
Figure 3.3.1.7.6-1 Hydrographic Survey Limits for REAS



Source: (US Army Corps of Engineers, 1998)

A range of factors influence the formation and evolution of the delta feature. Where steeper tributaries join a stream, sediment is often deposited in the form of tributary bars as sediment transport capacity drops in the shallower stream (**Figure 3.3.1.7.6-2**). There are also bedrock geologic features that flatten the stream at this location, increasing the likelihood of sediment deposition. Constrictions such as bridges and associated embankments create constrictions that cause backwater effects; these are worsened with debris allowed to accumulate on the bridge piers and reduce flow capacity. This location also features connections to wide floodplains that result in decreased flow velocities and increased deposition.

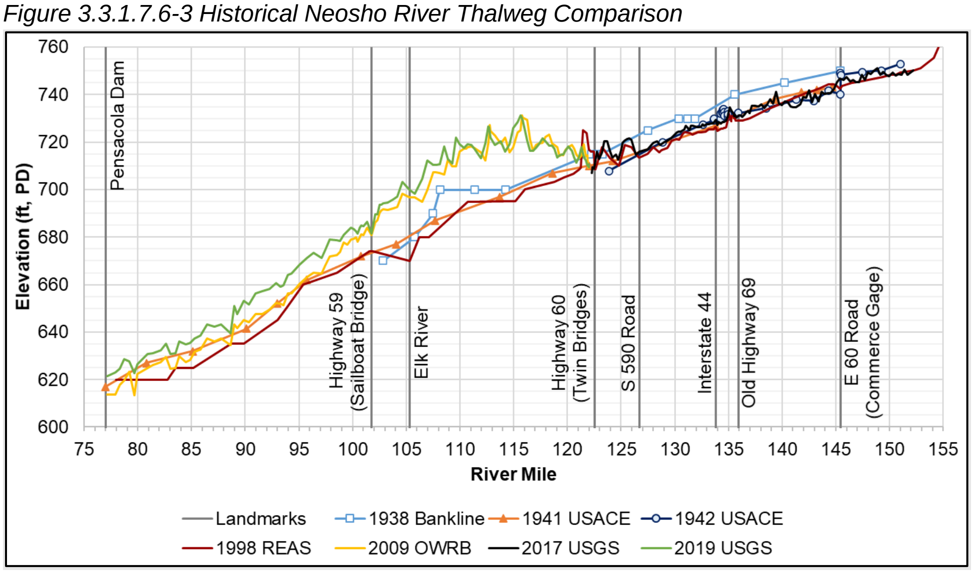
Figure 3.3.1.7.6-2 Illustration of Types of Bars that Occur in Alluvial Channels



Source: (Simons and Senturk, 1992)

Furthermore, the most recent surveys of the delta feature (Oklahoma Water Resources Board, 2009) (US Geological Survey, 2019) show the delta feature has reached a dynamic equilibrium height (**Figure 3.3.1.7.6-3**). This follows normal reservoir delta formation and evolution patterns as documented in the scientific literature (Vanoni, V.A., 2006).

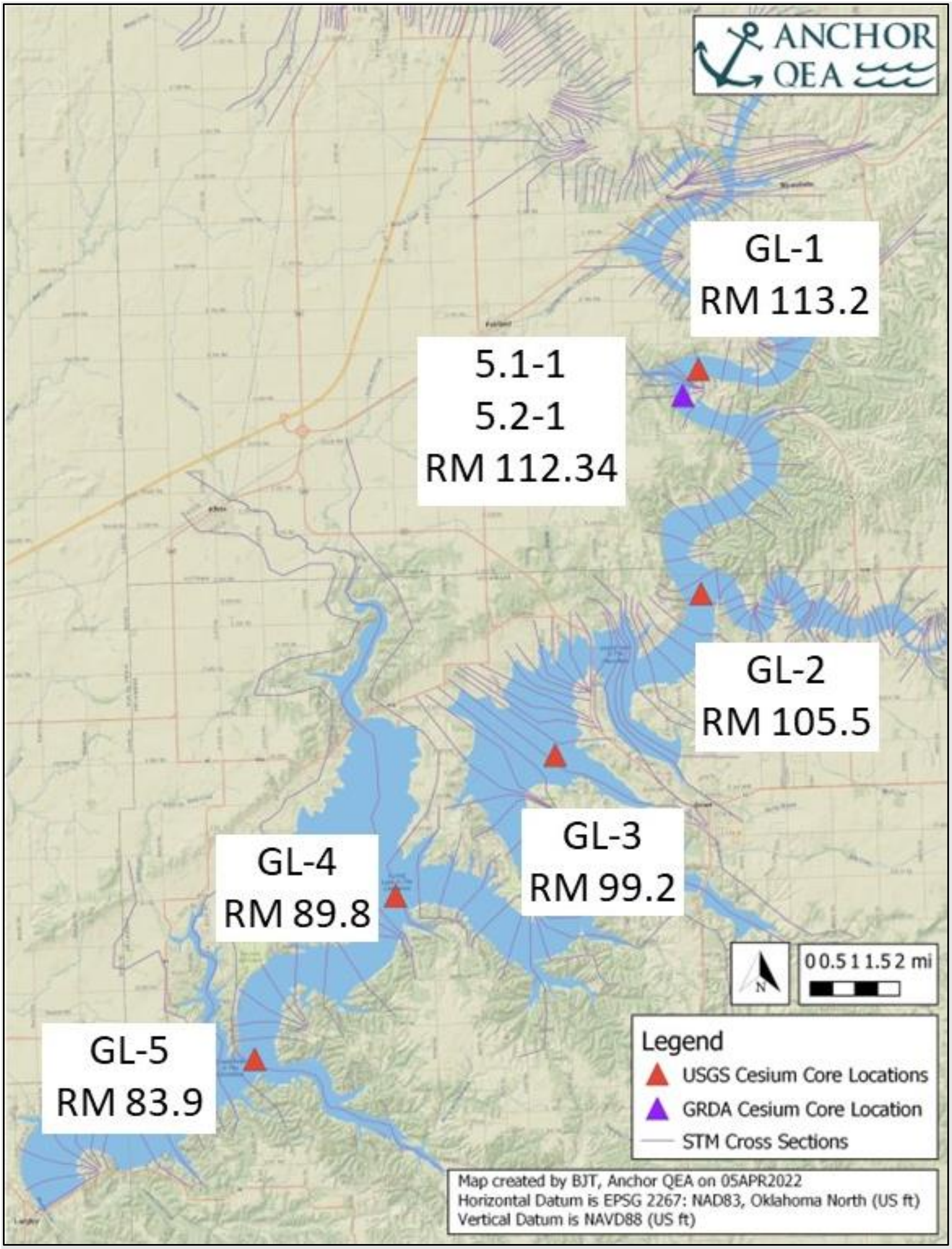
Figure 3.3.1.7.6-3 Historical Neosho River Thalweg Comparison



Vibracore Sediment Dating

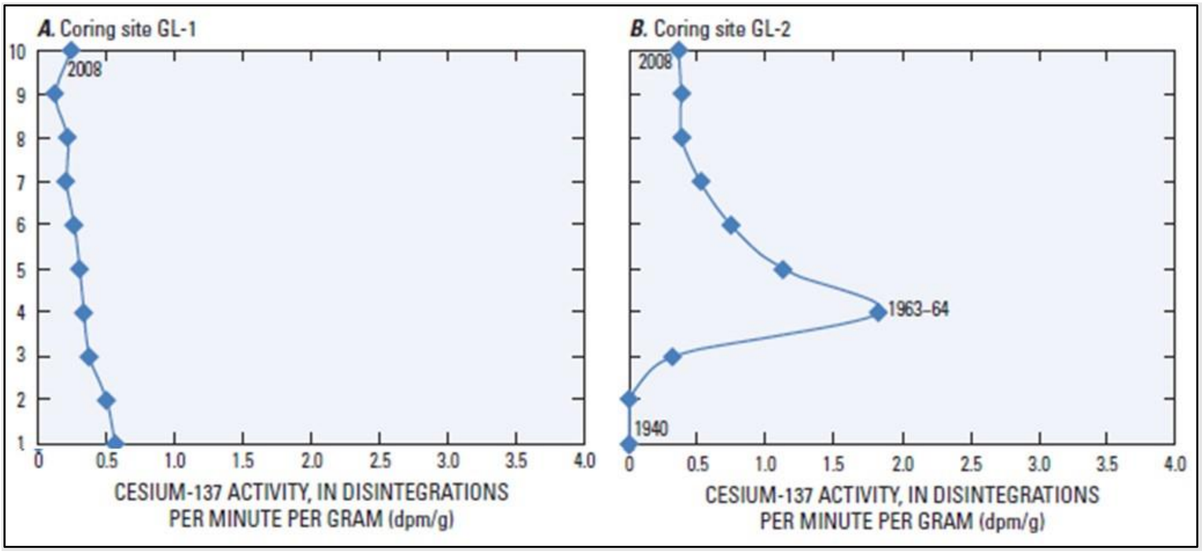
Two vibracore samples were sent for Cs-137 analysis to determine the approximate age of sediments and evaluate potential deposition rates on the delta feature. These cores were taken from RM 112.34 to confirm and expand on a 2008 USGS study (Juracek, K.E. and M.F. Becker, 2009), which took cores from various locations in Grand Lake (**Figure 3.3.1.7.6-4**).

Figure 3.3.1.7.6-4 Map Showing Locations of USGS and GRDA Core Samples Analyzed for Cs-137 Activity



Cs-137 is a non-naturally occurring isotope. It is created as a byproduct of nuclear fission and was first introduced to the atmosphere in approximately 1945. Ongoing nuclear testing increased Cs-137 concentration in the atmosphere until a nuclear test ban treaty in 1963, after which point Cs-137 concentrations have gradually decreased (**Figure 3.3.1.7.6-5**). In areas of continual deposition, concentrations in the soil follow similar trends and the isotope can therefore be used to estimate the date of deposition throughout a sediment column.

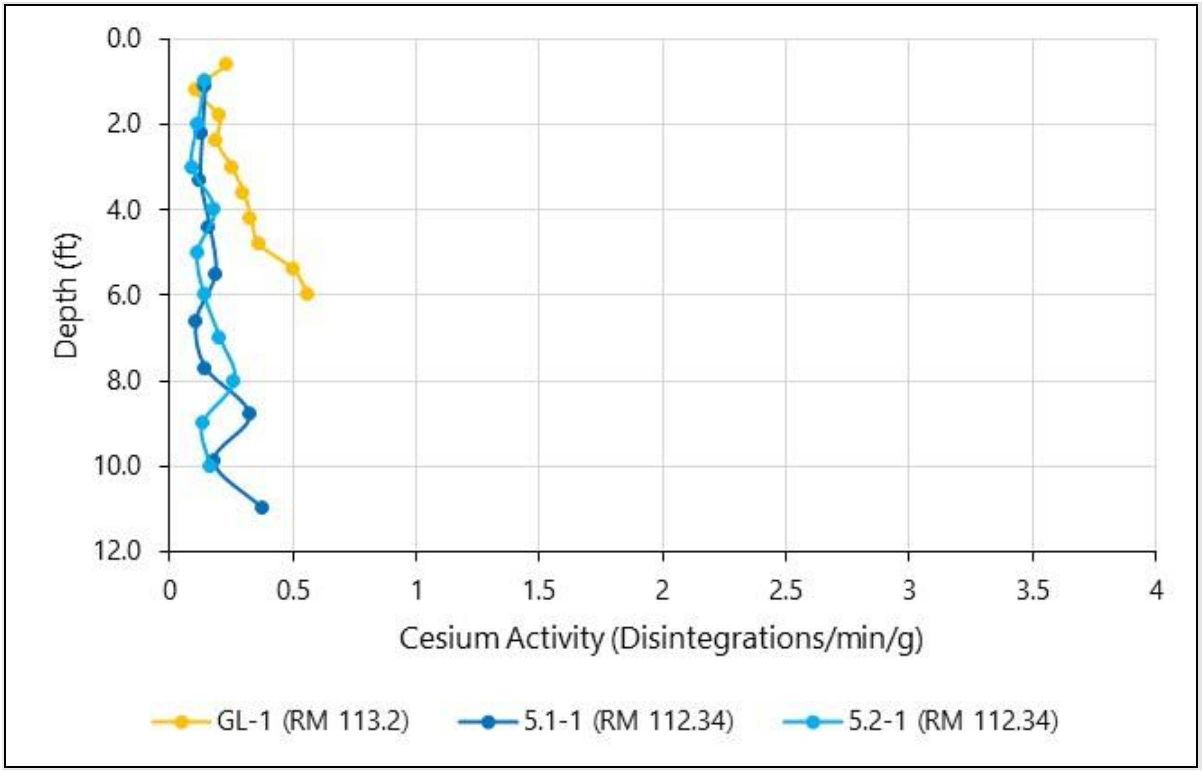
Figure 3.3.1.7.6-5 USGS Cesium Activity Results of Core Samples Taken from Delta Feature



Note: Sample GL-1 does not have a typical peak in Cs-137 activity, indicating all deposition occurred after 1963. Sample GL-2 has the well-defined Cs-137 activity peak (labeled) indicating continual deposition and allowing estimation of deposition rates.
Source: (Juracek and Becker, 2009)

GRDA's Cs-137 dating in the delta feature found similar results to a 2008 USGS study (Juracek, K.E. and M.F. Becker, 2009) that suggested the delta feature is not continually depositional (**Figure 3.3.1.7.6-6**). The material in the top 10 feet of sediment was all deposited after 1963, indicating cyclical erosion and deposition. As discussed by Juracek and Becker (2009), because it is relatively shallow, the sediment can be disturbed by waves and natural high-flow events. This further confirms the delta feature is behaving as a typical reservoir delta at dynamic equilibrium.

Figure 3.3.1.7.6-6 Comparisons of Relative Cesium Activity Between USGS Core Sample GL-1 and GRDA Samples 5.1-1 and 5.2-1



Notes: GL-1 activity levels were taken from Juracek and Becker (2009). The lack of defined cesium activity peak indicates all sediment collected in the core was deposited after 1963.

This finding is consistent with literature regarding reservoir delta features (Fan, J. and G.L Morris, 1992) (US Army Corps of Engineers, 1995) (Huang, J, et. al,, 2006) (Vanoni, V.A., 2006). It is also consistent with the findings of the Quantitative Analysis, which showed most sediment will be deposited on the downstream face of the delta feature. Further, it is confirmed by the STM results, which again indicate deposition will occur primarily on the downstream face of the delta feature. The delta feature will not continue to grow appreciably, nor will future sedimentation have a significant impact on upstream water levels.

Study results demonstrate sedimentation rates in Grand Lake and the associated tributaries are dictated primarily by the future incoming sediment loads, rather than Project operations. The differences in deposition rates and patterns for the *Baseline Operations* and *Anticipated Operations* scenarios are smaller than the differences between the *High Sedimentation* and *Low Sedimentation* scenarios. Furthermore, for all modeled scenarios, the sediment deposition follows typical reservoir deposition patterns, with sedimentation largely occurring downstream of the existing delta feature, rather than continuing to increase the delta feature crest elevation.

The City of Miami has claimed that Project operations will increase the delta feature size, thereby raising water levels in Miami. To assess the impact of Project operations on the delta feature size and upstream water levels, geometry from the predicted future sedimentation pattern was imported to the 1D UHM to evaluate flooding events and the effect on flooding in upstream reaches of the Neosho River through the City of Miami. The findings did not support the City of Miami's claims. Sediment loading rates, not GRDA Project operations, produced the largest impacts to both storage volume change and upstream water levels. Furthermore, the STM showed a majority of incoming material depositing on the downstream face of the delta feature, as expected based on literature reviews, typical delta feature evolution patterns, and the Quantitative Analysis.

1D UHM results were compared to determine relative impacts of 50 years of sediment accumulation under expected loading, *High Sedimentation* versus *Low Sedimentation* rates, and *Baseline Operations* versus *Anticipated Operations*. The results indicate that sediment loading, a natural phenomenon outside GRDA's control, has the largest impact on upstream water levels in the Neosho River, overshadowing any impacts caused by Project operations. Any impacts of the Project on water levels in the City of Miami for all evaluations are immaterial. Project operations, sediment loading, and future geometry show immaterial changes to water levels in the vicinity of the City of Miami. GRDA does not control the volume of incoming sediment, and the simulations indicate that, much like the findings of the H&H Study, natural processes dictate incoming sediment loads and therefore water levels in the study area, not Project operations.

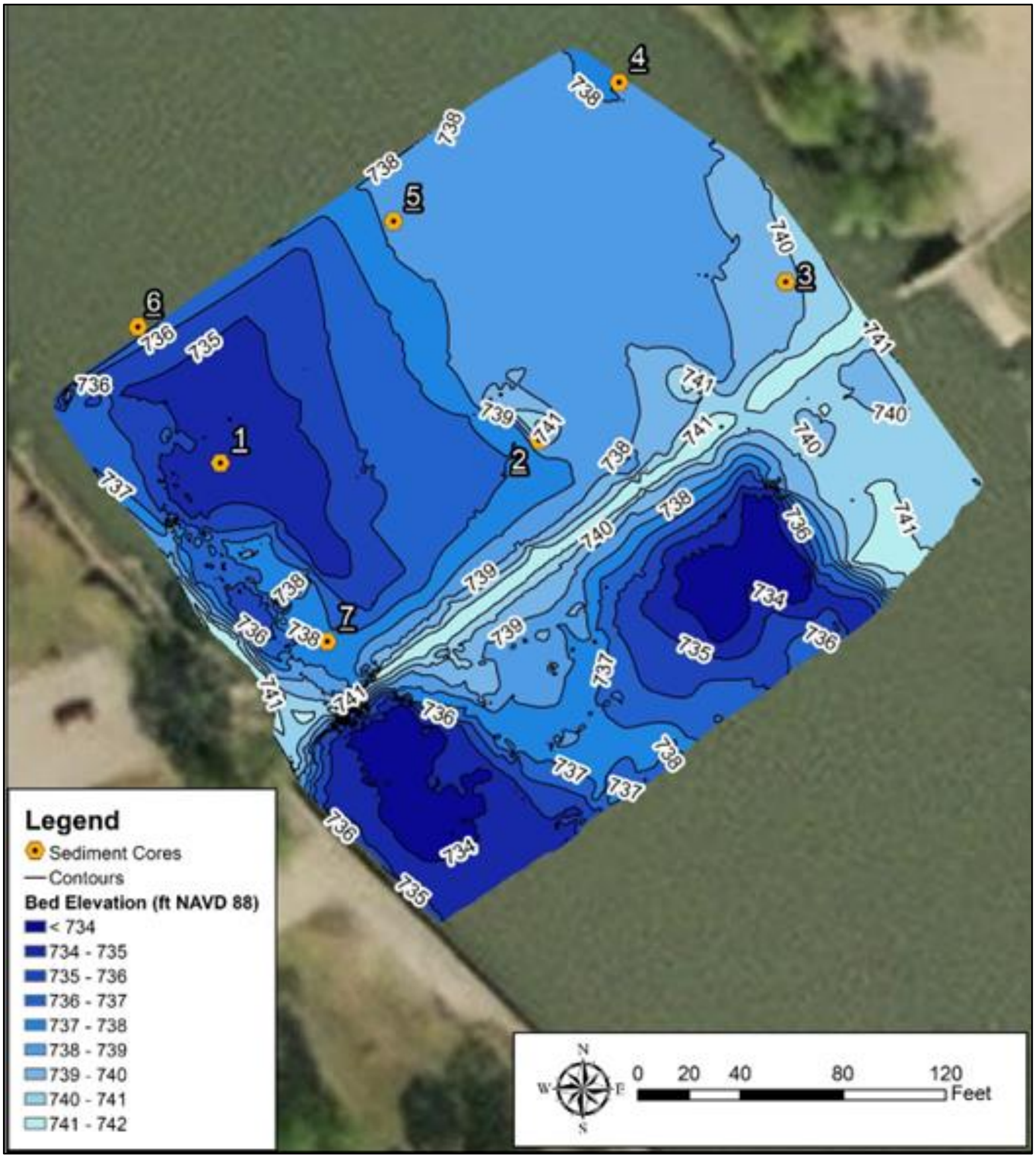
Bathymetry and Vibracore Sampling near Miami Low Head Dam

There is a low head dam at the Miami fairgrounds (approximately RM 135.25) on the Neosho River. This structure was completed in 1923, meaning it has been in place for approximately 100 years—and well in advance of the original construction of Pensacola Dam. During that time, it has served as an obstacle to transport of coarse gravel and sand moving as bedload that cannot be readily lifted over the structure and carried downstream. The City has continued to claim that coarse material is moving downstream in significant quantities; if that were correct, the area immediately upstream of the low head dam would be filled to approximately the elevation of the dam crest. Thus, to substantiate the City's claims, GRDA planned and performed an additional field investigation in November 2022 to determine whether course material has, in fact, filled the area immediately upstream of the low head dam.

The fieldwork consisted of two primary components: a bathymetric survey and vibracore sampling. Bathymetry data was collected with a sonar system using differential GPS to determine location. Vibracore sampling followed similar procedures to those in the previous effort described above.

Bathymetry data showed that the dam protrudes approximately 6 feet above the bed of the surrounding stream (**Figure 3.3.1.7.6-7**). After nearly 100 years of sediment transport through this area, the dam continues to protrude above the surrounding bed, indicating that there is not significant bedload transport. If there were, that coarse material traveling along the bed would be trapped upstream of the structure, creating an upstream channel elevation equal to the dam crest. Instead, there is a noticeable difference in elevation between the stream channel and the dam, which means that there is only limited, if any, bedload sediment transport in this area.

Figure 3.3.1.7.6-7 Bathymetry Map of the Surveyed Area near the Miami Low Head Dam



Seven locations were selected for vibracore sampling (**Figure 3.3.1.7.6-7**). These locations were selected to provide data from across the channel and at multiple depths. At each location, a 3-inch diameter vibracore was driven to refusal. Two of the seven recovered no sediment and had a depth to refusal of 0.0 feet. The remaining five samples collected 0.67 foot of sediment or less (**Table 3.3.1.7.6-1**).

Table 3.3.1.7.6-1 Vibracore Sampling Depths and Core Lengths

Core ID	Depth (ft)	Core Length (ft)
Core 1	7.6	0.00
Core 2	5.7	0.62
Core 3	4.5	0.37
Core 4	5.67	0.56
Core 5	6.25	0.50
Core 6	10.25	0.00
Core 7	7.33	0.67

Four of the recovered samples consisted of coarse material, with several showing signs of natural armoring (**Figure 3.3.1.7.6-8**). Core 7 consisted of finer sediments. The armoring of the bed is an expected natural process that increases resistance to bedload transport. This phenomenon has been described by Bunte and Abt (2001) and happens because a stream is able to transport fine sediments further downstream, leaving behind only coarser material. Sediment below the surface is protected by overlying layers, and as the smaller sediment is winnowed away by streamflow, the coarse armor layer is all that remains (Bunte & Abt, 2001).

Figure 3.3.1.7.6-8 Sample Image of Core 4 Showing Natural Armor Layer at Bed Surface and Finer Material Below

3.3.1.8 Contaminated Sediments

3.3.1.8.1 Sources of Contamination

The Tri-State Mining District (TSMD) encompasses an area of approximately 2,500 square miles that was extensively mined for lead and zinc from 1850 to 1950. The TSMD has a total of four superfund sites spanning Kansas, Missouri, and Oklahoma. In particular, Tar Creek and the Tar Creek Superfund site are located in the towns of Pitcher and Cardin, Oklahoma. The Tar Creek Superfund site, formerly known as the Picher Mining District, is a 40 square mile area within the TSMD that was highly productive. Cessation of mining operations in the mid-20th century left behind tailing piles and cavernous subterranean mines which have leached cadmium (Cd), lead (Pb), zinc (Zn), and other metals into nearby groundwater, streams, and rivers including Tar Creek and its tributaries (Andrews, W.J., et. al., 2009).[25]

The leachate and dust from the Tar Creek Superfund site transports metals into the Project. In addition, similar leaching processes occur at other TSMD mining sites located in the Spring River watershed, which transport metals into the Project via the Spring River. Although other metals such as iron, aluminum, and manganese are byproducts of mining process; these metals are also likely present from naturally occurring sources of local soils and bedrock such as clays or shales (Andrews, W.J., et. al., 2009).

The Tar Creek Superfund Site and other Superfund Sites within the TSMD have been thoroughly documented and the potentially responsible parties have been identified by the EPA. GRDA is not identified as a potentially responsible party.

3.3.1.8.2 Downstream Transport of Contamination

Cadmium can easily attach to sediments and become sequestered in those sediments upstream of the Project. Cd also has a high propensity to dissolve rather than precipitate. Both properties of Cd are the reason for the lack of detectable Cd in downstream sediments within the Project (Andrews, W.J., et. al., 2009).

Lead and zinc both oxidize readily and precipitate as oxides. Insoluble Pb oxides, carbonates, sulfides and Zn oxides, hydroxides, and hydroxycarbonate minerals all have great tendencies to adsorb onto organic or inorganic sediment surfaces (Andrews, W.J., et. al., 2009). If these sediment particles are small (i.e., silts and clays) as commonly identified by GRDA in recent sampling, they may be sequestered upstream of the Project, be passed from upstream into the Project in suspension, and accumulate in the Project or be passed through the Project downstream of Pensacola Dam.

An EPA Phase 1 Diagnostic-Feasibility Study showed sediments have a longitudinal decrease in Cd, Pb, and Zn concentrations from the Neosho-Spring confluence to the Pensacola Dam (OWRB and OSU, 1995). Temporally, the USGS found depositional profiles for Pb and Zn peaked in the 1980s, which could be attributed to a number of interacting factors such as historical mining activities, mine drainage, remediation, landscape stabilization, precipitation and associated runoff, and the erosion

[25] Parts of Tar Creek also flowed into collapses and increased the flow of water through the mine workings (Andrews et.al., 2009).

and transport of contaminated and clean sediments within the Grand Lake Basin (Juracek, K.E. and M.F. Becker, 2009).

3.3.2 Environmental Effects

In SD1 and SD2, the Commission identified the following issues related to geology and soils: (1) the effects of Project operation and maintenance on soil erosion and shoreline erosion; and (2) the effects of Project operations on sedimentation, including the transport and subsequent deposition of potentially contaminated sediment.

3.3.2.1 Effects of Project Operation and Maintenance on Erosion

Under the baseline operation (under the pre-2015 rule curve), GRDA implements an approved SMP to manage activities within the Project boundary for protection and maintenance of shoreline conditions.[26]

The plans focus on maintaining vegetated shorelines to help stabilize and control the potential effects of erosion. Shoreline protection measures have also been approved in several developed areas of the reservoir. Continued implementation of the plans will ensure erosion of Project lands resulting from authorized uses is prevented or minimized. The SMP is discussed in more detail in Section 3.9.

GRDA has a SMP that provides a comprehensive management system to ensure the reservoir and shoreline are managed in a manner consistent with license requirements, including the Project's environmental, public recreation, cultural, and scenic values. The SMP sets minimum standards for activities and improvements along the Project shoreline to minimize or avoid erosion from ground disturbing or vegetation management activities authorized on Project lands.

GRDA plans to continue the implementation of the SMP under the anticipated operation of the Project. Therefore, there are no differences between the baseline operation (under the pre-2015 rule curve) and the anticipated operation of the Project regarding erosion of the shoreline managed through the SMP.

In addition, the Comprehensive Hydraulic Model (CHM) Study evaluated a variety of inflow events with a range of starting pool elevations at Pensacola Dam in order to evaluate the maximum water surface elevations, extent of inundation and duration of inundation both upstream and downstream of the dam. The study results indicate anticipated operation (without a rule curve) have an immaterial impact on water surface elevations and inundation when compared to baseline operation (under the pre-2015 rule curve). The study has demonstrated the influence of the natural process is so great that any impact of the anticipated operation (without a rule curve) on erosion in the Project vicinity is negligible. The CHM is discussed in more detail in Section 3.4. Since neither the baseline operation (under the pre-2015 rule curve) of continuing with the current operation (under the current post-2015 rule curve) of the Project under the current license nor the anticipated operation of the Project have a material effect on any erosion due to reservoir elevation during high inflow conditions, from a reservoir elevation operation standpoint, there are no differences between the baseline operation (under the pre-2015 rule curve) and the anticipated operation of the Project.

[26] The VMP is the portion of the SMP that addresses vegetation management activities.

3.3.2.2 Effects of Project Operation on Sedimentation[27]

Sedimentation and associated impacts to water levels are not driven by Project operations. This finding is consistent with that of the H&H Study, which demonstrated that Project operations have limited ability to dictate WSE upstream of Pensacola Dam. GRDA has no control over the incoming sediment loads and adjusting Project operations does not have a meaningful impact on sediment depositional patterns. Impacts of future sedimentation are the result of incoming material, not Project operations. Therefore, there are no differences between the baseline operation (under the pre-2015 rule curve) and the anticipated operation of the Project.

The Sedimentation Study has shown that sediment moving through the system consists of fine, cohesive material. It has also evaluated a range of datasets for stream bathymetry and overland topography in the study area and concluded significant portions of the 1998 REAS data are unreliable, and the circa-1940 data are limited. To bound the uncertainties of the available datasets, multiple sediment transport simulations were performed, and the study showed that natural processes, not Project operations, dictates the rate of sedimentation in Grand Lake. Any material impacts to upstream WSE during large flow events are the result of sediment loading, which GRDA does not control. Furthermore, when the water level in Grand Lake is above 745 feet PD or expected to rise beyond that level, USACE assumes exclusive jurisdiction over Project operations and dictates operation of the reservoir to mitigate downstream flooding, and most (75.6%) of the sediment is delivered to the reservoir under exactly these conditions.

3.3.2.3 Effects of the Project Operation on Contaminated Sediment

GRDA extensively studied sediment transport in the approved study plan, including the development of a Sediment Transport Model. The STM found that Project operations do not materially affect sediment transport, whether over bank or otherwise. Project operations have limited ability to dictate water surface elevations upstream of Pensacola Dam. GRDA has no control over incoming sediment loads. Sediment depositional patterns would not be meaningfully impacted by adjusting Project operations. Future sedimentation impacts will be the result of the incoming supply of material; future anticipated Project operations will not impact sedimentation.

GRDA's anticipated operations (without a rule curve) do not have an effect on upstream water levels or the transport of contaminated sediment. Moreover, GRDA is not responsible for the presence of the heavy metals in the TSMD upstream of the Project. Therefore, there are no differences between the baseline operation (under the pre-2015 rule curve) and the anticipated operation of the Project.

3.3.3 Cumulative Effects

The proposed action in this case—FERC's issuance of a license to GRDA—is not likely to have significant effects on geology and soils but may result in cumulative effects on geology and soils when considered in the context of a variety of other activities in the Project area unrelated to the Project, including urban and suburban development and agricultural operations 66 miles upstream of the Pensacola Dam and 30 miles downstream to the Markham Ferry Project.

[27] GRDA is in the process of addressing the study modifications outlined in the study determination dated March 14, 2023. The results will be available by July 24, 2023.

When compared to baseline operation (under the pre-2015 rule curve), GRDA's anticipated Project operation (without a rule curve) would not have a significant impact on water surface elevation and, thus, effects on geology and soils resulting from reservoir elevation fluctuation (Section 3.4, CHM Study). However, GRDA's anticipated Project operation (without a rule curve), when considered in the context of other activities that occur in the Project area, including urban and suburban development, agricultural operations, and infrastructure improvements, may contribute to effects on geology and soils.

In this case, the cumulative effect of the proposed action and other activities in the Project area may result in increased erosion, which may in turn result in increased sedimentation and turbidity and have the potential to transport and deposit contaminated soils and sediments. These contaminated sediments could have deleterious effects on water quality and fisheries, including potential effects on spawning. As set forth in Section 3.3.1.8.1, EPA has jurisdiction over the Tar Creek Superfund Site and other Superfund sites within the Project area that have been identified by stakeholders. These sites have been thoroughly documented and the potentially responsible parties have been identified by EPA. FERC has previously acknowledged GRDA bears no responsibility.

Nevertheless, GRDA plans to continue to implement its existing SMP, which provides a comprehensive shoreline management program and is included as **Appendix E-28** of this FLA. As part of this relicensing process, GRDA has updated its SMP to incorporate additional provisions regarding the Project's environmental, public recreation, cultural, and scenic values, including provisions to address vegetation management, wetland impacts, and wildlife habitat impacts, as described in Section 3.9. The SMP, as updated, establishes a system to keep the Project shoreline stable along with ensuring the reservoir and shoreline are managed in a manner consistent with license requirements. The SMP also sets minimum standards for activities and improvements along the Project shoreline to minimize or avoid erosion from ground disturbing or vegetation management activities authorized on Project lands.

Consistent with its SMP, GRDA plans to continue its process of issuing authorizations for activities on its shorelines owned in fee, to ensure such activities do not result in additional soil erosion.

3.3.4 Proposed Environmental Measures

GRDA is proposing to continue implementation of an updated SMP to minimize or eliminate erosion or sedimentation impacts from authorized shoreline activities. No additional or new environmental measures related to geology and soil resources are proposed at this time.

3.3.5 Unavoidable Adverse Impacts

With the implementation of the proposed environmental measures discussed above, continued operation of the Project is not expected to adversely affect geology and soil resources under either the baseline operation (under the pre-2015 rule curve) or GRDA's anticipated operation (without a rule curve) proposal.

3.4 Water Resources

3.4.1 Affected Environment

3.4.1.1 Water Quantity

3.4.1.1.1 Existing Uses of Project Waters

The powerhouse has six main hydroelectric units with Francis-style hydraulic turbines and associated generators. The six hydroelectric units have an as-built turbine head of 117.5 feet. One additional hydroelectric unit, the house unit, has an as-built turbine head of 115 feet.[28]

Each of the six turbines has a nameplate capacity of 17,446 kW (23,395 hp) at a nameplate flow of 1,950 cfs. Each turbine operates at 150 rpm and the normal maximum flow for each turbine is 2,317 cfs (Grand River Dam Authority, 2004a). The house turbine, which operates at 720 rpm, has a name plate capacity of 500 kW (666 hp).[29] The combined generation capacity of all turbines is 105.176 MW.[30]

Each of the six main generating units has a generator nameplate rating of 21.640 MW and 24 MVA at 90% nameplate power factor. The generators are Westinghouse A/C, 60-cycle models generating at 13.8 kV.

The 500-kW house unit generator has a nameplate rating of 500 kW and 625 kVA at 80% nameplate power factor. The generator is a Westinghouse A/C, 60-cycle model which operates at 480 volts.

Based on the 2019 bathymetric survey of Grand Lake performed by the USGS, the Project reservoir encompasses 41,581 acres with a gross storage capacity of 1,307,289 acre-feet at a reservoir elevation of 742 feet PD (the bottom of the anticipated operating range). At a reservoir elevation of 745 feet PD, the reservoir encompasses 45,056 acres with a gross storage capacity of 1,437,348 acre-feet. The useable storage capacity of the Pensacola Project within the range of 742 to 745 feet PD is therefore 130,059 acre-feet (Hunter, S.L, et. al., 2020). The bathymetric map is in **Appendix E-9**.

Grand Lake is a drinking water source and is used by approximately 21,000 residential households and 500 commercial customers. In addition, GRDA issues yearly permits for domestic and agricultural water use (Grand River Dam Authority, 2017a).

3.4.1.1.2 Proposed Uses of Project Waters

GRDA will continue to use Project waters for multiple purposes under the new license including hydropower generation, water supply, public recreation, and wildlife habitat. Instead of managing the Project to target a specified seasonal elevation, GRDA's anticipated operation (without a rule curve) may fluctuate reservoir levels within the elevational range of 742 to 745 feet PD for purposes of responding to grid demands, market conditions, and the public interest, such as environmental and recreational considerations. GRDA's anticipated operation (without a rule curve) are described in more detail in Section 2.2.

28 The house unit is currently inoperable and scheduled to return to service in 2025.
29 Horsepower is calculated from watts: 750 watts equals 1 hp.
30 Output is turbine-limited for the six main units.

3.4.1.1.3 Hydrology and Streamflow

Inflow to the Pensacola Project comes mainly from three rivers which are tributaries to Grand Lake and include the Neosho River, Spring River, and Elk River. Flow data for the Neosho River is recorded by USGS surface water gaging station No. 07185000 and includes a drainage area of 5,926 square miles (US Geological Survey, 2022a). Flow data for the Spring River is recorded by USGS surface water gaging station No. 07188000 and includes a drainage area of 2,516 square miles (US Geological Survey, 2022b). Flow data for the Elk River is recorded by USGS surface water gaging station No. 07189000 and includes a drainage area of 851 square miles (US Geological Survey, 2022c). The drainage area at Pensacola Dam is 10,345 square miles (US Geological Survey, 2022). Mean daily flow data was retrieved for the period of record from January 1,1965 to December 31, 2021 for each river and the flows were combined to determine the total tributary flows and adjusted for the drainage area at the Project. Daily mean flows were obtained only for dates after January 1, 1965, to account for completion of the upstream John Redmond Reservoir in 1964.

Mean monthly flows at the Pensacola Dam for the period of record are shown in **Table 3.4.1.1.3-1**.

Table 3.4.1.1.3-1 Mean Monthly Flows at Pensacola Project, 1965-2021

Month	Mean Monthly Flow (cfs)
January	5,077
February	6,079
March	10,009
April	10,897
May	13,783
June	11,980
July	6,904
August	3,386
September	4,197
October	5,051
November	6,438
December	5,611

Source: (US Geological Survey, 2022a), (US Geological Survey, 2022b), (US Geological Survey, 2022c)

3.4.1.2 Water Quality

3.4.1.2.1 Water Quality Standards

Oklahoma’s water quality standards (OWQS) are published in Oklahoma Administrative Code Title 785, Chapter 45 and consist of designation of beneficial uses, water quality criteria to protect the designated uses, and antidegradation policies. The water quality criteria applicable to the Pensacola Project are included in **Table 3.4.1.2.1-1**.

The beneficial uses designated for Grand Lake include public and private water supply, and fish and wildlife propagation (FWP) as a warm water aquatic community (WWAC), agriculture irrigation, and primary body contact recreation (Oklahoma Water Resources Board, n.d.a).

Waters within the Project boundary are divided into four sections, each with a separate waterbody ID, in regard to whether the waterbody is meeting the designated water quality standards. These include Grand Lake Upper, Grand Lake Middle, Grand Lake Lower, and Grand River (Neosho River) below Pensacola Dam. All three sections of Grand Lake are impaired for fish consumption due to the presence of lead in fish tissue. In addition, Grand Lake Upper is impaired due to turbidity impacting the warm water aquatic community, and Grand Lake Lower is impaired due to low DO impacting the warm water aquatic community. Grand River (Neosho River) below Pensacola Dam is listed as impaired due to low DO impacting the warm water aquatic community and is listed for fish consumption (Oklahoma Department of Environmnetal Quality, 2022).

Table 3.4.1.2.1-1 Water Quality Criteria Applicable to the Pensacola Project

Parameter	Narrative/Numeric Criteria
Temperature	At no time shall heat be added to any surface water in excess of the amount that will raise the receiving water temperature more than 2.8 degrees Celsius (°C) outside the mixing zone.
pH	The pH values shall be between 6.5 and 9.0 in waters designated for fish and wildlife propagation; unless pH values outside that range are due to natural conditions.
DO	Except for naturally occurring conditions, dissolved oxygen criteria are set forth in Table 1 of Appendix G of this Chapter.[31] Additionally: For streams, no more than two DO samples shall exhibit a DO concentration of less than 2.0 mg/L in any given year. For lakes, no more than 50% of the water volume shall exhibit a DO concentration less than 2.0 mg/L. If no volumetric data is available, then no more than 70% of the water column at any given sample site shall exhibit a DO concentration less than 2.0 mg/L. If a lake specific study including historical analysis demonstrates a different percent volume or percent water column than described above is protective of the WWAC use, then that lake specific result takes precedence.
Bacteria	(a) Primary Body Contact Recreation involves direct body contact with the water where a possibility of ingestion exists. In these cases, the water shall not contain chemical, physical, or biological substances in concentrations that are irritating to skin or sense organs, or are toxic or cause illness upon ingestion by humans. (b) In waters designated for Primary Body Contact Recreation, the following limits for bacteria set forth in (c) of this section shall apply only during the recreation period of May 1 to September 30. The criteria for Secondary Body Contact Recreation will apply during the remainder of the year. (c) Compliance with 785:45-5-16 shall be based upon meeting the requirements of one of the options specified in (1) or (2) of this subsection (c) for bacteria. Upon selection of one (1) group or test method, said method shall be used exclusively over the time period prescribed therefore. Provided, where concurrent data exist for multiple bacterial indicators on the same waterbody or waterbody segment, no criteria exceedances shall be allowed for any indicator group. *Escherichia coli* (*E. coli*): The *E. coli* geometric mean criterion is 126/100 milliliters (mL). For swimming advisory and permitting purposes, *E. coli* shall not exceed a

[31] **Table 3.4.1.2.1-2** in this section includes 785:45 Table 1 of Appendix G information regarding warm water aquatic communities that are applicable to the Pensacola Project.

Parameter	Narrative/Numeric Criteria
	monthly geometric mean of 126/100 mL based upon a minimum of not less than five (5) samples collected over a period of not more than thirty (30) days. For swimming advisory and permitting purposes, no sample shall exceed a 75% one-sided confidence level of 235/100 mL in lakes and high use waterbodies and the 90% one-sided confidence level of 406/100 mL in all other Primary Body Contact beneficial use areas. These values are based upon all samples collected over the recreation period. For purposes of Sections 303(d) and 305(b) of the Federal Clean Water Act as amended, beneficial use support status shall be assessed using only the geometric mean criterion of 126/100 mL compared to the geometric mean of all samples collected over the recreation period. Enterococci: The Enterococci geometric mean criterion is 33/100 mL. For swimming advisory and permitting purposes, Enterococci shall not exceed a monthly geometric mean of 33/100 mL based upon a minimum of not less than five (5) samples collected over a period of not more than thirty (30) days. For swimming advisory and permitting purposes, no sample shall exceed a 75% one-sided confidence level of 61/100 mL in lakes and high use waterbodies and the 90% one-sided confidence level of 108/100 mL in all other Primary Body Contact Recreation beneficial use areas. These values are based upon all samples collected over the recreation period. For purposes of Sections 303(d) and 305(b) of the federal Clean Water Act, as amended, beneficial use support status shall be assessed using only the geometric mean criterion of 33/100 mL compared to the geometric mean of all samples collected over the recreation period.
Biological Criteria	(A) Aquatic life in all waterbodies with the beneficial use designation of Fish and Wildlife Propagation (excluding waters designated “Trout, put-and-take”) shall not exhibit degraded conditions as indicated by one or both of the following: Comparative regional reference data from a station of reasonable similar watershed size or flow, habitat type, and Fish and Wildlife beneficial use subcategory designation or by comparison with historical data from the waterbody being evaluated. (B) Compliance with the biological criteria to protect Fish and Wildlife Propagation set forth in this paragraph shall be based upon measures including, but not limited to, diversity similarity, community structure, species tolerance, trophic structure, dominant species, indices of biotic integrity (IBI), indices of well- being (IWB), or other measures.
Turbidity	(A) Turbidity from other than nature sources shall be restricted to not exceed the following numerical limits: Lakes: 25 Nephelometric Turbidity Units (NTU); and other surface waters: 50 NTU. (B) In waters where the background turbidity exceeds these values, turbidity from point sources shall be restricted to not exceed ambient level. (C) Numerical criteria listed in (A) of this paragraph apply only to seasonal base flow conditions. (D) Elevated turbidity levels may be expected during, and for several days after, a runoff event.
Sediments	Concentrations of loads of suspended or bedded sediments that are caused by human activity shall not impair the Fish and Wildlife Propagation use or any subcategory thereof.

Source: (Oklahoma Water Resources Board, n.d.b)

Table 3.4.1.2.1-2 DO Criteria to Protect Fish and Wildlife Propagation for WWAC

Life Stage	Dates Applicable	Minimum DO Criteria (mg/L)[32]	Seasonal Temperature (◦C)
Early life stages	April 1 to June 15	6.0[33]	25[34]
Other life stages			
• Summer Conditions	June 16 to October 15	5.0[31]	32
• Winter Conditions	October 16 to March 31	5.0	18

Source: (Oklahoma Water Resources Board, n.d.b)

3.4.1.2.2 Existing Water Quality Conditions

Water quality in Grand Lake and the Project tailwater supports a healthy warm water fishery and is a popular recreation area. Grand Lake is dendritic with numerous major and minor coves. It exhibits longitudinal zonation including a riverine zone, transition zone, and lacustrine zone. Each zone possesses unique physical, chemical, and biological characteristics. Grand Lake can be classified as a warm monomictic lake with the water column mixing freely in the winter at or above 4°C while thermal stratification occurs from mid-spring through mid-autumn. Grand Lake is classified as eutrophic based on measurements of chlorophyll, water clarity, and phosphorus (Grand River Dam Authority, 2017a).

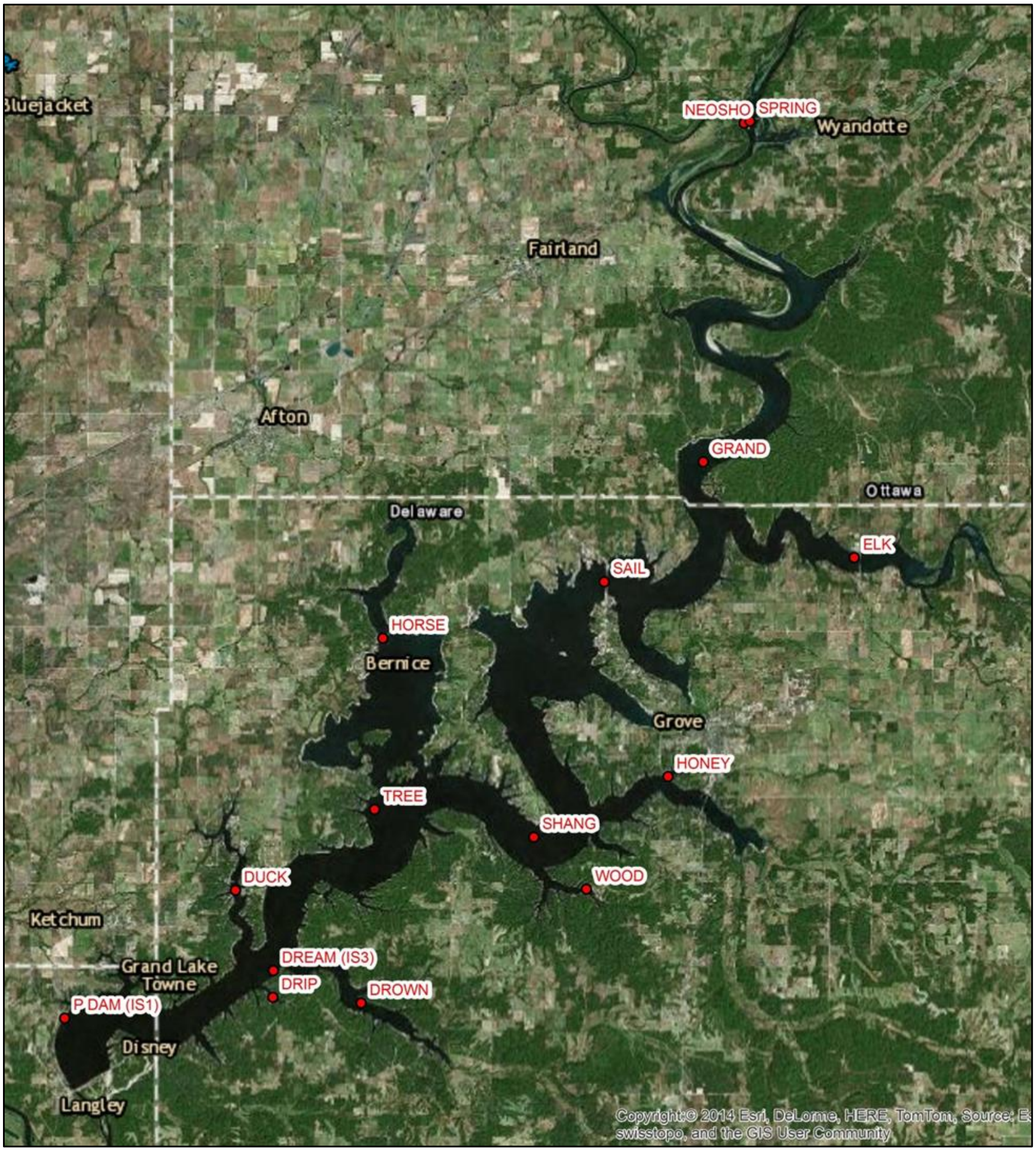
Water quality is largely flow dependent and changes depending on inflow from its major tributaries. Ongoing water quality data collection in the Grand River watershed identified several water quality stressors on Grand Lake. Major influences of water quality include nutrient runoff from nonpoint sources (primarily agricultural), internal nutrient loading, point discharge from municipal and industrial effluent, and runoff from acid mine drainage originating from abandoned mines within the TSMD upstream of the Project boundary in the Spring River and Neosho River watersheds (Grand River Dam Authority, 2017a).

3.4.1.2.3 Current Water Monitoring Data

GRDA has been monitoring water quality in Grand Lake from 1986 to 1992 and 2011 to the present. The current monitoring program, which has been in place since 2013, includes both near-surface sampling and water column profiles. GRDA collects water quality samples in Grand Lake at 15 sampling sites as shown in **Figure 3.4.1.2.3-1**. Samples are generally collected on a seasonal schedule during autumn, winter, spring, and summer. The autumn monitoring period is defined by the months of September, October, and November; winter period is defined by the months of December, January, and February; spring period is defined by the months of March, April, and May, and summer period is defined by the months of June, July, and August. Grab samples are collected within the top one meter of the water column and sent to the lab for analysis. Water profile samples measure water quality parameters in the field (Grand River Dam Authority, 2017a). **Table 3.4.1.2.3-1** lists the water quality variables measured at each site. **Table 3.4.1.2.3-2** includes the measured parameters and water quality monitoring results in Grand Lake from 2017 to 2021 collected by GRDA.

[32] DO shall not exhibit concentrations less than the criteria magnitudes expressed above in greater than 10% of the samples as assessed across all life stages and seasons.
[33] Because of natural diurnal DO fluctuations, a 1.0 mg/L DO concentration deficit shall be allowed for not more than eight hours during any twenty-four-hour period.
[34] Discharge limits necessary to meet summer conditions will apply from June 1 of each year. However, where discharge limits based on Early Life Stage (spring) conditions are more restrictive, those limits may be extended to July 1.

Figure 3.4.1.2.3-1 Locations of Fifteen Sample Locations



Although the water quality data shows evidence of stressors to Grand Lake, the current data suggests the overall water quality has been stable to improving when compared to data from the late 1980s. Generally, Grand Lake water quality is comparable to that of other similar sized eutrophic subtropical reservoirs (Grand River Dam Authority, 2017a).

Table 3.4.1.2.3-1 Water Quality Variables Measured at Each of the Fifteen Sites

Variable	**Unit**	**Depth**
Temperature	Celsius	Full profile
Conductivity	us/cm	Full profile
pH	standard unit	Full profile
Turbidity	NTU (depending on sonde)	Full profile
Chl-a *in situ*[35]	micrograms per liter (µg/L)	Full profile
DO	mg/L	Full profile
BGA-PC	cells/mL	Full profile
Laboratory Analytes/Grab Samples		
Variable	Unit	Depth
Chl-a	µg/L	1m
Total Suspended Solids (TSS)	mg/L	1m
Total Hardness	mg/L	1m
Total Alkalinity	mg/L	1m
Total Coliforms	MPN/100mL	1m
E. coli	MPN/100mL	1m
Total Nitrogen (TN)	mg/L	1m
Total Phosphorous (TP)	mg/L	1m
Nitrate+Nitrite (NO_X-N)	mg/L	1m
Orthosphosphate (PO_4-P)	mg/L	1m
Ammonia (NH_3)	mg/L	1m
Secchi Depth	feet	Recorded for routine sampling

[35] Not recommended for data analysis.

Table 3.4.1.2.3-2 Results of Surface Water Quality Monitoring in Grand Lake from 2017-2021 (unless otherwise noted displayed as arithmetic mean ± standard deviation)[36]

Parameter	Lower (Sample Sites: PDAM, DREAM, DRIP, DROWN, DUCK, and TREE)				Middle (Sample Sites: HONEY, HORSE, SAIL, SHANG, and WOOD)				Upper (Sample Sites: ELK, GRAND, NEOSHO, and SPRING)			
	Winter	**Spring**	**Summer**	**Autumn**	**Winter**	**Spring**	**Summer**	**Autumn**	**Winter**	**Spring**	**Summer**	**Autumn**
Secchi (m)	1.32 ± 0.55 Max: 2.51 Min: 0.5	1.02 ± 0.44 Max: 1.81 Min: 0.31	1.24 ± 0.59 Max: 2.96 Min: 0.25	1.39 ± 0.54 Max: 2.4 Min: 0.45	0.98 ± 0.45 Max: 2.08 Min: 0.16	0.80 ± 0.34 Max: 1.54 Min: 0.22	0.99 ± 0.37 Max: 2.13 Min: 0.3	0.96 ± 0.31 Max: 1.62 Min: 0.3	0.92 ± 0.47 Max: 1.61 Min: 0.1	0.52 ± 0.31 Max: 1.26 Min: 0.18	0.67 ± 0.27 Max: 1.3 Min: 0.25	0.57 ± 0.21 Max: 0.86 Min: 0.28
TSS (mg/L)	4.37 ± 2.37 Max:21.3 Min:1.0	9.54 ± 9.97 Max: 53.26 Min: 1.00	6.16 ± 4.93 Max:35.0 Min: 1.40	4.2 ± 1.69 Max: 8.44 Min: .80	10.04 ± 14.12 Max: 78.67 Min: 1.38	12.65 ± 8.15 Max: 47.06 Min:3.57	7.61 ± 5.01 Max: 39.17 Min: 1.70	6.74 ± 2.17 Max: 52.38 Min: 0.00	26.35 ± 48.24 Max: 197.65 Min: 4.0	22.52 ± 15.80 Max: 51.3 Min: 1.80	14.51 ± 9.51 Max: 85.45 Min: 3.56	26.50 ± 26.83 Max: 226.26 Min: 0.00
Hardness (mg/L)	128.22 ± 9.96 Max: 151.6 Min: 64.8	119.58 ± 27.98 Max: 159.2 Min: 54.8	103.56 ± 14.23 Max: 151.6 Min: 70.0	110.95 ± 6.25 Max: 154.0 Min: 95.6	130.66 ± 14.74 Max: 176.4 Min: 73.6	119.65 ± 35.17 Max: 217.0 Min: 52.0	109.54 ± 19.1 Max: 168.0 Min: 9.8	113.63 ± 7.43 Max: 145.6 Min: 104.8	158.41 ± 40.36 Max: 228.4 Min: 104.4	132.02 ± 34.28 Max: 195.2 Min: 64.8	129.76 ± 28.83 Max: 194.4 Min: 71.2	120 ± 15.14 Max: 174.8 Min: 99.2
Alkalinity (mg/L)	100.52 ± 11.87 Max: 126.4 Min: 48.4	93.35 ± 21.98 Max: 133.6 Min: 49.2	85.77 ± 11.98 Max: 133.2 Min: 56.8	93.02 ± 8.83 Max: 141.6 Min: 79.6	101.98 ± 12.81 Max: 131.6 Min: 60.4	95.53 ± 23.69 Max: 146.0 Min: 50.4	88.77 ± 14.71 Max: 141.6 Min: 60.0	94.38 ± 9.5 Max: 133.2 Min: 81.2	127.33 ± 28.73 Max: 152.0 Min: 68.0	106.5 ± 28.36 Max: 166.0 Min: 67.6	107.2 ± 20.52 Max: 160.0 Min: 62.8	107.94 ± 16.02 Max: 152.4 Min: 79.6
TN (mg/L)	1.12 ± 0.48 Max: 1.9 Min: 0.53	1.40 ± 0.46 Max: 2.15 Min: 0.67	0.66 ± 0.47 Max: 4.21 Min: <0.01	0.94 ± 1.72 Max: 1.44 Min: 0.11	1.09 ± 0.58 Max: 2.23 Min: 0.52	1.47 ± 0.49 Max: 2.42 Min: <0.01	0.64 ± 0.40 Max: 1.72 Min: 0.22	0.69 ± 0.43 Max: 1.91 Min: <0.01	1.75 ± 0.65 Max: 3.25 Min: 1.04	1.65 ± 0.52 Max: 2.92 Min: 1.2	0.90 ± 0.43 Max:2.22 Min: 0.22	1.15 ± 0.58 Max: 2.72 Min: 0.63
NH_3 (mg/L)	0.05 ± 0.04 Max: 0.15 Min: <0.01	0.06 ± 0.06 Max: 0.19 Min: 1.00	0.05 ± 0.08 Max: 0.91 Min: 1.4	0.03 ± 0.02 Max: 0.14 Min: 0.80	0.06 ± 0.04 Max: 0.19 Min: <0.01	0.07 ± 0.06 Max: 0.24 Min: 3.57	0.03 ± 0.02 Max: 0.24 Min: 1.70	0.04 ± 0.03 Max: 0.41 Min: <0.01	0.07 ± 0.07 Max: 0.25 Min: <0.01	0.09 ± 0.06 Max: 0.39 Min: <0.01	0.06 ± 0.15 Max: 1.02 Min: <0.01	0.08 ± 0.04 Max: 0.22 Min: <0.01
NO_X-N (mg/L)	0.85 ± 0.46 Max: 1.56 Min: 0.06	1.20 ± 0.25 Max: 1.62 Min: 0.04	0.28 ± 0.27 Max: 1.69 Min: <0.01	0.44 ± 0.40 Max: 1.26 Min: <0.01	0.94 ± 0.58 Max: 1.94 Min: 0.01	1.18 ± 0.34 Max: 1.96 Min: 0.17	0.29 ± 0.28 Max: 1.24 Min: <0.01	0.53 ± 0.57 Max: 1.8 Min: <0.01	1.63 ± 0.75 Max: 3.3 Min: 0.21	1.36 ± 0.42 Max: 3.43 Min: 0.3	0.42 ± 0.39 Max: 2.47 Min: <0.01	0.96 ± 1.17 Max: 2.89 Min: 0.01
TP (mg/L)	0.14 ± 0.08 Max: 0.41 Min: 0.06	0.13 ± 0.07 Max: 0.33 Min: 0.01	0.26 ± 1.21 Max:0.97 Min: <0.01	0.16 ± 0.27 Max: 0.25 Min: 0.02	0.14 ± 0.07 Max: 0.32 Min: 0.05	0.21 ± 0.39 Max: 0.39 Min: 0.44	0.08 ± 0.05 Max: 0.31 Min: 0.01	0.12 ± 0.21 Max: 0.26 Min: 0.05	0.17 ± 0.11 Max: 0.33 Min: 0.02	0.22 ± 0.13 Max: 0.44 Min: 0.02	0.10 ± 0.05 Max: 0.54 Min: 0.02	0.13 ± 0.08 Max: 0.32 Min: 0.04
PO_4 (mg/L)	0.08 ± 0.03 Max: 0.14 Min: 0.01	0.06 ± 0.04 Max: 0.35 Min: <0.01	0.09 ± 0.19 Max: 0.19 Min: <0.01	0.05 ± 0.03 Max: 0.20 Min: 0.01	0.08 ± 0.05 Max: 0.23 Min: 0.01	0.06 ± 0.04 Max: 0.38 Min: 0.01	0.04 ± 0.04 Max: 0.15 Min: <0.01	0.05 ± 0.02 Max: 0.24 Min: 0.02	0.09 ± 0.07 Max: 0.25 Min: <0.01	0.08 ± 0.05 Max: 0.2 Min: 0.01	0.05 ± 0.04 Max: 0.18 Min: 0.01	0.04 ± 0.03 Max: 0.22 Min: 0.02
Chl-a (µg/L)	5.67 ± 9.83 Max: 48.64 Min: 0.25	13.87 ± 17.0 Max: 107.48 Min: 0.0	19.45 ± 16.19 Max: 166.56 Min: 0.56	5.21 ± 4.18 Max: 30.21 Min: 0.84	9.27 ± 11.31 Max: 48.04 Min: 0.25	17.37 ± 15.21 Max: 87.07 Min: 0.04	21.63 ± 17.27 Max: 91.15 Min: 0.62	9.04 ± 7.52 Max: 59.19 Min: 1.96	6.54 ± 4.6 Max: 33.74 Min: 0.61	5.89 ± 6.82 Max: 59.43 Min: 0.06	24.79 ± 15.59 Max: 73.8 Min: 0.52	15.37 ± 20.51 Max: 70.26 Min: 0.25
Total Coliforms[37] (MPN/100mL)	33.1 (13.85-123.65) Max: >2419.6 Min: 1.0	126.6 (22.8-950.6) Max: >2419.6 Min: <1.0	841.4 (295.08 - 420) Max: >2419.6 Min: 36.4	126.45 (77.73-189.3) Max: >2419.6 Min: 27.2	118.35 (20.52-71.25) Max: >2419.6 Min: 1.0	436 (61.3 -1413.6) Max: >2419.6 Min: <1.0	1299.7 (307.6 - 2420) Max: >2419.6 Min: 18.7	248.1 (187.2 - 547.5) Max: >2419.6 Min: 47.1	80.9 (18.6-1378.2) Max: >2419.6 Min: 5.2	2420 (296.45-2420) Max: >2419.6 Min:20.3	613.1 (223.65-2419.6) Max: >2419.6 Min: 41.4	1046.2 (281.6 - 2420) Max: >2419.6 Min: 104.3
E. coli[38] (MPN/100mL)	2 (1-3.1) Max: 727.0 Min: <1.0	3.1 (1-22.8) Max: 87.8 Min: <1.0	0.5 (0.5-2) Max: 123.6 Min: <1.0	3.1 (1-7.5) Max: 549.3 Min: <1.0	2.5 (0.5-22.375) Max: >2419.6 Min: <1.0	7.5 (1-59.8) Max: 547.5 Min: <1.0	1 (0.5 - 3.1) Max: 387.3 Min: <1.0	3.1 (0.5-18.5) Max: 920.8 Min: <1.0	3.1 (1-235.9) Max: 2419.6 Min: <1.0	93.9 (19.45-312.2) Max: 1986.3 Min: 1.0	1 (0.5-6.2) Max: >2419.6 Min: <1.0	17.5 (0.75-37.55) Max: 1732.9 Min: <1.0

[36] The terms “Lower”, “Middle”, and “Upper” refer to the locations in Grand Lake.
[37] Displayed geometric mean ± standard deviation.
[38] Displayed geometric mean ± standard deviation.

Parameter	Lower (Sample Sites: PDAM, DREAM, DRIP, DROWN, DUCK, and TREE)				Middle (Sample Sites: HONEY, HORSE, SAIL, SHANG, and WOOD)				Upper (Sample Sites: ELK, GRAND, NEOSHO, and SPRING)			
	Winter	**Spring**	**Summer**	**Autumn**	**Winter**	**Spring**	**Summer**	**Autumn**	**Winter**	**Spring**	**Summer**	**Autumn**
Temp (°C)	6.41 ± 2.23 Max: 14.86 Min: 2.55	15.56 ± 5.30 Max: 26.04 Min: 4.48	27.61 ± 2.16 Max: 32.3 Min: 21.56	19.5 ± 5.39 Max: 29.61 Min: 10.43	6.09 ± 1.73 Max: 12.34 Min: 2.24	16.75 ± 5.25 Max: 26.47 Min: 5.55	27.81 ± 2.13 Max: 32.18 Min: 21.36	18.9 ± 6.17 Max: 30.25 Min: 9.15	6.71 ± 2.17 Max: 12.75 Min: 1.6	22.55 ± 5.41 Max: 25.67 Min: 3.56	28.43 ± 1.67 Max: 32.39 Min: 22.22	18.12 ± 7.71 Max: 29.52 Min: 8.19
DO (mg/L)	11.61 ± 1.39 Max: 16.49 Min: 8.39	10.48 ± 1.97 Max: 15.45 Min: 5.08	9.81 ± 11.51 Max: 18.94 Min: 1.32	7.46 ± 1.44 Max: 11.94 Min: 4.09	11.76 ± 0.80 Max: 14.68 Min: 9.2	10.31 ± 1.88 Max: 15.77 Min: 5.16	27.87 ± 160.02 Max: 16.97 Min: 2.94	8.27 ± 1.52 Max: 13.83 Min: 4.32	11.97 ± 1.0 Max: 13.73 Min: 9.78	8.07 ± 2.38 Max: 13.04 Min: 4.05	8.27 ± 2.28 Max: 17.0 Min: 0.0	8.26 ± 1.83 Max: 13.74 Min: 5.38
Cond (µS/cm)	280.09 ± 23.0 Max: 341 Min: 142	267.19 ± 54.48 Max: 397 Min: 147	239.61 ± 27.57 Max: 329 Min: 167	255.46 ± 10.43 Max: 295 Min: 205	290.34 ± 32.81 Max: 380 Min: 155	277.32 ± 61.23 Max: 435 Min: 147	251 ± 22.61 Max: 384 Min: 164	262.13 ± 16.25 Max: 333 Min: 199	327.29 ± 80.83 Max: 483 Min: 237	331.09 ± 71.17 Max: 484 Min: 191	300.23 ± 67.69 Max: 432 Min: 167	274.4 ± 42.16 Max: 381 Min: 200
pH (standard unit)	7.96 ± 0.63 Max: 9.47 Min: 6.79	7.58 ± 1.71 Max: 9.22 Min: 6.99	8.14 ± 0.55 Max: 9.37 Min: 6.93	7.50 ± 0.76 Max: 9.1 Min: 6.47	8.03 ± 1.06 Max: 8.87 Min: 7.18	7.38 ± 2.29 Max: 9.21 Min: 7.14	8.15 ± 0.54 Max: 9.38 Min: 7.08	7.64 ± 0.94 Max: 9.16 Min: 6.7	8.05 ± 0.6 Max: 8.6 Min: 7.21	7.92 ± 0.44 Max: 8.81 Min: 6.23	8.15 ± 0.36 Max: 9.08 Min: 7.1	7.72 ± 0.33 Max: 9.08 Min: 7.22
Chl-a in-situ (µg/L)	6.27 ± 7.48 Max: 52.1 Min: 1.5	19.34 ± 30.28 Max: 177.9 Min: 1.8	7.81 ± 4.56 Max: 102.6 Min: 2.4	5.25 ± 2.74 Max: 26.4 Min: 1.0	6.56 ± 2.98 Max: 37.0 Min: 1.8	21.91 ± 29.79 Max: 148.8 Min: 3.1	9.51 ± 5.21 Max: 61.4 Min: 3.4	9.45 ± 10.25 Max: 36.8 Min: 1.0	8.23 ± 8.08 Max: 22.9 Min: 0.5	34.57 ± 52.68 Max: 148.8 Min: 3.1	13.69 ± 8.87 Max: 127.4 Min: 5.7	8.02 ± 4.23 Max: 44.5 Min: 0.5
BGA PC (cells/mL)	1871.44 ± 2049.17 Max: 20257 Min: 36	4155.98 ± 2543.29 Max: 7593 Min: 0	8209.19 ± 5708.49 Max: 48561 Min: 134	4301.55 ± 3318.23 Max: 16229 Min: 463	2119.5 ± 1453.49 Max: 5928 Min: 309	4920.77 ± 3162.86 Max: 11919 Min: 0	8872.51 ± 7318.32 Max: 53043 Min: 897	5218.48 ± 4138.55 Max: 17260 Min: 224	2206.75 ± 2808.30 Max: 7131 Min: 92	4263.91 ± 3572.1 Max: 5401 Min: 0	11099.1 ± 6855.68 Max: 27926 Min: 224	6665.7 ± 4991.89 Max: 20086 Min: 1649
Turbidity (NTU)	6.54 ± 5.38 Max: 49.3 Min: 0.4	18.80 ± 19.38 Max: 71.9 Min: 0.5	9.79 ± 15.51 Max: 68.6 Min: 0.0	7.11 ± 6.88 Max: 22.3 Min: 0.0	13.96 ± 21.86 Max: 108.2 Min: 0.5	20.56 ± 18.57 Max: 71.2 Min: 1.1	10.46 ± 14.25 Max: 69.0 Min: 0.0	9.93 ± 7.74 Max: 41.9 Min: 1.0	73.59 ± 162.85 Max: 614.9 Min: 1.9	23.65 ± 22.69 Max: 268.4 Min: 2.6	13.9 ± 15.0 Max: 113.3 Min: 0.0	25.72 ± 21.61 Max: 72.6 Min: 3.8

Temperature and Dissolved Oxygen

Heat in water, measured as temperature, is primarily derived from incoming solar radiation absorbed by water molecules, dissolved organic compounds, turbidity, and other physiochemical properties in the impinged water. Average water temperatures in Grand Lake range from 6.4°C in the winter to 28.4°C in the summer, as shown in **Table 3.4.1.2.3-2**. Water temperatures can vary both spatially and temporally within the reservoir. Spatially, water temperatures in the spring are cooler in the lacustrine zone, warmer in the riverine zone, and vice versa in the fall. This phenomenon is likely the result of differences in water volume as the high specific heat of water buffers temperature changes between the riverine and lacustrine areas of the lake (Grand River Dam Authority, 2017a).

The Grand Lake water column mixes at or above 4°C in the winter and is thermally stratified during the late spring, summer, and early fall, as shown in **Table 3.4.1.2.3-3** (Nicolai, S.J. and A.R. Dzailowski, 2014). Thermal stratification is observed in late April/early May as the day length increases past the spring equinox and the lake surface water absorbs solar energy and dissipates it as heat. As the surface water absorbs the solar energy, the water layers where light is extinguished remain the same temperature or increase at a slower rate. This uneven heating of the water creates a temperature and density difference at depth; forming a stratified epilimnion, which is a surface is characterized by increased water temperature, pH, and DO due to its exposure to the air, wind mixing, and photosynthesis. The hypolimnion is characterized by cooler, denser water isolated from the surface, receiving no wind mixing and not enough light for photosynthesis. Thermal stratification typically dissipates by November (Grand River Dam Authority, 2017a).

Table 3.4.1.2.3-3 Mean Surface Temperature, Thermocline, and Anoxic Depth for Grand Lake from June to October 2011

Date	Mean Surface Temperature (°C)	Thermocline Depth (m)	Anoxic Depth (m)	Secchi Disk Depth (m)
June 6	29.9	2.2	27.0	-
June 21	25.4	9.8	15.3	-
July 5	29.6	12.4	11.2	1.2
July 19	31.9	10.8	7.3	1.1
August 1	32.5	10.0	6.9	1.3
August 17	28.3	12.2	11.3	-
September 7	26.8	15.4	15.2	1.7
September 23	22.8	19.5	17.9	-
October 14	21.6	23.0	19.3	2.0
October 28	18.5	-	27.6	1.3

Source: (Nicolai, S.J. and A.R. Dzailowski, 2014)

Solar radiation variability and heat directly influences the DO dynamics of Grand Lake. As with temperature, DO varies temporally over the course of the year. In the winter, DO is generally at or near saturation in a fully mixed water column as heat is evenly distributed. Due to lack of light and heat, photosynthesis rates and biomass of algae are low while respiration rates and oxygen consumption by bacteria are reduced. As the amount of solar radiation increases from winter to spring, production by algae and respiration rates increase. DO is the byproduct of photosynthesis and reaches levels exceeding the saturation point of the water in the epilimnion. In the denser, cooler, and isolated water in the hypolimnion, microbial detritivores continue to break down the abundance of allochthonous material derived from the large agricultural watershed upstream of the lake, which deletes oxygen in this water layer until the lake mixes in October and November (Grand River Dam Authority, 2017a).[39]

pH, Alkalinity and Hardness

The underlying geology of the area influences the pH in Grand Lake and the Grand River. Hydrogen ion activity, measured as pH, is decreased from neutrality in Grand Lake as the result of the dissolution of carbonate rich minerals, including limestone and dolomite, within the watershed. Grand Lake is a bicarbonate-type lake with moderately hard to hard water as a result of the dissociation equilibrium of carbonate minerals within the watershed. The total alkalinity, or acid neutralizing ability, of Grand Lake water is generally in a desirable range of 80-125 mg/L. Total hardness on Grand Lake ranges from moderately hard to hard, which indicates an abundance of cations. (e.g., Ca^{+}, Mg^{2+}) (Grand River Dam Authority, 2017a).

The acidity as measured by pH in Grand Lake ranges from neutral to alkaline, as shown in **Table 3.4.1.2.3-2**. During summer stratification, pH in the epilimnion may temporarily deviate from the state standard of 9.0 during periods of intense photosynthetic activity caused by seasonal algal blooms typical of large, eutrophic, warm-water reservoirs. The pH in the hypolimnion is consistently near neutral at 7.0 (Grand River Dam Authority, 2017a)

Nutrients

The overall driver of nutrient input into Grand Lake is the Neosho River, followed by the Spring and Elk Rivers. Internal phosphorus loading generally occurs from July through September and causes a notable late-summer boost to phosphorus concentrations within the reservoir upon late summer thermocline erosion (Grand River Dam Authority, 2017a). Based on current nutrient levels, Grand Lake is classified as eutrophic.

Nitrogen and phosphorus are important in driving the productivity of the system. However, an excess of nutrients can lead to negative consequences such as unsightly and/or toxic algae blooms, taste and odor issues for municipal drinking water customers, and general stress to aquatic communities. Anthropogenic nutrient sources are derived from agricultural runoff (e.g., fertilizer, manure), municipal sources (e.g., wastewater treatment), and industrial activities (e.g., poultry rendering) (Grand River Dam Authority, 2017a).

Phosphorus is measured in the form of total phosphorus (TP) and orthophosphorus. In Grand Lake, TP and orthophosphorus vary spatially and temporally, as shown in **Table 3.4.1.2.3-2**. Phosphorus concentrations decrease longitudinally along the river/reservoir gradient as the result of desorption from clay particles and uptake of phosphorus by algae.

[39] Allochthonous material is sediment or rock that originated at a distance from its present location.

Nitrogen as an element is available as dissolved gas (N_2), nitrate (NO_3), nitrite (NO_2), and ammonia (NH_3). In Grand Lake, Total Nitrogen ranges from 0.5-2.25 mg/L with the highest concentrations occurring in the spring and in the upper portions of Grand Lake. The same temporal and spatial variability occur with nitrate-nitrite and ammonia concentrations (Grand River Dam Authority, 2017a).

Heat and DO levels also play a role in the biochemical cycling of nutrients in Grand Lake. Specific processes including internal phosphorus loading, denitrification, and nitrification all contribute to available nutrients for algal growth and production. Following the consumption of nitrate-nitrite, internal release of phosphorus occurs under anoxic condition. In cold months, Grand Lake is mixing; both nitrogen and phosphorus are evenly distributed in the water column similar to DO. Under stratified conditions, oxygen depletion from aerobic respiration leads to anaerobic respiration in the hypolimnion. Denitrification, the process of microbial-mediated nitrate reduction, forms nitrogen gas and as a result, nitrate-nitrite in the hypolimnion is depleted. As redox conditions continue to fall and following the extirpation of nitrate, anaerobic bacteria begin to use iron as in their respiration chain, causing the release of iron-bound phosphate back into the water column. Furthermore, the breakdown of organic nitrogen in sediment detritus causes the increase in ammonia through ammonification. Upon thermocline erosion and mixing in the fall, these nutrients upwell from the hypolimnion, giving a late-season pulse of nutrients to an otherwise nutrient limited water column following the summer algal peak (Grand River Dam Authority, 2017a).

Bacteria

Fecal indicator bacteria are used to monitor water quality and protect recreational uses of the water. **Table 3.4.1.2.3-2** summarizes seasonal data on bacteria levels collected during routine sampling around Grand Lake. GRDA collects *E. coli* samples during the recreation season. GRDA currently voluntarily implements guidelines in its "*Bacteria Management Plan for Designated Swimming Areas in the Grand River Watershed*" for body contact in the designated swimming areas and parks in cases where bacteria sources can be ascertained to further protect and assess risk to health and public safety. The guidelines specify GRDA will actively investigate any reported illness associated with designated swimming areas in the waters and continue to monitor heavily used coves. In the event of contamination, GRDA developed steps in collaboration with other relevant state agencies to better assess risk to health and public safety and to determine and manage the sources of fecal contamination, which were based on the EPA's recreational water quality criteria, OWQS, and recommendations developed by interagency working groups (Grand River Dam Authority, 2015).

3.4.1.2.4 Metals/Tri-State Mining District

The TSMD, as described in Section 3.3.1.8, includes Tar Creek and the Tar Creek Superfund site which are located in the towns of Pitcher and Cardin, Oklahoma. Tar Creek is a tributary to the Neosho River at RM 142. Mining left behind tailing piles and cavernous subterranean mines which have leached Cd, Pb, Zn, and other metals into nearby groundwater, streams, and rivers. Tribal, state, and federal agencies continue to conduct cleanup and research efforts throughout the TSMD. Extensive data is available from the 1970s to the present day, which indicate the relative impact of the TSMD on Grand Lake water, sediment, and wildlife is limited (Grand River Dam Authority, 2017a).

Water Contamination from Tar Creek Superfund Site

The Neosho River and Spring River upstream of the Project vicinity, as well as Grand Lake, are on the ODEQ impaired water list for total recoverable lead (Oklahoma Department of Environmnetal Quality, 2022).

Toxicity Investigations

The effect the TSMD metals contamination has had on organisms is well documented and primary impacts have been upstream of the Pensacola Project. In areas near abandoned mines and mine waste piles within the TSMD, cases of acute and chronic toxicity to both terrestrial and aquatic wildlife are found. Canada geese collected from mine waste ponds experience elevated lead concentrations. Crayfish at sites affected by mining have shown decreased population densities and increased metals concentrations (Grand River Dam Authority, 2017a).

Many investigations into the effects of mine waste and runoff in organisms in Grand Lake have been completed over the past 30 years. McCormik extracted Grand Lake sediments at a pH of 6 for use in Daphnia bioassays and found no acute toxicity (McCormik, C.A., 1985).

An EPA Phase 1 study which evaluated overall toxicity in the area of the superfund site concluded there were no significant toxic effects upon sensitive species of small fish or micro-crustaceans exposed to water samples collected from Grand Lake. Furthermore, the study concluded the contaminants of concern appear to be chemically bound to sediments since toxic concentrations of metals could not be extracted under conditions that occur naturally in the lake. This study provided additional analysis on organism’s chronic exposure to Cd, Pb, and Zn by evaluation of 40 sediment samples from Grand Lake. The researchers concluded the lake sediments were likely not causing or substantially contributing to toxicity of sediment dwelling organisms (Grand River Dam Authority, 2017a).

In 2013, Oklahoma State University (OSU) and GRDA investigated toxicity of amphipods (*Heilisoma azteca*) and pond snails (*Heilisoma trivolvis*) in near shore sediment under conditions that would simulate sediment disturbance (e.g., wave action and dredging). In the EPA Phase 1 study, it was hypothesized sediment disturbance could cause the release of toxic concentrations of metals. Researchers from OSU and GRDA found survival and biomass, under both disturbed and undisturbed conditions, did not exhibit any significant differences between contaminated (Neosho, Spring, and Grand Rivers) and uncontaminated reference sites (Elk River) (Grand River Dam Authority, 2017a).

In summary, research spanning past decades indicated no acute or chronic toxicity as a result of metals contamination within Grand Lake. The result of the studies is consistent with expectations. Based on Grand Lake water chemistry including pH, hardness, and the presence of anoxic sediments, bioavailability of metals would be expected to be low (Grand River Dam Authority, 2017a).

Lead Fish Consumption Advisories

In 2007, ODEQ issued a fish consumption advisory due to lead levels for waters affected by runoff from the TSMD, including Grand Lake. Carcass preparations (i.e., skin-on, headless, eviscerated fish, with bones) of non-game fish (i.e., carp, freshwater drum, redhorse sucker, and smallmouth buffalo) from the Neosho River and Grand Lake; and catfish, non-game fish, and sunfish in the Spring River have led to concentrations high enough to warrant consumption restriction recommendations. Skinless fish fillets, the most common preparation type, are safe to eat from the Neosho River and Grand Lake. However, consumption of skinless fillets from non-game fish from the Spring River should be limited (Grand River Dam Authority, 2017a).

Mercury Fish Consumption Advisories

Mercury (Hg) contamination in fish is observed worldwide. Mercury is released through various anthropogenic and natural processes. Upon deposition from the atmosphere, mercury runs off into lakes, rivers, streams, and oceans. Chemical changes in the water alter the bioavailability of the deposited Hg to methylmercury (MeHg), which is taken up into the food chain where it biomagnifies in predators (Grand River Dam Authority, 2017a).

In 2011, seasonal Hg and MeHg dynamics were studied in Grand Lake. Researchers found Hg concentrations were driven by high inflow conditions. During low-flow conditions, biogeochemistry of the system controlled MeHg enrichment, sequestering both Hg and MeHg. This suggested Grand Lake sequesters watershed derived Hg inputs for reservoirs downstream. Furthermore, this research suggested Hg exposure to organisms is greatest during floods and in the upper reaches of the reservoir as most Hg enrichment occurs in deep anoxic waters that are not conducive to supporting life (Grand River Dam Authority, 2017a).

Between April 2010 and February 2013, 1,300 fish representing 30 species were collected from Grand Lake, Lake Hudson, and nearby farm ponds. Researchers found with the exception of Gar, mean Hg levels for all species were below EPA’s fish tissue residue criterion and wildlife criterion values. When compared to other Oklahoma lakes Hg tissue concentrations in Grand Lake were far below the Oklahoma average (Grand River Dam Authority, 2017a).

3.4.1.3 Flood Control

3.4.1.3.1 History of Flooding in the Basin

GRDA compiled a complete history of flooding in the Project vicinity upstream of the Pensacola Dam, which is provided in **Appendix E-10**. There is a long history of flooding along the Grand (Neosho) River and its tributaries prior to the creation of the Pensacola Dam and the River has cycled through flooding and drought for millennia.[40] The archaeological record of Indigenous people who lived in the watershed in Kansas, which includes the tributary Cottonwood River, indicates many groups moved seasonally from semipermanent settlements in the floodplain to higher locations, depending on the

[40] The Grand (Neosho) River is commonly known as the Neosho River in Kansas and the Grand River (not to be confused with the Grand River in Missouri) when referring either to the watercourse south of the Oklahoma–Kansas state line or the junction with the Spring River south of Miami, Oklahoma. For consistency with the name of the Grand River Dam project currently under relicensing, we use Grand River here but note that both historical and contemporary sources use either or both variously.

season and level of the river.[41] As growing numbers of non-Indigenous people forced Indigenous people off their traditional lands and onto reservations over the course of the nineteenth century, people of mostly European descent entered and occupied the area that would become Kansas and Oklahoma. Many settled permanently in the Neosho floodplain to take advantage of the rich agricultural and grazing lands they found there; others populated growing communities and towns where they established or worked for the businesses, schools, churches, and other organizations that supported their economy.

Along the entire course of the Neosho River and its many tributaries, non-Indigenous farmers, industrialists, and townspeople alike found themselves occupying land subject to almost annual flooding—sometimes, multiple times per year—that varied from nuisance water on fields or in basements to floods of epic and disastrous proportions. So too, these people grappled with periods of extreme drought in which rivers, creeks, and smaller waterbodies would dry up, creating shortages of fresh water because the remaining water was often polluted with raw sewage and other waste. Although extreme weather events compelled some people to give up and move away, most non-Indigenous people who settled along the Neosho and its tributaries resigned themselves to coexisting with the cycle of flooding and drought. Individuals, local groups, municipalities, state officials, and eventually, federal agencies participated in flood-control measures in the area that became Kansas and Oklahoma. Indeed, flood control features became and remain ubiquitous for those living and working along the Neosho River.

Documents from the time of non-Indigenous settlement of the area indicate the Neosho River experienced “seasons of flood” along its course almost every year since documentation began.[42] Weather patterns in the watershed and the geology of the riverbed and its surrounding environment both contribute to the regular flooding. The area is “subject to intense single storms over limited areas, as well as to general storms over large portions of the watershed.”[43] Both types of storms can cause channel overflow on limited reaches of the river or flood conditions over extensive portions of the river valley. As a result, a flood or floods occurred somewhere on the Neosho River or one of its tributaries most years on record; however, these floods varied in location and magnitude. A 1935 USACE report noted the difference in flood frequencies in the Grand (Neosho) River watershed between the reaches above and below the mouth of the Spring River just south of Miami, Oklahoma. As the report explained, this difference was due to two conditions. One was “the fact that due to the

[41] Arthur H. Rohn and Alice E. Emerson, “Great Bend Sites at Marion, Kansas,” *Wichita State University Publications in Anthropology* No. 1, 1984, quotation on 15. On file at Iola (Kansas) Public Library.

[42] Quotation from Defence of Western Frontier, Letter from the Secretary of War, in Reply to the Resolution of the House of Representatives of the 24th Ultimo, Relative to the Plan Proposed for the Defence of the Western Frontier; also, What Tribes of Indians Inhabit the Country Immediately West of Arkansas and Missouri, April 1, 1840, 2, Referred to the Committee on Military Affairs, April 1, 1840, 26th Congress, 1st Session, Serial Set Vol. No. 366, Session Vol. No. 4, House Doc. No. 161. See also Grand (Neosho) River, Okla., Watershed, Adjacent Area, and Details of Lower Grand River Valley,” map, October 1938, Appendix 1 of S. L. Scott, Lt. Chief Engineer, Little Rock District, to Chief of Engineers (via Southwestern Division), *Report on Survey of Pensacola, Markham Ferry, and Fort Gibson Reservoir Sites, Grand (Neosho) River, Okla.*, October 29, 1938, House Document No. 107, *U.S. Congressional Serial Set* (Washington, DC: GPO, 1939): 1–[viii]. The Grand River moves from north to south through Marion, Lyon, Coffey, Woodson, Allen, Neosho, Labette, and Cherokee Counties in Kansas, and Craig, Ottawa, Delaware, Mayes, Wagoner/Cherokee, and Muskogee Counties in Oklahoma. General statements about flooding frequency in this paragraph is based on reviewing and cataloging numerous sources (including historical society manuscript and photograph collections, newspapers, federal and state agency reports, and other relevant documents) gathered in Kansas and Oklahoma, as well as through databases and online sources such as newspapers.com, HathiTrust, the *Congressional Record*, and so on.

[43] *Grand (Neosho) River and Its Tributaries*, *Oklahoma*, *Kansas*, *Missouri*, *and Arkansas*, February 19, 1946, reprinted with correspondence in *U.S. Congressional Serial Set* (Washington, DC: GPO, 1948): 1–71, quotation on 23. According to this report, “a total of 62 storms having an average rainfall over a major division of the watershed of 3 inches or more in the period January 1900 through June 1944, with 53 of these storms having an average rainfall over the entire watershed of 3 inches or more” (19–20).

large amount of channel storage in the Kansas [and far northeastern corner of Oklahoma] area[s], flood flows in the upper reach are reduced in peak flow with consequent increase in duration."[44] The other was "the large channel capacity in the main stem below the mouth of Spring River," which made it "capable of carrying any flood from the Kansas area without overflow except when augmented by a considerable flow from Spring and Elk Rivers and other tributaries in Oklahoma."[45] The Corps estimated that floods above the mouth of Spring River occurred "with an average frequency of one major flood every 7 years; one moderate flood every 2 years; and one minor flood per year." As one person explained, the area around Miami, had "been inundated by every major flood on the Neosho River before [Pensacola Dam] was built."[46] By comparison, the Grand (Neosho) below the mouth of the Spring River only experienced about "one major flood every 10 years, one moderate flood every 4 years, and one minor flood every 2 years."[47] Statistically, the area around Miami has suffered more flooding than other, nearby reaches of the Neosho River. This increased probability of flooding predates the existence of Pensacola Dam.

As shown in the long and storied historical flood chronologies contained in **Figures 3.4.1.3.1-1** through **3.4.1.3.1-7**, the historical record indicates that especially disastrous floods at various locations in the Neosho River watershed occurred in 1826, 1844, 1885, 1895, 1902, 1903, 1904, 1909, 1927, 1941, 1943, 1948, 1951, 1986, and 1993. Specifically in the two southernmost Kansas counties, Neosho and Labette, and the two northeastern most Oklahoma counties, Ottawa and Delaware, the worst years were 1826, 1844, 1895, 1902–1904, 1917–1918, 1922, 1928, 1941, 1943, 1948, 1951, 1986, 1993, and 2007. During the nearly 200-year period outlined in the chronology, a major flood recurs about every other year.

[44] Report of the Division Engineer, *Arkansas River and Tributaries*, *3 Vols*., *Report of Corps of Engineers*, part 10, House Document No. 308, reprinted with illustrations in *U.S. Congressional Serial Set* (Washington, DC: GPO, 1936): 1215–341, quotation on 1231. Although the report refers to valley storage in "Kansas" and does not specify the small section of watershed in northeastern Oklahoma above the Spring River, the division of the river into two distinct reaches divided at the mouth of the Spring in the report and the similarity in topography around the Grand River between southeast Kansas and northeast indicates that this description of "Kansas" should include the small section of the river in Oklahoma north of the Spring.
[45] Report of the Division Engineer, *Arkansas River and Tributaries* 1230–231.
[46] Walter C. Burnham to Douglas G. Wright, Administrator, July 28, 1947, Operation Grand River Dam Project, GRDA-HQ.
[47] Report of the Division Engineer, *Arkansas River and Tributaries*, 1231.

Figure 3.4.1.3.1-1 Historical Flood Chronology 1826-1889

Neosho River Watershed Flooding Chronology

Year	Event
1826	Kansas climatologist T. B. Jennings described flooding on the Neosho in 1826 as "**carrying away wigwams, houses, and gathered and ungathered crops**."
1836	According to accounts gathered in the Coffey County Historical Society,(CCHS) Sac and Fox chief Soconut, "**swam his horse from bluff to bluff** (Indian Hill to Ottumwa Hill)" during the 1836 Neosho flood.
1844	Superintendent Thomas H. Harvey arrived at the Osage Sub Agency on May 22, 1844, where he found the Neosho, "very high, having overflowed its banks and covered the bottoms to a considerable depth, . . . **in most places more than a mile wide**."
1854	According to residents of Osage Mission (later St. Paul), the flood that year was a "**record breaker**."
ca. 1855-1856	"Spring rains sent the Neosho River out of its banks, flooding lowlands all through the area that was to be colonized [by a group of vegetarians." (*Iola Register*)
1857	A compilation of historical information from Emporia and Lyon Counties, Kansas, reported, "**A destructive flood swept down the Neosho**, carrying with it wigwams, houses and crops."
1865	*Neosho County Journal (NCJ)* described the Neosho as "very high."
1866	Neosho Indian Agent, G. C. Snow, reported that the Quapaws had suffered "severely" in 1866 "for food and clothing. Their crops were quite **all destroyed last year by the floods**"
1867	Neosho "overflow" in early July. *(NCJ)*
1868	Neosho "**overflowed for several days** during the first part of September." *(NCJ)*
1869	Neosho"**rose twenty feet in nine hours** and washed the ferry boats away." July saw the region "**submerged with the highest water in fifteen years**," with the Neosho "**rushing along over a stretch a mile in width**." *(NCJ)*
1870	A "small flood" occurred in late October. *(NCJ)*
1871	In July, the Neosho valley was flooded. *(NCJ)*
1873	Neosho was "very high" and had flooded the Osage Mission fairgrounds. *(NCJ)*
1875	A "small flood" occurred in August. *(NCJ)*
1876	Another "small flood" occurred in May. *(NCJ)*
1877	May 1877 flood was one "which makes the traditional oldest inhabitant shrug his shoulders and scratch his head, and reluctantly admit that he '**never did saw anything like it in these parts afore**.'" *(Marion County Record)*
1878	The Neosho **washed out the railroad track** "again." *(NCJ)*
1881	Another flood on the Neosho. *(NCJ)*
1884	"Big flood; no mail for four days" in May and another Neosho overflow in October. *(NCJ)*
1885	A 1948 Kansas State Board of Agriculture climate report noted that the July 1885 flooding of the Neosho was "**one of the greatest on record**" at Burlington and "**also close to the highest water ever known**" at Oswego.
1888	Chanute resident and weather watcher, Henry Stoelzing, reported a Neosho flood that year.
1889	Neosho "**was five miles wide at Humboldt**" during the 1889 flood. *(Spirit of Kansas)*

Figure 3.4.1.3.1-2 Historical Flood Chronology 1890-1909

Neosho River Watershed Flooding Chronology

Year	Event
1890	Three separate Neosho floods at Chanute in 1890, with the highest in November. (Stoelzing)
1891	***City of Miami founded within Indian Territory.***
1891	According to a history of Emporia and Lyon Counties, in June 1891, the water was **within three inches of the 1877 high mark**.
1892	***First levees built on the Neosho in Neosho County.***
1892	Neosho had "**been out of its banks for the past week, and within two feet of the 1885 marks**. Much wheat has been destroyed." *(NCJ)*
1894	Neosho was "very high" that spring. *(Terral Times)*
1895	The U.S. Army Corps of Engineers (Corps) called the 1895 flood, "**one of the greatest floods**" in the history of the Neosho River valley. Originating in southern Kansas, the flood "was constantly augmented in crest flow as it traveled downstream throughout the Oklahoma reach, where it caused exceptionally high stages at Wyandotte as well as at Wagoner." **The Corps estimated the peak discharge at Grove at 250,000 cfs**.
1896	"Rising" Neosho was expected to cause "much damage" at Humboldt in late May. *(Tecumsah Herald)*
1898	"Average-size flood" lasted approximately a week in May. *(NCJ)*
1899	Neosho was "out of its banks . . . and steadily rising," with levees breached "in several places," the bottom lands flooded "for miles up and down the river," and the water **nearly reaching the height of the 1885 flood**. *(Kansas City Star)*
1900	Flood in Chanute lasted seven days in September. (Stoelzing)
1901	***St. Louis–San Francisco Railway ("Frisco") railroad truss bridge constructed over the Neosho in Miami.***
1901	As reported in a local history, on April 13 the Cottonwood River south of Emporia was a mile wide and **the Neosho up 22 feet**.
1902	Neosho "reached the highest mark this morning and is still rising. . . . The river is a **mile wide**." *(Oklahoma City Weekly Times Journal)*
1903	"Floods in Indian territory have delayed traffic on the railroads seriously." Neosho was **three miles wide** in some locations and "covered with water [up] to ten feet deep. The Neosho river above Miami, I.T. has covered the prairie farms for miles south of the river's main channel." *(Guthrie Daily Leader)*
1904	Neosho inundated the new Miami toll bridge with "three feet of water. The freshet **ruined a thousand acres of corn**. Rural mail wagons cannot get one mile from the post office. The water reached within two feet of the Frisco bridge." *(Norman Democrat Topic)*
1905	"One of the heaviest rains known to the oldest settlers visited this section of the country Friday night. As a result, both the Neosho and Spring rivers were out of their banks." *(Miami Record-Herald [MRH])*
1906	Heavy rains "caused flood stages in a considerable portion of the Neosho River." *(Monthly Weather Review [MWR])*
1907	Neosho overflowed from January 18–24, 1907. *(NCJ)*
1908	**Flood stages at almost every location on the Neosho between Iola and Fort Gibson**. *(MWR)*
1909	Neosho and Cottonwood Rivers "**broke all previous records**" for flooding during the winter season. *(Topeka Capital)*

Figure 3.4.1.3.1-3 Historical Flood Chronology 1910-1932

Neosho River Watershed Flooding Chronology

Year	Event
1910	January floods again "**broke all records**" for winter flooding with ice dams causing flooding in the streets of Strawn. *(CCHS)*
1911	Flood at Lowell on the Spring River "**was worst ever experienced** at that place with the water nearly running over the dam." *(Galena Evening Times)*
1912	Neosho at flood stage "from Oswego southward, causing damage to crops and enforced suspension of business," and an estimated loss of $40,000. *(MWR)*
1912	***Missouri, Oklahoma & Gulf railroad bridge constructed over the Neosho.***
1915	Neosho on a "week's spree, a wild and reckless rampage, spreading ruin in its wake, overflowing its banks and surrounding territory. . . . **The city park is completely inundated**." *(MRH)*
1916	In June, the Neosho had been "in flood throughout its entire course in Kansas during the month. **In duration the flood was one of the longest on record**." *(MWR)*
1917	Tar Creek "on a rampage." *(MRH)*
1918	Heavy rain caused flooding in low places in the city, "and in many sections yards and streets were submerged. Water flowed over sidewalks in streams even in the high residence sections." *(MRH)*
1919	Workers building a new railroad bridge at Miami were discouraged from starting the job until "after the usual floods . . . had come and gone." *(MRH)*
1920	Neosho and Spring Rivers and Tar Creek, "[were] extremely high and [had] inundated the lowlands." *(MRH)*
1921	At their own peril, "hundreds of people" gathered at the South Main St. bridge to watch water "**14 feet above normal**" and a log jam wash out the approaches to the new bridge over the Neosho. *(MRH)*
1922	Due to heavy rains and flooding in Kansas, the Neosho was once again out of its banks at Miami where water "**entirely covered Riverview Park . . . and was flowing approximately two feet deep through the auditorium**." *(MRH)*
1923	1923 was a year of "outstanding floods" on the Neosho in both Kansas and Oklahoma brought on by "**four weeks of almost continuous and frequently excessive rains**" and with crest stages "**higher than any previously recorded**." *(MWR)*
1924	***Low dam at Riverview Park in Miami completed.***
1924	Crews repairing damages caused by fall and winter floods to the low dam and dance pavilion at Riverview Park were again facing setbacks due to the Neosho's rapid rise that spring. *(Miami News-Record [MNR])*
1926	"**Disastrous floods**" on the Neosho. *(MWR)*
1927	In April, the Neosho **rose 24 feet in the Miami area**, inundating highways and railroads, **causing 22 deaths**, and leading to an estimated half million dollars in damage. *(MNR)*
1928	Neosho was out of its banks in Iola and "from two to three feet over its banks in Coffey county, Parsons, and south to the Oklahoma line." *(Topeka Journal)*
1929	Neosho "flooding most of the bottom farms and causing considerable damage to growing crops."*(MNR)*
1930	June saw flood stages on the Neosho at Oswego and Fort Gibson. *(MWR)*
1931	Late fall rains caused "moderate" floods on the Neosho, which achieved flood stages at Le Roy, Iola, Chanute, Parsons, and Oswego. *(MWR)*
1932	"Young men with a knack for doing dangerous tricks" were riding logs on the Neosho over the "inundated" low dam in Miami "during its perilous flood stage." *(Miami Daily News-Record [MDNR])*

Figure 3.4.1.3.1-4 Historical Flood Chronology 1933-1946

Neosho River Watershed Flooding Chronology

Year	Event
1933	Neosho flood waters had blocked highways in the Miami area in three directions; Ottawa County was expected to experience "**its highest water in several years**." *(MDNR)*
1935	***State of Oklahoma created the Grand River Dam Authority (GRDA).***
1935	***In 1935, the "largest truss span in Oklahoma" at the time, according to a history of Ottawa County, was completed over the Neosho at Miami (location of current Rte. 66 bridge at approximate corner of E and 3rd Streets SW).***
1935	"Disastrous floods" occurred on the Neosho. (Kansas State Planning Board)
1936	***Congress enacted the Flood Control Act of 1936, which authorized several levee projects along stretches of the Neosho in Kansas, as well as "preliminary examinations and surveys for flood control" at "Pensacola Reservoir, Oklahoma."***
1937	Two "moderate overflows" of the Neosho. *(MWR)*
1938	***Congress enacted the Flood Control Act of 1938, which authorized many projects, arguably including the Pensacola Dam, and required the Secretary of War to acquire title to all lands necessary for the authorized dam and reservoir projects.***
1938	"Big flood" of the Neosho reported in numerous news outlets in Kansas and Oklahoma.
1939	***The Federal Power Commission issued the original license for the Pensacola Project to GRDA.***
1939	***Iola levee operational.***
1940	***Congress enacted a special statute that granted GRDA title to all federal and Native American–owned lands in the Project area, up to elevation 750 feet.***
1940	***Pensacola Dam completed.***
1941	**Floods were "the rule, rather than the exception," in the Neosho watershed** from April to October, where flood stages were "reached or exceeded . . . every month during this period except in May." *(MWR)*
1941	***Congress enacted the Flood Control Act of 1941, which directed the Corps to provide flood control at Pensacola Dam.***
1941	***FDR's Executive Order 8944 directed FWA administrator to take over Pensacola Dam for the war effort.***
1942	On the Cottonwood and Neosho, "crest stages were generally 3 to 5 feet above bankfull" in June "with the **overflow lasting about a week**." *(MWR)*
1943	***1901 Frisco railroad truss bridge replaced with another with no trusses.***
1943	According to FEMA, the Neosho "rose to its crest stage above bankfull in 76 hours at an average rate of 0.13 foot per hour with a maximum rate of 0.6 foot per hour and remained above bankfull stage for about 11 days."
1944	Flooding broke "all known records at Chanute, Erie, and St. Paul, and at the highway bridge east of Parsons," with the Neosho "**one vast sea, in some places four or five miles wide**." *(Parsons Sun)*
1944	***Congress enacted the Flood Control Act of 1944, which again granted the Corps all flood-control responsibilities at the Project.***
1945	"Big flood" washed out a railroad track near St. Paul and water from the Neosho overtopped levees. *(NCJ)*
1946	Neosho reached flood stage at Oswego in January. *(MWR)*
1946	***Congress enacted special legislation that returned the Pensacola Hydroelectric Project to GRDA following World War II, and in doing so, confirmed ownership responsibilities related to the conservation and flood pools.***

Figure 3.4.1.3.1-5 Historical Flood Chronology 1948-1978

Neosho River Watershed Flooding Chronology

Year	Event
1948	According to gaging information, the two crests that occurred at Commerce in 1948 were the **third- and fourth-highest known floods**, respectively, in order of magnitude at that location (prior to 1969).
1949	"Minor flooding along the Neosho at various locations." *(MWR)*
1950	The Corps reported that heavy rainfall caused a spring flood on the Neosho.
1951	U.S. Geological Survey reported that the Neosho "reached **flood heights far in excess of any previously known** as result of heavy storms."
1954	According to a 1979 consultant's report on the Miami Area Comprehensive Plan, "major floods causing **extensive damage to Miami development** occurred."
1955	Gaging information recorded the Neosho at Commerce above the 15-foot flood stage.
1957	"Swollen Neosho river waters spread over farmlands and roads." (*MNR*).
1958	"Neosho was flooding from Burlington, KS, to its mouth, with four to five feet of flooding lowlands in Miami." *(Tulsa Tribune)*
1959	Flooding on the Neosho. (CCHS)
1960	Another Neosho flood. (CCHS)
1961	Gaging information recorded that the crest at Commerce was the **fifth-highest known flood in order of magnitude** at Commerce (prior to 1969).
1962	Four separate floods on the Neosho. (CCHS)
1964	***Council Grove Dam/Reservoir completed.***
1964	High floodwaters at the Third Ave. bridge and **Miami fairgrounds had been flooding for a few days**. *(MNR)*
1965	***John Redmond (Strawn) Dam/Reservoir completed.***
1965	Another Neosho flood. (CCHS)
1967	***New "fairgrounds" bridge constructed over Neosho at Miami immediately upstream from the 1921 concrete arch bridge, which it replaced.***
1967	Neosho crested near Commerce above flood stage. *(MNR)*
1968	***Marion Dam/Reservoir completed.***
1969	In Miami, the Neosho **flooded Riverview Park and closed the park road**. *(Daily Oklahoman)*
1970	"Neosho rampage." *(Parsons Sun)*
1971	"Minor flooding" on Neosho. *(Tulsa World)*
1972	Neosho 2 feet over flood stage at Commerce. *(Daily Oklahoman)*
1973	Neosho "did the expected" and overflowed into Labette County lowlands. *(Parsons Sun)*
1974	Due to flooding, "Miami's Fairground . . . could have accommodated a water polo match last week, or a racing meet for sea horses." (clipping, Dobson Museum)
1975	Neosho receding after a "hit-run" flood of from 3 to 4 feet. *(Parsons Sun)*
1976	"**At least 3 bridges across Neosho and Spring in Ottawa County were blocked**" due to flooding. *(Tulsa World)*
1977	"High water brought a halt" to construction near the Miami fairgrounds. *(MNR)*
1978	Neosho 3 feet over flood stage at Commerce and expected to crest at 5 feet over flood stage. *(Tulsa World)*

Figure 3.4.1.3.1-6 Historical Flood Chronology 1979-2007

Neosho River Watershed Flooding Chronology

Year	Event
1979	Neosho "spilling out of its banks . . . gorged by rain concentrations." *(Parsons Sun)*
1980	Neosho "takes generous swath of land near Chanute." *(Wichita Eagle)*
1982	"Pumped up by heavy rains," the Neosho overflowed in Labette and Neosho Counties; more flooding expected into NE Oklahoma. *(Parsons Sun)*
1985	Ottawa County declared a disaster area due to flooding. Neosho **crested 13 feet above flood stage at Miami, damaging 300 homes and dozens of businesses**. *(Daily Oklahoman/Times)*
1986	"**One of the worst floods ever experienced in Miami** resulted from days of record-setting rainfall." (Miami Kiwanis Club pamphlet)
1987	***Congress enacted Public Law No. 100-202, which directed the Corps to investigate solutions to flooding problems in the City of Miami, including the adequacy of the United States' easements for flood control at the Pensacola Project.***
1987	Runoff from Tar Creek flooded streets and "at least 10 houses" in Miami and the Neosho was expected also to flood. *(Tulsa World)*
1988	Neosho crested at Chanute 7.9 feet above flood stage. *(Chanute Tribune)*
1989	Neosho flooding near Parsons and at Oswego; at Chetopa, "**most of the city park near the banks of the Neosho was standing under water**." *(Parsons Sun)*
1990	Neosho caused the flooding of Miami's Riverview Park. *(Daily Oklahoman)*
1992	Rain "forced the Neosho River from its banks, causing flooding" and closing streets in Miami. *(Daily Oklahoman)*
1992	***FERC relicensed the Pensacola Project for a new 30-year term, maintaining that "The Grand Lake flood pool . . . is controlled by the Corps for flood control storage, as mandated by the Flood Control Act of 1944, and not subject to Commission authority."***
1993	Neosho crested 9.5 feet above flood stage at Miami, **covering nearly two dozen city streets with water**." *(Daily Oklahoman)*
1994	"In Miami, **30–35 homes were evacuated** as the Neosho River inched out of its banks . . . eight months ago, a flood prompted the evacuation of the same homes." *(Tulsa World)*
1995	Neosho floodwaters **closed State Highway 125 near Miami fairgrounds**. *(Grove Sun)*
1996	***Congress enacted the Water Resources Development Act of 1996, which directed the Corps to undertake a real estate adequacy analysis at the Pensacola Project and authorized the Corps to acquire additional acreage from willing sellers.***
1997	"Neosho River spilling out of its banks near Commerce." *(Daily Oklahoman)*
1998	"**Major flooding** along the Neosho River near Oswego." *(Iola Register)*
2000	***Congress enacted the Water Resources Development Act of 2000, which directed the Corps to purchase easements for lands adversely affected by backwater flooding at the Pensacola Project.***
2000	"Neosho "**came within a foot of homes" in Miami**. *(Iola Register)*
2002	"A two-day total of 2.84 inches of rain at Miami helped push the Neosho River out of its banks, sending it six feet above flood stage." (Oklahoma Climatological Survey)
2004	Neosho and Spring both above flood levels, "cutting off access to low-lying areas." *(Oklahoman)*
2007	Neosho **overflow "engulfed" Miami, flooding over 600 homes in Miami alone**. (Oklahoma Farm Bureau)

Figure 3.4.1.3.1-7 Historical Flood Chronology 2015-2019

Neosho River Watershed Flooding Chronology

Year	Event
2015	"Moderate" flooding of Neosho near Commerce. (National Weather Service)
2018	***Congress enacted the Water Infrastructure Improvements for the Nation Act, which directed the Corps to convey to GRDA all property interests of the United States at the Pensacola Project, while retaining the Corps' exclusive jurisdiction over flood control.***
2019	Neosho had its eighth-highest crest at Commerce since 1940 with **Miami hit hard by a "record-breaking" flood**. *(Joplin Globe)*
2019	***Congress enacted the National Defense Authorization Act for Fiscal Year 2020, which Congress confirmed the Corps' exclusive jurisdiction over flood control at the Pensacola Project, prohibited other agencies from regulating water surface elevations, and defined the FERC-licensed project to consist only of lands within the then-current Project boundary.***

Less is known about the exact locations of the 1826 and 1844 floods than later ones, but by all accounts, they were of epic proportions. A Commissioner of Indian Affairs' 1826 annual report and a later chronicle of the history of what is now Neosho County indicate that the flood likely caused the greatest damage in present-day southeastern Kansas and northeastern Oklahoma.[48] Later reports locate the 1844 flooding variously in today's Woodson, Coffey, and Neosho Counties, but contemporary evidence shows that Neosho County was hard hit. According to Superintendent Thomas Harvey, when he arrived at the Osage Subagency on May 22, 1844, the Grand was "'very high, having overflowed its banks and covered the bottoms to a considerable depth, which [made] the river in most places more than a mile wide'"[49]

Starting with the "unusually high and destructive" 1885 flood, reporting on Grand River floods began to increase considerably.[50] Thereafter, federal and state flood reports and state and local news coverage reveal the sheer volume of overflows that people in the watershed endured. Year after year, floods in the Neosho River watershed inundated towns, farms, homes, and businesses; destroyed roads, railroads, bridges, and other infrastructure; and caused countless dollars in damages and often deaths. The September 1895 flood hit Neosho Falls, Emporia, Strawn, and Chetopa, Kansas, especially hard; in December that year, the flood "was confined largely to the Grand (Neosho) River Valley in Oklahoma."[51] The years from 1902 through 1904 saw a series of disastrous floods along the Grand and its tributaries from one end to the other, as well as along many other Kansas rivers. One account of the June 1903 flood in Indian Territory noted that the "Grand river . . . is three miles wide and the valley farms are now covered with water [up] to ten feet deep. The Neosho river above Miami, I.T. has covered the prairie farms for miles south of the river's main channel."[52] One year later, on June 7, 1904, the Grand was "two feet over the wagon bridge" in Miami; only ten days after that, the river was "higher than ever before known here. . . . Three miles above town, the river is six miles wide."[53]

[48] United States, Office of Indian Affairs Annual Report of the Commissioner of Indian Affairs, for the Years 1826–1839 ([1826–1839]), 1834, Report No. 474, Regulating the Indian Department, esp. 114, retrieved from https://search.library.wisc.edu/digital/A3YVW4ZRARQT7J8S; and William W. Graves, *The First Protestant Osage Missions*, *1820–1837* (Oswego, KS: Carpenter Press, 1949). See also James O. Wright and Charles G. Elliott, *The Prevention of Injury by Floods in the Neosho Valley*, Kansas, U.S. Office of Experiment Stations Bulletin No. 198 (Washington, DC: GPO, 1908); U.S. Army Corps of Engineers [USACE], Tulsa District, *Flood Plain Information: Neosho River and Tar Creek*, *Miami*, *Oklahoma* (Tulsa, OK: The District, 1969); and Kansas State Board of Agriculture, *Twenty-First Biennial Report*, *for the Years 1917 and 1918* (Topeka: Kansas State Board of Agriculture, 1919).

[49] In 1844, the Osage Subagency was located on the Grand River in southeastern Kansas likely near what is now St. Paul (once Osage Mission), Kansas in Neosho County. Harvey quoted in Louise Barry, comp., *The Beginning of the West: Annals of the Kansas Gateway to the American West*, *1540–1854* (Topeka, KS: Kansas State Historical Society, 1972), 513. See also Edward Charles Murphy and Others, *Destructive Floods in the United States in 1904*, U.S. Geological Survey Water Supply and Irrigation Paper No. 147, Series M, General Hydrographic Investigations, 15, 58th Congress, 3rd Session, Serial Set Vol. No. 4877, Session Vol. No. 98, House Document 464 (Washington, DC: GPO, 1905); H. A. Rice and Roger C. Rice, "The Relation of the Kansas Water Commission to the Flood Problem of Kansas," paper read before the Kansas Engineering Society, Tenth Annual Meeting, January 15–16, 1918, Lawrence, Kansas (Topeka, KS: W. R. Smith, 1918), 7; "Flooding of the Neosho River," comp. Erin Burdick, undated typescript [ca. 2019], on file at Coffey County Historical Society, Burlington, Kansas; Kansas State Board of Agriculture, *Twenty-First Biennial Report*, *for the Years 1917 and 1918*; William W. Graves, *Annals of Osage Mission* (repr., St. Paul, KS: Graves Memorial Library, 1987); "The Neosho River Watershed—Center of Worst Kansas Flood—That of 1844—1951 Flood Losses," in Ralph Richards, *What Are We Going to Do About It?* (n.p.: s.p., [1952]), 16–17; and USACE, *Flood Plain Information*.

[50] Wright and Elliott, *Prevention of Injury by Floods*, 11.

[51] *Report on Survey of Pensacola . . . Grand (Neosho) River*, *Okla*., October 29, 1938, House Document No. 107, 2. See also *Grand (Neosho) River and Its Tributaries*, 27; and J. L. Schley, Maj. Gen., Chief of Engineers, to Congress, Re: Grand (Neosho) River, Oklahoma, Markham Ferry and Fort Gibson Reservoirs, January 12, 1939, included in the full publication of House Document No. 107.

[52] "Railroad Traffic Delayed," *Guthrie (OK) Daily Leader*, June 1, 1903.

[53] "Toll Bridge in Danger," *Norman Democrat-Topic*, June 17, 1904, 2. See also "The Neosho River," *Vinita (OK) Daily Chieftain*, June 7, 1904, 3; "Some Water Marks," *(Bartlesville*, *Indian Territory) Weekly Examiner*, June 11, 1904, 1; and "Neosho Is High," *Hennessey (OK) Eagle*, June 16, 1904, 2.

Historical documents compiled to date indicate that the Grand River flooded all but nine of the sixty years from 1905 to 1965. The worst floods during this period occurred in 1909, primarily on the Cottonwood and Grand Rivers in Kansas; and 1917/1918 and 1928 on the Grand River and Tar Creek in Oklahoma; and 1927, 1941, 1943, 1948, and 1951 in both states. Accounts of the rise and fall of the Grand and its tributaries in southeastern Kansas and northeastern Oklahoma repeat the superlatives of similar events and damages incurred between 1885 and 1904. The July 1909 flood of the Cottonwood and Grand in Kansas, for example, was “as high as ever reported,” and the second flood that year, in November, broke “all previous records” for the fall season.[54] In June 1917, Tar Creek went on a “rampage,” flooding Picher, Oklahoma. November the next year witnessed the Neosho River and Tar Creek again overflowing their banks, spilling water into Miami, and “completely” submerging Picher.[55] In spring 1927, the river again overflowed its banks in both Oklahoma and Kansas, with “mad flood waters” inundating the bottomlands of most of the watershed from Iola to Miami. The flooding marooned “scores of motorists” trying to cross the Neosho (Grand) River at Miami, where the bridge was covered in water that had “attained [its] highest level in 23 years.”[56] Another flood in June 1928 covered large portions of Miami.[57]

In 1941, flooding caused heavy losses along the Grand River’s entire course. As one report described, floods were “the rule, rather than the exception” from April to October that year, with flood stage being “reached or exceeded” in every month except May.[58] Two floods in October 1941 saw the Grand “on spree again.” In early October, floodwaters all but surrounded Wyandotte, Oklahoma, cutting it off from the rest of Ottawa County; later October found the Grand River, Spring River, and others “spreading havoc” across Oklahoma generally.[59]

Both the Spring and Grand Rivers flooded again in May 1943. At 23.95 inches of rain that month, Miami experienced the “greatest monthly amount recorded at any station in the state.”[60] The Miami Public Utility Board superintendent noted that the water level, which reached the racetrack, exhibit

[54] Quotations from, respectively, Cottonwood and Neosho Rivers Flood Valleys,” *Topeka Capital*, July 10, 1909, and “Neosho and Cottonwood Rivers Raise 18 Feet,” *Topeka Capital*, November 15, 1909, both in [Collection:] Floods in Kansas, Clippings, Vol. 7, Kansas State Historical Society, Topeka (hereafter KSHS). See also E. H. Bowie, “Rivers and Floods,” *Monthly Weather Review* (July 1909): 399; and O. C. Burrows, “The Floods from Kansas City to St. Louis, MO,” *Monthly Weather Review* (July 1909): 399.

[55] Quotations from, respectively, “Rains Cause Washout on O.K.&M.,” *Miami Record-Herald*, June 8, 1917; and Rainfall Wednesday Greatest in Years; 4.30 Inches, Reports,” *Miami Daily Record-Herald*, November 7, 1918, 1. See also Alfred J. Henry, “Rivers and Floods, November 1918,” *Monthly Weather Review* (November 1918): 525.

[56] Quotations from, respectively, “Flood in Kansas . . . Neosho River State at Oswego Up to 22 Feet,” *Topeka Journal*, April 9, 1927, 1926, Floods in Kansas, Clippings, Vol. 7, KSHS; and “Highway Traffic out of Miami on No. 7 Is Resumed,” *Chickasha (OK) Daily Express*, April 18, 1927, 1. See also “River over Highway 7 Southwest of Miami,” and “Like Flood of 1922,” both in *Miami Record-Herald*, April 11, 1927, 1–2; and “Flood at Standstill Here; Death Toll from Storms in Other Sections Passes 100,” and “Neosho Believed to Be at Crest of 24-Foot Rise,” both in *Miami News-Record*, April 15, 1927, 1. See also “Report on Grand (Neosho) River, Kansas, Missouri, Arkansas, and Oklahoma,” June 4, 1931, Appendix 3, Folder: Grand (Neosho) River, Volume 2, Appendix 1–3, June 1931, 2 of 2, RG77, Corps of Engineers, Southwestern Division, Engineering Files—Harbors and Rivers, 1920–1940, Galveston–Grand (Neosho) River, HM2000, Box 21, E. SW8, NARA-Ft. Worth, TX (NARA-FW).

[57] “Airplane Views of Neosho River Flood in Vicinity of Miami,” and “Reporter in Airplane, Finds Floods over Wide Territory; Fairground Under Water and Miami Packing Company’s Plant is Endangered,” *Miami Daily News-Record*, June 26, 1928, 1, clippings in Folder: Floods, Ottawa County Historical Society, Dobson Museum, Miami, OK. Note that these images were printed a week after the flood itself.

[58] Bennett Swenson, “River Stages and Floods,” *Monthly Weather Review* (October 1941): 313–15, quotations on 314.

[59] “Water Forces Wyandotte’s Schools Shut,” *Miami Daily News-Record*, October 30, 1941, 1–2; quotation from “Floods Spreading Havoc over State,” *Miami Daily News-Record*, October 30, 1941, 1.

[60] “Rainfall,” typescript, May 1943, Folder: “History of the Grand River Dam Project with Reference to Reports of U.S. Army Engineers to Congress Prior to the Creation of the Grand River Dam Authority with Other Reports during the Construction of the Project,” ca. second half of 1943, Box 30, Alva J. Hickerson Papers, Identifier: 1983-002, Oklahoma State University, Archives, Stillwater, OK. See also M. V. Marcher, J. F. Kenny, and Others, *Hydrology of Area 40, Western Region, Interior Coal Province Kansas, Oklahoma, and Missouri: Neosho River, Verdigris River, Caney River, Spring River, Bird Creek*, U.S. Geological Survey Water-Resources Investigations Open-File Report 83–266 (1984), 46.

building, and swimming pool, was "the highest of any record."[61] Federal operation of the Pensacola Dam during the May flood was "credited with saving" the "big war plant" at the Oklahoma Ordnance Works immediately downstream.[62] Similar to accusations advanced in this relicensing proceeding today, some people blamed dam operators at the time for the "flood troubles" Miami and Wyandotte had suffered "where waters from the Grand river dam reservoir backed up into the outskirts."[63] Later review of the issue, however, indicated that "the effects of the backwater curve resulting from the 1943 May flood were below Miami."[64]

Flooding along the Neosho and its tributaries in June 1948 again submerged substantial portions of the town of Picher on Tar Creek and the lowlands in Kansas and Oklahoma. But the floods of July 1948 caused the most damage in Ottawa County, Oklahoma.[65] According to local news reports, "a new all-time high water mark reportedly was established at a point 12 miles north of Miami," a measurement that surpassed the previous record from spring 1943.[66] Perhaps the largest flood to hit Kansas and Oklahoma occurred in July 1951, when swollen rivers and streams wreaked havoc across the Midwest.[67] Other large floods occurred in 1986, 1993, and 2007. Flooding has continued off and on up to the present at various locations in the Grand River watershed, despite the many efforts made over the course of the twentieth century to prevent such flooding.[68]

3.4.1.3.2 Early Efforts to Control Flooding in the Basin

Non-Indigenous attempts at flood control on the Grand River and its tributaries began almost as soon as settlement began. Individual Kansans living in the watershed, especially those immediately adjacent to the river, became active in flood control efforts in the nineteenth century. Federal and state agencies got involved earlier in Kansas than they did in what was Indian Territory until Oklahoma became a state.[69] Private parties built the first known levees along the Neosho River in Neosho County near Erie, Kansas, in 1892.[70] Soon after, however, arguments over who should pay the costs versus who received the

[61] Minutes of the Public Utility Board of the City of Miami, OK, Book 2, City Hall, Miami, OK.
[62] "Dam Credited with Saving Big War Plant," *Tulsa Tribune*, May 11, 1943, Folder: Tables, Plates and Exhibits to Accompany Letter to Chief of Engineers, Dated May 29, 1943, from District Engineer, Tulsa District, Re: Flood of May 1943, Box 13, Hickerson Papers.
[63] "Grand Lake Backs Up," *Tulsa World*, May 12, 1943, Folder: Tables, Plates and Exhibits to Accompany Letter to Chief of Engineers, Dated May 29, 1943, from District Engineer, Tulsa District, Re: Flood of May 1943, Box 13, Hickerson Papers.
[64] Burnham to Wright, July 28, 1947. In his report, Burnham referenced a letter from R. C. Crawford, Brig. Gen., Acting Chief of Engineers, to Arthur Goldschmidt, July 2, 1947.
[65] "Picher Business Area under Water, *Miami Daily News-Record*, June 22, 1948, 1; and "River near Crest, Flood Expected to Ease Grip on Area," *Miami Daily News-Record*, June 24, 1948, 1.
[66] "Rampaging Neosho Nears Crest," *Miami Daily News-Record*, July 28, 1948, 1. See also "Neosho Leaves Banks in Wide Kansas Region," *Miami Daily News-Record*, July 20, 1948, 1; "Neosho River at New Peak, Lake's Rising," *Miami Daily News-Record*, July 21, 1948, 1; "Five-Foot Rise since Monday; Families Flee," *Miami Daily News-Record*, July 27, 1948; and "Waters Recede in Miami after Neosho Crests,' *Miami Daily News-Record*, July 29, 1948, 1.
[67] Scores of reports and articles have been written about the July 1951 floods. See, for example, U.S. Geological Survey and Canada—Department of Resources and Development, Water Resources Division, ["The Kansas Floods of 1951"], *Water Resources Review*, August 9, 1951, and USACE, "Floods of June–July 1951, Kansas and Oklahoma, presentation at ASCE Meeting, Oklahoma City, Ok, September 21, 1951, both in Folder: July 1951 Flood, Box 13, Hickerson Papers.
[68] See, for example, "Oklahoma Floods Force Thousands to Evacuate," *New York Times*, October 5, 1986, 26; "Flooding Forces Evacuation in Northeast Oklahoma," *UPI*, September 27, 1993, https://www.upi.com/Archives/1993/09/27/Flooding-forces-evacuation-in-northeast-Oklahoma/1678749102400/; and Sheila Stogsdill, "Rising Water Leaves Miami 'Indescribable,'" *The Oklahoman*, July 5, 2007, https://www.oklahoman.com/story/news/2007/07/05/rising-water-leaves-miami-indescribable/61760229007/.
[69] Early attempts to control water flow on the Grand River were the low dams people built across the river to harness power for adjacent industrial operations, notably mills. Examples were at Cottonwood Falls, Emporia, and Erie, Kansas, the latter of which the flood of 1885 destroyed forty feet. See Carrie Breese Chandler, "A History of the Old Mill at Cottonwood Falls," originally published in the *Chase County Leader*, February 7, 1934, in *Chase County Historical Sketches*, Vol. 1 (Cottonwood Falls, KS: Chase County Historical Society, 1940), 61–63; Murphy et al., *Destructive Floods in the United States in 1904*, 15; and Graves, *Annals of Osage Mission*, 360; "Neosho River," U.S. Geological Survey, Twenty-First Annual Report, 1899–1900, Part IV—Hydrography (Washington, DC: GPO, 1901), 245–53.
[70] Murphy et al., *Destructive Floods in the United States in 1904*, 15. See also Wright and Elliott, *Prevention of Injury by Floods*.

benefits of levees led the Neosho County Commissioners to assume county jurisdiction over flood control. Ultimately, the Kansas legislature took up the cause and passed an 1893 law that created levee districts and gave the Neosho County commissioners power over the entire levee-building process from planning to construction.[71] By 1904, nineteen levee districts existed in Neosho County.[72] By 1936, private individuals and the county had constructed fifty-one levees.[73]

At the same time local efforts to build levees in Neosho County ramped up in the 1890s, the federal government began working on flood control in Kansas broadly and on the Neosho specifically. In 1896, Corps engineer J. R. Van Frank conducted a survey of the Neosho from the north line of Neosho County to the south line of Labette County.[74] His superior, Captain William Sibert, reported to the Secretary of War that the "extremely small low-water discharge makes it impracticable to improve this stream for navigation purposes . . . and is not . . . worth of improvement by the United States."[75] Although this early Corps survey did not result in immediate federal aid to Kansans in Neosho and Labette Counties, Congress passed the Rivers and Harbors Appropriation Act of 1899, paving the way for the planning and funding of flood-control projects around the nation.[76]

By 1931, the Corps had begun making recommendations for a series of fifty-five levees along the Neosho River. Three of the proposed levees were near Miami in Ottawa County, Oklahoma; one straddled the border between Ottawa County, Oklahoma and Cherokee County, Kansas; and two more would have been located in southern Cherokee County, Kansas near Chetopa and Oswego.[77] No documentation exists to indicate that any of the fifty-five proposed levees were built. By the time Congress passed the Flood Control Act of 1936, which authorized flood-control projects (primarily levees) on the Neosho River, the original list of proposed levees was substantially shorter. All projects authorized in 1936 were in Kansas, and the authorizations required local entities to provide free easements and rights-of-way, release the US government from any future damages claims; and maintain and operate the structures after their completion.[78] The 1936 act authorized levees in the cities of Florence, Cottonwood Falls, Emporia, Neosho Rapids, Hartford, Burlington, LeRoy, Neosho Falls, Iola, Humboldt, and Chetopa; and in Cherokee, Chetopa, and Lyon Counties. Ultimately,

[71] L. Wallace Duncan, *History of Neosho and Wilson Counties*, Kansas (Fort Scott, KS: Monitor, 1902), 105–7; W. W. Graves, *History of Neosho County* (1949; repr., St. Paul, KS: Osage Mission Historical Society, 1986), 439–41, quotation on 439; and Graves, *Annals of Osage Mission*.
[72] Murphy et al., *Destructive Floods in the United States in 1904*, 92–93.
[73] *Report of the Division Engineer*, *Arkansas River and Tributaries*, *1243*.
[74] Floods in Kansas, letter from the Secretary of War, transmitting, with a letter from the Chief of Engineers, R*eport on Preliminary Examination of Floods in the State of Kansas*, August 7, 1917, referred to the Committee on Flood Control and ordered to be printed, with illustrations. August 7, 1917, 65th Congress, 1st Session, House Document No. 321, *U.S. Congressional Serial Set* (Washington, DC: GPO, 1917).
[75] J. R. Van Frank, Preliminary Examination of Neosho River, Kansas, from the North Line of Neosho County to the South Line of Labette County, October 19, 1896, Letter from Capt. William L. Sibert, November 24, 1896 and Letter from the Secretary of War, Transmitting, with a Letter from the Chief of Engineers, Report of Examination of Neosho River, Kansas, etc.), December 14, 1896, Referred to the Committee on Rivers and Harbors and Ordered to be Printed, December 14, 1896, 54th Congress, 2nd Session, Serial Set Vol. No. 3505, Session Vol. No. 29, House Doc. 83. See also Graves, *History of Neosho County*, 441; and "Provisions for Western Rivers," *Guthrie (OK) Daily Leader*, April 5, 1896, 1.
[76] Rivers and Harbors Appropriation Act of 1899, March 3, 1899, Ch. 425, Sec. 9, 30 Stat. 1151. 33 USC § 401 et seq.
[77] Levee Project Estimates ca. 1931, Folder: Grand (Neosho) River, Memphis District—Volume 3, Appendix 4–6, June 1931, RG77, Corps of Engineers, Southwestern Division, Engineering Files—Harbors and Rivers, 1920–1940, Grand (Neosho) River-Gulf Intercoastal Water Way, HM2000, Box 22, E. SW8, NARA-FW. The information in this document was included in the later "Report on the Grand (Neosho) River, A Tributary of the Arkansas River," Submitted in Compliance with Letter, Chief of Engineers, February 15, 1934, Folder: Grand (Neosho) River, Feb. 15, 1934, RG77, Corps of Engineers, Southwestern Division, Engineering Files—Harbors and Rivers, 1920–1940, Galveston–Grand (Neosho) River, HM2000, Box 21, E. SW8, NARA-FW.
[78] An Act Authorizing the Construction of Certain Public Works on Rivers and Harbors for Flood Control, and for Other Purposes, June 22, 1936, H.R. 8455, P.L. No. 738, 74th Congress, Sess. II (hereafter, Flood Control Act of 1936), 1571.

however, with the exception of the city of Iola, which built its levee, “local interests did not desire the construction of the proposed levees and would not provide the necessary rights of way.”[79]

The 1936 act also authorized preliminary examinations in Oklahoma of the Pensacola, Markham Ferry, and Fort Gibson reservoir sites.[80] The Flood Control Act of 1941 modified the general comprehensive plan for flood control in the Arkansas River Basin to include the Pensacola, Markham Ferry, and Fort Gibson Reservoirs on the Grand (Neosho) River in accordance with the recommendations of the Chief of Engineers in House Document 107 (Seventy-sixth Congress, first session).[81] In that report, the Corps recommended that the Pensacola reservoir, which GRDA had completed in 1940, should be expanded to provide a total of 960,000 acre-feet of storage between elevations 735 and 755 feet PD.[82] This recommendation was in contradiction to the dam GRDA had constructed under the provisions of Article 13 of its 1939 Federal Power Commission license, which reserved the storage capacity between elevations 745 and 755 feet PD but did not require GRDA to impound water above elevation 750 feet PD until the United States had acquired the necessary flowage rights between 750 and 755 feet PD.[83] As it was built and operating in 1942, the Pensacola reservoir provided 245,000 acre-feet of flood-control storage between elevations 745 feet PD, which is the upper elevation of the reservoir conservation pool, and 750 feet PD.[84] As of 1942, the additional 295,000 acre-feet of flood-control storage that would be gained between elevations 750 and 755 feet PD had not yet been acquired or cleared to allow for raising the flood-storage level to elevation 755 feet PD.[85]

The addition of Markham Ferry and Fort Gibson to the Arkansas River Basin plan and appropriation of funds for their construction in the 1941 Flood Control Act set the stage for completion of those two projects.[86] The Corps began construction on Fort Gibson Dam in 1942 but did not complete it until 1953.[87] GRDA began construction on the Markham Ferry Dam, which is now known as the Robert S. Kerr Dam and impounds Lake Hudson) in 1958 and completed it in 1964.[88]

Although some public Kansas entities and private corporations and individuals had built dams that created reservoirs to provide both flood control and water, typically on smaller tributaries, by the beginning of World War II, only a few of the Corps’ proposed flood-control projects along the Grand River in Kansas and Oklahoma had come to fruition. This inability to follow through on recommended projects stemmed mostly from localities’ refusal or inability to meet the level of cooperation and cost-sharing required for federal assistance.[89] Still, concern about flooding remained an issue, and federal,

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[79] R. V. Smrha, “Kansas Plan for Neosho River Basin Development,” *Journal of the American Water Works Association* 39, no. 7 (July 1, 1947): 673–79, quotation on 674.
[80] Flood Control Act of 1936, 1578–79, 1596.
[81] An Act: Authorizing the Construction of Certain Public Works on Rivers and Harbors for Flood Control, and for Other Purposes, P.L. No. 77-228, Chapter 377, 77th Congress, Sess. I, *U.S. Statutes at Large* 55, no. Main Section (1941): 638–51, quotation on 645; and *Report on Survey of Pensacola . . . Grand (Neosho) River, Okla.*, October 29, 1938, House Document No. 107.
[82] *Report on Survey of Pensacola . . . Grand (Neosho) River, Okla.*, October 29, 1938, 28.
[83] Federal Power Commission, License for Major Project, Project No. 1494, Oklahoma-Missouri, Grand River Dam Authority, issued January 1, 1939, finalized July 12, 1939, GRDA-HQ, 10.
[84] *Annual Report of the Chief of Engineers, United States Army*, 2 parts, House Document No. 658 (Washington, DC: GPO, 1942)—Part 1, Vol. 1, 980.
[85] *Annual Report of the Chief of Engineers,* 1942, 1:981.
[86] *Annual Report of the Chief of Engineers*, 1942, 1:982–84.
[87] USACE, “History of Fort Gibson Lake,” accessed December 2, 2022, https://www.swt.usace.army.mil/Locations/Tulsa-District-Lakes/Oklahoma/Fort-Gibson-Lake/History/#:~:text=Abandoned%20by%20the%20government%20in,of%20the%20first%20log%20fort.
[88] Glen Roberson, “Grand River Dam Authority,” Encyclopedia of *Oklahoma History and Culture*, accessed December 2, 2022, https://www.okhistory.org/publications/enc/entry.php?entry=GR006.
[89] *Grand (Neosho) River and Its Tributaries*, 38.

state, and local officials and the public continued to debate the best means of flood-control on the upper Grand.[90] In 1949, Kansans lobbied Congress for the construction of a series of four dams/reservoirs that would be coupled with soil conservation efforts along the Neosho.[91] Congress authorized three of the projects in the Flood Control Act of 1950, and the disastrous flood of 1951 emphasized how essential they were for flood control in the Neosho River watershed. Nonetheless, it would take more than a decade for each to be completed, with Council Grove in 1964; John Redmond, formerly known as Strawn Dam, in 1965; and Marion in 1968.[92]

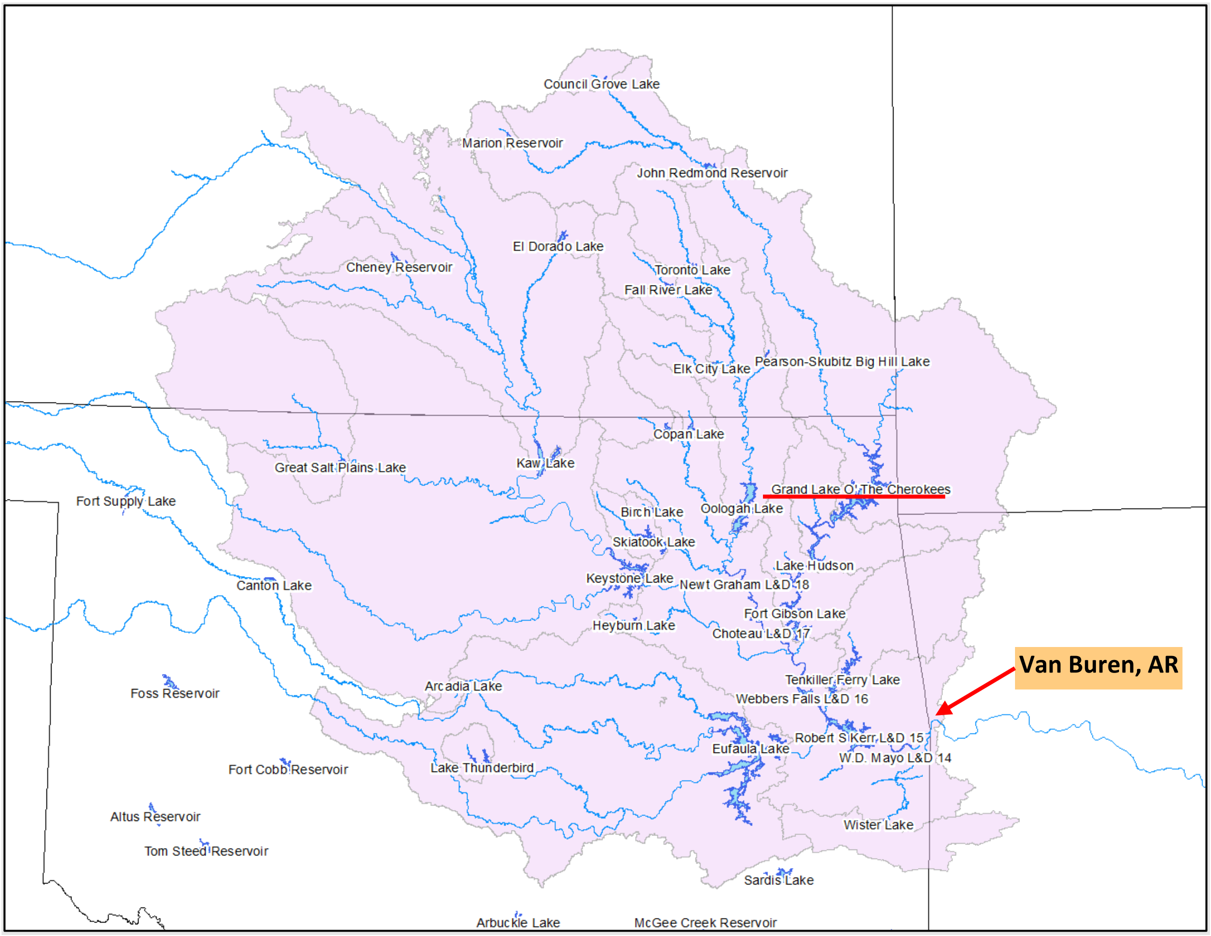
Since the late 1960s, efforts to control flooding on Grand River and its tributaries and the damages those floods cause have continued with local insurance studies, municipal planning and zoning, and local floodplain management programs coordinated through the Federal Emergency Management Agency (e.g., the National Flood Insurance Program). After a major flood in fall 1986 caused $11,000,000 in damages in Miami and the surrounding area, "several communities" inquired about what kind of help the Corps could provide in solving the flood problems. "Local interests" sought to understand the cause of the frequent flooding and "suggested potential solutions, including dredging, flood control reservoirs, channel improvement, levee protection, reservoir storage reallocations of the existing Grand River lakes, and other measures." In May 1987, Miami's mayor wrote to the Oklahoma governor, requesting "assistance in obtaining a Federal study to examine the flood situation and the flood control operation of Grand Lake."[93] Soon after, the Corps received funds and conducted a reconnaissance study of potential flood measures on the Grand River between the John Redmond Dam in Kansas and Miami. After examining "structural and non-structural solutions" for Miami specifically, the Corps recommended in March 1989 that a levee protection project was the economically feasible solution.[94] The Corps reported that spring that it expected to finalize a cost-sharing agreement with the city of Miami—a policy of which the mayor and city commissioners were aware—by fall 1989.[95] However, in June 1990, Miami's Board of Commissioners voted not to initiate feasibility studies and the Corps discontinued the studies.[96]

3.4.1.3.3 USACE Flood Control

Given the extensive history of flooding in the basin and the extensive federal infrastructure to address these events, the Tulsa District of USACE manages 35 water-control facilities—including Grand Lake (US Army Corps of Engineers, 2015). The system water control plan attempts to balance the percentage of storage contained in individual project flood pools above the shared control point at USGS gage no. 07250500 at Van Buren, Arkansas, which is displayed in **Figure 3.4.1.3.3-1**.

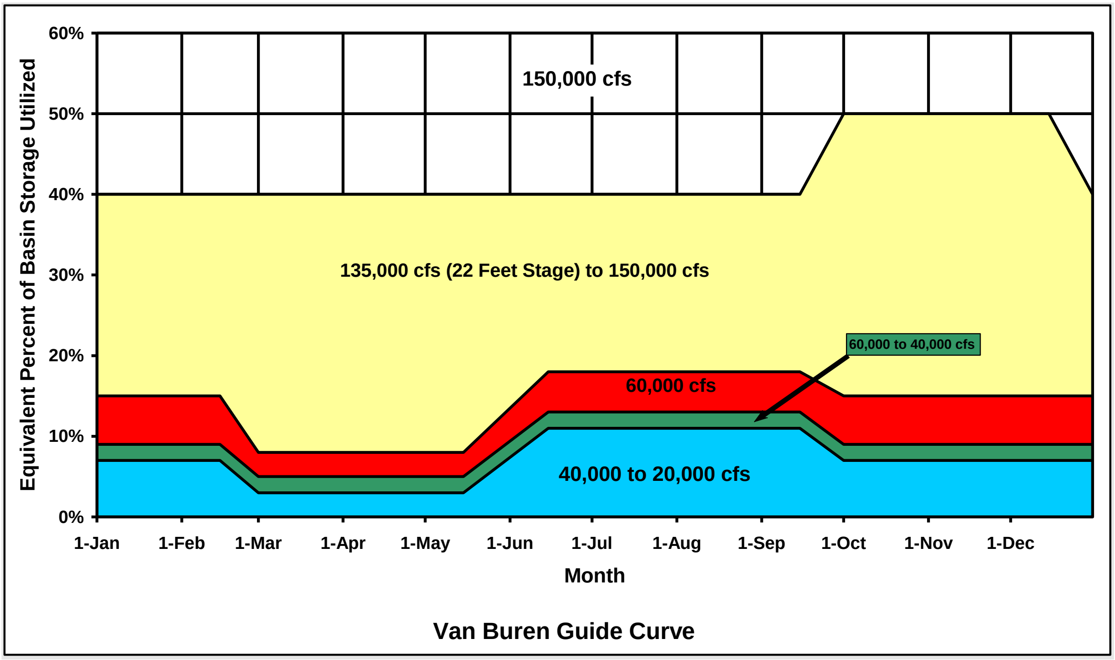
[90] *Grand (Neosho) River and Its Tributaries*, 41.
[91] Wanda Christy, comp., *Coffey County*, *Vol. 1*, *A Glimpse into Its Past*, *Present*, *and Future!* (Burlington, KS: Coffey County Today, 1987), 72.
[92] Flood Control Act of May 17, 1950, Public Law 516, 81st Congress, Chapter 188, 2nd Session. See also USACE, "History of Council Grove Lake," https://www.swt.usace.army.mil/Locations/Tulsa-District-Lakes/Kansas/Council-Grove-Lake/History/; "History of Marion Reservoir," https://www.swt.usace.army.mil/Locations/Tulsa-District-Lakes/Kansas/Marion-Reservoir/History/; and "History of John Redmond Reservoir," https://www.swt.usace.army.mil/Locations/Tulsa-District-Lakes/Kansas/John-Redmond-Reservoir/History/, all accessed December 1, 2022.
[93] Army Corps of Engineers, "Southwestern Division Report," *Energy and Water Development Appropriations for 1990, Hearings before a Subcommittee of the Committee on Appropriations, House of Representatives*, February 1, 1989, 101st Congress, 1st Sess. (Washington, DC: GPO, 1989), 918.
[94] Army Corps of Engineers, "Status Report, Southwestern Division," *Hearings before a Subcommittee of the Committee on Appropriations, House of Representatives*, July 21, 1991, 102nd Congress, 1st Sess. (Washington, DC: GPO, 1991), 565.
[95] "Southwestern Division Report," February 1, 1989, 871.
[96] "Status Report, Southwestern Division," July 21, 1991, 565.

Figure 3.4.1.3.3-1 Location of Van Buren Control Point in Relation to Grand Lake O' the Cherokees



There is a seasonal guide curve that regulates flow at Van Buren; the maximum flow is restricted to 150,000 cfs, as shown in **Figure 3.4.1.3.3-2**. In the figure, the yellow and white zones apply mostly to system flood operation. The blue, green, and red zones apply mostly to transition back to normal operations after a flood event. When flows at Van Buren are projected to exceed the seasonal guide curve, upstream reservoirs store water to limit flow at Van Buren. Other reservoirs or reservoir subsystems also have their own flood release restrictions. Reservoir balance levels throughout the system are managed to limit flooding systemwide (US Army Corps of Engineers, 2015).

Figure 3.4.1.3.3-2 Van Buren Guide Curve



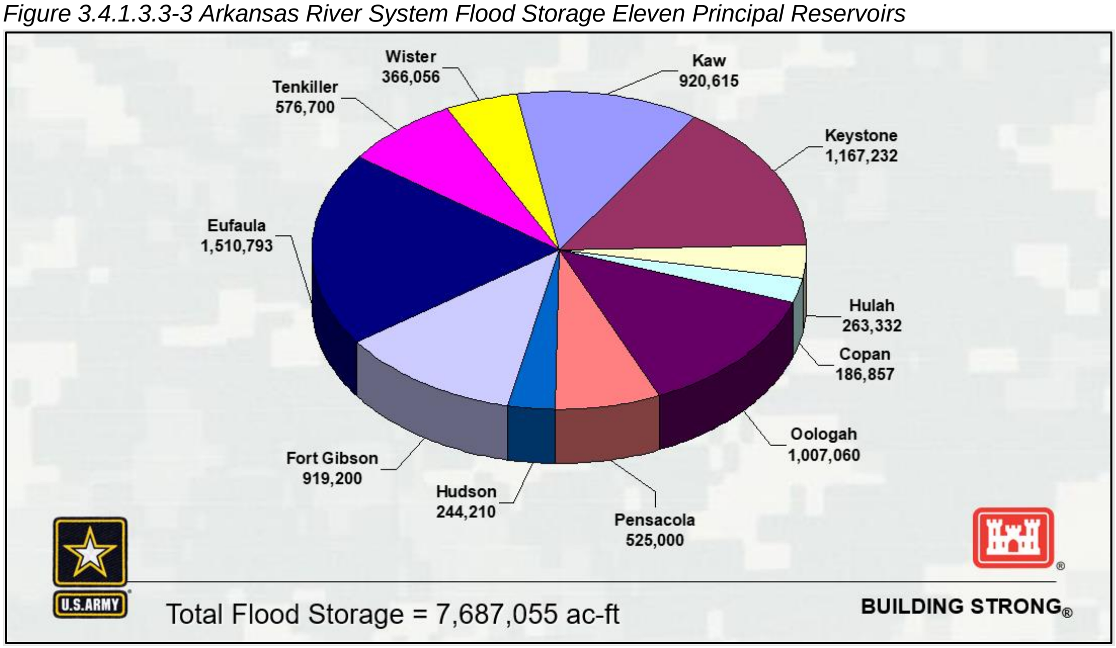
Source: (US Army Corps of Engineers, 2015)

The system water control plan focuses on eleven principal reservoirs:

- Kaw
- Keystone
- Hulah
- Copan
- Oologah
- Eufaula
- Pensacola (Grand Lake)
- Hudson
- Fort Gibson
- Tenkiller
- Wister

The division of flood storage between the eleven principal reservoirs is displayed in **Figure 3.4.1.3.3-3**. Upstream projects in subsystems are balanced with these eleven projects.

Figure 3.4.1.3.3-3 Arkansas River System Flood Storage Eleven Principal Reservoirs



Source: (US Army Corps of Engineers, 2015)

Regarding flood control operations at the Project, USACE follows the Pensacola Reservoir Water Control Manual (US Army Corps of Engineers, 1992). The flood control regulation schedule is as follows:

1. When the pool stage is below 745 feet PD, hydropower releases will be made by GRDA to meet its power requirements. If the pool is forecasted to exceed 745 feet PD, USACE may direct that flood control releases be made, provided that there is a sufficient volume of water indicated by stages at the upstream gages to fill the conservation pool.
2. When the reservoir exceeds 745 feet PD and is not forecasted to exceed 755 feet PD, USACE will direct releases that will not exceed 100,000 cfs below the dam and will be made in such a manner as to balance, as much as practical and within a reasonable time, the percentage of the flood control storage utilized in Pensacola Reservoir, Markham Ferry Reservoir, and Fort Gibson Lake.
3. When the reservoir exceeds 745 feet PD and is forecasted to exceed 755 feet PD, USACE will direct releases to reduce as much as practical the flood damage below the dam and to limit the reservoir elevation to 755 feet PD.
4. When the reservoir exceeds 755 feet PD and is rising, spillway gates will be opened to maintain the reservoir at elevation 755 feet PD or until all the gates are fully open.
5. When the reservoir exceeds 755 feet PD and is falling, the maximum discharge attained shall be held until the reservoir recedes to elevation 755 feet PD.
6. When the reservoir falls below 755 feet PD and is falling, USACE will direct releases that will not exceed 100,000 cfs and will be made in such a manner as to balance the percent of the flood control storage utilized in the 3-reservoir system. Evacuation of the flood control storage in this system will be governed by the provisions of Chapter 7 of the Arkansas River Basin Master Manual.

3.4.1.3.4 NDAA 2020

Flood control operations at the Project have long been under the exclusive jurisdiction of USACE under the authority of Section 7 of the 1944 Flood Control Act. USACE is also responsible for directing spillway releases in accordance with the procedures for system balancing of flood storage outlined in the Arkansas River Basin Water Control Master Manual (US Army Corps of Engineers, 1980). In 2019, Congress reenforced the Corps' exclusive jurisdiction for flood control operations at the Project in Section 7612(c) of NDAA 2020, which provides: "The Secretary [of the Army] shall have exclusive jurisdiction and responsibility for management of the flood pool for flood control operations at Grand Lake O' the Cherokees" (NDAA, 2020). NDAA 2020 also forbids FERC or any other agency from regulating water surface elevations of Grand Lake O' the Cherokees: "the Commission or any other Federal or State agency shall not include in any license for the project any condition or other requirement relating to—(i) surface elevations of the conservation pool; or (ii) the flood pool (except to the extent it references flood control requirements prescribed by the Secretary)" (NDAA, 2020). Although NDAA 2020 forbids the Commission and other agencies from regulating water surface elevations within the conservation pool of Grand Lake, the legislation requires that the Project remains subject to FERC's regulations for public safety and human health.

3.4.1.3.5 Project Impact on Downstream Flooding

USACE is responsible for managing 35 projects in the Arkansas River Basin. USACE operations of the Pensacola Project not only limit potential flooding immediately downstream of the Project, but limit potential flooding along the entire system of projects downstream of Pensacola, as well as providing systemwide benefits to navigation, hydropower, recreation, and fish and wildlife (US Army Corps of Engineers, 1980). Modifying flood control operations at Pensacola would:

1. Disrupt comprehensive management of the system of 35 projects in the Arkansas River Basin—an expansive area that encompasses significant portions of Arkansas, Kansas, Missouri, and Oklahoma.
2. Create unintended consequences adversely affecting socioeconomic, public and private infrastructure, natural resources, recreation, and other project uses both upstream and downstream of Pensacola Dam—and throughout the 4-state area administered by the Corps' Tulsa District.
3. Require a comprehensive update to the Arkansas River Basin Water Control Master Manual (US Army Corps of Engineers, 1980).
4. Require an act of Congress if the "exclusive jurisdiction and responsibility for management of the flood pool for flood control operations at Grand Lake O' the Cherokees" (NDAA, 2020) were to be passed from the Secretary of the Army to another entity.

3.4.1.3.6 Project Impact on Upstream Flooding

The Federal Emergency Management Agency has published Flood Insurance Studies (FIS) for Ottawa County, Oklahoma. The Ottawa County FIS was most recently updated in 2019 (Federal Emergency Management Agency, 2019), and the previous update was in 2010 (Federal Emergency Management Agency, 2010). Because the 2010 FIS provides more narrative detail than the 2019 FIS, information from both documents is included below. The 2010 and 2019 Ottawa County FIS reports are in **Appendix E-11**.

The communities covered by the Ottawa County FIS are listed in Section 1.1 of the 2010 FIS and Table 3 of the 2019 FIS. The combined communities list is as follows:

- Town of Afton
- City of Commerce
- Town of Fairland
- City of Miami
- Town of North Miami
- Ottawa County Unincorporated Areas
- Town of Peoria
- City of Picher
- Town of Quapaw
- Town of Wyandotte
- Wyandotte Nation

The streams studied by the FIS are listed in Section 2.1 of the 2010 FIS and Table 2 of the 2019 FIS. The combined list of studied streams is as follows:

- Bee Creek
- Belmont Run
- Brush Creek
- Coal Creek
- Council Hollow
- Cow Creek
- Devil's Hollow
- Elm Creek
- Fairgrounds Branch
- Fivemile Creek
- Flint Branch
- Fourmile Creek
- Garrett Creek
- Grand Lake
- Grand Lake Tributary 2
- Hickory Creek
- Horse Creek
- Horse Creek Tributary 3
- Horse Creek Tributary 3-1
- Horse Creek Tributary 3-2
- Horse Creek Tributary 3-2-1
- Hudson Creek
- Little Elm Creek
- Little Fivemile Creek
- Little Horse Creek
- Lost Creek
- Lytle Creek
- Mud Creek
- Neosho River
- Ogeechee Creek
- Quail Creek
- Roark Creek
- Slow Creek
- Spring River
- Squaw Creek
- Sycamore Creek
- Tar Creek
- Unnamed Creek 1
- Unnamed Creek 2
- Warren Branch
- Winds Creek
- Windy Creek
- Wolf Creek
- Wyandotte Ditch

Section 2.2 of the 2010 FIS noted "a tremendous amount of new housing and commercial development ***in the floodplain of the Neosho River***" (emphasis added). The City of Miami is the largest city in the county. Much of the city lies on the northern bank of the Neosho River, with fairgrounds and newer residential areas on the southern side of the Neosho River. The 2010 FIS states that: "While most residential properties and the larger part of Miami's business district are above flooding elevations, existing residential, commercial, and industrial areas have been inundated by past floods."

Section 2.3 of the 2010 FIS states:

> *Floods can occur in Ottawa County during any season but are most frequent during May and September. Autumn floods are often associated with widespread heavy rains north of a stalled cold front, or the interaction between a surface front and remnants of a tropical storm. Springtime floods usually occur in the warm sector of a slow-moving cyclone (Reference 5). Major flooding during the spring and summer months can also be produced by the intense rainfall associated with intense localized thunderstorms (Reference 3).*

The FIS is clear that flooding in Ottawa County is a function of rainfall in the watershed. The 2010 FIS states that "major flood problems in Ottawa County have occurred in ***all the floodplains of the streams studied in this report***" (emphasis added). As the FIS documentation shows, flooding is not a phenomenon limited to the Neosho River and/or Grand Lake.

The 2010 FIS includes narrative detail about major historical floods:

> *Major floods of record occurred on the Neosho River and Tar Creek in July 1951, May 1943, April 1944, July 1948, February 1985, October 1986, and July 2007. The July 1951 flood is believed to be the greatest flood known to have occurred in this area, with the Neosho River cresting at 34.03 in nearby Commerce. Newspapers pointed out the hazard to life and the substantial damage to property occasioned by this flood, which left 3,000 persons homeless (Reference 1). The July 2007 flood is believed to be the second highest flood in the City of Miami, with the Neosho River cresting at 29.25 feet. Over 200 homes were destroyed and 266 more homes suffered major damage in this flood (Reference 7). The May 1943 flood was the highest flood on the upper reaches of Tar Creek and the third highest flood on the Neosho River at Miami. The February 1985 flood, according to surveyed high water-marks, was between a 10- and 50-year flood for the Neosho River and Tar Creek (Reference 1).*
>
> *Past flood records on Little Elm Creek, Lost Creek, and Warren Branch are scarce. The February 1985 flood is the only record of flooding in these areas. Surveyed high-water marks indicate that this flood was less than a 10-year flood on Little Elm Creek, Lost Creek, and Warren Branch (Reference 2).*
>
> *Officials for the Town of Wyandotte have indicated that overland flooding has occurred along Wyandotte Ditch, while most flooding is the result of the backwater effects of Grand Lake[97] or from a combination of surface runoff and poor drainage.*

97 See Section 3.4.1.3.12 for updated information on "backwater effects."

Section 2.4 of the 2010 FIS discusses flood protection measures. The FIS mentions that three USACE flood control reservoirs operate in the Neosho River Basin above the City of Miami:

1. Council Grove,
2. Marion, and
3. John Redmond.

The FIS states that these three reservoirs, "which were completed since the July 1951 flood, reduce flood stages significantly at Miami." The FIS also discusses how the National Weather Service (NWS) provides flood warnings to the City of Miami for crests on the Neosho River, based on stage at the river gage near Commerce (USGS gage 07185000), which is approximately 9 miles upstream of the City of Miami. Regarding planned flood control projects, the 2010 FIS states:

> *There is currently a flood control project being planned for Tar Creek that would alleviate a large amount of local flooding now being experienced. There are no other flood protection measures known to exist or to be planned in the near future on Little Elm Creek, Tar Creek, Lost Creek, or Warren Branch.*

And regarding a levee in Wyandotte, the 2010 FIS states:

> *There was a provisionally accredited levee (PAL) in the northwestern part of the Town of Wyandotte which was certified to protect the school and surrounding area from the 1-percent-annual-chance flood resulting from backwater (elevation 756) from Grand Lake. Information about this PAL was available in the revised Wyandotte FIS dated December 19, 1997. The ground behind the PAL, however, has been filled in and has ceased to act as a levee; therefore, it has been removed from the FIRM. The previous PAL was not certified to protect from the 0.2-percent-annual-chance flood.*

At a reservoir elevation of 756 feet PD, USACE would be in control of operations at Grand Lake.

As information in both the 2010 and 2019 FIS reports shows, flooding in Ottawa County is not confined to Grand Lake and/or the Neosho River. Other portions of Ottawa County undergo flooding during high flows, as indicated by the extensive list of flooding sources in Section 2.1 of the 2010 FIS and Table 2 of the 2019 FIS. Furthermore, as the 2010 FIS describes, flooding of the Neosho River in Miami, Oklahoma is a function of what lies upstream of the community:

1. Principal flood problems are caused by rainfall in the watershed. Natural processes have a negative impact on Miami.
2. Three USACE reservoirs lie upstream of the City of Miami and reduce flood stage at Miami. USACE flood control has a positive impact on Miami.
3. NWS provides flood warnings based on the quantity of water coming down the Neosho River, and warnings are issued based on a USGS gage upstream of Miami. NWS focuses on what is coming from upstream of Miami, because that is where the threat of flooding lies.

3.4.1.3.7 Federal Flood Protection Projects

Information on federal funding involvement on upstream flood protection projects in the vicinity of the Project is scarce. The Energy and Water Development Appropriations Hearings describe federal efforts specifically for Miami, Oklahoma, and Vicinity by stating (US Government Printing Office, 1991):

Reconnaissance studies were completed in March 1989. The study area is the Grand (Neosho) River Basin from John Redmond Dam, Kansas, to the confluence of the Arkansas River, Oklahoma. The reconnaissance studies examined structural and non-structural solutions in the city of Miami. A levee protection project was found to be an economically feasible solution. In June 1990, the City Board of Commissioners voted not to initiate feasibility studies. The studies have been discontinued.

3.4.1.3.8 Previous Modeling Efforts

A number of analyses that focus on hydraulics upstream of Pensacola Dam have been performed in recent years. Each of these analyses is discussed below in chronological order below and include:

1. 1998 analysis by USACE
2. 2004 analysis by Holly
3. 2014 analysis by Dennis
4. 2015 analysis by FERC staff
5. 2015 analysis by Tetra Tech
6. 2016 supplemental analysis by Tetra Tech
7. 2022 analysis by Mead & Hunt

<u>1998 USACE Analysis</u>

In 1998, USACE completed a Real Estate Adequacy Study for the area around Grand Lake (US Army Corps of Engineers, 1998). The study was authorized by Congress in 1996. The hydraulic component of the study compared with-dam to no-dam scenarios. The study used steady state modeling and evaluated six storms of varying magnitude that occurred between 1951 and 1995. The downstream boundary condition was set to either normal depth or reservoir elevation. The study concluded that incremental rise in backwater in the City of Miami ranged from 0 feet for the 1951 storm up to approximately 2 feet for the 1993 storm (Federal Energy Regulatory Commission, 2015). The primary limitations of this analysis were:

1. Steady state modeling was used for analysis.
2. Constant reservoir elevations were used at Pensacola Dam.
3. With-dam was compared to no-dam scenarios. While this is not a limitation of an analysis that specifically focuses on the impact of the *presence* of the dam, it is a limitation if the study were to be used in the determination of Project *operational effects* during relicensing.

<u>2004 Holly Analysis</u>

In 2004, Dr. Forrest M. Holly Jr., Ph.D. completed an analysis in support of GRDA's proposal to modify the Pensacola Dam rule curve to a year-round target elevation of 744 feet PD (Holly, F.M., 2004). Holly used unsteady flow modeling, which represented a substantial improvement over the previous modeling effort. Constant reservoir elevations were used as the downstream boundary condition. The study concluded that raising the reservoir elevation from 742 to 745 feet PD would cause an increase in WSE of 0.2 feet at the downstream limit of developed areas in Miami and an increase of less than 0.1 feet at the upstream limit of Miami (Federal Energy Regulatory Commission, 2015). The primary limitation of this analysis was that constant reservoir elevations were used at Pensacola Dam.

2014 Dennis Analysis

In 2014, Alan Dennis completed an analysis of the area upstream of Pensacola Dam (Dennis, 2014). Dennis developed a HEC-RAS model that extended from Pensacola Dam upstream to USGS gage 07185000 (Neosho River near Commerce, OK).[98] Dennis developed the model as part of his M.S. thesis at the University of Oklahoma. Model parameters were calibrated using unsteady flow hydraulic modeling. The calibrated model was used to simulate numerous flow frequencies ranging from the 2-year flood event to the 500-year flood event, using steady-state hydraulic modeling. To analyze impacts of the proposed rule curve change on WSE upstream of Pensacola Dam, Dennis applied constant reservoir elevations of both 741 and 743 feet PD at the Dam. The primary limitations of this analysis were:

1. Steady state modeling was used for analysis.
2. Constant reservoir elevations were used at Pensacola Dam.

2015 FERC Independent Analysis

In 2015, FERC staff conducted an independent hydraulic analysis of potential impacts upstream of Pensacola Dam due to the proposed rule curve variance (Federal Energy Regulatory Commission, 2015). FERC staff performed unsteady flow analysis using the hydraulic model developed by Dennis as a basis. FERC staff modified Dennis' model to improve stability during unsteady flow modeling and also removed the portion of the reservoir downstream of Twin Bridges from the model. FERC staff modeled three separate historical flood events: October 1986, September 1993, and October 2009. Mass balance was used to calculate the downstream stage boundary condition. FERC staff reported that the model results "are similar to the Holly study, and validate the Dennis study" (Federal Energy Regulatory Commission, 2015). The primary limitation of this analysis was that mass balance was used to calculate the downstream boundary condition. The limitations of mass balance are discussed below.

2015 Tetra Tech Analysis

In 2015, Tetra Tech conducted a hydraulic analysis on behalf of the City of Miami. The study purpose was "to evaluate the effects of the presence and operation of Pensacola Dam and Grand Lake on flooding along the Neosho River in the vicinity of Miami, OK" (Tetra Tech, 2015). For a with-dam condition, Tetra Tech used a combined 1D and two-dimensional hydraulic model extending from Pensacola Dam to a point approximately 7 miles upstream of USGS gage 07185000 (Neosho River near Commerce, OK). For a no-dam condition, Tetra Tech used the same upstream boundary, but truncated the model geometry at a point approximately 6 miles downstream of Twin Bridges (Highway 60). Tetra Tech's reasoning was as follows:

> *Elimination of the reach between Sycamore Creek and the current location of Pensacola Dam in the pre-dam model is appropriate because the water-surface elevations and associated hydraulic conditions in this area in the absence of the dam have no effect on conditions in the primary area of interest in this study (i.e., City of Miami).*

Tetra Tech did not provide evidentiary support for this statement. Additionally, the stated study purpose was "to evaluate the effects of the presence **and operation** of Pensacola Dam" (emphasis

[98] HEC-RAS is Hydrologic Engineering Center's River Analysis System- Computer software that allows the user to perform one-dimensional steady flow, one and two-dimensional unsteady flow calculations, sediment transport/mobile bed computations, and water temperature/water quality modeling.

added) but Project operations were not evaluated. The study was limited to a comparison of with-dam conditions to no-dam conditions.

Tetra Tech used data from the 1940s, 2008, and 2015 in their analysis. Tetra Tech noted that, comparing the 1940s data to the 2015 data, there were elevation differences of up to 10 feet in the river channel and differences of up to 15 feet in the overbank. Tetra Tech attributed these differences solely to sediment deposition and did not attempt to quantify what portion of the difference was due to (1) differences in survey technology available in the 1940s as compared to 2015 or (2) the lack of data density in the 1940 data. In the upper reach of the model, because the locations of the 1940s cross-sections did not correspond with the 2015 cross-sections, Tetra Tech elected to lower the existing (2015) channel topography to pre-dam elevations, which were estimated using the 1940s data to provide a "best approximation of the pre-dam conditions." Downstream of Twin Bridges, where 1940s data was not available, Tetra Tech extrapolated the bed profile, "under the assumption that the river and overbank profile was consistent under pre-dam conditions." Tetra Tech summarized their approach to the creation of a no-dam geometry as follows:

> *Although there some* [sic] *uncertainty is introduced by this approach, the resulting cross sections provide a reasonable approximation of pre-dam conditions downstream from Twin Bridge, and this uncertainty has essentially no impact on model results upstream from Twin Bridges.*

Tetra Tech did not provide evidentiary support for the statement that "this uncertainty has essentially no impact on model results upstream from Twin Bridges."

Tetra Tech also compared aerial photography between 1938/1939 and 2015 and observed more vegetation along the Neosho River channel and in the overbanks near the City of Miami in the 2015 photography. Tetra Tech stated that:

> *The sedimentation and increased vegetation are directly related to the presence and operation of Pensacola Dam. Both of these factors contribute to increased flooding along the Neosho River in the City of Miami.*

Tetra Tech did not provide evidentiary support for the statement that sedimentation and increased vegetation "**are directly** *related* to the presence and operation of Pensacola Dam" (emphasis added). Tetra Tech calibrated model parameters for the with-dam condition to several historical flood events using observed high-water marks. Calibration data for the pre-dam or no-dam condition were not available. For the no-dam condition, Tetra Tech made "appropriate adjustments to the coefficients used in the calibrated with-dam model to better represent pre-dam conditions." Because no calibration data were available for a no-dam condition, the "appropriate adjustments" do not have evidentiary support.

Tetra Tech used cross-sections in Grand Lake that were spaced approximately 6,800 feet apart on average, even though continuous topographic and bathymetric data were available for Grand Lake. The cross-sections did not extend into the major bays and coves present along Grand Lake. Therefore, the storage volume in Grand Lake was not accurately represented.

Finally, a technical review of Tetra Tech's model by Mead & Hunt (Mead & Hunt, 2016) found that boundary conditions were not properly applied in the model, both spatially and temporally. Mead & Hunt also found that some of Tetra Tech's input hydrograph data did not match published USGS data.

In summary, the primary limitations of the 2015 Tetra Tech analysis were:

1. The stated study purpose was "to evaluate the effects of the presence **and operation** of Pensacola Dam" (emphasis added) but Project operations were not actually evaluated as part of the study.
2. The with-dam and no-dam model geometries covered different reaches of the river/lake domain. The study provided no quantification of the impact on simulation results caused by this difference in model domain.
3. The no-dam model geometry did not actually use the 1940s pre-dam data. Rather, the study authors used the 1940s data as a guide and created their own approximation of a pre-dam/no-dam geometric condition, using modern data. The authors stated that this approach had "essentially no impact on model results" but did not provide evidentiary support for that statement.
4. No-dam geometry parameters, which differed from with-dam parameters, were selected by the study authors in the absence of available calibration data. The authors made claims about the impact of the dam without providing evidentiary support. These unsupported claims could have influenced selection of no-dam geometry parameters, resulting in a model that did not accurately represent a no-dam hydraulic condition.
5. The storage volume in Grand Lake is not accurately represented by the model geometry, even though sufficient topographic and bathymetric data were available.
6. Some inflow boundary condition data was applied incorrectly, both spatially and temporally. Other inflow boundary condition data did not match published USGS data.

<u>2016 Tetra Tech Supplement</u>

In 2016, Tetra Tech conducted a supplement to their 2015 study "to specifically evaluate the effects of the temporary seasonal rule curve change on flooding along in *[sic]* the vicinity of City" (Tetra Tech, 2016). The with-dam hydraulic model developed for Tetra Tech's 2015 study was used for Tetra Tech's 2016 supplemental analysis. In addition to analyzing the same three historical flood events analyzed by FERC staff in 2015, Tetra Tech also analyzed the December 2015 flood event. Tetra Tech analyzed the four (4) flood events using three (3) initial reservoir elevations at Pensacola Dam: the historical reservoir elevation at the start of the event, an elevation of 741 feet PD, and an elevation of 743 feet PD. Tetra Tech agreed with the conclusions of Dennis (2014) and FERC (2015): the incremental increase in WSE near Miami due to the proposed rule curve change would be less than 0.2 feet. However, Tetra Tech's estimations of WSE near Miami were higher than FERC's estimations.

The primary limitation of the 2016 analysis was that Tetra Tech used mass balance to calculate the downstream stage at Pensacola Dam. Tetra Tech recognized this limitation and stated:

> *A limitation of the analysis is that is* [sic] *not possible to predict how the gates would have been operated under the different scenarios. As a result, the same gate operations were used for the* [sic] *each of the three starting water-surface elevation conditions.*

Mass balance is a crude approach to calculating stage hydrographs at Pensacola Dam during inflow events. The approach can be thought of as a "dead man at the controls" where Project operations do not change regardless of the initial reservoir elevation. In other words, the same Project operations that occurred historically are applied for theoretical initial reservoir elevations, without consideration that the Project would almost certainly be operated differently, had that theoretical starting elevation occurred. This crude approach ignores the fact that Project operations *are fundamentally a function of reservoir elevation*. By way of example, a mass balance approach means that the same gate openings would occur during a given inflow event for:

1. An initial reservoir elevation of 735 feet PD, an elevation 10 feet below the flood pool, and
2. An initial reservoir elevation of 755 feet PD, an elevation equal to the top of the flood pool, 2 feet below the crest of the dam, and 20 feet higher than the first example elevation.

As consideration of this example reveals, mass balance is indeed a crude approach that entirely ignores Project operations. *A mass balance approach will fundamentally always result in more extreme, less realistic differences when various initial reservoir elevations are simulated.*

Culminating with the Hydrologic and Hydraulic Study Updated Study Report in 2022, Mead & Hunt has conducted analysis of potential impacts upstream of Pensacola Dam due to GRDA's baseline operation and anticipated operation (Mead & Hunt, 2022). Performing the work on behalf of GRDA, Mead & Hunt used Tetra Tech's HEC-RAS model as a basis for model development. After identifying model deficiencies, Mead & Hunt transformed Tetra Tech's model, relying on published USACE best practices for hydraulic modeling. As discussed below, Mead & Hunt's modeling not only improved on previous efforts but also resolved the primary limitation of previous modeling efforts: *Mead & Hunt did not rely on the fundamentally unrealistic mass balance approach when computing stage hydrographs at Pensacola Dam.* The objectives, methodology, results, and conclusions of Mead & Hunt's work are discussed below.

3.4.1.3.9 H&H Study Objectives

The H&H Study goal was stated in GRDA's Revised Study Plan (Grand River Dam Authority, 2018a):

> *The overall H&H Study goal is to provide information, through modeling and mapping, to support the determination of the effects, if any, of GRDA's operations under the FERC-issued license for the Project upon several resource areas. Specifically, the H&H Study will: (1) determine the duration and extent of inundation under the current license operations of the Project during several measured inflow events; (2) determine the duration and extent of inundation under any proposed change in these operations that occurs during several measured or synthetic inflow events; (3) provide the model results in a format that can inform other analyses (to be completed separately) of Project effects, if any, in several resource areas; and (4) determine the feasibility of implementing alternative operation scenarios, if applicable, that may be proposed by GRDA as part of the relicensing effort.*

To meet the study goals, and on behalf of GRDA, Mead & Hunt developed an UHM and an OM that calculated stage hydrographs at Pensacola Dam, which were used as downstream boundary conditions for the UHM. Development of the OM is discussed in Section 3.4.1.3.10 and development of the UHM is discussed in Section 3.4.1.3.11.

3.4.1.3.10 Operations Model Development

USACE's RiverWare period-of-record model is a tool used by USACE Southwestern Division, Tulsa District to simulate reservoir operations on the Arkansas River system upstream of USGS gage 07250500 at Van Buren, Arkansas, including Pensacola Dam. The RiverWare model uses a daily time step and includes over 30 reservoirs. Mead & Hunt developed a Flood Routing Model (FRM) for GRDA to replicate, as closely as possible, the Project flow routing decisions in USACE RiverWare period-of-record model (RWM) as an input to the OM. The FRM was needed to investigate hypothetical events and operating scenarios that would be difficult and time-consuming to program into the RWM. The FRM includes three reservoirs (Pensacola, Kerr, and Fort Gibson), which operate as a subsystem for flow routing in the RWM and uses daily time steps like the RWM (Mead & Hunt, 2022).

Mead & Hunt developed an OM for GRDA to simulate flow routing, hydropower scheduling, and other constraints on an hourly time step to support the Project relicensing effort. The OM includes Pensacola Dam and Kerr Dam (Markham Ferry Project), which is downstream of Pensacola Dam. Both Pensacola Dam and Kerr Dam are owned and operated by GRDA, and flow routing decisions at both projects are regulated by USACE under certain conditions. Because electricity prices vary widely within a day, hourly time steps in the OM provide improved accuracy for hydropower operations simulation. Output from the FRM – most importantly the average daily total discharge and reservoir elevation at midnight – is used as an input to the OM. The OM seeks to optimize the hydropower generation revenue at each facility while simultaneously satisfying various physical and operational constraints, including the flow routing decisions based on the RWM model as simulated in the FRM (Mead & Hunt, 2022). For more details on USACE flood control, see Section 3.4.1.3.3 and Section 3.4.1.3.4.

The FRM and OM were validated against the RWM using the common metrics of the Coefficient of Determination and the NSE to evaluate modeled total discharge and elevation. The OM was also validated by comparing WSE results to USGS gage data upstream of Pensacola Dam for two historical events recommended by FERC.

The OM was used to simulate the reservoir levels resulting from different combinations of starting elevations, flow events, existing and future stage-storage relationships, and baseline or anticipated operation scenarios (Mead & Hunt, 2022). As discussed in Section 3.4.1.3.7, the primary limitation of previous analyses was the reliance on mass balance, a fundamentally unrealistic approach, to compute reservoir elevations (i.e., stage hydrographs) at Pensacola Dam. *Mead & Hunt's Operations Model, which was validated against USACE RiverWare period-of-record model, resolved the primary limitation of previous modeling efforts.*

3.4.1.3.11 Upstream Hydraulic Model Development

Mead & Hunt used Tetra Tech's HEC-RAS model, as described in Section 3.4.1.3.8, as a basis for UHM development. After identifying model deficiencies, Mead & Hunt transformed Tetra Tech's model, relying on published USACE best practices for hydraulic modeling. The result was an improved hydraulic model of Grand Lake and the river system upstream of Pensacola Dam (Mead & Hunt, 2022).

Mead & Hunt calibrated the UHM using several inflow events that represented a range of flows. Stream gage data were used for model boundary conditions and to compare measured WSE to simulated values. High water marks and loggers installed by the project team were also used to compare measured and simulated WSE. **Table 3.4.1.3.11-1** lists a summary of the historical event boundary conditions (Mead & Hunt, 2022).

Table 3.4.1.3.11-1 Summary of Historical Event Boundary Conditions Used in UHM Calibration

Historical Events	Peak Inflow (cfs)				Pensacola Peak Stage (feet, PD)
	Neosho River	Tar Creek	Spring River	Elk River	
July 2007	141,000	726	33,300	1,190	754.53
October 2009	46,100	4,630	66,200	39,300	749.59
December 2015	45,400	4,710	151,000	107,000	754.93
January 2017	10,200	678	15,900	1,140	742.82
April 2017	58,100	3,550	114,000	107,000	754.59
May 2019	91,400	6,410	109,000	66,500	755.08

Mead & Hunt also performed a flood frequency analysis for the study area. The total inflow to Pensacola Dam from 1940 (dam construction date) to 2019 (latest available data at time of data delivery from USACE) was used to calculate corresponding total inflows for annual recurrence intervals. **Table 3.4.1.3.11-2** presents the flood frequencies at Pensacola Dam (Mead & Hunt, 2022).

Table 3.4.1.3.11-2 Results of Flood Frequency Analysis at Pensacola Dam

Annual Recurrence Interval	Flow (cfs)
2	90,000
5	152,000
10	192,000
20	225,000
50	266,000
100	299,000
200	330,000
500	375,000

The calibrated HEC-RAS model was used to analyze a range of operating conditions at Pensacola Dam. Five historical inflow events and one synthetic inflow event were analyzed. **Table 3.4.1.3.11-3** presents inflow events and historical pool elevations at the start of inflow events (Mead & Hunt, 2022).

Table 3.4.1.3.11-3 List of Inflow Events Simulated and Historical Pool Elevations at Simulation Start

Inflow Event	Type	Estimated Return Period[1]	Pensacola Dam Historical Pool Elevation at Simulation Start (feet, PD)	Simulation Start/End Date
Sept. 1993	Historical	21 years	743.85	9/24/1993 – 10/16/1993
June 2004	Historical	1 year	743.42	6/13/2004 – 6/30/2004
July 2007	Historical	4 years	745.69	6/28/2007 – 7/25/2007
Oct. 2009	Historical	3 years	740.98	10/8/2009 – 10/21/2009
Dec. 2015	Historical	15 years	742.86	12/26/2015 – 1/16/2016
100-year	Synthetic	100 years	N/A[2]	

[1] Return period for peak inflow at Pensacola Dam.
[2] Because the 100-year event is synthetic, there is no historical pool elevation or event start/end dates; the duration of simulation is 12.5 days.

In addition to the historical pool elevation, eleven other starting pool elevations were simulated. Starting pool elevations were divided into two categories:

1. Starting pool elevations within GRDA's anticipated operational range of to 745 feet PD.
2. Extreme, hypothetical values of starting pool elevations outside GRDA's anticipated operational range. Values below and above GRDA's anticipated operational range were included in the study based on FERC's February 2022 Determination (Federal Energy Regulatory Commission, 2022a).

Table 3.4.1.3.11-4 lists the non-historical starting pool elevations analyzed. The OM was used to calculate stage hydrographs at Pensacola Dam for the various starting pool elevations. The starting pool elevations ranged from 734 up to 757 feet PD, which is the elevation of the crest of the dam (Mead & Hunt, 2022).

Table 3.4.1.3.11-4 List of Additional Initial Pool Elevations Simulated

Inflow Event	Pensacola Dam Pool Elevation at Simulation Start (feet, PD)	
	Anticipated Operational Range	Extreme, Hypothetical Range
Sept. 1993 (21 year)	742.0, 742.5, 743.0, 743.5, 744.0, 744.5, 745.0	734.0, 749.0, 753.0, 757.0
June 2004 (1 year)	742.0, 742.5, 743.0, 743.5, 744.0, 744.5, 745.0	734.0, 749.0, 753.0, 757.0
July 2007 (4 year)	742.0, 742.5, 743.0, 743.5, 744.0, 744.5, 745.0	734.0, 749.0, 753.0, 757.0
Oct. 2009 (3 year)	742.0, 742.5, 743.0, 743.5, 744.0, 744.5, 745.0	734.0, 749.0, 753.0, 757.0
Dec. 2015 (15 year)	742.0, 742.5, 743.0, 743.5, 744.0, 744.5, 745.0	734.0, 749.0, 753.0, 757.0
100-year	742.0, 742.5, 743.0, 743.5, 744.0, 744.5, 745.0	734.0, 749.0, 753.0, 757.0

USGS flow data were used to define inflow hydrographs at the upstream ends of the model for the historical inflow events. The synthetic inflow hydrographs for the 100-year event were based on the flood frequency analysis and a statistical analysis of historical inflow volumes. **Table 3.4.1.3.11-5** lists the peak inflows for the simulated events (Mead & Hunt, 2022).

Table 3.4.1.3.11-5 Summary of Peak Inflows Simulated to Analyze Upstream Impacts

Inflow Event	Peak Inflow (cfs)			
	Neosho River	Tar Creek	Spring River	Elk River
Sept. 1993 (21 year)	75,600	8,200	230,000	18,100
June 2004 (1 year)	24,800	749	10,500	577
July 2007 (4 year)	141,000	726	33,300	1,190
Oct. 2009 (3 year)	46,100	4,630	66,200	39,300
Dec. 2015 (15 year)	45,400	4,710	151,000	107,000
100-year	308,264	1,641	74,975	2,689

3.4.1.3.12 H&H Study Results

Maximum WSEs, inundation extents, and durations of inundation were extracted from HEC-RAS for each simulation. This document focuses on results of simulations with starting stages within GRDA's anticipated operational range (742 to 745 feet PD), and also focuses on Neosho River results. Comprehensive H&H Study results are included in the full study reports, which are in **Appendix E-12**.

Table 3.4.1.3.12-1 presents results of maximum WSE differences through Miami, OK for simulated starting pool elevations within GRDA's anticipated operational range. The first six rows in the table present maximum WSE differences for the various starting pool elevations for a given inflow event. The last two rows in the table present maximum WSE differences for the various natural inflow events, first for the historical inflow events simulated, then for all inflow events simulated (including the 100-year event). Stated another way, the first six rows in the table characterize the impact of starting pool elevations within GRDA's anticipated operational range and the last two rows characterize the impact of natural processes. Each of the four rightmost columns present maximum simulated differences in WSE for four individual river mile segments that cover Miami, OK.

The results show that the maximum simulated WSE differences due to a change in starting pool elevation within GRDA's anticipated operational range are orders of magnitude smaller than the maximum WSE differences that can be caused by natural processes. More specifically, regarding the difference in maximum WSE, the maximum impact of natural processes ranges from 46 to 3,188 times greater than the maximum simulated impact of GRDA's anticipated operational range (Mead & Hunt, 2022).

Table 3.4.1.3.12-1 Summary of Maximum WSE Differences through Miami, OK for Starting Elevations within GRDA's Anticipated Operational Range

Event(s)	Maximum WSE Differences Through Miami, OK (ft) for Starting Elevations Within GRDA's Anticipated Operational Range			
	RM 133-134	RM 134-135	RM 135-136	RM 136-137
Sept. 1993 (21 year)	0.20	0.16	0.14	0.12
June 2004 (1 year)	0.45	0.35	0.31	0.26
July 2007 (4 year)	0.16	0.12	0.08	0.07
Oct. 2009 (3 year)	0.13	0.10	0.09	0.08
Dec. 2015 (15 year)	0.04	0.04	0.05	0.05

Event(s)	Maximum WSE Differences Through Miami, OK (ft) for Starting Elevations Within GRDA's Anticipated Operational Range			
	RM 133-134	RM 134-135	RM 135-136	RM 136-137
100-year	0.01	0.01	0.01	0.02
Impact of inflow events (historical events only)	20.81	20.51	20.89	20.89
Impact of all inflow events (inc. 100-year event)	31.65	31.67	31.88	31.82

Similarly, **Table 3.4.1.3.12-2** presents results of maximum inundation area differences through Miami, OK for simulated starting pool elevations within GRDA's anticipated operational range. The results show the maximum simulated inundation area differences due to a change in starting pool elevation within GRDA's anticipated operational range are orders of magnitude smaller than the maximum inundation area differences that can be caused by natural processes. More specifically, regarding the difference in maximum inundation area, the maximum impact of natural processes ranges from 13 to 8,917 times greater than the maximum simulated impact of GRDA's anticipated operational range (Mead & Hunt, 2022).

Table 3.4.1.3.12-2 Summary of Maximum Inundation Area Differences through Miami, OK for Starting Elevations within GRDA's Anticipated Operational Range

Event(s)	Maximum Inundation Area Differences Through Miami, OK for Starting Elevations Within GRDA's Anticipated Operational Range			
	RM 133-134	RM 134-135	RM 135-136	RM 136-137
Sept. 1993 (21 year)	1.1%	0.8%	1.1%	0.9%
June 2004 (1 year)	11.3%	5.3%	6.2%	9.6%
July 2007 (4 year)	0.7%	0.8%	0.4%	0.2%
Oct. 2009 (3 year)	0.7%	0.4%	0.7%	0.7%
Dec. 2015 (15 year)	4.3%	0.2%	0.4%	0.5%
100-year	0.0%	0.1%	0.0%	0.0%
Impact of inflow events (historical events only)	143%	142%	134%	142%
Impact of all inflow events (inc. 100-year event)	162%	164%	147%	151%

Table 3.4.1.3.12-3 presents results of maximum duration differences through Miami, OK for simulated starting pool elevations within GRDA's anticipated operational range. The results show that the maximum simulated duration differences due to a change in starting pool elevation within GRDA's anticipated operational range are orders of magnitude smaller than the maximum duration differences that can be caused by natural processes. More specifically, regarding the difference in duration, the maximum impact of natural processes ranges from 42 to 223 times greater than the maximum simulated impact of GRDA's anticipated operational range (Mead & Hunt, 2022).

Table 3.4.1.3.12-3 Summary of Maximum Duration Differences through Miami, OK for Starting Elevations within GRDA's Anticipated Operational Range

Event(s)	Maximum Duration Differences Through Miami, OK (hours) for Starting Elevations Within GRDA's Anticipated Operational Range			
	RM 133-134	RM 134-135	RM 135-136	RM 136-137
Sept. 1993 (21 year)	1	1	2	1
June 2004 (1 year)	0	0	0	0
July 2007 (4 year)	2	3	3	2
Oct. 2009 (3 year)	0	4	3	2
Dec. 2015 (15 year)	1	1	1	0
100-year	1	1	1	0
Impact of inflow events (historical events only)	154	166	168	175
Impact of all inflow events (inc. 100-year event)	210	219	220	223

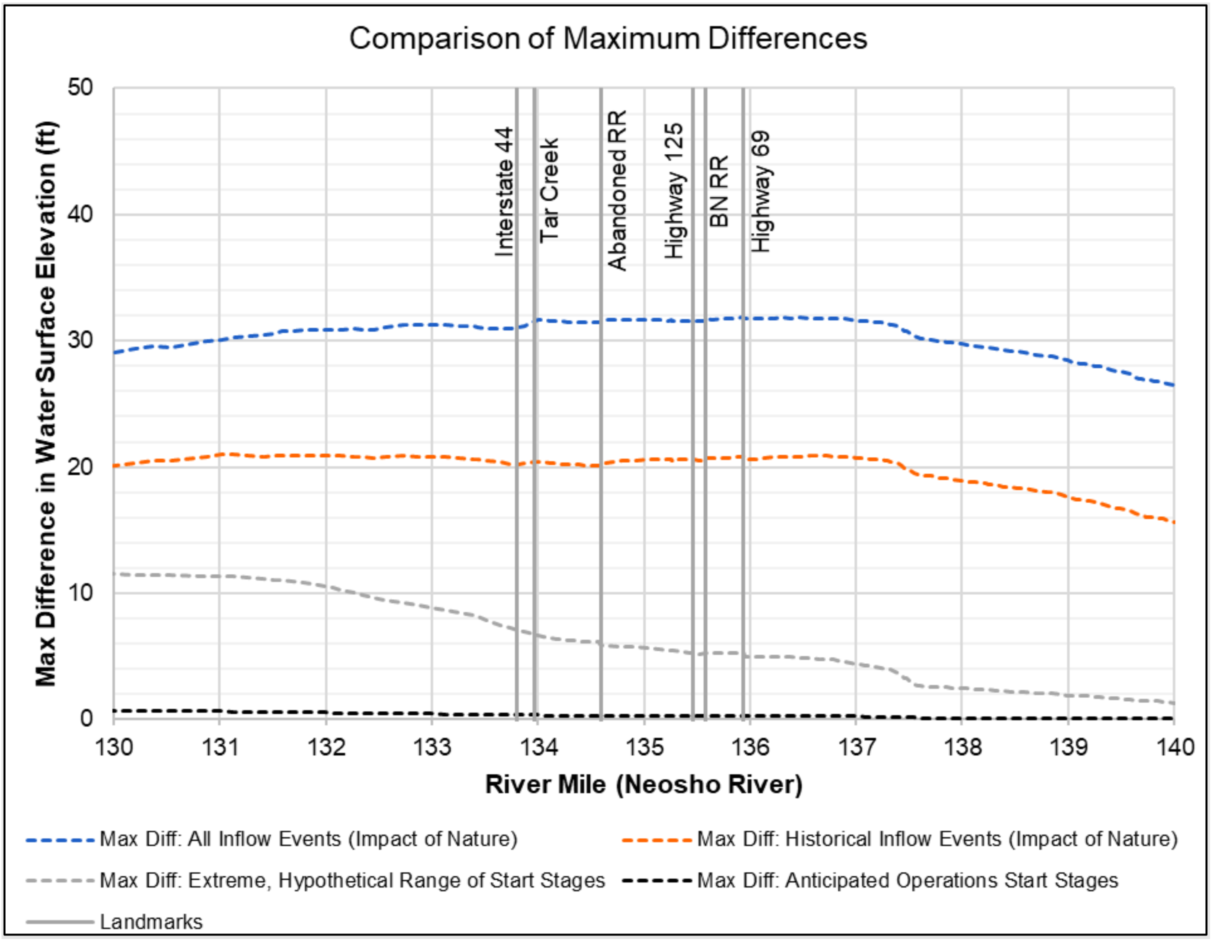
A graphical comparison shows how the magnitude of the natural inflow event is the primary determining factor of maximum WSE, as opposed to the starting pool elevation. **Figure 3.4.1.3.12-1** displays a comparison of maximum WSE differences through Miami, OK. The figure includes four plots of maximum difference in peak WSE:

1. Maximum difference due to changes in starting pool elevation within GRDA's anticipated operational range (742 to 745 feet PD).
2. Maximum difference due to changes in starting pool elevation at extreme, hypothetical values (734 to 757 feet PD) outside GRDA's anticipated operational range.
3. Maximum difference in WSE due to the magnitude of the historical inflow events (does not include synthetic, 100-year event).
4. Maximum difference in WSE due to the magnitude of the inflow event (1-year to 100-year).

Figure 3.4.1.3.12-1 shows the following:

1. The magnitude of the natural inflow event is the primary determining factor of maximum WSE.
2. Starting pool elevations within GRDA's anticipated operational range have an immaterial impact on upstream WSE.
3. Even if extreme, hypothetical values of starting pool elevations outside GRDA's anticipated operational range are used, the impact of natural processes is much greater than that of a 23-foot change in starting pool elevation (Mead & Hunt, 2022).

Figure 3.4.1.3.12-1 Comparison of Maximum WSE Differences near Miami, OK



GRDA anticipates the following operational parameters will apply during the new license term:

1. GRDA will no longer utilize a rule curve with seasonal target elevations.
2. GRDA will maintain the reservoir between elevations 742 and 745 feet PD for purposes of normal hydropower operations. While hydropower operations may occur when water surface elevations are outside this range (e.g., maintenance drawdowns and high-flow events), GRDA expects to generally maintain water surface elevations between 742 and 745 feet PD during normal Project operations.
3. Instead of managing the Project to target a specified seasonal elevation, GRDA's anticipated operations may fluctuate reservoir levels within the elevational range of 742 and 745 feet PD, for purposes of responding to grid demands, market conditions, and the public interest, such as environmental and recreational considerations.
4. GRDA will continue to adhere to USACE's direction on flood control operations in accordance with the Water Control Manual.

This operational scenario is henceforth referred to as "anticipated operation". To characterize the impact of anticipated operations on the range of inflow events and starting pool elevations studied, scenarios were simulated with (1) baseline operations and (2) anticipated operations. The suite of simulated starting pools and inflow events included:

1. The minimum and maximum starting pool elevations requested by FERC (734 and 757 feet PD),

2. The smallest and largest inflow events requested by FERC (1 year and 100 year), and
3. An event of historical importance to upstream communities that is within the studied range of starting pool elevations and within the studied range of inflow magnitudes (July 2007 event with OM period of record starting pool elevation). The starting pool elevation for this event was not arbitrary, but came out of the operational simulations, making it the most integrous comparison of the effects of anticipated operations versus baseline operations on maximum WSE in this study.

The maximum increase in peak WSE was 0.05 feet for all simulated comparisons between anticipated and baseline operations along all reaches studied, which includes Neosho River, Spring River, Elk River, Tar Creek. Increases in WSE were isolated to a few discrete locations. The results show that anticipated operations have an immaterial impact on upstream WSE as compared to baseline operations (Mead & Hunt, 2022).

Regarding inundation extent, a difference in extent based on differences in WSE of 0.05 feet or less at a few discrete locations cannot be effectively displayed on an inundation map. The extent of inundation for anticipated operations is virtually identical to the extent of inundation for baseline operations. No additional inundation maps were created because anticipated operations had an immaterial impact on maximum inundation extent as compared to baseline operations (Mead & Hunt, 2022).

Regarding duration, only the 100-year event simulations resulted in an increase in duration along any modeled reach. The maximum increase in duration was 2 hours, and the difference was isolated to a rural, sparsely populated location. Anticipated operations have an immaterial impact on duration of inundation as compared to baseline operations (Mead & Hunt, 2022).

3.4.1.3.13 H&H Study Conclusions

The H&H Study results demonstrate starting pool elevations at Pensacola Dam within GRDA's anticipated operational range have an immaterial impact on upstream WSE, inundation, and duration for a range of inflow events. Compared to starting elevations within GRDA's anticipated operational range, only natural inflows—and not Project operation—caused an appreciable difference in maximum WSE, maximum inundation extent, or duration. Similarly, comparing anticipated operations to baseline operations for a suite of simulations that spanned the FERC-requested range of starting pool elevations and inflow event magnitudes, the results demonstrate that anticipated operations have an immaterial impact on upstream WSE, inundation, and duration as compared to baseline operations (Mead & Hunt, 2022).

The impacts due to the size of the natural inflow event were orders of magnitude greater than any simulated impact due to Project operations. The maximum impact of natural processes typically ranged from over 10 to 100 times, even over 1,000 times, the maximum simulated impact of GRDA's anticipated operations (Mead & Hunt, 2022). These quantifications are based on dozens of simulations performed with the most detailed, robust, comprehensive model of Grand Lake and the Neosho River developed to date. These quantifications, and the conclusion that GRDA's anticipated operation will have an immaterial impact, agree with the compendium of historical flooding in the Basin, discussed in Section 3.4.1.3.1. Natural processes control the impact of flooding upstream of Pensacola Dam and throughout the Grand/Neosho basin. Flooding of communities upstream of the

Project has occurred both prior to and during the Project's existence. As discussed in Section 3.4.1.3.1, the frequency of flooding near Miami, Oklahoma has historically exceeded flooding frequency along other, nearby reaches of Neosho River. This increased statistical probability of flooding predates the existence of Pensacola Dam.

3.4.2 Environmental Effects

In SD1 and SD2, the Commission identified the following issues related to water resources: (1) the effects of Project operation for both power generation and flood control on water quantity, including its relationship to reservoir level, flooding upstream and downstream of Pensacola Dam, and drought/low flow periods and (2) the effects of Project operation on water quality, particularly on DO and temperature.

3.4.2.1 Effects of Project Operations on Reservoir Levels

The OM was used to determine the median reservoir elevation on an annual basis for both baseline operation (under the pre-2015 rule curve) and anticipated operation (without a rule curve). Under baseline operation (under the pre-2015 rule curve), the median reservoir elevation is 742.04 feet PD. The annual median elevation increases by 1.06 to 743.10 feet PD for anticipated operation (without a rule curve). Based on the annual median reservoir elevation change and the current Digital Elevation Model for the Project, the anticipated operation (without a rule curve) will result in additional inundation of approximately 1,184 acres, all of which is located within the Project boundary and within the normal operational fluctuation band historically experienced in current operation within rule curve requirements (Mead & Hunt, 2022).[99]

As described in Section 3 and shown in **Figure 3-2** and **Figure 3-3**, to demonstrate the reservoir elevation fluctuations for the current operation (under the current post-2015 rule curve) and the anticipated operation (without a rule curve), GRDA developed graphs showing the computed 10%, 25%, 50%, 75%, and 90% exceedance values for the observed and modeled reservoir elevations each day for the current operation (under the current post-2015 rule curve). The hourly headwater elevations from the OM used for development of the observed graph spans a time period from August 14, 2015 through December 31, 2022. The hourly headwater elevations from the OM used for development of the modeled graphs span a time period from April 1, 2004 through December 31, 2019.

3.4.2.2 Effects of Project Operations on Flooding[100]

3.4.2.2.1 Upstream Flooding

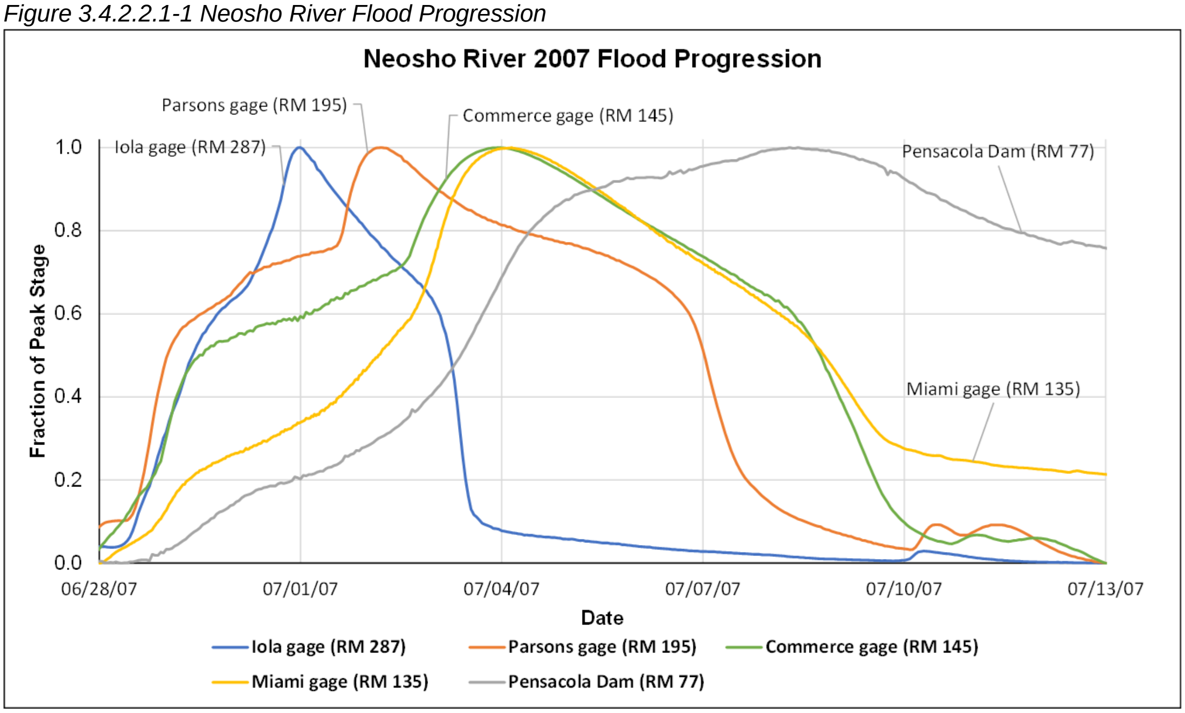
As discussed in Section 3.4.1.3.12, both the H&H Study results and historical records reflected in Section 3.4.1.3.1 show how natural processes have an outsized impact on flooding of communities upstream of the Project. Numerical analysis performed in the H&H Study shows that the maximum impact of natural processes range from 10 to over 1,000 times the maximum simulated impact of GRDA's anticipated operation (without a rule curve) (Mead & Hunt, 2022). This quantified result is based on analysis of maximum WSE, maximum inundation extent, and duration of inundation. For all metrics studied, the definitive conclusion was that the natural process impact is orders of magnitude greater than any simulated impact of GRDA's anticipated operation (without a rule curve). This

[99] See Section 2.11 of the H&H Study USR (**Appendix E-12**) for more details on development of the DEM (Mead & Hunt, 2022).
[100] GRDA is in the process of addressing the study modifications outlined in the study determination dated March 14, 2023. The results will be available by July 24, 2023.

quantified conclusion agrees with the historical record: natural flooding of communities upstream of the Project has occurred both prior to and during the Project's existence. The historical record shows natural processes will flood the Neosho/Grand basin, regardless of the presence and operation of flood control structures. Such is the magnitude of natural floods that accumulate in the 10,345 square mile watershed upstream of the Project that provides natural inflows to the Project.

Further data analysis of readily available USGS gage data for a recent flood that "engulfed" the City of Miami and flooded over 600 homes in Miami alone, as shown in the 2007 flood description in **Figure 3.4.1.3.1-6** agrees with the H&H Study conclusion and the historical record: flooding is due to natural processes. As USGS gage data show, flooding progresses from upstream to downstream on the Neosho River. **Figure 3.4.2.2.1-1** displays the USGS gage data for the 2007 flood. Flood peak stages move from upstream to downstream. The flood first passes through the Iola gage at RM 287, which is 210 river miles upstream of Pensacola Dam. Next, the flood passes through the Parsons gage at RM 195, which is 118 miles upstream of Pensacola Dam. Next, the flood passes through the Commerce gage at RM 145, which is 68 miles upstream of Pensacola Dam. Next, the flood passes through the Miami gage at RM 135, which is 58 miles upstream of Pensacola Dam. Finally, the flood reaches Pensacola Dam at RM 77. The flood does not start at Pensacola Dam and then move upstream toward the City of Miami. Rather, the massive flood, which accumulates as rainfall becomes runoff in the 10,345 square mile watershed upstream of the Project, moves from upstream to downstream.[101] This pronounced demonstration of flood progression from upstream to downstream over time is provided as additional corroborating evidence to support the H&H Study conclusion that natural processes have an outsized impact on flooding of communities upstream of the Project.

Figure 3.4.2.2.1-1 Neosho River Flood Progression



[101] This finding is also stated in the March 23, 2023 comments to the Commission provided by Ben Loring, as an individual, not acting in his current position as the City of Miami's attorney. In his comments on Page 3, he states the following about the 2007 flood: "*Everybody was warned the flood was coming down the Neosho River: Everybody prepared as best as they could. Everybody but GRDA."*

3.4.2.2.2 Downstream Flooding

Downstream of the dam, anticipated operation (without a rule curve) were compared to baseline operation (under the pre-2015 rule curve) for a suite of simulations that spanned a range of starting pool elevations and inflow event magnitudes. The results of the modeling demonstrate anticipated operation (without a rule curve) have an immaterial impact on downstream WSEs and inundation as compared to baseline operation (under the pre-2015 rule curve) (Mead & Hunt, 2022).

Initial stages at the Project can impact downstream WSEs and inundation, but out-of-bank inundation downstream of the Project is the result of spillway releases which are directed by USACE. Under authority of Section 7 of the 1944 Flood Control Act, the USACE is responsible for prescribing and directing the flood control operations of the Project. USACE is also responsible for directing spillway releases in accordance with the procedures for system balancing of flood storage outlined in the Arkansas River Basin Water Control Master Manual (US Army Corps of Engineers, 1980). This authority is reinforced by Section 7612 (c) of the NDAA 2020 which states: “The Secretary [of the Army] shall have exclusive jurisdiction and responsibility for management of the flood pool for flood control operations at Grand Lake O' the Cherokees” (NDAA, 2020).

<u>Cumulative Effects of Operations on Downstream Flooding</u>

The CEQ defines a cumulative effect as an impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency or person undertakes such actions.

The geographic scope for the cumulative effects of the Project includes 11 dams managed by the USACE, including the upstream Marion, Council Grove, and John Redmond Reservoirs and the reservoirs downstream of Grand Lake on the Grand River prior to its confluence with the Arkansas River. The anticipated operation could have the potential to affect downstream out of bank flooding for 30 to 50 years into the future.

The CHM Study found initial stages at the Project can impact downstream WSEs and inundation, but out-of-bank inundation downstream of the Project is the result of spillway releases which are directed by USACE based upon inflows to the Project that are not controlled by GRDA.

Using existing information and the results of resource studies conducted in support of the Project relicensing to describe the existing condition and analyze the potential effects of continued operation of the Project on resources identified by FERC as potentially cumulatively affected, there are no cumulative effects on downstream flooding in the geographic scope now or 50 years into the future.

3.4.2.3 Effects of Project Operations on Drought/Low Flow Periods

Through the DO mitigation plan, GRDA is required to maintain DO concentrations downstream of the Pensacola Project and Markham Ferry Project. In addition, reservoir elevations at the Markham Ferry Project need to be sufficient to operate the Salina Pumped Storage Project, as well as meeting water supply needs (Federal Energy Regulatory Commission, 2017a).

The additional water stored in the reservoir under the anticipated operation (without a rule curve) provides a benefit to drought/low flow periods, particularly during late August, September, and October when the baseline operation (under the pre-2015 rule curve) stores significantly less water (more than one foot less) than the anticipated operation (without a rule curve). The additional stored water could ensure water is available for downstream releases. Additionally, the artificial lowering of the reservoir according to the current operation rule curve coupled with attempting to fill the pool during the hottest and driest times of the season will no longer be a cause for conflict between natural resource concerns and arbitrary elevation targets required under the current operation rule curve.

If the US Drought Monitor declares severe to exceptional drought for the Grand/Neosho River basin, GRDA may commence additional releases from the Pensacola Project regardless of prevailing levels of Grand Lake. These releases do not exceed a rate equal to 0.06 feet of reservoir elevation per day, which is equivalent to 837 cfs over a 24-hour period. When severe to exceptional drought conditions end, GRDA returns the Pensacola Project to its normal operating levels.

3.4.2.4 Effects of Project Operation on Water Quality

3.4.2.4.1 Upstream Water Quality

Water surface fluctuations, with respect to lake size and morphometry, can influence water quality in both positive and negative ways (Baaker and Hilt, 2015) (US Army Corps of Engineers, 1983).[102] Large drawdowns in lake elevations can increase the risk of algal blooms and increase water retention time, water column nutrient concentrations, and temperature of shallow water layers. Water level decreases can increase water turbidity and total nutrients due to wind and wave mixing and resuspension (US Army Corps of Engineers, 1983). Large increases in water level as the result of flooding also tend to increase nutrients, bacteria, and turbidity while lowering water temperatures and algal biomass due to shorter residence time.

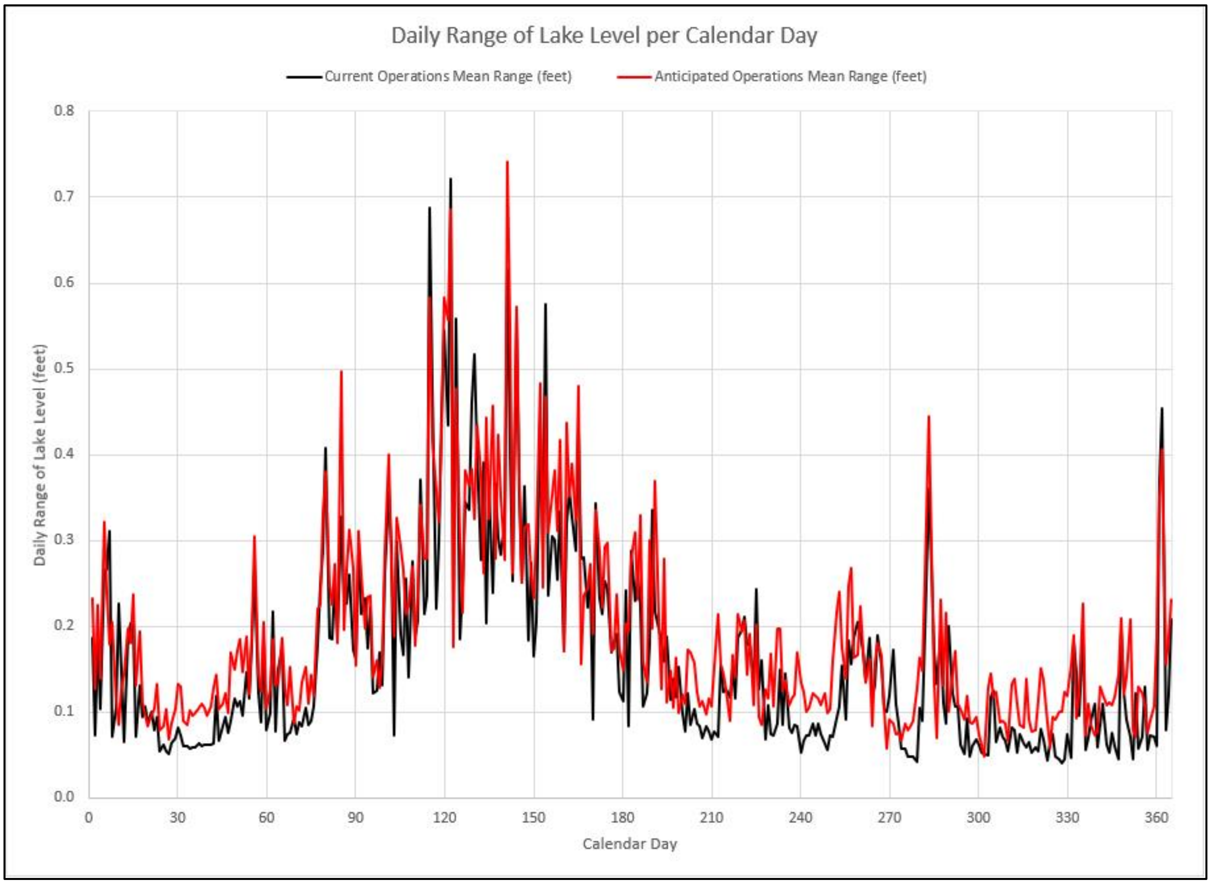
However, the reservoir level fluctuations that are expected to occur as part of the anticipated operation (without a rule curve) of the Project will be far lower than the extreme fluctuations necessary to influence water quality, as documented in the literature. Also, as stated in Section 3, under the anticipated operation (without a rule curve), the overall fluctuations are not going to be more severe than the current operation (under the current post-2015 rule curve). Therefore, water quality is not expected to be affected by the range of overall potential fluctuation of the reservoir elevations.

Furthermore, simulated average daily drawdowns as computed by the OM, under anticipated operation (without a rule curve) has an average daily range of ±0.19 feet as opposed to ±0.16 feet under current modeled operations (with a rule curve). **Figure 3.4.2.4.1-1** displays the daily range of lake level fluctuation per calendar day.

Since there is nearly no discernable difference in water quality from an average change in 0.03 feet more fluctuation, the anticipated operation (without a rule curve) compared to the current operation (under the current post-2015 rule curve) is not expected to incur any additional adverse or even measurable impacts to water quality.

[102] The published reference documents to support the discussion in this section are contained in Appendix E-13.

Figure 3.4.2.4.1-1 Simulated Average Daily Drawdowns as Computed by the Operations Model



3.4.2.4.2 Downstream Water Quality

<u>Dissolved Oxygen</u>

DO is an important consideration for lake management in the reservoir and tailrace below the dam. The lower section of Grand Lake is listed on the 303(d) list for DO since greater than 70% of the water column is often below 2.0 mg/L during the summer stratification period. Possible management strategies to completely eliminate anoxia are limited by the size of the watershed, water temperature, and amount of allochthonous material which will likely always result in high rates of respiration by microbes in the hypolimnion leading to anoxia. However, it has been suggested reductions in chlorophyll and perhaps nutrients may delay the onset of anoxia. The Project does not have the greatest impact on DO, and a broader strategy would be needed to address the occurrences of anoxia (Grand River Dam Authority, 2017a).

GRDA and OWRB collaborated to implement a DO mitigation plan to improve DO in the tailrace downstream of the Pensacola Dam. As previously discussed, summertime anoxia on Grand Lake encompasses the hypolimnion. The water intakes on the Pensacola Dam are at elevation 682 feet PD, or 62 feet below the summer elevation at 744 feet PD. Turbine use at the dam would ultimately send anoxic water into the tailrace and river below the dam. GRDA installed air baffles and a vacuum breaker bypass valve on the turbines; this allows GRDA to move water at both low and high wicket gates and successfully oxygenate the tailrace (Grand River Dam Authority, 2017a).

Under the approved DO mitigation plan, GRDA continuously monitors the DO and temperature downstream of the Pensacola Dam year-round. Three monitoring sondes are located at the Langley Bridge, which is approximately 0.58 miles downstream of the dam: one at the left edge of the river, one at the center of the channel, and one at the right edge of the river. Data from the monitoring sondes are transmitted via cellular telemetry. When any individual compliance sonde indicates a DO reading below any of the action limits, web-based software sends out an alarm email to all necessary personnel at GRDA, FERC, USFWS, ODWC, and OWRB. The email indicates the most recently measured DO concentration and states the appropriate response according to the mitigation plan. Once measurements rise above the action limit, the system sends an alert notification stating target values have been achieved (Grand River Dam Authority, 2022a).

The action limit is set by the OWQS criterion of 6 mg/L from October 16 through June 15 and 5 mg/L from June 16 through October 15. Beginning in 2018, the action limits were each increased by 0.5 mg/L to 6.5 mg/L and 5.5 mg/L, respectively during the summer months to prevent DO levels from dropping below the criterion.[103] Once the action limit is reached according to any of the Langley Bridge monitoring sondes, one turbine will begin running at 20% wicket gate, which is approximately 320 cfs, with full aeration. Once a release is started, it continues until the average DO level exceeds the appropriate criterion; depending on lake level conditions in Grand Lake and Lake Hudson, release will continue for three to eight hours. A second action limit has been set at 4.0 mg/L (4.5 mg/L during the summer months of June, July, and August). If the second action limit is reached, the first turbine will be increased to 25% wicket gate, which is approximately 430 cfs, and will continue for a minimum of two hours (Grand River Dam Authority, 2022a).

For study year 2021, the tailrace below the dam would be considered as not supporting DO for FWP beneficial use. While 8.04% were below the required DO criterion, three samples were below the nuisance criterion of 2 mg/L. DO values remained above standards during a large portion of the summer months. However, during a two-hour interval on July 15, 2021, DO dropped below the nuisance criterion level due to operator error by discontinuing aeration prematurely. Administrative controls have been implemented to prevent a similar situation from occurring in the future.

In the 2021 Annual Report, OWRB noted since the mitigation plan was implemented, water quality standards have typically been met during the summer months. DO values only drop below standards for short periods of time before mitigation efforts are able to increase the DO in the tailrace below the dam (Grand River Dam Authority, 2022a). As a testament of the success of this mitigation plan, Pensacola tailrace DO was below standards on average 29% of the time prior to implementation, with an average of 26 hours annually below 2 mg/L. Since implementation, Pensacola tailrace DO is on average below standards 7% of the time and spends only 30 minutes below 2 mg/L on average.

According to information reviewed as part of the 2018 license amendment increasing the late summer reservoir elevations by targeting a higher reservoir elevation of 742 feet PD and not 741 feet PD higher reservoir elevations are not expected to result in any significant changes in water quality, including DO levels in the reservoir (Federal Energy Regulatory Commission, 2017b).

[103] This change in action limits was described in the 2018 Dissolved Oxygen Annual Report filed with the Commission on April 1, 2019 (FERC Accession No. 20190401-5512).

The additional water stored in the reservoir under the anticipated operation (without a rule curve) particularly during late August, September, and October when the baseline operation (under the pre-2015 rule curve) store significantly less water (more than one foot less) than the anticipated operation (without a rule curve) provides a benefit to downstream DO concentrations. The additional stored water could help to ensure water is available for making releases to maintain DO concentrations during September and October (Federal Energy Regulatory Commission, 2017b). When compared to the baseline operation (under the pre-2015 rule curve), this availability of extra storage and pool flexibility in the anticipated operation (without a rule curve) for downstream DO correction can provide a significant improvement to DO concentrations downstream when utilized through the DO Mitigation Plan as well as during routine hydroelectric generation. Additionally, the artificial lowering of the reservoir according to the current operation rule curve then attempting to fill the pool during the hottest and driest times of the season will no longer be a cause for conflict between natural resource concerns and arbitrary elevation targets required under the current operation rule curve.

Overall, no significant changes in DO levels are expected for the anticipated operation (without a rule curve) versus the current operation (under the current post-2015 rule curve).

3.4.2.2.3 Water Temperature

Water quality monitoring conducted at Grand Lake, as shown in **Table 3.4.1.2.3-2**, and downstream monitoring stations (2021 DO Monitoring Report) indicate the Project meets the seasonal temperature standards to protect fish and wildlife propagation for warm water aquatic communities.

According to information reviewed as part of the 2018 license amendment increasing the late summer reservoir elevations by targeting a reservoir elevation of 742 feet PD and not 741 feet PD higher reservoir elevations are not expected to result in any significant changes in water quality, including water temperature, in the reservoir (Federal Energy Regulatory Commission, 2017b). Therefore, the changes to water temperature in the reservoir due to the anticipated operation (without a rule curve) when compared to the baseline operation (under the pre-2015 rule curve) are not expected to result in any significant changes in water temperature either.

Additional storage in the reservoir under the anticipated operation (without a rule curve) during the months of September and October as compared to baseline, are not expected to result in in any significant adverse impact to water temperature conditions downstream. Water drawn through the powerhouse comes from the hypolimnion at 682 feet PD and although a minor increase in water depth above the intake may occur under anticipated, seasonal stratification, the mixing patterns and average water temperatures at those depths are not expected to change.

Overall, no significant changes in water temperatures downstream of the dam are expected for the anticipated operation (without a rule curve) versus the current operation (under the current post-2015 rule curve).

3.4.3 Cumulative Effects

The proposed action in this case—FERC's issuance of a license to GRDA—is not likely to have significant effects on water resources but may result in cumulative effects on water resources when considered in the context of a variety of other activities in the Project area unrelated to the Project, including the USACE's operations of 11 dams both upstream and downstream of the Pensacola Project for flood control.[104]

When compared to baseline operation (under the pre-2015 rule curve), GRDA's anticipated Project operation (without a rule curve) would not have a significant impact on water quantity due to the USACE's immutable and exclusive responsibility for flood control at the Project, as described in Section 3.4.1.3.4. However, GRDA's anticipated Project operation (without a rule curve), when considered in the context of other activities that may occur in the Project area, including the USACE's operation and control of the 11 dams both upstream and downstream of the Project, may contribute to effects on water quantity and flood control.

In the case of power generation and drought/low flow periods, GRDA's anticipated Project operations (without a rule curve) when combined with the effects of the USACE's operation of 11 dams both upstream and downstream, may result in impacts that could cumulatively be positive, neutral, or negative based on various factors including arrival, magnitude, and timing of precipitation events, which are dictated by natural processes, at each of the generation facilities upstream and downstream of the Pensacola Project. What is certain is water must be passed from upstream facilities through the Pensacola Project to downstream facilities, and none of the facilities have an unlimited capacity to store water for power generation or to offset the negative impacts of drought or low flow periods.

Nevertheless, GRDA plans to continue to implement its anticipated operations, which provides an overall positive benefit to power generation and drought low/flow period operation.

3.4.4 Proposed Environmental Measures

The following environmental measure is being proposed by GRDA to address potential impacts to water quality caused by continued operation of the Project:

- Implement the DO Mitigation Plan enclosed in **Appendix E-14**, which describes the current efforts to reduce impacts of low DO on fish and aquatic resources downstream of the Pensacola Dam.

GRDA is not proposing any measures to address flooding because:

- Studies demonstrate that flooding in the vicinity of Miami and other locations in the upper reaches of Grand Lake and upstream of the Project is not attributable to GRDA's Project operations.
- Federal law prohibits the Commission or any other agency from imposing license measures related to water surface elevations of the conservation pool and confers exclusive jurisdiction upon the Corps to manage the flood pool.

[104] The system extends upstream from the Pensacola Project, to include Marion, Council Grove, and John Redmond Reservoirs and downstream from Grand Lake to Fort Gibson Reservoir on the Grand River prior to its confluence with the Arkansas River.

3.4.5 Unavoidable Adverse Impacts

With implementation of the proposed environmental measures listed in Section 3.4.3, continued operation of the Pensacola Project is not expected to adversely affect water resources.

3.5 Fish and Aquatic Resources

3.5.1 Affected Environment

3.5.1.1 Aquatic and Wetlands Habitat

3.5.1.1.1 Grand Lake Aquatic Habitat

The shoreline of Grand Lake is primarily comprised of rock and gravel substrate. The average depth is 36.3 feet with a maximum of 133 feet (Oklahoma Water Resources Board, 2009) See **Appendix E-15**.

Grand Lake is deepest just upstream of the dam and gets shallower further upstream. The shallow littoral habitat that is important for spawning and rearing of several fish species and other aquatic organisms is very abundant. Additional habitat in Grand Lake is provided by anthropogenic structures such as rip-rap, brush piles, and boat docks. There is little aquatic vegetation or standing timber within the reservoir (ODWC, 2008).

After the 1996 rule curve change, which facilitated the exposure of approximately 1,000 acres of mudflats for two months in late summer, GRDA initiated an experimental millet seeding program to increase aquatic vegetation for fish nursery habitat and waterfowl food supply. The program was discontinued in 2011 because it did not achieve the desired results (Grand River Dam Authority, 2016a).

During the period of 2004 to 2009, GRDA worked in collaboration with other agencies to establish native aquatic vegetation in Grand Lake (Grand River Dam Authority, 2007). Since the beginning of the program, ten founder colonies and approximately 14 acres of aquatic plants had been established and maintained in Grand Lake (Grand River Dam Authority, 2007) (Grand River Dam Authority, 2017a). The effort was halted after a six-year period when the period experienced two years of drought and two years of flood waters, which stopped the spread of the founder colonies in Grand Lake. Therefore, it was determined efforts to establish self-sustaining founder colonies that can provide meaningful wildlife and fishery habitat or expansion outside of protective areas was not feasible (Grand River Dam Authority, 2015).

As an alternative to the native aquatic vegetation, the OWRB recommended utilizing a new concept known as floating wetlands (Grand River Dam Authority, 2015). GRDA experimented with floating wetlands in 2010 and 2011 and concluded the floating wetland concept was not self-sustaining.

Artificial structures have been deployed in Grand Lake to enhance the fishery and protect shoreline habitat as part of GRDA's annual Rush-4-Brush program established in 2007. The artificial structures simulate natural brush piles and provide critical rearing habitat for fry, fingerlings, and young-of-the-year fish. The program also promotes habitat conservation by discouraging the once common practice of removing trees and shrubs along the shoreline to construct brush piles that were ultimately submerged by fisherman.

The program continues to engage the public as volunteers and serves as a critical outreach opportunity. Since the inception of the program, GRDA has provided more than 18,000 artificial structures to create an estimated 11 acres total of fishery habitat along the shorelines of GRDA's project lakes with the majority being deployed in Grand Lake.

3.5.1.1.2 Tailrace Aquatic Habitat

A hydrographic survey of the Pensacola Dam tailwater was conducted in 2011 (see **Appendix E-16**) that included the area 1,000 feet downstream of the dam. The deepest part of the tailrace directly downstream of the dam is approximately 12 feet deep; however, the majority of the tailrace is approximately 6 feet deep according to bathymetric maps created as a result of this survey (Oklahoma Water Resources Board, 2011). The tailrace is composed of three primary spillway channels and a single powerhouse tailrace. Each of the three spillway channels east of the powerhouse join a small tributary, Summerfield Creek, before connecting with the powerhouse tailrace channel, reforming into the mainstem of the Grand River.

Combined, the spillway channel is approximately 1.5 miles long with a dominant substrate of bedrock with some boulders and cobble, and several gravel bar islands. Due to summer stratification in the reservoir and the configuration of the powerhouse intake, water drawn from the hypolimnion of Grand Lake and immediately released from the powerhouse is colder than surface waters but is lower in DO. Through collaboration with several resource agencies, especially OWRB, GRDA has successfully mitigated for this issue through its DO Mitigation Plan included in **Appendix E-14**. The DO Mitigation Plan uses an alert system that allows GRDA to respond in real-time to quickly improve the DO conditions in the tailrace downstream of the Pensacola Dam. See Section 3.4.2.4.2 for additional information on water quality in the Project tailwaters.

The ODWC collected a variety of fishery data for Lake Hudson, which is directly downstream of Grand Lake, for over twenty years. Although not specific to the tailrace, these data indicate fish populations in the lake downstream of Grand Lake are stable (Grand River Dam Authority, 2016b).

3.5.1.1.3 Wetland Habitat

Grand Lake and the surrounding areas contain numerous wetlands. Wetlands are most abundant along the upper, shallow reaches of the reservoir. In the lower reaches, shoreline areas consist primarily of limestone bluffs, with wetlands restricted to coves and backwaters of inundated tributaries (Grand River Dam Authority, 2008a). Acreages of the various wetland types within the existing Project boundary are summarized in **Table 3.5.1.1.3-1**.[105]

Table 3.5.1.1.3-1 Wetlands Identified within the Pensacola Project Boundary

Wetland Type	Upstream of Dam		Downstream of Dan	
	Acres	Percentage	Acres	Percentage
Freshwater Emergent Wetlands	191.9	0.41	8.6	1.44
Freshwater Forested/Shrub	3,465.7	7.43	237.9	39.70

[105] Wetlands identified in the National Wetlands Inventory (including open water areas) within the Pensacola Project boundary that was approved by FERC in the Order Approving Revised Exhibit G Drawings, issued on January 27, 2014.

Wetland Type	Upstream of Dam		Downstream of Dan	
	Acres	Percentage	Acres	Percentage
Riparian Forested Shrub	564.1	1.21	0.0	0.00
Freshwater Pond	109.1	0.23	7.9	1.32
Lake	41,4867.0	88.94	317.8	53.04
Riverine	829.8	1.78	27.0	4.51
Total Wetlands	46,647.5	100.00	599.2	100.01*

*Does not add to 100.00% due to rounding
Source: (GAI Consultants, 2022)

GRDA completed a wetlands and riparian study to evaluate how the anticipated operation (without a rule curve) in the new license would affect wetland habitat, riparian habitat, and Wildlife Management Areas (WMA) compared to the baseline operation (under the pre-2015 rule curve). Using historical data to represent normal events, including 1-year flood events, the output of the OM produced a comparison of the median reservoir elevation under baseline operation (under the pre-2015 rule curve) versus the anticipated operation (without a rule curve) for the growing season (March 30 to November 2). This showed an increase in median reservoir elevation of 0.54 feet under the anticipated operation (without a rule curve) during the growing season.

To meet the objectives of the study, median reservoir elevations were mapped and compared to the wetland and habitat types from the USFWS National Wetlands Inventory (NWI) database. The difference in these two median reservoir elevations is referred to as the study area. The NWI database information was clipped below the baseline median reservoir elevation to remove areas of open water. An analysis of the NWI wetland acres and riparian acres that may be affected by the change in operations was then assessed. The study area is shown on the maps included in the Wetlands and Riparian Habitat Study report in **Appendix E-17**. The majority of the waterline difference in a horizontal direction ranges from a few feet to several feet wide along the shoreline. The study area includes 160.78 acres of wetland habitat, 2.7 acres of riparian habitat, and 28.54 acres of WMAs (Grand River Dam Authority, 2022b). The wetland composition, riparian composition, and WMA acreage included in the study area are shown in **Table 3.5.1.1.3-2, Table 3.5.1.1.3-3,** and **Table 3.5.1.1.3-4**, respectively.

Table 3.5.1.1.3-2 Wetland Composition within the Study Area

Wetland Habitat Type	Acres
Freshwater Emergent Wetlands	5.88 ac
Freshwater Forested	119.24 ac
Freshwater Scrub-Shrub	33.69 ac
Freshwater Open Water	1.97 ac
Total Wetland Acres	**160.78 ac**

Source: (Grand River Dam Authority, 2022b)

Table 3.5.1.1.3-3 Riparian Composition within the Study Area

Riparian Habitat Type	Acres
Riparian, Lotic, Forested, Deciduous	2.49 ac
Riparian, Lentic, Forested, Deciduous	0.21 ac
Total Riparian Habitat Acres	**2.70 ac**

Source: (Grand River Dam Authority, 2022b)

Table 3.5.1.1.3-4 Wildlife Management Areas within the Study Area

WMA Name	Acres
Connors Bridge	0.22 ac
Mallard Point	13.40 ac
West Spring River	28.54 ac
Total WMA Acres	42.16 ac

Source: (Grand River Dam Authority, 2022b)

Existing wetland acreage by habitat type within elevation bands 741 to 742 feet PD, 742 to 743 feet PD, 743 to 744 feet PD, and 744 to 745 feet PD is included in **Table 3.5.1.1.3-5**.

Table 3.5.1.1.3-5 Existing Wetland Acreage by Habitat Type One-Foot Elevation Bands 741 to 745 Feet PD.

Wetland Habitat Type	Acres in 741 to 742 Feet PD	Acres in 742 to 743 Feet PD	Acres in 743 to 744 Feet PD	Acres in 744 to 745 Feet PD
Freshwater Emergent Wetlands	39	12	11	15
Freshwater Forested	116	134	215	359
Freshwater Scrub-Shrub	39	42	73	90
Freshwater Open Water	0	0	0	8
Total Wetland Acres	**194**	**188**	**299**	**472**

Source: (Grand River Dam Authority, 2022b)

3.5.1.2 Fisheries

3.5.1.2.1 Historic Fish Assemblage

The Project reservoir supports a warm water fishery with a diverse assemblage of fish species, as shown in **Table 3.5.1.2.1-1.**[106] The primary sport fish in the Project reservoir and its tailwaters is the largemouth bass (*Micropterus salmoides*). Other sport fish important for the local economy include spotted bass (*Micropterus punctulatus*), white bass (*Morone chrysops*), hybrid striped bass (*Micropterus chyrsops x Micropterus saxatilis*), white crappie (*Pomoxis annularis*), black crappie (*Pomoxis nigromaculatus*), blue catfish (*Ictalurus furcatus*), channel catfish (*Ictalurus punctatus*), flathead catfish (*Pylodictis olivaris*), and Paddlefish (*Polyodon spathula*) (ODWC, 2008). Although not abundant in the reservoir, smallmouth Bass (*Micropterus dolomieu*) is also a sport fish of interest and is native to the watershed. To sustain the population of the sport fishery and paddlefish fishery, the ODWC regularly stocks hybrid striped bass and paddlefish within the Project. Primary forage species include gizzard shad (*Dorosoma cepedianum*) and threadfin shad (*Dorosoma petenense*) (ODWC, 2008). Rare, threatened, and endangered fish species are discussed in more detail in Section 3.7.

[106] The reference documents to support Table 3.5.1.2.1-1 are contained **in Appendix E-13**.

Table 3.5.1.2.1-1 Common and Scientific Names of Fishes Known to Occur in the Project Vicinity

Common Name	Genus	Species	Location(s)[107]	Reference(s)
Bigmouth Buffalo	*Ictiobus*	*cyprinellus*	TRIB, GL, TW	Aggus et al., 1987 Branson, 1967 ONHI, 2021[108] Zale et. al., 1990
Black Bullhead	*Ictalurus*	*melas*	TRIB, TW	Branson, 1967 Zale et al., 1990
Black Crappie	*Pomoxis*	*nigromaculatus*	TRIB, GL, TW	Aggus et al., 1987 Branson, 1967 ODWC, 2008 ONHI, 2021 Zale et al., 1990
Blue Catfish	*Ictalurus*	*furcatus*	TRIB, GL, TW	ODWC, 2008 ONHI, 2021 Zale et. al 1990
Blue Sucker	*Cycleptus*	*elongatus*	TRIB, GL, TW	Branson, 1967 ONHI, 2021 Zale et al., 1990
Bluegill	*Lepomis*	*macrochirus*	GL, TW	Aggus et al., 1987 Branson, 1967 ONHI, 2021 Zale et al., 1990
Brook Silverside	*Labidesthes*	*sicculus*	TRIB, GL, TW	Aggus et al., 1987 Branson, 1967 ONHI, 2021 Zale et al., 1990
Bullhead Minnow	*Pimephales*	*vigilax*	TRIB	Branson, 1967 ONHI, 2021
Channel Catfish	*Ictalurus*	*punctatus*	TRIB, GL, TW	Aggus et al., 1987 Branson, 1967 ODWC, 2008 ONHI, 2021 Zale et al., 1990
Common Carp	*Cyprinus*	*carpio*	TRIB, GL, TW	Aggus et al., 1987 Branson,1967 ONHI, 2021 Zale et al., 1990
Common Shiner	*Notropis*	*comutus*	TRIB, TW	Branson, 1967 Zale et al., 1990
Emerald Shiner	*Notropis*	*atherinoides*	TRIB	ONHI, 2021
Flathead Catfish	*Pylodictis*	*olivaris*	TRIB,GL,TW	Aggus et al., 1987 Branson, 1967 ODWC, 2008 ONHI, 2021 Zale et al., 1990
Freshwater Drum	*Aplodinotus*	*grunniens*	TRIB, GL, TW	Aggus et al., 1987 Branson, 1967 Zale et al., 1990
Ghost Shiner	*Notropis*	*buchanani*	TRIB	Branson, 1967 ONHI, 2021
Gizzard Shard	*Dorosoma*	*cepedianum*	TRIB, GL, TW	Aggus et al., 1987 Branson, 1967 ODWC, 2008 Zale et al., 1990

[107] TRIB is tributary, GL is Grand Lake, TW is Tailwater, and SUB is subsurface.
[108] ONHI is Oklahoma Natural Heritage Inventory; the reference for ONHI, 2021 http://obis.ou.edu/#/public/search/main.

Common Name	Genus	Species	Location(s)[107]	Reference(s)
Golden Shiner	*Notemigonus*	*crysoleucas*	TRIB, TW	Branson, 1967 ONHI, 2021 Zale et al., 1990
Green Sunfish	*Lepomis*	*cyanellus*	TRIB, GL, TW	Aggus et al., 1987 Branson, 1967 ONHI, 2021 Zale et. al. 1990
Highfin Carpsucker	*Carpoides*	*velifer*	TW	Branson, 1967 ONHI, 2021 Zale et al., 1990
Hybrid Striped Bass	*M.Chrysopsx* *M.Saxatilis*		GL, TW	ODWC, 2008 Zale et al., 1990
Largemouth Bass	*Micropterus*	*salmoides*	TRIB, GL, TW	Aggus et al., 1987 Branson, 1967 ODWC, 2008 ONHI, 2021 Zale et al., 1990
Logperch	*Percina*	*caprodes*	TRIB,GL,TW	Aggus et al., 1987 Branson, 1967 ONHI, 2021 Zale et. al 1990
Longear Sunfish	*Lepomis*	*megalotis*	TRIB, GL, TW	Aggus et al., 1987 Branson, 1967 ONHI, 2021 Zale et al., 1990
Longnose Gar	*Lepisosteus*	*osseus*	TRIB, GL, TW	Aggus et al., 1987 Branson, 1967 ONHI, 2021 Zale et al., 1990
Mississippi Silverside	*Menidia*	*audens*	TW	ONHI, 2021 Zale et al., 1990
Neosho Madtom	*Noturus*	*placidus*	TRIB	Branson, 1967 ONHI, 2021
Orangespotted Sunfish	*Lepomis*	*humilis*	TRIB, GL, TW	Aggus et al., 1987 Branson, 1967 ONHI, 2021 Zale et al., 1990
Ozark Cavefish	*Amblyopsis*	*rosea*	SUB	ONHI, 2021
Paddlefish	*Polyodon*	*spathula*	TRIB, GL, TW	Branson, 1967 ODWC 2008 ONHI, 2021 Zale et. al 1990
Quillback	*Carpoides*	*cyprinus*	TW	Zale et al., 1990
Red Shiner	*Cyprinella*	*lutrensis*	TRIB	Branson, 1967 ONHI, 2021
Redear Sunfish	*Lepomis*	*microlophus*	GL	Aggus et al., 1987 Branson, 1967 ONHI, 2021
River Carpsucker	*Carpoides*	*carpio*	TRIB, GL, TW	Aggus et al., 1987 Branson,1967 Zale et al., 1990
River Darter	*Percina*	*shumardi*	TRIB	Branson, 1967 ONHI, 2021
River Redhorse	*Moxostoma*	*carinatum*	TRIB, TW	Branson, 1967 ONHI, 2021 Zale et al., 1990
River Shiner	*Notropis*	*blennius*	TRIB	ONHI, 2021

Common Name	Genus	Species	Location(s)[107]	Reference(s)
Shorthead Redhorse	*Moxostoma*	*macrolepidotum*	TRIB, GL, TW	Aggus et al., 1987 Zale et al., 1990
Shortnose Gar	*Lepisosteus*	*platostomus*	TRIB, GL, TW	Aggus et al., 1987 Branson, 1967 ONHI, 2021 Zale et al., 1990
Smallmouth Bass	*Micropterus*	*dolomieu*	TRIB	Branson, 1967 ODWC, 2008 ONHI, 2021
Smallmouth Buffalo	*Ictiobus*	*bubalus*	TRIB, GL, TW	Aggus et al., 1987 Branson, 1967 ONHI, 2021
Spotted Bass	*Micropterus*	*punctulatus*	GL, TW	Aggus et al., 1987 Branson, 1967 ODWC, 2008 ONHI, 2021 Zale et al., 1990
Spotted Gar	*Lepisosteus*	*oculatus*	TRIB, GL, TW	Aggus et al., 1987 Branson, 1967 ONHI, 2021 Zale et al., 1990
Threadfin Shad	*Dorosoma*	*petenense*	GL	Branson, 1967 ODWC 2008 ONHI, 2021
Walleye	*Stizostedion*	*vitreum*	TRIB, TW	Branson, 1967 Zale et al., 1990
Warmouth	*Lepomis*	*gulosus*	TRIB, GL, TW	Aggus et al., 1987 Branson, 1967 ONHI, 2021 Zale et al., 1990
White Bass	*Morone*	*chrysops*	TRIB, GL, TW	Aggus et al., 1987 Branson, 1967 ODWC, 2008 ONHI, 2021 Zale et al., 1990
White Crappie	*Pomoxis*	*annularis*	TRIB, GL, TW	Aggus et al., 1987 Branson, 1967 ODWC, 2008 ONHI, 2021 Zale et al., 1990
White Sucker	*Catostomus*	*commersoni*	TRIB, TW	Branson, 1967 ONHI, 2021 Zale et al., 1990
Yellow Bullhead	*Ictalurus*	*natalis*	TRIB, TW	Branson, 1967 Zale et al., 1990

3.5.1.2.2 Fish Surveys

In 2021, under the Aquatic Species of Concern Study, a review of literature regarding the federally threatened Neosho madtom was completed.[109] The literature review, as outlined in the report, identified the previous observation or occurrence of Neosho Madtoms at four locations in the Project vicinity. Three of the observations designated as NOPL–79312, 75490, and 67425 were identified through a

[109] The literature review identified historical observations at three locations identified in Table D3 of Appendix D of the Aquatic Species of Concern Study Report (**Appendix E-18**). The survey resulting in the madtom observation named "NOPL-79312,75490,67425" in Table D3 is actually three separate observances. The information was obtained from the Sam Noble Museum records.

review of Sam Noble Oklahoma Museum of Natural History (OMNH) records and are believed to be from an ODEQ survey. The location of each of the three observations is listed as *County road west of Commerce; Sec 5/T28N/R22E; U07185000*. This description is coincident to the location of the Commerce gage (USGS 07185000). The known information is shown in **Table 3.5.1.2.2-1**.[110]

Table 3.5.1.2.2-1 Additional Survey Information for Neosho Madtom Historical Occurrences Obtained from the Sam Noble Museum

OMNH Number	Common Name	Number of Specimens	Water Body	Latitude	Longitude	Survey Date	Field Number
79312	Neosho Madtom	2	Neosho River	36.9286	-94.9572	9/4/2007	DEQ2007-24
75490	Neosho Madtom	1	Neosho River	36.9286	-94.9572	9/7/2004	DEQ2004-23
67425	Neosho Madtom	2	Neosho River	36.9286	-94.9572	9/4/2001	DEQ01-023

The single location mentioned above and designated as NOPL-ONHI in the Aquatic Species of Concern Study Report was identified through a request for information from the Oklahoma Natural Heritage Inventory (ONHI). Through an April 2023 GRDA follow up request for more information from the ONHI, GRDA received the best location information available from the ONHI in an email from Bruce Hoagland dated May 3, 2023. The follow up information provided by the ONHI for the location is believed to be associated with a common sampling site that has documented occurrences of the species reaching back to 1971; the information did not include location coordinates (latitude, longitude). No survey reports available; however, the information provided by the ONHI is outlined in **Table 3.5.1.2.2-2**.

Table 3.5.1.2.2-2 Additional Survey Information and Results Obtained from the Oklahoma Natural Heritage Inventory on May 3, 2023[111]

Survey Year	Common Name	Number of Specimens	Water Body	Location
1971	Neosho Madtom	5	Neosho River	NEOSHO RIVER. 4 MI. NW OF MIAMI. T28N, R22E, SEC 8. [REACH EXTENDS W OF FOUR MILE CREEK 29N 21E SEC 36.]
1972	Neosho Madtom	3	Neosho River	NEOSHO RIVER. 4 MI. NW OF MIAMI. T28N, R22E, SEC 8. [REACH EXTENDS W OF FOUR MILE CREEK 29N 21E SEC 36.]
1973	Neosho Madtom	25	Neosho River	NEOSHO RIVER. 4 MI. NW OF MIAMI. T28N, R22E, SEC 8. [REACH EXTENDS W OF FOUR MILE CREEK 29N 21E SEC 36.]
1974	Neosho Madtom	25	Neosho River	NEOSHO RIVER. 4 MI. NW OF MIAMI. T28N, R22E, SEC 8. [REACH EXTENDS W OF FOUR MILE CREEK 29N 21E SEC 36.]
1975	Neosho Madtom	11	Neosho River	NEOSHO RIVER. 4 MI. NW OF MIAMI. T28N, R22E, SEC 8. [REACH EXTENDS W OF FOUR MILE CREEK 29N 21E SEC 36.]
1976	Neosho Madtom	85	Neosho River	NEOSHO RIVER. 4 MI. NW OF MIAMI. T28N, R22E, SEC 8. [REACH EXTENDS W OF FOUR MILE CREEK 29N 21E SEC 36.]

110 No additional information or survey report is available for these occurrences.
111 Since there are repeat records in the same locality, the ONHI believes all data included in **Table 3.5.1.2.2-2** was collected by Jimmie Pigg.

Survey Year	Common Name	Number of Specimens	Water Body	Location
1983	Neosho Madtom	7	Neosho River	NEOSHO RIVER. 4 MI. NW OF MIAMI. T28N, R22E, SEC 8. [REACH EXTENDS W OF FOUR MILE CREEK 29N 21E SEC 36.]
1989	Neosho Madtom	1	Neosho River	NEOSHO RIVER. 4 MI. NW OF MIAMI. T28N, R22E, SEC 8. [REACH EXTENDS W OF FOUR MILE CREEK 29N 21E SEC 36.]
1990	Neosho Madtom	Specimens captured in a sample area of CA. 50 SQ Meters	Neosho River	NEOSHO RIVER. 4 MI. NW OF MIAMI. T28N, R22E, SEC 8. [REACH EXTENDS W OF FOUR MILE CREEK 29N 21E SEC 36.]
1991	Neosho Madtom	14	Neosho River	NEOSHO RIVER. 4 MI. NW OF MIAMI. T28N, R22E, SEC 8. [REACH EXTENDS W OF FOUR MILE CREEK 29N 21E SEC 36.]

Based on this literature review, agency comments, and the subsequent Study Plan Determinations (2018 and 2022), the need for Neosho madtom surveys were identified in portions of the Neosho River and Spring River. Seven sites were surveyed in Oklahoma on the Neosho River from the Craig/Ottawa County line south to the Highway 60 bridge. Four sites were surveyed on the Spring River between the Interstate 44 bridge downstream to the Highway 10 bridge. At each survey site, five points were surveyed by kick-seining where at least two surveyors thoroughly disturbed the substrate beginning at least four meters upstream of a stationary seine and then kicked in a downstream direction to the seine’s lead line. All fish captured were identified to species, measured for total length, and enumerated. Substrate and mean water-column velocities were also quantified to characterize the habitat conditions at each site.

At the Neosho River survey sites, 21 fish species were collected while kick-seining with red shiner (*Cyprinella lutensis*), emerald shiner (*Notropis atherinoides*), and channel catfish (*Ictalurus puctatus*) being the most abundant species with 209, 185, and 49 individuals, respectively. These three species accounted for 77.0% of the individuals collected.[112] The species collected, species richness, abundance, and catch per unit effort (CPUE) for the Neosho River surveys are shown in **Table 3.5.1.2.2-3**. Neosho madtoms were collected at five of the sites surveyed on the Neosho River. A discussion of the Neosho madtom, its habitat, and potential impacts from continued operation of the Project is included in Section 3.7.

Table 3.5.1.2.2-3 Neosho River Fish Survey Results

Common Name	Scientific Name	Richness (Total)	Relative Abundance	CPUE
Blue catfish	*Ictalurus furcatus*	34	0.06	0.62
Bluegill	*Lepomis macrochirus*	1	0.00	0.02
Bluntnose minnow	*Pimephales notatus*	3	0.01	0.05
Brindled madtom	*Noturus miurus*	1	0.00	0.02
Central stoneroller	*Campastoma anomalum*	1	0.00	0.02
Channel catfish	*Ictalurus punctatus*	49	0.09	0.89
Emerald shiner	*Notropis atheinoides*	185	0.32	3.36

112 There was an error in the Aquatic Species of Concern study report filed with the USR on September 30, 2022. In addition, the report has been updated as explained in responses to USFWS comments on the report received November 30, 2022. The updated report is in **Appendix E-18**.

Common Name	Scientific Name	Richness (Total)	Relative Abundance	CPUE
Freshwater drum	*Aplodinotus grunniens*	5	0.01	0.09
Ghost shiner	*Notropis buchanani*	1	0.00	0.02
Gravel chub	*Erimystax x-punctatus*	6	0.01	0.11
Green sunfish	*Lepomis cyanellus*	1	0.00	0.02
Logperch	*Percina caprodes*	2	0.00	0.04
Mississippi silverside	*Menidia audens*	5	0.01	0.09
Neosho madtom*	*Noturus placidus*	13	0.02	0.24
Redfin darter	*Etheostoma whipplei*	1	0.00	0.02
Red shiner	*Cyprinella lutrensis*	209	0.36	3.80
River darter	*Percina shumardi*	19	0.03	0.35
Slenderhead darter	*Percina phoxocephala*	14	0.02	0.25
Suckermouth minnow	*Phenocobius mirabilis*	12	0.02	0.22
Stonecat	*Noturus flavus*	4	0.01	0.07
White bass	*Morone chrysops*	9	0.02	0.16
	Species Richness	**21**		
	Total Abundance	**575**		
	CPUE	**16.43**		

Source: (Grand River Dam Authority, 2022c)

At the Spring River survey sites, 17 fish species were collected with white bass, red shiner, and emerald shiner being the most abundant species with 107, 93, and 51 individuals, respectively. These three species accounted for 73.2% of the individuals collected. Species collected, species richness, abundance and CPUE for the Spring River surveys are shown in **Table 3.5.1.2.2-4**. No Neosho madtoms were collected at any of the sites surveyed.

Table 3.5.1.2.2-4 Spring River Fish Survey Results

Common Name	Scientific Name	Richness (Total)	Relative Abundance	CPUE
Cardinal shiner	*Luxilus cardinalis*	16	0.05	0.80
Carmine shiner	*Notropis percobromus*	5	0.01	0.25
Central stoneroller	*Campastoma anomalum*	2	0.01	0.10
Channel catfish	*Ictalurus punctatus*	1	0.00	0.05
Emerald shiner	*Notropis atheinoides*	51	0.15	2.55
Flathead catfish	*Pylodictus olivaris*	1	0.00	0.05
Gravel Chub	*Erimystax x-punctatus*	30	0.09	1.50
Logperch	*Percina caprodes*	1	0.00	0.05
Mimic shiner	*Notropis vollucellus*	1	0.00	0.05
Mississippi silverside	*Menidia audens*	5	0.01	0.25
Red shiner	*Cyprinella lutrensis*	93	0.27	4.65
River darter	*Percina shumardi*	20	0.06	1.00
Slenderhead darter	*Percina phoxocephala*	7	0.02	0.35

Common Name	Scientific Name	Richness (Total)	Relative Abundance	CPUE
Spotted bass	*Micropterus punctulatus*	1	0.00	0.05
Stonecat	*Noturus flavus*	1	0.00	0.05
Threadfin shad	*Dorosoma petense*	1	0.00	0.05
White bass	*Morone chrysops*	107	0.31	5.35
	Species Richness	**17**		
	Total Abundance	**343**		
	CPUE	**17.15**		

Source: (Grand River Dam Authority, 2022c)

The Aquatic Species of Concern Study also identified two additional fish species of concern that may be present in the Project vicinity, which include the Neosho smallmouth bass (*Micropterus solomieui velox*) and paddlefish (*Polyodon spathula*). While neither species is listed under the ESA, they were identified as having the potential to be affected by anticipated changes in water level management at the Project. A description of each species, their habitat, and potential impacts related to anticipated water level management is included in the following sections.

Neosho Smallmouth Bass

The Neosho smallmouth bass is a genetically distinct subspecies of smallmouth bass. It is found in the western extent of the Ozark Highlands ecoregion and is known to occur in the Spring River, Elk River, and Neosho River among others in the region. Generally, they are found in clear streams, but can be found in pool habitats and larger streams that have various channel units, including runs and riffles. Spawning habitat for the species consists of low-velocity, nearshore waters that are close to cover. The fish prefers to construct nests in areas that have fine sediment substrates and avoids areas that have thick layers of silt and clay. Nest success is influenced by stream flows and is higher in years that have low stream flows and resulting low water velocities (Grand River Dam Authority, 2022c).

A review of existing fishery survey data indicated a smallmouth bass population is present within the study area, but there was no determination that the Neosho smallmouth bass subspecies was identified. ODWC sampling efforts (most recent in 2019) looked for the Neosho subspecies within the Neosho River and reservoir; however, the subspecies was not detected within the study area or surrounding drainages. The Aquatic Species of Concern Study concluded the Neosho smallmouth bass does not occur in the study area and continued operation of the Project is unlikely to affect the species (Grand River Dam Authority, 2022c).

Paddlefish

Adult paddlefish prefer deep, slow-moving pools of large rivers and associated lakes and reservoirs where they feed on zooplankton that are filtered from the water with specialized gills. The fish typically prefers areas with depths greater than 9.8 feet and current velocities below 1.6 feet per second (fps). The fish spawns in riverine areas with aggregations over hard substrates such as gravel and cobble. Spawning occurs March through June, and typically peaks in late March to early April in Oklahoma. Spawning appears to be initiated by rising water levels during periods of high flow with the highest recruitment occurring during years with extended high flow conditions during the spawning period (Grand River Dam Authority, 2022c).

In the Aquatic Species of Concern Study, data was compiled, and maps were developed to evaluate the amount and location of paddlefish spawning substrate within the Project. The study showed within the Project boundary, approximately 696 acres of paddlefish spawning substrate occurred within the Neosho River and 493 acres occurred within the Spring River. The study also showed the Neosho River has a much greater value to paddlefish than the Spring River (Grand River Dam Authority, 2022c). Habitat maps are included in the Aquatic Species of Concern Study Report, which is in **Appendix E-18**.[113] The area below the confluence of the two rivers was not evaluated since spawning activity in the section is unlikely due to poor spawning habitat availability. The study determined regardless of the future operations of the Project, the magnitude and timing of inflow events, which are not controlled by Project operation, are the main determinant of the conditions necessary for successful paddlefish spawning.

Lake Spawning Habitat Changes Overview Maps were developed in conjunction with the OM and are in **Appendix E-19**. The maps show the inundation difference between the baseline operation (under the pre-2015 rule curve) and anticipated operation of the Project. These maps were reviewed as part of the Aquatic Species of Concern Study to determine if the anticipated changes to operations would affect paddlefish spawning habitat. The study concluded that the inundation maps from the OM demonstrate a non-discernable change in the inundation of spawning areas for fish species that spawn in the lake under the anticipated operation (without a rule curve). (Grand River Dam Authority, 2022c).

3.5.1.3 Mussel Species

3.5.1.3.1 Historic Mussel Information

Historic mussel information from Branson, identified the likely distribution of nine mussel species in Grand Lake or the Neosho River (Branson, B.A., 1982). The species are shown in **Table 3.5.1.3.1-1**.

Table 3.5.1.3.1-1 Mussel Species in the Grand Lake or Neosho River

Common Name	Scientific Name
Mapleleaf	*Quadrula quadrula*
Monkeyface	*Quadrula metanerva*
Pearlshell	*Blebula rotunda*
Pimpleback	*Quadrula pustulosa*
Rabbitsfoot	*Quadrula cylindrica*
Threeridge	*Amblelma plicata*
Wabash pigtoe	*Fusconaia flava*
Washboard	*Megalonaias gigantean*

A review of state and federal databases indicated the Neosho mucket (*Lampsillis rafinesqueana*) may occur within the Neosho, Spring, and Elk Rivers (US Fish and Wildlife Service, n.d.b). The species

[113] The report has been updated as explained in responses to comments that were provided by the USFWS on November 30, 2022.

was listed as endangered by USFWS in 2013 and critical habitat was designated in 2015 (US Fish and Wildlife Service, 2015). The species is discussed in greater detail in Section 3.7.

3.5.1.3.2 Current Mussel Information

The Neosho mucket, rabbitsfoot (*Quadrula cylindrica*), and winged mapleleaf (*Quadrula fragosa*) were identified as rare species that either inhabit or have the potential to inhabit areas affected by Project operations (Grand River Dam Authority, 2022c). Therefore, qualitative mussel surveys using timed visual/tactile search methods were conducted in 2022. Surveys were conducted for a minimum of three person-hours per site. If listed mussel species were identified, additional quantitative surveys were to be completed.

During the qualitative surveys, if no live mussels were collected by the end of the third person-hour, the site survey was considered complete. If live mussels were found, an additional two person-hours of search effort were conducted. All live mussels collected during the qualitative surveys were placed in mesh bags and submerged in the stream. Upon completion of the surveys at each site, mussels were identified to species, enumerated, and returned to the approximate location where they were collected. The substrate composition of each survey location was also recorded. If any listed mussels were identified, an additional quantitative survey was to be completed. No listed mussels were identified during any of the surveys; therefore, no quantitative surveys were completed (Grand River Dam Authority, 2022c).

Mussel surveys were conducted during the week of July 18, 2022 and 193 mussels representing 13 species were collected. Bluefer (*Potamilus purpuratus)* was the most abundant species with 108 individuals collected, followed by 23 fragile papershell (*Utterbackia imbecillis*), 19 threehorn wartyback (*Obliquaria reflexa*), and 17 pink papershell (*Potamilus ohiensis*). A summary of the mussels collected during the qualitative surveys is shown in **Table 3.5.1.3.2-1**.

Table 3.5.1.3.2-1 Mussels Identified in Aquatic Species of Concern Study

Common Name	Scientific Name	Number of Individuals		
		Elk River	Spring River	Neosho River
Bluefer	*Potamilus purpuratus*	0	11	91
Flat floater	*Utterbackiana suborbiculata*	0	5	5
Fragile papershell	*Potamilus fagilis*	0	2	21
Lilliput	*Toxolasma parvum*	0	0	1
Mapleleaf	*Quadrula quadrula*	0	1	0
Paper pondshell	*Utterbackia imbecillis*	0	0	1
Pink papershell	*Potamilus ohiensis*	0	9	8
Pistolgrip	*Tritogonia verrucosa*	0	1	4
Plain pocketbook	*Lampsilis cardium*	1	4	0
Threehorn wartyback	*Obliquaria reflexa*	0	5	14
White heelsplitter	*Lamigona complanata*	0	0	1
Yellow sandshell	*Lampsilis teres*	0	0	3

Source: (Grand River Dam Authority, 2022c)

A summary of the qualitative mussel surveys conducted in the Elk River, Spring River, and Neosho River is provided in the sections below.

Elk River Mussel Survey

Three sites with potential habitat for the Neosho mucket and two additional community assessment sites were identified and surveyed on the Elk River. Habitat identified and sampled included shallow riffles and runs with a complex substrate mixture of gravel, sand, silt, cobble, and bedrock. All sites were searched for a minimum of three person-hours. Only one live mussel, a plain pocketbook *(Lampsilis cardium)*, was identified during the survey (Grand River Dam Authority, 2022c).

Spring River Mussel Survey

Two sites with potential habitat for the Neosho mucket and two additional community assessment sites were identified and surveyed on the Spring River. Habitat in the two most upstream sites was characterized by shallow runs and riffles with complex substrates of gravel, sand, bedrock, and silt, which provided suitable habitat for the species. The rest of the study area was characterized by deeper, slower moving water with silt and clay substrates. All sites were searched for a minimum of five person-hours and 43 mussels belonging to nine species were identified during the survey. The most abundant species was the bluefer with 11 individuals collected, followed by the pink papershell with nine (Grand River Dam Authority, 2018a).

Neosho River Mussel Survey

No shallow riffles or runs providing suitable habitat for the Neosho mucket were present in the Neosho River study area. The habitat was dominated by deep, slow-moving lentic waters. Four community assessment sites were surveyed on the Neosho River. All sites were searched for a minimum of five person-hours and 149 individuals were collected belonging to ten species. The most abundant species was bluefer with 91 individuals collected, followed by fragile papershell with 21, and threehorn wartyback with 14 (Grand River Dam Authority, 2022c).

3.5.1.4 Invasive Species

Several invasive fish and mussel species have been identified in the Project vicinity. They include bighead carp (*Hypophthalmichthys noblis*), pacu (*Colossoma macropomumand*, *Colossoma brachypomum*), zebra mussel (*Driessena polymorpha*), and Asian clams (*Corbicula fluminea*). A description of each species is included in the following paragraphs.

3.5.1.4.1 Bighead Carp

The bighead carp is an invasive species native to southern and central China. It originated when the species escaped an Arkansas fish farm. The species has now been recorded in at least 18 states and are reproducing up and down the Mississippi River (Oklahoma Department of Wildlife Conservation, n.d.a). Bighead carp use flood events as the primary spawning cue (US Geological Survey, n.d.). Adult bighead carp have been confirmed at several sites in the Grand River drainage basin, including the Neosho River in Ottawa County, Grand River in Mayes County, upper Grand Lake, and Lake Hudson.

3.5.1.4.2 Pacu

Sightings of pacu occur in Grand Lake, but they are rare. Pacu are readily available from pet stores and are likely released once they have outgrown their aquaria. The fish are native to South American and not believed to survive the temperatures experienced during winters in Oklahoma. They are herbivores but also occasionally feed on small fish and insects. They have teeth used to cut through vegetation and crush seeds that fall into the water. They do not pose a serious threat to native species at Grand Lake; however, do cause concern from the public since they are sometimes misidentified as piranha (ODWC, 2008).

3.5.1.4.3 Zebra mussels

Zebra mussels were first identified in Grand Lake in 2005 (Grand River Dam Authority, 2017a). They are small mussels with a striped zebra-like pattern, originally from the Caspian Sea region of Asia. They threaten native mussels, fish, and wildlife by outcompeting them for food. They can attach to hard surfaces such as boats and water intake pipes. Their microscopic young, known as velligers, are easily transported in bilges, livewells, and boat motors (Oklahoma Department of Wildlife Conservation, n.d.b). Moving a boat from an infested water to a non-infested water without first removing all water and/or attached zebra mussels can spread the species to new areas. Zebra mussels attached within water intake pipes can disrupt water withdrawals by reducing the withdrawal capacity.

3.5.1.4.4 Asian Clam

The Asian clam was first collected from Grand Lake in the 1970s (Grand River Dam Authority, 2017a). Asian clams occur in small to large rivers, lakes, and ponds in a variety of substrate types. The clam is a filter that removes particles from the water column and can be found at the sediment surface or slightly buried. Asian clam larvae do not require a fish host to reach their juvenile state; therefore, they are able to reproduce at a faster rate than native clams and out-compete them for limited resources (Missouri Department of Conservation, n.d.a). Asian clam disruptions include biofouling of municipal and industrial systems.

3.5.1.5 Macroinvertebrates

Macroinvertebrate sampling data collected in September 2022 in three locations within the Project boundary: one each on the Neosho River, Spring River, and Elk River found a total of 1,679 individuals representing 21 macroinvertebrate families. The monitoring site on the Elk River showed the most diversity with 1,089 individuals representing 21 macroinvertebrate families. The Neosho River site included 448 individuals representing 19 families. The Spring River site included 142 individuals representing 5 families. The five most prevalent macroinvertebrate families were Chironomidae (531), Leptophlebididae (306), Caenidae (250), Baetidae (190), and Naididae (98).

GRDA also identified macroinvertebrate sampling data collected between 2001 and 2018 in five Grand Lake tributaries outside of the Project boundary. These tributaries include Drowning Creek, Horse Creek, Sycamore Creek, Tar Creek, and Whitewater Creek. A total of 10,535 individuals representing 76 different macroinvertebrate families were identified at the non-Project sampling locations. The five most prevalent macroinvertebrate families identified were Chironomidae (3,844), Hydropsychidae (1,536), Asellidae (1,052), Heptageniidae (730), and Baetidae (588).

A map showing the locations of all macroinvertebrate sampling sites and monitoring data for both Project and non-Project monitoring sites is in **Appendix E-20.**

3.5.2 Environmental Effects

In SD1 and SD2, the Commission identified the following issues regarding fish and aquatic resources: (1) effects of project operations (including fluctuations in water levels, and downstream releases) on aquatic habitat and resources in the Project's vicinity (e.g. resident and migratory fish populations; fish spawning, rearing, feeding, and overwintering habitats; mussels and macroinvertebrate populations and habitat); (2) the effects of entrainment on fish populations at the Project; and (3) the effects of Project operation and maintenance activities and Project-related recreation on non-native invasive aquatic species, including zebra mussels (*Driessena polymorpha*) and Asian clams (*Corbicula fluminea*).

3.5.2.1 Effects of Project Operations on Aquatic Habitat and Resources

3.5.2.1.1 Wetlands

Wetlands are relatively resilient to water level fluctuations and impacts that can occur tend to be longer term. Therefore, GRDA produced simulated results from the OM for the baseline operation (under the pre-2015 rule curve), current operation (under the current post-2015 rule curve), and anticipated operation (without a rule curve) to analyze effects of operations on wetlands. The OM utilized inflow data from the period November 1, 2004 through October 31, 2019 for the growing season of March 30 through November 2 of each year. The simulated results produced the average (median) daily low water elevation during the growing season of 742.78, 743.07, and 743.33-feet PD for the baseline, current, and anticipated operations, respectively.

In addition, the simulated results produced one-foot elevation bands according to the baseline, current operation (under the current post-2015 rule curve) and anticipated operation (without a rule curve), as displayed in **Table 3.5.2.1.1-1**.

Table 3.5.2.1.1-1 Average Annual Days within Elevation Bands During the Growing Season for the One-Foot Elevation Bands According to the Baseline, Current, and Anticipated Operation

Elevation Band (feet PD)	Average Annual Days During Growing Season within Elevation Band		
	Baseline Operation	Current Operation	Anticipated Operation
741-742	53	25	7
742-743	36	73	84
743-744	49	61	43
744-745	31	32	34

Overall, GRDA's anticipated operation (without a rule curve) under the new license will result in water level fluctuations of three feet (742 to 745 feet PD) versus a fluctuation of four feet (741 to 745 feet PD) under the baseline operation (under the pre-2015 rule curve). As a result, fewer overall impacts to wetlands, riparian areas, and wildlife management areas are expected under the anticipated operation (without a rule curve) than baseline operation (under the pre-2015 rule curve) (Grand River Dam Authority, 2022b).

Additional wetlands have experienced permanent inundation between reservoir elevations 741 and 742 feet PD under the current operation (under the current post-2015 rule curve) and will continue to experience permanent inundation under the anticipated operation (without a rule curve) and median reservoir elevations will increase by approximately 0.54 feet. [114, 115] This is not expected to result in significant changes but may result, over time, in a net increase in wetlands or conversion of existing wetlands to another wetland type (Grand River Dam Authority, 2022b).

The net increase in wetlands expected to occur as a result of the anticipated operation (without a rule curve) is an incremental positive benefit compared to the baseline operation (under the pre-2015 rule curve). The slight conversion over time of wetlands from one type to another as a result when compared to the baseline operation (under the pre-2015 rule curve) is expected to be a negligible change because the conversions that occur are not expected to reduce any particular rare type of wetlands that occur within the Project boundary.

3.5.2.1.2 Spawning Habitat for Paddlefish

The magnitude and timing of inflow events, which are not controlled by Project operations, are the main determinant of the conditions necessary for successful paddlefish spawning. Therefore, there are no differences between the baseline operation (under the pre-2015 rule curve) and the anticipated operation of the Project.

3.5.2.1.3 Spawning Habitat for Lake Spawning Fish

On Grand Lake, important and highly sought after fish species such as largemouth bass, white crappie, and black crappie tend to begin their spawning behavior in mid-April. The most critical time for lake spawning species and their spawning success is the very early spawning season. At that time, the spawning species require either stable or increasing water levels to assure the immobile fertilized eggs and sac fry do not become desiccated under reducing water levels during the several day-period before they become mobile larvae/fry. Mobile larvae are less susceptible than the fertilized eggs and hatchlings and can move slight distances to avoid desiccation. As the season progresses, the young-of-year rapidly develop and become less susceptible to fluctuating water levels due to their increased size and mobility. This progression of spawning has adapted to the natural cycle of hydrology where water levels are higher during the early spring months and as the season progresses water levels tend to recede over the late spring and summer season with less available precipitation.

<u>Median Reservoir Elevations</u>

GRDA utilized the OM to evaluate reservoir elevations during the spawning and recruitment season, for lake spawning fish including bass (April 1 to July 31) under both baseline operation (under the pre-2015 rule curve) and anticipated operation (without a rule curve) to determine possible impacts to

[114] Most of these areas that became exposed with the reservoir was lowered below 742 feet PD are located in the upper reaches of the reservoir and were not functioning as wetlands. Their frequent exposure hampered the establishment of wetland vegetation and were not functioning as wetlands. As a result, these areas were discussed and described previously as mudflats.

[115] For reference, the median increase in elevation equates to 548 model-derived acres in total. This figure is not restricted to wetland areas only, it is a comprehensive figure that includes all land types that will become inundated more-frequently.

spawning habitat. For current operation (under the post-2015 current rule curve), the median reservoir elevation during the spawning season is 744.01 feet PD. The median elevation during the anticipated operation (without a rule curve) is 0.10 feet higher at 744.11 feet PD during the spawning season. This results in a median of an additional 110 model-derived acres being inundated and available for use by fish during the spawning season. This increased acreage under the anticipated operation (without a rule curve) is expected to be an improvement over the baseline operation (under the pre-2015 rule curve). Therefore, no adverse impacts and only positive impacts are anticipated due to an increased median elevation under anticipated operation (without a rule curve).[116] Depending upon which month(s) the elevations are higher can also have impacts to spawning success.

Annually from April through July, the median reservoir elevations differ for the current operation (under the current post-2015 rule curve) and the anticipated operation (without a rule curve), as shown in **Table 3.5.2.1.3-1**.

Table 3.5.2.1.3-1 Median Reservoir Elevations by Month for Current Operations Versus Anticipated Operations

Month	Current Operations Under the Current Rule Curve (feet PD)	Anticipated Operations without a Rule Curve (feet PD)	Difference (feet)	Difference (inundated acres)
April	742.08	743.72	1.64	1,877
May	743.82	744.99	1.17	1,353
June	744.21	744.72	0.51	605
July	744.03	743.26	(0.77)	(824)

From a median reservoir elevation standpoint, the anticipated operation (without a rule curve) to hold the reservoir lower during the early spawning period provides, in general, in the order of 1,000 additional acres of shallow spawning habitat (inundation) when it is most-critical during the early spawning season than the current operation (under the current post-2015 rule curve). At the same time, the reduced inundation in the month of July is not expected to adversely affect the lake spawning fish later in the spawning season because the young-of-year are mobile. This reduced acreage of submergence later in the year is much less significant than the increased submergence early in the spawning season such that overall, the anticipated operation (without a rule curve) allows the reservoir elevation to follow the natural cycle more-closely and provide an overall positive impact to lake spawning fish.

Overall Fluctuations

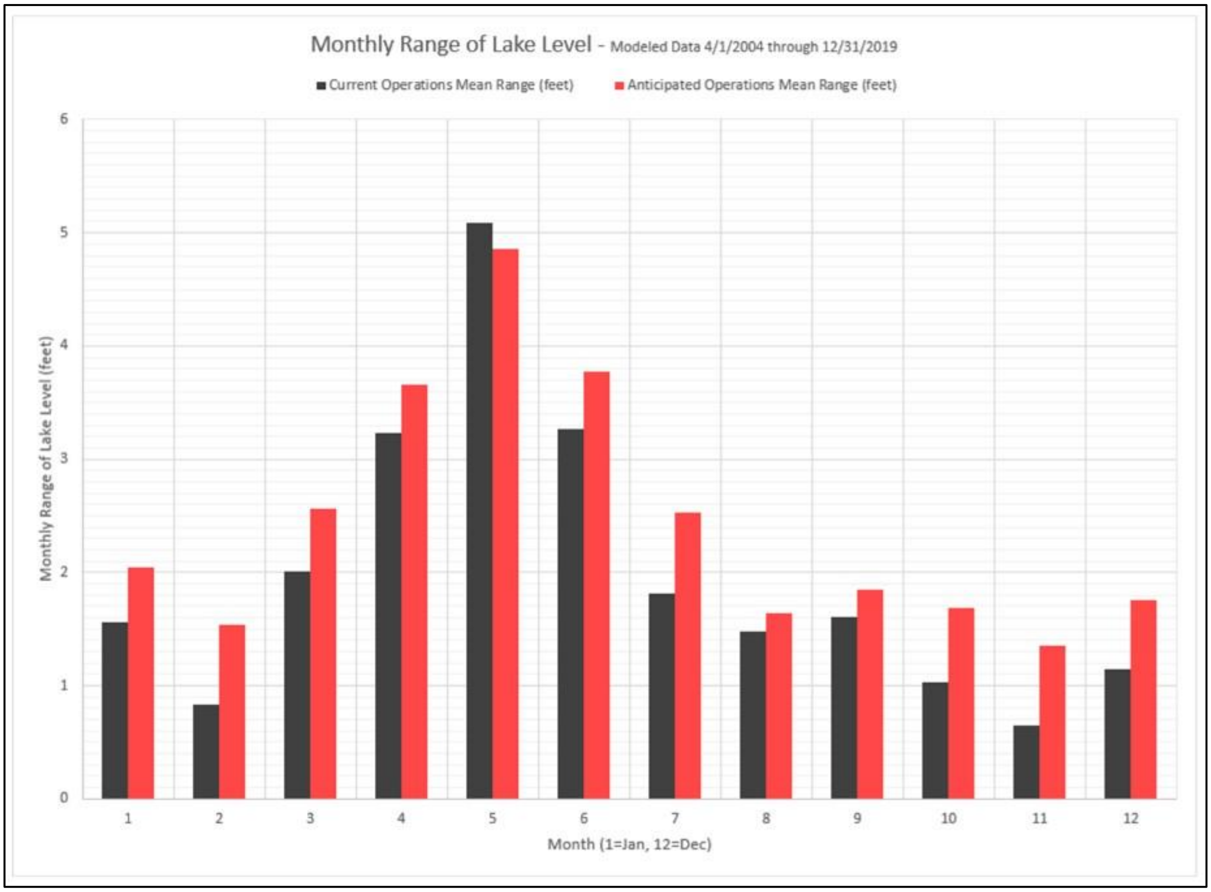
Large annual reservoir elevation fluctuations can have an adverse effect upon spawning habitat for lake spawning fish within the reservoir due to dewatering of habitat from May 1 to July 31 each year.

As shown in Figure 3-2 and Figure 3-3, and further illustrated in **Figure 3.5.2.1.3-1**, under the anticipated operation (without a rule curve), the overall fluctuations from April 1 to April 30 each year in the OM show approximately 0.4 feet more fluctuation than the current operation (under the current post-2015 rule curve). From May 1 to May 31 each year in the OM shows less fluctuation (0.2 feet)

[116] The acreage figures in this section differ from the DLA for the following two reasons: 1) The anticipated acreage in the DLA was based upon a period of May 15 to July 8 instead of May 1 until July 31, and 2) The DLA utilized the baseline operation (under the pre-2015 rule curve) instead of the current operation (under the current post-2015 rule curve).

than the current operation (under the current post-2015 rule curve). For the period June 1 to June 30 each year in the OM, anticipated operation (without the rule curve) shows more fluctuation (0.5 feet) than the current operation (under the current post-2015 rule curve). From July 1 to July 31 each year, the anticipated operation (without the rule curve) in the OM shows more fluctuation (0.7 feet) than the current operation (under the current post-2015 rule curve).

Figure 3.5.2.1.3-1 Monthly Range of Reservoir Elevation



With the findings that the anticipated operation (without a rule curve) according to the OM provides a higher median elevation and provides more spawning habitat during important parts of the spawning season habitat, it is possible the impact of the additional spawning areas can be undone if the higher reservoir elevations show significant fluctuation compared to the fluctuation experienced for the current operation (under the current post-2015 rule curve). As a result, GRDA analyzed and compared the fluctuations for both the current operation (under the current post-2015 rule curve) and the anticipated operation (without a rule curve) to determine if there are significant differences percentage-wise per month and in which months those percentage changes occur. **Table 3.5.2.1.3-2** summarizes the analysis.

Table 3.5.2.1.3-2 Overall Fluctuations by Month for Current Operations Versus Anticipated Operations

Month	Current Operations Under the Current Rule Curve (approximate feet)	Anticipated Operations Without a Rule Curve (approximate feet)	Difference approximate feet)	Differences (inundated acres at median elevations plus difference)	Percent of Available Lost to Fluctuation[117]
April	3.3	3.7	0.4	Current: 3,801 Anticipated: 4,222	Current: 9.1% Anticipated: 9.7%
May	5.1	4.9	(0.2)	Current: 5,875 Anticipated: 4,363	Current: 13.4% Anticipated: 9.6%
June	3.3	3.8	(0.5)	Current: 3,781 Anticipated: 4,359	Current: 8.6% Anticipated: 9.7%
July	1.8	2.5	(0.7)	Current: 2,093 Anticipated: 2,841	Current: 4.8% Anticipated: 6.6%

From an overall reservoir elevation fluctuation standpoint, the anticipated operation (without a rule curve) to hold the reservoir lower during the early spawning period provides more shallow spawning habitat (i.e., inundation) when it is most-critical during the early spawning season than compared to the current operation (under the current post-2015 rule curve), as shown in **Figure 3-2** and **Figure 3-3**. The fluctuation percentages in **Table 3.5.2.1.3-2** change due to fluctuation in the early spawning season for April and do not show a significant difference in the percentages lost to fluctuation (9.1% for current operation and 9.7% for anticipated operation) such that any additional potential spawning habitat benefits (additional submerged acreage) provided by the anticipated operation (without a rule curve) would on average be fully negated by the 0.6% increased fluctuation percentage that is predicted to occur under the anticipated operation (without a rule curve). Therefore, for the month of April, the anticipated operation (without a rule curve) is expected on average to produce a slight positive net benefit to lake spawning.

For the month of May, the anticipated operation (without a rule curve) is expected to produce on average an additional 1,500 acres of submerged acreage for potential spawning over the current operation (under the current post-2015 rule curve) and experiences less fluctuation than the current operation (under the current post-2015 rule curve) during the critical early spawning season. This results in a fully-positive benefit to spawning under the anticipated operation (without a rule curve) on average annually during the month of May.

On average, annually for the months of June and July, the data does not suggest a significant adverse effect on the success of lake spawning fish in moving from the current operation (under the current post-2015 rule curve) to the anticipated operation (without a rule curve). As stated previously, because the young-of-year are most-mobile during this period and any fluctuation occurring during this time-period is less critical such that overall, the anticipated operation (without a rule curve) allows

[117] Difference in acres as shown on the reservoir area and storage capacity curve included in Appendix B-4 A, divided by total submerged acres at median elevation * 100. The higher the percentage the greater anticipated impact.

the reservoir elevation to follow the natural cycle more-closely and provide an overall net positive impact to lake spawning fish and no significant adverse impact.

Daily Fluctuations

As state previously, due to the immobility of spawning beds in the early parts of the spawning season, large rapid daily average fluctuations can have an adverse effect upon the reproductive success of lake spawning fish due to dewatering during the early part of the spawning period from April 1 to July 31 each year.

The simulated average daily reservoir fluctuations as computed by the OM, under anticipated operation (without a rule curve) has an average daily range of ±0.28 feet as opposed to ±0.25 feet under current modeled operations (with the current rule curve) for the period April 1 to July 31 each year. **Figure 3.4.2.4.1-1** displays the daily range of lake level fluctuation per calendar day for water quality purposes, but the same figure applies for assessing the impact upon spawning habitat for lake spawning fish, if the period April 1 to July 31 is the subject of the review.

There is nearly no discernable difference in average daily reservoir level fluctuations (0.03 feet) corresponding to habitat, for the anticipated operation (without a rule curve) compared to the current operation (under the current post-2015 rule curve). Therefore, daily fluctuations during the spawning season are not expected to incur any additional adverse or even measurable impacts to the success of lake spawning fish.

3.5.2.2 Effects of Project Operations on Macroinvertebrates and Mussels

Under the anticipated operation (without a rule curve) the median annual reservoir elevation is 743.46 feet PD, this elevation, while 0.54 feet higher than the baseline (under the pre-2015 rule curve) annual median, is within the baseline normal band of operation. This results in a model-derived acreage of 1,184 acres of additional land that may be inundated on an annual basis that can serve as additional macroinvertebrate and mussel habitat. In addition, as described in Section 3.4.2.4, this increased median is not expected to result in changes to water quality for the macroinvertebrate and mussel populations. The net increase in additional reservoir surface elevation that is expected to occur as a result of the anticipated operation (without a rule curve) is an additional positive benefit compared to the baseline operation (under the pre-2015 rule curve).

3.5.2.2.1 Overall Annual Fluctuations

Large annual reservoir elevation fluctuations can have an adverse effect upon macroinvertebrates and mussels within the reservoir due to dewatering of habitat.

As stated in Section 3, under the anticipated operation (without a rule curve), the overall fluctuations are not going to be more severe than the current operation (under the current post-2015 rule curve). Therefore, macroinvertebrates and mussels are not expected to be significantly adversely affected by the range of overall potential fluctuation of the reservoir elevations under the anticipated operation (without a rule curve) versus the current operation (under the current post-2015 rule curve) on an annual fluctuation basis.

3.5.2.2.1 Daily Fluctuations

Due to the relatively limited mobility of some macroinvertebrates and most mussel species, large rapid daily average fluctuations can have an adverse effect upon macroinvertebrates and mussels within the reservoir due to dewatering of habitat.

The simulated average daily reservoir fluctuations as computed by the OM under anticipated operation (without a rule curve) has an average daily range of ±0.19 feet, as opposed to ±0.16 feet under current modeled operations (with the current rule curve). **Figure 3.4.2.4.1-1** displays the daily range of lake level fluctuation per calendar day for water quality purposes, but the same figure applies for assessing the impact upon macroinvertebrates and mussels.

Since there is nearly no discernable difference in available habitat (0.03 feet) and all species of mussels and most species of macro-invertebrates are at least mobile enough to withstand the difference, the anticipated operation (without a rule curve) compared to the current operation (under the current post-2015 rule curve) is not expected to incur any additional adverse or even measurable impacts to macroinvertebrates and mussels.

3.5.2.3 Effects of Entrainment on Fish Populations

The Project contains vertical trash racks in front of the intakes to the powerhouse. The bottom of the trash racks is at an elevation of 682.0 feet PD.[118] Units #1 through #6 are served by two intake bays with an open width between the piers of 14 feet each, or 28 feet total. [119] The house unit is served by one intake bay that also has an open width of 14 feet. The rated hydraulic capacity of each of Units #1 through #6 as stated in Exhibit A is 1,950 cfs and the house unit is rated at 60 cfs. At a minimum elevation of 742.0 feet PD, this provides and approach velocity for each of the six main units of 1.2 feet per second for the six main units and 0.07 feet per second for the house unit. [120, 121]

The clear spacing of the trash racks at the Project is 3.34 inches.

An entrainment study titled "*Entrainment Susceptibilities of Fishes Inhabiting the Lower Portion of Grand Lake, Oklahoma*" was conducted between August 1988 and July 1989, and is in **Appendix E-21**. Researchers from OSU found 99.5% of entrainment was gizzard shad, followed by 0.21% white crappie , and 0.16% channel catfish. The study concluded entrainment at the Project was limited because recreationally and commercially important sport and food fishes were not abundant near the dam intakes due to their biology. While small gizzard shad (<130 mm) were susceptible to winter entrainment, the species biomass in the overall lake fisheries assemblage indicates mortality and removal is inconsequential to the overall population. The study determined due to the low entrainment rates of gamefish and seasonality of shad entrainment, there would be no significant improvement in the Grand Lake fisheries with the installation of entrainment deterrence devices (Sorenson, Kent, 1990). The OM was used to determine median reservoir elevations during the calendar year. Under the baseline operation (under the pre-2015 rule curve) the median reservoir elevation is 742.04 feet PD. Under the

[118] Elevation as shown on Exhibit F-6.
[119] Intake bay widths are scaled from Exhibit F-9.
[120] [(742 feet-682 feet) * (2 * 14 feet)] / 1,950 cubic feet/second = 1.2 feet/second.
[121] [(742 feet-682 feet) * (1 * 14 feet)] / 60 cubic feet/second = 0.07 feet/second.

anticipated operation (without a rule curve), the median reservoir elevation increases an average of 1.06 to 743.10 feet PD. This extra foot of water does not significantly change the depth water is drawn from, alter the species entrained, or the seasonality of entrainment. Therefore, the anticipated operation (without a rule curve) is not expected to increase fish entrainment or adversely impact fish populations.

The effects upon fish populations as a result of the anticipated operation (without a rule curve) in comparison to the baseline operation (under the pre-2015 rule curve) are not expected to result in any differences.

3.5.2.4 Effects of Project Operation and Recreation on Aquatic Invasive Species

3.5.2.4.1 Bighead Carp

Since bighead carp use large inflow events as a spawning cue, natural high flow conditions rather than the anticipated operation (without a rule curve) have the potential to spread this species. The anticipated operation of the project will not increase the magnitude, duration, or timing of large inflow events. GRDA and its Project operations do not control inflow events. Therefore, there are no differences between the baseline operation (under the pre-2015 rule curve) and the anticipated operation of the Project.

3.5.2.4.2 Pacu

While the anticipated operation (without a rule curve) will provide an additional 696.13 inundated acres, the ODWC indicates Pacu do not pose a serious threat to native species at Grand Lake (ODWC, 2008). Therefore, both the anticipated operation (without a rule curve) and baseline operation (under the pre-2015 rule curve) of the Project is not expected to adversely impact native species at Grand Lake.

3.5.2.4.3 Zebra Mussels and Asian Clams

Although the anticipated operation is not expected to impact the populations of the zebra mussels or Asian clams, recreational use at the Project does have the potential to spread the species to other waters. The main method of preventing the spread of these species is to educate the public recreating on infested lakes to implement BMPs before transporting recreational equipment from an infested water to non-infested waters. Common BMPs to prevent the spread of these species include cleaning, draining, and drying boats and equipment. The risk of spreading invasive species is expected to remain the same under the anticipated operation as under the baseline operation (under the pre-2015 rule curve).

3.5.3 Proposed Environmental Measures

No additional environmental measures are required to reduce the spread of invasive species within the Project because there is no identified difference between the baseline operation (under the pre-2015 rule curve) and anticipated operation (without a rule curve).

3.5.4 Unavoidable Adverse Impacts

Continued operation of the Project is not expected to result in unavoidable adverse impacts to fish and aquatic resources.

3.6 Terrestrial Resources

3.6.1 Affected Environment

3.6.1.1 Botanical Resources

The Pensacola Project is located in a transitional zone between the Ozark Highlands and Central Plains ecoregions in northeastern Oklahoma. Maps showing the vegetation communities surrounding Grand Lake are in **Appendix E-22**. The majority of lands within the Project vicinity are located within the Ozark Highlands ecoregion where oak-hickory and oak-hickory-pine are the primary forested cover types. Typical species on dry uplands and ridgetops include black oak (*Quercus velutina*), white oak (*Quercus alba*), blackjack oak (*Quercus marilandica*), post oak (*Quercus stellate*), winged elm (*Ulmus alata*), and several hickories (*Carya spp*.). The oak-hickory-pine cover type includes all of these species plus shortleaf pine (*Pinus echinate*). Mesic forests include sugar maple (*Acer saccharum*), white oak, and northern red oak (*Quercus rubra*) and are typical of north facing slopes and ravines. Willows (*Salix spp*.), bottomland oaks (*Quercus spp*.), maples (*Acer spp*.), hickories (*Carya spp*.), birch (*Betula spp*.), American elm (*Ulmus americana*), and sycamore (*Plantanus occidentalis*) are typical on floodplains and low terraces (Grand River Dam Authority, 2008).

In the far northern portion of the Project, primarily within the Neosho River arm of Grand Lake, the oak-hickory forests transition into the grassland/forest mosaic of the Central Irregular Plains ecoregion. Typical dominant species of the tallgrass prairie sites within this ecoregion include big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), Indiangrass (*Sorghastrum nutans*), and switchgrass (*Panicum virgatum*). Dry upland forests similar to the oak-hickory forests in the Ozark Highlands ecoregion are common on low rocky hills in the region.

Riparian corridors are typically forested with species including American elm, oaks, hackberry (*Celtis occidentalis*), black walnut (*Juglans nigra*), sycamore, and pecans (*Carya illinoinensis*). Substantial portions of the Central Irregular Plains have been converted to agricultural croplands on plains and pasturelands on steeper slopes (Grand River Dam Authority, 2008).

3.6.1.1.1 Invasive Plant Species

Oklahoma has three state-listed noxious weeds, which include Canada thistle (*Cirsium arvense*), musk thistle (*Cardus nutans*), and scotch thistle (*Onopordum acanthium*). Canada Thistle is widely distributed in Nebraska and other northern states but currently there are no known infestations in Oklahoma. Musk thistle populations are found in northeastern and central counties of Oklahoma, including the Project vicinity. In 1991, several OSU Extension educators began biocontrol of the musk thistle using two thistle-feeding weevils. OSU Extension educators have redistributed over 900,000 weevils throughout the state since the biocontrol program began. These efforts have successfully decreased the severity of infestation in northern Oklahoma counties. Scotch thistle infestations have occurred outside of the Project vicinity in the western portion of the state, primarily in Roger Mills and Custer Counties (Oklahoma State University Extension, 2020).

The Oklahoma Invasive Plant Council developed a watch list of invasive plants by region in the state. There are 15 plants on the watch list for the northeast region of Oklahoma, as shown in **Table**

3.6.1.1.1-1. These plants are not currently abundant in the region; control efforts can be implemented before permanence is established.

Table 3.6.1.1.1-1 Invasive Species Watch List for Northeast Oklahoma

Common Name	Scientific Name
Alligatorweed	*Alternanthera philoxeroides*
Amur honeysuckle (bush honeysuckle)	*Lonicera maackii*
Beefsteak plant (purple mint)	*Perilla frutescens*
Callery pear	*Pyrus calleryana*
Common teasel	*Dipsacus fullonum*
Garlic mustard	*Alliaria petiolota*
Kudzu	*Pueraria montana*
Japanese stiltgrass (Nepalense browntop)	*Microstegium uimineum*
Mimosa (silktree)	*Albizia julibrissin*
Nutgrass (purple nutsedge)	*Cyperus rotundus*
Princess tree (royal paulownia)	*Paulownia tomentosa*
Purple loosestrife	*Lythrum salicaria*
Sulfur cinquefoil (erect cinquefoil)	*Potentilla recta*
Tree of heaven	*Ailanthus altissima*
Water hyacinth	*Eichhornia crassipes*

Source: (Oklahoma Invasive Plant Council, n.d.)

3.6.1.2 Wildlife Resources

3.6.1.2.1 Mammal Species

There are a variety of mammal species in the Project vicinity. Common mammal species in the upland deciduous forest areas include armadillo (*Dasypus novemcinctus*), eastern cottontail (*Sylvilagus floridanus*), fox squirrel (*Sciurus niger*), raccoon (*Procyon lotor*), red fox (*Vulpes vulpes*), striped skunk (*Mephitis mephitis*), Virginia opossum (*Delphis virginiana*), and white-tailed deer (*Odocoileus virginianus*). Common mammals in bottomland forest areas include all of these species, plus muskrats (*Ondatra zibethicus*) and beaver (*Castor canadensis*). Common mammal species associated with grassland and savannah areas are the American badger (*Taxidea taxus*), black-tailed jackrabbit (*Lepus californicus*), deer mouse (*Peromyscus maniculatus*), and least shrew (*Cryptotis parva*) (Grand River Dam Authority, 2008). Several rare bat species are also located in the Project vicinity and are discussed in Section 3.7.

3.6.1.2.2 Avian Species

According to the E-Bird Grand Lake O' the Cherokees, Recreation Area No. 1 (Cherokee State Park) Checklist, 130 avian species have been identified at the Cherokee State Park in Mayes County, Oklahoma (eBird, n.d.). The checklist is in **Appendix E-23**. The avian species most often observed at the Project according to the checklist included American coot (*Fulica americana*), Canada goose (*Branta canadensis*), American white pelican (*Pelecanus erythrorhynchos*), Bonaparte's gull (*Chroicocephalus philadelphia*), gadwall (*Mareca strepera*), black vulture (*Coragyps atratus*), doublecrested cormorant (*Phalacrocorax auratus*), red-tailed hawk (*Buteo jamaicensis*), barn swallow (*Hirundo rustica*), and eared grebe (*Podiceps nigricollis*) (eBird, n.d.a).

Raptor species identified at the Project included bald eagle (*Haliaeetus leucocephalus*), American kestral (*Falco sparvierius*), Cooper's hawk (*Accipiter cooperii*), Mississippi kite (*Ictinia mississippiensis*), osprey (*Pandoin haliaetus*), red shouldered hawk (*Buteo lineatus*), and red-tailed hawk (eBird, n.d.a).

Grand Lake is an over-wintering and migratory stop for many avian species. Cormorants, gulls, pelicans, and herons are among the non-game birds that are present at the Project each year. A diverse array of waterfowl such as geese and dabbling, diving, perching, sea, and stiff-tailed ducks are also present at the Project during migration. Mallards (*Anas platyrhynchos*) are the only dabbling duck that over-winter on Grand Lake. Canadian geese (*Branta canadensis*) and wood ducks (*Aix sponsa*) are year-round residents (Grand River Dam Authority, 2008).

3.6.1.2.3 Herptile Species

A review of the Oklahoma Biological Survey Distribution of Oklahoma Amphibians and Reptiles by Recorded Siting database, conducted in 2016, identified 90 herptile species within the four counties the Pensacola Project is located (Grand River Dam Authority, 2017a). The species are shown in **Table 3.6.1.2.3-1**.

Common amphibian species include the American toad (*Anaxyrus americanus*), spadefoot toad (*Scaphiopus spp*.), gray tree frog (*Hyla versicolor*), and narrow-mouthed toad (*Gastrophryne spp*.). Common turtle species include snapping turtles (*Chelydra serpentine*), mud turtles (*Kinosternon spp*.), softshell turtles (*Apalone spp*.), common sliders (*Trachemys scripta*), map turtles (*Gaptemys pseudogeographica*), and box turtles (*Terrapene spp*.). Common lizard species include western slender glass lizard (*Ophisaurus attenuatus*), collard lizard (*Crotaphytus collaris*), Texas horned lizard (*Phrynosoma corundum*), and several species of skinks (*Eumeces spp.*). Common snake species include western rat snakes (*Pantherophis obsoletus*), water snakes (*Nerodia spp*.), bullsnakes (*Pituophis melanoleucus sayi*), and venomous snakes such as copperhead (*Agkistrodon contortrix*), western cottonmouth (*Agkistrodon piscivorus*), timber rattlesnakes (*Crotalus horridus*), and western pygmy rattlesnakes (*Sistrurus miliarius*) (Grand River Dam Authority, 2008).

Table 3.6.1.2.3-1 Herptile Species in the Pensacola Project Vicinity

Common Name	Scientific Name
Alligator snapping turtle	*Macroclemys temmincki*
American toad	*Anaxyrys americanus*
Black rat snake	*Elaphe obsoleta*
Blind snake	*Leptophilops dulcis*
Bullfrog	*Rana catesbeiana*
Bull snake	*Pituophis melanoleucus sayi*
Brown snake	*Storeria dekayi*
Cave salamander	*Eurycea lucifuga*
Central newt	*Notophthalmus viridescens louisianensis*

Common Name	Scientific Name
Chicken turtle	*Deirochelys reticularia miaria*
Coachwhip	*Masticophis flagellum*
Coal skink	*Eumeces anthracinus*
Collared lizard	*Crotaphytus collaris*
Common gartersnake	*Thamnophis sirtalis*
Common musk turtle	*Sternotherus odoratus*
Common slider (red-eared slider)	*Trachemys scripta*
Copperhead	*Agkistrodon contortrix*
Corn snake	*Elaphe guttata emoryi*
Cottonmouth	*Agkistrodon piscivorus*
Crawfish frog	*Rana areolata*
Cricket frog	*Acris crepitans*
Diamondback water snake	*Nerodia rhombifera*
Dusky salamander	*Desmognathus fuscus*
Eastern box turtle	*Terrapene carolina*
Eastern narrow mouthed toad	*Gastrophryne carolinensis*
Eastern hog-nosed snake	*Heterodon platyrhinos*
Fence lizard	*Sceloporous undulatus hyacinthinus*
Five-lined skink	*Eumeces fasciatus*
Flat-headed snake	*Tantilla gracilis*
Fowler’s toad	*Bufo woodhousei*
Gray treefrog	*Hyla versicolor*
Great plains skink	*Eumeces obsoletus*
Graham’s crayfish snake	*Regina grahamii*
Ground skink	*Scincella lateralis*
Ground snake	*Sonora semiannulata*
Grotto salamander	*Typidoclonion (eurycea) spelaeus*
Hurter’s spadefoot	*Scaphiopus hurteri*
Long-tailed salamander	*Eurycea longicauda*
Lined snake	*Tropidoclonion lineatum*
Many-ribbed salamander	*Eurycea multiplicata*
Map turtle	*Graptemys geographica*
Mediterranean house gecko	*Hemidactylus turcicus*
Milk snake	*Lampropeltis triangulum*
Mississippi mud turtle	*Kinosternon subrubrum*
Missouri river cooter	*Pseudemys concinna*
Mudpuppy	*Necturus maculosus*
Narrow salamander	*Ambystoma texanum*
Northern banded water snake	*Neroidia sipedon*
Northern green frog	*Rana clamitans*
Northern leopard frog	*Rana pipiens*
Northern slimy salamander	*Plethodon glutinosus*
Ouachita dusky salamander	*Desmognathus brimleyorum*

Common Name	Scientific Name
Ouachita map turtle	*Graptemys ouachitensis*
Oklahoma salamander	*Eurycea tynerensis*
Ornate box turtle	*Terrapene ornata*
Ozark zigzag salamander	*Plethodon dorsalis angusticlavius*
Plain-bellied water snake	*Nerodia erythrogaster*
Plains leopard frog	*Rana blairi*
Plains spadefoot	*Scaphiopus bombifrons*
Prairie kingsnake	*Lampropeltis calligaster*
Prairie skink	*Eumeces septentrionalis*
Racer	*Coluber constrictor*
Red-bellied snake	*Storeria occipitomaculata*
Ring-necked snake	*Diadophis puntatus*
Rough earth snake	*Virginia striatula*
Rough green snake	*Opheodrys aestivus*
Scarlet snake	*Cemophora coccinea*
Snapping turtle	*Chelydra serpentine*
Six-lined racerunner	*Cnemidophorus sexlineatus*
Southern leopard frog	*Rana utricularia*
Southern red-backed salamander	*Plethydon serratus*
Speckled kingsnake	*Lampropeltis getulus*
Spiny softshell turtle	*Apalone spinifera*
Spotted salamander	*Ambystoma maculatum*
Spring peeper	*Pseudacris crucifer or Hyla crucifer*
Strecker’s chorus frog	*Pseudacris streckeri*
Striped chorus frog	*Pseudcris triseriata*
Texas horned lizard	*Phrynosoma cornutum*
Timber rattlesnake	*Crotalus horridus*
Western ribbonsnake	*Thamnophis proximus*
Western pygmy rattlesnake	*Sisturus miliarius*
Worm snake	*Carphophis amoenus vermis*
Yellow mud turtle	*Klinosternon flavescens*

Source: (Grand River Dam Authority, 2017a)

3.6.1.2.4 Fish and Waterfowl Habitat Management Plan

GRDA developed a Fish and Waterfowl Habitat Management Plan under Article 411 of the existing license, which was approved by the Commission on May 22, 2003. Since the approval of the FWHMP, GRDA has worked with the FWHMP Technical Committee to provide habitat mitigation measures at the Pensacola Project. Some of the mitigation strategies used were less successful than anticipated. In response to these challenges, GRDA and the FWHMP Technical Committee began to explore alternative mitigation solutions that would meet the objectives of the FWHMP. In January of 2016, an Interagency Agreement between ODWC and GRDA was signed, which allows GRDA to fulfill the requirements of the FWHMP through adjacent site restoration and wetland development and therefore eliminated the need to add a similar license article under the new license (Grand River Dam Authority, 2018b).

On May 24, 2018, GRDA filed the final implementation plan for the Coal Creek Wildlife Management Area with FERC. Once it is approved, the plan is intended to carry out the interagency agreement by specifying the scope of activities that will be taken by GRDA and ODWC to use the mitigation fund pursuant to the FWHMP (Grand River Dam Authority, 2018b).

3.6.2 Environmental Effects

In SD1 and SD2, the Commission identified the following issues regarding Terrestrial Resources: (1) the effects of the frequency timing, amplitude, and duration of reservoir fluctuations and flow releases from the Project on riparian, wetland, and littoral vegetation community types; (2) the effects of Project operation and maintenance activities (e.g., road and facility maintenance and Project related recreation on wildlife and wildlife habitat); (3) the effects of Project operation and maintenance on avian species, including avian electrocution and collision with Project generator leads; (4) the effects of Project operation and maintenance activities and Project related recreation on non-native invasive botanical and wildlife species; and (5) the effects of Project operation and maintenance activities and Project related recreation on terrestrial resources of cultural significance to Native American Tribes in the Project area, including wild strawberries.

3.6.2.1 Effects of Reservoir Fluctuation/Flow Releases on Riparian, Wetland, and Littoral Vegetation

The effect of Project operation (i.e., reservoir fluctuation) on riparian, wetland, and littoral vegetation is discussed in Section 3.5.2.1.

3.6.2.2 Effects of Project Operation on Wildlife and Wildlife Habitat

The effects of Project operations on threatened and endangered species are discussed in Section 3.7.

Project facilities and FERC-approved recreation sites are fully developed sites; natural vegetation has been disturbed and does not provide quality habitat for most wildlife species. Therefore, routine maintenance of these sites is unlikely to adversely affect wildlife or their habitat.

Non-Project use of Project lands has the potential to affect wildlife habitat. GRDA has implemented a SMP to minimize or avoid impacts to wildlife habitat. The SMP has been updated as part of this licensing process to incorporate additional provisions regarding vegetation management, wetland impacts, and wildlife habitat impacts. A more detailed discussion of the updated SMP is in Section 3.9.

3.6.2.3 Effects of Project Operation and Maintenance on Avian Species

Except for the point of interconnect within the non-Project switching station, the primary transmission lines and other energized facilities that are part of the Project are not exposed such that avian species, including migratory bird species, would be at risk for electrocution or collision. Therefore, the operation and maintenance of the Project is unlikely to adversely affect avian species, including migratory bird species.

Regarding the exposed point of interconnect within the non-Project switching station, the switching station is routinely visited as part of general operation and maintenance. General operation and maintenance visits to the switching station have not identified any chronic conditions or electrocution or collision with avian species or migratory birds. Therefore, the operation and maintenance of the Project is unlikely to adversely affect avian species, including migratory bird species.

3.6.2.4 Effects of Project Operation on Invasive Botanical and Wildlife Species

Routine maintenance of Project facilities and recreation sites poses a risk of spreading invasive terrestrial species by transporting invasive plant seeds or plant parts from infested areas to non-infested areas. The risk of spreading invasive species is expected to remain the same under the anticipated operation as under the baseline operation (under the pre-2015 rule curve).

3.6.2.5 Effects of Project Operations on Terrestrial Resources of Cultural Significance

Effects of Project operations on terrestrial resources of cultural significance are discussed in Section 3.11.

3.6.3 Proposed Environmental Measures

The following environmental measures are being proposed by GRDA to address potential impacts to terrestrial resources caused by continued operation of the Project:

- GRDA will continue to implement the updated SMP to minimize or avoid impacts to terrestrial resources resulting from authorized non-Project use of Project lands. GRDA will implement measures for erosion and siltation control during ground disturbing activities related to the operation and maintenance of the Project to mitigate the impacts of erosion and siltation on the resource.

3.6.4 Unavoidable Adverse Impacts

With the implementation of the proposed environmental measures, continued operation of the Project is not expected to result in unavoidable adverse effects to Terrestrial Resources.

3.7 Threatened and Endangered Resources

3.7.1 Affected Environment

FERC issued a memorandum with a list of federally threatened, endangered, candidate, and proposed species from the USFWS Information for Planning and Consultation (IPaC) website on January 11, 2018. A copy of the memorandum and official species list is in **Appendix E-24**. GRDA completed an updated review of the IPaC website on October 14, 2022 to account for any changes since the 2018 list was generated. The official species list generated in 2022 is in **Appendix E-25**. In addition to the threatened, endangered, proposed, and candidate species, the official species list also identified the potential presence of the bald eagle within the Project vicinity. Threatened, endangered, candidate, and proposed species are shown in **Table 3.7.1-1** and described in the following sections.

Table 3.7.1-1 Threatened, Endangered, Candidate, and Proposed Species Identified in IPaC Official Species Lists

Common Name	Scientific Name	Group	Status
Gray bat	*Myotis grisescens*	*Mammal*	*Endangered*
Indiana bat	*Myotis sodalis*	*Mammal*	*Endangered*

Common Name	Scientific Name	Group	Status
Northern long-eared bat	*Myotis septentrionalis*	*Mammal*	*Threatened*
Ozark big-eared bat	*Corynorhinus townsendii igens*	*Mammal*	*Endangered*
Tricolored bat	*Perimyotis subflavus*	*Mammal*	*Proposed Endangered*
Piping plover	*Charadrius melodus*	*Bird*	*Threatened*
Rufa red knot	*Calidris canutus rufa*	*Bird*	*Threatened*
Alligator snapping turtle	*Macrochelys temminickii*	*Reptile*	*Proposed Threatened*
Neosho madtom	*Noturus placidus*	*Fish*	*Threatened*
Ozark cavefish	*Amblyopsis rosae*	*Fish*	*Threatened*
Neosho mucket	*Lampsilis rafinesqueana*	*Mussel*	*Endangered*
Rabbitsfoot [122]	*Quadrula cylindrica cylindrica*	*Mussel*	*Threatened*
Winged Mapleleaf [123]	*Quadrula fragosa*	*Mussel*	*Endangered*
American burying beetle	*Nicrophorus americanus*	*Insect*	*Threatened*
Monarch butterfly	*Danaus plexippus*	*Insect*	*Candidate*

Source: (Federal Energy Regulatory Commission, 2018b), (US Fish and Wildlife Service, 2022)

GRDA completed a draft biological assessment (BA) providing an analysis of anticipated Project effects for the thirteen identified species that may occur within the Project vicinity, which is included in **Appendix E-26**.[124]

3.7.1.1 Gray Bat

The gray bat is a federally endangered mammal. Gray bats are reliant on limestone cave systems and are found in oak-hickory forests in the Ozark Highlands of Oklahoma. The bats use caves year-round as both maternity sites and hibernacula to raise young and overwinter (Oklahoma Department of Wildlife Conservation, n.d.c). Gray bats feed primarily on insects that have an aquatic larval stage; therefore, maternity sites are often located within three miles of a large lake or river. Two gray bat caves have been documented in the Project vicinity, with one cave located outside of the Project boundary and both are utilized to varying degrees as maternity caves. The land adjacent to cave (Cave DL-91) is owned and managed by the Nature Conservancy for the protection of the cave and its inhabitants (i.e., Ozark cavefish and gray bat) (Grand River Dam Authority, 2008). The other cave (Cave DL-2) is located both on GRDA property (the entrance) and on private property (the alternative exit) (Federal Energy Regulatory Commission, 1991).

Acoustic surveys conducted by GRDA during the summers of 2015 and 2016 indicated gray bats were the second most frequent bat species detected on Grand Lake and were found in both developed and undeveloped areas. The gray bat accounted for 15.7% of the 274 bats identified during the mobile surveys and 11.3% of the 34,319 bats identified during the stationary surveys. The findings of the acoustic survey indicate there is no specific well defined foraging area, rather the entire lake is used as a foraging area (Grand River Dam Authority, 2017b).

[122] Rabbitsfoot identified in FERC's 2018 official species list, but not in the updated 2022 official species list.
[123] Winged mapleleaf identified in FERC's 2018 official species list, but not in the updated 2022 official species list.
[124] The thirteen species included in the BA include the gray bat, Indiana bat, northern long-eared bat, Ozark big-eared bat, tricolored bat, piping plover, rufa red knot, alligator snapping turtle, Neosho madtom, Ozark cave fish, Neosho mucket, American burying beetle, and monarch butterfly.

GRDA conducted a Terrestrial Species of Concern Study in 2021 and 2022. The Terrestrial Species of Concern Study Report is in **Appendix E-27**. A portion of the study focused efforts on gray bats and two caves they are known to use in the Project vicinity, which are identified as Cave DL-2 and Cave DL-91. Infrared-illuminated entrance and night vision optics were used to conduct non-intrusive exit surveys and population estimates of gray bat colonies exiting Cave DL-2 and Cave DL-9 in the 2021 and 2022 summer maternity and post maternity seasons. These surveys were used to document habitation, assist in estimating colony size at the respective caves, and monitor movements of the colony during potential high water and flood events on Grand Lake.

In 2021, exit surveys were conducted at Cave DL-2 on June 22 and Cave-DL-91 on June 24 and July 16. No monitoring was conducted related to high-water events in 2021. In 2022, exit surveys were conducted at Cave DL-2 on June 22 and Cave DL-91 exit surveys were conducted on May 10 (high water event), June 22, and August 4. Results of the exit surveys are shown in **Table 3.7.1.1-1**.

Table 3.7.1.1-1 Population Estimates of Caves DL-2 and DL-91 in the 2021 and 2022 Maternity Seasons

Date	Survey Method	Cave DL-2 Population	Cave DL-91 Population
6/22/2021	Exit Survey	11,800	-
6/24/2021	Exit Survey	-	510
7/16/2021	Exit Survey	-	20,440
5/10/2022	Exit Survey	-	20,620
6/22/2022	Exit Survey	-	6,600
6/27/2022	Exit Survey	13,300	-
8/04/2022	Exit Survey	-	23,877

Source: (Grand River Dam Authority, 2022d)

The gray bat roost at Cave DL-2 was first documented in 1981 when the estimated colony population was 13,700 bats; the population size has remained relatively constant over the past 25 years. The estimated post maternity population at Cave DL-91 for both years falls within the range of 10,000 to 19,905 bats (average = 18,245) observed over the past decade (Grand River Dam Authority, 2022d).

Cave abandonment may result from high water events or late-season migration after young are able to fly. Under favorable conditions the colony vacates Cave DL-2 entirely in mid-summer and migrates to Cave DL-91 about 3.1 miles away, where it typically remains until migration to hibernacula in November. Surveys conducted since 2007 have shown during high water events, the colony has successfully relocated from Cave DL-2 to Cave DL-91. If flood events occur early in the spring from April to early May followed by receding lake levels, the colony often returns to Cave DL-2 for the maternity season. During the May 2022 high water event, the colony successfully migrated to Cave DL-91 (Grand River Dam Authority, 2022d).

The entrance to Cave DL-2 is located at elevation 746 feet PD and becomes totally inundated when the elevation of Grand Lake is at 752 feet PD. Evacuation of the cave generally does not begin until Grand Lake reaches an elevation of 751 feet PD. At this elevation, there is approximately one foot of flyway between the top of the water in the cave and the rock ceiling. In 2008, a small, high passage within Cave DL-2 was identified and minimally excavated and enlarged to provide an alternative escape route for exiting bats, especially during high water. Additional excavation and enlargement of this high passage was completed in 2013. An inspection of this high passage since 2011, including the 2022 survey period, revealed scattered guano, indicating it had been used by bats. A post-inundation monitoring visit to the Cave DL-2 following a flood event in 2015 failed to give any indication a take occurred as a result of the inundation. It is presumed the colony successfully vacated to another location (Grand River Dam Authority, 2022d).

3.7.1.2 Indiana Bat

The Indiana bat is a federally endangered mammal. Over 80% of the entire population hibernates in caves in Indiana, Missouri, and Kentucky. Oklahoma is located on the southwestern edge of the bat's range and only a few Indiana bats have been recorded in the state. One cave located in LeFlore County is known to be used regularly as a winter hibernacula for the species (Oklahoma Department of Wildlife Conservation, n.d.d). No critical habitat for the species has been identified in the Project vicinity. No Indiana bats were identified during acoustic surveys conducted by GRDA in the summers of 2015 and 2016 (Grand River Dam Authority, 2017b).

3.7.1.3 Northern Long-Eared Bat

The northern long-eared bat (NLEB) is a federally endangered mammal. It occurs throughout portions of the Ozark Highlands and Ouachita Mountains regions of eastern Oklahoma. At least nine NLEB hibernacula are known in Oklahoma, though multiple individuals have been documented at additional cave locations. The NLEB uses limestone caves in the Ozark Highlands that are used by other listed bats, including the gray bat. The NLEB does not rely on caves for its entire life cycle (Oklahoma Department of Wildlife Conservation, n.d.e). It roosts during the summer months underneath loose bark or in cavities or crevices of both live and dead trees. Non-reproducing females and males may also roost in cool places such as caves or mines. NLEB feed in the forest interior and hibernate in caves and mines during the winter (US Fish and Wildlife Service, n.d.c). Unlike other bats, the NLEB does not gather in large colonies in winter and single bats and small groups will often hibernate in narrow cracks or crevices in caves (Oklahoma Department of Wildlife Conservation, n.d.e). There has been no critical habitat identified for the species in the Project vicinity.

The Pensacola Project is located within the bat's range, and they were detected during acoustic surveys conducted by GRDA in the summers of 2015 and 2016. NLEB accounted for 0.4% of the 273 bats calls identified during mobile surveys and 0.2% of the 34,319 bats calls identified during stationary surveys (Grand River Dam Authority, 2017b).

3.7.1.4 Ozark Big-Eared Bat

The Ozark big-eared bat is a federally endangered mammal. They historically occurred in at least five Oklahoma counties; but currently there are only known populations in Adair, Cherokee, and Sequoyah Counties. The bats live in limestone and sandstone talus caves found in oak-hickory forests of the Ozark Highlands and rely on caves as both maternity sites for raising young and as hibernacula. They forage within one to five miles of their caves. Since the bat is not migratory, individuals often use the same caves annually. During certain periods in their life cycle, the species is very sensitive to disturbance. Human visitation and vandalism of occupied caves can cause cave abandonment (Oklahoma Department of

Wildlife Conservation, n.d.f). No Ozark big-eared bats were identified during 2015 and 2016 GRDA acoustic surveys (Grand River Dam Authority, 2016a). No critical habitat for the species has been identified in the Project vicinity. According to the ODWC publication, *Bats of Oklahoma Field Guide*, the bats only occur within Adair, Cherokee and Sequoyah Counties, all of which are outside of the Project vicinity (Oklahoma Department of Wildlife Conservation, 2013).

3.7.1.5 Tricolored Bat

On September 13, 2022, USFWS proposed to list the tricolored bat as an endangered species under the ESA. The bat faces extinction due to the impacts of white-nose syndrome, a deadly disease affecting cave-dwelling bats across the country (US Fish and Wildlife Service, n.d.d).

The tricolored bat is one of the smallest bats native to North America and is typically 3 to 3.5 inches long. It varies in color from pale yellow to golden brown (Oklahoma Department of Wildlife Conservation, n.d.g). The bat is active from spring to fall, primarily roosting among live and dead leaf clusters of live or recently dead hardwood trees. The bats have also been known to roost in other areas including among pine needles, eastern red cedar, and within artificial roosts like barns, bridges, concrete bunkers, and rarely within caves. Female bats return to the same summer roosting locations year after year. The bat typically hibernates in caves and mines during the winter. Where caves are not common, it often hibernates in road culverts and sometimes in tree cavities and abandoned wells. The tricolored bat typically returns to the same hibernaculum each year (US Fish and Wildlife Service, n.d.d).

During acoustic surveys conducted by GRDA in the summers of 2015 and 2016, tricolored bats were the most frequently identified bat species. They accounted for 75.2% of the 206 bat calls identified during mobile surveys and 74.0% of the 34,319 bat calls identified during stationary surveys (Grand River Dam Authority, 2017b).

3.7.1.6 Piping Plover

The piping plover is a federally endangered avian species and typically breeds along shorelines of rivers and lakes from Kansas to Canada. Only one nesting record exists in the Oklahoma panhandle. The bird overwinters on the Gulf Coast. Many reservoirs throughout the state have harbored piping plovers for brief periods and single birds are usually documented at stopover sites. Piping plovers often select mudflats and sandbars to forage for invertebrates. The birds in Oklahoma are part of the Northern Great Plains Population (Oklahoma Department of Wildlife Conservation, n.d.h). Piping plovers typically migrate alone or in small groups and are often seen along sandbars of major rivers and mudflats of reservoirs. They use sparsely vegetated or bare shorelines to forage for small invertebrates. Piping plovers could occur in areas with suitable foraging habitat within the Project vicinity when migrating (Grand River Dam Authority, 2017a).

The mudflats on the reservoir that historically occurred when the reservoir was lowered to 741.0 feet PD and could have been used by the piping plover are well-documented in the record for this Project.[125]

[125] In the Commission's Environmental Assessment for the Application for Amendment of License to Modify Rule Curve dated December 6, 1996 (Accession # 961206-0071), according to the 1996 environmental assessment (EA) which cited Erickson and Leslie, 1988, operation elevations between 735 to 742 feet PD produce 4,993.9 acres of mudflats. In addition, according to the

Since the current operation (under the current post-2015 rule curve) no longer includes a target of 741.0 feet PD, the mudflats no longer form regularly as they did as part of the baseline operation (under the pre-2015 rule curve).

According to the Oklahoma Biodiversity Information System, there is only one recorded sighting of a piping plover in Oklahoma, which was sited in Cleveland County in 1993. There have been no sightings of the piping plover in the Oklahoma Natural Heritage Inventory for the Project (ONHI, 2021). In addition, eBird.org has no record of sightings of piping plover at its Grand Lake O' the Cherokees Recreation Area Number 1 observation site nor its Grand Lake O' the Cherokees Off Road Trail observation site (eBird, n.d.a)(eBird, n.d.b). Although the species may use mudflats or sandbars within the Project boundary during migration through the area, it is not classified as critical habitat for the species.

3.7.1.7 Rufa Red Knot

The rufa red knot is listed as a federally threatened avian species and breeds along the shores of the arctic, overwinters in Chile, and only travels through the state of Oklahoma. They prefer to forage on mudflats and use their bills to probe the substrate for mollusks, invertebrates, and seeds. Oklahoma is not known as a critical breeding or staging area for the species and ideal foraging habitat for the species is limited within the state. Less than five sightings of the species are reported in Oklahoma annually. Of those, 85% have been reported during fall migration (Oklahoma Department of Widlife Conservation, n.d.f). The species may use mudflats or sandbars within the Project vicinity during migration through the area. As with the piping plover (Section 3.7.1.6), large areas of mudflats on the reservoir that historically could have been used by the rufa red knot no longer form on a regular basis under the current operation (under the current post-2015 rule curve) of the Project.

No critical habitat has been identified in the Project boundary. According to the Oklahoma Biodiversity Information System, there are no recorded sighting of a rufa red know in Oklahoma. In addition, eBird.org has no record sightings of rufa red knot at its Grand Lake O' the Cherokees Recreation Area Number 1 observation site nor its Grand Lake O' the Cherokees Off Road Trail observation site (eBird, n.d.a) (eBird, n.d.b).

3.7.1.8 Alligator Snapping Turtle

The alligator snapping turtle (*Macrochelys temminckii*) is a proposed federally threatened reptile species. It is the largest turtle found in North America. The turtles are found in river systems that flow into the Gulf of Mexico and are restricted to east central and southeastern lakes, rivers, and sloughs. They feed on a variety of foods including fish crayfish, mussels, birds, mammals, and other reptiles (Oklahoma Department of Wildlife Conservation, n.d.i). Females lay eggs in sandy soils or other dry substrates within approximately 650 feet (200 meters) from the water's edge. Juvenile turtles require small streams with

ODWC, as outlined in the EA, an operation down to an elevation of 741.0 feet PD would expose 500 to 1,000 acres of mudflats. The 500 to 1,000 acres of mudflats are the mudflats referenced in Exhibit E of the DLA. The mudflats referenced in the DLA are only pertinent to any discussion of impacts if the Commission is to complete a review of the baseline operation as defined in the DLA because the baseline operation analysis includes a target of 741.0 feet PD from August 15 to October 15 each year prior to 2016. In late 2015, the operational minimum target was established at 742.0 feet PD which is the current operation (under the current post-2015 rule curve). Prior to the change, GRDA consulted with the USFWS on its July 30, 2015 application (Accession # 20150730-5167. The USFWS in their letter dated June 29, 2015 concluded the variance eliminating the August 15 to October 15 target of 741.0 feet PD was not likely to adversely affect federally-listed species.

mud and gravel bottoms with submerged structures, such as trees, which allow for foraging and predator protection. Adult turtles require streams and rivers with submerged logs and undercut banks, clean water, and ample prey.

In conjunction with the proposed listing, USFWS is also proposing a 4(d) rule that would allow incidental take associated with the following activities:

- Construction operation and maintenance activities that occur near or in a stream, such as installation of stream crossings, replacement of existing instream structures (e.g., bridges, culverts, water control structures, boat landings, etc., and operation and maintenance of existing flood control or other existing structures when implemented with industry and/or state-approved construction stormwater BMPs for construction;
- Silviculture practices and forest management activities that use state-approved construction stormwater BMPs to protect water and sediment quality and stream or riparian habitat; or
- Maintenance dredging activities that occur within the previously disturbed portion of the navigable waterway as long as activities do not encroach upon suitable turtle habitat outside the maintained portion of the channel (US Fish and Wildlife Service, 2021).

3.7.1.9 Neosho Madtom

The Neosho madtom is a federally threatened fish. It is a small member of the catfish family, generally smaller than three inches in length. Historically in Oklahoma, the fish occurred within the Neosho River, Spring River, and Illinois River, but is currently limited to the stretches of the Neosho River and Spring River between the Oklahoma/Kansas state line and Grand Lake (Oklahoma Department of Wildlife Conservation, n.d.j). The fish inhabits riffle and bar habitat with loose pebble and gravel substrates, moderate to high water velocities, and relatively shallow water.

The need for Neosho madtom surveys was identified for portions of the Neosho River and Spring River in the Commission's 2022 SPD. The results of these fishery surveys, including the species and number of fish captured, are described in more detail in Section 3.5.1.2.

Neosho madtoms were collected at five of the seven sampling sites on the Neosho River. The water velocity at the Neosho River sites ranged from 0.6 to 3.4 fps and averaged was 1.7 fps. The substrate composition at the sampling sites varies. The largest particle sizes comprised greater than 40% of substrates in the upstream sites to less than 5% of the remaining sites (Grand River Dam Authority, 2022c).

No Neosho madtoms were collected from any of the four Spring River sampling sites. The average water velocity at the Spring River Sites was 2.7 fps (ranging from 2.0 to 3.1 fps). The largest substrate size distribution ranged from 5% to 40%, with a trend for more even distribution of particle sizes in the downstream sites (Grand River Dam Authority, 2022c).

3.7.1.10 Arkansas Darter

In SD2, the Commission requested impacts to the Arkansas darter, although not currently a federally listed species, be addressed because the species is known to occur in the Spring River upstream of the Project vicinity. The species was not identified in the IPaC Official Species List provided by FERC in 2018 or the updated IPaC Official Species List from 2022. The species prefers shallow clear, cool water, sand or silt bottom streams with spring fed pools and abundant rooted aquatic vegetation. During late summer when some stream may become intermittent, the fish persists in large deep pools. The fish feeds on a variety of aquatic insects and some plant materials (US Fish and Wildlife Service, n.d.e). The species is known to occur in southwest Missouri in the Spring River (Missouri Department of Conservation, n.d.b). The species was not identified in historic fish assemblage for the Project or identified in 2022 fish surveys. Therefore, the species is not likely to occur within the Project vicinity.

3.7.1.11 Ozark Cavefish

The Ozark cavefish is a federally threatened fish species. The Ozark cavefish is a small fish that grows to a maximum length of two inches and lacks pigment, making it appear as a pinkish-white color. The fish is a cave organism and has only been documented in Ottawa and Delaware Counties. The fish feeds on small aquatic invertebrates and has also been reported to feed on bat guano, such as that of the gray bat (Oklahoma Department of Wildlife Conservation, n.d.k). The Ozark cavefish is known to occupy 41 caves in Oklahoma, but only two caves are located near Grand Lake. The first cave is located downstream of the dam and outside the portion of the lake influenced by the anticipated Project operations. The second cave is located approximately one mile south of Grand Lake at elevation 770 feet PD, well above the maximum anticipated operating level (Grand River Dam Authority, 2004b). There is no designated critical habitat for the species in the Project vicinity (US Fish and Wildlife Service, 2021).

3.7.1.12 Neosho Mucket

The Neosho mucket is a federally endangered mussel species. The species is associated with shallow riffles and runs with gravel substrates and moderate to swift currents. They do not occur in reservoirs that lack riverine characteristics (US Fish and Wildlife Service, n.d.b).

Critical habitat has been designated for the species; however, it is restricted to portions of the Elk River, Neosho River, and Spring River. Critical habitat within the Neosho River and Spring River are located upstream of and unaffected by Project operation. The critical habitat located on the Elk River has been designated as Unit NM2 and includes 12.6 miles of the Elk River from Missouri Highway 59 at Noel, McDonald County, Missouri, to the confluence of the Buffalo Creek immediately downstream of the Oklahoma/Missouri state line in Delaware County, Oklahoma.

As part of the Aquatic Species of Concern Study, a detailed investigation of existing Neosho mucket information, including ODWC reports, peer-reviewed scientific publications, and to the extent possible, unpublished information gathered from other entities was conducted. The study area includes approximately eight miles of critical habitat in Unit NM2 on the Elk River. However, only one mile of critical habitat is located within the Project boundary. This investigation indicated the occurrence of the Neosho mucket within the study area is extremely rare in the Oklahoma portions of the Neosho River and Spring River; however, some of the locations fall within the study area of the Elk River. Based on the historical data, a data gap was identified in the records regarding the presence or absence of endangered mussel species within the Elk River portion of the Project. Based on the investigation, Phase 2 mussel surveys were conducted in select portions of the Elk River, Neosho River, and Spring River, which included:

- The portion of the Elk River from the Missouri/Oklahoma state line to the confluence with Buffalo Creek (approximately 1 river mile),
- The portion of the Spring River from Warren Branch to the confluence with the Neosho River (approximately 10.5 river miles), and
- The portion of the Neosho River from Riverview Park in the City of Miami to the confluence with the Spring River (approximately 13 river miles).

A three-phase mussel survey methodology was developed by GRDA and reviewed by USFWS. Phase 1 included identification and mapping of potential Neosho mucket habitat, Phase 2 included qualitative sampling to evaluate the presence of Neosho mucket in any areas of potential habitat identified, and Phase 3 included quantitative quadrat sampling to estimate the density of Neosho muckets in any areas where the species was detected. A summary of the mussel study results was discussed in Section 3.5.1.3. In the Elk River study area, three sites of potential Neosho mucket habitat and two additional community assessment sites were surveyed. In the Neosho River study area, no areas of suitable habitat were identified. In the Spring River study area, two areas of suitable Neosho mucket habitat and two additional community assessment sites were surveyed. However, to characterize the mussel community present within the study area, four sites were surveyed which identified 193 mussels representing 13 species from 13 surveyed sites. No Neosho muckets or other listed mussels were identified during the surveys.

3.7.1.13 Rabbitsfoot Mussel

The Rabbitsfoot mussel is a federally threatened mussel species. The mussel tends to select areas with a sandy or gravel bed, often in side-channels with slower flow near the shore. In Oklahoma, the species was historically found in the Verdigris River, Neosho River, Spring River, Illinois River, Blue River, and Little River. Though they still exist in the Neosho River and Spring River, they are considered very rare or extirpated in the Oklahoma portion of both rivers (Oklahoma Department of Wildlife Conservation, n.d.l).

As part of the Aquatic Species of Concern Study, a detailed investigation of existing rabbitsfoot information, including ODWC reports, peer-reviewed scientific publications, and to the extent possible, unpublished information gathered from other entities was conducted. This investigation showed the closest critical habitat for the species is located 25 miles upstream of the Project in Jasper County, Missouri on the Spring River. No live specimens have been found in the Oklahoma segment of the Spring River. Based on the literature review and no rabbitsfoot mussel were found during 2022 mussel surveys within the Elk River, Neosho River, or Spring River, the Aquatic Species of Concern Study report concluded it is not likely a rabbitsfoot population occurs within the Project vicinity (Grand River Dam Authority, 2022c).

3.7.1.14 Winged Mapleleaf

The winged mapleleaf is a federally endangered species. While included in the 2018 official species list, the updated official species list obtained in 2022 does not include the species. The mussel requires habitat with high water quality and is typically found on stream beds that vary from sand to gravel. The species was historically known to occur within the Boggy River, Kiamichi River, Neosho River, and Little River in Oklahoma. Currently the only known population in the state occurs in the Little River (Oklahoma Department of Wildlife Conservation, n.d.m). A review of historic data for the species completed as part of the Aquatic Species of Concern Study indicated no winged mapleleaf specimens have been previously found within the Elk River, Neosho River, Spring River, or surrounding drainages leading up to the Project reservoir. The only recognized population in Oklahoma is in the Little River, which is 175 miles from the Project. The species was not identified during 2022 mussel surveys conducted in the Elk River, Neosho River, Spring River. Therefore, the study concluded it is not likely that there is a population of winged mapleleaf within the Project vicinity.

3.7.1.15 American Burying Beetle

On October 15, 2020, USFWS published a final rule reclassifying the American burying beetle (ABB) from a federally endangered to a federally threatened species. The publication also included a final rule under the authority of Section 4(d) of the ESA that provides measures necessary and advisable to provide for the conservation of the species. Outside of designated conservation lands, incidental take of ABB is allowed. The rule notes in the Southern Plains analysis area, land use changes such as urban development or conversion to agricultural lands are not considered a threat to the viability of the species (US Fish and Wildlife Service, 2020).

ABB are habitat generalists and may use a variety of habitats that provide friable moist soils with leaf litter and a variety of native vegetation above eight inches in height to maintain soil moisture and support prey species (Grand River Dam Authority, 2022d). ABB prefer open, oak-hickory forests with native grass cover but are also found in closed canopy forests and prairie areas. The beetle is nocturnal and spends the daylight hours buried in loose soils. It feeds on the carcasses of dead animals, especially small birds and rodents. When a carcass is located, it is buried in the soil and ABB female lay eggs near it. When eggs hatch, the larvae feed on the carcass for about two months until they pupate and emerge as adults (Oklahoma Department of Wildlife Conservation, n.d.n). There is suitable habitat for the species within the Project vicinity, but the Project is located outside of conservation priority areas.

While the ABB uses a variety of habitats, USFWS identified the following characteristics that are considered unfavorable for use by ABBs based on disturbance, vegetation structure, unsuitable soil conditions, and carrion availability (Grand River Dam Authority, 2022d):

- Land that is tilled regularly, planted in monoculture, and does not contain native vegetation.
- Pasture or grassland that has been maintained through frequent mowing, grazing, or herbicide application at a height of eight inches or less.
- Urban areas with maintained lawns, paved surfaces, or roadways.
- Soil stockpiles without vegetation.
- Wetlands or permanent water bodies with standing water or saturated soils. Areas adjacent to wetlands and/or riparian areas are not considered unfavorable, since they may be important for ABB seeking moist soils during dry conditions.

ABB surveys were conducted in 2021 and 2022 in coordination with the Terrestrial Species of Concern Study. Presence/absence surveys were conducted in accordance with USFWS American Burying Beetle Range-Wide Presence/Absence Survey Guidance dated May 2018. GRDA also consulted with USFWS regarding the location of survey areas to ensure the survey areas sufficiently covered the ABB habitat types.

During the surveys, six baited pitfall bucket traps were deployed within suitable, representative terrain within Delaware and Ottawa Counties when weather conditions met ABB guidance weather parameters. The weather parameters include (Grand River Dam Authority, 2022d):

- Nighttime temperature during the survey period above 60°F.
- Wind speeds no greater than 10 miles per hour in excess of 20% of the time between 9:00 p.m. and 4:00 a.m.
- Precipitation less than 0.5 inches between 9:00 p.m. and 4:00 a.m.

In 2021, surveys were conducted between July 18 and July 23 and in 2022, between June 9 and June 14. No ABB were detected in any of the surveys (Grand River Dam Authority, 2022d).

3.7.1.16 Monarch Butterfly

On December 17, 2020, USFWS announced that the listing of the monarch butterfly as endangered or threatened was warranted but was precluded by higher priority listing actions. The decision is the result of extensive species status review that compiled and assessed the monarch's current and future status. The monarch is now a candidate species under the ESA. As a candidate species, its status will be reviewed annually until a listing decision is made (US Fish and Wildlife Service, 2020).

The monarch butterfly is one of the most recognized North American butterflies, 3.5 to 4 inches long with striking orange and black wings. Two distinct populations of monarchs can be found in the United States. The western migratory population breeds in the western part of the country and winters near the California coast. The eastern migratory population breeds in the central and eastern part of the country (which includes Oklahoma) and winters in Mexico. Milkweed plants are very important for caterpillars, but adult butterflies feed on flowing plants like goldenrod, asters, and gayfeather (Oklahoma Department of Wildlife Conservation, n.d.o).

Habitat for the species is located within the Project vicinity. It is unknown when or if the species will be reclassified and what conservation measures will be recommended by USFWS if it is reclassified.

3.7.1.17 Western Prairie Fringed Orchid

The western prairie fringed orchid is a federal threatened plant species. It is found in moist tallgrass prairies. The species was not included on the IPaC Official Species List created by FERC in 2018 or in the updated IPaC Official Species List received in 2022. Additionally, the USFWS website indicates the species appears to be extirpated from the state of Oklahoma (US Fish and Wildlife Service, n.d.f). Therefore, the species is unlikely to be located in the Project vicinity.

3.7.1.18 Bald Eagle

The bald eagle is known to be located within the Project vicinity. As of August 9, 2007, the bald eagle population has recovered to the extent it no longer requires the protection of the ESA. The species remains protected by the Migratory Bird Treaty Act and Bald and Golden Eagle Protection Act. Bald eagles typically nest near rivers, lakes, and reservoirs and are opportunistic feeders, with fish being their main food source. They also feed on waterfowl, turtles, small mammals, and carrion (US Fish and Wildlife Service, n.d.g).

Currently, GRDA conducts aerial bald eagle surveys each year in January and April. Adults, juveniles, paired eagles, and active nests are counted during the January surveys and nesting locations from previous years are inspected for new activity during the April survey. Observers look for new eagle nests and check previous eagle nesting sites for activity and record the numbers of juveniles and adults present during the survey. New nesting locations from both surveys are marked via global positioning system coordinates; the location is reviewed to determine if the nest is within the Project boundary. Information collected during the surveys is shared with the George Miksch Sutton Avian Research Center to update their bald eagle nesting database (Grand River Dam Authority, 2019). Eagle nest location information is utilized by GRDA in their review of any SMP-authorized activities.

3.7.2 Environmental Effects

In SD1 and SD2, the Commission identified the following issues regarding threatened and endangered resources: (1) the effects of Project operation and maintenance on federally listed endangered, threatened, and candidate fish and aquatic species and critical habitat including Neosho madtom, Ozark cavefish, Neosho mucket, rabbitsfoot mussel, winged mapleleaf, and Arkansas darter; and (2) the effects of Project fluctuations and flow releases from the Project on federally listed wildlife and plant species and critical habitat including: western prairie fringed orchid, gray bat, Indiana bat, NLEB, Ozark big-eared bat, piping plover, rufa red knot, and ABB. To assess the effects of operation and maintenance and Project fluctuations on listed and candidate species, along with critical habitat, GRDA developed a BA. The BA is available in **Appendix E-26**.

3.7.2.1 Effects of Project Operations and Maintenance on Federally Listed Fish and Aquatic Species, and Critical Habitat

3.7.2.1.1 Alligator Snapping Turtle

Activities that involve ground disturbance near or within a stream (i.e., culverts, boat landings, vegetation clearing etc.) have the potential to impact the species due to erosion and sedimentation. Activities that involve dredging in areas of suitable habitat or ground disturbance within areas of suitable nesting habitat also have the potential to impact the species.[126]

GRDA is required to obtain the necessary federal permits if it undertakes any dredging activities as part of its day-to-day operations of the Project.[127] In addition, GRDA's current process for issuing non-Project use permits for dredging as part of the SMP requires the applicant to provide GRDA proof that all other permits (including USACE Section 404 permits) have been received prior to authorizing any dredging activities under permit as part of the SMP. Since the USACE is the agency responsible for the undertaking when issuing Section 404 dredging permits and the responsibility for protection of listed species prior to issuance of Section 404 permits is with the USACE, GRDA can conclude activities for which the USACE has issued a Section 404 permit either does not impact TE species or requires permit conditions appropriately addressing any activities that could adversely affect TE species. Therefore, no additional environmental measures are required in the SMP for the protection of protected species from dredging are being proposed.

[126] Alligator snapping turtles will nest in loose, dry, sandy soils within 200 meters of the water's edge.
[127] GRDA does not have any dredging activities currently planned as part of its day-to-day maintenance activities.

To avoid impacts resulting from erosion and sedimentation, under anticipated operation (without a rule curve) GRDA is proposing in the updated SMP, to incorporate requirements to follow appropriate state-approved BMP measures for erosion and sediment control. The updates will assure no additional impacts from sedimentation and erosion project by non-Project uses of Project land where permits are issued through the SMP protect water and sediment quality and stream and riparian habitat into all SMP permits involving ground disturbance near or within the Project reservoir.

For day-to-day maintenance activities that occur as day-to-day operations, GRDA is currently required under Article 19 of Form L-3 to "…take all reasonable measures to prevent, soil erosion on lands adjacent to streams or other waters, stream sedimentation, and any form of water or air pollution." This protection is expected to remain in place under the anticipated operation (without a rule curve).

Under the current operation (under the current post-2015 rule curve), protection against sedimentation and erosion during dredging and during day-to-day operations is already in place. As outlined in the BA in **Appendix E-26**, the degree of the impact of changes in water levels in moving from the current operation (under the current post-2015 rule curve) to the anticipated operation (without a rule curve) is unknown, but the level of impact is expected to be negligible. Therefore, the anticipated operation (without a rule curve) of the Project "may affect, but is not likely to adversely affect" the species; however, the effects on the species are expected to be insignificant or provide an incremental benefit.[128]

3.7.2.1.2 Neosho Madtom

The Aquatic Species of Concern Study concluded there can be changes in river velocities between the baseline operation (under the pre-2015 rule curve) and anticipated operation (without a rule curve). The change in median water surface elevations between the current operation (under the current post-2015 rule curve) and anticipated operation (without a rule curve) could potentially have an effect on the species. However, the analysis outlined in the BA in **Appendix E-26** demonstrates changes to project operations will not meaningfully influence velocity at these sites. Discharge of the inflowing rivers is the most influential factor on velocity in these areas, and discharge naturally varies substantially in the Neosho and Spring River systems. Additionally, since water velocity and subsequent near-bed shear stress are primary determinants of substrate composition, no meaningful changes to sediment composition or deposition are expected. Therefore, both the current operation (under the current post-2015 rule curve) and anticipated operation (without a rule curve) "may affect, but are not likely to adversely affect" the Neosho madtom.

3.7.2.1.3 Ozark Cavefish

There are no known occurrences of the Ozark cavefish within the Project boundary. The known occurrences within the Project vicinity are not impacted by water level fluctuations associated with Project operations. Therefore, under both the current operation (under the current post-2015 rule

[128] It is worthy of note, the added language of the SMP for erosion and sediment control will serve as a continuous reminder for GRDA to comply with the requirements of Article 19 of Form L-3 when issuing permits for non-Project use under the SMP.

curve) and anticipated operation (without a rule curve), continued operation and maintenance of the Project will have no effect on the species. See the BA in **Appendix E-26**.

3.7.2.1.4 Neosho Mucket

As part of the Aquatic Species of Concern Study, a three-phase mussel survey methodology was used to evaluate the presence of Neosho muckets and Neosho mucket habitat in the Elk River, Neosho River, and Spring River. The study identified three areas with suitable habitat in the Elk River, no areas in the Neosho River, and two areas in the Spring River. No Neosho mussels were identified via the 2022 mussel surveys. While no Neosho muckets were identified in the 2022 surveys, suitable habitat was identified, and a population may be present within the Project. As outlined in the BA in **Appendix E-26**, the changes between current operation (under the current post-2015 rule curve) and anticipated operation (without a rule curve) will have no meaningful influence on the species. Instead, discharge of the inflowing rivers is the most influential factor on velocity in these areas, and discharge naturally varies substantially in the systems. Based on the lack of Neosho mucket detected in the action area, and the fact that the anticipated operation (without a rule curve) is not expected to meaningfully influence velocity or substrate conditions in the area, the anticipated operation (without a rule curve) “may affect, but is not likely to adversely affect” the Neosho mucket.

3.7.2.1.5 Rabbitsfoot Mussel

Based on literature review, existing data, and 2022 mussel survey results, the Aquatic Species of Concern Study concluded it is unlikely a rabbitsfoot mussel population occurs within the Project vicinity. Therefore, under both the current operation (under the current post-2015 rule curve) and anticipated operation (without a rule curve), there will be no effect on the species.

3.7.2.1.6 Winged Mapleleaf

Based on literature review, existing data, and 2022 mussel survey results, the Aquatic Species of Concern Study concluded it is unlikely a winged mapleleaf population occurs within the Project vicinity. Therefore, under both the current operation (under the current post-2015 rule curve) and anticipated operation (without a rule curve), there will be no effect on the species.

3.7.2.1.7 Arkansas Darter

In SD2, the Commission requested impacts to the Arkansas darter be addressed. The species is not currently a federally listed species and was not identified in the IPaC Official Species List provided by FERC in 2018 or the updated IPaC Official Species List from 2022. While the fish is known to occur in southwest Missouri in the Spring River, it has not been identified in the historic fish assemblage or in 2022 fish surveys within the Project. Since there are no records of the species occurring in the Project vicinity, under both the current operation (under the current post-2015 rule curve) and anticipated operation (without a rule curve), there will be no effect on the species.

3.7.2.2 Effects of Reservoir Fluctuation and Flow Releases on Federally Listed Wildlife and Plant Species and Critical Habitat

3.7.2.2.1 Western Prairie Fringed Orchid

In SD2, the Commission requested impacts to the western prairie fringed orchid be addressed. The species was not identified in the IPaC Official Species List provided by FERC in 2018 or the updated IPaC Official Species List from 2021. Additionally, USFWS indicates this species is likely extirpated from the state of Oklahoma (US Fish and Wildlife Service, n.d.f). Since the species is unlikely to be located within the Project vicinity, both the current operation (under the current post-2015 rule curve) and anticipated operation (without a rule curve) will have no effect on the species.

3.7.2.2.2 Gray Bat

Cave DL-91 is not located within the Project boundary. The entrance to Cave DL-2 lies within the Project boundary. During GRDA's control of the operation of the reservoir, Cave DL-2 will not be affected because the entrance of the cave is higher than 745 feet PD. Most of the subterranean part of the cave including the alternative exit of the cave lies outside of the Project boundary (based on a 750 feet PD contour). Water only enters cave DL-2 when the releases directed by USACE for flood control result in elevations of 750 feet.

In addition, the OM analysis shows the Project reservoir will exceed 746 feet PD only about 0.4% more frequently under anticipated operation (without a rule curve) than baseline operation (under the pre-2015 rule curve). As previously noted, evacuation of Cave DL-2 generally does not begin until the elevation of Grand Lake exceeds 751 feet PD. According to the OM analysis, this will occur about 0.2% less frequently under anticipated operation (without a rule curve) than baseline operation (under the pre-2015 rule curve). At elevation 752 feet PD, when Cave DL-2 becomes totally inundated, there is no change in the frequency of occurrence between anticipated operation (without a rule curve) and baseline operation (under the pre-2015 rule curve). All reservoir elevations that would impact the two gray bat caves are outside of the anticipated operation (without a rule curve) elevations of 742 to 745 feet PD. As outlined in the BA in **Appendix E-26**, the anticipated change in operations is expected to have minimal influence on cave-obligate species.

As outlined in the BA in **Appendix E-26**, the anticipated operation (without a rule curve) is expected to result in a minimal reduction of foraging habitat. The Project has and will continue to periodically inundate a maternity roost during the USACE flood control operation. Based on surveys of the cave, the bats evacuate the cave when these events occur. Nonetheless, these periodic flooding events have the potential to adversely affect the gray bat. These potential impacts are not part of the federal action under consideration, but are reasonably certain consequences, a function of the existing Pensacola Project facilities and not the anticipated operation and are not direct impacts of the anticipated operation (without a rule curve). The frequency and extent of inundation of this maternity roost is predicted to be similar between baseline (under the pre-2015 rule curve) and anticipated operation (without a rule curve). Therefore, the anticipated operation (without a rule curve) "may affect, but is not likely to adversely affect" the gray bat.

Under the baseline operation (under the pre-2015 rule curve), GRDA currently monitors gray bat populations and conducts inspections of cave protection measures for the two documented caves in the Project vicinity. Both of the caves are not inundated under GRDA's operation and maintenance activities within the conservation pool. The caves are only inundated during high-flow events when the USACE has exclusive jurisdiction for flood control. Therefore, GRDA is proposing to discontinue monitoring of the gray bat populations and cave protection measures under the anticipated operation (without a rule curve). The anticipated operation (without a rule curve) reservoir fluctuations and flow releases are not likely to adversely affect the species. Therefore, continued monitoring is not necessary for the protection of the species during the upcoming license period.

At a meeting on February 27, 2017 associated with the annual report regarding Article 405 of the existing license, GRDA concluded permitted vegetation management activities may affect but are not likely to adversely affect the gray bat. USFWS concurred with the findings and recommended GRDA consult with USFWS if a certain threshold of permits, acreage, or distance of shoreline was to be disturbed. Under the baseline operation (under the pre-2015 rule curve), GRDA consults with USFWS with respect to TE species if over 100 vegetation management permits are issued in the Responsible Growth Shoreline Management Classification (SMC) in a particular year, or if any single project involved more than 100 feet of shoreline being cleared (Grand River Dam Authority, 2017b). GRDA is proposing to continue this tracking and notification process under the anticipated operation (without a rule curve).

Under the anticipated operation (without a rule curve), GRDA is proposing to consult with USFWS before proposed Project operation and maintenance activities or proposed SMP permit issuance involving ground disturbing or vegetation management activities within ¼ mile of a known hibernacula to obtain measures to require and avoid adverse impacts to the species before the implementation of the resulting activities. GRDA will implement the USFWS-recommended measures during its maintenance activities or incorporate the measures into the SMP permit before it is issued for such activities.

GRDA is also proposing that Project operation and maintenance activities and any SMP permits issued that involve removal of trees greater than three inches in diameter breast height (dbh) be limited to being conducted outside of the April 1 to October 31 timeframe. The only exception to this requirement is if the tree causes an immediate human health hazard, it can be removed immediately.

Regarding ground-disturbing activities and vegetation management, the anticipated operation (without a rule curve) provides more protection than the current operation (under the current post-2015 rule curve). Therefore, it is expected the anticipated operation (without a rule curve) is less likely to have an adverse effect upon the species than the baseline operation (under the pre-2015 rule curve).

3.7.2.2.3 Indiana Bat

Only one cave in LeFlore County, Oklahoma (outside Project vicinity) is known to be used by the Indiana bat as a hibernaculum. Acoustic bat surveys conducted in 2015 and 2016 along the shorelines of the Pensacola Project did not identify the species. As outlined in the BA in **Appendix E-26**, the anticipated operation (without a rule curve) is expected to result in a relatively minimal reduction of suitable foraging and summer roosting habitat potentially utilized by the Indiana bat. However, the species has not been documented in recent surveys, and the loss in habitat is expected to be dispersed across the Project area. In addition, habitat is available immediately adjacent to the Project area. Therefore, the anticipated operation (without a rule curve) “may affect, but is not likely to adversely affect” the Indiana bat.

3.7.2.2.4 Northern Long-Eared Bat

Under the current operation (under the current post-2015 rule curve), no environmental measures are currently in place for the protection of the NLEB.

Pup Season

To predict reservoir elevations that may occur in the future under the anticipated operation (without a rule curve) and to replicate reservoir elevations under the baseline operation (under the pre-2015 rule curve), GRDA used the OM and inflow data from April 1, 2004 through December 31, 2019 provided by the USACE RiverWare Model to simulate the resulting reservoir elevations and determine the median reservoir elevation during the NLEB pup season (May 1 to July 31) for both the baseline (under the pre-2015 rule curve) and anticipated operation (without a rule curve).

The OM is further explained in Section 3.4.1.3.10.

Roosting Habitat

To predict reservoir elevations that may occur in the future under the anticipated operation (without a rule curve) and to replicate reservoir elevations under the baseline operation (under the pre-2015 rule curve), GRDA used the OM and inflow data from April 1, 2004 through December 31, 2019 provided by the USACE RiverWare Model to simulate the resulting reservoir elevations and determine the median reservoir elevation during the growing season for roosting trees (March 31 to November 2) for both the baseline (under the pre-2015 rule curve) and anticipated operation (without a rule curve).

As discussed in Section 3.5.2.1.1, the anticipated operation (without a rule curve) is expected to increase the median elevation during the growing season by 0.54 feet. This results in additional inundation on a non-continuous basis of 548 model-derived acres. This could result in a maximum loss of 166 acres of trees under the anticipated operation (without a rule curve) which is considered minor.[129] However, the NLEB utilizes trees that are primarily dead or dying with loose bark as roost trees during the pup season. Therefore, the additional inundation under the anticipated operation (without a rule curve) may temporarily increase the amount of NLEB roosting habitat and is not likely

[129] According to Section 3.9.1.1 of this application, 66.8% of the shoreline is either forested or contains woody wetlands. Therefore, of the 548 model-derived acres, approximately 366 acres would be considered forested or woody wetlands. According to Table 7.3-1 of the Shoreline Management Plan enclosed with this application, there is a total of 519.85 miles of shoreline on Grand Lake. Utilizing a 200-foot buffer to describe the Project’s shoreline vicinity, multiplied by 519.85 miles of shoreline, the shoreline vicinity (519.8 miles * 200-foot buffer) includes 12,601 acres in the Project vicinity buffer, with 30.41% of the shoreline either forested or contains woody wetlands; this equates to 3,831 acres of forested or woody wetlands within the buffer. If at-most 166 acres out of 3,831 acres (4.3%) could be affected, this is considered minor because of the percentage and the fact that the reservoir is not continuously held 0.54 feet higher during the growing season; not all species of trees will be killed due to the higher median elevation expected under the anticipated operation (without a rule curve).

to adversely affect the NLEB population during its critical time (the pup season) beyond the effects experienced under the baseline operation (under the pre-2015 rule curve).

As discussed in the BA included in **Appendix E-26**, the loss in habitat due to the anticipated operation (without a rule curve) is expected to be dispersed across the Project area. Therefore, anticipated operation (without a rule curve) “may affect, but is not likely to adversely affect” the northern long-eared bat.

Vegetation management activities involving removal of trees within ¼ mile of a hibernacula or removal of trees greater than three inches in diameter during the bat’s active season (April 1 to October 31) have the potential to impact the species. To avoid such impacts, GRDA is proposing that Project operation and maintenance activities and any SMP permits issued that involve removal of trees greater than three inches in dbh be limited to being conducted outside of the April 1 to October 31 timeframe. The only exception to this requirement is if the tree causes an immediate human health hazard, it can be removed immediately.

Under the anticipated operation (without a rule curve), GRDA is also proposing to consult with USFWS before proposed Project operation and maintenance activities or proposed SMP permit issuance involving ground disturbing or vegetation management activities within ¼ mile of a known hibernacula to obtain measures to require and avoid adverse impacts to the species before the implementation of the resulting activities. GRDA will implement the USFWS-recommended measures during its maintenance activities or incorporate the measures into the SMP permit before it is issued for such activities.

Additionally, under the anticipated operation, GRDA is proposing to track vegetation management permits issued in the Responsible Growth SMC and submit an annual report to FERC, USFWS, and ODWC. If this tracking shows over 100 vegetation management permits are issued or over 100 feet of shoreline is cleared, GRDA will consult with USFWS and ODWC regarding potential mitigation needs for the bat. Therefore, under the anticipated operation, continued Project operation and maintenance involving ground disturbance and vegetation management are not likely to adversely affect the species.

For g ground-disturbing activities and vegetation management, based on reviews of current operations, there was no adverse impact to NLEB. The anticipated operation (without a rule curve) is even less likely to adversely affect NLEB.

3.7.2.2.5 Ozark Big-Eared Bat

Under the current operation (under the current post-2015 rule curve), no environmental measures are currently in place for protection of Ozark Big-Eared bats.

The bats live in limestone and sandstone talus caves found in oak-hickory forests of the Ozark Highlands and rely on caves as both maternity sites for raising young and as hibernacula. They forage within one to five miles of their caves. Since the bat is not migratory, individuals often use the same caves annually. During certain periods in their life cycle, the species is very sensitive to disturbance. Human visitation and vandalism of occupied caves can cause cave abandonment (Oklahoma Department of Wildlife Conservation, n.d.f). Based upon the 2015-2016 GRDA acoustic surveys, it is unlikely the Ozark big-eared bat occurs within the Project vicinity.

Due to the lack of known populations, as outlined in BA in **Appendix E-26**, the anticipated operation (without a rule curve) “may affect, but is not likely to adversely affect” the Ozark big-eared bat.

If the species is ever documented in limestone caves along the shoreline, under the anticipated operation (without a rule curve), GRDA has proposed to monitor the caves on the shoreline of the reservoir to discourage human intrusion, vandalism, and looting. As a result, the anticipated operation of the facility could provide more protection to the Ozark big-eared bats than the current operation (under the current post-2015 rule curve). Therefore, under the anticipated operation (without a rule curve), there will be more protection than under the current operation (under the current post-2015 rule curve).

3.7.2.2.6 Tricolored Bat

Under the current operation (under the current post-2015 rule curve), no environmental measures are currently in place for protection of tricolored bats.

Pup Season

The OM was used to determine the median reservoir elevation during the Tricolored pup season (May 1 to July 31) for both the baseline operation (under the pre-2015 rule curve) and anticipated operation (without a rule curve). Under the baseline operation (under the pre-2015 rule curve), the median reservoir elevation is 744.05 feet PD during this period. The median elevation increases by 0.14 feet (less than two inches) to 744.29 feet PD for the anticipated operation (without a rule curve). Based on the model-derived acreage for the Project, the anticipated operation (without a rule curve) will result in additional inundation of approximately 265 acres during the pup season, all of which is located within the normal operational fluctuation band in both the baseline (under the pre-2015 rule curve) (741 to 745 feet PD) and anticipated operation (without a rule curve) (742 to 745 feet PD) (Hunter, S.L, et. al., 2020). Even if the base of trees containing roosting bats were inundated in the narrow shoreline band adjacent to the reservoir resulting from the 0.14-foot median increase in WSE, the inundation itself would not cause a take of tricolored bats unless a non-volant bat fell out of the tree into the water. As outlined in the BA in **Appendix E-26**, the anticipated reservoir fluctuations and flow releases under either the baseline operation (under the pre-2015 rule curve) or the anticipated operation (without a rule curve) “may affect, but are not likely to adversely affect” the species.

Roosting Habitat

As discussed in Section 3.5.2.1.1, and the BA in **Appendix E-26**, the anticipated operation (without a rule curve) is expected to increase the median elevation during the growing season by 0.54 feet. This results in additional inundation on a non-continuous basis of 548 model-derived acres. This could result in a minor loss of trees, as discussed in Section 3.7.2.2.4.

The anticipated operation (without a rule curve) is expected to result in a reduction of suitable foraging and summer roosting habitat potentially utilized by the tricolored bat; however, the loss in habitat is expected to be dispersed across the Project area and habitat is available immediately adjacent to the Project Area. Therefore, the anticipated operation (without a rule curve) “may affect, but is not likely to adversely affect” the tricolored bat.

Vegetation management activities within ¼ mile of a hibernacula or removal of trees greater than three inches in diameter during the bat’s active season have the potential to impact the species. To avoid such impacts, GRDA is proposing that Project operation and maintenance activities and any SMP permits issued that involve removal of trees greater than three inches in dbh limit such work to the November 1 – March 31 timeframe. The only exception to this requirement is if the tree causes an immediate human health hazard, it can be removed immediately.

Under the anticipated operation (without a rule curve), GRDA is also proposing to consult with USFWS before proposed Project operation and maintenance activities or proposed SMP permit issuance involving ground disturbing or vegetation management activities within ¼ mile of a known hibernacula to obtain measures to require and avoid adverse impacts to the species before the implementation of the resulting activities. GRDA will implement the USFWS-recommended measures during its maintenance activities or incorporate the measures into the SMP permit before it is issued for such activities.

Additionally, under the anticipated operation, GRDA is proposing to track vegetation management permits issued in the Responsible Growth SMC and submit an annual report to FERC, USFWS, and ODWC. If this tracking shows over 100 vegetation management permits are issued or over 100 feet of shoreline is cleared, GRDA will consult with USFWS and ODWC regarding potential mitigation needs for the bat. Therefore, the under the anticipated operation, continued Project operation and maintenance involving ground disturbance and vegetation management may affect, but are not likely to adversely affect the species.

Regarding ground-disturbing activities and vegetation management, the anticipated operation, through the updated SMP, provides more protection than the baseline operation. Therefore, it is expected the anticipated operation is less likely to have an adverse effect upon the species than the baseline operation (under the pre-2015 rule curve).

3.7.2.2.7 Piping Plover

Since there is no critical habitat for the species within the Project and the Project could only provide potential stopover habitat during the migratory season, both the current operation (under the current post-2015 rule curve) and anticipated operation (without a rule curve) will have no effect on the piping plover. See the BA in **Appendix E-26**.

3.7.2.2.8 Rufa Red Knot

Since there is no critical habitat for the species within the Project and the Project could only provide potential stopover habitat during the migratory season, both the current operation (under the current post-2015 rule curve) and anticipated operation (without a rule curve) will have no effect on the piping plover. See the BA in **Appendix E-26**.

3.7.2.2.9 American Burying Beetle

While there is suitable habitat for the ABB within the Project vicinity, relicensing studies conducted in 2021 and 2022 did not identify any beetles. As outlined in the BA in **Appendix E-26**, impacts to suitable habitat are not anticipated to substantially change under the anticipated operation (without a rule curve). Although an estimated 420 acres of potentially suitable ABB habitat would be differentially inundated, the effects to the species are expected to be negligible. The anticipated operation (without a rule curve) over the current operation (under the current post-2015 rule curve) "may affect, but is not likely to adversely affect" the species.

Since no beetles were identified in the Project vicinity and the existing 4(d) rule allows incidental take of individuals that may be impacted, the anticipated reservoir fluctuations and flow releases are not likely to adversely affect the species. The anticipated effects to the species are expected to be the same for the current operation (under the current post-2015 rule curve) and anticipated operation (without a rule curve).

Based on a review of the requirements for qualification under the 4(d) rule and preliminary 4(d) assessment performed through the USFWS IPaC online evaluation of ABB under the 4(d) rule (USFWS IPaC accessed May 2023), it appears the anticipated operation (without a rule curve) qualifies as "Activities Excepted from Take Prohibitions" under the USFWS's October 15, 2020, Programmatic Biological Opinion on Final 4(d) Rule for the American Burying Beetle (US Fish and Wildlife Service, 2020).

3.7.2.2.10 Monarch Butterfly

The anticipated operation (without a rule curve) is not expected to result in the direct take of monarch butterfly during any life stage. As outlined in the BA in **Appendix E-26**, the anticipated operation (without a rule curve) has the potential to impact monarch butterfly habitat as the median reservoir level increases. However, the extent of this impact is expected to be minimal and temporary. Impacts to potential habitat are not anticipated to substantially change under the anticipated operation (without a rule curve). Therefore, the anticipated operation (without a rule curve) "may affect, but is not likely to adversely affect" the monarch butterfly.

3.7.2.3 Effects of Project Operation and Maintenance on Bald Eagle

Vegetation management and construction activities within 660 feet of an active eagle nest during the nesting season have the potential to impact the bald eagle. Under the baseline operation (under the pre-2015 rule curve), the location of active bald eagle nests was one factor evaluated when reviewing SMP permit applications. Under the anticipated operation, GRDA is proposing to review Project operation and maintenance activities and SMP permit applications to determine if the proposed activities are located within 660 feet of an active nest. If so, Project work will be scheduled, or conditions will be added to the SMP permit before issuance, to restrict the timing of the work to occur outside of the eagle nesting season. If activities cannot be conducted outside of the nesting season, GRDA will confer with USFWS prior to conducting the work or issuing the SMP permit.

Anticipated operations, including the updated SMP condition for a review of active nests within 660 feet, provide more protection than the current operation (under the current post-2015 rule curve). Therefore, it is expected the anticipated operation is less likely to have an adverse effect upon the species than the current operation (under the current post-2015 rule curve).

3.7.3 Proposed Environmental Measures

The following environmental measures are being proposed by GRDA to address potential impacts to threatened, endangered, proposed and candidate species caused by continued operation of the Project:

- In order to protect the alligator snapping turtle, all future permits issued under the SMP that allow ground-disturbance near the project reservoir will require the permittee to follow appropriate measures such as construction stormwater BMPs to reduce sedimentation directly entering the waterway. Such measures will protect water quality, as well as stream and riparian habitat. GRDA will also implement the same measures during its day-to-day maintenance activities involving ground disturbance near the Project reservoir.
- In order to protect the gray bat, NLEB and tricolored bat, GRDA is proposing to track vegetation management permits issued in the Responsible Growth SMC and submit an annual report to FERC, USFWS, and ODWC. If this tracking shows over 100 vegetation management permits are issued or over 100 feet of shoreline is cleared, GRDA will consult with USFWS and ODWC regarding potential mitigation needs for gray bats, NLEB, and tricolored bats.
- In order to protect the gray bat, NLEB, and tricolored bat, GRDA will review Project operation and maintenance activities and all SMP applications to determine if any work is proposed within ¼ mile of a known hibernaculum. If so, GRDA will confer with USFWS before conducting the work or issuing SMP permits for the activity. The Project work and SMP permits issued by GRDA will include any conditions required by USFWS to avoid impacts to the hibernacula.
- In order to protect the gray bat, NLEB, and tricolored bat, any Project operation and maintenance activity or SMP permit issuance for vegetation management activities located over ¼ mile from any known hibernacula involving removal of trees greater three inches in diameter will include provisions prohibiting tree removal between April 1 and October 31 t unless the tree causes an immediate human health hazard.
- In order to protect the bald eagle, any Project operation and maintenance activities and SMP applications involving ground disturbance or vegetation management will be reviewed to determine whether the proposed activities are located within 660 feet of an active eagle nest. If so, the Project work will be scheduled to occur, or conditions will be added to the SMP permit to, restrict timing of the work to occur outside of the nesting season. If the work cannot be conducted outside the nesting season, GRDA will notify the USFWS before completing the work.

3.7.4 Unavoidable Adverse Impacts

With the implementation of the proposed environmental measures, continued operation of the Project is not expected to result in unavoidable adverse effects to threatened, endangered, or candidate species.

3.8 Recreation Resources

Grand Lake was formed in 1940 when the Pensacola Dam was completed and impounded the three primary perennial waterbodies, the Neosho River, Spring River, and Elk River. Grand Lake is located in Craig, Delaware, Mayes, and Ottawa Counties in northeast Oklahoma. The lake contains approximately 45,056 surface acres of water at an elevation of 745 feet PD.

The eighteen counties located in northeast Oklahoma are locally known as the Green Country due to their rivers, lakes, tallgrass prairies, and rolling green hills (TravelOK.com, n.d.), Grand Lake is the premier recreational lake in northeast Oklahoma. Bass fishing is very popular and draws both local and out-of-state anglers to the area (Grand River Dam Authority, 2017a). There are numerous public recreational facilities on Grand Lake that offer public opportunities for fishing, camping, swimming, trail riding, and other outdoor and water-related activities.

3.8.1 Affected Environment

3.8.1.1 Existing Recreational Resources

GRDA operates and maintains five FERC-approved public access sites for the Project. Many additional non-Project sites are owned, operated, and maintained by other entities including the state of Oklahoma, local municipalities, or private owners. Non-Project sites include six state parks with a total of nine access areas, five public access sites, and several river channel sites located downstream of the Pensacola Dam along the Grand River. The sites are listed by county in order from upstream to downstream in **Table 3.8.1.1-1**, **Table 3.8.1.1-2**, and **Table 3.8.1.1-3** and locations are shown in **Figure 3.8.1.1-1**.

Table 3.8.1.1-1 FERC-Approved Recreation Sites within the Pensacola Project Boundary

Recreation Site	Type	County	Owner	Operator
Wolf Creek Public Access	FERC Approved	Delaware	GRDA	City of Grove
Monkey Island Public Boat Ramp	FERC Approved	Delaware	GRDA	GRDA
Seaplane Base Public Access	FERC Approved	Delaware	GRDA	GRDA
Big Hollow Public Access	FERC Approved	Delaware	GRDA	GRDA
Duck Creek Bridge Access Area	FERC Approved	Delaware	GRDA	GRDA

Table 3.8.1.1-2 State Park (Non-Project) Recreation Sites in the Pensacola Project Vicinity

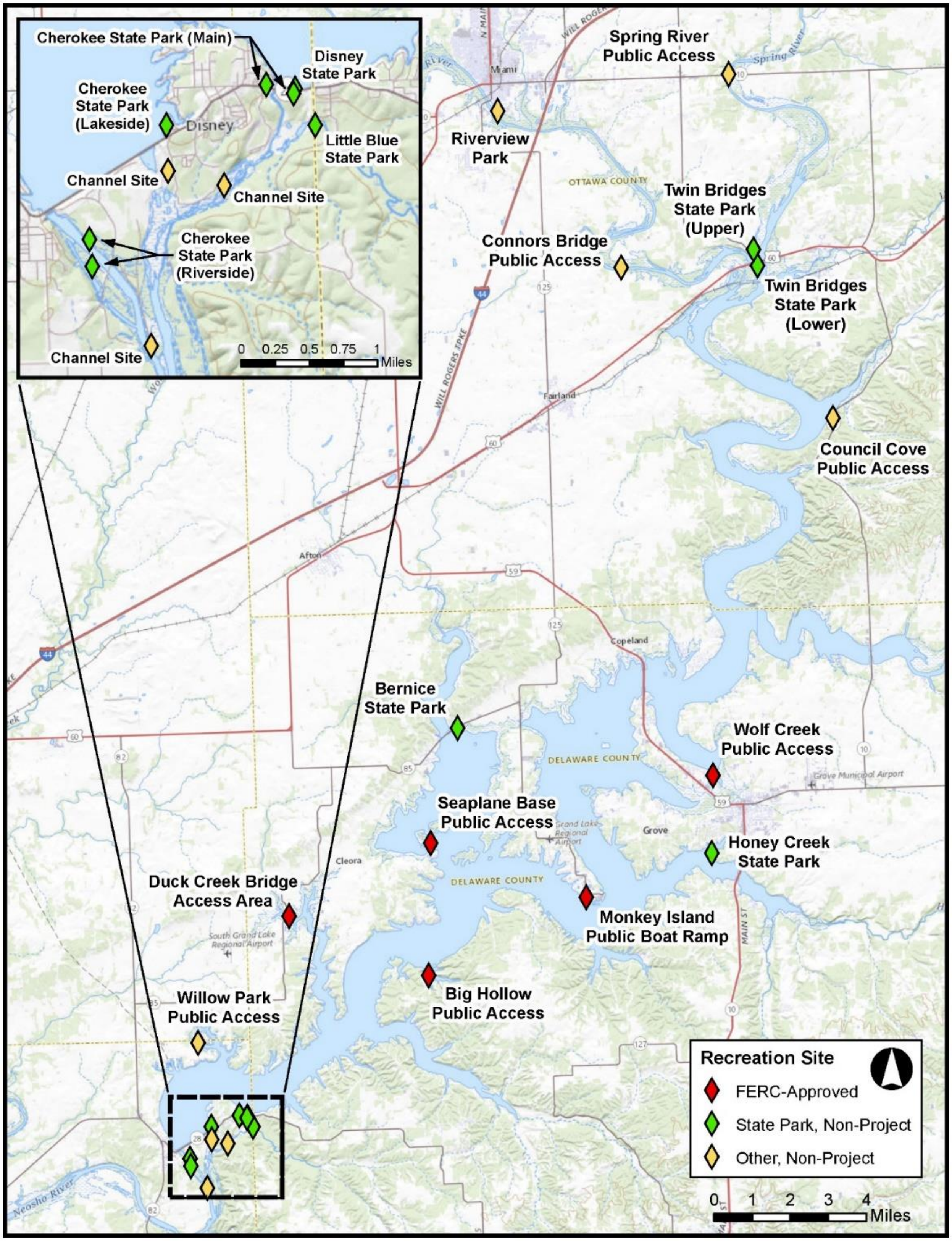
Recreation Site	Type	County	Owner	Operator
Twin Bridges State Park (Upper)	State Park	Ottawa	OTRD*	OTRD
Twin Bridges State Park (Lower)	State Park	Ottawa	OTRD	OTRD
Honey Creek State Park	State Park	Delaware	OTRD	OTRD
Bernice State Park	State Park	Delaware	OTRD	OTRD
Disney State Park	State Park	Mayes	OTRD	OTRD
Cherokee State Park (Main)	State Park	Mayes	OTRD	OTRD
Cherokee State Park (Lakeside)	State Park	Mayes	OTRD	OTRD
Little Blue State Park	State Park	Delaware, Mayes	OTRD	OTRD
Cherokee State Park (Riverside)	State Park	Mayes	OTRD	OTRD

* OTRD - Oklahoma Department of Tourism and Recreation

Table 3.8.1.1-3 Other Non-project Recreation Sites in Pensacola Project Vicinity

Recreation Site	Type	County	Owner	Operator
Spring River Public Access	Public Access Site	Ottawa	Ottawa County	Ottawa County
Riverview Park	Public Access Site	Ottawa	City of Miami	City of Miami
Connors Bridge Public Access	Public Access Site	Ottawa	Ottawa County	Ottawa County
Council Cove Public Access	Public Access Site	Ottawa	Ottawa County	OTRD
Willow Park Public Access	Public Access Site	Mayes	Town of Ketchum	Town of Ketchum
Channel Sites (Downstream)	Public Access Site	Mayes	GRDA	OTRD

Figure 3.8.1.1-1 Recreation Sites in the Pensacola Project Vicinity



Source: (Grand River Dam Authority, 2021b)

3.8.1.2 Recreation Plans

The Grand Lake area offers an abundance of opportunities for outdoor recreation. GRDA has an existing RMP approved by FERC in 1998. The state of Oklahoma approved its Statewide Comprehensive Outdoor Recreation Plan (SCORP) in 2017. Both plans are summarized in the sections below.

3.8.1.2.1 Pensacola Recreation Management Plan

Article 407 of the existing license for the Project required GRDA to develop a RMP, which was submitted to the Commission for review on October 3,1997. The plan was modified and approved in FERC order issued on August 14, 1998. The plan presented a Lake Use Report with background information and recreation use estimates for the Project. The plan also described the lake patrol program in which police officers patrol the Project reservoir to enforce non-project use licenses and permits and Grand Lake regulations. The plan also described the Licensee's permitting program for shoreline development around the reservoir. This permitting program has since evolved into the SMP which was originally approved by the Commission in 2008. An update to the exiting SMP is in **Appendix E-28**. The existing RMP also described the processes used by GRDA to authorize fishing tournaments at the reservoir, including use of GRDA police officers to assist with tournaments as necessary, and incorporated ODWC recommendations regarding weigh-in criteria and proper operation of live wells and aerated holding tanks. The FERC-approved plan required recreation monitoring to occur every six years and the plan contents be evaluated to assess the need to make changes to the management practices for recreation use and shoreline development.

3.8.1.2.2 Oklahoma SCORP

The Oklahoma SCORP was updated in 2017 to address 2018 to 2022. The SCORP, titled *Oklahoma State of Health: The People, Economy, and the Environment., 2018-2022*, provides a description of the recreation resources available in Oklahoma, analysis of recreation users; and agencies that manage the public recreation resources, as well as issues to be addressed and actions to be implemented during 2018-2022 to protect, preserve, and provide for the enjoyment of Oklahoma's outdoor recreation resources. GRDA is recognized as a state agency that manages recreation in the SCORP.

The SCORP identified the following seven priority issues to focus on during the period 2018-2022:

- Water quality and quantity - establish BMPs for state and municipal properties, involve recreation managers in water planning, and educate the public regarding water issues;
- Loss of accessible public recreation space - develop solutions to reductions in the amount of neighborhood parks and provide education to communities on value of land ordinances;
- Education of a life of health and quality - encourage educational programs using parklands to promote physical activity and improve the quality of life;
- Funding and valuation of public recreation - hold workshops to address pricing and economics of public recreation, establish a goal for recreation facilities to be self-sufficient, and have open disclosure on the cost of public recreation service;
- Collaboration, cooperation, and communication – OTRD should host an annual recreation rally to encourage collaboration, cooperation, and communication with other recreation resource managers;
- Statewide Trails Plan - prepare a new statewide trails plan; and
- Open Project Selection Process (OPSP) - review and revise the existing online OPSP website (Oklahoma Tourism and Recreation Development, 2017).

3.8.1.3 Estimated Use of Existing Recreation Resources

Pursuant to the study plan determination issued on November 8, 2018, GRDA conducted a Recreation Facilities Inventory and Use Study to gather information to understand and document recreation utilization and needs within the Project vicinity. The study consisted of the following activities, which are described in the sections below:

- Recreation Observation Survey
- Recreation Visitor Use Interviews
- Facility Condition Assessments
- Boat Ramp Elevation Data Collection

3.8.1.3.1 Recreation Observation Surveys

Each recreation site listed in **Table 3.8.1.1-1**, **Table 3.8.1.1-2**, and **Table 3.8.1.1-3** were surveyed for usage six times per month between May and September of 2020.[130] Three surveys were conducted on weekdays (Monday-Thursday) and three were on weekend days (Friday-Sunday) each month. Three surveys were mandatory on holiday weekends including Memorial Day, Independence Day, and Labor Day. Surveys were completed between the hours of 7:00 a.m. and 7:00 p.m. During each survey, a total of one hour was spent at each site, unless roads were impassible due to high water events. Efforts were made to vary the survey times for each of the sites throughout the five-month survey period. Recreation surveys included counting individuals and vehicles, classifying the primary and secondary recreation activities, and interviewing visitors at the sites. Photos were taken at each recreation site during each survey, focusing on the public access boat ramps, water levels at boat ramps, typical activities, or the lack of visitors or activity (Grand River Dam Authority, 2021b).

The most popular recreational activities observed at the surveyed sites included camping, shoreline fishing, boat fishing, boating, and picnicking (Grand River Dam Authority, 2021b). **Table 3.8.1.3.1-1** shows the total number of visitors and vehicles observed at each recreation site for all survey days.

Table 3.8.1.3.1-1 Total Visitors and Vehicles Observed at Each Surveyed Site for All Survey Days

Recreation Site	Type of Recreation Site	Total Number Observed	
		Visitors	Vehicles
Wolf Creek Public Access	FERC-Approved	547	1,587
Monkey Island Public Boat Ramp	FERC-Approved	90	66
Seaplane Base Public Access	FERC-Approved	158	85
Big Hollow Public Access	FERC-Approved	1	0
Duck Creek Bridge Public Access	FERC-Approved	36	58
Twin Bridges State Park (Upper)	State Park	888	1,168
Twin Bridges State Park (Lower)	State Park	398	761
Honey Creek State Park	State Park	1,026	2,036
Bernice State Park	State Park	1,860	1,989
Disney State Park	State Park	180	255
Cherokee State Park (Main)	State Park	174	206

[130] Observation surveys at the river channel sites were only conducted twice per month, once on a weekday and once on a weekend alternating between morning and afternoon per the approved study plan.

Recreation Site	Type of Recreation Site	Total Number Observed	
		Visitors	Vehicles
Cherokee State Park (Lakeside)	State Park	859	666
Little Blue State Park	State Park	2,674	1,454
Cherokee State Park (Riverside)	State Park	453	686
Spring River Public Access	Public Access	132	108
Riverside Park	Public Access	82	91
Connors Bridge Public Access	Public Access	89	86
Council Cove Public Access	Public Access	108	81
Willow Park Public Access	Public Access	65	149
Channel Sites (downstream)	Public Access	218	105
Total Number Observed-All Sites		**10,038**	**11,673**

The five sites with the greatest number of visitors are all state parks and included Little Blue with the greatest number of visitors at 2,674, followed by Bernice with 1,860 visitors, Honey Creek with 1,026 visitors, Twin Bridges Upper with 888 visitors, and Cherokee Lakeside with 859 visitors (Grand River Dam Authority, 2021b). The sites with the highest vehicle counts were those that offer several recreation opportunities. Those sites that only provide parking for boat access had lower vehicle counts overall. A more detailed description of the results of the recreation observation survey and the completed survey forms are available in the Recreation Study Report in **Appendix E-29**.

3.8.1.3.2 Estimate of Current and Future Recreation Use

Results from the Recreation Study show 10,038 users were observed over 30 primary recreation season observations for an average of 334.6 users per day.[131] Assuming each observation accounted for an entire recreation day, the total recreation days as surveyed during the 2020 primary recreation season (183 days at 334.6 users per day) is 61,231.8 days. In order to estimate winter recreation use, GRDA assumed recreation during the winter recreation season is approximately 25% of the primary recreation season total.[132] Therefore, it is estimated the Project experienced 15,307.95 winter recreation days. This provides an annual total of 76,539.75 recreation days for the recreation facilities in the Project vicinity in 2020.

As stated in the Socioeconomic Study Report in **Appendix E-30**, the counties within the region of influence (ROI) are projected to have a population increase of 60.2% between 2020 and 2075.[133] GRDA assumed the 60.2% population growth rate for the ROI will have a corresponding impact on recreation use. Therefore, the number of recreation days for recreation facilities in the Project vicinity is expected to increase to 122,616.7 recreation days by 2075.

[131] Primary recreation season is defined as April through September.
[132] Winter recreation season is defined as October through March.
[133] Region of Influence refers to Craig, Delaware, Mayes, and Ottawa Counties, Oklahoma.

3.8.1.3.3 Recreation Visitor Use Interviews

According to the approved study plan, GRDA developed an electronic visitor interview form to collect visitor information regarding the following items:

- General use information,
- Resident/visitor,
- Purpose/duration of visit,
- Distance traveled,
- Day use/overnight lodging,
- History of site/area visitation,
- Types of recreational activity participation,
- Other sites visited,
- General satisfaction with recreation sites and areas in need of improvement,
- Effects of Project operations on recreation, and
- Accessibility of the facilities (Grand River Dam Authority, 2021b).

Due to COVID-19 safety precautions, interview questions were asked by surveyors, who then entered the visitor's responses into an electronic form to avoid the need for the public to handle the surveyor's electronic device.

Visitor interviews were conducted at all sites except Big Hollow Public Access and Willow Park Public Access, as no visitors were present during any of the surveys at these two sites. While use was noted at these two sites (i.e., vehicles with boat trailers in parking lot), no visitors were physically present on either site to interview when the surveys occurred. A total of 163 visitor interviews were conducted ranging from a low of one visitor interview at the Duck Creek Bridge Public Access to 23 visitor interviews at Bernice State Park (Grand River Dam Authority, 2021b). Sites with campsites generally had more visitors to interview than sites with high boater usage, since the boaters were often on the water and not present when the surveys were conducted.

First-time visitors were more likely to visit larger sites and travel longer distances, averaging 177.06 miles, to get to a site. Repeat and regular visitors were more likely to visit smaller sites and traveled shorter distances, averaging 48.8 miles, to get to a site. The majority of visitors interviewed who identified fishing and boating as their primary use rated the facilities as "totally acceptable", "acceptable", or "neutral". The visitors interviewed were also asked to rate whether the reservoir level was a problem for their ability to safely use the site. Most respondents indicated reservoir levels were either "no problem", "a small problem", or "neither" (Grand River Dam Authority, 2021b). A more detailed listing of survey results and comments received during the interviews are in the Recreation Study Report in **Appendix E-29.**

3.8.1.3.4 Recreation Facility Inventory & Condition Assessment

An inventory of recreation amenities at each of the 20 recreation sites was completed on September 22 and 23, 2020. The condition of each amenity was assigned a rating according to the following scale:

- N: Needs Replacement (broken/missing components or nonfunctional),
- R: Needs Repair (structural damage or otherwise in obvious disrepair),
- M: Needs Maintenance (ongoing maintenance issue, primarily cleaning), or
- G: Good Working Condition (functional and well maintained) (Grand River Dam Authority, 2021b).

Table 3.8.1.3.4-1, **Table 3.8.1.3.4-2**, and **Table 3.8.1.3.4-3** provide summaries of the amenities for each recreation site surveyed.

Table 3.8.1.3.4-1 Summary of Recreational Amenities at Each FERC-Approved Recreation Site

Grand Lake Area Recreation Site FERC-Approved	Number of Each Amenity Per Site						
	Boat Launch Ramp or Lane	Dock or Pier	Mooring Dock	Pavilion	Picnic Table	Restroom	Trash Receptacle
Wolf Creek Public Access	5	1	4	1	6	1	7
Monkey Island Public Boat Ramp	1	-	-	-	-	-	-
Seaplane Base Public Access	1	-	-	-	-	-	-
Big Hollow Public Access	1	-	-	-	-	-	-
Duck Creek Bridge Public Access	1	-	-	-	-	-	-

Source: (Grand River Dam Authority, 2021b)

Barrier free access is provided at each amenity type at Wolf Creek Public Access.

All amenities in **Table 3.8.1.3.4-1** received a “G” rating other than those listed below:

- Big Hollow Public Access: boat ramp was rated M, “gravel needs grading”
- Monkey Island Public Boat Ramp: rated M, “washed out gravel”

Table 3.8.1.3.4-2 Summary of Recreation Amenities at Each State Park Site

Grand Lake Area Recreation Site State Park (Non-Project)	Number of Each Amenity Per Site						
	Boat Launch Ramp or Lane	Dock or Pier	Mooring Dock	Pavilion	Picnic Table	Restroom	Trash Receptacle
Twin Bridges (Upper) State Park	-	-	-	5	Many	3	5
Twin Bridges (Lower) State Park	2	-	1	1	4	1	2
Honey Creek State Park	1	1	1	2	Many	3	5
Bernice State Park	2	1	-	-	2	-	-
Disney State Park	3	-	-	-	2	-	-
Cherokee Main State Park	-	-	-	1	4	1	2
Cherokee Lakeside State Park	1	-	-	1	3	1	3
Little Blue State Park	-	-	-	-	-	5	3
Cherokee Riverside State Park	-	-	-	1	1	3	4

Source: (Grand River Dam Authority, 2021b)

Barrier-free access is provided at the following sites/amenities:

- Bernice State Park: restroom
- Twin Bridges (Lower) State Park: mooring dock, pavilion, and restroom
- Twin Bridges (Upper) State Park: restroom
- Cherokee Main State Park: pavilion
- Cherokee Lakeside State Park: pavilion and restroom
- Cherokee Riverside State Park: pavilion restroom, and trash receptacles

All amenities were assigned “G” ratings, other than those listed below:

- Bernice State Park: boat ramp was rated G/M, one boat ramp is in good condition, and one needs concrete work.
- Bernice State Park: dock was not in place at time of survey and was not rated.

Table 3.8.1.3.4-3 Summary of Recreation Amenities at Other Public Access Sites

Grand Lake Area Recreation Site Public Access (Non-Project)	Number of Each Amenity Per Site						
	Boat Launch Ramp or Lane	Dock or Pier	Mooring Dock	Pavilion	Picnic Table	Restroom	Trash Receptacle
Spring River Public Access	1	-	-	-	-	-	-
Riverview Park[134]	2	-	-	2	8	3	3
Connors Bridge Public Access	2	1	-	-	-	-	-
Council Cove Public Access	1	-	-	-	2	-	-
Willow Park Public Access	1	-	1	-	-	-	-
Channel Sites	-	-	-	-	-	-	-

Source: (Grand River Dam Authority, 2021b)

Barrier-free access is provided at the following sites/amenities:

- Connors Bridge Public Access: boat ramp
- Riverview Park: pavilion and restroom on east side of river and boat launch on west side

All amenities were assigned “G” ratings, other than those listed below:

- Council Cove Public Access: boat ramp was rated R, “rutted gravel”
- Council Cove Public Access: picnic table was rated N, “east table should be replaced, and the west table should be relocated”

The completed Recreation Facility Inventory and Condition forms and more detailed descriptions of the amenities found at each recreation site are in the Recreation Study Report in **Appendix E-29**.

[134] Riverview Park has one launch on the northeast side of the river (Site A) and one site on the southwest side of the river (Site B).

3.8.1.3.5 Boat Ramp Elevation Data

During the recreation observation surveys, reservoir elevations were recorded and photo-documented at each recreation site with a boat ramp. Photos documented high and low water elevations at each site.

The upper elevation of the reservoir conservation pool is 745 feet PD. During the survey period, Grand Lake fluctuated between 742.2 and 748.29 feet PD. The highest reservoir elevation was recorded on May 30, 2020 and the lowest was recorded on September 26, 2020. GRDA assessed boat launches to evaluate the reservoir surface elevation range at which the boat ramps are accessible. All boat ramps were accessible at the recorded lowest water elevation of 742.2 feet PD during the survey. At the highest elevation of 748.29 feet PD and second highest elevation at 747.29 feet PD, nine of the sixteen boat ramp sites were accessible. The reservoir elevation exceeded the conservation pool elevation of 745.0 feet PD during all survey dates within the month of May, which coincides with the normal spring runoff period (Grand River Dam Authority, 2021b). During the remaining survey dates, the reservoir elevation remained within the conservation pool.

More detailed information regarding water levels experienced during each survey and the photos documenting the high and low water elevations at each site are in the Recreation Study Report in **Appendix E-29**.

Overall, GRDA's Law Enforcement documents boat grounding assistance dispatches and historically experiences a significant increase when Grand Lake reaches an elevation near 741.0 feet PD.[135]

To provide more detail on the upper and lower elevations at which boat ramps become unusable, GRDA utilized the terrain information and bathymetry information that was utilized as part H&H Study to develop upland and submerged (bathymetry) contour maps for each of the sixteen boat ramps. Two types of maps for each site were developed and are available in **Appendix E-31**.

The first map for each boat ramp is used to specify the upper reservoir elevation (feet PD), or upper limit of usability, where the boat ramp becomes unusable. Although the perspective, determination, and experience determine the usability on a case-by-case basis, for purposes of this analysis GRDA has determined the ramp becomes unusable when the entire parking lot has been covered with water.

The second map for each boat ramp is used to specify the lower reservoir elevation or lower limit of usability in feet PD, where the boat ramp becomes unusable. Much like the upper limit of usability, the lower limit of usability is based upon the boater's perspective, determination, and experience on a case-by-case basis. However, since the shorelines of the reservoir are characterized as gravel on the surface, reservoir elevations do not drop rapidly, and boat launching occurs where concrete surfaces are not present at launches, the lowest elevation of the concrete or hard surface at the boat ramp cannot be used to determine the lower limit of usability. The slope of the shoreline below the ordinary high-water mark at the location of the ramp or any other available anecdotal information is being used to determine the lower elevation of usability.

[135] This information has been previously filed by GRDA with the Commission on May 29, 2015 (Accession # 20150529-5043) as the 2013-2014 vessel grounding report for Grand Lake (Attachment A), and the USACE peer review on the Floodplain Analysis. Both documents were also referenced in GRDA's July 30, 2015 Request for Expedited Approval of Temporary Variance (Accession # 20150730-5167).

The Upper and lower limits of usability of boat ramps is shown in **Table 3.8.1.3.5-1**.

Table 3.8.1.3.5-1 Upper and Lower Limits of Boat Ramp Usability

Grand Lake Area Recreation Site Public Access	Upper Limit Feet PD	Lower Limit Feet PD	Determining Factors
Wolf Creek Public Access	750	737	Submerged Parking Lot Lack of Slope at Ramp
Monkey Island Public Boat Ramp	751	734	Submerged Parking Lot Lack of Slope at Ramp Slope
Seaplane Base Public Access	748	734	Submerged Parking Steep Underwater Slope
Big Hollow Public Access	755	738	Submerged Facility Steep Underwater Slope
Duck Creek Bridge Public Access	748	742	Submerged Parking Steep Underwater Slope
Twin Bridges (Lower) State Park	748	740	Submerged Facility Steep Underwater Slope
Honey Creek State Park	755	738	Submerged Facility Steep Underwater Slope
Bernice State Park	753	736	Submerged Parking Long Distance from Original Shore
Disney State Park	745	737	Ramp Closed when Gates are Open Steep Underwater Slope
Cherokee Lakeside State Park	745	734	Ramp Closed when Gates are Open Steep Underwater Slope
Spring River Public Access	750	741	Submerged Parking Flanking Steep Underwater Slope
Riverview Park A	753	740	Submerged Parking Steep Underwater Slope
Riverview Park B	753	739	Submerged Facility Steep Underwater Slope
Connors Bridge Public Access	747	744	Submerged Parking Steep Underwater Slope
Council Cove Public Access	748	739	Submerged Parking-User-Developed Ramp Long Distance from Original Shore
Willow Park Public Access	754	740	Submerged Facility Steep Underwater Slope

3.8.1.3.6 Capacity at Highly Used Recreation Sites

The sites with the highest visitor counts (>300) and vehicle counts (>300) were analyzed further to assess the factors determining the site's capacity, the average use capacity observed, and whether expansion is necessary to facilitate additional capacity. **Table 3.8.1.3.6-1** summarizes this analysis for the eight recreation sites where over 300 visitors and/or vehicles were observed during the survey period; these include one FERC-approved site and seven state park sites.

With the exception of Little Blue State Park, all highly utilized recreation sites had an average of at least 25% parking capacity available. Based on the average parking space availability and the projected population growth of 18.1% over the next 10 years, parking availability will not be limited at these highly used sites.[136] Little Blue State Park has additional parking capacity along the side of the entry road. Potential development of formal additional parking capacity is limited by topography and would be challenging because additional capacity could reduce the appeal of swimming, one of the site's primary recreational activities.

Table 3.8.1.3.6-1 Limiting Factors to Vehicle Capacity at Highly Utilized Recreation Sites

Recreation Site	Limiting Capacity Factor	Average Use Capacity and Percent Capacity	Capacity Improvement Expansion Needs
Wolf Creek Public Access	Primary Activity: Boat Launch Vehicle parking spaces: 15 Trailer parking spaces: 85[137]	Total vehicles: 1,587 Vehicle/30 days: 53 Site Capacity: 100 % Capacity: 53%	Boat Launching is well-utilized. Parking available for all users. Expansion not needed.
Bernice Creek State Park	Primary Activity: Camping RV sites w/ parking: 33 Primitive sites w/ parking: 28 Additional parking spaces: 28	Total vehicles: 1,989 Vehicle/30 days: 66 Site Capacity: 89 % Capacity: 74%	Camping sites are well-utilized. Parking available for all users. Expansion not needed.
Honey Creek State Park	Primary Activity: Camping RV sites w/ parking: 30 Primitive sites w/ parking: 150 Trailer parking spaces: 20	Total vehicles: 2,036 Vehicle/30 days: 68 Site Capacity: 200 % Capacity: 34%	Camping sites are well-utilized. Parking available for all users. Expansion not needed.
Little Blue State Park	Primary Activity: Swimming Camp sites w/ parking: 18 Additional parking spaces: 5	Total vehicles: 1,454 Vehicle/30 days: 48 Site Capacity: 23 **% Capacity: 200%**	Overflow parking on road, at State Park entrance, and Reservoir bottom. Site restricted by topography and geography. Expansion not feasible.
Twin Bridges State Park (Lower)	Primary Activity: Camping RV sites w/ parking: 17 Primitive sites w/ parking: 10 Vehicle parking spaces: 12 Trailer parking spaces: 53[138]	Total vehicles: 761 Vehicle/30 days: 25 Site Capacity: 39 % Capacity: 64%	Camping sites are well-utilized. Parking available for all users. Expansion not needed.
Twin Bridges State Park (Upper)	Primary Activity: Camping RV sites w/ parking: 46 Primitive sites w/ parking: 54 Vehicle parking spaces: 72	Total vehicles: 1,168 Vehicle/30 days: 39 Site Capacity: 105 % Capacity: 37%	Camping sites are well-utilized. Parking available for all users. Expansion not needed.
Cherokee Lakeside State Park	Primary Activity: Camping Small RV sites w/ parking: 11 Primitive sites with parking: 6 Trailer parking spaces: 30	Total vehicles: 666 Vehicle/30 days: 22 Site Capacity: 47 % Capacity: 47%	Camping sites are well-utilized. Parking available for all users. Expansion not needed.
Cherokee Riverside State Park	Primary Activity: Camping RV sites w/ Parking: 33 Additional parking spaces: 5	Total vehicles: 686 Vehicle/30 days: 23 Site Capacity: 38 % Capacity: 61%	Camping sites are well-utilized. Parking available for all users. Expansion not needed.

Source: (Grand River Dam Authority, 2021b)

[136] Average population increase reflects the average difference in population of the four counties in the ROI from the 2020 Census and the population projections included in the 2012 Oklahoma State of the State Report.
[137] Parking at Wolf Creek was expanded significantly to accommodate fishing tournament traffic. The smaller lot includes 85 trailer parking spaces, the expanded lot includes 208 spaces. Only those trailer parking spaces in the smaller lot are considered for capacity calculations.
[138] Counting the boat launch trailer parking spaces (53) would skew the capacity results at Twin Bridges State Park Lower, as the primary recreation activity was camping. Therefore, the calculation did not include the boat launch parking spaces.

3.8.2 Environmental Effects

In SD1 and SD2, the Commission identified the following issues regarding recreation resources; (1) whether the existing recreation facilities and public access locations are adequate to meet current and future recreation demand; (2) the effects of Project operation (reservoir fluctuation) on access to existing recreation facilities; (3) the effects of Project operation on the “visitor experience” at Grand Lake; and (4) the adequacy of the existing RMP to manage development and use of the Project’s recreation facilities.

3.8.2.1 Adequacy of Existing Facilities to Meet Current and Future Recreation Demand

As discussed in the Recreation Study Report, none of the FERC-approved recreation sites exceeded their capacity. The site with the most visitors observed was Wolf Creek Public Access. It experienced use at only 53% of its capacity; therefore, there are many opportunities for increased recreational use at the existing sites without the need to improve existing or develop new recreational facilities.

During the Recreation Study, the recreation facility condition assessment identified the following maintenance needs to FERC-approved recreation sites:

- Big Hollow Public Access:
    - Gravel approach needs maintenance
    - No Part 8 sign
- Duck Creek Bridge Public Access:
    - “Steep Drop Off” sign needs repairs
    - Part 8 sign does not meet current standards
- Monkey Island Public Boat Ramp:
    - Concrete ramp needs to be cleaned of loose gravel
    - Access drive in need of maintenance
    - No Part 8 sign
- Seaplane Base Public Access:
    - Gravel parking area needs maintenance
    - No Part 8 sign
- Wolf Creek Public Access:
    - No Part 8 sign

The recommended maintenance of access roads, parking areas, and boat ramps was completed in 2020. Review and, if necessary, installation, repair, or replacement of all Part 8, regulatory, and directional signage has been recommended as a mitigation measure in Section 3.8.3. The existing FERC-approved recreation facilities are adequate for current and projected future recreation demand. The increased diligence in site and sign maintenance under the anticipated operation (without a rule curve) is expected to be an improvement when compared to the baseline operation (under the pre-2015 rule curve).

3.8.2.2 Effects of Reservoir Fluctuation on Access to Existing Facilities

During the Recreation Study, each boat landing site was evaluated to determine if the facility was accessible during high and low water events. The highest water level observed during the survey occurred on May 30, 2020, when the reservoir elevation was 748.29 feet PD. The lowest water level observed during the survey was on September 26, 2020, when the reservoir elevation was 742.2 feet PD. All of the FERC-approved sites were accessible during the lowest water elevation experienced during the surveys. Only the Duck Creek Bridge Public Access was inaccessible due to flooding at the two highest reservoir elevations experienced during the survey period, 747.83 and 748.29 feet PD. All of the FERC-approved sites were accessible when reservoir elevations were within the conservation pool.

As part of the OM, median water elevations during the recreation season (June 1 to October 31) under both the baseline operation (under the pre-2015 rule curve) and anticipated operation (without a rule curve) were determined. Under the anticipated operation (without a rule curve), the median water elevations are anticipated to be 743.07 feet PD, versus the baseline operation (under the pre-2015 rule curve) elevation of 743.17 feet PD. For boat launching purposes, the 0.07-foot (less than one inch) difference in median reservoir elevation is virtually indistinguishable.

3.8.2.3 Effects of Project Operation on Visitor Experience

In order to determine the effects of Project operations (water level fluctuations) on the Grand Lake visitor experience, each interviewed visitor was asked to rate whether the reservoir water level at the site inhibited the visitor's ability to safely swim, launch or take out a boat, safely boat, fish along the shoreline, access the shoreline, use the docks, or impacted the scenic quality of the shoreline. Most interviewed visitors responded they had "no problem", "a small problem", or "neither" regarding the effect of reservoir water levels on recreation.

As previously discussed, the OM was used to determine mean reservoir elevations under both the anticipated operation (without a rule curve) and baseline operation (under the pre-2015 rule curve). The less than one inch decrease in mean reservoir elevation in the anticipated operation (without a rule curve) is not expected to have an adverse effect on the visitor experience. Therefore, the expected differences in the visitor experience from water levels when comparing the baseline operation (under the pre-2015 rule curve) to the anticipated operation is negligible.

3.8.2.4 Adequacy of Recreation Management Plan

Since activities at several recreation sites are proposed under Section 3.8.3, the existing RMP will need to be updated to address recreation site maintenance and address future recreation monitoring over the term of the new license. The improvements proposed under the anticipated operation (without a rule curve) will be an advancement for recreation when compared to the baseline operation (under the pre-2015 rule curve) because without the anticipated operation, the recreation improvements are not expected to occur.

3.8.3 Proposed Environmental Measures

GRDA is proposing several recreation enhancements at the FERC-approved recreation sites. The proposed recreation enhancement measures are shown in **Table 3.8.3-1**.

Table 3.8.3-1 Proposed Recreation Improvements by Site

Grand Lake Recreation Site	Proposed Improvements
Wolf Creek Public Access	Install Part 8 Sign
Monkey Island Public Boat Ramp	Install Part 8 Sign
Seaplane Base Public Access	Install Part 8 Sign

Grand Lake Recreation Site	Proposed Improvements
Big Hollow Public Access	Install Part 8 Sign
Duck Creek Bridge Public Access	Install "Steep Drop-Off" Sign Install Part 8 Sign

The proposed enhancements consist of installation of new signage. As one of the stated Project purposes is the safe recreational access to the Project waters, the new signage will improve the safety of the recreational experience, make it clear to the recreationists that the site is open to the public without discrimination, and provide contact information to report problems with the recreation site at each of the FERC-approved recreation sites.

GRDA has developed an RMP, which addresses updated maintenance policies for the FERC-approved recreation sites. To address future recreation needs during the term of the new license, the RMP also includes a provision and methodology to complete a recreation use survey, recreation site inventory, and recreation site condition assessment in year 25 after the license is issued.

The RMP as proposed under the anticipated operation (without a rule curve) will be an advancement for recreation facilities when compared to the baseline operation (under the pre-2015 rule curve) because without the anticipated operation, the RMP activities are not expected to occur. The RMP is enclosed as **Appendix E-32**.

3.8.4 Unavoidable Adverse Impacts

Continued operation of the Project will not result in unavoidable adverse impacts to recreation resources.

3.9 Land Use and Shoreline Management

The Project is located in Craig, Delaware, Mayes, and Ottawa Counties in northeast Oklahoma. The area is known as the Green Country due to the rivers, lakes, tallgrass prairies, and rolling green hills typically present in the region (TravelOK.com, n.d.).

3.9.1 Affected Environment

3.9.1.1 Existing Land Use

GRDA completed a Socioeconomic Study (**Appendix E-30**) associated with relicensing the Project. As part of the study, the general land use patterns in 2001 and 2019 were compared in the four county ROI. The amount of each land use/cover category in the ROI, based on highest to lowest percentage in 2019, is shown in **Table 3.9.1.1-1**. A map showing the different land use/cover categories in the ROI is in **Appendix E-33**. In 2001, agricultural lands account for approximately 57.9% of the lands located within the ROI, followed by forest cover and woody wetlands (30.4%); developed areas (5.4%); open water (3.8%); herbaceous, scrub/shrub, emergent herbaceous wetlands (2.3%); and barren land (0.2%). In 2019, agricultural lands decreased slightly to account for approximately 56.8% of the lands located within the ROI, followed by forest cover and woody wetlands (29.4%); developed areas (6.3%); open water (3.8%); herbaceous, scrub/shrub, emergent herbaceous wetlands (3.5%); and barren land (0.2%).

Table 3.9.1.1-1 Land Use/Cover in the Pensacola Project ROI

Land Use/Cover Category	2001 Percentage	2019 Percentage
Hay/Pasture	54.88	52.86
Deciduous Forest	28.07	26.95
Cultivated Crops	3.06	3.95
Open Water	3.76	3.80
Developed, Open Space	3.88	3.59
Herbaceous	1.92	2.49
Developed, Low Intensity	1.03	1.60
Mixed Forest	1.18	1.16
Woody Wetlands	0.92	1.00
Scrub/shrub	0.24	0.89
Developed, Medium Intensity	0.34	0.79
Developed, High Intensity	0.12	0.27
Evergreen Forest	0.26	0.27
Barren Land	0.22	0.23
Emergent Herbaceous Wetlands	0.11	0.14

Source: (Grand River Dam Authority, 2021c)

A review of lands adjacent to Grand Lake showed 66.8% of lands are either forested or contain woody wetlands, 14.6% are designated as agricultural or crop lands, and 9.6% are developed areas (Grand River Dam Authority, 2021c).

3.9.1.2 Shoreline Management Plan

3.9.1.2.1 Original Shoreline Management Plan Development

Grand Lake is a popular location for recreation and residential development, particularly summer homes due to the scenic quality, recreational opportunities, and proximity to major population centers in Oklahoma and the surrounding states. The majority of the shoreline above elevation 750 feet PD is privately owned. As a result, numerous residences and businesses have been constructed around the reservoir, adjacent to the Project boundary (Grand River Dam Authority, 2008).

Increasing development and competing uses for resources around the lake resulted in the need for a clearly defined, comprehensive, and consistent management strategy for the Project’s shoreline. As a result, GRDA developed an SMP through consultation with stakeholders including resource agencies and members of the public. The SMP formalized many processes and criteria used under GRDA’s historic shoreline permitting system to manage and balance the public and private uses of the Project’s shoreline.

On July 21, 2008, GRDA voluntarily filed the SMP for Commission approval. The SMP ensures the Project reservoir and shoreline are managed in a manner consistent with license requirements and Project purposes. The SMP also provides for reasonable residential and commercial development at the Project, while protecting the Project’s environmental, public recreation, cultural, and scenic values.

The SMP was approved in FERC Order Modifying and Approving Shoreline Management Plan issued on October 17, 2013 (2013 Order).

Ordering paragraph I of the 2013 Order required GRDA to complete and file an updated SMP within six years of the order. The updated plan was to include provisions for (1) quantifying the effects of permitted vegetation removal and mitigating the effects in other areas; (2) provisions for identifying existing wetlands potentially affected by proposed shoreline activities, evaluating their functions and values, assessing the probable effects of proposed activities on wetland, and addressing adverse effects on wetland from permitted activities through appropriate mitigation; and (3) provisions for identifying wildlife habitats potentially affected by proposed shoreline activities and evaluating their functions and values, assessing the probable effects of proposed activities on wildlife habitats, and addressing adverse effects on wildlife habitats from permitted activities through appropriate mitigation.

Ordering paragraph D of the Order Extending License Term, Modifying Relicensing Process Plan and Schedule, Granting Extensions of Time, and Amending Storm Adaptive Management Plan issued on September 9, 2019 extended the deadline for filing the SMP until January 1, 2023, to coincide with the deadline for filing the DLA.

3.9.1.2.2 Updated Shoreline Management Plan

GRDA updated the SMP as required in the 2013 Order, which is in **Appendix E-28**. New provisions required in the 2013 Order and other updates are discussed in the paragraphs below.

<u>New Vegetation Management Provisions</u>

The vegetation management section has been updated to address the requirements in the 2013 Order. A summary of vegetation management activities taking place between 2017 and 2021 are discussed. Due to the limited number of vegetation management permits issued for activities, such as new lawn development or view corridors, which may change the character of vegetation within the Project boundary, vegetation mitigation is not warranted at this time. In the updated SMP, GRDA is proposing to continue tracking all vegetation management permits issued in the Responsible Growth SMC and reassess the need for vegetation mitigation measures during the next SMP update in six years following the approval of the SMP. GRDA will continue to report the number of permits issued and will provide additional information regarding the number of permits and acreage of area for permits issued for vegetation management in its annual report.

In order to address the potential for a large increase in vegetation management permits between SMP updates, GRDA is also proposing to continue the current practice of consulting with the ODWC and USFWS in the event more than 100 vegetation management permits are issued in the Responsible Growth SMC in any calendar year, or in the event vegetation removal is proposed in an individual project where over 100 feet of shoreline includes vegetation removal.

Vegetation management permits issued in Responsible-Growth Sensitive, Wildlife, and Stewardship SMCs require consultation with the ODWC and USFWS prior to issuance. During this consultation, the resource agencies may request vegetation mitigation be incorporated into any permits issued.

GRDA has also added information in the enforcement section of the SMP to allow for the ability to require vegetation mitigation for any unauthorized vegetation management activities.

<u>New Wetland Impact Provisions</u>

A new wetland impact section has been added to the updated SMP. GRDA does not typically allow SMP activities within wetland areas and already requires appropriate erosion and sediment control measures be implemented for all permits issued that involve ground disturbing activities. This requirement avoids impacts to wetlands and the Project reservoir.

GRDA is proposing to begin documenting potential wetland impacts by tracking all permits that may impact wetlands. The number of permits issued, wetland acreage impacted, wetland type, and functional value of wetlands will be recorded. This information will be compiled in an annual report submitted to FERC, ODWC, and USFWS. GRDA will assess the need for wetland mitigation measures during the next SMP update in six years following the approval of this SMP.

GRDA has also added information in the enforcement section of the SMP to allow for the ability to consider wetland mitigation for any unauthorized vegetation management permits.

<u>New Wildlife Habitat Impact Provisions</u>

A new wildlife habitat impacts section has been added to the updated SMP. Since the wildlife habitat for common species within the Project is typical of the entire Project vicinity, SMP-authorized activities will not adversely impact species that may utilize similar habitat in areas adjacent to the Project.

GRDA is instead proposing to focus its wildlife habitat provisions on threatened and endangered species habitat. GRDA is proposing to evaluate each permit’s potential impact to TE species and require the implementation of mitigation measures to minimize or avoid impacts to TE species as permit conditions. If the project applicant is unwilling to implement required mitigation measures, the permit would be denied. Since the mitigation measures would be incorporated into any permit issued, no additional tracking of TE species habitat is currently being proposed.

<u>Other SMP Modifications</u>

The items below describe modifications to specific sections of the updated SMP.

- Structure of SMP: updated to incorporate new provisions and other updates.
- Public Participation and Agency Consultation: updated to incorporate public outreach associated with the SMP update.
- Pensacola Project Description: updated based on information from the most recent Supporting Technical Information Document and current rule curve.
- Water Quality: updated to incorporate current water quality standards and recent testing results.
- Fish and Wildlife Species: updated to incorporate more recent fish and wildlife information than was available at the time the original SMP was written.
- Threatened and Endangered Species: updated to incorporate information from FLA Section 3.7.
- Wetlands: updated to incorporate information from Wetlands and Riparian Habitat relicensing study.

- Land Use: updated to include current permitting information and information from the Socioeconomic Study relicensing study.
- Cultural Resources: updated to discuss ongoing relicensing studies and identify Native American Tribes that were consulted regarding the SMP update.
- Socioeconomic Resources: updated to incorporate information from the Socioeconomic Study.
- Summary of Recreation in the Project Vicinity: updated to include information from the Recreation Study conducted for relicensing.
- Responsible Growth-Sensitive SMC: updated to combine the former Responsible Growth-Wetland and Responsible Growth-Sensitive SMC areas.
- Commercial Uses and Residential Uses: updated to identify no new gravel mining or new private wastewater treatment facilities would be permitted on any GRDA owned lands within the Project boundary.
- SMC maps: updated to incorporate changes in classifications since the last SMP maps were approved (i.e., lands reclassified as Stewardship due to results of wetland delineations, etc.).
- The maps also combined the Responsible Growth-Wetland and Responsible Growth-Sensitive classifications in the existing SMP. A comparison of the amount of shoreline included in each SMC in the updated SMP versus the existing SMP was also completed.
- Habitable Structures: updated to include information on the development of Habitable Structure standards and information regarding annual reporting.
- Dredging/Excavation Policy: updated to change the requirement for sediment sampling to be conducted for all dredging permits issued, to only require sediment sampling in the area upstream of the Highway 59 bridge (Sailboat Bridge). This is due to the higher levels of zinc, lead, and cadmium that are present in higher concentrations in the upper portions of the reservoir than in the lower portions.
- Licenses to Encroach: updated to discuss procedures used to identify and address encroachments, describes the annual reporting requirements, and summarizes the most recent annual report.
- Actions Available for Enforcement: revised to include provisions allowing GRDA to require mitigation for unauthorized activities regarding vegetation management, wetland impacts, or TE Species habitat impacts.
- Tracking Non-Project Use: revised to include information regarding tracking of vegetation management permits in the Responsible Growth SMC, permits issued that may impact wetlands, and requirements to submit annual reports to FERC, ODWC, and USFWS.

3.9.2 Environmental Effects

In SD1 and SD2, the Commission identified the following issues regarding Land Use: (1) the adequacy of the existing SMP to control non-Project use of Project lands (e.g., permitting piers, boat docks, and other facilities); (2) the adequacy of the existing SMP to protect environmental and cultural resources at the Project; and (3) the effects of Project operations on tribal lands.

3.9.2.1 Adequacy of SMP to Control Non-Project Use of Project Lands

The updated SMP that will be implemented as part of the anticipated Project operations sets additional standards for activities permitted on Project lands, which includes piers, boat docks, and other facilities, and establishes a permitting and review process for non-Project uses such that it protects the Project's environmental resources of the Project. In addition, the updated SMP provides additional protection for sensitive resources that have the potential to occur within the Project as described in Section 3.7. Such additional protections are not included in the current SMP that would remain in place as part of the baseline operation (under the pre-2015 rule curve). As a result, the baseline operation (under the pre-2015 rule curve) would provide less protection than the anticipated operation and would not provide adequate control of non-Project uses of Project lands to protect environmental resources including those that need additional protection.

3.9.2.2 Adequacy of Existing SMP to Protect Environmental and Cultural Resources

The updated SMP that will be implemented as part of the anticipated operation (without a rule curve) includes processes to protect environmental resources and includes new provisions to address vegetation management, wetland, and wildlife habitat impacts required in the 2013 Order. The SMP does not specifically identify the location of cultural resources due to their sensitive nature. However, GRDA evaluates potential impacts to known cultural sites in their permit review process. The Cultural Resources Study identified and assessed historic structures, cultural sites, and traditional cultural properties within the Project vicinity. As part of this relicensing, GRDA is proposing to establish a HPMP as described in Section 3.11 that sets standards for GRDA to follow in the event there are potential impacts to cultural resources. The original SMP that would be implemented under the baseline operation (under the pre-2015 rule curve) did not need to be significantly updated to provide additional protection for general environmental resources or cultural resources, other than sensitive environmental resources discussed in Section 3.9.2.1. As a result, the baseline operation (under the pre-2015 rule curve) would provide primarily the same protections in this category as the updated SMP. Also, the updated SMP to be implemented under the anticipated operation would provide no less protection than under the baseline operation (under the pre-2015 rule curve).

3.9.2.3 Effects of Project Operations on Native American Lands

Over the last several years, as part of the development of this application, GRDA completed a comprehensive review and legal analysis of all lands identified by BIA from its Trust Asset and Accounting Management System report and map provided to the Commission in 2018. **Appendix A-5** contains GRDA's report of this effort, together with title work conducted on all parcels identified by BIA occurring within or immediately adjacent to the current Project boundary.

As a result of this effort, GRDA has concluded that 8.122 acres of Native American land held in Trust are within the Project boundary.[139]

GRDA determined the influence of natural processes in providing inflows to the Project has such a great influence on water surface elevations upstream of the Pensacola Dam such that any effects due to the anticipated operation of the project to lands, including Native American lands, are negligible.

In addition to the water surface elevation finding, through extensive study recently completed on historic, archaeological, and TCPs within the Project boundary, the other shoreline protection measures being

[139] This figure is based upon the information provided to the BIA on March 9, 2023. As of the writing of this application the BIA is reviewing the information provided on March 9, 2023 and has not had an opportunity to provide a response. If the figure requires additional update based upon future discussions with the BIA, the updated information will be filed with the Commission.

implemented and the development and implementation of the HPMP, the overall anticipated operation of the Project is not expected to have an adverse effect on Native American lands. Under the baseline operation (under the pre-2015 rule curve), the effects are expected to be the same, but the HPMP developed to protect historic, archaeological, and TCPs, would not be implemented.

3.9.3 Cumulative Effects

The proposed action in this case—FERC's issuance of a license to GRDA—is not likely to have significant effects on land use but may result in cumulative effects on land use when considered in the context of a variety of other activities in the Project area unrelated to the Project, including urban and suburban development and agricultural operations up to an elevation of 760 feet PD.

When compared to baseline operation (under the pre-2015 rule curve), GRDA's anticipated Project operation (without a rule curve) will not have a significant impact on water surface elevation and, thus, effects on land use resulting from reservoir elevation fluctuation (see CHM Study at Section 3.4). However, GRDA's anticipated operation (without a rule curve), when considered in the context of other, non-Project-related activities that occur in the Project area, including urban and suburban development, agricultural operations, and infrastructure improvements, may contribute to effects on land use, including on tribal lands.

In this case, the cumulative effect of the proposed action and other activities in the Project area may result in increased erosion, which may in turn result in increased sedimentation and turbidity and have the potential to transport and deposit contaminated soils and sediments. These contaminated sediments could have deleterious effects on water quality and fisheries, including potential effects on spawning. As set forth in Section 3.3.1.8.1, EPA has jurisdiction over the Tar Creek Superfund Site and other Superfund sites within the Project area that have been identified by stakeholders. These sites have been thoroughly documented and the potentially responsible parties have been identified by EPA. FERC has previously acknowledged that GRDA bears no responsibility.

In addition, GRDA plans to continue to implement its existing SMP, which provides a comprehensive shoreline management program and is included as **Appendix E-28** of this FLA. As part of this relicensing process, GRDA has updated its SMP to incorporate additional provisions regarding the Project's environmental, public recreation, cultural, and scenic values, including provisions to address vegetation management, wetland impacts, and wildlife habitat impacts. See Section 3.9. The SMP, as updated, establishes a system to keep the Project shoreline stable along with ensuring the reservoir and shoreline are managed in a manner consistent with license requirements. The SMP also controls shoreline development on areas owned by GRDA where it sets minimum standards for activities and improvements along the Project shoreline to minimize or avoid adverse impacts from management activities authorized on Project lands.

Consistent with its SMP, GRDA plans to continue its process of issuing authorizations for activities on its shorelines owned in fee, to ensure that such activities do not result in additional soil erosion.

Nevertheless, GRDA plans to continue to implement its anticipated operations, which has been demonstrated to provide more overall protections for the resources which are present within the Project boundary and tribal lands up to an elevation of 760 feet PD. See Section 4.2.

3.9.4 Proposed Environmental Measures

The following environmental measures are being proposed by GRDA to address potential impacts to land use caused by continued operation of the Project:

- GRDA is proposing to implement the updated SMP to adequately control the non-Project use of public lands and protect environmental and cultural resources within the Project boundary.

3.9.5 Unavoidable Adverse Impacts

With the implementation of the proposed environmental measures, continued operation of the Project is not expected to cause unavoidable adverse impacts to land use.

3.10 Aesthetic Resources

3.10.1 Affected Environment

The lands adjacent to the northern and western shorelines of the Project consist of rolling plains with occasional hills and ridges. The shorelines in these areas generally have gentle slopes. The lands adjacent to the southern and eastern shorelines consist of deep ravines and narrow valleys separated by gently rolling uplands. Shorelines in these areas are primarily steep with rocky beaches and bluffs. There is a variety of vegetation along the Project shorelines ranging from forested areas to developed residential and commercial development with manicured lawn areas. The overall river basin is dominated by deciduous forest (Grand River Dam Authority, 2008).

The amount of shoreline development varies between the upper and lower portions of the Project. The upper portion of the reservoir includes undeveloped shoreline, with many areas protected from future development by GRDA's SMP under the Wildlife Management Area and Stewardship land classifications (Grand River Dam Authority, 2008). These areas exhibit relatively natural aesthetics. The majority of the lower portion of the reservoir is highly developed. **Figure 3.10.1-1**, **Figure 3.10.1-2**, **Figure 3.10.1-3**, **Figure 3.10.1-4**, **Figure 3.10.1-5**, and **Figure 3.10.1-6** provide photographs of Grand Lake and the Project facilities.

Figure 3.10.1-1 Pensacola Dam, Powerhouse and Tailrace Looking Upstream

Figure 3.10.1-2 Pensacola Dam Looking West

Figure 3.10.1-3 Pensacola Dam East Spillways and Grand Lake Looking Northwest

Figure 3.10.1-4 View of Grand Lake Looking Upstream of the Dam

Figure 3.10.1-5 Monkey Island Area Looking Northeast into a Cove

Figure 3.10.1-6 Twin Bridges State Park at the Confluence of the Neosho River (L) and Spring Creek (R)

3.10.2 Environmental Effects

GRDA has implemented a SMP which regulates residential and commercial development within the Project boundary, while protecting the Project's environmental, public recreation, cultural, and scenic values. The SMP minimizes aesthetic effects of the Project. In SD2, the Commission did not identify any potential resource issues relating to aesthetic resources. Since the SMP is proposed to be implemented under the new license, as it is currently implemented under the baseline operation (under the pre-2015 rule curve), it is anticipated continued Project operations will have no difference in effects on aesthetic resources.

3.10.3 Proposed Environmental Measures

No potential resource issues were identified relating to aesthetic resources; therefore, no specific aesthetic measures other than continued implementation of the SMP are proposed.

3.10.4 Unavoidable Adverse Impacts

Continued operation of the Project will not result in unavoidable adverse impacts to aesthetic resources.

3.11 Cultural Resources

Section 106 of the NHPA directs federal agencies to take into account the effects of their undertakings on historic properties within the Area of Potential Effect (APE) and to afford the ACHP a reasonable opportunity to comment. The regulations implementing Section 106 define "historic properties" as any pre-contact or historic period district, site, building, structure, or individual object included in or eligible for inclusion in the NRHP. This term includes artifacts, records, and remains that are related to and located within historic properties, as well as TCPs that meet the NRHP criteria.

To meet the interests and requirements of all consulting parties, GRDA established the CRWG. GRDA convened the CRWG at least quarterly, or as needed, in completing the four-year Cultural Resources Study effort. The effort includes information-gathering activities necessary to characterize archaeological and historic resources and historic properties of traditional religious and cultural importance within the Project's APE.

The Cultural Resources Study is composed of the following efforts:

- Cultural Historic Investigation
- Archaeological investigations in 2019 and 2020-Volume I
- Archaeological investigations in 2020 and 2021-Volume II
- Archaeological investigations in 2021 and 2022-Volume III
- TCP Inventory and TCP Effects Analysis
- APE identification based on H&H Study results, other relicensing studies, and information gathered during the early stages of the cultural resources study
- Proposed HPMP development

The study reports and the updated HPMP are in **Appendix E-34**. The cultural resources study reports and the updated HPMP contain sensitive, non-public information related to the location and character of cultural resources; therefore, pursuant to 18 CFR § 388.112, GRDA requests privileged designation of these reports in their entirety and the Commission maintain these reports in its non-public file.

3.11.1 Affected Environment

3.11.1.1 Area of Potential Effect

The initial APE for the Project contains all lands within the current FERC-approved Project boundary. More specifically, the initial APE used for the Cultural Resources Study encompasses land up to an approximate elevation of 750 feet PD.

Based upon study information collected by the Cultural Resources Study, the initial H&H study season, and other studies, the initial APE used for the Cultural Resources Study was to be finalized, if necessary, by adjusting it to include lands or properties outside the current Project boundary where Project operations or Project-related recreation activities or other enhancements may cause changes in the character or use of historic properties. At the end of the initial study season, GRDA concluded there was no need to make any modifications to the initial APE. GRDA's conclusion was based upon study information collected in the Cultural Resources Study, the initial study season H&H study, and other studies. The Commission indicated GRDA's initial study season finalization of the APE was premature because the extent to which Project operation affects lands outside of the current Project boundary (initial APE) was unclear until the H&H Study was finalized in the final study season (2022).

GRDA completed the H&H Study in the final study season. Therefore, GRDA has proposed a final APE as part of the updated HPMP. The effects of the anticipated operation of the Project on the APE are discussed in Section 3.11.2.1.

3.11.1.2 Cultural Historical Properties

The investigations of cultural historical properties were conducted to document and evaluate the potential effects of the Project operation on known historic resources, including the Pensacola Dam Historic District and Splitlog Church. In addition, a resource survey was conducted for unknown above ground historic properties within the APE. The APE consists of areas within the current Project boundary and includes lands or properties outside the Project boundary where Project operations or Project-related recreation activities or other enhancements may cause changes in the character or use of historic properties. The survey was conducted, assessing any associated buildings or structures over 50 years old for their respective eligibility for listing on the NRHP. Identified historic resources were also evaluated for the potential effects from the renewal of the license for the Project.

The Pensacola Dam Historic District was established in 2003 when the dam and its associated structures were determined eligible for the NRHP and listed at that time. Splitlog Church was determined eligible for the NRHP and listed in 1972. The investigation determined the renewal of the Project license will have no adverse effect on the Pensacola Dam Historic District or Splitlog Church.

The Stepps Ford Bridge and Spring River Bridge over State Highway 10 were previously recommended as eligible for listing on the NRHP. However, these two bridges have since been demolished and replaced with modern structures. An additional eighteen historic bridges were identified within the APE. Of the eighteen bridges, thirteen had been previously surveyed, with the remaining five newly identified. However, all eighteen bridges were deemed not eligible for listing on the NRHP based on a lack of historic significance and/or material integrity, with six of the bridges recently replaced with modern structures. The investigation determined the renewal of the Project license will have no adverse effect on the twenty bridges identified.

The report is incorporated in **Appendix E-34**. This report is not provided in public versions of this application because it remains privileged in its entirety and non-public in the Commission's files.

3.11.1.3 Archaeological Properties

Archaeological investigations were completed during three separate field seasons, which include 2019-2020, 2020-2021, and 2021-2022.

3.11.1.3.1 Field Season 2019-2020

This field season was divided into two distinct mobilizations with two distinct goals. During the first mobilization, an archaeological reconnaissance was conducted on 34 previously recorded sites within and immediately adjacent to the Project APE that were designated as "high priority" by members of the CRWG. In early 2020, four additional sites were added to the list of high priority sites requested for assessment by the CRWG, for a final priority site total of 38. The goal of the site reconnaissance efforts was to relocate the 38 sites and assess their current condition, integrity, and document ongoing disturbances. During the 2019-2020 field effort, the mapped locations of 37 of the 38 sites, totaling 239.1 acres, were visited. Findings from the reconnaissance investigations varied. Of the visited sites, seven sites were considered "potentially threatened" due to their locations, current condition, and/or other mitigating factors. Additional management actions were recommended for the seven sites.

The second mobilization was the systematic archaeological survey of high-archaeological potential Quaternary alluvial landforms (Qals) previously identified in the Pre-Fieldwork Study commissioned by GRDA (Cerimele, Nicole, et. al., 2019). The 29 Qals located within the Project APE were determined by the CRWG to have high potential to retain intact archaeological deposits. Ten Qals were investigated during the field mobilization. The total area of the surveyed landforms was 838 acres. Eight previously unrecorded archaeological sites were identified, delineated, and fully documented. Three isolated finds were also recorded. Five of the newly recorded sites are recommended for additional archaeological investigations to determine eligibility to the NRHP. Two sites are also recommended for additional work to fully delineate the site boundaries beyond the Project APE.

The 2019-2020 report known as Volume I is incorporated in **Appendix E-34**. This report contains sensitive, non-public information related to the location and character of cultural resources; therefore, pursuant to 18 CFR § 388.112, GRDA requests privileged designation of these reports in their entirety and that the Commission maintain these reports in its non-public file.

3.11.1.3.2 Field Season 2020-2021

This field season built upon the efforts reported in Volume I. The investigations fell within the Project APE and consisted of locating and assessing conditions at 11 previously recorded sites, surveying 16 Qals determined to have a high potential for cultural materials (Cerimele, Nicole, et. al., 2019), and visual inspection of exposed bluffs along the lake shoreline to identify potential rock shelters and caves. Additionally, one site outside of the Project APE was revisited at the request of the CRWG.

Locations of six of the 11 previously recorded sites were visited, but the sites could not be found. The remaining five sites were relocated and assessed. Four were recommended as potentially eligible and require additional work to determine NRHP eligibility.

A systematic archaeological survey of 16 previously identified Qals was conducted, which included pedestrian survey and shovel test excavations. Additionally, 13 islands were surveyed. The total surveyed area encompassed between the 16 Qals and 13 islands was 2,108 acres. Eleven new archaeological sites were identified and preliminarily evaluated. Three isolated finds were also recorded. Six of the newly recorded sites were recommended for additional archaeological investigations to determine eligibility to the NRHP.

The bluff face visual inspection surveys for 60.4 linear miles of high potential exposed bluff faces were completed to identify potential rock shelters or caves that may contain archaeological deposits.

The 2020-2021 report known as Volume II is incorporated in **Appendix E-34**. This report contains sensitive, non-public information related to the location and character of cultural resources; therefore, pursuant to 18 CFR § 388.112, GRDA requests privileged designation of these reports in their entirety and the Commission maintain these reports in its non-public file.

3.11.1.3.3 Field Season 2021-2022

This field season built upon the efforts reported in Volumes I and II. The total survey area for this study fell within the Project APE and consisted of locating and assessing conditions at five previously recorded sites, surveying three Late Qals determined to have a high potential for cultural materials, survey of an unnamed island, and completion of the visual inspection of exposed bluffs along the lake edge to identify potential rock shelters and caves.

Archaeological reconnaissance was conducted on five previously recorded sites within and immediately adjacent to the Project APE; these were not revisited during the previous field efforts. The goal of the site reconnaissance efforts was to relocate the sites and, if found, assess their current condition, document ongoing disturbances, and assess integrity if possible. The last remaining previously recorded site mapped within the Project APE that was not revisited was determined to be on a ridgetop 50 to 100 feet above the 745 foot PD elevation and well outside of any potential Project impact.

Of the five previously recorded sites investigated, two did not reveal evidence of an archaeological presence at either location plotted within the Project APE. Three sites were able to be relocated and assessed. One of the three relocated sites was found well outside of the Project APE and is not subject to any Project related impacts. A second site was found to be well maintained, positioned outside of the Project APE, and does not appear to be prone to any Project related effects. The third site was found on a high bluff below the Pensacola Dam. The site was found to consist of a mixed pre-contact and post-contact assemblage. This site is currently being affected by disturbances in the form of all-terrain vehicle trails and traffic and is recommended as potentially eligible with additional work to determine NRHP eligibility.

A systematic archaeological survey of three previously identified Late Qals located within the Project APE was conducted, with a total survey area of 259.5 acres. One new archaeological site was identified on Qal 3 and was preliminarily evaluated. The newly recorded site was recommended for additional archaeological investigations to determine eligibility to the NRHP. In addition to survey of the Qals, a single unnamed island located in the main channel of the Grand River was surveyed. The island encompasses approximately 124.3 acres of low-lying landform. No cultural resources were identified during the island survey.

GRDA also completed the remaining 14 linear miles of bluff face survey. Two of the potential bluff areas remain inaccessible and were not inspected. These locations would not be viable for bluff shelters.

The 2021-2022 report known as Volume III is incorporated in **Appendix E-34**. This report contains sensitive, non-public information related to the location and character of cultural resources; therefore, pursuant to 18 CFR § 388.112, GRDA requests privileged designation of these reports in their entirety and the Commission maintain these reports in its non-public file.

3.11.1.4 Traditional Cultural Properties

GRDA completed an inventory of TCPs that compiled information about the locations, types, and number of TCPs within the Project APE. The intent of the study was to identify NRHP-eligible TCPs within the Project APE. Study information was collected and compiled from interviews with Native American Tribal members. Information about TCPs within the Project APE is considered privileged and confidential at the explicit request of Native American Tribes; access to data on the nature and locations of individual TCPs is restricted to the cultural consultant conducting the study, to each respective Native American Tribe, and to GRDA.

The TCP Inventory identified NRHP-eligible TCPs within the Project APE, and the inventory is incorporated in **Appendix E-34**. The TCP Inventory contains sensitive, non-public information related to the location and character of cultural resources; therefore, pursuant to 18 CFR § 388.112, GRDA requests privileged designation of these reports in their entirety and the Commission maintain these reports in its non-public file.

3.11.1.5 Historic Properties Management Plan

The HPMP is a compliance and management plan that integrates the entirety of federal and state cultural resources program requirements with ongoing practices, such as hydropower generating activities, allowing for the identification of potential compliance and preservation actions that may occur over the course of a license period. The intent is to ensure historic properties, as defined under federal law, which may be affected by the generation of hydropower are appropriately managed for scientific research, education, and cultural, religious, and traditional uses for future generations. The HPMP is designed to comply with the requirements of applicable federal and state laws and regulations, including the NHPA, Native American Graves Protection and Repatriation Act of 1990, Archaeological Resources Protection Act of 1979, and the Commission guidelines for development of the HPMP.

GRDA prepared and circulated a draft HPMP to participants of the CRWG on July 1, 2022 and as part of the DLA. The updated HPMP is incorporated as **Appendix E-34**. The incorporated version of the HPMP continues to be in the process of finalization in consultation with the CRWG. The finalized HPMP will be provided to the Commission upon completion of the finalization process. The HPMP contains sensitive, non-public information related to the location and character of cultural resources; therefore, pursuant to 18 CFR § 388.112, GRDA requests privileged designation of these reports in their entirety and the Commission maintain these reports in its non-public file.

3.11.2 Environmental Effects

In SD1 and SD 2, the Commission identified the following issues regarding Cultural Resources: (1) the effects of the Project operation on historic and archaeological resources within the APE that may be eligible for inclusion in the NRHP; and (2) the effects of Project operation and maintenance on properties of traditional religious and cultural importance to Native American Tribes within the APE that may be eligible for inclusion in the NRHP.

3.11.2.1 Effects of Project Operation of the APE

Upon completion of the H&H Study and all studies in the final study season, GRDA determined the influence of natural processes providing inflows to the Project have such a great influence on water surface elevations upstream of the Pensacola Dam that any effects due to the anticipated operation of the Project to lands outside the initial APE, which is the current Project boundary, are negligible.

On December 23, 2022 GRDA requested concurrence from the CRWG on the APE for the Project. In the letter, GRDA indicated the following: “As a result of this work, GRDA in the USR concluded that the APE should not extend beyond the Project boundary, because the H&H Study demonstrates that the Project does not affect lands outside the Project boundary.”

On January 9, 2023, the Osage Nation responded to GRDA's request indicating:

> "The Osage Nation believes the 2019 letter[140] is sufficient to show our concurrence with the APE."

On January 23, 2023, the Cherokee Nation filed a letter with the Commission indicating:

> "GRDA's request for concurrence may be premature with pending study modifications at this point."

On January 23, 2023, the BIA responded to GRDA's request indicating the following:

> "The Bureau of Indian Affairs, Eastern Oklahoma Regional Office ("BIA") is in receipt of the Grand River Dam Authority's ("GRDA") December 23, 2022, letter in which it requests concurrence with its continued definition of the Area of Potential Effect ("APE") for its relicensing undertaking. GRDA's proposed definition is as follows:
>
>> All lands within the FERC-approved Project Boundary encompassing GRDA-owned lands and approximate elevation of 750 feet PD. The APE also includes lands or properties outside the Project Boundary where Project operations or Project-related recreation activities or other enhancements may cause changes in the character or use of historic properties, if any such properties exist.
>
> BIA concurs with GRDA's continued use of the proposed definition of the APE subject to the following comments.
>
> As GRDA continues through the relicensing proceedings, it is the BIA's understanding that the APE could still be subject to change. BIA remains interested in the effects to tribal and individually owned trust lands, as well as historic and cultural properties, both within and near the Project Boundary, a line that is itself being reevaluated in this relicensing undertaking. BIA considers the formulation of the final definition of the APE to be an iterative process and anticipates that GRDA's proposed definition of the APE will be reevaluated and potentially modified. Therefore, BIA's concurrence is subject to these understandings.

On January 23, 2023, the Quapaw Nation responded to GRDA's request indicating they do not concur.

On February 1, 2023, the Oklahoma Archaeological Society responded to GRDA's request as follows:

> "We concurred with this APE definition in previous correspondence (letters dated February 21, 2019 and November 29, 2021). Acknowledging that various studies have been conducted since that time, those investigations have focused on the first component on the APE definition—specifically, the project boundary as delineated by the designated elevation marker of 750 feet msl. The archaeological studies have been well-executed and provided data regarding previously identified and newly recorded sites within the surveyed areas, as well as assessments of historic properties and areas that warrant additional attention.

[140] In a January 5, 2023 response from the Osage Nation, a representative indicated they already provided a concurrence on the APE in the 2019 letter they attached and requested if a new concurrence was required. In GRDA's January 5, 2023 response to their inquiry, GRDA responded with the following: "GRDA acknowledges that that Osage Nation concurred on the APE placement back in 2019, per the correspondence you provided in your email. As GRDA reported in the USR, the additional modeling work conducted in 2022 did not warrant a change in the APE, however, FERC required GRDA to seek concurrence from the CRWG in its comments issued November 29, 2022. I would suggest either a letter that indicates the Osage Nation concurs with GRDA's conclusion that the APE does not require refinement in light of the modeling work conducted in 2022 or you can continue to rely on your 2019 concurrence letter if you conclude that no change to the APE is warranted." GRDA's January 5, 2023 response facilitated the Osage Nation's January 9, 2023 response.

> Does GRDA have information to offer regarding the latter part of the APE definition—specifically "lands or properties outside the project boundary where… project-related recreation activities or other enhancements" may impact historic properties? If so, please provide more details about that information and how it affects GRDA's and FERC's recommendations regarding the APE definition, if at all.
>
> If no such information exists, I will continue to favor the APE definition above as it allows for consideration of factors that have not yet been addressed under the consultation process.

On February 7, 2023, the Delaware Nation responded to GRDA's request as follows:

> "We have no concern with the APE. Please proceed as planned."

3.11.2.2 Effects of Project Operation on Historic and Archaeological Resources

The investigations of cultural historical properties concluded the continued operation of the Project would have no adverse effect on historical properties.

The investigations of archaeological properties concluded the continued operation of the Project can affect certain specific archaeological properties.

3.11.2.3 Effects of Project Operations and Maintenance on Traditional Cultural Properties

The TCP Inventory study identified NRHP-eligible TCPs in the Project vicinity. GRDA has completed a Project adverse effects assessment, which has been incorporated into this application as **Appendix E-34**. The Project assessment contains sensitive, non-public information related to the location and character of cultural resources; therefore, pursuant to 18 CFR § 388.112, GRDA requests privileged designation of these reports in their entirety and the Commission maintain these reports in its non-public file.

For each assessed TCP, the relevant Tribe-identified adverse effects, from their perspective, which are attributable to the Project including recreational activities on Grand Lake (e.g., flooding, inundation, litter/trash, impacts to the soundscapes and viewsheds, etc.), increased difficulties in access, impacts due to flooding, as well as a range of Tribally identified adverse effects related to partial and/or full inundation of the TCP. In addition, the TCP effects analysis includes GRDA's perspectives on Project-related effects on identified TCPs within the Project's APE. While GRDA in many instances acknowledges the impacts identified by each Tribe, it does not always concur that the effects are attributable to the Project (in whole or in part).

3.11.3 Cumulative Effects

The proposed action in this case—FERC's issuance of a license to GRDA—is not likely to have significant effects on cultural resources but may result in cumulative effects on cultural resources when considered in the context of a variety of other activities in the Project area unrelated to the Project, including urban and suburban development and agricultural operations up to an elevation of 760 feet PD.

When compared to baseline operation (under the pre-2015 rule curve), GRDA's anticipated Project operation (without a rule curve) will not have a significant impact on water surface elevation and, thus, effects on cultural resources resulting from reservoir elevation fluctuation (see CHM Study at Section 3.4). However, GRDA's anticipated Project operation (without a rule curve), when considered in the context of other activities that occur in the Project area, including urban and suburban development, agricultural operations, and infrastructure improvements, may contribute to effects on cultural resources. This includes historical and archaeological resources within the APE that may be eligible for the NRHP and TCPs within the APE that may be eligible for inclusion in the NRHP.

In this case, the cumulative effect of the proposed action and other activities in the Project area unrelated to the Project may result in increased erosion, which may in turn result in increased sedimentation and turbidity and have the potential to transport and deposit contaminated soils and sediments. These contaminated sediments could have deleterious effects on TCPs, water quality, and fisheries, including potential effects on spawning. As set forth in Section 3.3.1.8.1, EPA has jurisdiction over the Tar Creek Superfund Site and other Superfund sites within the Project area that have been identified by stakeholders. These sites have been thoroughly documented and the potentially responsible parties have been identified by EPA. FERC has previously acknowledged that GRDA bears no responsibility.

GRDA plans to implement its HPMP included in **Appendix E-34**. The HPMP includes measures to protect, mitigate, or enhance cultural historical, archaeological, and TCPs such that the anticipated operation of the Project will not significantly impact these currently identified properties and properties that may be identified in the future.

In addition, GRDA plans to continue to implement its existing SMP, which provides a comprehensive shoreline management program and is included as **Appendix E-28** of this FLA. As part of this relicensing process, GRDA has updated its SMP to incorporate additional provisions regarding the Project's environmental, public recreation, cultural, and scenic values, including provisions to address vegetation management, wetland impacts, and wildlife habitat impacts. See Section 3.9. The SMP, as updated, establishes a system to keep the Project shoreline stable along with ensuring the reservoir and shoreline are managed in a manner consistent with license requirements. The SMP also controls shoreline development on areas owned by GRDA where it sets minimum standards for activities and improvements along the Project shoreline to minimize or avoid adverse impacts from management activities authorized on Project lands.

Nevertheless, GRDA plans to continue to implement its anticipated operations, which has been demonstrated to provide more overall protections for the resources which are present within the Project boundary and tribal lands up to an elevation of 760 feet PD. See Section 4.2.

3.11.4 Proposed Environmental Measures

GRDA developed the updated HPMP in consultation with the CRWG and consultation is ongoing as part of this application. The HPMP includes measures to protect, mitigate, or enhance cultural historical, archaeological, and TCPs such that the anticipated operation of the Project does not adversely impact these currently identified properties and properties that may be identified in the future.[141]

[141] The incorporated version of the HPMP continues to be in the process of finalization in consultation with the CRWG. The finalized HPMP will be provided to the Commission upon completion of the finalization process.

3.11.5 Unavoidable Adverse Impacts

Continued operation of the Project is not expected to result in unavoidable adverse impacts to cultural or historic resources.

3.12 Socioeconomic Resources

3.12.1 Affected Environment

GRDA completed a Socioeconomic Study to provide baseline information on socioeconomics, including population and employment in the Project vicinity and state of Oklahoma. The ROI for the study was defined as Craig, Delaware, Mayes, and Ottawa Counties in Oklahoma where the Project and Project impacts are located. Baseline socioeconomic information for the ROI is included in the following section.

3.12.1.1 Population Size and Density

The population of the state of Oklahoma increased consistently between 2000 and 2020. As shown in **Table 3.12.1.1-1**, the state's population increased by 0.06% between the 2010 and 2020 decennial census to 3,956,971. The population in the ROI increased by 6.1% between 2000 and 2010 to 131,145. However, the population in the ROI decreased by 5.6% from 2010 to 2020 to 123,835. Based on the Demographic State of the State Report, the Oklahoma's population is expected to increase by 40.4% to 5,560,007 by 2075 (Oklahoma Department of Commerce, 2012). The population of the four counties in the ROI is expected to increase by 60.3% to 198,444 during the same period (Grand River Dam Authority, 2021c).

The average population density within the ROI is 47.2 persons per square mile, less than the statewide average of 57.7 persons per square mile; however, three of the four counties within the ROI have higher population densities than the statewide average. The population densities ranged from a low of 18.5 persons per square mile in Craig County to a maximum of 64.3 persons per square mile in Ottawa County (US Census Bureau, n.d.a).

The ROI includes a total of 62,671 housing units. The number of housing units ranged from a low of 6,375 units in Craig County to a maximum of 24,236 units in Delaware County. The housing unit density within the ROI is 23.9 housing units per square mile, less than the statewide average of 25.7 units per square mile. However, three of the four counties within the ROI have higher housing unit densities than the statewide average. The housing unit densities ranged from a low of 8.4 units per square mile in Craig County and a maximum of 32.4 units per square mile in Delaware County (US Census Bureau, n.d.a). More detailed information about population size, population density, and housing are included in the Socioeconomic Study Report in **Appendix E-30**.

Information regarding the ethnicity of persons living within the ROI is discussed in Section 3.13.

Table 3.12.1.1-1 Population Characteristics

Population Characteristic	Craig County	Delaware County	Mayes County	Ottawa County	ROI	State
2000 Population Total* (Decennial Census)	14,950	37,077	38,369	33,194	123,590	3,751,351
2010 Population Total* (Decennial Census)	15,029	43,009	41,259	31,848	131,145	3,956,971
2020 Population Total* (Decennial Census)	14,107	40,397	39,046	30,285	123,825	3,959,353
2075 Population Projection*	14,075	79,945	68,504	35,920	198,444	5,560,007
2010-2020 Population Change	-6.10%	-6.10%	-5.40%	-4.90%	-5.60%	0.06%
2020 -2075 Population Change	-0.20%	97.90%	75.40%	18.60%	60.30%	40.40%
Population Density** (persons per square mile)	18.5	54.8	59.6	64.3	47.2	57.7
Total Housing Units**	6,375	24,236	18,340	13,720	62,671	1,762,129
Housing Unit Density** (units per square mile)	8.4	32.8	28.0	29.1	23.9	25.7

*-Source: (Grand River Dam Authority, 2021c); **-Source: (US Census Bureau, n.d.a)

3.12.1.2 Economic Activity and Employment

The top five non-farm industries contributing to earnings within the state of Oklahoma were trade, transportation, and utilities at 19.9%; government at 19.8%; professional and business services at 12.2%; educational and health services at 12.17%; and manufacturing at 8.7%. The top industries by employment within each of the counties in the ROI are shown in **Table 3.12.1.2-1**. State and local government was the top industry in Craig and Ottawa Counties, agriculture was the top industry in Delaware County, and manufacturing was the top industry in Mayes County. The largest employment was in Mayes County at 19,028, followed by Delaware County at 17,360, Ottawa County at 13,981, and Craig County at 5,904 (Grand River Dam Authority, 2021c).

Table 3.12.1.2-1 Top Specialized Industry by Employment

Industries	Percent of Jobs	Number of Jobs (1000’s)
Craig County		
State and Local Government	19%	1.7
Agriculture	14.3%	1.3
Health and Social Assistance	10.6%	.95
Transportation	2.7%	.24
Utilities	2.0%	.18
Delaware County		
Agriculture	8.4%	1.4
Construction	8.3%	1.4
Real Estate	4.8%	0.78
Arts and Entertainment	2.2%	0.35
Forestry and Fishing	0.5%	0.09

Industries	Percent of Jobs	Number of Jobs (1000's)
Mayes County		
Manufacturing	15.5%	2.8
State and Local Government	13.6%	2.5
Retail	12.4%	2.2
Agriculture	9.0%	1.6
Construction	9.0%	1.6
Ottawa County		
State and Local Government	35.2%	5.7
Agriculture	7.4%	1.2
Manufacturing	7.0%	1.1
Other Services	5.9%	0.96
Forestry and Fishing	0.5%	0.09

Source: (Grand River Dam Authority, 2021c)

In March of 2015, the Oklahoma Department of Commerce published an economic impact study titled *The Economic Impact of the Grand River Dam Authority*. This study summarized the economic benefits associated with the operation and construction of GRDA facilities, as well as other positive effects from GRDA, including the Pensacola Project. The study indicated an annual positive economic impact of $510 to $581 million was due to the employment and payroll. associated with operations. The estimated economic impact resulting from tourism, quality of life, and relative power costs are expected to contribute an additional $240 to $260 million (Grand River Dam Authority, 2021c).

As shown in **Table 3.12.1.2-2**, the unemployment rate, labor force participation, median household income, per capita income is lower for the four counties in the ROI than the state of Oklahoma as a whole, while the percentage of people living in poverty is higher. Additional information on low-income environmental justice (EJ) communities is provided in Section 3.13.

Table 3.12.1.2-2 Employment and Income

Measure	Craig County	Delaware County	Mayes County	Ottawa County	State of Oklahoma
Unemployment Rate (2020)	5.4%	5.3%	5.0%	5.7%	6.1%
Civilian Population (16 years and older in labor force)	51.9%	48.1%	56.0%	55.5%	60.7%
Median Household Income	$41,701	$39,742	$48,853	$39,070	$51,424
Per Capita Income	$20,704	$22,976	$23,861	$20,209	27,432
Persons Living in Poverty	19.5%	20.7%	15.5%	20.6%	15.6%

Source: (Grand River Dam Authority, 2021c)

3.12.1.3 Infrastructure

In the SPD, the Commission determined flooding of critical infrastructure can degrade the structural integrity of public facilities and render them temporarily unusable while causing social and economic disruption for those dependent on the infrastructure. As a result, FERC recommended that GRDA complete an Infrastructure Study to determine a range of inflow conditions for which H&H Model results show Project

Operations may influence the frequency or depth of flooding. Specifically, the Commission requested maps and tables identifying the frequency and depth of inundation for each item of infrastructure.

The H&H Model of the area upstream of the Project, as well as a range of hypothetical starting reservoir elevations from 734 feet PD to 757 feet PD and inflow events representing a range of flood frequencies, were used for the study. Hydraulic results were extracted at infrastructure locations. Infrastructure locations were mapped, and tabular data of inundation depth were developed. The difference in depth between different starting reservoir elevations were also tabulated.

According to analysis results, only 7% of the infrastructure locations studied experience an appreciable increase in maximum inundation depth for different starting reservoir elevations within GRDA's anticipated operational range of 742 to 745 feet PD. In addition, all appreciable increases in maximum inundation depth occur during high-flow conditions when USACE controls the flood control operations under the Flood Control Act of 1944, and its other statutory mandates, except when the time of maximum inundation depth is solely a function of inflow event arrival time and not reservoir elevation. This means the time of maximum depth at the infrastructure location was completely independent of the Project reservoir elevation. The inflow event moved down the river and arrived at the infrastructure location completely independent of Project operations.

The Infrastructure Study Report is available in **Appendix E-35**.

3.12.2 Environmental Effects

In SD2, the Commission identified the following issue regarding environmental justice: the effects of Project operation and maintenance on minority and low-income populations, including members of Native American Tribes.

3.12.3 Cumulative Effects

The proposed action in this case—FERC's issuance of a license to GRDA—is not likely to have adverse effects on socioeconomic resources. This analysis does not change when considering cumulative effects on socioeconomic resources in the context of a variety of other activities in the Project area unrelated to the Project, including urban and suburban development and agricultural operations in Craig, Delaware, Mayes, and Ottawa Counties.

Section 3.0 of the Socioeconomic Study Report (**Appendix E-30**) addresses cumulative socioeconomic impacts from continued operation of the Project. The cumulative impacts were divided into six categories, general land use patterns, population trends, housing, economic activity, employment, and income and poverty. The study determined the Project operation and maintenance is not expected to contribute to land use changes or adversely impact population trends and housing, but will continue to provide economic benefits for economic activity and employment opportunities in the Project area.

The Proposed action operation and maintenance has a significant positive impact on socioeconomic resources within Craig, Delaware, Mayes, and Ottawa Counties. However, the Project's operation and maintenance, when considered in the context of other activities that occur in the Project area, including urban and suburban development, agricultural operations, infrastructure improvements, and probably most-importantly, the overall health of the regional, state, and national economy may result in impacts that could cumulatively be positive or neutral based primarily on the health of the economy at any given time.

The operation and maintenance of the Project, provides a significant overall benefit to the socioeconomic resources through its continued operation regardless of other cumulative factors and the overall cumulative effects on socioeconomic resources can only be reduced, at most, to a neutral state with the anticipated operation of the Project.

3.12.4 Proposed Environmental Measures

As currently occurs under the baseline operation (under the pre-2015 rule curve), the Project will continue to have beneficial impacts on the socioeconomic resources of the four counties, ROI, and state under the anticipated operation. GRDA is not proposing any new measures related to socioeconomic resources.

3.12.5 Unavoidable Adverse Impacts

Continued operation of the Pensacola Project will not result in unavoidable adverse impacts to socioeconomic resources.

3.13 Environmental Justice

3.13.1 Affected Environment

The following sections provide information on EJ communities within the geographic scope of the existing and anticipated Pensacola Project boundaries.[142] This includes areas within McDonald County in Missouri and Craig, Delaware, Mayes, and Ottawa Counties in Oklahoma.

3.13.1.1 Race, Ethnicity and Low-Income Data

The US Census Bureau 2020 five-year estimates were reviewed for race, ethnicity, and low-income data within the Project geographic scope. The state, county, census block group, and census tract data are summarized in **Table 3.13.1.1-1**.

Table 3.13.1.1-1 Pensacola Project Environmental Justice Community Information

Pensacola Project Geographic Scope	RACE AND ETHNICITY DATA										LOW INCOME DATA
	Total Population (count)	White Alone Not Hispanic (count)	African American (count)	Native American/ Alaska Native (count)	Asian (count)	Native Hawaiian & Other Pacific Islander (count)	Some Other Race (count)	Two or More Races (count)	Hispanic or Latino (count)	Total Minority (%)	Households Below Poverty Level (%)
State of Missouri	6,124,160	4,826,943	692,510	20,646	122,506	7,876	12,840	178,162	262,677	21.2	12.9
McDonald County	22,882	16,577	428	614	339	587	145	1,566	2,626	27.6	17.7
Census Tract 702 Block Group 3	1,487	1,188	0	51	0	0	0	248	0	20.1	10.1
Census Tract 703 Block Group 2	1,421	727	0	54	38	0	0	24	578	48.8	21.6

142 The area within one mile of either the existing or anticipated Project boundary, whichever is larger, is known as the geographic scope in regard to EJ communities when there are no major construction activities planned.

Pensacola Project Geographic Scope	RACE AND ETHNICITY DATA										LOW INCOME DATA
	Total Population (count)	White Alone Not Hispanic (count)	African American (count)	Native American/ Alaska Native (count)	Asian (count)	Native Hawaiian & Other Pacific Islander (count)	Some Other Race (count)	Two or More Races (count)	Hispanic or Latino (count)	Total Minority (%)	Households Below Poverty Level (%)
State of Oklahoma	3,949,342	2,563,119	282,134	288,801	85,858	5,820	6,774	285,369	431,467	35.1	14.7
Craig County	14,274	8,932	426	3,029	118	21	0	1,201	547	37.4	15.6
Census Tract 3731 Block Group 1	1,399	1,030	0	263	0	0	0	84	22	26.4	12.4
Census Tract 3735 Block Group 1	1,249	824	0	310	52	2	0	45	16	34.0	9.5
Census Tract 3735 Block Group 2	1,045	737	12	223	0	2	0	62	9	29.5	15.1
Delaware County	42,741	27,051	213	9,606	525	36	5	3,633	1,672	36.7	16.8
Census Tract 3756.01 Block Group 1	1,123	582	0	163	2	0	0	162	214	48.2	19.9
Census Tract 3756.01 Block Group 2	2,022	1,420	84	299	5	0	0	158	56	29.8	14.7
Census Tract 3756.01 Block Group 3	958	538	0	229	5	0	0	186	0	43.8	15.0
Census Tract 3756.02 Block Group 1	1,332	899	0	321	0	0	0	86	26	32.5	11.5
Census Tract 3756.02 Block Group 2	1,032	876	0	92	0	0	0	47	17	15.1	14.7
Census Tract 3756.02 Block Group 3	1,029	817	6	90	4	0	0	91	21	20.6	10.8
Census Tract 3757.01 Block Group 1	1,366	1,046	4	197	11	0	0	57	51	23.4	9.0
Census Tract 3757.01 Block Group 2	1,418	1,135	25	141	47	0	0	50	20	20.0	6.2
Census Tract 3757.01 Block Group 3	1,378	1,121	0	108	2	0	0	143	4	18.7	10.5
Census Tract 3757.02 Block Group 1	833	629	0	103	0	0	0	51	50	24.5	19.1
Census Tract 3757.02 Block Group 2	2,099	1,593	0	176	0	0	0	101	229	24.1	12.8
Census Tract 3757.02 Block Group 3	724	564	4	78	0	0	0	29	49	22.1	23.5
Census Tract 3758.03 Block Group 1	460	276	0	152	0	0	0	32	0	40.0	9.7
Census Tract 3758.03 Block Group 2	1,066	735	0	201	14	0	0	62	54	31.1	16.6
Census Tract 3758.03 Block Group 3	677	422	0	185	2	0	0	50	18	37.7	15.6
Census Tract 3758.04 Block Group 1	606	333	0	235	7	2	0	29	0	45.0	11.3
Census Tract 3758.04 Block Group 2	657	595	0	52	0	0	0	10	0	9.4	6.9
Census Tract 3758.05 Block Group 1	926	723	0	133	13	0	0	14	43	21.9	9.8
Census Tract 3758.05 Block Group 2	846	699	0	86	0	0	0	61	0	17.4	9.4
Census Tract 3758.05 Block Group 3	601	471	0	50	0	3	0	77	0	21.6	12.0
Census Tract 3758.06 Block Group 1	906	813	0	56	0	0	0	0	37	10.3	19.4
Census Tract 3758.06 Block Group 2	624	380	0	111	4	0	0	96	33	39.1	23.8
Census Tract 3759.01 Block Group 1	1,187	902	0	193	18	0	1	67	6	24.0	9.8
Census Tract 3759.01 Block Group 3	600	358	0	242	0	0	0	0	0	40.3	27.7

Pensacola Project Geographic Scope	RACE AND ETHNICITY DATA										LOW INCOME DATA
	Total Population (count)	White Alone Not Hispanic (count)	African American (count)	Native American/ Alaska Native (count)	Asian (count)	Native Hawaiian & Other Pacific Islander (count)	Some Other Race (count)	Two or More Races (count)	Hispanic or Latino (count)	Total Minority (%)	Households Below Poverty Level (%)
Census Tract 3759.02 Block Group 1	579	300	0	237	0	0	0	42	0	48.2	44.1
Census Tract 3759.02 Block Group 2	832	384	0	140	0	0	0	0	8	27.8	13.0
Mayes County	41,098	26,242	158	7,989	156	138	15	4,869	1,531	36.1	16.6
Census Tract 407 Block Group 1	1,397	908	12	234	11	32	0	102	68	35.0	20.2
Census Tract 407 Block Group 2	948	685	14	110	9	0	0	99	31	27.7	17.4
Census Tract 407 Block Group 3	617	437	0	129	0	0	0	51	0	29.2	19.3
Ottawa County	31,283	20,003	327	6,184	226	204	22	2,476	1,841	36.1	18.6
Census Tract 5741 Block Group 1	251	132	0	63	6	0	0	32	18	47.4	5.4
Census Tract 5741 Block Group 3	1,783	1,233	16	359	23	0	0	118	34	30.8	16.0
Census Tract 5742 Block Group 1	506	259	6	125	0	1	0	66	49	48.8	15.3
Census Tract 5743 Block Group 1	1,451	809	60	291	18	62	0	162	49	44.2	20.8
Census Tract 5743 Block Group 3	684	473	13	111	0	0	0	54	33	30.8	20.3
Census Tract 5744 Block Group 1	827	563	4	151	0	0	0	55	54	31.9	31.4
Census Tract 5744 Block Group 2	863	490	9	196	10	0	3	122	33	43.2	20.8
Census Tract 5744 Block Group 3	1,038	613	4	159	0	0	0	124	138	40.9	21.2
Census Tract 5745 Block Group 1	1,173	703	31	160	9	35	0	145	90	40.1	38.6
Census Tract 5745 Block Group 2	420	312	0	32	0	9	0	31	36	25.7	30.1
Census Tract 5745 Block Group 3	734	474	21	128	0	18	0	43	50	35.4	13.1
Census Tract 5746 Block Group 1	1,237	693	110	92	25	28	0	146	143	44.0	20.3
Census Tract 5746 Block Group 2	797	460	0	237	3	2	0	67	28	42.3	37.8
Census Tract 5746 Block Group 3	627	423	5	82	27	0	0	84	6	32.5	8.7
Census Tract 5746 Block Group 4	1,717	1,215	10	271	6	0	7	166	42	29.2	12.8
Census Tract 5747 Block Group 1	982	639	0	267	3	0	0	67	6	34.9	2.9
Census Tract 5747 Block Group 2	1,409	914	10	321	3	0	0	149	12	35.1	7.2
Census Tract 5747 Block Group 3	1,949	1,346	10	386	29	8	0	132	38	30.9	9.5
Census Tract 5748 Block Group 1	1,639	1,150	0	378	0	0	0	55	56	29.8	18.6
Census Tract 5748 Block Group 3	1,525	1,034	1	330	0	2	0	99	59	32.2	15.6
Census Tract 5749 Block Group 1	1,002	765	0	162	2	0	9	39	25	23.7	17.8
Census Tract 5749 Block Group 2	1,511	864	7	456	8	0	0	125	51	42.8	14.0
Census Tract 5749 Block Group 3	1,119	746	0	258	20	0	0	44	51	33.3	20.2

Source: (US Census Bureau, n.d.b) (US Census Bureau, n.d.c)

3.13.1.2 Environmental Justice Communities

GRDA evaluated the census block groups and tracts within the geographic scope of the Project to determine if there were any EJ communities present. Three evaluation methods were used to make this determination: the 50% analysis method, meaningful greater analysis method, and low-income threshold method.

To qualify as an EJ community under the 50% analysis method, the total percentage of the minority population must exceed 50% of the total population.

To qualify as an EJ community under the meaningful greater analysis method, the block group minority population must exceed 30.4% for block groups in McDonald County; 41.1% for block groups in Craig County; 40.4% for block groups in Delaware County; 39.7% for block groups in Mayes County; and 39.7% for block groups in Ottawa County.[143]

To qualify as an EJ community under the low-income threshold method, the percentage of the population below the poverty level must equal or exceed the poverty level in the county in which it is located. As shown in Table 3.13.1.1-1 in the previous section, the poverty level in each county within the Pensacola Project geographic scope are as follows: McDonald County is 17.7%; Craig County is 15.6%; Delaware County is 16.8%; Mayes County is 16.6%; and Ottawa County is 18.6%.

The three analysis methods identified 27 EJ communities within the Pensacola Project geographic scope, which are indicated with a "Yes" in **Table 3.13.1.2-1**.

Table 3.13.1.2-1 Environmental Justice Communities within the Geographic Scope of the Project

County	Census Tract and Block Group Number	50% Analysis Method (Y/N)	Meaningful Analysis Method (Y/N)	Low Income Threshold Method (Y/N)
McDonald	Tract 703, Block Group 2	No	**Yes**	**Yes**
Delaware	Tract 3756.01, Block Group 1	No	**Yes**	**Yes**
Delaware	Tract 3756.01, Block Group 3	No	**Yes**	No
Delaware	Tract 3757.02, Block Group 1	No	No	**Yes**
Delaware	Tract 3757.02, Block Group 3	No	No	**Yes**
Delaware	Tract 3758.04, Block Group 1	No	**Yes**	No
Delaware	Tract 3758.06, Block Group 1	No	No	**Yes**
Delaware	Tract 3758.06, Block Group 2	No	No	**Yes**
Delaware	Tract 3759.01, Block Group 3	No	No	**Yes**
Delaware	Tract 3759.02, Block Group 1	No	**Yes**	**Yes**
Mayes	Tract 407, Block Group 1	No	No	**Yes**
Mayes	Tract 407, Block Group 2	No	No	**Yes**
Mayes	Tract 407, Block Group 3	No	No	**Yes**
Ottawa	Tract 5741, Block Group 1	No	**Yes**	No
Ottawa	Tract 5742, Block Group 1	No	**Yes**	No

[143] Meaningful Greater Analysis Method: McDonald County minority pop. 27.6 X 1.1 = 30.4; Craig County minority pop. 37.4 X 1.1 = 41.1; Delaware County minority pop. 36.7 X 1.1 = 40.4; Mayes County minority pop. 36.1 X 1.1 = 39.7; Ottawa County minority pop. 36.1 X 1.1 = 39.7.

County	Census Tract and Block Group Number	50% Analysis Method (Y/N)	Meaningful Analysis Method (Y/N)	Low Income Threshold Method (Y/N)
Ottawa	Tract 5743, Block Group 1	No	**Yes**	**Yes**
Ottawa	Tract 5743, Block Group 3	No	No	**Yes**
Ottawa	Tract 5744, Block Group 1	No	No	**Yes**
Ottawa	Tract 5744, Block Group 2	No	**Yes**	**Yes**
Ottawa	Tract 5744, Block Group 3	No	**Yes**	**Yes**
Ottawa	Tract 5745, Block Group 1	No	**Yes**	**Yes**
Ottawa	Tract 5745, Block Group 2	No	No	**Yes**
Ottawa	Tract 5746, Block Group 1	No	**Yes**	**Yes**
Ottawa	Tract 5746, Block Group 2	No	**Yes**	**Yes**
Ottawa	Tract 5748, Block Group 1	No	No	**Yes**
Ottawa	Tract 5749, Block Group 2	No	**Yes**	No
Ottawa	Tract 5749, Block Group 3	No	No	**Yes**

Maps showing the Project boundary and location of project-related construction in relation to all identified EJ communities within the Pensacola Project geographic scope are shown in **Figure 3.13.1.2-1**, **Figure 3.13.1.2-2**, **Figure 3.13.1.2-3**, **Figure 3.13.1.2-4**, and **Figure 3.13.1.2-5**. Each map also identifies all sensitive receptor locations, including childcare centers, fire departments, hospitals, nursing homes, police stations, and schools located within the Pensacola Project geographic scope.

Figure 3.13.1.2-1 Craig and Mayes Counties, Oklahoma Sensitive Receptor Location Map

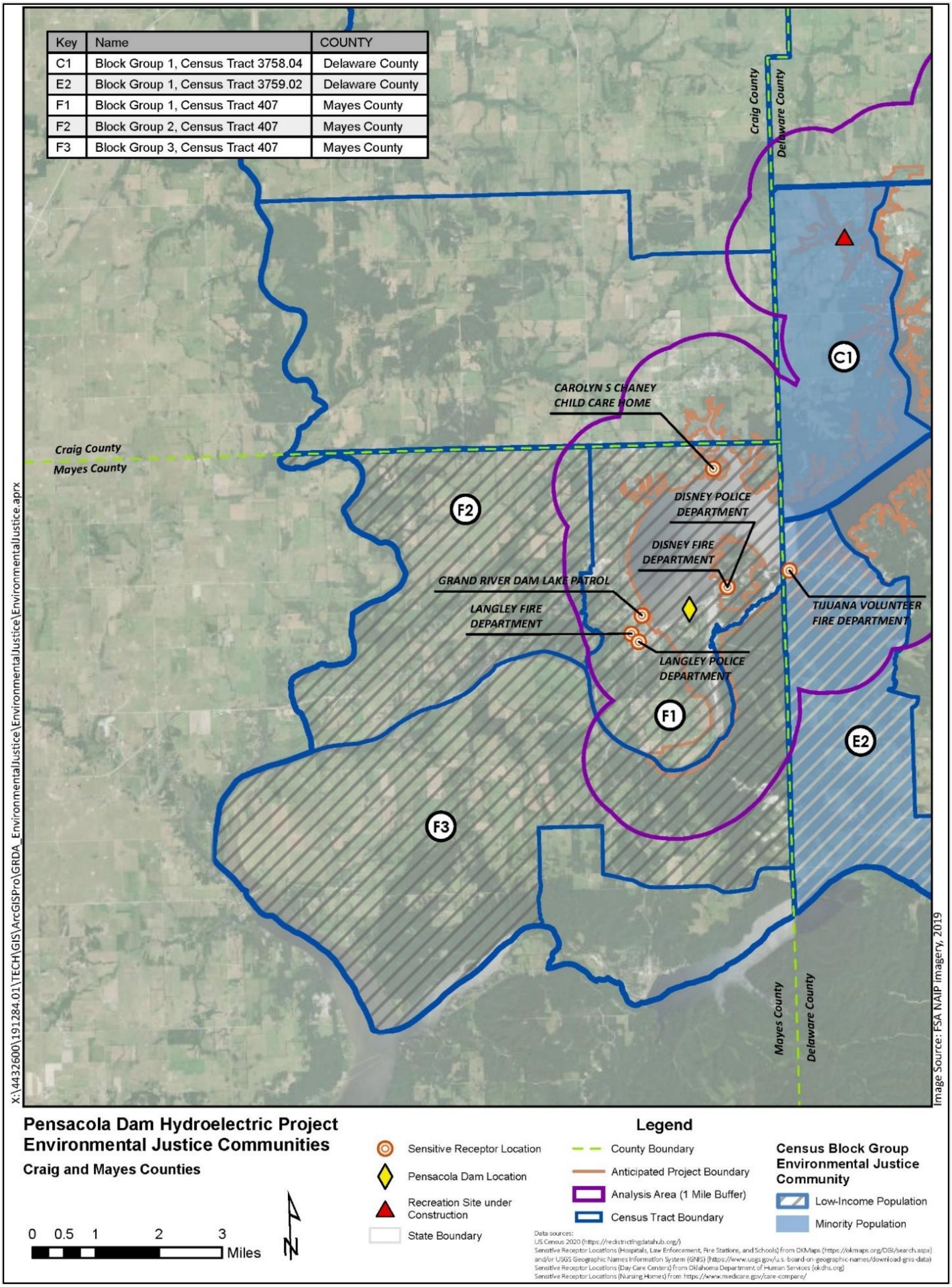
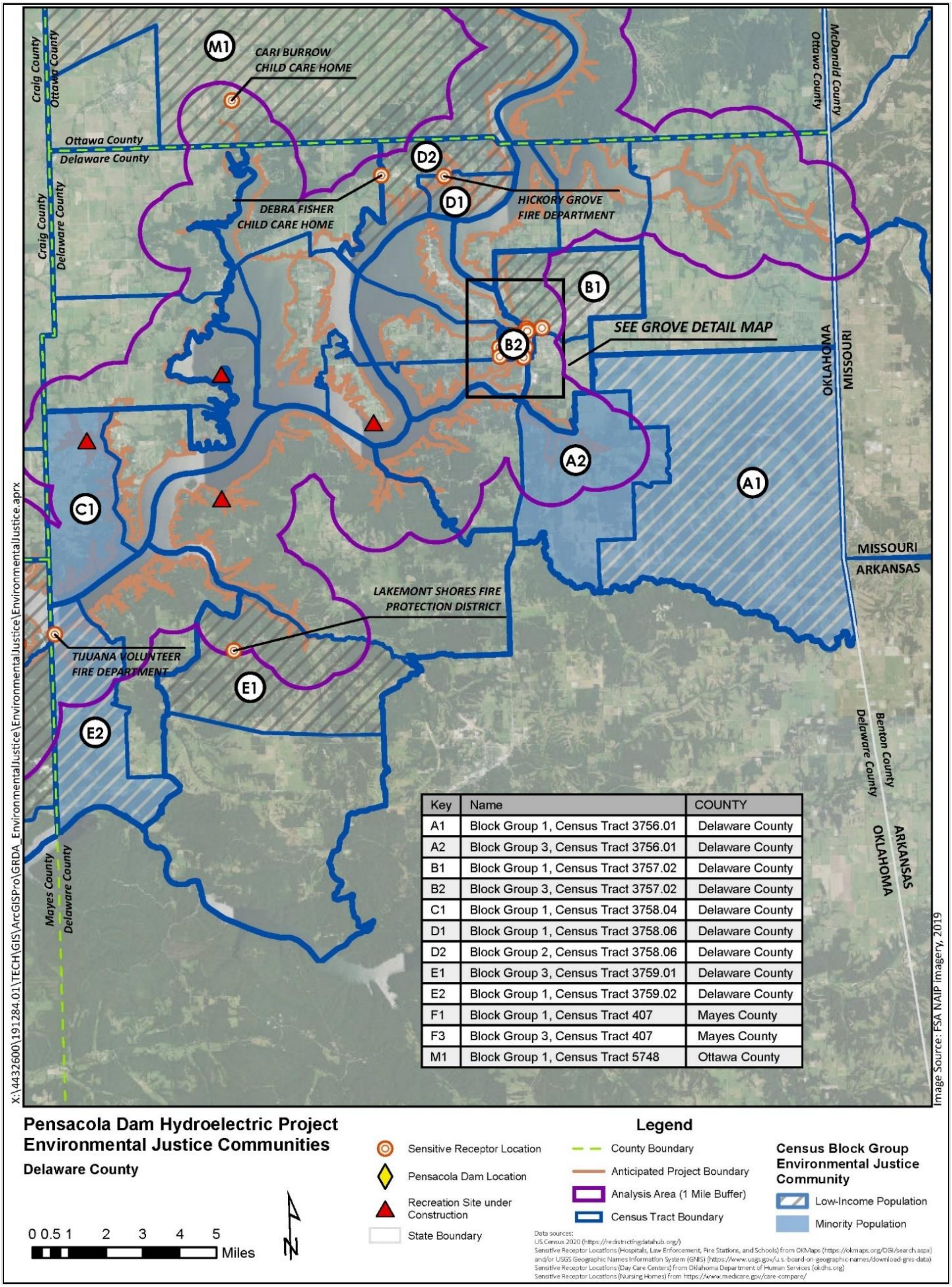


Figure 3.13.1.2-2 Delaware County, Oklahoma and McDonald County, Missouri Sensitive Receptor Location Map



Key	Name	COUNTY
A1	Block Group 1, Census Tract 3756.01	Delaware County
A2	Block Group 3, Census Tract 3756.01	Delaware County
B1	Block Group 1, Census Tract 3757.02	Delaware County
B2	Block Group 3, Census Tract 3757.02	Delaware County
C1	Block Group 1, Census Tract 3758.04	Delaware County
D1	Block Group 1, Census Tract 3758.06	Delaware County
D2	Block Group 2, Census Tract 3758.06	Delaware County
E1	Block Group 3, Census Tract 3759.01	Delaware County
E2	Block Group 1, Census Tract 3759.02	Delaware County
F1	Block Group 1, Census Tract 407	Mayes County
F3	Block Group 3, Census Tract 407	Mayes County
M1	Block Group 1, Census Tract 5748	Ottawa County

Figure 3.13.1.2-3 City of Grove, Oklahoma Sensitive Receptor Location Map

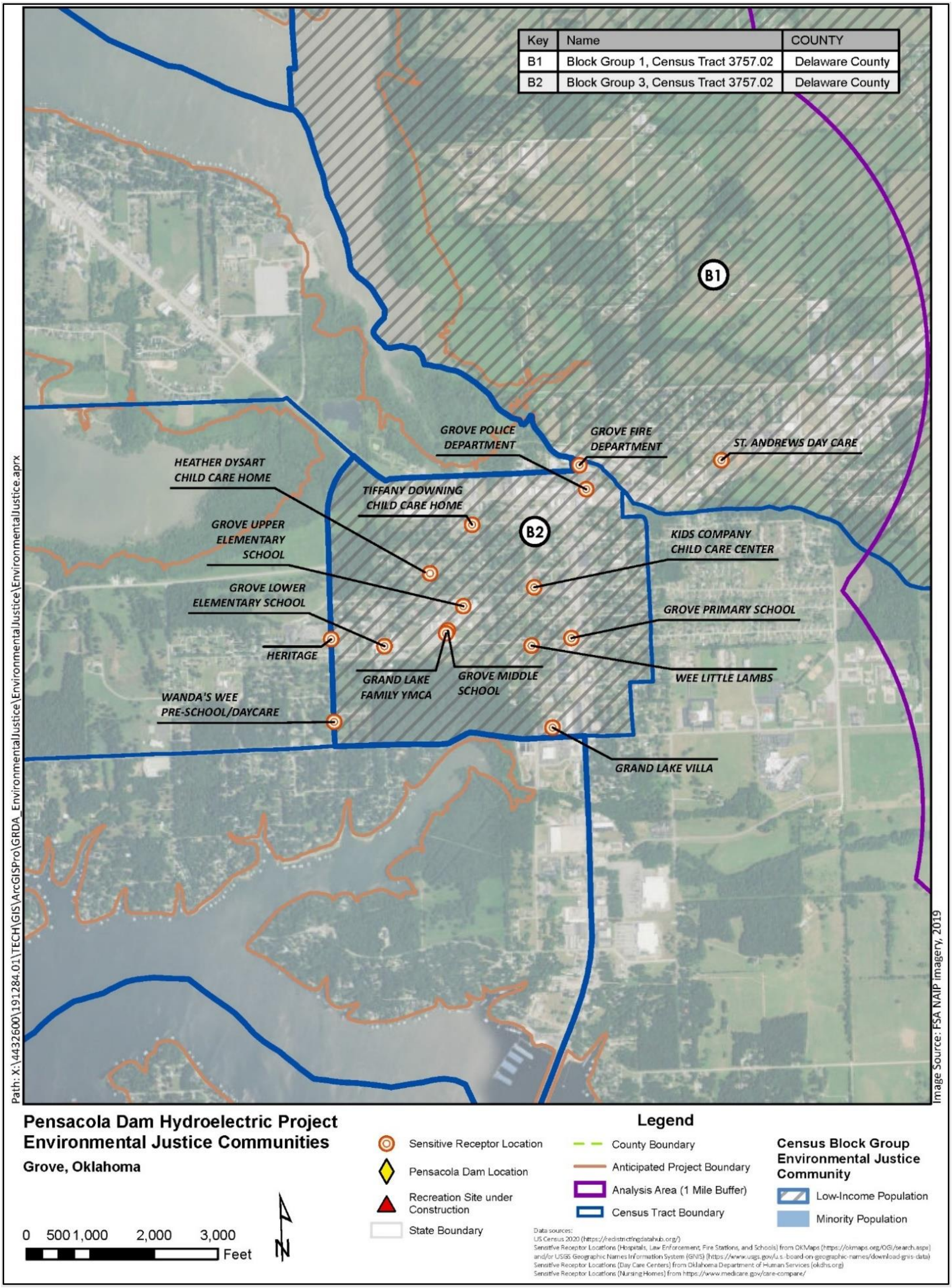
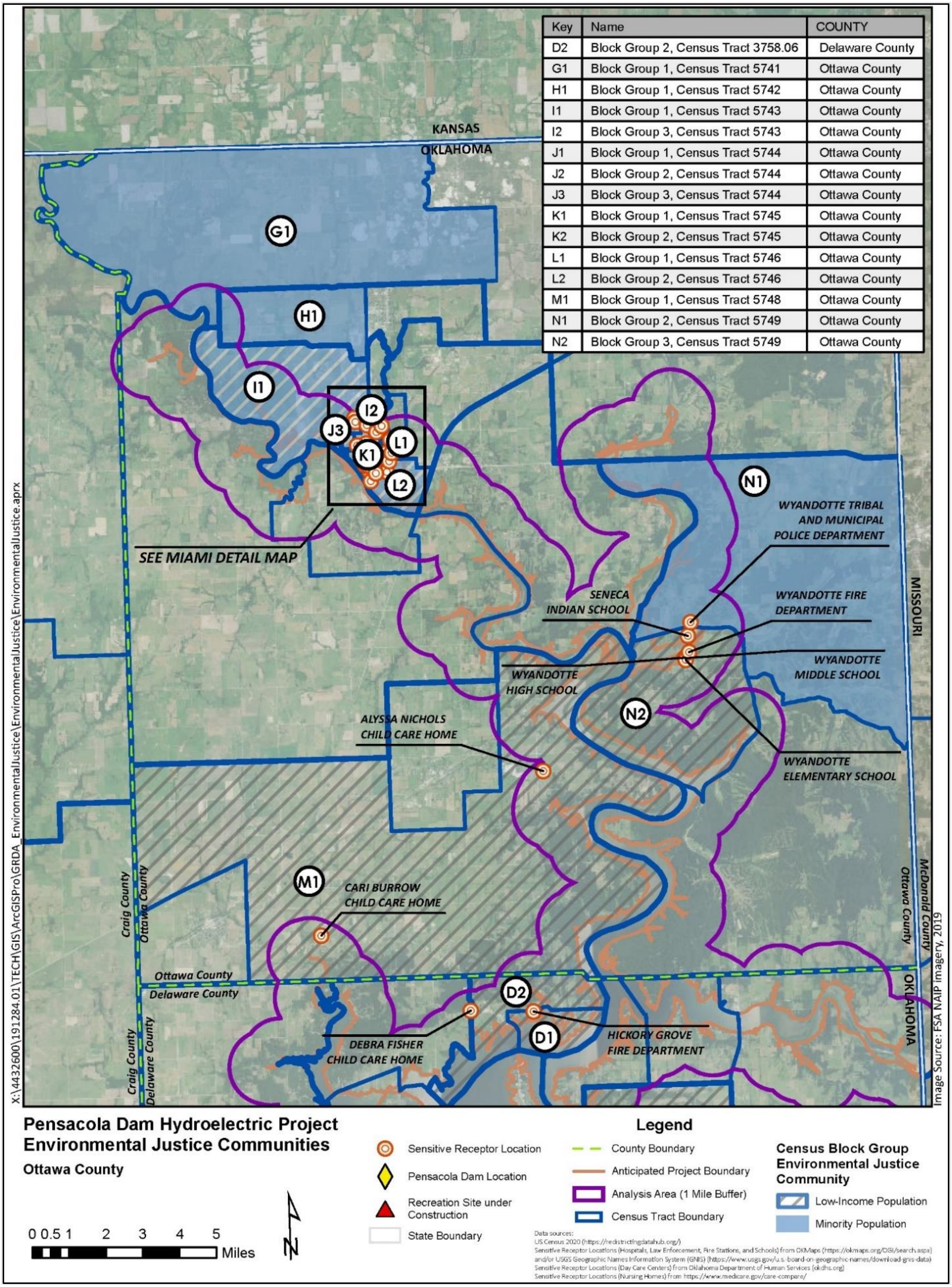
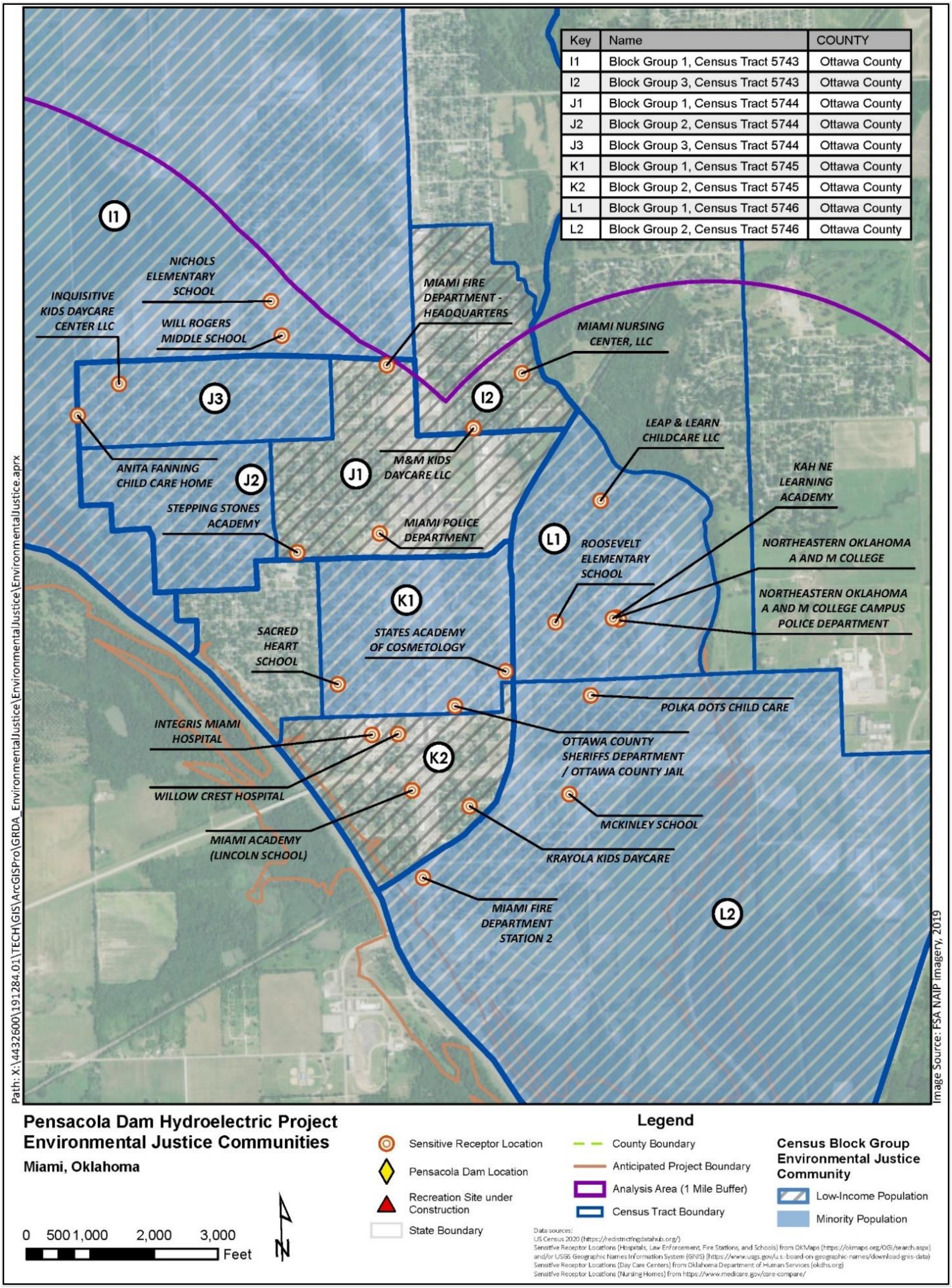


Figure 3.13.1.2-4 Ottawa County, Oklahoma Sensitive Receptor Location Map



Key	Name	COUNTY
D2	Block Group 2, Census Tract 3758.06	Delaware County
G1	Block Group 1, Census Tract 5741	Ottawa County
H1	Block Group 1, Census Tract 5742	Ottawa County
I1	Block Group 1, Census Tract 5743	Ottawa County
I2	Block Group 3, Census Tract 5743	Ottawa County
J1	Block Group 1, Census Tract 5744	Ottawa County
J2	Block Group 2, Census Tract 5744	Ottawa County
J3	Block Group 3, Census Tract 5744	Ottawa County
K1	Block Group 1, Census Tract 5745	Ottawa County
K2	Block Group 2, Census Tract 5745	Ottawa County
L1	Block Group 1, Census Tract 5746	Ottawa County
L2	Block Group 2, Census Tract 5746	Ottawa County
M1	Block Group 1, Census Tract 5748	Ottawa County
N1	Block Group 2, Census Tract 5749	Ottawa County
N2	Block Group 3, Census Tract 5749	Ottawa County

Figure 3.13.1.2-5 City of Miami, Oklahoma Sensitive Receptor Location Map



Detailed information regarding each of the sensitive receptor locations within the Pensacola Project geographic scope is shown in **Table 3.13.1.2-2**.

Table 3.13.1.2-2 Sensitive Receptor Locations within the Geographic Scope of the Project

Sensitive Receptor Location	Distance from Existing Project Boundary (Miles)	Project Related Effects	Mitigation Measures to Minimize Project-Related Impacts
Sensitive Receptor Type: Child Care			
Alyssa Nichols Child Care	0.78	None	None
Anita Fanning Child Care	0.27	None	None
Cari Burrow Child Care	0.62	None	None
Carolyn S Chaney Child Care	0.12	None	None
Debra Fisher Child Care	0.48	None	None
Grand Lake Family YMCA	0.32	None	None
Heather Dysart Child Care	0.32	None	None
Heritage	0.39	None	None
Inquisitive Kids Daycare Center, LLC	0.42	None	None
Kah Ne Learning Academy	0.26	None	None
Kids Company Child Care Center	0.39	None	None
Krayola Kids Daycare	0.29	None	None
Leap & Learn Childcare, LLC	0.47	None	None
M&M Kids Daycare, LLC	0.89	None	None
Polka Dots Child Care	0.33	None	None
St. Andrews Day Care	0.49	None	None
Stepping Stones Academy	0.37	None	None
Tiffany Downing Child Care	0.17	None	None
Wanda’s Wee Pre-School/Daycare	0.23	None	None
Wee Little Lambs	0.30	None	None
Sensitive Receptor Type: Fire Station			
Disney Fire Department	0.01	None	None
Grove Fire Department	0.14	None	None
Hickory Grove Fire Department	0.20	None	None
Lakemont Shore Fire Protection District	0.89	None	None
Langley Fire Department	0.30	None	None
Miami Fire Department Headquarters	0.98	None	None
Miami Fire Department Station No. 2	0.07	None	None
Tijuana Volunteer Fire Department	0.06	None	None
Wyandotte Fire Department	0.09	None	None
Sensitive Receptor Type: Hospital			
Integris Miami Hospital	0.20	None	None
Willow Crest Hospital	0.27	None	None
Sensitive Receptor Type: Law Enforcement			
Disney Police Department	0.01	None	None
Grand River Dam Lake Patrol	0.07	None	None

Sensitive Receptor Location	Distance from Existing Project Boundary (Miles)	Project Related Effects	Mitigation Measures to Minimize Project-Related Impacts
Grove Police Department	0.21	None	None
Langley Police Department	0.28	None	None
Miami Police Department	0.60	None	None
NE Oklahoma A&M College Campus Police Dept.	0.24	None	None
Ottawa County Sheriff's Department and Jail	0.45	None	None
Wyandotte Tribal and Municipal Police Department	0.29	None	None
Sensitive Receptor Type: Nursing Home			
Grand Lake Villa	0.14	None	None
Miami Nursing Center, LLC	0.91	None	None
Sensitive Receptor Type: School			
Grove Lower Elementary School	0.37	None	None
Grove Middle School	0.33	None	None
Grove Primary School	0.38	None	None
Grove Upper Elementary School	0.40	None	None
McKinley School	0.43	None	None
Miami Academy (Lincoln School)	0.17	None	None
Nichols Elementary School	0.92	None	None
Northeastern Oklahoma A&M College	0.25	None	None
Roosevelt Elementary School	0.43	None	None
Sacred Heart School	0.18	None	None
Seneca Indian School	0.02	None	None
States Academy of Cosmetology	0.57	None	None
Will Rogers Middle School	0.87	None	None
Wyandotte Elementary School	0.08	None	None
Wyandotte High School	0.04	None	None
Wyandotte Middle School	0.05	None	None

3.13.1.3 Project Related Impacts to EJ Communities and Sensitive Receptor Locations

GRDA does not anticipate any adverse Project-related impacts on any EJ communities or sensitive receptor locations when comparing the baseline to the anticipated operation of the Pensacola Project. The Project is an existing hydroelectric facility that has been in operation since 1940.

GRDA is anticipating the following operational parameters to apply to the Pensacola Project during the new license term:

- GRDA will no longer utilize a rule curve with seasonal target elevations.
- GRDA will maintain the reservoir between elevations 742 and 745 feet PD for purposes of normal hydropower operations. While hydropower operations may occur when water surface elevations are outside this range (e.g., maintenance drawdowns and high-flow events), GRDA expects to maintain water surface elevations between 742 and 745 feet PD during normal Project operations.
- Instead of managing the Project to target a specified seasonal elevation, GRDA's anticipated operations may fluctuate reservoir levels within the elevational range of 742 and 745 feet PD, for

purposes of responding to grid demands, market conditions, and the public interest, such as environmental and recreational considerations.

- GRDA will continue to adhere to USACE's direction on flood control operations in accordance with the Water Control Manual (US Army Corps of Engineers, 1992).

Although anticipated operations are different from baseline operation (under the pre-2015 rule curve), studies completed by GRDA have demonstrated the influence of the natural processes is so great that any impact of the anticipated reservoir elevation operations is negligible.

GRDA has not proposed any major construction as part of the new license. However, minor maintenance to improve several recreation sites is proposed.

Any impacts resulting from the recreation improvements are expected to be minimal and limited to the immediate recreation site area. Additionally, appropriate erosion and sediment control best management practices will be implemented during the recreation improvements to prevent movement of sediment to Project waters. The proposed recreation improvements are expected to benefit all populations regardless of EJ community status by improving recreational access at the Project. Such improvements are not expected to occur under the under the baseline operation (under the pre-2015 rule curve).

3.13.1.4 Public Outreach

GRDA initiated the Pensacola Project relicensing with the filing of the NOI and PAD on February 1, 2017. The filing was also sent to the relicensing distribution list consisting of relevant resource agencies, Native American Tribes, non-governmental organizations, and other parties interested in the relicensing. FERC held a series of public information sessions regarding the procedure for relicensing the Pensacola Project. Meetings were held in Oklahoma at the following locations and dates: Langley on November 14 and 15, 2017; Grove on November 15, 2017; and Miami on December 13, 2017. Meetings included an overview of the ILP and specific process plan, opportunities for public comment, and a discussion of how FERC assesses information needs during the study planning process. FERC also held government-to-government tribal consultation meetings on December 13, 2017 with the following participating Native American Tribes: Cherokee Nation, Eastern Shawnee Tribe, Miami Tribe, Muscogee Creek Nation, Ottawa Tribe, Peoria Tribe Quapaw Tribe, Seneca-Cayuga Nation, and Wyandotte Nation. FERC also held a government-to government tribal consultation meeting with the Osage Nation in Pawhuska, Oklahoma on December 14, 2017.

FERC conducted four scoping meetings in Oklahoma to receive input from resource agencies, Native American Tribes, and other interested parties on the scope of the environmental analysis for the Pensacola Project relicensing. The meetings provided an overview of the Integrated Licensing Process, provided information on stakeholder participation, and provided opportunities for public comment. The scoping meeting dates and locations were held as follows:

- February 7, 2018 – Langley
- February 7, 2018 – Grove
- February 8, 2018 – City of Miami
- February 9, 2018 – City of Tulsa

Comments on the PAD and requests for additional studies were addressed in GRDA's PSP. GRDA filed the PSP with FERC on April 27, 2018. Subsequent to the PSP filing, GRDA held PSP meetings on May 30 and 31, 2018 at the GRDA Ecosystems and Education Center. The purpose of the meetings was to provide information on each study plan in the PSP and to provide an opportunity for meeting attendees to ask questions related to the proposed studies. Based on comments received on the PSP, GRDA filed a RSP with FERC on September 24, 2018. On November 8, 2018, FERC issued a Study Plan Determination.

The ISR was filed on September 30, 2021 and ISR meetings were held on October 12, 13, and 14, 2021. The ISR included information on the studies completed during the first study season and GRDA-requested study modifications. Stakeholders also recommended several study modifications and one new study in their comments on the ISR. FERC issued study plan determinations on February 24, 2022 and May 27, 2022.

GRDA filed the USR on September 30, 2022. The USR included reports for all Commission-approved study plans; no study modifications or additional studies were proposed. In accordance with FERC's amended ILP process and schedule issued on September 9, 2019, the USR meeting was held on October 12 and 13, 2022.

All documents noted above are public documents and are available on FERC eLibrary and GRDA's relicensing website at https://grda.com/pensacola-hydroelectric-project -relicensing/.

In order to determine if additional outreach was needed for non-English speaking communities, GRDA reviewed the 2020 American Community Survey Table S1601 Language Spoken At Home data. This review indicated 93.3% to 98.9% of the population of the counties within the Project vicinity speak English only or speak English "very well" (US Census Bureau, 2020). Based on this data, language does not appear to be a major barrier in the Project vicinity. Therefore, no mitigation measures for non-English-speaking communities or EJ communities have been proposed in this application. Information regarding the languages spoken in each county within the Project vicinity is shown in **Table 3.13.1.4-1**.

Table 3.13.1.4-1 Languages Spoken in the Pensacola Project Vicinity

Location	Speak Only English (%)	Speak English only or Speak English " Very Well" (%)	Speak Language Other Than English (%)	Other Languages Spoken (%)			
				Spanish	Asian and Pacific Islander	Indo-European	Other Languages
Missouri							
McDonald County	87.3	93.3	12.7	8.7	2.0	0.7	1.3
Oklahoma							
Craig County	97.4	98.7	2.6	1.6	0.5	0.1	0.4
Delaware County	95.4	98.7	4.6	1.8	0.9	0.3	1.7
Mayes County	95.0	98.9	5.0	1.6	0.3	1.5	1.5
Ottawa County	94.2	98.0	5.8	4.0	1.0	0.2	0.5

Source: (US Census Bureau, 2020)

3.13.2 Environmental Effects

In SD2, the Commission identified the following issue regarding environmental justice: the effects of Project operation and maintenance on minority and low-income populations, including members of Native American Tribes.

Based upon study results, no adverse impacts to EJ communities have been identified. Under the base line operation, the conclusion is the same.

The following beneficial impacts will continue to be provided for EJ communities under the anticipated operation of the Project:

- A source for a reliable water supply,
- Continued public recreation opportunities,
- Continued public safety presence by GRDA law enforcement presence in the Project vicinity,
- Affordable, renewable, and reliable source of electrical power,
- Support for the regional electric grid upon demand when other beneficial intermittent sources of renewable energy such as wind and solar are unable to produce due to lack of wind and sunlight,
- Preservation and conservation of natural resources on the shoreline providing an overall enhancement of the quality of life in the Project vicinity, and
- Employment opportunities that would otherwise be absent without the Project.

The following beneficial impacts will be enhanced for EJ communities under the anticipated operation of the Project compared to the current operation:

- An estimated increase in renewable power generation of 2GWh annually, and its subsequent off-set of 2 GWh currently obtained annually from emitting sources,
- Increased ability for the Southwestern Power Pool to rapidly bring online new intermittent renewable energy sources such as wind and solar without expensive and long-term enhancement projects to enhance the electric grid, and
- Increased navigational safety on the reservoir during the summer and fall seasons.

3.13.3 Proposed Environmental Measures

GRDA is not proposing any new environmental measures specific to EJ communities at the Project.

3.13.4 Unavoidable Adverse Impacts

Continued operation of the Project is not expected to result in unavoidable adverse impacts to EJ communities.

4. Developmental Analysis

This section analyzes the cost of continued operation and maintenance of the Pensacola Project under the current operation (under the current post-2015 rule curve) and anticipated operation (without a rule curve) alternatives. Costs are associated with the operation and maintenance of the Pensacola Project's facilities, as well as the cost of providing proposed environmental mitigation measures.

4.1 Power and Economic Benefits of the Project

The Project has six main generating units with a nameplate capacity of 17,446 kW or 23,395 hp at a nameplate flow of 1,950 cfs for each unit. This results in an installed generating capacity of 17.46 kW for each of the six units because power output is turbine-limited for the main units. There is also one house generating unit with a nameplate capacity of 500kW or 666 hp.[144] The combined installed generation capacity of all seven units is 105.176 MW.

4.1.1 Current Annual Value of Developmental Resources

The average annual gross revenue from 2018 to 2022 was $23,165,216 as shown in Table 9-1 of Exhibit D. As part of the study effort for this license application, an OM was developed in accordance with the approved study plan. The OM has the ability to model both the baseline operation (under the pre-2015 rule curve), current operation (under the current post-2015 rule curve), and anticipated operation (without a rule curve) of the Project. To provide a proper comparison of the estimated change in Project generation, the OM estimates an average annual generation for the period (January 1, 2010 to December 31, 2019) under the baseline operation (under the pre-2015 rule curve) of 392 gigawatt hours (GWh) and 413 GWh under the anticipated operation (without a rule curve), with an average annual increase of 21 GWh, or a 5.3% increase over the baseline operation (under the pre-2015 rule curve). Of the increased generation, 12.027 GWh was produced during on-peak times and 9.149 GWh was produced off-peak. Using the nominal market prices for average, on-peak and off-peak generation reported in Exhibit D (Table 9-1), the value of this average annual power increase is $997,700.

The OM also estimates the operation reflecting the current operation (under the current post-2015 rule curve) in place since 2015 (January 1, 2016 to December 31, 2019) of 467 GWh for the current operation (under the current post-2015 rule curve) and 493 GWh for the anticipated operation (without a rule curve), with an average annual increase of 26 GWh, or a 5.6% increase over the current operation (under the current post-2015 rule curve). Of the increased generation, 15.057 GWh was produced on-peak and 11.193 GWh was produced off-peak. Using the nominal market prices for average on-peak and off-peak generation reported in Exhibit D (Table 9-1), the value of this average annual power increase is $1,238,600.

4.1.2 Current Annual Cost of Project Operations, Maintenance, Repairs, and Administration

Estimated annual cost of Project operations includes the costs of operation and maintenance expenses, FERC fees, depreciation, and administrative and general expenses. As an agency of the state of Oklahoma, GRDA is exempt from most federal, state, and local taxes. The average operational cost from 2018 to 2022 was $9,938,655 per year.

[144] Horsepower is calculated from watts: 750 watts equals 1 hp.

4.2 Comparison of Alternatives

4.2.1 Current Alternative

Under the current operation (under the current post-2015 rule curve) alternative, GRDA would continue to operate the Pensacola Project according to the terms and conditions of the current license implemented post August 4, 2015, including maintaining the current Project boundary, facilities, existing operation and maintenance procedures, and existing environmental measures.

GRDA currently implements several measures that contribute to the protection and enhancement of environmental resources, which include:

- SMP to help control erosion and sedimentation within the Project boundary, protect terrestrial resources and manage land use resources within the Project.
- Operates the Project for maintenance of water supply, to the extent practicable.
- Water customers who hold 30 to 50-year contracts with GRDA for raw water.
- FWHMP which includes a mitigation fund that funds, designs, implements, and evaluates protect to protect, mitigate, and enhance fish and wildlife resources.
- DO Mitigation Plan to mitigate low DO levels downstream of the Pensacola Dam.
- Gray Bat Compliance Plan and cave monitoring to protect the endangered bat.
- RMP for the management of the Project's five formal recreation sites at the Project.
- SHPO consultation before beginning any land clearing or ground disturbing activities within the Project boundaries, including recreation developments.

4.2.2 Anticipated Operation Alternative

Under the anticipated operation alternative GRDA anticipates that the following operating parameters will occur during the new license term:

- GRDA will no longer utilize a rule curve with seasonal target elevations.
- GRDA will maintain the reservoir between elevations 742 and 745 feet PD for purposes of normal hydropower operations. While hydropower operations may occur when water surface elevations are outside this range (e.g., maintenance drawdowns and high-flow events), GRDA expects to maintain water surface elevations between 742 and 745 feet PD during normal Project operations.
- Instead of managing the Project to target a specified seasonal elevation, GRDA's anticipated operations may fluctuate reservoir levels within the elevational range of 742 and 745 feet PD, for purposes of responding to grid demands, market conditions, and the public interest, such as environmental and recreational considerations.[145]

GRDA will continue to adhere to USACE's direction on flood control operations in accordance with the Water Control Manual (US Army Corps of Engineers, 1992).

[145] With the changing power grid from less reliance upon on-demand sources such as hydropower and more on integration to the power grid of numerous intermittent renewable energy sources such as wind and solar (which are intermittent on an almost daily basis), the anticipated operation of the Project that is not restricted to a specific rule curve will allow for greater flexibility to provide an immediate response to support the stability of the grid at all times. GRDA receives requests by the Southwest Power Pool on average about every 45-60 days to increase generation to stabilize the grid in the region due to unexpected significant reductions of generation from numerous independent intermittent solar and wind energy sources.

Under the anticipated operation alternative, GRDA would also implement several environmental measures from the existing license, as well as several new environmental measures. Proposed environmental measures under the anticipated operation alternative include the following:

- GRDA will implement an updated SMP with new provisions to address vegetation management and impacts to wetlands, wildlife habitat, and TE species, as described in Section 3.7 and Section 3.9. The updated SMP will help control erosion and sedimentation, protect terrestrial resources, protect TE species, protect cultural resources, and manage land use resources within the Project.
- GRDA will continue to implement the DO Mitigation Plan to reduce impacts of low DO on fish and aquatic resources downstream of the Pensacola Dam.
- GRDA will implement construction stormwater BMPs for erosion and sediment control prior to conducting ground disturbing activities related to operation or maintenance of the Project to minimize or eliminate the impacts of erosion and siltation.[146]
- GRDA will implement the RMP as included in **Appendix E-32.**
- GRDA will implement the HPMP developed in consultation with the CRWG. The HPMP includes measures to protect, mitigate, or enhance cultural, historical, archaeological, and TCPs such that the anticipated operations of the Project do not adversely impact currently identified properties and properties that may be identified in the future.

4.3 Cost of Environmental Measures

The cost of environmental measures is provided in Table 5.5.1 of Exhibit D.

[146] There are no planned ground-disturbing activities. GRDA does not consider existing recreation site maintenance of parking areas as a ground-disturbing activity.

5. Conclusions and Recommendations

5.1 Comprehensive Development and Recommended Alternative

This section is completed by FERC in the NEPA document.

5.2 Unavoidable Adverse Effects

With the implementation of the environmental measures proposed in this application, continued Project operation is not expected to adversely affect geology and soils, water resources, fish and aquatic resources, terrestrial resources, threatened and endangered resources, recreation resources, land use and shoreline management, aesthetic resources, cultural resources, socioeconomic resources, or EJ communities.

5.3 Recommendations of Fish and Wildlife Agencies

Recommendations received from fish and wildlife agencies will be addressed by FERC in the NEPA document.

5.4 Consistency with Comprehensive Plans

Section 10(a)(2) of the Federal Power Act requires FERC to consider the extent to which a proposed project is consistent with existing federal and state comprehensive plans, as defined in 18 CFR § 2.19.

The following presents a current listing of FERC-approved comprehensive plans identified in SD2 that may be applicable to the relicensing of the Pensacola Project. This application was prepared in consultation with various resource agencies, including those that prepared the comprehensive plans outlined in the following sections.

If environmental reviews conducted by the resource agencies identified any operational characteristics that require mitigation, appropriate mitigation has been proposed herein. As such, continued operation of the Project with the proposed mitigation measures is not expected to adversely impact resources in the Project vicinity.

5.4.1 USACE Plans

5.4.1.1 Arkansas River Basin, Arkansas and Oklahoma, Feasibility Report. (1991)

This report detailed the feasibility study completed by the Little Rock and Tulsa USACE Districts, Arkansas Soil and Water Commission, and OWRB. In Arkansas, the study evaluated the usability of the Arkansas River as a water supply source and determined the feasibility of new flood control measures and reconstruction of existing Arkansas River levees. The Oklahoma portion of the study evaluated opportunities for new multiple-purpose projects. It also analyzed improvements to the McClellan-Kerr Arkansas River Navigation System Operating Plan (US Army Corps of Engineers, 1991).

The report indicated the Arkansas River water quality had improved and is suitable as a raw water source for municipal, industrial, and agricultural use. The study also indicated major replacements and repairs to 14 Arkansas River levees were economically feasible but are not typically considered a federal responsibility.

All potential new projects studied in Arkansas and Oklahoma were determined not to be economically feasible. Operating plan studies indicated the benefits and impacts of the three plans investigated were very similar. No additional federal action was recommended in the report (US Army Corps of Engineers, 1991).

Continued operation of the Pensacola Project is consistent with this plan/report.

5.4.2 National Park Service Plans

5.4.2.1 The Nationwide Rivers Inventory (1993)

The Nationwide Rivers Inventory is a listing of more than 3,200 free-flowing river segments in the United States that are believed to possess one or more “outstandingly remarkable” values. The Grand River is not listed in the inventory (National Park Service, n.d.c).

5.4.3 Oklahoma Department of Wildlife Conservation Plans

5.4.3.1 Bottomland Hardwoods of Eastern Oklahoma (1985)

The plan assessed the status trends and values of bottomland hardwood forest habitat in 28 eastern Oklahoma counties. Objectives of the report were to identify values and importance of bottomland hardwoods; determine past trends, current status, and future trends of habitat type; and analyze alternatives for enhancing and maintaining bottomland forest habitat (Oklahoma Department of Libraries, 1985).

GRDA implements an SMP for the Project. Lands within shorelines classified as Stewardship, Responsible Growth-Sensitive, and Wildlife Management Areas will continue to protect bottomland hardwood habitat within the Project boundary. Therefore, there are no conflicts between the plan and continued operation of the Project.

5.4.3.2 Eastern Oklahoma Wetlands Plan: Lower Mississippi Valley Joint Venture-North American Waterfowl Management Plan (1989)

The plan outlines specific actions to conserve and protect wetlands and waterfowl habitat in eastern Oklahoma and describes strategies to accomplish the actions (Grand River Dam Authority, 2017a).

GRDA’s SMP provides protections for wetlands and waterfowl habitat within the Stewardship, Responsible Growth-Sensitive, and Wildlife Management Areas land classifications. Therefore, there are no conflicts between the plan and continued operation of the Project.

5.4.4 Oklahoma Water Resources Board Plans

5.4.4.1 Update of the Oklahoma Comprehensive Water Plan, Publication No. 139 (1997)

The plan contains watershed planning region reports, technical data, study findings and reports, and policy recommendation (Oklahoma Water Resources Board, n.d.c). The plan was last updated in 2012. OWRB is in the process of updating the plan for 2025. The beneficial use designations for Grand Lake include public and private water supply and the Project is managed accordingly.

5.4.4.2 Oklahoma's Water Quality Standards and Implementation of Oklahoma's Water Quality Standards (2002)

The Oklahoma Water Quality Standards are published in Oklahoma Administrative Code Title 785, Chapter 45 and were most recently updated effective September 13, 2020. The standards consist of a designation of beneficial uses, water quality criteria to protect the designated uses, and antidegradation policies (Oklahoma Water Resources Board, n.d.a).

GRDA will obtain water quality certification from the DEQ prior to issuance of the new license.

5.4.4.3 Oklahoma Tourism & Recreation Department Statewide Comprehensive Outdoor Recreation Plan (2001)

The Oklahoma SCORP was updated in 2017 to address actions for 2018 to 2022. The SCORP includes a description of recreation resources available in Oklahoma, analysis of recreation users, agencies that manage the public recreation resources, issues to be addressed, and actions to be implemented to protect, preserve, and provide for the enjoyment of Oklahoma's outdoor recreation resources.

GRDA is recognized in the SCORP as a state agency that manages recreation (Oklahoma Tourism and Recreation Development, 2017). The Project's FERC-approved recreation plan is consistent with the Oklahoma SCORP.

5.4.5 US Fish and Wildlife Service Plans

5.4.5.1 Unique Wildlife Ecosystems of Oklahoma (1979)

The plan indicates unique wildlife ecosystems are wildlife habitats that are significantly different from other habitats in the region or are the best representative example in the region or larger geographic area that support natural fish and wildlife communities. The plan provides a summary of unique wildlife ecosystems in Oklahoma (Grand River Dam Authority, 2017a).

GRDA implements an SMP for the Project and lands within shorelines classified as Stewardship, Responsible Growth-Sensitive, and Wildlife Management Areas and will continue to protect bottomland hardwood forest habitat within the Project boundary. Therefore, there are no conflicts between the plan and continued operation of the Project.

5.4.5.2 Land Protection Plan for Texas/Oklahoma Bottomland Hardwoods and Migratory Waterfowl (1985)

The plan provides status, trends, and values of bottomland hardwood forest habitat in 28 eastern Oklahoma counties. The report identifies and prioritizes important bottomland hardwood forest habitat, which includes 13 tracts located along the Little River, Deep Fork River, Neosho River, Verdigris River, McKinney Creek, Gaines Creek, Clear Creek, and Muddy Boggy Creek. However, significant amounts of congruous mature bottomland hardwood were only identified along the Little River and Deep Fork River. (Grand River Dam Authority, 2017a).

GRDA implements an SMP for the Project and lands within shorelines classified as Stewardship, Responsible Growth-Sensitive, and Wildlife Management Areas and will continue to protect bottomland hardwood forest habitat within the Project boundary. Therefore, there are no conflicts between the plan and continued operation of the Project.

5.4.5.3 Fisheries USA: The Recreational Fisheries Policy of the United States Fish & Wildlife Service (1989)

This policy defines USFWS's role in the management of recreational fishery resources and is intended to ensure high-quality recreational fisheries through federal cooperation and partnership (US Fish and Wildlife Service, 1986).

Fishing is a year-round activity on Grand Lake. The Project reservoir supports a high-quality fishery for largemouth, hybrid, striped, and white bass; crappie catfish; and paddlefish. There are no conflicts between this policy and continued operation of the Project.

5.4.5.4 Whooping Crane Recovery Plan (1986)

The Whooping Crane Recovery Plan was updated in 2007. The goal of the plan is to protect the whopping crane and its habitat and allow the population to grow and become ecologically and genetically stable. Whooping cranes migrate through the Great Plains states, including Oklahoma (US Fish and Wildlife Service, 2007).

There are no conflicts between this plan and continued operation of the Project.

6. Maintenance Work - Yet To Be Defined

GRDA has provided in this FLA, analyses of the potential effects of the anticipated operation of the Project regarding reasonably foreseeable future actions, required under the new license for the operation and maintenance of the Project. However, there will be a future need for actions in the day-to-day operation of the Project under the new license, for which the schedule and full scope of environmental effects cannot be determined at this time and some of which will require separate approval from the Commission prior to implementation. However, many actions that can be considered in-kind replacements that do not result in a requirement to modify the approved exhibits, do not require prior-authorization for the Commission in the aspect of dam safety, or do not require prior consultation under the HPMP should be allowed to proceed without prior Commission approval.

Examples of such yet to be defined maintenance work that may occur during the term of the License include, but are not limited to the following types of activities:

- Replacement of gate seals, gate repairs, concrete repairs, etc. that do not require a drawdown.
- Replacement of boat launch hard surfaces (in kind).
- Grading of existing roads and parking areas.
- Replacement of existing signs or placement of new signs.
- Mowing and vegetation management at recreation sites and other Project facilities.
- Removal of hazardous trees from recreation sites or Project facilities.
- Replacement of turbine runners that do not result in a significant increase in authorized capacity or increase in water use.
- Any other maintenance to existing facilities that occurs above or below the OHWM that do not result in a required change to the approved exhibits or plans, provided all local, state, and federal permits are obtained prior to construction and followed during construction.

Impacts from yet to be determined maintenance work can generally be classified into categories based on impact areas or a combination thereof where specific mitigation measures can be implemented to avoid adverse impacts to the resources. The three general areas of impact are as follows:

- Impacts to the structure or facility itself (examples: concrete replacement, equipment replacement, or equipment resurfacing).
- Terrestrial impacts.
- Aquatic impacts.

The Commission is aware of the need for yet to be determined maintenance work over the course of the new license and has previously established requirements that allow such activities to currently occur under each license in Article 3 of the L-Form Articles for each license issued without prior Commission approval. The license for the Project falls into L-Form Category 9 of which Article 3 states the following (emphasis added):

> *The project area and project works shall be in substantial conformity with the approved exhibits referred to in Article 2 herein or as changed in accordance with the provisions of said article. Except when emergency shall require for the protection of navigation, life, health, or property, there shall not be made without prior approval of the Commission any substantial alteration or addition not in conformity with the approved plans to any dam or other project works under the*

> *license or any substantial use of project lands and waters not authorized herein; and any emergency alteration, addition, or use so made shall thereafter be subject to such modification and change as the Commission may direct.* ***Minor changes in project works, or in uses of project lands and waters, or divergence from such approved exhibits may be made if such changes will not result in a decrease in efficiency, in a material increase in cost, in an adverse environmental impact, or in impairment of the general scheme of development;*** *but any of such minor changes made without the prior approval of the Commission, which in its judgment have produced or will produce any of such results, shall be subject to such alteration as the Commission may direct.*

GRDA proposes the following conditions be included in the new license for yet to be determined maintenance activities that will occur during the upcoming license term. By following the requirements and/or conditions listed below in Section 6.1, the Licensee proposes to complete yet to be determined maintenance activities under L-Form Article 3 as minor changes in project works or in uses of Project lands or waters because the activity will not and cannot be considered to "result in an adverse environmental impact or an impairment of the general scheme of development within the judgment of the Commission." without prior Commission approval.

The following requirements and/or conditions shall be implemented by GRDA in the planning and/or execution of any yet to be determined maintenance activities that will occur during the term of the new license, where applicable. If the activity is unable to follow the requirements and/or conditions, there could be adverse environmental impacts and the activity cannot proceed as a minor change as defined in the L-Form Article 3 without prior FERC approval.

6.1 Conditions for Implementation of Minor Changes in Project Works or Uses Without Prior Commission Approval

The following requirements and/or conditions shall be implemented by GRDA in the planning and/or execution of any yet to be determined maintenance activities that will occur during the term of the new license where applicable. If the activity is unable to follow the requirements/conditions, there could be adverse environmental impacts and the activity cannot proceed as a minor change as defined in the L-Form Article 3 without prior FERC approval.

6.1.1 Structures or Facilities

Yet to be determined maintenance activities could produce adverse impacts to the structures or facilities which would be contrary to the conditions and intent of the requirements of the new license. Adverse impacts can be avoided if the following conditions and/or requirements are followed:

- No changes will be made to the structure without following the requirements outlined in the upcoming Programmatic Agreement or Historic Properties Management Plan (Section 3.11.3).
- No changes will be made to the structure or the facilities such that they no longer substantially conform to the approved Exhibits in the new license.
- No changes will be made to the structure or the facilities such that they no longer comply with the requirements of compliance plans developed as a result of the new license.

6.1.2 Terrestrial Areas

Yet to be determined maintenance activities could produce adverse impacts to the terrestrial areas of the Project which would be contrary to the conditions and intent of the requirements of the new license. Adverse impacts can be avoided if the following conditions/requirements are followed:

- No ground-disturbing activities can occur without following the requirements outlined in the Programmatic Agreement or Historic Properties Management Plan (Section 3.11.3).
- All applicable local, state, and federal permits will be obtained prior to construction and will be followed during construction.
- For ground-disturbing activities, appropriate erosion and sediment control best management practices will be implemented (Section 3.6.3).
- Prior to the activity, GRDA will complete a search of the IPaC database or an equivalent database and follow any protected conditions to avoid adverse impacts to any listed species.

6.1.3 Aquatic Areas

Yet to be determined maintenance activities can produce adverse impacts to the aquatic areas of the Project which would be contrary to the conditions and intent of the requirements of the new license. Adverse impacts can be avoided if the following conditions and/or requirements are followed:

- All applicable local, state, and federal permits will be obtained prior to construction and will be followed during construction.
- Prior to the activity, GRDA will complete a search of the IPAC database and follow any protected conditions to avoid adverse impacts to any listed species.

7. Consultation Documentation

A distribution list that includes the names and addresses of federal, state, and interstate resource agencies, Native American Tribes, and interested members of the public that were consulted in the preparation of this environmental document can be found attached to the cover letter of this filing and has not been duplicated in this section.

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