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Grand River Dam Authority

October 29, 2021

Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 First Street, N.E.
Washington, DC 20426

RE: Pensacola Project (1494-438)
Summary of Initial Study Report Meeting

Dear Secretary Bose:

The Grand River Dam Authority (GRDA) is relicensing the Pensacola Hydroelectric Project (FERC No. 1494) using the Federal Energy Regulatory Commission's (Commission or FERC) Integrated Licensing Process (ILP). In accordance with section 5.15(c) of the Commission's regulations, GRDA filed its Initial Study Report (ISR) on September 30, 2021. Following its filing of the ISR, GRDA held ISR meetings with federal and state resource agencies, Native American tribes, local governmental entities, and other interested stakeholders on October 12-14, 2021. Due to Covid-19, the ISR meetings were conducted virtually; however, GRDA estimates that approximately 60 individuals participated in the ISR meetings. GRDA appreciates the commitment to this process by all relicensing participants and the productive technical dialogue that occurred in the ISR meetings.

With this letter, and as required by section 5.15(c)(3) of the Commission's regulations, GRDA is filing its summary of the ISR meetings. GRDA's meeting summary consists of the agenda for each day of the meeting (Attachment A), an attendee registration list (Attachment B), and the PowerPoint presentation for each study (Attachment C). With regard to the presentation materials for the Cultural Resources Working Group meeting held on October 14, 2021 (Attachment D), this material contains sensitive information regarding cultural resources, and therefore is being filed as privileged information that is exempt from public disclosure. In accordance with FERC regulations, GRDA respectfully requests the Commission to place this information in the non-public file. *See* 18 C.F.R. § 388.112.

Following GRDA's filing of the meeting summary today, relicensing participants have 30 days—until November 29, 2021—to file any disagreements with the summary or any proposed modified or new studies, in accordance with section 5.15(c)(4).

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If there are any questions or comments regarding this submittal, please contact me by phone at (918) 981-8472 or by email at darrell.townsend@grda.com.

Sincerely,

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cc: Stakeholder Distribution List (via email)

Attachment A: Agenda
Attachment B: Attendee List
Attachment C: Study Report Presentations
Attachment D: Cultural Resources Information (Privileged)

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September 23, 2021

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Attachment A

Agenda

Agenda for Initial Study Report Meeting

Meeting Date / Time:	Tuesday, October 12 (9:00 AM to 5:30 PM CDT) Wednesday, October 13 (9:00 AM to 5:30 PM CDT) Thursday, October 14 (9:00 AM to 3:00 PM CDT) Note: Meeting will be conducted virtually.

Tuesday, October 12, 2021: 9:00 AM to 5:30 PM CDT

A. 9:00 to 9:15 AM: Welcome and Introductions – GRDA

B. 9:15 to 9:30 AM: Meeting Purpose 18 C.F.R. § 5.15(c)(2) – GRDA

C. 9:30 to 10:15 AM: Bathymetry Study – USGS

D. 10:15 to 10:30 AM: Break

E. 10:30 to 12:00 PM: Hydrologic and Hydraulic Modeling Study – Mead & Hunt

1. Review of Operations Model
2. Review of Upstream Model Results

F. 12:00 to 1:00 PM: Lunch

G. 1:00 to 3:45 PM: Hydrologic and Hydraulic Modeling Study (continued) – Mead & Hunt

1. Review of Upstream Model Results (continued)
2. Upstream Model Results-Area of Potential Effect (APE) for Cultural Resources Studies
3. Review of Downstream Hydraulic Model

H. 3:45 to 4:00 PM: Break

I. 4:00 to 5:00 PM: Infrastructure Study – Mead & Hunt

J. 5:00 to 5:30 PM: Closing and Adjourn

***Note: If topics are discussed in a shorter time frame than listed in the agenda, the meeting will move forward with the next topic listed in the agenda.**

Wednesday, October 13, 2021: 9:00 AM to 5:00 PM CDT

K. 9:00 to 9:15 AM: Welcome and Introductions – GRDA

L. 9:15 to 9:30 AM: Meeting Purpose 18 C.F.R. § 5.15(c)(2) – GRDA

M. 9:30 to 12:00 PM: Sedimentation Study – Anchor QEA/Simons and Associates

N. 12:00 to 1:00 PM: Lunch

O. 1:00 to 2:00 PM: Recreation Facilities Inventory and Use Survey – Mead & Hunt

P. 2:00 to 2:30 PM: Socioeconomics Study – Enercon

Q. 2:30 to 2:45 PM: Break

R. 2:45 to 3:45 PM: Aquatic Species of Concern Study – Horizon Environmental Services

1. Paddlefish Sub-Study
2. Rare and Aquatic Species Sub-Study
3. Wetland and Terrestrial Sub-Study

S. 3:45 to 4:15 PM: Cultural Resources Study (Public Summary) – Wood

T. 4:15 to 5:00 PM: Closing and Adjourn

Note: If topics are discussed in a shorter time frame than listed in the agenda, the meeting will move forward with the next topic listed in the agenda.

Thursday, October 14, 2021: 9:00 AM to 3:00 PM CDT

(Non-Public Cultural Resources Working Group Members Only)

U. 9:00 to 9:15 AM: Welcome and Introductions – GRDA

V. 9:15 to 9:30 AM: Meeting Purpose 18 C.F.R. § 5.15(c)(2) – GRDA

W. 9:30 to 12:00 PM: Cultural Resources Study – Wood

1. Archaeology
    a. 2019-2020 Fieldwork Report
    b. 2020-2021 Fieldwork Report
2. Architectural Report

X. 12:00 to 1:00 PM: Lunch

Y. 1:00 to 2:00 PM: TCP Inventory – Algonquin

CC. 2:00 to 3:00 PM: Plans for Second Year Study

DD. 3:00 PM: Closing and Adjourn

Note: If topics are discussed in a shorter time frame than listed in the agenda, the meeting will move forward with the next topic listed in the agenda.

Attachment B

Attendee List

Does not include attendee list for October 14, 2021 since it was a non-public meeting with the Cultural Resources Working Group (CRWG)

October 12, 2021: Pensacola Project (1494)-Initial Study Report Meeting Attendance

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October 12, 2021: Pensacola Project (1494)-Initial Study Report Meeting Attendance

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Attachment C

Study Report Presentations

October 12, 2021

Grand River Dam Authority
Initial Study Report Meeting
Pensacola Project (1494)

October 12-14, 2021

Housekeeping Items

- Meeting is being recorded
- Mute your lines
- Utilize the “raise your hand” feature to ask a question
- If audio issues exist, please use the “chat” feature
- Participant discussion and dialogue are encouraged
- Lunch will be from 12:00-1:00 PM
- If an individual study presentation finishes early, we will proceed with the next agenda item

Purpose of Meeting

- Describe GRDA’s overall progress in implementing its relicensing study plan
- Results for each study to date will be presented
- A meeting summary will be filed with FERC by October 30, 2021
- The meeting summary will include only the meeting agenda and presentations
- All stakeholder comments must be submitted in writing
- The deadline for filing all written comments or questions is November 29, 2021

Remaining Relicensing Study Schedule

Activity	Responsible Party	Commission Deadline
File Initial Study Report (ISR)	GRDA	September 30, 2021
Hold ISR meeting (meeting on study results and any proposals to modify study plan)	GRDA	October 15, 2021
File ISR Meeting Summary	GRDA	October 30, 2021
File Meeting Summary Disagreements	Stakeholders	November 29, 2021
File Responses to Disagreements	GRDA	December 29, 2021
Commission Resolution of Disagreements (if necessary)	FERC	January 28, 2022
Second Field Season	GRDA	November 2021-September 2022
File Updated Study Report (USR)	GRDA	September 30, 2022
Hold USR Meeting	GRDA	October 15, 2022
File USR Meeting Summary	GRDA	October 30, 2022
File Meeting Summary Disagreements	Stakeholders	December 29, 2022
Commission Resolution of Disagreements (if necessary)	FERC	January 28, 2023
File Draft License Application (DLA)	GRDA	January 1, 2023

Questions?

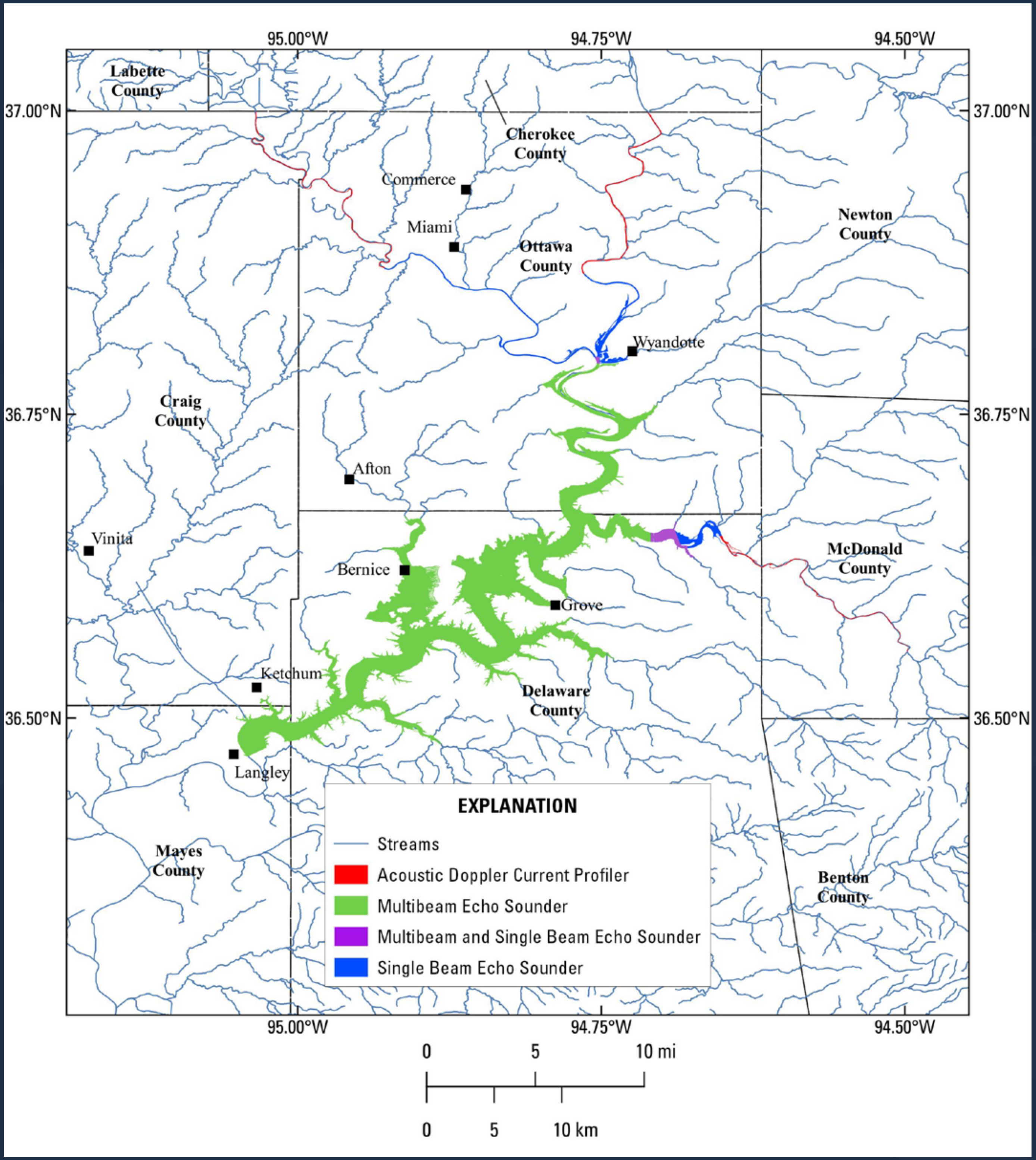
Grand Lake O’ the Cherokees and Major Tributaries Bathymetric Surveys 2016-2019

GRDA

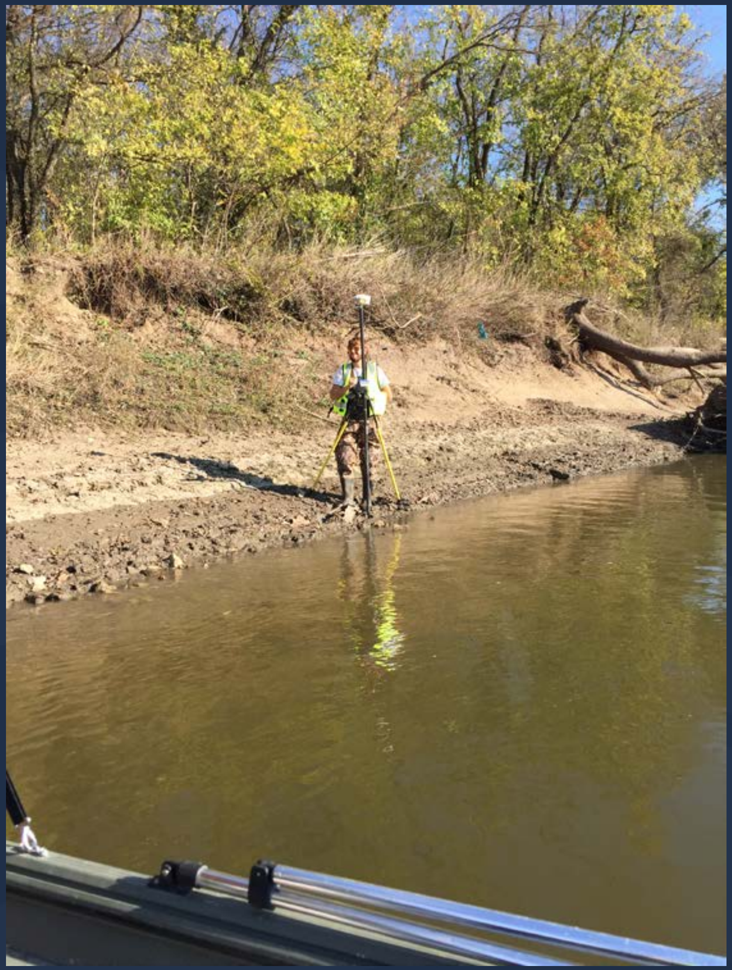
Developed in cooperation with the Grand River Dam Authority

USGS
science for a changing world

Study Area

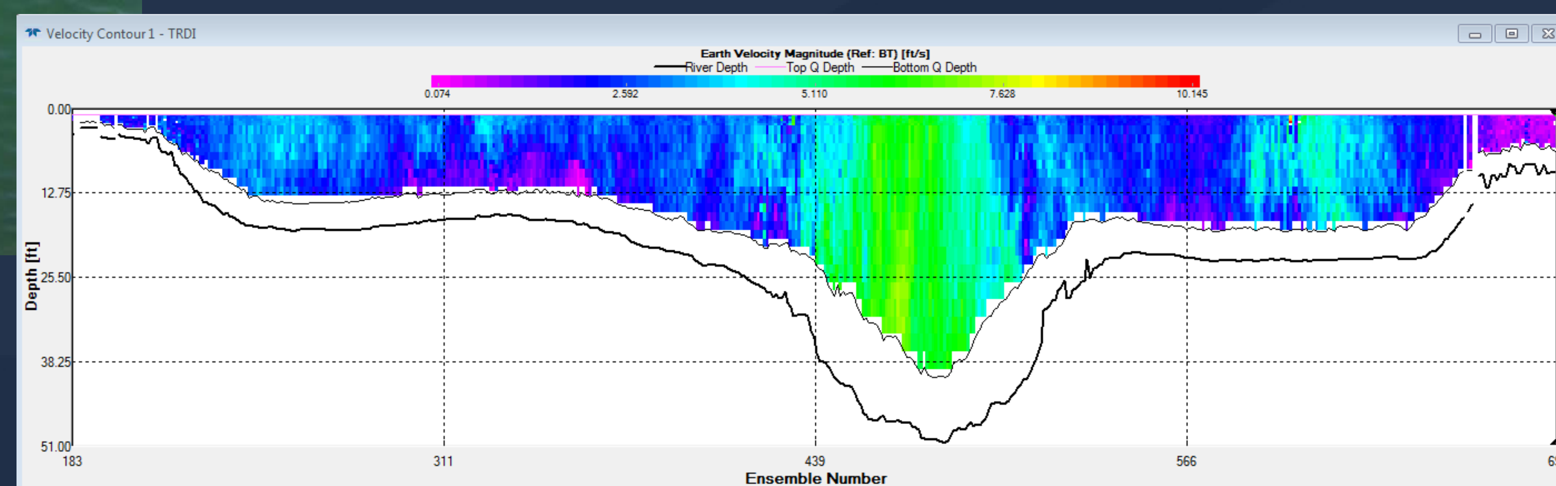

95.00°W
94.75°W
94.50°W
37.00°N
36.75°N
36.50°N
Labette County
Cherokee County
Commerce
Miami
Ottawa County
Newton County
Wyandotte
Craig County
Afton
Vinita
Bernice
Grove
McDonald County
Ketchum
Delaware County
Langley
Mayes County
Benton County
EXPLANATION
Streams
Acoustic Doppler Current Profiler
Multibeam Echo Sounder
Multibeam and Single Beam Echo Sounder
Single Beam Echo Sounder
0 5 10 mi
0 5 10 km

GPS Benchmarks and Water Surface Elevations



- 9 benchmarks; 4hr GNSS established, OPUS processed
- 74 RTK calibrations before and after each day
- 650 water surface elevation collected approx. every 500’
- RTK 3-minute averaged points – VRS network MoDOT

Acoustic Doppler Current Profiler (ADCP) Bathymetric Survey 2016-17



- ADCP = Teledyne RD instruments RiverRay's
- Blanking distance 0.6 feet
- GPS on boats

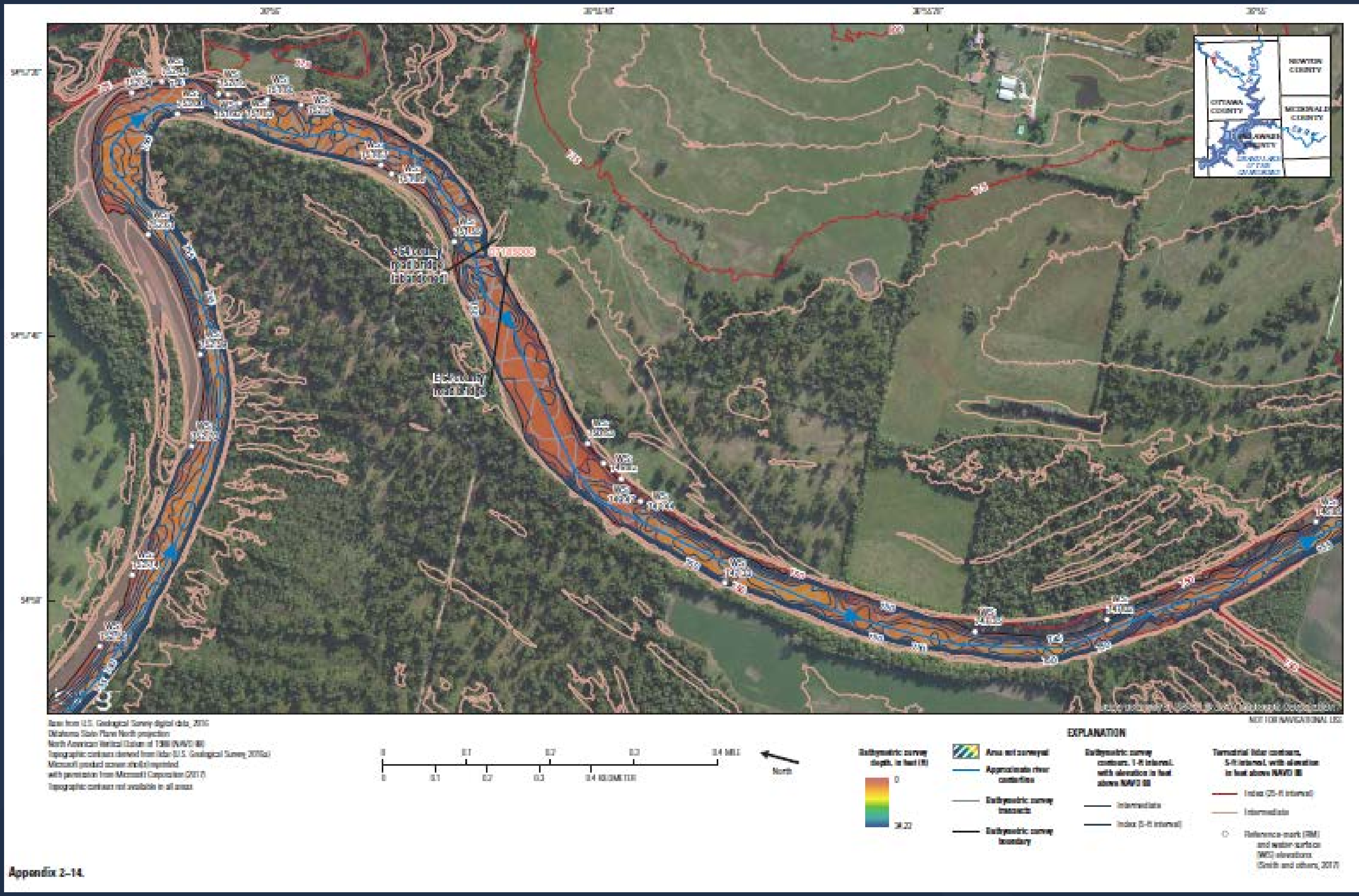
Acoustic Doppler Current Profiler (ADCP) Bathymetric Survey 2016-17

- 2 ADCP Boats towed by Kayaks
- Sinusoidal pattern
- Diagonally bank to bank
- 100 feet spacing, 25 feet near crossing

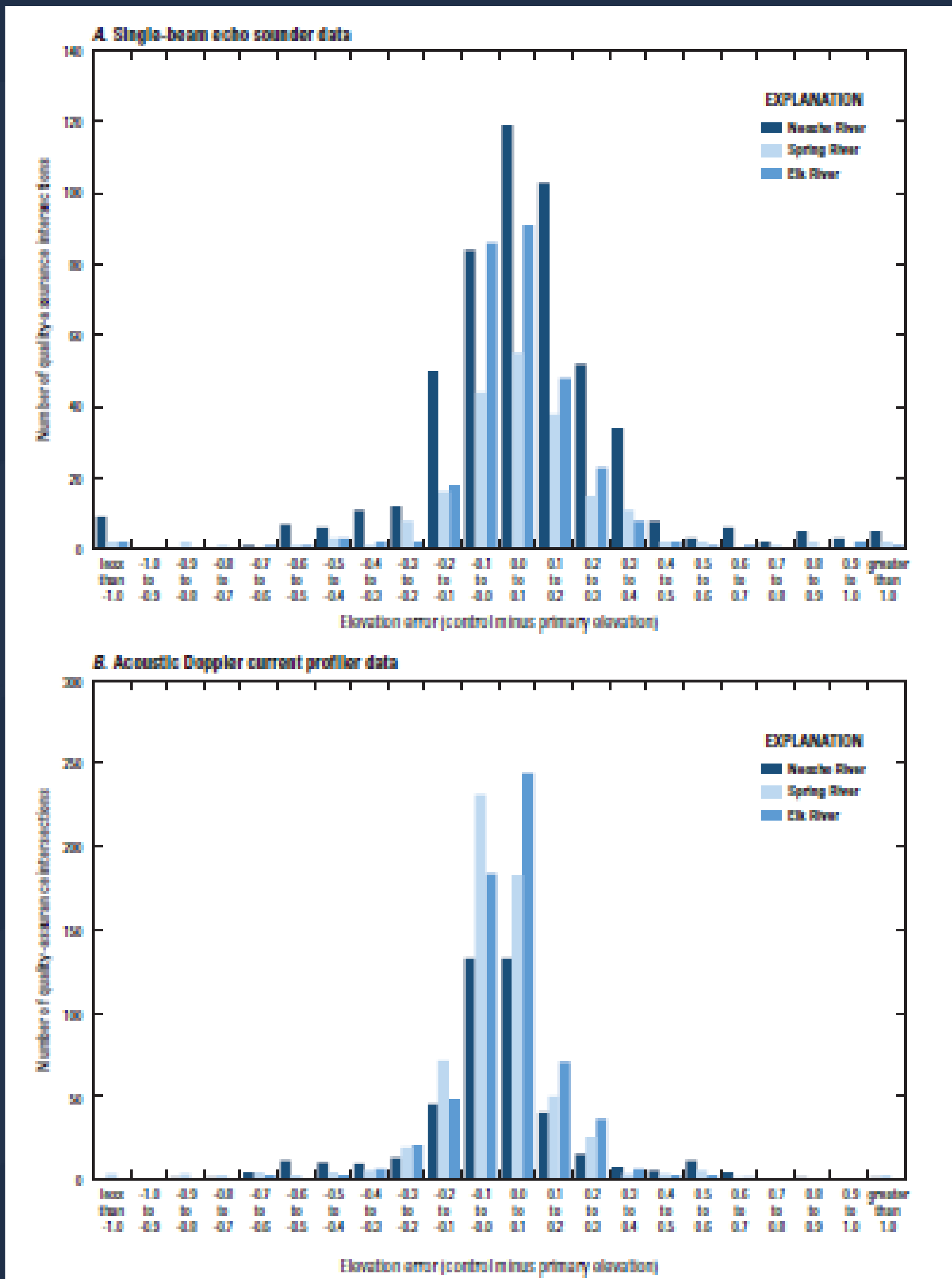
Single Beam Echosounder Bathymetric Survey 2016-17

- Hydrographic Systems Echotrac CV100 Single Beam Ecosounder
- Blanking distance is 1.1 feet
- Perpendicular to bank spaced 100’, 25’ at crossings
- Vessel speed kept under 5 ft/s

ADCP Bathymetric Survey 2016-17 Results

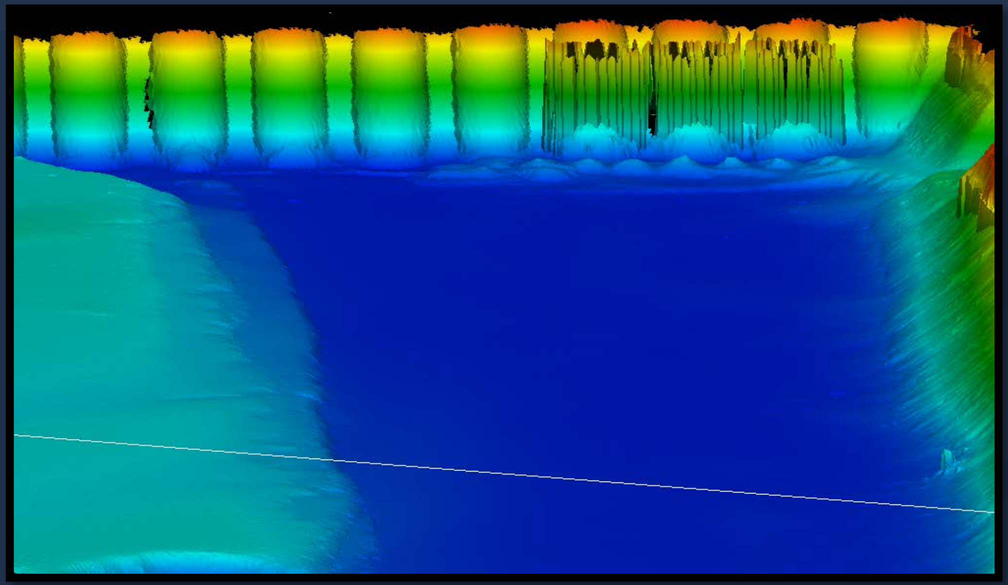


ADCP/Single Beam Echosounder QA/QC Results



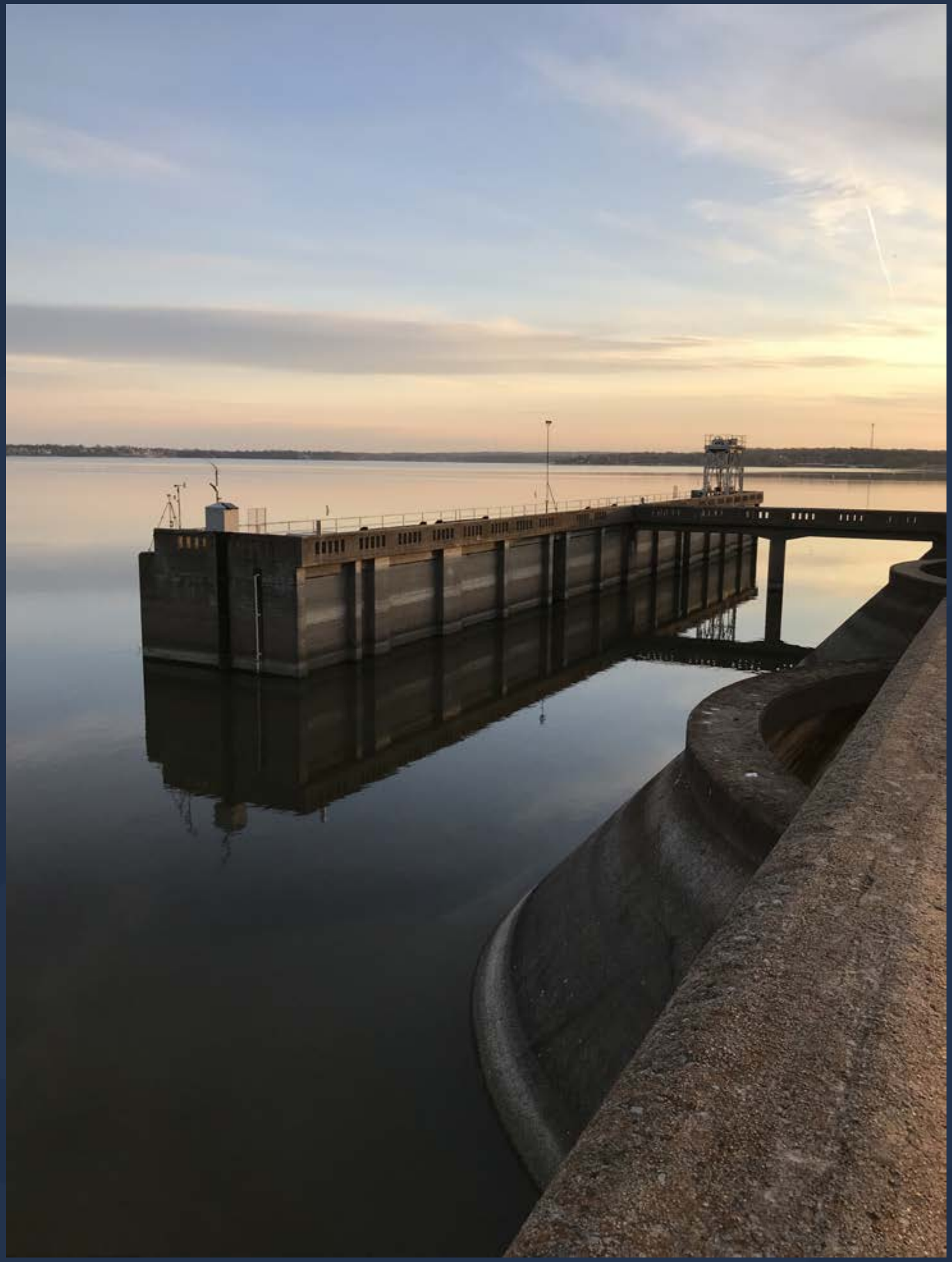
- Over 2,700 QA/QC Points
- Intersections
- RMSE <0.5
- Larger Errors Single Beam
- Bar Checks and Speed of Sound checks

Grand Lake O' the Cherokees Multibeam Bathymetric Survey 2019



Project Summary

- Develop a detailed bathymetric map of Grand Lake O’ the Cherokees (Grand Lake) with 2 ft. contours
- Determined the relation between:
  - Lake stage and surface area
  - Lake stage and storage
- Computed lake capacity was compared to previously published results



Previous Data Collection/Capacity Tables

USGS
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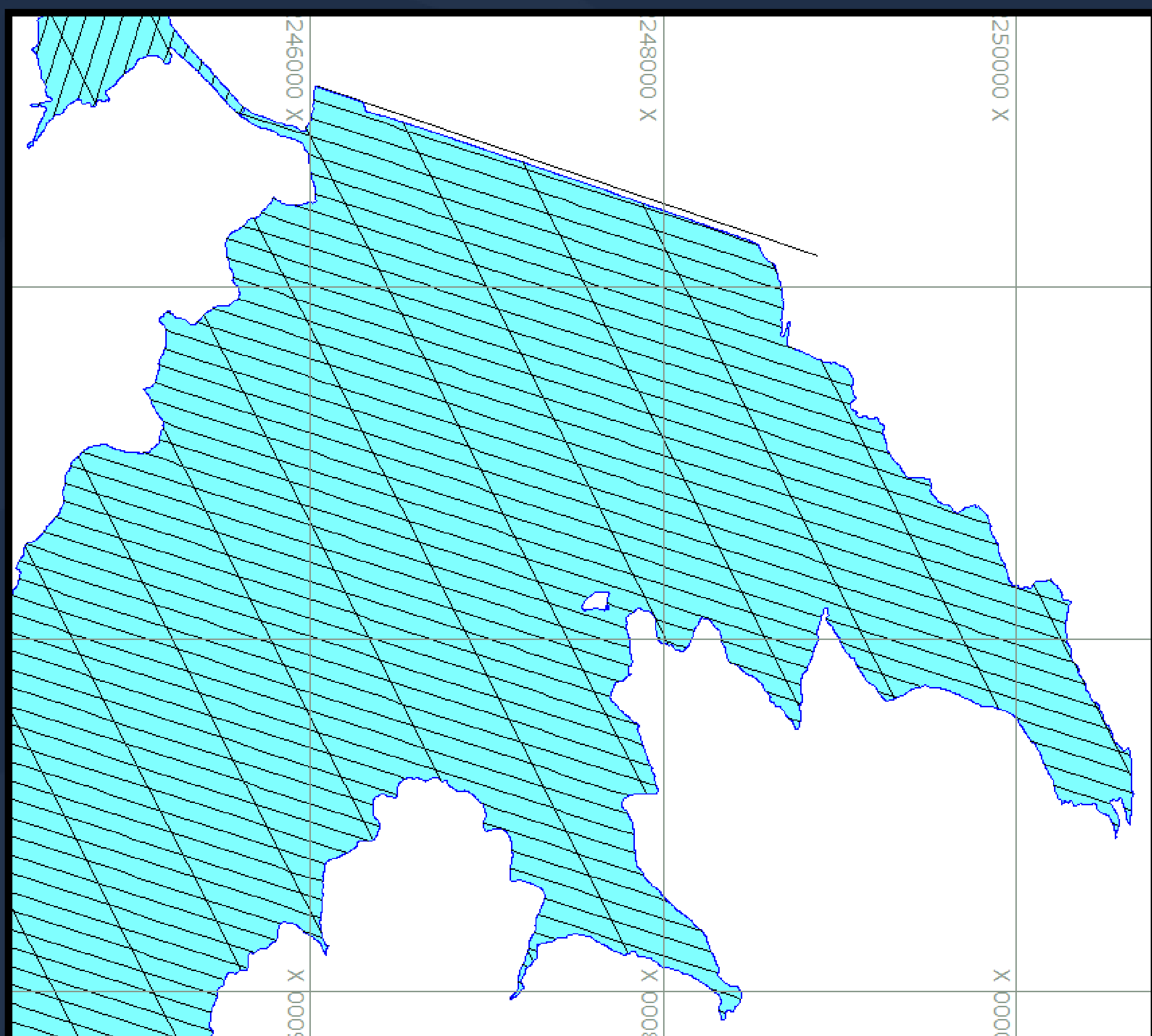
- 1940 – as built, survey points
- 1949 –updated with higher elevations
- 2009 – Single beam
- 2019 – Updated with river bathymetry
- 2020 – This study, adding multi-beam lake



- Single Beam data has previously been collected using transect lines.
- The transect lines to the left are 100-foot spacing parallel to dam; 500-foot spacing 45° from dam
- The Single beam would yield a survey point about every foot

(Ashworth and Others, 2017)

Bathymetric Collection Methods

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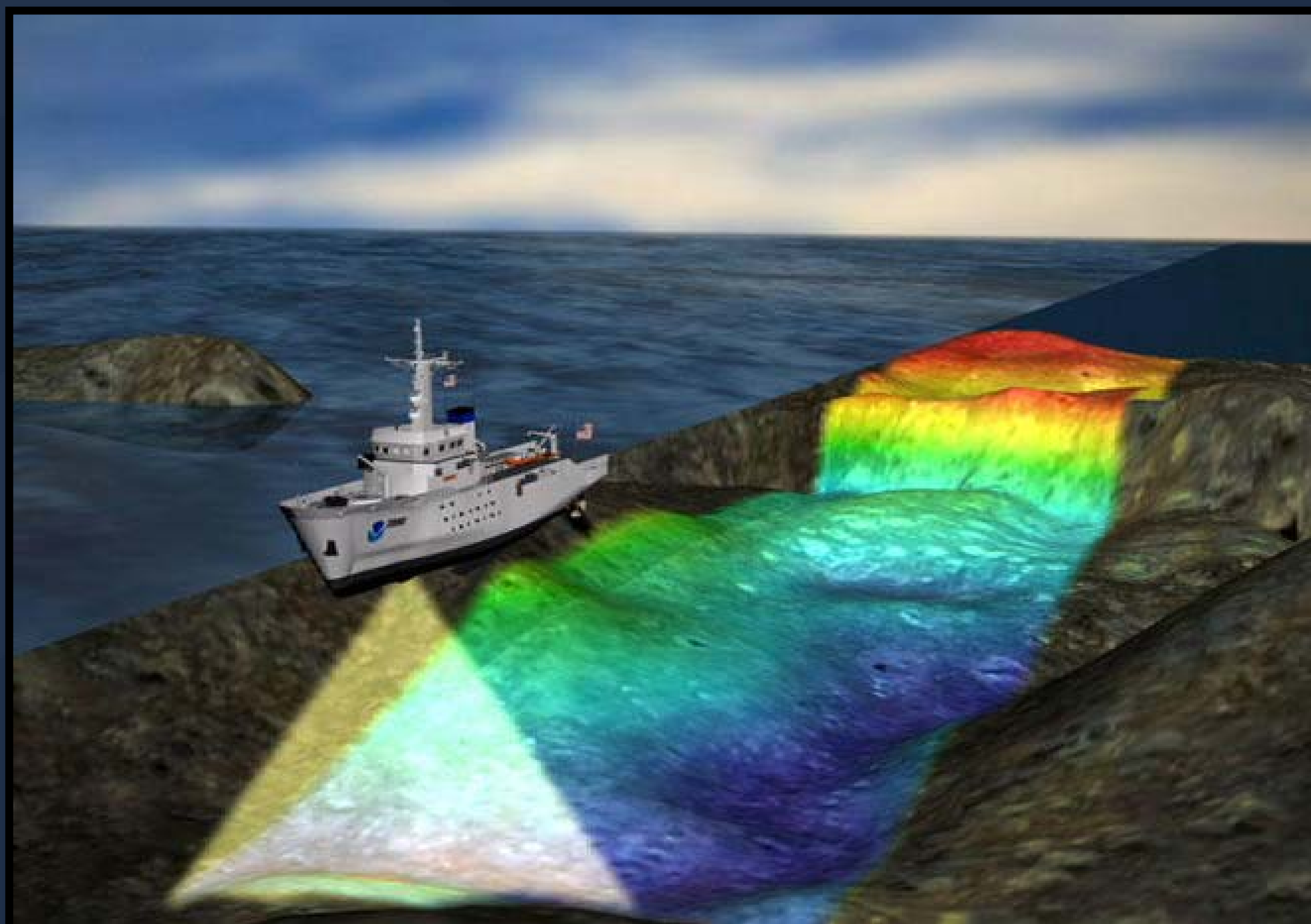
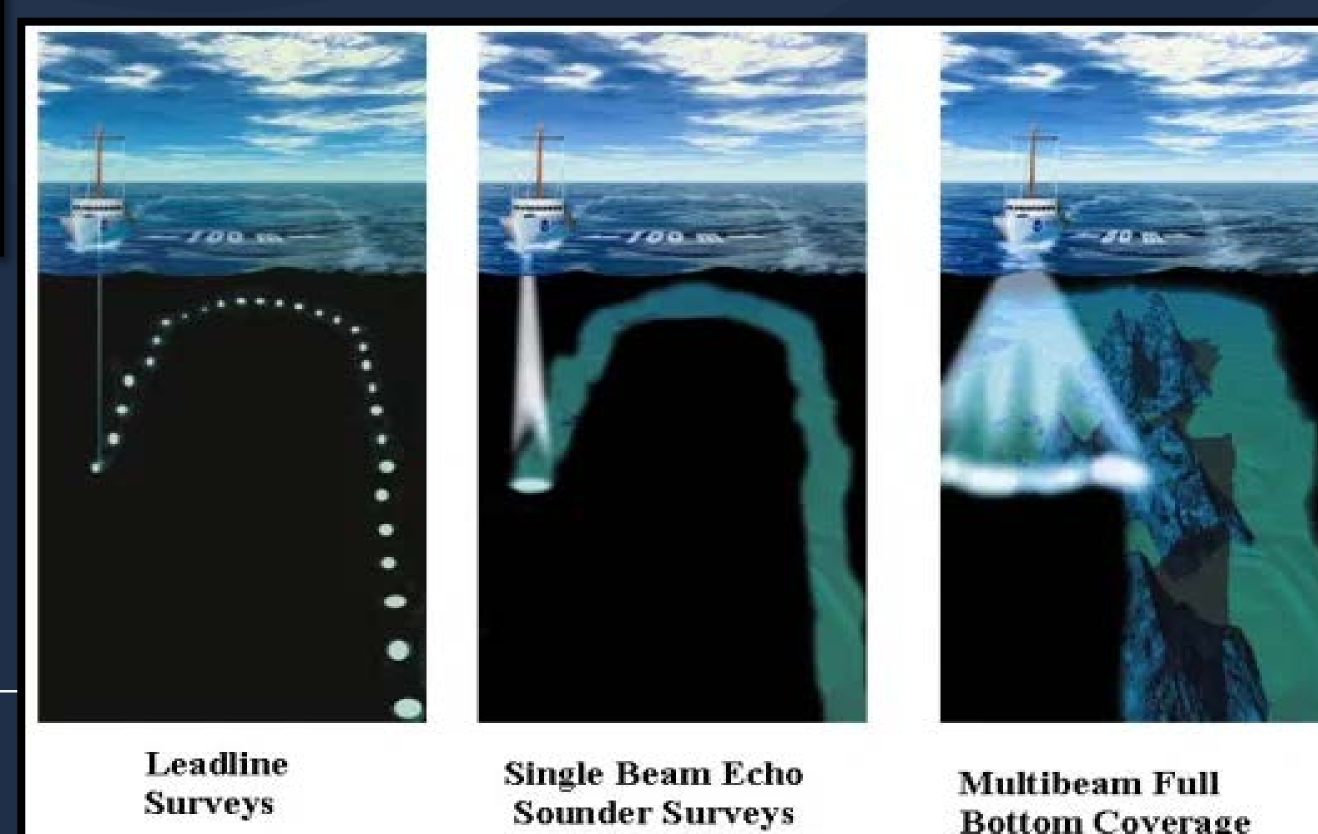


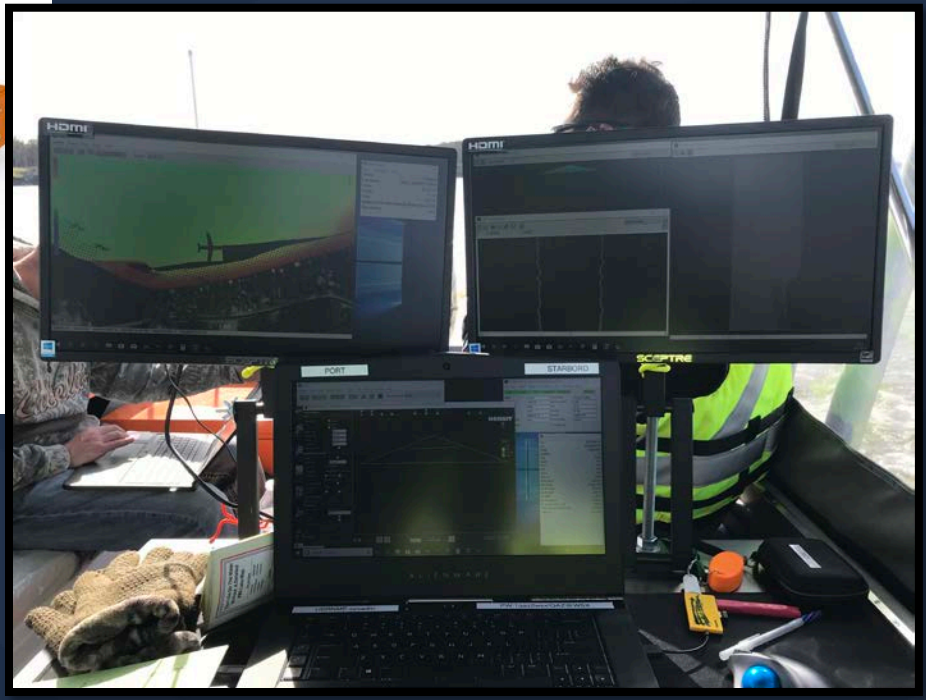
- The data at Grand Lake were not collected using Survey Lines.
- The boat's navigation screen was used to guide data collection and overlap previously collected data by 15-33% depending on the type of data.
- Methods used ensured 100% coverage.



(NOAA, 2017)

Multibeam Mapping System (MBMS)

- Multibeam Echosounder
- Inertial Navigation System
- Data Collection/Processing System



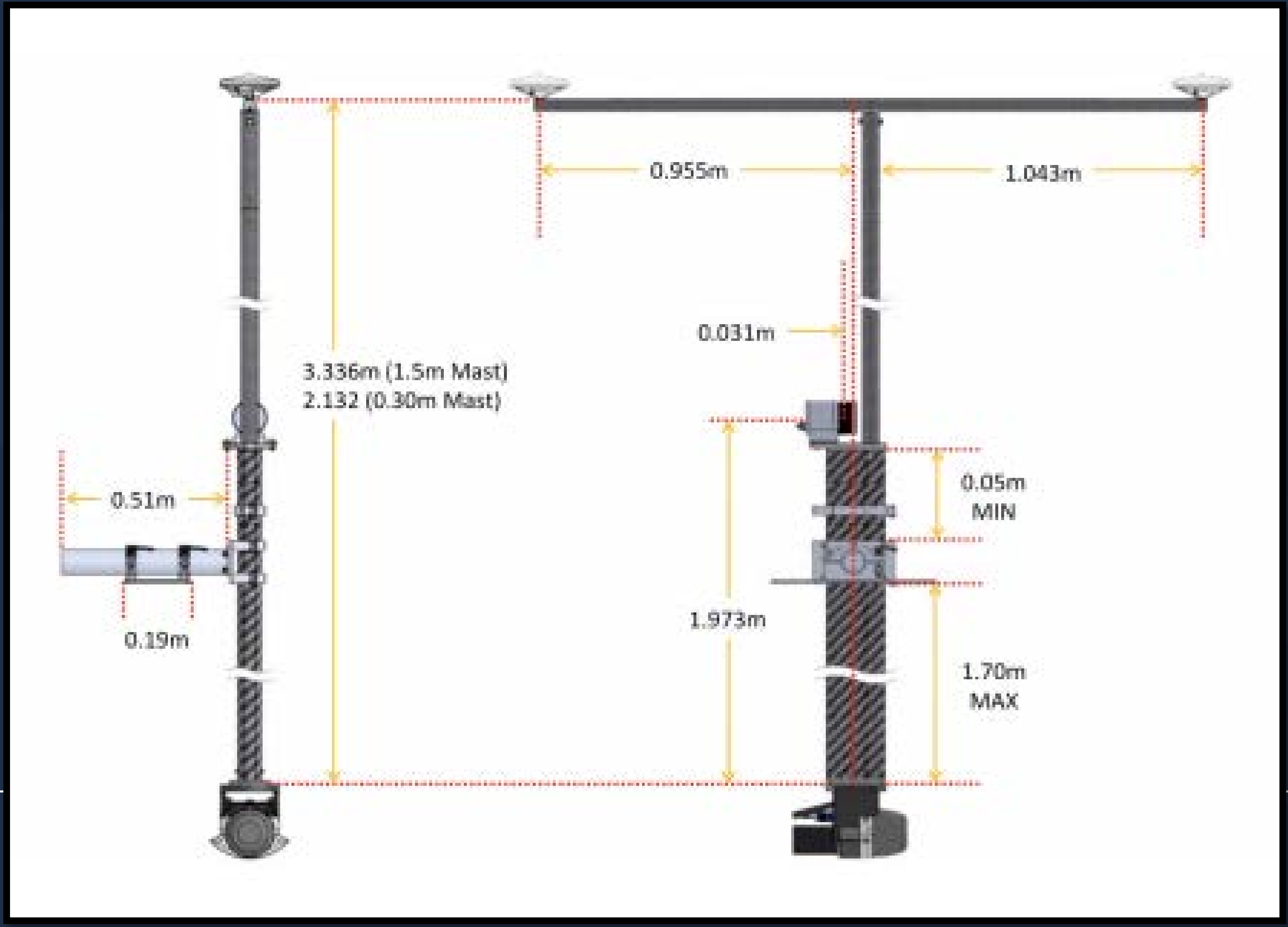
Multibeam Equipment:

1. Sonar
   1. NORBIT iWBMSh

(NORBIT, 2014a)

Multibeam Equipment:

1. Sonar Mount
    1. Norbit Portus Pole
        - The Norbit Portus Pole is extremely light and constructed of Carbon Fiber.
        - The pole raises and lowers as well as swivels to help when encountering debris in the water.
        - The Pole measurements and offsets are 100% repeatable assisting in consistency.



(NORBIT, 2014b)

Inertial Navigation System:

- GPS and Positional Correction
- Applanix POS MV OceanMaster
- The Oceanmaster blends GNSS with angular rate and acceleration data from an IMU and GPS Azimuth Measurement System to produce an accurate full six degrees-of-freedom position and orientation solution.
- This system is all built into the NORBIT iWBMSh

Data Collection/Processing System

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Software:

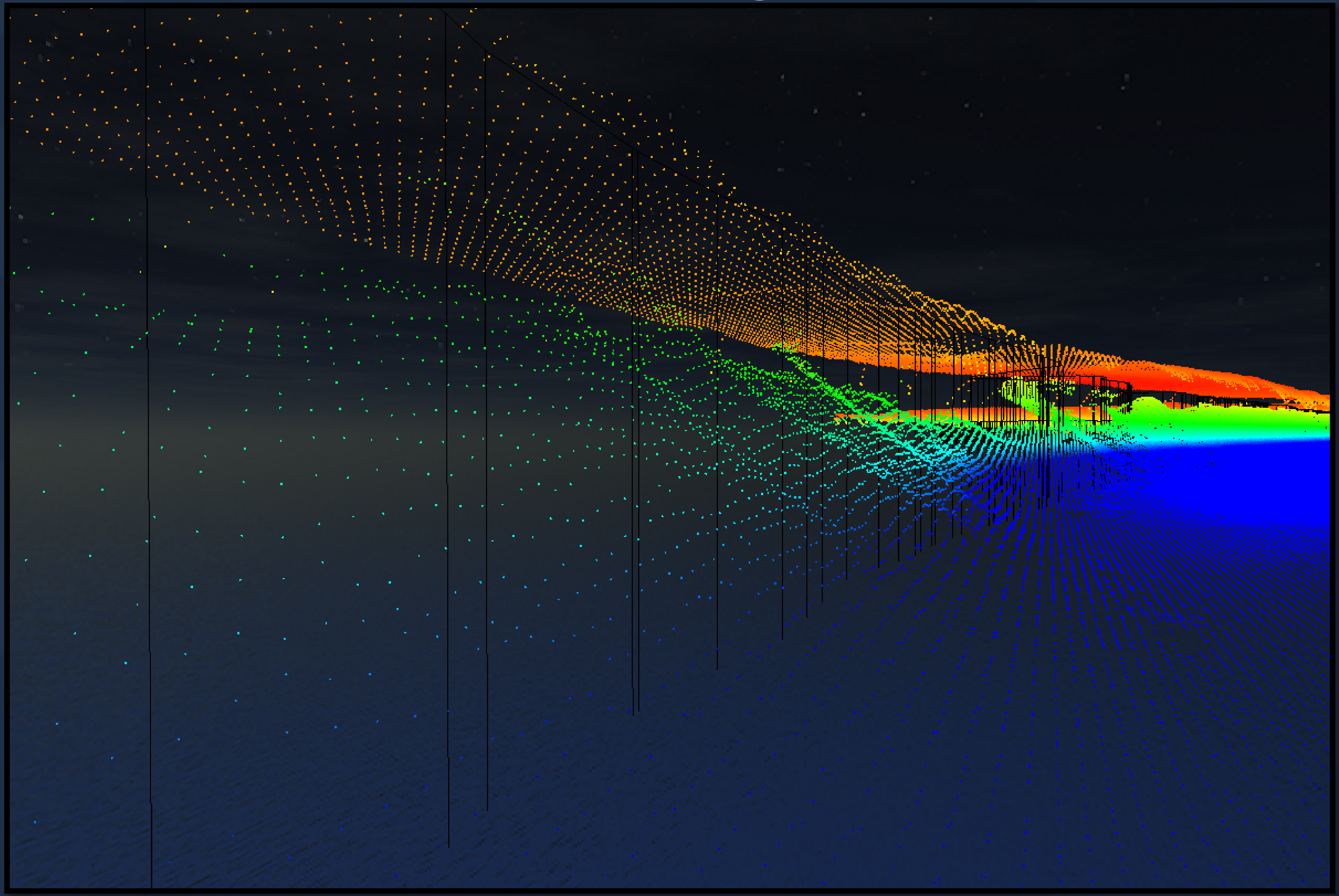
USGS
science for a changing world

- Software used for Data Collection was HYPACK

- https://www.hypack.com/products/hypack

Software:

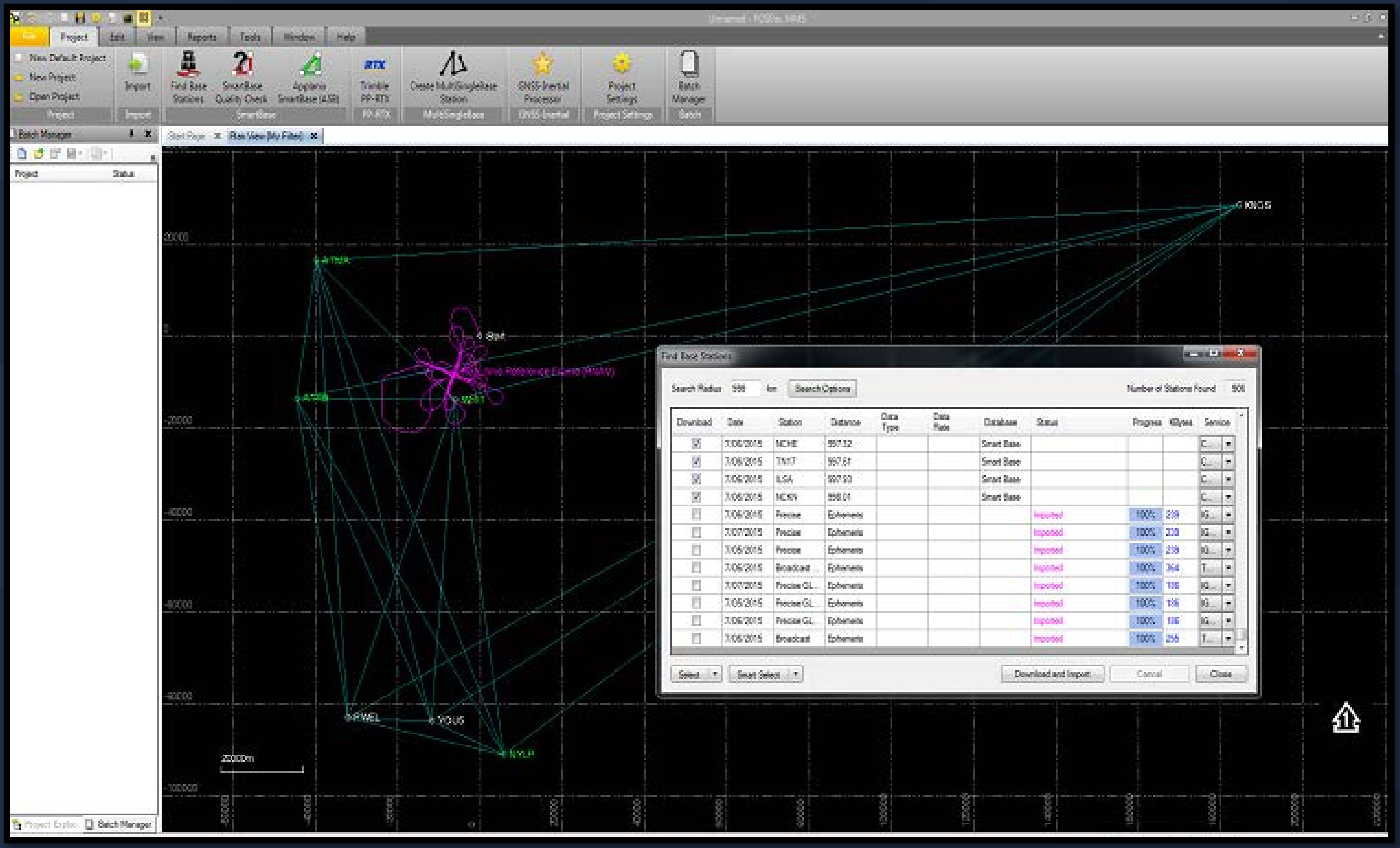
- Software used for Data Processing was HYSWEEP



- https://www.hypack.com/products/hysweep

Software:

- Software used for GPS Processing was POSPac



- https://www.applanix.com/products/pospac-mms.htm

Velocity of Sound in Water:

- Needed to accurately calculate depth based on acoustic waves
- AML Oceangraphic Base X2 Sound Velocity Profiler
- Collected once an hour at different locations
- Data applied to Multi Beam data in post-processing

Current Collection Methods

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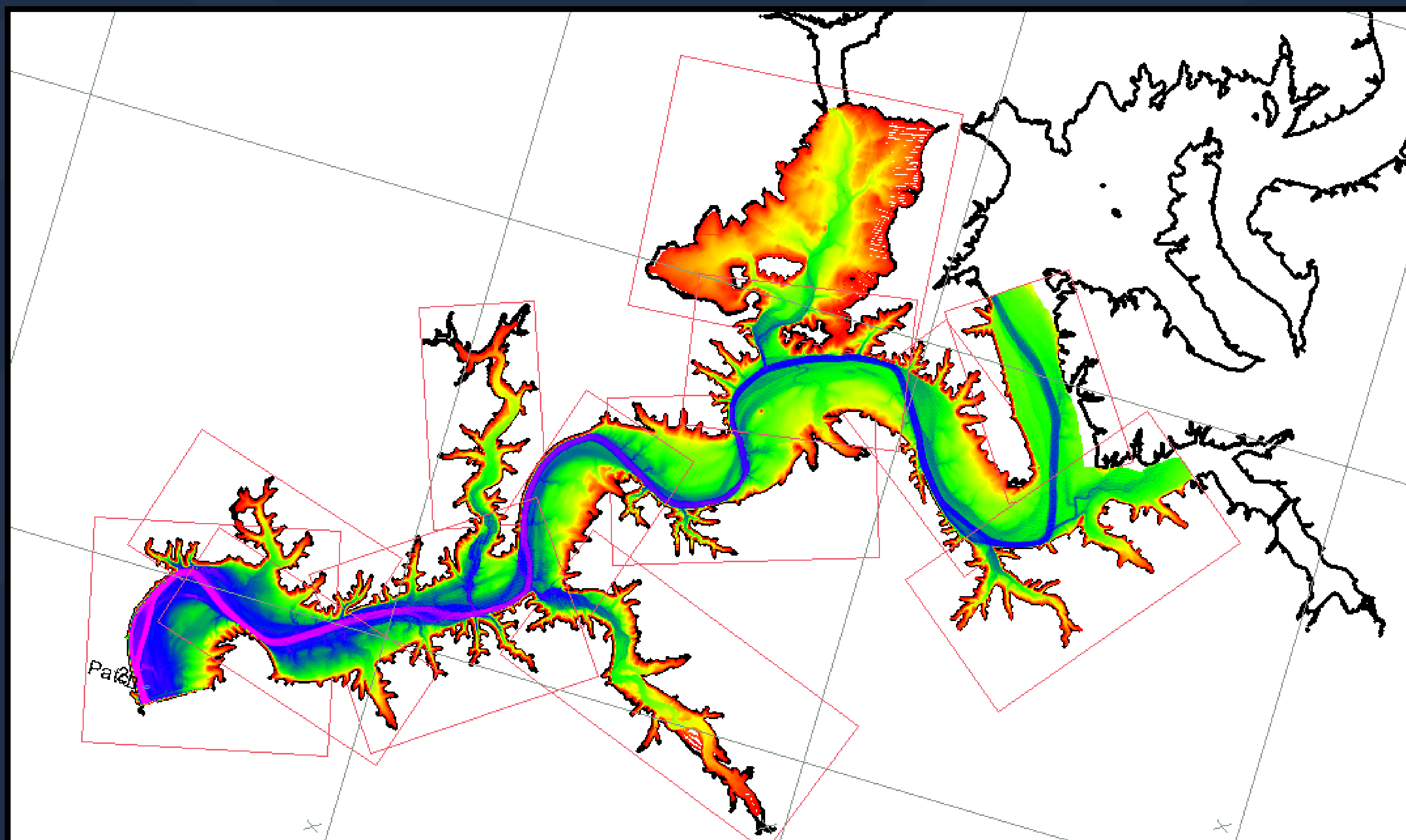
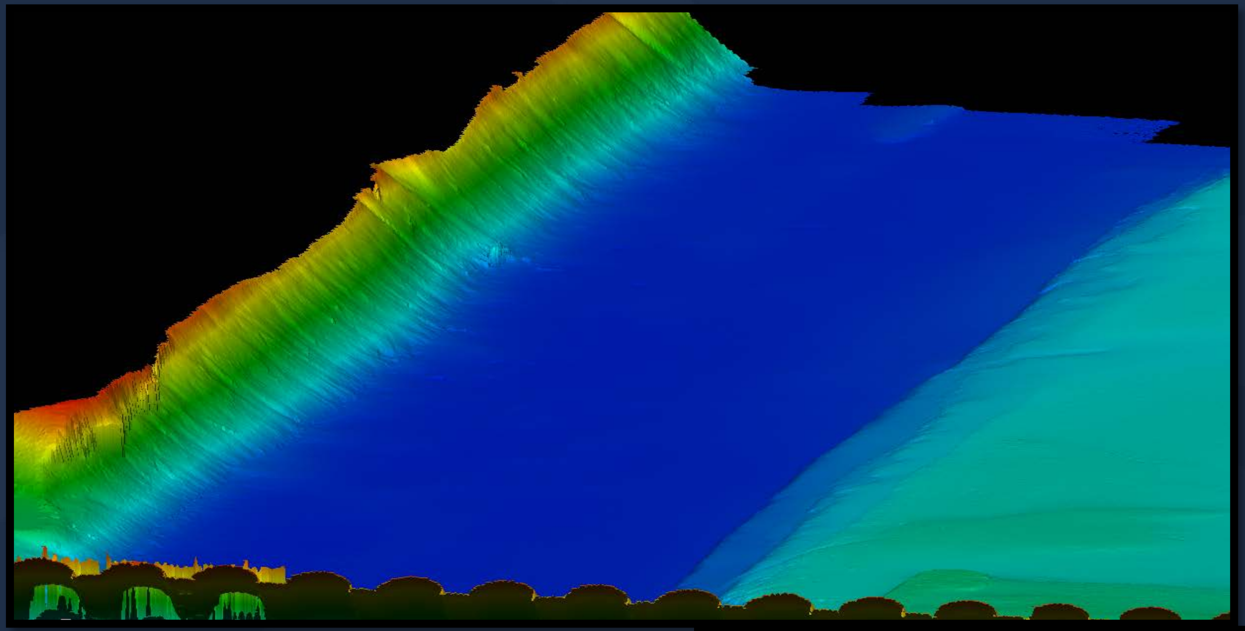
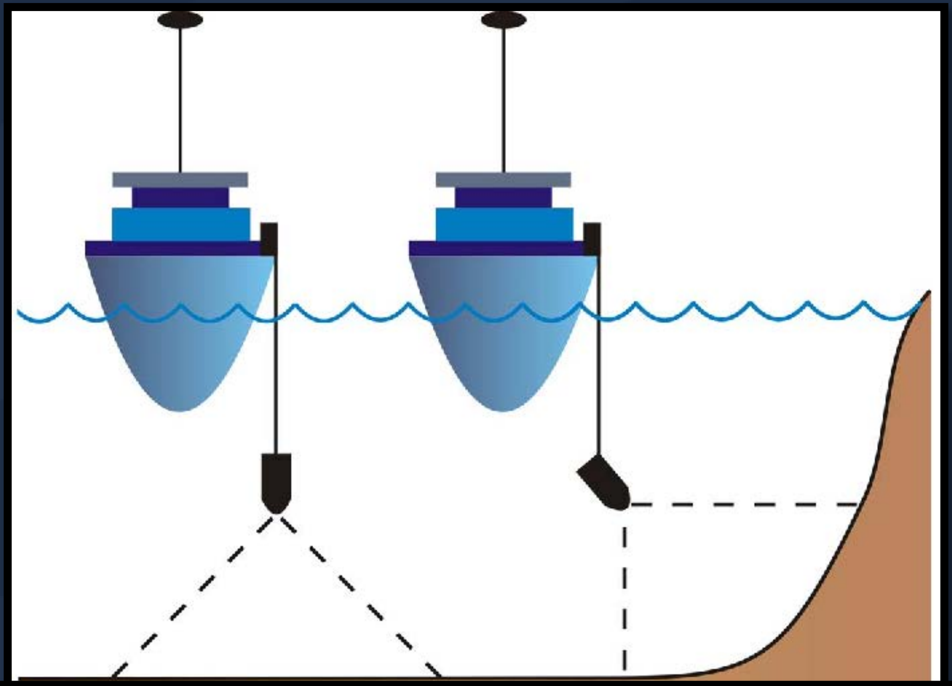
- Data Collection of Grand Lake showing the main channel.

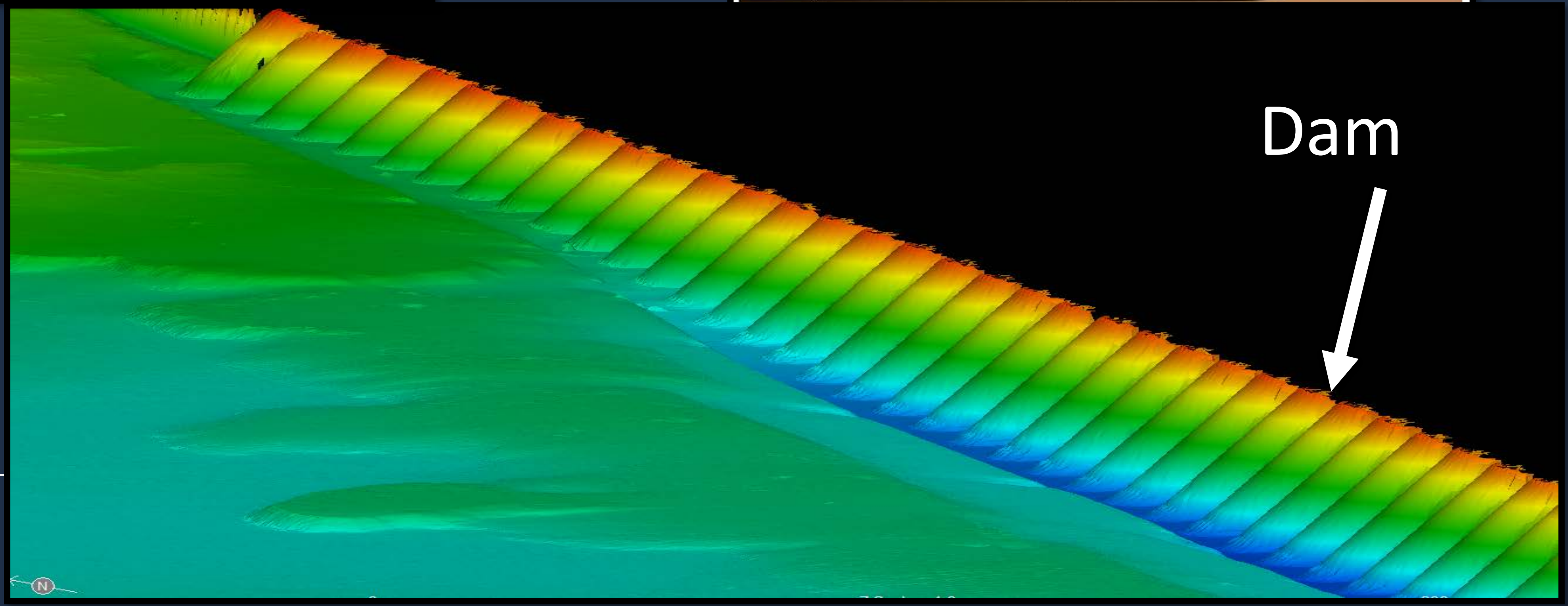


Data Collection on Slopes

The Norbit Multibeam allows you to curve the beam angle in the direction you would like to survey to ensure 100% lake coverage up the water surface in some instances.







(NORBIT, 2014a)

Data Collection in Difficult Areas

Software:

- Software used for Map Creation was Global Mapper

https://www.bluemarblegeo.com/working-with-bathymetric-data/

Stage-Storage Relation

USGS
science for a changing world

Table 1. Surface area and capacity at specified water-surface elevations for Grand Lake O' the Cherokees in northeastern Oklahoma from a bathymetric survey completed during April 1–July 31, 2019, augmented with previously collected single-beam sonar data and lidar point-cloud data.

[ft, feet; NAVD 88, North American Vertical Datum of 1988; winter conservation pool elevation is 742.0 ft above Pensacola Datum, 743.4 ft above NAVD 88, and the top of dam elevation is 757.0 ft above Pensicola Datum, 758.4 ft above NAVD 88]

Water-surface elevation,[1] in ft	Water-surface elevation,[2] in ft	Capacity,[3] in acre-ft	Surface area, in acres	Water-surface elevation,[1] in ft	Water-surface elevation,[2] in ft	Capacity,[3] in acre-ft	Surface area, in acres	Water-surface elevation,[1] in ft	Water-surface elevation,[2] in ft	Capacity,[3] in acre-ft	Surface area, in acres
626.00	624.60	100	60	672.00	670.60	65,400	4,040	718.00	716.60	563,900	19,960
628.00	626.60	300	110	674.00	672.60	73,900	4,470	720.00	718.60	605,100	21,260
630.00	628.60	500	170	676.00	674.60	83,300	4,960	722.00	720.60	649,000	22,660
632.00	630.60	1,000	270	678.00	676.60	93,700	5,420	724.00	722.60	695,700	24,020
634.00	632.60	1,600	360	680.00	678.60	105,100	5,930	726.00	724.60	745,100	25,330
636.00	634.60	2,400	430	682.00	680.60	117,400	6,420	728.00	726.60	797,100	26,730
638.00	636.60	3,300	500	684.00	682.60	130,800	6,950	730.00	728.60	852,100	28,220
640.00	638.60	4,400	580	686.00	684.60	145,200	7,460	732.00	730.60	910,100	29,760
642.00	640.60	5,600	640	688.00	686.60	160,600	7,990	734.00	732.60	971,000	31,260
644.00	642.60	7,000	710	690.00	688.60	177,100	8,570	736.00	734.60	1,035,300	33,010
646.00	644.60	8,500	840	692.00	690.60	195,000	9,300	738.00	736.60	1,103,200	34,900
648.00	646.60	10,300	950	694.00	692.60	214,400	10,050	740.00	738.60	1,174,900	36,860
650.00	648.60	12,300	1,070	696.00	694.60	235,100	10,760	742.00	740.60	1,250,900	39,240
652.00	650.60	14,600	1,210	698.00	696.60	257,400	11,490	**743.40**	**742.00**	**1,307,300**	**41,580**
654.00	652.60	17,200	1,410	700.00	698.60	281,100	12,190	744.00	742.60	1,332,500	42,390
656.00	654.60	20,300	1,690	702.00	700.60	306,200	12,930	746.00	744.60	1,419,400	44,580
658.00	656.60	24,000	1,970	704.00	702.60	332,900	13,710	748.00	746.60	1,510,900	46,850
660.00	658.60	28,200	2,270	706.00	704.60	361,000	14,460	750.00	748.60	1,606,900	49,190
662.00	660.60	33,000	2,530	708.00	706.60	390,600	15,160	752.00	750.60	1,707,800	51,690
664.00	662.60	38,400	2,800	710.00	708.60	421,700	15,910	754.00	752.60	1,813,800	54,390
666.00	664.60	44,200	3,070	712.00	710.60	454,300	16,740	756.00	754.60	1,925,500	57,300
668.00	666.60	50,700	3,360	714.00	712.60	488,800	17,720	758.00	756.60	2,043,300	60,520
670.00	668.60	57,700	3,680	716.00	714.60	525,200	18,750	**758.40**	**757.00**	**2,067,700**	**61,180**

[1]Elevations are referenced to the North American Vertical Datum of 1988.

[2]Elevations are referenced to the Pensacola Datum, a local datum established in 1940 by the U.S. Army Corps of Engineers for the Penscola Dam impounding Grand Lake O' the Cherokees. Pensacola Datum is calculated by subtracting 1.40 ft from NAVD 88.

[3]Capacities were computed from a surface triangulated irregular network that was computed at about 0.47 ft at the 95th-percentile value for the approximately 6.8-million-point quality-assurance dataset. The explanation of the vertical accuracy calculation is in the "Bathymetric Surface and Contour Quality Assurance" section of this report. Capacities have been rounded to the nearest hundred.

Real-Time Stage-Storage Relation

USGS
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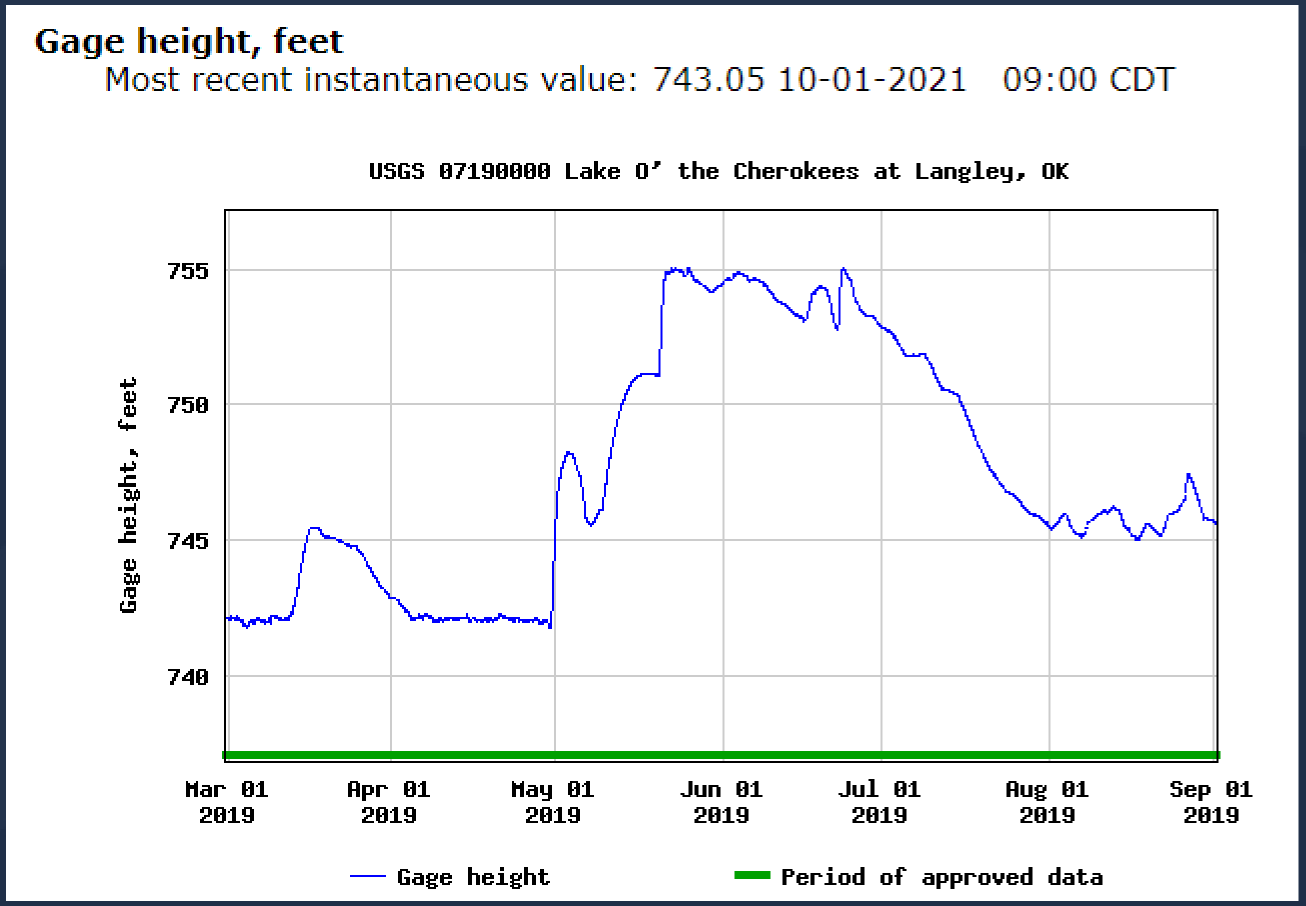
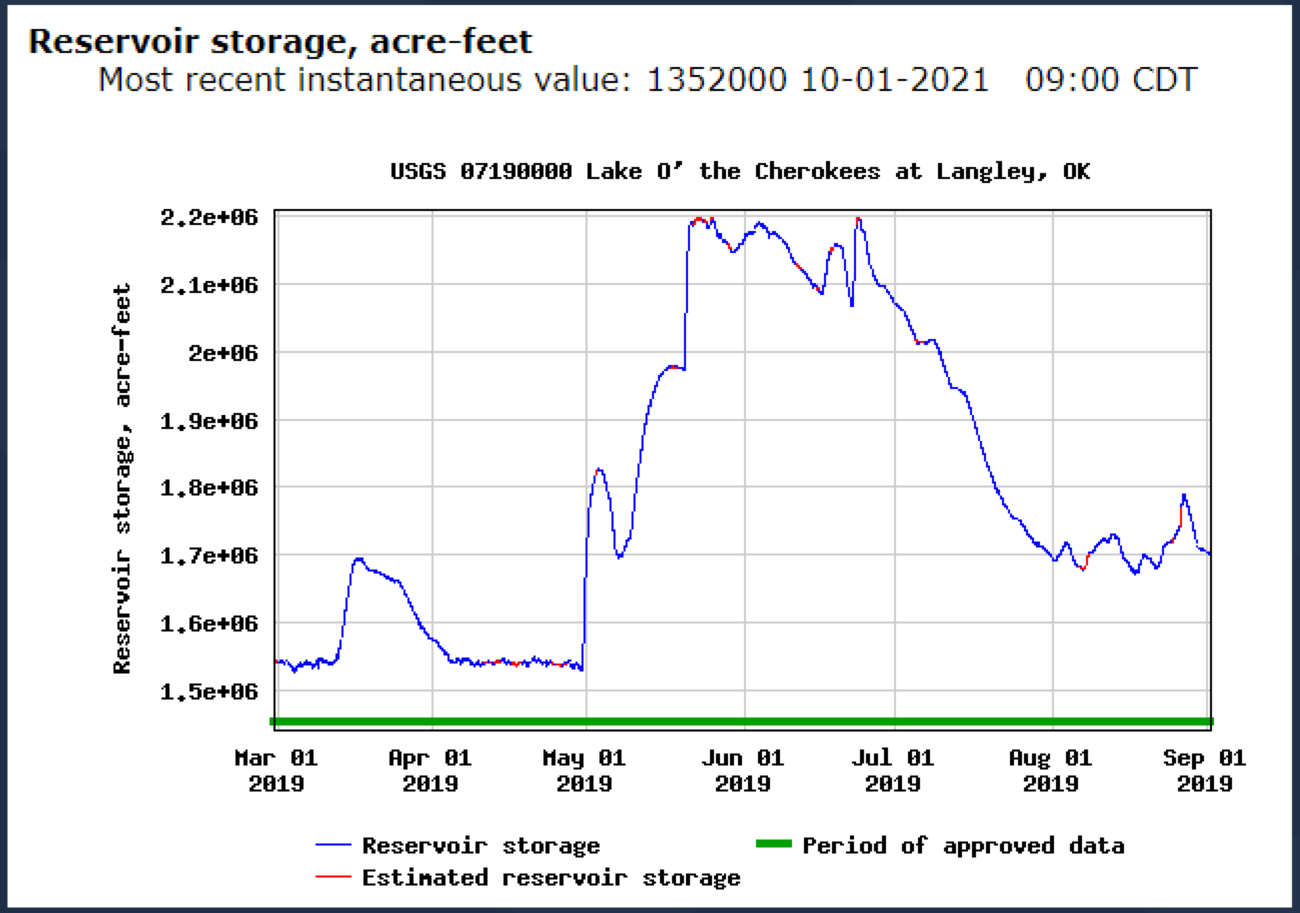
Stage, and Storage are reported in real time at USGS station 07190000

https://waterdata.usgs.gov/ok/nwis/uv?site_no=07190000





Results Compared

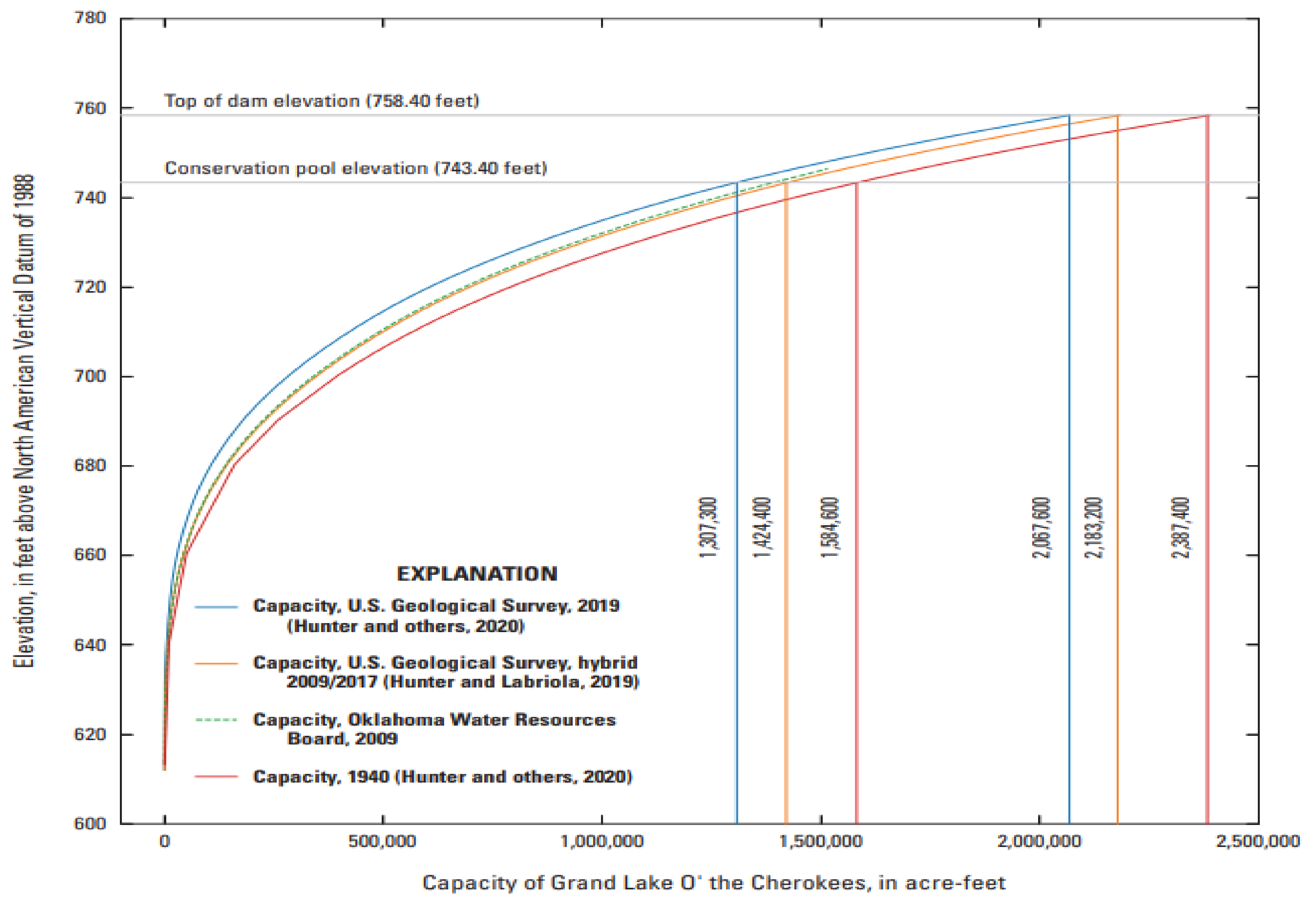
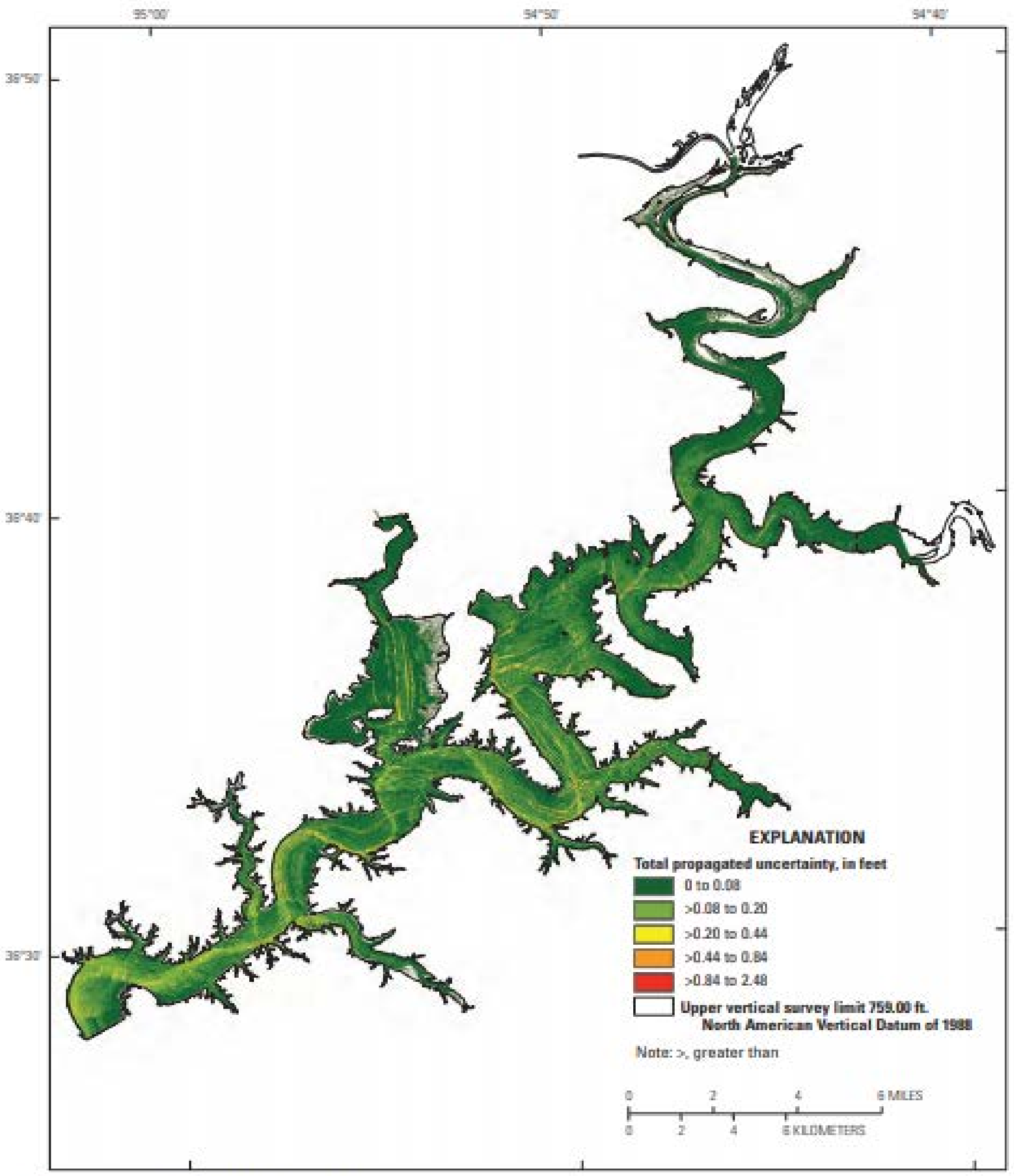


Figure 5. Capacity of Grand Lake O' the Cherokees as calculated with elevation data from 1940, from the Oklahoma Water Resources Board (2009), from the U.S. Geological Survey hybrid 2009/17 study (Hunter and Labriola, 2019), and from bathymetric data collected in 2019 and compiled for this study. Modified from figure 4 in Hunter and Labriola (2019).

Multi-Beam Bathymetric QA/QC Results



Base from U.S. Geological Survey digital data, 1:205,000
Oklahoma State Plane North projection
North American Datum of 1983

Figure 4. Extent of multibeam bathymetric data collected in 2019 and the total propagated uncertainty pertaining to the collected data, Grand Lake O' the Cherokees, northeastern Oklahoma.

- Field Monitor Screen - Data
- Beam Angle Checks
- Patch Tests

- 6.8 million QA/QC Data Points
- Calculated Error 0.47 feet
- Total Propagated Uncertainty (TPU)
- 95% of data <0.47 feet

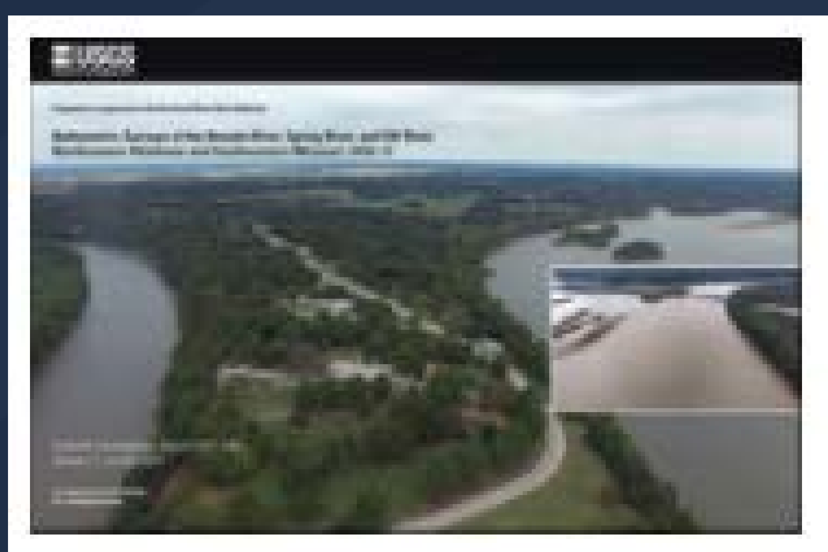
USGS Review Process

- Fundamental Science Practices
- Data collection review and approval
- Draft report initial review
- Supervisor Review
- 2 Colleague Reviews (Specialists)
- Reports Specialist Review
- USGS Editorial/Figures Review
- Bureau Review
- Publication/Layout Review

Published Reports and Data

https://pubs.er.usgs.gov/publication/sim3467

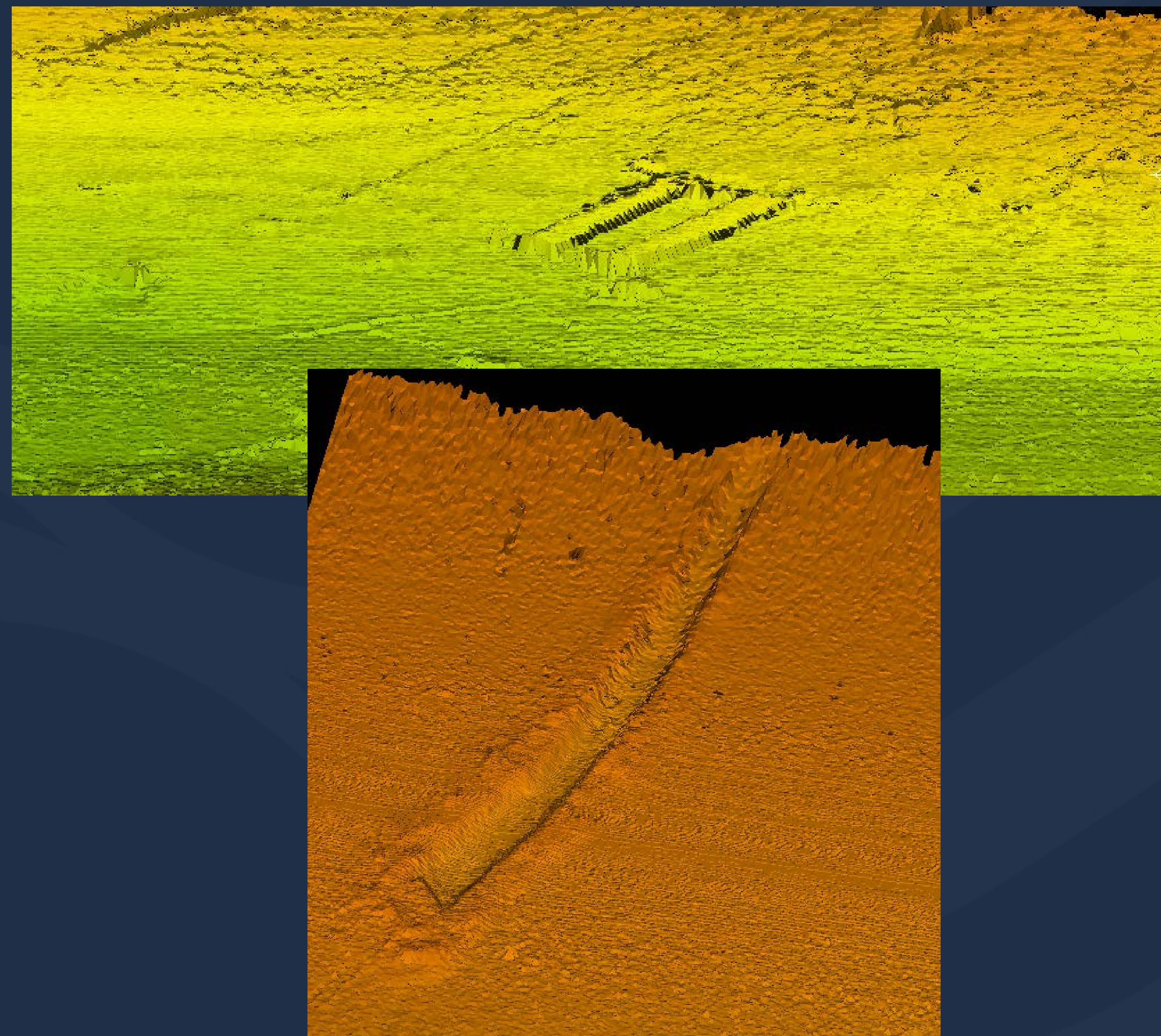
https://www.sciencebase.gov/catalog/item/5e4c001fe4b0ff554f6c6531



https://pubs.er.usgs.gov/publication/sir20175101

https://www.sciencebase.gov/catalog/item/59357d5be4b06a58eb675596

Questions?



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Hydrologic and Hydraulic Modeling: Operations Model

Pensacola Hydroelectric Project
Project No. 1494

October 12, 2021

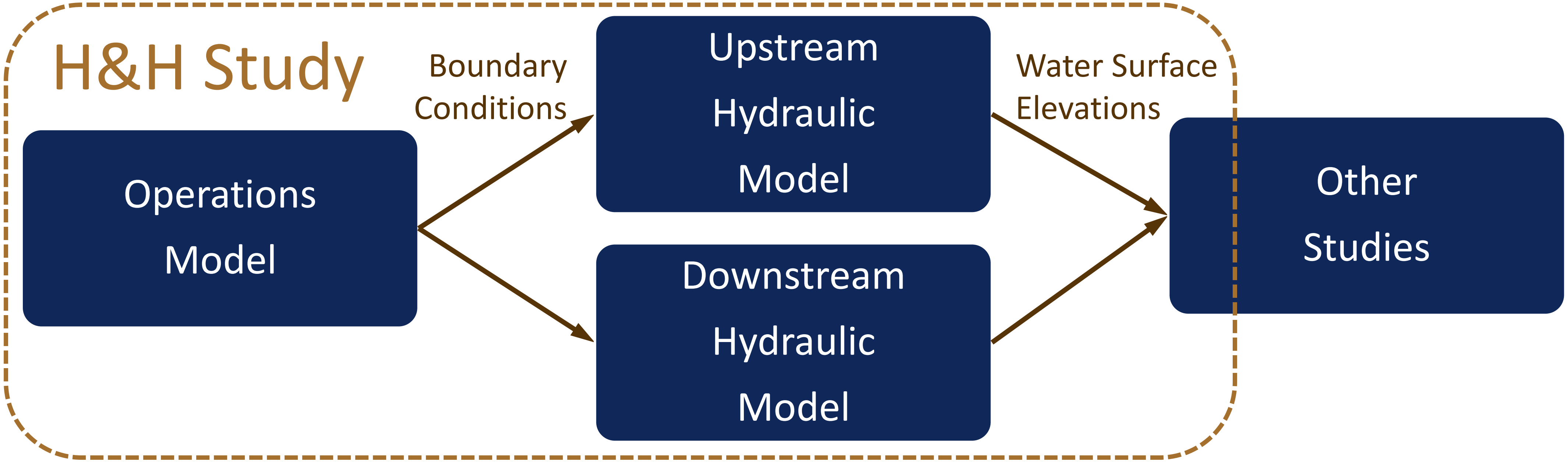
Presentation Outline

1. Relicensing Timeline, Study Objectives, and Vertical Datums
2. Operations Model Objectives
3. Operations Model Methods
4. Overview of RiverWare, Flood Routing, and Operations Models
5. Input Data
6. Solution
7. Validation
8. Planned Improvements
9. Computed Scenarios

H&H Study Overview

Operations Model
Upstream Hydraulic Model
Downstream Hydraulic Model

H&H Study Overview

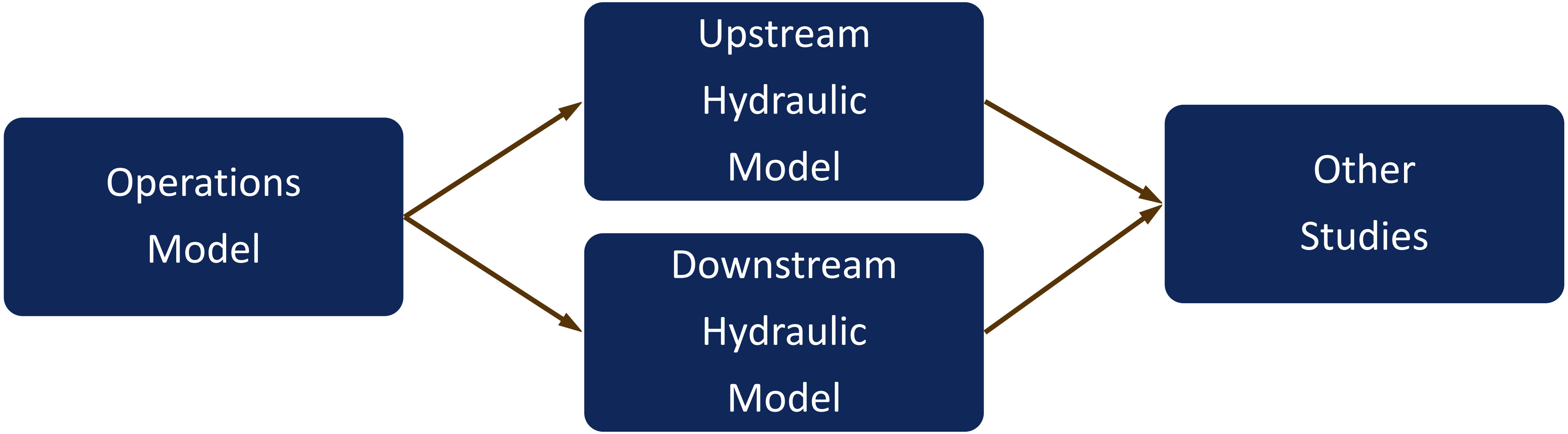


FERC's SPD and Order on Request for Clarification and Rehearing required a model input status report and conference call to discuss model inputs and calibration.

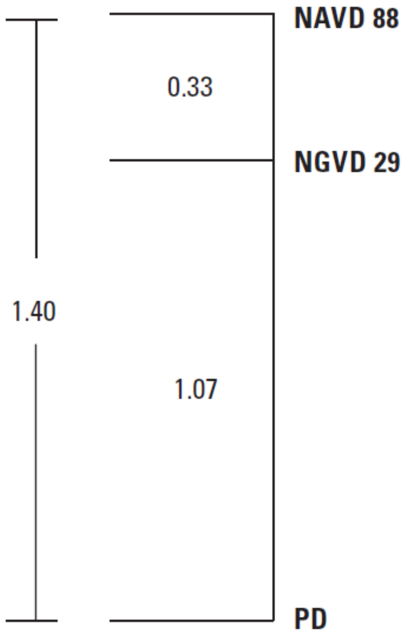
- Model Input Status Report (MISR) filed with FERC on March 30, 2021
- Technical Conference held April 21, 2021
- Some information presented today will be similar

H&H Study Objectives

1. Analyze inundation under current license operations of the Project during several measured inflow events.
2. Provide model results in a format that can inform other analyses.
3. Determine feasibility of implementing anticipated future operations as part of relicensing effort.



Vertical Datums



	Elevations, in feet		
	NAVD 88	NGVD 29	PD
Conservation pool	743.40	743.07	742.00
Top of the dam	758.40	758.07	757.00

Operations Model

Operations Model Objectives

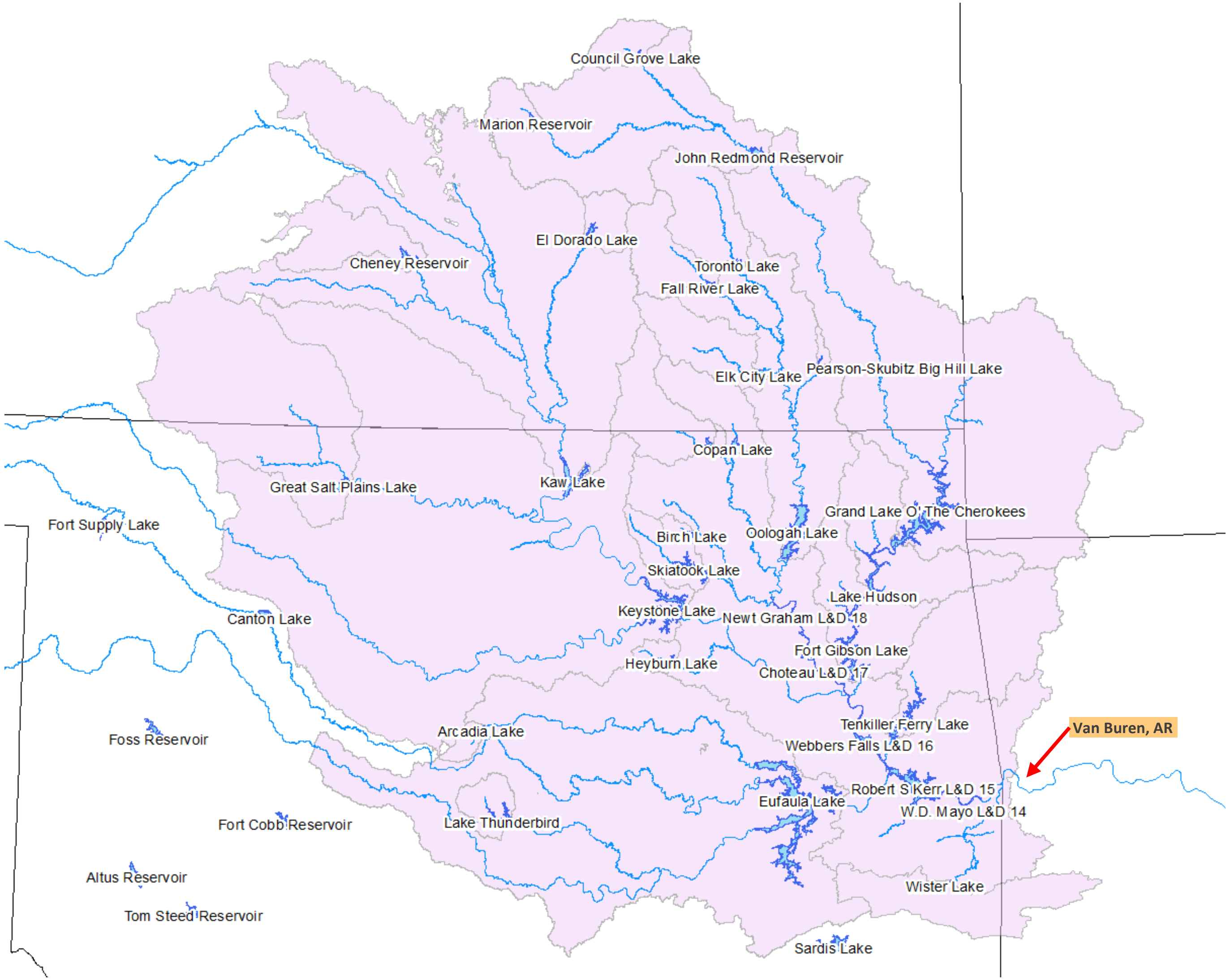
1. Validate results with USACE RiverWare model data
2. Synthesize hypothetical events that inform and set boundary conditions of a Comprehensive Hydraulic Model (CHM)

Operations Model Methods

1. Define relationship of physical constraints with inflow at the Pensacola Dam (i.e. friction headloss, turbine generator efficiency, discharge rating curves, etc.)
2. Develop a VBA (Visual Basic for Applications) based model in Microsoft Excel
3. Calculate hourly outflows and generation based on current license operations represented in RiverWare…
4. …and any anticipated future operations under several inflow events
5. Use Operations Model to inform and set boundary conditions of CHM for each considered operations scenario

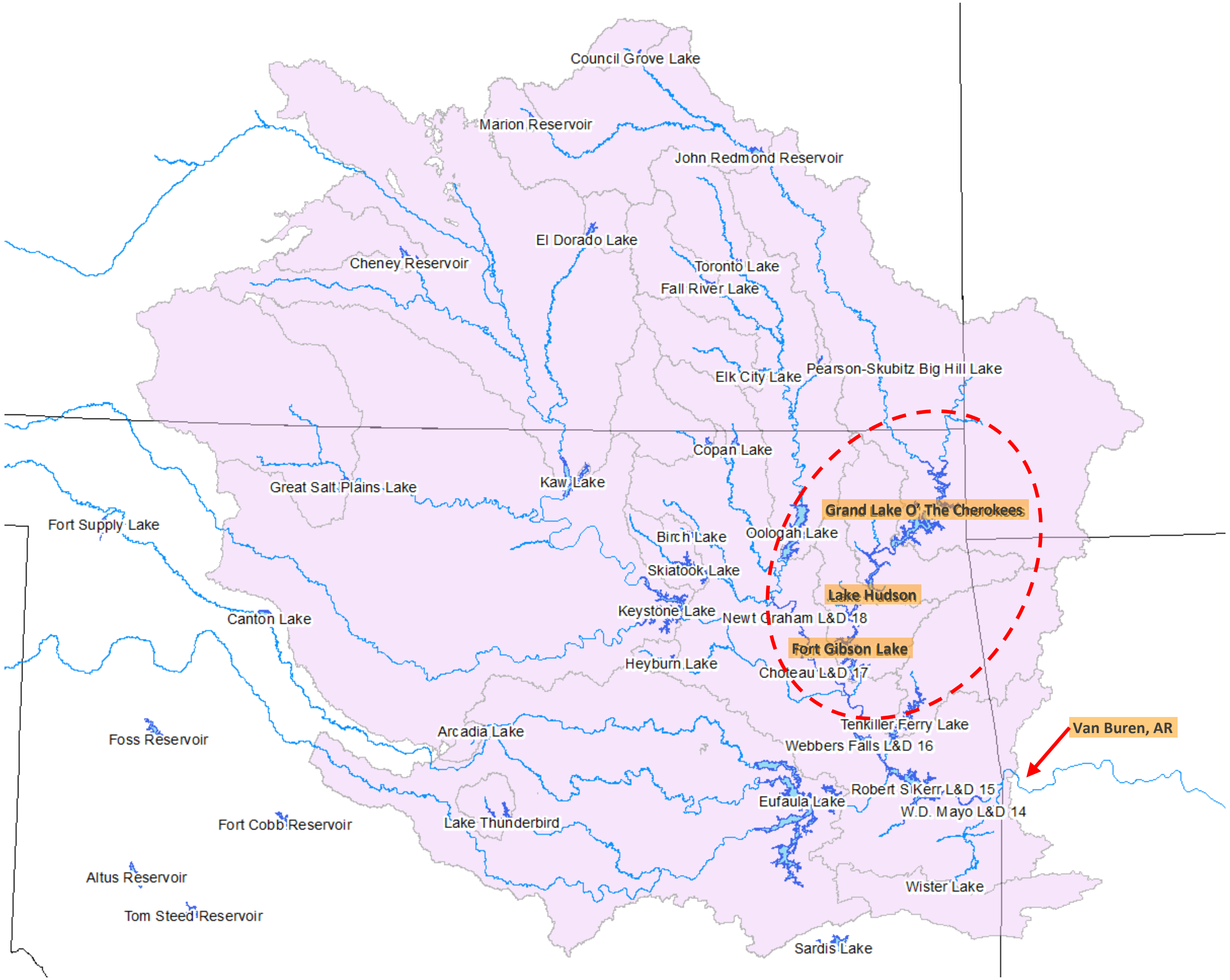
Overview: RiverWare, Flood Routing, and Operations Models

USACE RiverWare Model



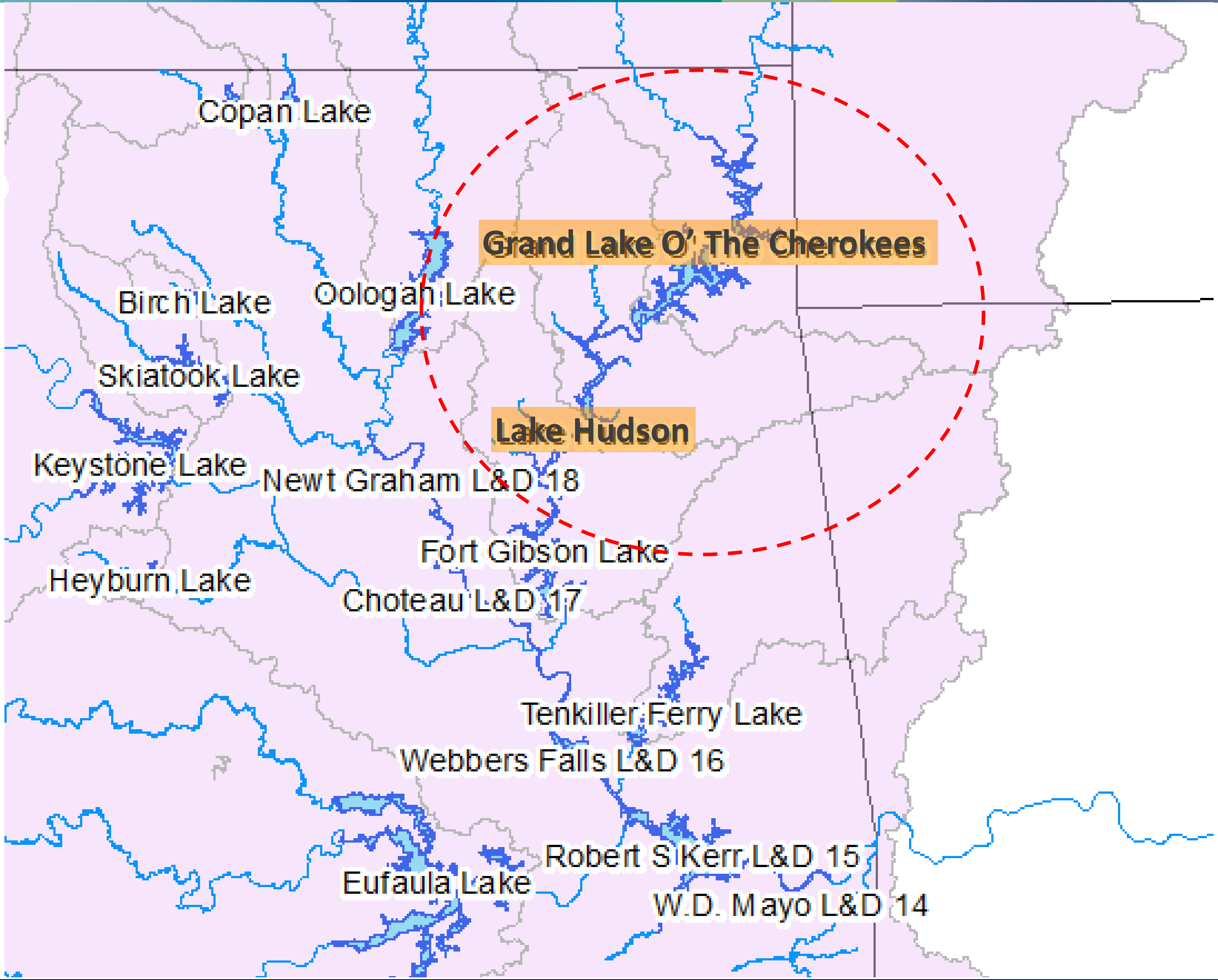
- 1940 through 2019
- Daily time step
- 30+ Reservoirs
- Methods
  - Hydrologic Routing
  - Flood Control
    - Channel Capacity
    - Ramping Rates
    - Balance Levels
    - Control at Van Buren, AR
  - Conservation & Power

Flood Routing Model



- 1940 through 2019
- Daily time step
- 3 Reservoirs (subsystem)
- Methods
  - Hydrologic Routing
  - Flood Control
    - Channel Capacity
    - Ramping Rates
    - Balance Levels
    - ~~Control at Van Buren, AR~~
  - ~~Conservation & Power~~
  - Excel and VBA

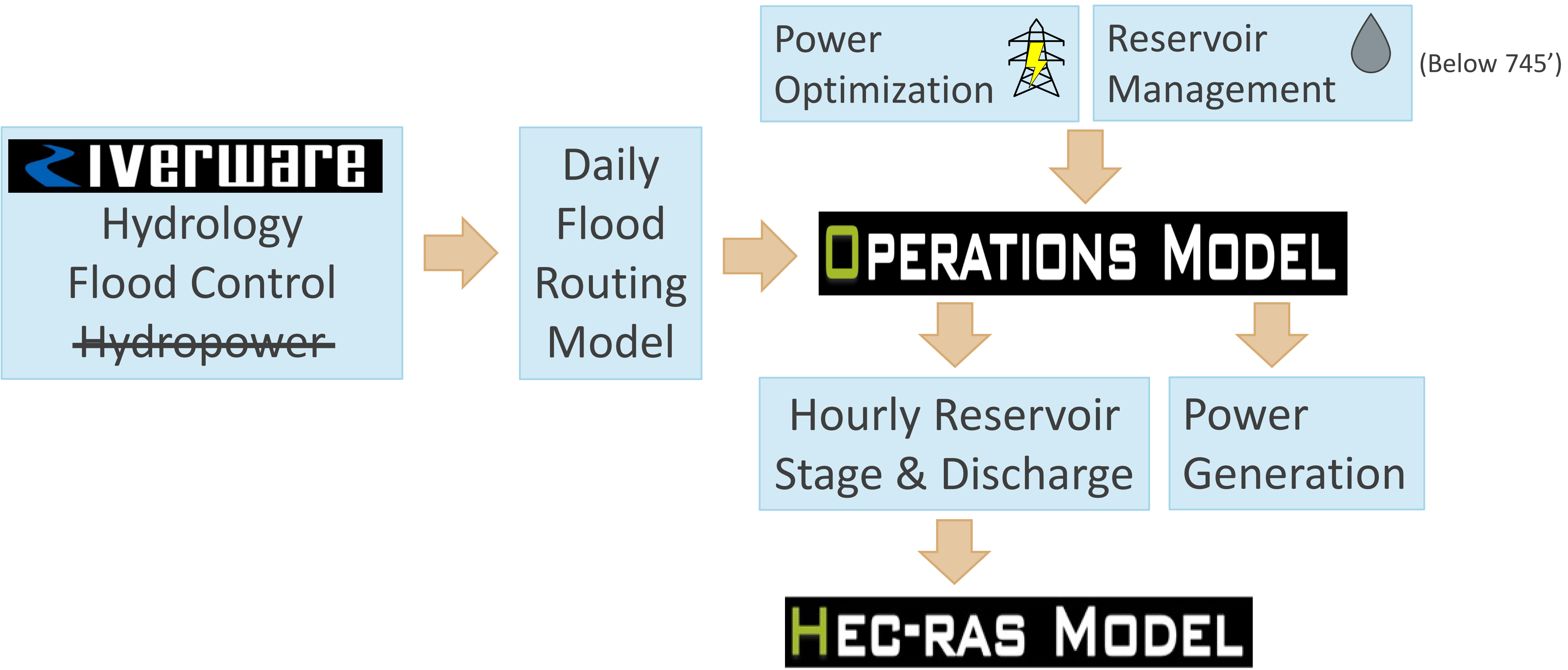
Operations Model



- 2004 through 2019
- Hourly time step
- 2 Reservoirs
- Methods
  - Hydrologic Routing
  - Flood Control
  - Detailed Hydropower Operations
  - Excel and VBA

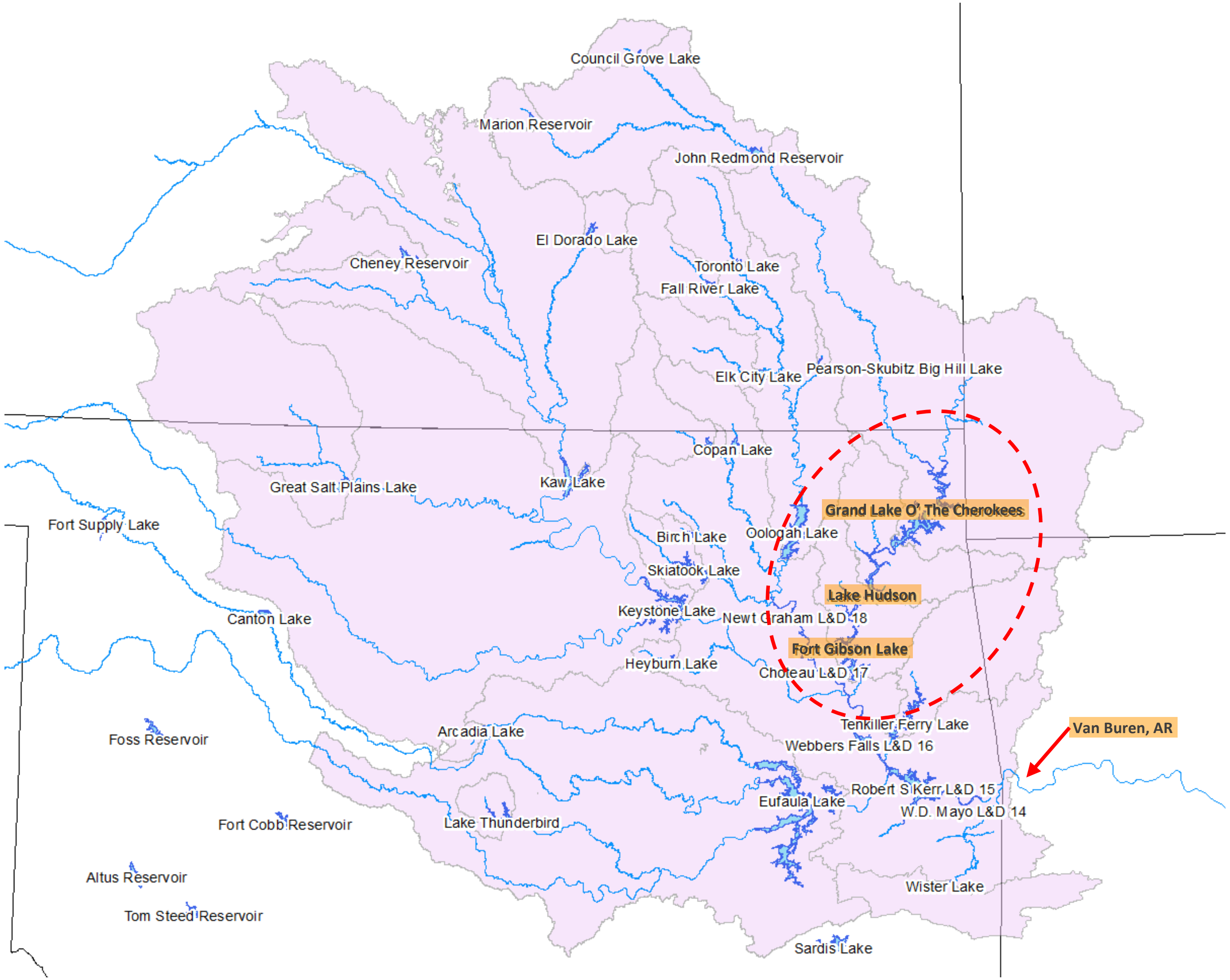
Overview: Model Process

OPERATIONS MODEL



Input Data

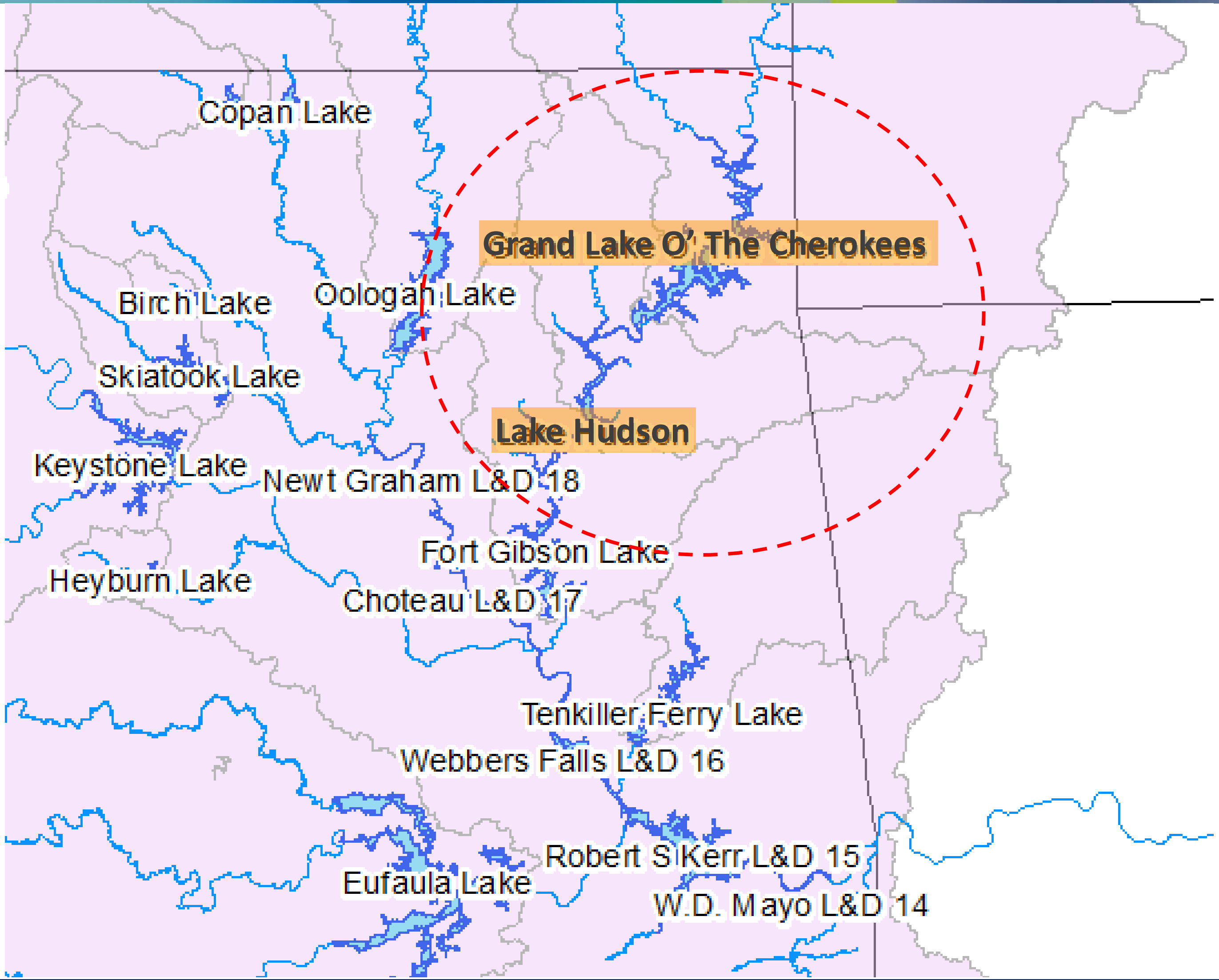
USACE RiverWare Data



- Time series:
  - River discharge
  - Local reservoir inflow
  - Evaporation & seepage
- Rating tables:
  - Elevation-storage-area
  - Operating level-storage
  - Max regulated spill
  - Induced surcharge
  - Seasonal res. elevation
  - Hydrologic routing parameters

Operations Model

OPERATIONS MODEL

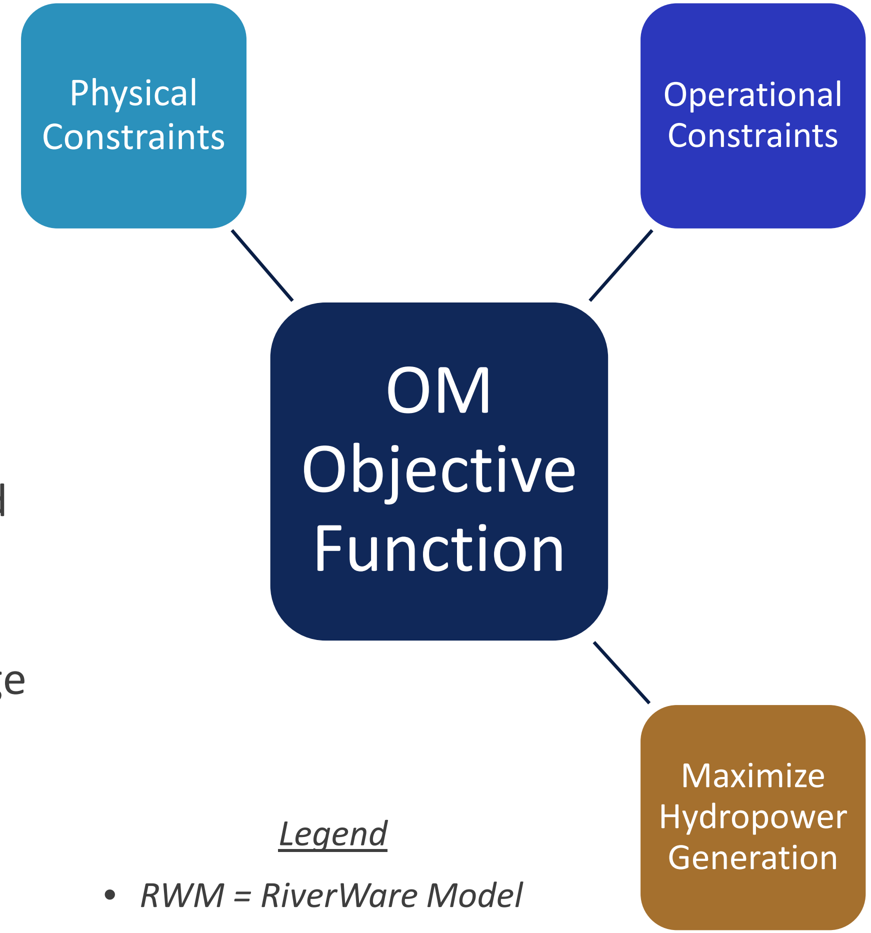


- Flood Routing Model
- Other time series
  - Electricity prices
  - Unit outages
  - Dissolved oxygen derate (Pensacola)
- Other rating tables
  - Turbine headloss, max discharge, and efficiency
  - Elevation-storage-area (USGS, 2020)
  - Tailwater rating
  - Spillway capacity

Solution

Operations Model Solution

- Power
  - Discharge, net head, and efficiency
- Net head
  - Reservoir elevation
  - Tailwater and friction loss
    - Discharge
- Efficiency
  - Turbine discharge, net head, and dissolved oxygen valve open/closed
- Storage volume
  - Inflow, turbine discharge, spillway discharge, evaporation, and seepage
- Reservoir elevation
  - Elevation vs. storage from RWM
- Spillway capacity from RWM
- Hydrologic routing from RWM



Legend

- *RWM = RiverWare Model*
- *FRM = Flood Routing Model*
- *OM = Operations Model*

- Total discharge from FRM
  - Pool > 0.5 feet from target
- Turbine discharge
  - Best efficiency point, maximum discharge, storage volume/inflow, electricity prices, production cost, units online
- Target reservoir elevation
  - Seasonal
- Revenue
  - Scheduled power
  - Electricity price
    - Day-ahead
    - Real-time

Validation

Validation Variables and Metrics

- Selected Variables
  - Total discharge
  - Reservoir elevation
- Others (not selected)
  - Reservoir storage
  - Balance level
    - These are corollaries for elevation. Because elevation is more intuitive, it was selected.

- Metrics
  - Coefficient of Determination, R^2
    - Measures linearity between source and modeled variables.
  - Nash-Sutcliffe Efficiency, NSE
    - Measures linearity and accuracy (1:1 slope line)
  - NSE indicates over- or under-prediction at higher/lower variable values but is more sensitive to extreme values
  - Reviewing R^2 and NSE together is useful

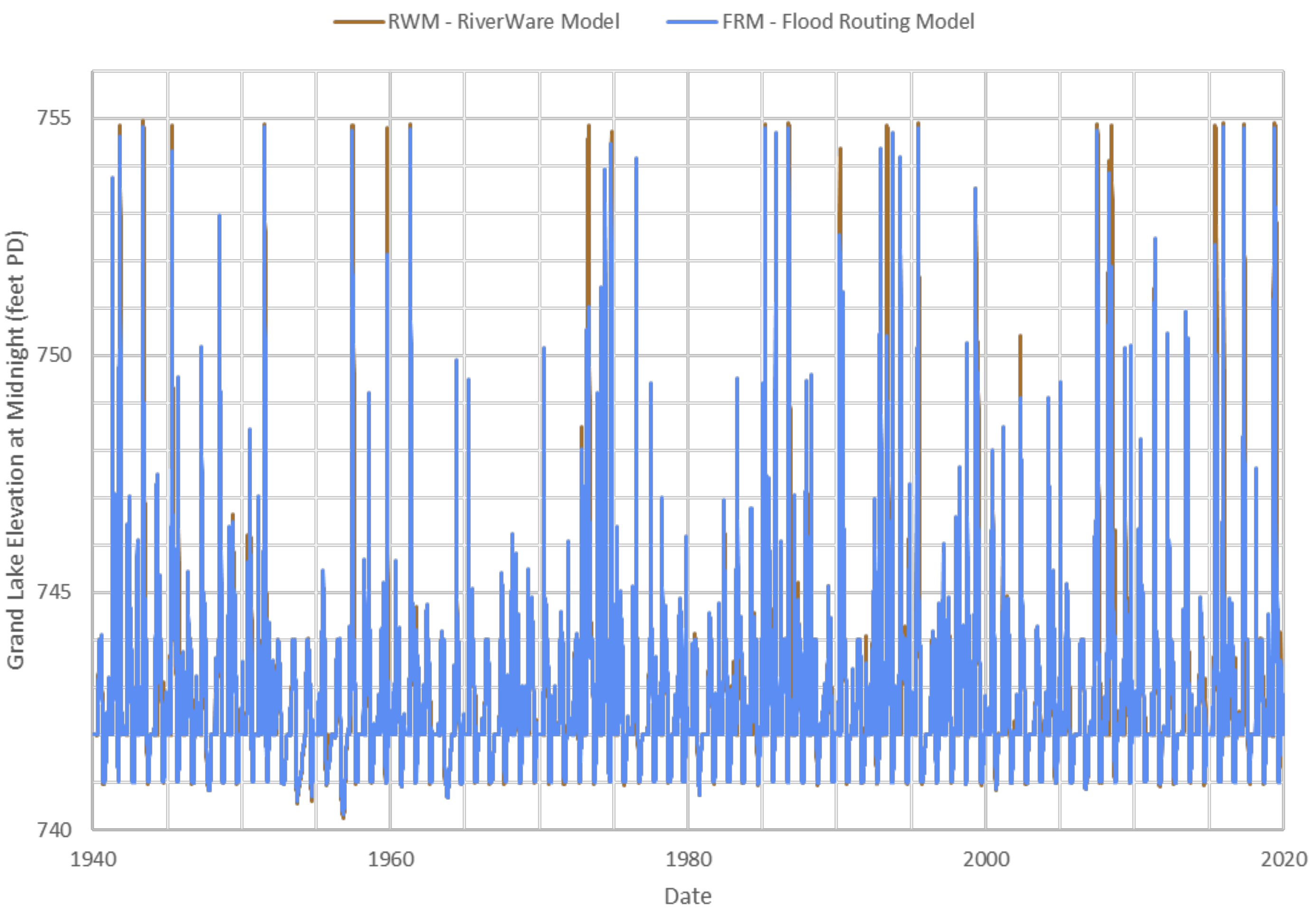
$$R^2 = \left[\frac{\sum_{i=1}^{n} (O_i - \bar{O})(P_i - \bar{P})}{\sqrt{\sum_{i=1}^{n} (O_i - \bar{O})^2} \sqrt{\sum_{i=1}^{n} (P_i - \bar{P})^2}} \right]^2$$

$$NSE = 1 - \frac{\sum_{i=1}^{n} (O_i - P_i)^2}{\sum_{i=1}^{n} (O_i - \bar{O})^2}$$

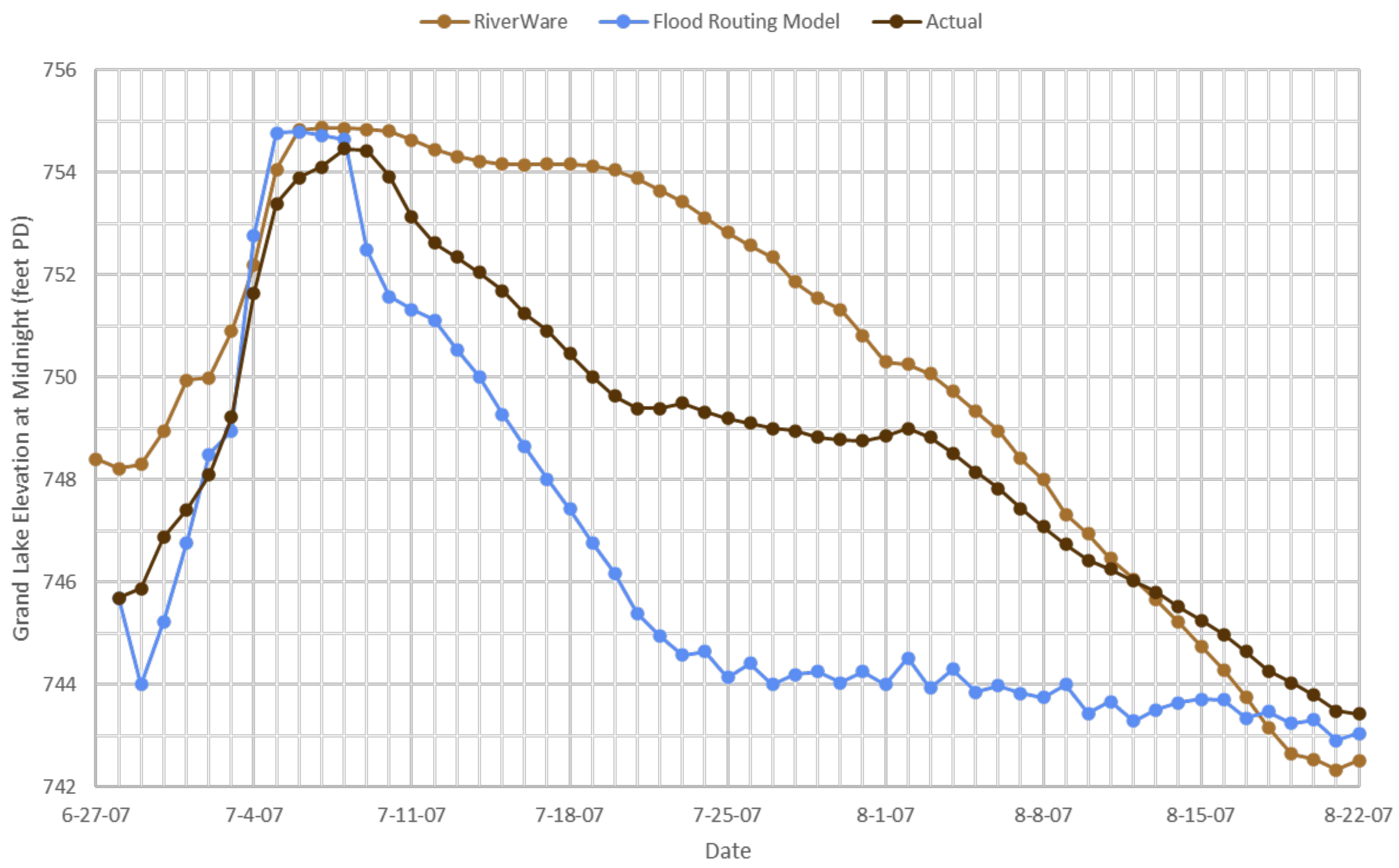
Metric	Range	Not Satisfactory	Satisfactory	Good	Very Good
R^2	0 to 1	≤ 0.60	0.60 to ≤ 0.75	0.75 to ≤ 0.85	> 0.85
NSE	-∞ to 1	≤ 0.50	0.50 to ≤ 0.70	0.70 to ≤ 0.80	> 0.80

Validation Results: FRM vs. RWM

- FRM using RWM inputs for:
  - Historical inflows
  - Evaporation & seepage
  - Elevation vs. storage
  - Reservoir operating balance levels
  - Max spill and induced surcharge
  - Seasonal target elevations
  - Hydrologic routing
  - Ramping rates
  - Downstream channel regulating discharges
- Following validation, some inputs may be updated
  - E.g., to use new USGS bathymetry



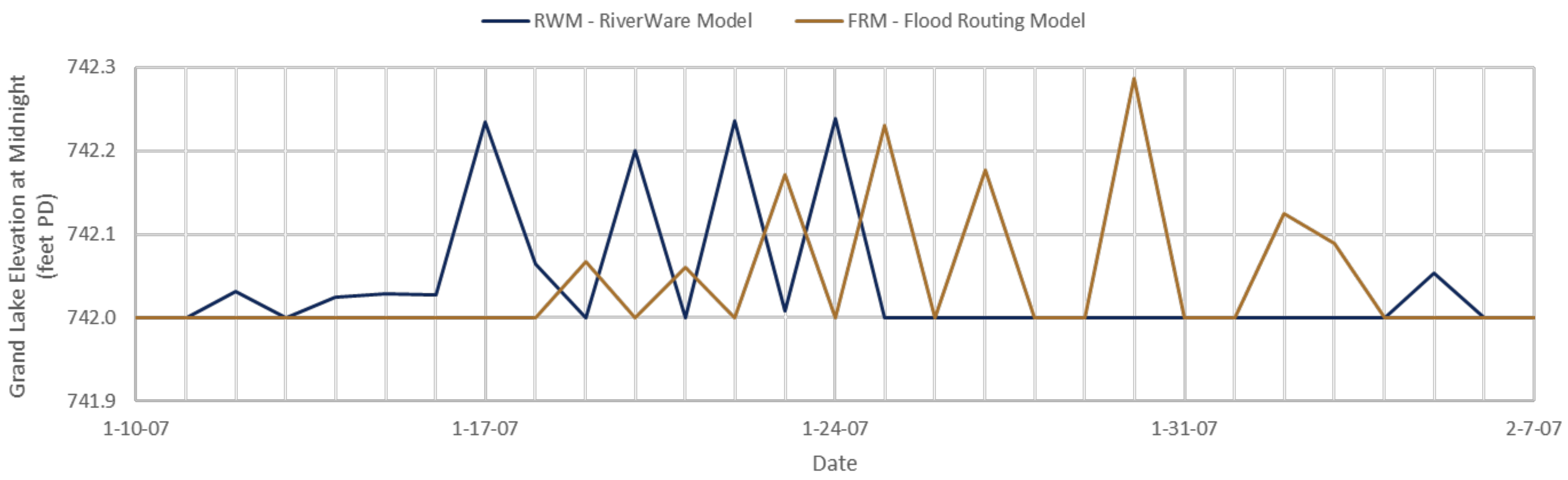
Validation Results: FRM vs. RWM



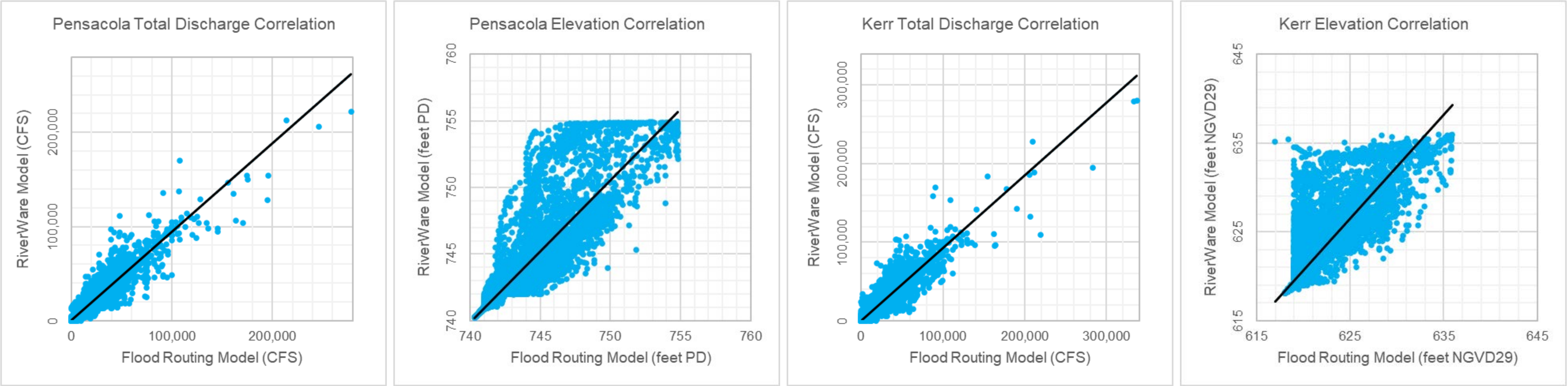
- Main difference: Van Buren
  - RWM will sometimes recommend higher reservoir elevations for extended periods to manage discharge at Van Buren
  - Apparent Result: underprediction of elevations by FRM in correlation plots
  - Actual Result: underprediction of duration of peak stages by FRM
- Artificially decreases correlation

Validation Results: FRM vs. RWM

- RWM time step oscillation
  - Rule set changes at key elevations / balance levels (e.g., top of conservation pool)
  - Balance level changes between reservoirs at alternating time steps
  - Result: oscillations from one time step to the next, decreases apparent correlation
  - Affects RWM and FRM
- Solution: time-averaging across two model time steps



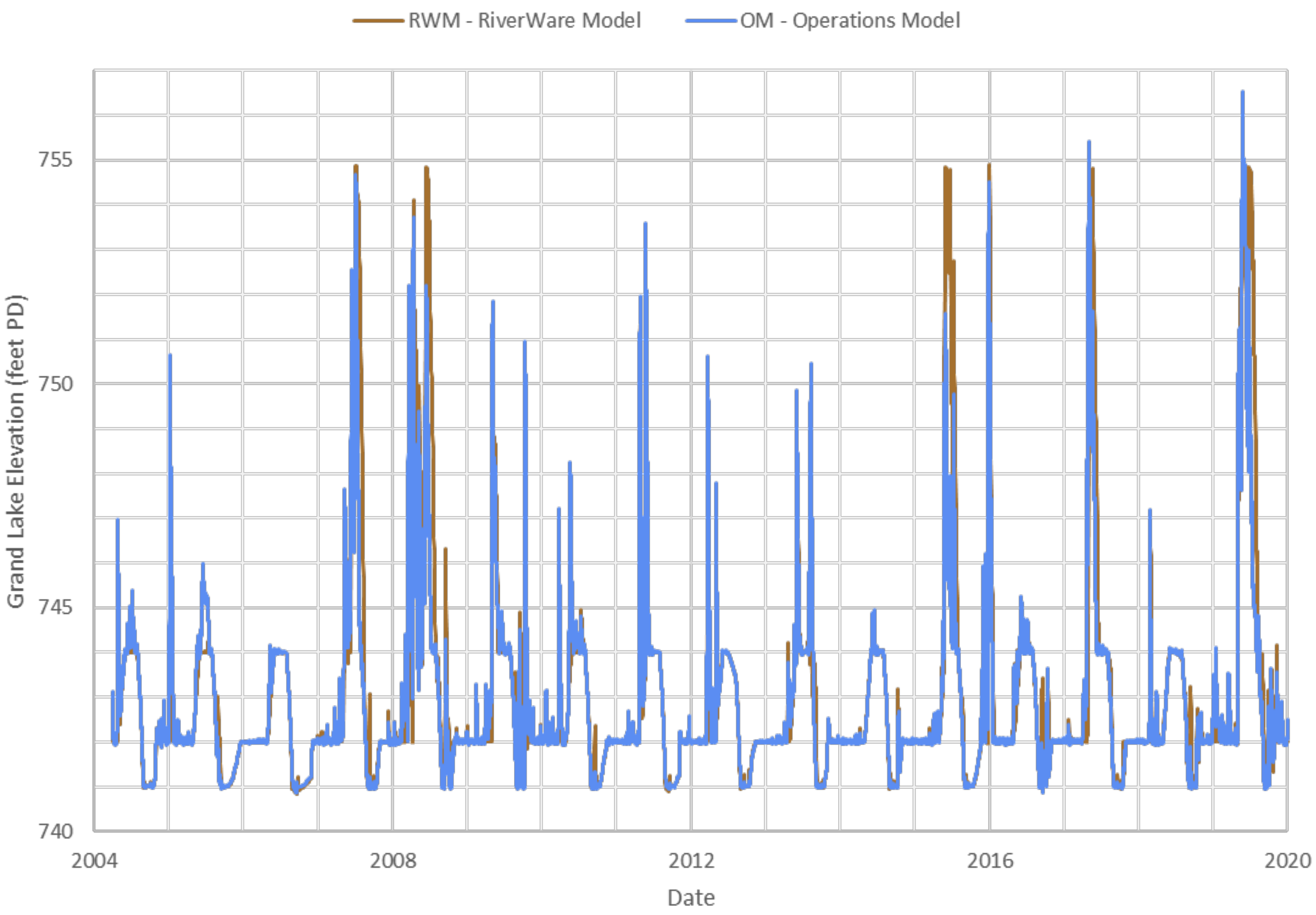
Validation Results: FRM vs. RWM



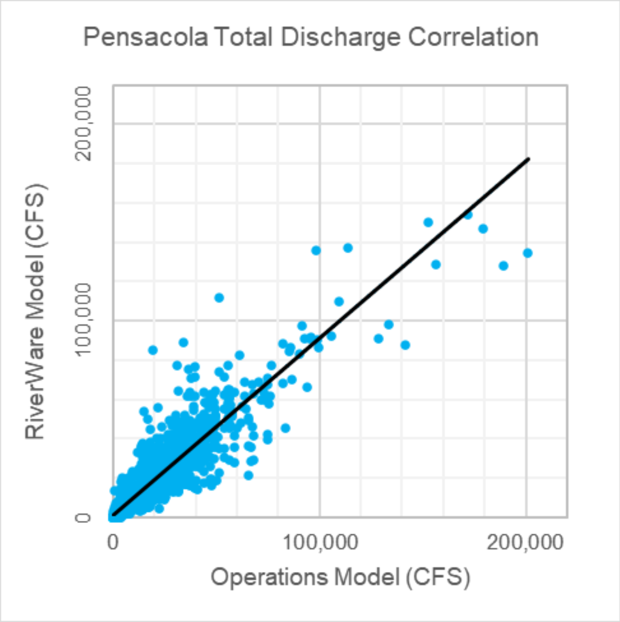
	Pensacola		Kerr	
	Discharge	Elevation	Discharge	Elevation
NSE	0.89 (Very Good)	0.81 (Very Good)	0.87 (Very Good)	0.68 (Satisfactory)
R^2	0.90 (Very Good)	0.81 (Good)	0.88 (Very Good)	0.752 (Good)

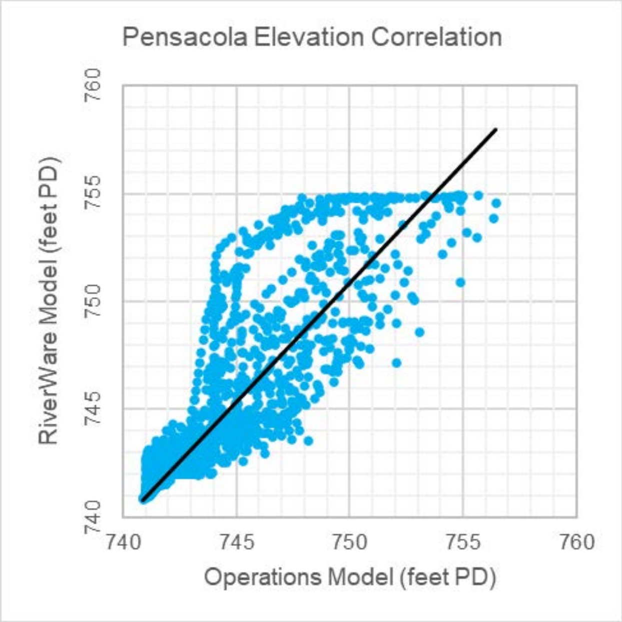
Validation Results: OM vs. RWM

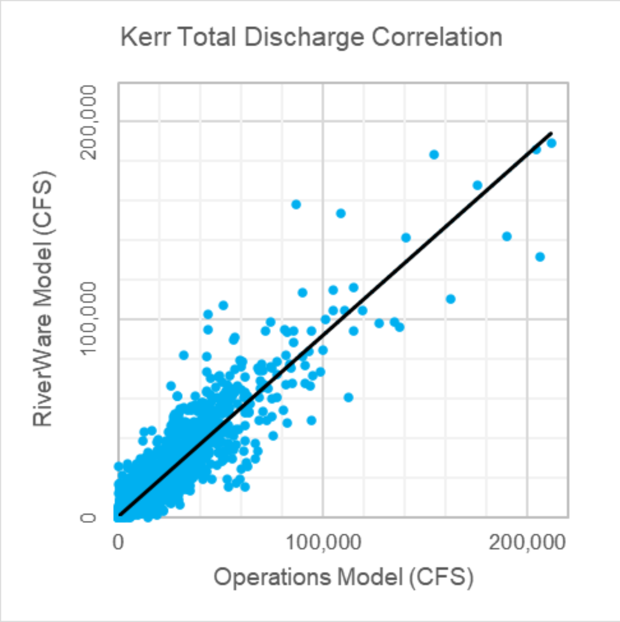
- OM adds hydropower optimization onto FRM predictions of discharge
  - Transitions from low-flow to higher-flow rules when reservoir elevation > target + 0.5’
  - Simplified approach, can be improved going forward
- Result: correlation metrics slightly lower than FRM vs. RWM

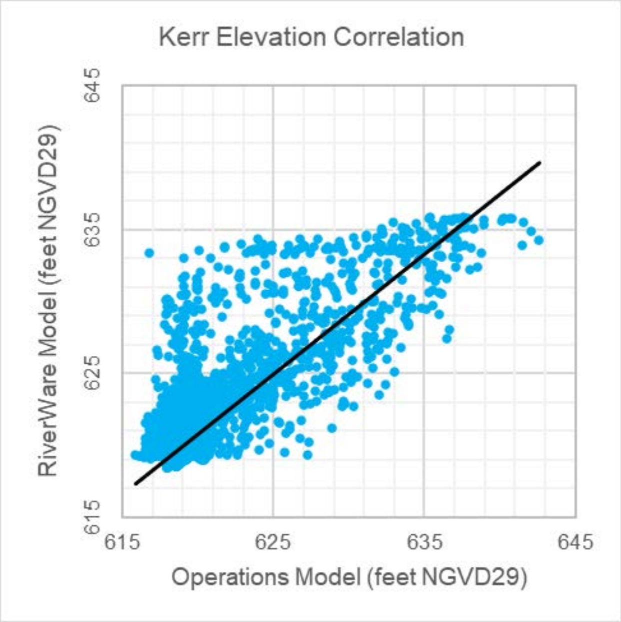


Validation Results: OM vs. RWM









	Pensacola		Kerr	
	Discharge	**Elevation**	**Discharge**	**Elevation**
NSE	0.87 (Very Good)	0.80 (Very Good)	0.87 (Very Good)	0.61 (Satisfactory)
R^2	0.86 (Very Good)	0.81 (Good)	0.86 (Very Good)	0.69 (Satisfactory)

Note: RWM values appear different than in previous slide because start of analysis period is different for comparisons of FRM (1940) and OM (2004).

Validation Results

The FERC SPD recommends GRDA demonstrate it has validated its model results against the RiverWare model output.

Conclusion: Despite

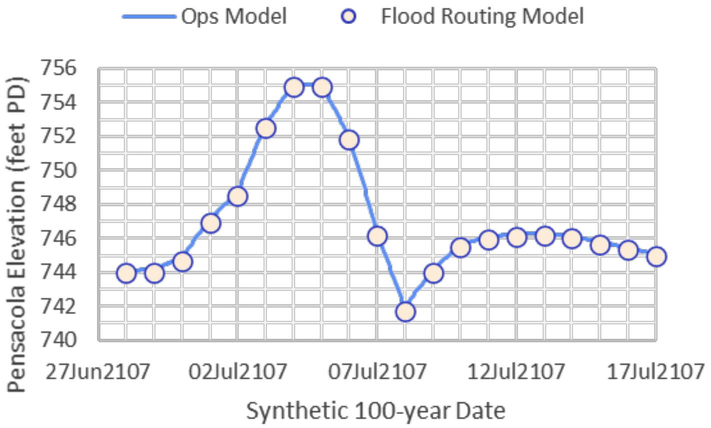
- limitations of RWM rules reflected in FRM,
- missing control point at Van Buren, and
- layering of detailed hydropower optimization rules…

…validation results indicate satisfactory, good, or very good correlation to the RiverWare model output.

Planned Improvements

Planned Improvements

- FRM: Ramping Rates
  - Synthetic 100-year event, pool drops below target on the falling limb (after peak)



- Solution: Add logical checks so target elevation takes precedence over Allowable Falling Release Change (AFRC)

- OM: Turbine Shutoff
  - Real-time power price below production cost: generation buy-back
  - Spillway discharge assumed constant for day
  - Result: Less OM discharge than recommended by FRM, reservoir levels peak higher
- Solution: Adjust spillway discharge hourly in OM

- OM: FRM Stage Matching
  - Within flood pool, OM matches total discharge from FRM
  - Pool > Target + 0.5'
  - Different initial elevations, different time of rule shift
  - Result: Higher starting elevations may peak lower
- Solution: Add criteria to blend both discharge and elevation matching to FRM in flood pool

Scenarios

Note: Some initial elevation vs. flow event combinations were not analyzed because they are impractical and uninformative to study. The full range of initial elevations was analyzed for the 100-year event to determine the effects of extreme high or low initial elevations.

Pensacola Initial Elevation (feet PD)	Sep 1993	Jun 2004	Jul 2007	Oct 2009	Dec 2015	100-year
757						✔ (PENS only)
745	✔	✔	✔	✔	✔	✔
744	✔	✔	✔	✔	✔	✔
743	✔	✔	✔	✔	✔	✔
742	✔	✔	✔	✔	✔	✔
740						✔ (PENS only)
734						✔ (PENS only)
Historical (Varies)	✔	✔	✔	✔	✔	

Thank you

Hydrologic and Hydraulic Modeling: Upstream Hydraulic Model

Pensacola Hydroelectric Project Project No. 1494

October 12, 2021

Presentation Outline

1. Purpose and Objectives
2. UHM Development
3. UHM Calibration
4. Flood Frequency Analysis
5. Inflow Event Analysis
6. Definition of Material Difference
7. Simulated Scenarios
8. Study Results
9. Discussion of Results
10. Conclusions

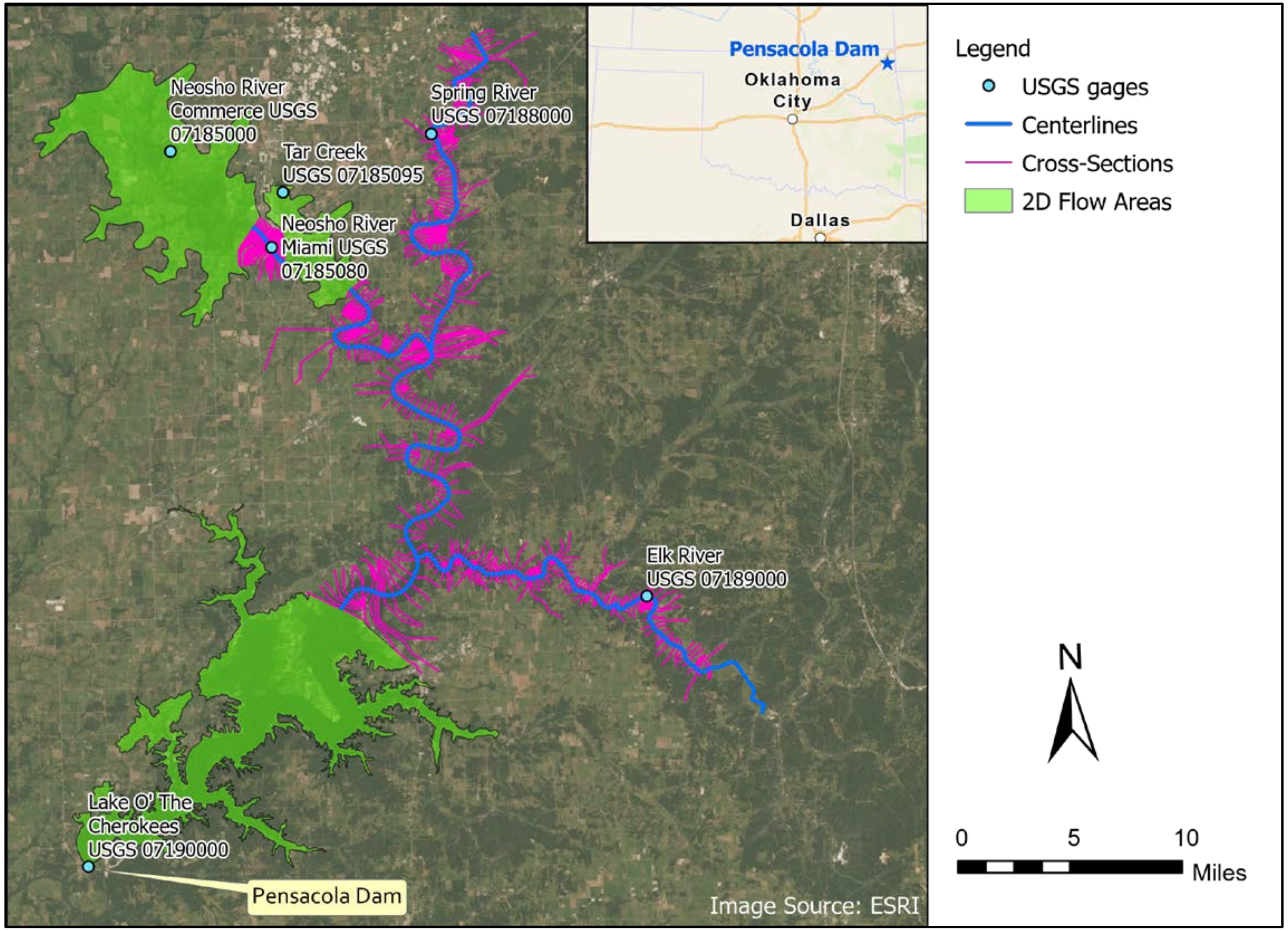
Purpose and Objectives

Purpose and Objectives of UHM

1. Analyze inundation upstream of Pensacola Dam under current license operations of the Project during several measured inflow events.
2. Provide model results in a format that can inform other analyses.
3. Determine feasibility of implementing anticipated future operations that may be proposed by GRDA as part of relicensing effort.

UHM Development

Study Area



Neosho River Commerce USGS 07185000
Spring River USGS 07188000
Tar Creek USGS 07185095
Neosho River Miami USGS 07185080
Elk River USGS 07189000
Lake O' The Cherokees USGS 07190000
Pensacola Dam
Image Source: ESRI
Pensacola Dam
Oklahoma City
Dallas
Legend
USGS gages
Centerlines
Cross-Sections
2D Flow Areas
N
0
5
10
Miles

Background

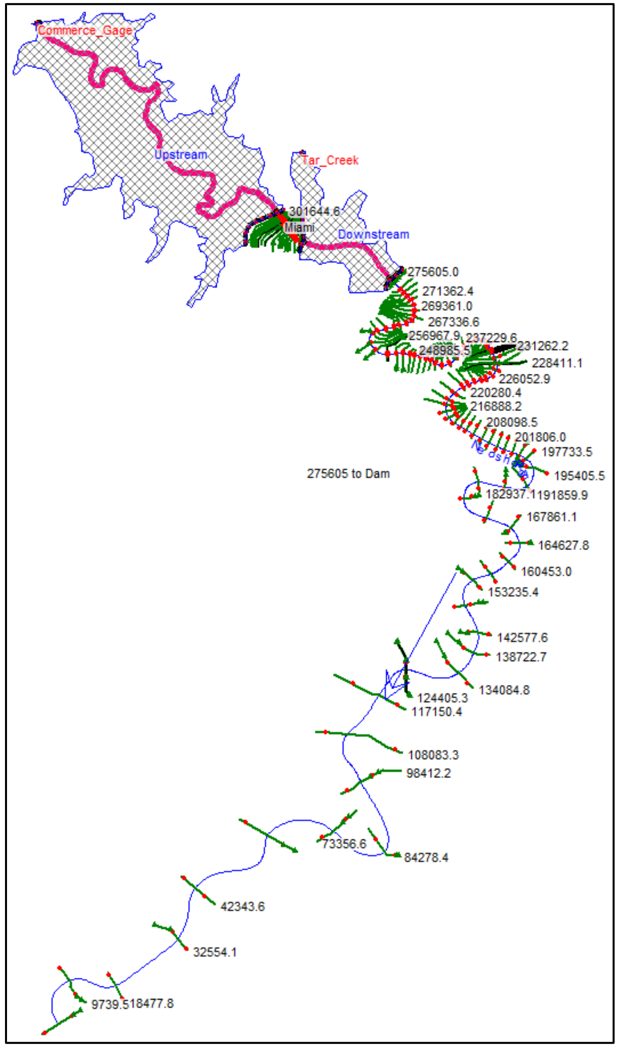
1. Tetra Tech previously developed HEC-RAS model of the study area (Tetra Tech, 2015, 2016).
2. Tetra Tech model developed in 5.0 beta version of HEC-RAS.
3. Mead & Hunt used Tetra Tech's model as the base for UHM development.
4. Mead & Hunt used 5.0.7 (official release) for UHM.

Development of UHM

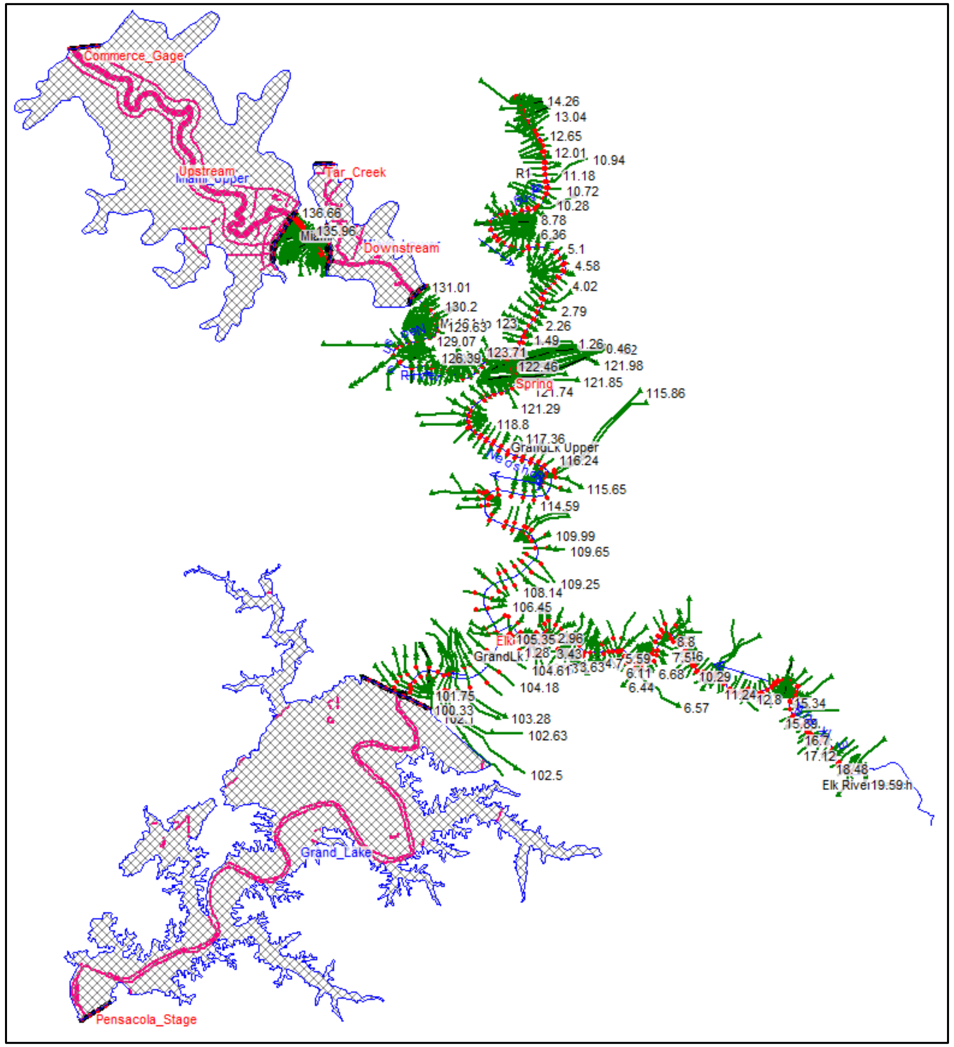
1. Converted from beta version of HEC-RAS to version 5.0.7.
2. Two-dimensional (2D) flow area (FA) added for Grand Lake.
3. Upstream 2DFAs expanded to fully contain inundation from larger flow events.
4. Mesh reviewed and adjusted in accordance with USACE guidance (USACE, 2016a).
5. Cross-sections were extended to fully contain the inundation from larger flow events.
6. 1D/2D flow boundaries adjusted in accordance with USACE guidance (USACE 2016a, USACE 2016b).
7. Bridge geometries were updated to reflect current conditions.
8. Banks and ineffective flow areas adjusted in accordance with USACE guidance (USACE, 2016b).
9. Elk River was added to the model.
10. Spring River was added to the model.
11. USGS 2019 Grand Lake bathymetry incorporated into model (Hunter, Trevisan, Villa, & Smith, 2020).
12. Computational parameters adjusted in accordance with USACE guidance (USACE, 2016a).

Model Comparison

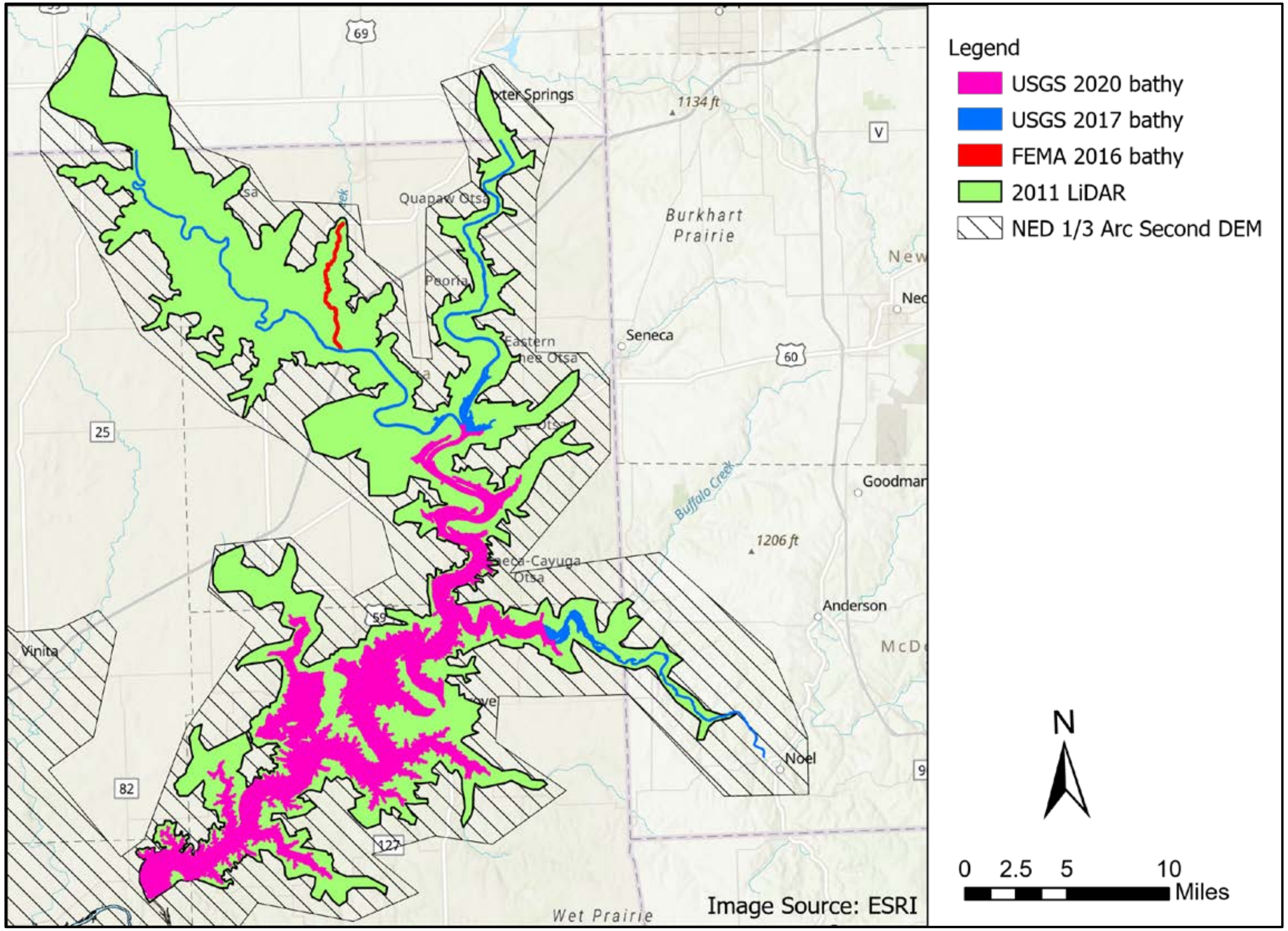
Tetra Tech (2016)



Mead & Hunt (2021)



Elevation Sources



UHM Calibration

Calibration Overview

1. UHM calibrated using several historical events.
2. Stream gage data used for model boundary conditions.
3. Simulated water surface elevations (WSELs) compared to measured WSELs.

Stream Gage Data

1. Neosho River near Commerce, OK (USGS Gage No. 07185000)
2. Neosho River at Miami, OK (USGS Gage No. 07185080)
3. Tar Creek at 22nd Street Bridge at Miami, OK (USGS Gage No. 07185095)
4. Spring River near Quapaw, OK (USGS Gage No. 07188000)
5. Elk River near Tiff City, MO (USGS Gage No. 07189000)
6. Grand Lake O' the Cherokees at Langley, OK (USGS Gage No. 07190000)

Historical Events used for Calibration

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

Manning's n-values

Overbank

Land Cover	n-value
Field crops	0.040
Pasture	0.080
Urban	0.070
Urban dense	0.090
Water	0.040
Woody veg	0.100
Woody veg dense	0.150

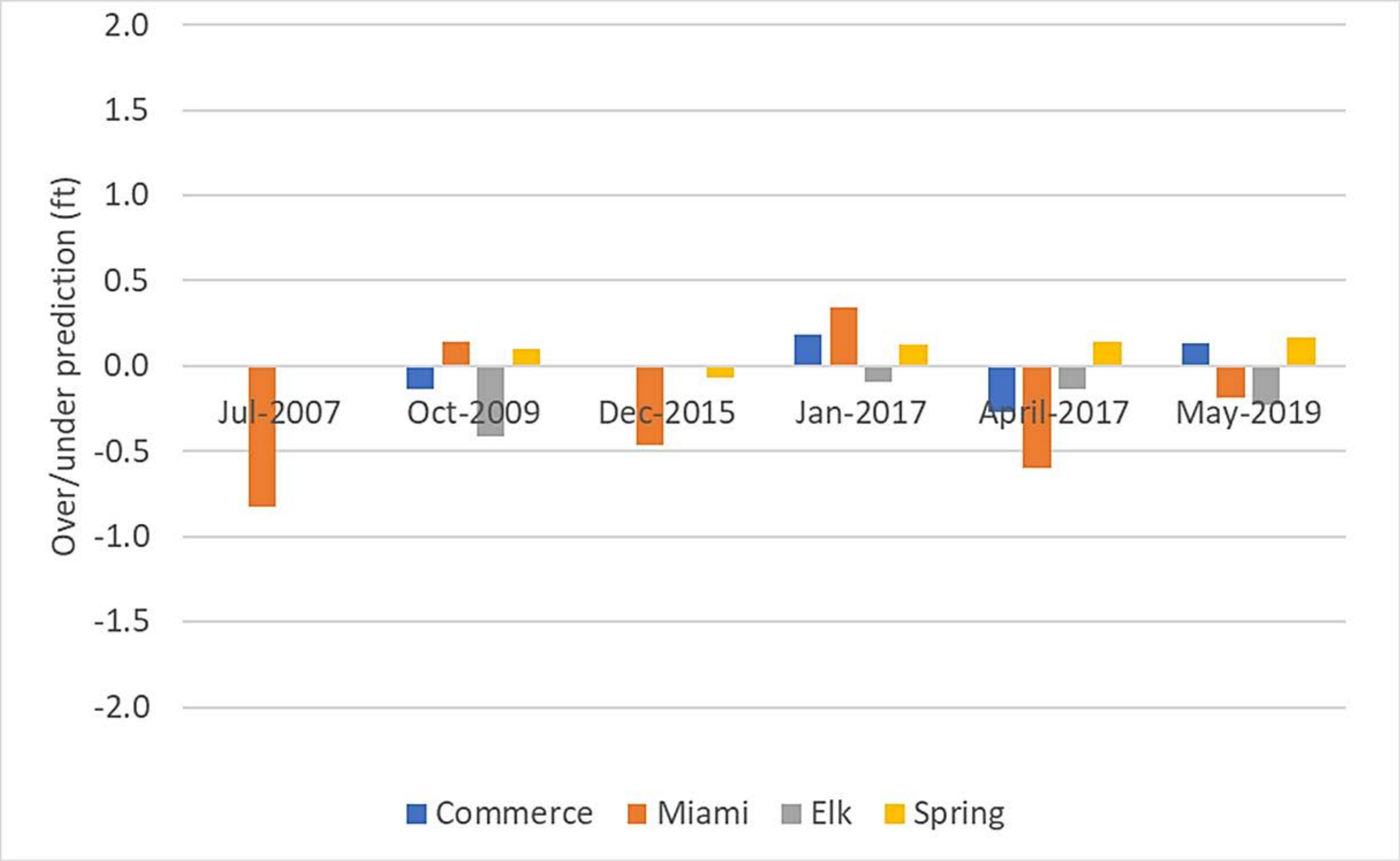
Channel

Reach	n-value
Grand Lake (reservoir, up to RM 121.29)	0.020
Neosho River (RM 121.51 up to 128.81)	0.035
Neosho River (RM 129.07 up to RM 135.44)	0.037
Neosho River (RM 135.47 up to RM 152.2)	0.025
Elk River (full reach)	0.042
Spring River (full reach)	0.038

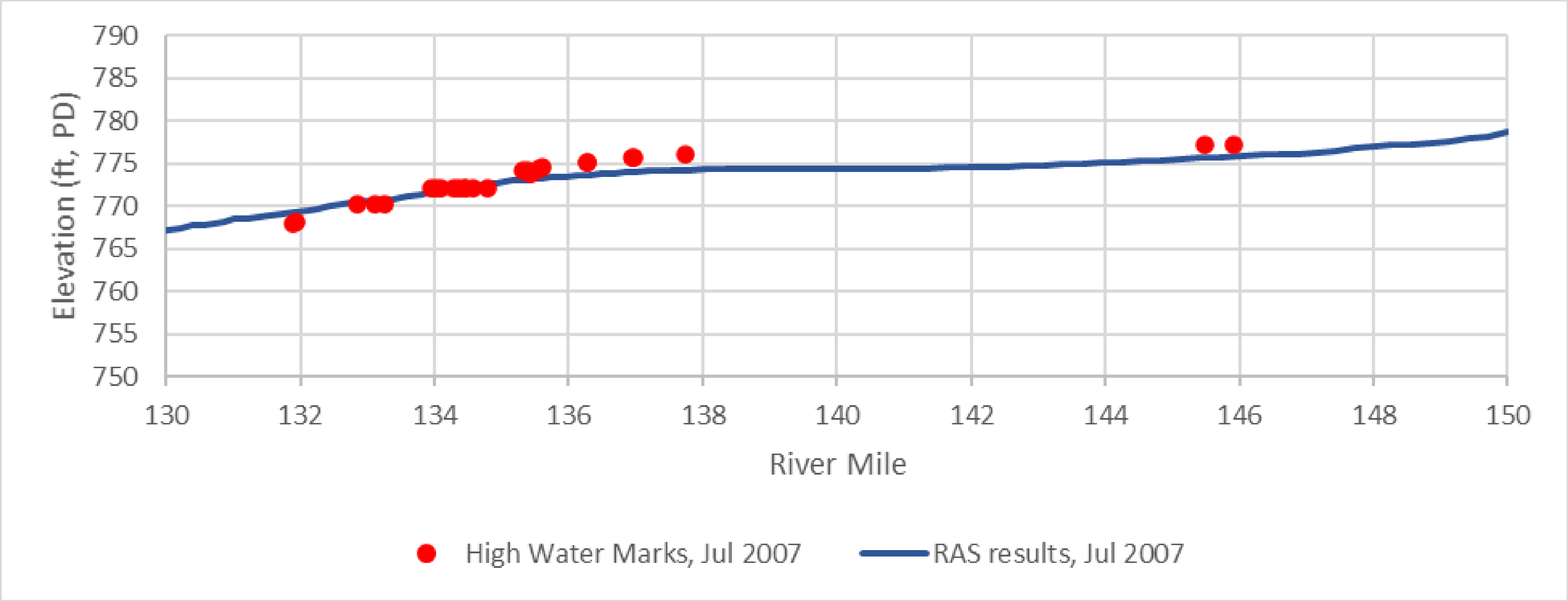
Flow Roughness Values

Neosho River		Spring River		Elk River	
Flow (cfs)	Roughness Factor	Flow (cfs)	Roughness Factor	Flow (cfs)	Roughness Factor
0	0.60	0	0.79	0	1.15
20,000	0.60	20,000	0.79	40,000	1.15
40,000	0.70	40,000	0.94	60,000	0.80
45,000	0.70	60,000	0.94	80,000	0.80
50,000	1.00	80,000	0.94	100,000	1.00
55,000	1.25	100,000	1.00	120,000	1.00
60,000	1.25	120,000	1.00	140,000	1.00
80,000	1.25	140,000	1.10	160,000	1.00
90,000	1.30	160,000	1.10	350,000	1.00
110,000	1.30	180,000	1.00		
140,000	1.30	350,000	1.00		
150,000	1.30				
160,000	1.00				
350,000	1.00				

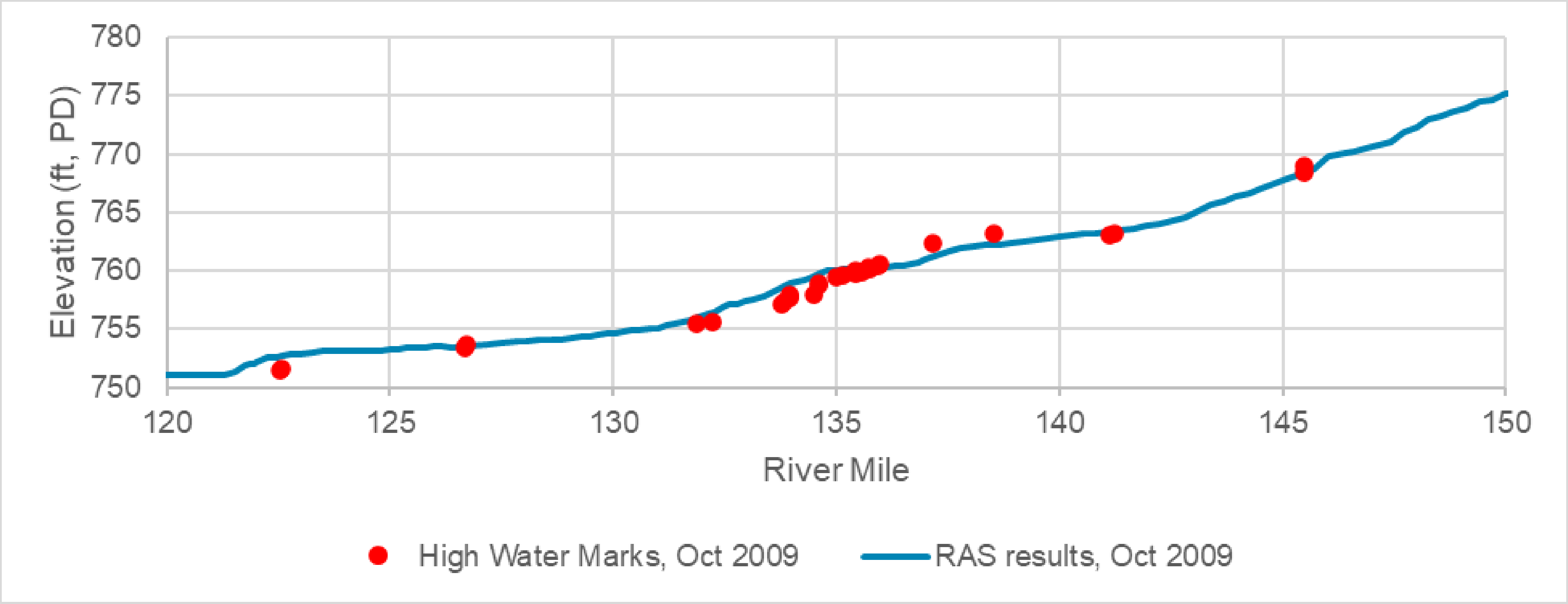
Calibration Results: USGS Gages



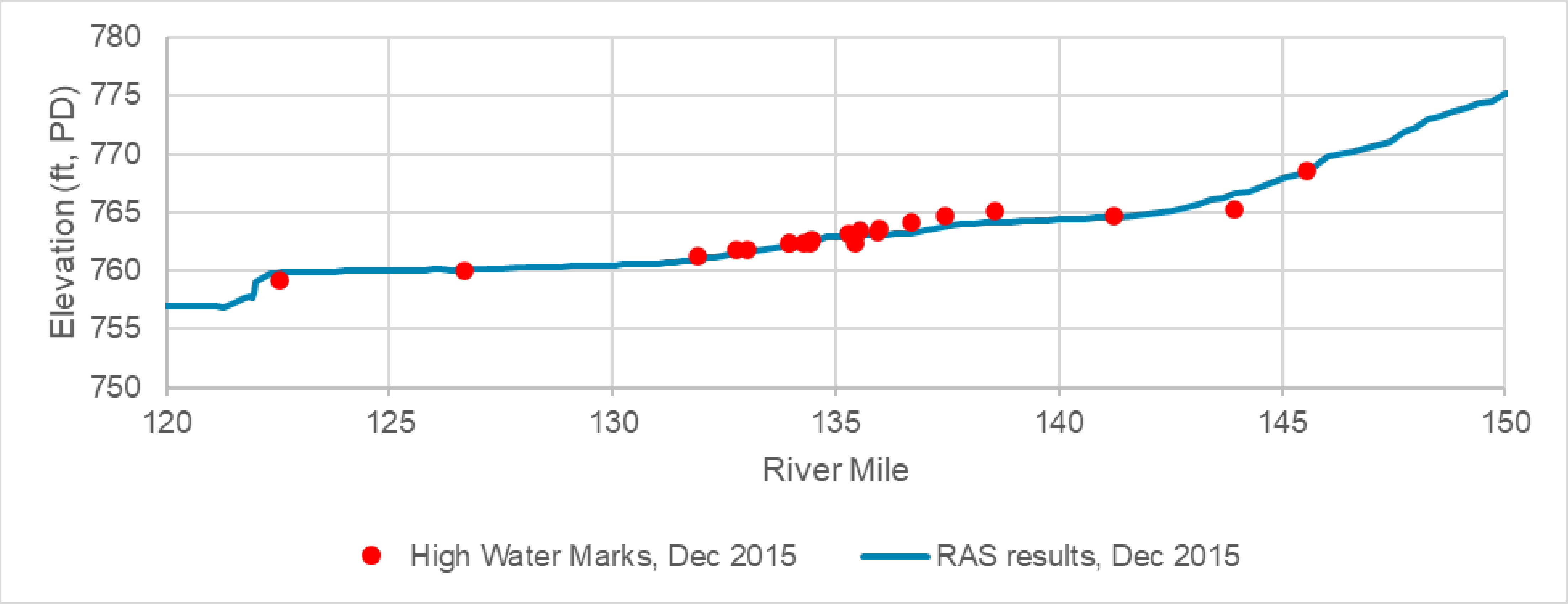
Calibration Results: July 2007 HWM



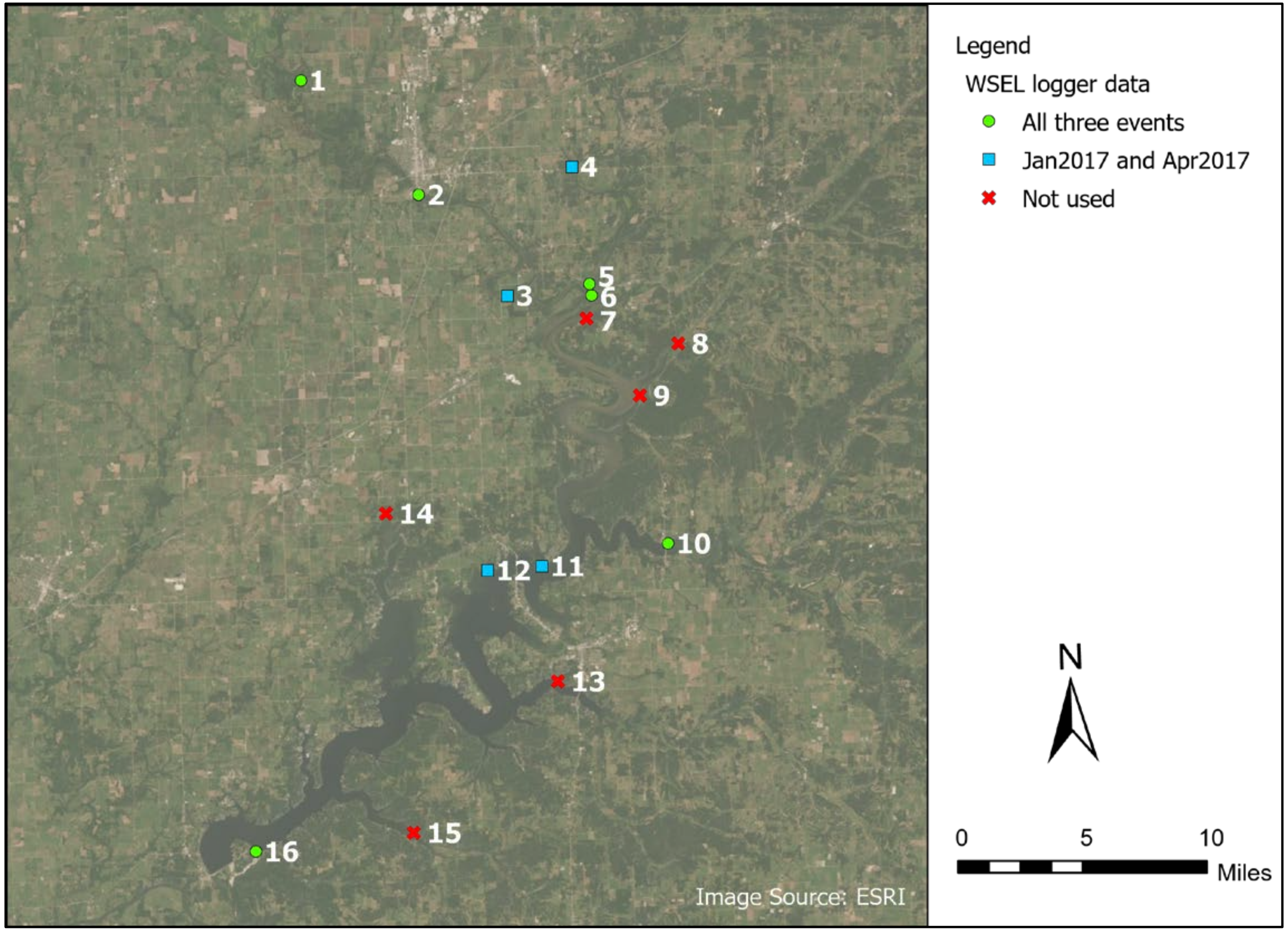
Calibration Results: October 2009 HWM



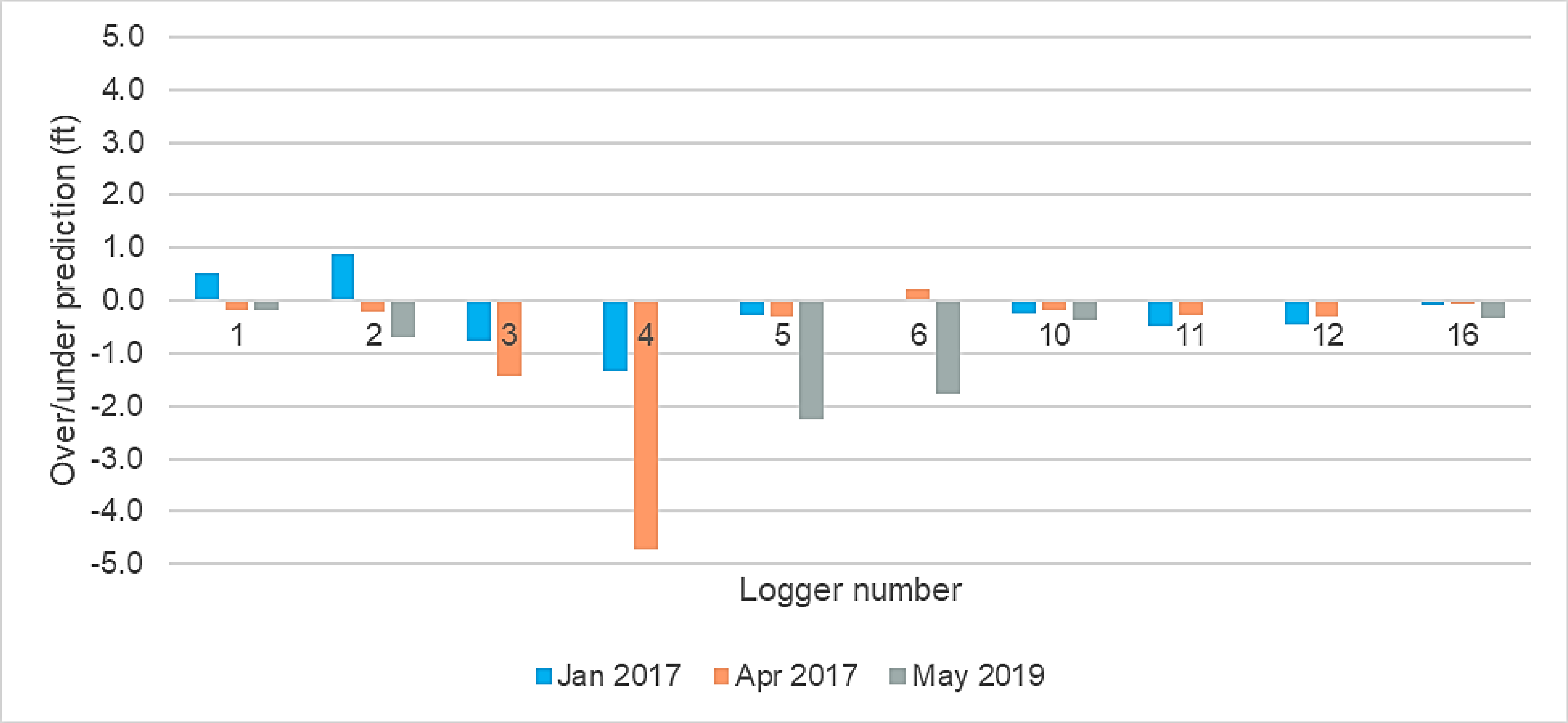
Calibration Results: December 2015 HWM



Calibration Data: Logger Locations



Calibration Results: Logger Data



July 2007 Additional Data

1. Publicly available stage data in hourly increments from October 2007 onward was used during calibration.
2. City of Miami comment: request pre-October 2007 data from USGS.
3. USGS Tulsa Field Office provided pre-October 2007 data with disclaimer.

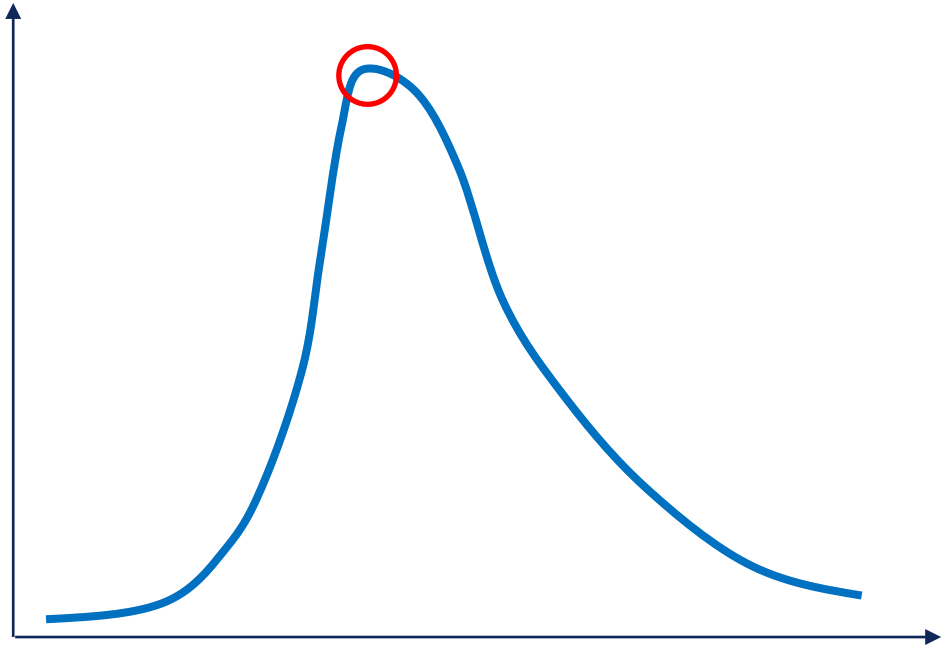
USGS Disclaimer:

Please note that prior to October 2007, instantaneous stage values were not considered a reportable data product. A small possibility exists that some of the data provided in this email was not processed in accordance with current USGS standards and could contain errors.

Publicly Available USGS Data

1. Peak Streamflow: Maximum flow that occurred during USGS water year.
2. Streamflow Measurements: USGS field measurements; independent of gage-recorded values.

Peak Streamflow



Streamflow Measurements

July 2007 Comparisons

Comparisons:

1. Neosho River at Miami:
   - Identical stage: (1) Peak Streamflow stage, (2) pre-October 2007 USGS max WSEL, (3) USGS daily max WSEL.
   - No Streamflow Measurements.
   - No way to compare various USGS measurements.
2. Elk River near Tiff City:
   - Identical stage: (1) Peak Streamflow stage, (2) pre-October 2007 USGS max WSEL.
   - Only Streamflow Measurement occurred six days after peak.
   - No way to compare various USGS measurements.

July 2007 Comparisons

Comparisons:

3. Neosho River near Commerce:
   - Multiple USGS Streamflow Measurements available.
   - Magnitude of differences between HEC-RAS and USGS is similar to magnitude of differences between various USGS measurements.
4. Spring River near Quapaw:
   - Identical stage: (1) Peak Streamflow stage, (2) pre-October 2007 USGS max WSEL.
   - USGS Streamflow Measurement available.
   - Difference between USGS measurements exceeds difference between HEC-RAS results and USGS measurements.

Findings/Conclusions on Additional Data

The following factors were considered when determining if the model should be recalibrated to match the pre-October 2007 USGS data for the July 2007 event:

1. USGS disclaimer
2. [Difference between various USGS measurements] ≥ [Differences between USGS and HEC-RAS]
3. USACE guidance: ± 5% flow measurement (“optimistic”) translates to stage error of ± 1.0 feet

- ➢Goal of UHM development/calibration: single geometry for variety of synthetic/hypothetical simulations.
- ➢Adjusting model calibration to match a dataset suspected to have accuracy issues contradicts that goal.
- ➢Conclusion: inadvisable to recalibrate model.

Flood Frequency Analysis

Flood Frequency Analysis

Data source: USACE Period of Record Riverware model

- Total inflow to Grand Lake
- Start: 1940 (construction date of dam)
- End: 2019 (latest available data at time of data delivery)

Annual peak flows extracted using HEC-SSP version 2.2

Graphical Frequency Analysis of Peak Inflows performed

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

Inflow Event Analysis

Study Plan Determination

FERC SPD:

If the flood frequency analysis shows that the selected historical inflow events do not exceed a 100-year recurrence interval, inflow events up to and including the 100-year recurrence interval would be evaluated in the CHM.

100-year inflow at Pensacola Dam: 300,000 cfs

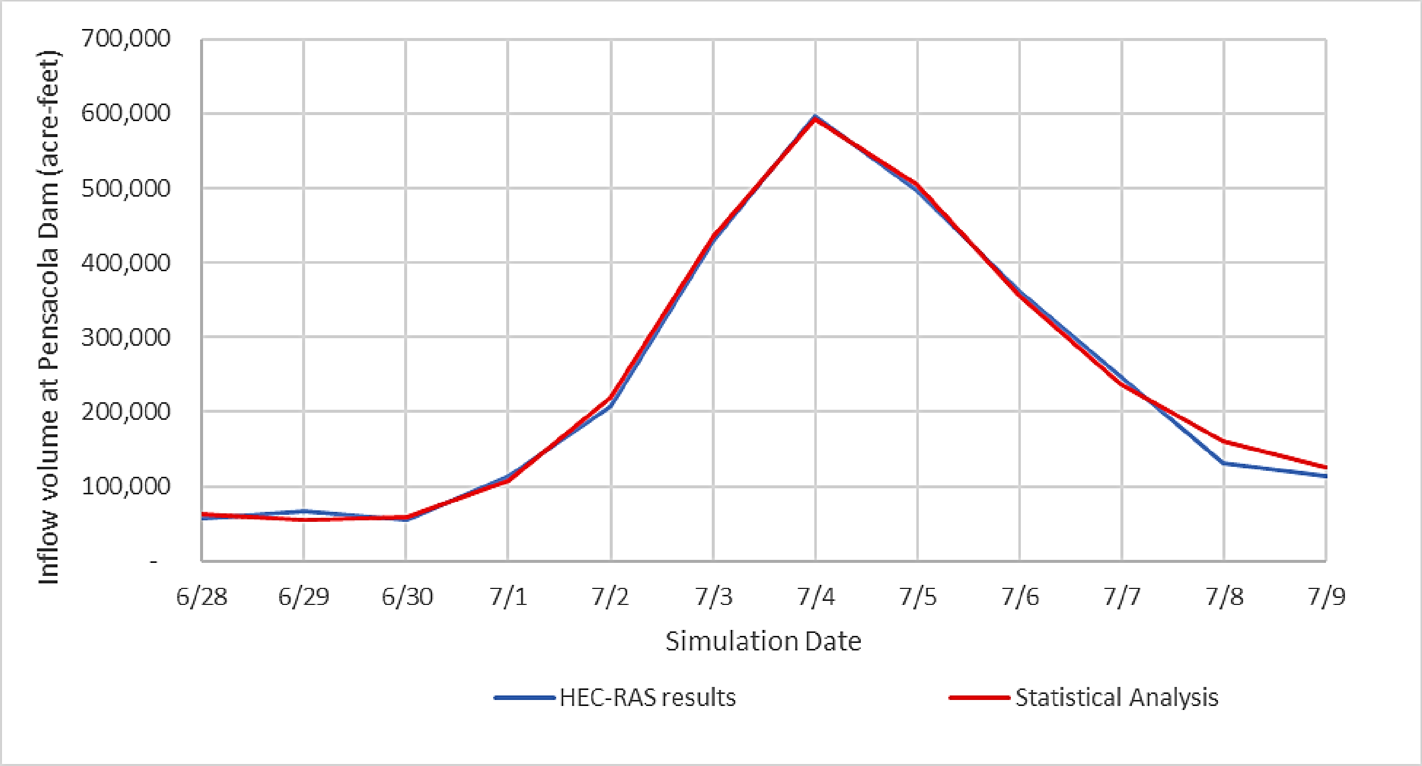
July 2007: largest event of recent record on the Neosho River

- Peak flow of 141,000 cfs at Commerce gage
- Peak inflow of 130,000 cfs at Pensacola Dam
- 4-year event at Pensacola Dam

100-Year Hydrograph Development

Scaled July 2007 event to represent 100-year inflow to Pensacola Dam.

1. Peak inflow based on flood frequency analysis.
2. Statistical analysis of historical inflow volumes and peak flows used to adjust inflow hydrograph volume.



Definition of Material Difference

Revised Study Plan

The H&H study area will encompass the channel and overbank areas of the Grand/Neosho River watershed that have a material difference in water surface elevation due to Project operation during the measured inflow events of the H&H Study. A material difference in water surface elevation due to Project operations will be based on professional judgment.

Government Agencies

1. FEMA requires base flood elevations to "match within one-half foot" at the transition between a revised study and the study it is replacing (Office of the Federal Register, 2021).
2. USACE engineering manual for the Hydrologic Engineering Requirements for Reservoirs: the point of intersection between pre-project and post-project WSEL profiles is established where the profiles are within one foot of each other (U.S. Army Corps of Engineers, 2018).
3. USGS field measurements:
   - Excellent: flow measurement is within 2% of the actual value.
   - Good: flow measurement is within 5% of the actual value.
   - Gage inflows increased and decreased by 2%. Difference in WSEL ~0.5 feet.

Proposed Definition, Results

Defining material difference as 0.5 feet of water surface elevation for out of bank events or 0.5 feet of water surface elevation within the banks where inundation impacts infrastructure or other sensitive resources.

Study results confirmed that water surface elevation differences at the upstream ends of the model did not exceed 0.5 feet for either in bank or out of bank events.

Simulated Scenarios

Simulated Scenarios

Inflow Event	Type	Estimated Return Period[1]	Pensacola Dam Starting Pool Elevation (ft, PD)	Simulation Start/End Date
Sept. 1993	Historical	21 years	743.85[2], 742, 743, 744, 745	9/24/1993 – 10/2/1993
June 2004	Historical	1 year	743.42[2], 742, 743, 744, 745	6/13/2004 – 6/18/2004
July 2007	Historical	4 years	745.69[2], 742, 743, 744, 745	6/28/2007 – 7/10/2007
Oct. 2009	Historical	3 years	740.98[2], 742, 743, 744, 745	10/8/2009 – 10/16/2009
Dec. 2015	Historical	15 years	742.86[2], 742, 743, 744, 745	12/26/2015 – 1/2/2016
100-year	Synthetic	100 years	734, 740, 742, 743, 744, 745, 757[3]	N/A[4]

1 Return period for peak inflow at Pensacola Dam.

2 Historical pool elevation of Pensacola Dam.

3 Crest elevation of Pensacola Dam.

4 Because the 100-year event is synthetic, there is no historical start or end date. The duration of simulation is 12.5 days, which is consistent with the simulated duration of the July 2007 event upon which it was based.

Boundary Conditions for Scenarios

Downstream boundary condition

- Output from Operations Model (OM) used as downstream stage boundary condition.

Upstream boundary conditions

- USGS gage data used for historical inflow events.
- Synthetic hydrographs used for 100-year inflow event.

Peak Inflows

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

Peak Pool Elevations

Event	Pensacola Dam Pool Elevation (ft, PD)		Difference (ft)
	Lowest Peak	Highest Peak	
September 1993	754.93	754.93	0.00
June 2004	744.71	745.14	0.43
July 2007	754.23	754.96	0.73
October 2009	750.27	750.84	0.57
December 2015	754.34	754.82	0.48
100-year	754.90	757.00	2.10

Study Results

Study Results

1. Maximum WSEL and maximum inundation extent extracted for each simulation.
2. Presentation formats:
   - Tables of maximum WSELs
   - Profile plots of maximum WSELs
   - Maps of maximum inundation extents
3. Comparisons
   - Starting pool elevations
   - Inflow events

Discussion of Results

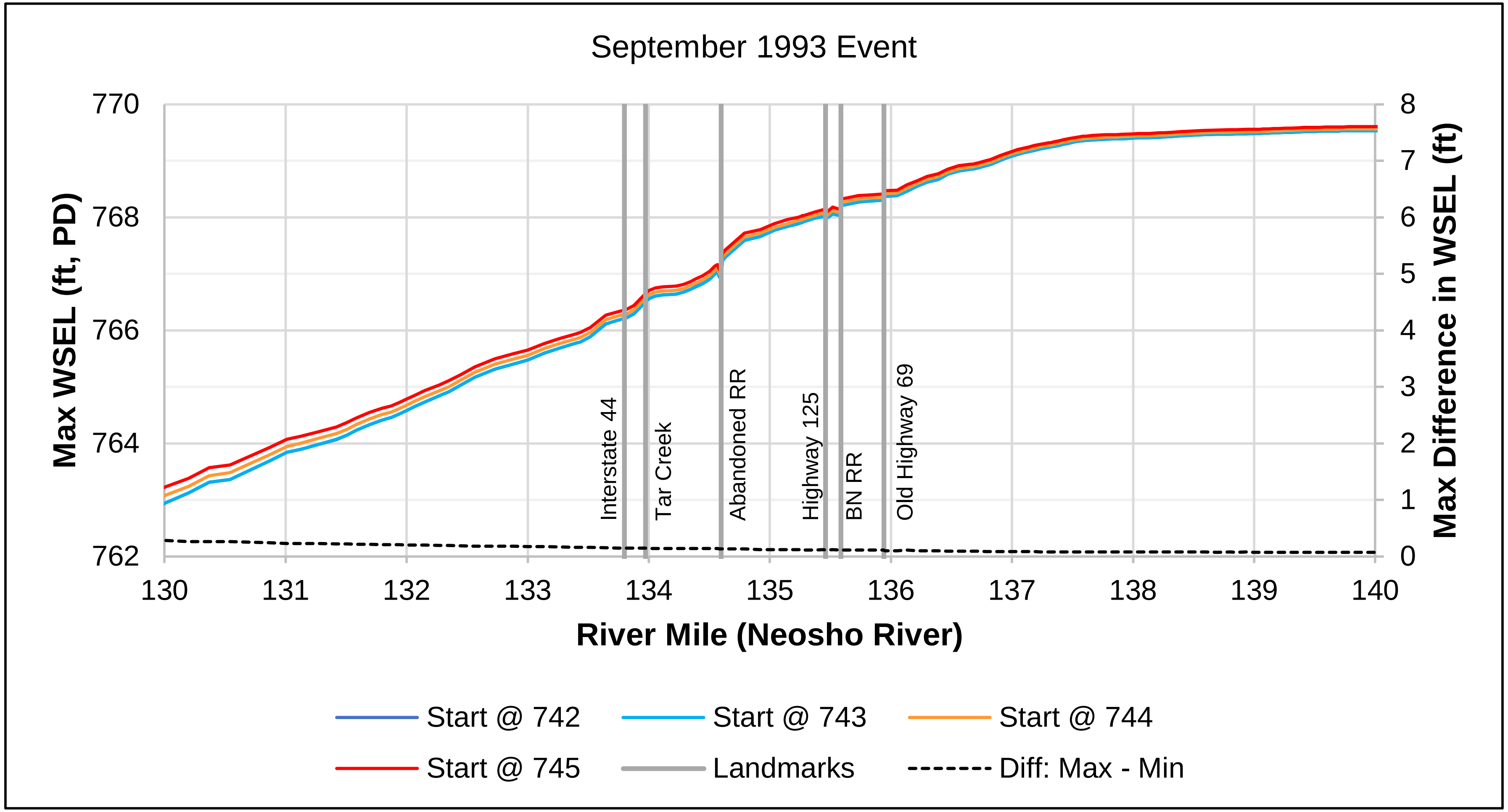
Maximum WSEL Differences

Event	Maximum WSEL Difference (ft)			
	Neosho River	Spring River	Elk River	Tar Creek
September 1993	0.36	0.12	0.04	0.15
June 2004	0.69	0.92	0.42	0.32
July 2007	1.40	1.22	0.75	0.13
October 2009	0.84	0.48	0.62	0.06
December 2015	0.49	0.32	0.54	0.18
100-year	2.10	0.33	1.91	0.05
Historical Starting Elevation	20.95	36.78	26.84	20.54

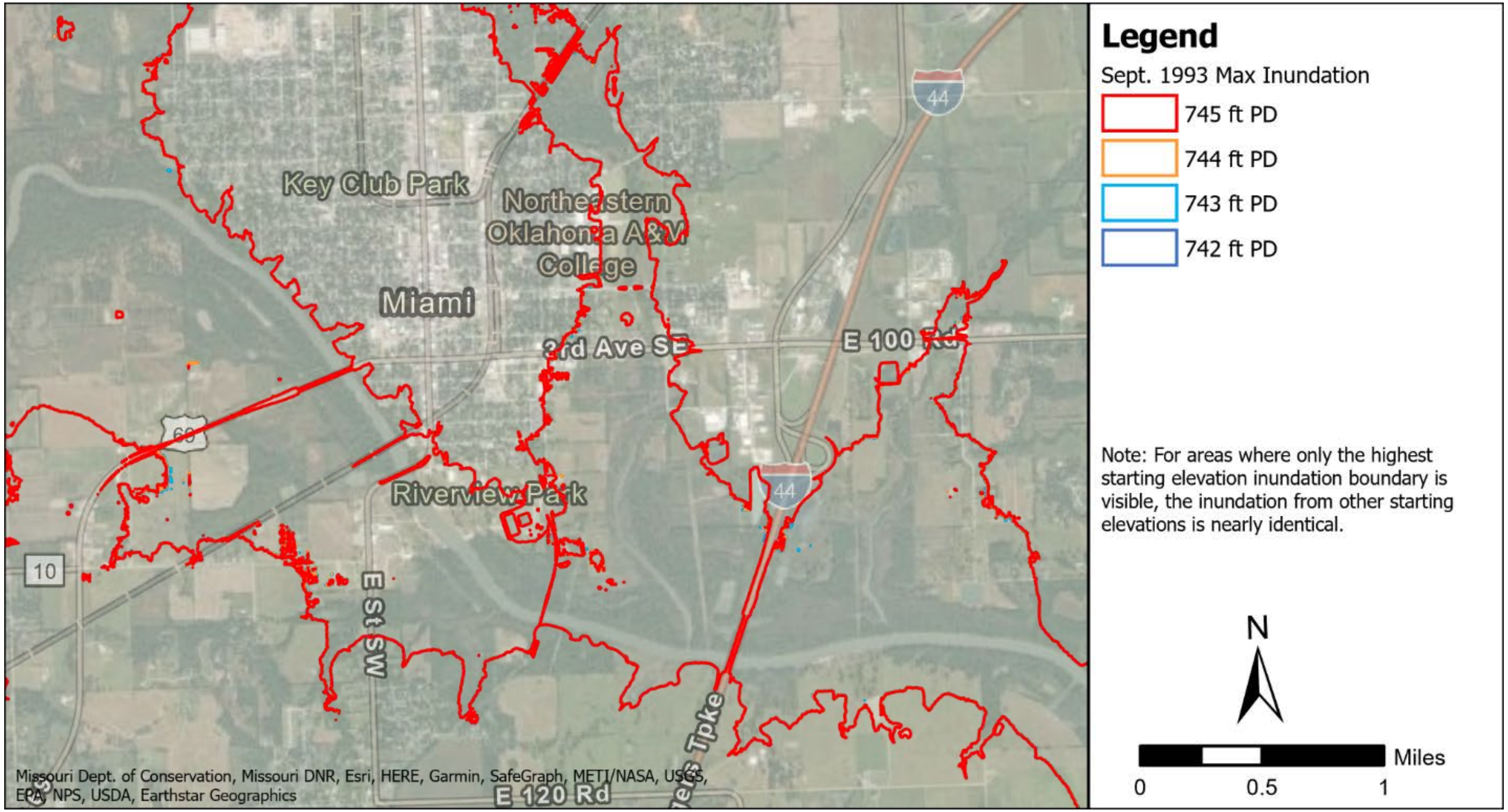
Inundation Area Differences

Event	Maximum Area of Inundation (acres)		Difference (%)
	Smallest	Largest	
September 1993	82,007	82,093	0.1%
June 2004	49,743	50,469	1.4%
July 2007	80,257	81,148	1.1%
October 2009	70,648	70,985	0.5%
December 2015	78,020	78,473	0.6%
100-year	92,525	94,141	1.7%
Historical Starting Stage	50,551	82,029	47.5%

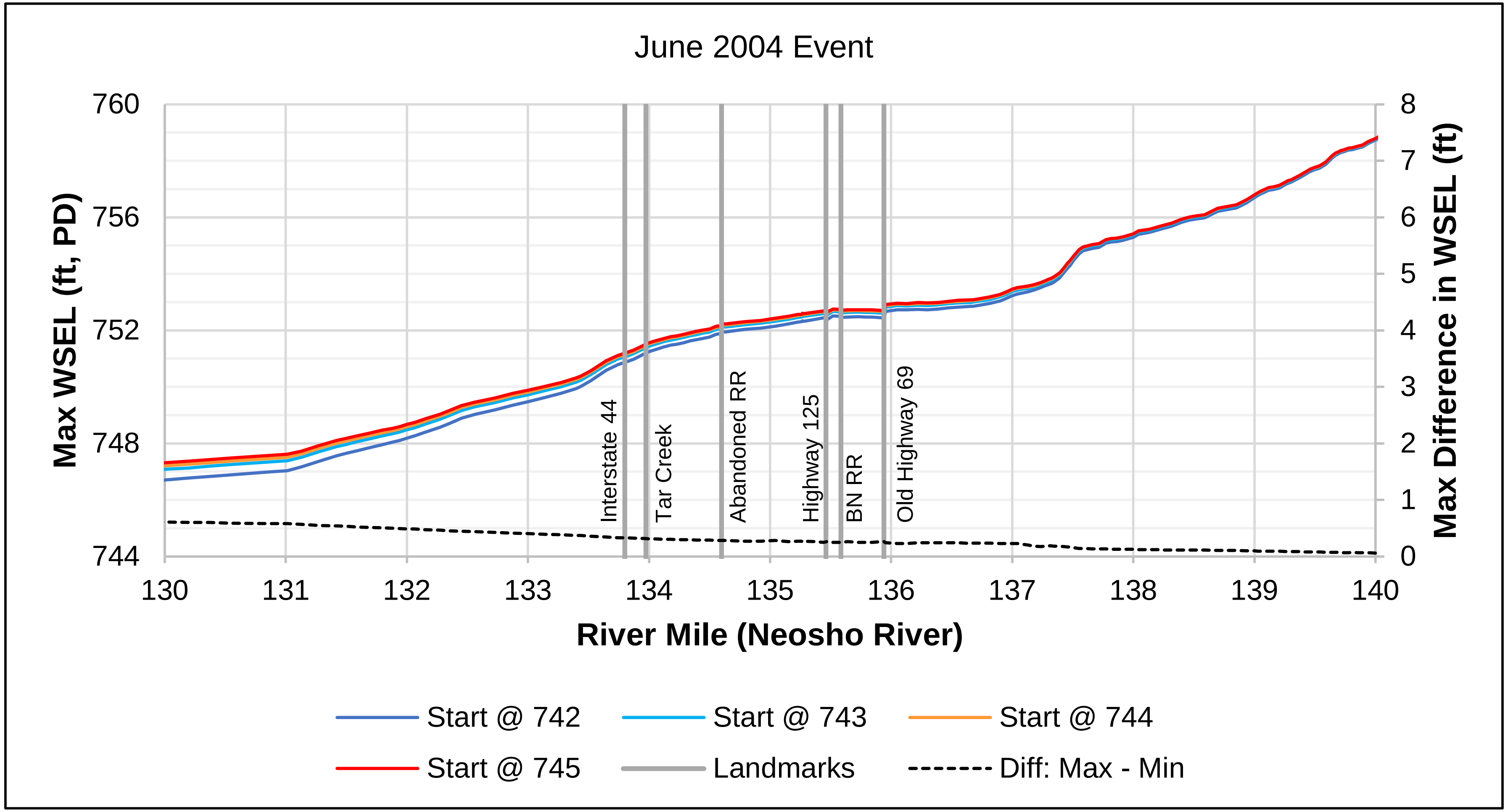
September 1993 WSEL Profiles



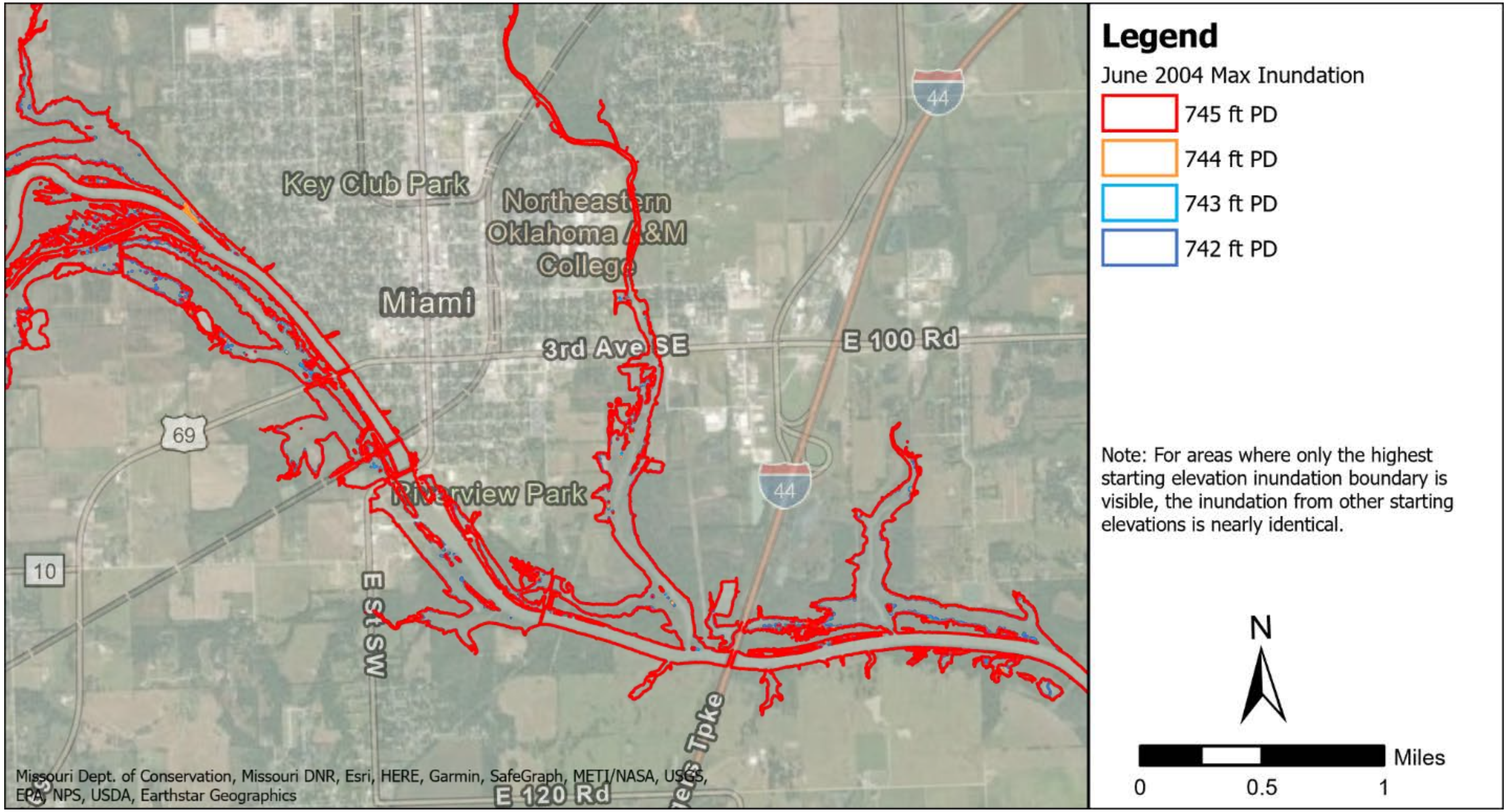
September 1993 Inundation Extent



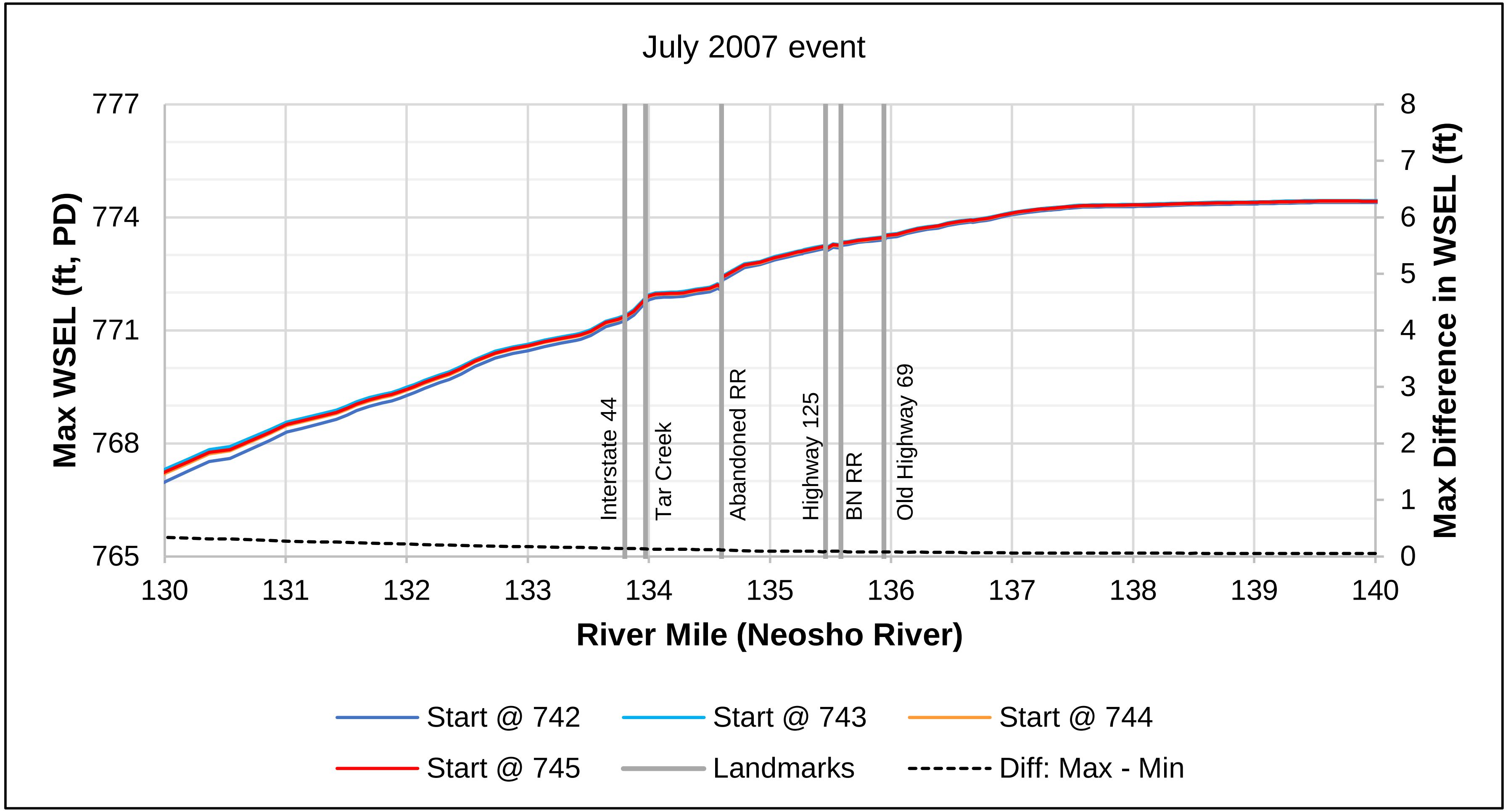
June 2004 WSEL Profiles



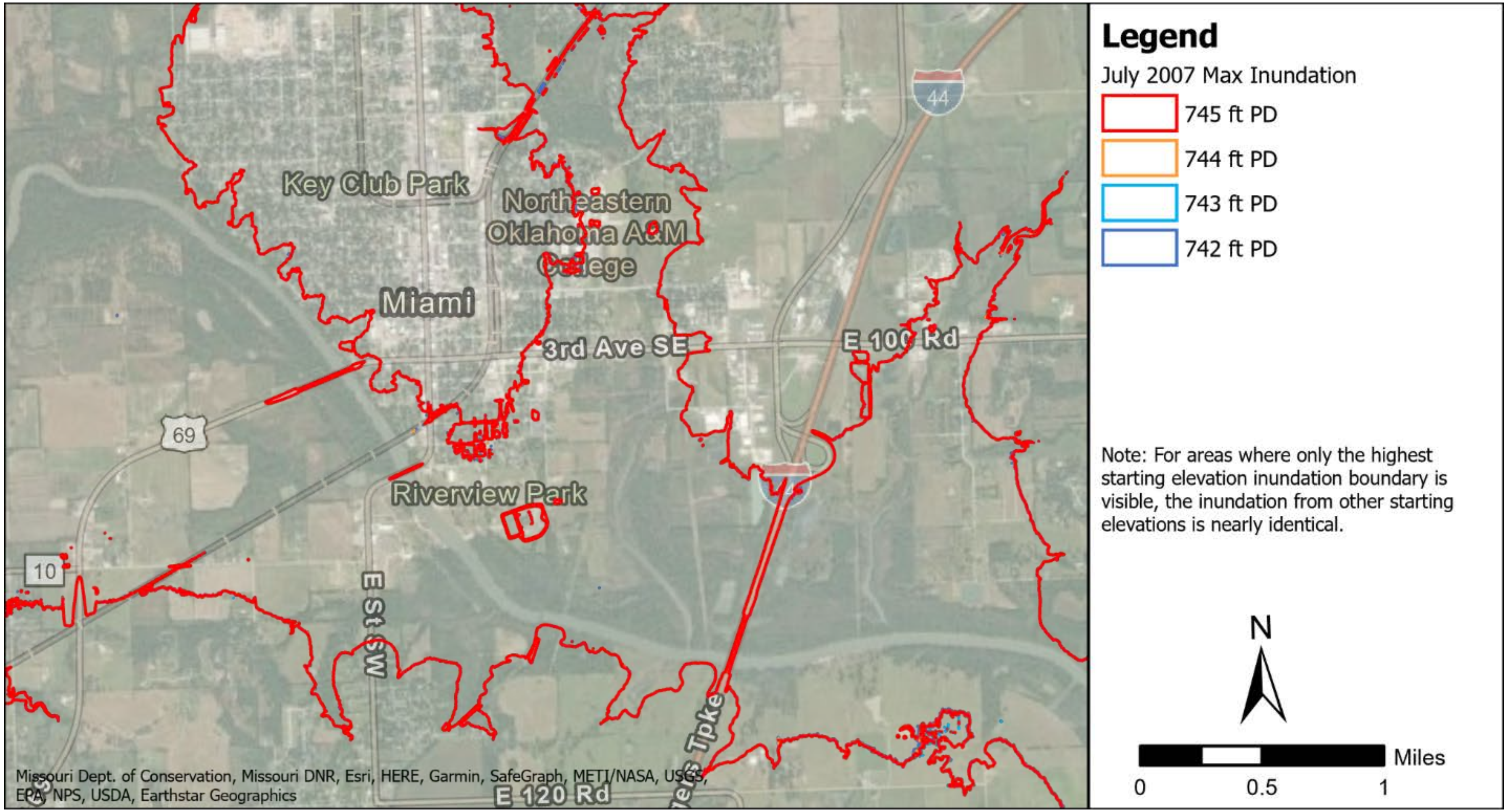
June 2004 Inundation Extent



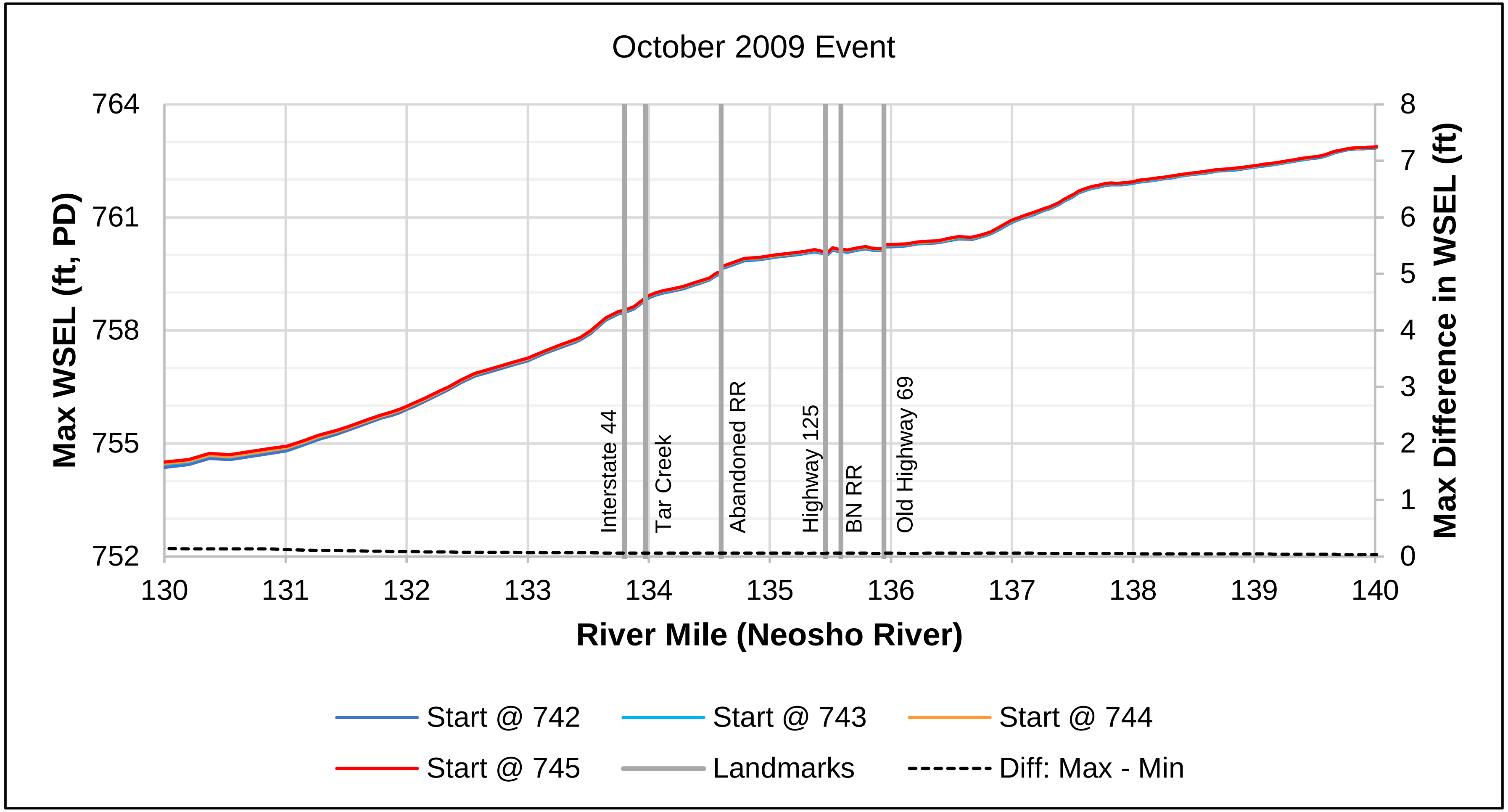
July 2007 WSEL Profiles



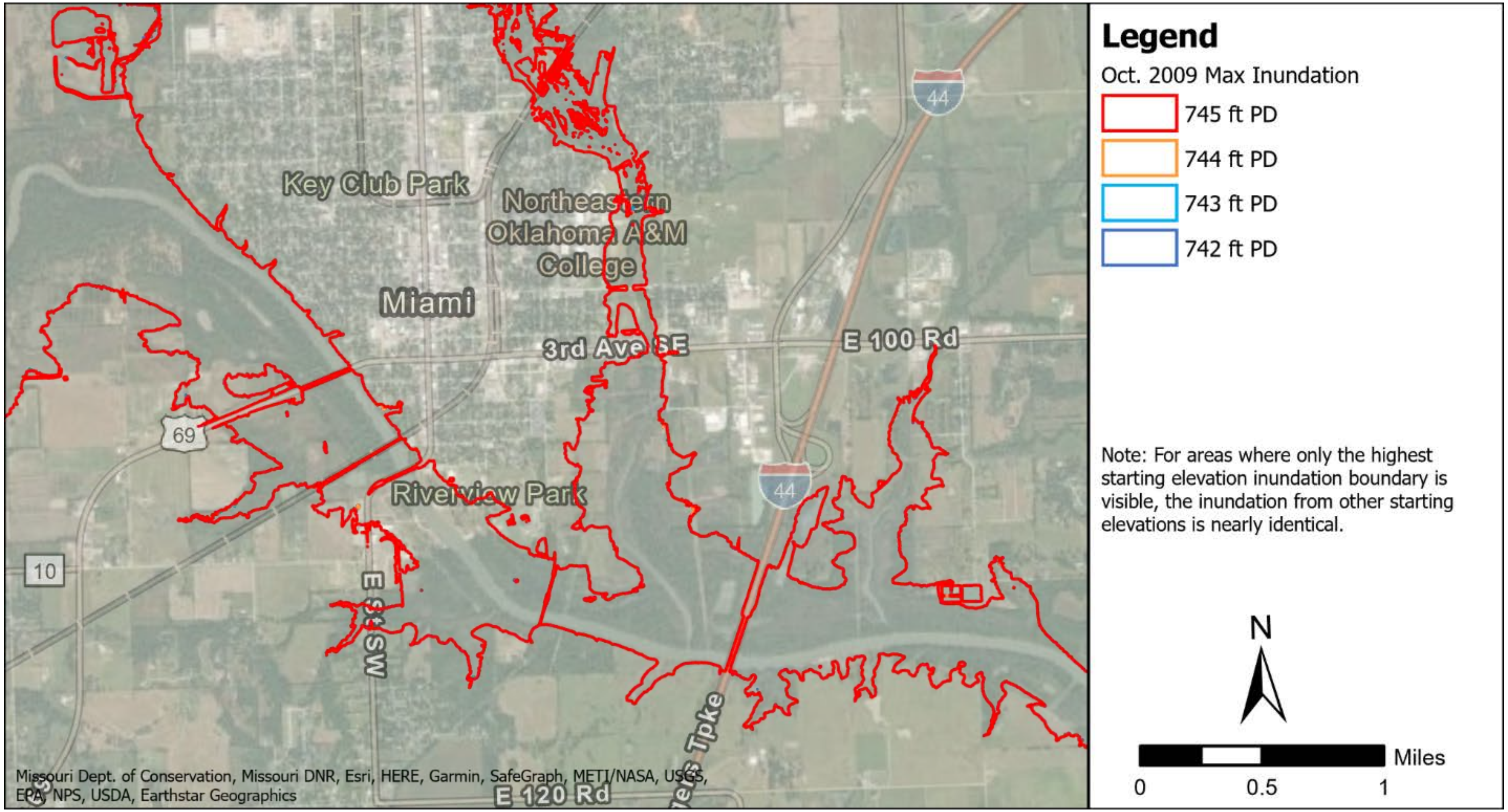
July 2007 Inundation Extent



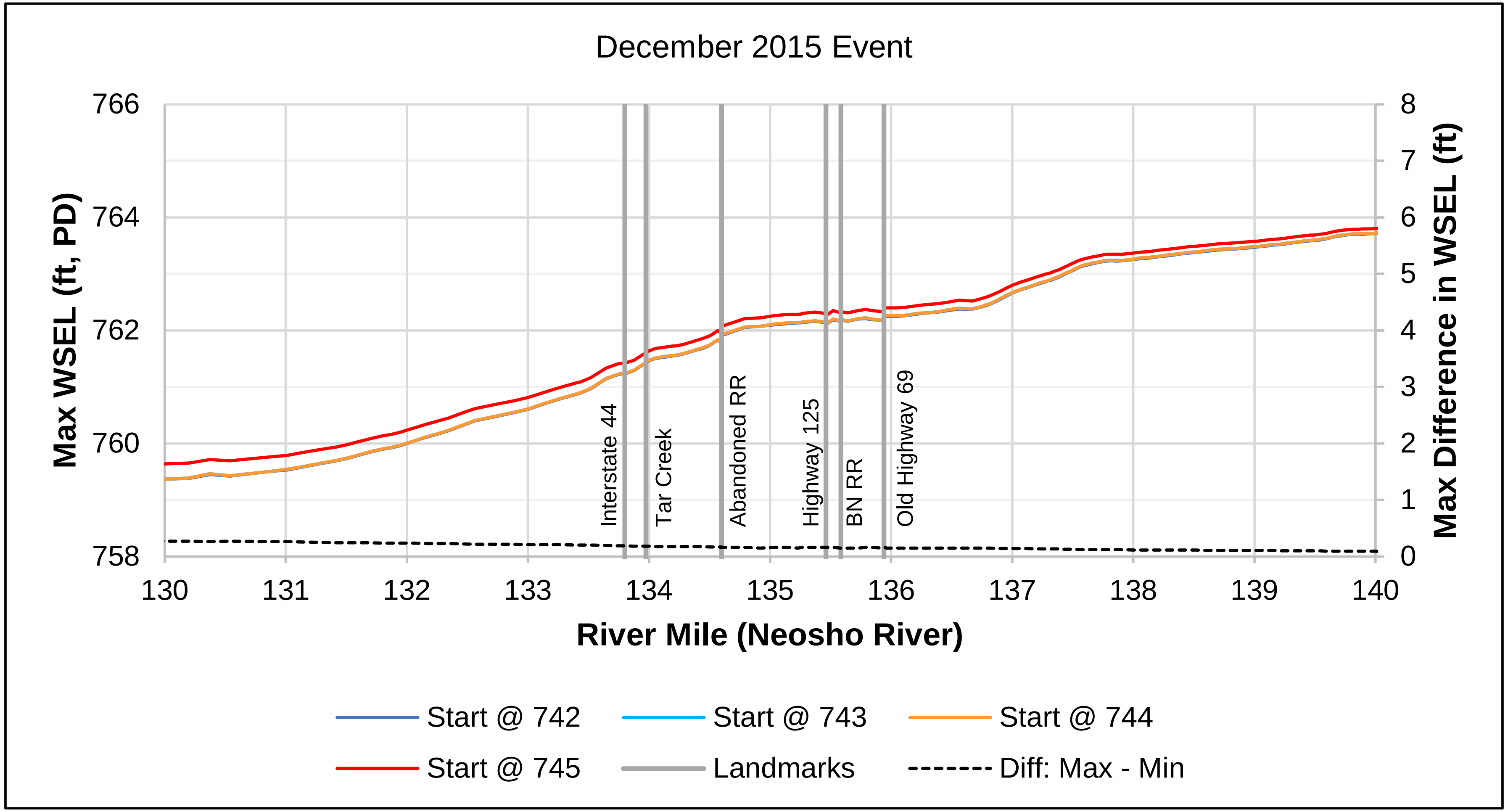
October 2009 WSEL Profiles



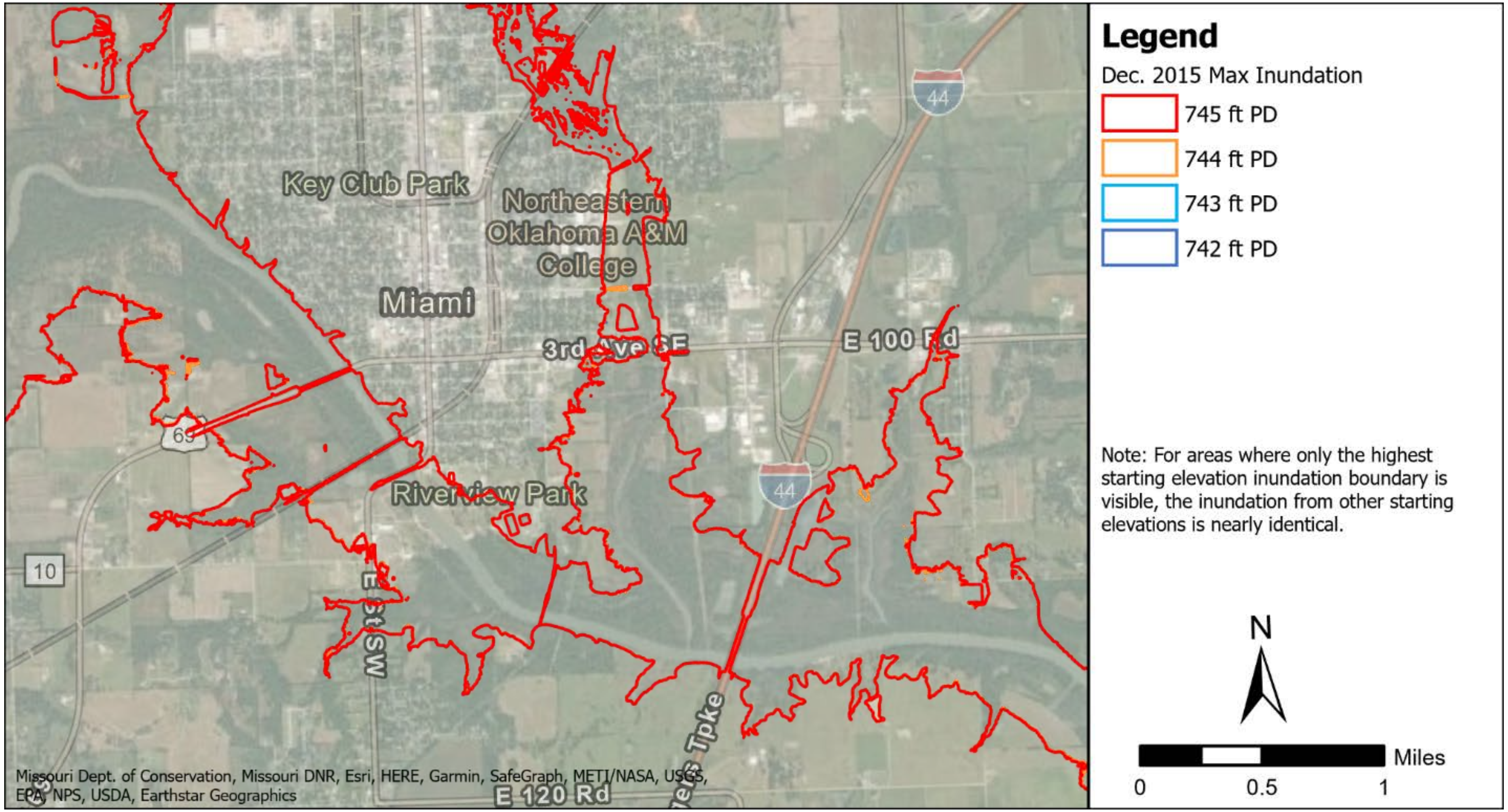
October 2009 Inundation Extent



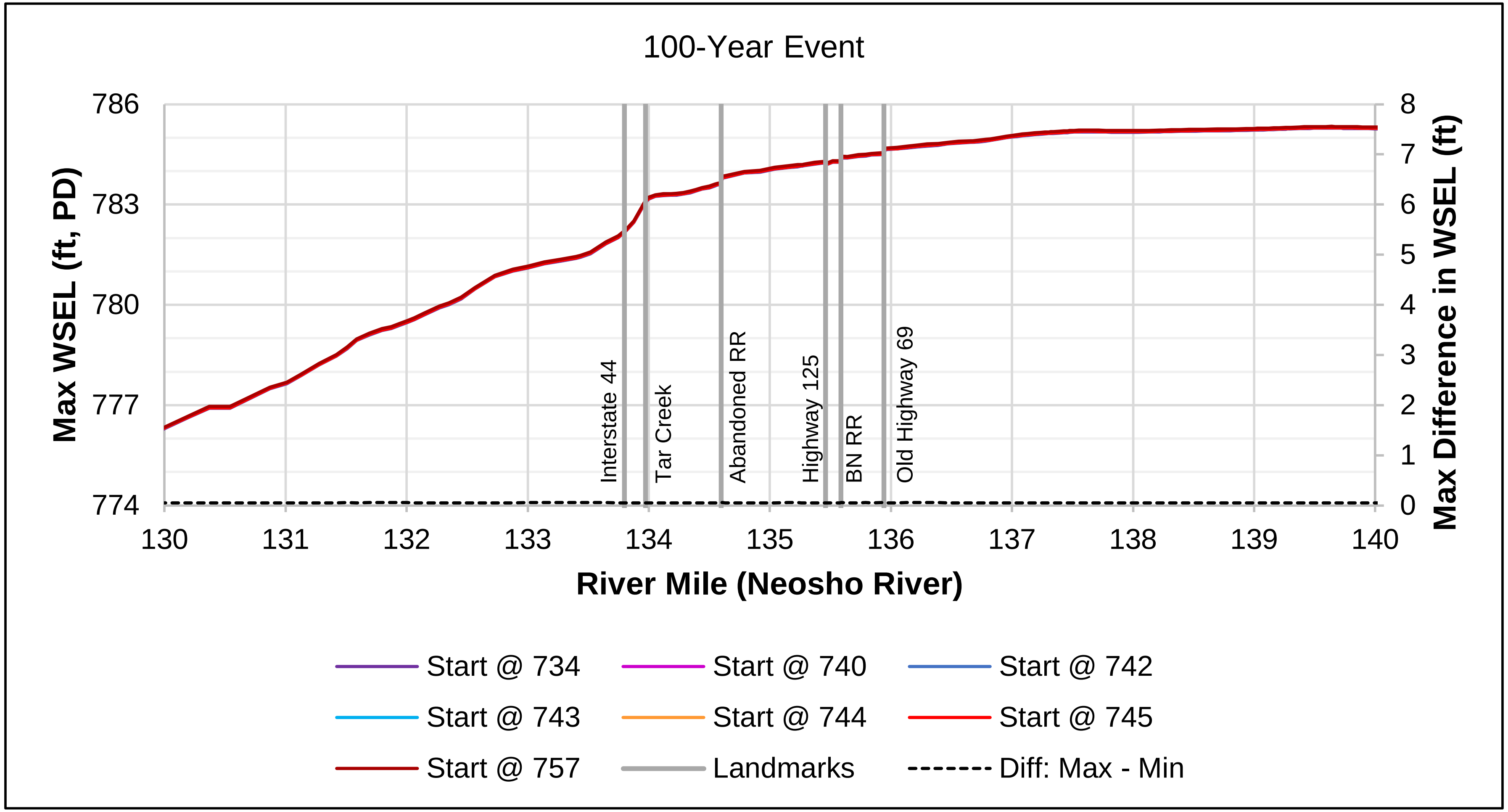
December 2015 WSEL Profiles



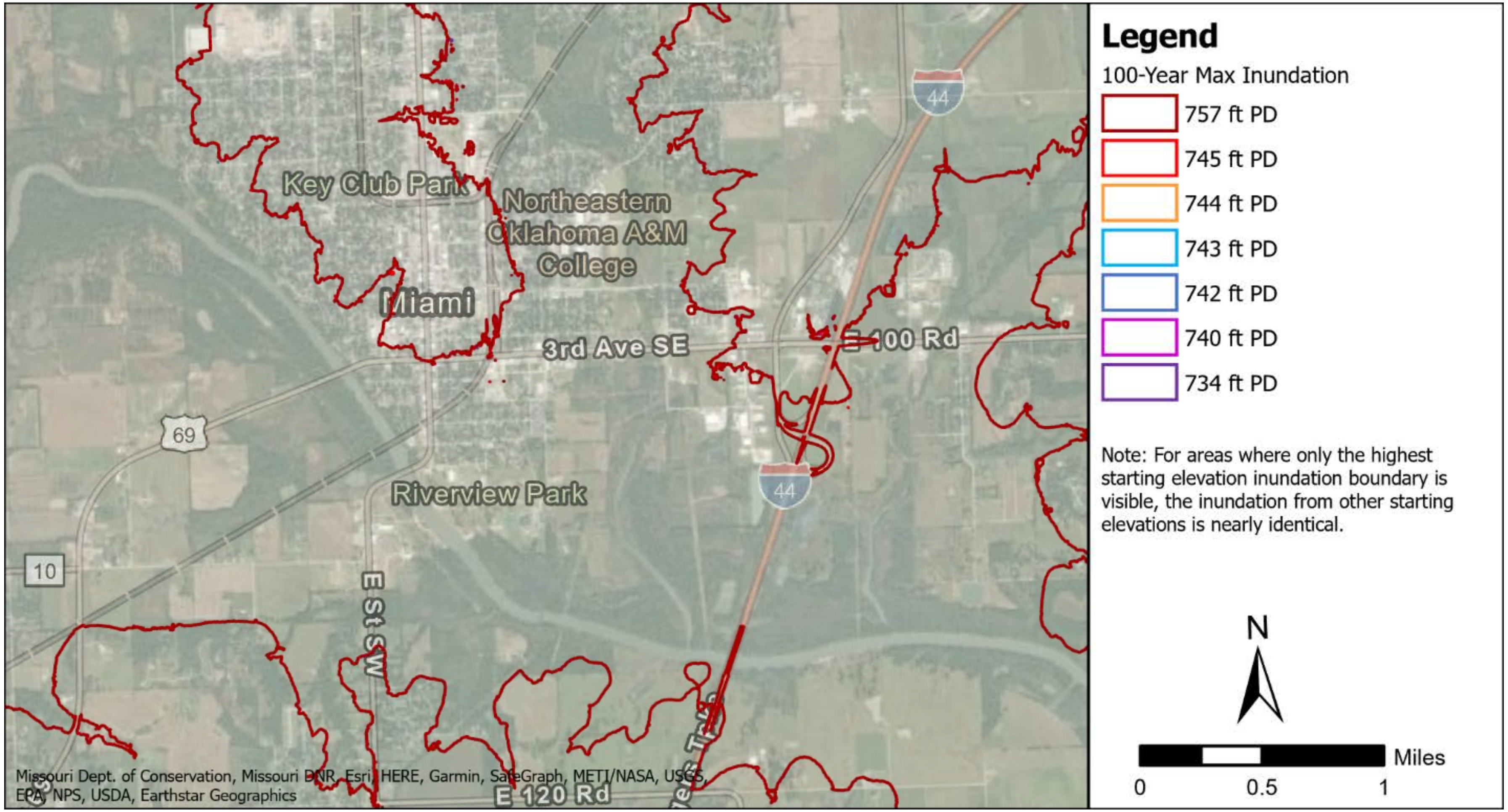
December 2015 Inundation Extent



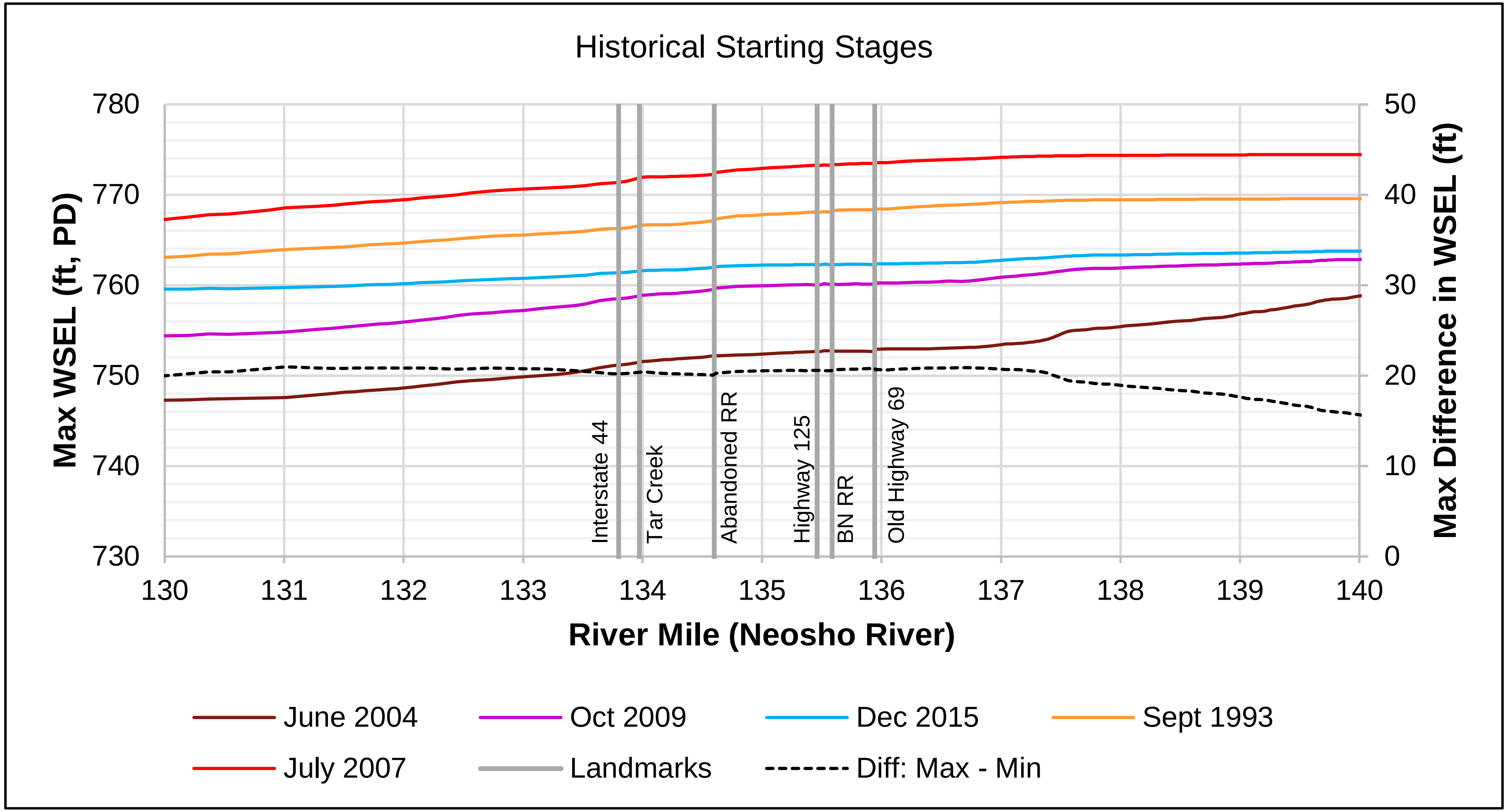
100-Year WSEL Profiles



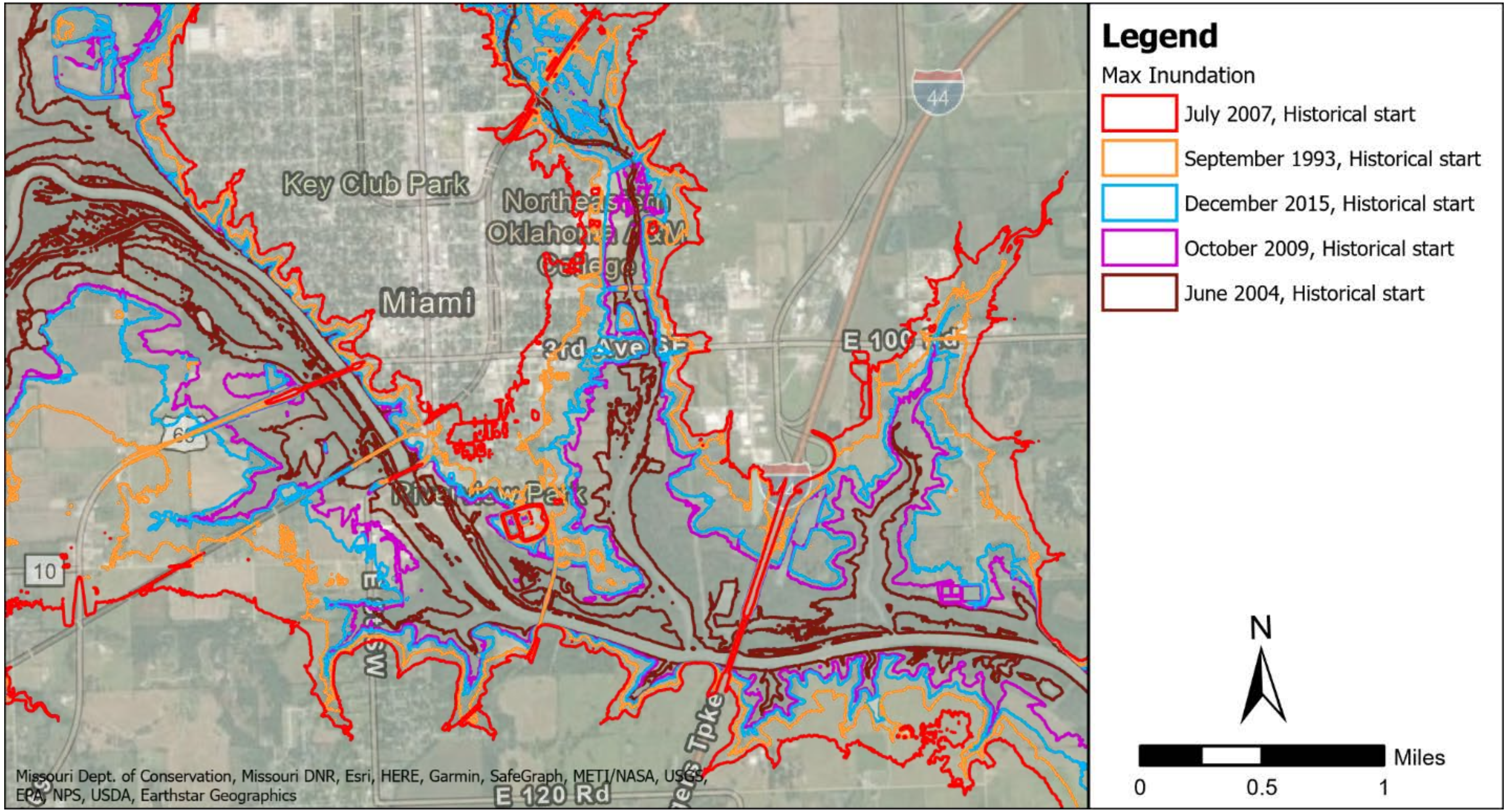
100-Year Inundation Extent



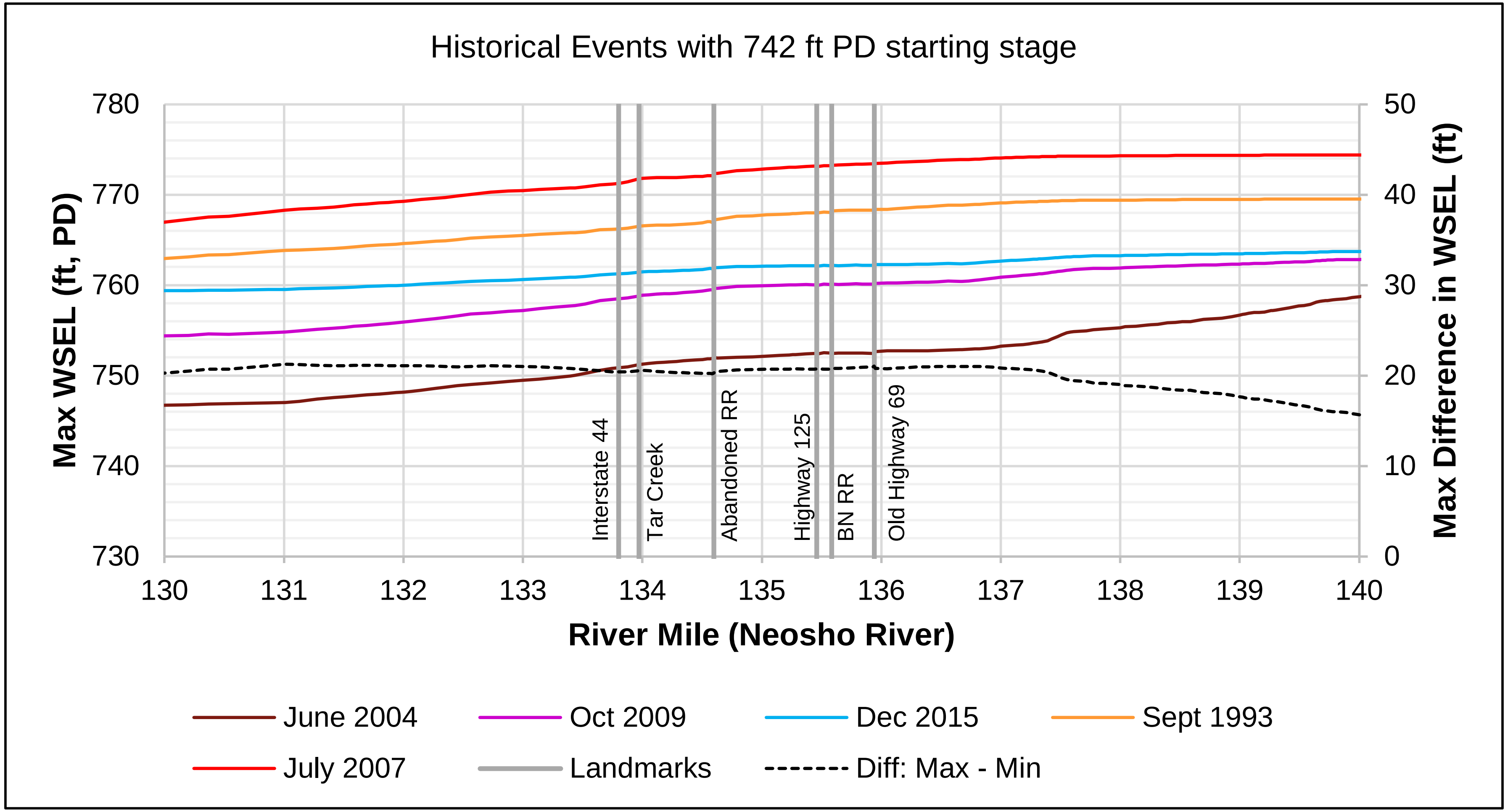
Historical Starting Stage WSEL Profiles



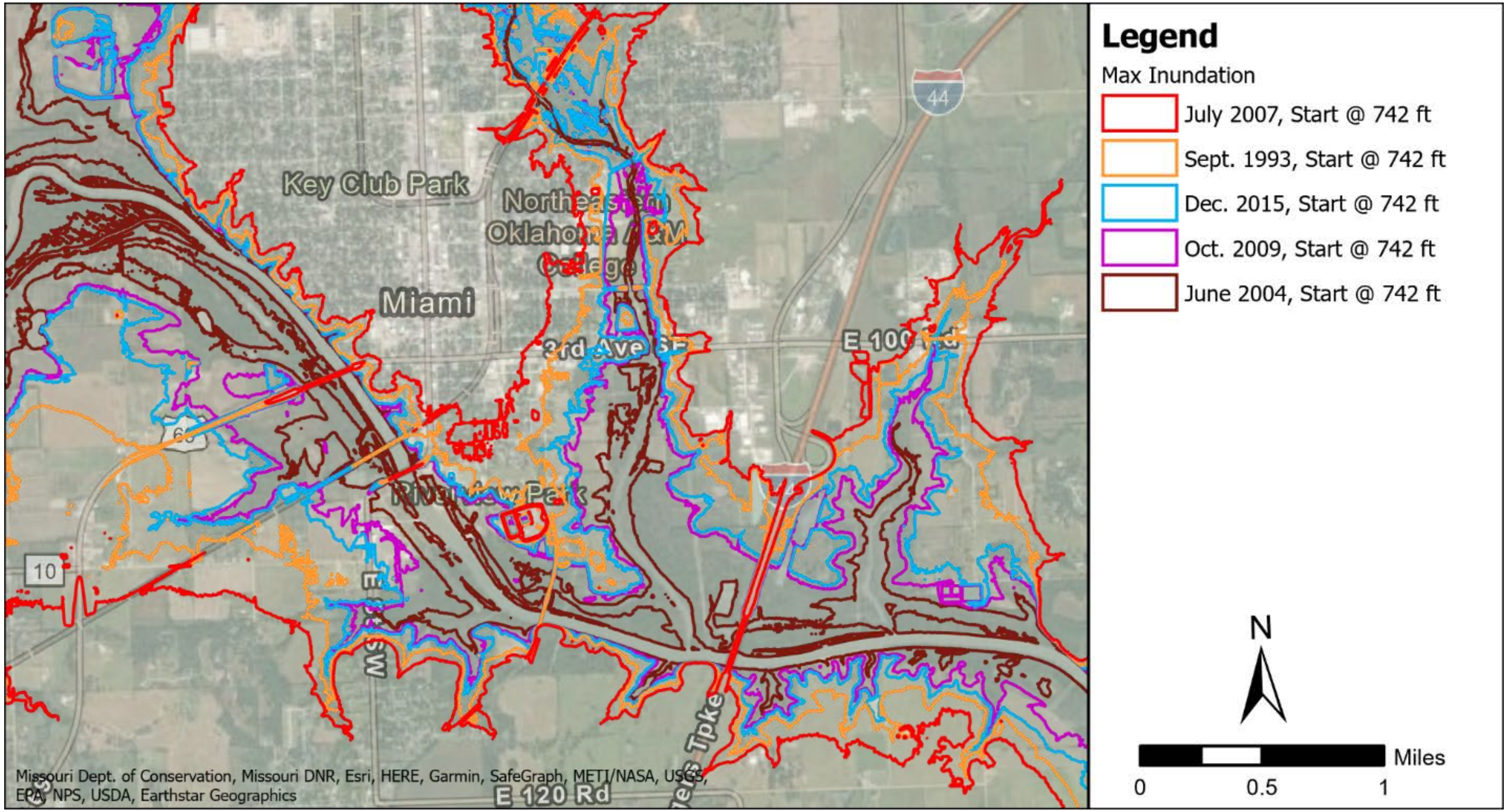
Historical Starting Stage Inundation Extent



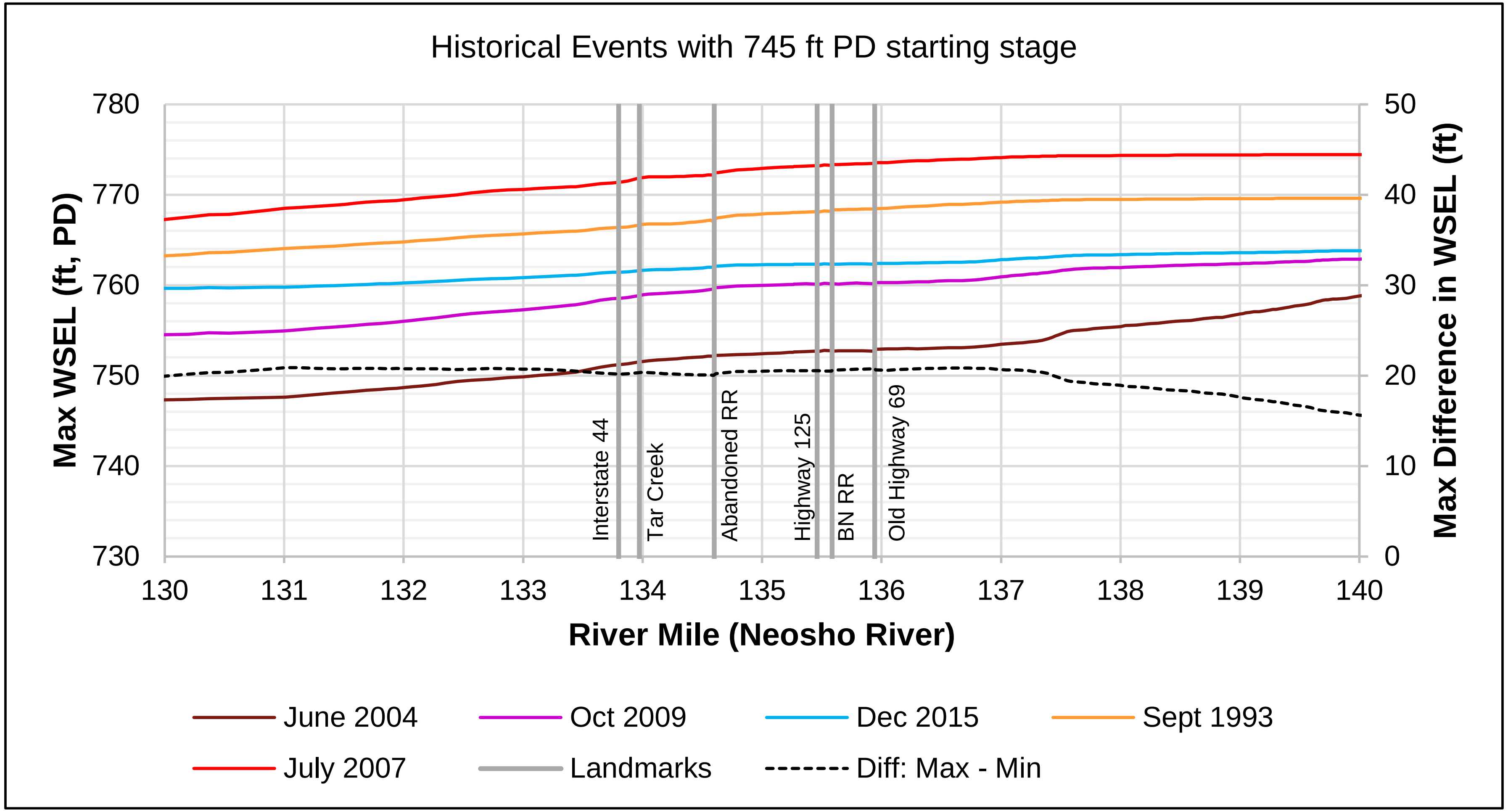
742 ft PD Starting Stage WSEL Profiles



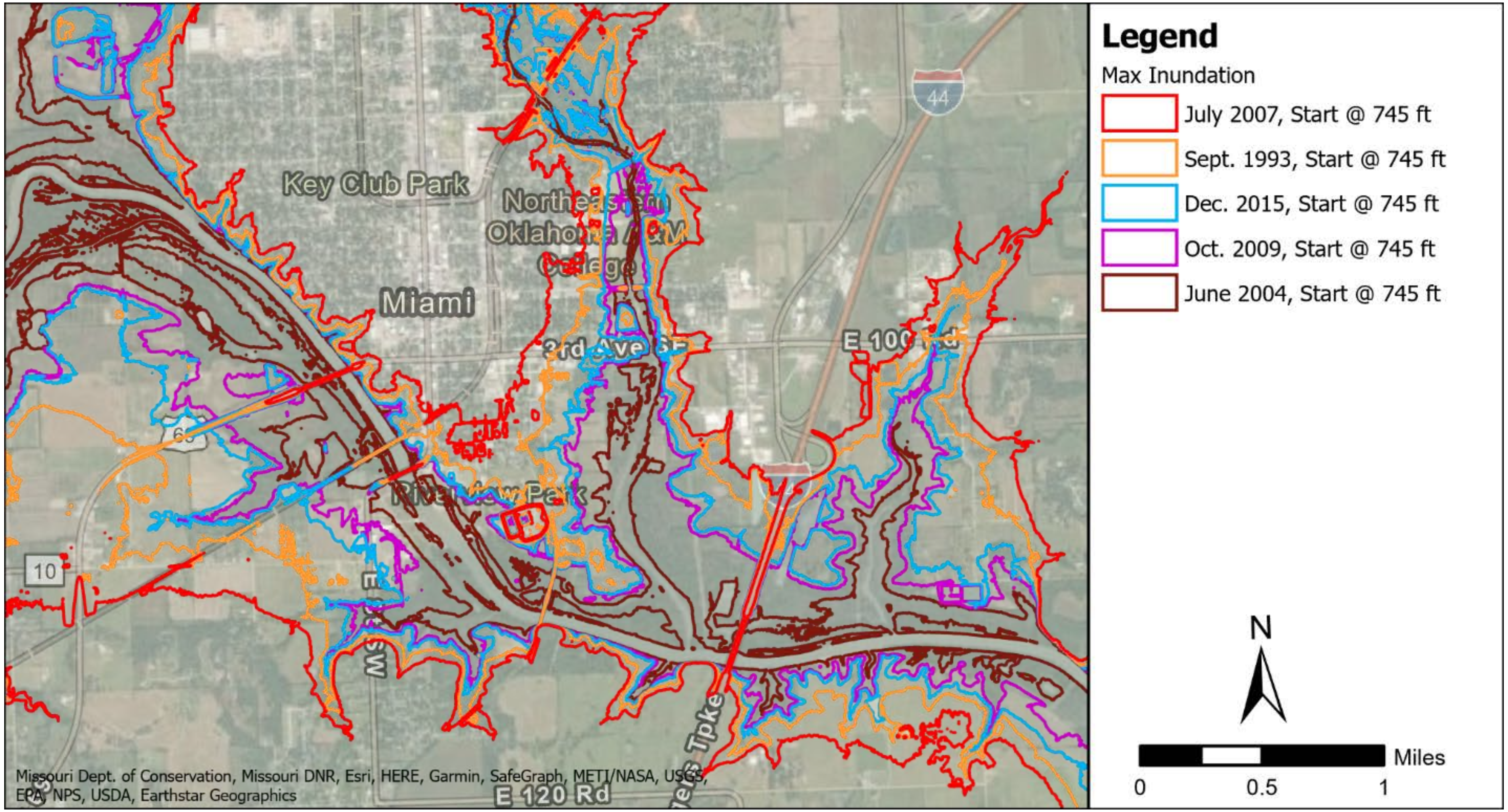
742 ft PD Starting Stage Inundation Extent



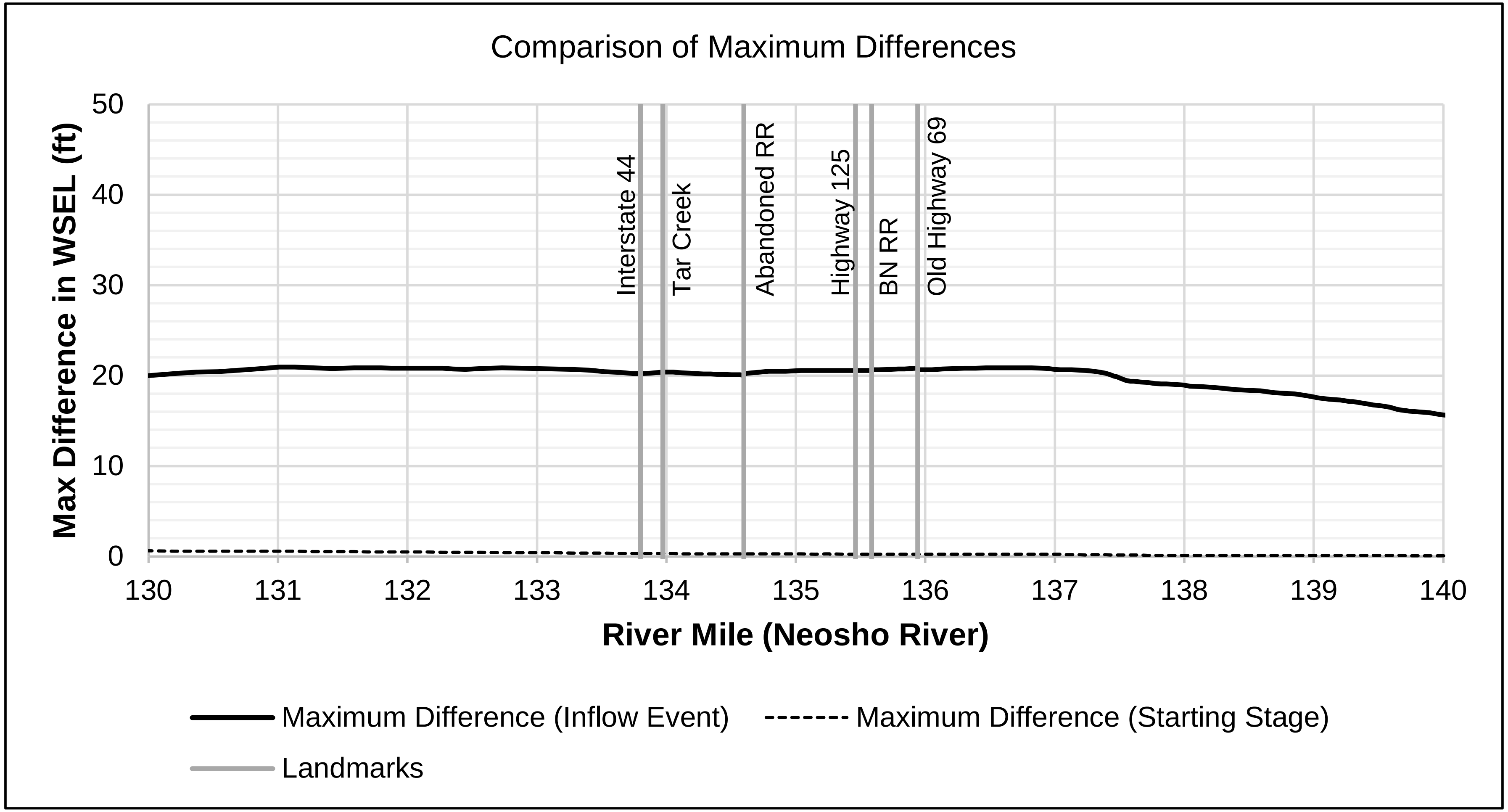
745 ft PD Starting Stage WSEL Profiles



745 ft PD Starting Stage Inundation Extent



Comparison of Maximum WSEL Differences



Conclusions

Conclusions

1. The initial stage at Pensacola Dam has an immaterial impact on upstream WSELs and inundation.
2. Only a different inflow event caused an appreciable difference in maximum WSEL and maximum inundation extent.
3. The differences in WSEL and inundation extent due to the size of the inflow event were an order of magnitude greater than the differences in WSEL and inundation extent due to the initial stage at Pensacola Dam.

Thank you

Hydrologic and Hydraulic Modeling: Downstream Hydraulic Model

Pensacola Hydroelectric Project Project No. 1494

October 12, 2021

Presentation Outline

1. Purpose and Objectives of DHM
2. Model Development
3. Model Calibration
4. Simulated Scenarios
5. Study Results
6. Discussion of Results
7. Conclusions

Purpose and Objectives of DHM

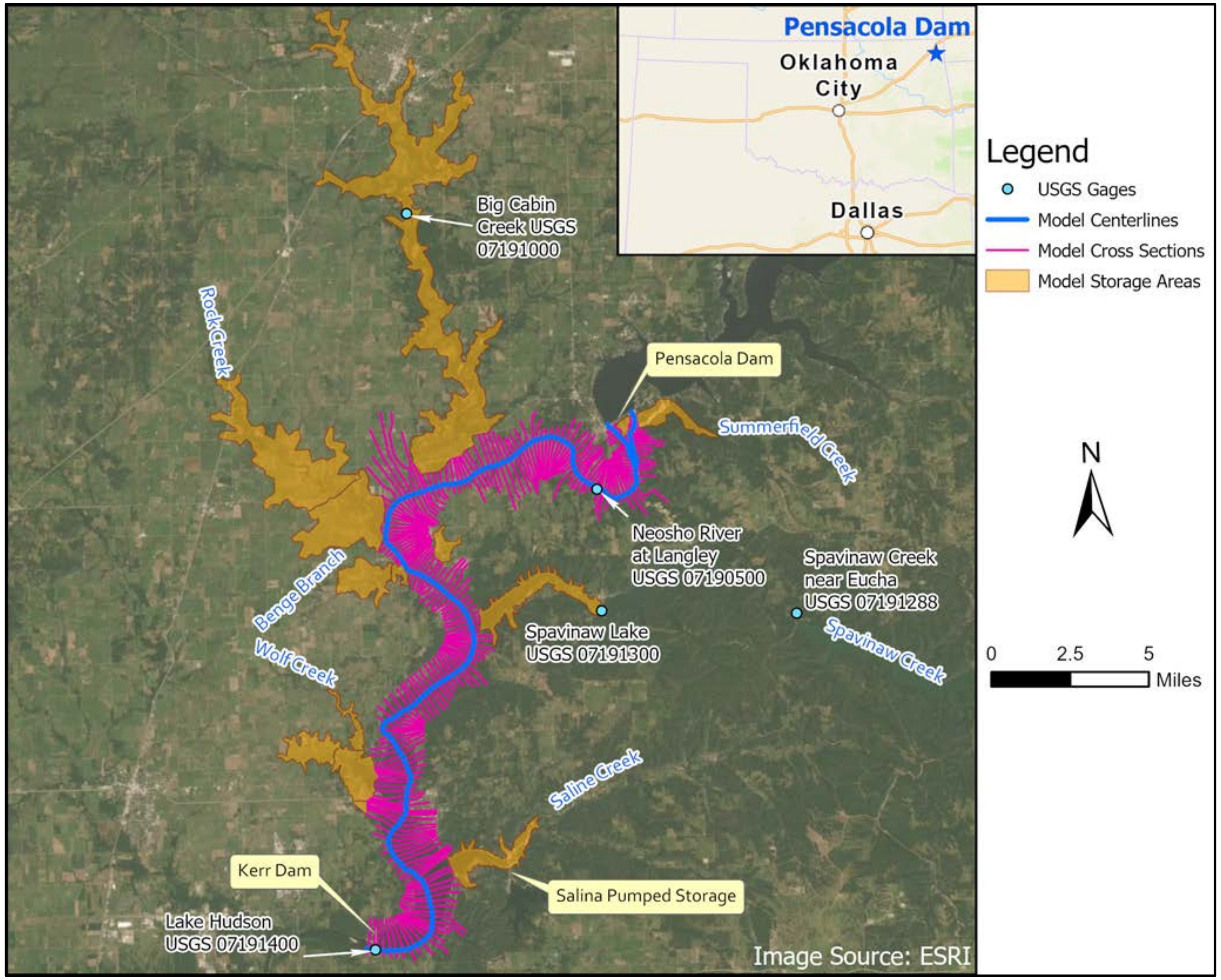
1. Analyze inundation downstream of Pensacola Dam under current license operations of the Project during several measured inflow events.

2. Provide model results in a format that can inform other analyses.

3. Determine feasibility of implementing anticipated future operations that may be proposed by GRDA as part of the relicensing effort.

Model Development

Study Area



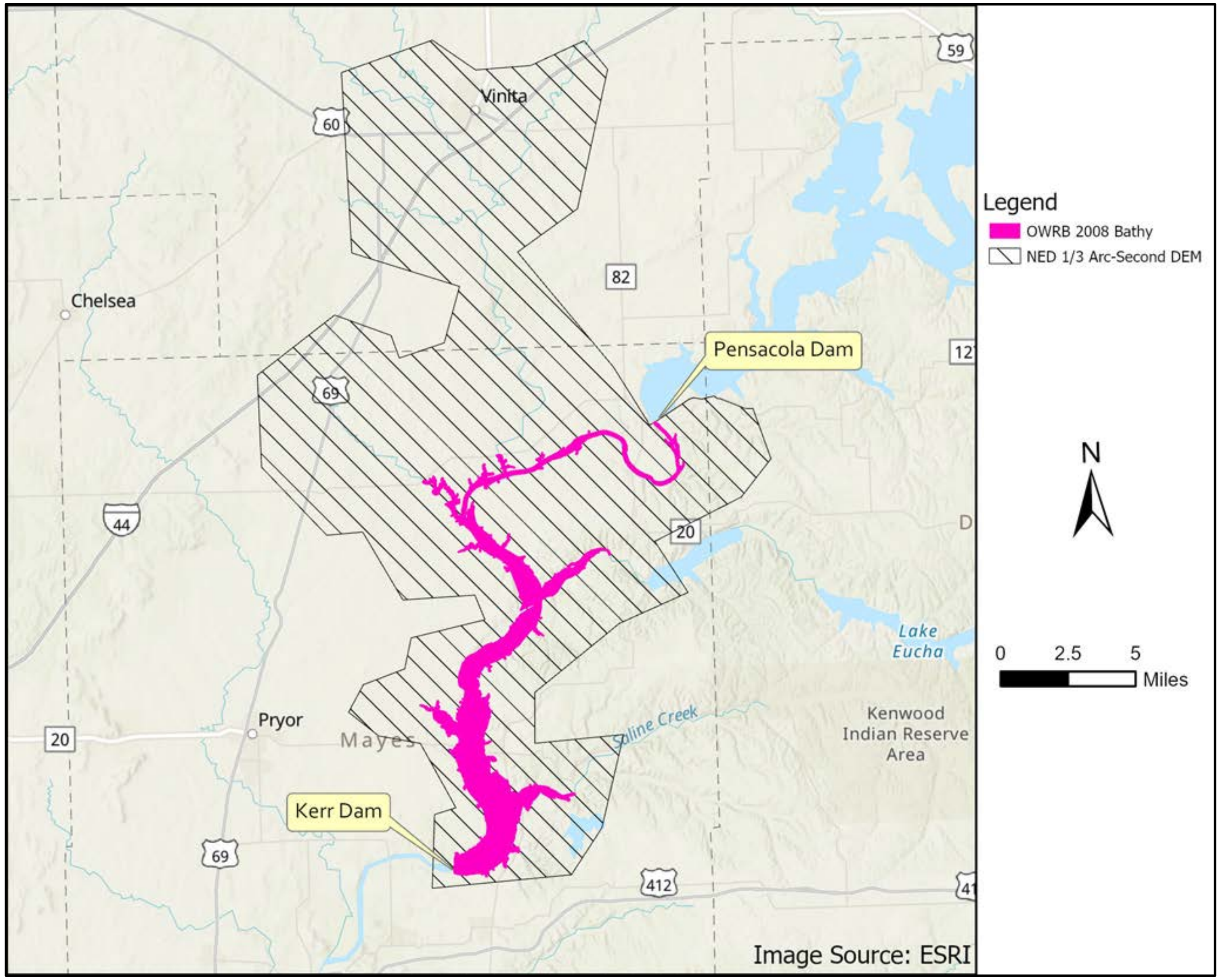
Pensacola Dam
Oklahoma City
Dallas
Legend
USGS Gages
Model Centerlines
Model Cross Sections
Model Storage Areas
Big Cabin Creek USGS 07191000
Rock Creek
Pensacola Dam
Summerfield Creek
Neosho River at Langley USGS 07190500
Spavinaw Creek near Eucha USGS 07191288
Benge Branch
Spavinaw Lake USGS 07191300
Spavinaw Creek
Wolf Creek
Saline Creek
Kerr Dam
Salina Pumped Storage
Lake Hudson USGS 07191400
Image Source: ESRI
N
0 2.5 5
Miles

Model Development

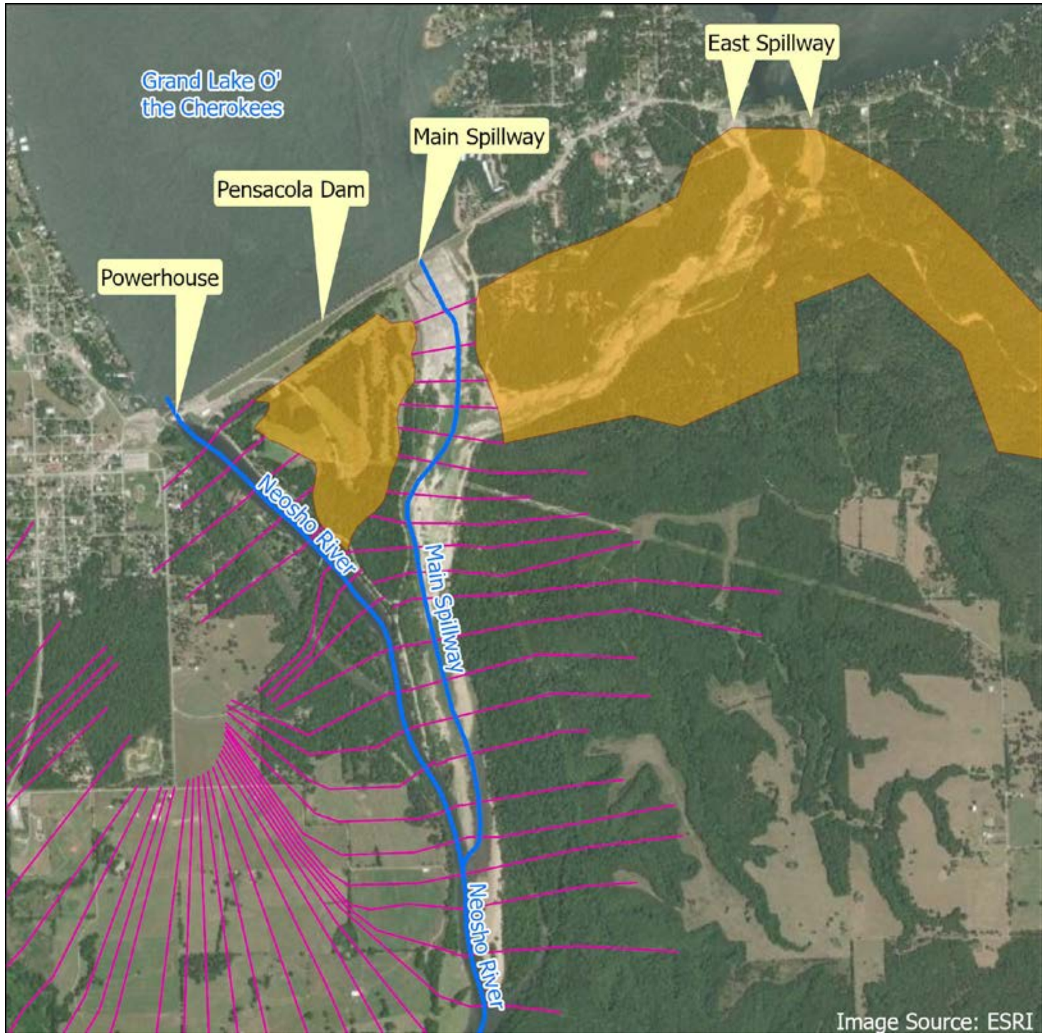
- One dimensional (1D) unsteady-state HEC-RAS model
  - Version 5.0.7

- Model Extents:
  - Downstream: Just downstream of Kerr Dam (RM 47.86) for calibration ONLY
  - Upstream: Just downstream of Pensacola Dam (RM 76.88)

Topographic and Bathymetric Data



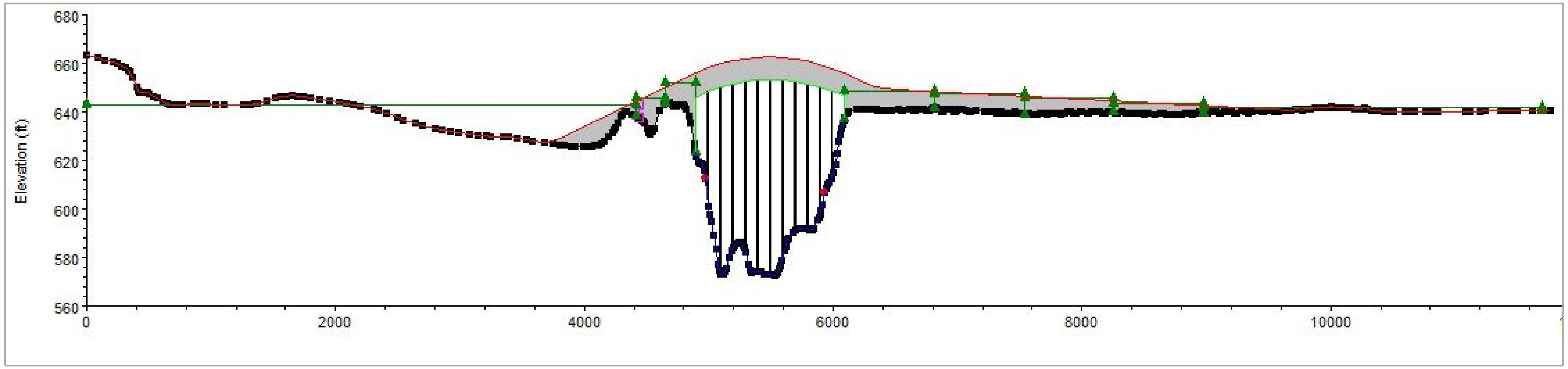
Model Geometry



- 1D cross sections for Neosho River channel and Lake Hudson
  - Parallel reaches for Neosho River and Main Spillway channel downstream of Pensacola Dam
- Storage areas at various tributaries
  - Represent available storage outside main flow path of reservoir
  - Flow exchange between the river channel and Main Spillway channel

Model Geometry

- Four bridges cross the Neosho River and Lake Hudson
  - Defined based on record drawings from ODOT and GRDA
- Kerr Dam represented as inline structure
  - Flow hydrograph boundary defined for model calibration



Model Geometry

- Manning's n-values derived from aerial imagery prior to calibration
  - Guidance from USACE's *Hydraulic Reference Manual*

Land Use Category	n-Value
Channel	0.030
Pasture high grass or mature row crops	0.035
Mature field crops	0.040
Light brush and trees	0.060
Urban or residential	0.070
Dense urban or residential	0.090
Medium to dense brush	0.100

Model Calibration

Model Calibration

- Model calibrated using four historic events

Event	Simulation Start/End Date	Pensacola Dam Peak Outflow	Kerr Dam Peak Outflow
July 2007	June 10, 2007 – July 23, 2007	106,941 cfs	99,034 cfs
April 2008	April 7, 2008 – April 17, 2008	82,340 cfs	91,287 cfs
April 2011	April 20, 2011 – May 15, 2011	80,559 cfs	91,852 cfs
May 2015	May 17, 2015 – June 9, 2015	107,246 cfs	121,400 cfs

- Calibrated based on measurements at USGS gage on Neosho River near Langley (Site No. 07190500)

Boundary Conditions for Calibration

- Inflow boundary conditions developed from USGS Gages

USGS Gage No.	Station Name
07191000	Big Cabin Creek near Big Cabin, OK
07191288	Spavinaw Creek near Eucha, OK
07191300	Spavinaw Lake at Spavinaw, OK

- Inflow hydrographs to represent outflows from Pensacola Dam
  - From GRDA times series operations data that is summarized and sent to USACE monthly
  - East spillway as lateral inflow hydrograph

Boundary Conditions for Calibration

- Lateral inflow hydrographs
  - Big Cabin Creek and Lake Spavinaw inflows transferred from USGS gages
  - Flows from Salina pumped storage derived from power consumption and generation time series data
    - Converted from MW to cfs using conversion factors for pumping and generating modes
    - Positive flows = inflows from power generation
    - Negative flows = withdrawals from pumping
- Outflows for Kerr Dam from GRDA and USACE time series data
- Normal depth boundary condition at downstream end of model
  - WSELs upstream of Kerr Dam not sensitive to boundary condition

Model Calibration

- Uniform lateral inflow hydrograph to account for flow from ungaged tributaries and direct rainfall on Lake Hudson
  - Computed for each event to minimize differences between modeled and observed WSELs at Kerr Dam

Model Calibration

- Manning’s n-values adjusted in conjunction with lateral inflows
  - Goal: match observed WSELs at Langley Gage for all events with single model geometry
  - Calibrated model includes 8% increase in Manning’s n-values

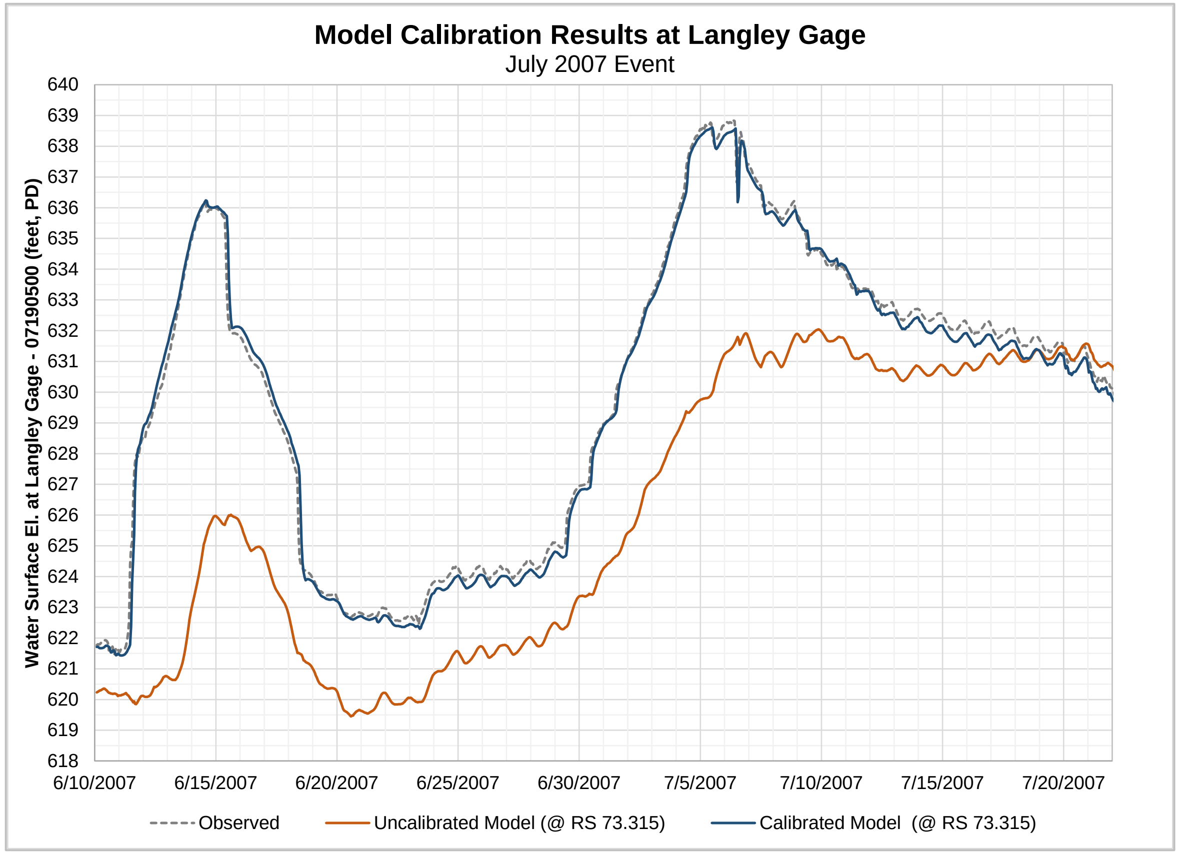
Land Use Category	Calibrated n-Value
Channel	0.0324
Pasture high grass or mature row crops	0.0378
Mature field crops	0.0432
Light brush and trees	0.0648
Urban or residential	0.0756
Dense urban or residential	0.0972
Medium to dense brush	0.1080

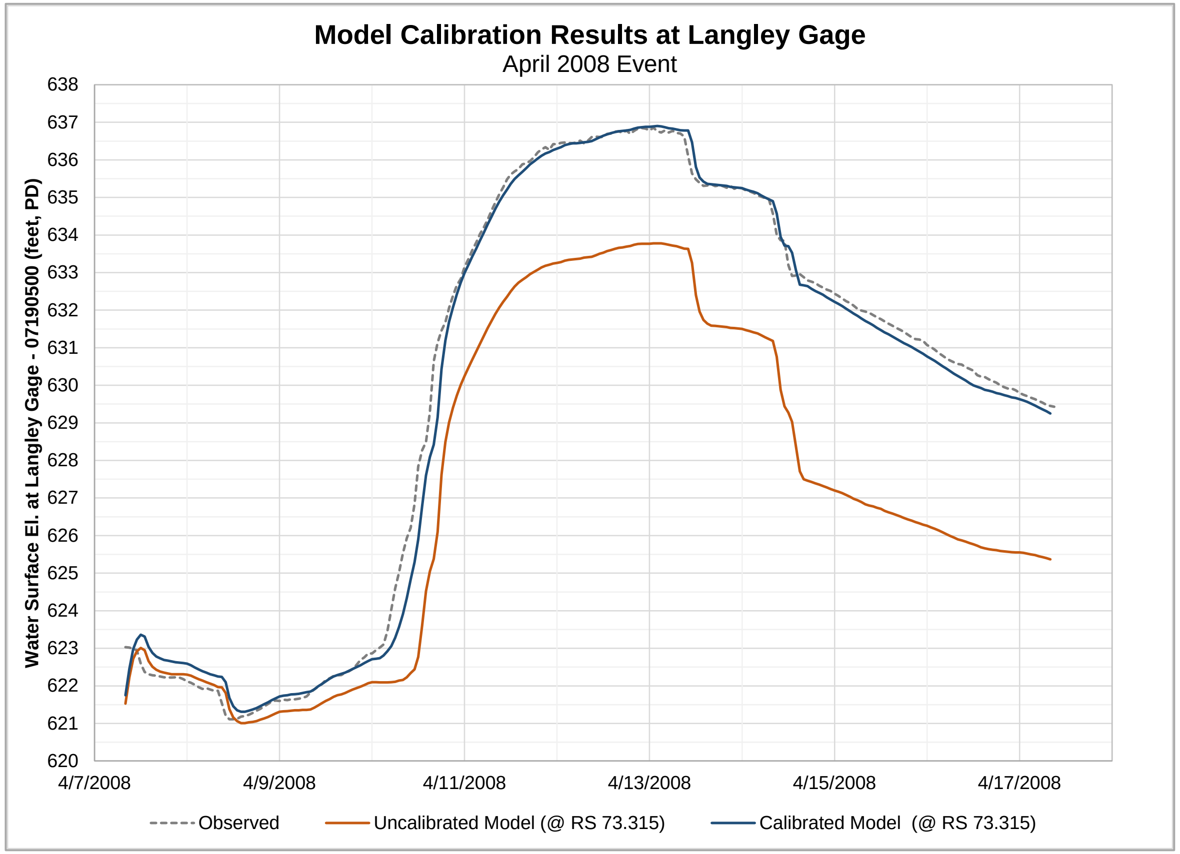
Calibration Results

- Computed stage hydrographs at the Langley Gage show a good match to the observed stages throughout the events

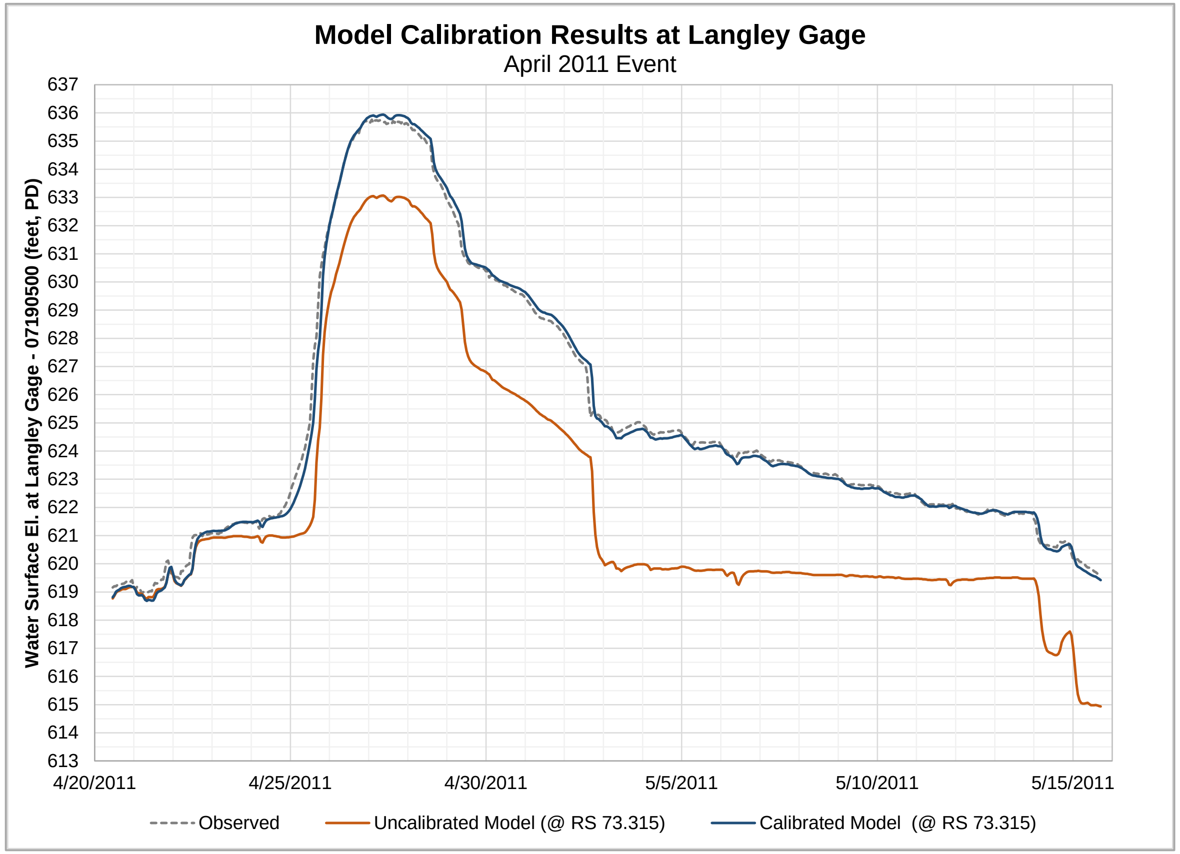
Event	Observed Peak WSEL at Langley Gage (No. 07190500) (feet, PD)	Modeled Peak WSEL at Langley Gage (RS 73.315) (feet, PD)	Over/Under Prediction (feet)
June 2007	638.9	638.6	-0.3
April 2008	636.9	636.9	0.0
April 2011	635.8	635.9	0.1
May 2015	639.5	639.6	0.1

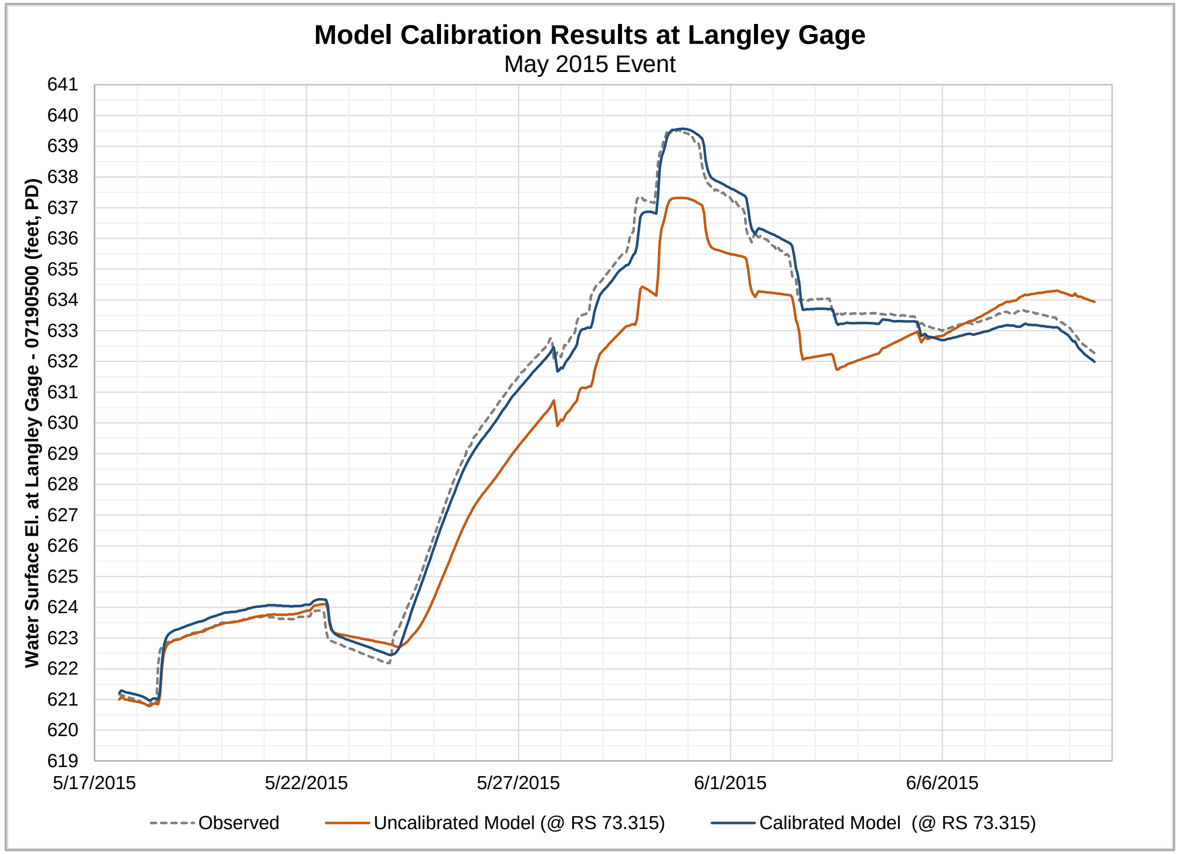
Calibration Results





Calibration Results





Simulated Scenarios

Simulated Scenarios

Inflow Event	Type	Estimated Return Period for Peak Inflow to Pensacola Dam	Pensacola Dam Starting Pool Elevation (ft, PD)	Simulation Start/End Date
Sept. 1993	Historical	21 years	743.85[1], 742, 743, 744, 745	Sept. 24, 1993 – Oct. 17, 1993
June 2004	Historical	1 year	743.42[1], 742, 743, 744, 745	June 13, 2004 – June 24, 2004
July 2007	Historical	4 years	745.69[1], 742, 743, 744, 745	June 28, 2007 – July 29, 2007
Oct. 2009	Historical	3 years	740.98[1], 742, 743, 744, 745	Oct. 8, 2009 – Oct. 22, 2009
Dec. 2015	Historical	15 years	742.86[1], 742, 743, 744, 745	Dec. 26, 2015 – Jan. 17, 2016
100-year	Synthetic	100 years	742, 743, 744, 745,	N/A (duration of simulation = 24 days)

[1] Historical starting stage

Modified Model Geometry

- Calibrated model modified for use in simulating the various scenarios
- Downstream end of calibrated model truncated to just upstream of Kerr Dam
  - Removed inline structure representing Kerr Dam
  - Removed the two model cross sections downstream of Kerr Dam
- Used downstream stage boundary condition at Kerr Dam

Boundary Conditions for Scenarios

- Output from Operations Model (OM) used as boundary conditions to HEC-RAS model
  - Stage at Kerr Dam = stage hydrograph boundary condition at downstream-most cross section
  - Outflows from Pensacola Dam powerhouse = inflow hydrograph boundary condition
  - OM reports spillway flows from Pensacola Dam as a single value for each time step
    - Spillway flows divided between main and east spillways using ratio of maximum discharge capacities
      - 69 percent for main spillway as inflow boundary condition
      - 31 percent for east spillway as lateral inflow hydrograph to east spillway storage area

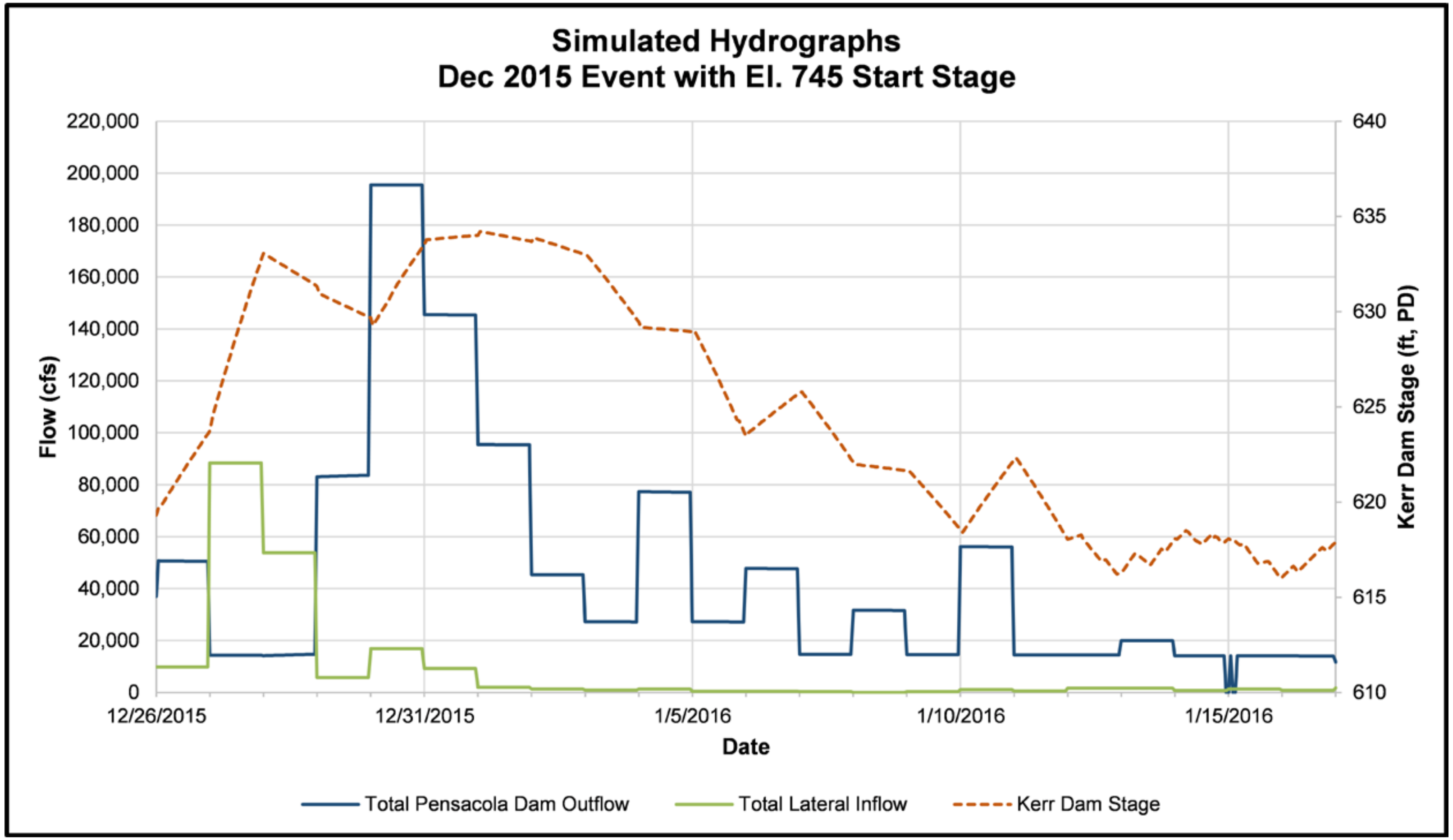
Boundary Conditions for Scenarios

- The OM reports lateral inflows between Pensacola and Kerr Dams as a single value for each time step
- For input into HEC-RAS, lateral inflows divided between tributary and local inflows based on drainage area ratios
  - Tributary inflows from Summerfield Creek, Big Cabin Creek, Spavinaw Creek and Saline Creek represented as lateral inflow hydrographs
  - Local inflow represented using a lateral inflow hydrograph distributed along the length of Lake Hudson

Lateral Inflow Component	Ratio
Summerfield Creek	0.02
Big Cabin Creek	0.41
Saline Creek	0.10
Spavinaw Creek	0.33
Local inflow	0.14

Boundary Conditions for Scenarios

Example of Model Boundary Conditions



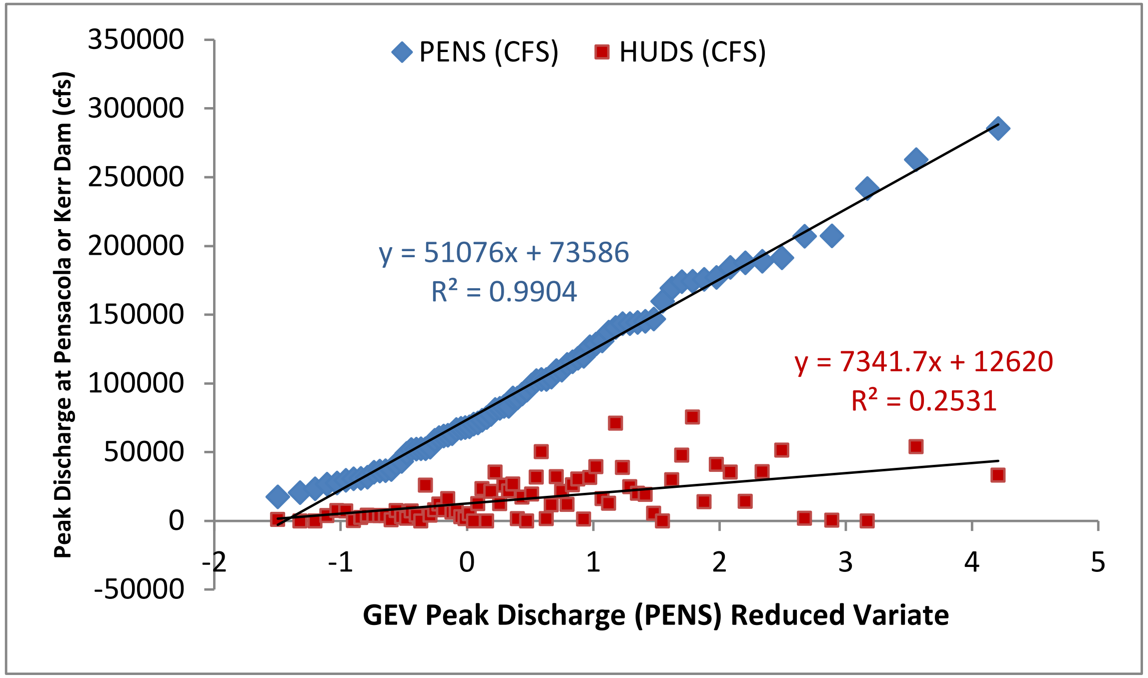
Boundary Conditions for Scenarios: 100-yr

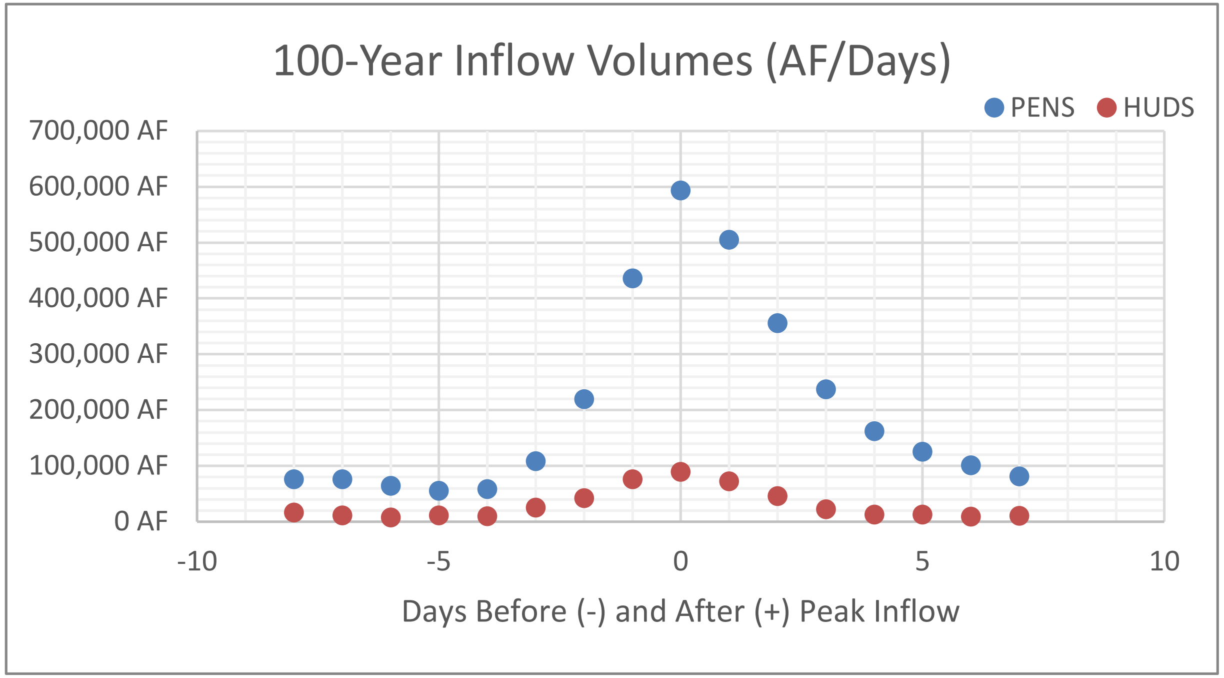
- For 100-year event, a statistical analysis of historical inflow volume was conducted to correlate lateral inflows at Lake Hudson against the peak inflows to Pensacola Dam
  - Based on coefficient of determination (R^2) best-fit calculation assuming a Generalized Extreme Value (GEV) distribution

- Analysis showed poor correlation between peak inflows at Pensacola Dam and peak inflows into Lake Hudson
  - Hydrologically independent watersheds
  - Long travel time for rainfall to reach Pensacola Dam

- Still a positive correlation between increasing peak inflow at Pensacola Dam and increasing lateral inflow to Lake Hudson

Boundary Conditions for Scenarios: 100-yr





- Resulting inflow volume curve used to develop 100-year lateral inflow to Lake Hudson
  - Drainage area ratios used to divide into local and tributary inflow hydrograph boundary conditions

Study Results

Study Results

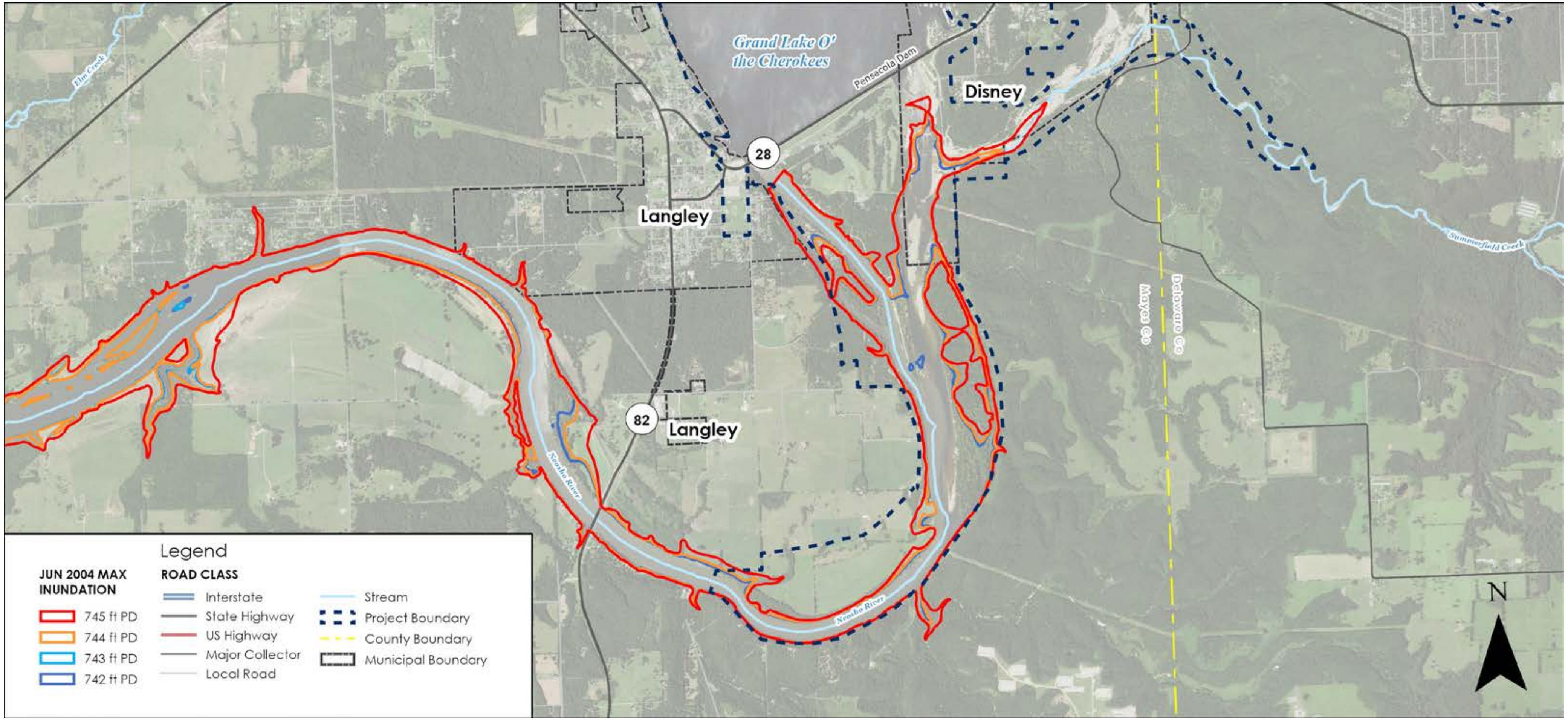
- Tabular results
  - Compare max WSELs for each event with varying starting stages at Pensacola Dam
  - Compare max WSELs using historical starting stages at Pensacola Dam

- Graphical water surface profiles
  - Same comparisons as tabular results

- Inundation Maps
  - 10 map sheets to cover study area
  - Maximum inundation extents
  - Same comparisons as tabular results

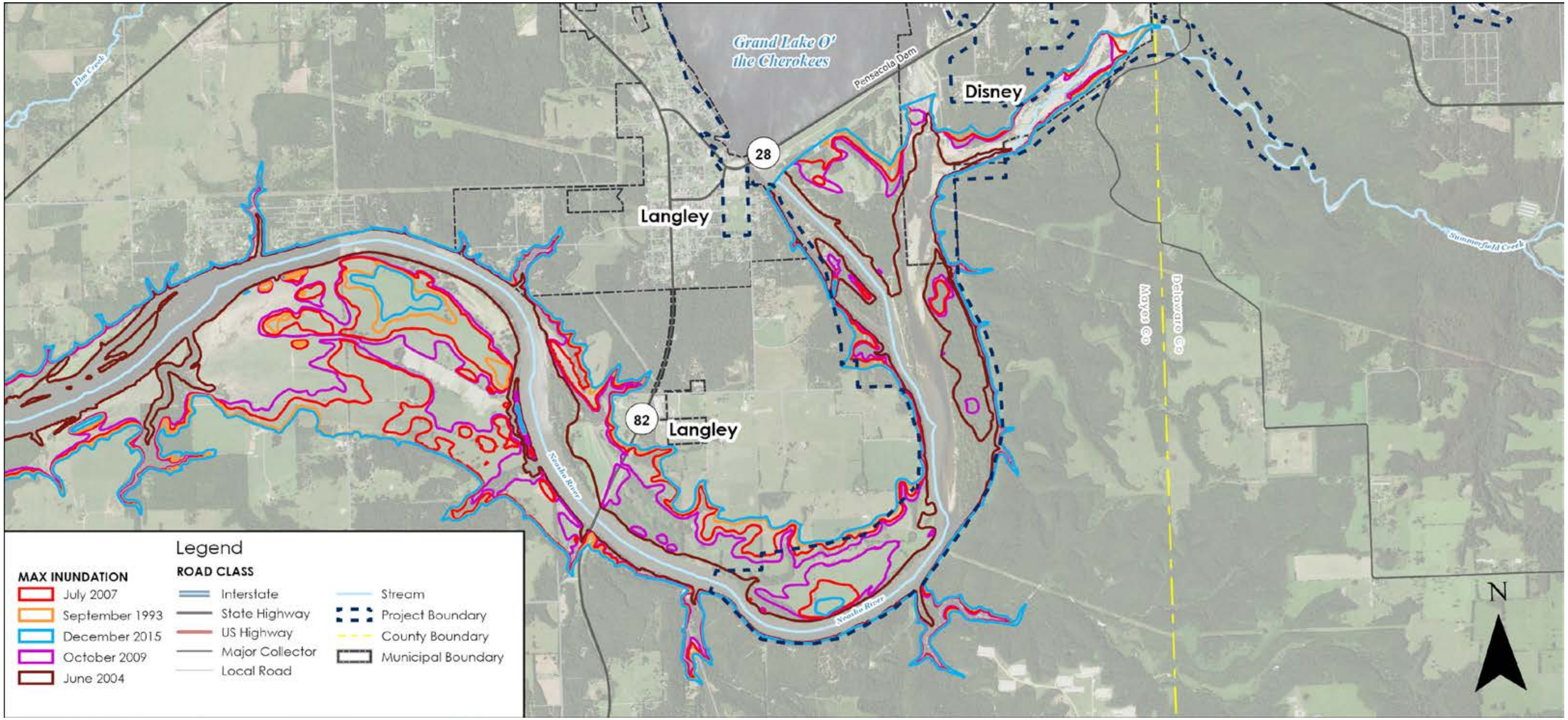
Study Results

Example of Inundation Mapping – June 2004 Event



Study Results

Example of Inundation Mapping – Historical Starting Stages



Study Results

Event	Area of Inundation (acres)		Difference (%)
	Smallest	Largest	
September 1993	18,679	19,013	1.8%
June 2004	12,202	13,005	6.4%
July 2007	17,277	18,327	5.9%
October 2009	16,276	17,851	9.3%
December 2015	18,806	19,243	2.3%
100-year	19,166	19,803	3.3%
Historical Starting Stage	12,246	19,411	45.3%

Discussion of Results

September 1993 Event

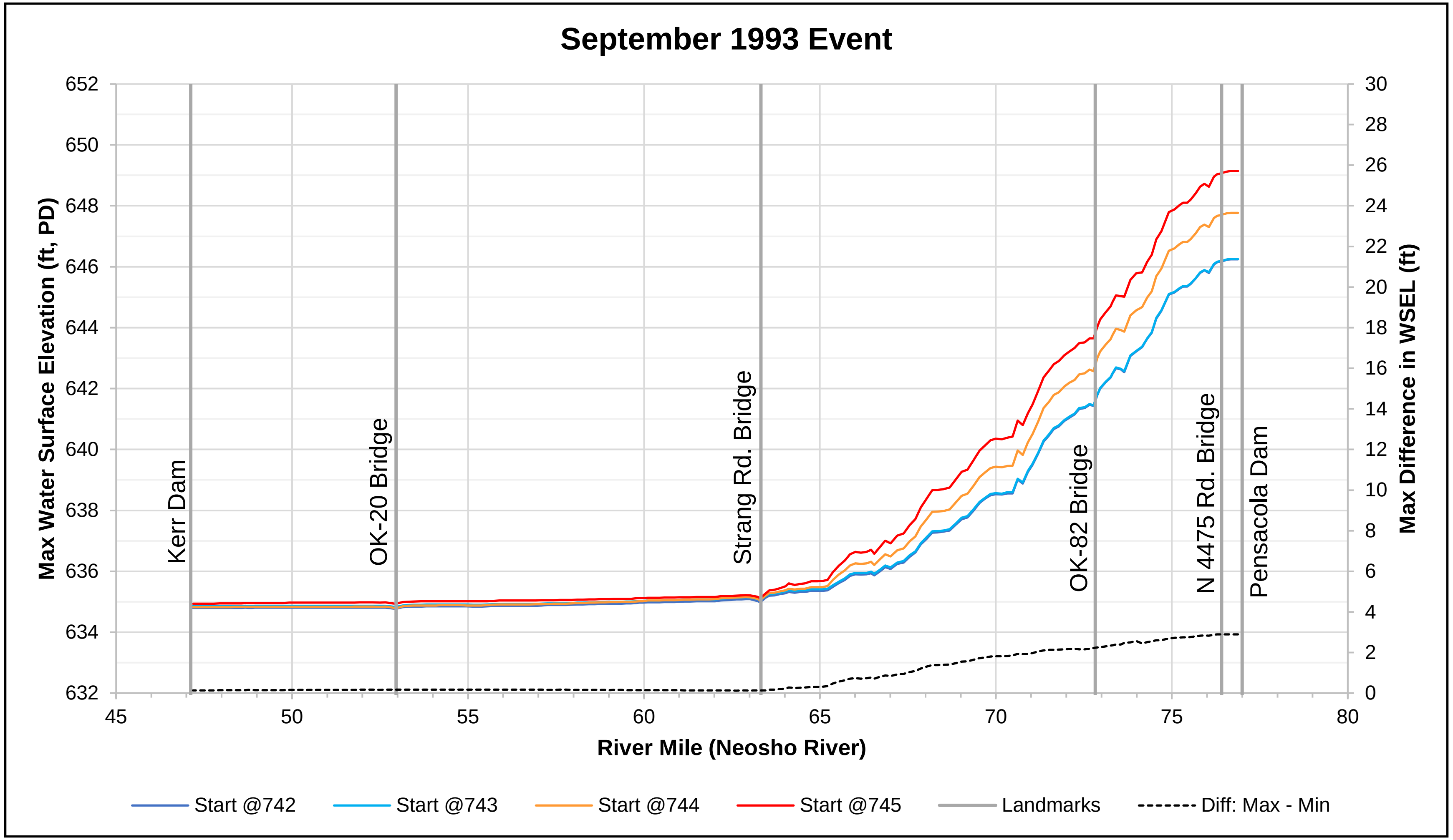
- Third largest maximum releases from Pensacola Dam of events analyzed
  - Largest release for 745 feet PD starting stage
  - Smallest release for 742 feet PD starting stage

- Highest peak stage at Kerr Dam coincides with largest release from Pensacola Dam
  - Peak stages only differ slightly

- Variability in releases -> differences in max WSEL and inundation in upper portion of model

- Smaller differences in max WSEL and inundation in downstream portion of model
  - No appreciable differences in maximum inundation

September 1993 Event



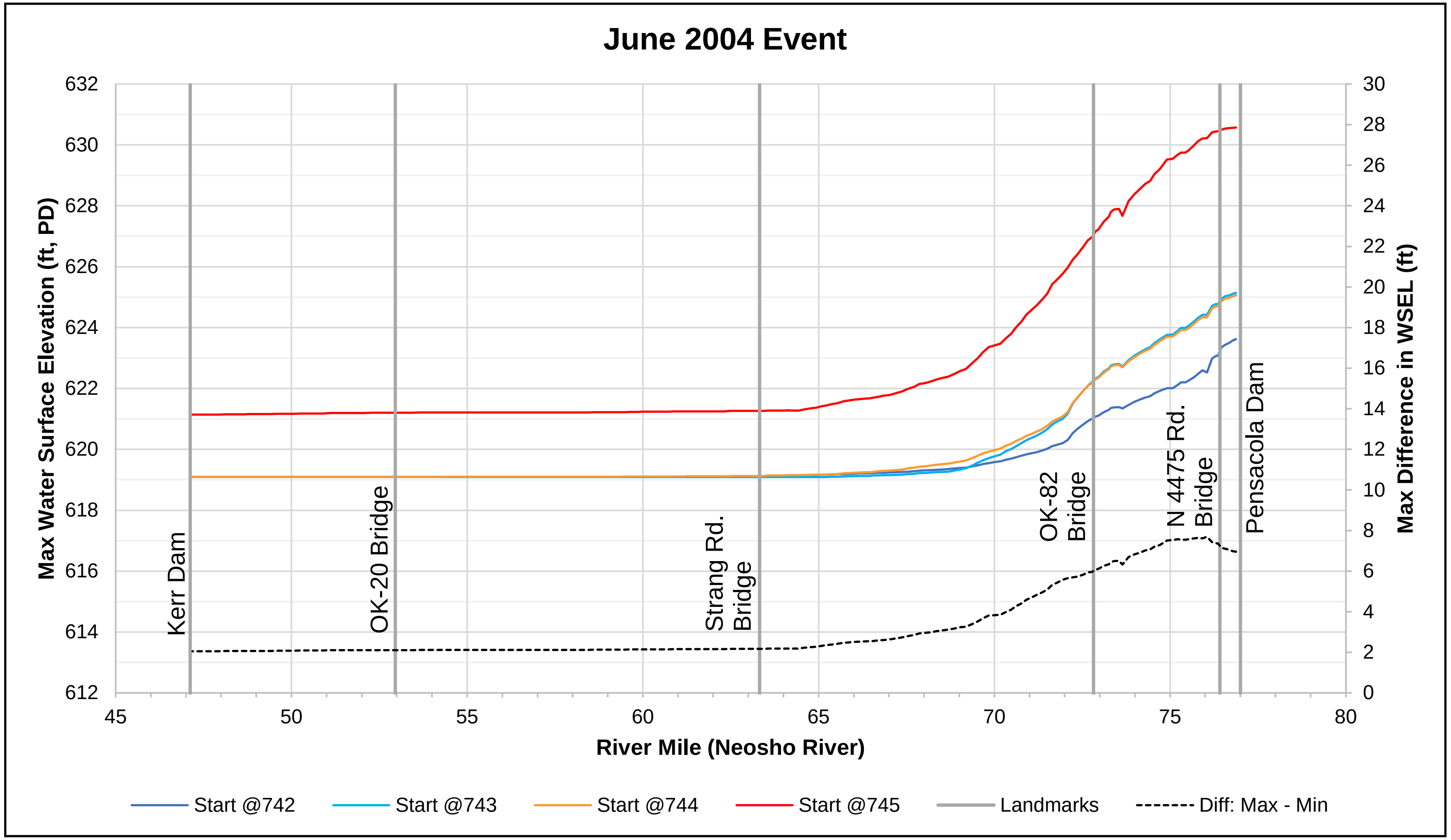
June 2004 Event

- Smallest releases from Pensacola Dam of events analyzed
  - Largest release for 745 feet PD starting stage
  - Smallest release for 742 feet PD starting stage

- Peak stages at Kerr Dam:
  - Highest peak stage coincides with largest release from Pensacola Dam
  - Lowest peak stage for 742-, 743-, and 744-feet PD starting stages (identical)

- Variability in releases -> differences in max WSEL and inundation in upper portion of model

June 2004 Event



July 2007 Event

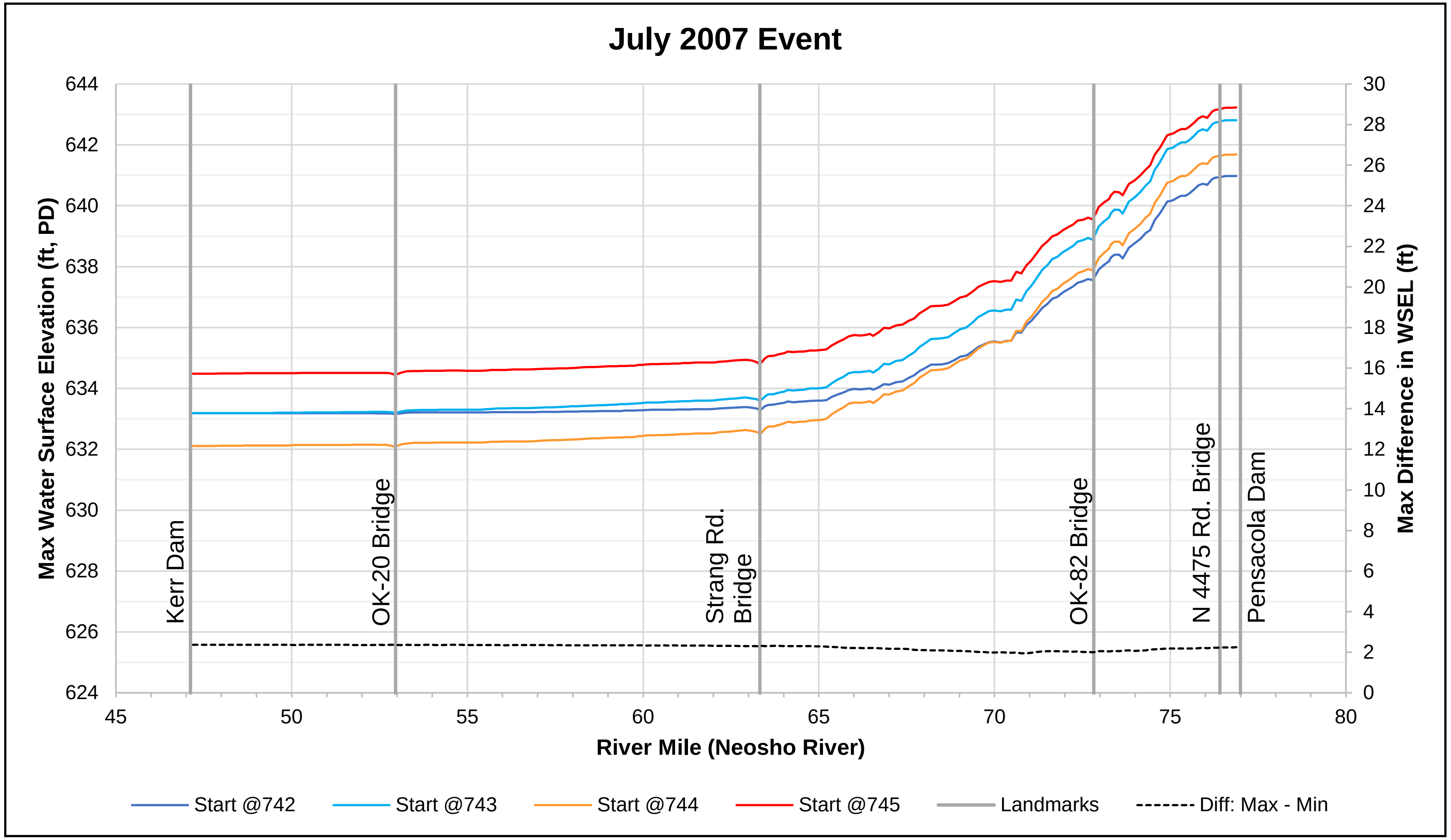
- Third smallest releases from Pensacola Dam of events analyzed
  - Largest release for 745 feet PD starting stage
  - Smallest release for 742 feet PD starting stage

- Peak stages at Kerr Dam don't follow trend of releases from Pensacola Dam
  - Highest peak stage for 745 feet PD starting stage
  - Lowest peak stage for 744 feet PD starting stage

- Nearly uniform differences in Max WSELs throughout model

- Differences in max inundation extents not uniform throughout model
  - More pronounced in upper portion (flatter floodplain)

July 2007 Event



October 2009 Event

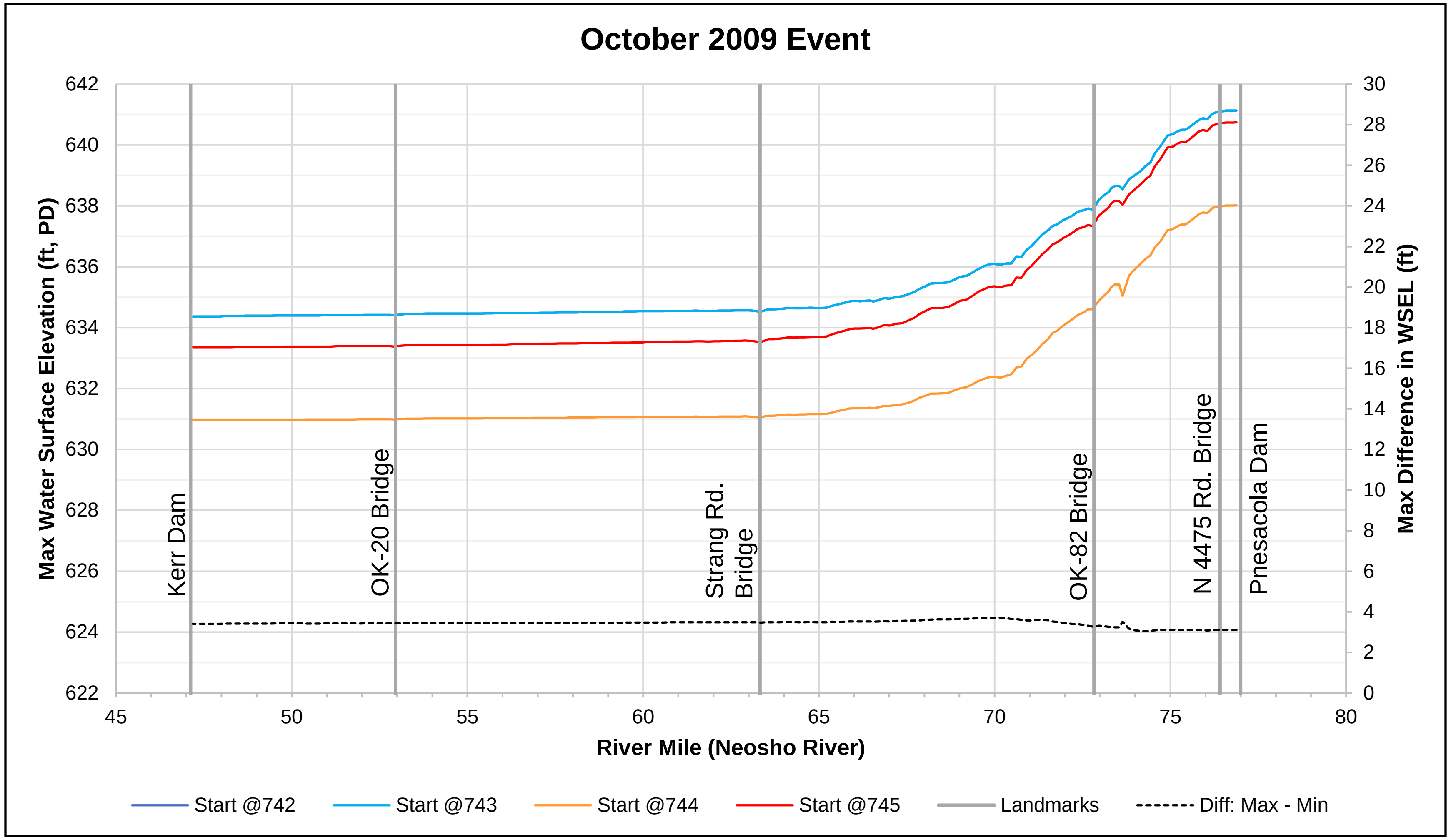
- Second smallest releases from Pensacola Dam of events analyzed
  - Largest release for 742 feet PD starting stage
  - Smallest release for 744 feet PD starting stage

- Highest peak stage at Kerr Dam coincides with largest release from Pensacola Dam
  - Differ by 3.4 feet between 744 versus 742 feet PD starting stages

- Nearly uniform differences in max WSELs throughout the model

- Differences in max inundation extents not uniform throughout model
  - More pronounced in upper portion (flatter floodplain)

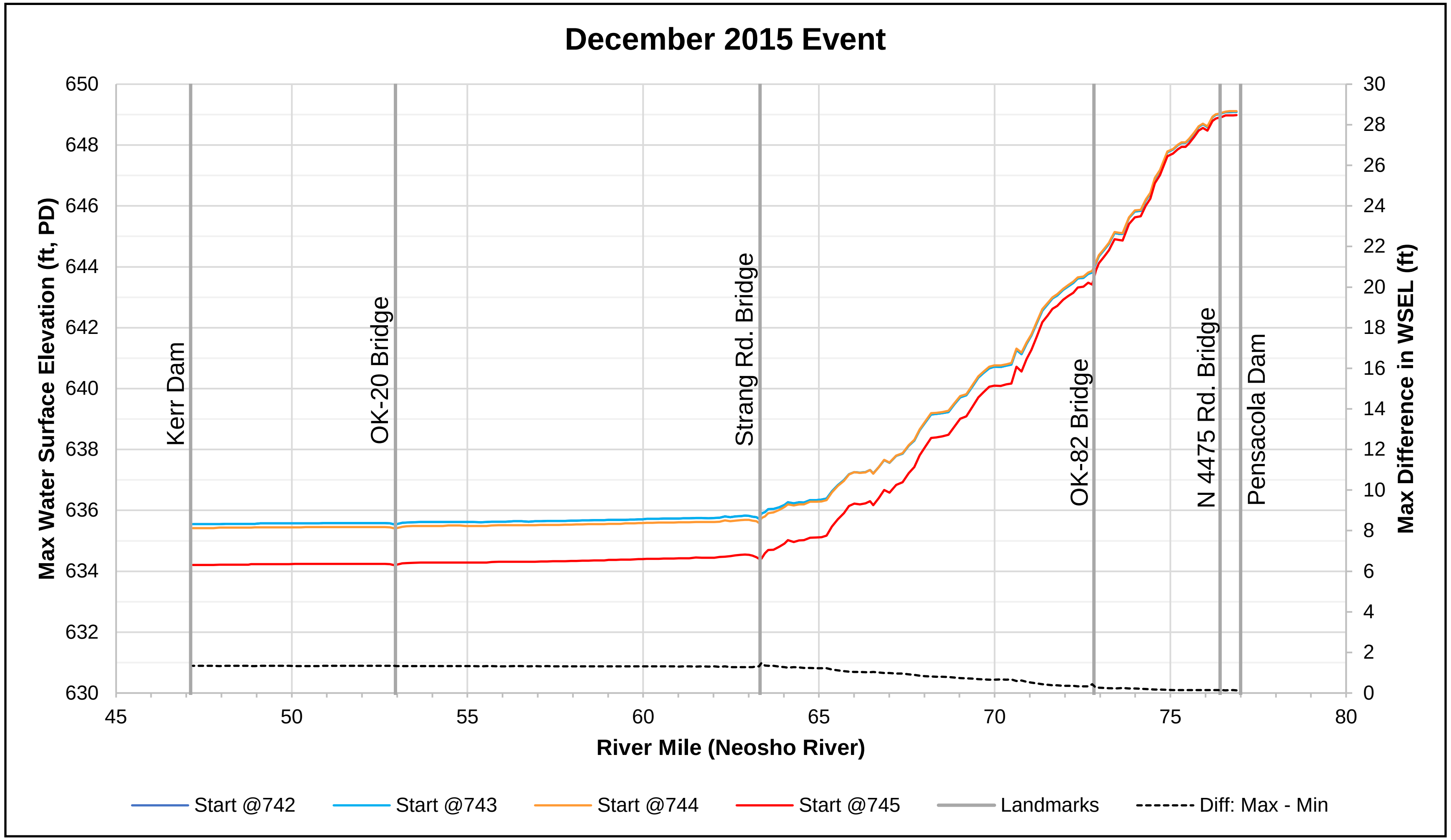
October 2009 Event



December 2015 Event

- Second largest releases from Pensacola Dam of events analyzed
  - Peak releases nearly identical for all starting stages
- Peak stages at Kerr Dam differ by maximum of approximately 1.3 feet
  - 742- and 743-feet PD starting stages produce highest peak stage
  - Inconsistency could be due to limitations with the Operations Model
- Differences in Max WSEL:
  - Small in upper portion of model
  - More pronounced in lower portion of model (approx. 1.3 feet at Kerr Dam)
- Max inundation extents nearly identical except for 745-foot starting stage
  - Differences in max inundation extents don't vary significantly throughout model

December 2015 Event



100-year Event

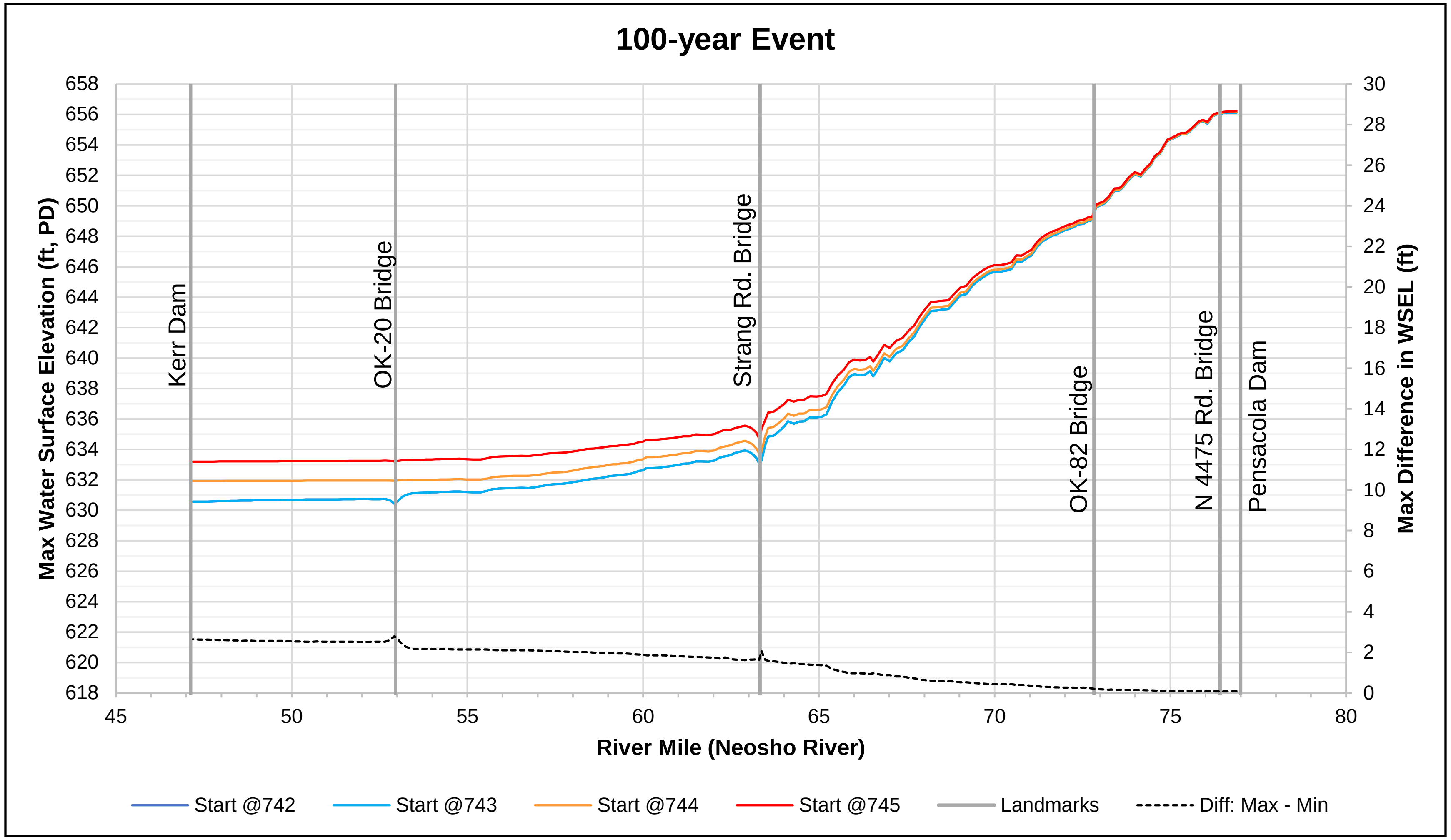
- Largest releases from Pensacola Dam of events analyzed
  - Peak releases identical for all starting stages

- Peak stages at Kerr Dam differ by maximum of approximately 2.6 feet
  - Highest peak stage for 745-foot PD starting stage
  - Lowest peak stage for 742-foot PD starting stage

- Differences in Max WSEL:
  - Small in upper portion of model
  - More pronounced differences in lower portion of model (approx. 2.6 feet at Kerr Dam)

- Max inundation extents nearly identical except for 745-foot starting stage
  - Differences in max inundation extents vary the most in upper portion of model

100-year Event



Compare Historical Starting Stages

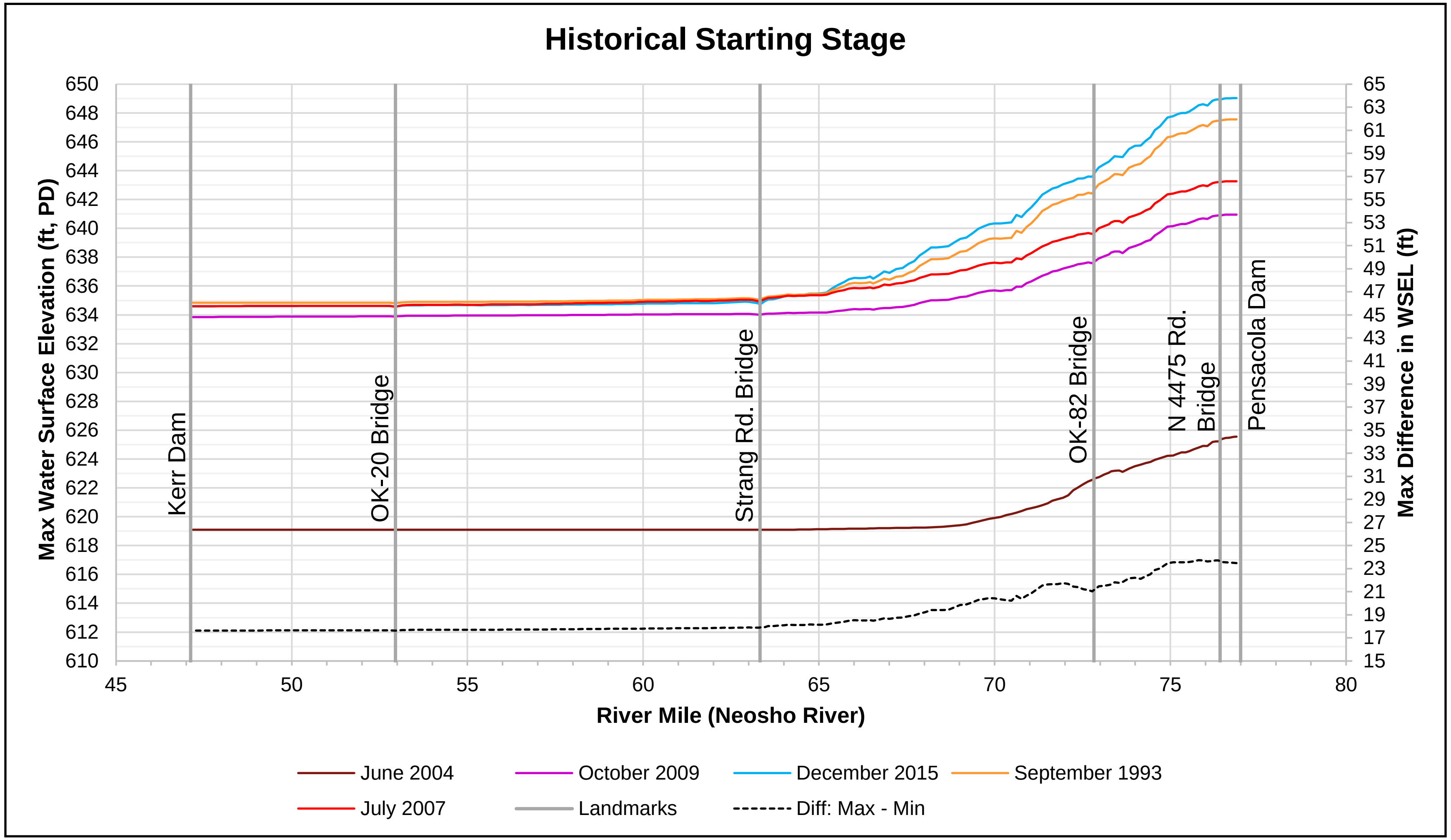
- Releases from Pensacola Dam vary significantly between all the flow events using historical starting stages
  - Lowest of 23,000 cfs for June 2004 event
  - Highest of 195,000 cfs for December 2015 event

- Peak stages at Kerr Dam differ by approximately 15.8 feet

- Large differences in maximum WSELs throughout the model
  - Larger differences through upstream portion of the model

- Differences in max inundation extents throughout the model
  - Most pronounced through upper portion of model

Compare Historical Starting Stages



Conclusions

Conclusions

- Initial stages at Pensacola Dam have an influence on downstream WSELs and out-of-bank inundation

- Out-of-bank inundation is result of spillway releases directed by USACE
  - Section 7 of 1944 Flood Control Act: USACE responsible for flood control operations
  - Arkansas River Basin Water Control Master Manual: System balancing of flood storage
  - Section 7612 (c) of National Defense Authorization Act of Fiscal Year 2020: "The Secretary [of the Army] shall have exclusive jurisdiction and responsibility for management of the flood pool for flood control operations at Grand Lake O' the Cherokees"

- Known limitations and planned improvements to the Operations Model could alter model results

Thank you

Mead & Hunt

Setting the Stage for Continued Study

Pensacola Hydroelectric Project
Project No. 1494

October 12, 2021

Presentation Outline

1. Review of Overall Study Purposes
2. Study Area for First Study Period
3. Study Results Defining Second Period Study Area
4. Study Area for Second Study Period

Overall Study Purposes

Selecting Studies to Implement.

- There shall be a nexus between Project operations and effects.
- Study results shall inform the development of license requirements.

Overall Study Purposes (continued)

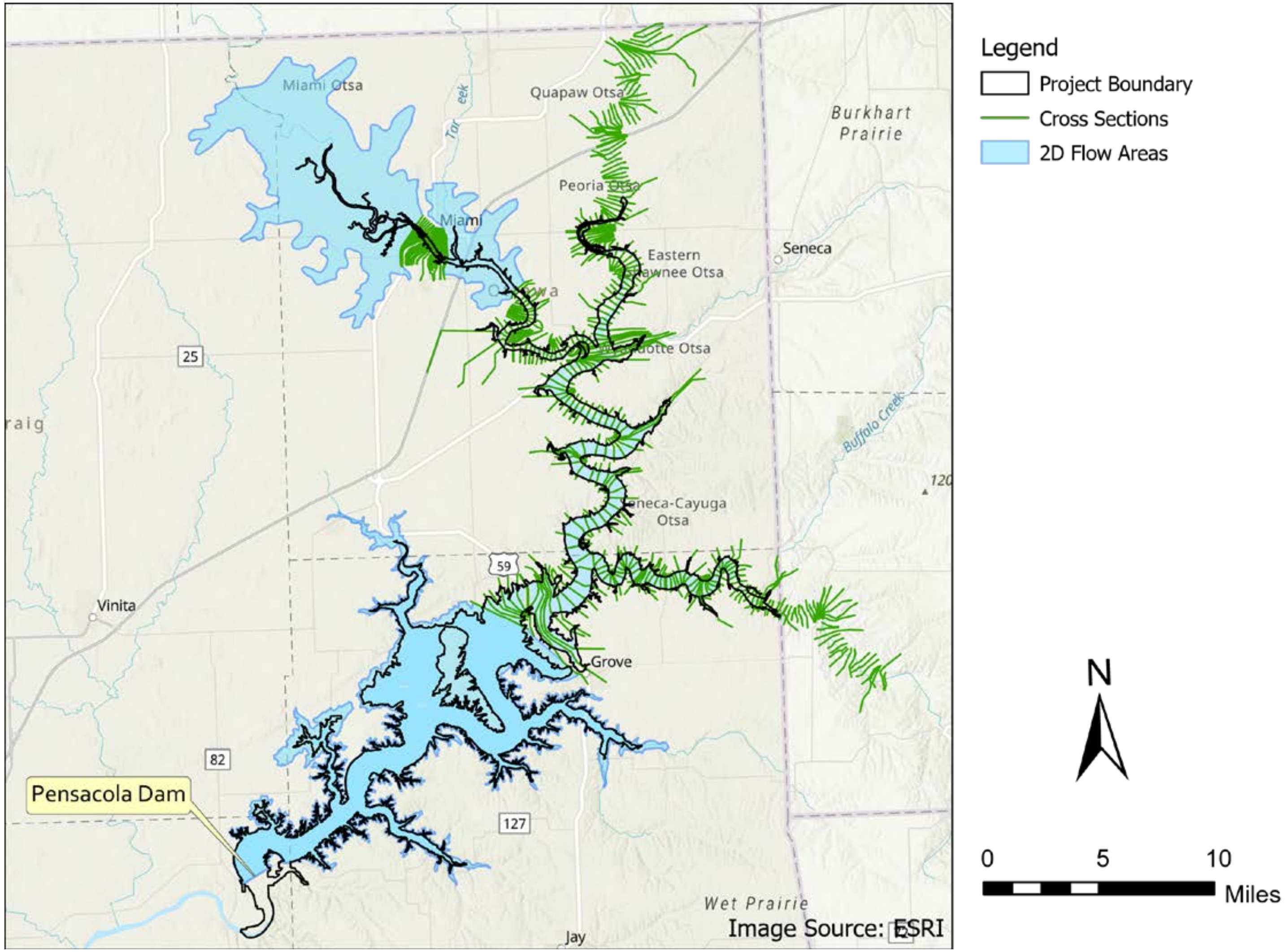
What Should Studies Accomplish?

- Address identified data needs.
- Reasonably inform analysis of effects of operation.

First Study Period Study Areas

Study	First Study Area or APE
H&H Study	Anticipated upstream and *downstream* H&H model extent.
Bathymetry	Anticipated upstream H&H model extent.
Infrastructure	
Sedimentation	
Aquatic and Terrestrial Species of Concern	
Wetlands and Riparian	
Recreation	Broad Assessment of Project Vicinity (Green Country Region) and Specific Recreation Sites.
Socioeconomic	Broad Assessment of Project Vicinity (Craig, Delaware, Mayes, and Ottawa Counties).
Cultural	APE is current Project Boundary, mapped to approximately 750 ft.

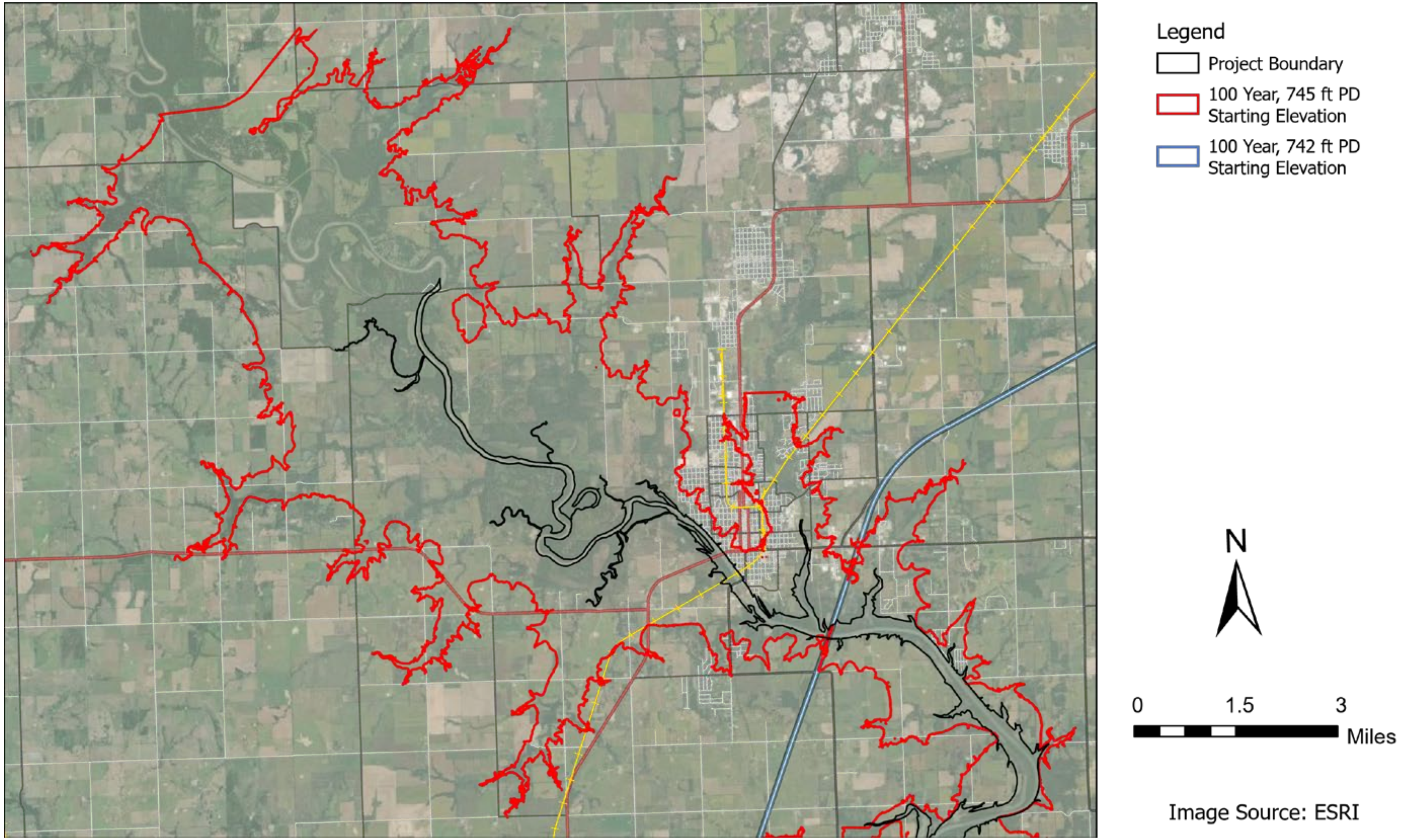
Upstream H&H Model Extent



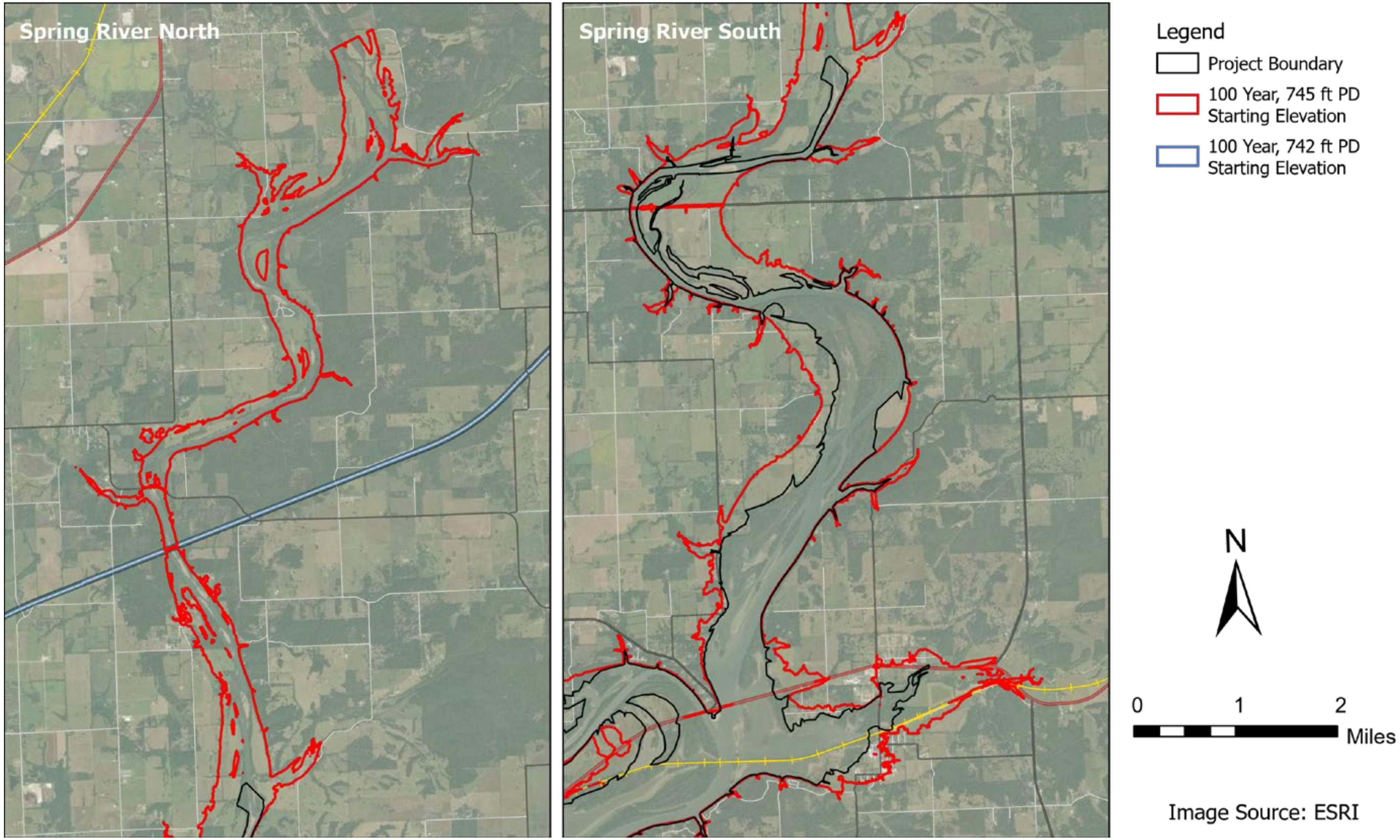
H&H Study Conclusion

The initial operating stage at Pensacola Dam has an immaterial impact on upstream water surface elevations and inundation.

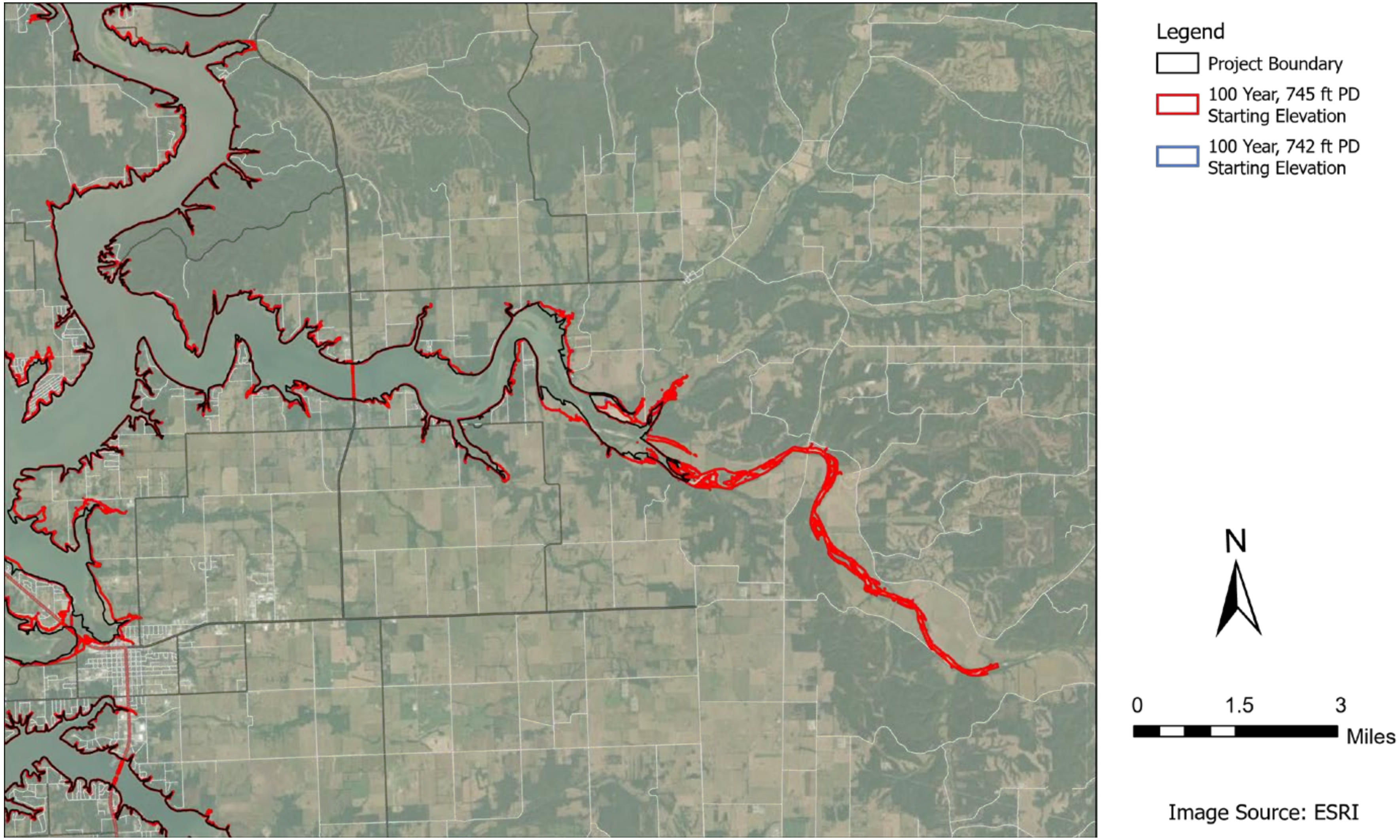
Flooding Extent Upstream (Neosho River)



Flooding Extent Upstream (Spring River)



Flooding Extent Upstream (Elk River and Buffalo Creek)



Anticipated Future Operations

1. To be developed through studies in second study period.
2. Evaluate different pool elevations up to 745 Feet PD.
3. Project boundary is approximately mapped to an elevation of 750 Feet
4. Future operations may be influenced by results of:
   - H&H Study.
   - Aquatic and Terrestrial Species of Concern Studies.
   - Wetland and Riparian Study.
   - Cultural Resources Study.
5. GRDA will indicate its anticipated future operations in the License Application.

Second Period Study Areas

Study	Second Study Period Area or APE
H&H	Create Lentic and Lotic Maps.
Sedimentation	Area impacted by anticipated future operations.
Aquatic and Terrestrial Species of Concern	Use Lentic and Lotic maps.
Wetlands and Riparian	
Cultural Resources	Continue to use Project Boundary as APE (no change from studies to date).
Recreation Facilities Inventory and Use	Complete; no second study period.
Socioeconomic	
Bathymetry	
Infrastructure	No inundation increases due to anticipated future operations: No second period study needed.

Thank you

Infrastructure Report

Pensacola Hydroelectric Project
Project No. 1494

October 12, 2021

Presentation Outline

1. Study Objectives and Schedule
2. Study Area
3. Methodology
4. Study Results
5. Discussion of Results
6. Conclusions

Study Objectives and Schedule

Study Objectives

1. In consultation with the stakeholders, determine list of infrastructure types to be included in the study. Include infrastructure types that have the potential to be flooded under USACE-directed flood control operations and GRDA's Project operations.

2. Determine range of inflow conditions for which model results show Project operations are likely to have an effect on flooding. Provide maps and tables identifying frequency and depth of flooding for each item of infrastructure under existing operations and for the range of inflow conditions where operations may have an effect on flooding.

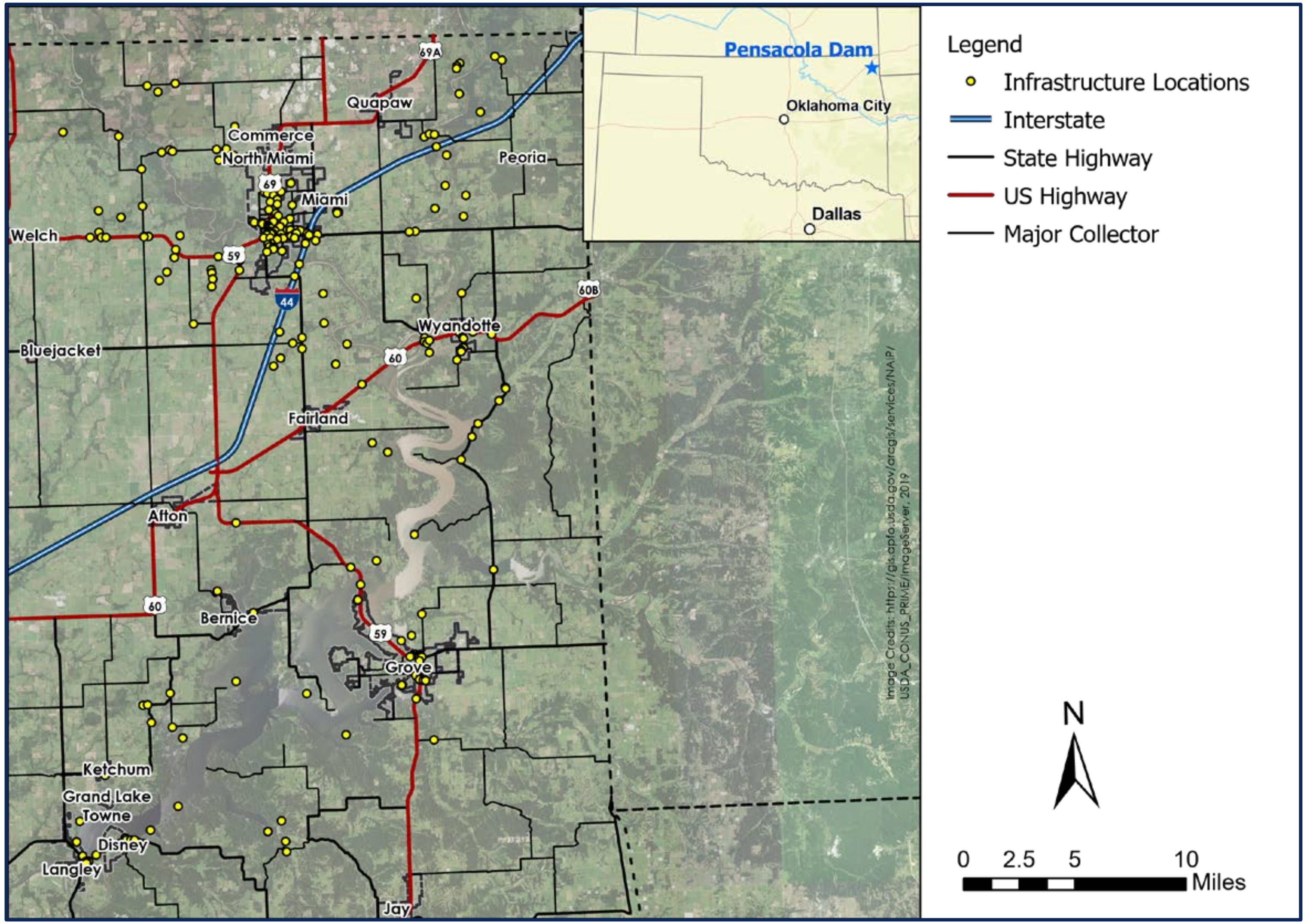
3. Provide additional maps and tabular information based on anticipated future operations.

Schedule and Tasks

STUDY SEASON	MAJOR TASKS
1	• Develop list of infrastructure types. • Consult with stakeholders to update list of infrastructure types. • Map infrastructure locations. • Determine a range of inflow conditions for which modeling results show that Project operations are likely to have an effect on frequency and depth of flooding. • Prepare maps and tabular data as part of analysis. • Develop an Initial Study Report (ISR).
2	• Stakeholder comments on the ISR are addressed.

Study Area

Study Area



Pensacola Dam
Oklahoma City
Dallas
Legend
Infrastructure Locations
Interstate
State Highway
US Highway
Major Collector
Quapaw
Commerce
North Miami
Miami
Peoria
Welch
Bluejacket
Wyandotte
Fairland
Afton
Bernice
Grove
Ketchum
Grand Lake Towne
Disney
Langley
Jay
69A
69
59
44
60
60B
N
0
2.5
5
10
Miles
Image Credits: https://gis.apfo.usda.gov/arcgis/services/NAIP/USDA_CONUS_PRIME/ImageServer, 2019

Methodology

Methodology Overview

1. Defined list of infrastructure types.
2. Gathered and mapped locations.
3. Consulted with stakeholders to refine the infrastructure list.
4. Extracted inundation characteristics from simulation results.

Infrastructure Types and Data Sources

1. Oklahoma Digital Data Online
2. United States Geological Survey (USGS) Geographic Names Information System (GNISS)
3. Environmental Protection Agency (EPA) Facility Registry Service (FRS)
4. Federal Aviation Administration (FAA)
5. Homeland Infrastructure Foundation Level Database (HIFLD)

Consultation with Stakeholders

1. Emergency Management Agencies
   - County, City, and Tribal emergency management entities contacted via email.
   - Followed up with phone calls.

2. Tribal Consultation
   - Certified return-receipt letters sent for tribal consultation.
   - If no receipt was received, additional certified letter sent, followed by phone calls.

Inflow Events Analyzed

1. Correlating a recurrence interval at each infrastructure location not feasible; flow at each location is unique based on position in the watershed.
2. Recurrence intervals at the Project can be considered when reviewing inundation depths and the criticality of each infrastructure location.
3. Flood frequency at the Project:
    1. September 1993 event: recurrence interval of 21 years.
    2. July 2007 event: recurrence interval of 4 years.
    3. December 2015 event: recurrence interval of 15 years.

Modeling Scenarios

1. September 1993 event, starting reservoir elevation of 742 ft PD
2. September 1993 event, starting reservoir elevation of 745 ft PD
3. July 2007 event, starting reservoir elevation of 742 ft PD
4. July 2007 event, starting reservoir elevation of 745 ft PD
5. December 2015 event, starting reservoir elevation of 742 ft PD
6. December 2015 event, starting reservoir elevation of 745 ft PD

Maximum Inundation Depth

1. Simulations were based on historical inflow events with modified reservoir starting elevation.
2. Real life experience during historical events:
   - Maximum inundation depth only occurred when USACE took control of Project operations pursuant to its exclusive jurisdiction under Section 7 of the Flood Control Act of 1944 (33 U.S.C. 709),
   - Except when the time of maximum inundation depth was solely a function of inflow event arrival time and not reservoir elevation.
3. Simulated maximum inundation depths for various inflow events and reservoir starting elevations:
   - Maximum inundation depths only occur when reservoir elevation is above 745 feet PD (USACE would control),
   - Except when the time of maximum inundation depth is solely a function of inflow event arrival time and not reservoir elevation.

Mapping and Tabular Data

1. Each infrastructure location assigned unique ID.
2. Maximum depths extracted from hydraulic modeling results at each infrastructure location.
3. Maps:
   - Series of 37 maps at 1:24,000 scale created for entire upstream modeling area.
   - Additional series of 5 maps at 1:12,000 scale created for developed/urbanized areas.
   - Total of 42 maps for a given inflow event.
   - Three sets of maps created, one for each inflow event.
4. Tables:
   - Maximum depths for all six simulated scenarios at each infrastructure location.
   - Difference in maximum depth for starting reservoir elevations also provided.

Study Results

Inundation Area

1. Total increase in inundation area due to starting reservoir elevation of 745 ft PD – 3 feet higher than a starting reservoir elevation of 742 feet PD – is less than 1 percent for all simulated events.

Event	Difference in Inundation Area
September 1993	0.3 %
July 2007	0.1 %
December 2015	0.6 %

Classification of Difference in Depth

Infrastructure locations with differences in depth greater than 0.1 feet were divided into three classes:

1. Class 1: greater than 0.1 feet up to 0.3 feet (>0.1 ft, <0.3 ft).
2. Class 2: greater than or equal to 0.3 feet up to 0.5 feet (≥0.3 ft, <05 ft).
3. Class 3: greater than or equal to 0.5 feet (≥ 0.5 ft).

Class 1 Differences (>0.1 ft, <0.3 ft)

Infrastructure ID	Map Panel	Location	Difference in Depth (ft)		
			Sept. 1993 event	July 2007 event	Dec. 2015 event
57	B4, B4-3	Rockdale Blvd Bridge	0.2	0.1	0.0
94	B4, B4-3	Lion Taylor Park	0.2	0.1	0.0
97	B4, B4-4	Little Elm Creek Bridge	0.2	0.1	0.2
103	B4, B4-3	Riverview Park South	0.1	0.1	0.2

Class 2 Differences (≥0.3 ft, <05 ft)

Infrastructure ID	Map Panel	Location	Difference in Depth (ft)		
			Sept. 1993 event	July 2007 event	Dec. 2015 event
127	C4	Hudson Creek Bridge	0.1	0.4	0.3
150	C6	Wyandotte High School	0.1	0.4	0.3

Class 3 Differences (≥ 0.5 ft)

Infrastructure ID	Map Panel	Location	Difference in Depth (ft)		
			Sept. 1993 event	July 2007 event	Dec. 2015 event
139	C5	Twin Bridges State Park	0.1	0.7	0.4
140	C6	Shawnee Branch Bridge	0.1	0.7	0.2
166	E3	Fly Creek Bridge	0.0	0.0	0.5
167	E3	Bernice State Park	0.0	0.1	0.5
175	F3	Cherokee Seaplane Base	0.0	0.1	0.5
181	F5	Wolf Creek Park	-0.1	0.0	0.5
185	F5	Grove Springs Park	0.0	0.1	0.5
206	G3	Bacon’s Heliport	0.0	0.1	0.5

Discussion of Results

Results Discussed

1. Only selected results are presented due to time constraints and because the results are so similar at nearly all the locations with Class 1, Class 2, or Class 3 differences.
2. Report contains full descriptions of each location with Class 1, Class 2, or Class 3 differences.
3. In report, the inflow event that causes the largest difference in depth is discussed first, followed by discussion of difference in depth for the other two inflow events.
4. **For all locations, any increased depth resulting from a starting reservoir elevation of 745 feet does not result in any additional loss of infrastructure use.**

Class 1 Example

Rockdale Boulevard Bridge (ID 57)

Class 1 Example

Rockdale Boulevard Bridge (ID 57)

- September 1993 event:
  - Inundated by 1.3 feet of water for September 1993 event if starting reservoir elevation is 742 feet.
  - Inundation depth increases to 1.5 feet if starting reservoir elevation is 745 feet.
  - Infrastructure location is inundated regardless of starting reservoir elevation.
- July 2007 event: inundated in either scenario (6.7 feet of depth vs 6.8 feet of depth)
- December 2015 event: not inundated in either scenario.
- For all three inflow events, increasing the starting reservoir elevation from 742 feet to 745 feet does not result in additional loss of infrastructure use.

Class 1 Summary

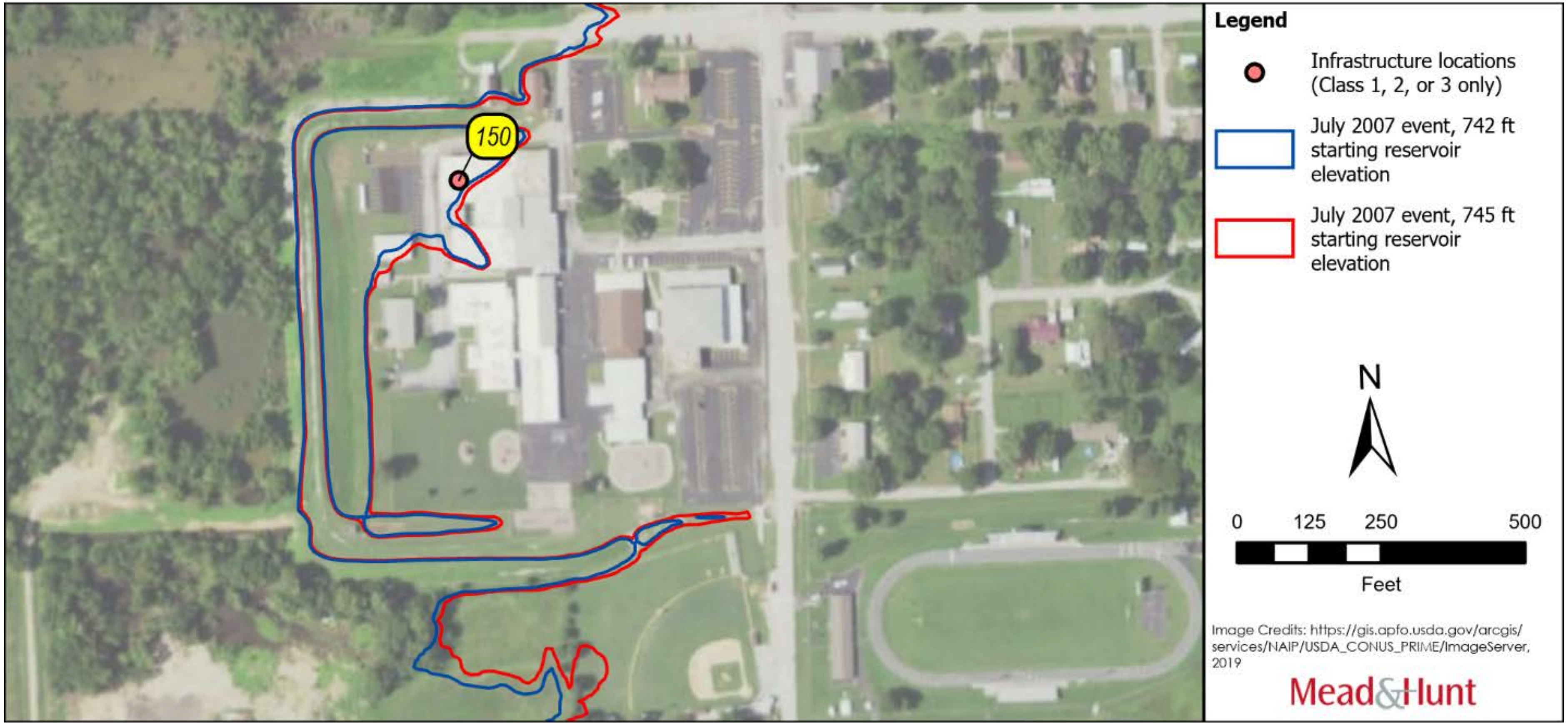
1. For two Class 1 locations (**Rockdale Boulevard Bridge** and **Lion Taylor Park**), the December 2015 event does not inundate the location for either scenario.

2. For the remaining Class 1 locations (**Little Elm Creek Bridge** and **Riverview Park South**), all three events inundate the infrastructure.

3. For all Class 1 locations, any increased depth resulting from a starting reservoir elevation of 745 feet does not result in any additional loss of infrastructure use.

Class 2 Example

Wyandotte High School (ID 150)



Class 2 Example

Wyandotte High School (ID 150)

- July 2007 event:
  - Inundated by 0.6 feet of water for July 2007 event if starting reservoir elevation is 742 feet.
  - Inundation depth increases to 1.0 feet if starting reservoir elevation is 745 feet.
  - Infrastructure location is inundated regardless of starting reservoir elevation.
- September 1993 event: inundated in either scenario (2.2 feet of depth vs 2.3 feet of depth)
- December 2015 event: inundated in either scenario (2.1 feet of depth vs 2.4 feet of depth).
- For all three inflow events, increasing the starting reservoir elevation from 742 feet to 745 feet does not result in additional loss of infrastructure use.

Class 2 Summary

1. There is only one other Class 2 location: **Hudson Creek Bridge**. The bridge is inundated for all three inflow events.
2. For both Class 2 locations, any increased depth resulting from a starting reservoir elevation of 745 feet does not result in any additional loss of infrastructure use.

Class 3 Example

Twin Bridges State Park (ID 139)

Class 3 Example

Twin Bridges State Park (ID 139)

- July 2007 event:
  - Inundated by 7.8 feet of water for July 2007 event if starting reservoir elevation is 742 feet.
  - Inundation depth increases to 8.5 feet if starting reservoir elevation is 745 feet.
  - Infrastructure location is inundated regardless of starting reservoir elevation.
- September 1993 event: inundated in either scenario (12.4 feet of depth vs 12.5 feet of depth)
- December 2015 event: inundated in either scenario (10.0 feet of depth vs 10.4 feet of depth).
- For all three inflow events, increasing the starting reservoir elevation from 742 feet to 745 feet does not result in additional loss of infrastructure use.

Class 3 Summary

1. For the remaining Class 3 locations (**Shawnee Branch Bridge**, **Fly Creek Bridge**, **Bernice State Park**, **Cherokee Seaplane Base**, **Wolf Creek Park**, **Grove Springs Park**, and **Bacon's Heliport**), all three events inundate the infrastructure.
2. **Bacon's Heliport** is unique because it is a floating structure. Depths reported in the Infrastructure Report for **Bacon's Heliport** are based on DEM elevations.
3. For all Class 3 locations, any increased depth resulting from a starting reservoir elevation of 745 feet does not result in any additional loss of infrastructure use.

Conclusions

Conclusions

1. Only 6% of infrastructure locations experience an appreciable increase in maximum inundation depth due to a starting reservoir elevation increase from 742 feet to 745 feet (PD datum).
2. All appreciable increases in maximum inundation depth occur during high-flow conditions when USACE controls flood control operations under the Flood Control Act of 1944, except when the time of maximum inundation depth is solely a function of inflow event arrival time and not reservoir elevation.
3. Therefore, no additional impacts exist due to Project operation.

Thank you

Attachment C

Study Report Presentations

October 13, 2021

Grand River Dam Authority
Initial Study Report Meeting
Pensacola Project (1494)

October 12-14, 2021

Housekeeping Items

- Meeting is being recorded
- Mute your lines
- Utilize the “raise your hand” feature to ask a question
- If audio issues exist, please use the “chat” feature
- Participant discussion and dialogue are encouraged
- Lunch will be from 12:00-1:00 PM
- If an individual study presentation finishes early, we will proceed with the next agenda item

Purpose of Meeting

- Describe GRDA's overall progress in implementing its relicensing study plan
- Results for each study to date will be presented
- A meeting summary will be filed with FERC by October 30, 2021
- The meeting summary will include only the meeting agenda and presentations
- All stakeholder comments must be submitted in writing
- The deadline for filing all written comments or questions is November 29, 2021

Remaining Relicensing Study Schedule

Activity	Responsible Party	Commission Deadline
File Initial Study Report (ISR)	GRDA	September 30, 2021
Hold ISR meeting (meeting on study results and any proposals to modify study plan)	GRDA	October 15, 2021
File ISR Meeting Summary	GRDA	October 30, 2021
File Meeting Summary Disagreements	Stakeholders	November 29, 2021
File Responses to Disagreements	GRDA	December 29, 2021
Commission Resolution of Disagreements (if necessary)	FERC	January 28, 2022
Second Field Season	GRDA	November 2021-September 2022
File Updated Study Report (USR)	GRDA	September 30, 2022
Hold USR Meeting	GRDA	October 15, 2022
File USR Meeting Summary	GRDA	October 30, 2022
File Meeting Summary Disagreements	Stakeholders	December 29, 2022
Commission Resolution of Disagreements (if necessary)	FERC	January 28, 2023
File Draft License Application (DLA)	GRDA	January 1, 2023

Questions?

Grand Lake Sedimentation Study Initial Study Report

October 13th, 2021

Anchor QEA
Simons & Associates

ANCHOR QEA

GRDA

Simons & associates

Outline

- Overview of study
- Water level monitoring
- Sediment sampling
  - Grab samples
  - SEDflume sampling
  - Transport measurements
- Model development
  - Planned procedure
  - Hydraulic calibration
  - Challenges
  - Sediment calibration

Study Overview

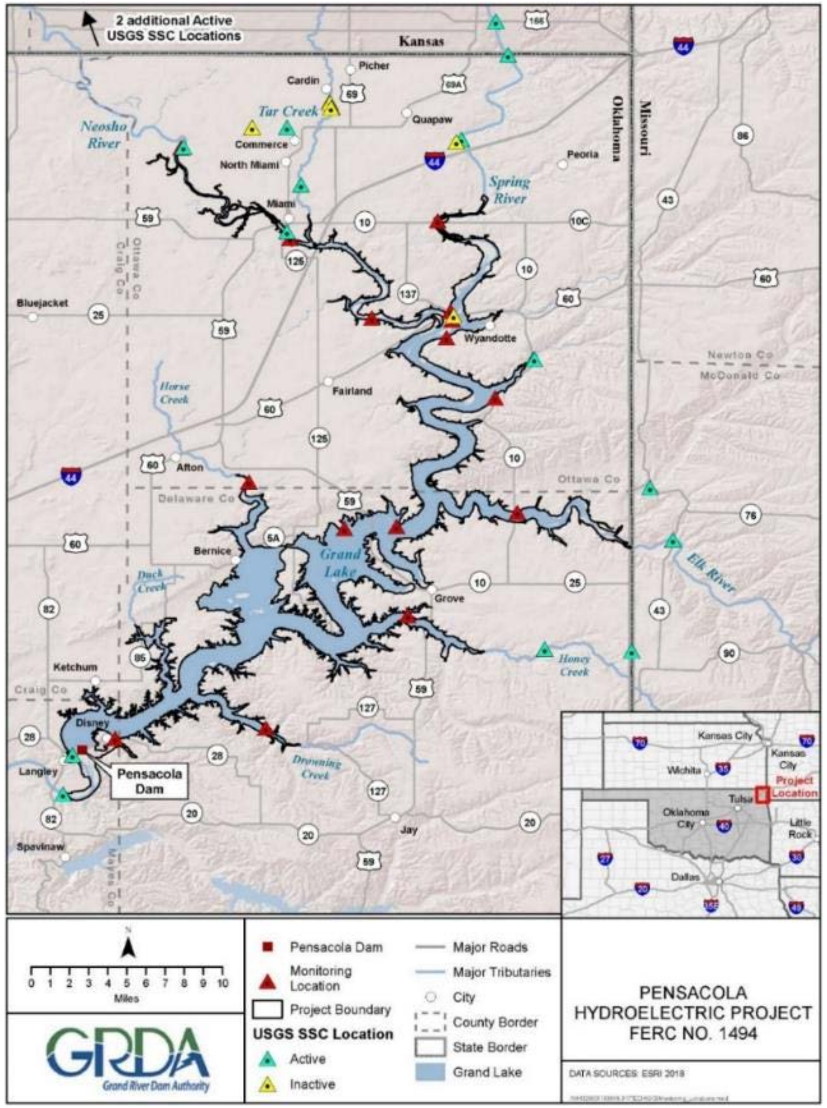
- Pensacola Hydroelectric Project going through FERC relicensing process
- Evaluate water levels throughout the watershed
  - Upstream Hydrologic Model (UHM) developed as part of the H&H Study by Mead & Hunt
  - Water level monitoring to calibrate UHM
- Evaluate overall trends and impacts of sedimentation
  - Accumulation in reservoir affects flood storage
  - Accretion/erosion in upstream reaches may affect future stream flows
- Sediment Transport model (STM) to evaluate sedimentation
  - Requires additional inputs & field sampling
    - Sediment parameters on streambeds
    - Sediment inflow volumes
  - Model will predict future deposition & erosion

Outline

- Overview of study
- Water level monitoring
- Sediment sampling
  - Grab samples
  - SEDflume sampling
  - Transport measurements
- Model development
  - Planned procedure
  - Hydraulic calibration
  - Challenges
  - Sediment calibration

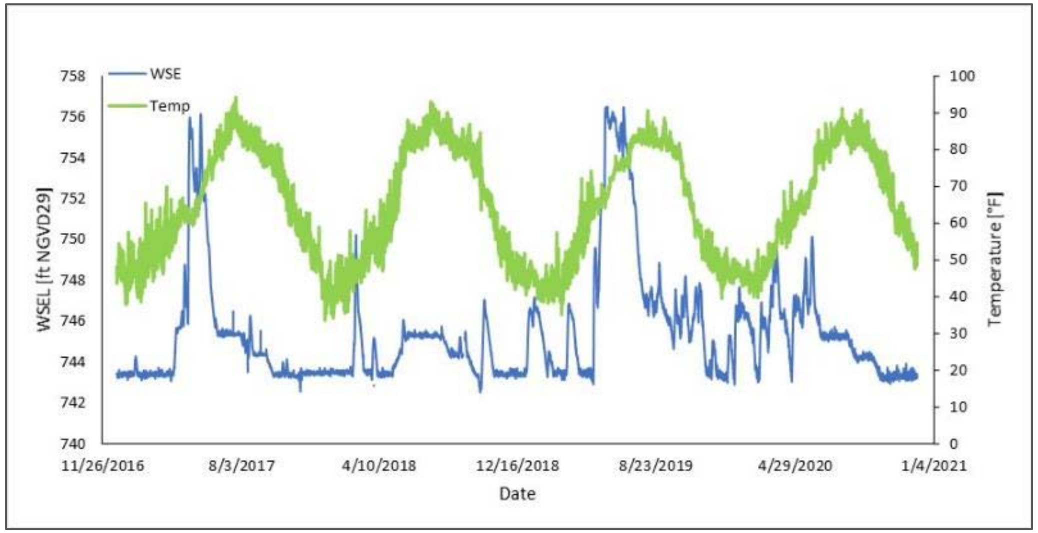
Water Surface Monitors

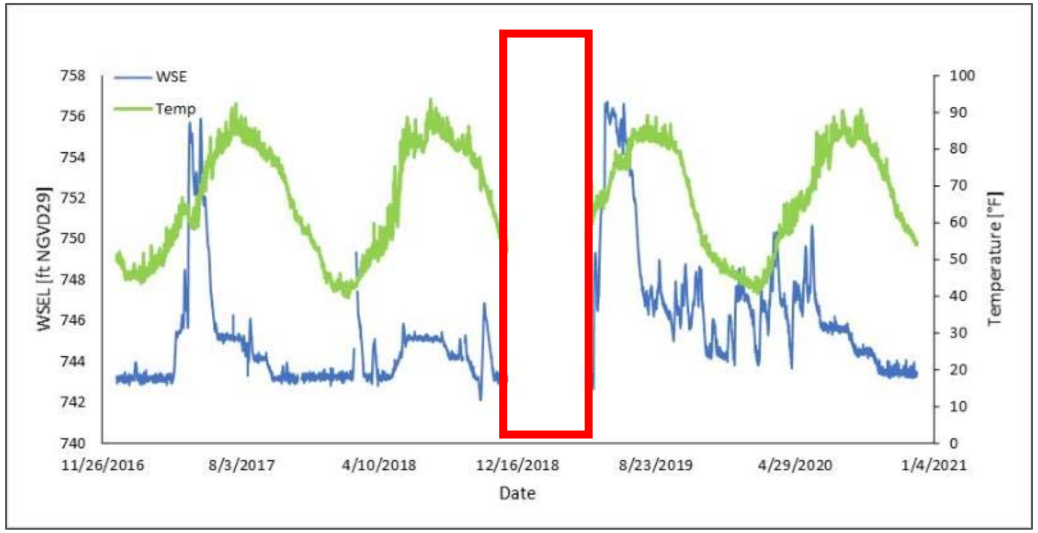
- Installed at 16 locations
  - Dec 2016



Water Surface Monitors

- Installed at 16 locations
  - Dec 2016
- Retrieved
  - Aug 2017
  - Mar 2018
  - Apr 2019
  - Dec 2020
- Data gaps in some records
  - Loggers washed away, vandalized
  - Inaccessible due to high water levels





Outline

- Overview of study
- Water level monitoring
- Sediment sampling
  - Grab samples
  - SEDflume sampling
  - Transport measurements
- Model development
  - Planned procedure
  - Hydraulic calibration
  - Challenges
  - Sediment calibration

Sediment Grab Sampling

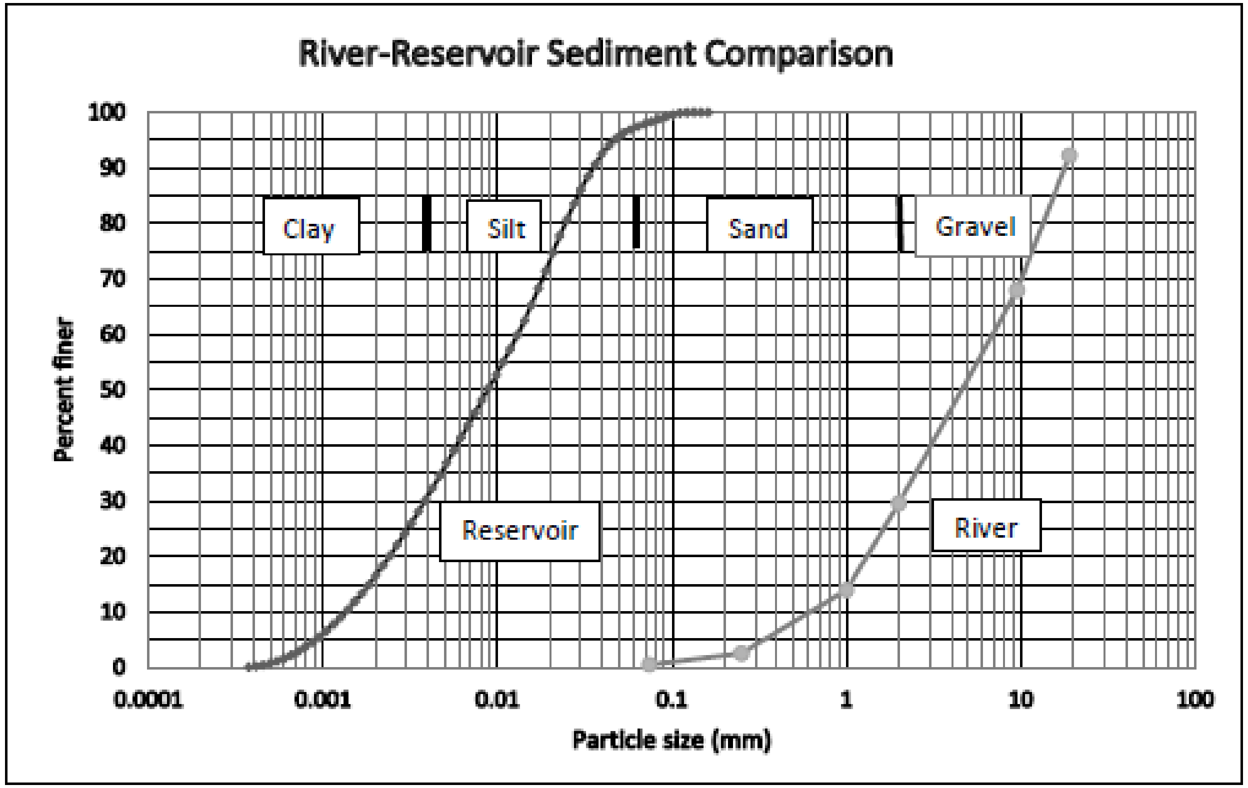
- 62 surface sediment samples collected Dec 2019

Location	Samples per Study Plan	Samples Collected
Neosho Upstream of Miami	2	3
Neosho Miami – Wyandotte	5	17
Neosho Downstream of Wyandotte	3	9
Tar Creek	10	13
Spring River	10	10
Sycamore Creek	0	1
Elk River	0	8
Horse Creek	0	1
TOTAL	**30**	**62**

- Results showed mix of gravel & cohesive material

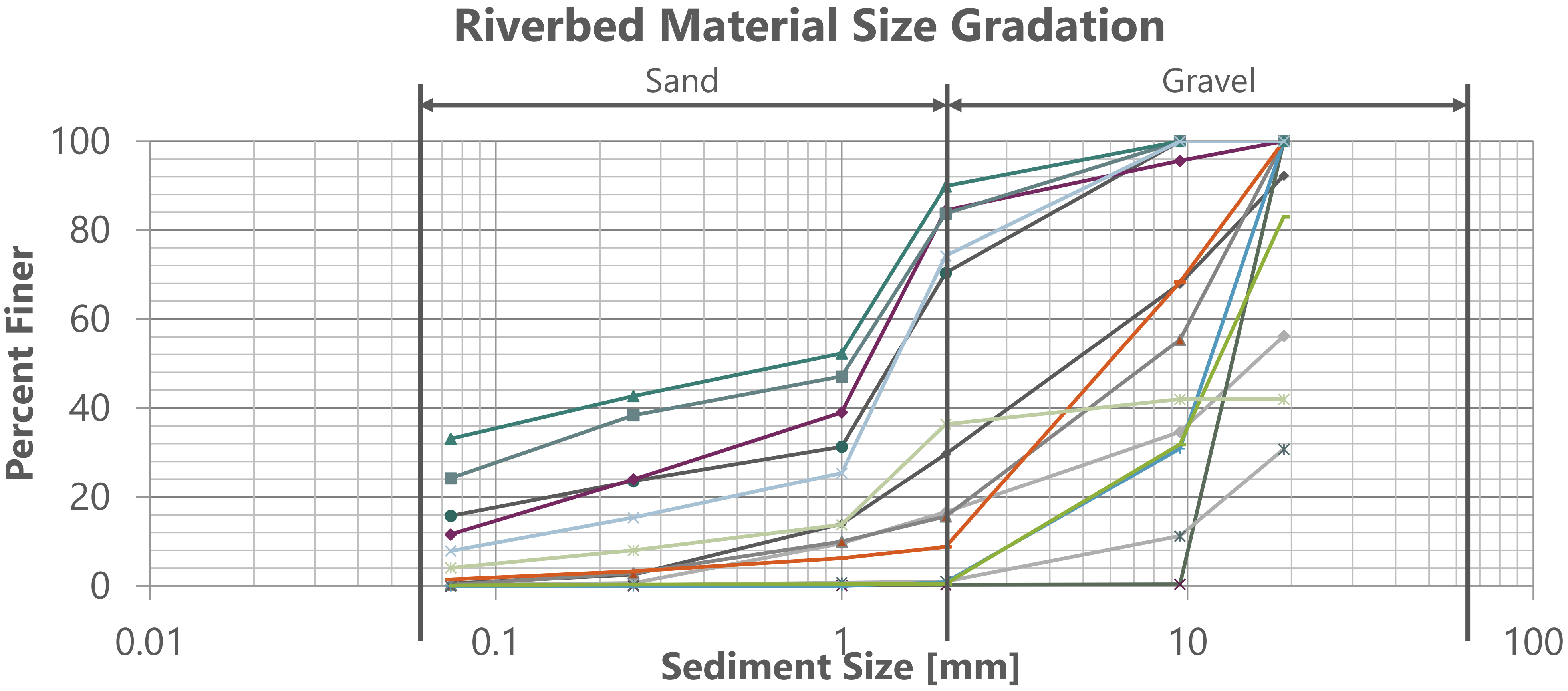
Bed Material Analysis: Bimodal Distribution

- Riverbed: Primarily gravel & sand
- Lakebed: Primarily silt & clay



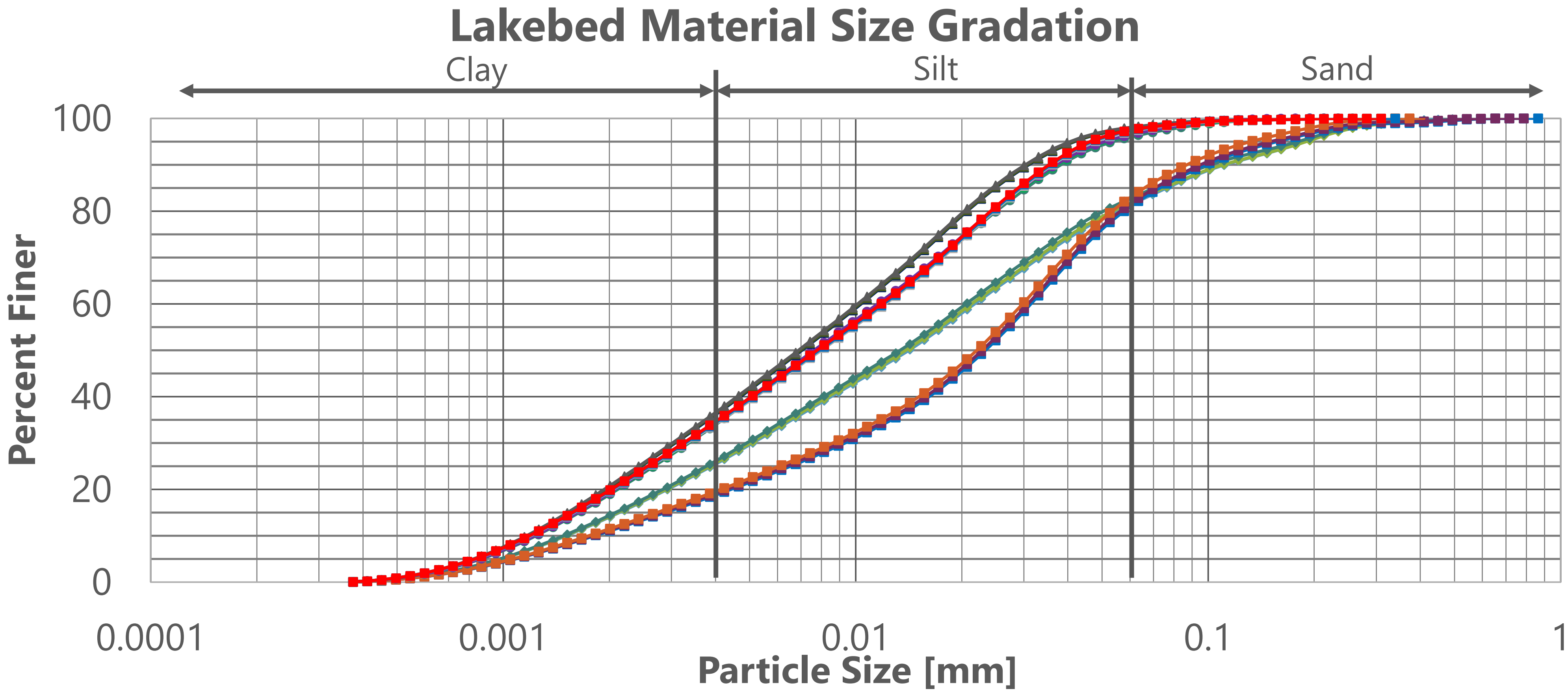
Bed Material Analysis

- Riverbed samples: primarily gravel with some sand



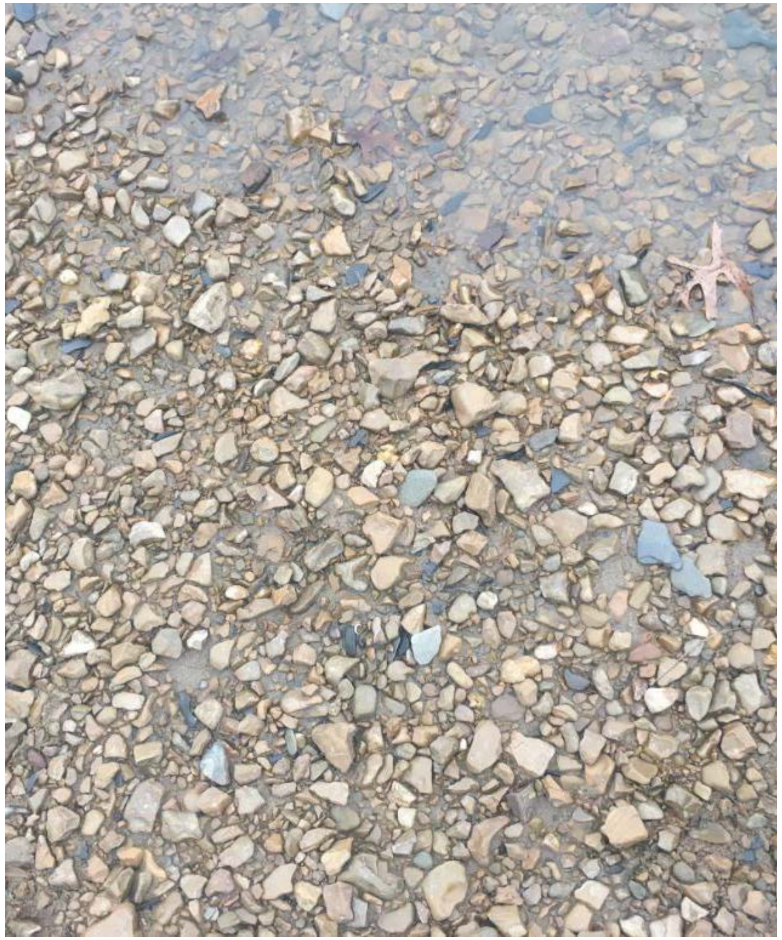
Bed Material Analysis

- Lakebed samples: primarily silt and clay



Bed Material Analysis

- Neosho riverbed
- Grand Lake bed



Critical Shear

- Cohesive sediment requires additional information for modeling
- Critical shear stress
  - No sediment transport below critical shear
  - Non-cohesive sediment (sand, gravel, rocks)
    - Based on density & grain size
    - Constant throughout sediment layer
    - Individual grains move independently
  - Cohesive sediment (clay, silt)
    - Based on cohesive forces
    - Typically changes with depth due to consolidation
    - Clumps of sediment may move together

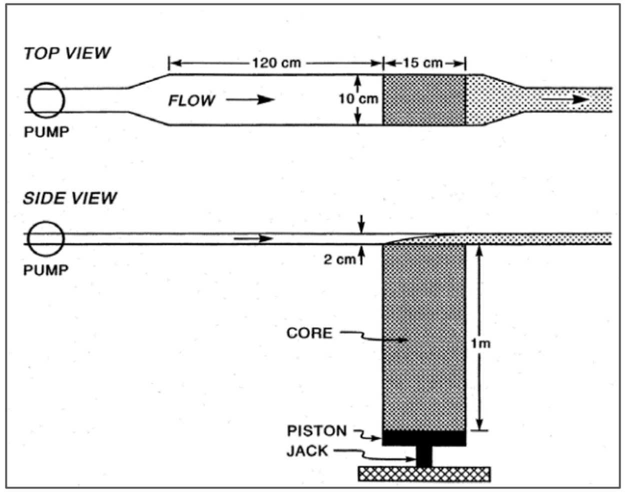
SEDflume Core Sampling

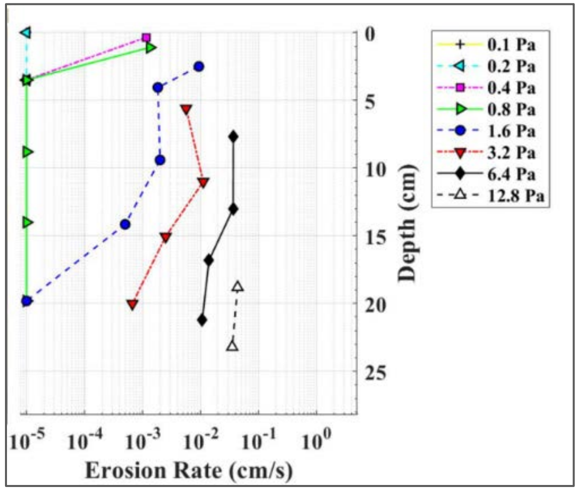
- Box cores collected Mar 2020
  - Not included in original plan

SEDflume Core Sampling

- Box cores collected Mar 2020
  - Not included in original plan
- Critical shear stress evaluations
  - Core is placed in SEDflume
  - Water flows over core surface at known shear stress
  - Core raised into flume as it erodes
  - Rate of erosion at specified shear recorded

Images from Integral



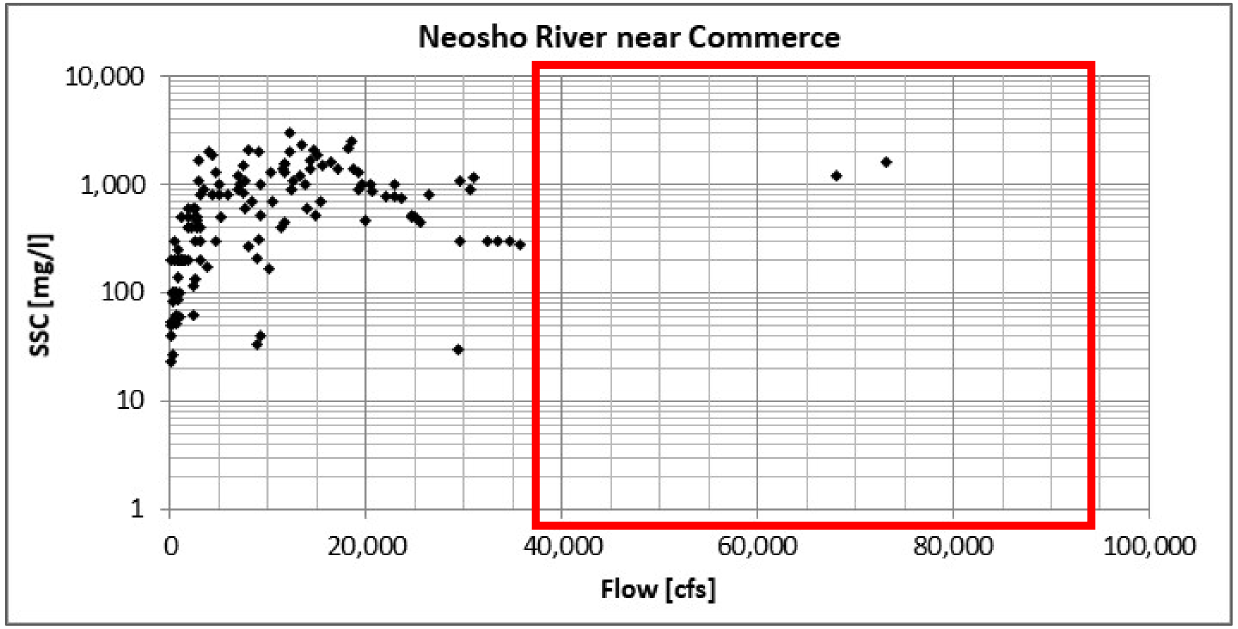


SEDflume Test Results

Sample Depth [cm]	Median Grain Size [µm]	Wet Bulk Density [g/cm^3]	Dry Bulk Density [g/cm^3]	Loss on Ignition	τ_{no} [Pa]	τ_1 [Pa]	τ_c Linear [Pa]	τ_c Power [Pa]	Final τ_c [Pa]
0.0	11.89	1.25	0.46	5.2%	0.2	0.4	0.24	0.25	0.25
5.3	11.78	1.39	0.70	5.0%	0.8	1.6	0.86	0.75	0.80
10.8	13.68	1.41	0.73	5.2%	0.8	1.6	0.86	0.74	0.80
15.6	13.54	1.4	0.78	5.2%	0.8	1.6	0.86	0.72	0.80
20.4	13.47	1.43	0.77	5.3%	1.6	3.2	1.84	1.73	1.73
MEAN	**12.87**	**1.38**	**0.69**	**5.2%**	**0.84**	**1.68**	**0.93**	**0.84**	**0.88**

Sediment Transport Data

- USGS Gages
  - Neosho near Commerce (E 60 Rd)
  - Tar Creek near Commerce (Hwy 69)
  - Spring near Quapaw (E 57 Rd)
  - Elk near Tiff City, MO (Hwy 43)
- Suspended Sediment Concentration (SSC)
  - Periodically sampled
  - Relationships between discharge and SSC
  - Calculate approximate volume of sediment moving through system
  - Gaps in USGS dataset



Sediment Transport Sampling

- Locations of USGS Gages
- Follow USGS sampling guidelines
- SSC measurements
    - Typically fines
- Bedload transport
    - No bedload during flow conditions sampled

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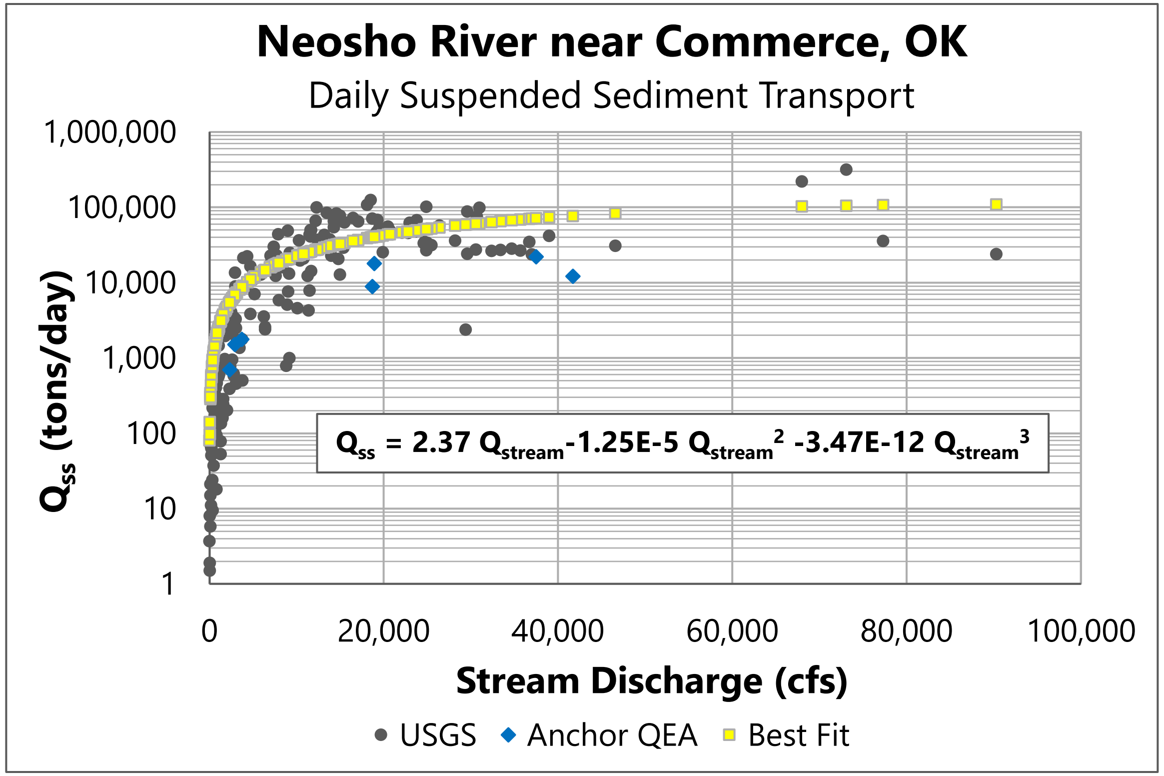
GRDA

Sediment Transport vs. Discharge

- Filled data gaps in USGS records
- Fit relationship between discharge and sediment transport

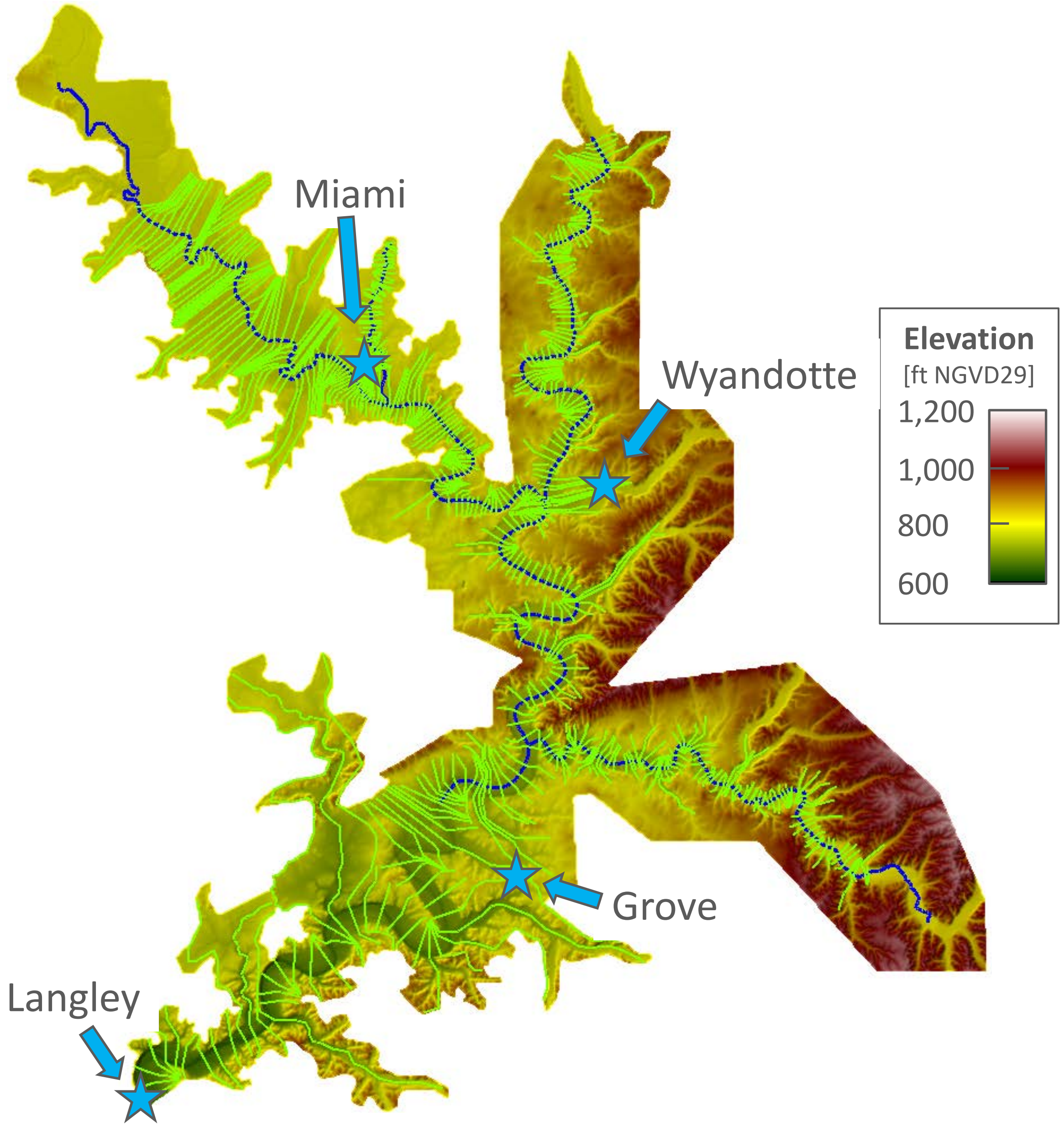


Outline

- Overview of study
- Water level monitoring
- Sediment sampling
  - Grab samples
  - SEDflume sampling
  - Transport measurements
- Model development
  - Calibration/validation
  - Hydraulic calibration
  - Challenges
  - Sediment calibration

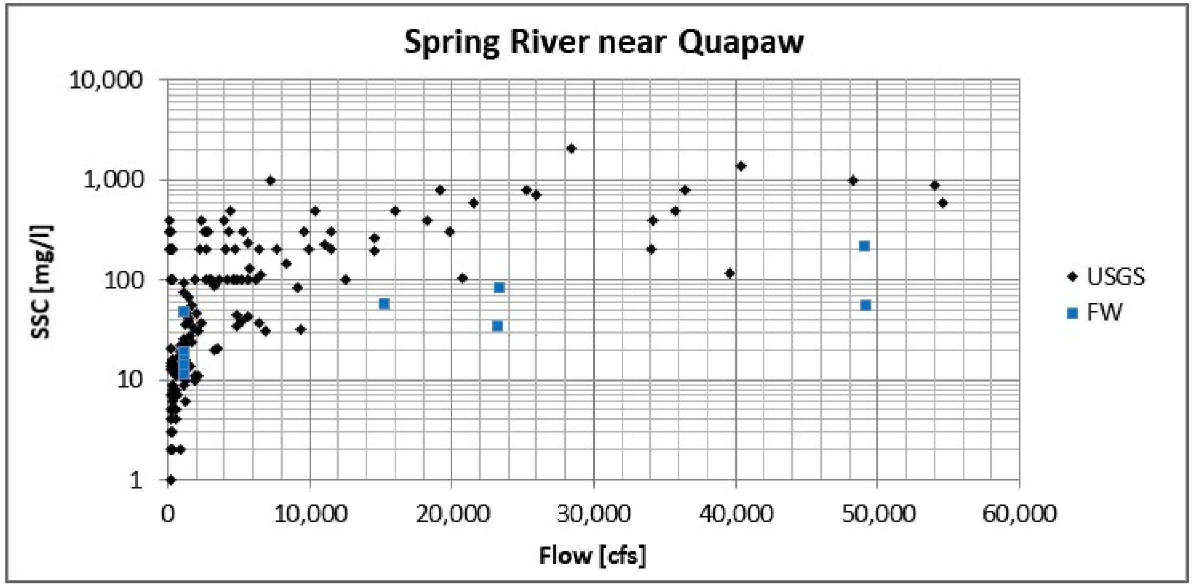
STM Development

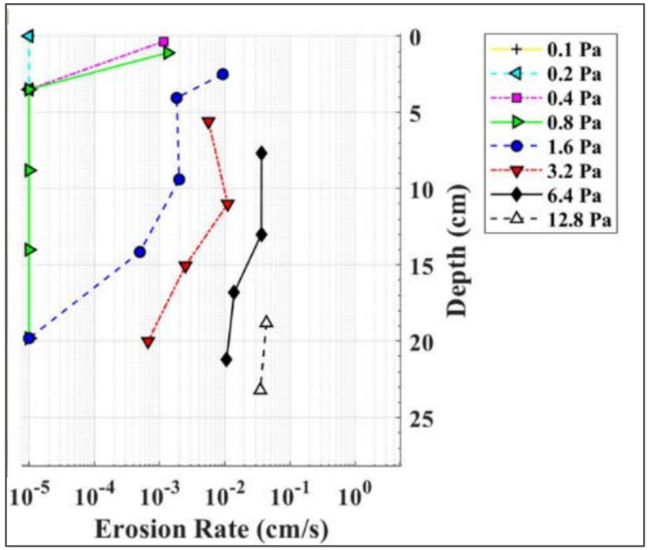
- Sediment Transport Model (STM)
  - Three terrain datasets
    - 1998 Bathymetry/topography
      - From 1998 REAS information
    - 2009 Bathymetry/topography
      - Grand Lake: 2009 OWRB survey
      - Upstream areas: 2017 USGS survey
    - 2019 Bathymetry/topography
      - Grand Lake: 2019 USGS survey
      - Upstream areas: 2017 USGS survey



STM Calibration

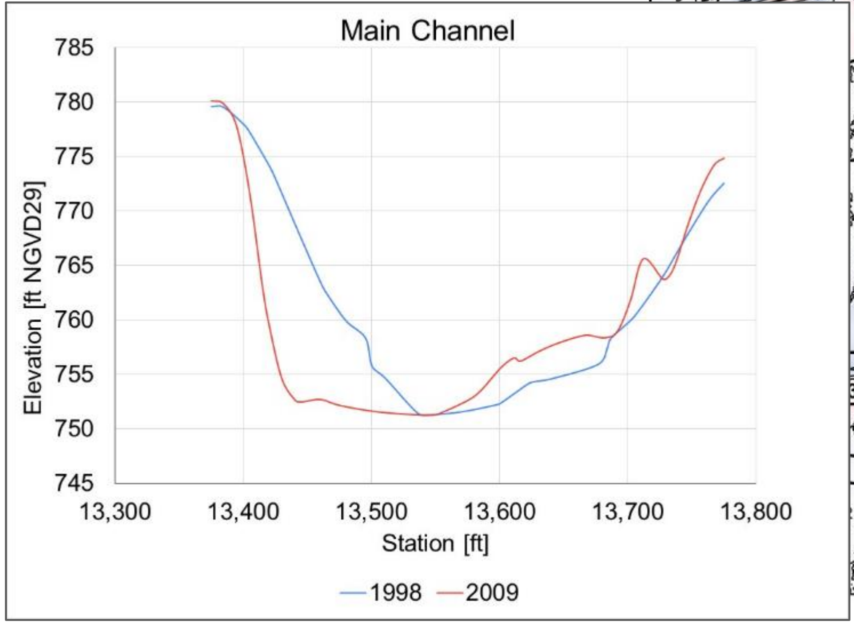
- Start with 1998 terrain
- Create sediment input files
    - Based on field data, lab analyses

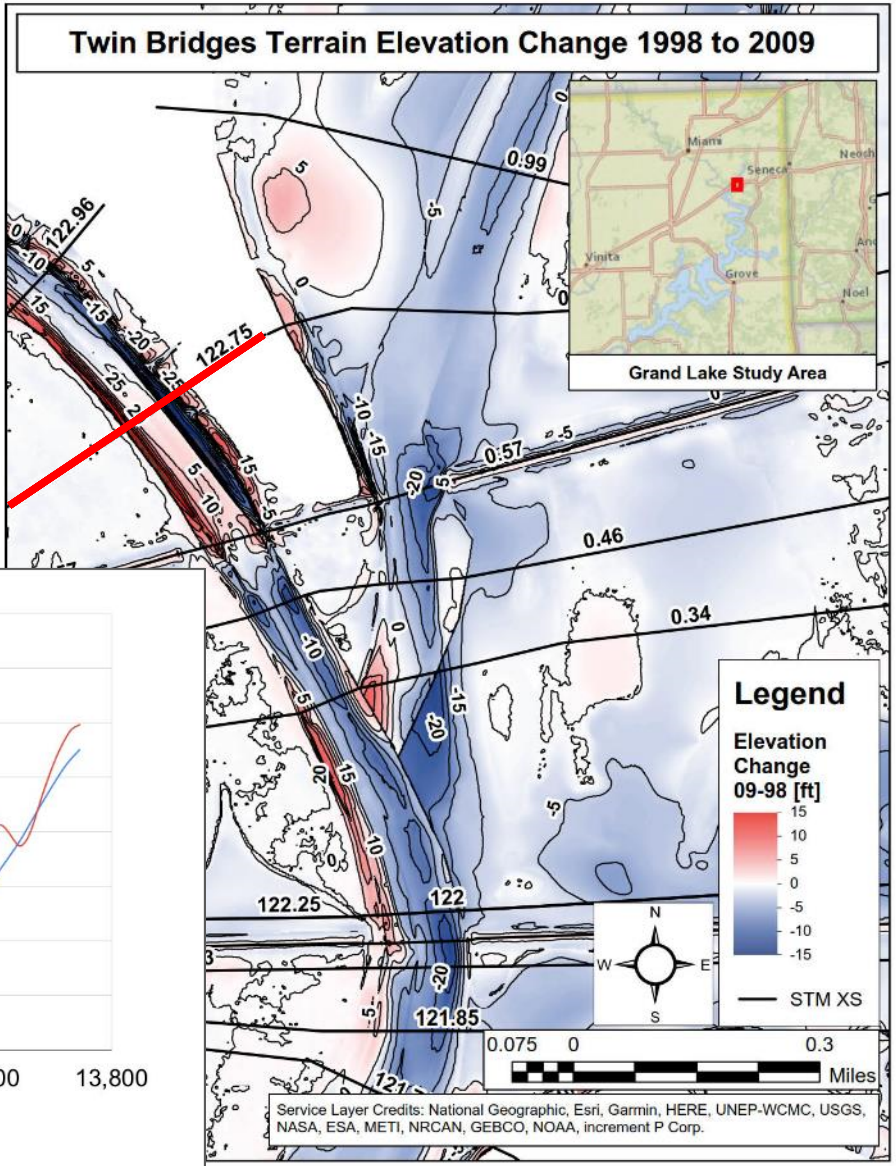




STM Calibration

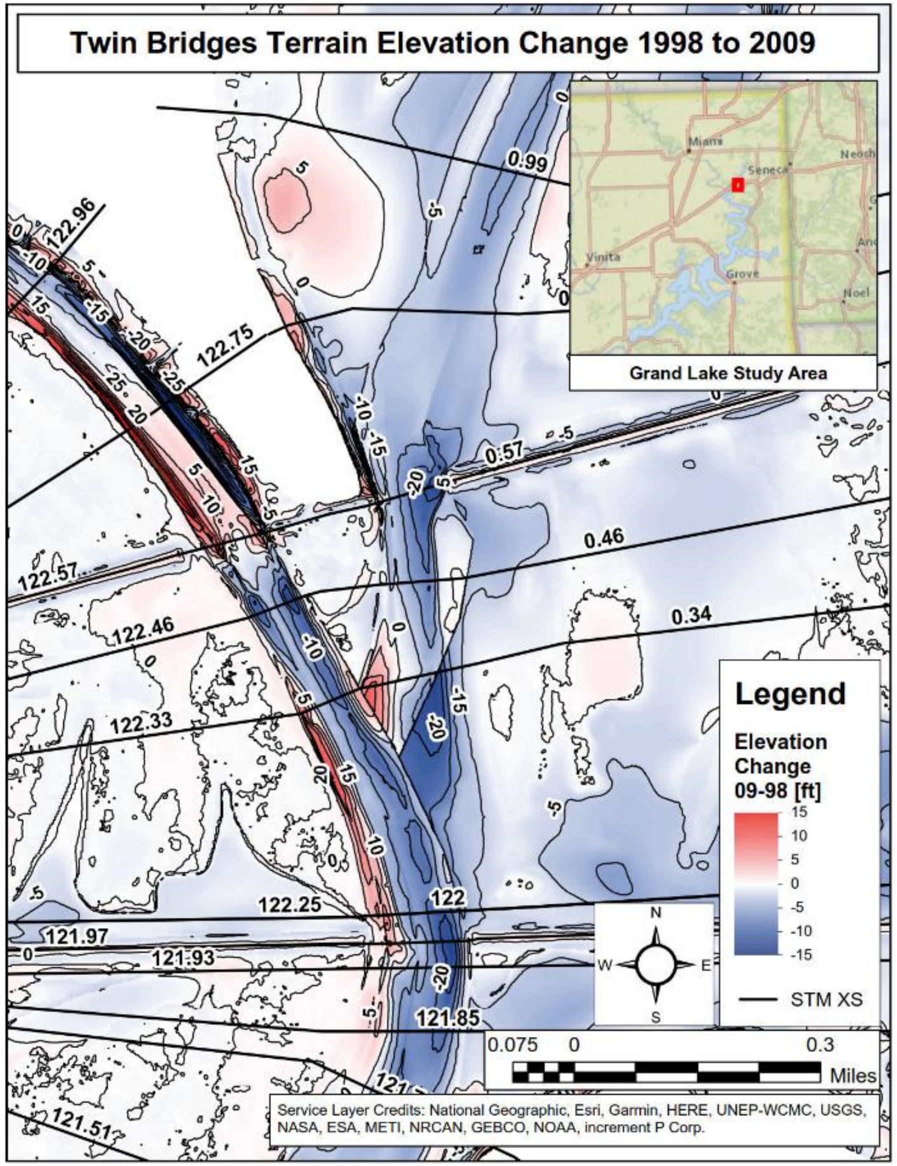
- Start with 1998 terrain
- Create sediment input files
  - Based on field data, lab analyses
- Run model for 1998 – 2009
  - Calibrate sediment erosion/deposition patterns to measured channel data





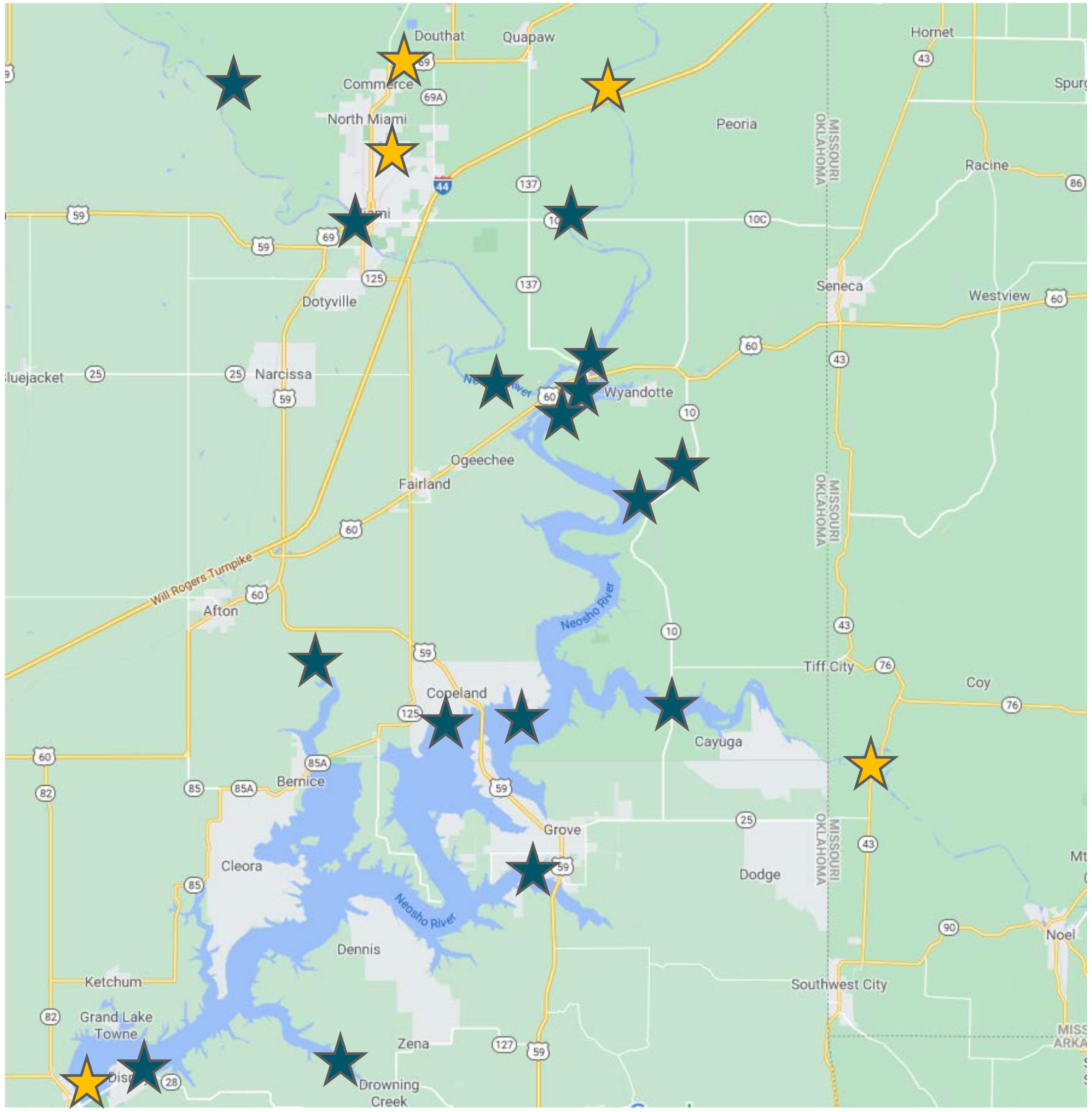
STM Calibration

- Start with 1998 terrain
- Create sediment input files
  - Based on field data, lab analyses
- Run model for 1998 – 2009
  - Calibrate sediment erosion/deposition patterns to measured channel data
- Run model for 2009 – 2019
  - Validate model predictions against measured channel data



STM Hydraulic Calibration

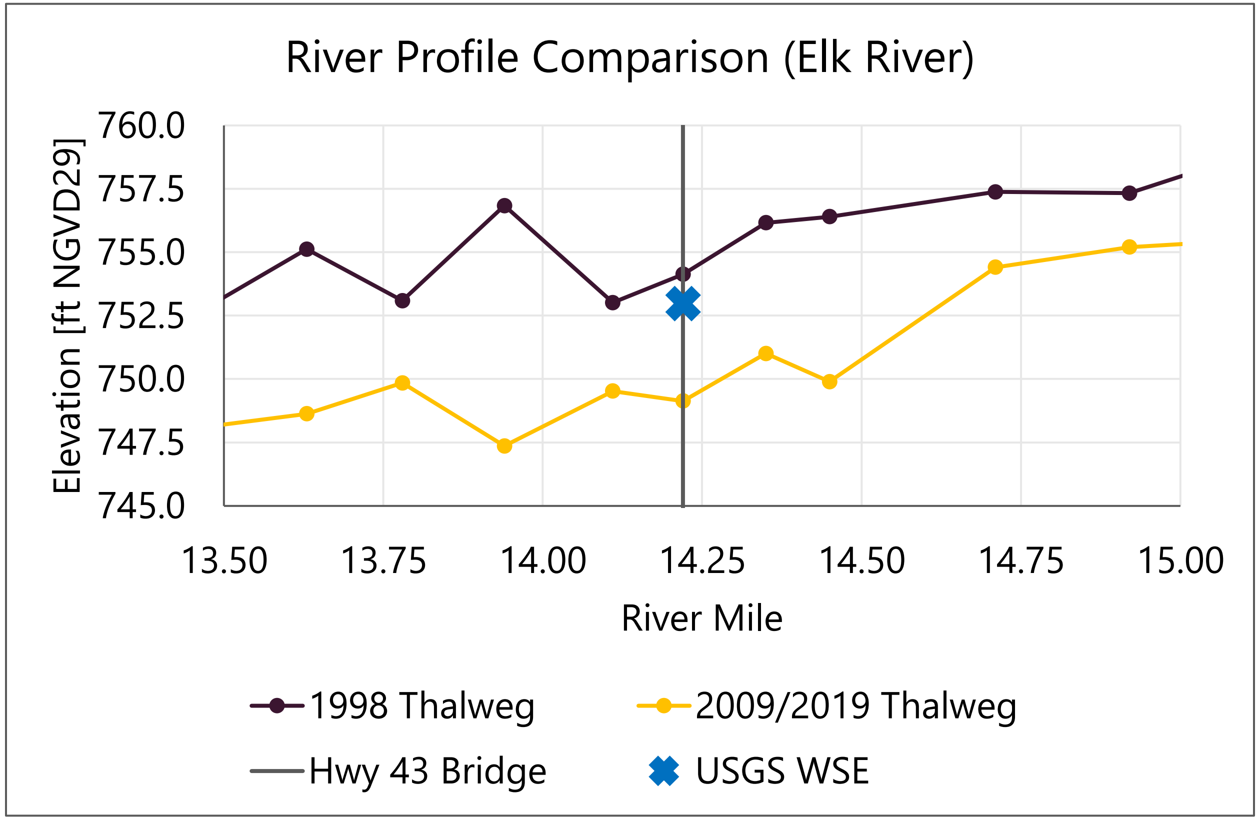
- Match recorded Water Surface Elevation (WSE) data
  - **USGS gaging stations**
    - Neosho River
    - Tar Creek
    - Spring River
    - Elk River
    - Pensacola Dam
  - **High water marks**
  - **Anchor QEA monitoring sites**



GRDA

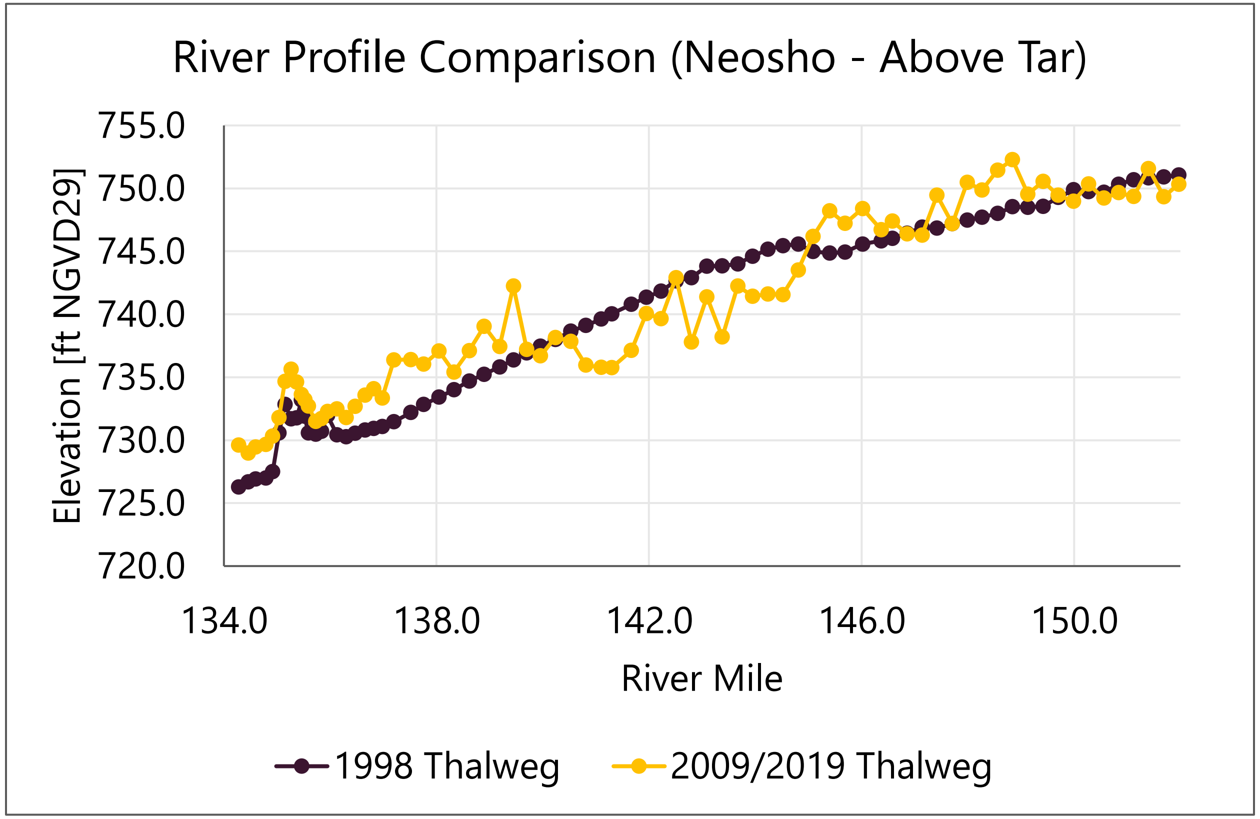
1998 Geometry Inconsistencies

- Elk River at Hwy 43 Bridge
  - USGS gage WSE < 1998 riverbed



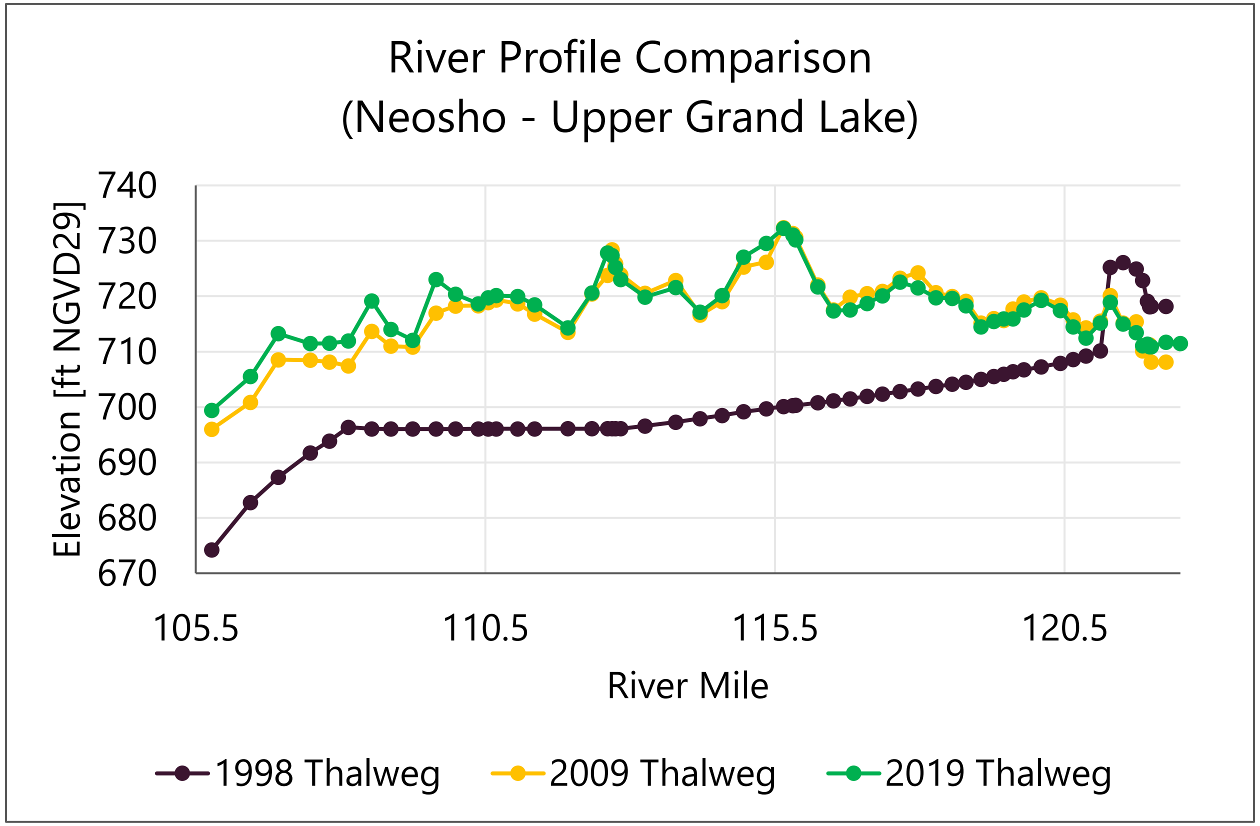
1998 Geometry Inconsistencies

- Neosho River above Tar Creek
  - Artificially smooth profile



1998 Geometry Inconsistencies

- Neosho River, Upper Grand Lake
  - 20-30 ft apparent elevation difference

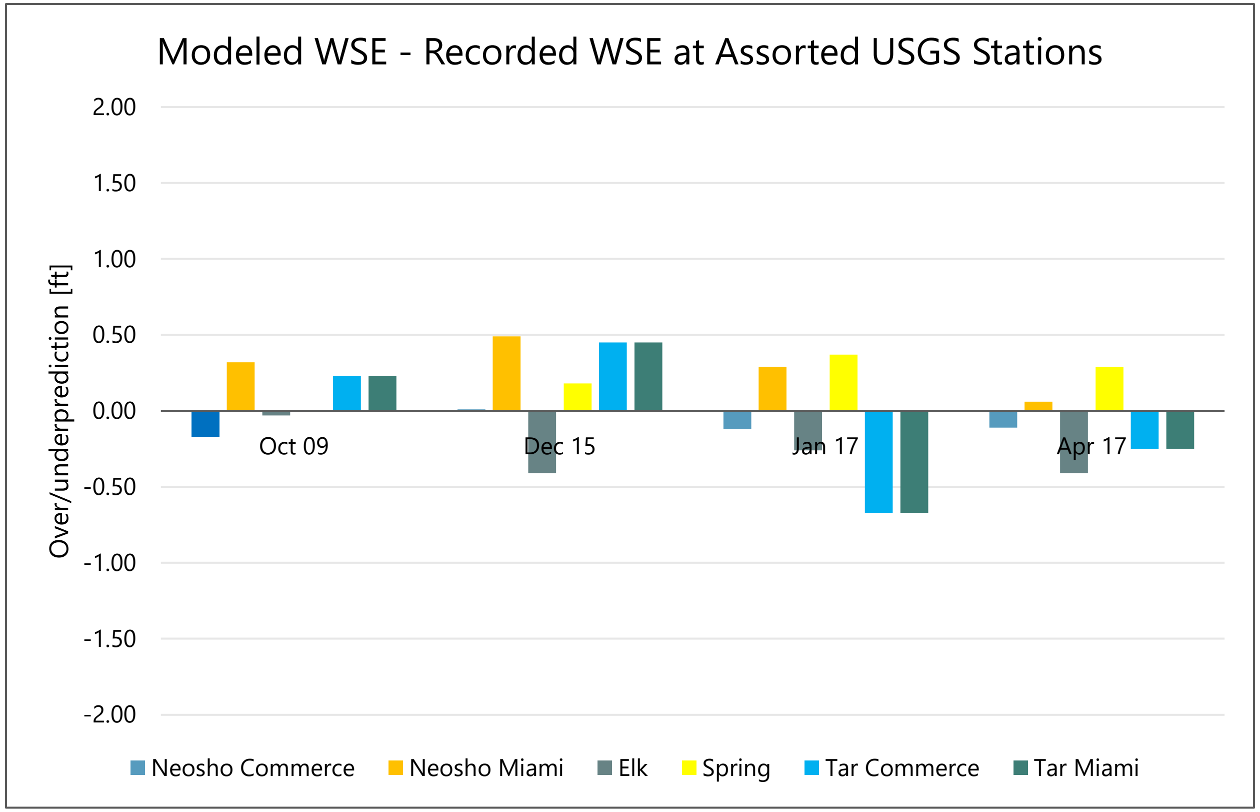


Addressing Inconsistencies

- 1998 dataset is unreliable, not required under Study Plan
  - Verified by point analysis of original datasets
- Calibrate 2009 geometry for hydraulics
  - Matches geometry used for UHM

Hydraulic Correlation with USGS Gages

- Model hydraulic calibration shows good agreement with USGS gages
  - Average difference between simulated and recorded WSEs is 0.04 ft (model over-predicts WSE)



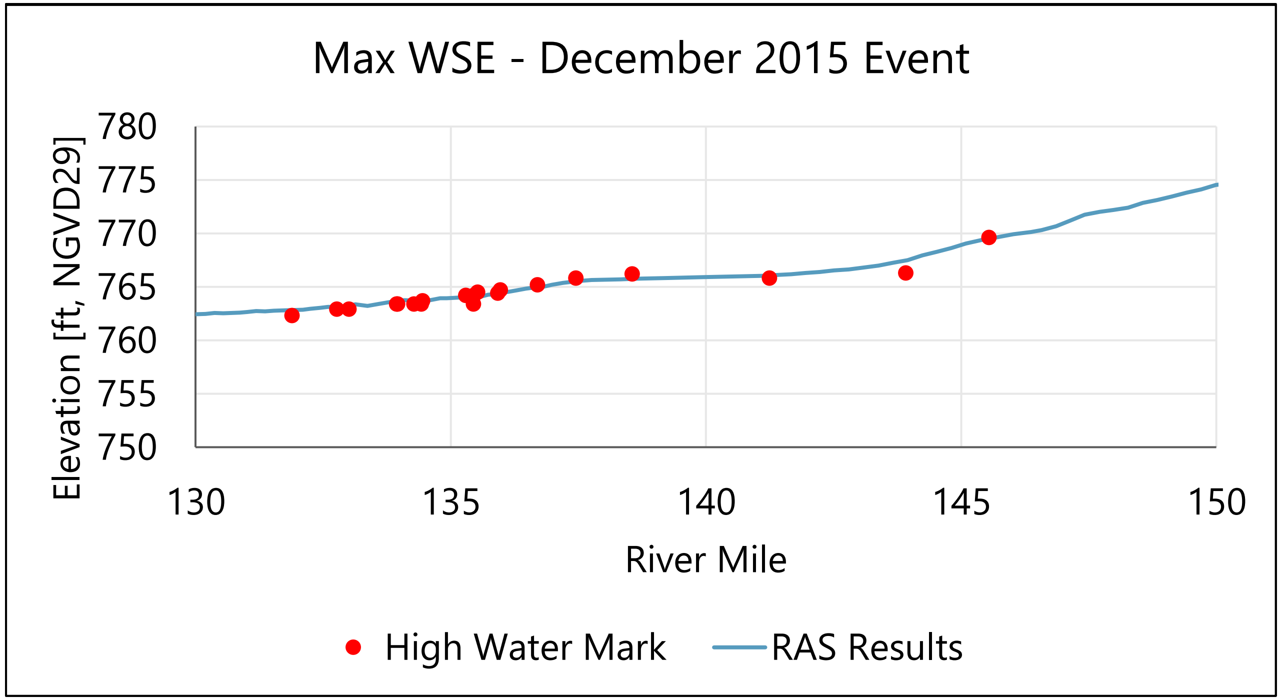
Comparison to measured HWM

- Average differences are:

  +0.61 ft with July 2007 event

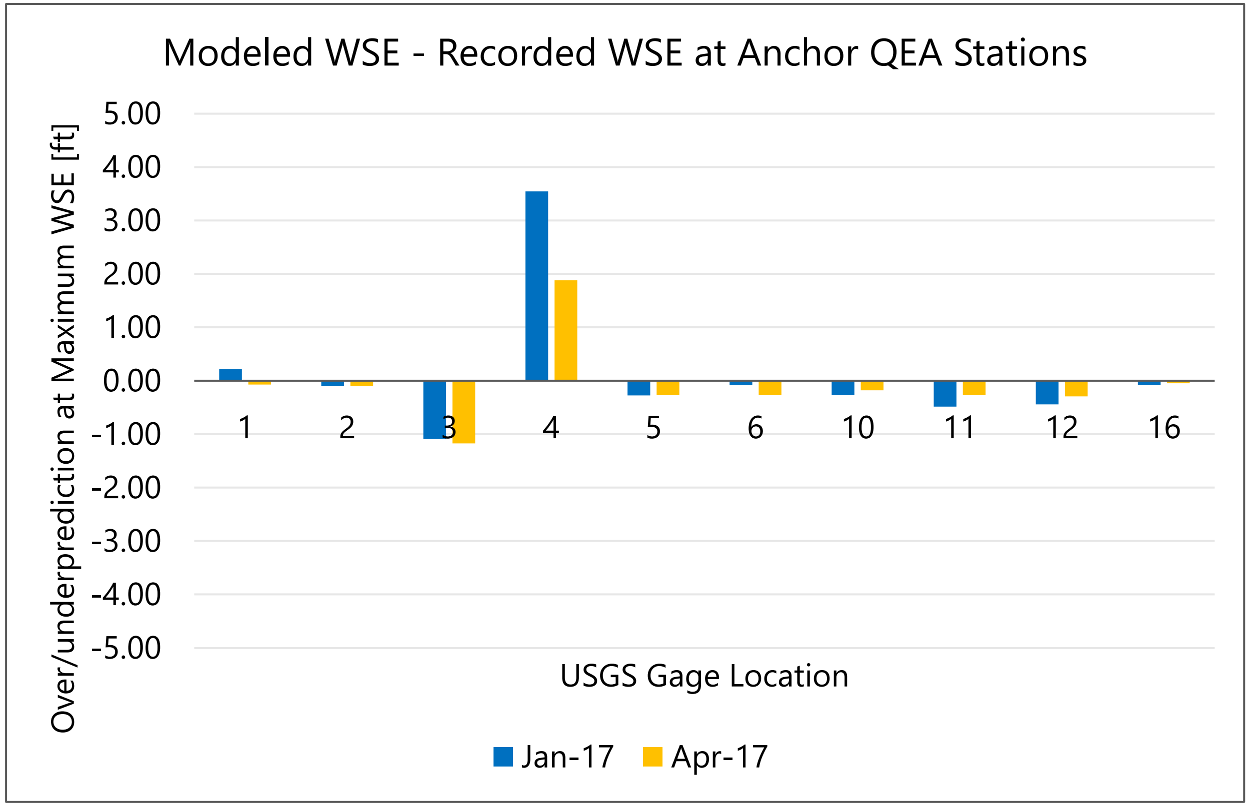
  -0.47 ft for October 2009 event

  +0.15 ft for December 2015 event



Comparison to Anchor QEA Loggers

- Average differences are:
  - +0.10 ft for January 2017 event
  - -0.08 ft for April 2017 event



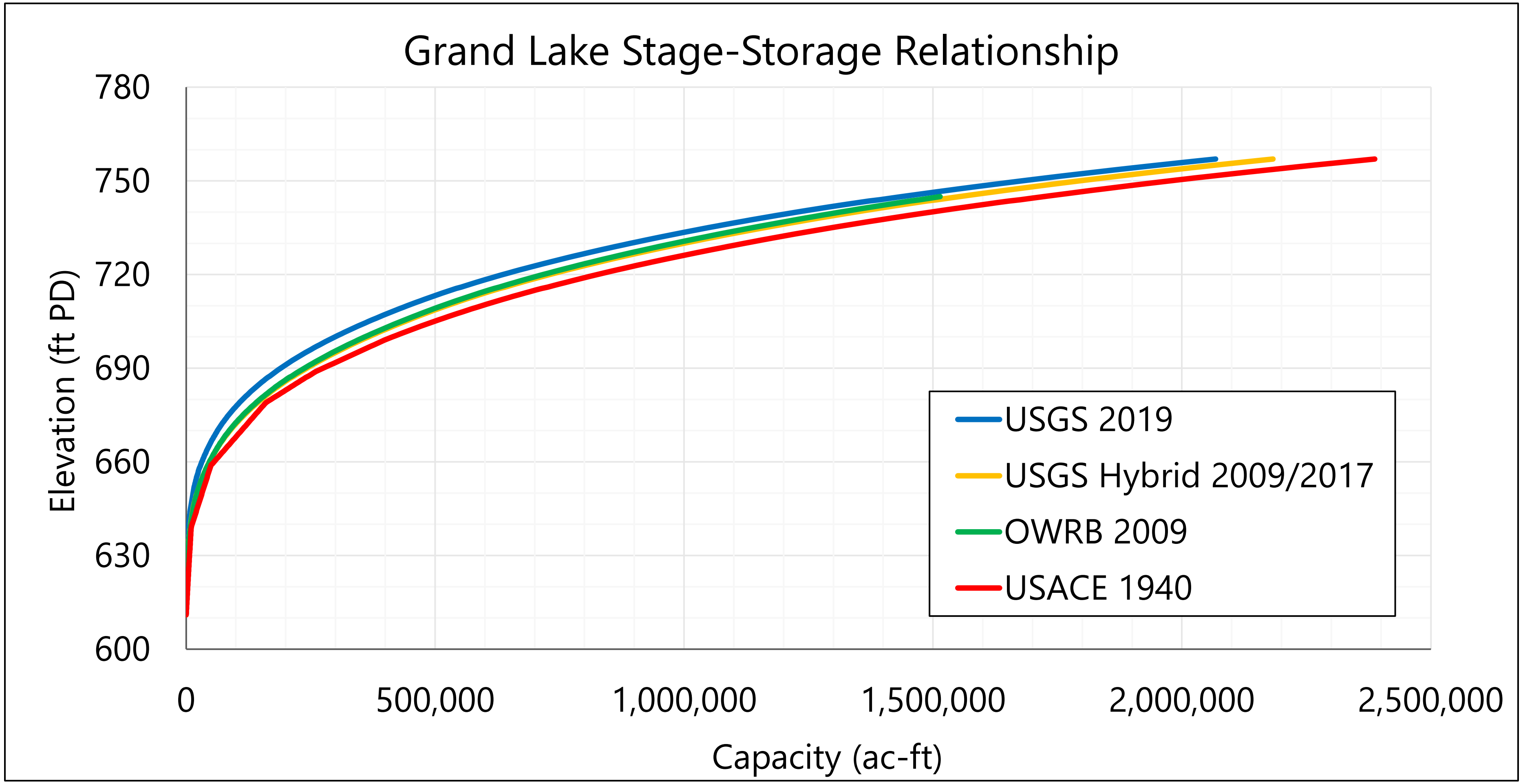
Sediment Calibration

- Sediment calibration based on 2009 – 2019
  - Primarily Grand Lake; lower reaches of Elk, Neosho
  - Known stage-storage curves used to validate accumulation in reservoir
- Two methods to measure changes from 2009 – 2019
  - Compare volume changes from 1998 – 2009
    - USGS/USACE/OWRB stage-storage curves
    - Terrain files
  - Compare terrain data sediment accumulation in Grand Lake to erosion in upstream areas

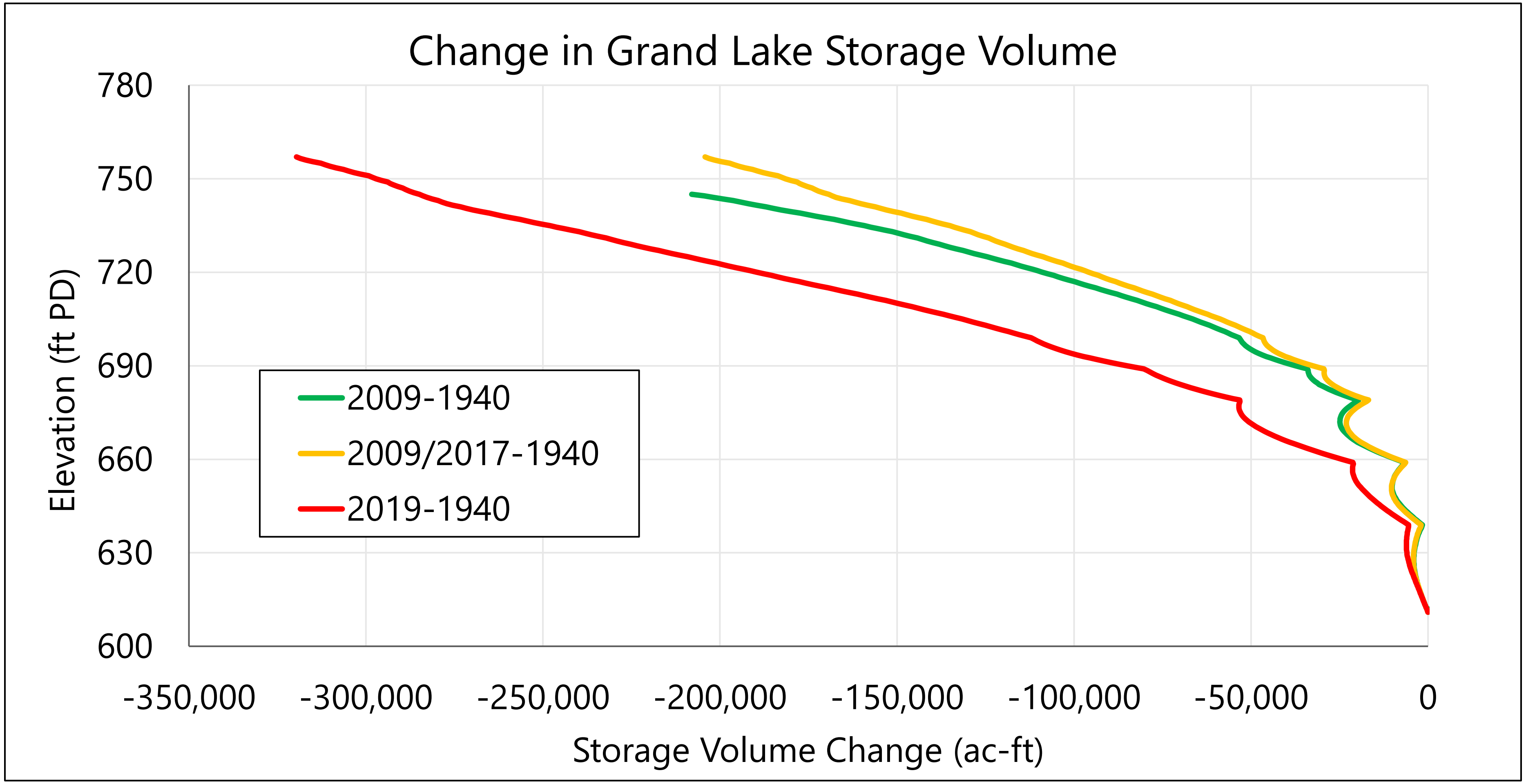
Sediment Transport – Reservoir Storage

- Using daily flow and sediment rating curves – compute sediment inflow over time
- Compare tonnage of sediment (converted to volume using sediment density) to change in reservoir storage
- Density issues (consolidation over time, compare to data)

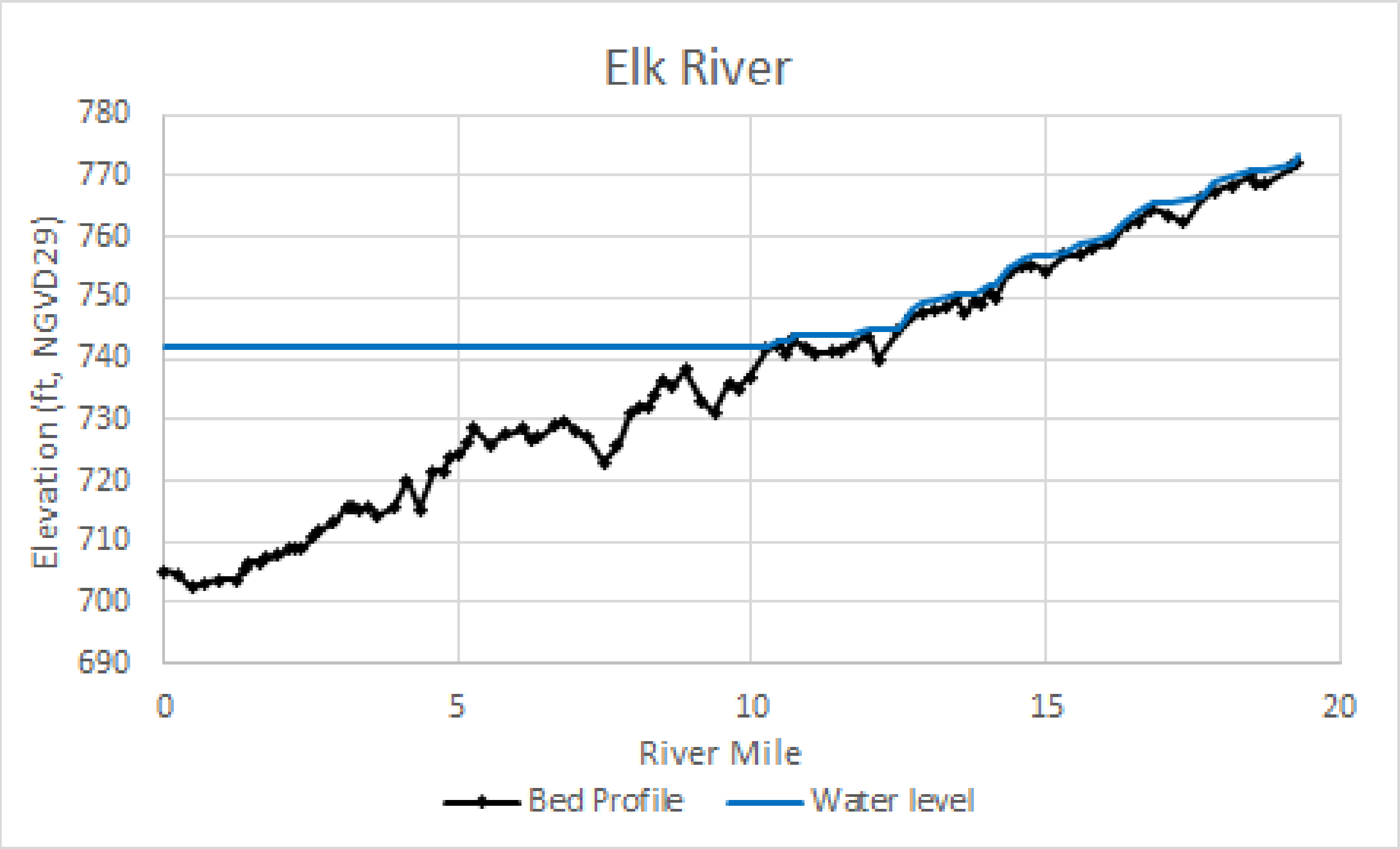
Reservoir Storage Volume Analysis



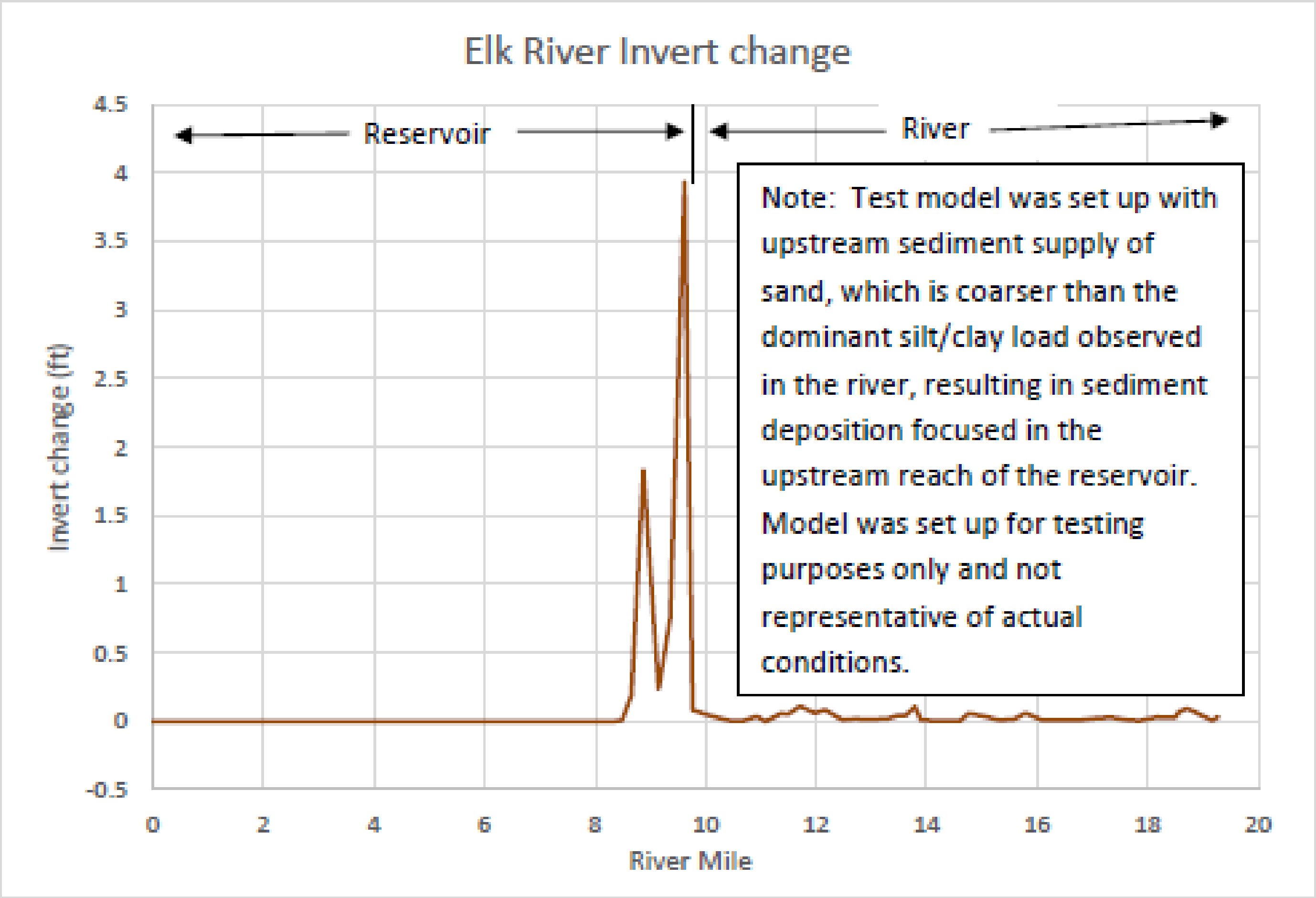
Reservoir Storage Volume Analysis



HEC-RAS Testing



HEC-RAS Testing



Sediment Transport Analysis

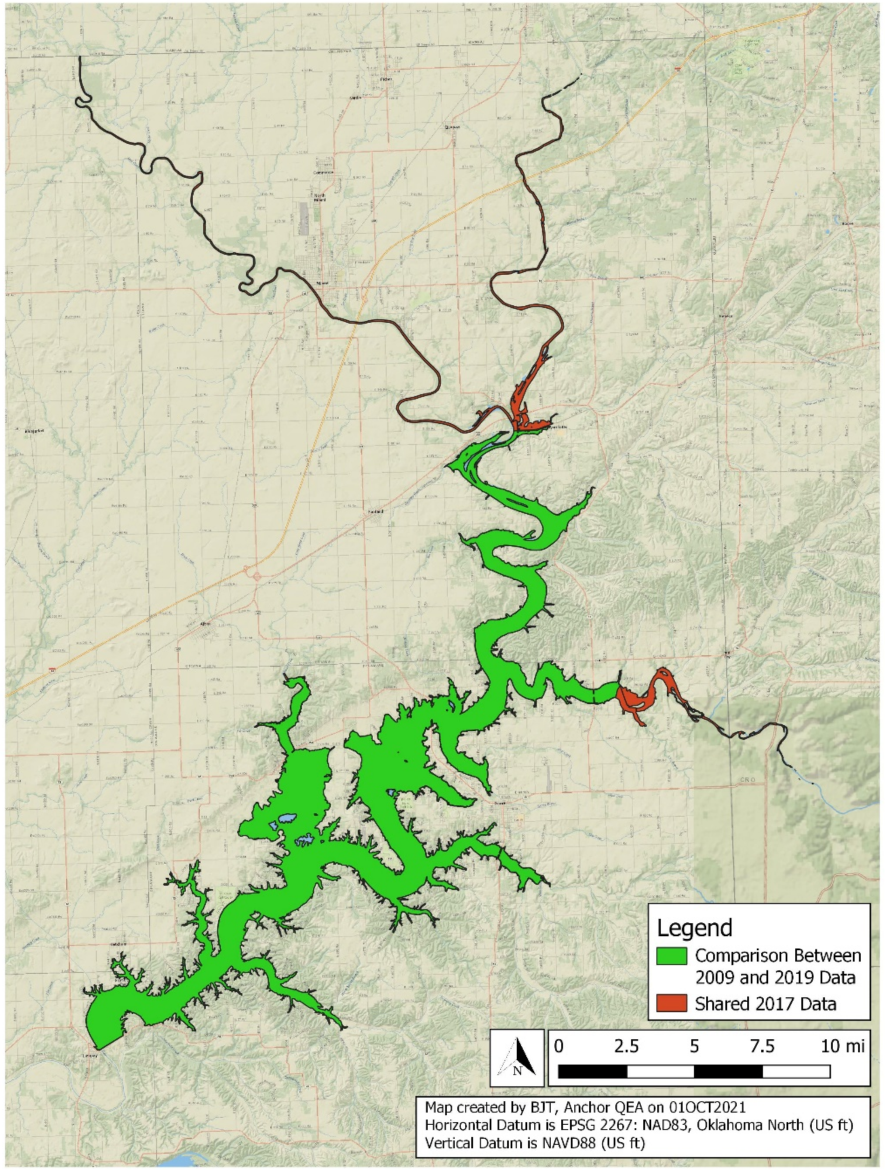
- 1-D *HEC-RAS* STM is being calibrated for sediment transport metrics
- Sediment data (topographic information, stream discharge volumes, water surface elevations, and sediment parameters both in the lake and streambeds and moving through major tributaries) are being developed into input files for *HEC-RAS*
- Model calibration for sediment transport and deposition (based on change in geometry 2009-2019)
- Model calibration will be finalized by the end of 2021; study report to be updated at that time
- STM may be modified as necessary based upon relicensing participant comments
- STM will analyze effects under current operation and compare results to anticipated future operations
- Observed and predicted effects of sedimentation on the power pool will be described in the USR

Sediment Calibration

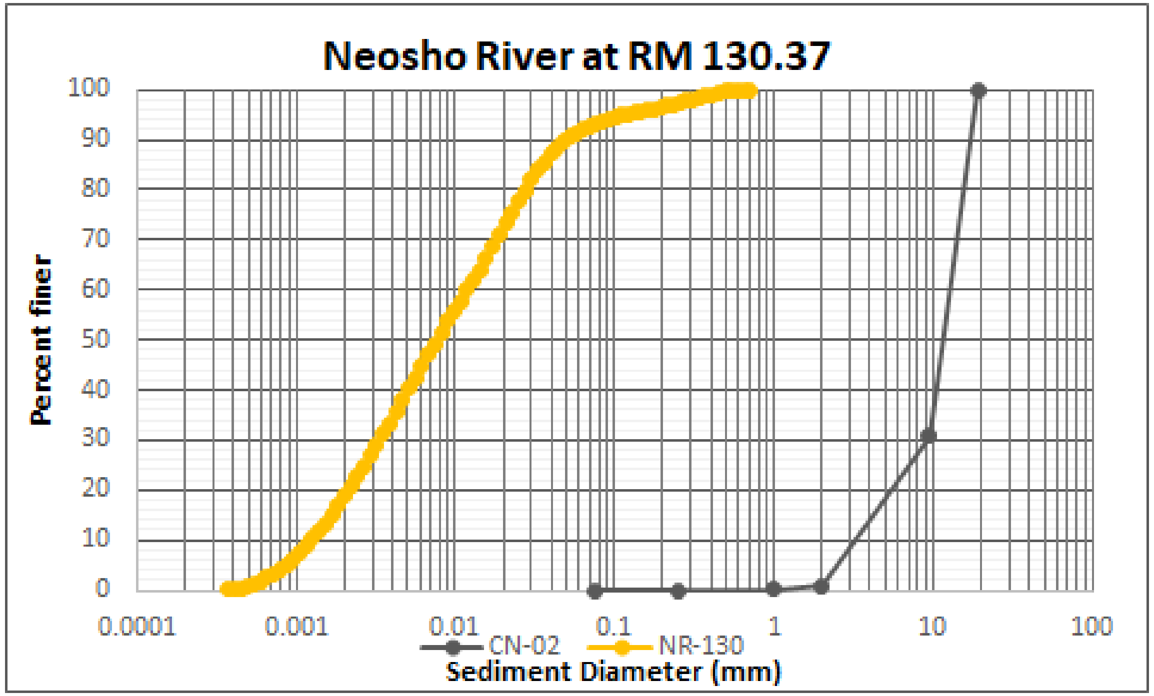
- Sediment calibration is ongoing
  - Upstream hydrology uses historic hydrographs 2009 – 2019
  - Downstream boundary uses historic water levels in Grand Lake 2009 - 2019
  - Upstream boundary conditions for sediment inflow developed based on suspended sediment rating curves
  - Development of bed material representing initial conditions considering wide range of size distributions in close proximity

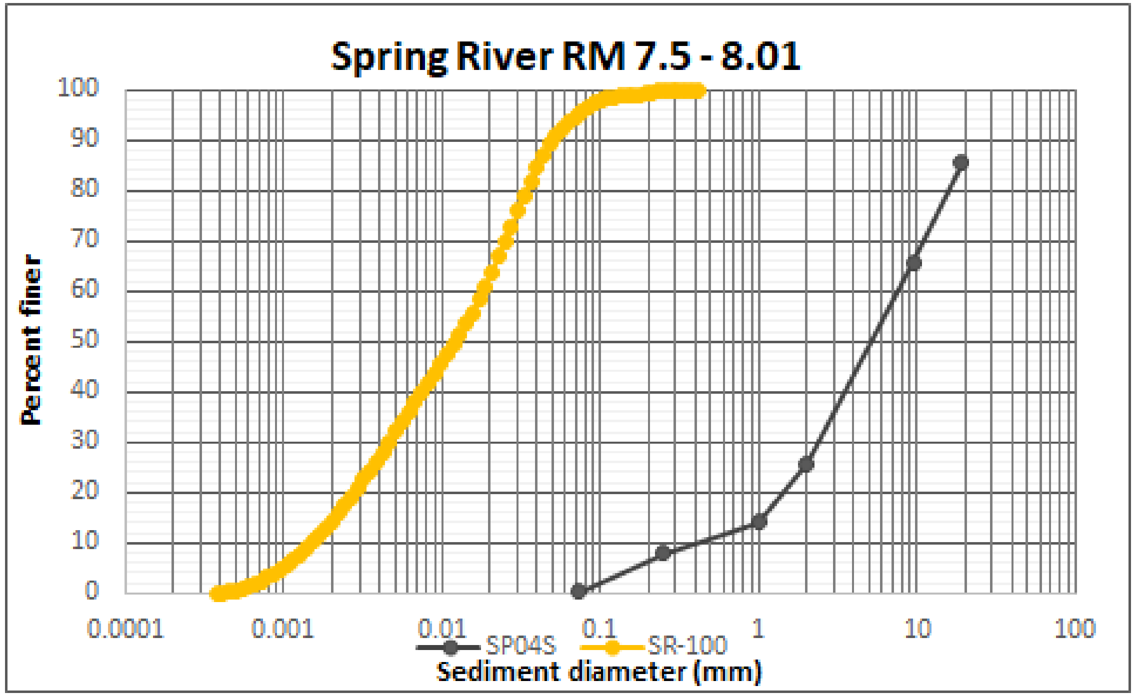
Sediment Calibration

- Calibration extents limited to overlap of:
  - 2009 OWRB
  - 2019 USGS

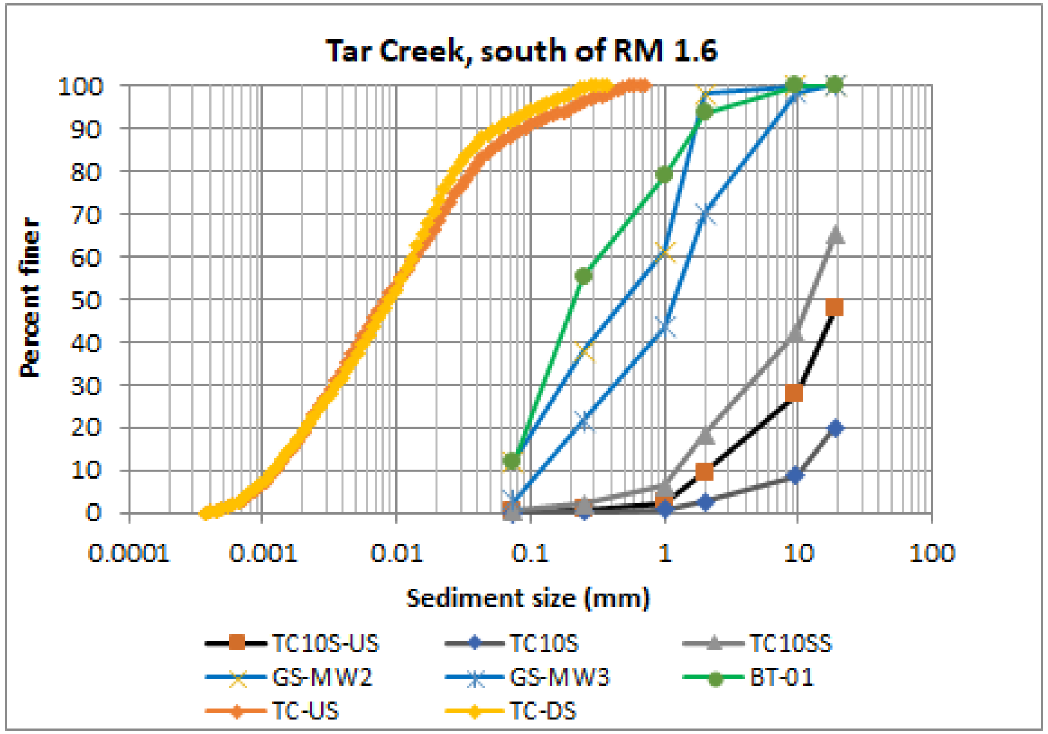


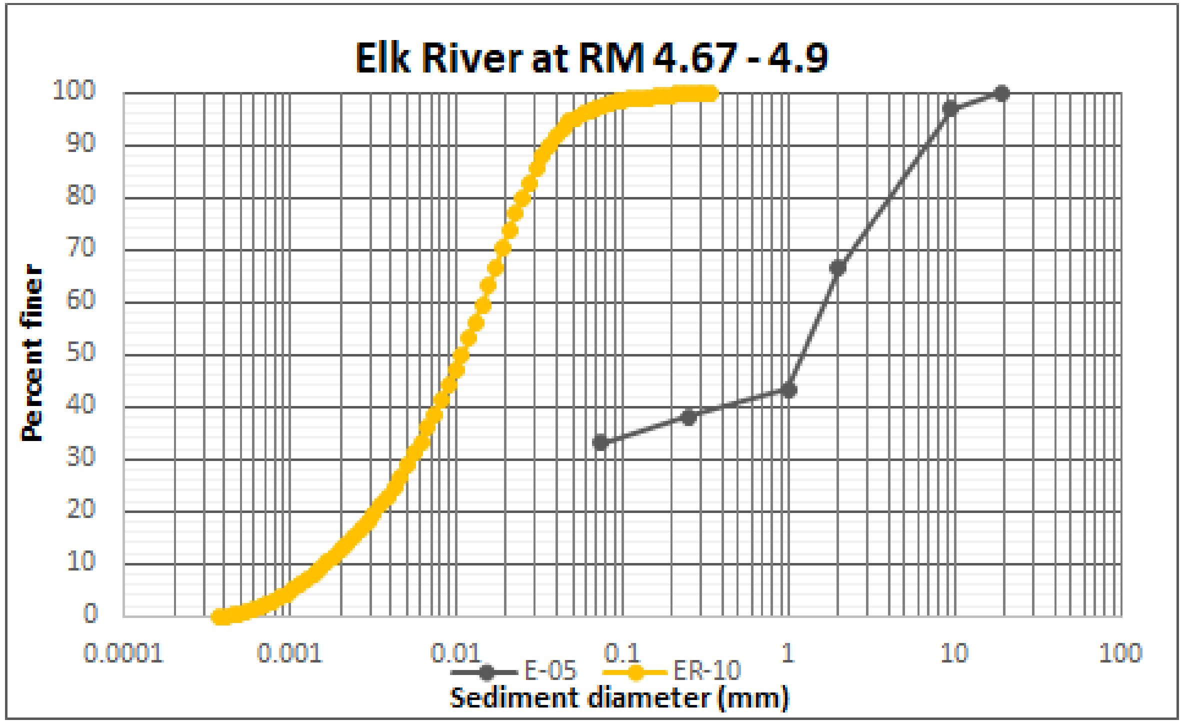
Sediment Calibration





Sediment Calibration





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Sediment Calibration

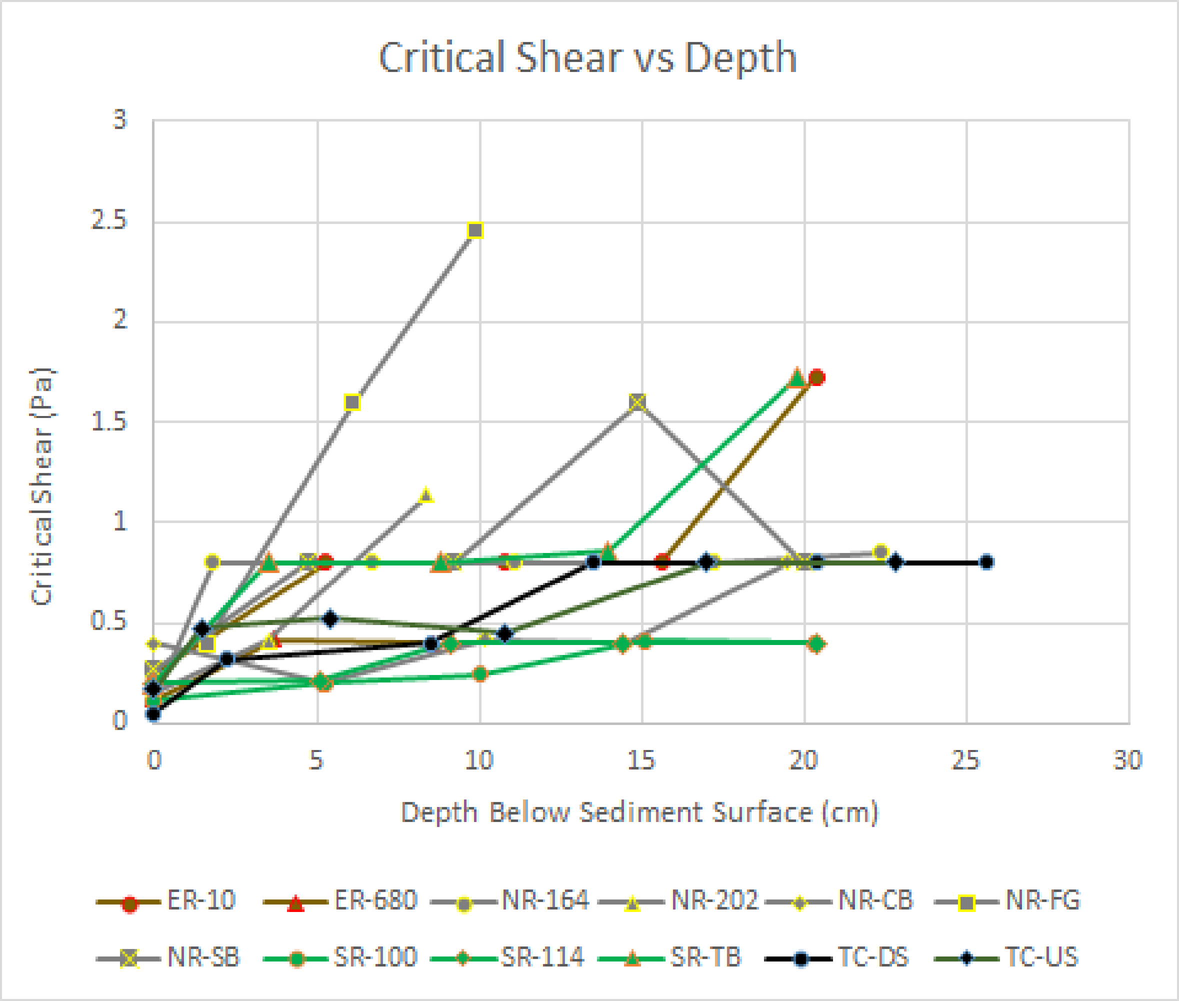
- Sediment calibration is ongoing
  - Sediment density
  - Cohesive erosion parameters

Sediment Calibration

Cohesive Sediment Density Summary:

Sediment Core	Min Dry Density		Max Dry Density		Mean Dry Density (lb/ft^3)
	lb/ft^3	% of Mean	lb/ft^3	% of Mean	
Minimum	21.2	56.7%	43.7	105.4%	36.8
Mean	39.4	72.6%	61.7	118.5%	52.7
Maximum	76.2	90.0%	103.0	140.0%	93.0

Sediment Calibration

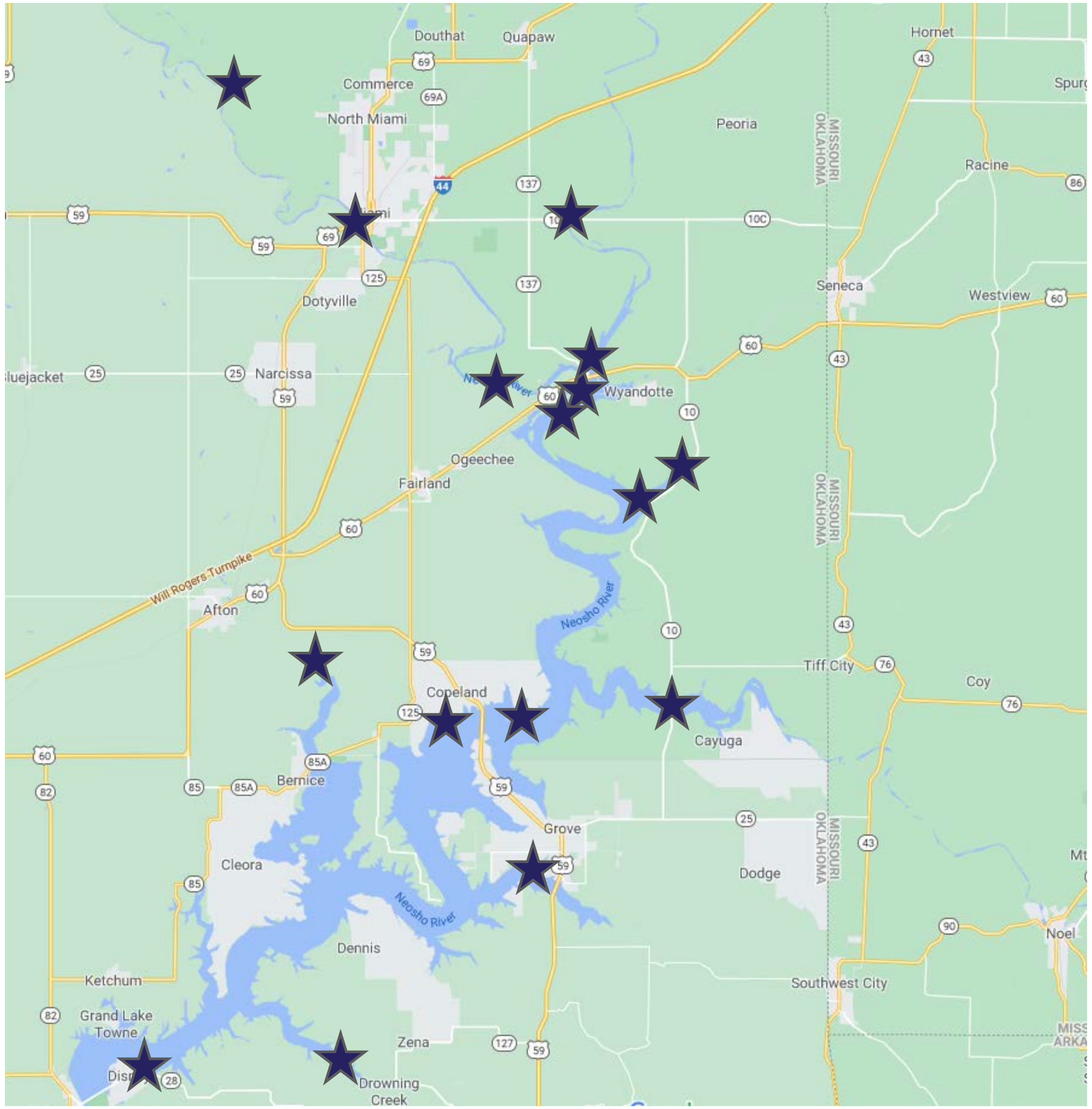


STM Calibration Steps

- Upstream Q & Q_{ss} BC (done)
- Downstream WSE BC (done)
- Finalize initial condition sediment properties (in progress)
- Finalize cohesive erosion parameters (in progress)
- Calibration runs to finalize parameters
- Comparison to bathy change, Q_{ss} data, and other analyses
- Documentation of results

Summary

- Water level monitoring



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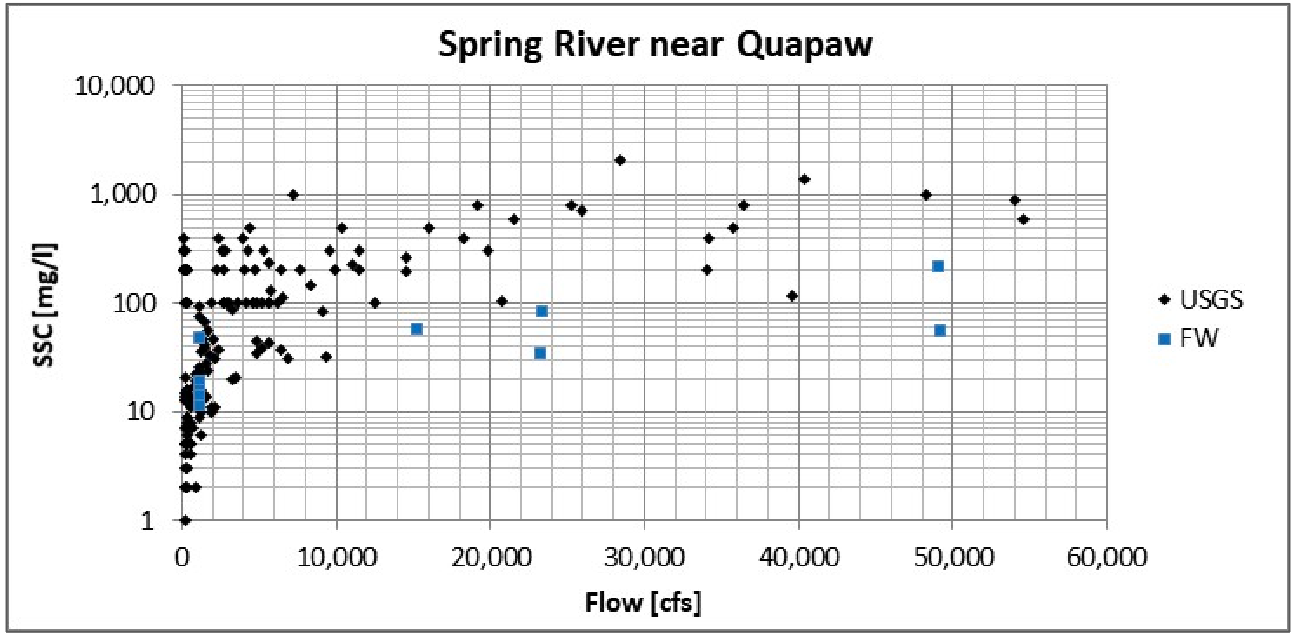
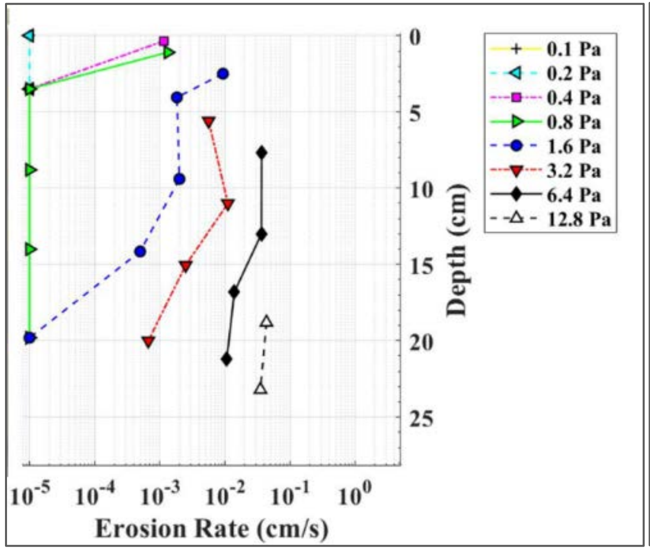
Summary

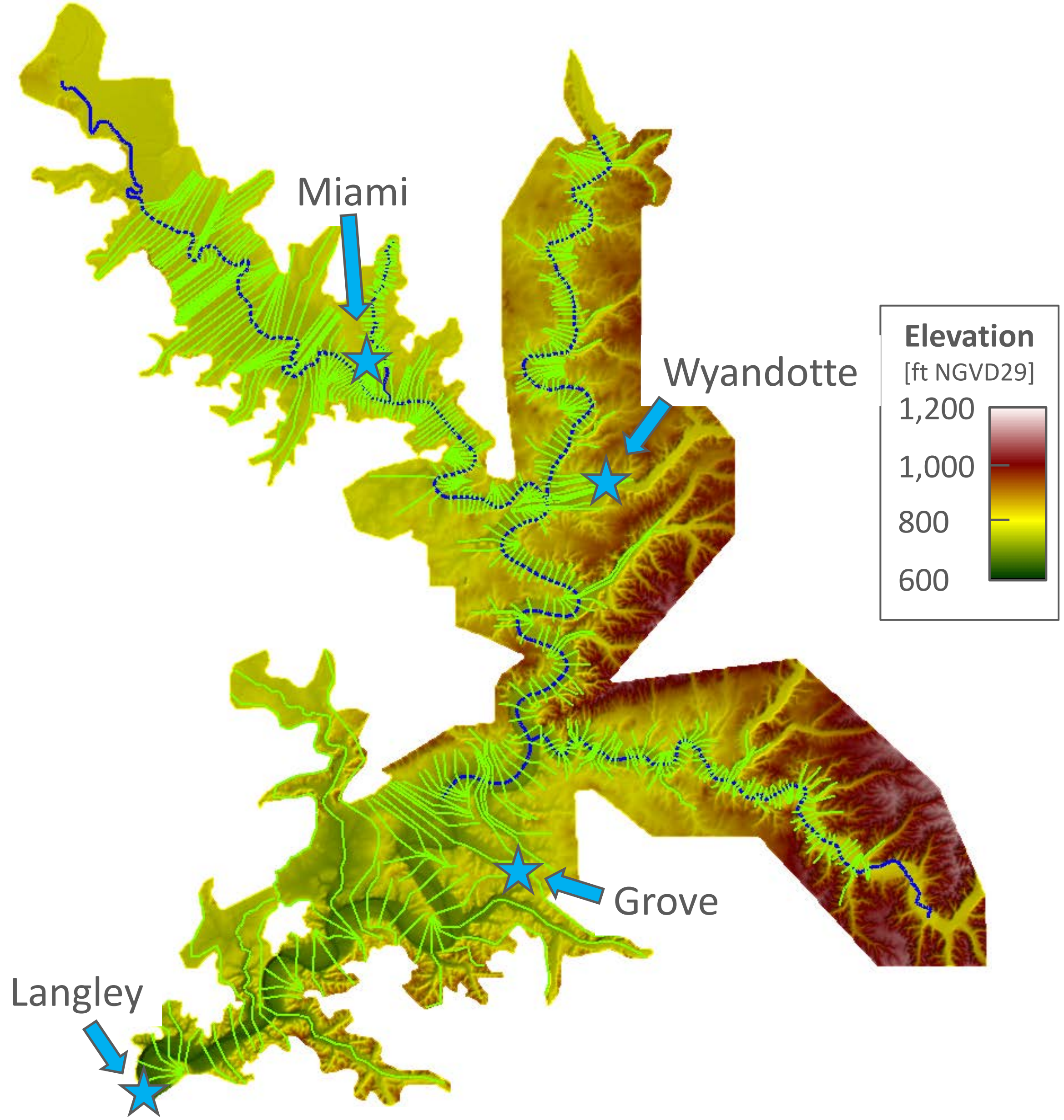
- Water level monitoring
- Sediment sampling
  - Grab samples
  - SEDflume sampling
  - Transport measurements





Summary

- Water level monitoring
- Sediment sampling
  - Grab samples
  - SEDflume sampling
  - Transport measurements
- Model development
  - Planned procedure
  - Hydraulic calibration
  - Challenges
  - Sediment calibration



Recreation Facilities Inventory and Use

Pensacola Hydroelectric Project
Project No. 1494

October 13, 2021

Presentation Outline

1. Study Objectives and Schedule
2. Study Area
3. Methodology
4. Study Results
5. Discussion
6. Conclusions

Study Objectives and Schedule

Study Objectives

1. Characterize recreational use.
2. Estimate future public recreation demand.
3. Assess condition of GRDA's FERC-approved recreation facilities.
4. Evaluate effects of continued operation on recreation (in Exhibit E of License Application).

Schedule and Tasks

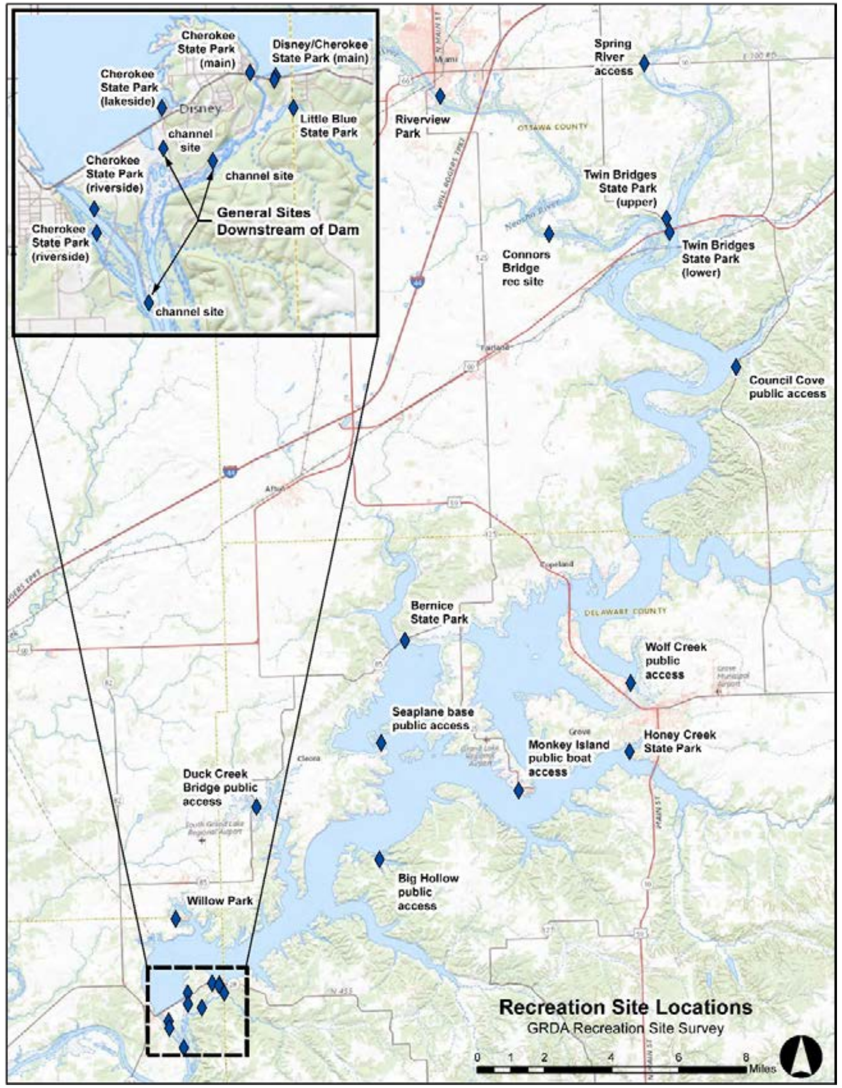
STUDY PERIOD	MAJOR TASKS
1	May through September 2020.
2	No Additional Study Activities.

Study Area

Study Area

Twenty (20) Recreation Sites (Located Around Reservoir)

- Five (5) FERC-approved sites.
  - Big Hollow Public Access
  - Duck Creek Bridge Access Area
  - Monkey Island Public Boat Ramp
  - Sea Plane Base Public Access
  - Wolf Creek Public Access
- Nine (9) State Park sites.
  - Bernice
  - Disney
  - Honey Creek
  - Little Blue
  - Twin Bridges Lower
  - Twin Bridges Upper
  - Cherokee Main
  - Cherokee Lakeside
  - Cherokee Riverside
- Five (5) public access sites.
  - Connors Bridge
  - Council Cove
  - Riverview Park
  - Spring River
  - Willow Park
- River channel sites (informal).



Methodology

Methodology Overview

1. Perform recreation observation surveys.
2. Perform recreation visitor use surveys.
3. Conduct facility condition assessment.
4. Evaluate Project operation effects (in Exhibit E of the License Application).

Recreation Observation Surveys

1. Conducted May through September 2020.
2. Thirty (30) one-hour visits to each of the twenty (20) sites.
   - Six (6) visits per month.
     - Three (3) weekend visits.
     - Three (3) weekday visits.
3. Bi-monthly surveys of river channel informal sites.

Recreation Visitor Use Surveys

1. Conducted May through September 2020.
   - During recreation observation surveys.
   - Required willing participant.
2. Electronic Questionnaire
   - General use information.
   - Resident or visitor.
   - Purpose and duration of visit.
   - Distance traveled.
   - Day use or overnight lodging.
   - History of site/visitation area.
   - Types of recreation participation (primary, secondary, other).
   - General satisfaction.
   - Water level effects.

Facility Condition Assessment

1. Conducted September 22 and 23, 2020.
2. FERC-Approved Sites.
   - Big Hollow Public Access.
   - Duck Creek Bridge Access Area.
   - Monkey Island Public Boat Ramp.
   - Sea Plane Base Public Access.
   - Wolf Creek Public Access.
3. Inventory of amenities and available parking.
4. Assign a condition rating.
   - N-needs replacement.
   - R-needs repair.
   - M-needs maintenance.
   - G-good working condition.

Project Operations Effects Review

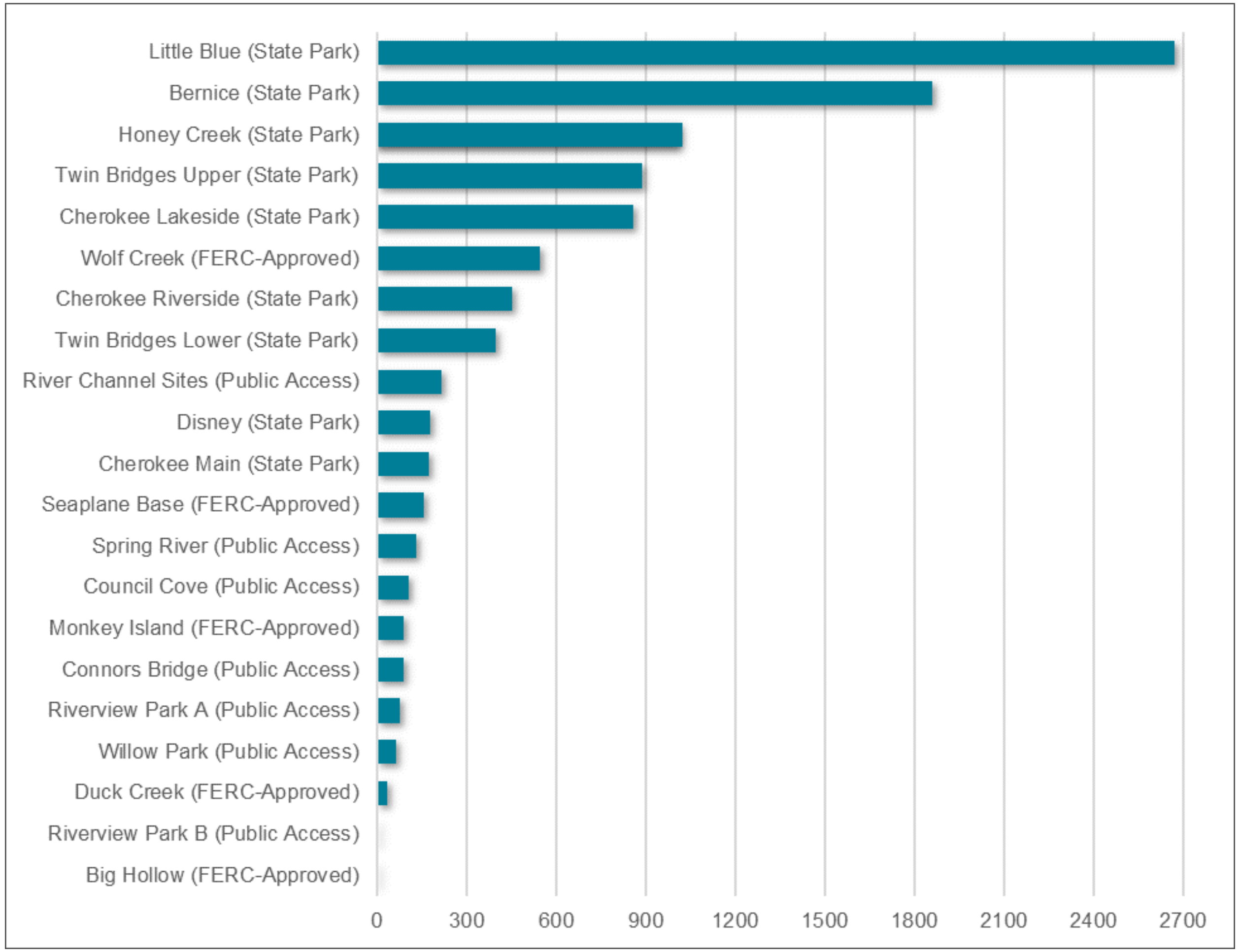
1. Captured images of the usability of the recreation site during various water elevations.
2. Water Level Survey Questions.
   - Safely Swimming
   - Launching/Taking Out Boat
   - Safely Boating
   - Fishing Along Shoreline
   - Accessing Shoreline
   - Using Docks
   - Scenic Quality

Study Results

Current Recreation Use-Visitors

Recreation sites with most users.

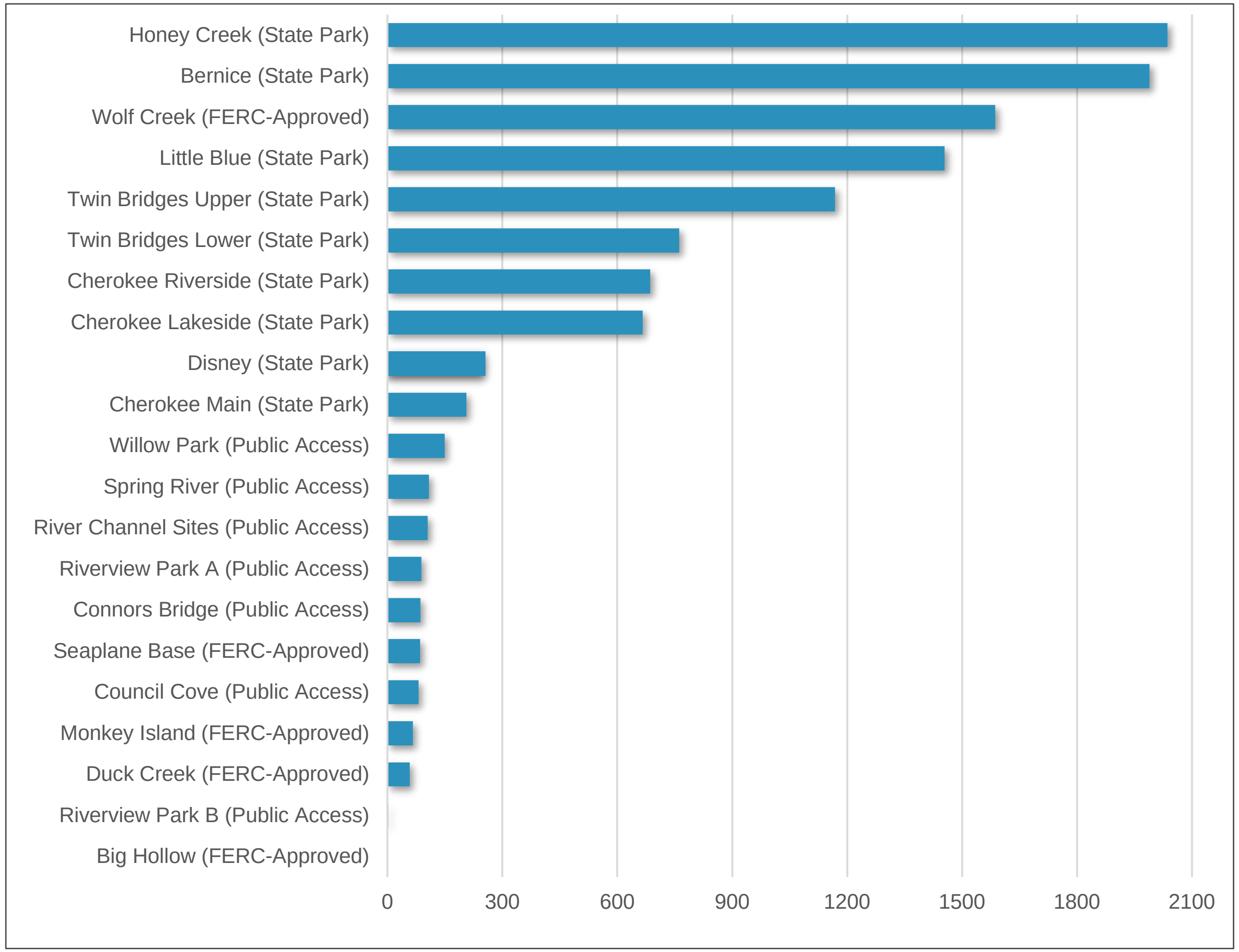
- Little Blue State Park.
  - 2,674 visitors during surveys.
- Bernice State Park.
  - 1,860 visitors during surveys.
- Honey Creek State Park.
  - 1,026 visitors during surveys.
- Twin Bridges State Park (upper).
  - 888 visitors during surveys.
- Cherokee Lakeside Sate Park.
  - 859 visitors during surveys.



Current Recreation Use-Vehicles

Recreation sites with most vehicles.

- Honey Creek State Park.
  - 2,036 vehicles during surveys.
- Bernice State Park.
  - 1,989 vehicles during surveys.
- Wolf Creek Park.
  - 1,587 vehicles.
- Little Blue State Park.
  - 1,454 vehicles.
- Twin Bridges State Park (upper).
  - 1,168 vehicles.



Current Recreation Use-Opportunities

Recreation opportunities in the Project vicinity.

- Bank Fishing.
- Boat Fishing.
- Pleasure Boating.
- Water Crafting.
- Picnicking.
- Swimming.
- Sight-Seeing.
- Hunting or Hunting Access.
  - Big Hollow, Honey Creek, Little Blue, Riverview Park, and River Channel Sites.
- Rafting.
- Wildlife Viewing.
  - All sites.
- Camping.
  - State Parks.

Future Recreation Demand-Population

Population Growth (2010-2020 U.S. Census)

- Nowata County - (11.5%)
- Wagoner County - 10.8%
- Cherokee County - 0.2%
- Adair County - (14.1%)
- Sequoyah County - (7.3%)
- Muskogee County - (6.6%)
- Okmulgee County - (8.4%)
- McIntosh County - (6.5)%
- Ottawa County – (4.9%)

- Craig County – (6.1%)
- Delaware County – (2.6%)
- Mayes County – (5.4%)
- Tulsa County – 10.9%
- Creek County – 2.3%
- Rogers County – 9.6%
- Pawnee County – (6.2%)
- Osage County – (3.5%)
- Washington County – 2.9%

Total 4.5% growth over 2010-2019

Socioeconomic Study: 40% growth by 2075

Facility Condition Assessment

1. Recommended Improvements.
   - Big Hollow.
     - Surface requires grading.
     - FERC recreation sign missing.
   - Duck Creek.
     - FERC recreation sign missing.
     - Steep drop sign needs to be replaced.
   - Monkey Island.
     - Repair/grade access road and ramp.
     - FERC recreation sign missing.
     - Conflicting entrance signage.
   - Seaplane Base.
     - Surface requires grading.
     - FERC recreation sign missing.
   - Wolf Creek.
     - FERC recreation sign missing.

Grand Lake Area Recreation Site	Amenity (assigned a G rating, unless noted otherwise)						
	Boat Launch Ramp/Lane	Dock or Pier	Mooring Dock	Pavilion	Picnic Table	Restroom	Trash Receptacle
FERC-Approved							
• Big Hollow	1 Lane	-	-	-	-	-	-
• Duck Creek	1 Lane	-	-	-	-	-	-
• Monkey Island	1 Lane	-	-	-	-	-	-
• Seaplane Base	1 Lane	-	-	-	-	-	-
• Wolf Creek	6 Lanes	2 Piers	4 Docks	1 Pavilion	6 Tables	1 Rest Room	7 Receptacles

Big Hollow boat launch ramp/lane rating = M, gravel needs grading.
Monkey Island boat launch ramp/lane rating = M, grade access drive.
Wolf Creek: each facility type provides barrier-free access.

Recreation Visitor Use Surveys

Water Levels.

- FERC-Approved Sites
  - Not a problem (NP).
  - Small problem (SP).
  - Neither (N).
  - Moderate problem (MP).
  - Large problem (LP).
  - No opinion/Not applicable (NA).

Interview Site	Rating Criteria	Rating Scale Percentages (some criteria may not add up to 100% due to rounding)					
		NP	SP	N	MP	LP	NA
FERC-Approved Sites (12 interviewed visitors)							
Duck Creek (1 Visitor)	Safely Swim						100%
	Launch/Take Out Boat						100%
	Safely Boat						100%
	Fish Along Shoreline						100%
	Access Shoreline						100%
	Use Docks						100%
	Scenic Quality						100%
Monkey Island (2 Visitors)	Safely Swim	50%					50%
	Launch/Take Out Boat	50%					50%
	Safely Boat	100%					
	Fish Along Shoreline	50%					50%
	Access Shoreline	100%					
	Use Docks	100%					
	Scenic Quality	100%					
Seaplane Base (3 Visitors)	Safely Swim	66%	34%				
	Launch/Take Out Boat	66%			34%		
	Safely Boat	100%					
	Fish Along Shoreline		100%				
	Access Shoreline		34%		66%		
	Use Docks			34%			66%
	Scenic Quality	66%	34%				
Wolf Creek (6 Visitors)	Safely Swim	83%			17%		
	Launch/Take Out Boat	50%			17%	17%	17%
	Safely Boat	50%				17%	34%
	Fish Along Shoreline	50%	17%			17%	34%
	Access Shoreline	33%	17%		17%	17%	17%
	Use Docks	17%			17%[22]		66%
	Scenic Quality	33%	17%				50%

Recreation Visitor Use Surveys

Water Levels.

- State Parks
  - Not a problem (NP).
  - Small problem (SP).
  - Neither (N).
  - Moderate problem (MP).
  - Large problem (LP).
  - No opinion/Not applicable (NA).

Interview Site	Rating Criteria	Rating Scale Percentages (some criteria may not add up to 100% due to rounding)					
		NP	**SP**	**N**	**MP**	**LP**	**NA**
State Park Sites (non-project) (129 interviewed visitors)							
• Bernice (23 Visitors)	Safely Swim	70%	9%	4%	4%		13%
	Launch/Take Out Boat	30%		39%	4%	9%	17%
	Safely Boat	39%		43%			17%
	Fish Along Shoreline	52%	4%	17%			26%
	Access Shoreline	78%	9%		4%		9%
	Use Docks	4%	4%	57%		4%	30%
	Scenic Quality	87%					13%
• Disney (6 Visitors)	Safely Swim	33%		67%			
	Launch/Take Out Boat			83%	17%		
	Safely Boat			83%	17%		
	Fish Along Shoreline		17%	83%			
	Access Shoreline	67%		17%	17%		
	Use Docks	17%		83%			
	Scenic Quality	100%					
• Honey Creek (13 Visitors)	Safely Swim	54%	8%	31%			8%
	Launch/Take Out Boat	31%		46%	8%	8%	8%
	Safely Boat	46%		46%			8%
	Fish Along Shoreline	23%	8%	54%	8%		8%
	Access Shoreline	31%	8%	38%	8%		15%
	Use Docks	31%	8%	38%	8%		15%
	Scenic Quality	69%	8%	15%			8%
• Little Blue (18 Visitors)	Safely Swim	78%	6%	6%			11%
	Launch/Take Out Boat	6%	11%	32%	6%		44%
	Safely Boat	11%	6%	28%	6%		50%
	Fish Along Shoreline	44%	6%	6%			44%
	Access Shoreline	61%	11%				28%
	Use Docks	6%	6%	33%	6%		50%
	Scenic Quality	72%					28%

Recreation Visitor Use Surveys

Water Levels.

- State Parks (continued)
  - Not a problem (NP).
  - Small problem.
  - Neither.
  - Moderate problem.
  - Large problem.
  - No opinion/Not applicable.

Interview Site	Rating Criteria	Rating Scale Percentages (some criteria may not add up to 100% due to rounding)					
		NP	SP	N	MP	LP	NA
State Park Sites (non-project) (129 interviewed visitors)							
• Twin Bridges Lower (17 Visitor)	Safely Swim	24%		29%	18%	6%	24%
	Launch/Take Out Boat	35%	6%	35%	12%		12%
	Safely Boat	53%		35%			12%
	Fish Along Shoreline	47%		12%	18%	6%	18%
	Access Shoreline	41%	6%	12%	12%		29%
	Use Docks	24%	6%	35%		6%	29%
	Scenic Quality	59%	6%	12%	6%		18%
• Twin Bridges Upper (7 Visitors)	Safely Swim	29%		43%			29%
	Launch/Take Out Boat	29%		43%			29%
	Safely Boat	29%		43%			29%
	Fish Along Shoreline	14%		57%			29%
	Access Shoreline	14%		57%			29%
	Use Docks	14%		57%			29%
	Scenic Quality	14%	29%	43%			14%
• Cherokee Main (10 Visitors)	Safely Swim	70%		10%			20%
	Launch/Take Out Boat	40%	10%	20%			30%
	Safely Boat	30%	10%	20%	10%		30%
	Fish Along Shoreline	40%	10%	30%			20%
	Access Shoreline	70%		10%			20%
	Use Docks	20%		40%			40%
	Scenic Quality	60%	10%				30%
• Cherokee Lakeside (16 Visitors)	Safely Swim	81%		13%		6%	
	Launch/Take Out Boat	31%	6%	44%			19%
	Safely Boat	25%		44%	6%		25%
	Fish Along Shoreline	31%		38%			31%
	Access Shoreline	38%	19%	19%			25%
	Use Docks	25%		44%			31%
	Scenic Quality	63%		6%		6%	25%

Recreation Visitor Use Surveys

Water Levels.

- State Parks (continued)
  - Not a problem.
  - Small problem.
  - Neither.
  - Moderate problem.
  - Large problem.
  - No opinion/Not applicable.

Interview Site	Rating Criteria	Rating Scale Percentages (some criteria may not add up to 100% due to rounding)					
		NP	SP	N	MP	LP	NA
State Park Sites (non-project) (129 interviewed visitors)							
• Cherokee Riverside (19 Visitors)	Safely Swim	21%	5%	37%		5%	32%
	Launch/Take Out Boat		11%	42%		5%	42%
	Safely Boat	11%	11%	42%			37%
	Fish Along Shoreline	37%	11%	21%	5%		26%
	Access Shoreline	32%	26%	16%	5%		21%
	Use Docks	11%		42%			47%
	Scenic Quality	53%	11%	11%			26%

Recreation Visitor Use Surveys

Water Levels.

- Other Access Sites
  - Not a problem (NP).
  - Small problem (SP).
  - Neither (N).
  - Moderate problem (MP).
  - Large problem (LP).
  - No opinion/Not applicable (NA).

Interview Site	Rating Criteria	Rating Scale Percentages (some criteria may not add up to 100% due to rounding)					
		NP	SP	N	MP	LP	NA
Public Access Sites (non-project) (22 interviewed visitors)							
• Connors Bridge (6 Visitors)	Safely Swim	17%		33%			50%
	Launch/Take Out Boat	17%	17%	50%			17%
	Safely Boat		17%	50%			33%
	Fish Along Shoreline	50%			17%		33%
	Access Shoreline	67%			33%		
	Use Docks			50%			50%
	Scenic Quality	67%	17%				17%
• Council Cove (3 Visitors)	Safely Swim	33%		33%			33%
	Launch/Take Out Boat	33%		33%	33%		
	Safely Boat	67%		33%			
	Fish Along Shoreline	33%		33%			33%
	Access Shoreline	100%					
	Use Docks			100%			
	Scenic Quality	100%					

Recreation Visitor Use Surveys

Water Levels.

- Other Access Sites
  - Not a problem (NP).
  - Small problem (SP).
  - Neither (N).
  - Moderate problem (MP).
  - Large problem (LP).
  - No opinion/Not applicable (NA).

Interview Site	Rating Criteria	Rating Scale Percentages (some criteria may not add up to 100% due to rounding)					
		NP	SP	N	MP	LP	NA
Public Access Sites (non-project) (22 interviewed visitors)							
• Riverview Park (5 Visitors)	Safely Swim		20%	20%	40%	20%	
	Launch/Take Out Boat	20%			20%	20%	40%
	Safely Boat	40%			20%		40%
	Fish Along Shoreline	60%	20%		20%		
	Access Shoreline	60%	20%		20%		
	Use Docks	40%				20%	40%
	Scenic Quality	60%		20%		20%	
• Spring River (6 Visitors)	Safely Swim	17%	17%	17%		33%	17%
	Launch/Take Out Boat	50%		17%	33%		
	Safely Boat	50%	17%	17%		17%	
	Fish Along Shoreline	83%	17%				
	Access Shoreline	67%	33%				
	Use Docks			50%		17%	33%
	Scenic Quality	83%	17%				
• River Channel Sites (2 Visitors)	Safely Swim					50%	50%
	Launch/Take Out Boat					50%	50%
	Safely Boat					50%	50%
	Fish Along Shoreline	50%					50%
	Access Shoreline				50%		50%
	Use Docks					50%	50%
	Scenic Quality	50%					50%

Recreation Site Pictures

Site Pictures Water Levels.

- 742.2 Feet PD (lowest) to 748.29 Feet PD (highest)
  - Elevation at Pensacola Dam.

Discussion

Recreation Site Capacity

Recreation Site Capacity
- Parking capacity is generally limiting for formal recreation sites
- Total 4.5% population growth (2010-2020)

Recreation Site	Limiting Capacity Factor	Average Use Capacity and Percent Capacity		Capacity Improvement Expansion Needs
Wolf Creek	Primary Activity: Boat Launch Vehicle parking spaces: 15 Trailer parking spaces: 85[7]	Total vehicles: Vehicle/30 days: Site Capacity: % Capacity:	1,587 53 100 53%	Boat Launching is well-utilized. Parking available for all users. Expansion not needed.
Bernice Creek State Park	Primary Activity: Camping RV sites w/ parking: 33 Primitive sites w/ parking: 28 Additional parking spaces: 28	Total vehicles: Vehicle/30 days: Site Capacity: % Capacity:	1,989 66 89 74%	Camping sites are well-utilized. Parking available for all users. Expansion not needed.
Honey Creek State Park	Primary Activity: Camping RV sites w/ parking: 30 Primitive sites w/ parking: 150 Trailer parking spaces: 20	Total vehicles: Vehicle/30 days: Site Capacity: % Capacity:	2,036 68 200 34%	Camping sites are well-utilized. Parking available for all users. Expansion not needed.
Little Blue State Park	Primary Activity: Swimming Camp sites w/ parking: 18 Additional parking spaces: 5	Total vehicles: Vehicle/30 days: Site Capacity: % Capacity:	1,454 48 23 200%	Overflow parking on road, at State Park entrance. Site restricted by topography and geography. Expansion not feasible.

[7] The Wolf Creek smaller lot includes 85 trailer parking spaces. The expanded lot includes 208 spaces. Only those trailer parking spaces in the smaller lot are considered for capacity calculations.

Recreation Site Capacity (continued)

Recreation Site Capacity

- Parking capacity is generally limiting for formal recreation sites
- Total 4.5% population growth (2010-2020)

Recreation Site	Limiting Capacity Factor	Average Use Capacity and Percent Capacity		Capacity Improvement Expansion Needs
Twin Bridges Lower State Park	Primary Activity: Camping RV sites w/ parking: 17 Primitive sites w/ parking: 10 Vehicle parking spaces: 12 Trailer parking spaces: 53[8]	Total vehicles: Vehicle/30 days: Site Capacity: % Capacity:	761 25 39 64%	Camping sites are well-utilized. Parking available for all users. Expansion not needed.
Twin Bridges Upper State Park	Primary Activity: Camping RV sites w/ parking: 46 Primitive sites w/ parking: 54 Vehicle parking spaces: 72	Total vehicles: Vehicle/30 days: Site Capacity: % Capacity:	1,168 39 105 37%	Camping sites are well-utilized. Parking available for all users. Expansion not needed.
Cherokee Lakeside State Park	Primary Activity: Camping Small RV sites w/ parking: 11 Primitive sites with parking: 6 Trailer parking spaces: 30	Total vehicles: Vehicle/30 days: Site Capacity: % Capacity:	666 22 47 47%	Camping sites are well-utilized. Parking available for all users. Expansion not needed.
Cherokee Riverside State Park	Primary Activity: Camping RV sites w/ Parking: 33 Additional parking spaces: 5	Total vehicles: Vehicle/30 days: Site Capacity: % Capacity:	686 23 38 61%	Camping sites are well-utilized. Parking available for all users. Expansion not needed.

[8]Counting the boat launch trailer spaces (53) would skew the capacity results at Twin Bridge State Park Lower, as the primary recreation activity was camping. Therefore, the calculation did not include the boat launch parking spaces.

Spring River Boat Launch

747.83 Feet PD

742.20 Feet PD

Riverview Park Boat Launch

748.29 Feet PD

742.20 Feet PD

Twin Bridges Boat Launch

748.29 Feet PD

742.20 Feet PD

Connors Bridge Boat Launch

747.83 feet PD

742.20 Feet PD

Wolf Creek Boat Launch

748.29 Feet PD

748.29 Feet PD

Wolf Creek Boat Launch (continued)

748.29 Feet PD

747.83 Feet PD

Wolf Creek Boat Launch (continued)

742.20 Feet PD

742.20 Feet PD

Wolf Creek Boat Launch (continued)

742.20 Feet PD

742.20 Feet PD

Honey Creek Boat Launch

748.29 Feet PD

742.20 Feet PD

Disney Boat Launch

748.29 Feet PD

742.20 Feet PD

Riverside Boat Launch

747.83 Feet PD

742.20 Feet PD

Duck Creek Boat Launch

748.29 Feet PD

742.20 Feet PD

Seaplane Base Boat Launch

748.29 Feet PD

742.20 Feet PD

Bernice Boat Launch

748.29 Feet PD

748.29 Feet PD

Bernice Boat Launch (continued)

742.20 Feet PD

742.20 Feet PD

Conclusions

Conclusions

1. All sites have adequate capacity for the foreseeable future.
   - Exception: Little Blue State Park parking capacity (increased capacity limited by topography).
2. No new recreation sites need to be established.
3. Most popular recreation activities.
   - Camping, Shoreline Fishing, Boat Fishing, Boating, and Picnicking.
4. All FERC-approved recreation sites rated as good.
   - Exception: Monkey Island needs access road/parking work and signage work.
5. All boat launches accessible and usable at elevations of at least 742 feet PD.
6. Nine (9) of sixteen (16) boat launches are accessible at elevations exceeding 747 feet PD.
7. Most respondents indicated either no problem, a small problem, or neither regarding the effect of water levels on recreation.

Thank you

SOCIOECONOMIC STUDY

THE GRAND RIVER DAM AUTHORITY—PENSACOLA PROJECT

GRDA

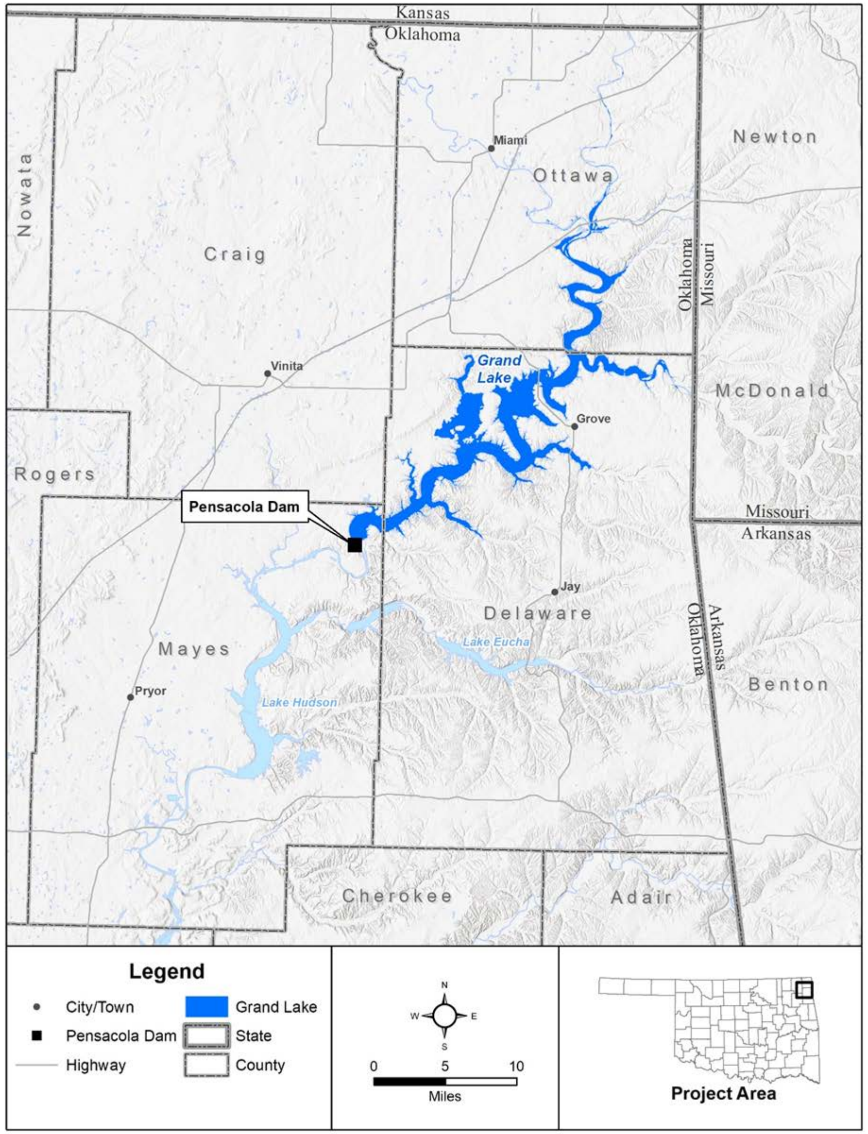
Agenda

- Introduction
- Report Topics
  - Land Use
  - Population Trends
  - Demography
  - Housing Trends (Availability and Value)
  - Economics (Study Area and GRDA)
  - Income and Poverty
  - Stakeholder Outreach
  - Cumulative Impacts
- Summary

Introduction

The goal of GRDA's socioeconomics study was to gather, synthesize, and report on existing information necessary to qualitatively evaluate the socioeconomic effects of the Pensacola Project in the study area.

The study area used for this evaluation is defined as a four-county area that includes Craig, Delaware, Mayes and Ottawa Counties, Oklahoma.



Land Use

The Socioeconomic Study reviewed general land use trends, parks and recreational areas, and shoreline development.

Primary land use and land cover types in the four-county study area are agricultural and forest (approximately 86%).

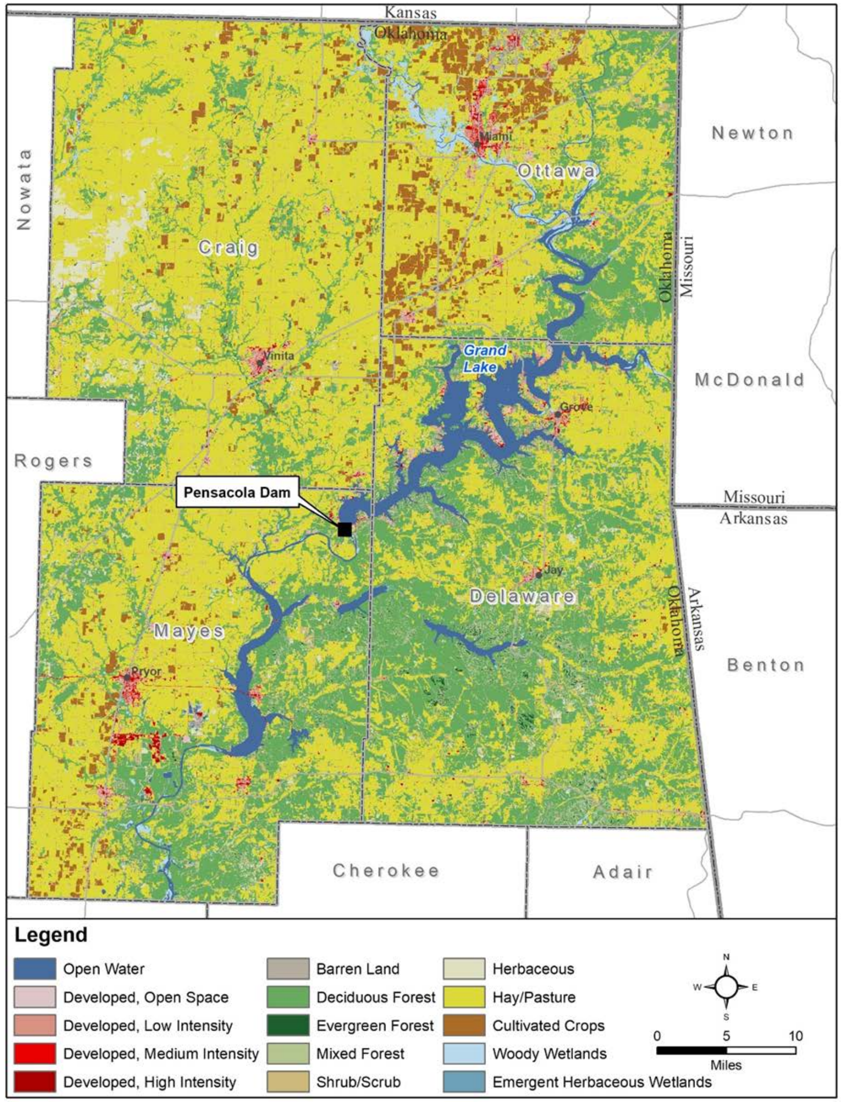
- Developed areas cover approximately 6%.
- Land cover has seen minor changes between 2001 and 2019.
- Land cover adjacent to Grand Lake is primarily Deciduous Forest and Woody Wetlands.

There are five state parks and numerous privately operated facilities, boat launches, recreational vehicle sites, and wildlife areas.

- GRDA operates and maintains the Duck Creek Bridge Public Access Area, Seaplane Bass Public Access Area, Monkey Island Public Boat Ramp, Big Hollow Public Access, and Wolf Creek Public Access Area.

Development along the shoreline of Grand Lake primarily consists of residential, commercial, and limited agricultural lands.

(Multi-Resolution Land Characteristic Consortium)



Population Trends

The study evaluated population trends in the four-county area and the State of Oklahoma between 2000 to 2020, and projected population out to 2075.

The population of the four counties within the study area increased between 2000 and 2010; however, according to the latest census is now showing a decline from 2010 to 2020.

The population in Oklahoma, by contrast, has had consistent increases between 2000 and 2020.

The projected population for 2075 show declining populations for Craig County; while Delaware, Mayes and Ottawa Counties and the State of Oklahoma are expected to have an increasing population trend.

Characteristic	Craig County	Delaware County	Mayes County	Ottawa County	Oklahoma
2010 Population Total (Decennial)	15,029	41,487	41,259	31,848	3,751,351
2019 Population Total (Estimate)	14,142	43,009	41,100	31,127	3,956,971
2020 Population Total (Decennial)	14,107	40,397	39,046	30,285	3,959,353
2075 Population Total (Projection)	14,075	79,945	68,504	35,920	5,560,007

Demography

Characteristic	Craig County	Delaware County	Mayes County	Ottawa County	Oklahoma
White	60.8%	62.9%	61.3%	63.9%	63.5%
Black or African American	2.7%	0.3%	0.5%	1%	7.3%
American Indian and Alaska Native	20.2%	21.5%	21.1%	18.8%	8.4%
Asian	0.5%	1.2%	0.5%	0.5%	2.3%
Native Hawaiian and Other Pacific Islander	0.02%	0.1%	0.1%	0.8%	0.2%
Some Other Race	1.1%	1.5%	1.1%	1.8%	5.4%
Two or More Races	14.6%	12.5%	15.5%	13.1%	12.8%
Hispanic or Latino	3.0%	4.0%	3.5%	5.6%	11.9%
Education – high school graduate or higher, % of persons aged 25 years+, 2014–2018 estimate	86.6%	83.9%	86.6%	84.9%	87.8%

Housing Trends: Availability

For Housing, the Socioeconomic Study evaluated both the availability and value of housing within the study area.

Total housing, occupancy, and housing availability followed a similar trend as population in that it typically increased between 2000 to 2010 and decreased between 2010 and 2020.

- The one exception is Ottawa County where total housing and occupancy have been declining since 2000.

The greatest change during this period occurred in the Vacancy Units Category, which typically showed an increase for all counties and the state between 2000 to 2010 and a decrease from 2010 to 2020.

- The one exception is Mayes County, which saw a continued increase through 2020.

(U.S. Census Bureau)

	Name	2000 to 2010 Change (%)	2010 to 2020 Change (%)
Craig County	Total Housing Units	4.1	-5.3
	Occupied Units	1.1	-4.5
	Vacancy Units	24.3	-9.4
	Vacancy	2.5	-0.7
Delaware County	Total Housing Units	10.1	-1.8
	Occupied Units	8.3	3.8
	Vacancy Units	13.6	-12.5
	Vacancy	1.1	-3.7
Mayes County	Total Housing Units	9.1	-4
	Occupied Units	8.4	-5.3
	Vacancy Units	13.2	3.5
	Vacancy	0.6	1.2
Ottawa County	Total Housing Units	-4	-3.8
	Occupied Units	-6.3	-2.5
	Vacancy Units	12.4	-11.2
	Vacancy	2.2	-1.2
Oklahoma	Total Housing Units	10	4.8
	Occupied Units	6.8	7.2
	Vacancy Units	35.5	-9.5
	Vacancy	2.6	-1.9

Housing Trends: Value

Both Median Housing Value and Median Rent showed an increasing trend through 2019 for the study area and the state.

Between 2000 and 2010, Craig County showed the greatest increase in Median House Value (67%) followed closely by Ottawa County at 66.7%.

- Mayes County had the greatest increase in Median Rent at 47.5% during this period.

Between 2010 and 2019, Delaware County had the greatest increase in Median Housing Value (27.6%), whereas Ottawa County had the greatest increase in Median Rent at 30.2%.

Name	2000 ($)	2010 ($)	2000 to 2010 Change (%)	2019 Estimate ($)	2010 to 2019 Change (%)
Craig County					
Median House Value ($)	52,100	87,000	67.0	109,000	25.3
Median Rent ($/month)	396	551	39.1	752	36.5
Delaware County					
Median House Value ($)	81,900	92,400	12.8	117,900	27.6
Median Rent ($/month)	390	535	37.2	688	28.6
Mayes County					
Median House Value ($)	66,500	89,200	34.1	112,800	26.5
Median Rent ($/month)	394	581	47.5	745	28.2
Ottawa County					
Median House Value ($)	47,200	78,700	66.7	86,300	9.7
Median Rent ($/month)	355	520	46.5	677	30.2
Oklahoma					
Median House Value ($)	70,700	111,400	57.6	147,000	32.0
Median Rent ($/month)	456	659	44.5	814	23.5

(U.S. Census Bureau)

Economics: Study Area

The primary sectors of employment in the four-county area include government, agriculture and manufacturing.

- Craig – State and Local Government (19 %)
- Delaware – Agriculture (8.4 %)
- Mayes – Manufacturing (15.5 %)
- Ottawa – State and Local Government (35.2 %)

Other industries include retail, construction, real estate, health care, transportation, arts and entertainment, forestry and utilities.

Total employment in the four-county area was 56,183 jobs in 2018.

Between 2014 and 2018, US Census Bureau reports show the percentage of population that contributed to the labor force ranged from approximately 56% for Mayes and Ottawa, Counties to about 48% for Delaware County.

Characteristic	Craig County	Delaware County	Mayes County	Ottawa County	Oklahoma
2018 GDP	$437 Million	$781.9 Million	$1.4 Billion	$889.8 Million	$190.8 Billion
Labor Force Population (%)	51.9	48.1	56.0	55.5	60.7

(National Association of Counties, Oklahoma Department of Commerce

Economics: GRDA & Grand Lake

GRDA has provided multiple economic benefits to the study area and the state.

- Between 2015 and 2020, the operations of GRDA is estimated to provide between $510 to $581 million to the state economy.
- GRDA supports over 7,100 jobs with 25% of those directly related to the Grand River Energy Center.

The Oklahoma Department of Commerce estimated economic impact of tourism, quality of life, and relative power costs are expected to contribute approximately $240–$260 million to the state between 2015 and 2020.

In 2018, the Oklahoma Tourism and Recreation Department noted that total spending on recreational travel in the study area included:

- $18.0 million in Craig County,
- $194.6 million in Delaware County,
- $49.8 million in Mayes County, and
- $337 million in Ottawa County.

The construction of a new generation plant at the Grand River Energy Center in Mayes County is projected to generate an additional $210 million in additional economic activity within the first year of construction and another $214 million in the second year.

(National Association of Counties, Oklahoma Department of Commerce

Income and Poverty

The Socioeconomic Study, Section 1.6, evaluated income and poverty for the fourcounty study area and the state of Oklahoma using the latest available data (2019).

The median household income for the four-county area ranged from $39,070 in Ottawa County to $48,853 in Mayes County.

The per capita Income for the four-county area ranged from $20,209 in Ottawa County to $23,861 in Mayes County.

According to the US Census, in 2019 the percentage of people living in poverty is consistently higher in the four-county study area than for the State of Oklahoma.

2019 Characteristic	Craig County	Delaware County	Mayes County	Ottawa County	Oklahoma
Poverty (Families)	12.9%	13.3%	14.1%	15.8%	10.8%
Poverty (Individual)	18.6%	18.3%	18.1%	20.7%	15.2%

(U.S. Bureau of Labor Statistics, U.S. Census Bureau)

Stakeholder Outreach

As outlined in the FERC-approved study plan, GRDA sent letters to 179 stakeholders to request input for the Socioeconomic Study.

- These included local, state and federal agencies, Tribal organizations and individuals, congressional delegations, non-governmental organizations, and interested public residents.

GRDA received responses from eight stakeholders:

- U.S. Bureau of Indian Affairs
- City Manager of Grove, Oklahoma
- United Keetoowah Band of Cherokees
- The State of Oklahoma
- America’s Boating Club, Grand Lake Commander
- City of Miami
- The Miami Tribe of Oklahoma
- Larry Bork *et al.*

Cumulative Impacts

The Socioeconomic Study's cumulative impacts analysis evaluated potential compounding socioeconomic impacts associated with the continued operation of the Pensacola Hydroelectric Project during the proposed operating term with past, present, and reasonably foreseeable future actions.

For the purposes of this analysis:

- past actions were those related to the resources at the time of hydropower plant licensing and construction or to the earliest date of available data,
- present actions are those related to the resources at the time of current operation of the hydropower plant, and
- future actions are considered to be those that are reasonably foreseeable through the end of hydropower plant operation.

Findings:

- The continued operation of the Pensacola Hydroelectric Project is not anticipated to result in noticeable changes to land use trends, population, demography, and housing.
- The Pensacola Project provides multiple economic benefits to the economy in the four-county study area by creating jobs and providing pathways for higher wages and assisting in the reduction of poverty.
- Thus, relicensing this site is not anticipated to have any cumulative socioeconomic impacts in conjunction with past, present and future actions.

Summary

GRDA and the Pensacola Hydroelectric Project will continue to benefit the employment and economics of the four-county study area through job opportunities, higher wages, and support of local tourism.

The continued operations of the Pensacola Hydroelectric Project are anticipated to have no adverse socioeconomic impacts.

Questions / Discussion

Aquatic Species of Concern Study

PADDLEFISH SUB-STUDY

Paddlefish Background

Polyodon spathula, aka Spoonbill

Native to large rivers of eastern Oklahoma

Support a prominent snag fishery in Grand Lake and tributaries

Paddlefish angling has an estimated economic impact of 18.2 million dollars in Oklahoma

Grand Lake is a prominent Paddlefish fishery

ODWC Paddlefish Research Center

Paddlefish Background

Planktivorous

Inhabit deep slow moving water in large rivers and associated lakes and reservoirs

Electrical receptors on rostrum assist in detecting zooplankton

Food is filtered from the water using specialized gill rakers

Large spring spawning aggregations in tributary rivers provide opportunities for snag anglers

Paddlefish Background

Spawning occurs in large groups over hard substrates (e.g., cobble) in riverine environments
- Oklahoma: spawning peaks in late March and early April

Spawning is episodic and strongly tied to springtime pulse events
- Initiated by rising water levels and occurring during periods of high flow

Paddlefish spawn demersal eggs which adhere to the substrate
- Hard substrates such as gravel and cobble are considered key
- Eggs that fall on sand or silt may have reduced survival

Previous Research on Grand Lake Paddlefish

1) Recruitment trends

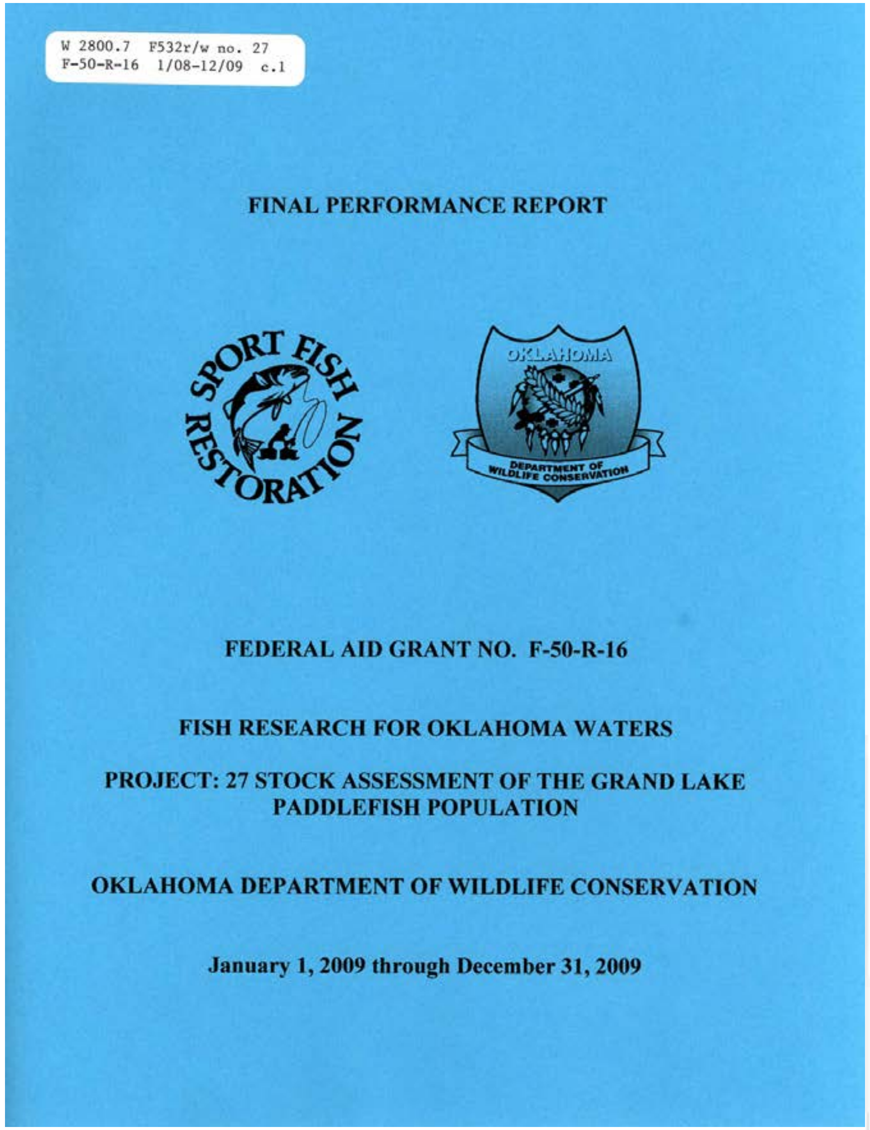
- What factors influence recruitment?
- Age Paddlefish and examine annual recruitment in relation to environmental conditions
- 2009 Stock Assessment of the Grand Lake Paddlefish Population (Gordon 2009)

2) Spawning habitat

- Hard substrates are presumed to be critical
- Estimate spawning habitat by quantifying the amount of hard substrate inundated under various flow levels
- Benthic Habitat Mapping of Grand Lake Tributaries as it Relates to Paddlefish Recruitment (Schooley and O'Donnell 2016)

3) Where is most recruitment occurring?

- Using Dentary Bone Microchemistry to Identify Natal River… (Whitledge and Schooley 2019)



FINAL PERFORMANCE REPORT

FEDERAL AID GRANT NO. F-50-R-16

FISH RESEARCH FOR OKLAHOMA WATERS

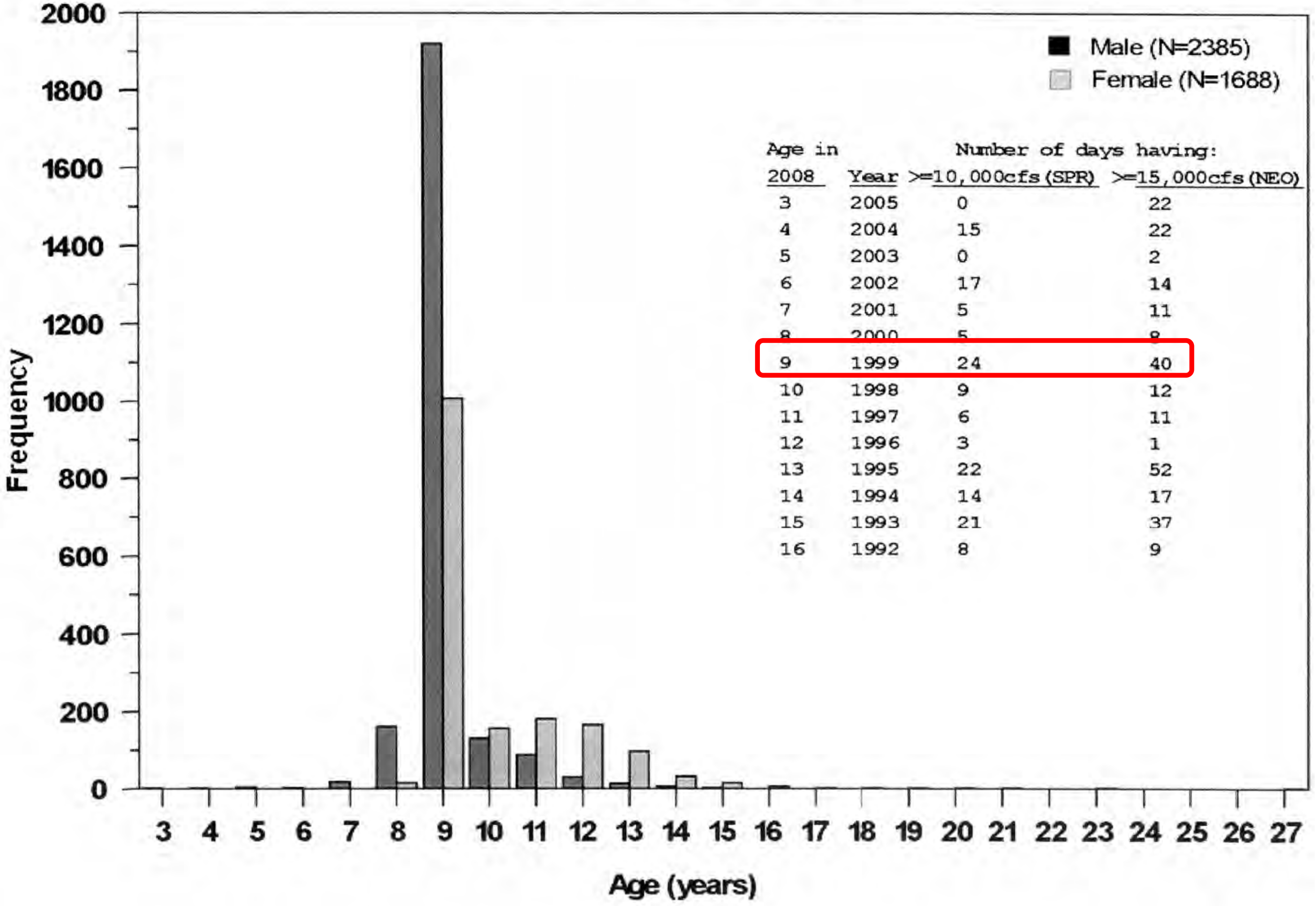
PROJECT: 27 STOCK ASSESSMENT OF THE GRAND LAKE PADDLEFISH POPULATION

OKLAHOMA DEPARTMENT OF WILDLIFE CONSERVATION

January 1, 2009 through December 31, 2009

Figure 5.

Frequency histograms for male and female paddlefish age
(2008 Oklahoma harvest data)



Age in 2008	Year	Number of days having: >=10,000cfs (SPR)	>=15,000cfs (NEO)
3	2005	0	22
4	2004	15	22
5	2003	0	2
6	2002	17	14
7	2001	5	11
8	2000	5	8
9	1999	24	40
10	1998	9	12
11	1997	6	11
12	1996	3	1
13	1995	22	52
14	1994	14	17
15	1993	21	37
16	1992	8	9

Schooley and O’Donnell 2016

Used consumer grade sonar to map hard substrates (e.g., cobble, gravel, bedrock) in the Spring and Neosho rivers upstream to the first barrier

- Soft substrates (H<0.386), hard substrates (H>0.386)

Estimated spawning habitat was simulated over a range of river stages

Predictive models were developed to estimate Proportional Habitat Availability (PHA) under different flow conditions in each tributary

Neosho River has greater value to Paddlefish recruitment than Spring River

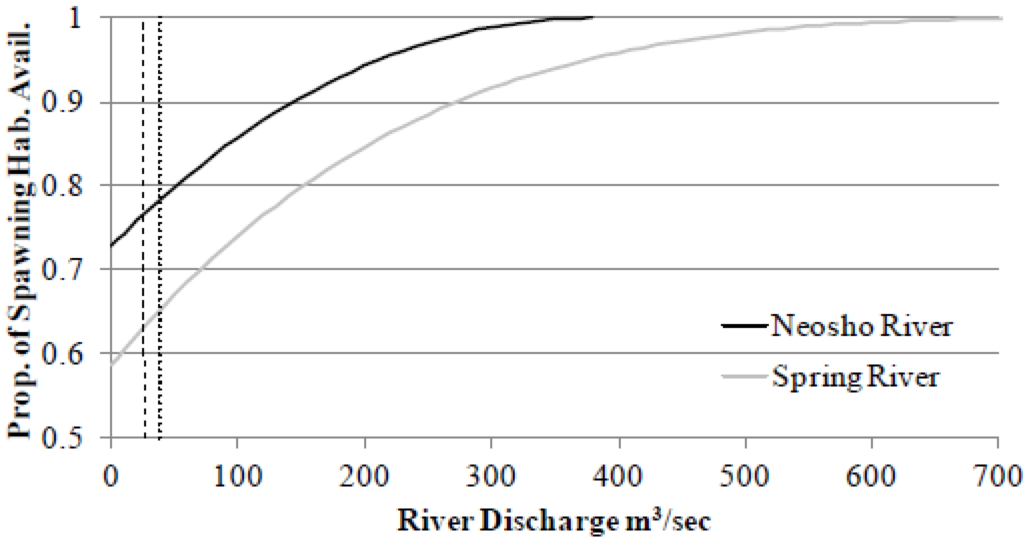


Figure 16. Proportional habitat availability models for the Neosho and Spring rivers. Vertical dashed and dotted lines indicate median springtime discharge 25.46 and 38.23 m^3/sec for the Neosho and Spring rivers, respectively, as measured in 2015 and 2016.

Whitledge and Schooley 2019

Geologic differences between the Neosho and Spring River watersheds result in differences between strontium:calcium (Sr:Ca) ratios

Sr:Ca ratios from center of dentary bone were used to infer natal river

775 Paddlefish analyzed from three year classes

- 87% were identified as Neosho River origin
- 7% Spring River origin
- Percentages differed among year classes, but Spring River-origin fish represented ≤ 10% in all three year classes sampled

Most recruitment happening in Neosho River

Previous Research Summary

Paddlefish year-class recruitment is variable, and strongly tied to high springtime flows

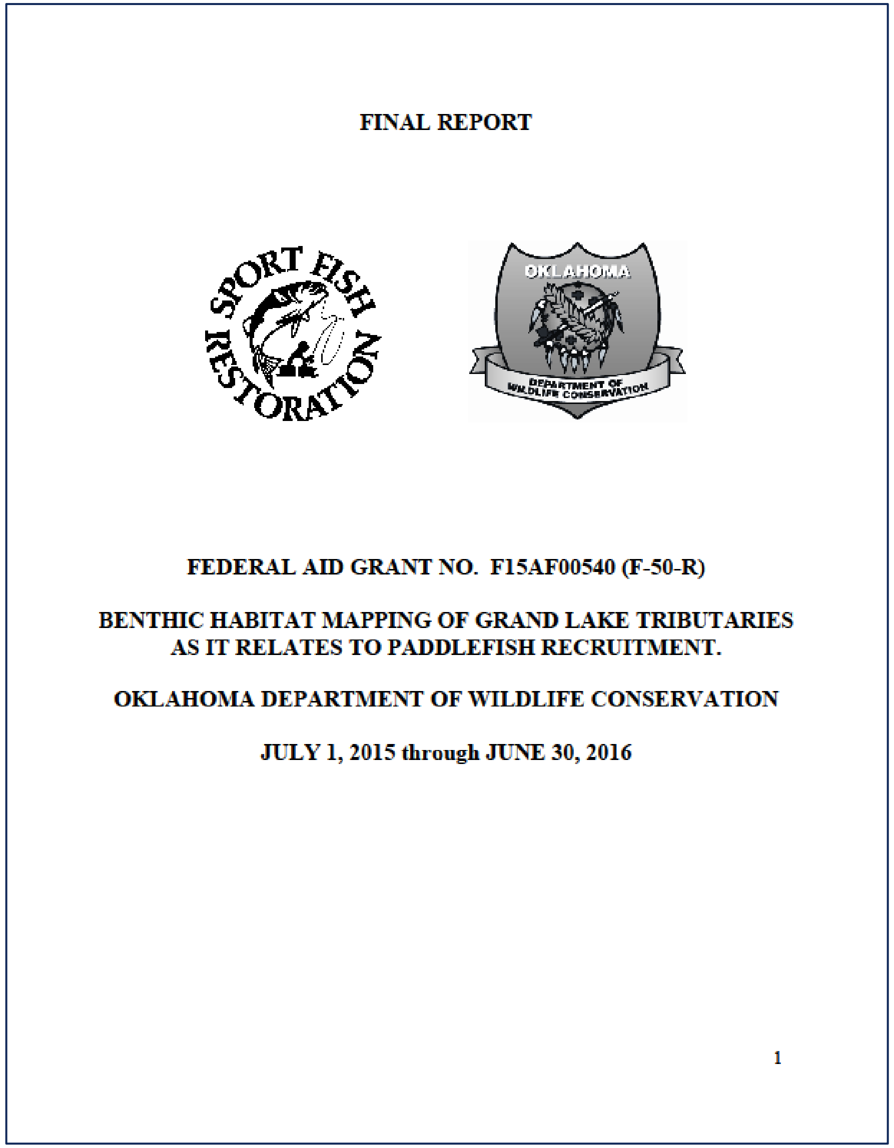
Based on spawning substrates, the Neosho River demonstrates greater Proportional Habitat Availability (PHA) at lower river stages, and therefore has greater value for Paddlefish reproduction than the Spring River

Dentary bone microchemistry suggests Neosho River recruits dominate the population

Paddlefish Sub-study

Estimate area of Paddlefish spawning substrate affected by project operations and the corresponding effect on Paddlefish recruitment

- Map data from ODWC's Benthic Habitat Mapping of Grand Lake Tributaries as it Relates to Paddlefish Recruitment (Schooley and O'Donnell 2016)
- Examine relationship between Paddlefish spawning habitat and the Project



FINAL REPORT

FEDERAL AID GRANT NO. F15AF00540 (F-50-R)

BENTHIC HABITAT MAPPING OF GRAND LAKE TRIBUTARIES AS IT RELATES TO PADDLEFISH RECRUITMENT.

OKLAHOMA DEPARTMENT OF WILDLIFE CONSERVATION

JULY 1, 2015 through JUNE 30, 2016

1

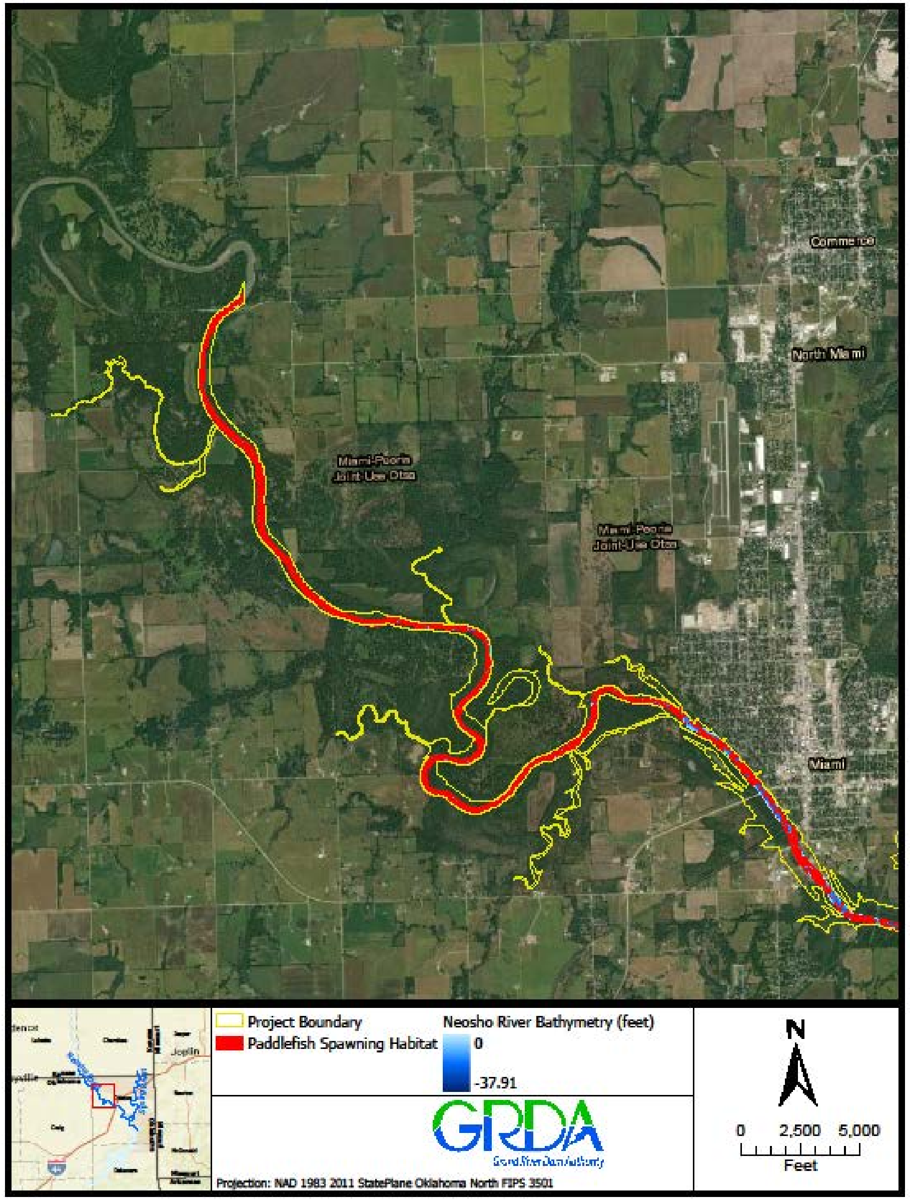
Paddlefish Sub-study

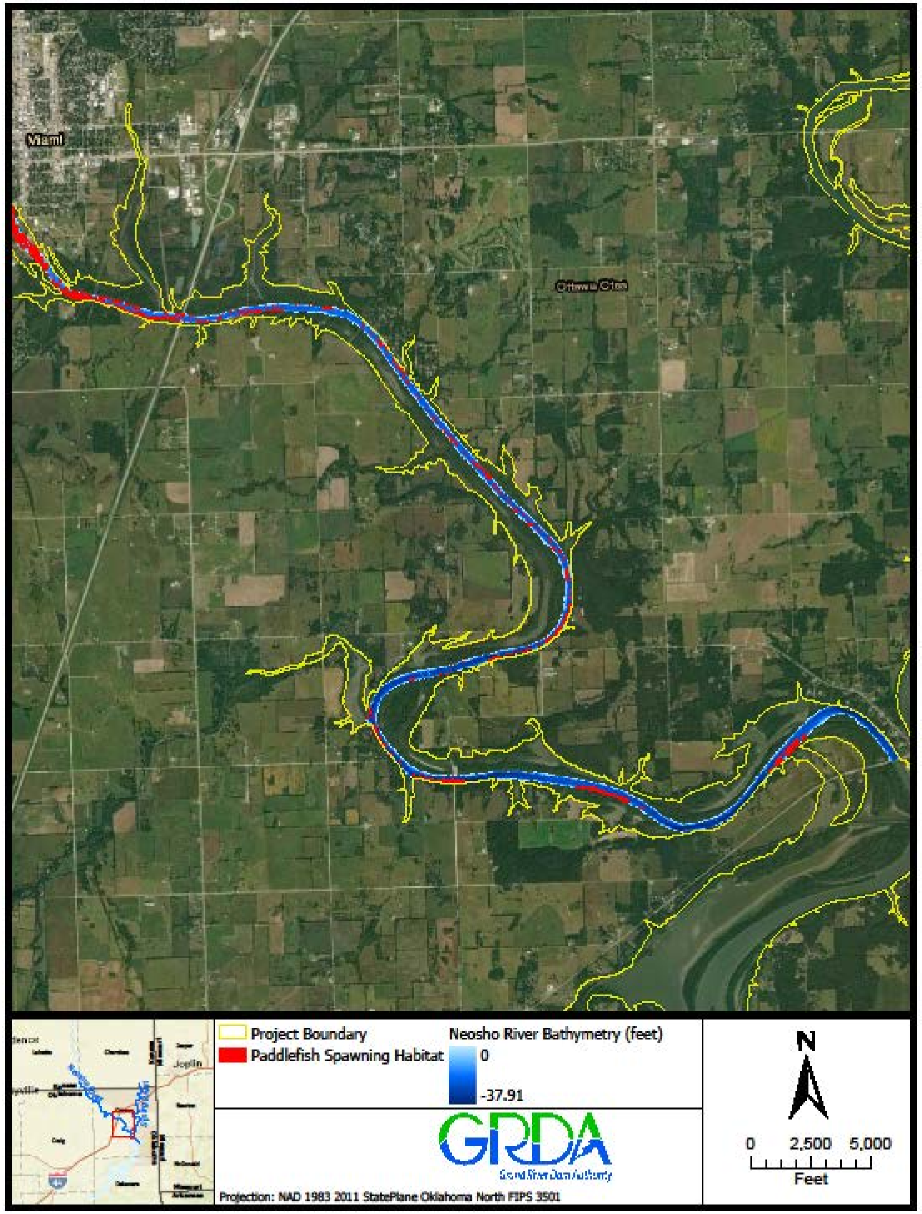
Spatially explicit depth and hardness data from the above studies were provided by the study authors

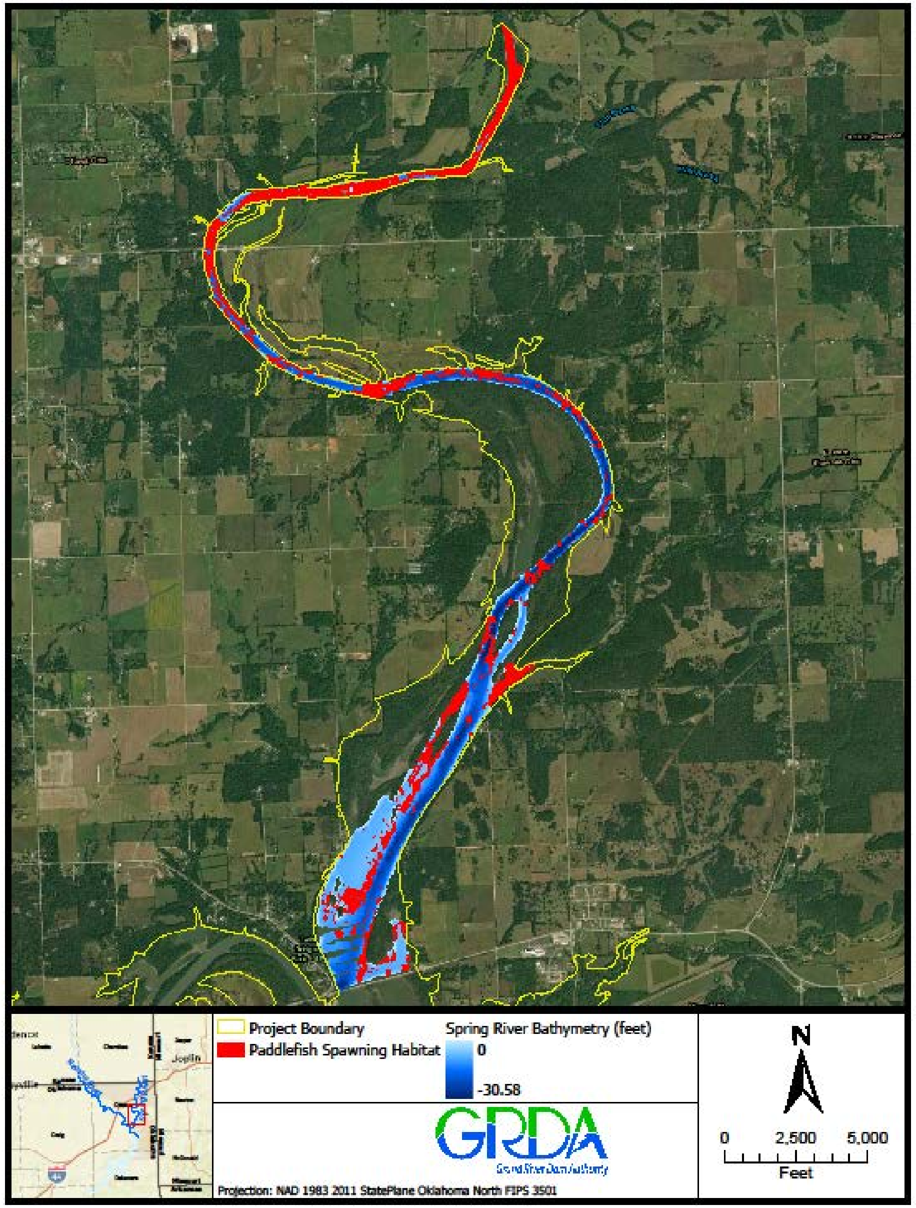
Data compiled and formatted for use in GIS

Generated maps of Paddlefish spawning habitat within the Project Boundary

Quantified the amount of suitable spawning substrate within the Project Boundary in each river system


Commerce
North Miami
Miami-Peoria Joint-Use Otsa
Miami-Peoria Joint-Use Otsa
Miami
Joplin
Project Boundary
Paddlefish Spawning Habitat
Neosho River Bathymetry (feet)
0
-37.91
GRDA
Grand River Dam Authority
N
0 2,500 5,000
Feet
Projection: NAD 1983 2011 StatePlane Oklahoma North FIPS 3501


Miami
Joplin
Project Boundary
Paddlefish Spawning Habitat
Neosho River Bathymetry (feet)
0
-37.91
GRDA
Grand River Dam Authority
N
0 2,500 5,000
Feet
Projection: NAD 1983 2011 StatePlane Oklahoma North FIPS 3501


Project Boundary
Paddlefish Spawning Habitat
Spring River Bathymetry (feet)
0
-30.58
N
0
2,500
5,000
Feet
Projection: NAD 1983 2011 StatePlane Oklahoma North FIPS 3501

Results

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

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

Conclusions

Approximately 70% of Paddlefish spawning substrate in each river occurs within the Project Boundary.

Availability of Paddlefish spawning substrate increases in upstream areas which are minimally impacted by Project operations at high inflow conditions required for successful spawning.

The river/reservoir interface below the confluence of the Spring and Neosho rivers is used as a staging area in late winter and early spring as Paddlefish wait for high flow pulses to move upstream and begin spawning.

Previous research suggests Paddlefish recruitment success is strongly tied to hydrology and is best in years with extended high flow conditions during the spawning period in the Neosho River.

Occurrence of such events have a much greater influence on Paddlefish recruitment than reservoir levels, and therefore, no additional analysis is proposed.

Aquatic Species of Concern

SPECIES OF CONCERN SUB-STUDY

olsson

Species of Concern

Neosho mucket (*Lampsilis rafinesqueana*)

Rabbitsfoot (*Quadrula cylindrica cylindrica*)

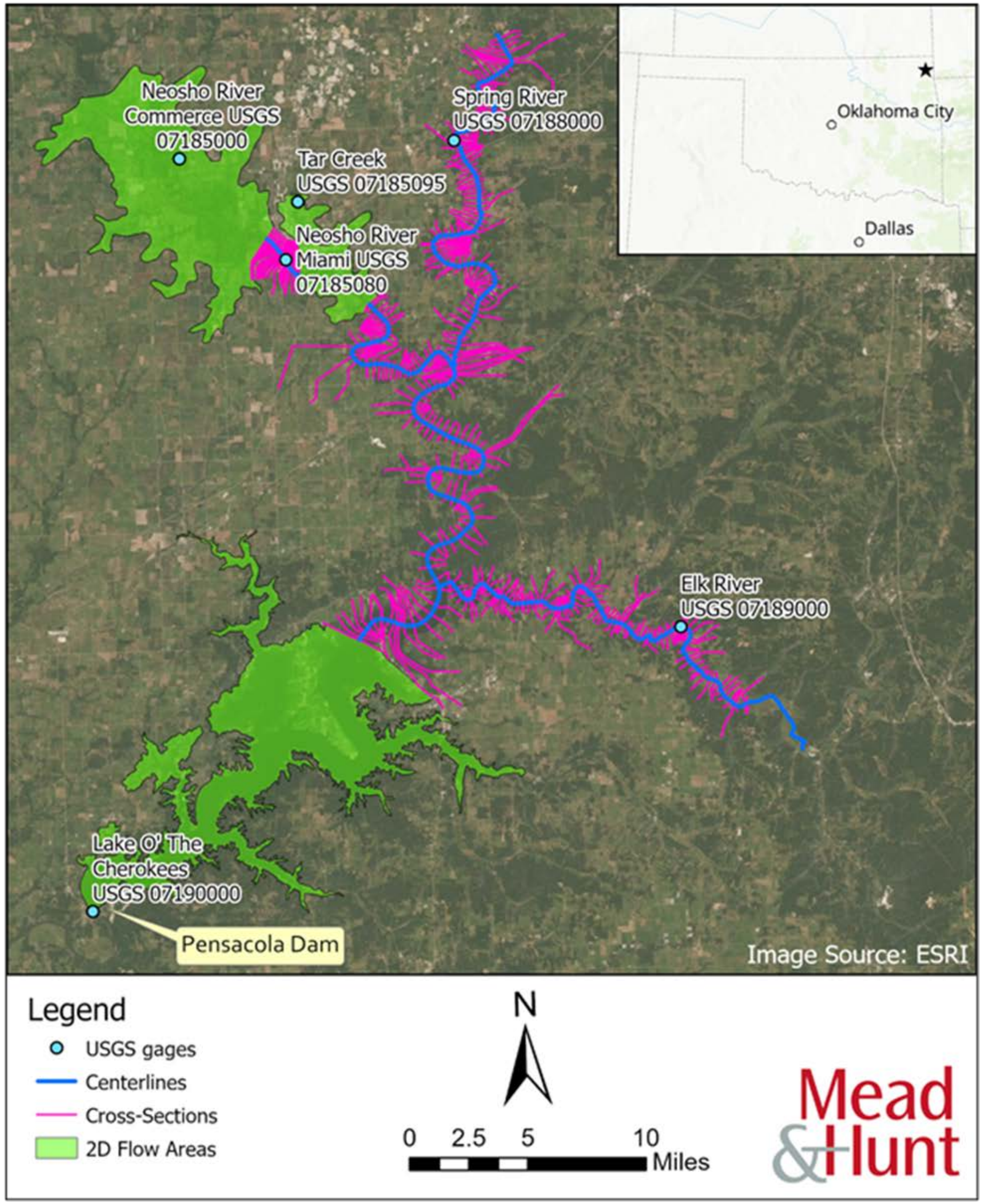
Winged mapleleaf (*Quadrula fragosa*)

Neosho madtom (*Noturus placidus*)

Neosho smallmouth Bass (*Micropterus dolomieu velox*)

Study Area

- Grand Lake in portions of Craig, Mayes, Delaware, and Ottawa counties, Oklahoma.
- Corresponds to those counties associated with the Hydrologic and Hydraulic (H&H) Study
- The study area extends upstream from Pensacola Dam:
  - Neosho River to within approximately 3 miles of the Kansas state line,
  - Spring River to within 6.5 miles of the Kansas state line,
  - Elk River to the upstream to the Missouri state dictated by the H&H model,
  - Tar Creek to just upstream of the U.S. Geological Survey (USGS) gage at 22nd Avenue Bridge,
  - Bays/coves within Grand Lake associated with tributaries flowing into the lake.



Neosho Mucket (*Lampsilis rafinesqueana*) Background

Currently Found in Arkansas River System

- Neosho River, Spring River, Elk River

Historically observed in seventeen streams within Neosho, Illinois and Verdigris River Basins

Found in shallow riffles/runs in moderate to swift-moving water, but may use backwater habitat

Spawn in April-May

Female brood glochidia through August

Glochidial Host: Largemouth bass (*Micropterus salmonides*), smallmouth (*Micropterus dolomieu*) and spotted bass (*Mocropterus punctulatus*)

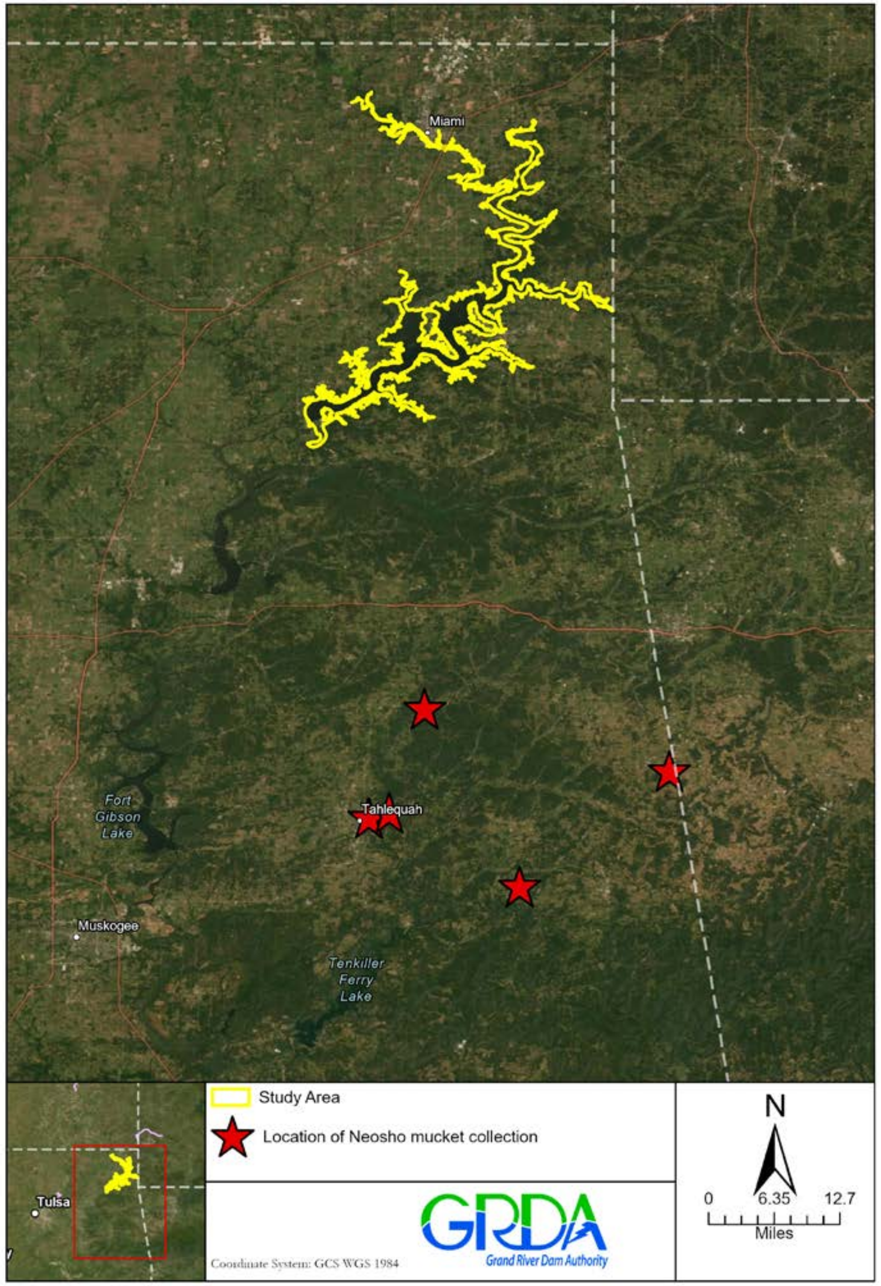
Neosho Mucket (*Lampsilis rafinesqueana*) Habitat and Conservation Status

Endangered effective October 17, 2013 – listed wherever found

Critical habitat within Elk River in Oklahoma (Unit NM2)

Declining in Neosho River (last observed 2014)

Stable in Spring and Elk Rivers (last observed in 2017)



Known Locations of Neosho Mucket

Neosho Mucket
Date Review & Phase II Recommendations

Summary of Current Data

Recent studies found no live or relic shell of federally listed mussels within or upstream of the project extent (EcoAnalyst 2018)

Surveys within Spring River from project boundary to state line did not identify live listed mussels.

No presence or absence data within Elk River portion of the GRDA project boundary.

- USFWS 5-year review suggested population might extend into Elk river within the project extent

Only One live Neosho Mucket found during bridge construction project (2014)

Phase II Recommendations

Conduct listed mussel survey within Elk River from confluence of Buffalo Creek upstream to Missouri State line

Rabbitsfoot Mussel (*Quadrula cylindrica cylindrica)* Background

Found in the Verdigris, Illinois, and Little rivers

Historically observed in Verdigris, Neosho, Spring, Illinois, Blue, and Little rivers in Oklahoma

Found in rivers that have a moderate current and clear,shallow water with sand and gravel substrates

Spawn in May-June

Glochidial Host: Blacktail shiner (*Cyprinella venusta*), red shiner (*Cyprinella lutrensis*), bluntface shiner (*Cyprinella camu ra*), cardinal shiner (*Luxilus cardinalis*), whitetail shiner (*Cyprinella galctura*), spotfin shiner (*Cyprinella spiloptera*), and bigeyed chub (*Hybopsis amblops*)

Rabbitsfoot Mussel
Habitat and Conservation Status

Quadrula cylindrica cylindrica

Endangered effective October 17, 2013 – listed wherever found

Critical habitat in Spring River in Missouri (Unit RF1), and the Neosho River in central Kansas (Unit RF3)

Rabbitsfoot Mussel
Data Review & Phase II Recommendations

Summary of Current Data

Most recent studies found no live or relic shell of federally listed mussels within or upstream of the project extent (Eco Analyst 2017)

Surveys within Spring River from project boundary to state line did not identify live listed mussels.

No known occurrence data within the project area

Closest critical habitat - 25 miles upstream from the Project Area in Jasper County Missouri on the Spring River.

No live specimens have been found in Oklahoma segment of the river during recent surveys (EcoAnalysts 2018).

The five year (USFWS 2020b) acknowledges the Oklahoma segment of the river as historic range with no extant population.

Phase II Recommendations

No Surveys recommended

Winged Mapleleaf (*Quadrula fragosa)* Background

Within Oklahoma, currently found only in Little River

Historically found in Boggy, Kiamichi, Neosho, and Little rivers of Oklahoma

Found in streams with high water quality and sand, cobble, or rubble substrate, often in dense mussel beds with many mussel species

Fall tachytictic or short-term brooder

Glochidial Host: Channel catfish (*Ictalurus punctatus),* Blue catfish (*Ictalurus furcatus*)


USFWS/Midwest Region

Winged Mapleleaf
Habitat and Conservation Status

Endangered effective June 20, 1991, endangered wherever found except experimental population

No critical habitat designated

Winged Mapleleaf
Data Review & Phase II Recommendations

Summary of Current Data

Recent studies found no live or relic shell of federally listed mussels within or upstream of the project extent (EcoAnalyst 2018)

Surveys within Spring River from project boundary to state line did not identify live listed mussels.

Sam Nobel Museum, Oklahoma State invertebrate collection department and ODWC indicate that no specimens have been previously found within the Neosho, Spring, and Elk Rivers or surrounding drainages leading up to the reservoir.

The only recognized population in Oklahoma is within the Little River which is 175 miles from the study area.

Phase II Recommendations

No additional studies recommenced

Neosho Madtom (*Noturus placidus*) Background

Native to the Illinois River, Neosho River, Cottonwood Creek, and Spring River in Oklahoma

Extant Oklahoma populations restricted to the Neosho River upstream from Grand Lake

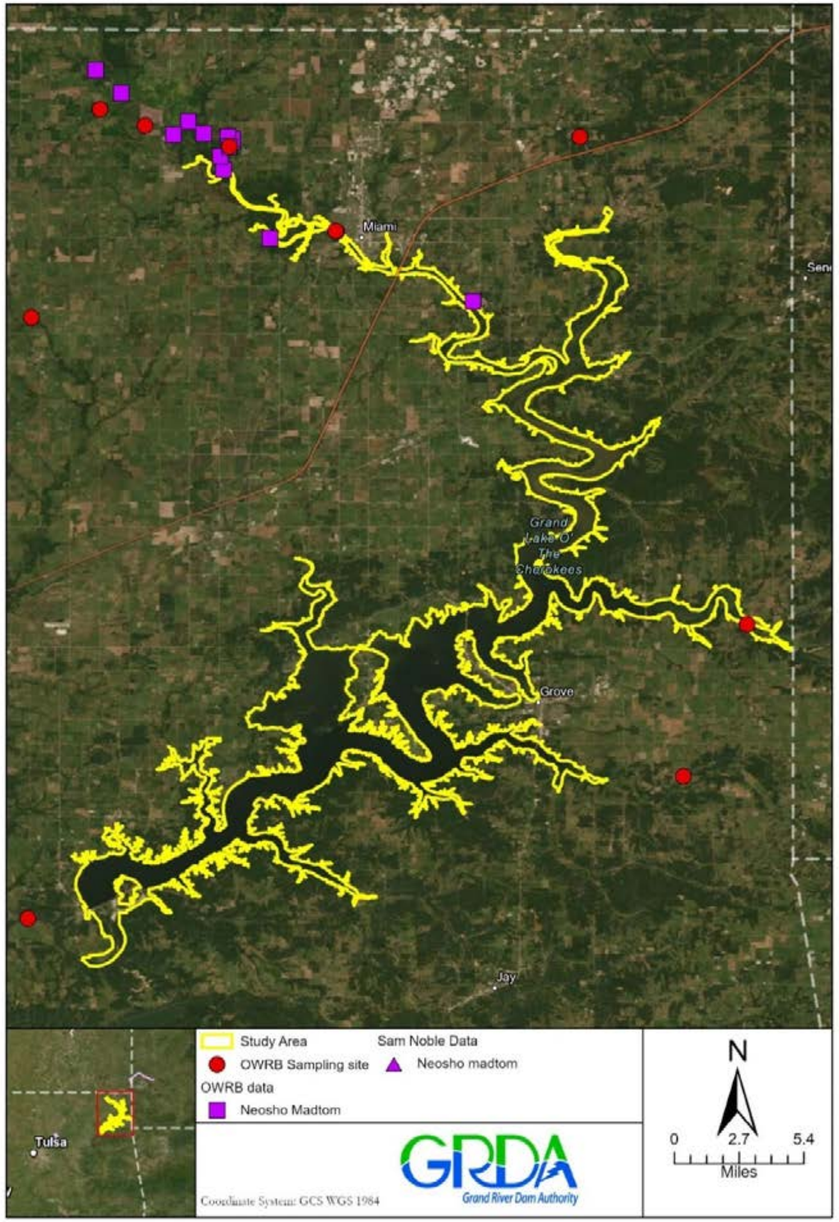
Found in riffles and bar habitats with loose pebble and gravel substrate, moderate to high water velocities, and shallow depths

Neosho Madtom
Habitat and Conservation Status

Noturus placidus

Threatened effective June 22, 1990 – listed wherever found

No critical habitat



Known Locations of Neosho Madtom

Neosho Madtom
Data Review & Phase II Recommendations

Summary of Current Data

Found in the drainages of the study area from 1969-2007

2016 – Last known survey near the project by OWRB

2007 - The closest collection point within the study area

Phase II Recommendations

Targeted sampling within the 20 mile stretch of the Neosho River from HWY 60 to the Craig/Ottawa County line in locations that contain riffles and moderate to low-velocity gravel bar habitats.

Neosho Smallmouth Bass (*Micropterus dolomieu velox*) Background

Native to western extent of the Ozark Highlands ecoregion

- Spring River, Elk River, Neosho River, Spavinaw Creek, Spring Creek, Illinois River, Baron Fork, Sallisaw Creek, Lee Creek, Clear Creek, Mulberry River, Big Piney Creek, and the Illinois Bayou

Found in streams that have watersheds with coarse-textured soils

Constructs nests in fine sediment substrates and low water velocity

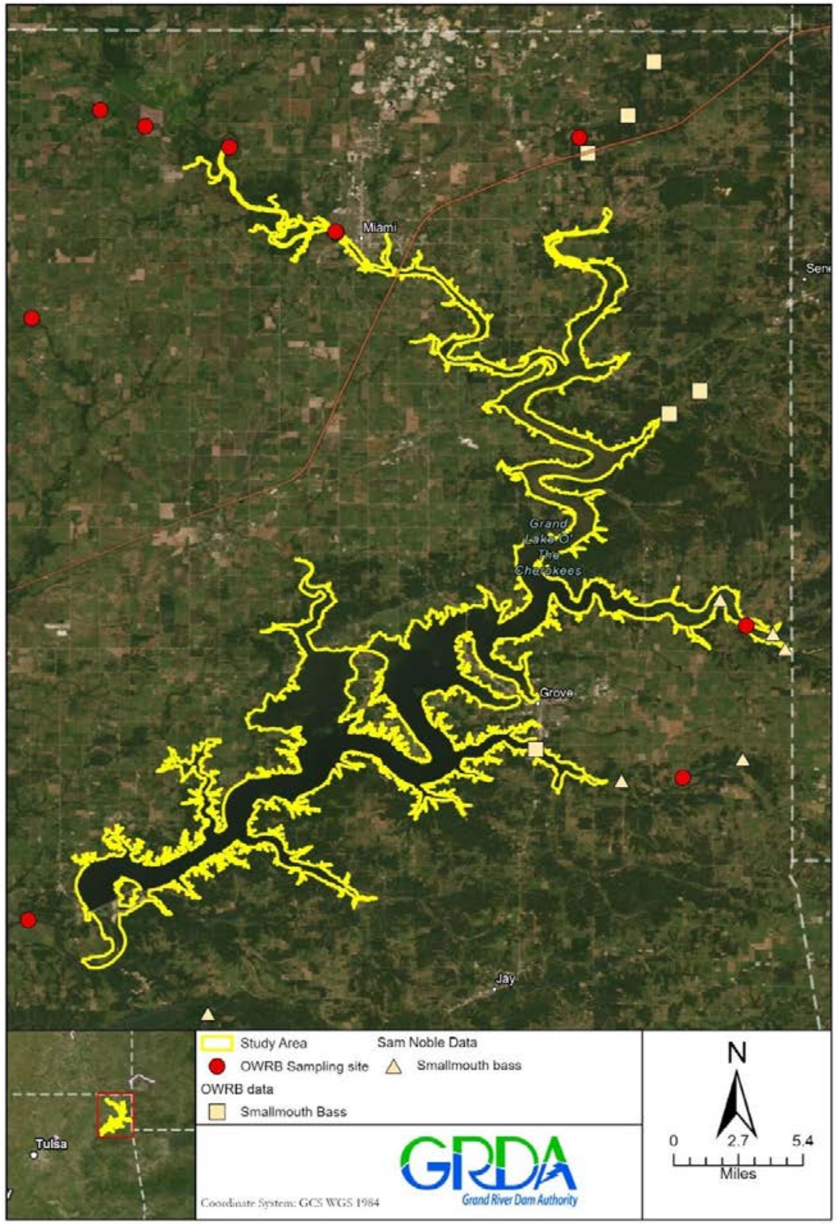

Missouri Department of Conservation

Neosho Smallmouth Bass
Habitat and Conservation Status

Oklahoma species of concern

Conservation would provide a “diversified portfolio” that would contribute to maintaining the overall adapt-ability of Smallmouth Bass to future climate change or habitat-related stressors (Schindler et al. 2010)

No critical habitat



Known Locations of Neosho Smallmouth Bass

Neosho Smallmouth Bass
Data Review & Phase II Recommendations

Summary of Current Data

Records show smallmouth bass population present within the drainages of the study area

Identified as a genetically distinct subspecies of smallmouth bass (Stark and Echelle 1998, Tayler et al. 2018)

Known to occur in the Spring River, Elk River, Neosho River, Honey Creek, Spavinaw Creek, Spring Creek, Sycamore Creek, Illinois River, Baron Fork, Sallisaw Creek, Lee Creek, Clear Creek, the Mulberry River, Big Piney Creek, and the Illinois Bayou (Brewer and Long 2015, Taylor et. Al 2018).

Smallmouth bass from OWRB and the Sam Nobel Museum found within the study area not likely Neosho strain

ODWC sampling efforts (locations not disclosed), did not detect the Neosho subspecies of the smallmouth bass within this project area or surrounding drainages

Phase II Recommendations

No additional studies recommenced

Conclusions

MUSSELS

Neosho Mucket

Surveys within critical habitat in Elk River from Buffalo Creek to Missouri state line

Rabbitsfoot Mussel & Winged Mapleleaf

No additional surveys suggested

FISH

Neosho Madtom

Targeted sampling within the Neosho River from HWY 60 to the Craig/Ottawa County line

Neosho Smallmouth Bass

No additional surveys suggested

Terrestrial Species of Concern Study for the Pensacola Hydroelectric Project (Project; FERC [Federal Energy Regulatory Commission] No. 1494); Craig, Delaware, Mayes and Ottawa Counties, Oklahoma

Prepared For:

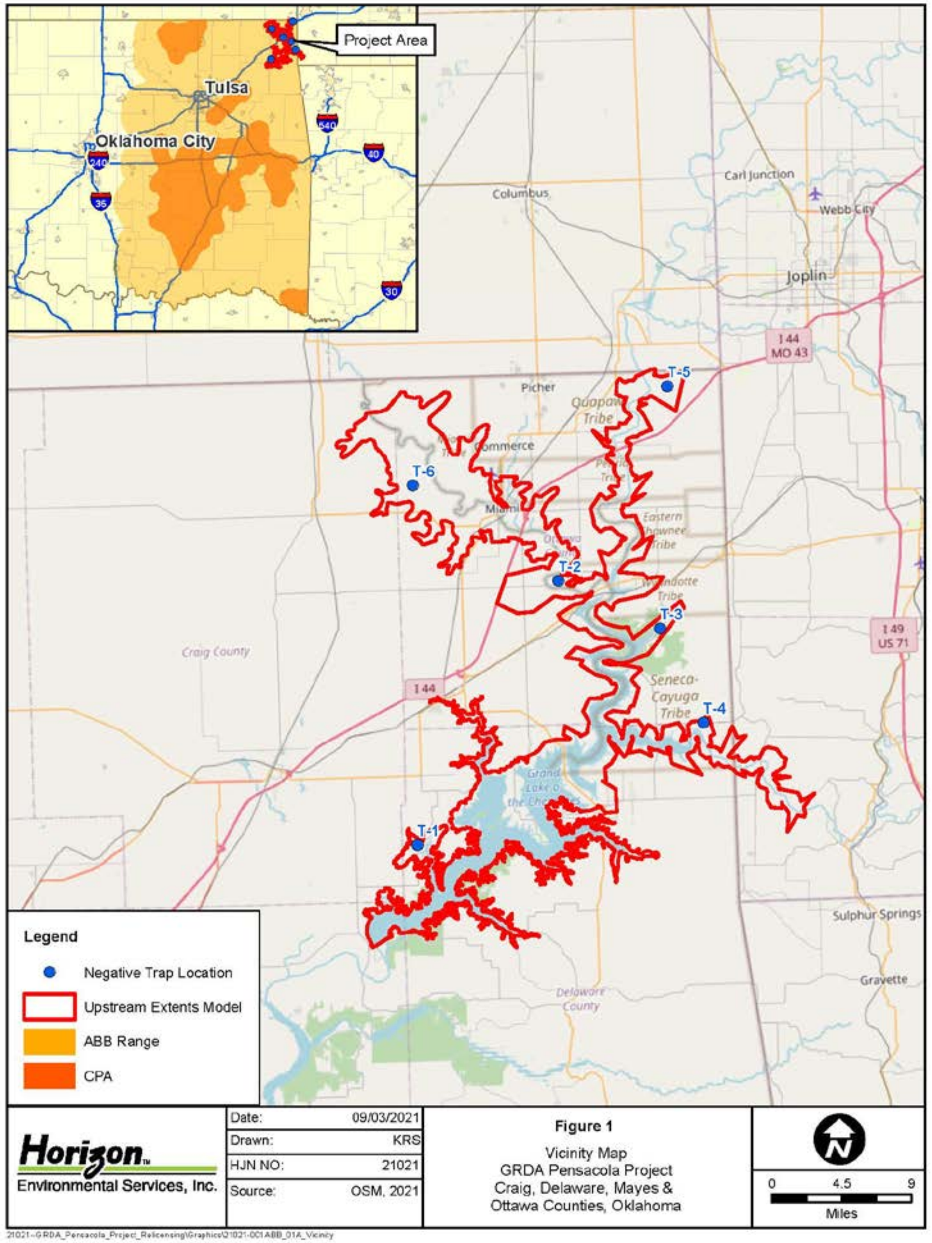
Grand River Dam Authority

Prepared By:

Horizon Environmental Services, Inc.

Study Period One, American Burying Beetle

- ❖ The American burying beetle (ABB) is currently listed as federally threatened.
- ❖ Six traps were placed across all suitable habitat types.
- ❖ The presence/absence survey ran from July 18, 2021, to July 23, 2021.
- ❖ Weather parameters were valid during the survey.
- ❖ No American burying beetles were found during the survey.

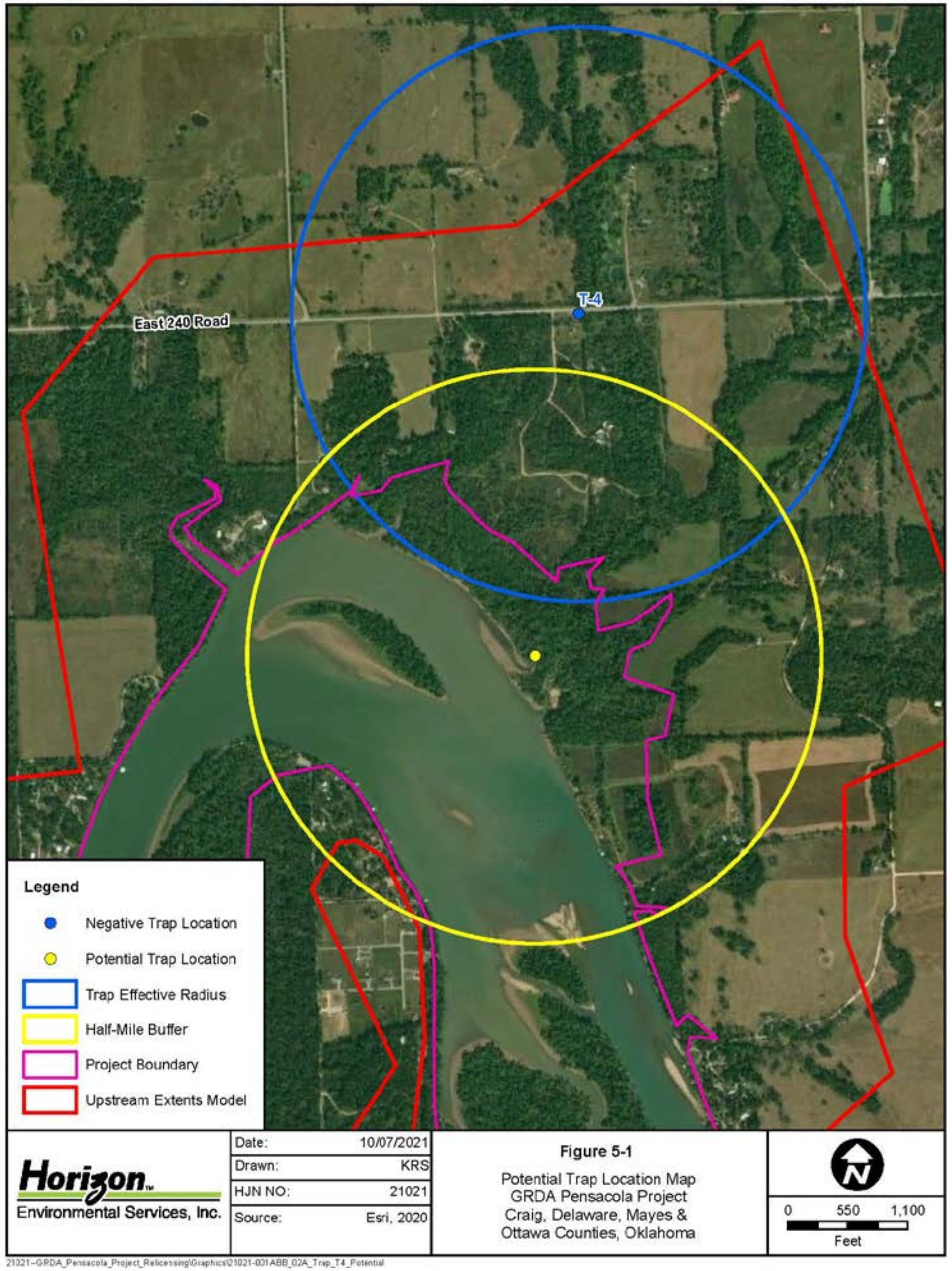


Trap Placement

- Traps were placed across the overall study area in consultation with United States Fish and Wildlife Service (USFWS) ABB lead biologist Kevin Stubbs.
- Traps have a 0.5-mile effective radius.
- Traps covered the range of suitable habitat types (native mixed prairie, forest, and mosaic habitat).
- Horizon used the upstream model extents provided by Mead & Hunt to select areas of significant terrestrial coverage within the potential area of effect.
- The H&H model has indicated that Project operation effects are limited to the Project boundary rather than the upstream model extents used for the 2021 survey.

Study Period Two, American Burying Beetle

- ❖ The Revised Study Plan (RSP) calls for two years of presence/absence surveys.
- ❖ ABB surveys are imprecise in coverage (0.5-mile effective radius) and cannot be limited to the Project boundary.
- ❖ ABBs have been recorded to move approximately 10 km (6.2 miles) in 6 nights. Any potential ABB captures would not necessarily be indicative of ABB occupancy or typical use land within the Project boundary as opposed to luring into the area from potentially preferable, occupied habitat outside of the Project boundary.
- ❖ GRDA proposes to forego the second study period survey as the results may not accurately represent potential Project effects.



Study Period One, Gray Bat

❖ Previous exit surveys support historical evidence that during high water or flood events during the maternity season, a maternity colony of the endangered gray bat vacates cave DL-2 (Beaver Dam Cave) – whose passage lies within the flood pool of Grand Lake – and migrates to an alternative cave.

❖ Complete inundation of the cave passage of DL-2 occurs at about elevation 752 feet Pensacola Datum.

❖ In October 2008, a small existing alternate passage was minimally excavated and enlarged with additional enlargement completed in 2013.

❖ Post-inundation monitoring visits to the cave following a flood event in 2019 failed to give any indication that take had occurred as a result of inundation, and that the colony had successfully vacated to another location.

Table 1. Records of highwater events where the elevation of Grand Lake exceeded elevation 750.00 feet PD from 2005-2019.

At elevation 752 feet PD, the existing flyway inside cave DL-2 is completely inundated, preventing colony exit and re-entry.

Year	Date Beginning	Date Ending	Maximum Elevation (ft)	Total Duration	Effect on Colony
2011	27-Apr	28-Apr	750.80	2 days	Successfully Vacated
2011	25-May	26-May	751.71	2 days	Successfully Vacated
2015	27 May	22 June	754.89	27 days	Successfully Vacated
2017	30 April	25 May	754.77	26 days	Successfully Vacated
2019	14 May	15 July	755.02	63 days	Successfully Vacated

Study Period Two, Gray Bat

If the results of the H&H Study indicate anticipated operations may impact cave DL - 2, the success of enlarging the alternative escape route for exiting bats in avoiding take will again be reviewed.

Wetlands and Riparian Habitat Study for the Pensacola Hydroelectric Project (Project; FERC [Federal Energy Regulatory Commission] No. 1494); Craig, Delaware, Mayes and Ottawa Counties, Oklahoma

Prepared For:

GRDA
Grand River Dam Authority

Prepared By:

Horizon™
Environmental Services, Inc.

Study Period One

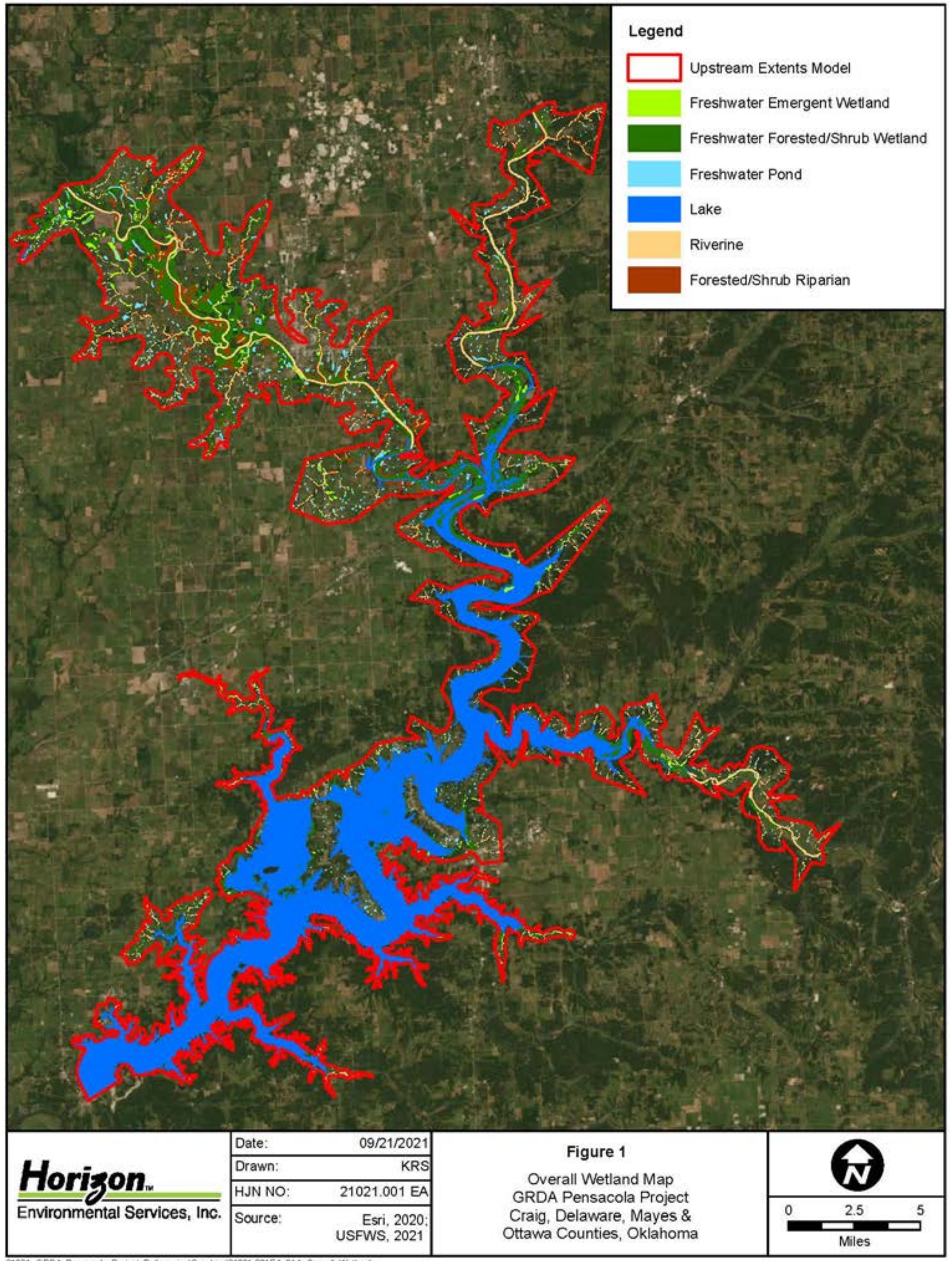
According to the approved study plan, GRDA has completed the following:

- ❖ Used the United States Fish and Wildlife Service (USFWS) National Wetlands Inventory (NWI) and GRDA's Shoreline Management Plan (SMP) maps to identify, display, and describe the current composition of wetland communities within and adjacent to the study area.
- ❖ Used that data to develop a Geographic Information System (GIS) database on the extent, classification, and plant community structure of wetland and riparian habitats within and adjacent to the study area.
- ❖ Used the GIS database to estimate the total acres of wetlands and riparian habitats that currently exist within the study area.
- ❖ For the purpose of initial review, Horizon used the Upstream Model extents provided by Mead & Hunt to clip habitat polygons to for acreage totals.

Database Contents

The database displays 4,236.06 acres of riparian habitat types and 54,980.72 acres of wetland habitat types including:

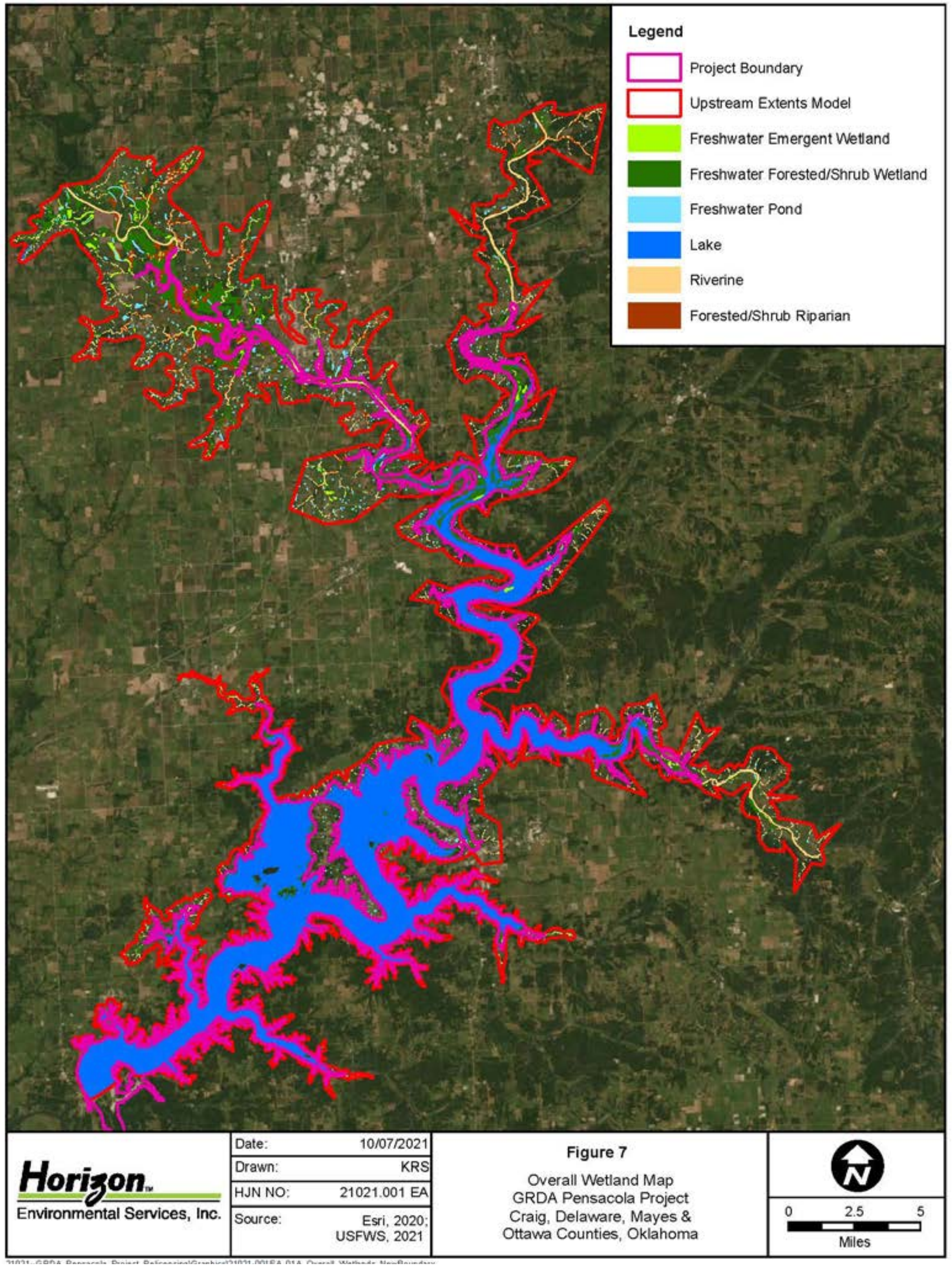
- ❖ 626.94 acres of Palustrine Emergent Wetlands
- ❖ 752.04 acres of Palustrine Scrub-Shrub Wetlands
- ❖ 8,328.6 acres of Palustrine Forested Wetlands
- ❖ 45,273.14 acres of Open Water (including ponds, rivers and lakes)



Database Analysis

Based upon results of the H&H Study, the second study period will determine Project effects, if any, including habitat changes in currently designated Wildlife Management Areas (WMAs). GRDA will:

- ❖ Apply updated Project boundary
- ❖ Overlay inundation maps generated by the Comprehensive Hydraulic Model (CHM)
- ❖ Identify extent, duration and seasonality of inundation occurring within the Project boundary.



Database Analysis Continued

If it is determined, based on the results of the H&H Study, that anticipated operations impact wetlands in the Study area, GRDA will:

- ❖ Perform field verification of the cover-type maps.
- ❖ Ground truth any major deviations from preliminary wetland cover-type maps.
- ❖ Update database and wetland acreages accordingly.

The results of the field verification will allow GRDA to provide a more accurate estimate of the acreage of wetlands that may be potentially impacted by anticipated operation of the Project.

wood.

Environment & Infrastructure Solutions, Inc.
Cultural Resources Program

Cultural Resources Investigations at Grand Lake o' the Cherokees, 2019-2021

Grand River Dam Authority (GRDA)
Pensacola Hydroelectric Project (FERC No. 1494-438)

Thaddeus G. Bissett, Ph.D., RPA
Wood E&IS Senior Archaeologist

Clockwise from top right: Fish hatchery; cave site; Will Tarrant (Seneca-Cayuga Nation) with Wood archaeologist; surface-find artifact

FERC Relicensing: Compliance with Section 106 of the National Historic Preservation Act (NHPA)

Take into account:

- Effects of Project operation / maintenance on **historic** / **archeological** resources within APE that *may be eligible for inclusion in National Register of Historic Places (NRHP).*

- Effects of Project operation / maintenance on **properties of traditional religious and cultural importance** to Native American Tribes within APE that *may be eligible for inclusion in National Register.*

To facilitate, the Cultural Resources Working Group (CRWG) was created…

GRDA Pensacola Dam FERC Relicensing: Cultural Resources Study, Key Agencies / Organizations and Timeline

Cultural Resources Working Group (CRWG) membership:

- **GRDA**
- **Tribal Historic Preservation Officers and Tribal Representatives of 23 Native American Tribes**
- **Oklahoma State Historic Preservation Office (SHPO)**
- **Oklahoma Archaeological Survey (OAS)**
- **Bureau of Indian Affairs (BIA)**
- **FERC representatives**

Quarterly meetings for planning, review, consultation, and discussion

Additional communications and consultation as needed outside of quarterly meetings

Forum for:

- General consultation
- Discussion / review of cultural resources study plan, results, and resource management
- Planning activities

Assist GRDA to address study objectives

Cultural Resources Study Objectives

Determine Project Boundary and Area of Potential Effect (APE)

Establish survey methods for identification of historic and cultural resources

Evaluate and establish archaeological site significance / status in consultation with CRWG

Develop inventory of Traditional Cultural Properties (TCPs) within Project Boundary (privileged information)

Maintain appropriate security regarding other potentially privileged site / resource location information

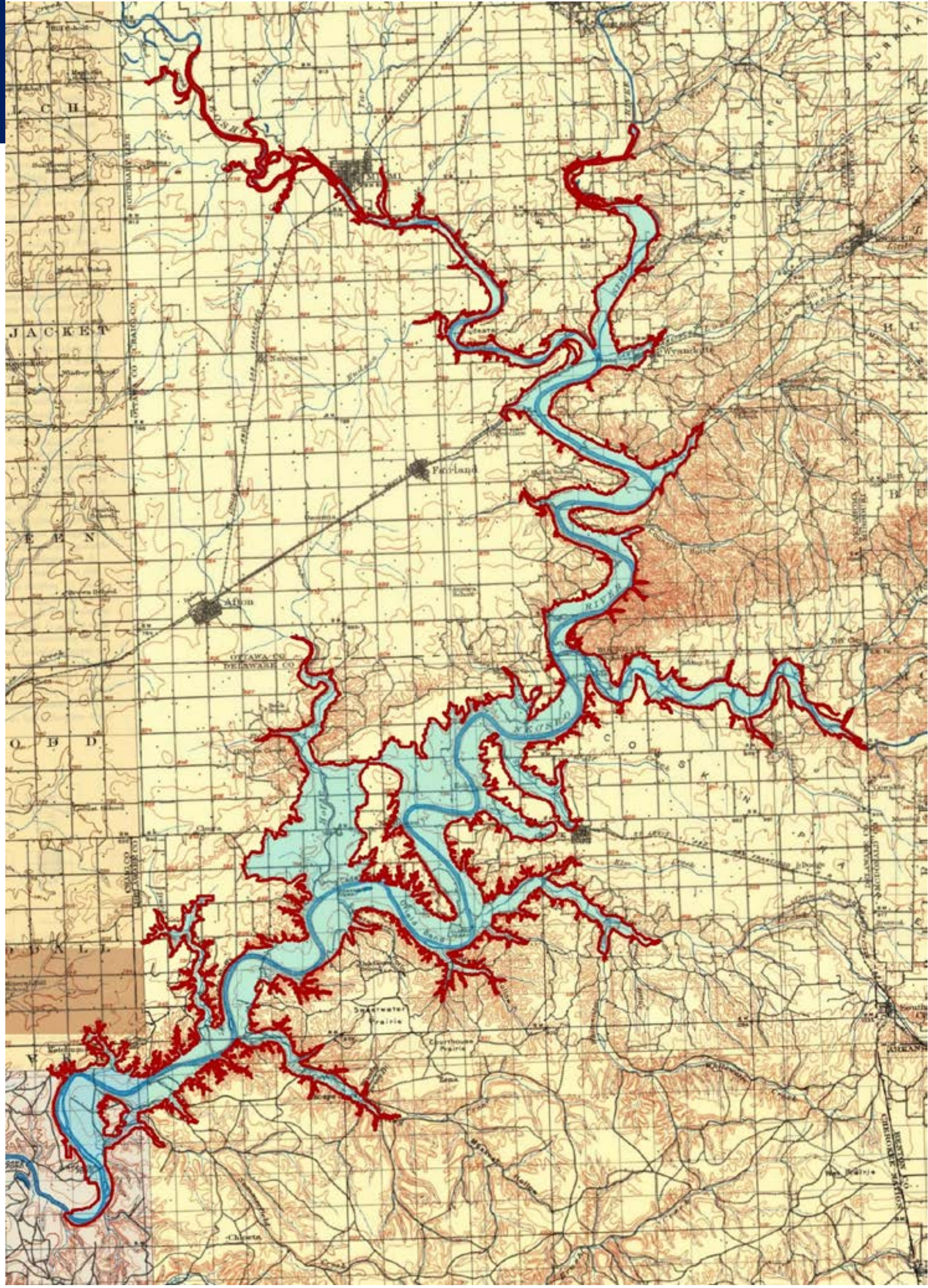
Timeline of CRWG Quarterly Meetings

- **January 3, 2019**
- **March 27, 2019**
- **May 29, 2019**
- **September 4, 2019**
- **December 13, 2019**
- **March 26, 2020**
- **July 9, 2020**
- **September 29, 2020**
- **December 15, 2020**
- **March 23, 2021**
- **June 29, 2021**
- **October 14, 2021 (ISR Meeting)**

All intended to help guide the process of cultural resource inventory and assessment / evaluation within the FERC-approved Project Boundary

PROJECT BOUNDARY / AREA OF POTENTIAL EFFECTS (APE) AND STUDY / SURVEY AREAS

- **Approx. 57,600 ac. (23,310 ha) encompassed within Project boundary**
- **Generally, APE extends to 750-ft contour**
- **Pre-fieldwork study: 105 archaeological sites previously recorded within or in direct proximity to the Project APE**
- **29 high-potential landforms (QALs); and**
- **ca. 60.4 linear miles of bluffline (high potential for caves / bluff shelters)**



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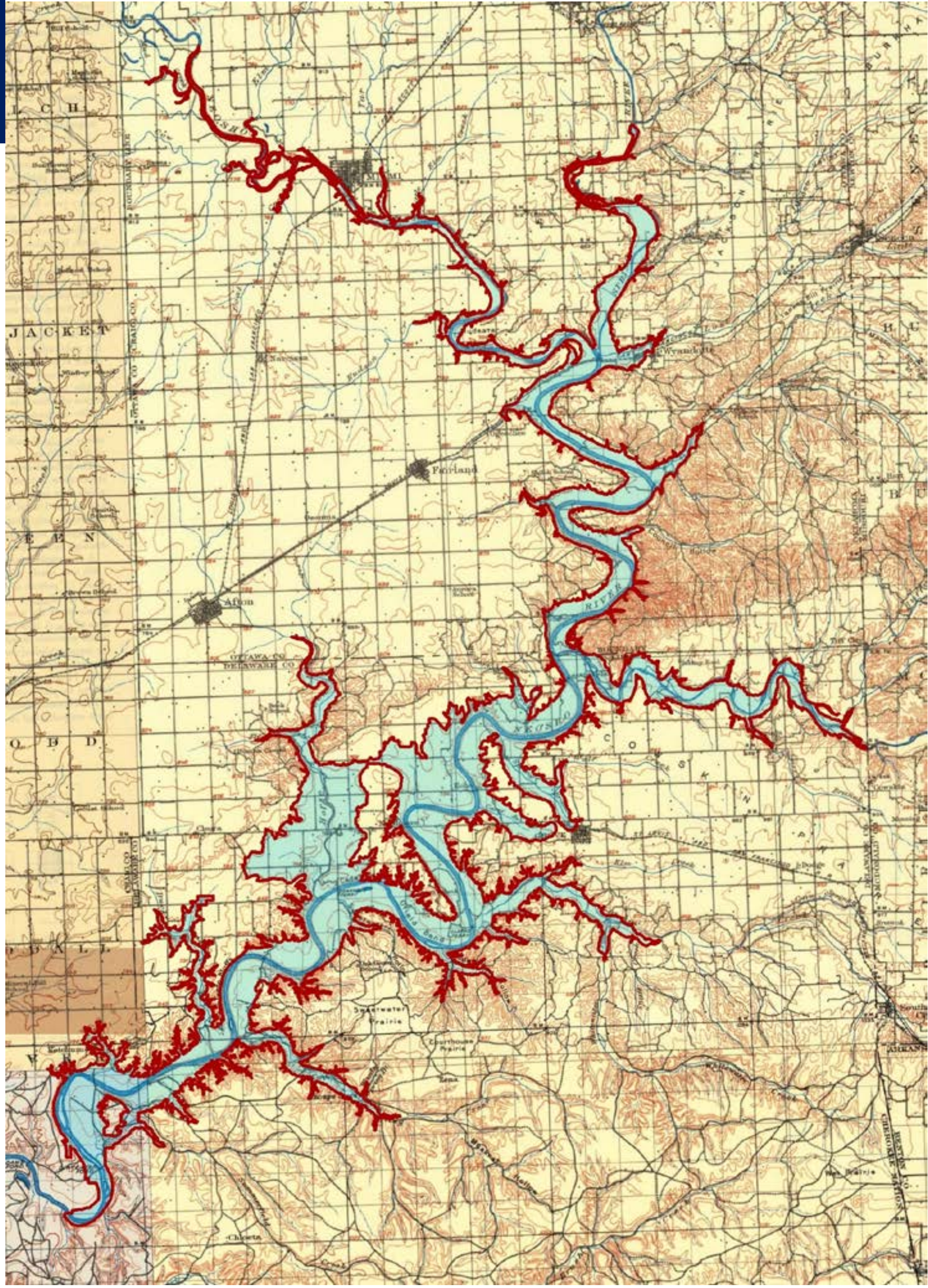

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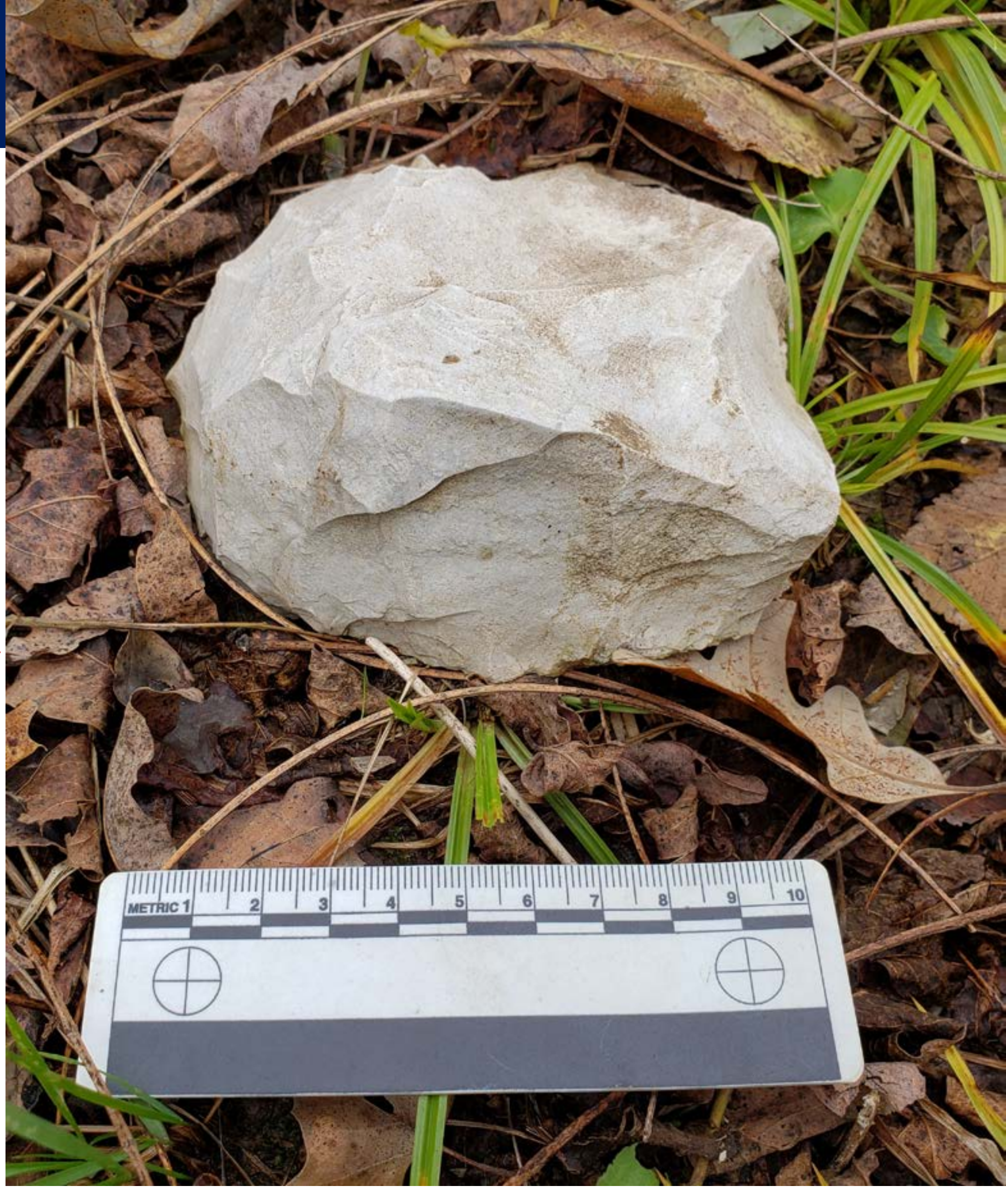

Pre-Contact lithic artifact found on ground surface at previously recorded site

PROJECT BOUNDARY / AREA OF POTENTIAL EFFECTS (APE) AND STUDY / SURVEY AREAS

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- **Pre-fieldwork study: 105 archaeological sites previously recorded within or in direct proximity to the Project APE**

- **29 high-potential landforms (QALs); and**

- **ca. 60.4 linear miles of bluffline (high potential for caves / bluff shelters)**

Alluvial deposition observed at QAL

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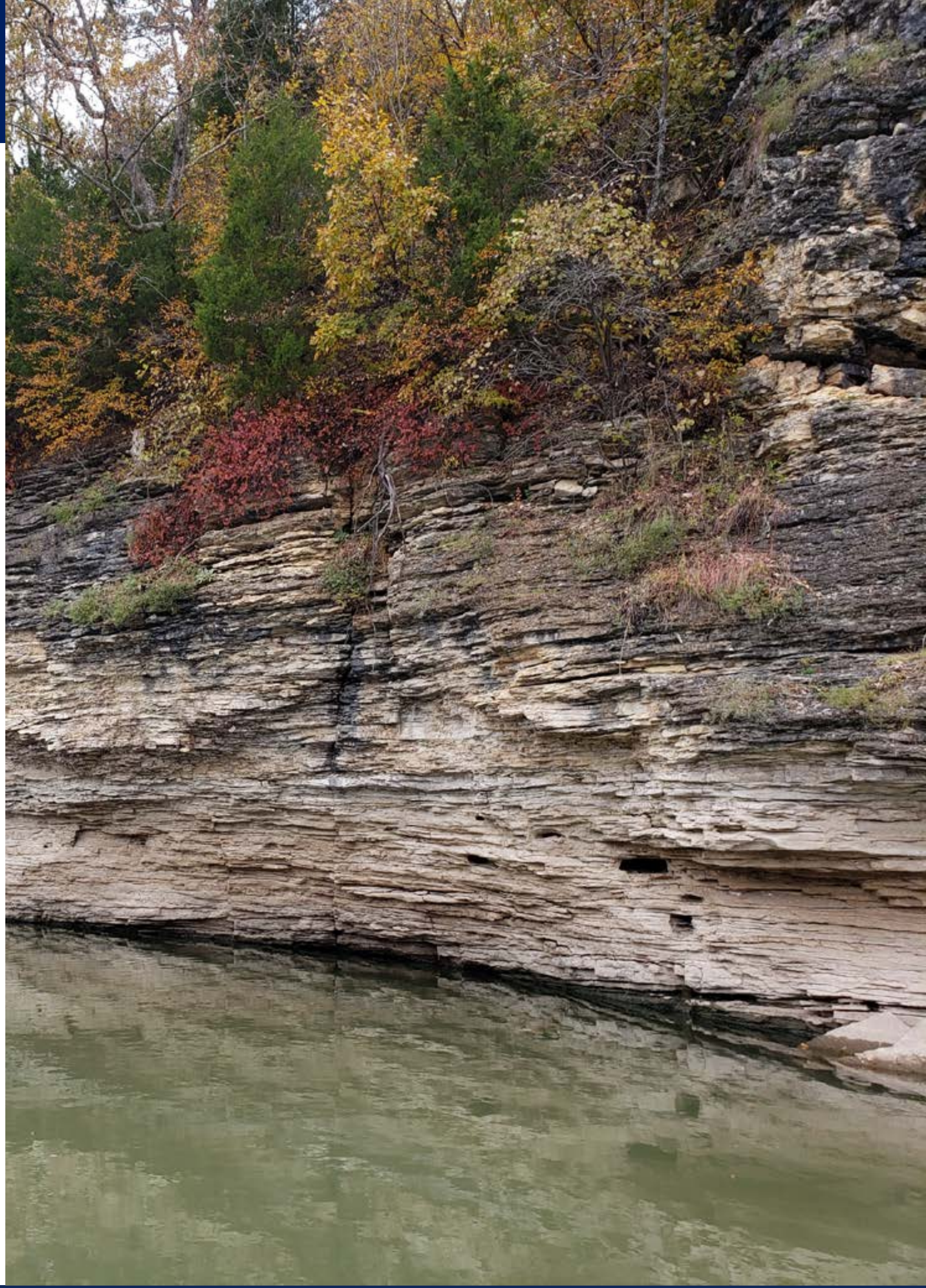

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- **12 islands > 2.0 ac within the APE**

- **ca. 60.4 linear miles of bluffline (high potential for caves / bluff shelters)**

2019-2021: Relocate / revisit previously recorded site locations within Project APE

- **Determine accuracy of mapped site locations and sizes**
- **Assess site condition and integrity**
- **Additional testing to define size / depth of archaeological deposits**
- **Make recommendations of NRHP eligibility where possible**

38 sites selected by Cultural Resources Working Group (CRWG) for priority evaluation and assessment

Revisit remaining sites (if possible)

2020-2021: Archaeological Survey of High-Potential Areas

- Survey using standard archaeological field methods
  - Shovel testing
  - Pedestrian survey
- Determine area and vertical extent of archaeological materials
- Assess site integrity / condition / status
- Make recommendations, re: NRHP eligibility and need for additional testing



2019-2021: Bluffline / shoreline survey for caves & rock- / bluff-shelters

- Boat-based survey of shoreline and bluffs
- Done during leaf-off conditions, improve shoreline visibility
- Document locations and photograph
- No entry into potential shelters / caves due to safety and respect for / sensitivity of cultural deposits

September 2020: NRHP eligibility testing of 3 sites

- **Previously recorded sites:**
  - **34DL48**
  - **34MY220**
  - **34MY282**
- **Remote sensing to identify buried cultural deposits / features / possible burials**
- **Test unit excavation**
- **Bucket augering to depths unreachable by standard excavation**

2020: Architectural historical assessment of above-ground structures, buildings and other architectural resources within Project APE

- **Documentation of historical architectural resources**

- **Review of previous determinations and findings of significance**

- **Determine status / condition of existing resources**

- **Assess NRHP eligibility and significance of current and previously un-recorded resources**



2019 – 2021: Previously recorded Site reconnaissance and evaluation

38 Priority Sites selected by CRWG for initial reconnaissance

Site Type	Count
Bluff- / Rock-shelter / Cave	14
Village site	8
Open habitation	8
Possible mound	4
Cemetery	4

- **19 submerged beneath the lake**
- **11 located outside the APE**
- **1 tested and found to lack archaeological integrity**
- **7 recommended potentially "at risk"**

Archaeological testing at previously recorded site, Dec. 2019

2019 – 2021: "AT RISK" PRIORITY SITES

Sites "at risk" primarily from:

- Erosion
- Recreational activity
- Looting and vandalism (potential, or observed)

Site Number	Site Type(s)	Potential / Active Threats
34DL24	Bluff Shelter	Erosion, Recreational Activity
34DL48	Bluff Shelter (not threatened); Open Habitation (threatened)	Erosion, Recreational Activity, Looting / Vandalism
34DL104	Bluff Shelter	Recreational Activity, Looting / Vandalism
34MY220	Open Habitation	Erosion, Recreational Activity, Looting / Vandalism
34MY282	Open Habitation	Erosion
34OT9	Open Habitation	Recreational Activity
34OT226	Bluff Shelter	Looting / Vandalism, Recreational Activity

Recommendations to GRDA included:

- Protective measures
- Informational signage at public boat ramps
- GRDA Police monitoring of sites
- NRHP eligibility testing at 3 sites

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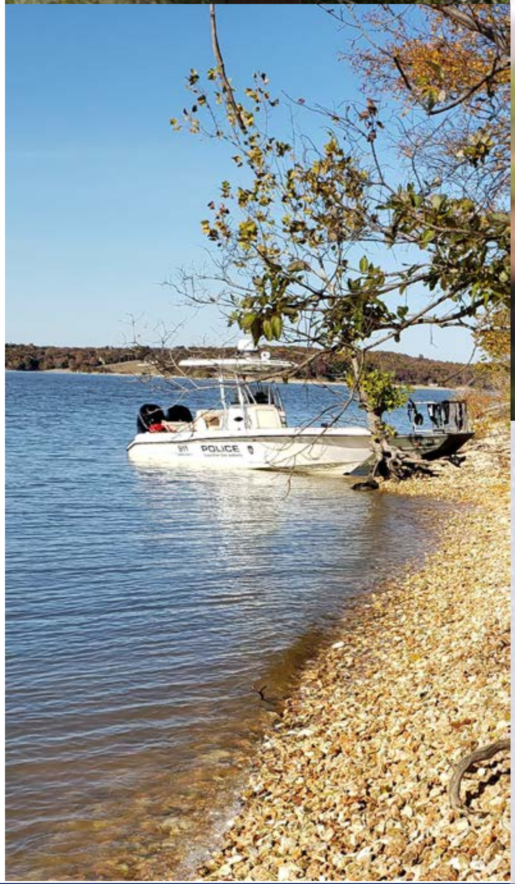
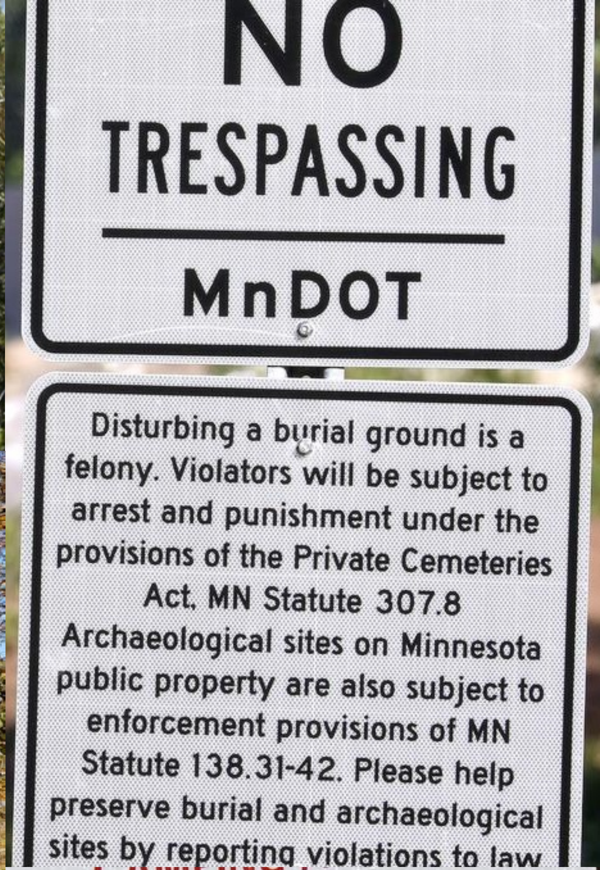
- Informational signage at public boat ramps
- GRDA Police monitoring of sites
- <u>NRHP eligibility testing at 3 sites (done Sept 2020)</u>





2020 – 2021: Other Previously Recorded Sites

Continued visits to other previously recorded sites within Project APE

Visits / attempted visits made to 100 sites (5 remain for future effort)

Status / Condition	Count
Eligible for NRHP	2
Potentially Eligible	11
Not eligible	2
Destroyed	2
Unassessed	88

Unassessed:

- outside APE
- submerged
- could not relocate at mapped location

Additional work to assess NRHP eligibility is management option for sites listed as "potentially eligible."

Former location of site (outside APE and destroyed by development)

2020 – 2021: PHASE I CULTURAL RESOURCES SURVEY

Phase I survey around Grand Lake:
January of 2020 – March 2020 (COVID-delayed)

Continued, November 2020 – March 2021

Survey of QALs in early 2020
- **8 new sites recorded**

Survey of QALs and Islands, late 2020 / early 2021
- **11 new sites recorded**

Period / Site Type	Count
Pre-Contact	13
Pre-Contact / 19th-20th Century	5
Cherokee Cemetery, 19th-20th Century	1
TOTAL NEW SITES	**19**

2020 – 2021: Phase I Cultural Resources Survey

Site recommendations / management assessments:

Unassessed: 3 sites
- Sites at edge of APE, no landowner permission to follow site outside APE; or
- Necessary work for assessment not possible

Not eligible for NRHP: 4 sites
- Lack archaeological integrity

Potentially eligible for NRHP: 12 sites
- Sites appear to contain significant / intact archaeological deposits
- Sites have research potential

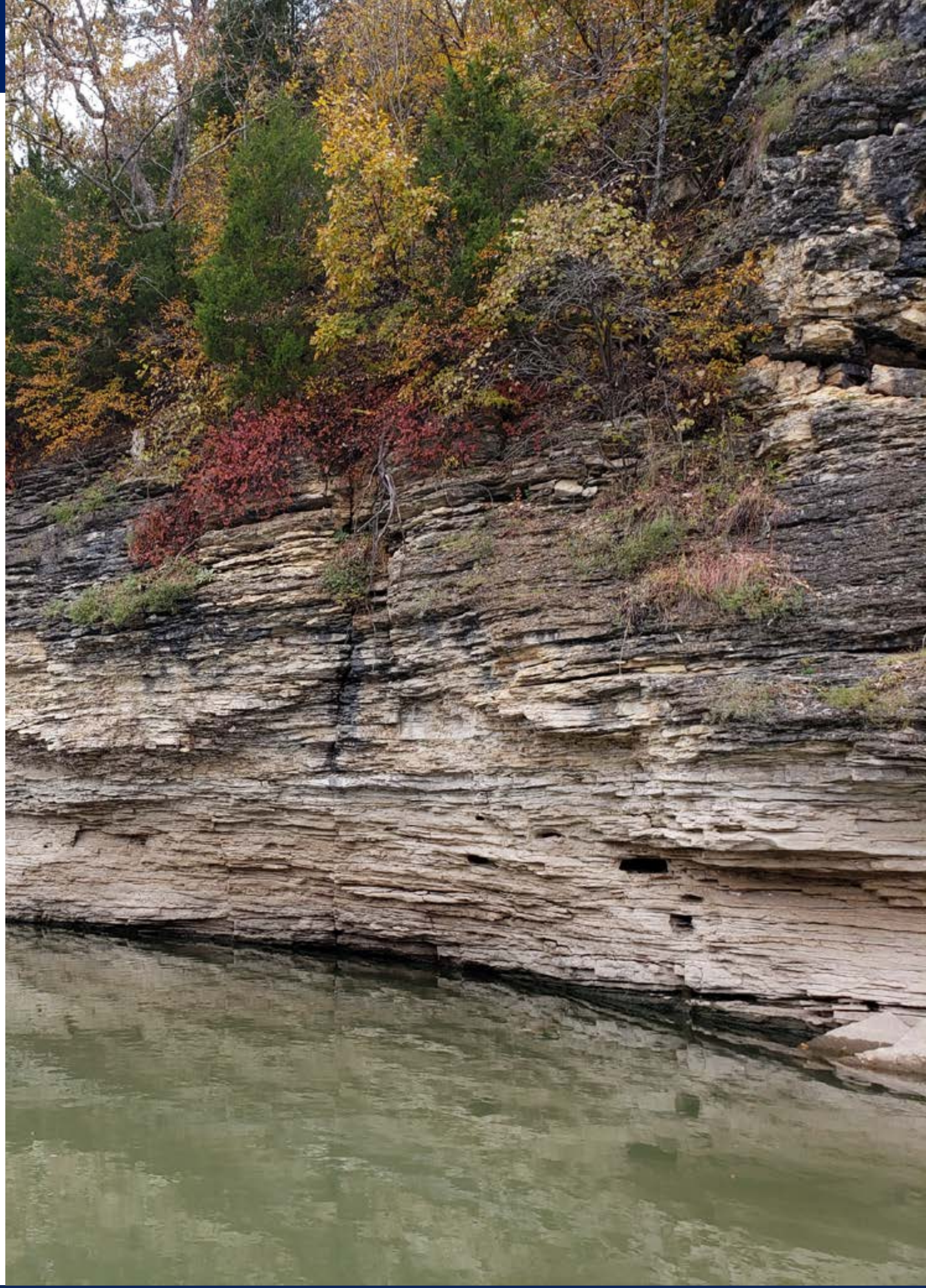
Looking out of Project APE from new site 34OT224

Buried soil(s) at new site 34OT227, pot. eligible / research potential

2020 – 2021: Phase I Cultural Resources Survey

Bluff- / Rock-shelter and Cave Survey

- **Boat-based visual inspection and survey of high-potential areas**
- **83 areas, 60.4 linear miles:**
  - **survey completed of 61 bluff areas**
- **24 possible cave / bluff- / rock-shelter locations**
- **Unsurveyed areas (22 areas) planned for future field efforts**



September 2020: Phase II testing at 3 sites

Wood previously assessed 7 sites as "at risk"

Testing to determine NRHP eligibility
- **34DL48 (Site 1)**
- **34MY220 (Site 2)**
- **34MY282 (Site 3)**

Geophysical survey: Magnetometer and soil resistivity

Test unit excavation: 1-x-1 m test units

Bucket augering (4" bucket) to reach deposits too deep to access with standard excavation methods

SEPTEMBER 2020: PHASE II TESTING AT 34DL48 (SITE 1)

Shallow and eroded soils

Artifacts redeposited in surface gravels

Wood field team at work

Test unit excavation indicated shallow and eroded soils, no intact archaeological deposits

34DL48 (terrestrial) recommended not eligible for NRHP

34DL48 (terrestrial) not eligible for NRHP

September 2020: Phase II testing at 34MY220 (Site 2)

Intact features at depths up to 120 cm below surface

Late Archaic tool from feature, ca. 120 cm deep

Pottery recovered

Bucket augering indicated archaeological deposits present at up to 4.5 m (14.8 ft) below surface

Completed excavation unit

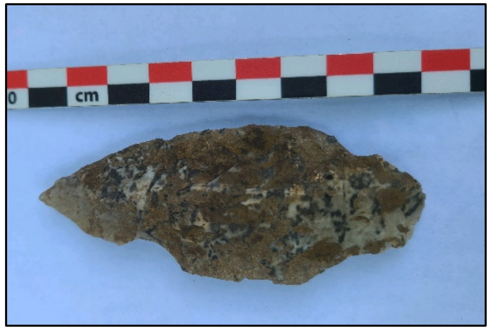
34MY220 recommended <u>eligible for NRHP</u>

SEPTEMBER 2020: PHASE II TESTING AT 34MY282 (SITE 3)

Intact features at depths up to 60 cm below

Bucket augering shows archaeological deposits up to 3 m (10 ft) deep

Projectile points indicate multiple time periods represented



34MY282 recommended <u>eligible for NRHP</u>

SEPTEMBER 2020: ARCHITECTURAL HISTORICAL SURVEY

Surveyed 22 above-ground architectural resources:

- **17 previously recorded structures, buildings, and bridges**
- **5 newly surveyed bridges**

September 2020: Architectural Historical Survey

No change to NRHP eligibility of Pensacola Dam Historic District or Splitlog Church and Cemetery

Pensacola Dam Historic District

Splitlog Church/Cayuga Mission Church and Cemetery

September 2020: Architectural Historical Survey

NRHP-eligible bridges demolished / replaced by OKDOT in 2017 and 2018

Stepps Ford Bridge (demolished 2017)

Spring River Bridge (demolished 2018)

No other bridges, buildings, or other structures identified as NRHP eligible within the Project APE

Further work / Concluding Remarks

Remaining work effort within Project APE includes:

- **Revisitation and assessment of 5 previously recorded sites**
- **Complete survey of 3 QALs and other areas not yet surveyed**
- **Consult with GRDA and CRWG regarding further archaeological testing / work at sites recommended as potentially eligible**

A typical morning view…