GRDA
Grand River Dam Authority

April 27, 2018

Via E-Filing

Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 First Street NE
Washington, D.C. 20426

Subject: **Pensacola Hydroelectric Project (FERC No. 1494-438); Filing of Proposed Study Plan**

Dear Secretary Bose:

The Grand River Dam Authority (GRDA) hereby electronically files its Proposed Study Plan (PSP) for the Pensacola Hydroelectric Project (FERC No. 1494) (the "Project"). GRDA filed a Notice of Intent (NOI) and Pre-Application Document (PAD) for the relicensing of the Project on February 1, 2017 pursuant to the Federal Energy Regulatory Commission's (FERC or Commission) Integrated Licensing Process (ILP) rules, 18 CFR §§ 5.5 and 5.6. The PSP is filed pursuant to the ILP process plan and schedule included in the Commission's January 12, 2018 Scoping Document 1 (SD1) and in accordance with 18 CFR § 5.11. A copy of this letter and the PSP has been posted to GRDA's Pensacola Project relicensing website (http://www.grda.com/pensacola-hydroelectric-project-relicensing/).

The purpose of this filing is to provide the Commission, the resource agencies, Native American tribes, and other interested parties with a PSP that provides descriptions of studies proposed by GRDA. Several parties submitted comments to the Commission on the Pensacola Project PAD and the Commission's SD1, along with official study requests. GRDA has addressed study requests in this PSP, either with specific study plans to address identified information needs, or by specifically noting why study requests were not adopted by GRDA. The PSP also contains additional information requested by the Commission in its March 13, 2018 comment letter.

Pursuant to ILP regulations (18 CFR § 5.11), GRDA has scheduled study plan meetings for **Wednesday, May 30, 2018 from 9:00 a.m. to 5:00 p.m. (lunch on your own from 12:00 to 1:00 p.m.) and Thursday, May 31 from 9:00 a.m. to 12:00 p.m. at the GRDA Ecosystems and Education Center, 420 E. Highway 28, Langley, Oklahoma**. GRDA has also scheduled a Cultural Resources Working Group (CRWG) meeting for **Thursday, May 31 from 1:00 to 5:00 p.m.** at the same location. The agendas for these meetings will be posted on the Pensacola Project relicensing website at least one week prior to the meeting.

In accordance with the Commission's process plan and schedule included in SD1, following the study plan and CRWG meetings, relicensing participants will have until July 26, 2018 to file comments on the PSP, after which GRDA will file its Revised Study Plan (RSP) by August 25, 2018. When preparing the RSP, GRDA will give due consideration to all comments received and will work with relicensing participants, as appropriate, in refining the individual study plans over the next several months when developing the RSP. Following GRDA's filing of the RSP, the Commission's Study Plan Determination is expected by September 24, 2018.

GRDA appreciates the opportunity to work with the Commission and other interested parties in this ongoing effort to relicense the Project. If there are any questions or comments regarding this submittal, please contact me by phone at (918) 256-0723 or by email at dtownsend@grda.com.

Sincerely,

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Enclosure
cc: Distribution list (see attached)

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Pensacola Hydroelectric Project, FERC No. 1494

Proposed Study Plan

April 2018

TABLE OF CONTENTS

ATTACHMENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

1-D ..... one dimensional
2-D ..... two dimensional
ACHP ..... Advisory Council on Historic Preservation
AIR ..... Additional Information Request
APE ..... Area of Potential Effects
AUC ..... Allowable Use Category
BIA ..... Bureau of Indian Affairs
CCWMA ..... Coal Creek Wildlife Management Area
C.F.R. ..... Code of Federal Regulations
CHM ..... Comprehensive Hydraulic Model
CRWG ..... Cultural Resources Working Group
DLA ..... Draft License Application
DO ..... Dissolved Oxygen
EA ..... Environmental Assessment
EPA ..... Environmental Protection Agency
ESA ..... Endangered Species Act
FEMA ..... Federal Emergency Management Agency
FERC ..... Federal Energy Regulatory Commission
FLA ..... Final License Application
FPA ..... Federal Power Act
FWHMP ..... Fish and Waterfowl Habitat Management Plan
GIS ..... Geographic Information System
GRDA ..... Grand River Dam Authority
HEC-RAS ..... Hydrologic Engineering Center's River Analysis System
H&H Study ..... Hydrologic and Hydraulic Modeling Study
HPMP ..... Historic Properties Management Plan
IA ..... Interagency Agreement
ILP ..... Integrated Licensing Process
ISR ..... Initial Study Report
kVA ..... kilovolt amp
kW ..... kilowatt
LEAD ..... Local Environmental Action Demanded

LiDAR..... Light Detection and Ranging
Mitigation Fund ..... fish and wildlife mitigation fund
MW..... megawatt
NAVD ..... North American Vertical Datum of 1988
NEPA ..... National Environmental Policy Act
NGO..... non-governmental organization
NGVD..... National Geodetic Vertical Datum of 1929
NHPA ..... National Historic Preservation Act
NOI..... Notice of Intent
NWI ..... National Wetlands Inventory
OAS ..... Oklahoma Archaeological Survey
ODWC..... Oklahoma Department of Wildlife Conservation
OSU ..... Oklahoma State University
OU..... University of Oklahoma
OU2..... Operable Unit 2
OWRB..... Oklahoma Water Resources Board
PAD..... Pre-Application Document
PD ..... Pensacola datum
PLP ..... Preliminary Licensing Proposal
PM&E..... protection, mitigation, and enhancement
Project..... Pensacola Hydroelectric Project
PRP..... potentially responsible party
PSP..... Proposed Study Plan
RM ..... river mile
RSP..... Revised Study Plan
SD1 ..... Scoping Document 1
SD2 ..... Scoping Document 2
SHPO..... State Historic Preservation Officer
SMC ..... Shoreline Management Classification
SMP ..... Shoreline Management Plan
SQG..... sediment quality guidelines
STID..... Supporting Technical Information Document
TAAMS..... Trust Asset and Accounting Management System
TCP..... Traditional Cultural Properties
Technical Committee ..... fish and wildlife technical committee

TSMD ..... Tri-State Mining District
USACE..... U.S. Army Corps of Engineers
U.S.C. ..... U.S. Code
USFWS ..... U.S. Fish and Wildlife Service
USGS..... U.S. Geological Survey
USR ..... Updated Study Report
VMP ..... Vegetation Management Plan
WMA ..... Wildlife Management Area

1.0 INTRODUCTION AND BACKGROUND

The 120-megawatt (MW) Pensacola Hydroelectric Project (Pensacola Project or Project), owned and operated by the Grand River Dam Authority (GRDA), is licensed by the Federal Energy Regulatory Commission (FERC or Commission) as Project No. 1494. GRDA is a non-appropriated 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." The existing license for the Pensacola Project was issued on April 24, 1992, and will expire on March 31, 2022. GRDA is applying for a new license for the Pensacola Project.

In accordance with FERC regulations at 18 Code of Federal Regulations (C.F.R.) Part 5, GRDA is utilizing FERC's Integrated Licensing Process (ILP) for preparing its relicensing application. This Proposed Study Plan (PSP) is being filed with FERC pursuant to 18 C.F.R. § 5.11 and the Process Plan and Schedule referenced in FERC's Scoping Document 1 (SD1 – see Table 6.1-1 in this PSP). Notification of availability of this PSP is also being distributed to federal and state resource agencies, Native American Tribes, local governments, non-governmental organizations (NGO), and other interested parties (collectively referred to as "relicensing participants").

1.1 Project Location and Description

As licensed by FERC, the Project serves multiple purposes, including hydropower generation, water supply, public recreation, and wildlife enhancement. As directed by Congress under the Flood Control Act of 1944, 58 Stat. 887, 890-91, and under the jurisdiction of the U.S. Army Corps of Engineers (USACE), the Project also serves as part of the McClellan-Kerr Arkansas River Navigation System of reservoirs providing navigation and flood control throughout the Grand and larger Arkansas River basin (Figure 1.1-1). USACE has exclusive jurisdiction over Grand Lake for flood control purposes, and USACE has designated a flood control pool for Grand Lake that extends above the 745-foot elevation Pensacola datum (PD).[1,2]

The Project is located northeast of Tulsa on the Grand/Neosho River (referred to as the Grand River) in Craig, Delaware, Mayes, and Ottawa counties, Oklahoma (Figure 1.1-2). The Grand River originates as the Neosho River in Kansas and flows south through northeastern Oklahoma approximately 460 miles before discharging into the Arkansas River near the town of Fort Gibson. Below its confluence with the Spring River at river mile (RM) 122.6,[3] near Wyandotte and State Highway 60, where the Twin Bridges crosses the river in Ottawa County, the Neosho River becomes the Grand River. The Pensacola Dam is located at RM 77 and creates Grand Lake.

[1] All elevations referenced are relative to PD. PD elevations can be converted to National Geodetic Vertical Datum of 1929 (NGVD) by adding 1.07 feet and to North American Vertical Datum of 1988 (NAVD) by adding 1.40 feet (for example, elevation 745 feet PD = 746.07 feet NGVD = 746.4 feet NAVD88)(http://ok.water.usgs.gov/projects/webmap/miami/datum.htm).

[2] In response to a PAD comment by N. Larry Bork (3/13/18), in general, elevations will be converted to and expressed in PD using the above conversion factors.

[3] In previous project documents this value is cited as RM 131, which comes from Holly (2004).

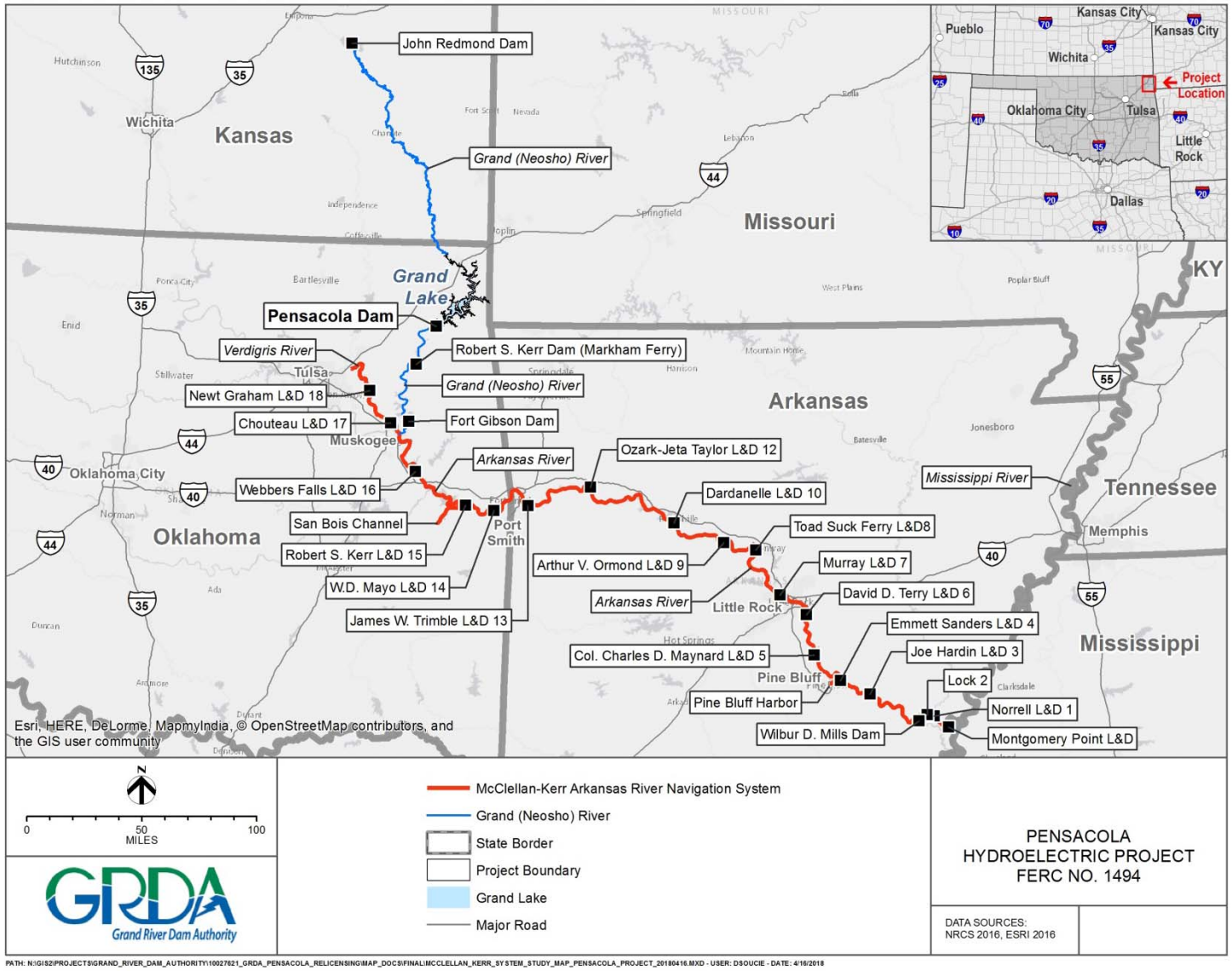

Figure 1-1.1. McClellan-Kerr River system.

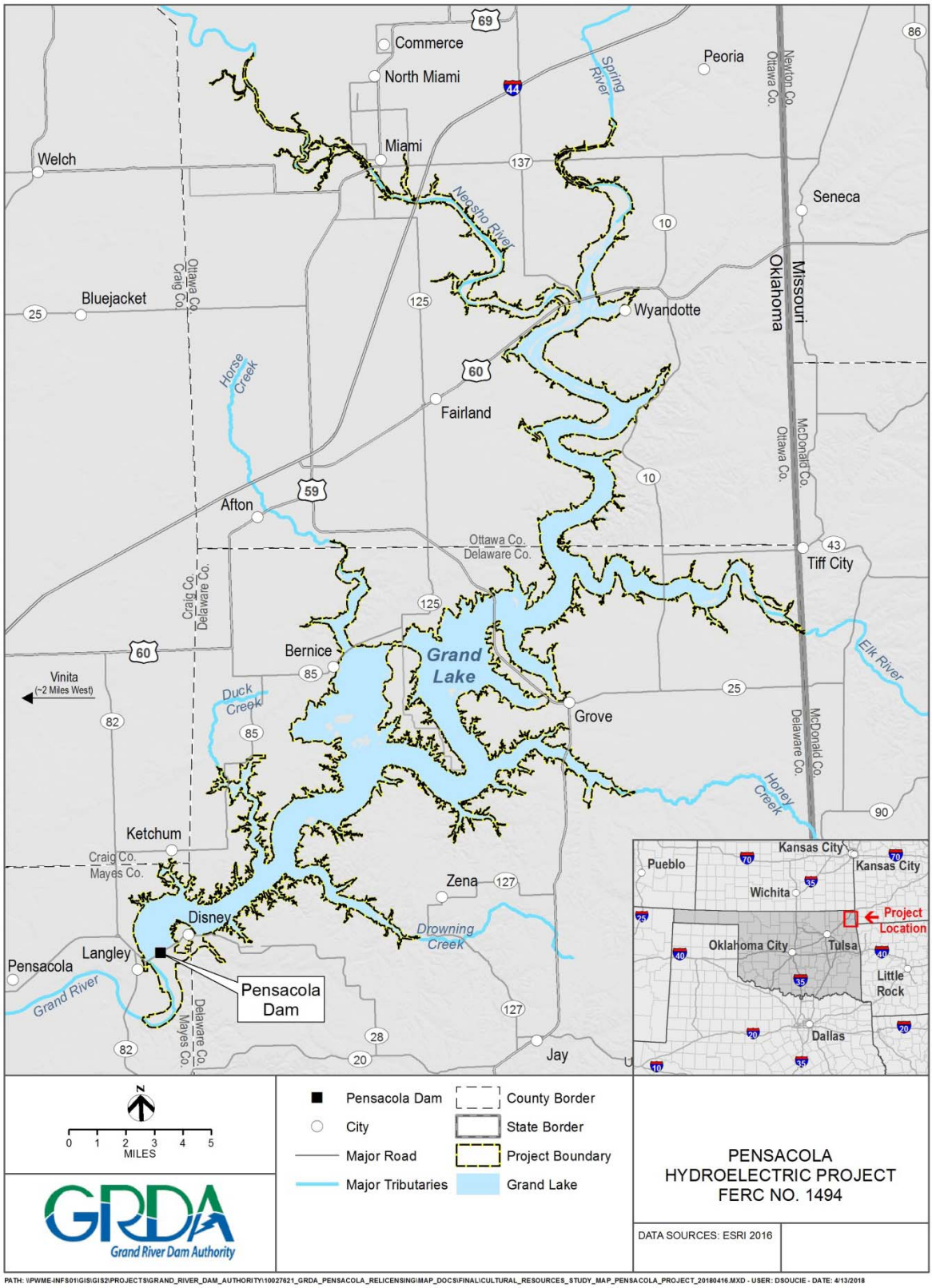

Figure 1-1.2. Pensacola Project vicinity.

The Project consists of: (a) a reinforced-concrete dam with a multiple-arch section 4,284 feet long, a spillway 861 feet long containing twenty-one radial gates, a non-overflow gravity section 451 feet long, and two non-overflow abutments, comprising an overall length of 5,950 feet and a maximum height of 147 feet; (b) a reinforced-concrete, gravity-type spillway section 886 feet long containing twenty-one radial gates and located about 1 mile east of the main dam; (c) the Grand Lake reservoir, which extends approximately 66 miles upstream from the Pensacola Dam, has a surface area of approximately 45,200 acres, a storage capacity of 1,680,000 acre-feet at normal maximum water surface elevation of 745 feet PD, below which is known as the conservation pool, and approximately 667 miles[4] of shoreline; (d) six, 15-foot-diameter steel penstocks supplying flow to six turbines each rated at 17,446 kilowatts (kW) attached to six generators each rated at 24,000 kilovolt amp (kVA) or 21,600 kW, and one 3-foot-diameter penstock supplying flow to one turbine rated at 500-kW[5] attached to an identically rated generator, located in a powerhouse immediately below the dam; (e) a tailrace approximately 300 feet wide and a spillway channel approximately 850 feet wide, both about 1.5 miles long; and (f) appurtenant facilities (FERC 1996; GRDA 2010).

In addition, GRDA operates and maintains five FERC-approved recreation sites at the Project including: (1) Duck Creek Bridge Public Access Area; (2) Seaplane Base Public Access; (3) Monkey Island Public Boat Ramp; (4) Big Hollow Public Access; and (5) Wolf Creek Public Access. These facilities provide public access to Grand Lake for boating, fishing, and other recreational activities.

The Project Boundary is defined by a combination of a metes and bounds description and generally follows contour elevation 750 feet PD. It encompasses 53,965 acres, including the 45,200 acres of the Project reservoir (at the upper extent of the conservation pool of 745 feet PD). The Project Boundary encompasses all Project facilities and works, Project recreation areas, and a shoreline buffer around the entire reservoir (generally between 745 and 750 feet PD).

To balance the multiple uses of the reservoir, GRDA currently operates the Project to target reservoir surface elevations known as the Project's rule curve[6], shown in Table 1.1-1 and Figure 1.1-3.

[4] The Project license states there are 1,300 miles of shoreline around the Pensacola Project and, traditionally, GRDA has referenced 1,300 miles of shoreline for Grand Lake. However, it has been determined that the 1,300 value relates to the total shoreline miles of GRDA's three hydropower projects. For consistency in management and tracking of matters related to the Shoreline Management Plan (SMP), in 2008, based on a new Geographic Information System (GIS) system, GRDA hand digitized the data available at the time, which resulted in a total amount of shoreline within the Project Boundary of 522 miles. With technological advances in the GIS field, more accurate data (including LiDAR) indicate that the amount of shoreline within the Project Boundary is 667 miles.

[5] The 2011 Supporting Technical Information Document (STID) mistakenly identifies the unit as 625 kW and will be corrected in a future revised STID (GRDA 2011).

[6] Order Amending License and Dismissing Application for Temporary Variance, 160 FERC ¶ 61,001 (2017).

Table 1.1-1. Target elevations for Pensacola Project.

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

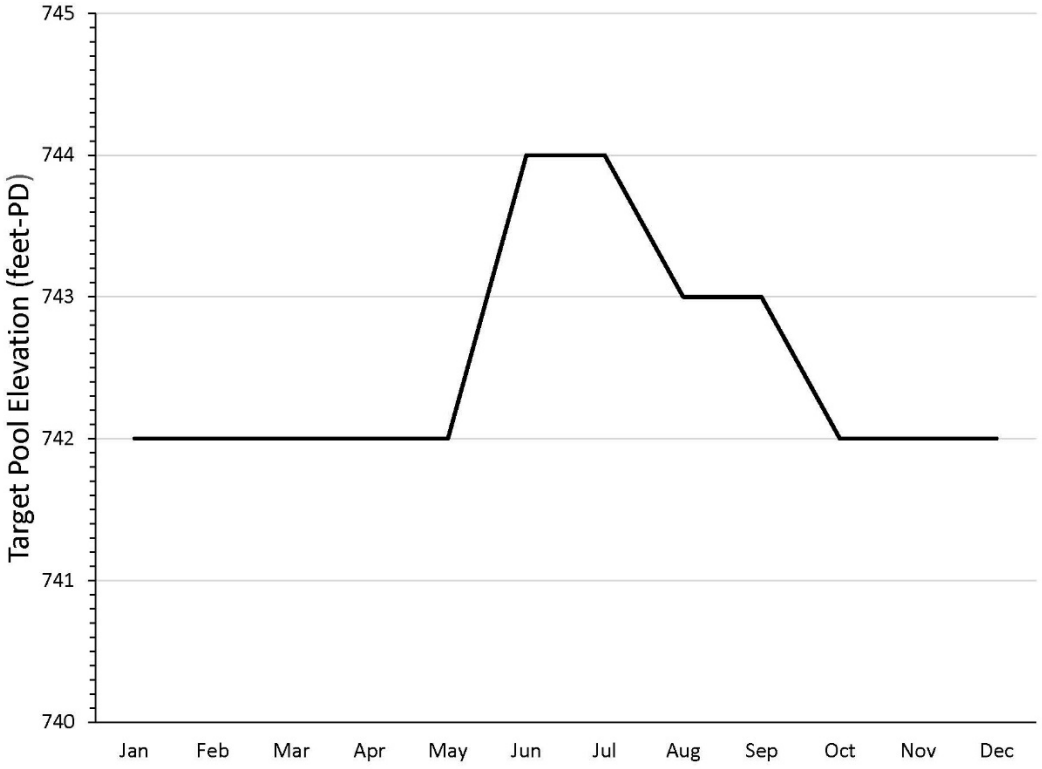

Figure 1.1-3. Pensacola Project rule curve.

1.2 Initiation of the Integrated Licensing Process (ILP)

Pursuant to 18 C.F.R. § 5.5(a), GRDA filed a Notice of Intent (NOI) to relicense the Project and a Pre-Application Document (PAD) with FERC on February 1, 2017 (GRDA 2017). Copies of the NOI and PAD can be found through FERC's e-library http://www.ferc.gov/docs-filing/elibrary.asp or through GRDA's public relicensing site at http://www.grda.com/pensacola-hydroelectric-project-relicensing/.

1.3 FERC Abeyance

In light of the rule curve license amendment proceeding that was ongoing at the time of the filing of the NOI and PAD and the lack of a quorum of FERC commissioners to rule on the amendment application, on February 15, 2017, FERC issued a Letter Order holding the relicensing process in abeyance. Six months later, once a quorum of commissioners was restored, FERC approved the rule curve amendment.[7] Two weeks later, FERC issued a Letter Order on August 24, 2017, lifting the abeyance and providing a revised ILP process plan and schedule. As a result of the abeyance, the ILP process for this relicensing lags several months behind the process envisioned in the Commission's regulations. Specifically, to meet the statutory deadline under section 15(c) of the Federal Power Act (FPA) to file the Final License Application (FLA) two years prior to license expiration, 16 U.S. Code (U.S.C.) 808(c)(1), GRDA must file its relicensing application by March 31, 2020. At that point in the ILP, GRDA will have completed only a single season of studies, with the second study season underway.

GRDA's proposal to resolving this disparity between the license application filing deadline and the ILP process—in a manner that allows for full completion of environmental studies and input from relicensing participants *before* GRDA files its FLA—appears in Section 6.2 of this PSP.

1.4 Public and Native American Government-to-Government Meetings

Prior to the formal commencement of the relicensing process in January 2018, FERC held a series of public information sessions regarding the procedure for relicensing the Pensacola Project. Meetings were held in Langley (November 14 and 15, 2017), Grove (November 15, 2017), and Miami, Oklahoma (December 13, 2017). The meetings included an overview of the ILP and a discussion of the specific process plan, opportunities for public comment, and how FERC assesses information needs during the study planning process.

In addition, FERC held government-to-government tribal consultation meetings with several Native American Tribes in Miami, Oklahoma, on December 13, 2017,[8] and with the Osage Nation in Pawhuska, Oklahoma, on December 14, 2017.

1.5 Resumption of the ILP and Environmental Scoping

On January 12, 2018, FERC issued notice of the PAD and NOI and commencement of the relicensing pre-filing process. FERC's January 12, 2018 notice also designated GRDA as FERC's non-federal representative for carrying out informal consultation, pursuant to Section 7 of the Endangered Species Act (ESA), and Section 106 of the National Historic Preservation Act (NHPA). In addition, the notice requested that relicensing participants provide comments regarding the PAD and provide study requests. Concurrently, FERC issued SD1 to outline the subject areas to be addressed in its environmental analysis of the Project pursuant to the National Environmental Policy Act (NEPA)[9].

[7] Order Amending License and Dismissing Application for Temporary Variance, 160 FERC ¶ 61,001 (2017).
[8] Tribes represented at the meeting included: Cherokee Nation, Eastern Shawnee Tribe, Miami Tribe, Muscogee Creek Nation, Ottawa Tribe, Peoria Tribe, Quapaw Tribe, Seneca-Cayuga Nation, and Wyandotte Nation.
[9] 42 U.S.C. § 4321 *et seq*.

On February 7, 8, and 9, 2018, FERC held agency and public scoping meetings in Langley, Grove, Miami, and Tulsa, Oklahoma. A site visit to the Project was held on February 8, 2018, and was available to all relicensing participants and the public. Representatives of Oklahoma Department of Agriculture, Food and Forestry, Bureau of Indian Affairs (BIA), and the Miami News participated in the site tour.

In accordance with ILP regulations, comments on the PAD and SD1 and study requests were due to FERC by March 13, 2018, within 60 days of FERC's notice of the PAD and NOI and commencement of the pre-filing process.

2.0 DEVELOPMENT OF GRDA'S PROPOSED STUDY PLAN (PSP)

The purpose of this PSP is to describe GRDA's proposed methodologies for conducting studies and to address relicensing participant study requests. This PSP also provides FERC and relicensing participants with the opportunity to comment on the studies proposed by GRDA. The individual study plans for the proposed studies are included in Attachment A of this PSP.

2.1 FERC's Study Plan Criteria

FERC's ILP regulations at 18 C.F.R. § 5.9 specify required components of study requests to allow GRDA, as well as FERC staff, to determine the appropriateness and relevance of the proposed study to the relicensing. Under 18 C.F.R. Section 5.9(b) of FERC's ILP regulations, these required components of the study request (the "Study Criteria") are as follows:

(1) Describe the goals and objectives of each study and the information to be obtained (§ 5.9(b)(1));

This section describes why the study is being requested and what the study is intended to accomplish, including the goals, objectives, and specific information to be obtained. The goals of the study should clearly relate to the need to evaluate the effects of the Project on a particular resource. The objectives are the specific information that needs to be gathered to allow achievement of the study goal.

(2) If applicable, explain the relevant resource management goals of the agencies or Indian tribes with jurisdiction over the resource to be studied (§ 5.9(b)(2));

This section should clearly establish the connection between the study request and management goals or resource of interest. A statement by an agency connecting its study request to a legal, regulatory, or policy mandate needs to be included that thoroughly explains how the mandate relates to the study request, as well as the Project impacts.

(3) If the requester is not a resource agency, explain any relevant public interest considerations in regard to the proposed study (§ 5.9(b)(3));

This section is for non-agency requestors or Native American Tribes to establish the relationship between the study request and the relevant public interest considerations.

(4) Describe existing information concerning the subject of the study proposal, and the need for additional information (§ 5.9(b)(4));

This section should discuss any gaps in existing data by reviewing the available information presented in the PAD or information relative to the Project that is known from other sources. This section should explain the need for additional information and why the existing information is inadequate.

(5) Explain any nexus between Project operation and effects (direct, indirect, and/or cumulative) on the resource to be studied, and how the study results would inform the development of license requirements (§ 5.9(b)(5));

This section should clearly connect Project operations and Project effects on the applicable resource. This section should also explain how the study results would inform the development of protection, mitigation, and enhancement (PM&E) measures.

(6) Explain how any proposed study methodology is consistent with generally accepted practices in the scientific community or, as appropriate, considers relevant tribal values and knowledge. This includes any preferred data collection and analysis techniques, or objectively quantified information, and a schedule including appropriate field season(s) and the duration (§ 5.9(b)(6));

This section should provide a detailed explanation of the study methodology. The methodology may be described by outlining specific methods to be implemented or by referencing an approved and established study protocol and methodology.

(7) Describe considerations of level of effort and cost, as applicable, and why any proposed alternative studies would not be sufficient to meet the stated information needs (§ 5.9(b)(7));

This section should describe the expected level of cost and effort to conduct the study. If there are proposed alternative studies, this section should address why the alternatives would not meet the stated information needs.

2.2 Comments and Study Requests from Relicensing Participants

A total of 61 comment letters from federal and state resource agencies, Native American Tribes, non-governmental organizations, and other interested parties were filed with FERC regarding the relicensing of the Pensacola Project from January 8, 2018 through March 19, 2018. Comments received were a combination of general comments regarding the Project, comments on the PAD and SD1, and study requests. In accordance with ILP regulations, comments on the PAD and SD1 and study requests were due to FERC by March 13, 2018. A total of 27 formal and individual study requests were made by relicensing participants and FERC. Based on these requests and its independent evaluation of resources at the Project, GRDA has prepared its PSP, which is described in Section 3 of this PSP, with the actual proposed study plans appearing in Attachment A of this PSP. GRDA's response to all study requests received is detailed in Section 4 of this PSP.

In many instances, GRDA received comments instead of a study request. While the purpose of this PSP document is to set forth GRDA's study plan for the relicensing effort—and not to respond to every comment received—in some instances the comments related to proposed

studies. GRDA's responses to these relevant comments are detailed in the discussion of study requests in Sections 4.2 and 4.3.

Several organizations (as listed below) filed PAD and SD1 comments that did not include formal study requests or relate to the proposed studies. While the comments may not directly relate to studies, GRDA will give them due consideration and ensure all identified issues are addressed and all necessary NEPA requirements are incorporated into its Environmental Exhibit (Exhibit E) of the relicensing application.

- City of Grove
- Environmental Protection Agency (EPA)
- Grand Riverkeeper
- LEAD Agency, Inc. (Local Environmental Action Demanded)
- Southwest Power Administration

Attachment B of this PSP provides a table detailing all of the comment letters and study requests that were received from relicensing participants. Comment letters and all documents filed with FERC can be accessed through FERC's eLibrary at www.ferc.gov/docs-filing/elibrary.asp by searching under Docket P-1494-438.

3.0 OVERVIEW OF GRDA'S PSP

3.1 Proposed Studies

Based on studies proposed in the PAD and in response to the study requests and comments received during the scoping period, GRDA is proposing the following studies and information-gathering efforts:

1. Hydrologic and Hydraulic Modeling Study (H&H Study)
2. Sedimentation Study
3. Recreation Facilities Inventory and Use Survey
4. Cultural Resources Study
5. Socioeconomics Study

Specific study requests relevant to the above-listed resource areas are referenced in Section 4 of this PSP.

3.1.1 Hydrologic and Hydraulic Modeling Study

GRDA is proposing an H&H Study to identify areas inundated during the current operation of the Project, as well as during any operational changes that may be proposed as part of the relicensing effort. In addition to the inundation area, the study will provide other flood routing specifics such as the frequency, timing, amplitude, and duration of the inundation.

The overall H&H Study goal is to provide information through modeling and mapping to determine the effect of the operation of the Project upon several resource areas. Specifically, the H&H Study will: (1) determine the duration and extent of inundation under the current

operation of the Project during several measured inflow events; (2) determine the duration and extent of inundation under any proposed change in operation 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) about Project effects, if any, in several resource areas; and (4) determine the feasibility of implementing alternative operation scenarios that may be proposed by GRDA as part of the relicensing effort.

A Comprehensive Hydraulic Model (CHM) will be constructed to determine the inundation areas and other flood routing specifics during several measured inflow events where inflow hydrographs already exist. To evaluate the effects of any proposed operational changes, a separate Operations Model will be constructed to synthesize hypothetical events that inform the CHM. Information gathered from these models will be used to inform separate analyses about the effects of inundation on various resources and will be summarized in future licensing documents.

A model input status report, initial technical report, and final technical report will be prepared as part of the H&H Study. The H&H Study Plan is included in Attachment A of this PSP and provides additional details regarding the overall study, models being developed, and methodology.

3.1.2 Sedimentation Study

GRDA is proposing to conduct a Sedimentation Study to address whether operation of the Project has influenced sedimentation in the Grand/Neosho watershed upstream of Grand Lake, and if so, the extent to which sedimentation has affected water levels in these areas during high flow events. This study has been designed as a one-year study, with the possibility of a second year of study, depending upon the results of the first year of study.

The overall goal of this study is to acquire a better understanding of the interaction between sedimentation processes, operation of the Project, and the extent and duration of inundation. All of the proposed goals are intended to provide a clear understanding of the sediment transport processes and patterns upstream of Grand Lake on the Grand/Neosho, Spring, and Elk rivers and Tar Creek.

Study Year One will involve analyzing historical sediment accretion and deposition patterns in the area upstream of Grand Lake in the Grand/Neosho, Spring and Elk rivers and Tar Creek. Study Year One will consist of the following four tasks: (1) Background Data and Literature Review; (2) Bathymetric Dataset Comparisons; (3) Operational Change Analysis; and (4) Data Synthesis and Reporting. Contingent Study Year Two, if determined to be necessary, will involve field data collection and data synthesis and reporting. A technical report will be developed for each study year, as necessary, as part of this study. The Sedimentation Study Plan is included in Attachment A of this PSP and provides additional details regarding the overall study and methodology.

3.1.3 Recreation Facilities Inventory and Use Survey

GRDA is proposing to conduct a Recreation Facilities Inventory and Use Survey as part of this PSP. The goals of this study are to gather information regarding current recreational use, and identify recreation resources and activities that may be affected by the continued operation of the Project. The study area will include the five FERC-approved recreation facilities on Grand Lake that are owned, operated, and maintained by GRDA.

There are three tasks associated with conducting this study: (1) Recreation Facility Inventory and Condition Assessment; (2) Recreation Visitor Use Data; and (3) Data Analysis and Reporting. Task 1 will involve collecting information regarding each of the five recreation areas via photo documentation and completing a Facilities and Inventory and Condition Form. Recreation visitor use data will be collected during Task 2 via field reconnaissance and conducting personal interviews at each of the five recreation locations. Task 3 of this study will be the data analysis and development of the study report. The Recreation Facilities Inventory and Use Survey Study Plan is included in Attachment A of this PSP and provides additional details regarding the overall study and methodology.

3.1.4 Cultural Resources Study

GRDA is proposing to conduct a Cultural Resources Study as part of this PSP. The goals of this study are: (1) to identify historic properties within the Project's Area of Potential Effects (APE) that are being adversely affected by Project operations (if any), including properties of traditional religious and cultural importance; and (2) to develop a Historic Properties Management Plan (HPMP) in consultation with the Oklahoma State Historic Preservation Officer (SHPO), Oklahoma Archaeological Survey (OAS), and Native American Tribes, that provides for the long-term management of historic properties within the APE over the term of the new license. This study will consist of the following seven tasks: (1) Determine the APE; (2) Background Research and Archival Review; (3) Pre-fieldwork Report; (4) Reconnaissance Surveys; (5) Identify Traditional Cultural Properties (TCP); (6) Programmatic Agreement; and (7) Develop a HPMP.

A Pre-fieldwork Study Report, Study Year One Reconnaissance Survey Report, Study Year Two Reconnaissance Survey Report, and a draft HPMP will be developed as part of this study. GRDA anticipates developing a draft HPMP in consultation with the Cultural Resources Working Group (CRWG), which will be included as part of GRDA's FLA filed with the Commission. The Cultural Resources Study Plan is included in Attachment A of this PSP and provides additional details regarding the overall study and methodology.

3.1.5 Socioeconomics Study

GRDA is proposing to perform a Socioeconomics Study to gather, synthesize, and report on existing information necessary to qualitatively evaluate the socioeconomic effects of the Pensacola Project in the study area. The objectives of the study are to describe baseline economic conditions in the Project area and to identify the socioeconomic contribution of the Project in the state and the region.

GRDA will perform a desktop review of available regional socioeconomic data. Available information on the demographic and economic conditions of the region will be compiled and summarized in a final study report to present a qualitative assessment for the study area. The Socioeconomics Study Plan is included in Attachment A of this PSP and provides additional details regarding the overall study and methodology.

3.2 Phased Approach to Study Implementation

As detailed in the individual study plans appearing in Attachment A, GRDA proposes to integrate these individual studies, where appropriate, to inform both the scoping of studies during the second year of studies, and to undertake its environmental effects analysis in the

Environmental Exhibit of the relicensing application, as required under FERC's ILP regulations, 18 C.F.R. 5.18. For example, the outputs of the H&H Study at the end of Study Year One will be incorporated into the process under the Cultural Resources Study for prioritizing areas for study during Study Year Two. The outputs of the H&H Study also will be used to evaluate effects on resources in which a specific study is not proposed as part of this PSP. In the Environmental Exhibit, for example, the H&H Study will be used to evaluate any effects on aquatic and terrestrial resources using the wealth of existing information already available in these resource areas.

4.0 GRDA'S RESPONSE TO STUDY REQUESTS RECEIVED

As noted above, GRDA received a total of 27 study requests submitted by FERC staff, federal and state resource agencies, Native American Tribes, and other relicensing participants. Some of these study requests did not provide all of the information required by FERC's ILP regulations (18 C.F.R. § 5.9(b)), as set forth in Section 2.1 of this PSP. Regardless, in an effort to be complete, GRDA has attempted in this PSP document to identify and evaluate all study requests submitted, including those that may not have fully complied with FERC's Study Criteria. Table 4.0-1 summarizes the results of GRDA's review of the formal study requests and determination based on the Study Criteria. Where possible, GRDA consolidated common themes and elements expressed in the study requests (Table 4.0-2). The correspondence from relicensing participants requesting studies and providing comments is listed in Attachment B of this PSP.

Table 4.0-1. Summary of formal study requests and GRDA's responses.

	Requested Study	Entity	Date	Proposed for Study / Proposed for Study with Modifications	Not Proposed for Study	Correlation to GRDA Study
1	Flooding and Sedimentation Study	FERC	3/13/2018	✓		With regard to the flooding component of this study request, see Sections 3.1.1 and 4.2.1 of this PSP. With regard to the sedimentation component of this study request, see Sections 3.1.2 and 4.2.2 of this PSP.
2	Flooding Inundation of Tribal Lands Study	BIA	3/5/2018		✓	See Sections 4.1.1 and 4.3.1 of this PSP.
3	Inundation Study	U.S. Fish and Wildlife Service (USFWS)	3/13/2018	✓		Hydrologic and Hydraulic Modeling Study. See Sections 3.1.1 and 4.2.1 of this PSP.
4	Quantifying the Effects of Increased Water Level within the Grand Lake Watershed	Oklahoma Department of Wildlife Conservation (ODWC)	3/13/2018		✓	This issue will be addressed in the relicensing application's Environmental Exhibit using study outputs and existing information, where appropriate. See Section 4.3.3 of this PSP.
5	Impacts of Grand Lake Elevation Manipulation on Headwater River Hydrology and Paddlefish Spawning / Recruitment	ODWC	3/13/2018		✓	This issue will be addressed in the relicensing application's Environmental Exhibit using study outputs and existing information, where appropriate. See Section 4.3.4 of this PSP.
6	Sedimentation Contaminant Study	ODWC	3/13/2018		✓	See Section 4.3.2 of this PSP.

	Requested Study	Entity	Date	Proposed for Study / Proposed for Study with Modifications	Not Proposed for Study	Correlation to GRDA Study
7	Impoundment Fluctuation Studies	ODWC	3/13/2018	✓		Hydrologic and Hydraulic Modeling Study. See Sections 3.1.1 and 4.2.1 of this PSP.
8	Wetland Documentation	ODWC	3/13/2018		✓	This issue will be addressed in the relicensing application's Environmental Exhibit using study outputs and existing information, where appropriate. See Section 4.3.7 of this PSP.
9	Loss of Wildlife Lands from Flooding	ODWC	3/13/2018		✓	This issue will be addressed in the relicensing application's Environmental Exhibit using study outputs and existing information, where appropriate. See Section 4.3.8 of this PSP.
10	Recovery of Lost Wildlife Mitigation Opportunity	ODWC	3/13/2018		✓	See Section 4.3.9 of this PSP.
11	Alteration of Tailwater Fish Habitat Downstream of Pensacola Dam as a Result of Hydropower Operations	ODWC	3/13/2018		✓	This issue will be addressed in the relicensing application's Environmental Exhibit using study outputs and existing information, where appropriate. See Sections 4.1.2 and 4.3.5 of this PSP.

	Requested Study	Entity	Date	Proposed for Study / Proposed for Study with Modifications	Not Proposed for Study	Correlation to GRDA Study
12	Changes in Tailwater Fish Populations Due to Hypolimnetic Releases	ODWC	3/13/2018		✓	This issue will be addressed in the relicensing application's Environmental Exhibit using study outputs and existing information, where appropriate. See Sections 4.1.2 and 4.3.6 of this PSP.
13	Cultural Resource Study	OAS	3/13/2018	✓		Cultural Resources Study. See Sections 3.1.4 and 4.2.3 of this PSP.
14	Flood Routing Study	Miami Tribe (also supported by Eastern Shawnee Tribe, Ottawa Tribe, Seneca-Cayuga Nation, Wyandotte Nation, City of Miami, and Larry Bork)	3/13/2018	✓		Hydrologic and Hydraulic Modeling Study. See Sections 3.1.1 and 4.2.1 of this PSP.
15	Cultural Resources Assessment Study	Miami Tribe (also supported by Eastern Shawnee Tribe, Ottawa Tribe, Seneca-Cayuga Nation, Wyandotte Nation, City of Miami, and Larry Bork)	3/13/2018	✓		Cultural Resources Study. See Sections 3.1.4 and 4.2.3 of this PSP.

	Requested Study	Entity	Date	Proposed for Study / Proposed for Study with Modifications	Not Proposed for Study	Correlation to GRDA Study
16	Contaminated Sediment Transport Study	Miami Tribe (also supported by Eastern Shawnee Tribe, Ottawa Tribe, Seneca-Cayuga Nation, Wyandotte Nation, City of Miami, and Larry Bork)	3/13/2018		✓	See Section 4.3.2 of this PSP.
17	Infrastructure Impacts Study	Miami Tribe (also supported by Eastern Shawnee Tribe, Ottawa Tribe, Seneca-Cayuga Nation, Wyandotte Nation, and Larry Bork)	3/13/2018		✓	See Section 4.3.11 of this PSP.
18	Economic & Socioeconomic Impact Analysis	Miami Tribe (also supported by Eastern Shawnee Tribe, Ottawa Tribe, Seneca-Cayuga Nation, Wyandotte Nation, and Larry Bork)	3/13/2018	✓		Socioeconomic Study. See Sections 3.1.5 and 4.2.4 of this PSP.

	Requested Study	Entity	Date	Proposed for Study / Proposed for Study with Modifications	Not Proposed for Study	Correlation to GRDA Study
19	Flora & Fauna Impacts	Miami Tribe (also supported by Eastern Shawnee Tribe, Ottawa Tribe, Seneca-Cayuga Nation, Wyandotte Nation, and Larry Bork)	3/13/2018		✓	See Section 4.3.10 of this PSP.
20	Full Basin-up Archaeological and Cultural Resources Assessment	Cherokee Nation	3/13/2018	✓		Cultural Resources Study. See Sections 3.1.4 and 4.2.3 of this PSP.
21	Flood Routing Study	City of Miami (also supported by Larry Bork, Miami Tribe, Eastern Shawnee Tribe, Ottawa Tribe, Seneca-Cayuga Nation, and Wyandotte Nation)	3/13/2018	✓		Hydrologic and Hydraulic Modeling Study. See Sections 3.1.1 and 4.2.1 of this PSP.
22	Contaminated Sediment Transport Study	City of Miami (also supported by Larry Bork, Miami Tribe, Eastern Shawnee Tribe, Ottawa Tribe, Seneca-Cayuga Nation, and Wyandotte Nation)	3/13/2018		✓	See Section 4.3.2 of this PSP.

	Requested Study	Entity	Date	Proposed for Study / Proposed for Study with Modifications	Not Proposed for Study	Correlation to GRDA Study
23	Socioeconomic and Infrastructure Improvement Study	City of Miami (also supported by Larry Bork, Miami Tribe, Eastern Shawnee Tribe, Ottawa Tribe, Seneca-Cayuga Nation, and Wyandotte Nation)	3/13/2018	✓		With regard to the socioeconomics component of this study request, see Sections 3.1.5 and 4.2.4 of this PSP. With regard to the infrastructure improvement component of this study, see Section 4.3.11 of this PSP.
24	Cultural Resources Assessment Study	City of Miami (also supported by Larry Bork)	3/13/2018	✓		Cultural Resources Study. See Sections 3.1.4 and 4.2.3 of this PSP.
25	Comprehensive Flood Routing Study	Larry Bork (Counsel on behalf of citizens of City of Miami)	3/13/2018	✓		Hydrologic and Hydraulic Modeling Study. See Sections 3.1.1 and 4.2.1 of this PSP.
26	Contaminated Sediment Transport Study	Larry Bork (Counsel on behalf of citizens of City of Miami)	3/13/2018		✓	See Section 4.3.2 of this PSP.
27	Socioeconomic Impact on Miami from the Backwater Effect of Pensacola Dam	Larry Bork (Counsel on behalf of citizens of City of Miami)	3/13/2018	✓		Socioeconomic Study. See Sections 3.1.5 and 4.2.4 of this PSP.

Table 4.0-2. Formal study requests filed with FERC.

	Requested Study	FERC	BIA	USFWS	ODWC	OAS	Miami Tribe	Eastern Shawnee Tribe	Ottawa Tribe	Seneca-Cayuga Nation	Wyandotte Nation	Cherokee Nation	City of Miami	N. Larry Bork[1]
1	Flooding/Inundation Study	✓		✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
2	Sedimentation Study	✓												
3	Flooding Inundation of Tribal Lands Study		✓											
4	Contaminated Sediment Transport Study				✓		✓	✓	✓	✓	✓		✓	✓
5	Quantifying the Effects of Increased Water Level within the Grand Lake Watershed				✓									
6	Impacts of Grand Lake Elevation Manipulation on Headwater River Hydrology and Paddlefish Spawning / Recruitment				✓									
7	Alteration of Tailwater Fish Habitat Downstream of Pensacola Dam as a Result of Hydropower Operations				✓									
8	Changes in Tailwater Fish Populations Due to Hypolimnetic Releases				✓									
9	Wetland Documentation				✓									
10	Loss of Wildlife Lands from Flooding				✓									
11	Recovery of Lost Wildlife Mitigation Opportunity				✓									
12	Flora and Fauna Impacts						✓	✓	✓	✓	✓			✓
13	Cultural Resources Study					✓	✓	✓	✓	✓	✓	✓	✓	✓
14	Socioeconomic Study						✓	✓	✓	✓	✓		✓	✓
15	Infrastructure Improvement Study						✓	✓	✓	✓	✓		✓	✓

Notes:
1 Counsel for City of Miami citizens.

4.1 General Study Considerations

The studies proposed by GRDA in this PSP are intended to collect information and data to inform the development of the Preliminary Licensing Proposal (PLP)/Draft License Application (DLA) (which under the current schedule will be filed no later than November 3, 2019), FLA (which under the current schedule will be filed no later than March 31, 2020), FERC's environmental document under the NEPA, and eventual license conditions. As such, GRDA intends to perform studies that collect information that would be used to inform the assessment of Project-related resource impacts (if any) in the Environmental Exhibit of the PLP/DLA, FLA, and FERC's Environmental Assessment (EA) and are consistent with FERC's Study Criteria.

The numerous comments and study requests as filed with FERC raise common issues that deserve a detailed response, explaining GRDA's reasons for proposing in this PSP either to reject a study request altogether, or to propose a different scope or methodology from a requested study. These over-arching, common themes are discussed in the subsections that follow.

4.1.1 Flood Control Operations

Several commenters take the position that the Commission has jurisdiction over flood control operations at the Project, that flood control is a licensed purpose of the Project, and that the Commission in this relicensing effort should consider measures to mitigate effects of flooding. These comments allege "backwater flooding caused by the Project's operations during heavy precipitation events";[10] that Pensacola Dam "as currently operated exacerbates natural flooding by increasing the frequency, depth, and duration of water on property for which there are no flowage easements"[11]; "that every increase in lake elevation decreases the flood control capacity" of the Project;[12] and that "previous studies demonstrate the patent inadequacy of the footprint as FERC has defined it."[13] Accordingly, these commenters request measures under the new license "requiring GRDA to operate pursuant to a revised rule curve, to acquire flowage easements, and to implement other mitigation measures such as infrastructure improvements."[14]

As indicated in Section 3.1 of this PSP, GRDA proposes to conduct a comprehensive H&H Study that will model the Grand/Neosho River, including several tributaries, both upstream and downstream of Pensacola Dam. The modeling effort under the H&H Study will produce a tool for analyzing the effects of GRDA's operation of the Project under the new license, as well as indirect and cumulative impacts associated with flood control operations conducted at the direction of the USACE.

[10] Comments of the City of Miami, Oklahoma on Pre-Application Document, Scoping Document 1 and Study Requests at 1, Project No. 1494-438 (filed March 13, 2018) ("City of Miami Comments").
[11] *Id. See also* Larry Bork, Goodell Stratton Edmonds & Palmer, Comments of Plaintiffs on PAD, Scoping Document 1 and Requesting Studies Within the Relicensing of the Pensacola Project, pp. 1-2 (filed March 13, 2018) (hereinafter "Bork Comments"); Comments of Miami Tribe of Oklahoma on Grand River Dam Authority's Pre-Application Document and FERC's Scoping Document 1, and Miami Tribe of Oklahoma's Study Requests at 3, Project No. 1494-438 (filed March 13, 2018) ("Miami Tribe Comments").
[12] Miami Tribe Comments at 4.
[13] Bork Comments at 2.
[14] City of Miami Comments at 1.

In this regard, it is premature for any relicensing participant to conclude whether GRDA's Project operations under its license cause or contribute to: (1) upstream flooding beyond existing flowage easements; (2) overbank conditions that may result in deposition of heavy metals and other contaminants from upstream Superfund sites; (3) access and transportation impediments during high precipitation events; or (4) other adverse effects. The whole purpose of the H&H Study will be to better understand the interrelated complexities and effects associated with GRDA's operations under its FERC-issued license, USACE flood control operations, and other factors (including natural conditions) that influence and affect inundation in the Grand/Neosho River and its tributaries.

In fact, USACE has already analyzed this issue and independently concluded, pursuant to Congressional direction,[15] that its flood control operations *alone* have significantly contributed to upstream flooding beyond existing easements. In its Draft Report *Grand Lake, Oklahoma, Preliminary Analysis of Flood Control Operation*, USACE concluded:

- Flood control operations for selected historic events appear to impact lands where no easements are held.
- Flood control operations for selected frequency flood events appear to impact lands where no easements are held.
- Some of the selected frequency floods and historic flood events would have exceeded the limits of existing flowage easements for the without-flood-control condition (hydropower only).
- All evaluated flood events would tend to exceed the limits of existing flowage easements to a greater degree for the with-flood-control operation condition (flood control and hydropower).[16]

In a follow-up 2006 Letter Report, USACE concluded: "Based on the backwater modeling of selected historic storms and frequency events, water surface elevations were found to be up to 4.3 feet higher than existing elevations at selected locations *due to flood control operations of the reservoir.*"[17] In response to Congress' direction that full federal funding for a feasibility study be recommended if flood control operations are "a significant cause of the backwater effects,"[18] the 2006 report recommended that the Assistant Secretary of the Army (Civil Works) determine "that Federal actions have been a significant cause of the backwater effects on land around Grand Lake, Oklahoma and . . . proceed with a feasibility study at full Federal expense."[19] In 2007, the Assistant Secretary for the Army determined that "federal actions have contributed to backwater effects,"[20] and recommended that a feasibility study be funded by the United Sates.

[15] Pub. L. No. 106-541, § 449(a)(1) (2000) (directing USACE to "evaluate the backwater effects specifically due to flood control operations on land around Grand Lake, Oklahoma").
[16] USACE, Grand Lake, Oklahoma, Preliminary Analysis of Flood Control Operation at 6 (Draft Report, August 2002). On April 12, 2018, USACE filed this report in the FERC docket for this relicensing proceeding.
[17] Grand Lake, Oklahoma, May 2006 Letter Report at 5 (2006) (emphasis added). On April 12, 2018, USACE filed this report in the FERC docket for this relicensing proceeding.
[18] Pub. L. No. 106-541, § 449(b)(2).
[19] May 2006 Letter Report at 5.
[20] U.S, Department of the Army, Office of the Assistant Secretary Civil Works, Memorandum for the Director of Civil Works (Sep. 14, 2007). On April 12, 2018, USACE filed this memorandum in the FERC docket for this relicensing proceeding.

Moreover, the Tetra Tech model previously commissioned by the City of Miami recognized that a multitude of factors—both natural and anthropogenic—contribute to high water levels upstream of the Project during high precipitation events.[21] Moreover, the 2004 report prepared by Dr. Forrest Holly concludes that the City of Miami "is located just upstream of the zone of significant flood-level effects that would result from raising the Pensacola Dam power pool to 745 ft PD," and that "the river steepens significantly upstream of about RM 139, effectively eliminating significant backwater effects upstream of that point."[22] Dr. Holly's 2004 analysis also found that the downstream limit of developed areas in the vicinity of Miami is RM 142.

GRDA is confident that the H&H Study will build on these prior investigations and improve understanding of the dynamic and complex factors that influence the magnitude, duration, and frequency of inundation along the Grand/Neosho River and its tributaries. Based on participants' comments, however, two essential qualifications of this effort are warranted:

1. *Effects of USACE Flood Control Operations Must Be Understood.* Like the previous studies Congress required of the USACE, an important aspect of the H&H Study will be to analyze and distinguish the effects of USACE flood control operations, as opposed to simply analyzing effects of the Pensacola Dam operations generally. As GRDA has explained repeatedly for years, flood control operations at Pensacola Dam are under the exclusive jurisdiction of the USACE pursuant to the Flood Control Act of 1944.[23] The Commission also has repeatedly—and recently—acknowledged the exclusivity of USACE's jurisdiction.[24] USACE's recent correspondence with the City of Miami,[25] together with the wealth of information recently filed in this relicensing docket by USACE, demonstrate that flood risk management, through the entire system of 35 projects in USACE's Tulsa District (an area that straddles three states), is within

[21] *See* Motion of City of Miami, Oklahoma for Leave to Intervene and Protest, Att. C – Hydraulic Analysis of the Effects of Pensacola Dam on Neosho River Flooding in the Vicinity of Miami, Oklahoma at viii, Project No. 1494-433 (filed July 22, 2016).

[22] *Analysis of Effect of Grand Lake Power-Pool Elevations on Neosho River Levels During a Major Flood* at 5 (Jan. 27, 2004).

[23] Incorporated by reference are GRDA's other filings with the Commission that address this issue. *See*, *e.g.*, Letter from Charles R. Sensiba, Troutman Sanders LLP, to Kimberly D. Bose, Federal Energy Regulatory Commission, Project No. 1494-438 (filed March 9, 2018); Response of Grand River Dam Authority to Comments on Environmental Assessment, Project No. 1494-437 (filed Feb. 21, 2017); Answer of Grand River Dam Authority to Motions to Intervene and Comments on License Amendment Application, Project No. 1494-437 (filed Nov. 8, 2016); Answer of Grand River Dam Authority to City of Miami, Project No. 1494-432 (filed Aug. 11, 2015).

[24] *E.g.*, *Grand River Dam Auth.*, 160 FERC ¶ 61,001, at PP 3, 49 n.67 (2017); *Grand River Dam Auth.*, 67 FERC ¶ 62,239 at p. 64,431 (1994) (noting that "any attributions to issues such as flooding or backwater conditions within the flood pool cannot be reached and are, in any event, under the purview of the U.S. Army Corps of Engineers"); *Grand River Dam Auth.*, 59 FERC ¶ 62,073, at p. 63,247 (1992) (stating that the 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"); *Grand River Dam Auth.*, License Affecting Navigable Waters and Reservations of the United States at Article 14, Project No. 1494 (July 26, 1939) (providing that the "operation of the project by the Licensee, so far as such operation may affect the use, storage, and discharge from storage, or waters, shall at all times be subject to the control of the Secretary of War under such rules and regulations as he may prescribe in the interests of navigation and flood control . . .").

[25] Letter from Jennifer A. Aranda, U.S. Army Corps of Engineers, to Carlos Gutierrez, Davis Wright Tremaine at 2, Project No. 1494-438 (filed Apr. 3, 2018).

the exclusive purview of the USACE and is a matter that is well beyond the scope of this relicensing effort. Simply stated, neither the Commission nor GRDA have any control over USACE's decisions related to flood control at the Project. For this reason, GRDA's H&H Study is designed to evaluate the full range of factors that influence inundation along the Grand/Neosho River and its tributaries, such that the Commission can properly analyze the direct effects of its licensing action, as well as understand the indirect and cumulative effects of actions that are beyond its licensing jurisdiction—including the flood operations of USACE.[26]

2. *Mitigation for USACE Flood Control Operations Is Beyond the Scope of the Commission's Relicensing.* At this early stage of the relicensing process, it is premature for participants to seek any mitigation—because Project-related effects have yet to be studied or analyzed.[27] As several participants raised the issue of mitigation for flooding damages, however, GRDA believes it is appropriate to address this issue at the outset of this relicensing process.

The FERC relicensing process is not the forum to address the issue of whether the United States possesses sufficient flowage easements to sustain USACE's flood control operations. Since the very beginning of this Project over 75 years ago, the top of the conservation pool for purposes of the Commission-issued license has been 745 feet PD, and the buffer zone for purposes of carrying out Project purposes under the FPA has been established at approximately elevation 750 feet PD.[28] Lands above that elevation have *never* been GRDA's responsibility; to the contrary, the acquisition of flowage easements for purposes of USACE's flood control operations has *always* been a responsibility of the federal government. For example:

- In 1942, after the Project was acquired by the United States under section 16 of the FPA to support the World War II effort,[29] President Roosevelt directed the Federal Works Administration to acquire additional acreage at the Project for purposes of flood control.[30]

[26] In the recently completed rule curve license amendment proceeding, the Commission recognized that USACE flood operations are a cumulative effect at this Project. Final Environmental Assessment, Amendment of Article 401 to Modify Reservoir Elevation Rule Curve at 21, Project No. 1494-437 (issued May 11, 2017) ("[T]he flood studies reviewed in the Draft EA provide a thorough analysis of the cumulative effects of the proposed action in the amendment application, in addition to analyzing the effects of operation with the proposed rule curve under normal conditions.").

[27] *See infra* § 4.1.5.

[28] *See*, *e.g.*, *Grand River Dam Auth.*, License Affecting Navigable Waters and Reservations of the United States at Article 12, Project No. 1494 (July 26, 1939) (directing GRDA to "acquire all necessary lands, easements, and rights-of-way up to elevation 750"); Pub. L. No. 76-597, 54 Stat. 303 (1940) ("[T]here is hereby granted to the Grand River Dam Authority, a public corporation of the State of Oklahoma, all the right, title, and interest held by the United States and by individual Indians and tribes of Indians in Indian lands located in Ottawa, Delaware, Craig, and Mayes Counties, Oklahoma, lying below an elevation of seven hundred and fifty feet above mean sea level, which may be required for the Grand River Dam Reservoir . . . .").

[29] 16 U.S.C. § 809; Exec. Order No. 8944 (1941).

[30] U.S. Army Corps of Engineers, *Grand Lake, Oklahoma, Real Estate Adequacy Study* at 2 (1998) [hereinafter, *Real Estate Adequacy Study*].

- When requiring the return of the Project to GRDA following the War effort, Congress required that the Secretary "retain all lands or interests therein of the United States above elevation seven hundred and fifty feet mean sea level necessary or desirable for operation of the Grand River Dam project at a pool elevation of seven hundred and fifty-five feet above mean sea level at the Grand River Dam, and [GRDA] shall grant to the Secretary on behalf of the United States flowage rights on all lands or interests therein of [GRDA] above elevation seven hundred and fifty feet mean sea level which are necessary or desirable for such operation."[31] Congress also provided that federal lands, "lying between elevations 750 and 760 feet above mean sea level, may be used perpetually by the United States, and its duly authorized agencies and representatives, to flow thereon and withdraw therefore the waters of the Pensacola Reservoir of the Grand River Dam project for the purpose of and in connection with controlling floods and the production of hydroelectric power."[32]
- When effectuating the transfer of the Project as directed by Congress, President Truman noted the Secretary of the Interior's power and duty "for the acquisition of an additional five feet of reservoir storage for the Grand River Dam Project."[33] In response, the Secretary acquired 11,700 acres of flowage easements between GRDA's Project Boundary and elevations 750 and 757 feet PD at the Dam and elevations 750 and 760 feet PD in the upper reaches of the reservoir.[34]
- During the 1946 to 1950 period, a dispute arose between USACE and the Southwest Power Administration as to whether the United States (not GRDA) possessed sufficient flowage easements for flood control purposes. USACE's analysis concluded that "an additional 11,750 acres of easements should be acquired for purpose of the project for flood control."[35]
- Following heavy flooding in 1986, Congress directed USACE to conduct additional studies to determine the adequacy of the United States' easements for flood control purposes.[36]
- In 1996, Congress directed USACE to "complete a study of flooding in the Grand/Neosho Basin and tributaries in the vicinity of the Pensacola Dam . . . to determine the scope of backwater effects of operation of the dam and to identify any lands that that the Secretary determines have been adversely impacted by such operation or should have been originally purchased as flowage easements for the project.[37] Further, Congress authorized USACE to "acquire from willing sellers such real property

[31] Pub. L. No. 79-573 § 3, 60 Stat. 743, 744 (1946).
[32] Pub. L No. 79-712, 60 Stat. 974 (1946).
[33] Exec. Order No. 9839 (1947).
[34] *Real Estate Adequacy Study* at 2.
[35] *Id*.
[36] H.R. Rep. No. 100-498, at 693 (1987) (Conf. Rep.).
[37] Pub. L. No. 104-303, § 560, 110 Stat. 3658, 3784 (1996).

interests in any lands identified in the study as the Secretary determines are necessary to reduce adverse impacts identified in the study . . . ."[38]

- Again in 2000, Congress directed USACE to conduct a study to determine the feasibility of "addressing the backwater effects of the operation of the Pensacola Dam" and "purchasing easements for any land that has been adversely affected by backwater flooding in the Grand/Neosho River basin."[39] As described above, USACE determined that federal flood control operations have been a significant cause of backwater effects and that the federal government should fully fund a feasibility study to address the issue.
- Finally, USACE recently informed relicensing participants that it has extensively studied the feasibility of acquiring flowage easements related to its flood control operations at the Project in the past, and that it plans to seek funding to assess the need for and feasibility of flood mitigation measures "through the Silver Jackets program."[40]

This extensive history—dating back more than 75 years—unquestionably demonstrates that Congress, the President, and USACE have long recognized that: (1) GRDA's responsibilities for its Project-related operations extend only to elevation 750 feet PD; (2) the United States bears responsibility for flowage easements above 750 feet PD: and (3) any mitigation needed for flood-control activities is exclusively a responsibility of the United States—not GRDA. Moreover, "[t]he FPA does not . . . confer on this Commission any jurisdiction or authority to resolve disputes between the licensee and third parties that concern interests in real property."[41] The Commission has recognized that such matters are to be addressed as provided under sections 10(c) and 21 of the FPA.[42]

4.1.2 Environmental Baseline

Several study requests, including requests for cultural resources assessments and hydraulic modeling, have sought to analyze environmental and other resources under a "pre-project" scenario. However, FERC's longstanding policy is to evaluate project effects based on the current environment—not under any hypothetical pre-project conditions. As the Commission has explained, it is not required to "pretend that current projects do not exist, or to require applicants to gather information to recreate a 50-year-old environmental base upon which to make present day development decisions."[43]

[38] *Id.*
[39] Pub. L. No. 106-541, § 449 (2000).
[40] Letter from Jennifer A. Aranda, U.S. Army Corps of Engineers, to Carlos Gutierrez, Davis Wright Tremaine at 2, Project No. 1494-438 (filed Apr. 3, 2018).
[41] *Halecrest Co.*, 60 FERC ¶ 61,121 at p. 61,413 (1992), *order on reh'g*, 63 FERC ¶ 61,307 (1993); *see also JDJ Energy Co.*, 101 FERC ¶ 61,059 at PP 10-12 (2002).
[42] *See Grand River Dam Auth.*, 156 FERC ¶ 61,106 at P 67 (2016); *E. Bay Mun. Util. Dist.*, 66 FERC ¶ 61,199 at p. 61,449 & n.16 (1994). Moreover, as the U.S. Court of Appeals for the 10th Circuit noted nearly 20 years ago in litigation concerning this Project, parties seeking to file claims against the USACE for flooding damages may file an action at the U.S. Court of Federal Claims. *See Dalrymple v. GRDA*, 145 F.3d 1180, 1187 (10th Cir. 1998).
[43] *See City of Tacoma, Washington,* 67 F.E.R.C. ¶ 61,152 (citing FERC Statutes and Regs. Preambles 1986-1990 ¶ 30,853 at 31,401).

FERC's identification of current project conditions as the appropriate baseline for evaluating environmental and other impacts of a project has been upheld upon judicial review. In 1999, the Ninth Circuit determined, in *American Rivers v. FERC*, that it was "more than reasonable . . . for the Commission to conduct its 'evaluation and consideration of the appropriateness of requiring enhancement measures . . . in the context of today's environment and not in the context of the world as it existed [in the past].'"[44] According to the court, evaluation of a pre-project environment, to the extent that such a hypothetical situation could even be recreated, would only be useful for determining the current cumulative effect of historical changes on natural resources.[45] Shortly after the *American Rivers* decision, the D.C. Circuit rejected efforts of a number of petitioners to require FERC to evaluate impacts on fish and wildlife as if an existing dam were not in place.[46] The court confirmed FERC's choice of existing conditions as the environmental baseline, incorporating by reference the reasoning of the Ninth Circuit in *American Rivers*.[47]

For these reasons, GRDA's proposed study plans do not propose to conduct analyses of pre-project conditions. Instead, consistent with long-standing Commission and judicial precedent, the existing environment and the project as it exists today is the baseline for all of GRDA's proposed studies.

4.1.3 Cultural Resources Investigations in Inundated Areas

Similar to comments on the environmental baseline, several relicensing participants suggest that GRDA's cultural resources investigations should include "river bottom surveys" or assessments of "permanently inundated areas." For example, the Miami Tribe's comments reference a "voluminous record of archeological sites within the original pool at the time it was filled" and assert that the cultural resources assessment study must include a review of "pre-dam archeology," including river bottom surveys.[48]

Such requests are inconsistent with Section 106 of the NHPA and its implementing regulations. Under Section 106, federal agencies must take into account the effect of their undertakings on any "historic property."[49] A historic property is defined by the implementing regulations as "any prehistoric or historic district, site, building, structure, or object" that is included in, or eligible for inclusion in, the National Register of Historic Places.[50] The regulations identify four criteria for evaluating whether properties are eligible for the National Register. However, in addition to satisfying at least one of the four listed criteria, the regulations *also* require that, in order to qualify as a "historic property," a property must "possess integrity of location, design, setting, materials, workmanship, feeling, and association."[51]

According to a National Register bulletin addressing how to apply the National Register Criteria for Evaluation, a property "will always possess several, and usually most," of these seven

[44] *American Rivers v. FERC*, 201 F.3d 1186, 1198 (1999).
[45] *Id.* at 1197.
[46] *Conservation Law Foundation v. FERC*, 216 F.3d 41 (2000).
[47] *Id.* at 46.
[48] Miami Tribe Comments at 12. The City of Miami endorsed and incorporated in its own comments the Miami Tribe's request for "comprehensive cultural resources assessment study…including permanently inundated areas." City of Miami Comments at 20.
[49] 54 U.S.C. § 306108.
[50] 36 C.F.R. § 800.16(*l*)(1).
[51] 36 C.F.R. § 60.4.

aspects in order to retain historic integrity.[52] The bulletin also sets out a series of steps for determining whether a property can be said to have "integrity." The first two steps are to (1) "define the essential physical features that must be present for a property to represent its significance," and (2) to "determine whether the essential physical features are visible enough to convey their significance."[53] In addition, the bulletin makes clear that while it is not necessary for a property to retain all its historic physical features over the course of time, a property must retain the essential physical features that enable it to convey its historic identity.[54] The original license for the Pensacola Project was issued in 1939, which means that any archaeological resources within the inundation zone of the reservoir before the original pool was filled have been under water for close to eighty years. As such, these resources are either preserved in place and unaffected by continued operation of the Project, or are highly unlikely to have retained their essential physical features after being inundated for such a long period of time. Another National Register bulletin, which focuses specifically on archaeological properties, explains that when evaluating integrity, archaeologists are focused on "the level of preservation or quality of information" of a property.[55] The bulletin notes that a property with integrity has deposits that are "relatively intact and complete," rather than being "severely impacted by later cultural activities or natural processes."[56]

In identifying historic properties under Section 106 of the NHPA, an agency is required to make a reasonable and good faith effort, which allows the agency to take into account "the likely nature and location of historic properties within the area of potential effects," as well as the nature and extent of potential effects on historic properties.[57] Even if any permanently inundated properties were to possess integrity, continued operation of the Pensacola Project under a new license would not create any additional potential effects on the property, given that the property would remain inundated, as it has been for decades.[58]

For these reasons, GRDA's Cultural Resources Study Plan does not propose to conduct investigations in areas that are permanently inundated and instead to focus in areas where continued Project operations may affect historic properties. Relicensing participants requesting such a broad and prohibitively expensive study scope have identified no instance in which the Commission has required a license applicant to undertake an investigation of permanently inundated areas. As the Advisory Council of Historic Preservation (ACHP) has explained:

> [A]rchaeological identification efforts for a license renewal from the Federal Energy Regulatory Commission likely would not involve the entire APE. Rather it would be directed to those locations within the APE that are experiencing project related effects associated with operation, usually along the shoreline.[59]

[52] National Register Bulletin, "How to Apply the National Register Criteria for Evaluation," at p. 44 (rev. 1997).
[53] *Id.* at p. 45.
[54] *Id.* at p. 46.
[55] National Register Bulletin, "Guidelines for Evaluating and Registering Archaeological Properties," at p. 25 (2000).
[56] *Id.*
[57] 36 C.F.R. § 800.4(b)(1).
[58] "Effect" is defined as "alteration to the characteristics of a historic property qualifying it for inclusion in or eligibility for the National Register. 36 C.F.R. § 800.16(i).
[59] Section 106 Archaeology Guidance at p. 17.

4.1.4 Addressing the Effects of Climate Change

Some relicensing participants included a climate change component to their flooding/inundation study requests. GRDA's PSP has not adopted this proposed element. FERC precedent uniformly maintains that climate change studies are not needed in hydropower licensing proceedings. FERC has acknowledged that climate change is a complex issue, but under NEPA and Council on Environmental Quality regulations, it is afforded discretion based on its expertise and experience to determine the scope of an environmental analysis based on available information.[60]

FERC has explained that climate change models would not allow it "to predict matters such as water supply or flow within a given basin during the 30 to 50-year term of a typical hydropower license in such a manner to assist the Commission in analyzing alternatives and determining appropriate mitigation for environmental impacts."[61] In addition, FERC has determined that climate change studies are not likely to yield reliable data that can be used to develop license requirements.[62] FERC has found that conventional hydrological studies, monitoring techniques, and predictive models can be used to effectively study and evaluate the effects of projects on environmental resources.[63]

4.1.5 Protection, Mitigation and Enhancement Measures

GRDA received comments and requests concerning proposed PM&E measures for the Project. Per the ILP, assessing the need for and adequacy of any such measures now is premature. As such, GRDA is not proposing to incorporate into its studies or otherwise address PM&E measures at this point in the relicensing process.

In accordance with the Commission's regulations at 18 C.F.R. § 5.11, this PSP describes GRDA's proposed approaches for collecting information and data required to meet FERC's ILP study requirements. The resource studies will culminate in the preparation of study reports. The study reports will develop information sufficient for characterizing, as part of the Environmental Exhibit in the relicensing application, the existing environment and evaluating any potential impacts of continued project operations. Prior to GRDA's filing of the FLA with FERC, this analysis will be available for comment by relicensing participants as part of GRDA's PLP/DLA.

4.2 Study Requests Included in GRDA's PSP

4.2.1 Flooding/Inundation Study

Requests for studies outlined and recommended several approaches with names synonymous to an H&H Study. Such names used by relicensing participants are CHM, flood routing studies, inundation studies, impoundment fluctuation studies, comprehensive flood routing studies, and operations models. Although this study plan will not directly title the proposed and recommended

[60] *See Eagle Crest Energy* Company, 153 FERC ¶ 61,058, at P 39 (2015).
[61] *See Id.*, *see also Alabama Power Company*, 155 FERC ¶ 61,080, P 29 (2016) ("attempting to predict future flow scenarios that may occur due to climate change or other conditions would be too speculative given the state of the science at this time").
[62] *See Alaska Energy Authority*, 144 FERC ¶ 61,040, at P 8 (2013).
[63] *Id.*, at P 9.

studies incorporated into this H&H Study Plan using all of the synonymous descriptions, the study plan incorporates all of them (regardless of how they have been previously referenced). The specific relicensing participants requesting an H&H Study are FERC, BIA, USFWS, ODWC, City of Miami, Miami Tribe, Eastern Shawnee Tribe, Ottawa Tribe, Seneca-Cayuga Nation, Wyandotte Nation, Cherokee Nation, and N. Larry Bork (counsel for the City of Miami citizens).

Regarding recommended approaches and items to include in the H&H Study, FERC, BIA, ODWC, and City of Miami made specific recommendations about approaches and items to include in the H&H Study. The specific recommendations of the Miami Tribe, Eastern Shawnee Tribe, Ottawa Tribe, Seneca-Cayuga Nation, Wyandotte Nation, and N. Larry Bork (counsel for the City of Miami citizens) are the same as the City of Miami recommendations. The USFWS and Cherokee Nation did not provide any specific recommended approaches to the H&H Study.

The proposed H&H Study will provide information through modeling and mapping to determine the effect of the operation of the Project upon several resource areas. The H&H Study will determine the duration and extent of inundation under the current operation of the Project during several measured inflow events, determine the duration and extent of inundation under any proposed change in operation that occurs during several measured or synthetic inflow events, provide the model results in a format that can inform other analyses (to be completed separately) about Project effects, if any, in several resource areas, and will determine the feasibility of implementing alternative operation scenarios that may be proposed by GRDA as part of the relicensing effort.

The modeling conducted as part of the H&H Study will encompass the Neosho, Spring, and Elk rivers and Tar Creek and use Hydrologic Engineering Center's River Analysis System (HEC-RAS) software and incorporate some two dimensional (2-D) analysis, where appropriate.

The H&H Study will compare current channel geometry to historical channel geometry to compare flood routing specifics resulting from sediment accretion and erosion in the river channels.

Description of USACE and GRDA Flood Control Operations

As explained above,[64] GRDA's responsibilities for its Project-related operations extend only to elevation 750 feet PD, consistent with the Flood Control Act of 1944, USACE's 1992 Water Control Manual for the Pensacola Reservoir, and the Water Control Agreement for the Pensacola Dam.

Upstream Sedimentation

FERC requested the H&H Study to assess how rule curve modifications to reduce flooding may contribute to sedimentation upstream of Grand Lake. As explained elsewhere in this PSP, GRDA is proposing to conduct a sedimentation study.[65]

Flood Frequency Analysis

FERC requests a flood frequency analysis to establish arbitrary flood events (10-year, 25-year, 50-year, and 100-year) and the City of Miami requests a flood frequency analysis to establish arbitrary flood frequency curves. Such effort necessarily would need to be based upon numerous assumptions with misleading results. Each individual tributary can have several different inflow

[64] *See supra* § 4.1.1.
[65] *See supra* § 3.1.2, *infra* § 4.2.2.

events which could lead to an arbitrary recurrence interval at Pensacola Dam. Instead, the H&H Study proposes a flood frequency analysis for the peak inflow event observed during the measured inflow event used in the CHM model runs at Pensacola Dam.

Analysis of Pre-Dam Conditions and Previous Rule Curves

City of Miami makes several requests to analyze pre-dam conditions or previous rule curves and compare them to current conditions. Because FERC's environmental baseline policy considers current conditions, the H&H Study does not include any efforts to compare the current or proposed operation to pre-dam conditions or previous rule curves.[66] The City of Miami states their reasoning for requesting a model of pre-dam conditions is to "evaluate the adequacy of the easements using the USACE procedures." The adequacy of USACE's flowage easements is beyond the scope of this relicensing process,[67] but can be determined by mapping and a comparison of the inundation areas. Therefore, a pre-dam model or a previous rule curve model run is not part of the H&H Study. This conclusion is supported by "A Guide to Understanding and Applying the Integrated Licensing Process Study Criteria" (Study Criteria Guidelines) released by FERC in March 2012.

Evaluate Alternatives to Reduce Inundation

FERC and City of Miami each recommend several evaluations of alternates to potentially reduce inundation. This request is premature because the contribution, if any, of Project operation to the inundation has not yet been determined. Should the results of the H&H Study demonstrate that GRDA's Project operations adversely affect water levels in areas in which flowage easements do not exist, at that time GRDA in the PLP/DLA may consider evaluating potential measures to address such effects. However, as explained above, USACE flood control operations are not within the scope of this relicensing process.[68]

Evaluating Future Conditions

City of Miami, Miami Tribe, Eastern Shawnee Tribe, Ottawa Tribe, Seneca-Cayuga Nation, Wyandotte Nation, and N. Larry Bork (counsel for the City of Miami citizens) request model runs to evaluate potential impacts due to continued sedimentation and vegetation growth along the channel margins. The existing information provides sufficient information to address this concern.

Use of Existing Information

The following existing information will not be included or used as a model basis for the H&H Study:

USACE (1996) and Simons (1998) Models

Both the USACE and the Simons Models utilize a USACE HEC software called HEC-2 released in 1990. The Neosho River from Twin Bridges to just upstream of the U.S. Geological Survey (USGS) gage at Commerce was modeled as steady-state in these efforts. Since the efforts utilize data collected in 1995 and 1997 (topography and bathymetry) and they do not include Grand Lake, they will not be used as a model basis for the H&H Study.

[66] *See supra* § 4.1.2.
[67] *See supra* § 4.1.1.
[68] *See supra* § 4.1.1.

OU Model (Dennis 2014)

During a previous license amendment request, GRDA commissioned a hydraulic study through the University of Oklahoma (OU) in 2014. The OU Model was developed using one-dimensional (1-D) HEC-RAS software and included the Neosho River and several major tributaries from Pensacola Dam to the USGS gage at Commerce. The OU model relied on the 1996 USACE bathymetry data for the Neosho River between Twin Bridges and the USGS gage at Commerce. The model also relied on 2008 bathymetric survey information for Grand Lake from the Oklahoma Water Resources Board (OWRB), and Light Detection and Ranging (LiDAR)-acquired topography collected for the USGS in 2011 was used to represent the overbank areas.

Due to the age of the bathymetry data (1996) and the limited purpose for its development to support a specific change in the rule curve, this model will not be used as a model basis for the H&H Study.

FERC Model (2015)

In 2015, FERC created an independent hydraulic model in response to the proposed license amendment to modify the rule curve. The FERC Model was created using the OU Model as a basis in 1-D HEC-RAS software and was modified to overcome the original limits of the OU Model. The FERC model was an unsteady-state[69] analysis for the Neosho River, but did not include the portion of the Grand Lake downstream of Twin Bridges and was calibrated using roughness values from historic flood events.

Because the model does not represent the Spring River, Elk River or Grand Lake, this model will not be used as a model basis in the H&H Study.

FEMA Tar Creek Model (2015)

As part of Federal Emergency Management Agency (FEMA) flood risk mapping efforts for the Grand Lake Watershed, the FEMA Tar Creek Model was developed. The FEMA Model extends approximately 7.5 miles up Tar Creek. After a review of the FEMA Model, it was determined that utilizing available LiDAR (survey conducted by the USGS in 2011) data as the model basis for the Tar Creek portion of the watershed is not the best approach to attain the goals of the H&H Study and, therefore, the FEMA Model will not be used as a basis for the H&H Study.

Hydrology

Miami Tribe, Eastern Shawnee Tribe, Ottawa Tribe, Seneca Cayuga Nation, Wyandotte Nation, and N. Larry Bork (counsel for the City of Miami citizens) also request the use of the USACE Flood Operations Model for the Arkansas Basin Reservoir System. The USACE Flood Operations Model is a basin-wide model used by the USACE to plan flood control operations throughout the entire Arkansas River basin and is not specific to the Pensacola Project. Its primary intent is for planning flood control operations. Therefore, it is not relevant to this relicensing effort and will not be utilized as part of the H&H Study.

[69] An unsteady-state model utilizes varying inflows through the cycle of the inflow event to show the conditions as the inflow event moves through the river system. Unsteady state modeling is considered to be the most-representative of natural conditions occurring in the river system during the inflow event.

Bathymetry
The 2015 Tetra Tech bathymetric data is being superseded by the most-current 2017 USGS bathymetric data.

Other Requests
City of Miami requests a cost estimate to purchase additional flowage easements. As described above, the adequacy of USACE's flowage easements and other issues related to property rights and ownership are beyond the scope of this relicensing process.[70]

Model Run Parameters
City of Miami and BIA recommend specific parameters and numbers of model runs for the H&H Study. These specifics and the reasons for the approach in the H&H Study are outlined in Section 2.6 of the H&H Study plan.

Deliverables
BIA recommends development of an additional web-based map viewer for the H&H Study. The viewer would be designed for the non-technical audience. While GRDA understands the need to make the results of the H&H Study understandable to the non-technical audience, the requested viewer would not accomplish this result. Due to current technological limitations of web-based tools to demonstrate modeling results, this type of viewer would require the creation and use of an entirely separate steady-state 1-D model that relicensing participants have acknowledged would be insufficient for this relicensing effort. Instead, GRDA will work with BIA and other relicensing participants to ensure that modeling reports are user-friendly and understandable to a non-technical audience.

Relicensing Participant Consultation
City of Miami, Miami Tribe, Eastern Shawnee Tribe, Ottawa Tribe, Seneca-Cayuga Nation, Wyandotte Nation, and N. Larry Bork (counsel for the City of Miami citizens) recommended development of a protocol for extensive consultation during the H&H Study. The proposed H&H Study Plan includes significant detail on the methodology that relicensing participants can provide detailed comments on. GRDA has also proposed an additional progress report near the middle of the study season. Beyond that proposed measure, the ILP provides an adequate forum for consultation on studies because it is divided into two study seasons which will include consultation with relicensing participants on the initial study results after the first year of studies.

4.2.2 Sedimentation Study

The FERC requested an assessment of how rule curve modifications to reduce inundation duration and extent may contribute to upstream sedimentation. The proposed Sedimentation Study addresses this issue.

4.2.3 Cultural Resources Study

OAS, Miami Tribe (supported by the City of Miami, Eastern Shawnee Tribe, Ottawa Tribe, Seneca-Cayuga Nation, Wyandotte Nation), and Cherokee Nation have requested a Cultural Resources Study to assess the Project's effects on archaeological, historical, and Tribal resources. The requesters recommend that the APE for this study be defined broadly to include the Grand Lake Reservoir to elevation 760, as well as any adjacent areas that are periodically

[70] *See supra* § 4.1.1.

inundated by Grand Lake. The Miami Tribe further requests that the APE include "all Tribal Property in the vicinity of the Project." The Miami Tribe recommends specific study methods; the Cherokee Nation requested that GRDA conduct a "full basin-up archaeological and cultural resources assessment." Both the Miami Tribe and Cherokee Nation recommended that GRDA develop an HPMP to provide for the management and treatment of archaeological resources that may be affected by the Project.

GRDA has proposed a Cultural Resources Study to (1) identify historic properties within the Project's APE that are being adversely affected by Project operations (if any), including properties of traditional religious and cultural importance; and (2) to develop an HPMP in consultation with the Oklahoma SHPO, OAS, and Native American Tribes that provides for the long-term management of historic properties within the APE over the term of the Project's new license. The proposed Cultural Resources Study Plan is a reasonable and good faith effort to carry out appropriate identification efforts. As a component of the Cultural Resources Study, GRDA proposes to define an APE in consultation with the CRWG that takes into account areas where Project-related activities may directly or indirectly cause alterations in the character or use of historic properties, if any such properties exist. In the proposed Cultural Resources Study Plan, GRDA also recognizes that the geographical extent of the APE may be refined based on the results of the H&H Study or other studies if such studies indicate that the Project has the potential to adversely affect historic properties in areas outside the current Project Boundary. This approach is appropriate and consistent with the ACHP's *Section 106 Archaeology Guidance* (Section 106 Guidance), which notes that "[t]he APE is not static, but should be adjusted as a federal agency develops details of the undertaking and learns more about potential historic properties and how they may be affected." The APE can be modified in consultation with the CRWG if the results of the H&H Study (or another study) indicate the potential for an adverse Project effect.

The proposed Cultural Resources Study Plan adopts an approach generally recommended by the Miami Tribe that includes the CRWG in the planning of field investigations and provides for on-going consultation with the CRWG during the ILP and after the new license is issued. While the methods proposed by GRDA are not identical to those recommended by the Miami Tribe, GRDA proposes to (1) work with the CRWG to identify high-priority areas and sites within the APE for study during the 2-year ILP process for purposes of informing FERC's analyses under both Section 106 and the NEPA; and (2) continue cultural resource investigations post-licensing over a longer period of time as part of the HPMP. This approach recognizes the limited, 2-year window for conducting cultural resources studies during Project relicensing—particularly when considering the vast geographic area occupied by the Project and other areas that may be affected by Project operations. The proposed Cultural Resources Study would include an initial literature review and archival research, the development of a Pre-fieldwork Study Report, consultation with the CRWG to identify appropriate areas for field investigations, multi-year Reconnaissance Surveys of the APE (including areas that may be refined based on the results other relicensing studies), a study of TCPs, and the development of an HPMP in consultation with the CRWG to provide for the management of historic and archaeological resources within the APE (including provisions for additional investigations during the term of the new license).

As explained above,[71] a "full basin-up" archaeological and cultural resources study, including areas that are permanently inundated by the Project, would be inconsistent with the ACHP's Section 106 Guidance which states that "archaeological identification efforts for a license

[71] *See supra* § 4.1.3.

renewal from the Federal Energy Regulatory Commission likely would not involve the entire area of potential effects (APE). Rather it would be directed to those locations within the APE that are experiencing project related effects associated with operation, usually along the shoreline." GRDA does not envision performing identification efforts at a basin-wide level without evidence that the Project is having an effect on archaeological or historic resources across the entirety of the 10,300-square-mile Grand River Basin. A basin-wide inventory and assessment of archaeological resources is neither practical nor warranted.

4.2.4 Socioeconomics Study

City of Miami, Miami Tribe, and N. Larry Bork (counsel for the City of Miami citizens) request detailed data and economic modeling specifically related to potential flood impacts in the Project vicinity which are a cumulative effect in the area, and go beyond the scope of relicensing. The requested analyses are related to property values, insurance, tourism and recreation, taxes, business closures, relocations and employment losses, education, emergency services, infrastructure capital and maintenance expenses, exploration and mining, agricultural development, hunting, fishing and trapping, quality of life, and others.

GRDA has proposed a Socioeconomics Study that will rely upon existing information to define the baseline economic conditions in the region under current operations to a level that will allow for assessment of any potential changes between the existing condition and proposed operational changes. To the extent that quantifiable information is available regarding the requested socioeconomic information, including land and resource values, tourism, employment, education, electric generation, and regional industry and agricultural trends, it will be summarized in the proposed study. Analysis of flood insurance, property values, taxes, infrastructure access, and emergency services related to flood conditions is outside the scope of this study.

4.3 Study Requests Excluded from GRDA's PSP

4.3.1 Federal Lands

Several relicensing participants requested study of land ownership at the Project to determine whether the Project occupies any federal lands or interest in lands. The USFWS, for example, requested a study "to determine if operation of the Project at surface elevation levels within the Project Boundary causes or contributes to flooding that affects federal lands or interests in lands that are held in trust for any Indian tribe or individual Indian."[72] On March 12, 2018, the U.S. Department of the Interior, BIA filed trust maps with FERC based on land inventory data from BIA's Trust Asset and Accounting Management System (TAAMS). BIA's maps depict parcels, adjacent to and in the vicinity of the Project, that BIA has identified as either trust lands or restricted fee lands.[73] BIA's filing noted that these maps "do not attempt to identify which tracts are within the boundaries of or affected by the Pensacola Project."[74] However, both the Miami Tribe of Oklahoma and City of Miami contend that the Project occupies lands held by the United

[72] Letter from Joanna E. Polk, U.S. Fish and Wildlife Service, to Kimberly D. Bose, Federal Energy Regulatory Commission, at 5, Project No. 1494-483 (filed March 13, 2018).
[73] *See* United States Department of the Interior, Bureau of Indian Affairs' Trust Lands Maps, Project No. 1494-438 (filed March 12, 2018).
[74] *Id.* at 2.

States in trust for a Native American Tribe or Individual Indians.[75] Commission staff has requested BIA, with regard to the parcels depicted in its maps, to "describe the nature of the federal interest held by the federal government" and particularly "whether the title of the land is held in trust by the federal government or in fee by a tribe or individual Indian."[76] BIA filed additional information in response to this request on April 11, 2018.

Throughout the long history of this Project, the Commission repeatedly and uniformly has concluded that the Project does not occupy any federal lands.[77] This conclusion is supported by the many times in which Congress, the President, and USACE have consistently established that GRDA has no responsibilities for land ownership above elevation 750 feet PD, as summarized above. GRDA's FERC-approved Project Boundary—while it is a metes and bounds survey—generally follows the 750-foot PD contour elevation.

Nonetheless, GRDA recognizes that the question of whether the Project actually occupies any federal lands or interests in lands presents a complex set of issues, including:

- Whether BIA's TAAMS contains accurate and current information on federal land ownership in the vicinity of the Project;
- Whether the information presented in BIA's TAAMS maps presents a full depiction of property ownership within each parcel that is noted as trust land, e.g., whether in light of the extraordinary and complex history associated with this Project, GRDA has a preexisting flowage easement on these parcels, or whether the United States maintains a right to use these lands for flood control or other purposes;[78]
- Whether the depicted lands are actually within the FERC-approved Project Boundary, or simply near or adjacent to the Project Boundary;[79] and
- Whether any lands adjacent to or in the vicinity of the Project, to which the United States holds an interest, are needed for purposes of the Project, based on the results of the relicensing studies (including the H&H Study) and the Commission's evaluation under the FPA.[80]

GRDA—which provided information to BIA for use in producing its TAAMS maps—will continue to work with BIA, Commission staff, and other relicensing participants to address this issue in the normal course of the relicensing effort. However, no specific study related to this matter is needed. Rather, as is required for every license applicant, GRDA's PLP/DLA will contain a set

[75] Miami Tribe Comments at 1-2; City of Miami Comments at 6.
[76] Letter from Stephen Bowler, Federal Energy Regulatory Commission, to Eddie R. Streater, Bureau of Indian Affairs, at 1, Project No. 1494-438 (issued March 15, 2018).
[77] *See*, *e.g.*, *Grand River Dam Auth.*, 158 FERC ¶ 62,003 at P 1 (2017); Final Environmental Assessment at 50, Project No. 1494-437 (issued May 11, 2017) (finding that "the Pensacola Project boundary, as currently defined, does not occupy Tribal lands held in trust"); *Grand River Dam Auth.*, 153 FERC ¶ 62,080 at P 1 (2015); *see also* Comments of U.S. Department of the Interior – OEPC at 2, Project No. 1494-437 (filed October 21, 2016) ("as currently defined, the Project Boundary does not occupy Indian lands")
[78] *See supra* § 4.1.1.
[79] The actual placement of the Project Boundary has not been evaluated for decades, and even under the Commission's relatively recently updated standards, the boundary is only required to be "positionally accurate to ±40 feet, in order to comply with the National Map Accuracy Standards for maps at a 1:24,000 scale." 18 C.F.R. § 4.41(h).
[80] *See* 16 U.S.C. §§ 769(11), 803(a)(1).

of proposed Project Boundary maps as part of its Exhibit G,[81] and Exhibit A will identify "[a]ll lands of the United States that are enclosed within the project boundary . . . identified and tabulated by legal subdivisions of a public land survey of the affected area or, in the absence a public land survey, by the best available legal description."[82] All relicensing participants will have an opportunity to review and comment on these documents.

4.3.2 Contaminated Sediment Transport Study

ODWC, City of Miami, N. Larry Bork (counsel for City of Miami citizens), and Miami Tribe (supported by the Eastern Shawnee Tribe, Ottawa Tribe, Seneca-Cayuga Nation and Wyandotte Nation) have requested a Sedimentation Contaminant Study. The information requested focuses on analyzing the potential effect of increased flooding associated with Project operations on contaminated sediment deposition along the Neosho drainage system including: Neosho River, Spring River, Mud Creek, Coal Creek, and Tar Creek.

GRDA is not proposing to conduct this requested study. As an initial matter, the Project is not at all responsible for the presence of any heavy metals in Tar Creek. As such, this type of study would not "inform the development of license requirements," as required by FERC's ILP regulations.[83] As FERC has recognized in other contexts, since GRDA is not responsible for the presence of heavy metals and has no ability to mitigate effects of these substances, this type of study would not inform this relicensing process.[84]

Moreover, the Tar Creek superfund site has been well documented and the potentially responsible parties (PRP) have been identified by the EPA. The Tri-State Mining District (TSMD) encompasses an approximate 2,500 square mile area that was extensively mined for lead and zinc from 1850-1950. This historic mining area contains the Tar Creek superfund site and is the source for sediment-bound metals in Grand Lake. The effect that TSMD metals contamination has had on organisms is well documented through various studies (McCormick 1985, OWRB and Oklahoma State University (OSU) 1995, MacDonald et al. 2010, and Morrison et.al. 2014) over the years, and the primary impacts have been observed upstream of the Pensacola Project. The EPA conducted a Phase 1 Study that evaluated overall toxicity in the area of the superfund site and concluded that there were no significant toxic effects upon sensitive species of small fish or micro-crustaceans exposed to water samples collected from Grand Lake (OWRB and OSU 1995). Furthermore, the study concluded that 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 (OWRB and OSU 1995).

In the EPA Phase 1 Study it was postulated that sediment disturbance could cause the release of toxic concentrations of metals (OWRB and OSU 1995). Researchers found that under both disturbed and undisturbed conditions that survival and biomass did not exhibit any significant differences between contaminated (Neosho, Spring, and Grand rivers) and uncontaminated reference sites (Elk River) (Morrison et.al. 2014). In summary, past research spanning decades indicate no acute or chronic toxicity as a result of metals contamination within Grand Lake. The

[81] 18 C.F.R. § 4.51(h).
[82] 18 C.F.R. § 4.51(b)(6).
[83] 18 C.F.R. § 5.9(b)(5).
[84] *See, e.g.*, Study Plan Determination for the Toledo Bend Project at 17, Project No. P-2305 (issued Aug. 6, 2009) (rejecting the risk assessment study for the accumulation of Mercury and Sediment into the Toledo Bend Reservoir "[d]ue to the lack of a nexus between project operation and the resource to be studied").

result of these 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 (Atkinson et al. 2007).

Also, there is no need for this relicensing process to address this issue, as EPA has an existing program in place to address it. Under EPA's Operable Unit 2 (OU2),[85] EPA has developed a remedial action plan for the residential areas[86] of the Superfund Site. The action plan requires EPA to sample soils to determine whether contaminants in the soils are at levels above those protective of human health. If contaminants are found above established threshold levels, EPA would excavate contaminated soils, which are transported off-site. The excavated areas are then back-filled with clean soil.[87] Through 2015, EPA has remediated 2,940 residential areas.[88] Current soil sampling assessments and remediation are being addressed by The Oklahoma Department of Environmental Quality through a cooperative agreement with EPA Region 6.[89]

Finally, although relicensing participants have requested this study on the basis that overbanking events along Tar Creek have deposited heavy metals in adjacent soils, there is no indication that such overbanking is attributable to GRDA's operations under its license. Even if the results of the H&H Study later demonstrate that GRDA's operations influence water levels in Tar Creek, the fact that GRDA is not responsible for the presence of the heavy metals in the Creek renders this a cumulative effect, at best, that can be analyzed by the Commission using existing information.[90] Morrison et al. (2018) conducted a study on the distribution and bioavailability of trace metals in shallow sediments from Grand Lake. The purpose of this study was to assess whether TSMD-specific sediment quality guidelines (SQG), developed for small streams and tributaries draining the TSMD, are predictive of biological effects within the greater lake body. Thus, investigations focused on determining trace metal distribution within the northern reaches of Grand Lake, emphasizing shallow water areas (≤ 6 meter depth), and the effects of sediment disturbance on trace metal bioavailability and toxicity to freshwater amphipods (*Hyalella azteca*) and snails (*Helisoma trivolvis*). No significant mortality or differences in growth occurred under natural or disturbed sediment conditions for either aquatic invertebrate despite using some sediments that exceeded both general- and TSMD-specific SQGs.

In summary, the TSMD contains the Tar Creek superfund site located upstream of the Pensacola Project and is the source of sediment-bound metals in Grand Lake. GRDA is not responsible for the presence of heavy metals in Tar Creek. Heavy metal contamination in sediment in Grand Lake is a cumulative effect in the area due to seasonal flooding upstream and is not directly related to Project operations. As summarized in Section 6.3 of the PAD and briefly above, existing information demonstrates that prior flooding in the area has not caused significant sediment transport of heavy metals and there is no evidence of acute or chronic

[85] EPA, Record of Decision, Residential Areas Operable Unit 2 (August 1997).
[86] "Residential areas" includes single-family residences, apartments, condominiums, and high access areas (places frequented by children such as daycares, playgrounds and schoolyards).
[87] *Id.*
[88] https://cumulis.epa.gov/supercpad/SiteProfiles/index.cfm?fuseaction=second.cleanup&id=0601269.
[89] *Id.*
[90] *See* CEQ, *Considering Cumulative Effects Under the National Environmental Policy Act*, P. 3 (January 1997) (finding that decisions on cumulative effects "must be supported by the best analysis based on *the best data we have* or are able to collect.")(emphasis added); *see also id.*at P. 31 ("Obtaining information on cumulative effects is often the biggest challenge . . . In some cases, federal agencies or the project proponent will have adequate data.").

toxicity as a result of metals contamination within Grand Lake. The EPA has identified the PRPs and has a program in place to address the remediation of the Tar Creek superfund site. For these reasons, GRDA believes that this study request does not meet FERC's Study Criterion No. 5 related to Project "nexus" and that a Contaminated Sediment Study is not warranted for the Pensacola Project.

4.3.3 Quantifying the Effects of Increased Water Level within the Grand Lake Watershed

ODWC has requested a study Quantifying the Effects of Increased Water Level within the Grand Lake Watershed. The ODWC requests that a model be developed to quantify the amount of riverine/lotic habitat that will transition to reservoir/lentic habitat if the year-round operating pool is increased to 745 feet above sea level. The ODWC requests that the model also quantify specific seasonal inundation of currently riverine/lotic habitats.

GRDA is proposing an H&H Study as part of this PSP. As part of the H&H Study, a CHM will be constructed to determine the inundation areas and other flood routing specifics during several measured inflow events where inflow hydrographs already exist. To evaluate the effects of any proposed operational changes, a separate operations model will be constructed to synthesize hypothetical flood event that informs the CHM. Informing the CHM with the synthetic event will predict the inundation areas and other flood routing specifics that could occur because of operational changes. This will allow for a comparison between flood routing specifics resulting from differing operation scenarios. The information provided from these models will be used to quantify potential changes in lotic/lentic habitat in the Project area.

The models that will be produced as components of the H&H Study, along with existing information, will be used to assess the amount of lotic habitat that would potentially transition to lentic habitat if existing Project operations were to change. This information will also be used to analyze any seasonal changes. Additionally, GRDA will use information resulting from the H&H Study to confirm the Shoreline Management Classifications (SMC) as defined in the Project's Shoreline Management Plan (SMP). GRDA will provide the results and analysis from the H&H Study and evaluate potential changes in lotic/lentic habitats in the PLP/DLA and FLA as part of the relicensing process.

4.3.4 Impacts of Grand Lake Elevation Manipulation on Headwater River Hydrology and Paddlefish Spawning / Recruitment

ODWC has requested a study on the Impacts of Grand Lake Elevation Manipulation on Headwater River Hydrology and Paddlefish Spawning / Recruitment. ODWC requests GRDA to use sonar and/or Geographic Information System (GIS) to develop bathymetric baseline maps of headwaters and habitats to model changes in inundation of gravel shoals and off-channel habitats as a result of artificial, seasonal manipulation of reservoir elevation.

There is a wealth of information on Paddlefish in Oklahoma and multiple studies have been performed to collect bathymetry data for the Neosho, Spring, and Elk rivers. During 2015 and 2016, the ODWC conducted a benthic habitat mapping effort in the Neosho and Spring rivers from the Kansas state line to the confluence at Twin Bridges State Park. ODWC used GIS and field measurements (sonar) to quantify spawning habitat availability at various river stages within a range of historical spring measurements (Schooley et al. 2016).

Additionally, in 2017, USGS collected bathymetric data for the Neosho, Spring and Elk rivers. The bathymetric data extends along both the Neosho, and Spring Rivers from the Kansas/Oklahoma state line downstream to the confluence of the two rivers near Twin Bridges. The bathymetric data also extends along the Elk River from just downstream of Noel, Missouri, to the Oklahoma State Highway 10 bridge near Grove, Oklahoma (USGS 2017).

GRDA is proposing an H&H Study as part of this PSP. The H&H Study will include a CHM that will be constructed to better understand the inundation areas and other flood routing specifics during several measured inflow events where inflow hydrographs already exist. The USGS data from the 2017 survey will be incorporated into the CHM as part of the study. In addition to the CHM, a separate operations model will be constructed to synthesize a hypothetical event that informs the CHM. The information from these models will provide additional data that will be used to analyze potential impacts to Paddlefish spawning habitat / recruitment in the Project vicinity.

As described above, bathymetric data already exists for the Neosho, Spring, and Elk rivers. Using existing habitat information (Schooley et al 2016), recent bathymetric data, and the models developed for the H&H Study, GRDA will have sufficient information to analyze changes in inundation of gravel shoals and off-channel habitats resulting from potential changes in reservoir elevation and to assess any potential impacts to Paddlefish spawning habitat / recruitment. For these reasons, GRDA does not believe that a separate study is necessary. GRDA will provide an analysis on potential impacts to Paddlefish spawning / recruitment in the PLP/DLA and FLA as part of the relicensing process.

4.3.5 Alteration of Tailwater Fish Habitat Downstream of Pensacola Dam as a Result of Hydropower Operations

The ODWC has requested a study on the Alteration of Tailwater Fish Habitat Downstream of Pensacola Dam as a Result of Hydropower Operations. The ODWC states that *"If a change in "power pool" operations is granted under this license, GRDA will be allowed discretion over all water up to 745 feet above sea level. This could allow for much different water-release schedules based solely on peak electrical generation times. How will this change in water releases affect the downstream fish habitat in Grand River?"*

At this time GRDA is not proposing any changes to hydropower operations and facilities that would result in changes to water releases downstream of the Pensacola Project. Should GRDA decide to evaluate potential changes in hydropower operations, existing bathymetric data along with the CHM and operations models being developed as part of the proposed H&H Study would be used to analyze any potential impacts to fish habitat downstream of the Project. Since GRDA is not proposing any changes to hydropower operations and facilities at this time, GRDA believes that existing information as presented in the PAD is sufficient for FERC to assess any potential Project effects and develop future license requirements for the Pensacola Project.

4.3.6 Changes in Tailwater Fish Populations Due to Hypolimnetic Releases

ODWC has requested a study on the Changes in Tailwater Fish Populations Due to Hypolimnetic Releases. The ODWC states that *"If a change in "power pool" operations is granted under this license, GRDA will be allowed discretion over all water up to 745 feet above sea level. This could allow for much different water-release schedules based solely on peak*

electrical generation times. What changes in fish populations downstream can be expected due to changes in water releases at Pensacola Dam?"

As a result of the elevation of the intake, during summer stratification water that is low in dissolved oxygen (DO) from the hypolimnion is released downstream into the tailrace during generation. Through collaboration with resource agencies, especially OWRB, GRDA has successfully mitigated for this issue through 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.

Through its installation and operation of air baffles and vacuum breaker bypass vales on the turbines, GRDA is able to move water at both low and high wicket gates and successfully oxygenate the tailrace. Currently GRDA has an automated system of water quality sondes that send email alarms to dam operators when DO is getting low in the tailrace. Operators then turn on the generators until DO levels are at or above state standards. In 2014, with implementation of the mitigation protocol, DO values were below criterion in only 1.6 percent of the samples from June through October. Results indicated that when DO values dropped to a level to trigger the mitigation protocols, the DO concentrations were brought back above criterion within the hour (OWRB 2015). Since the implementation of this program, GRDA has almost eliminated instances of acute DO occurrences below the dam. Section 6.2 of the PAD provides additional information on water quality in the Project tailwaters.

At this time, GRDA is not proposing any changes to hydropower operations and facilities that would result in changes to water releases downstream of the Pensacola Project. Since GRDA has successfully mitigated for low DO issues in the Project tailwaters and is not proposing any changes to hydropower operations and facilities, GRDA believes that existing information as presented in the PAD is sufficient for FERC to assess any potential Project effects and develop future license requirements for the Pensacola Project.

4.3.7 Wetland Documentation

ODWC has requested a Wetland Documentation Study to identify key aquatic habitat areas in the Project vicinity to provide information on the extent and quality of wetlands and aquatic vegetation.

Wetlands in the Project vicinity are confined to inlets and coves along the numerous small tributaries that enter the reservoir and are more abundant along the upper, shallower reaches of the northern and western shores of the reservoir where silty soils and gently sloping banks provide favorable conditions for wetland vegetation (GRDA 2008). Shoreline areas within the reservoir's lower reaches primarily consist of limestone bluffs, with wetlands restricted to coves and backwaters of inundated tributaries. Acreages of the various wetland types occurring in the Project vicinity are summarized in Section 6.5 of the PAD.

GRDA, in coordination with interested parties, developed a SMP in 2008 that was approved by FERC in 2013 (GRDA 2008; FERC 2013). Land use along Grand Lake's shoreline is managed through a permitting system described in the SMP. Management regulations preclude construction below elevation 750 feet PD without prior authorization from GRDA. Shoreline management is defined by the SMP's SMC and Allowable Use Categories (AUC). The SMP system includes seven SMCs: Project Operations Areas, Municipal/Public Use Areas, Stewardship Areas, Wildlife Management Areas (WMA), Responsible Growth Areas, Responsible Growth-Wetlands Areas, and Responsible Growth-Sensitive Areas. The AUCs

define the use types that will be permitted in those areas. The SMP helps define management responsibilities of both GRDA and FERC under the Project's license and the FPA, respectively (GRDA 2008).

GRDA has made qualitative evaluations of existing shoreline uses and environmental resources immediately adjacent to and/or within the Project. The basis of the evaluation was a series of maps produced using existing GIS databases that included palustrine wetlands, contour and bathymetric data, and aquatic and terrestrial habitats considered significant by state and federal wildlife agencies. GRDA compared these resources with existing shoreline development data obtained by GRDA staff through a lake-wide global positioning system effort, review of aerial photography, and the personal and corporate knowledge of GRDA staff and stakeholders.

Shoreline management classification maps are included as Appendix B to the SMP. Classifications and categories are contained in a GRDA database and updated periodically, with a lake-wide review of all classifications scheduled every 6 years. Lake-wide updates are scheduled to occur in 2019, six years after the SMP Order issuance in 2013.

GRDA uses existing information from state and federal agencies, including National Wetlands Inventory (NWI) data, as well as shoreline development data obtained by GRDA staff to document existing wetlands within the Project vicinity. GRDA also performs wetland delineations as necessary as part of their permitting process under the SMP. GRDA does not believe that a wetland documentation study is necessary based on the existing information and due to the continued implementation of the SMP. Any potential impacts to existing wetlands will be addressed in the PLP/DLA and FLA as part of the relicensing process. Any potential PM&E measures to minimize potential impacts to wetlands will also be provided in the PLP/DLA and FLA as necessary.

4.3.8 Loss of Wildlife Lands from Flooding

The ODWC has requested a study on the Loss of Wildlife Lands from Flooding to quantify the amount of WMA acres at maximum expected Project pool. The study would involve mapping the habitat in the fluctuation zone at full pond and quantifying the acreage available.

As part of Article 406 of the current license, GRDA manages 1,630 acres of Project lands as four WMAs located either adjacent to streams entering the reservoir or as islands within the reservoir (GRDA 2015). Additionally, Article 411 requires GRDA to implement a Fish and Waterfowl Habitat Management Plan (FWHMP) to mitigate effects of the Project on fish and waterfowl habitat. As described in detail below,[91] GRDA, in consultation with ODWC and other parties, has employed several strategies over the years to effectively mitigate these effects. More recently, GRDA, in partnership with ODWC, has proposed development of the Coal Creek Wildlife Management Area (CCWMA) for wildlife purposes with the focus on conservation and restoration of grasslands, bottomland hardwoods, wetlands, and riparian areas (GRDA 2016a; ODWC 2016; GRDA and ODWC 2017). Review and approval of the CCWMA are ongoing at the time of this PSP.

GRDA is proposing an H&H Study as part of this PSP. As part of the H&H Study, a CHM will be constructed to determine the inundation areas and other flood routing specifics during several measured inflow events where inflow hydrographs already exist. To evaluate the effects of any

[91] *See infra* § 4.3.9.

proposed operational changes that GRDA may propose, a separate operations model will be constructed to synthesize a hypothetical flood event that informs the CHM. Informing the CHM with the synthetic event will predict the inundation areas and other flood routing specifics that could occur because of operational changes. This will allow for a comparison between flood routing specifics resulting from differing operation scenarios. The information provided from these models will be used to map wildlife habitat in the fluctuation zone at full pond and quantify the acreage available.

Using existing information and the models produced as components of the H&H Study, GRDA will have sufficient data to map wildlife habitat in the fluctuation zone at full pond and quantify the acreage available and, therefore, a separate study is not necessary. GRDA will provide the results and analysis from the H&H Study and quantify available wildlife habitat in the PLP/DLA and FLA as part of the relicensing process. Any potential impacts to wildlife lands in the Project area will be discussed in the PLP/DLA and FLA and potential PM&E measures provided as appropriate.

4.3.9 Recovery of Lost Wildlife Mitigation Opportunity

The ODWC has requested a study on the Recovery of Lost Wildlife Mitigation Opportunity to identify lost resource benefits from what it characterizes as inaction/mismanagement of mitigation funds within the FWHMP.

Article 404 of the current license required GRDA to annually seed mudflats for habitat improvement. The Commission removed Article 404 from the license in its May 22, 2003 Order, Approving Fish and Waterfowl Habitat Management Plan. In an effort to mitigate any negative effects to fish and waterfowl, the Commission added Article 411 to the license requiring GRDA to file a FWHMP. The FWHMP as approved by FERC establishes a fish and wildlife mitigation fund (Mitigation Fund) and a fish and wildlife technical committee (Technical Committee[92]), to fund, design, implement, and evaluate projects that would protect, mitigate, and enhance fish and wildlife resources at the Pensacola Project.

GRDA's FWHMP incorporated the requirements of Article 404 which required GRDA to annually seed 1,000 acres of mudflats along Grand Lake's shoreline with Japanese millet (*Echinochloa esculenta*). Incorporating these requirements enabled the Technical Committee to adaptively manage this program, leaving GRDA and the Technical Committee free to decide when and how to seed millet each year based on prevailing conditions at Grand Lake like weather, lake levels, and river flows. Millet seeding was not successful in several years, in part, because Article 404 and the Mudflat Seeding Plan did not allow GRDA to alter or defer seeding based on such conditions. Moving the requirements of Article 404 to the FWHMP gave GRDA and the Technical Committee more flexibility to manage the program. However, the program still did not achieve the desired results and was discontinued in 2011. GRDA also conducted several years of aquatic plantings which also proved ineffective, despite the efforts of GRDA and the Technical Committee.

In response to these challenges, the Technical Committee began to explore alternate mitigation solutions that would meet the objectives of the FWHMP and Article 411 of the license. In January 2016, these efforts culminated with the signing of an Interagency Agreement (IA)

[92] The Technical Committee consists of GRDA, ODWC, USFWS, OWRB, USACE, USGS's Oklahoma Cooperative Fish and Wildlife Research Unit, and OSU.

between ODWC and GRDA, which allows GRDA to fulfill the requirements of the FWHMP and Article 411 through adjacent-site restoration and wetland development. The IA provided for adjacent-site restoration and management. The restored habitat negates the need to perform millet seeding and is expected to directly benefit waterfowl in the Grand Lake/Neosho River Basin (ODWC 2016, as cited in GRDA 2016b).

By letter dated February 3, 2017, GRDA distributed the draft Implementation Plan for the CCWMA (GRDA and ODWC 2017). The purpose of the Implementation Plan is to establish the management goals and measures for the joint development and operation by GRDA and the ODWC of the proposed CCWMA. The proposed CCWMA is a 540-acre tract that includes wetlands providing important wildlife habitat (GRDA 2016a; ODWC 2016), which was purchased by GRDA and is located along the Neosho River immediately adjacent to the Pensacola Project. This plan was developed by GRDA and ODWC in consultation with the Technical Committee. A revised CCWMA plan was distributed to the Technical Committee for comment on April 23, 2018, and will be filed with FERC at the conclusion of the 30-day comment period.

For these reasons, there is no basis for ODWC's assertions of inaction and mismanagement. GRDA, ODWC, and other parties have worked together over many years to employ various strategies to mitigate for habitat effects, and GRDA is confident that the CCWMA will be a permanent, successful solution to this long-elusive challenge. Because ODWC's assertions lack a factual basis, the proposed study request is unneeded, and additional information resulting from the H&H Study, coupled with a wealth of existing information, will be sufficient to assess potential Project effects on fish and wildlife resources.

4.3.10 Flora and Fauna Impacts

The Miami Tribe (supported by Eastern Shawnee Tribe, Ottawa Tribe, Seneca-Cayuga Nation Wyandotte Nation, and N. Larry Bork [counsel for the City of Miami citizens]) has requested a Flora and Fauna Impacts Study. The Miami Tribe states in its study request letter that *"First, an assessment of flora and fauna impacts must include meaningful and ongoing consultation and coordination with environmental and natural resources departments for each area tribe."* and *"Second, any study approved for evaluation of flora and fauna impacts should be led and coordinated by an independent third party with expertise in assessment of impacts to flora and fauna."* This study request does not meet the Study Criteria as specified by C.F.R. 18, §5.9(b) of FERC's regulations on the ILP. Study requests should demonstrate the need for additional, site-specific information for purposes other than general research. Requestors should also describe why existing information is insufficient to inform the development of license requirements and/or contribute to the development of PM&E measures.

The Miami Tribe's study request is an overly broad request and does not identify or specify any potential resource issues or explain what additional information the Tribe believes is necessary for FERC to conduct its NEPA analysis for the relicensing of the Pensacola Project and aid in the development of future license requirements.

As stated in Section 7.4 of the PAD, GRDA has not identified any existing information or data regarding wildlife or botanical resources that suggests that the Project's operation will adversely impact these resources in the Project area. Further, current license commitments (Articles 406 and 411) and a FWHMP provide lands and wildlife management areas to mitigate ongoing impacts and enhance wildlife resources. The existing SMP includes a Vegetation Management Plan (VMP) and measures to limit impacts of any ground-disturbing and ongoing maintenance activities on terrestrial resources. GRDA believes that this available information is sufficient to

evaluate any potential effects of continued operation of the Project and that no additional information is necessary for FERC to perform its NEPA analysis for the Project.

4.3.11 Infrastructure Improvement Study

The Miami Tribe (supported by N. Larry Bork [Counsel for Citizens of City of Miami], Eastern Shawnee Tribe, Ottawa Tribe, Seneca-Cayuga Nation and Wyandotte Nation) has requested an Infrastructure Impacts Study to evaluate current and future impacts on infrastructure resulting from the operation and maintenance of the Pensacola Project. The Miami Tribe states in its study request *"Project-related activities, especially the operation and maintenance of the Pensacola Dam at the current levels permitted by the amended rule curve, adversely affect City and Tribal infrastructure and on lands outside the current Project boundary that have been permanently or periodically inundated due to Project-related flooding."*

GRDA is not proposing to conduct the requested infrastructure improvement study. Under FERC's ILP Study Criteria, a study requestor must demonstrate a reasonable connection between Project operations and effects on the resource in question. As licensed by FERC, the Project serves multiple purposes, including hydropower generation, water supply, public recreation, and wildlife enhancement. As directed by Congress under the Flood Control Act of 1944, 58 Stat. 887, 890- 91, the USACE has exclusive jurisdiction over Grand Lake for flood control purposes. USACE has designated a flood control pool for Grand Lake that extends above the 745-foot PD elevation of the conservation pool. The access and infrastructure issues identified by the Miami Tribe and other relicensing participants are absent during normal Project operations, when Grand Lake levels are within the conservation pool. Thus, any effects that may result from USACE's flood control operations at Grand Lake under Section 7 of the Flood Control Act of 1944, 58 Stat. 887, 890-91, are beyond the scope of this relicensing process and will not inform the development of any mitigation measures that the Commission may require under the FPA.[93]

4.4 FERC Additional Information Requests (AIRs)

In its comments dated March 13, 2018, FERC staff requested additional information about the Pensacola Project based on their review of the PAD. The following identifies the information requests and GRDA's response for each requested item.

4.4.1 AIR 1 Project Operations

On page 1, the PAD indicates that Grand Lake has a surface area of 45,200 acres at elevation 745 feet (Pensacola datum). However, the project's license states that the surface area of the reservoir is 46,500 acres at 745 feet. Please explain this discrepancy. In addition, please provide, based on the most recent information available, a surface area-lake elevation curve for the project that shows the reservoir surface area at elevations 745 feet, 750 feet, and 755 feet.

The Project license states that the surface area of Grand Lake is 46,500 acres at 745 feet PD, and traditionally GRDA has referenced the 46,500-acre surface area value. With technological advances in the GIS field, more accurate data (including LiDAR) indicate that the surface area is approximately 45,200 at 745 feet PD.

[93] *See supra* § 4.1.1.

The most recently published area-capacity curve developed for the Pensacola Project is a 2009 update prepared by the USACE based on the 2009 LiDAR data. With the addition of newly acquired bathymetry, GRDA is in the process of updating the current area-capacity curve to reflect the updated subsurface areas and volumes. GRDA will submit the new curve separately as soon as the update is complete.

4.4.2 AIR 2 Fisheries and Aquatic Resources

The PAD at page 34 describes entrainment studies conducted in 1990 to support the prior relicensing of the project. Please file the study report entitled, "Entrainment Susceptibilities of Fishes Inhabiting the Lower Portion of Grand Lake, Oklahoma" (Sorensen, 1990), in the docket for the current relicensing and describe any factors that may have changed regarding the study's assumptions since its completion. Please include a description of any current operational measures you are taking to manage potential fish entrainment.

The study report titled, "Entrainment Susceptibilities of Fishes Inhabiting the Lower Portion of Grand Lake, Oklahoma" (Sorensen 1990), is provided in Attachment C of this PSP.

Data for an entrainment study of the hydropower intake area was collected from August 1988 to July 1989 as part of an Environmental Impact Assessment of Pensacola Dam. Researchers from Oklahoma State University found that 99.5 percent of entrainment was Gizzard Shad, followed by White Crappie (0.21 percent), and Channel Catfish (0.16 percent). The study concluded that entrainment at the Pensacola Dam was limited because recreationally and commercially important sport and food fishes were not abundant near the dam intakes due to their biology. Although small Gizzard Shad (<130 millimeters) were susceptible to winter entrainment, the biomass of this species in the overall lakeside fisheries assemblage suggested that mortality and removal was inconsequential to the population. Overall, fishes were not entrained in rates that reflect their relative abundance in Grand Lake as only 8 of the 25 species documented in the lake were found entrained below the dam. This study suggested that due to the low entrainment rates of game fish and seasonality of shad entrainment, implementation of entrainment deterrence devices would not lead to significant improvement in Grand Lake fisheries.

As a result of this study, GRDA did not put operational measures in place to manage fish entrainment through the electric generators. Since the time of the study, no structural or operational changes to the dam have occurred that would change the depth water is drawn from which in turn could alter the species and seasonality of fish entrainment. No changes have occurred to lake physics or seasonal characteristics as Grand Lake is still a warm monomictic reservoir with seasonal summertime stratification and anoxia. Due to the depth of the water intake structures below the thermocline in anoxic summer waters, study and mitigation efforts have focused on reducing and eliminating releases of anoxic waters during power generation in the summertime. Thus, structural and operational changes were made to improve DO conditions below the tailrace of Pensacola Dam and are detailed in Section 6.2 of the PAD.

4.4.3 AIR 3 Land Use

The PAD at page 4 describes the existing Shoreline Management Plan for the project including the requirement for updates to be filed every 6 years, with the next update being due in 2019. Please describe the status of the required update to the Shoreline Management Plan.

Given the timing of the deadline for SMP updates (October 2019) relative to the relicensing schedule, GRDA will be proposing to integrate the next SMP update into the relicensing process. GRDA would file the updated SMP with its FLA (which under the current schedule will

be filed no later than March 31, 2020). GRDA will submit a formal request for extension of the SMP update deadline in the fall of this year, once FERC issues its Study Plan Determination.

4.4.4 AIR 4 Cultural Resources

The PAD at page 138 states that archaeological surveys of the project area were conducted between 1937 and 1940 by the Works Progress Administration, and that additional survey work continued after the creation of Grand Lake. The PAD also states that detailed records of these studies and reports on these investigations are not currently available. In the study plan for your proposed Phase I Cultural Resource Background Study, please clarify the steps taken to locate and obtain the study reports or records from these surveys and any plans GRDA has to review the existing pre- and post-construction records.

The Cultural Resources Study Plan, provided in Attachment A of this PSP, includes the requested detail.

5.0 NEXT STEPS: FINALIZING GRDA'S STUDY PLAN

5.1 Study Plan Meeting

The purpose of the Study Plan Meeting is to clarify the intent and contents of GRDA's PSP and identify any outstanding issues or information needed with respect to the proposed studies. In accordance with 18 C.F.R. § 5.11, GRDA is to hold the Study Plan Meeting required by the ILP within 30 days after the deadline for filing the PSP (no later than May 27). Due to an unavoidable conflict identified by the Tribes the week of May 21, meetings are scheduled for May 30, 2018, from 9:00 a.m. to 5:00 p.m. and May 31, from 9:00 a.m. to 12:00 p.m., at GRDA's Ecosystems and Education Center in Langley, Oklahoma. The background, concepts, and studies described in this PSP will be presented during the Study Plan Meetings. In addition, GRDA has scheduled a CRWG meeting for May 31, 2018, from 1:00 to 5:00 p.m. at the same location. The meeting agendas will be filed with FERC and will be available through GRDA's public relicensing website at http://www.grda.com/pensacola-hydroelectric-project-relicensing/.

To assist with meeting planning and logistics, GRDA requests that all relicensing participants who plan to attend the PSP meetings RSVP by sending an email to jjaggars@grda.com by May 21, 2018. Meeting RSVPs or questions about the meeting may also be directed by phone or mail to:

Ms. Jacklyn Jaggars
Administrative Assistant
Grand River Dam Authority
420 E Highway 28
Langley, OK 74350
(918) 256-0723
jjaggars@grda.com

5.2 Comments on the PSP

Comments on GRDA's PSP, including any revised information or study requests, must be filed with FERC within 90 days after the deadline for filing this PSP, or by July 26, 2018. Pursuant to

18 C.F.R. § 5.12, comments must also include an explanation of any study plan concerns and any accommodations reached with GRDA regarding those concerns. All proposed modifications to the PSP must also meet the aforementioned Study Criteria.

5.3 Revised Study Plan (RSP)

Upon receiving comments on the PSP, GRDA will update study plans based on comments that are consistent with FERC's Study Criteria. Pursuant to 18 C.F.R. § 5.13(a), by August 25, 2018, GRDA will file with FERC a RSP, including a summary of GRDA's proposed responses to all PSP comments. For any requested study submitted as part of PSP comments that GRDA does not adopt in the RSP, GRDA will explain the rationale for its decision with reference to the Study Criteria.

5.4 Study Plan Determination and Dispute Resolution (if Needed)

FERC will issue its study plan determination by September 24, 2018, within 30 days of GRDA's filing of the RSP. If any portions of the final Study Plan Determination are disputed by federal agencies with Section 4(e) and Section 18 authority or an agency or Tribe with authority to issue Section 401 water quality certification for the Project, a formal dispute resolution process will be initiated, as provided for under C.F.R. 18 § 5.14, and a final study dispute determination (constituting amendment of the approved study plan) for the disputed study components will be issued in December 2018.

6.0 IMPLEMENTATION OF FINAL STUDY PLAN

As required by 18 C.F.R. § 5.15, GRDA will provide progress reports in general, as study work progresses, and as detailed in the individual study plans (Attachment A), file an Initial Study Report (ISR), hold a meeting with relicensing participants and FERC staff to discuss the initial study results (ISR Meeting), file an Update Study Report (USR), and hold a meeting with relicensing participants and FERC staff to discuss the final study results (USR Meeting). GRDA will submit all study documents that must be filed with FERC via FERC's e-library system. Public study documents will also be provided through GRDA's public relicensing website (http://www.grda.com/pensacola-hydroelectric-project-relicensing/).

6.1 Relicensing Schedule

Table 6.1-1. Process plan and schedule. [1]

18 C.F.R.	Lead	Activity	Timeframe	Deadline
§ 5.5(a)	GRDA	Filing of NOI and PAD	Actual filing date	2/1/2017
§ 5.7	FERC	Initial Tribal Consultation Meeting	Waived	12/13/2018, 12/14/2018
§5.8	FERC	FERC Issues Notice of Commencement of Proceeding and SD1	Waived	1/12/2018

18 C.F.R.	Lead	Activity	Timeframe	Deadline
§5.8 (b)(3)(viii)	FERC/ Relicensing Participants	Public Scoping Meetings and Environmental Site Review	Within 30 days of NOI and PAD notice and issuance of SD1	Week of 2/5/2018
§ 5.9	Relicensing Participants / FERC	File Comments on PAD, SD1, and Study Requests	Within 60 days of NOI and PAD notice and issuance of SD1	3/13/2018
§5.10	FERC	FERC Issues Scoping Document 2 (SD2), if necessary	Within 45 days of deadline for filing comments on SD1	4/27/2018
§5.11(a)	GRDA	File Proposed Study Plans	Within 45 days of deadline for filing comments on SD1	4/27/2018
§5.11(e)	GRDA/ Relicensing Participants	Study Plan Meetings	Within 30 days of deadline for filing proposed Study Plans	Week of 5/21/2018 [2]
§5.12	Relicensing Participants	File Comments on Proposed Study Plan	Within 90 days after proposed study plan is filed	7/26/2018
§5.13(a)	GRDA	File Revised Study Plan	Within 30 days following the deadline for filing comments on proposed Study Plan	8/25/2018
§5.13(b)	Relicensing Participants	File Comments on Revised Study Plan (if necessary)	Within 15 days following Revised Study Plan	9/9/2018
§5.13(c)	FERC	FERC Issues Study Plan Determination	Within 30 days following Revised Study Plan	9/24/2018
§5.14(a)	Mandatory Conditioning Agencies	Notice of Formal Study (if necessary)	Within 20 days of Study Plan Determination	10/14/18
§5.14(l)	FERC	Study Dispute Determination	Within 70 days of notice of formal study dispute	12/23/18
§5.15(a)	GRDA	Conduct First Season Field Studies	October 2018 – August 2019	
§5.15(c)(1)	GRDA	File Initial Study Reports	No later than one year from Study Plan approval	9/24/2019
§5.15(c)(2)	GRDA	Initial Study Results Meeting	Within 15 days of Initial Study Report	10/09/2019
§5.15(c)(3)	GRDA	File Study Results Meeting Summary	Within 15 days of Study Results Meeting	10/27/2019
§5.15(c)(4)	Relicensing Participants / FERC	File Meeting Summary Disagreements / Modification to Study / Requests for New Studies	Within 30 days of filing Meeting Summary	11/26/2019
§5.15(c)(5)	GRDA	File Responses to Disagreements / Modification / New Study Requests	Within 30 days of disputes	12/28/2019

18 C.F.R.	Lead	Activity	Timeframe	Deadline
§5.15(c)(6)	FERC	Resolution of Disagreements / Study Plan Determination (if necessary)	Within 30 days of filing responses to disputes	1/27/2020
§5.15	GRDA	Conduct Second Season Field Studies	October 2019 – August 2020	
§5.15 (f)	GRDA	File Updated Study Reports	No later than two years from Study Plan approval	9/24/2020
§5.15(c)(2)	GRDA	Second Study Results Meeting	Within 15 days of Updated Study Report	10/11/2020
§5.15(c)(3)	GRDA	File Study Results Meeting Summary	With 15 days of Study Results Meeting	10/26/2020
§5.15(c)(4)	Relicensing Participants / FERC	File Meeting Summary Disagreements / Modification to Study / Requests for New Studies	Within 30 days of filing Meeting Summary	11/25/2020
§5.15(c)(5)	GRDA	File Responses to Disagreements / Modification / New Study Requests	Within 30 days of disputes	12/27/2020
§5.15(c)(6)	FERC	Resolution of Disagreements / Study Plan Determination (if necessary)	Within 30 days of filing responses to disagreements	1/26/2021
§5.16(a)	GRDA	File Preliminary Licensing Proposal (or Draft License Application) with FERC and distribute to relicensing participants	Not later than 150 days before final application is filed	11/3/2019 [3]
§5.16 (e)	FERC / Relicensing Participants	Comments on GRDA Preliminary Licensing Proposal, Additional Information Request (if necessary)	Within 90 days of filing Preliminary Licensing Proposal (or Draft License Application)	2/3/2020 [3]
§5.17 (a)	GRDA	License Application Filed		3/31/2020 [3]

Notes:
1. Shaded milestones are unnecessary if there are no study disputes.
2. Due to an unavoidable conflict identified by the Tribes the week of May 21, the PSP meeting is scheduled for the week of May 28 (see Section 5.1 of this PSP for details).
3. Because of delay caused by ILP abeyance, these deadlines fall before completion of the ILP pre-filing milestones required by § 5.15 of FERC's regulations.

6.2 Relationship of Study Program to License Application Deadline

Many of GRDA's proposed studies are scheduled to require two full years to complete field work and analysis. In addition, as described in Section 3 of this PSP and in the individual study plans included in Attachment A, depending on results of the H&H Study, GRDA may determine, in consultation with relicensing participants, that a second field season for some studies is warranted.

As described in more detail in Section 1.3 of this PSP, the delay in the ILP process due to a lack of a quorum of FERC commissioners resulted in an incongruity between the ILP process and the statutory deadline under the FPA for GRDA to file its FLA with FERC. Under the current relicensing schedule (Table 6.1-1), nearly the entire second field season (October 2019-August 2020) and associated study reporting (USR; due September 2020) are scheduled to occur *after* GRDA files both the PLP/DLA (due November 2019) and FLA (due March 2020). GRDA is concerned that this unintended result will create challenges and redundancies in the relicensing effort, as both the DLA/PLP and FLA will be supported by incomplete information, while studies in the second season will be ongoing. This process would be administratively challenging, as GRDA and other relicensing participants would be forced to prepare and comment on an incomplete DLA/PLP and FLA, and then supplement and re-review the incomplete documents as the second study season concludes.

To avoid this circumstance and align the ILP process with the license expiration date, GRDA will be seeking a modest extension of the existing license term, such that the license application filing date can be adjusted, as appropriate, to match the ILP process. The Commission has adopted this strategy in other projects facing other uncontrollable circumstances,[94] and GRDA believes that a reasonable extension in this case will be widely supported, as this approach would benefit all relicensing participants by allowing the ILP to proceed as envisioned in FERC's regulations.

GRDA expects to conduct informal outreach to relicensing participants in this approach as part of the upcoming study plan meetings. Once GRDA and relicensing participants have completed the ongoing effort to develop the study plan and FERC issues its Study Plan Determination, GRDA anticipates filing the license extension application with the Commission at that time.

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ATTACHMENT A. STUDY PLANS

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Pensacola Hydroelectric Project, FERC No. 1494

Proposed Study Plan

Hydrologic and Hydraulic Modeling Study

Prepared for

GRDA
Grand River Dam Authority

Prepared by

Mead & Hunt
www.meadhunt.com

April 2018

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LIST OF ACRONYMS

1-D ..... one-dimensional
2-D ..... two-dimensional
BIA ..... Bureau of Indian Affairs
CHM ..... Comprehensive Hydraulic Model
DEM ..... digital elevation model
FEMA ..... Federal Emergency Management Agency
FERC ..... Federal Energy Regulatory Commission
GRDA ..... Grand River Dam Authority
HEC ..... Hydrologic Engineering Center
HEC-RAS ..... Hydrologic Engineering Center's River Analysis System
H&H ..... Hydrologic and Hydraulic
LiDAR ..... Light Detection and Ranging
NED ..... National Elevation Dataset
NGVD ..... National Geodetic Vertical Datum
OK ..... Oklahoma
OU ..... University of Oklahoma
OWRB ..... Oklahoma Water Resources Board
PAD ..... Pre-Application Document
PD ..... Pensacola datum
Project ..... Pensacola Hydroelectric Project
PSP ..... Proposed Study Plan
SD1 ..... Scoping Document 1
USACE ..... U.S. Army Corps of Engineers
USFWS ..... U.S. Fish and Wildlife Service
USGS ..... U.S. Geological Survey
VBA ..... Visual Basic for Applications

1.0 INTRODUCTION

The Grand River Dam Authority (GRDA) filed a Pre-Application Document (PAD) with the Federal Energy Regulatory Commission (FERC) on February 1, 2017, as part of relicensing the Pensacola Hydroelectric Project (Pensacola Project or Project; FERC No. 1494). In Section 7 of the PAD, GRDA proposed a Hydrologic and Hydraulic Modeling Study (H&H Study) that will model the Grand/Neosho River, including several tributaries, both upstream and downstream of Pensacola Dam. The modeling effort under the H&H Study will produce a tool for analyzing the effects of GRDA's operation of the Project under the new license, as well as indirect and cumulative impacts associated with flood control operations, which are under the exclusive jurisdiction of the U.S. Army Corps of Engineers (USACE).

As indicated in Section 3.1 of the main body of the Proposed Study Plan (PSP), GRDA proposes to conduct a comprehensive H&H Study as presented in this study plan.

FERC's January 12, 2018 Scoping Document 1 (SD1) identified the following environmental resource issues to be analyzed for the Project relicensing:

- 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 the Pensacola Dam, and drought/low flow periods.

In addition to the inundation area, the H&H Study will provide other flood routing specifics such as the frequency, timing, amplitude, and duration of the inundation. The information obtained from the H&H Study will also inform separate analyses about the effects of inundation on resources such as geology and soils, water resources, fisheries and aquatic resources, terrestrial resources, threatened and endangered resources, cultural resources, and power generation. The H&H Study will also help determine lands needed for Project purposes and, therefore, inform FERC's determination of the placement of the Project Boundary.

FERC, Bureau of Indian Affairs (BIA), U. S. Fish and Wildlife Service (USFWS), City of Miami, Miami Tribe, Eastern Shawnee Tribe, Ottawa Tribe, Seneca-Cayuga Nation, Wyandotte Nation, Cherokee Nation, and N. Larry Bork (counsel for the City of Miami citizens) subsequently submitted formal requests related to flood control operations and inundation. Sections 4.1.1 and 4.2.1 of the main body of the PSP detail GRDA's response to these requests.

2.0 STUDY PLAN ELEMENTS

2.1 Study Goals and Objectives

The overall H&H Study goal is to provide information, through modeling and mapping, to support the determinination 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 such 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.

2.2 Agency and Native American Tribe Resource Management Goals

The modeling and mapping results can inform separate efforts to assess Project effects on resources such as geology and soils, water resources, fisheries and aquatic resources, terrestrial resources, tribal lands, paddlefish spawning recruitment, wildlife lands, threatened and endangered resources, cultural resources, and power generation. Such analyses, in turn, can inform agency decision making pursuant to their statutory obligations.

2.3 Background and Existing Information

There is a considerable amount of public information available to support and inform the H&H Study. The information consists of previous hydraulic models, flow, stage and high-water mark data (hydrology), bathymetry, topography, and sedimentation.

Hydraulic Models

Several hydraulic models have previously been developed for portions of the Grand Lake Watershed. Previous hydraulic models on the Neosho River upstream from Grand Lake and a hydraulic model of Tar Creek are currently available in the public record. Additionally, a previously cited, but not publicly available, model exists that extends from Twin Bridges State Park, Fairland, Oklahoma (OK) (Twin Bridges) to the U. S. Geological Survey (USGS) Gage No. 07185000, Neosho River near Commerce, OK (USGS gage at Commerce) (Holly 2001, 2004); however, due to inaccessibility, this model will not be reviewed or used as a basis in the H&H Study. The publicly available hydraulic models that will be discussed further are listed below as they are commonly cited:

- USACE Model (1996)
- Simons Model (1998)
- University of Oklahoma (OU) Model (Dennis 2014)
- FERC Model (2015)
- Tetra Tech Models (Tetra Tech 2010, 2013, 2015)
- Federal Emergency Management Agency (FEMA) Tar Creek Model (2015)

USACE (1996) and Simons (1998) Models

Both the USACE and Simons Models utilize a USACE Hydrologic Engineering Center (HEC) software called HEC-2, which was released in 1990. The Neosho River from Twin Bridges to just upstream of the USGS gage at Commerce was modeled as steady-state[1] in these efforts. Since the efforts utilize data collected in 1995 and 1997 (topography and bathymetry) and do not include Grand Lake, they will not be used as a model basis for the H&H Study.

[1] A steady-state model utilizes a constant inflow value that does not vary with time.

OU Model (Dennis 2014)
GRDA commissioned a hydraulic study through the University of Oklahoma (OU) in 2014 for a previous Project license amendment request. The OU Model was developed using one-dimensional (1-D) HEC-River Analysis System (RAS) software and included the Neosho River and several major tributaries from Pensacola Dam to the USGS gage at Commerce. The OU Model relied on the 1996 USACE bathymetry data for the Neosho River between Twin Bridges and the USGS gage at Commerce and on 2008 bathymetric survey information for Grand Lake from the Oklahoma Water Resources Board (OWRB). The model also used Light Detection and Ranging (LiDAR)-acquired topography collected for the USGS in 2011 to represent overbank areas.

The OU Model will not be used as a model basis for the H&H Study due to the age of the bathymetry data (1996) and the limited purpose for which this model was developed.

FERC Model (2015)
In 2015, FERC developed an independent hydraulic model in response to the proposed license amendment to modify the rule curve under the Project's license. The FERC Model was created using the OU Model as a basis in 1-D HEC-RAS software and was modified to overcome the original limits of the OU Model. The FERC model was calibrated using roughness values from historic flood events and was an unsteady-state[2] analysis for the Neosho River; however, the model did not include the portion of the Grand Lake downstream of Twin Bridges.

The FERC Model will not be used as a model basis in the H&H Study because it does not represent the Spring River, Elk River, or Grand Lake.

Tetra Tech Models (2010, 2013, 2015)
In 2010, 2013, and 2015, the City of Miami commissioned Tetra Tech to develop a hydraulic model. The 2010 and 2013 Models utilized proprietary FLO-2D software, which has both 1-D and two-dimensional (2-D) capabilities. The 2010 and 2013 Models utilized USACE 1996 topography and Simons 1998 bathymetry to focus on the vicinity of the City of Miami and the Neosho River.

The 2015 Model improved upon the 2010 and 2013 Models by utilizing HEC-RAS Version 5.0 software, which also has 1-D and 2-D capabilities. The 2015 Model included unsteady-state 1-D and 2-D areas for the Grand/Neosho River from Pensacola Dam to the USGS gage at Commerce. It also incorporated bathymetric survey data for the Grand/Neosho River collected by Tetra Tech in April 2015 specifically for the 2015 Model.

Although the 2015 Model has some deficiencies and requires several improvements for use in the H&H Study, it provides the best existing model basis for moving forward into the H&H Study. The 2015 Model, along with proposed improvements, will be used as a basis for the H&H Study. The list of improvements, including updated bathymetric data from 2017, are outlined in Section 2.6, Methodology.

[2] An unsteady-state model utilizes varying inflows through the cycle of the inflow event to show the conditions as the inflow event moves through the river system. Unsteady-state modeling is considered to be the most-representative of natural conditions occurring in the river system during the inflow event.

FEMA Tar Creek Model (2015)

FEMA developed the Tar Creek 1-D HEC-RAS Model as part of their flood risk mapping efforts for the Grand Lake Watershed. The FEMA Model extends approximately 7.5 miles up Tar Creek from its confluence with the Spring River. After a review of information associated with the FEMA Model, it was determined that utilizing available USGS 2011 LiDAR data as the model basis for the Tar Creek portion of the watershed, versus the data from the FEMA model, is not the best approach to attain the goals of the H&H Study. Therefore, the FEMA Model will not be used as a basis for the H&H Study.

Hydrology

The following hydrology information will be reviewed and utilized, as appropriate, in the H&H Study.

- USGS data from the following six gages:
  - Neosho River near Commerce, OK (USGS Gage No. 07185000).
  - Neosho River at Miami (USGS Gage No. 07185080).
  - Tar Creek at Miami, OK (USGS Gage No. 07185095).
  - Spring River near Quapaw, OK (USGS Gage No. 07188000).
  - Elk River near Tiff City, MO (USGS Gage No. 07189000).
  - Lake O' The Cherokees at Langley, OK (USGS Gage No. 0719000).
- GRDA records of flow release and water surface elevations at Pensacola Dam.
- Surveyed high-water marks during and after historical inflow events.

Topography

The following sources of topographic data will be reviewed and utilized, as appropriate, in the H&H Study:

- LiDAR survey conducted by the USGS in 2011 (does not cover entire study area).
- USGS 1/3 arc-second (10-meter) National Elevation Dataset (NED) digital elevation model (DEM).

LiDAR coverage is not available in the upper reaches of some of the tributaries associated with the H&H Study. For those areas without coverage, information from the NED will be used for the H&H Study.

Bathymetry

The following sources of bathymetric data will be reviewed and utilized, as appropriate, in the H&H Study:

- 2008 OWRB bathymetric survey for Lake Hudson extending from just upstream of Kerr Dam to just downstream of the Project.
- 2009 OWRB bathymetric survey of Grand Lake and 4.5 miles of the Neosho River upstream of the confluence of the Spring River.
- 2017 USGS bathymetric survey of the Neosho River, Spring River, and Elk River.

Sedimentation Historical Cross-Sections

The H&H Study proposes to use the cross-section information from the 1996 USACE Hydraulic Model or 1997 USACE DEM data, where appropriate, for comparison in determining the impact of sedimentation on the results of current model runs.

Operations Model

The following sources of data will be reviewed and utilized, as appropriate, in the Operations Model.

- Facility drawings (GRDA)
- Turbine hill curves (Siemens 1999 and Bertrand 2009)
- Generator efficiency vs. load curves (Siemens 1999 and Bertrand 2009)
- Turbine index testing (Siemens 1999 and Bertrand 2009)
- Turbine air valve operation vs. turbine efficiency data (Bertrand 2009)
- USACE spillway discharge capacity rating (USACE 1990 and 1991)
- Reservoir stage-storage curves for Grand Lake
- Historical observed operations data (headwater elevation, tailwater elevation, and discharge) collected by GRDA

Area Capacity Curve

The 2009 OWRB area capacity curves for Grand Lake contained in the hydrographic survey report will be reviewed and utilized, as appropriate, in the H&H Study.

2.4 Nexus between Project Operations and Effects on Resources

Project operation influences water levels of the Grand/Neosho River, as well as some tributaries, both upstream and downstream of Pensacola Dam. The H&H Study will help quantify these influences; improve understanding of the magnitude, duration, and frequency of such influences; identify the operational sources of such influences (e.g., hydroelectric operations and USACE flood control operations); and assist in analyzing resource-level effects that could be associated with these influences. The H&H Study will also help identify changes in areas inundated, if any, that may be associated with any changes to current operations that may be proposed by GRDA as part of the relicensing effort.

2.5 Study Area

The overall H&H Study will encompass the channel and overbank areas of the Grand/Neosho River watershed that have a measurable difference in water surface elevations due to Project operation during the measured inflow events of the H&H Study (See also Section 2.6 Methodology of this study plan). Initially, along the main tributaries, the study will extend upstream from the Pensacola Dam along the Grand/Neosho River to within approximately 3 miles of the Kansas State line, upstream along the Spring River to within 6.5 miles of the Kansas State line, and upstream along the Elk River approximately 11.5 miles beyond the State

line into Missouri, and along Tar Creek which will extend just upstream of the USGS gage at the 22nd Avenue Bridge (Figure 2.5-1). The study will also encompass the bays/coves within Grand Lake associated with tributaries flowing into the lake.

The overall H&H Study will also include channel and overbank areas that have a measurable difference in water surface elevations due to Project operation during the measured inflow events extending downstream of the Pensacola Dam.

While this Section 2.5 identifies the initial H&H Study area, as descried in Section 2.6 below, the Comprehensive Hydraulic Model (CHM) will be refined, as necessary and appropriate, through an iterative process.

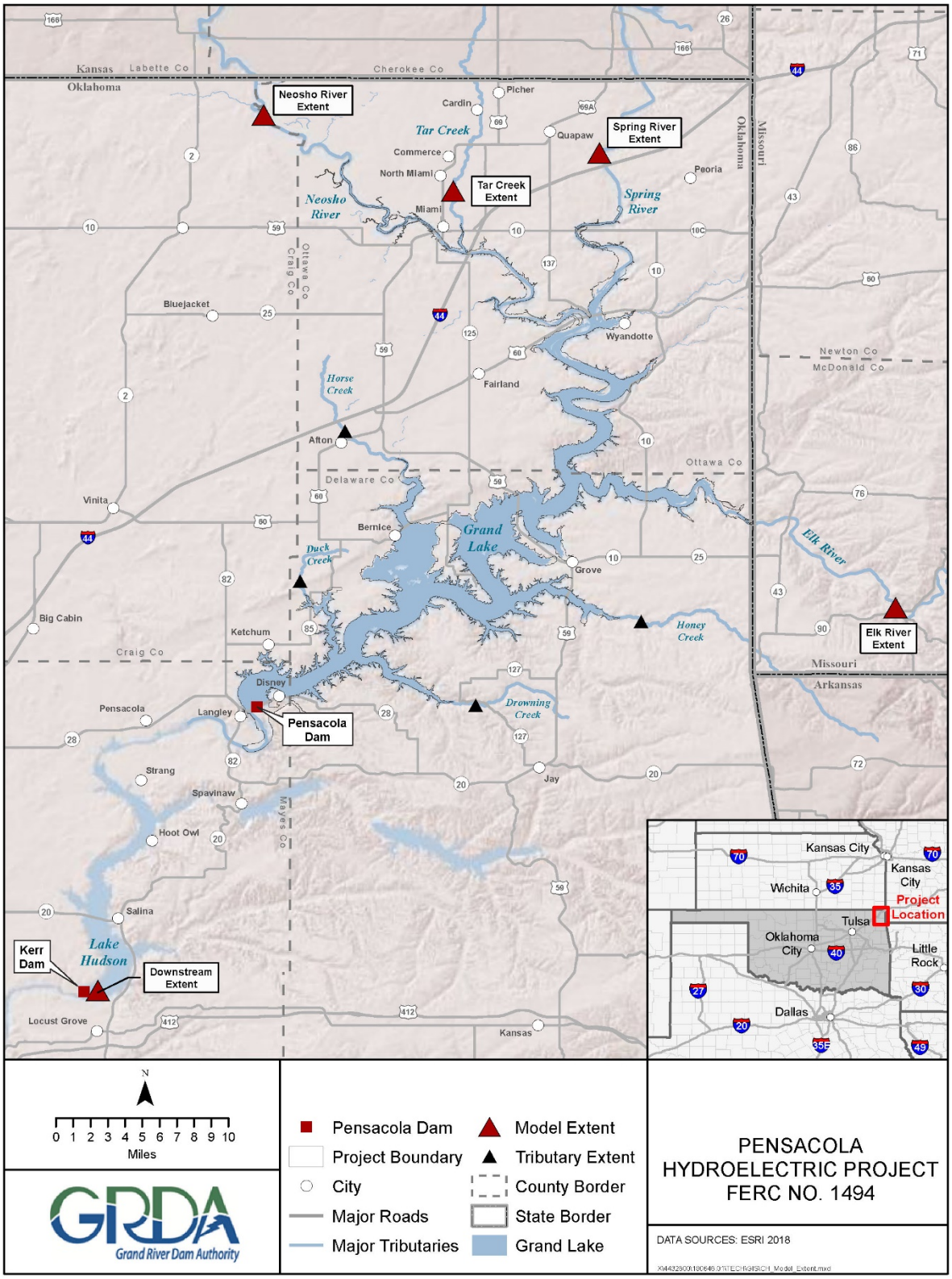

Figure 2.5-1. H&H modeling initial study area.

2.6 Methodology

For the H&H Study, a CHM will be constructed to determine the inundation areas and other flood routing specifics during several measured inflow events where inflow hydrographs already exist.

To evaluate the effects of any proposed operational changes, a separate Operations Model will be constructed to synthesize hypothetical events that inform the CHM. Informing the CHM with the synthetic or hypothetical events will predict the water surface elevations and other flood routing specifics that could occur because of changes to Project operations. This will allow for a comparison between flood routing specifics resulting from different operation scenarios.

To evaluate the extent to which sedimentation affects the results of the CHM, the CHM with the current channel geometry will be modified by inserting historical channel geometry in the place of the 2017 channel geometry to create a new CHM. The new CHM will be re-run under a wide range of inflow events and operating scenarios. This will allow for a comparison between flood routing specifics resulting from the effect of sediment accretion and erosion in the river channels. The effects of the Project operation on sediment accretion and erosion will be the subject of a separate Sedimentation Study.

A hydrology analysis will provide context to the magnitude of measured inflow events being used for runs of the CHM. As a result, the flood frequency at the Pensacola Dam of all the measured inflow events where hydrographs already exist will be determined to provide a frame of reference to their overall magnitude and recurrence.

Comprehensive Hydraulic Model (CHM)

The CHM will use the USACE HEC-RAS software Version 5.0.3 or later. This software is the engineering standard for this type of analysis because it is the most up-to-date version of the software. The software has the capability to perform unsteady-state analyses in both 1-D and 2-D. The Tetra Tech 2015 Model will be utilized as a basis to create the new CHM. Like the Tetra Tech 2015 Model, the CHM will be a single (inflow) event model.

In addition to using the Tetra Tech 2015 Model as a basis on the Grand/Neosho River, the CHM will also extend upstream and include the Spring River, Elk River, Tar Creek and downstream through Lake Hudson to just upstream of Kerr Dam.

For upstream terrain and bathymetric data, the CHM will represent overbank areas using the DEM derived from the 2011 USGS LiDAR data. Where needed, the DEM derived from the 2011 LiDAR will be supplemented with a coarser 1/3 arc-second DEM gathered from the USGS NED. The bathymetric data collected by the OWRB will be used to represent the bottom of Grand Lake.

The bathymetric data for the Neosho, Spring, and Elk Rivers gathered during the 2017 USGS survey will also be incorporated into the CHM. The 2017 USGS bathymetric data extends along both the Neosho and Spring Rivers from the Kansas/Oklahoma state line downstream to the confluence of the two rivers near Twin Bridges. The 2017 USGS bathymetric data also extends along the Elk River from just downstream of Noel, Missouri, to the Oklahoma State Highway 10 bridge near Grove, Oklahoma. USGS has processed the survey data into a DEM that will represent the channel bottom. The DEM of the channel bottom will be merged with the DEM used in the CHM that represents the overbank areas and bathymetry within Grand Lake.

The CHM will also incorporate various stream crossings/bridges according to the original design drawing geometries obtained (or according to field verification, if design drawings are not available).

For upstream of Pensacola Dam, the CHM will utilize the Tetra Tech 2015 Model as a basis for the location of cross-sections and 2-D areas included within the model. A review of the location of the Tetra Tech 2015 Model basis cross-sections will be completed and additional cross-sections to provide the necessary model resolution will be added to make the CHM more robust than the Tetra Tech 2015 Model (e.g. the number of cross-sections in Grand Lake will be increased and cross-sections for the Spring River and the Elk River will be added to the CHM).

The upper portions of Grand Lake (upstream of Sailboat Bridge) will be represented as 1-D cross-sections with adequate spacing and configuration to represent the reservoir volume. The study reach through Grand Lake downstream of Sailboat Bridge will be represented as a 2-D model. Both the 1-D cross-sections and 2-D grid will be extracted using the 2011 USGS LiDAR data and USGS 1/3 arc-second DEM (where needed) for the overbank portions, along with the 2009 OWRB Bathymetric Data for Grand Lake for the reservoir bottom

Spring River will be represented as a 1-D reach. The 1-D cross-sections will be extracted using the 2011 USGS LiDAR data and a USGS 1/3 arc-second DEM (where needed) for the overbank portions, along with the 2017 USGS bathymetric data obtained for the channel bottom.

Elk River will be represented as a 1-D reach, with cross-sections extracted using the 2011 USGS LiDAR and a USGS 1/3 arc-second DEM (where needed) to represent the overbank areas, along with the 2017 USGS bathymetric data for the channel bottom.

Tar Creek will be represented as a 2-D model, with the 2-D grid extracted using the 2011 USGS LiDAR and a USGS 1/3 arc-second DEM (where needed) to represent the overbank areas. In place of bathymetry, the 2011 LiDAR data will be used.

For the CHM section downstream of Pensacola Dam, an unsteady-state 1-D HEC-RAS model will be developed, extending from just downstream of the Pensacola Dam, through Lake Hudson to just upstream of Kerr Dam.

For downstream terrain, the 1/3 arc-second (approximately 10-meter resolution) DEM from the NED will be used. The topographic data will be downloaded from the USGS and compiled to generate a single, large DEM to represent the study area.

For downstream bathymetry, the 2008 bathymetric survey for Lake Hudson by the OWRB extending from just upstream of Kerr Dam to just downstream of the Project will be utilized. It will represent the river/reservoir bottom throughout the downstream section of the CHM. The bathymetric data will be merged with the NED to create the terrain model that will be used in the CHM.

In the downstream study reach, the CHM will also incorporate various stream crossings/bridges according to the original design drawing geometries obtained (according to field verification if design drawings are not available). These bridges include Highway 82, Strang Road, and Highway 20.

Hydraulic roughness coefficients are an important part of the CHM. Therefore, aerial photography and site observations will be used to establish roughness coefficients, which will be

cross-checked against the coefficients used in the 2015 Tetra Tech Model in the areas where the two models overlap. Standard Manning's n references will be utilized to correlate the existing overbank land uses to roughness coefficients. During calibration of the CHM, roughness values will be adjusted as appropriate to improve consistency with observed high water marks or flood conditions.

Operations Model

The Operations Model is a tool that will be used to synthesize and create events that inform or set the boundaries[3] of a CHM run. In addition to the operation of the Project, the model will account for cumulative effects of project operations on the upstream and downstream dams operated by the USACE, but the model will not explicitly include those projects.

The extent of the Operations Model will include Grand Lake upstream of Pensacola Dam and downstream (possibly through Lake Hudson upstream of Kerr Dam) as far as required to synthesize inflows to create CHM input boundaries. The Operations Model will utilize a level-pool routing method.

A comparison of the water surface elevations and other flood routing specifics that could occur from different operating scenarios will be based on the different CHM boundary conditions synthesized through the Operations Model for those same operating scenarios. This comparison will illustrate the change in inundation areas and other flood routing specifics arising from the operational changes. The Operations Model can also be used to predict differences in power for different operating scenarios.

The Operations Model will be a Microsoft Excel spreadsheet-based tool, including Visual Basic for Applications (VBA) subroutines to enhance the functionality of the Excel model. The Operations Model will calculate hourly outflows and generation based on various physical constraints (i.e. friction headloss between the reservoir and the turbines, turbine generator efficiency curves, dissolved oxygen valves opened and closed, spillway discharge rating curves, reservoir stage-storage curves, tailwater rating curves, and turbine maximum discharge vs. head rating curves), USACE flood routing operations, and Project operating rules.

Friction loss will be calculated based on facility drawings.

Turbine and generator efficiency curves will be developed from existing turbine hill curve, generator efficiency vs. load curve, turbine index testing, and turbine air valve operation vs. turbine efficiency data.

Spillway discharge capacity rating curves for Pensacola Dam will be transcribed from existing USACE curves and extrapolated to higher elevations as needed. The Operations Model will not track how many spillway gates are open or what the gate opening height is at any given time; rather an elevation vs. capacity table will be used to determine the maximum potential spillway discharge for any given reservoir elevation. The model may discharge less than full capacity

[3] The boundaries of the CHM are best described as the stage hydrograph at the dam. When operational changes are being modeled, the Project outflow hydrograph must be synthesized, and a hypothetical stage hydrograph needs to be created based upon the operation of the facility. The hypothetical or synthetic stage hydrograph created using the operations model will set the boundaries for the CHM model run.

through the spillway, according to the other model constraints, but it will not exceed the maximum capacity of the spillway.

Reservoir stage-storage curves will be transcribed from existing curves.

The tailwater rating curve for Pensacola Dam will be developed based on historical observed tailwater elevation and discharge data collected by GRDA.

The turbine maximum discharge vs. head rating curves will be based on existing turbine efficiency curves.

For predictive comparisons (i.e., not for calibration to historical events, but rather for hypothetical comparisons, such as comparisons between different initial reservoir elevations), the amount of total discharge required at each time step during a flood event when the USACE would dictate flood control operations will be determined either from rating curves to be provided by USACE, or from an analysis of historical hourly operations data (headwater level, inflow, and total outflow) will be used to generate a representative rating curve.

Calibration

Calibration of the CHM is necessary before the results can be considered representative. The CHM will be calibrated using several historic inflow events that represent a relatively broad range of the recorded and surveyed high water marks available. The CHM will be adjusted until calibration is completed. The calibration will be considered complete when the predicted water-surface elevations approach the measured values and timing of the predicted stage hydrograph between the CHM and the inflow event recorded at stream gages within the study area are acceptable.

Calibration of the Operations Model is also necessary before results of the Operations Model or the CHM can be considered representative. The Operations Model will be calibrated using several wide-ranging operational periods of historical operations data at the Pensacola Dam. The modeled annual power generation totals will be compared to the observed historical annual power generation totals to assess the effectiveness of the calibration. Model inputs which can be varied to effect a better calibration include operating rules, physical system characteristics, hydrologic routing methods, and quality control processes applied to observed historical data.

Study Area Determination

Section 2.5 outlines an initial study area for the CHM. Unlike the Operations Model, which will include Grand Lake upstream of Pensacola Dam and downstream as far as required to synthesize inflows to create CHM input boundaries, the CHM study area will be determined through an iterative process. In the iterative process, several CHM runs at varying ranges of measured inflow events and operating scenarios will be required to determine the actual extent upstream to which the CHM will need to reach. If a CHM run demonstrates a measurable water surface elevation difference at the most-upstream extent of the CHM that is also significant in terms of effects on resources, the CHM will need to be extended upstream. When the CHM results for a range of measured inflow events no longer show overbank areas that have a measurable water surface elevation difference, the CHM upstream extent will be finalized.

Model Runs

A minimum of six inflow hydrographs (including the 2007[4] inflow hydrograph) for the current licensed operating scenario will be run at starting reservoir elevations at Pensacola Dam ranging from 742 feet to 745 Pensacola datum (PD)[5] in one-foot increments.

An additional suite of model runs following the same parameters will also be run for each alternate operating scenario that GRDA may propose using the synthetic inflow data created by the Operations Model.

Sedimentation

To evaluate the extent to which sedimentation affects the results of the CHM, the model with the current channel geometry will be modified by inserting the 1996/1997 USACE channel geometry in the place of the 2017 channel geometry to create a new CHM. The new CHM will be re-run under a wide range of inflow events and operating scenarios, which will allow for a comparison between flood routing specifics resulting from the effect of sediment historically deposited in the river channels. The effects of the Project operation on sediment accretion and erosion will be the subject of the separate Sedimentation Study. Since historical channel geometry data is only available for the Grand/Neosho River channel and Grand Lake, this comparison will be limited to the effects of sedimentation in the Grand/Neosho River and Grand Lake.

Flood Frequency

To provide a perspective about the frequency of the inflow events utilized in individual runs of the CHM, a flood frequency analysis will be completed to provide a recurrence interval for each modeled inflow event at the Project.

Because responsibility for flood regulation (USACE vs. GRDA) and the amended license rule curves for Grand Lake are based on the current and projected future elevations at the gage near Pensacola Dam, inflow recurrence intervals should properly be based on the total inflow at the location of the gage, just upstream of the dam. The inflow at a point just upstream of Pensacola Dam is not a historically-observed parameter. Therefore, calculations including the total turbine and spillway discharge, reservoir stage-storage curves, headwater level, and USGS stream gage discharge will be used when creating the (back-calculated) inflow data set for the frequency analysis.

Ungaged inflow will be determined based on the total discharge at the dam, plus the change in storage in the reservoir, minus other (observed) inflows for a given time step. Hydrologic routing will be used to combine the observed and ungaged inflow at a point just upstream of the dam. The reservoir level gage that produced the headwater level data is not a perfect instrument. Reservoir level gage reading fluctuations on the order of a few hundredths of a foot can significantly alter the back-calculated inflow time series values and can even result in large negative values if the reservoir level decreases substantially without a corresponding recorded outflow. A time-averaging procedure will be used to eliminate negative values due to imprecision/fluctuation in the reservoir level gage data.

[4] The 2007 inflow hydrograph is the largest inflow event of recent record on the Neosho River.

[5] All elevations referenced are relative to PD. PD elevations can be converted to National Geodetic Vertical Datum of 1929 (NGVD) by adding 1.07 feet and to North American Vertical Datum of 1988 (NAVD) by adding 1.40 feet (for example, elevation 745 feet PD = 746.07 feet NGVD = 746.4 feet NAVD88)(http://ok.water.usgs.gov/projects/webmap/miami/datum.htm).

Area Capacity Curve

The OWRB has developed up-to-date area capacity curves for Grand Lake. However, the area capacity curves only reach to an upper elevation of 745 PD feet, which matches upper elevation of the conservation pool. The OWRB curve will be modified to reach an upper elevation of 760 feet PD and will identify areas above the elevation of 745 PD, which is outside of GRDA's operation of the Project.

Deliverables

To allow relicensing participants to better understand the CHM and the Operations Model, GRDA will provide a model input status report in April 2019. This will allow relicensing participants to obtain information on model runs proposed as part of the H&H Study.

To allow relicensing participants to review the modeling results, the H&H Study will provide a technical report, maps displaying areas of inundation, and maps comparing the inundation areas under varying operation constraints beginning with a starting reservoir elevation of 742 feet PD and increasing in one-foot increments to a maximum of 745 feet PD. The technical report will also include the results of flood frequency analyses and the modified area capacity curve.

The technical report will document the data sources, the input hydrology, how the CHM and the Operations Model were developed, the assumptions used in creating the models, the calibration processes, and their results. It will provide an explanation of the USACE involvement in Project operation, graphs and summary tables for stage and outflows synthesized by the Operations Model, and an explanation of input parameters for each CHM scenario run. The technical report will also include a description of the flood frequency analysis, the results of the analyses, and a description of the limitations of the analyses.

Inundation depth maps layered on recent aerial photos with the current Project Boundary depicted will be provided in electronic format. Each set of inflow event maps will include an inundation line to represent the maximum water surface elevation, the current flowage easements, and identification of any stuctures within the inundation areas. Flood maps will include overlays of ownership of lands flooded.

Another set of inundation maps to be provided will be identical to the maps described above, but but will incorporate the inundation areas resulting from CHM runs with the 1996/1997 USACE channel geometry visible as a separate layer. This set of maps will incorporate a description of the change in anticipated impacts of sediment accumulated in the river system since 1996/1997.

2.7 Consistency with Generally Accepted Scientific Practice

The H&H Study incorporates methods and data that are consistent with generally accepted scientific practice. The scope of the study will encompass the entire area that is inundated during measured inflow events. This includes the Spring River, Elk River, Grand/Neosho River, and Tar Creek.

Specifically, after a thorough data review and inventory, the study will incorporate the 2017 USGS bathymetric data and the 2011 LiDAR information. It will also incorporate bridge

geometry (or field-verified information) when developing cross-sections for critical locations where existing infrastructure are believed to restrict the flow beyond the channel or floodplain.

The CHM in the H&H Study will use HEC-RAS Version 5.0.3 or later software, which is the standard in the engineering community for hydraulic studies of river systems. It will incorporate both 1-D and 2-D reaches to accurately represent the flow patterns both in the vicinity of bridges and in areas of broad floodplains within the study area.

The limitations to any previous hydraulic models will be further addressed by extending the model further upstream and including the Spring and Elk Rivers into the model to address stakeholder interest, including tribal interests. In addition, the resolution of cross-sections in Grand Lake will be increased to understand in detail the interactions of the various major tributaries when they enter Grand Lake.

The CHM will be calibrated using several historic inflow events that represent a relatively broad range of the recorded and surveyed high water marks available and all model elevations will reference National Geodetic Vertical Datum (NGVD) 1929 as a common datum.

The Operations Model will be a Microsoft Excel spreadsheet-based tool, including VBA subroutines to enhance the computation efficiency of the Excel model. Calibration of the Operations Model will be completed using several wide-ranging operational periods of historical operations data at the Pensacola Dam. The modeled annual power generation totals will be compared to the observed historical annual power generation totals to assess the effectiveness of the calibration. Model inputs which can be varied to effect a better calibration include operating rules, physical system characteristics, hydrologic routing methods, and quality control processes applied to observed historical data.

2.8 Schedule

The schedule for completion of the H&H Study is displayed in Table 2.8-1.

Table 2.8-1. H&H modeling study schedule.

Task	Completion Date
Anticipated Completion of Study Plan Determination Process	9/24/2018
Model Input Status Report	04/01/2019
Initial Study (Technical) Report	09/24/2019
Second Field Season-Additional Analysis and Updates	08/01/2020
Updated Study (Technical) Report	09/24/2020

2.9 Level of Effort and Cost

The total estimated cost for the entire H&H Study as outlined in the Methodology section of this study plan is approximately $800,000.

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Pensacola Hydroelectric Project, FERC No. 1494

Proposed Study Plan

Sedimentation Study

Prepared for

Prepared by

Mead & Hunt

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April 2018

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LIST OF ACRONYMS

ADCP ..... Acoustic Doppler Current Profiler
CHM ..... Comprehensive Hydraulic Model
FERC ..... Federal Energy Regulatory Commission
GRDA ..... Grand River Dam Authority
LiDAR ..... Light Detection and Ranging
OWRB ..... Oklahoma Water Resources Board
Project ..... Pensacola Hydroelectric Project
PSP ..... Proposed Study Plan
SD1 ..... Scoping Document 1
SSC ..... suspended sediment concentration
SWAT ..... soil and water assessment tool
USACE ..... U.S. Army Corps of Engineers
USGS ..... U.S. Geological Survey

1.0 INTRODUCTION

The Pensacola Hydroelectric Project (Pensacola Project or Project), owned and operated by the Grand River Dam Authority (GRDA), is licensed by the Federal Energy Regulatory Commission (FERC or Commission) as Project No. 1494. GRDA is a non-appropriated 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." As licensed by FERC, the Project serves multiple purposes, including hydropower generation, water supply, public recreation, and wildlife enhancement. As directed by Congress under the Flood Control Act of 1944, 58 Stat. 887, 890-91, the U.S. Army Corps of Engineers (USACE) has exclusive jurisdiction over Grand Lake for flood control purposes.

FERC's January 12, 2018 Scoping Document 1 (SD1) identified the following resource issue to be analyzed for the Project relicensing:

- Effects of project operations on sedimentation within the project boundary.

FERC subsequently submitted a formal request related to sedimentation. Section 4.2.1 of the main body of the Proposed Study Plan (PSP) details GRDA's response to the request.

GRDA proposes to conduct a Sedimentation Study to address whether operation of the Project has influenced sedimentation in the Grand/Neosho watershed upstream of Grand Lake, and if so, the extent to which sedimentation has affected water levels in these areas during high flow events.

The Sedimentation Study has been designed as a one-year study, with the possibility of a second year of study, depending upon the results of the first year of study. The first year of the study (Study Year One) will analyze historical sediment data to determine accretion and deposition patterns along the Grand/Neosho, Spring, and Elk rivers and Tar Creek upstream of Grand Lake to determine whether operation of the Project influences sedimentation in the watershed upstream of Grand Lake. The second year of study (Study Year Two) is contingent upon the results of the first year of study and will include the collection of field data, as provided below.

2.0 STUDY PLAN ELEMENTS

2.1 Study Goals and Objectives

The overall Sedimentation Study goal is to acquire a better understanding of the interaction between sedimentation processes, operation of the Project, and the extent and duration of inundation. All study goals are intended to provide a clear understanding of the sediment transport processes and patterns upstream of Grand Lake on the Grand/Neosho, Spring, and Elk rivers and Tar Creek.

Study Year One Goals
Study Year One of the Sedimentation Study will: (1) review all relevant previous reports and sediment sampling investigations conducted within the basin; (2) evaluate long-term trends in

sedimentation by spatially and temporally comparing bathymetric data sets; and (3) develop a relationship between water levels or operation scenarios in the upper reaches of Grand Lake where Project operations may influence riverine flow in the Grand/Neosho, Spring, and Elk rivers and Tar Creek (under normal Project operations as opposed to flood control operations under the control of USACE) by considering commonly occurring flows.

Contingent Study Year Two Goals
The decision to move into Study Year Two will be based on the results of the Study Year One. Study Year Two will occur if the results of Study Year One indicate that GRDA's operations pursuant to its FERC license materially affect riverine flow in the Grand/Neosho, Spring, and Elk rivers and Tar Creek under a range of common flows (under normal project operations as opposed to flood operations under the control of USACE), and that such effects on riverine flow may significantly increase water surface elevations in these reaches of the watershed. The contingent Study Year Two will incorporate collection and analysis of field data to better quantify effects on water surface elevations due to Project-related sedimentation.

Study Year Two will: (1) expand the study area, if necessary, based upon the results of Study Year One; (2) collect water level information in conjunction with the collection of Acoustic Doppler Current Profiler (ADCP) data; (3) collect supplemental suspended sediment concentration (SSC) data at selected locations as determined in the year one analysis; (4) collect bed material samples for particle size distribution analysis at proposed field measurement locations; (5) complete a critical shear analysis from the findings from physical field measurement surveys; and (6) given the additional information from Study Year Two, reevaluate the relationship of Project operations and sedimentation to the extent and duration of inundation.

2.2 Agency and Native American Tribe Resource Management Goals

The Sedimentation Study results can inform separate analyses to assess Project effects on resources such as geology and soils, water resources, fisheries and aquatic resources, terrestrial resources, tribal lands, paddlefish spawning recruitment, wildlife lands, threatened and endangered resources, cultural resources, and power generation. Such analyses, in turn, can inform agency decision-making pursuant to their statutory obligations.

2.3 Background and Existing Information

There is a considerable amount of public information available to support and inform the Sedimentation Study. The current understanding of sediment transport mechanisms is good, and there are several existing specialized studies that have taken place within the Grand/Neosho watershed on localized sediment transport. The primary focus of many of the previous localized sediment transport studies has been on the toxicity of the sediments. The toxicity of the sediments is not within the scope of this Sedimentation Study, but the previous localized sediment studies have produced data points for estimating transport rates within the Neosho and Spring rivers that will be useful to this Sedimentation Study.

The existing information below will be reviewed and utilized in this Sedimentation Study, as appropriate, to meet the study goals:

- Historic streamflow data and sources for current streamflow data collected by the U.S. Geologic Survey (USGS)
- Historic water-surface elevation data and sources for current water surface elevation data from USGS and GRDA
- Historic suspended sediment concentration (SSC) data from USGS
- 2008 Oklahoma Water Resources Board (OWRB) bathymetric survey for Lake Hudson extending from just upstream of Kerr Dam to just downstream of the Project
- 2009 OWRB bathymetric survey of Grand Lake and 4.5 miles of the Neosho River upstream of the confluence of the Spring River
- Sediment information (USGS / Andrews et al. / Ingersoll et al. / Juracek et al. 2009)
- Light Detection and Ranging (LiDAR) Survey of the project area (Dewberry/USGS 2011)
- 2015 Tetra Tech bathymetric survey of the Neosho River from Twin Bridges to the USGS gage located at Commerce
- Sediment information (USGS / Smith 2016)
- 2016 USACE H&H Technical Report – Loss of Flood Storage at Grand Lake
- A 2017 USGS bathymetric survey of the Neosho River, Spring River, and Elk River
- Soil and Water Assessment Tool (2018)

City of Miami, Miami Tribe, Eastern Shawnee Tribe, Ottawa Tribe, Seneca Cayuga Nation, Wyandotte Nation, and N. Larry Bork (counsel for the City of Miami citizens) provided a list of existing information to be used in their requested contaminated sediment transport study. The toxicity of the sediments is not within the scope of this Sedimentation Study. However, the list of existing information provided in these study requests will be reviewed and, as applicable, incorporated into this Sedimentation Study.

2.4 Nexus between Project Operations and Effects on Resources

The operation of the Pensacola Project affects the elevations of Grand Lake. The Sedimentation Study will allow relicensing participants to understand the relationship between Project operations and sedimentation pertaining to the extent and duration of inundation.

2.5 Study Area

The overall Sedimentation Study will encompass the Grand/Neosho, Spring, and Elk rivers and Tar Creek with the focus on the upper reaches and areas immediately upstream of Grand Lake.

Study Year One
Locations of the areas where existing data has been collected are generally depicted in Figure 2.5-1 as Active and Inactive USGS SSC locations.

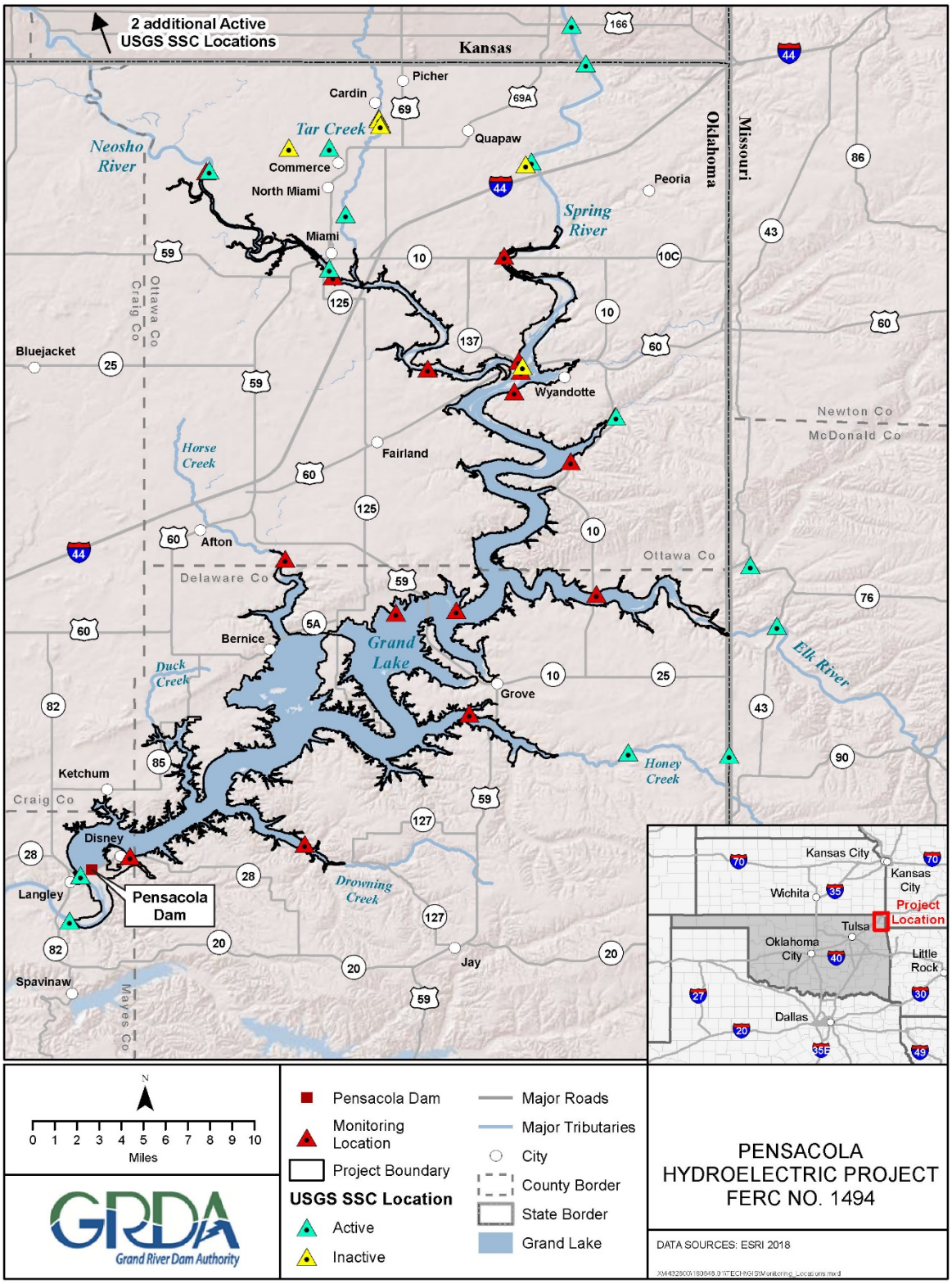

Figure 2.5-1. Existing USGS data locations and potential field monitoring locations.

Contingent Study Year Two
Locations that could be monitored are generally depicted in Figure 2.5-1 as Monitoring Locations[1]. The study area will be expanded or narrowed, if necessary, based upon the results of Study Year One.

2.6 Methodology

Study Year One
Study Year One will involve analyzing historical sediment accretion and deposition patterns in the area upstream of Grand Lake in the Grand/Neosho, Spring, and Elk rivers and Tar Creek.

Background Data and Literature Review
Several specific studies have taken place within the Grand Lake watershed with respect to localized sediment transport. These studies focused on sediments from Tar Creek and have produced data points that are useful in estimating transportation rates and deposition within the Neosho River downstream of its confluence with Tar Creek.

For physical data, there is a lengthy sediment concentration record along the Grand/Neosho, Spring, and Elk rivers and Tar Creek that has been collected by the USGS. Recent suspended sediment data exists for several sampling locations while the USGS continues to monitor the basin (Table 2.6-1).

All relevant previous reports and historic sediment sampling investigations conducted within the basin will be reviewed. Previous report findings and sample results will be assimilated to develop an understanding of in-stream sediment type and physical processes at work in the Grand Lake watershed.

Bathymetric Dataset Comparisons
Rivers involve complex interactions between water, sediment transport, and bed geometry. Understanding sedimentation processes in rivers depends on predicting the effects of these interactions, including channel migration and cross-sectional change. Several structures run across the Neosho River passing through the City of Miami, which can act as hydraulic "choke-points". The existence of these choke-points adds friction losses which can result in a decrease in entrained sediment concentrations as velocities decrease due to backwater effects.

To evaluate long-term trends in sedimentation, bathymetric data sets collected over time for the Grand/Neosho and Spring rivers will be compared. Bathymetric data collection has been performed by the OWRB, Tetra Tech, and the USGS between 2008 and 2017 and will provide a basis for sediment volume change estimates. Data sets prior to this time will also be reviewed for applicability. Cross-sectional data between survey periods will be compared and analyzed volumetrically for changes across each profile. This analysis will inform estimates of accretion and erosion rates and will provide spatial information about sediment transport patterns in the tributaries and the basin.

[1] ADCP readings (if necessary) will at a minimum, be taken in the same monitoring locations depicted in Figure 2.5-1. Other monitoring locations could include bridges near monitoring locations.

Table 2.6-1. List of available USGS historical suspended sedimentation data.

-			Period of Record			
-	**USGS Station ID**	**Site Name**	**Discharge**	**Stage**	**SSC [1]**	**Precip**
Active Sites	07183500	Neosho River near Parsons, KS	1990-2018	2007-2018	1958-2017	N/A
	07184500	Labette Creek near Oswego, KS	2012-2018	2012-2018	1940-1945	N/A
	07185000	Neosho River near Commerce, OK	1990-2018	2007-2018	1944-2016	N/A
	07185080	Neosho River at Miami, OK	N/A	2007-2018	2015-2017	N/A
	07185090	Tar Creek near Commerce, OK	2007-2018	2007-2018	2004-2016	N/A
	07185095	Tar Creek at 22nd Street Bridge at Miami, OK	1989-2018	2007-2018	1988-2006	N/A
	07187600	Spring River near Baxter Springs, KS	2009-2018	2008-2018	2014-2018	N/A
	07188000	Spring River near Quapaw, OK	1989-2018	2007-2018	1944-2018	2017-2018
	07188550	Sycamore Creek near Wyandotte, OK	N/A	N/A	N/A	N/A
	07189000	Elk River near Tiff City, MO	1990-2018	2007-2018	1993-2009	2017-2018
	07189100	Buffalo Creek at Tiff City, MO	2000-2018	2007-2018	2005	N/A
	07189540	Cave Springs Branch near South West City, MO	1997-2018	2007-2018	2007	N/A
	07189542	Honey Creek near South West City, MO	1997-2018	2007-2018	2007	N/A
	07190500	Neosho River near Langley, OK	2016-2018	2016-2018	1945-1947	N/A
	365955094424100	Spring River at KS-OK State Line, KS	N/A	N/A	N/A	N/A
Inactive Sites	07185025	Elm Creek at Commerce, OK	N/A	N/A	2005	N/A
	071850825	Tar Creek near Cardin, OK	N/A	N/A	2005	N/A
	071850870	Lytle Creek near Cardin, OK	N/A	N/A	2005	N/A
	071850875	Tar Creek above Douthat Bridge near Cardin, OK	N/A	N/A	2005	N/A
	07185088	Tar Creek near Picher, OK	N/A	N/A	2005	N/A
	07188007	Beaver Creek above Spring River near Quapaw, OK	2000-2006	2000-2006	2005	N/A
	07188180	Spring River near Wyandotte, OK	2004-2006	2006	2004-2006	N/A

Notes:
1 Suspended sediment concentration (milligrams per liter) [mg/L]) – data sporadically available.

The sedimentation rates and patterns determined from the cross-sectional analysis will be compared to results of recent soil and water assessment tool (SWAT) modeling currently being conducted for GRDA by Parsons. The current SWAT modeling effort is being conducted to evaluate nitrogen and phosphorus loading, but it is suited to estimate the relative contributions of upland shoreline sediment sources. Relative sediment contributions along the river system estimated by the SWAT model will be compared to the spatial erosion and sedimentation cross-section data for potential correlation.

The more commonly occurring flow rates have the greatest effect on how sediment moves through a river system and how the river is shaped. The effective discharge is the flow along a river that transports the most sediment throughout the year. The USGS has SSC data at several locations in the Grand/Neosho River watershed (See also Figure 2.5-1). These data will be correlated with flow to develop regression equations relating suspended sediment discharge with flow upstream of Grand Lake in the Grand/Neosho, Spring, and Elk rivers and Tar Creek. Using daily flow data (and/or flow duration analysis), suspended sediment transport estimates will be developed. An effective discharge analysis will be conducted based on the relationships developed between flow and suspended sediment discharge.

Operational Change Analysis

The Comprehensive Hydraulic Model (CHM) that will be a product of the proposed Hydrologic and Hydraulic Modeling Study will be calibrated for lower discharge events, so that it can be utilized to estimate the effects of GRDA's operations under the FERC license on sediment transport upstream.

The CHM model will then be analyzed under different operational scenarios to determine the relative change in velocities throughout the study area. These relative changes in velocity will be related to sediment transport characteristics to quantify changes to sedimentation patterns under different operational scenarios.

Data Synthesis and Reporting

The final step of Study Year One will assimilate the findings from previous documented studies and from the bathymetric data set comparison into an understanding of the sediment transport processes and patterns throughout the study area. Existing data will be used to quantify historic sediment transport rates. These rates could be used to project future sediment loading estimates.

Study Year One deliverables will include a report of findings and associated figures summarizing findings from the literature review, sediment deposition, and erosion patterns. The report will give numerical details of sediment transport and deposition patterns in relevant areas, both spatially and temporally. It will also provide a summary of the relationship between Project operations, sedimentation, and water levels upstream of Grand Lake to inform GRDA's decision as to whether Study Year Two is warranted. To the extent that significant Project-related sedimentation effects are determined in Study Year One, the study would be extended to Study Year Two as previously described.

Contingent Study Year Two

In the event Study Year Two is triggered based on the results of the Study Year One, Study Year Two will incorporate collection and analysis of field data to better quantify effects on water surface elevations due to Project-related sedimentation.

Field Data Collection

Study Year Two involves the collection of field data. In addition to the analysis of historic USGS flow and sediment data, developing the relationship between water levels and velocities upstream of Grand Lake in the Grand/Neosho, Spring, and Elk rivers and Tar Creek can allow for greater understanding of sediment transport mechanisms throughout the basin.

Water levels and velocity profiles will provide insight into long-term geomorphic processes at work in the Grand/Neosho River watershed upstream of Grand Lake. Combined with water level data, velocity measurements will provide additional information about long-term sediment transport mechanisms at work. Collecting velocity profile data will inform which size particles are mobilized under different flow conditions and further inform the rate of sediment transport.

ADCP data will be collected to give the velocity distribution across the surveyed cross section. Additionally, this data collection will provide current cross-section bathymetric data that will be used in the cross-section comparison analysis. Water level sensors will also be placed at multiple locations throughout the basin to collect one full year of data. Potential ADCP and water level sensor locations are generally outlined as field monitoring locations in Figure 2.5-1.

During low-flow conditions at riverine locations (and possibly reservoir locations depending on exposure of bed), bed material samples will be collected to determine particle size distribution. Using critical shear analysis and the ADCP velocity data correlated to flow, sediment mobility analyses will be conducted using the sampled particle size distribution.

Supplemental suspended sediment samples will be collected at selected field data locations generally outlined as field monitoring locations in Figure 2.5-1. The exact locations and methodology for their collection will be determined after analysis of the Study Year One data.

ADCP data and suspended sediment sampling will also be conducted over a wide a range of flows to cover the hydrologic range. This would be dependent on hydrologic conditions as they develop over the available time-period for field data collection.

Data Synthesis and Reporting

The final step of Study Year Two will assimilate the findings from Study Year One, previous documented studies, bathymetric data set comparison, and physical field measurement surveys into a more in-depth understanding of the sediment transport processes and patterns throughout the study area. Existing and collected data will be used to further quantify historic sediment transport rates. These rates could also be used to further project future sediment loading estimates.

Study deliverables will include a report summarizing the findings of Study Year One and further report on the findings and associated figures summarizing findings from the overall insights and trends developed from the water level and velocity profile analysis and the various components of sediment analysis. The report will give further numerical details of sediment transport and deposition patterns in relevant areas both spatially and temporally to determine whether operation of the Project influences sedimentation and consequently the duration and extent of inundation. Results and all field data will be made available.

2.7 Consistency with Generally Accepted Scientific Practice

The Sedimentation Study follows generally accepted scientific practice. It incorporates the best available information and generally accepted methods. The scope of the study will encompass the major tributaries upstream of Grand Lake in the Grand/Neosho, Spring, and Elk rivers and Tar Creek.

2.8 Schedule

The schedule for completion of the Sedimentation Study is displayed in Table 2.8-1.

Table 2.8-1. Sedimentation study schedule.

Task	Completion Date
Anticipated Completion of Study Plan Determination Process	09/24/2018
Study Year One (Technical) Report (Initial Study Report)	09/24/2019
Study Year Two (Technical) Report (Updated Study Report)	09/24/2020

2.9 Level of Effort and Cost

The estimated cost for completion of Study Year One as outlined in the Methodology section of this study plan is approximately $140,000.

The estimated cost for completion of contingent Study Year Two as outlined in the Methodology section of the study plan is approximately $290,000.

3.0 REFERENCES

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Pensacola Hydroelectric Project, FERC No. 1494

Proposed Study Plan

Recreation Facilities Inventory and Use Survey

Prepared for

Prepared by

April 2018

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LIST OF ACRONYMS

ADA..... Americans with Disabilities Act
FERC ..... Federal Energy Regulatory Commission
GRDA..... Grand River Dam Authority
ILP..... Integrated Licensing Process
OTRD..... Oklahoma Tourism and Recreation Department
PAD..... Pre-Application Document
PD ..... Pensacola datum
PM&E..... protection, mitigation and enhancement
Project..... Pensacola Hydroelectric Project
RMP ..... Recreation Management Plan
SCORP ..... Statewide Comprehensive Outdoor Recreation Plan
SD1 ..... Scoping Document 1
SMP ..... Shoreline Management Plan
USFS ..... U.S. Forest Service
USFWS ..... U.S. Fish and Wildlife Service

1.0 INTRODUCTION

Project operations at the Pensacola Hydroelectric Project (Pensacola Project or Project; FERC No. 1494), specifically of Grand Lake, have the potential to affect public access and recreation opportunities in the Project Boundary. Grand River Dam Authority (GRDA) operates and maintains five Federal Energy Regulatory Commission (FERC)-approved recreation facilities in accordance with the current license, as outlined in the Recreation Management Plan (RMP; GRDA 1997) required by license Article 407. An up-to-date inventory and condition assessment of existing Project recreation areas and user surveys will be helpful in understanding current recreation use and future recreation facility needs.

GRDA filed a Pre-Application Document (PAD) with the FERC on February 1, 2017, as part of the relicensing of the Project. In Section 7 of the PAD, GRDA identified a Recreation Facilities Inventory and Use Survey as a proposed study to characterize recreation resources within the Project Boundary. FERC's January 12, 2018, Scoping Document 1 (SD1) identified the following environmental resource issues related to recreation to be analyzed for the Project relicensing:

- Whether existing facilities and public access are adequate to meet current and future recreation demand;
- Effects of Project operation (reservoir fluctuation) on access to existing recreation facilities; and
- Adequacy of the existing Recreation Management Plan to manage development and use of the Project's recreation facilities.

No recreation study requests or comments were received from relicensing participants.

2.0 STUDY PLAN ELEMENTS

2.1 Study Goals and Objectives

The goals of this study are to gather information regarding current recreational use, and identify recreation resources and activities that may be affected by the continued operation of the Project. Consistent with FERC's study request, the specific objectives of the study are to:

- Characterize current recreational use of the Project area;
- Estimate future demand for public recreation use at the Project;
- Gather information on the condition of recreation facilities and identify any need for improvement; and
- Evaluate the potential effects of continued operation of the Project on recreation resources and access in the Project area.

2.2 Agency and Native American Tribe Resource Management Goals

The Oklahoma Tourism and Recreation Department (OTRD) promotes the development and operation of tourism and recreation opportunities throughout the State. The OTRD uses the Oklahoma Statewide Comprehensive Outdoor Recreation Plan (SCORP) as a planning tool to assist in preserving, developing, and assuring accessibility to outdoor recreation resources (OTRD 2012).

2.3 Background and Existing Information

Section 6.7 of the PAD describes existing information about recreation facilities and opportunities in the Project area. The Project's Grand Lake is the premier recreational lake in northeast Oklahoma (FERC 2014). Bass fishing is very popular and draws both local and out-of-state anglers to the area. Public recreation facilities at Grand Lake are available at facilities owned and operated by GRDA and others, including five state parks around the shoreline and at more than a dozen privately operated facilities. Together, these facilities offer numerous boat launches, marinas, tailwater fishing facilities, and fishing piers available to the public, as well as several wildlife areas, two visitor centers, several public overlooks, and one golf course. In addition, there are many popular, unimproved sites that can be used to access Grand Lake to launch boats, fish, and swim. There are also many campgrounds on Grand Lake providing tent, trailer, and recreational vehicle sites.

Development along the shoreline adjacent to Grand Lake primarily consists of residential, light commercial and business, and limited agricultural lands. Grand Lake is a popular location for recreation and residential development, particularly summer homes, due in part to the scenic quality of the reservoir and surrounding landscape, recreational fishing, and proximity to major population centers in Oklahoma, Kansas, Missouri, and Arkansas (GRDA 2008). Although lands adjacent to Grand Lake are mostly privately owned, GRDA owns title along the shoreline and has authority to prescribe and enforce rules and regulations for commercial and recreational use of the lake. GRDA manages the shoreline of the Project in accordance with its Shoreline Management Plan (SMP) and operates a lake patrol to enforce boating regulations. The SMP serves as a planning tool to guide GRDA in the protection and enhancement of the Project's environmental, recreational, and other values. Since 1992, over 2,600 private and 120 commercial boat docks have been permitted on Grand Lake[1].

The Project is located in the Ozark Plateau's Grand River lake region, which provides a host of recreational activities, including fishing, hunting, boating, hiking, camping, biking, rock climbing, cave exploration, and off-highway vehicles activities. Tourism is the stimulus for recreational developments in the region including resorts, campgrounds, lake marinas, vacation homes, and associated support services (USFWS 2002).

Grand Lake is a popular recreation spot for local residents and tourists. Although some recreational activities such as boating take place year-round on Grand Lake, the primary recreation season typically spans May 1 through September 30. Recreational opportunities and activities at the Project include sailing, fishing, rafting (tying together of two or more anchored

[1] FERC - 75 FERC, 59 FERC ¶62,073, Grand River Dam Authority, Project No. 1494-002 - Oklahoma, Federal Energy Regulatory Commission, (Apr. 24, 1992)

boats), pleasure boating, and hunting. Additional details regarding these recreational opportunities and activities are provided in Section 6.7.3 of the PAD.

The FERC Form 80 Licensed Hydropower Development Recreation Report filed April 1, 2015, identified publicly available recreation amenities within the Project Boundary including 90 boat launch areas, 58 marinas, 15 swim areas, 27 campgrounds with over 2,000 camp and cottage sites, 47 active recreation areas (e.g., playgrounds, golf course), 32 picnic areas, 7 overlooks, and 6 visitor centers (GRDA 2015b). GRDA operates and maintains five FERC-approved public access sites, which are listed in Table 2.3-1. These facilities are discussed in more detail in Section 6.7.2 of the PAD. The State of Oklahoma and several municipalities and private operators also maintain publicly available recreation facilities around the reservoir. The FERC-approved recreation sites, state parks, and other public access points are shown in Figure 2.5-1.

Table 2.3-1. FERC-approved recreation facilities on Grand Lake.

Site Name	Amenities
Duck Creek Bridge Public Access	Boat launch, informal parking area.
Seaplane Base Public Access	Boat launch, informal parking area.
Monkey Island Public Boat Ramp	Boat launch, concrete parking area.
Big Hollow Public Access	Boat launch.
Wolf Creek Public Access	Boat launch, four courtesy docks, mooring dock, restroom. Also includes parking for 71 vehicles with trailers, 8 single vehicles, and 5 Americans with Disabilities Act (ADA) accessible parking spaces with sidewalks, one fish cleaning pavilion, and one event pavilion.

Recreation monitoring conducted from March 2014 through February 2015 in support of the FERC Form 80 requirements indicated that none of the FERC-approved Project recreation facilities and other publicly available recreation facilities at the Project were utilized to their maximum capacity. The boat launch areas, which include the five FERC-approved Project recreation facilities, had a capacity utilization rate of approximately 11 percent (GRDA 2015a).

2.4 Nexus between Project Operations and Effects on Resources

The Pensacola Project currently provides several public recreational opportunities. The results of this study, in conjunction with existing information, will be used to inform analysis in the license application regarding potential Project effects on public recreation.

2.5 Study Area

This study will take place at Grand Lake in Delaware County, Oklahoma. The study area includes the five FERC-approved recreation facilities on Grand Lake. This is an appropriate study area as it includes lands and recreation facilities managed by GRDA under the existing license. The Project's recreation facilities are shown in Figure 2.5-1.

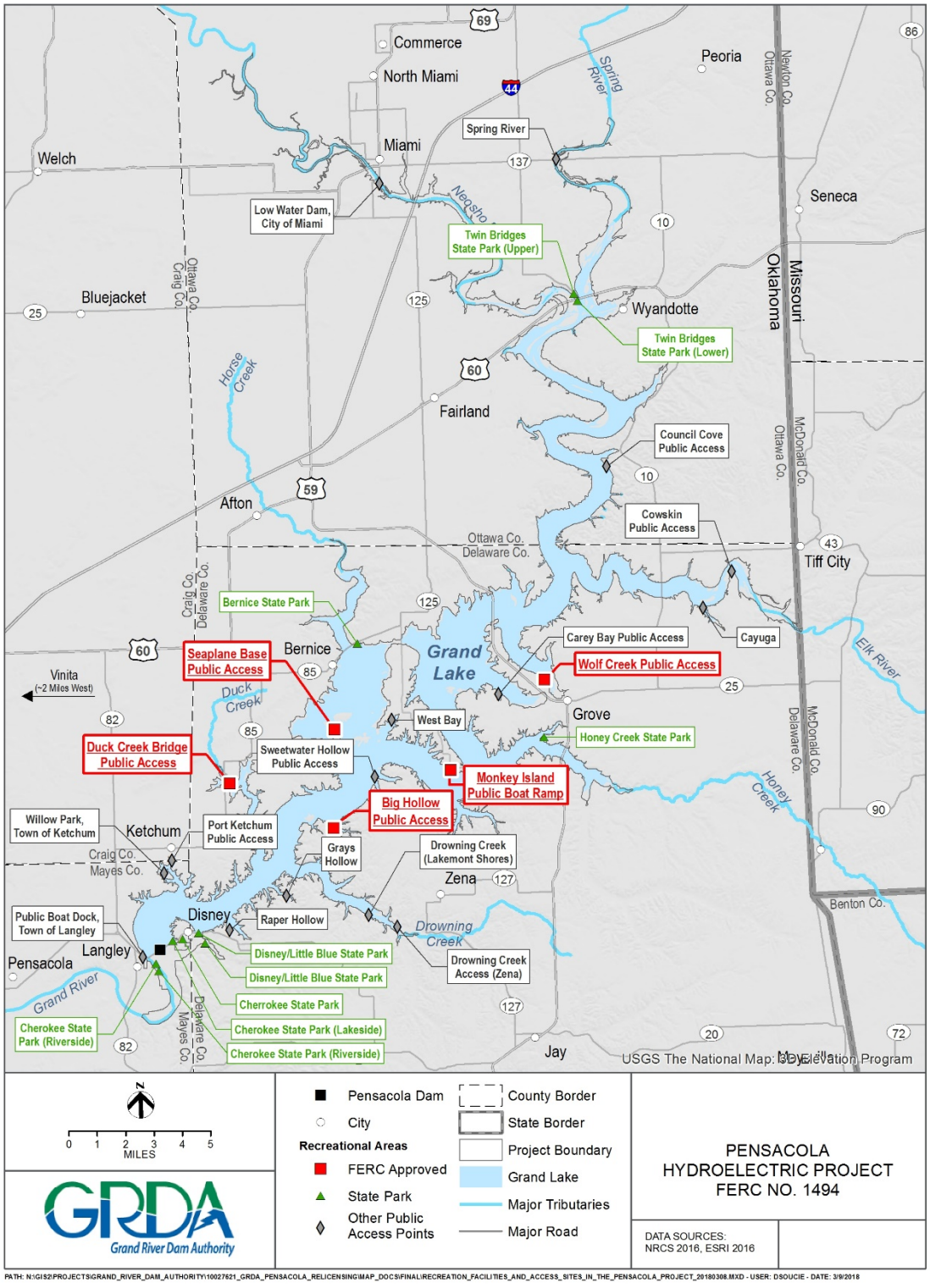

Figure 2.5-1. Recreation facilities and access sites at the Pensacola Project.

2.6 Methodology

2.6.1 Recreation Facility Inventory and Condition Assessment

Information will be collected for each of the FERC-approved recreation areas listed in Table 2.3-1 using a Facilities Inventory and Condition Form (provided in Appendix A). GRDA will record the following information for each recreational facility including:

- A description of the type and location of existing recreation facilities;
- The type of recreation provided (boat access, angler access, picnicking, etc.);
- Existing facilities and sanitation;
- The type of vehicular access and parking (if any);
- Suitability of facilities to provide recreational opportunities and access for persons with disabilities (i.e., compliance with current ADA standards for accessible design); and
- Photographic documentation of recreation facilities.

Additionally, a qualitative assessment of the condition of the recreation facilities will be performed. Site conditions at state- or privately-owned commercial facilities will not be assessed. Using the Facilities Inventory and Condition Form, the recreation amenities available at each recreation facility will be rated using the following criteria: (N) Needs replacement (broken or missing components, or non-functional); (R) Needs repair (structural damage or otherwise in obvious disrepair); (M) Needs maintenance (ongoing maintenance issue, primarily cleaning); and (G) Good condition (functional and well-maintained). If a facility is given a rating of "N", "R", or "M", an explanation for the rating will be provided. The age of the facilities and signs of overuse will also be noted.

2.6.2 Recreation Visitor Use Data

GRDA will collect visitor use data at Project recreation facilities through a combination of in-person surveys, field reconnaissance, and photo documentation. GRDA will conduct field reconnaissance and interviews with respondents at the following Project recreation facilities during the prime recreational season from May 2019 through September 2019:

- Duck Creek Bridge Public Access;
- Seaplane Base Public Access;
- Monkey Island Public Boat Ramp;
- Big Hollow Public Access; and
- Wolf Creek Public Access.

Surveys will begin at 8:00 AM and continue until 6:00 PM to capture a range of recreational activities throughout the day. GRDA intends to conduct surveys pursuant to the schedule presented in Table 2.6-1.

Table 2.6-1. Visitor use survey schedule.

Month	Survey and Reconnaissance
May	▪ Two weekend days (one within Memorial Day Weekend) ▪ Two randomly selected weekdays
June	▪ Two weekend days ▪ Two randomly selected weekdays
July	▪ Two weekend days (one within the weekend after July 4th) ▪ Two randomly selected weekdays
August	▪ Two weekend days ▪ Two randomly selected weekdays
September	▪ Two weekend days (one within Labor Day Weekend) ▪ Two randomly selected weekdays

GRDA expects that one team of two technicians will rotate between each of the recreation sites listed above (in random order) and will spend approximately one hour at each site conducting interviews. GRDA anticipates providing respondents with the option to complete the interview digitally (i.e., on an iPad/tablet) or to answer interview questions orally. Before rotating to the next site, technicians will record relevant conditions, including observed recreational activities, estimated number of vehicles, and number of recreational users. General information regarding date, time, and weather conditions will also be recorded by technicians.

GRDA has developed an interview/survey instrument that draws from general concepts and guidance from the *National Visitor Use Monitoring Handbook* (USFS 2007) as well as from other relicensing studies approved by FERC for in-person interviews during the recreation visitor use surveys as detailed in Table 2.6-1. The questionnaire is provided in Appendix B of this study plan. The questionnaire is designed to collect information about:

- General user information;
- Resident/visitor;
- Purpose and duration of visit;
- Distance traveled;
- Day use/overnight lodging;
- History of visiting the site or area;
- Types of recreational activities respondents participated in or plan to participate in during their visit, including primary and secondary recreation activities;
- Other recreational sites that respondents visited or intend to visit during their trip;
- General satisfaction with recreational opportunities, facilities, and the respondents overall visit and/or areas that need improvement;
- Effects of project operations on recreation use and access; and
- Accessibility of facilities.

2.6.3 Data Analysis and Reporting

GRDA will prepare a report summarizing the results of the Recreation Facilities Inventory and Use Assessment to include information presenting the results of the field inventory, on-site

interviews and field reconnaissance, and representative photographs of the recreation facilities. GRDA anticipates that the Recreation Facilities Inventory and Use Assessment Report will include the following elements:

- Project Introduction and Background
- Study Objectives
- Study Area
- Methodology
- Study Results
- Discussion and Analysis
- Variances from FERC-approved Study Plan and Proposed Modifications
- Location maps and photos
- Any agency correspondence and or consultation
- References

The results of the Recreation Facilities Inventory and Use Assessment will be used to describe existing public access and use of the Project and evaluate the potential effects of continued operation of the Project on recreation resources and activities in the Project area; and identify potential PM&E measures that could be implemented to enhance recreation or mitigate project effects on recreation in the Preliminary Licensing Proposal/Draft License Application and Final License Application, as appropriate.

2.7 Consistency with Generally Accepted Scientific Practice

The methods for this study are consistent with accepted professional practices such as those provided in the U.S. Forest Service's National Visitor Use Monitoring Program (July 2007). The overall approach is commonly used in relicensing proceedings and is consistent with generally accepted methods for recreation studies and analytical techniques used by federal and state agencies. In addition, the proposed methods for this study are consistent with FERC study requirements under the Integrated Licensing Process (ILP).

2.8 Schedule

This study plan is anticipated to be finalized in late 2018. At this time, GRDA intends to conduct the Recreation Facilities Inventory and Use Assessment Study from May 2019 through September 2019. Upon completion of field work, the data will be analyzed and a final study report will be included as part of the Initial Study Report.

2.9 Level of Effort and Cost

This estimated level of effort for this study is approximately 570 man-hours. The estimated cost of this study is expected to be approximately $ 75,000.

3.0 REFERENCES

FERC (Federal Energy Regulatory Commission). 2014. Draft Environmental Assessment for Hydropower License Salina Pumped Storage Project – FERC Project No. 2524-021 Oklahoma. November 2014.

GRDA (Grand River Dam Authority). 1997. Grand Lake O' The Cherokees Recreation Management Plan Pensacola Hydroelectric Project FERC Project No. 1494-002. Vinita, OK.

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GRDA. 2015a. Pensacola Hydroelectric Project FERC Form 80. April 2015.

GRDA. 2015b. Pensacola Hydroelectric Project Public Recreation Management Plan Monitoring Report. April 2015.

OTRD (Oklahoma Tourism and Recreation Department). 2012. Statewide Comprehensive Outdoor Recreation Plan 2013 – 2017. November 2012.

USFS (U.S. Forest Service). 2007. National Visitor Use Monitoring Handbook. National Visitor Use Monitoring Program, U.S. Forest Service, Washington, D.C.

USFWS (U.S. Fish and Wildlife Service). 2002. *Ozark plateau national wildlife refuge* proposed refuge expansion environmental assessment. September 2002. [Online]. URL: http://www.fws.gov/southwest/refuges/oklahoma/Ozark/ (Accessed September 16, 2010).

APPENDIX A. FACILITY INVENTORY AND CONDITION FORM

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RECREATION FACILITY INVENTORY AND CONDITION ASSESSMENT
Pensacola Hydroelectric Project (FERC No. 1494)

Location:	
Date:	**Surveyor:**
Photo Number(s):	

Type of Amenity	#	ADA	Condition	Notes
Boat Launch Ramp/Lane			N / R / M / G	
Dock/Pier			N / R / M / G	
Mooring Dock			N / R / M / G	
Pavilion			N / R / M / G	
Picnic Table			N / R / M / G	
Restroom			N / R / M / G	
Trash Receptacles			N / R / M / G	
Other			N / R / M / G	

PARKING	Total Spaces: _____ Standard: _____ ADA: _____ Double (trailer): _____ Other: _____	**Condition**
	Surface Type: *Asphalt* *Concrete* *Gravel* *Other:*_____	N / R / M / G

Signs	#	Size	Material	Condition	Comments
FERC Project			wood / metal / other	N / R / M / G	
Facility ID			wood / metal / other	N / R / M / G	
Regulations			wood / metal / other	N / R / M / G	
Directional			wood / metal / other	N / R / M / G	
Interpretive			wood / metal / other	N / R / M / G	

N - Needs replacement (broken or missing components, or non-functional)
R - Needs repair (structural damage or otherwise in obvious disrepair)
M - Needs maintenance (ongoing maintenance issue, primarily cleaning)
G - Good condition (functional and well-maintained)
If a facility is given a rating of "N", "R", or "M", provide specific details.

ADDITIONAL COMMENTS/NOTES:
Note the age of the facilities (if known) as well as any signs of overuse.

APPENDIX B. VISITOR USE SURVEY QUESTIONNAIRE

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ON-SITE/IN-PERSON RECREATION INTERVIEW
Pensacola Hydroelectric Project (FERC No. 1494)

Grand River Dam Authority (GRDA) is the licensee, owner, and operator of the 120 megawatt (MW) Pensacola Hydroelectric Project (Project or Pensacola Project) which is licensed by the Federal Energy Regulatory Commission (FERC). The five FERC-approved recreation facilities associated with the Project are all located along the Project's reservoir, Grand Lake. The current operating license for the Project was issued on April 24, 1992, and expires on March 31, 2022. GRDA must file its application with FERC for a new license no later than March 31, 2020. As part of the relicensing process, GRDA is conducting studies on environmental resources to enable FERC to prepare an environmental document. The purpose of this survey is to collect information about use of the Project's five FERC-approved recreation facilities.

Interview Location:	**Duck Creek Bridge Public Access☐ Seaplane Base Public Access☐ Big Hollow Public Access☐**	
	Monkey Island Public Boat Ramp☐ Wolf Creek Public Access☐	
Home Zip Code: _____	**Date:** _____	
	Time: _____	
Are you: **Male ☐**	**Female ☐**	**Prefer not to answer ☐**
Interviewer:		

Q-1. Regarding the Grand Lake area, do you consider yourself: (**Please circle one)**

1. A regular visitor to this area (*3 or more times per year*)
2. An occasional visitor (*1-2 times per year*)
3. An infrequent visitor (*Less than 1 time per year*)
4. This is my first visit

Q-2. On this trip to the Grand Lake area, when did you arrive?

Arrival Date **Arrival Time**

_____/_____/_____ _____AM/PM

When do you expect to leave the Grand Lake area?

Departure Date **Departure Time**

_____/_____/_____ _____AM/PM

Q-3. During the last 12 months (including this trip), which month(s) did you visit the Grand Lake area? **(Please select all that apply)**

Jan ☐ Feb ☐ Mar ☐ Apr ☐ May ☐ Jun ☐ Jul ☐ Aug ☐ Sep ☐ Oct ☐ Nov ☐ Dec ☐

Q-4. Which of the following recreation areas at or near Grand Lake did you visit for recreation during the past 12 months? **(Please select all that apply)**

- ☐ Duck Creek Bridge Public Access
- ☐ Seaplane Base Public Access
- ☐ Big Hollow Public Access
- ☐ Monkey Island Public Boat Ramp
- ☐ Wolf Creek Public Access
- ☐ None of the above
- ☐ Other (Please list)

_____

_____

Q-5. About how many miles did you travel to get to the Grand Lake area?

A. _____miles

Q-6. Are you staying overnight in the Grand Lake area (not including at your own home) on this trip?

1. Yes 2. No

Q-7. If you answered yes to **Q-6**, at what type of accommodations will you be staying? (**Please select one)**

1. RV/Auto/Tent Campground
2. Motel/hotel
3. Bed and Breakfast
4. Vacation or rental home
5. Other (Please specify: _____)

Q-8. How many people (including you) are in your group?

A. _____people

Q-9. Which of the following best describes your group during this trip?

1. Individual
2. Adult group (over 21)
3. Youth group (under 21)
4. Family (with children)
5. Mixed group (families and friends of various ages)

Q-10. On this trip to the Grand Lake area, in which of the following activities have you or do you expect to participate? (**Please select all that apply**)

1. Bank fishing	5. Picnicking	8. Hunting
2. Boat fishing	6. Swimming	9. Rafting
3. Pleasure Boating	7. Sight-seeing	10. Other (please describe)
4. Personal watercraft		

Q-11. Of the activities you circled in Q-10 above, what is the primary activity that you participated in, or expect to participate in, on this visit? (Please write in the corresponding number **from above**)

A. Primary activity # _____

Q-12. If you specified that boating or fishing is the primary activity you participated in please rate the following:

	Totally Unacceptable	Unacceptable	Neutral	Acceptable	Totally Acceptable
Safety	1	2	3	4	5
Enjoyment	1	2	3	4	5
Crowding	1	2	3	4	5
Overall Experience	1	2	3	4	5

Q-13. If you participated in recreational activities in the Grand Lake area today or in the past, please rate the following:

	Duck Creek	Seaplane Base	Big Hollow	Monkey Island	Wolf Creek
Accessibility					
Parking					
Crowding					
Safety					
Condition of Recreation Facilities					
Available Facilities					
Overall Experience					

Q-14. Please indicate whether or not the water level of the reservoir was a problem for each of the following at the recreation area you are currently visiting.

(Circle one number for each)	Not a problem	A small problem	Neither	A moderate problem	A large problem	No opinion/ Not applicable
Ability to safely swim	5	4	3	2	1	❑
Ability to launch or take out boat	5	4	3	2	1	❑
Ability to safely boat	5	4	3	2	1	❑
Ability to fish along the shoreline	5	4	3	2	1	❑
Ability to access the shoreline	5	4	3	2	1	❑
Scenic quality of the shoreline	5	4	3	2	1	❑
Ability to use docks	5	4	3	2	1	❑
Other (specify)	5	4	3	2	1	❑

Q-15. Please share any other comments that you have regarding recreation on Grand Lake near the Pensacola Project:_____

_____

_____

_____

_____

_____

_____

_____

_____

Thank you for completing the Recreation Survey!

Pensacola Hydroelectric Project, FERC No. 1494

Proposed Study Plan

Cultural Resources Study

Prepared for

Prepared by

April 2018

TABLE OF CONTENTS

APPENDICES

LIST OF FIGURES

LIST OF ACRONYMS

ACHP ..... Advisory Council on Historic Preservation
APE..... Area of Potential Effects
BIA ..... Bureau of Indian Affairs
C.F.R..... Code of Federal Regulations
CRWG..... Cultural Resources Working Group
FERC ..... Federal Energy Regulatory Commission
FLA ..... Final License Application
FR ..... Federal Register
GRDA..... Grand River Dam Authority
HPMP..... Historic Properties Management Plan
ILP..... Integrated Licensing Process
ISR ..... Initial Study Report
NAGPRA..... Native American Graves Protection and Repatriation Act
NAVD ..... North American Vertical Datum
NEPA ..... National Environmental Policy Act
NGVD..... National Geodetic Vertical Datum
NHPA ..... National Historic Preservation Act
NOI..... Notice of Intent
NRHP..... National Register of Historic Places
OAS ..... Oklahoma Archaeological Survey
OLI ..... Oklahoma Landmarks Inventory
PA ..... Programmatic Agreement
PAD..... Pre-Application Document
PD ..... Pensacola datum
P.L..... Public Law
Project..... Pensacola Hydroelectric Project
PSP..... Proposed Study Plan
SD1 ..... Scoping Document 1
SHPO..... State Historic Preservation Officer
TCP..... traditional cultural properties
THPO ..... Tribal Historic Preservation Officer
U.S.C. ..... U.S. Code
USGS..... U.S. Geological Survey
USR ..... Updated Study Report
WPA..... Works Progress Administration

1.0 INTRODUCTION

The Grand River Dam Authority (GRDA) filed a Pre-Application Document (PAD) with the Federal Energy Regulatory Commission (FERC) on February 1, 2017 as part of the relicensing of the Pensacola Hydroelectric Project (Pensacola Project or Project; FERC No. 1494). In Section 7 of the PAD, GRDA identified a Cultural Resources Study as a proposed study or information gathering activity necessary to characterize archaeological and historic resources and historic properties of traditional religious and cultural importance within the Project's Area of Potential Effects (APE). FERC's January 12, 2018 Scoping Document 1 (SD1) identified the following environmental resource issues to be analyzed for the Project relicensing:

- Effects of the Project operation and maintenance on historic and archeological resources that may be eligible for inclusion in the National Register of Historic Places (NRHP or National Register).
- Effects of Project operation and maintenance on properties of traditional religious and cultural importance to Native American Tribes.

In SD1, FERC indicated its intent to analyze the resource issues above for both cumulative and site-specific effects. The Commission has tentatively defined the geographic scope for cultural resources at the Grand Lake Reservoir to elevation 760 feet Pensacola datum (PD),[1] as well as any adjacent upland areas that are periodically inundated.

The Oklahoma Archeological Survey (OAS), Cherokee Nation, and Miami Tribe of Oklahoma (as supported by the City of Miami, Eastern Shawnee Tribe, Seneca-Cayuga Nation, Wyandotte Nation, and Ottawa Tribe) subsequently submitted formal requests related to cultural resources.[2] Sections 4.1.3 and 4.2.3 of the main body of the Proposed Study Plan (PSP) details GRDA's response to the requests.

[1] Unless otherwise noted, all elevations referenced are relative to PD. PD elevations can be converted to National Geodetic Vertical Datum of 1929 (NGVD) by adding 1.07 feet and to North American Vertical Datum of 1988 (NAVD) by adding 1.40 feet (for example, elevation 745 feet PD = 746.07 feet NGVD = 746.4 feet NAVD88)(http://ok.water.usgs.gov/projects/webmap/miami/datum.htm).

[2] During PSP development, GRDA conducted early outreach to a number of relicensing participants to discuss foundational concepts of the proposed Cultural Resources Study Plan. These stakeholders include the Cherokee Nation, Bureau of Indian Affairs (BIA), U.S. Department of the Interior's Solicitor's Office, Miami Tribe of Oklahoma, Osage Nation, OAS, and Oklahoma State Historic Preservation Officer. GRDA appreciated the engagement and cooperation of these stakeholders.

2.0 STUDY PLAN ELEMENTS

2.1 Study Goals and Objectives

The goals of the Cultural Resources Study are: (1) to identify historic properties[3] within the Project's APE that are being adversely affected by Project operations (if any), including properties of traditional religious and cultural importance; and (2) to develop an Historic Properties Management Plan (HPMP) in consultation with the Oklahoma State Historic Preservation Officer (SHPO), OAS, and Native American Tribes[4], that provides for the long-term management of historic properties within the APE over the term of the new license. The primary objectives for meeting these goals are:

- Consult with Commission staff, the Oklahoma SHPO, OAS, Native American tribes, Bureau of Indian Affairs (BIA) and other identified parties (collectively, the "Cultural Resources Working Group" or "CRWG") to determine the Project's APE.
- Conduct background research and an archival review.
- Prepare a Pre-fieldwork Report based on the results of the background literature and archival review.
- Consult with the CRWG to identify and target appropriate areas of the APE for field investigation during Project relicensing.
- During Study Years One and Two, conduct field investigations to include a Phase I Reconnaissance Survey (Reconnaissance Survey) of targeted areas which would include a visual inspection and the excavation of limited shovel tests. If sites are identified, delineate in the field.
- Following Study Year One, prepare a Reconnaissance Survey Report as part of the Initial Study Report (ISR) that provides study results and recommendations for identified archaeological resources and/or additional investigations, as necessary. Following Study Year Two, prepare the same report as part of the Updated Study Report (USR) for the sites identified during the Study Year Two investigation.
- Determine appropriate management measures for identified resources and the need for additional resource investigations in consultation with the CRWG.
- Develop an HPMP in consultation with the CRWG to provide appropriate measures for the management of historic properties within the Project's APE through the term of the new license. The HPMP would be prepared during the Integrated Licensing Process

[3] For purposes of this Cultural Resources Study Plan, the term "historic properties" will have the same definition as the regulations of the Advisory Council on Historic Preservation (36 C.F.R. § 800.16(l)).

[4] FERC has identified the following Native American Tribes as consulting parties for this undertaking: Alabama-Quassarte Tribal Town, Apache Tribe of Oklahoma, Caddo Nation of Oklahoma, Cherokee Nation, Delaware Nation, Delaware Tribe of Indians, Eastern Shawnee Tribe of Oklahoma, Iowa Tribe of Oklahoma, Kiowa Tribe of Oklahoma, Little Traverse Bay Bands of Odawa Indians, Miami Tribe of Oklahoma, Modoc Tribe of Oklahoma, Muscogee (Creek) Nation, Osage Nation, Otoe-Missouria Tribe of Indians, Ottawa Tribe of Oklahoma, Peoria Tribe of Oklahoma, Quapaw Tribe of Oklahoma, Sac and Fox Nation of Oklahoma, Seneca-Cayuga Nation, Shawnee Tribe of Oklahoma, Tonkawa Tribe of Oklahoma, United Keetoowah Band of Cherokees, Wichita and Affiliated Tribes, Wyandotte Tribe of Oklahoma. Unless otherwise specified, the term "Native American Tribes" as used in this Proposed Study Plan (PSP) refers collectively to the Tribes identified by FERC as consulting parties.

(ILP) and filed with FERC as part of GRDA's relicensing application. As appropriate, the HPMP may include provisions for additional studies to be conducted post-licensing, on a schedule determined in consultation with the CRWG.

The ILP affords a limited, 2-year window (Study Year One and Study Year Two) for conducting cultural resources studies during Project relicensing – particularly when considering the vast geographic area occupied by the Project and other areas that may be affected by Project operations. Recognizing the constraints of the ILP in the context of the overall geographical scope of the anticipated APE for the Pensacola Project is important to developing study methods and schedules that can realistically achieve the goals of the study. For this reason, GRDA's approach to the study will be to: (1) work with the CRWG to identify high-priority areas and sites within the APE for study during the 2-year ILP process, for purposes of informing FERC's analyses under both Section 106 and the National Environmental Policy Act (NEPA); and (2) continue cultural resource investigations post-licensing (as necessary) over a longer period of time as part of the HPMP. This longer-term phased approach has been successfully implemented at other large FERC-licensed projects.

2.2 Agency and Native American Tribe Resource Management Goals

In considering a new license for the Project, FERC has the lead responsibility for compliance with applicable federal laws, regulations, and policies pertaining to historic properties, including the National Historic Preservation Act of 1966, as amended (NHPA)[5]. Section 106 of the NHPA (Section 106)[6] directs federal agencies to take into account the effects of their undertakings on historic properties and to afford the Advisory Council on Historic Preservation (ACHP) a reasonable opportunity to comment.

The regulations implementing Section 106 (36 Code of Federal Regulations [C.F.R.] Part 800) 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 properties of traditional religious and cultural importance (often referred to as "traditional cultural properties" [TCP]) that meet the National Register Criteria.

The Secretary of the Interior has established the criteria for evaluating properties for inclusion in the NRHP (36 C.F.R. Part 60). In accordance with the criteria, properties are eligible if they are significant in American history, architecture, archaeology, engineering, or culture. The quality of significance is present in historic properties that possess integrity[7] of location, design, setting, materials, workmanship, feeling, or association and meet one or more of the National Register Criteria:

[5] 54 U.S.C. § 300101 *et seq.*
[6] 54 U.S.C. § 306108
[7] Integrity is the authenticity of a property's historic identity, evidenced by the survival of physical characteristics that existed during the property's pre-contact or historic period (National Park Service 1997). The integrity of archaeological resources is generally based on the degree to which remaining evidence can provide important information. If the context and association of archaeological material found at a site are disturbed, the archaeological site may not possess integrity and would, therefore, be ineligible for inclusion in the NRHP.

- Criterion A: Are associated with events that have made a significant contribution to the broad patterns of our history; or
- Criterion B: Are associated with the lives of persons of significance in our past; or
- Criterion C: That embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components could lack individual distinction; or
- Criterion D: That have yielded, or could be likely to yield, information important in prehistory or history.

Normally, NRHP eligibility requires a property to be at least 50 years of age. Resources less than 50 years of age that are highly significant and meet the "special criteria considerations" as outlined in the regulations (36 C.F.R. 60.4) also may be eligible for the NRHP.

The implementing regulations of Section 106 are intended to accommodate historic preservation concerns with the needs of federal undertakings through a process of consultation among agency officials, federally recognized Native American Tribes, SHPOs, Tribal Historic Preservation Officers (THPO), and other parties, including the public, as appropriate.

Concurrent with the filing of the PAD and Notice of Intent (NOI), GRDA requested designation as the Commission's non-federal representative for carrying out informal consultation pursuant to Section 106. The Commission granted GRDA's request by notice dated January 12, 2018. While GRDA is authorized to consult in an informal capacity, the Commission remains legally responsible for all agency findings and determinations under Section 106.

2.3 Background and Existing Information

Archaeological and historic resources within the Project's vicinity have been inventoried by avocational archaeologists and historians and as a result of prior cultural resources studies in the area. In preparing the PAD, GRDA conducted a search of publicly available literature, as well as records housed at the OAS to summarize the cultural context of the Project and to identify known archaeological and historic resources within a one-mile buffer zone of the Project, including those properties listed in or eligible for the NRHP. While the one-mile buffer is much larger than the expected APE for this undertaking, a review of previously reported archaeological and historic resources within a one-mile radius of the Project was conducted to characterize the types of historic properties that may occur within the APE.

Section 6.9 of the PAD summarizes the pre-contact and historic context for the Project and presents information on reported archaeological sites and historic resources. In total, 195 archaeological sites were identified within one mile of the Project. One of the archaeological sites (34DL285) within the search radius is considered eligible for inclusion in the NRHP. A total of 50 of the sites are considered not eligible for inclusion in the NRHP, 125 have unknown NRHP eligibility statuses, and the remaining 19 sites have unassessed NRHP eligibility statuses. Sites within the current FERC-established Project Boundary (which approximately follows the 750-foot PD contour) are either considered not eligible for the NRHP or have not been evaluated for NRHP eligibility.

The Oklahoma SHPO's website for the NRHP in Oklahoma was also consulted during development of the PAD to identify any NRHP-listed or eligible historic architectural properties

or districts within one mile of the Project. A total of eight NRHP historic architectural properties/districts are located within one mile of the Project. One of the eight properties/districts (Pensacola Dam Historic District) is located within the current Project Boundary. The Pensacola Dam Historic District was listed on the NRHP in September 2003. The district includes three buildings – a substation, an observation building, and a powerhouse designed by noted Oklahoma architect John Duncan Forsyth. Four structures – the multi-arched dam, two spillways, and a pumping/intake structure – are also included in the historic district.

Additionally, the Oklahoma Landmarks Inventory (OLI) Database found 150 other historical sites within one mile of the Project.

The Project Boundary encompasses an historic district listed in the NRHP, as well as archaeological and historic resources which may be eligible for inclusion in the NRHP (but have not been evaluated). In addition, there may be unknown historic properties or archeological sites within the APE. This proposed Cultural Resources Study will identify historic and archaeological resources within the Project's APE that may be affected by relicensing the Project.

2.4 Nexus between Project Operations and Effects on Resources

The continued operation and maintenance of the Project may have the potential to directly, indirectly, or cumulatively affect historic properties listed in or eligible for inclusion in the NRHP during the term of any new license issued by the Commission. Effects on cultural resources may potentially result from Project-related activities, such as reservoir level fluctuations attributable to hydropower operations, modifications to Project facilities, or other Project-related, ground-disturbing activities (e.g., new construction).

Effects on the integrity of cultural resources can come from a variety of sources, including the ongoing direct, indirect, or cumulative effects of shoreline fluctuations, recreation, public use, shoreline development, and routine maintenance activities. These potential activities are most likely to impact archaeological sites along the reservoir's shoreline.

2.5 Area of Potential Effects

In SD1, FERC tentatively identified the geographic scope for cultural resources as the Grand Lake Reservoir, to elevation 760 feet PD, as well as any adjacent upland areas that are periodically inundated by Grand Lake. FERC concluded that "existing operation and maintenance of the Project, in combination with other developmental and non-developmental activities within the Grand River Basin, may cumulatively affect cultural resources located on lands adjacent to the reservoir, including by flooding of adjacent lands" (FERC 2018).

The study area for the Cultural Resources Study includes the APE (Figure 2.5-1). GRDA intends to define an APE in consultation with the CRWG as a component of the Cultural Resources Study. GRDA tentatively proposes the following APE, which will be refined through consultation and informed by the result of other studies conducted in support of Project relicensing:

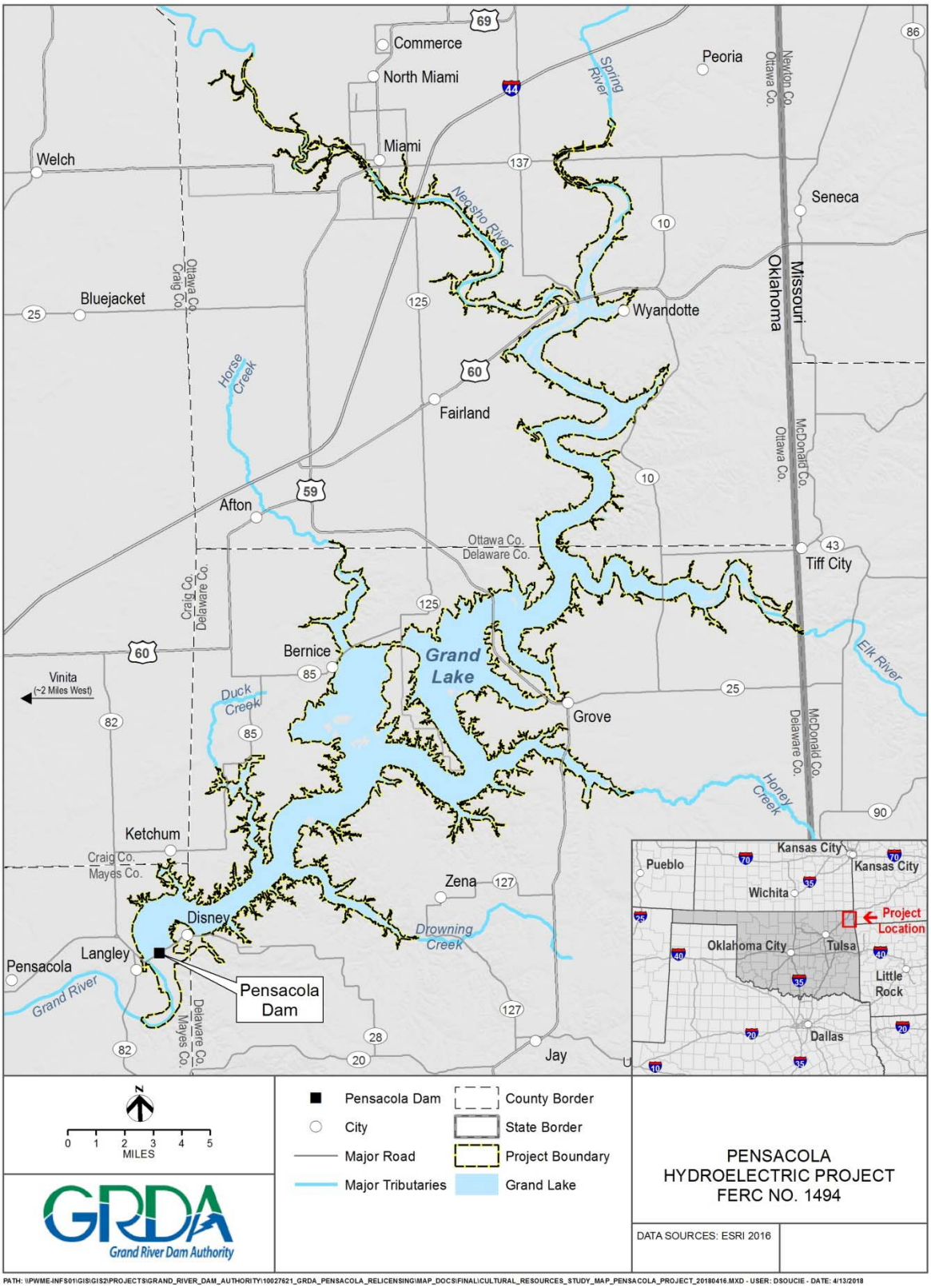

Figure 2.5-1. Proposed Area of Potential Effects.

The APE for this undertaking includes all lands within the FERC-approved Project Boundary. 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.

2.6 Methodology

2.6.1 Area of Potential Effects

GRDA has tentatively proposed an APE as presented in Section 2.5. Pursuant to the implementing regulations of Section 106 at 36 C.F.R. § 800.4(a), GRDA will consult with the CRWG to determine and document the APE for the Project as defined in 36 C.F.R. § 800.16(d).

As tentatively defined in Section 2.5, the APE includes lands outside the current Project Boundary where Project-related operations or activities may have a direct, indirect, or cumulative effect on historic properties. Based on the results of hydraulic modeling and other studies, the geographic extent of the APE may be refined in consultation with the CRWG in Study Year Two.

2.6.2. Background Research and Archival Review

GRDA will conduct background research and an archival review to inform the specific research design and the historic and environmental contexts of the APE. The background research and archival review will be conducted by a qualified cultural resources professional[8]. GRDA will review relevant sources of information that may include (but are not necessarily limited to):

- Information on archaeological sites, historic architectural resources, and previous cultural resources studies on file with OAS, Oklahoma SHPO, and Native American Tribes;
- Available reports on previous cultural resources studies conducted within the APE[9];
- A review of the OLI and Oklahoma's NRHP listings;
- Historic maps and aerial photographs of the APE, including relevant plat and Sanborn maps;
- Aerial photographs of the APE;

[8] For purposes of this Cultural Resources Study Plan, a "qualified cultural resources professional" is defined as an individual who meets the Secretary of the Interior's Professional Qualification Standards (48 Federal Register [FR] 44738-44739, Sept. 1983) and the standards established by the Oklahoma SHPO.

[9] As discussed in the PAD, archaeological surveys of the Project area were conducted between 1937 and 1940 by the Works Progress Administration (WPA), and additional survey work continued after the creation of Grand Lake. In developing the PAD, GRDA reviewed archival information and documents on file with OAS. The WPA reports were not readily available from OAS or in GRDA's archives. As part of this background research and archival review task, GRDA will conduct an additional review of its archives, consult with OAS, and review information on file with local and state repositories in an effort to obtain copies of the WPA reports.

- Relevant documents related to Project construction;
- Relevant information available from local repositories;
- Information on the current and historical environment, including mapped soils, bedrock geology, geomorphology, physiography, topography, and hydrology in the vicinity of the APE;
- Relevant historical accounts of the Project area;
- Relevant management plans for the Project;
- Historic context statements for Management Region 3 available from the Oklahoma SHPO; and
- Any additional relevant information made available by the CRWG or other relicensing participants.

As part of the background research and archival review, GRDA may undertake limited field observations to better characterize and document existing shoreline conditions at the reservoir and inform the Pre-fieldwork Report (see Section 2.6.3 of this study plan).

2.6.3 Pre-fieldwork Report

GRDA will prepare a Pre-fieldwork Report based on the results of the background literature review that will identify and map:

- Previously reported archaeological sites, historic resources, and relevant map-documented structures;
- Areas with archaeological sensitivity, such as pre-Project terrace landforms, the outlets of tributary streams, and other landscape features; Pre-project trails and roads; and historic towns, villages, or other population centers; and
- Areas identified within the APE where erosion or other Project-related effects are occurring.

2.6.4 Reconnaissance Surveys

Based on the Pre-fieldwork Report, GRDA will consult with the CRWG to identify high-priority areas and sites within the APE for study during the 2-year ILP process for purposes of informing FERC's analyses under both Section 106 and the NEPA.

GRDA will conduct a Reconnaissance Survey of the Project's APE during Study Year One and Study Year Two. The proposed methods for the Reconnaissance Survey are the same for both study years and take into account the nature and extent of potential effects on historic properties and the likely nature and location of historic properties within the APE (36 C.F.R. 800.4(b)(1)). The Reconnaissance Survey will be conducted by a qualified cultural resources professional retained by GRDA and will be in accordance with the Secretary of the Interior's Standards and Guidelines for Archaeology and Historic Preservation (48 Federal Register [FR] 44716, Sept. 1983) and guidance documents promulgated by the Oklahoma SHPO, including:

- Guidelines for Developing Archaeological Survey Reports in Oklahoma and Report Components (Oklahoma SHPO 2013a); and
- Architectural/Historical Resources Survey Field Guide (Oklahoma SHPO 2013b).

The Reconnaissance Survey will include a visual reconnaissance of the exposed portions of the reservoir shoreline areas within the APE to identify any previously recorded or unrecorded archaeological and/or historic architectural resources. If archaeological material is observed during the Reconnaissance Survey, GRDA will delineate site boundaries. The maximum length and width of each site will be measured and recorded and the site's location geo-located. Site dimensions and elevations will be recorded on standardized field forms along with sketch maps of site settings and notations regarding landform, site aspect, temporal affiliations (if possible) and density of observed materials, site condition, any evidence of Project-related effects, and the nature of site deposits. Site boundaries will be located on Project maps and U.S. Geological Survey (USGS) topographic maps. Based on the judgment of the archaeologist, visual reconnaissance may be augmented by limited subsurface testing (e.g., shovel test pits) to record site depth, stratigraphy, and other features. GRDA will geo-locate, record, and collect any observed artifacts, features, or other pre-contact or historic period cultural material (as appropriate), and any new archaeological sites discovered will be documented on Oklahoma Archaeological Site Survey Form (Appendix A) or Isolated Find Form (Appendix B).

Treatment and disposition of any human remains that may be discovered will be managed in a manner consistent with the Native American Graves Protection and Repatriation Act (NAGPRA) (Public Law [P.L.] 101-601; 25 U.S. Code [U.S.C.] 3001 *et seq*.)[10]; the Council's Policy Statement Regarding Treatment of Burial Sites, Human Remains, and Funerary Objects (ACHP 2007); and the Burial Desecration Law – Oklahoma Statute Chapter 47 (Section 1168.0 - 1168.6). Any human remains, burial sites, or funerary objects that are discovered will at all times be treated with dignity and respect. In the event that any Native American graves and/or associated cultural items are inadvertently discovered, GRDA will immediately notify the Oklahoma SHPO, OAS, and potentially affected Native American Tribes.

If individual historic architectural resources or districts that potentially meet the NRHP criteria are observed, GRDA will geo-locate the resource and delineate the boundary. Relevant dimensions will be estimated and recorded, and the location will be documented on Project maps and USGS topographic maps. GRDA will take a minimum of two representative photos of the architectural resources, and GRDA will record land use patterns, the general age of the area, the character of the building stock (such as type, style, building material, integrity, and condition), the landscaping, and particularly notable and representative features. GRDA will complete a Historic Preservation Resource Identification Form for each resource (Appendix C).

Information on cultural resources from this reconnaissance survey will be used to determine the potential for adverse effects on identified archaeological and historic resources created by the continued operation of the Project and to support development of the HPMP. Where the potential for adverse effects from continued operation of the Project is determined, the HPMP will describe appropriate management or treatment measures that may include formal site evaluations to determine the NRHP-eligibility of a site or specific mitigation and treatment measures.

[10] Pursuant to 43 C.F.R. Part 10, NAGPRA applies to human remains, sacred objects, and items of cultural patrimony (described as "cultural items" in the statute) located on federal or tribal lands or in the possession and control of federal agencies or certain museums. Regardless of where cultural items are discovered, the principles described in NAGPRA's implementing regulations will serve as guidance for GRDA's actions should the remains or associated artifacts be identified as Native American and to the extent such principles and procedures are consistent with any other applicable requirements.

Following Study Year One, GRDA will prepare a Reconnaissance Survey Report as part of the ISR that provides study results and recommendations for identified archaeological and historic resources, including any recommendations for additional cultural resources investigations, as appropriate. GRDA will consult with the CRWG regarding the Study Year One Reconnaissance Survey Report.

During Study Year Two, GRDA will conduct a second Reconnaissance Survey of the APE. The locations of the Study Year Two survey will be determined in consultation with the CRWG. GRDA expects that the results of the hydraulic modeling study will assist GRDA and the CRWG in refining the appropriate areas for study during Study Year Two, if needed. Following Study Year Two, GRDA will prepare a Reconnaissance Survey Report as part of the USR that provides study results and recommendations for identified archaeological and historic resources, including any recommendations for additional cultural resources investigations, as appropriate. GRDA will consult with the CRWG regarding the Study Year Two Reconnaissance Survey Report.

2.6.5 Traditional Cultural Properties

TCPs are properties of traditional religious and cultural importance to a Native American Tribe that meet the National Register criteria (36 C.F.R. § 800.16(l)(1)). TCPs may be eligible for inclusion in the NRHP because of their association with cultural practices or beliefs of a living community that are (1) rooted in that community's history, and (2) important in maintaining the continuing cultural identity of the community.

GRDA recognizes the special expertise that the Native American Tribes have in identifying properties that have traditional and religious significance to their communities. As such, GRDA will consult with Native American Tribes to develop specific methods and approaches to conducting a TCP inventory for lands within the APE. GRDA proposes to consult with Native American Tribes during Study Year One to develop the specific TCP study methods and to initiate the TCP study during Study Year Two.

2.6.6 Programmatic Agreement

Pursuant to 36 C.F.R. Part 800.14(b), GRDA anticipates that FERC will enter into a Programmatic Agreement (PA) with the Oklahoma SHPO for managing historic properties that may be affected by Project operations or activities during the term of the new license. The PA will formally meet the Commission's obligations under NHPA Section 106 for the relicensing of the Project, and is likely to provide for GRDA to implement an HPMP for the long-term management of historic properties during the new license term.

2.6.7 Historic Properties Management Plan

In anticipation of a PA, GRDA will prepare an HPMP providing measures that will direct GRDA's management of historic properties within the Project's APE throughout the term of the new license. The HPMP is not intended to be a static document, but will include measures for additional consultation and processes for additional identification and treatment of historic properties. GRDA will develop the HPMP in consultation with the CRWG; through this consultation, GRDA and the CRWG will develop specific management measures to be incorporated into the HPMP. GRDA anticipates that the CRWG will have an ongoing role in the HPMP implementation. GRDA expects to file the HPMP with FERC as part of its relicensing

application, such that it may be approved and implemented immediately upon the effective date of the new license issued by FERC.

GRDA has outlined the following three goals for managing historic resources under the HPMP:

- Continue ongoing operations of the Project while maintaining and preserving the integrity of historic properties within the Project Boundary, in consultation with the CRWG;
- To the extent possible, avoid, minimize, or mitigate adverse effects on historic properties that would be affected by the continued operation of the Project under the new license, in consultation with the CRWG; and
- Ensure historic properties are managed in an efficient and cost-effective manner that does not impede GRDA's ability to comply with the terms of its operating license and other applicable federal, state, and local statutes.

To address these goals, GRDA will develop an HPMP in consultation with the CRWG and in accordance with the Guidelines for the Development of Historic Properties Management Plans for FERC Hydroelectric Projects, promulgated by the FERC and the ACHP on May 20, 2002. At a minimum, GRDA anticipates that the HPMP will address the following items (ACHP and FERC 2002):

- Any additional studies necessary to assist in the identification or management of historic properties within the APE, including a schedule for completing such studies;
- A plan and schedule for completing Reconnaissance Surveys of areas within the APE identified in consultation with the CRWG, including areas where Reconnaissance Surveys could not be completed during the ILP;
- Potential effects on historic properties resulting from the continued operation and maintenance of the Project;
- Management and treatment measures for historic properties (including any identified TCPs);
- Protection of historic properties threatened by potential ground-disturbing or land-clearing activities during the term of the new license;
- Protection of historic properties threatened by other direct or indirect Project-related activities, including routine Project maintenance;
- The resolution of unavoidable adverse effects on historic properties;
- Treatment and disposition of any human remains that are discovered;
- Provisions for unanticipated discoveries of previously unidentified cultural resources within the APE;
- A dispute resolution process;
- Categorical exclusions from further review of effects;
- Public interpretation of the historic and archaeological values of the Projects, if any;
- Specific measures and a schedule for implementing the HPMP;

- Roles and responsibilities of GRDA, the Oklahoma SHPO, OAS, Native American Tribes, and other individuals and organizations in regards to implementation of the HPMP; and
- Coordination with the CRWG during implementation of the HPMP.

2.7 Consistency with Generally Accepted Scientific Practice

The proposed methods for this study are consistent with accepted scientific practices. The overall approach complies with the ACHP's Section 106 Archaeology Guidance (ACHP 2009)[11] and is consistent with cultural resources studies conducted in support of other relicensing proceedings in Oklahoma. The Cultural Resources Study will allow GRDA to identify archaeological resources that are potentially affected (directly or indirectly) by the Project and to develop appropriate management measures for those resources. In addition, the proposed methods for this study are consistent with FERC study requirements under ILP. No alternative approaches to this study are necessary.

2.8 Schedule

GRDA will initiate consultation with the Oklahoma SHPO and Native American Tribes to seek concurrence regarding the Project's APE in May 2018, as part of the planned PSP and CRWG meetings. Background research and archival reviews and consultation to develop TCP inventory methods will be conducted from September 2018 – April 2019. GRDA anticipates the Pre-fieldwork Study Report will be completed in April 2019, and that the Study Year One Reconnaissance Survey will be completed from May 2019 – August 2019. The Study Year One Reconnaissance Survey Report will be prepared as part of the ISR which will be filed in September 2019. GRDA expects that the Study Year Two Reconnaissance Survey will be conducted from May 2020 – August 2020. The Study Year Two Reconnaissance Survey Report will be prepared as part of the USR which will be filed in September 2020. GRDA anticipates that the TCP inventory will also be initiated during Study Year Two. GRDA will consult with the CRWG in the development of a draft HPMP and expects to file the HPMP with the Commission concurrent with the March 31, 2020 filing of the Final License Application (FLA).

2.9 Level of Effort and Cost

The estimated level of effort for this study is approximately 4,000 man-hours. The estimated cost of this proposed study is $450,000.

[11] The ACHP's guidance states that "[A] federal agency is not expected to conduct a 100 percent survey of the area of potential effects. Rather, the identification effort should be conditioned by where effects are likely to occur and the likely impact of these effects on listed or eligible archaeological sites. For example, archaeological identification efforts for a license renewal from the Federal Energy Regulatory Commission likely would not involve the entire area of potential effects (APE). Rather it would be directed to those locations within the APE that are experiencing project related effects associated with operation, usually along the shoreline."

3.0 REFERENCES

ACHP (Advisory Council on Historic Preservation). 2007. Policy Statement Regarding Treatment of Burial Sites, Human Remains and Funerary Objects. [Online] URL: http://www.achp.gov/docs/hrpolicy0207.pdf. Accessed January 2018.

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ACHP and FERC (Federal Energy Regulatory Commission). 2002. Guidelines for the Development of Historic Properties Management Plans for FERC Hydroelectric Projects. [Online] URL: http://www.achp.gov/ferc-hpmp.pdf. Accessed January 2018.

FERC. 2018. Scoping Document 1 for the Pensacola Hydroelectric Project, P-1494. January 12, 2018.

National Park Service. 1997. National Register Bulletin: How to Complete the National Register Registration Form. National Park Service, National Register of Historic Places, Washington, D.C.

SHPO (Oklahoma State Historic Preservation Office). 2013a. Fact Sheet #16: Guidelines for Developing Archaeological Survey Reports in Oklahoma and Report Components. [Online] URL: http://www.okhistory.org/shpo/factsheets/fs16archreports.pdf. Accessed January 2018.

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APPENDIX A.
OKLAHOMA ARCHAEOLOGICAL SITE SURVEY FORM

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OKLAHOMA ARCHAEOLOGICAL SITE SURVEY FORM

Site#:

County:

COMPLETE ALL SECTIONS

1.SITE NUMBER AND NAME:

Site Name: (derived from owner's assigned name, etc.)

Project No.: (Temporary number or name during project.)

2.LOCATIONAL INFORMATION:

U.T.M. Reference

Zone: 14
Northing: **Easting:**

Legal Description

____1/4 of ____ 1/4 of ___1/4 **of Section ___ Township ____ Range ____**

U.S.G.S. Quad Name: **Quad Date (revised):**

Other Locational References (i.e., benchmarks, road intersections, bridges, etc., please give distance and bearing to site):

3.OWNER(S) OF PROPERTY:

Name:
Street and Number:
City/Town, State:
Zip:

4.SITE SURVEYED BY:

Name:

Date Recorded:

Reported by (if different):

Name:

Date Reported:

Time spent at site and time of day:

5.CULTURAL AFFILIATION - Cultural Periods (underline one):

Unassigned prehistoric
Paleoindian:
- Early
- Middle
- Late

Archaic:
- Early
- Middle
- Late

Woodland:
- Eastern – may be eastern?
- Plains

Village Farming/Mississippi
Plains Village
Protohistoric/Historic Ind.
Historic non-Indian

Archaeological Cultures, Phases, etc. represented:

How was cultural affiliation determined (diagnostic artifacts, radiocarbon dates, etc.):

6.HISTORIC PHASE IDENTIFICATION (ETHNIC):
Underline appropriate group.

1. Choctaw
2. Cherokee
3. Saux-Fox
4. Pottawatomie
5. Seminole
6. Comanche
7. Apache
8. Kiowa
9. Kiowa-Apache
10. Kickapoo
11. Pawnee
12. Arapaho
13. Ottawas
14. Wichita
15. Quapaw
16. Osage
17. Cheyenne
18. Caddo
19. Shawnee
20. Delaware
21. Creek
22. Dakotas
23. Chickasaw
24. 12 & 17
25. Missouri-Otos
26. Iowa
27. Anglo-American
28. French
29. Spanish
20. Other:

How was historic identification determined?:

7.HISTORIC SITE RANGE (underline one):

0. Missing data; unknown
1. pre-1800
2. 1800-1830
3. 1830-1859
4. 1860-1889
5. 1890-1929
6. 1930-1950
7. 1800-1900
8. 1800-present
9. 1900-present

8.INFERRED SITE TYPE
Please underline those that apply (can be more than one category)

Open habitation w/o mounds	Petroglyph/pictograph
Open habitation with mounds	Isolated burials (<2)
Earth mound (not midden mound)	Cemetery (>2)
Mound complex	Specialized activity sites
Stone mounds/rock piles	Rock alignments (tepee rings, etc.)
Burned rock concentrations	Historic farmstead
Non-mound earthworks	Historic mill/industrial
Rock shelter	Historic fort
Cave	Dugout
Quarry/workshop	Historic trash dump

9.MIDDEN AT SITE (underline):

Don't know	Present, earth
Absent	Present, shell
	Present, rock

10.MATERIALS COLLECTED:

Type	**Number**
Ceramics	
Projectile points/base frags.	
Hafted scrapers	
Drills	
Bifaces/biface fragments	
Unifaces	
Perforators/gravers	
Spokeshaves	
Scrapers (unhafted)	
Debitage (flakes, cores, chunks)	
Ground/pecked/battered stone	
Worked bone/shell	
Human bone	
Faunal remains	
Floral remains	
Other prehistoric	
Historic (describe)	
	Total Items:

Briefly describe diagnostic artifacts including type names. Attach outline drawings:

Materials observed but not collected:

Name and address of owner of other collections from site:

11.ARTIFACT REPOSITORY

Name of institution where artifacts are to be stored:

Photos:
Number of black and white photos:
Number of color photos:

Name and address of institution where photos are filed:

12.EVIDENCE OF RECENT VANDALISM OBSERVED? (Yes or No):

13.SITE CONDITION (underline one):

1. apparently undisturbed
2. <25% disturbed
3. 26-50% disturbed
4. 51-75% disturbed
5. 76-99% disturbed
6. totally destroyed
7. disturbed, % unknown

14.MAJOR LAND USE (underline those that apply):

Cultivated field
Pasture
Woods, forest
Road/trail
Ditch/dike/borrow pit
Landfill
Modern cemetery
Mining
Inundated
Industrial
Residential
Recreation
Commercial
Military
Logging/fire break
Scrub/secondary growth/oil field
Modern dump

Other:

15.AMOUNT OF GROUND SURFACE VISIBLE (underline one):

1. <10%
2. 11-25%
3. 26-50%
4. 51-75%
5. 76-90%
6. 91-100%

Survey Conditions (wet, dry, sunny, ground coverage, etc.):

16.PHYSIOGRAPHIC DIVISION (underline one):

1. High Plains
2. Gypsum Hills
3. Wichita Mountains
4. Red Bed Plains
5. Arbuckle Mountains
6. Sandstone Hills
7. Prairie Plains
8. Ozark Plateau
9. Ouachita Mountains
10. Red River Plains

17.LANDFORM TYPE (underline one):

1. Floodplain
2. Terrace
3. Hillside - Valley wall
4. Dissected Uplands
5. Undissected Uplands

18.LOCALITY TYPE - SPECIFIC SITE SETTING (underline one):

1. Level
2. Knoll - low land
3. Blowout
4. Ridge – upland
5. Mesa
6. Slope
7. Bluff crest
8. Bluff base

19.SOILS (if known):
Association: **Series:**
Type:

20.ELEVATION/SLOPE:

Elevation amsl:
Slope (degrees): **Slope facing direction:**

21.NATURAL VEGETATION (underline one):

1. Short grasses
2. Mixed grasses
3. Tall grasses
4. Cross Timber
5. Shin-oak
6. Mesquite
7. Juniper-pinon
8. Oak-hickory forest
9. Oak-pine
10. Loblolly pine forest

22.SITE AREA (Square Meters):
Basis for area estimate (underline one):
1. Taped 2. Paced 3. Guessed 4. Range-finder
5. Alidade/transit

Confident of site boundaries? (Yes or No):

_____

23.DESCRIPTION OF SITE:

Give physical description of site and its setting, including dimensions, features, nature of materials and artifact concentrations. Include copy of U.S.G.S. topographic map with site location and boundaries marked (and sketch map if appropriate).

24.DRAINAGE (underline one):

1. Arkansas
2. Beaver - N. Canadian
3. Canadian
4. Caney
5. Cimarron
6. Deep Fork
7. Illinois
8. Kiamichi
9. Little R. (McCurtain County)
10. Muddy Boggy
11. Neosho
12. North Fork Red
13. Poteau
14. Red
15. Salt Fork Arkansas
16. Salt Fork Red
17. Verdigris
18. Washita

25.NEAREST NATURAL SOURCE OF WATER (underline one):

1. Permanent stream/creek
2. Intermittent stream
3. Permanent stream
4. Intermittent spring/seep/bog
5. Natural lake
6. River
7. Slough or oxbow lake
8. Relic stream channel
9. Also consider wells if site is historic

26.DISTANCE TO WATER (in 10's of meters):

27.INVESTIGATION TYPE (underline one):

1. Reconnaissance (survey)
2. Intensive (survey & testing)
3. Excavated
4. Volunteered report

28.SIGNIFICANCE STATUS (underline one):

National Register Property
Eligible for National Register
Nominated to National Register by S.H.P.O.
Considered eligible but not nominated by S.H.P.O.
Inventory site
National Register status not assessed

29.DISCUSS THE POTENTIAL SIGNIFICANCE OF THE SITE:

30.PUBLISHED OR FORTHCOMING REPORTS ON THE SITE:

APPENDIX B.
ISOLATED FIND FORM

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OKLAHOMA ARCHEOLOGICAL SURVEY
ISOLATED FIND RECORD

County: **Temp. No.:** **Find No.:**
U.S.G.S. Topo(Date)
Cultural Affiliation:

Project:
Location:

U.T.M.: Zone: **Northing:** **Easting:**
__1/4_of__1/4 of__ 1/4 of __ 1/4 **of Section ___ Township ___ Range ___**

Present Owner:
Address:

Description of Find Locale:

Topographic Setting:
State of Preservation: **Cultivation:**
Erosion: **Vegetation:**
Soil: **Elevation:** **Slope:**
Location of Water Supply:

Landmarks to Aid in Relocating Locale:

Published Reports on Finds:

Artifacts Collected:

Artifacts or Features Observed at Find Locale:

Data From Test Pits or Other Explorations:

Materials Reported from Area:

Remarks (Why Find Locale and Not Site):

Recorded by:
Date: **Photos:**

APPENDIX C.
HISTORIC PRESERVATION RESOURCE IDENTIFICATION FORM

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HISTORIC PRESERVATION RESOURCE IDENTIFICATION FORM

PLEASE TYPE ALL DATA IN UPPERCASE - FIELDS IN RED ARE REQUIRED

1. PROPERTY NAME: _____

2. RESOURCE NAME: _____

3. ADDRESS: _____

4. CITY: _____ 5. VICINITY: _____

6. COUNTY NAME: _____

7. LOT: _____ 8. BLOCK: _____ 9. PLAT NAME: _____

10. SECTION: _____ 11. TOWNSHIP: _____ 12. RANGE: _____

13. LATITUDE (NORTH): (ENTER AS: "dd.ddddd") _____

14. LONGITUDE (WEST): (ENTER AS: "-dd.ddddd") _____

15. UTM ZONE: _____ 16. NORTHINGS: _____ 17. EASTINGS: _____

18. RESOURCE TYPE: _____

19. HISTORIC FUNCTION: _____

20. CURRENT FUNCTION: _____

21. AREA OF SIGNIFICANCE, PRIMARY: _____

22. AREA OF SIGNIFICANCE, SECONDARY: _____

23. DESCRIPTION OF SIGNIFICANCE:

24. DOCUMENTATION RESOURCE:

25. NAME OF PREPARER: _____

59. SURVEY PROJECT _____ 26. PROJECT NAME: _____

27. DATE OF PREPARATION: _____ 28. PHOTOGRAPHS _____

29. YEAR: _____

30. ARCHITECT/BUILDER: _____

31. YEAR BUILT: _____

32. ORIGINAL SITE: _____ 33. DATE MOVED: _____

34. FROM WHERE: _____ 35. ACCESSIBLE: _____

36. ARCHITECTURAL STYLE: _____

37. OTHER ARCHITECTURAL STYLE: _____

38. FOUNDATION MATERIAL: _____

39. ROOF TYPE: _____ 40. ROOF MATERIAL: _____

41. WALL MATERIAL, PRIMARY: _____

42. WALL MATERIAL, SECONDARY: _____

43. WINDOW TYPE: _____ 44. WINDOW MATERIAL: _____

45. DOOR TYPE: _____ 46. DOOR MATERIAL: _____

47. EXTERIOR FEATURES: _____

48. INTERIOR FEATURES: _____

49. DECORATIVE DETAILS: _____

50. CONDITION OF RESOURCE: _____

51. DESCRIPTION OF RESOURCE:

52. COMMENTS:

53. ATTACH LOCATION MAP

54. LISTED ON NATIONAL REGISTER: _____

55. NATIONAL REGISTER ENTRY: _____

56. CONTINUATION

Pensacola Hydroelectric Project, FERC No. 1494

Proposed Study Plan

Socioeconomics Study

Prepared for

Prepared by

April 2018

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF ACRONYMS

FERC ..... Federal Energy Regulatory Commission
GRDA..... Grand River Dam Authority
ILP..... Integrated Licensing Process
ISR ..... Initial Study Report
OTRD..... Oklahoma Tourism and Recreation Department
PAD..... Pre-Application Document
Project..... Pensacola Hydroelectric Project
PSP ..... Proposed Study Plan
SCORP ..... Statewide Comprehensive Outdoor Recreation Plan
SD1 ..... Scoping Document 1
USACE..... U.S. Army Corps of Engineers

1.0 INTRODUCTION

The Pensacola Hydroelectric Project (Pensacola Project or Project), owned and operated by the Grand River Dam Authority (GRDA), is licensed by the Federal Energy Regulatory Commission (FERC or Commission) as Project No. 1494. GRDA is a non-appropriated 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." As licensed by FERC, the Project serves multiple purposes, including hydropower generation, water supply, public recreation, and wildlife enhancement. As directed by Congress under the Flood Control Act of 1944, 58 Stat. 887, 890-91, the U.S. Army Corps of Engineers (USACE) has exclusive jurisdiction over Grand Lake for flood control purposes.

FERC's January 12, 2018 Scoping Document 1 (SDI) identified the following resource issue to be analyzed for the Project relicensing:

- Effects of any proposed changes in project operation or maintenance on socioeconomic resources.

The City of Miami, Miami Tribe (as supported by the Eastern Shawnee Tribe, Ottawa Tribe, Seneca-Cayuga Nation, and Wyandotte Nation), and N. Larry Bork (counsel for City of Miami citizens) subsequently submitted formal requests related to socioeconomics. Section 4.2.4 of the main body of the Proposed Study Plan (PSP) details GRDA's response to the requests.

2.0 STUDY PLAN ELEMENTS

2.1 Study Goals and Objectives

The goal of this study is to gather, synthesize, and report on existing information necessary to qualitatively evaluate the socioeconomic effects of the Pensacola Project in the study area.

The objectives of the study are to:

- Describe baseline economic conditions in the Project area.
- Identify the socioeconomic contribution of the Project in the state and the region.

2.2 Agency and Native American Tribe Resource Management Goals

Recreation in the Project area provides socioeconomic benefits to the region. The Oklahoma Tourism and Recreation Department (OTRD) promotes the development and operation of tourism and recreation opportunities throughout the State. The primary goal of the OTRD is to expand the economy of Oklahoma through increased tourism promotion and development (OTRD 2018). The OTRD uses the Oklahoma Statewide Comprehensive Outdoor Recreation Plan (SCORP) as a planning tool to assist in preserving, developing, and assuring accessibility to outdoor recreation resources (OTRD 2012).

2.3 Background and Existing Information

Section 6.10 of the Pre-Application Document (PAD) summarizes existing information on socioeconomic resources in the Project area. The Pensacola Project dam and hydroelectric generating facility is located northeast of Tulsa on the Grand (Neosho) River (Grand River) in Craig, Delaware, Mayes, and Ottawa counties, Oklahoma. The Pensacola Dam creates the Grand Lake O' The Cherokees, also known as Grand Lake.

The entirety of the Project resides in Craig, Delaware, Mayes, and Ottawa counties, which are located along the northeastern border of the state of Oklahoma. Ottawa County, the northernmost of the four counties occupied by the Pensacola Project, has two incorporated cities, six incorporated towns, and one unincorporated community with a total estimated population of 31,981 as of the 2015 census. Mayes County, located to the southwest of Ottawa County, has one incorporated city, twelve incorporated towns, and five unincorporated communities with a total estimated population of 40,887 in 2015. Delaware County, located to the east of Mayes County, has two incorporated cities, five incorporated towns, and two unincorporated communities with a total estimated population of 41,459 in 2015. Craig County, located to the northwest of Delaware County, has one incorporated city, four incorporated towns, and one unincorporated community with a total estimated population of 14,818 in 2015 (U.S. Census Bureau 2016).

Current uses around Grand Lake include residential and commercial development, agriculture, and wildlife management areas. Lands surrounding the Project vicinity are generally rural and undeveloped, but historically, mining for lead and zinc was prevalent in Ottawa County, Oklahoma, and mining for coal was prevalent in Craig County, Oklahoma (Oklahoma Historical Society 2009). Approximately 53 percent of land within the Project Boundary is deciduous forestlands. Residential, commercial, and other development accounts for approximately 11 percent of total land area within the Project Boundary. Approximately 53 percent of lands adjacent to the Project boundary are undeveloped forestlands. In addition, 31 percent of lands adjacent to the Pensacola Project are designated as agricultural/crop lands. The majority of these agricultural areas are in Ottawa County (GRDA 2008). Grand Lake is also the premier recreational lake in northeast Oklahoma (FERC 2014), and the popularity of water-based recreation at Grand Lake has resulted in significant economic development, particularly in real estate, goods, and services.

Detailed reports on the economic conditions in the state and region are sufficient to describe the socioeconomic conditions in the study area and the Project's contributions to the state and regional economy. Existing studies on the socioeconomics in the region include:

- Data regarding the Economic impact of the GRDA (Oklahoma Department of Commerce 2012a, updated in 2015)
- Demographic data including land use, population, and employment data (U.S. Census Bureau 2015, 2016; Oklahoma Department of Commerce 2012b, 2015; Oklahoma Employment Security Commission 2016; Oklahoma Historical Society 2009; and GRDA 2008)
- Estimating Non-Market Value for the Grand River Watershed (Brand et al. 2017)
- Estimating Lake Amenity Values on Grand Lake o' the Cherokees (Ghimire et al. 2017)

2.4 Nexus between Project Operations and Effects on Resources

The presence of the Pensacola Project provides significant contributions to the state and regional economy. The results of the study, in conjunction with existing information, will be used to inform analysis in the license application.

2.5 Study Area

The entirety of the Project resides in Craig, Delaware, Mayes, and Ottawa counties, which are located along the northeastern border of the state of Oklahoma (Figure 2.5-1). The study area for this desktop review will primarily focus on these four counties. Project-related economic impacts are also felt in the broader northeastern Oklahoma region, and the state of Oklahoma as a whole, and this study proposes to provide that information to the extent it is available.

2.6 Methodology

A desktop review of available regional socioeconomic data will be completed. Information on the demographic and economic conditions of the region will be compiled and can be readily obtained from governmental agencies, such as the U.S. Census Bureau and the Oklahoma Department of Commerce. Parties to the relicensing as well as local industry organizations will be queried for available, verifiable data. Available county level economic data is presented in the PAD and includes population, income, and labor force. In addition, GRDA will provide information from published sources, including those listed in Section 2.3, to present a qualitative assessment for the study area, including:

- State and regional population, income, and employment data;
- State and regional industry trends (e.g., goods and services; agricultural use);
- Regional trends in land and resource values (e.g., tribal practices; hunting, fishing, eco-tourism, outfitting, trapping, recreation, tourism, exploration, and mining activities);
- Pensacola Project's economic impact on the state and region under current operations;
- The potential state and regional economic impact of proposed operations.

2.7 Consistency with Generally Accepted Scientific Practice

The proposed methods for this study are consistent with FERC study requirements under the Integrated Licensing Process (ILP).

2.8 Schedule

The study will be complete and a final study report will be included as part of the Initial Study Report (ISR) filing in September 2019.

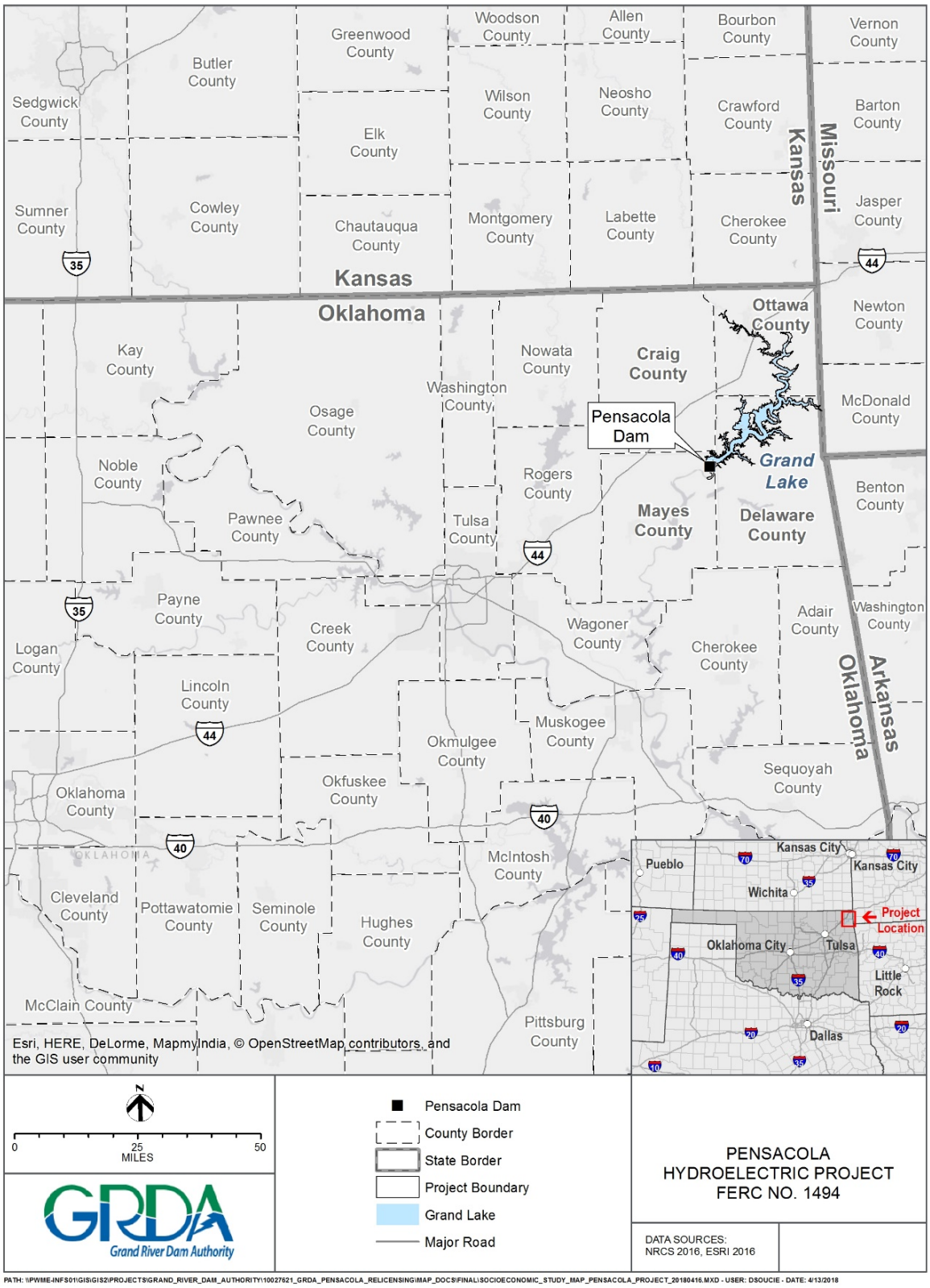

Figure 2.5-1. Location map of the Pensacola Project.

2.9 Level of Effort and Cost

The estimated cost of this study is expected to be approximately $75,000.

3.0 REFERENCES

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ATTACHMENT B. LIST OF COMMENT LETTERS AND STUDY REQUESTS AS FILED WITH FERC

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List of comment letters and study requests regarding the Pensacola Project relicensing as filed with FERC from January 8, 2018 through March 19, 2018.

Date Letter Filed	Filing Party	Description of Filing
January 8, 2018	Leslie and Ruth Ann Farris*	General comments
January 9, 2018	Melinda Stotts*	General comments
January 11, 2018	Brad Williams*	General comments
January 16, 2018	Judy Judkins*	General comments
January 16, 2018	Roger and Tiffani Lacy*	General comments
January 16, 2018	Paul and Dava Marquez*	General comments
January 22, 2018	Pauline Klinefelter*	General comments
January 22, 2018	John A. Fox (Osage Nation)	General comments
January 23, 2018	Patricia A. Bridgewater*	General comments
January 23, 2018	Judy Judkins*	General comments
January 23, 2018	Ike and Nancy Lacy*	General comments
January 23, 2018	Rod Lloughdam*	General comments
January 23, 2018	Aaron Milligan*	General comments
January 23, 2018	David R. Walker*	General comments
January 23, 2018	Kellie Wilson*	General comments
January 26, 2018	Harry T. Griffin*	General comments
January 26, 2018	Danny and Linda M. Trujillo*	General comments
January 29, 2018	E. W. Fletcher*	General comments
January 30, 2018	Barbara Haile*	General comments
January 31, 2018	Eldon Mercer*	General comments
February 2, 2018	Flo Ray*	General comments
February 2, 2018	Evertt J. Stamback*	General comments
February 5, 2018	Bobby L. and Becky J. Blunk*	General comments
February 5, 2018	Darrel L. Testerman*	General comments
February 6, 2018	Cean Wilson Mooney*	General comments
February 6, 2018	Robin Still*	General comments
February 6, 2018	Jeri White-Potts*	General comments
February 7, 2018	Roy T. Collins*	General comments
February 7, 2018	Donna Schoenhals*	General comments
February 8, 2018	Debbie Bradley*	General comments
February 15, 2018	Patti Baker*	General comments
February 20, 2018	Kent Carson*	General comments
February 20, 2018	Al Newkirk*	General comments

Date Letter Filed	Filing Party	Description of Filing
February 20, 2018	Al Newkirk (second letter)*	General comments
February 22, 2018	Rachel C. Pruitt*	General comments
February 26, 2018	Jack Elsey*	General comments
March 5, 2018	Eddie R. Streater (BIA)	Study request
March 5, 2018	Eddie R. Streater (BIA)	PAD comments
March 5, 2018	Eddie R. Streater (BIA)	SD1 comments
March 6, 2018	Carolyn J. McCool*	General comments
March 12, 2018	Retha Johnson*	General comments
March 12, 2018	Dr. J. Mark Osborn*	General comments
March 12, 2018	Mayor Ed Trumbull (City of Grove)	Letter of support
March 13, 2018	Ethel Cook (Ottawa Tribe of Oklahoma)	Letter of support for Miami Tribe's study requests
March 13, 2018	Ellen Roberts*	General comments
March 13, 2018	Carlos E. Gutierrez (City of Miami)	PAD and SD1 comments and study requests
March 13, 2018	N. Larry Bork (Counsel for Citizens of Miami)	PAD and SD1 comments and study requests
March 13, 2018	Stephen Bowler (FERC)	PAD comments and study requests
March 13, 2018	ODWC	PAD and SD1 comments and study requests
March 13, 2018	Fritha Ohlson (SWPA)	SD1 comments
March 13, 2018	Jonna E. Polk (USFWS)	PAD and SD1 comments and study requests
March 14, 2018	Elizabeth Toombs (Cherokee Nation)	General comments
March 14, 2018	Susan Nott*	General comments
March 14, 2018	Glenna J. Wallace (Eastern Shawnee Tribe of Oklahoma)	Letter of support for Miami Tribe's study requests
March 14, 2018	Kimeka Price (EPA)	Scoping comments
March 14, 2018	Douglas G. Lankford (Miami Tribe of Oklahoma)	PAD and SD1 comments and study requests
March 14, 2018	Kary L. Stackelbeck (OAS)	SD1 comments
March 14, 2018	William L. Fisher (Seneca-Cayuga Nation)	Letter of support for Miami Tribe's study requests
March 14, 2018	Norman Hildebrand Jr. (Wyandotte Nation)	Letter of support for Miami Tribe's study requests
March 19, 2018	Earl L. Hatley (Grand Riverkeeper L.E.A.D.)	SD1 comments
March 19, 2018	Rebecca Jim (L.E.A.D.)	SD1 comments

* Indicates comment is from a citizen.

ATTACHMENT C. ENTRAINMENT SUSCEPTIBILITIES OF FISHES INHABITING THE LOWER PORTION OF GRAND LAKE, OKLAHOMA

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ENTRAINMENT SUSCEPTIBILITIES OF FISHES INHABITING THE LOWER PORTION OF GRAND LAKE, OKLAHOMA

By

KENT MICHAEL SORENSON

Bachelor of Science

South Dakota State University

Brookings, South Dakota

1985

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
MASTER OF SCIENCE
July 1990

ENTRAINMENT SUSCEPTIBILITIES OF FISHES
INHABITING THE LOWER PORTION OF
GRAND LAKE, OKLAHOMA

Thesis Approved:

Thesis Adviser

Dean of the Graduate College

ACKNOWLEDGEMENTS

I wish to express sincere appreciation to Dr. Al Zale for his encouragement and advice throughout my graduate candidacy. I also thank Dr. Rudy Miller and Dr. Dale Toetz for serving on my graduate committee. My gratitude also extends to Dr. Bill Fisher and Matt Lechner for their help early in the study.

I would like to thank the staff and technicians of the Oklahoma Cooperative Fish and Wildlife Research Unit for their unwavering ability to allocate the time and equipment needed for this project. A deep appreciation goes to Jan Mord and Vince Travnichek. Their help in the field was invaluable, and I thank them for making fieldwork efficient and entertaining. I would also like to acknowledge the financial support and cooperation of the Grand River Dam Authority.

Finally, I would like to thank my family. To my father, John, and my mother, Sherry, thank you for the support and understanding throughout my education. Their guidance and belief in me is highly valued as I continue to pursue a career in fisheries.

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Chapter I

INTRODUCTION

This thesis is comprised of one manuscript written for submission to the Transactions of the American Fisheries Society. Chapter I is an introduction to the rest of the thesis. The manuscript is complete as written and does not require additional support material. The manuscript is contained in Chapter II and is titled 'Entrainment susceptibilities of fishes inhabiting the lower portion of Grand Lake, Oklahoma.'

Chapter II

ENTRAINMENT SUSCEPTIBILITIES OF FISHES INHABITING THE LOWER PORTION OF GRAND LAKE, OKLAHOMA

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Abstract.-I documented the seasonal dynamics of juvenile and adult fish in the vicinity of the Pensacola Dam hydropower facility on Grand Lake, Oklahoma, to determine species-specific entrainment susceptibilities. Fishes in Grand Lake were sampled monthly from August 1988 to July 1989 using gill nets, trap nets, and electrofishing gear. Water quality profiles were recorded concurrently. I used techniques typically used to quantify foraging preferences of selective predators to estimate the entrainment susceptibilities of individual species to non-selective "predation" by hydropower intakes. Relative abundances of fishes in Grand Lake were compared to relative abundances of fishes entrained (obtained from a concurrent study estimating entrainment rates) using Strauss' electivity index to determine species-specific entrainment susceptibilities. Wilcoxon's signed-rank test was used to incorporate sampling error and test statistical significance. Fishes were not entrained at rates reflecting their relative abundance in the lake. Only 8 of the 25 species collected in Grand Lake were entrained. Entrainment of gizzard shad exceeded expectations based on their relative abundance in the reservoir and it was the only species significantly susceptible to entrainment. Susceptibility to entrainment of all other species was negative or proportional to relative abundance. High midwinter entrainment of gizzard shad resulted from their

habitation of deep water proximal to the turbine intakes and cold-induced torpor. Entrainment was size-selective being skewed to enhance the selection of small fish. Occasional entrainment of white crappie and channel catfish was probably a result of the predilection of these species for structural cover in deep water as afforded by the forebay of the intake structure. Hypolimnetic anoxia associated with summer stratification precluded entrainment of all species during summer.

Extensive research on the effects of hydropower on adult and juvenile fish has been conducted in coldwater systems. These studies addressed upstream and downstream passage associated with the completion of life cycles of anadromous salmon and shad in the Pacific Northwest and New England (e.g., Schoeneman et al. 1961; Raymond 1979; Bell and Kynard 1985). Fish passing through hydropower plants may be subject to both immediate and delayed mortality. Common forms of immediate mortality include decapitation and crushing; delayed forms include deaths resulting from internal injuries, sudden pressure changes, and predation (Cramer and Oligher 1964; Cada 1988). Of no less importance are the fishes merely displaced downstream from the dam, because they are lost from the reservoir fishery.

Entrainment in warm-water reservoirs has not been studied because of the absence of obligatory migrants in these systems. However, many warmwater reservoirs contain populations of once-anadromous, now land-locked species (e.g., striped bass, Morone saxatilis; Scruggs 1955) which range widely (Pflieger 1975) and are subject to entrainment. In addition, many reservoir fishes are pelagic and nomadic (Pflieger 1975), rendering them vulnerable to entrainment. Grand Lake O' the Cherokees (Grand Lake) is an 18,818-hectare multi-purpose hydropower impoundment completed by the Grand River Dam Authority (GRDA) in 1940 by inundation of the Grand (Neosho) River by the Pensacola Dam. Grand

Lake was authorized by Congress to provide flood control, recreation, and hydropower, and the hydroelectric generating plant was granted a 50-year operating license. The license expired in 1988 and required renewal for the GRDA to continue hydropower generation. Relicensing required the GRDA to prepare an environmental impact assessment of the hydropower project. This assessment provided an opportunity to examine the effects of entrainment by the hydropower plant on adult and juvenile fishes in a warm-water reservoir.

The only previous study on entrainment of adult and juvenile warm-water fish was on the Ohio River (Greenup Dam, Vanceburg, Kentucky). Seasonal spatial and temporal distributions of fishes remained unchanged throughout the nine month duration of the study. At least 80 percent of the fish detected hydroacoustically immediately upstream of the forebay trashracks were entrained into the turbine gallery. Of those entrained, 93 percent were gizzard shad (Dorosoma cepedianum) and freshwater drum (Aplodinotus grunniens). Sport fish were entrained at a lower rate than expected as judged by their relative abundances upstream from the dam. However, no work was done during the winter months when streamflows peaked and entrainment potentials probably were greatest (Olson et al. 1988).

Simply documenting the presence of fishes in areas of potentially high entrainment risk does not allow estimation

of entrainment because the assumption of equal species-specific entrainment susceptibility is likely erroneous (Helvey 1985). Entrainment susceptibility is regulated by attraction to intake structures, taxis to current, and body length due to the relationship between swimming speed and body length (Jones et al. 1974). Behavioral activities of a species may enhance or diminish entrainment potential, but species-specific entrainment susceptibilities have only been inferred by investigating behaviors and life histories (Helvey 1985).

Estimates of entrainment susceptibility can be made by comparing relative abundances of fishes subject to entrainment to the relative abundances of fishes entrained. My goal was to assess the possible effects of hydropower generation on fish populations in the lower portion of Grand Lake. Accordingly, my objectives were to: determine if relative abundances of fishes in the lower portion of Grand Lake were reflected by species-specific entrainment rates; determine if seasonal distribution of fishes contributed to the entrainment susceptibilities of fishes in the lower portion of Grand Lake; and determine if temporal differences in water quality affected entrainment rates of fishes in the lower portion of Grand Lake.

STUDY SITE

Grand Lake is a monomictic reservoir in northeastern Oklahoma with a mean depth of 13 meters and a maximum depth of about 45 meters. It has a capacity of 1,672,000 acre-feet at the top of the power pool (elevation 745 feet MSL). It has a shoreline of of 998 km and is about 88 km long from the confluence of the Neosho and Spring rivers in the north to the dam in the south. It has an irregular shoreline with numerous bays and small coves and has a shoreline development index value of 43.1. The average discharge during 44 years of record (1939-1981) was 6809 cfs (Oklahoma Water Resources Board 1984). This equates to a flushing rate of about once every 100 days.

The hydropower intakes are housed in a structure about 20 meters off the face of the dam (Figure 1). Three 4.6-m diameter penstocks supply water to six-14,400-kw generators. Net generating head is about 120 ft. The top of the intake is at elevation 705 feet MSL and the bottom is at elevation 682 feet MSL. The intake structure is about 35 m long and distance between the upstream trashracks and the intakes is about 6 m.

METHODS

Field techniques

The fish assemblage inhabiting Grand Lake in the vicinity of Pensacola Dam was sampled at about monthly intervals from August 1988 to July 1989 using three gear types (gill nets, trap nets, and electrofishing). The study area encompassed the lower section of Grand Lake within about 3 km of the hydroelectric facility (Figure 2). The area was divided into 22 sampling blocks, each roughly 500-m square (Figure 2).

From August through December 1988, twelve monofilament-nylon experimental gill nets were set each month. The nets were 2.4 m deep, 91.4 m long, and included six 15.2-m panels with bar mesh sizes of 3.81, 5.08, 6.35, 7.62, 8.89, and 10.16 cm. A stratified-random sampling design was used to select net locations and depths, with emphasis placed on the four blocks in the vicinity of the hydropower intakes (blocks 1, 2, 5, and 6; Figure 2). Four nets were set at randomly selected locations in these blocks, and the remainder were set in randomly selected blocks throughout the study area. Four nets were set at the surface, four at mid-water, and four at the bottom. Nets were fished for 24 hours. All captured fish were removed, identified, weighed (g), measured (mm total length), and

released. Each net set constituted one unit of effort. Effort was increased to 16 net sets per month from January through July 1989 by the addition of four nets in block 1.

Ten trap nets were set in the study area on each sampling date. Trap nets were set in coves in sampling blocks 1 (2 nets), 4 (4 nets), 8 (3 nets), and 13 (2 nets). The nets were constructed of tarred 1.3-cm nylon mesh stretched over two 1.8x0.9-m frames and four 0.76-m diameter hoops; a single 12.7-m lead extended perpendicularly from the mouth of each net. The trap nets were set perpendicular to shore with their leads extending towards shore and fished for 24 hours. All captured fish were removed, identified, weighed, measured, and released. Each net set constituted one unit of effort in the catch-rate analyses.

A commercially-produced 6.1-m aluminum electrofishing boat (Coffelt Manufacturing, Inc., Flagstaff, AZ) was used to complete 10 standardized electrofishing transects each month from August through December 1988. Pulsed direct current (300 volts, 6 to 8 amperes, 60% pulse width, 80 pulses per second) was applied in 500-m linear transects. Transects were completed at randomly selected stations stratified as follows: three along the east shoreline (blocks 4, 8, and 13), one along the west shoreline (blocks 1, 5, 9, 14, 19, 20, and 22), one along the face of the dam in block 1, one along the shoreline in block 1, and four in open-water blocks. Two of the open-water transects were in

the vicinity of the hydropower intakes (blocks 1, 2, 5, and 6; Figure 1). All captured fish were identified, weighed, measured, and released. Total catches of each species in each transect will constitute catch-per-unit-effort rates (i.e., number per transect). Effort was increased to 12 electrofishing transects per month from January through July 1989 by the addition of two open water transects in block 1.

Water quality profiles of the water column about 150 m directly upstream from the hydroelectric facility were recorded in association with fish sampling. Water temperature, dissolved oxygen concentration, pH, and conductivity were measured with a Hydrolab Surveyor II at 1-m intervals from the surface to a depth of 20 m; additional measurements were taken at 5-m intervals to the bottom.

Analyses

Mean catch-per-unit-effort (CPUE) rates (by gear) of all species in aggregate and of species composing >1% of total catch were plotted over time to assess seasonal trends in abundance at the study sites. A catch index value combining the two most effective gear types for each species was calculated for each sampling date to facilitate evaluation of seasonal trends in abundance of major species; the index incorporated the relative magnitude of gear-specific catch rates by date and treated both gears

equally. Monthly gear-specific CPUE rates were divided by the highest CPUE of that gear type obtained over the study duration to calculate a relative CPUE value ranging from 0 to 1. The catch index value was the mean of the two relative CPUE rates. For example: Monthly index value = [(Gear 1 monthly CPUE/Gear 1 highest observed CPUE)+(Gear 2 monthly CPUE/Gear 2 highest observed CPUE)]/2. All three gear types were used to calculate the index value for all species in aggregate. The index values were used only to facilitate evaluation of seasonal trends; they were not used in the quantitative analyses.

Analysis of variance was used to test whether significant differences existed in mean CPUE rates of all species among sampling dates. Duncan's multiple comparison procedure was used to identify months during which CPUE rates were significantly different (alpha = 0.05). Length-frequency distributions of fishes collected in Grand Lake were constructed for comparison with fishes collected in the entrainment samples.

A concurrent study conducted by the Oklahoma Cooperative Fish and Wildlife Research Unit estimated monthly entrainment of fishes at the Pensacola Dam hydropower facility (Fisher and Zale 1990). Entrained fish were collected in modified fyke nets positioned in the draft tubes. The densities of entrained fish were multiplied by monthly discharges to estimate total monthly entrainment. A

total of nine species were entrained (gizzard shad, white crappie (Pomoxis annularis), channel catfish (Ictalurus punctatus), bluegill (Lepomis macrochirus), blue catfish (Ictalurus furcatus), green sunfish (Lepomis cyanellus), freshwater drum, white bass (Morone chrysops), and bigmouth buffalo (Ictiobus cyprinellus); Appendix A). Most entrained individuals were small (<200 mm), with the exception of a few catchable-sized channel catfish and one large bigmouth buffalo.

These entrainment estimates were compared to relative abundances of fishes in monthly collections from Grand Lake to estimate entrainment susceptibilities of species present. I used techniques typically used to quantify foraging preferences of selective predators to quantify susceptibilities of individual species to non-selective 'predation' by the turbine intakes. The linear electivity index (Strauss 1979) was used to determine relative susceptibilities of individual species to entrainment; the index is defined as

$$L=r-p$$

where r and p are the relative abundances of a species in entrainment samples and Grand Lake, respectively. Strauss' index was used mainly because of its simplicity, but its linear property gives the advantage of having symmetrical deviation of the index for all values where r does not equal p (Lechowicz 1982). Relative abundances of each species in

pooled monthly collections (all three gear types) and in pooled monthly turbine-net samples were compared. L ranges from -1 to +1, with positive values indicating enhanced susceptibility to entrainment and negative values indicating lower susceptibility to entrainment. The expected value for a species entrained in proportion to its relative abundance (i.e., random susceptibility) is zero. Wilcoxon's signed-rank test (Hollander and Wolfe 1973; Kohler and Ney 1982) was used to determine if susceptibilities were significantly different from random. Relative abundances of each species in pooled monthly collections and in individual turbine-net samples collected in a month were compared using this nonparametric paired test (Appendix B).

RESULTS

A total of 25 species composed of 3,726 individuals was collected in the lower Grand Lake study area with all three gear types from August 1988 to July 1989. Gizzard shad dominated the total catch (34.2%), followed by white crappie (14.3%), brook silverside (Labidesthes sicculus; 13.9%) and bluegill (13.8%); 10 species individually composed >1% of the total catch and 95.4% in aggregate (Figure 3).

The white bass was the most abundant (27.3%) of the 15 species in the gill net catch, followed by white crappie (23.8%), channel catfish (18.4%), and gizzard shad (10.2%). Ten species individually composed >1% of the gill-net catch

and 97.6% in aggregate. White crappie (51.7%) and bluegill (37.5%) dominated the trap-net catch. Six of the 14 species collected with trap nets individually composed >1% of the catch and 98.2% in aggregate. The electrofishing catch was dominated by gizzard shad (51.6%). Brook silversides composed 22.3% of the electrofishing catch and 7 other species individually contributed at least 1%. In aggregate, these 9 species (out of 20) composed 97.7% of the electrofishing catch (Appendix C).

Gear-specific catch rates of all species in aggregate exhibited only modest seasonal fluctuations (Table 1). Catch rates of all species in aggregate for all gear types tended to be low and stable in autumn and winter and higher, yet variable, in spring and summer (Figure 4). Significant differences existed among monthly mean catch rates of all species in aggregate (Appendix D) only for trap nets ($P=0.0012$); no significant difference existed among monthly mean catch rates of all species in aggregate in gill nets ($P=0.1320$) or by electrofishing ($P=0.1177$).

Of the 11 major species present in lower Grand Lake (i.e., species that composed >1% of the total catch), significant differences existed among monthly mean catch rates of only three (bluegill, channel catfish, and gizzard shad) in the gear type most effective for each. Catch rates of bluegill in trap nets and channel catfish in gill nets were significantly elevated during July 1989 and June 1989,

respectively. Catch rates of gizzard shad in electrofishing samples were significantly higher in November 1988 than during the remainder of the study period. Gill net catches of white bass peaked in April 1989, but the increased catch rate was not significant. Although elevated in summer, no significant differences existed among the monthly mean catch rates of the remaining abundant and entrained species in the gear type most effective for each (white crappie in trap nets, and green sunfish in electrofishing samples).

The length-frequency distribution of gizzard shad collected in lower Grand Lake was largely unimodal and primarily composed of adult sizes; the entrained gizzard shad consisted of mainly young-of-the-year individuals (Figure 5). The length frequency distribution of white crappie in Grand Lake consisted of unimodal adult-sized (>200 mm) individuals; entrained white crappie were represented by smaller (<200 mm) individuals. Channel catfish in Grand Lake were represented by wide size ranges of individuals including multiple age-classes and catchable-sized individuals. Entrained channel catfish were represented largely by sub-adult individuals, but catchable-sized fish were also collected.

Of 9 species entrained, 8 were collected in lower Grand Lake. A single bigmouth buffalo was taken in entrainment samples, but the species was absent in Grand Lake collections. Species that composed >1% of the Grand Lake

assemblage but which were not entrained, included brook silversides, largemouth bass, smallmouth buffalo, and longear sunfish. Thirteen other species also collected in Grand Lake were absent from entrainment samples.

Susceptibility to entrainment of the 9 species entrained from August 1988 to July 1989 was positive (as judged by the linear electivity index) only for gizzard shad and bigmouth buffalo over the entire period (Table 2). However, susceptibility to entrainment was significantly positive only for gizzard shad over the entire August 1988 to July 1989 period; susceptibility was significantly negative for all other species (Table 2).

Entrainment susceptibilities of individual species varied among months as relative abundances in Grand Lake and in entrainment samples changed. However, significant positive susceptibility to entrainment was limited to gizzard shad and only from February through June 1989 (Figure 6). Entrainment of gizzard shad did not differ significantly from random during other months except during November 1988 when they were significantly negatively susceptible to entrainment. Monthly entrainment susceptibilities of all other species were either random or significantly negative over the entire period (Appendix B).

Seasonal trends in susceptibility to entrainment were evident only for gizzard shad, white crappie, and channel catfish. Entrainment susceptibilities of gizzard shad were

depressed in autumn and enhanced in late winter, spring, and summer (Figure 6). The inverse, albeit less dramatic, was evident for white crappie and channel catfish (Figure 6). Entrainment susceptibilities of white bass, bluegill, blue catfish, green sunfish, and freshwater drum were typically random or slightly negative and showed no distinct seasonal trends.

Limnological characteristics of the water column in the immediate vicinity of Pensacola Dam (Figures 7 and 8) were largely dictated by seasonal reservoir stratification dynamics. Strong stratification was evident from August through October 1988 (Figure 7), but dissolved oxygen concentrations in 1988 were <2 mg/L over the entire range of depths encompassed by the intakes only during August (Figure 7). Stratification was absent from November 1988 through March 1989 (Figure 8), intermediate in May 1989 (Figure 8), and returned to patterns exhibited in October 1988 (Figure 7) and August 1988 (Figure 7) in June and July 1989, respectively. Dissolved oxygen concentrations were <2 mg/L over the entire range of depths encompassed by the intakes, similar to August 1988 profiles (Figure 7), again during July 1989. Only two fish were caught in gill nets set below the thermocline during periods when the reservoir was stratified; these may have become enmeshed during net retrieval.

DISCUSSION

The relative abundances of individual fish species in the hydropower intake area of Grand Lake did not accurately reflect relative entrainment rates. Both lake and entrainment samples were dominated by gizzard shad, but entrainment of this species often exceeded its relative abundance, suggesting it was more susceptible to entrainment than other fishes present in lower reaches of Grand Lake. The gizzard shad accounted for over 99% of the total abundance in entrainment samples (Fisher and Zale 1990), but it composed about 34% of the collections in Grand Lake. The gizzard shad was also the most frequently entrained species at Greenup Dam, Kentucky (Olson et al., 1988).

Gizzard shad tend to travel in large schools (Miller and Robison 1973; Pflieger 1975) which may predispose them to additional entrainment risk. At an offshore cooling intake off the Karachi coast of Pakistan, schooling fishes were generally more vulnerable to entrainment, as they were often sluggish, weak swimmers, and were generally of small size (Moazzam and Rizvi 1980). Schooling fishes were entrained at an offshore cooling intake off the California coast more often than resident reef fishes (Helvey 1985). Whereas gizzard shad are not a physically hardy species (Miller 1960), I do not believe them to be weak swimmers. However, schooling behavior may tend to magnify the

consequence of an encounter with the hydropower intakes because entrainment is the fate of many individuals simultaneously.

Entrainment susceptibilities of other entrained species in Grand Lake (white crappie, channel catfish, bluegill, blue catfish, green sunfish, bigmouth buffalo, freshwater drum, and white bass) were negative and many species present in lower Grand Lake were absent in entrainment samples. These were often species that, due to their behavior and habitat preferences were not present in the deeper waters near the intake structures. For example, the brook silverside was numerically the third most abundant fish present in Grand Lake but was absent from entrainment samples. It spends most of its life within a few centimeters of the surface and never goes deeper than a few meters (Pflieger 1975). The largemouth bass (Micropterus salmoides) was not collected in entrainment sampled despite being the seventh most abundant fish collected in Grand Lake. Largemouth bass prefer weedy littoral areas and when in deeper water are found near bottom (Pflieger 1975).

Pelagic species other than gizzard shad (i.e., white bass, hybrid striped bass, and freshwater drum) did not appear to be susceptible to entrainment. Hybrid striped bass are stocked at locations far upstream of the intakes (Jim Smith, Oklahoma Department of Wildlife Conservation, pers. com.). Stocking them far upstream allows them time to

grow before encountering the intakes and renders them less apt to be entrained. White bass migrate to tributary streams to spawn (Pflieger 1975), and by the time the young encounter the intakes, they too are likely large enough to effectively resist intake velocities. Freshwater drum were not abundant in the lower portion of Grand Lake and were entrained at rates proportional to, or less than, their monthly relative abundances.

White crappie and channel catfish were the only species other than gizzard shad often entrained. Although never significantly susceptible to entrainment, these were the only other species to frequently exhibit enhanced likelihood of entrainment as indicated by Strauss' index. Because lower Grand Lake is largely devoid of cover, the entrainment of these species may have resulted from their attraction to the cover afforded by the intake structure. Inasmuch as the intake structure offered cover, it also caused local vertical velocity gradients having an unknown effect on orientation and behavior (Hocutt and Edinger 1980).

Fishes may become entrained because of behaviors that bring them into direct contact with the intake water currents at times when their vision is impaired or when intake hydraulics disorient their position in the flow (Helvey 1985). Confusion caused by these factors may prevent fishes from vacating areas where intake velocities make entrainment imminent. In addition, the Pensacola plant

is a load-control facility exhibiting frequent start-ups during peak electrical demand. This method of operation may have promoted entrainment of white crappie and channel catfish that were inhabiting the forebay during periods of non-generation.

Entrainment was size-selective and consisted primarily of small, young-of-the-year individuals. Although the hydroelectric facility's trash racks precluded entrainment of exceptionally large individuals, it is likely that size-selective entrainment was a function of the positive relationship between swimming speed and body length (Jones et al. 1974). Large individuals could attain swimming speeds required to escape intake velocities whereas smaller fish were unable to escape and were entrained. High entrainment rates of young-of-the-year gizzard shad during winter were likely a product of their size-mediated swimming ability, sensitivity to low temperatures (Miller 1960; Heidinger 1983), and propensity to 'hibernate' in deep water during winter (Velasquez 1939; Jester and Jensen 1972).

Seasonal changes in relative abundance were not reflected by similar entrainment rate changes. In fact, relative abundances in the lake were most often opposite those in the entrainment samples. Gizzard shad entrainment peaked during late winter and early spring coincident with their lowest CPUE rates and relative abundances in Grand Lake. Similarly, entrainment rates of other species (white

crappie and channel catfish) were highest in late summer, autumn, and early winter, corresponding temporally with their lowest CPUE rates and relative abundances. The apparent high susceptibility of gizzard shad to entrainment during winter may have been due, in part, to sampling gear limitations. Gill nets were the only gear used to sample the profundal areas inhabited by the gizzard shad in the winter. Cold water renders passive gears less effective by reducing the activity of fish, ultimately leading to underrepresentation in the abundance estimates in the lake. The enhanced electivity index values (i.e., high susceptibility) may be an artifact of inadequate sampling gear performance, which artifically lowered the relative abundance estimates of gizzard shad in the winter samples of lower Grand Lake.

Seasonal stratification of Grand Lake influenced vertical fish distributions and entrainment rates. Fish were absent from the hypolimnion, but the thermocline was typically present at depths below the upper edge of the turbine intakes. Accordingly, stratification capable of inhibiting entrainment was present only during mid-summer. The two lowest estimates of monthly turbine entrainment were recorded in August 1988 and July 1989 when dissolved oxygen concentrations were <2 mg/L over the entire range of depths encompassed by the intakes. Gizzard shad, white crappie, and channel catfish avoid waters with dissolved oxygen

concentrations less than 2 mg/L (Gebhart and Summerfelt 1978). However, low rates of entrainment during these months suggested that stratification was destabilized by hydropower generation in the forebay of the intake structure and allowed habitation of the forebay structure at the depth of the intakes by fish.

To minimize the effects of entrainment at hydropower facilities, methods to divert fish away from areas of high risk and practices to increase survival of entrained fish have been used. Operation of hydropower facilities at peak efficiency minimizes the probability of encounter of excess stress during turbine passage. Operation at low efficiency subjects entrained fish to increased cavitation, excess turbulence, and shear forces. However, no single operational or design approach decreases mortality rates to <10% on a consistent basis (Cada 1988). Where operational or design alterations are not feasible, appreciable decreases in mortality are best obtained through exclusion from areas of high entrainment risk. Due to the low entrainment rates of game fish and the seasonality of gizzard shad entrainment, implementation of entrainment deterrance devices would probably not lead to a significant improvement in the fishery of Grand Lake.

In summary, entrainment of recreationally and commercially important sport and food fishes by the Pensacola Dam hydroelectric facility was limited because

these species were not abundant in the vicinity of the dam and their relative susceptibilities to entrainment were low. Gizzard shad, especially young-of-the-year, were seasonally susceptible to entrainment, but dominance of the reservoir's fish assemblage by this species suggested that effects of entrainment were minimal or inconsequential. Because gizzard shad are often considered over-abundant in impoundments (Miller 1960; Jenkins 1957), it seems unlikely that selective entrainment of this species is deleterious to the ichthyofauna of Grand Lake.

My research may be applicable to many morphologically similar southern reservoirs built primarily for hydropower generation. Application to smaller reservoirs, those not stratifying, or those with faster flushing rates (i.e., more riverine in nature) may be limited. Relevance to pumped-storage facilities would only be incurred during generation periods and not to pump phases of operation.

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Table 1. Total catches (N), mean catch-per-unit-effort (CPUE) values, and standard deviations (SD) of CPUE of all fish species in aggregate, by gear type, collected in Grand Lake, August 1988 to July 1989.

	Gill net			Trap net			Electrofishing		
Month	N	CPUE	SD	N	CPUE	SD	N	CPUE	SD
AUG 88	59	4.92	7.14	70	7.00	9.24	26	2.60	3.72
SEP 88	47	3.92	8.50	57	5.70	5.77	73	7.30	10.35
OCT 88	29	2.50	4.46	15	1.50	2.17	245	24.50	48.31
NOV 88	16	1.33	1.87	7	0.70	1.16	578	57.90	87.84
DEC 88	38	3.17	6.64	32	3.20	2.10	115	12.10	21.55
JAN 89	18	1.06	1.61	21	2.10	2.13	36	3.00	7.52
FEB 89	39	2.44	6.90	5	0.50	0.71	161	13.42	32.22
MAR 89	15	0.94	1.39	64	6.40	9.81	326	27.17	71.84
APR 89	88	5.50	6.95	124	12.40	13.47	207	17.25	20.94
MAY 89	169	7.22	9.98	52	5.20	5.29	165	13.75	19.97
JUN 89	142	8.88	16.49	100	10.00	13.22	87	7.25	9.19
JUL 89	47	2.94	7.70	146	14.60	14.49	307	25.58	33.63
	707	3.80	8.06	693	5.78	9.06	2326	17.40	40.03

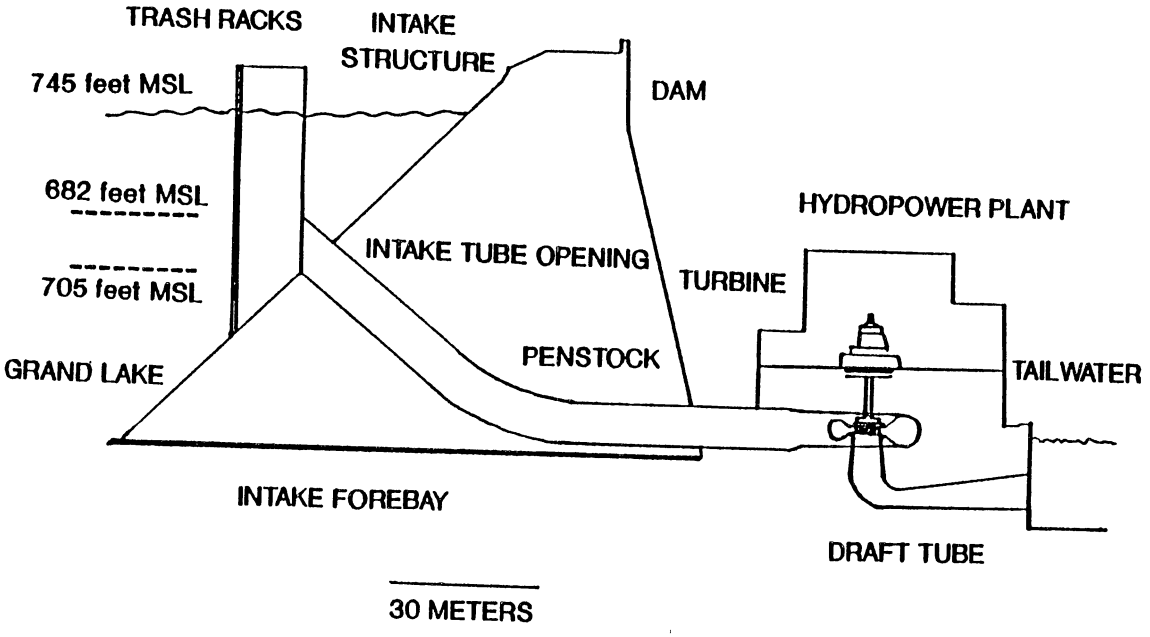
Table 2. Turbine-entrainment susceptibilities of fishes in Grand Lake, August 1988 to July 1989. The relative abundances of fishes in entrainment and Grand Lake samples are denoted r and p, respectively. L is Strauss' linear electivity index. The symbols + and - represent positive and negative susceptibility, respectively. Probability values are given in parentheses (Wilcoxon's signed rank test).

Species	r	p	L	Susceptibility
Gizzard shad	0.995	0.342	+0.653	+ (0.0008)
White crappie	0.002	0.143	-0.141	- (<0.0002)
Channel catfish	0.002	0.036	-0.034	- (<0.0002)
Bluegill	<0.001	0.135	-0.135	- (<0.0002)
Blue catfish	<0.001	0.003	-0.003	- (<0.0002)
Green sunfish	<0.001	0.017	-0.017	- (<0.0002)
Bigmouth buffalo	<0.001	0.000	+<0.001	- (<0.0002)
Freshwater drum	<0.001	0.007	-0.007	- (<0.0002)
White bass	<0.001	0.074	-0.074	- (<0.0002)

FIGURE CAPTIONS

1. Diagrammatic Representation of Pensacola Dam Hydroelectric Facility Showing Structures Referred to in Text.
2. Fish Sampling Blocks in the Lower Grand Lake Study Area.
3. Relative Numeric Abundances (%) of Fishes Constituting >1% of the Total Catch Captured Using all Gear Types in Lower Grand Lake, August 1988 to July 1989.
4. Numeric Catch-Per-Unit-Effort Rates (+1 SD) by Gear and Combined-Gear Catch Index Values of all Fishes in Aggregate, Lower Grand Lake, August 1988 to July 1989.
5. Length-Frequency Distributions of Gizzard Shad Collected in Grand Lake Samples and Entrainment Samples August 1988 to July 1989.
6. Monthly Entrainment Susceptibility Trends for Gizzard Shad, White Crappie, and Channel Catfish Calculated as Electivity Indices from August 1988 to July 1989.

7. Water Temperature and Dissolved Oxygen Concentration Profiles Directly Upstream From the Pensacola Dam Hydroelectric Facility, August and October 1988. The bars along the right vertical axes indicate the depths of the turbine intakes.
8. Water Temperature and Dissolved Oxygen Concentration Profiles Directly Upstream From the Pensacola Dam Hydroelectric Facility, November 1988 and May 1989. The bars along the right vertical axes indicate the depths of the turbine intakes.


TRASH RACKS
INTAKE STRUCTURE
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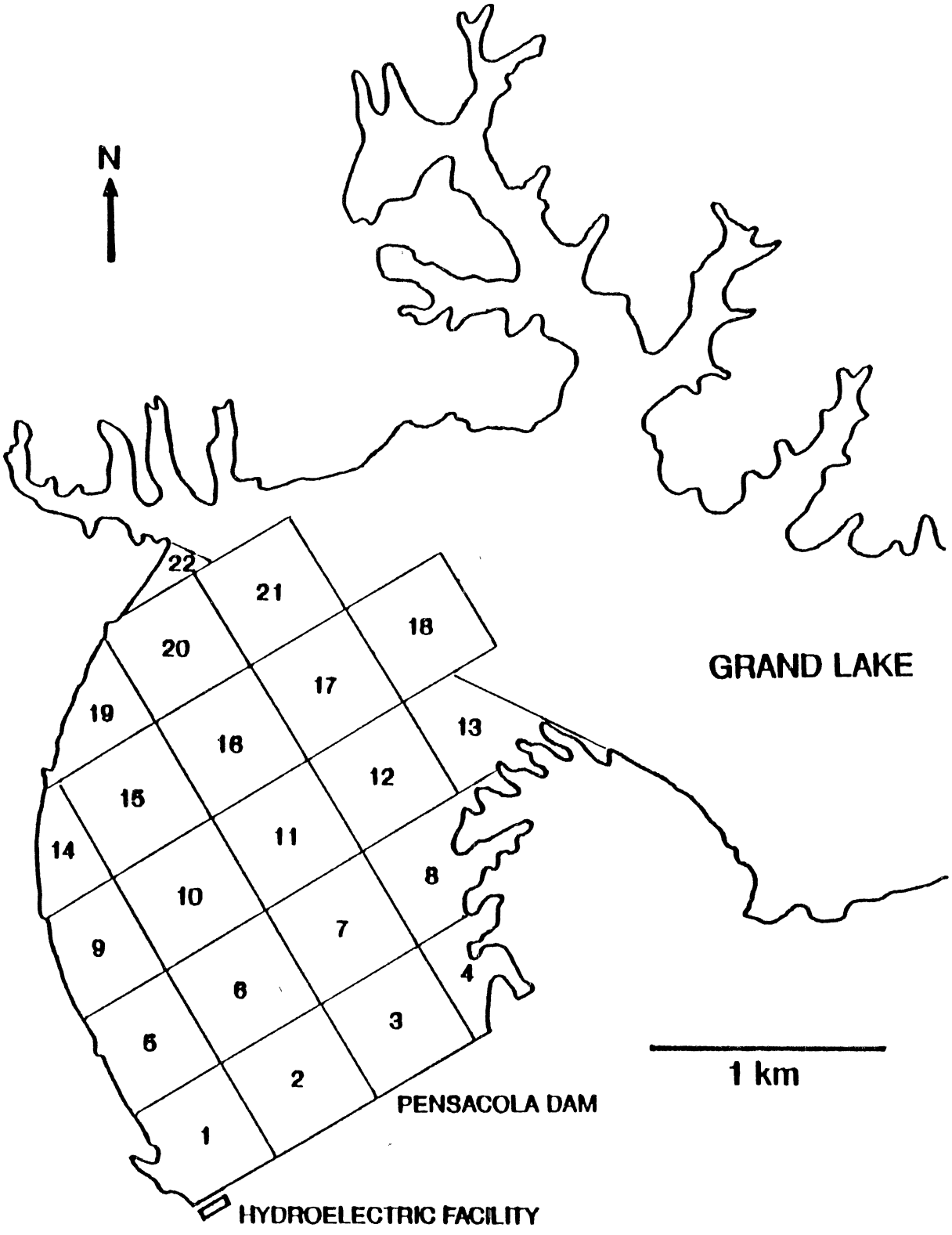
DAM
682 feet MSL
HYDROPOWER PLANT
INTAKE TUBE OPENING
TURBINE
705 feet MSL
PENSTOCK
GRAND LAKE
TAILWATER
INTAKE FOREBAY
DRAFT TUBE
30 METERS


N
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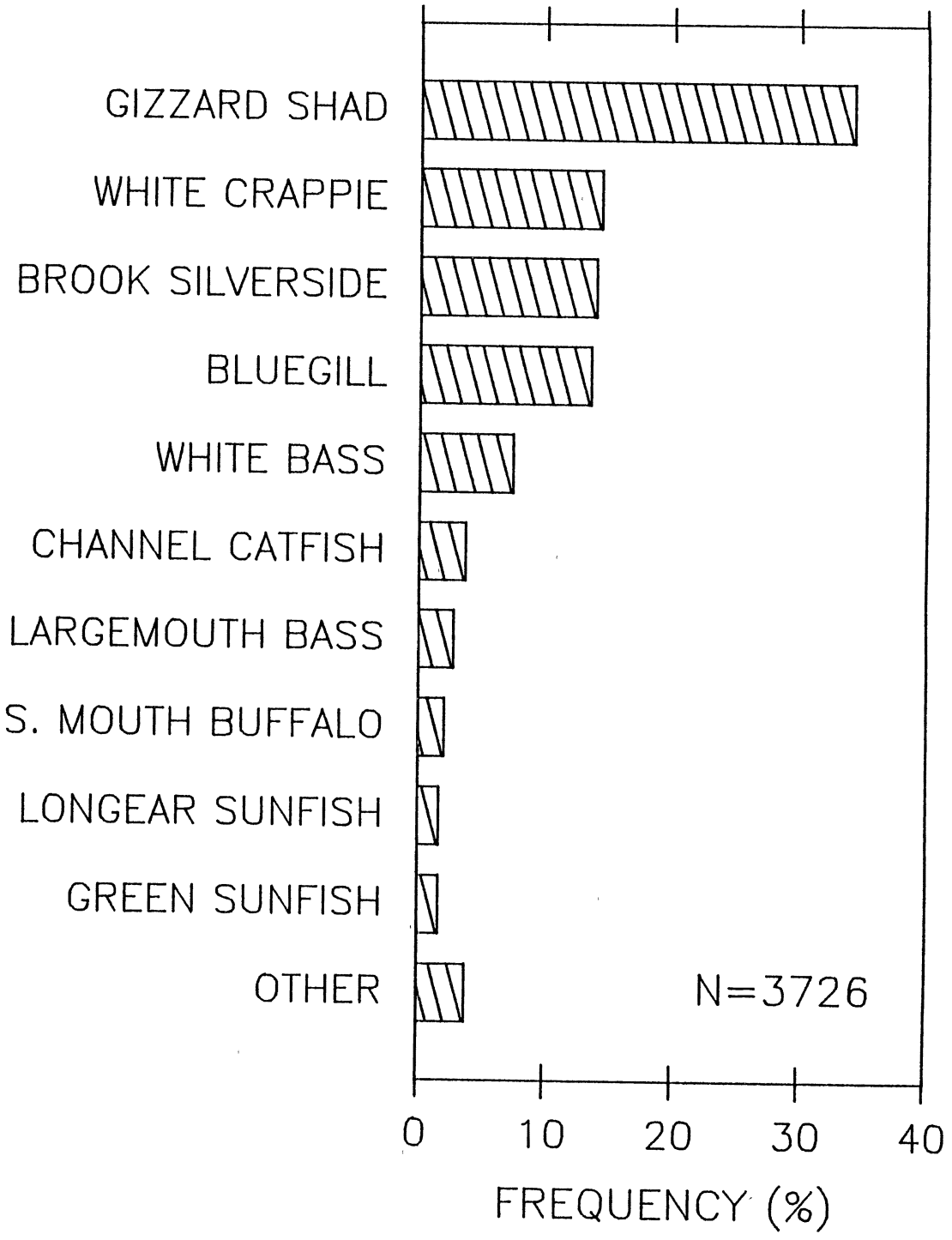
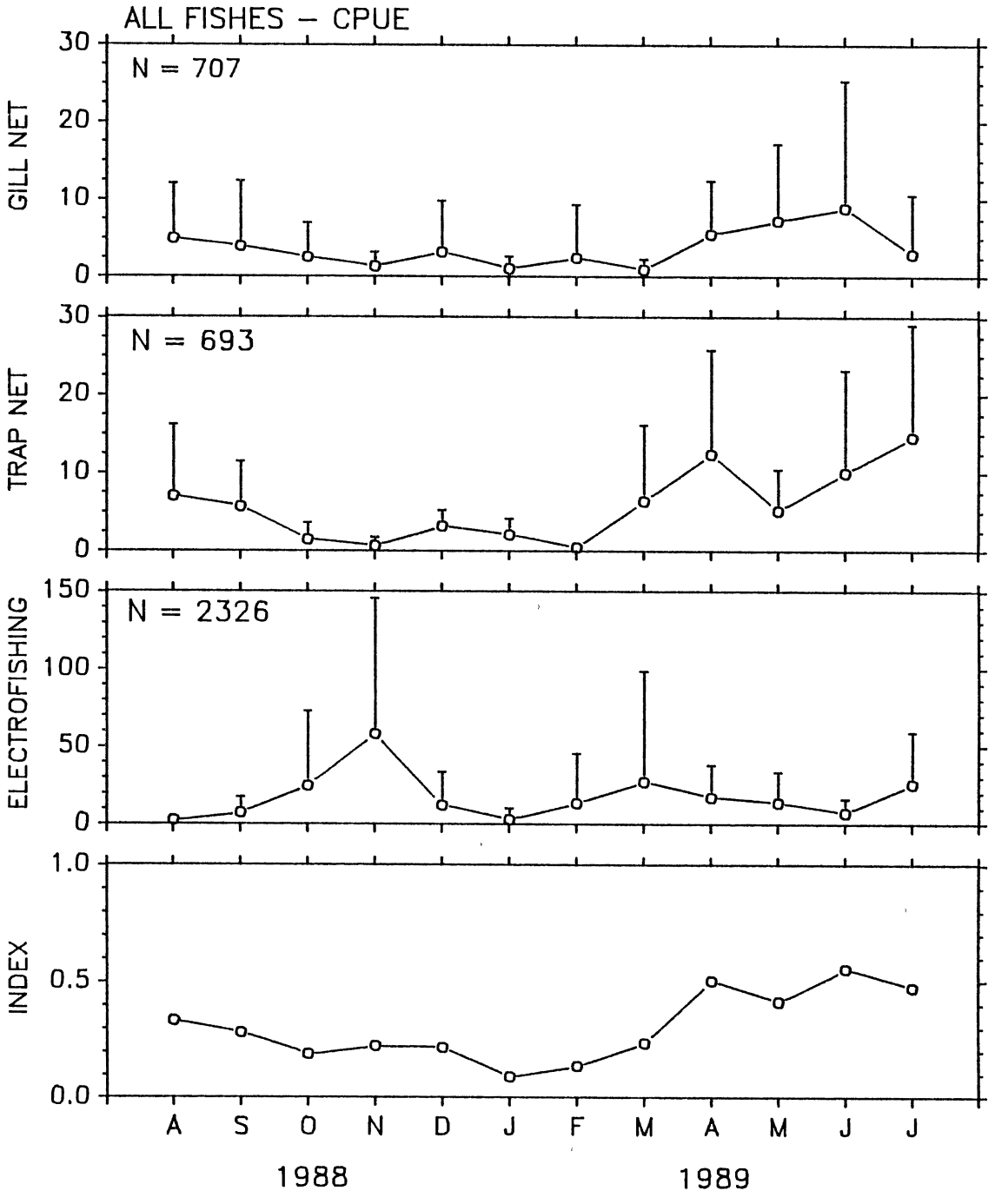
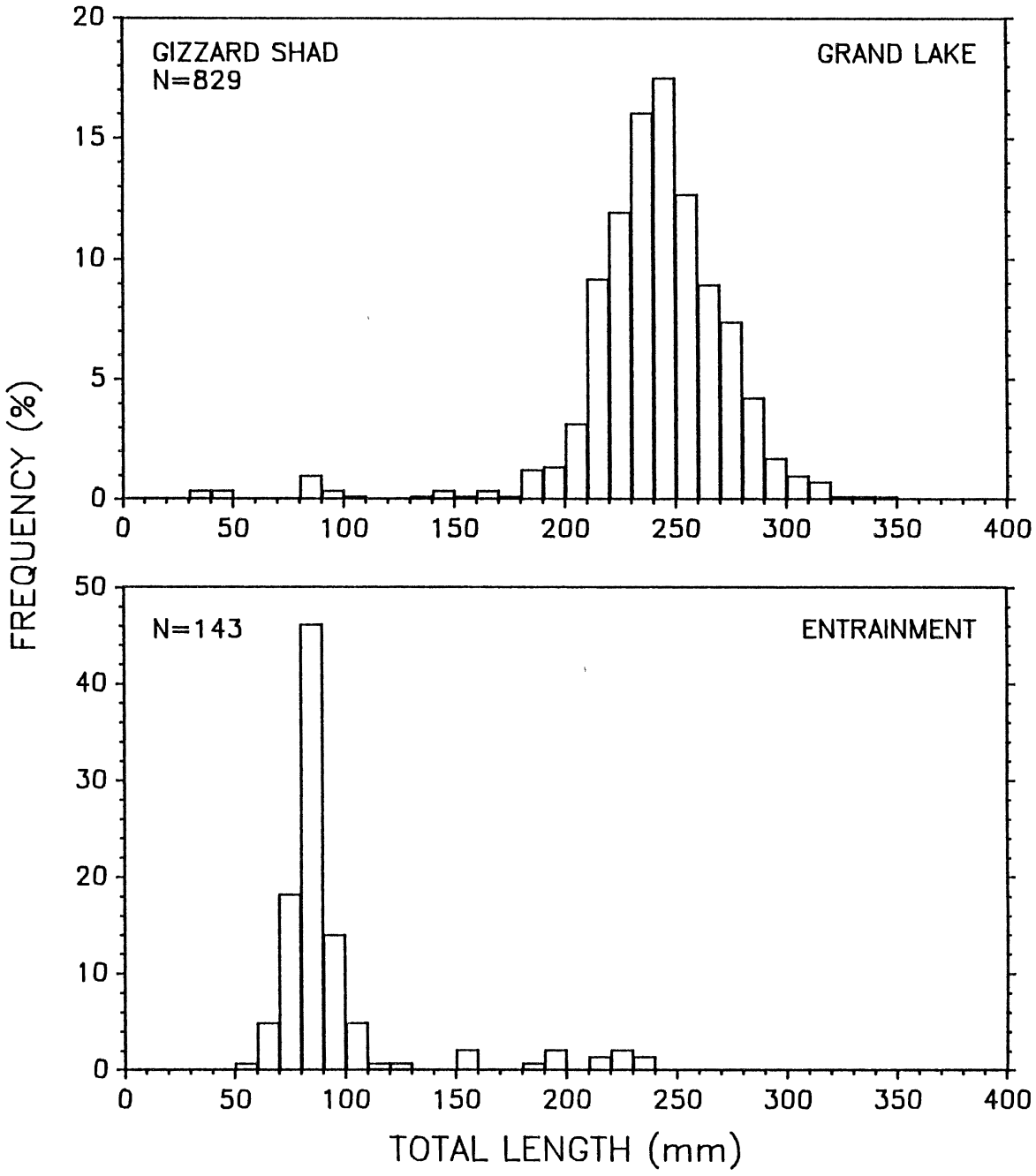
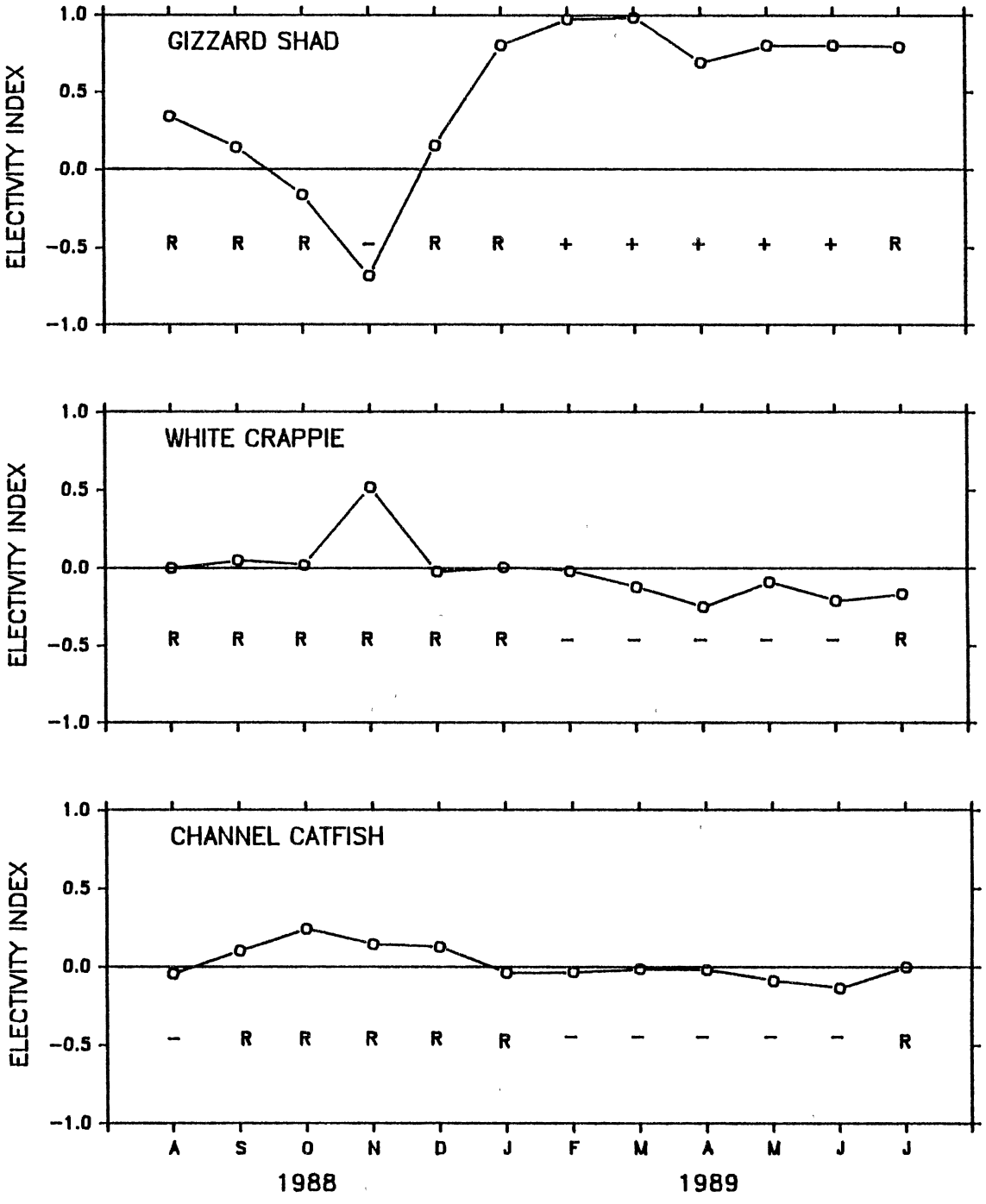
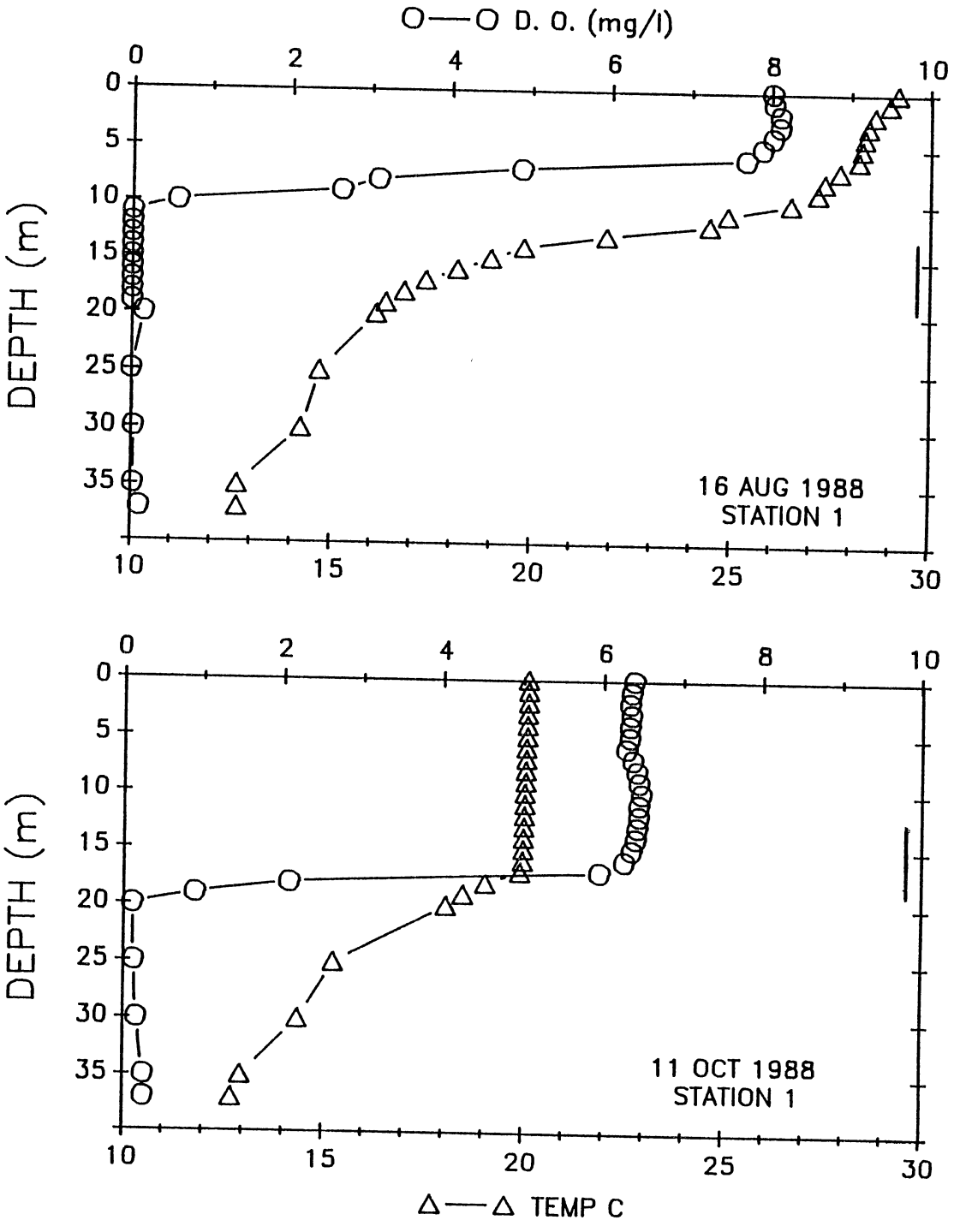
21
18
20
17
19
16
13
15
12
14
11
8
10
7
9
4
6
3
5
2
1
GRAND LAKE
1 km
PENSACOLA DAM
HYDROELECTRIC FACILITY

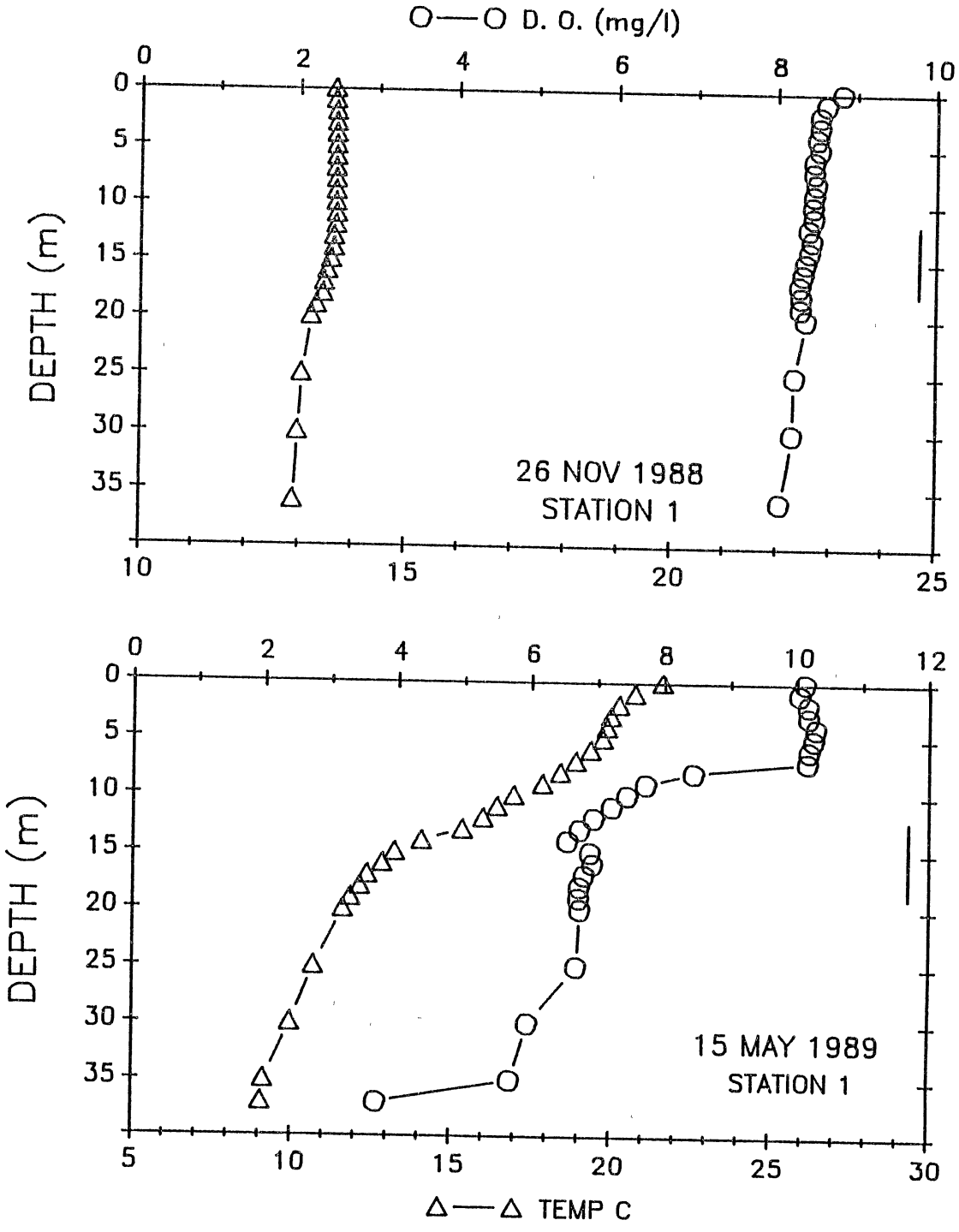

GIZZARD SHAD
WHITE CRAPPIE
BROOK SILVERSIDE
BLUEGILL
WHITE BASS
CHANNEL CATFISH
LARGEMOUTH BASS
S. MOUTH BUFFALO
LONGEAR SUNFISH
GREEN SUNFISH
OTHER
N=3726
0
10
20
30
40
FREQUENCY (%)


ALL FISHES – CPUE
GILL NET
N = 707
TRAP NET
N = 693
ELECTROFISHING
N = 2326
INDEX
30
20
10
0
150
100
50
1.0
0.5
0.0
A S O N D J F M A M J J
1988
1989


GIZZARD SHAD
N=829
GRAND LAKE
N=143
ENTRAINMENT
FREQUENCY (%)
TOTAL LENGTH (mm)
0
5
10
15
20
30
40
50
0
50
100
150
200
250
300
350
400


GIZZARD SHAD
WHITE CRAPPIE
CHANNEL CATFISH
ELECTIVITY INDEX
1.0
0.5
0.0
−0.5
−1.0
R R R − R R + + + + + R
R R R R R R − − − − − R
− R R R R R − − − − − R
A S O N D J F M A M J J
1988
1989


O—O D. O. (mg/l)
DEPTH (m)
16 AUG 1988
STATION 1
11 OCT 1988
STATION 1
Δ—Δ TEMP C


O—O D. O. (mg/l)
DEPTH (m)
26 NOV 1988
STATION 1
15 MAY 1989
STATION 1
△—△ TEMP C

APPENDIX A

MONTHLY ENTRAINMENT RATES

Table A.1. Monthly entrainment rates of all fishes entrained at Pensacola Dam hydroelectric facility, August 1988 to July 1989 (Fisher and Zale 1990).

Month	Total	Gizzard shad	White crappie	Channel catfish	Blue-gill	Blue cat-fish	Green sun-fish	Big-mouth buffalo	Fresh-water drum	White bass	Uniden-tified
Aug 88	9150	4488	4026	0	0	0	0	0	636	0	0
Sep 88	14706	6491	2047	1834	2744	722	0	0	0	816	0
Oct 88	16272	7852	1035	3984	0	913	0	0	0	0	2488
Nov 88	21563	4474	11454	3227	0	0	0	0	0	0	0
Dec 88	55144	37708	4104	9640	0	0	2408	0	0	0	0
Jan 89	21500	17307	4193	0	0	0	0	2314	1377	0	0
Feb 89	8949493	8949493	0	0	0	0	0	0	0	0	0
Mar 89	4270989	4266504	0	4449	0	0	0	0	0	0	0
Apr 89	925433	920816	4623	0	0	0	0	0	0	0	0
May 89	998264	992382	0	1850	2190	1850	0	0	0	0	0
Jun 89	44319	44319	0	0	0	0	0	0	0	0	0
Jul 89	5950	5950	0	0	0	0	0	0	0	0	0
Total		15257784	31482	2498	493	3535	2408	2314	2013	816	2488
Percent		99.5	0.21	0.16	0.03	0.02	0.01	0.01	0.01	<0.01	0.02

APPENDIX B

SUSCEPTIBILITY VALUES

Table B.1. Turbine-entrainment susceptibilities of fishes in Grand Lake, August 1988. The relative abundances of fishes in entrainment and Grand Lake samples are denoted r and p, respectively. L is Strauss' linear electivity index. The symbols +, R, and - represent positive, random, and negative susceptibility, respectively. Probability values are given in parentheses. Probability values >0.05 were judged as indicating random susceptibility (Wilcoxon's signed rank test).

Species	r	p	L	Susceptibility
Gizzard shad	0.490	0.148	+0.342	R (0.9680)
White crappie	0.440	0.439	+0.001	R (0.6892)
Channel catfish	0	0.045	-0.045	- (0.0434)
Bluegill	0	0.084	-0.084	- (0.0434)
Blue catfish	0	0.006	-0.006	- (0.0434)
Green sunfish	0	0.026	-0.026	- (0.0434)
Bigmouth buffalo	0	0	--	--
Freshwater drum	0.070	0.026	+0.044	R (0.5028)
White bass	0	0.084	-0.084	- (0.0434)

Table B.32. Turbine-entrainment susceptibilities of fishes in Grand Lake, September 1988. The relative abundances of fishes in entrainment and Grand Lake samples are denoted r and p, respectively. L is Strauss' linear electivity index. The symbols +, R, and - represent positive, random, and negative susceptibility, respectively. Probability values are given in parentheses. Probability values >0.05 were judged as indicating random susceptibility (Wilcoxon's signed rank test).

Species	r	p	L	Susceptibility
Gizzard shad	0.441	0.299	+0.142	R (0.9602)
White crappie	0.139	0.090	+0.049	R (0.0075)
Channel catfish	0.125	0.023	+0.102	R (0.3844)
Bluegill	0.187	0.395	-0.208	R (0.3844)
Blue catfish	0.052	0	+0.052	R (0.3174)
Green sunfish	0	0.034	-0.034	- (0.0052)
Bigmouth buffalo	0	0	--	--
Freshwater drum	0	0	--	--
White bass	0.055	0.028	+0.027	R (0.0750)

Table B.3. Turbine-entrainment susceptibilities of fishes in Grand Lake, October 1988. The relative abundances of fishes in entrainment and Grand Lake samples are denoted r and p, respectively. L is Strauss' linear electivity index. The symbols +, R, and - represent positive, random, and negative susceptibility, respectively. Probability values are given in parentheses. Probability values >0.05 were judged as indicating random susceptibility (Wilcoxon's signed rank test).

Species	r	p	L	Susceptibility
Gizzard shad	0.482	0.644	-0.162	R (0.2628)
White crappie	0.064	0.045	+0.019	R (0.1616)
Channel catfis	0.245	0.003	+0.242	R (0.6744)
Bluegill	0	0.080	-0.080	- (0.0118)
Blue catfish	0.056	0.010	+0.046	R (0.1616)
Green sunfish	0	0.017	-0.017	- (0.0118)
Bigmouth buffalo	0	0	--	--
Freshwater drum	0	0.017	-0.017	- (0.0118)
White bass	0	0.017	-0.017	- (0.0118)

Table B.4. Turbine-entrainment susceptibilities of fishes in Grand Lake, November 1988. The relative abundances of fishes in entrainment and Grand Lake samples are denoted r and p, respectively. L is Strauss' linear electivity index. The symbols +, R, and - represent positive, random, and negative susceptibility, respectively. Probability values are given in parentheses. Probability values >0.05 were judged as indicating random susceptibility (Wilcoxon's signed rank test).

Species	r	p	L	Susceptibility
Gizzard shad	0.207	0.890	-0.683	- (0.0434)
White crappie	0.531	0.012	+0.519	R (0.0802)
Channel catfish	0.150	0.007	+0.143	R (0.5028)
Bluegill	0	0.030	-0.030	- (0.0434)
Blue catfish	0	0.002	-0.002	- (0.0434)
Green sunfish	0.112	0.005	+0.107	R (0.5028)
Bigmouth buffalo	0	0	--	--
Freshwater drum	0	0.002	-0.002	- (0.0434)
White bass	0	0.008	-0.008	- (0.0434)

Table B.5. Turbine-entrainment susceptibilities of fishes in Grand Lake, December 1988. The relative abundances of fishes in entrainment and Grand Lake samples are denoted r and p, respectively. L is Strauss' linear electivity index. The symbols +, R, and - represent positive, random, and negative susceptibility, respectively. Probability values are given in parentheses. Probability values >0.05 were judged as indicating random susceptibility (Wilcoxon's signed rank test).

Species	r	p	L	Susceptibility
Gizzard shad	0.684	0.530	+0.154	R (0.6600)
White crappie	0.074	0.097	-0.023	R (0.2846)
Channel catfish	0.175	0.049	+0.126	R (0.0512)
Bluegill	0	0.108	-0.108	- (0.0034)
Blue catfish	0	0	--	--
Green sunfish	0	0.016	-0.016	- (0.0034)
Bigmouth buffalo	0.042	0	+0.042	R (0.3174)
Freshwater drum	0.025	0	+0.025	R (0.3174)
White bass	0	0.070	-0.070	- (0.0034)

Table B.6. Turbine-entrainment susceptibilities of fishes in Grand Lake, January 1989. The relative abundances of fishes in entrainment and Grand Lake samples are denoted r and p, respectively. L is Strauss' linear electivity index. The symbols +, R, and - represent positive, random, and negative susceptibility, respectively. Probability values are given in parentheses. Probability values >0.05 were judged as indicating random susceptibility (Wilcoxon's signed rank test).

Species	r	p	L	Susceptibility
Gizzard shad	0.805	0	+0.805	R (1.0000)
White crappie	0.195	0.200	+0.005	R (1.0000)
Channel catfish	0	0.040	-0.040	R (0.1096)
Bluegill	0	0.120	-0.120	R (0.1096)
Blue catfish	0	0.013	-0.013	R (0.1096)
Green sunfish	0	0	--	--
Bigmouth buffalo	0	0	--	--
Freshwater drum	0	0.013	-0.013	R (0.1096)
White bass	0	0.147	-0.147	R (0.1096)

Table B.7. Turbine-entrainment susceptibilities of fishes in Grand Lake, February 1989. The relative abundances of fishes in entrainment and Grand Lake samples are denoted r and p, respectively. L is Strauss' linear electivity index. The symbols +, R, and - represent positive, random, and negative susceptibility, respectively. Probability values are given in parentheses. Probability values >0.05 were judged as indicating random susceptibility (Wilcoxon's signed rank test).

Species	r	p	L	Susceptibility
Gizzard shad	1.000	0.029	+0.971	+ (<0.0002)
White crappie	0	0.020	-0.020	- (<0.0002)
Channel catfish	0	0.034	-0.034	- (<0.0002)
Bluegill	0	0.005	-0.005	- (<0.0002)
Blue catfish	0	0.005	-0.005	- (<0.0002)
Green sunfish	0	0.005	-0.005	- (<0.0002)
Bigmouth buffalo	0	0	--	--
Freshwater drum	0	0	--	--
White bass	0	0.117	-0.117	- (<0.0002)

Table B.8. Turbine-entrainment susceptibilities of fishes in Grand Lake, March 1989. The relative abundances of fishes in entrainment and Grand Lake samples are denoted r and p, respectively. L is Strauss' linear electivity index. The symbols +, R, and - represent positive, random, and negative susceptibility, respectively. Probability values are given in parentheses. Probability values >0.05 were judged as indicating random susceptibility (Wilcoxon's signed rank test).

Species	r	p	L	Susceptibility
Gizzard shad	0.999	0.017	+0.982	+ (<0.0002)
White crappie	0	0.123	-0.123	- (<0.0002)
Channel catfish	0.001	0.015	-0.014	- (<0.0002)
Bluegill	0	0.049	-0.049	- (<0.0002)
Blue catfish	0	0	--	--
Green sunfish	0	0	--	--
Bigmouth buffalo	0	0	--	--
Freshwater drum	0	0	--	--
White bass	0	0.017	-0.017	- (<0.0002)

Table B.9. Turbine-entrainment susceptibilities of fishes in Grand Lake, April 1989. The relative abundances of fishes in entrainment and Grand Lake samples are denoted r and p, respectively. L is Strauss' linear electivity index. The symbols +, R, and - represent positive, random, and negative susceptibility, respectively. Probability values are given in parentheses. Probability values >0.05 were judged as indicating random susceptibility (Wilcoxon's signed rank test).

Species	r	p	L	Susceptibility
Gizzard shad	0.995	0.303	+0.692	+ (<0.0002)
White crappie	0.005	0.255	-0.250	- (<0.0010)
Channel catfish	0	0.021	-0.021	- (<0.0002)
Bluegill	0	0.131	-0.131	- (<0.0002)
Blue catfish	0	0	--	--
Green sunfish	0	0.021	-0.021	- (<0.0002)
Bigmouth buffalo	0	0	--	--
Freshwater drum	0	0.005	-0.005	- (<0.0002)
White bass	0	0.122	-0.122	- (<0.0002)

Table B.10. Turbine-entrainment susceptibilities of fishes in Grand Lake, May 1989. The relative abundances of fishes in entrainment and Grand Lake samples are denoted r and p, respectively. L is Strauss' linear electivity index. The symbols +, R, and - represent positive, random, and negative susceptibility, respectively. Probability values are given in parentheses. Probability values >0.05 were judged as indicating random susceptibility (Wilcoxon's signed rank test).

Species	r	p	L	Susceptibility
Gizzard shad	0.994	0.189	+0.805	+ (<0.0002)
White crappie	0	0.212	-0.212	- (<0.0002)
Channel catfish	0.002	0.093	-0.091	- (<0.0002)
Bluegill	0.002	0.111	-0.109	- (0.0010)
Blue catfish	0.002	0.010	-0.008	- (<0.0002)
Green sunfish	0	0.036	-0.036	- (<0.0002)
Bigmouth buffalo	0	0	--	--
Freshwater drum	0	0.008	-0.008	- (<0.0002)
White bass	0	0.150	-0.150	- (<0.0002)

Table B.11. Turbine-entrainment susceptibilities of fishes in Grand Lake, June 1989. The relative abundances of fishes in entrainment and Grand Lake samples are denoted r and p, respectively. L is Strauss' linear electivity index. The symbols +, R, and - represent positive, random, and negative susceptibility, respectively. Probability values are given in parentheses. Probability values >0.05 were judged as indicating random susceptibility (Wilcoxon's signed rank test).

Species	r	p	L	Susceptibility
Gizzard shad	1.000	0.195	+0.805	+ (0.0434)
White crappie	0	0.210	-0.210	- (0.0434)
Channel catfish	0	0.137	-0.137	- (0.0434)
Bluegill	0	0.222	-0.222	- (0.0434)
Blue catfish	0	0	--	--
Green sunfish	0	0.021	-0.021	- (0.0434)
Bigmouth buffalo	0	0	--	--
Freshwater drum	0	0	--	--
White bass	0	0.018	-0.018	- (0.0434)

Table B.12. Turbine-entrainment susceptibilities of fishes in Grand Lake, July 1989. The relative abundances of fishes in entrainment and Grand Lake samples are denoted r and p, respectively. L is Strauss' linear electivity index. The symbols +, R, and - represent positive, random, and negative susceptibility, respectively. Probability values are given in parentheses. Probability values >0.05 were judged as indicating random susceptibility (Wilcoxon's signed rank test).

Species	r	p	L	Susceptibility
Gizzard shad	1.000	0.206	+0.794	R (0.6528)
White crappie	0	0.166	-0.166	R (0.1802)
Channel catfish	0	0.001	-0.001	R (0.1802)
Bluegill	0	0.316	-0.316	R (0.1802)
Blue catfish	0	0	--	--
Green sunfish	0	0.020	-0.020	R (0.1802)
Bigmouth buffalo	0	0	--	--
Freshwater drum	0	0.014	-0.014	R (0.1802)
White bass	0	0.154	-0.154	R (0.1802)

APPENDIX C

TOTAL CATCHES AND RELATIVE ABUNDANCE BY GEAR

Table C.1. Total catches (N) and relative abundances (%) of fishes captured with gill nets, trap nets, and by electrofishing in Grand Lake, August 1988 to July 1989.

Species	Gill net		Trap net		Electrofishing		Combined	
	N	%	N	%	N	%	N	%
Blue catfish Ictalurus furcatus	11	1.6	0	0.0	0	0.0	11	0.3
Bluegill Lepomis macrochirus	0	0.0	260	37.5	243	10.4	514	13.8
Brook silverside Labidesthes sicculus	0	0.0	0	0.0	518	22.3	518	27.7
Channel catfish Ictalurus punctatus	130	18.4	2	0.3	4	0.2	136	3.7
Common carp Cyprinus carpio	11	1.6	1	0.1	11	0.5	23	0.6
Freshwater drum Aplodinotus grunniens	13	1.8	3	0.4	10	0.4	26	0.7
Flathead catfish Polyodictus olivaris	2	0.3	0	0.0	0	0.0	2	0.1
Green sunfish Lepomis cyanellus	0	0.0	18	2.6	44	1.9	62	1.7
Gizzard shad Dorosoma cepedianum	72	10.2	1	0.1	1202	51.7	1275	34.2
Hybrid striped bass Morone saxatilis x M. chrysops	34	4.8	0	0.0	0	0.0	34	0.9
Hybrid sunfish Lepomis sp.	0	0.0	3	0.4	1	<0.1	4	0.1
Longear sunfish Lepomis megalotis	0	0.0	17	2.5	46	2.0	63	1.7
Logperch Percina caprodes	0	0.0	0	0.0	8	0.3	8	0.2
Largemouth bass Micropterus salmoides	5	0.7	19	2.7	81	3.5	105	2.8
Longnose gar Lepisosteus osseus	0	0.0	0	0.0	2	0.1	2	0.1
Paddlefish Polyodon spathula	7	1.0	0	0.0	0	0.0	7	0.2
Rainbow trout Oncorhynchus mykiss	2	0.3	0	0.0	1	<0.1	3	0.1
River carpsucker Carpiodes carpio	5	0.7	0	0.0	6	0.3	11	0.3
Redear sunfish Lepomis microlophus	0	0.0	1	0.1	0	0.0	1	<0.1
Smallmouth buffalo Ictiobus bubalus	52	7.4	1	0.1	27	1.2	80	2.1
Slender madtom Noturus exilis	0	0.0	0	0.0	1	<0.1	1	<0.1
Spotted bass Micropterus punctulatus	3	0.4	2	0.3	30	1.3	35	0.9
White bass Morone chrysops	192	27.2	0	0.0	83	3.6	275	7.4
White crappie Pomoxis annularis	168	23.8	358	51.7	6	0.3	532	14.3
Warmouth Lepomis gulosis	0	0.0	7	1.0	2	0.1	9	0.2
TOTAL	707		693		2326		3726	

APPENDIX D

ANOVA OF MONTHLY MEAN CPUE

Table D.1. Sums of squares (SS), F, and probability values (P) of analyses of variance testing whether differences existed among monthly mean numeric catch-per-unit-effort rates, by gear, of fishes collected in Grand Lake, August 1988 to July 1989. Asterisks denote significant differences (alpha = 0.05).

Species	Gill net			Trap net			Electrofishing		
	SS	F	P	SS	F	P	SS	F	P
Blue catfish	1.34	1.15	0.3280	--	--	--	--	--	--
Bluegill	--	--	--	845.07	3.10	0.0012*	320.90	1.64	0.0956
Brook silverside	--	--	--	--	--	--	7642.59	1.30	0.2329
Channel catfish	108.61	1.85	0.0505	0.17	0.91	0.5344	0.40	0.80	0.6363
Common carp	0.59	0.73	0.7079	0.09	1.00	0.4513	1.08	0.80	0.6418
Freshwater drum	2.44	1.55	0.1186	0.27	0.73	0.7102	1.27	1.41	0.1761
Flathead catfish	0.23	1.88	0.0449*	--	--	--	--	--	--
Green sunfish	--	--	--	2.30	1.19	0.3036	10.05	0.53	0.8783
Gizzard shad	85.73	1.75	0.0665	0.09	1.00	0.4513	24836.80	3.30	0.0005*
Hybrid striped bass	11.64	1.22	0.2755	--	--	--	--	--	--
Hybrid sunfish	--	--	--	0.43	0.93	0.5173	0.09	1.14	0.3363
Longear sunfish	--	--	--	7.49	0.84	0.5964	15.37	1.25	0.2642
Logperch	--	--	--	--	--	--	2.11	0.92	0.5247
Largemouth bass	0.42	0.94	0.5014	6.49	2.50	0.0077*	37.55	1.20	0.2927
Longnose gar	--	--	--	--	--	--	0.14	0.83	0.6127
Paddlefish	0.37	1.11	0.3594	--	--	--	--	--	--
Rainbow trout	0.06	0.88	0.5617	--	--	--	0.07	0.92	0.5255
River carpsucker	0.58	0.83	0.6134	--	--	--	0.41	0.87	0.5762
Redear sunfish	--	--	--	0.09	1.00	0.4513	--	--	--
Smallmouth buffalo	24.09	1.30	0.2282	0.09	1.00	0.4513	15.99	2.55	0.0062*
Slender madtom	--	--	--	--	--	--	0.07	0.92	0.5255
Spotted bass	0.51	1.67	0.0814	0.17	0.91	0.5344	8.05	1.37	0.1961
White bass	138.14	1.58	0.1081	--	--	--	420.59	0.93	0.5169
White crappie	135.96	1.80	0.0572	795.57	1.80	0.0622	0.96	0.84	0.6025
Warmouth	--	--	--	0.05	0.94	0.5017	0.30	0.92	0.5255
TOTAL	1045.76	1.51	0.1320	2338.43	3.09	0.0012*	26340.49	1.56	0.1177

VITA

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Master of Science

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