ECOSYSTEMS & WATERSHED MANAGEMENT
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GRDA
Grand River Dam Authority

January 20, 2022

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

Subject: Pensacola Hydroelectric Project (FERC Project No. 1494-438)
Sedimentation Study Technical Meeting

Dear Secretary Bose:

On January 14, 2022, the Grand River Dam Authority (GRDA) held the technical meeting for the Sedimentation Study as part of the relicensing process for the Pensacola Hydroelectric Project (FERC No. 1494). The purpose of the technical meeting was to review the results of the Sedimentation Study since the Initial Study Report (ISR) and discuss GRDA's proposed modified study plan for the study as described in its response filed on December 29, 2021.

The list of attendees for the meeting is attached as Attachment A and the presentation is attached as Attachment B.

GRDA looks forward to receiving the Commission's determination for the second study season in the relicensing process.

If you have any questions, please contact Jacklyn Jaggars at jacklyn.jaggars@grda.com or 918-981-8473.

Sincerely,

Brian Edwards
Executive Vice President

Attachment A
List of Attendees

Pensacola Project (FERC No. 1494)
Sedimentation Study Technical Meeting
January 14, 2022
9:00 AM
Virtual

First Name	Last Name	Email	Title	Company
Norman	Hildebrand	nhildebrand@wyandotte-nation.org	Second Chief	Wyandotte Nation
N. Larry	Bork	lbork@gseplaw.com	Mr.	Goodell Stratton Edmonds & Palmer, LLP
Allison	Ross	allison.ross@bia.gov	Environmental Protection Specialist	Bureau of Indian Affairs, Eastern Oklahoma
Laura	Rozumalski	lrozumalski@anchorqea.com	Principal Engineer	Anchor QEA
Rachel	McNamara	rachel.mcnamara@ferc.gov	Recreation and Land Use Coordinator	FERC
Tyler	Gipson	tyler.gipson@swpa.gov	Engineer	Southwestern Power Administration
Walker	Stanovsky	walkerstanovsky@dwt.com	Associate Attorney	Davis Wright Tremaine LLP
Elizabeth	Toombs	elizabeth-toombs@cherokee.org	Tribal Historic Preservation Officer	Cherokee Nation
James	Munkres	jwmunkres@osagenation-nsn.gov	Archaeologist	Osage Nation
Mike	Plunkett	mike.plunkett@odwc.ok.gov	NE Regional Supervisor	Oklahoma Department of Wildlife
Stephen	Bowler	stephen.bowler@ferc.gov	South Branch Chief	FERC
Tyler	Rychener	tyler.rychener@wsp.com	Environmental Scientist	WSP
Bo	Reese	breese@miamiokla.net	City Manager	City of Miami Oklahoma
Randall	Kolar	kolar@ou.edu	Professor	University of Oklahoma
Rebecca	Jim	rjim@neok.com	Executive Director	LEAD Agency, Inc.
Robert	Nairn	nairn@ou.edu	Professor	OU
Shanon	Phillips	shanon.phillips@conservation.ok.gov	Water Quality Division Director	Oklahoma Conservation Commission
Bob	Simons	rksimons@rksimons.com	Dr.	Simons & Associates
Nicholas	Funk	nicholas.funk@wsp.com	Environmental Analyst	WSP-USA
Kate	Moore	kate.moore@bia.gov	Regional Archeologist	SPRO BIA
kimeka	price	price.kimeka@epa.gov	Environmental Engineer	U.S. E.P.A. Region 6
Craig	Gannett	craiggannett@dwt.com	Partner	Davis Wright Tremaine LLP
David	Williams	david.j.williams@usace.army.mil	Chief, Hydrology and Hydraulics Branch	USACE Tulsa District
Kevin	Stubbs	kevin_stubbs@fws.gov	Fish and Wildlife Biologist	USFWS
Rick	Schlottke	rschlottke@sctribe.com	Environmental Director	Seneca Cayuga Natgion
Alynda	Foreman	alynda.foreman@wsp.com	Lead Ecologist	WSP
Jeanne	Sweet-Edwards	jeanne.edwards@ferc.gov	Environmental Biologist	FERC
Valery	Giebel	valery.giebel@sol.doi.gov	Attorney	Dept. of the Interior
Josh	Johnston	josh.johnston@odwc.ok.gov	Regional Supervisor of Fisheries	Oklahoma Department of Wildlife Conservation
Kristina	Wyckoff	kwyckoff@okhistory.org	Section 106 Coordinator / Historical Archaeologist	Oklahoma State Historic Preservation Office
Lynda	Ozan	lozan@okhistory.org	Deputy SHPO	OK/SHPO
Brad	Johnston	brad.johnston@odwc.ok.gov	Fisheries Biologist	Oklahoma Department of Wildlife Conservation
Bless	Parker	bparker@miamiokla.net	Mayor	City of Miami
Brent	Teske	bteske@anchorqea.com	Water Resources Engineer	Anchor QEA
Chayla	(Nelson) Witherspoon	chn1513@utulsa.edu	Intern	DOI-SOL
Martin	Lively	martinlively@gmail.com	Grand Riverkeeper	LEAD Agency, Inc.
Amber	Leasure-Earnhardt	amber.leasure-earnhardt@ferc.gov	Attorney-Advisor	FERC
Agatha	Benjamin	benjamin.agatha@epa.gov	Environmental Engineer/Scientist	USEPA
Jay	Greska	jay.greska@wsp.com	Lead Consultant	WSP
Dai	Thomas	dai.thomas@tetratech.com	Senior Engineer	Tetra Tech
Darrell	Townsend	darrell.townsend@grda.com	VP	GRDA

Pensacola Project (FERC No. 1494)
Sedimentation Study Technical Meeting
January 14, 2022
9:00 AM
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First Name	Last Name	Email	Title	Company
Elizabeth	McCormick	elizabeth.mccormick@troutman.com	Associate	Troutman Pepper Hamilton Sanders
Peggy	Ziegler	pziegler@gseplaw.com	Litigation Paralegal	Goodell, Stratton, Edmonds & Palmer LLP
Shawn	Puzen	shawn.puzen@meadhunt.com	Consultant	Mead & Hunt
Scott	Cox	scott.cox@odwc.ok.gov	Biologist	ODWC
Tyler	Cline	tcline@miamiokla.net	Director of Utilities	City of Miami OK
Brad	Rogers	brad.rogers@conservation.ok.gov	Water Quality Liaison	Oklahoma Conservation Commission
Jesse	Piotrowski	jesse.piotrowski@meadhunt.com	Water Resources Engineer	Mead & Hunt
Ryan	Greif	ryan.greif@meadhunt.com	H&H Engineering Supervisor	Mead & Hunt
Miroslav	Kurka	miro.kurka@meadhunt.com	Group Leader	Mead & Hunt, Inc.
Tamara	Jahnke	tamara.jahnke@grda.com	Asst Gen Counsel	GRDA
Earl	Hatley	earlhatley77@gmail.com	President	LEAD Agency, Inc.
Steve	Jacoby	steve.jacoby@grda.com	VP Gen Engineering	Grand River Dam Authority
Charles	Sensiba	charles.sensiba@troutman.com	Partner	Troutman Pepper
Shannon	O'Neil	shannononeil@dwt.com	Associate	Davis Wright Tremaine
Neetu	Deo	navreet.deo@ferc.gov	Coordinator	FERC
Dan	Sullivan	daniel.sullivan@grda.com	CEO	Grand River Dam Authority
Bob	Harshaw	robert.harshaw@grda.com	Program Manager	Grand River Dam Authority
Steve	Jacoby	steven.jacoby@grda.com	Engineer	Grand River Dam Authority
Nick	Hathaway	nick.hathaway@meadhunt.com	Engineer	Mead & Hunt
Bob	Simons	lksimons1@gmail.com	Owner	Simons & Associates
Brian	Edwards	brian.edwards@grda.com	Executive Vice President	Grand River Dam Authority

Attachment B
Sedimentation Study Presentation

Grand Lake Sedimentation Study Initial Study Report

January 14th, 2022

Anchor QEA
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

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

- Study Tasks:
  - Analyze historical data
  - Collect additional field measurements to determine sediment properties
  - Develop HEC-RAS sediment transport model
  - Determine sediment supply from the main stem river and tributaries
  - Analyze historical sedimentation trends and extrapolate trends

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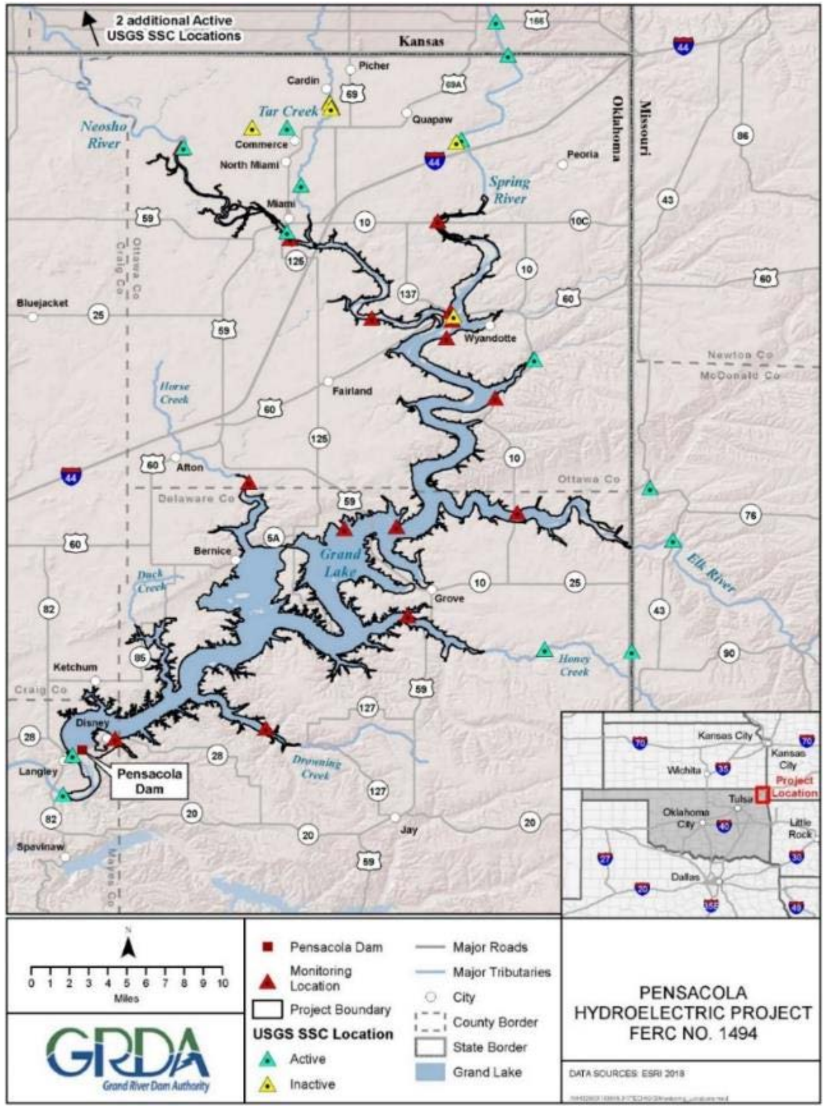
- Model development
    - Planned procedure
    - Hydraulic calibration
    - Challenges
    - Sediment calibration

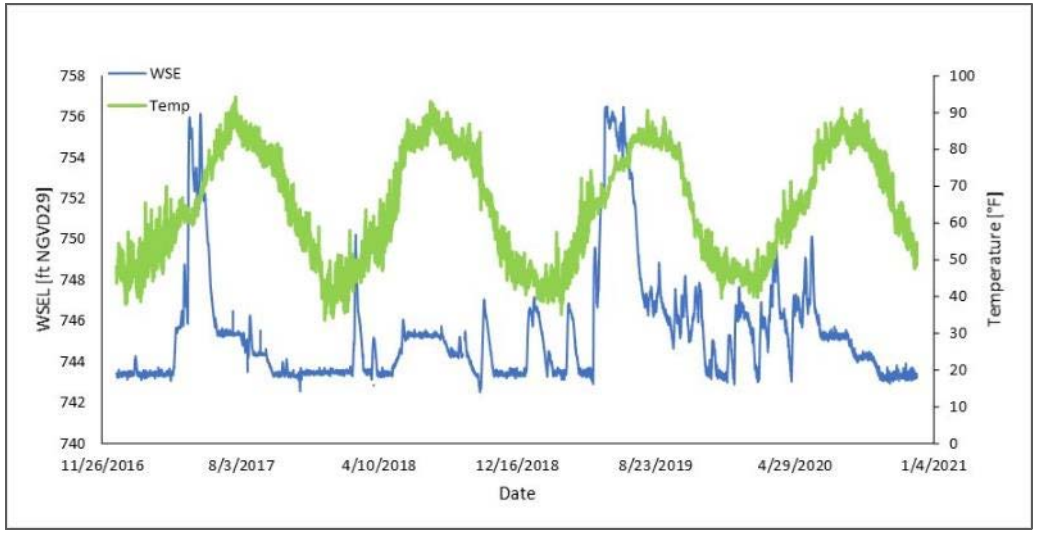
Water Surface Monitors

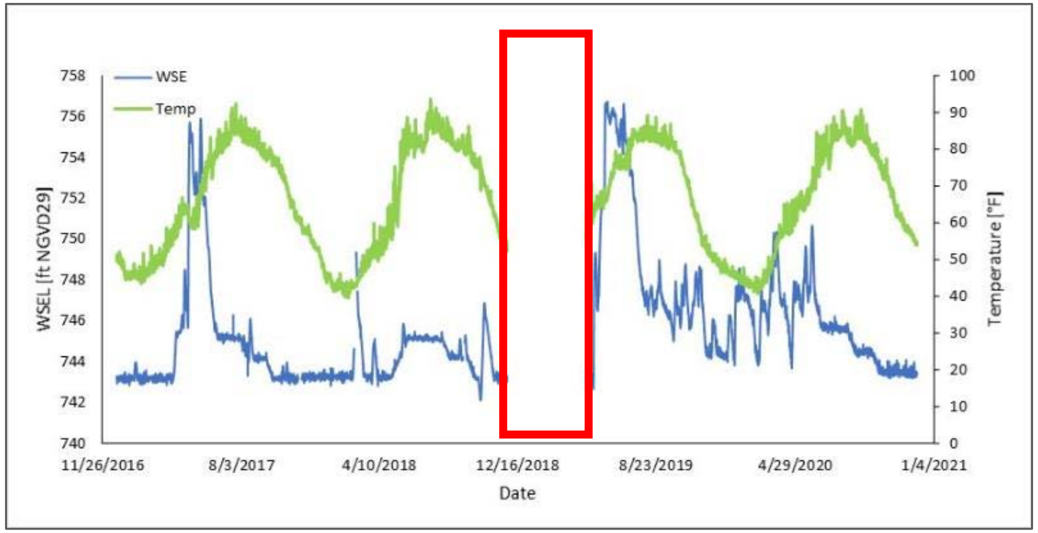
- Installed at 16 locations
  - Dec 2016



Water Surface Monitors

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





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- Model development
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    - Hydraulic calibration
    - Challenges
    - Sediment calibration

Sediment Grab Sampling

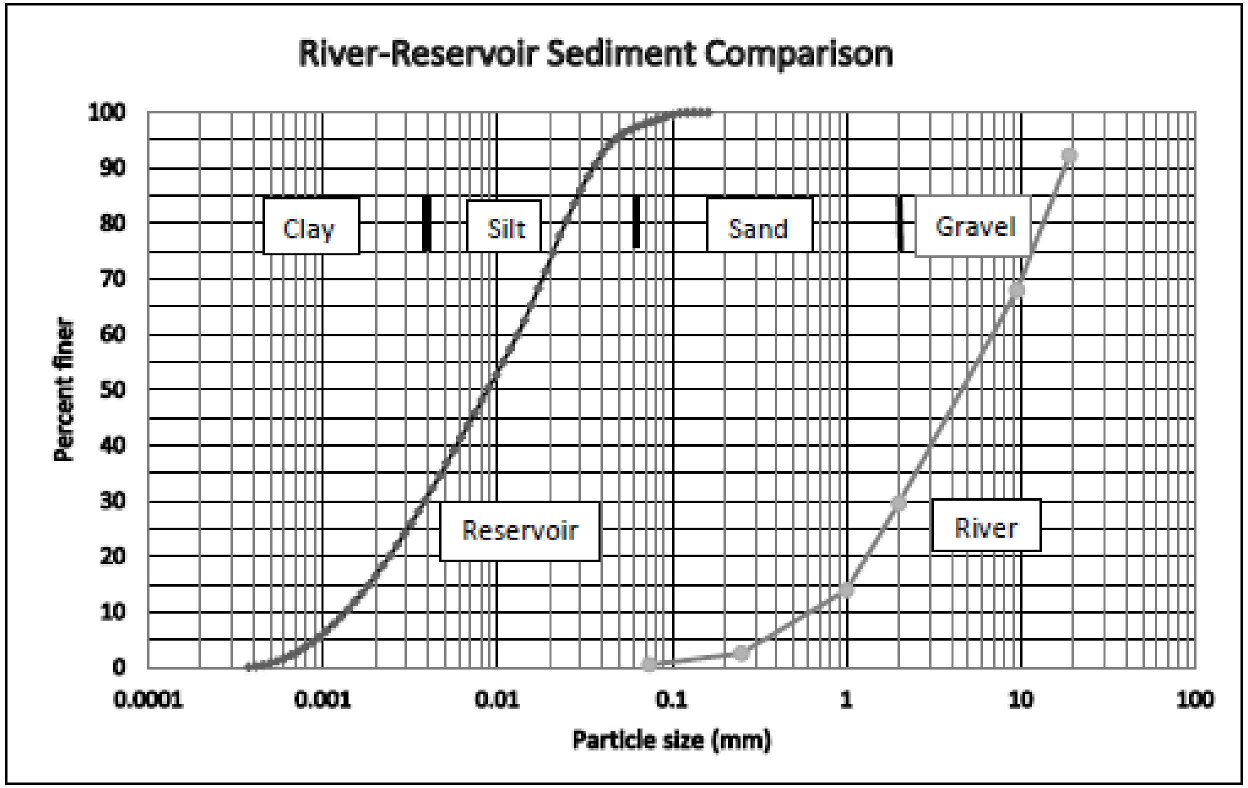
- 62 surface sediment samples collected Dec 2019

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

- As presented in ISR:
  - Cohesive sediment in the system is washed downstream and into the reservoir
  - Riverbed is primarily sand and gravel
  - Lakebed is primarily silt and clay



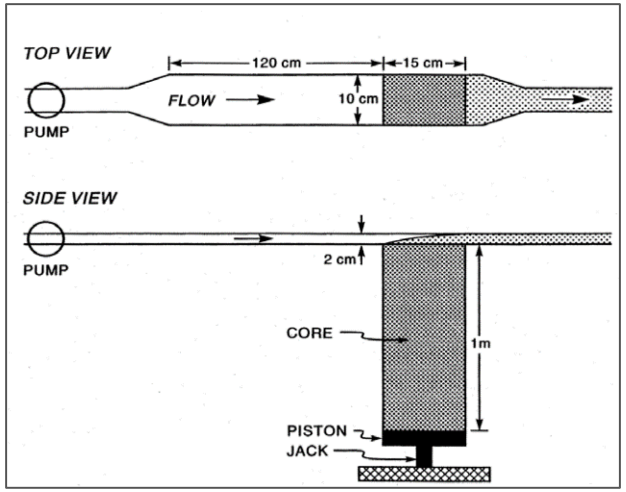
Critical Shear Stress

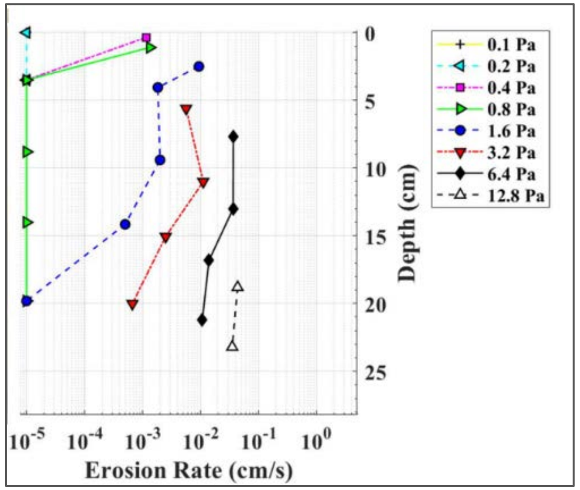
- Cohesive sediment requires additional information for modeling
- Critical shear stress
  - No sediment transport below critical shear
  - Non-cohesive sediment (sand, gravel, rocks)
    - Based on density & grain size
    - Constant throughout sediment layer
    - Individual grains move independently
  - 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
  - Needed critical shear stress information to develop cohesive sediment parameters for modeling
- 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 Sampling

- Locations of USGS Gages
- Follow USGS sampling guidelines
- SSC measurements
  - Typically fines
- Bedload transport
  - Measurements showed no bedload transport

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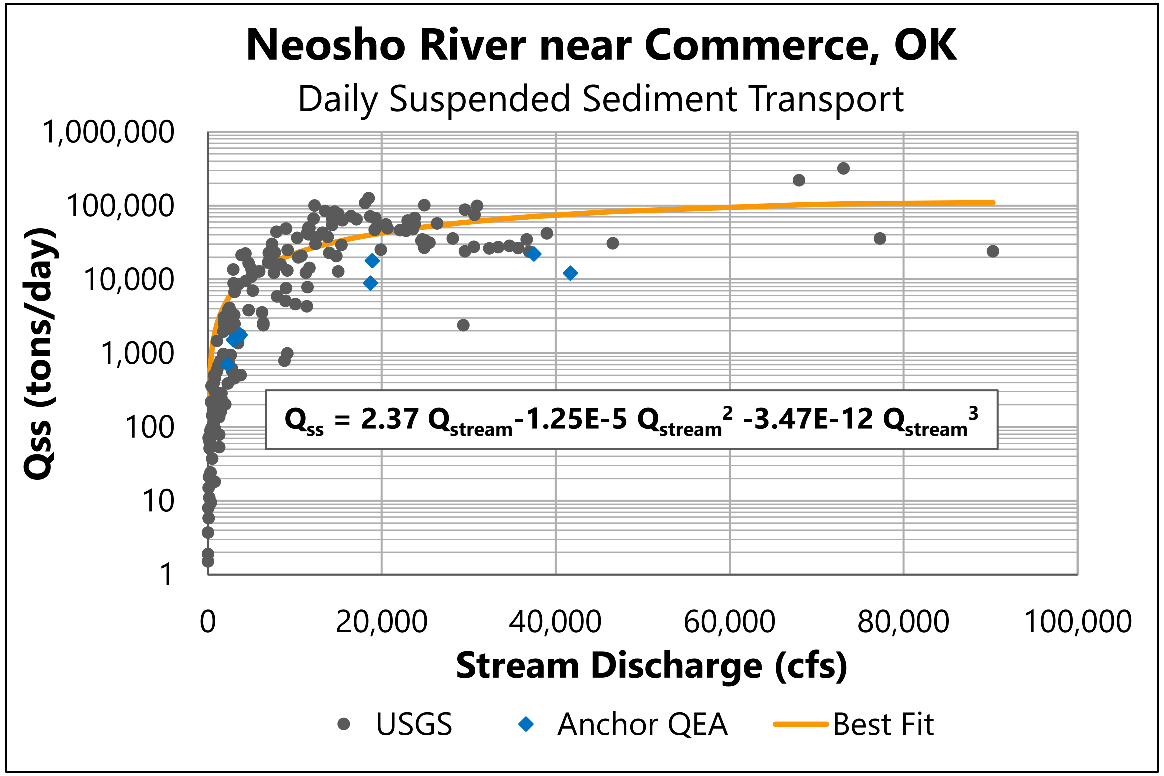
Sediment Transport vs. Discharge

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

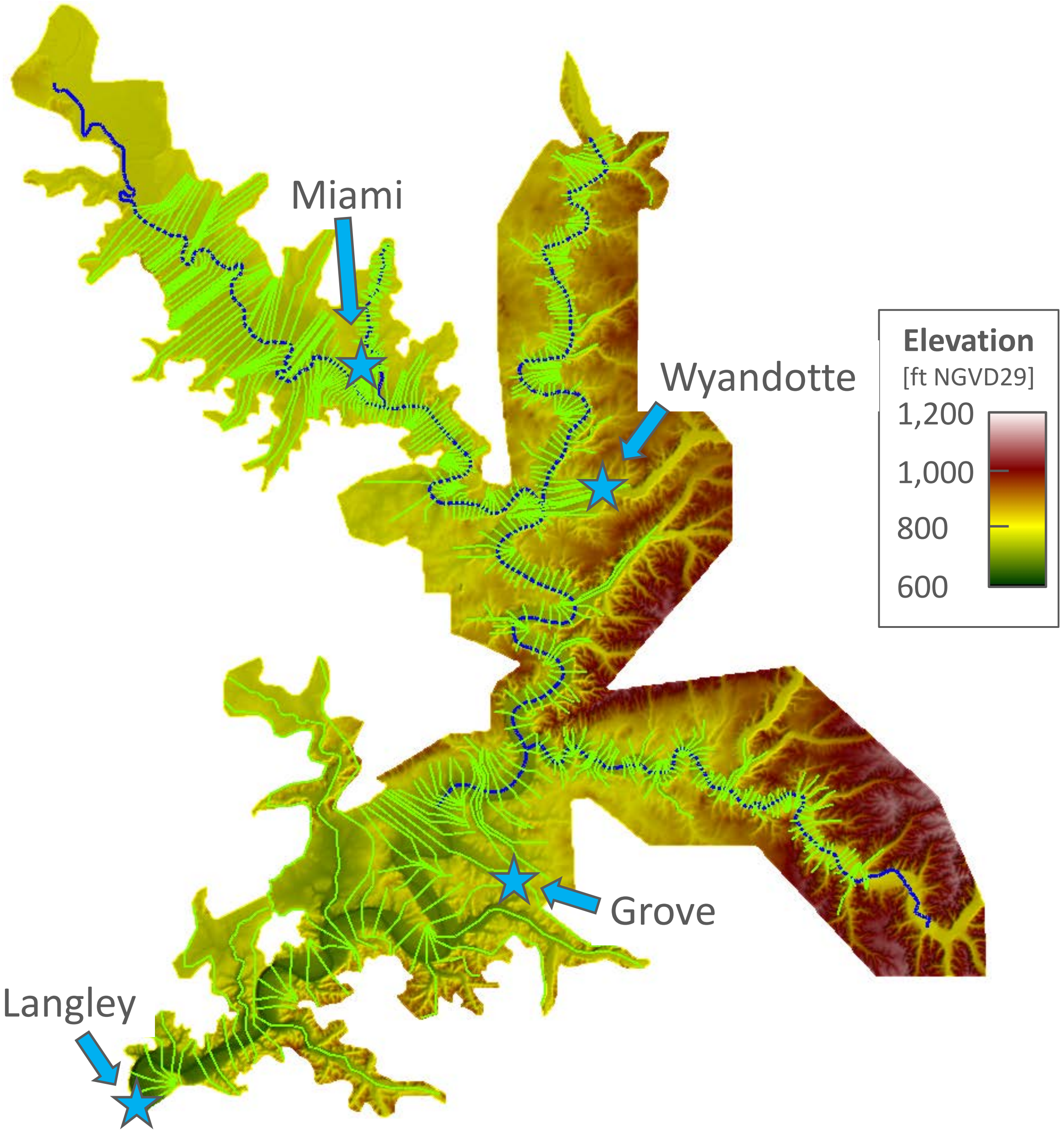


Outline

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

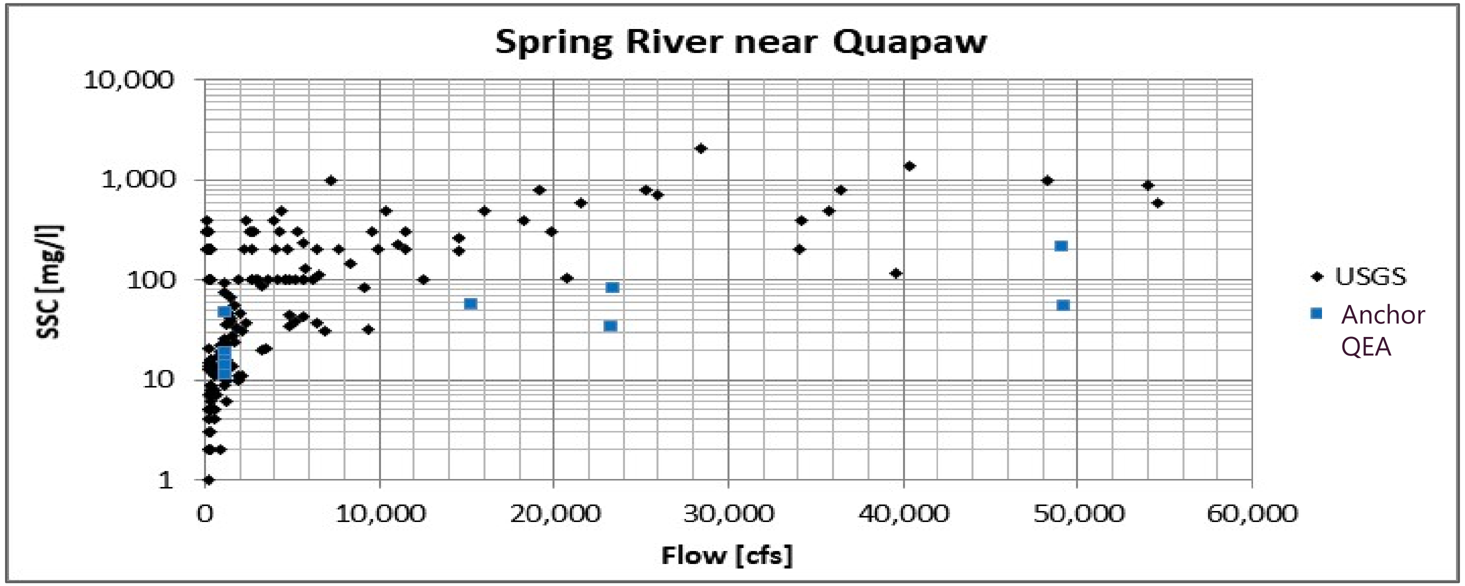
STM Development

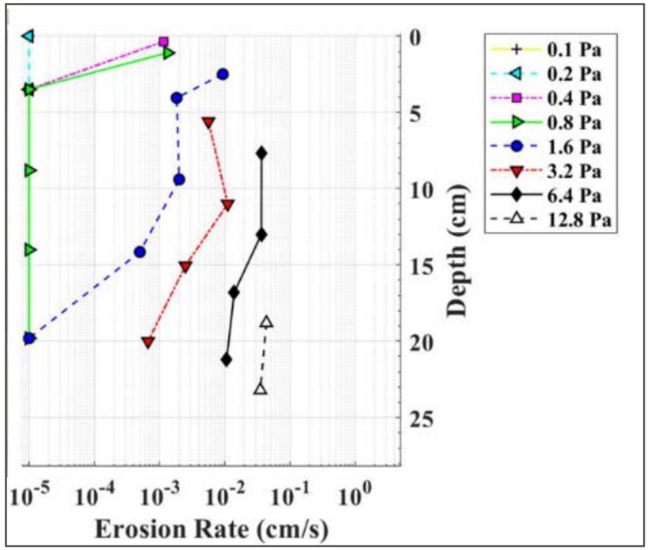
- Sediment Transport Model (STM)
  - Three terrain datasets
    - 1998 Bathymetry/topography
      - From 1998 REAS information
    - 2009 Bathymetry/topography
      - Grand Lake: 2009 OWRB survey
      - Upstream areas: 2017 USGS survey
    - 2019 Bathymetry/topography
      - Grand Lake: 2019 USGS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



STM Calibration

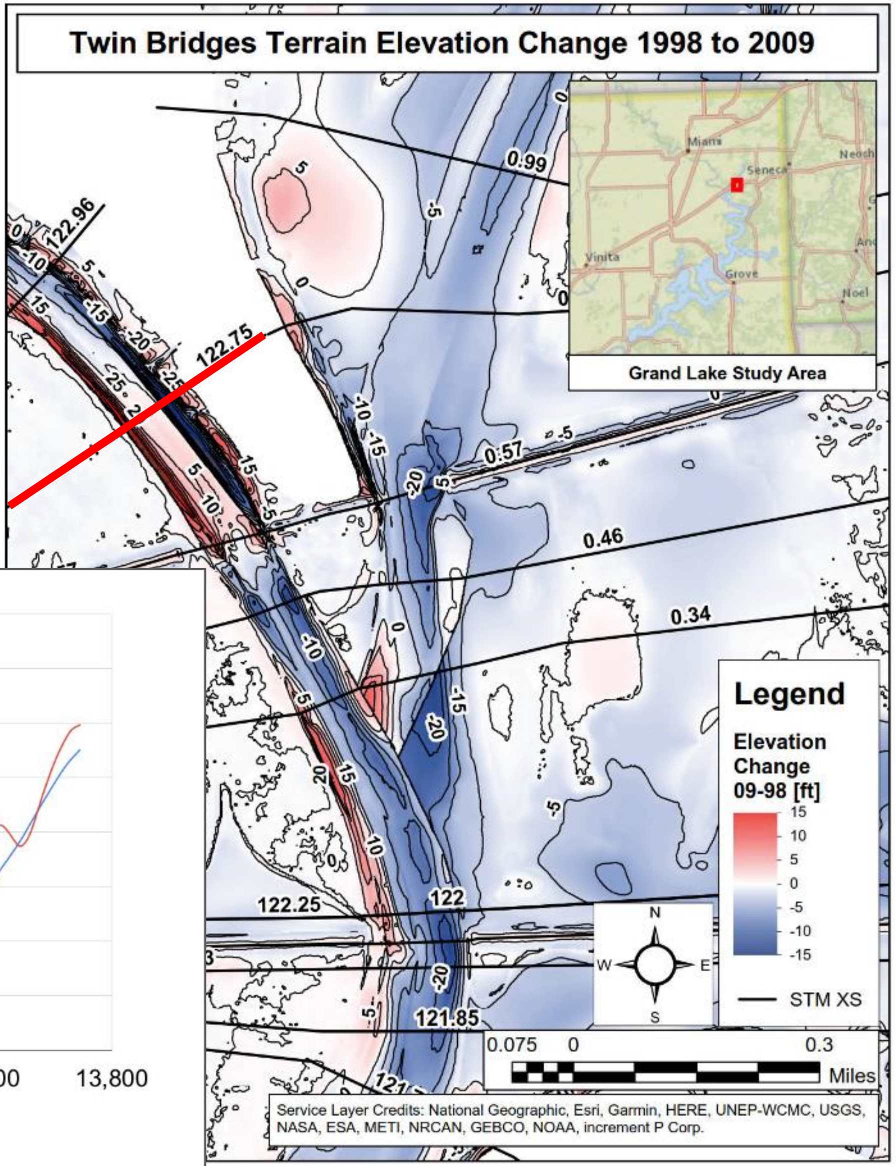
- Start with 1998 terrain
- Create sediment input files
  - Based on field data, lab analyses

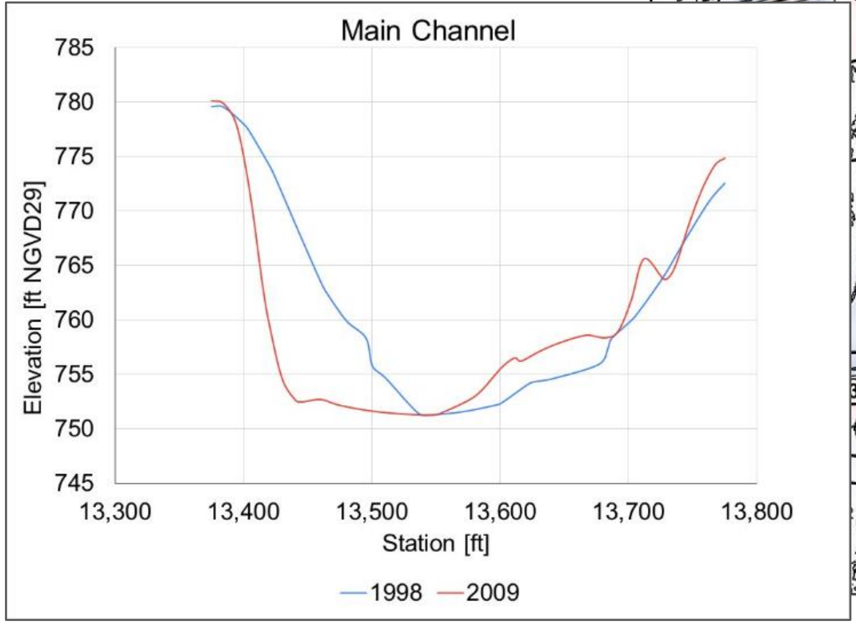




STM Calibration

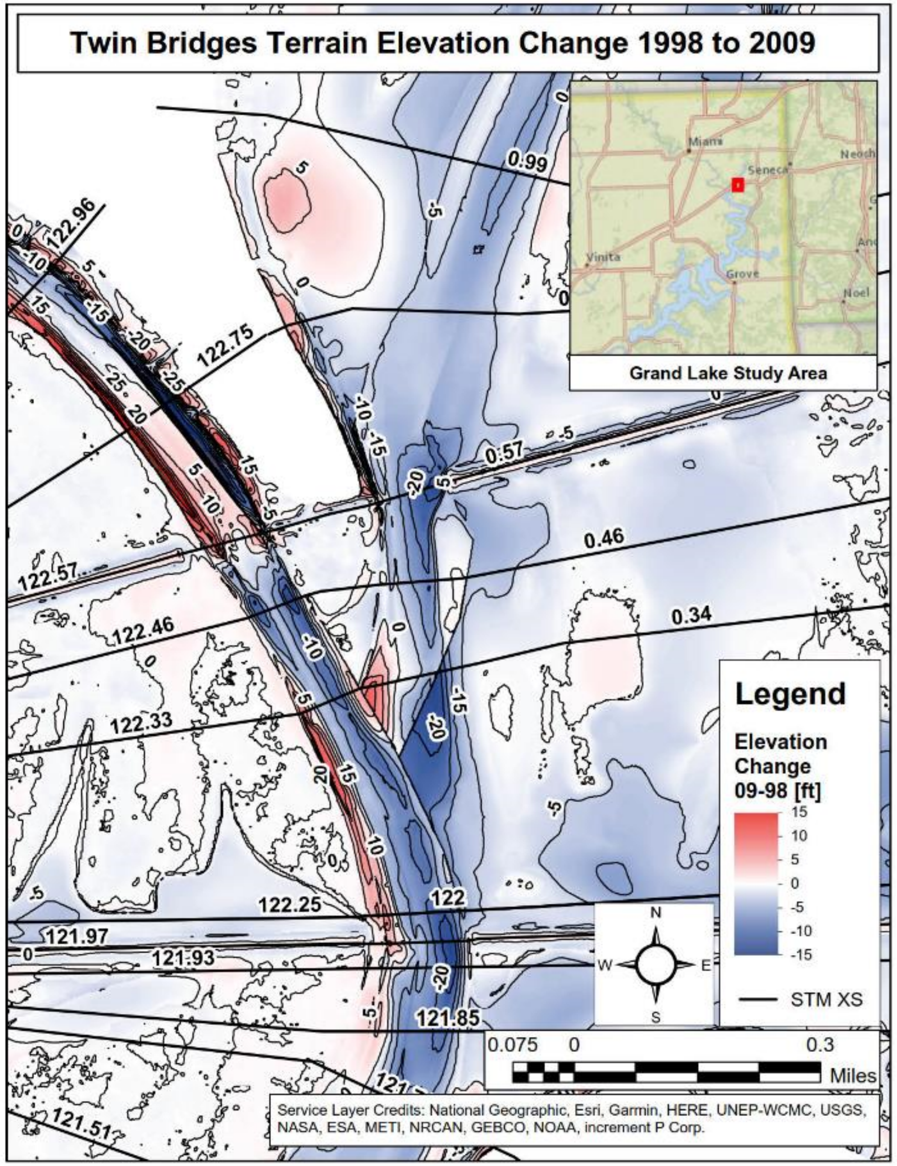
- Start with 1998 terrain
- Create sediment input files
  - Based on field data, lab analyses
- Run model for 1998 – 2009
  - Calibrate sediment erosion/deposition patterns to measured channel data





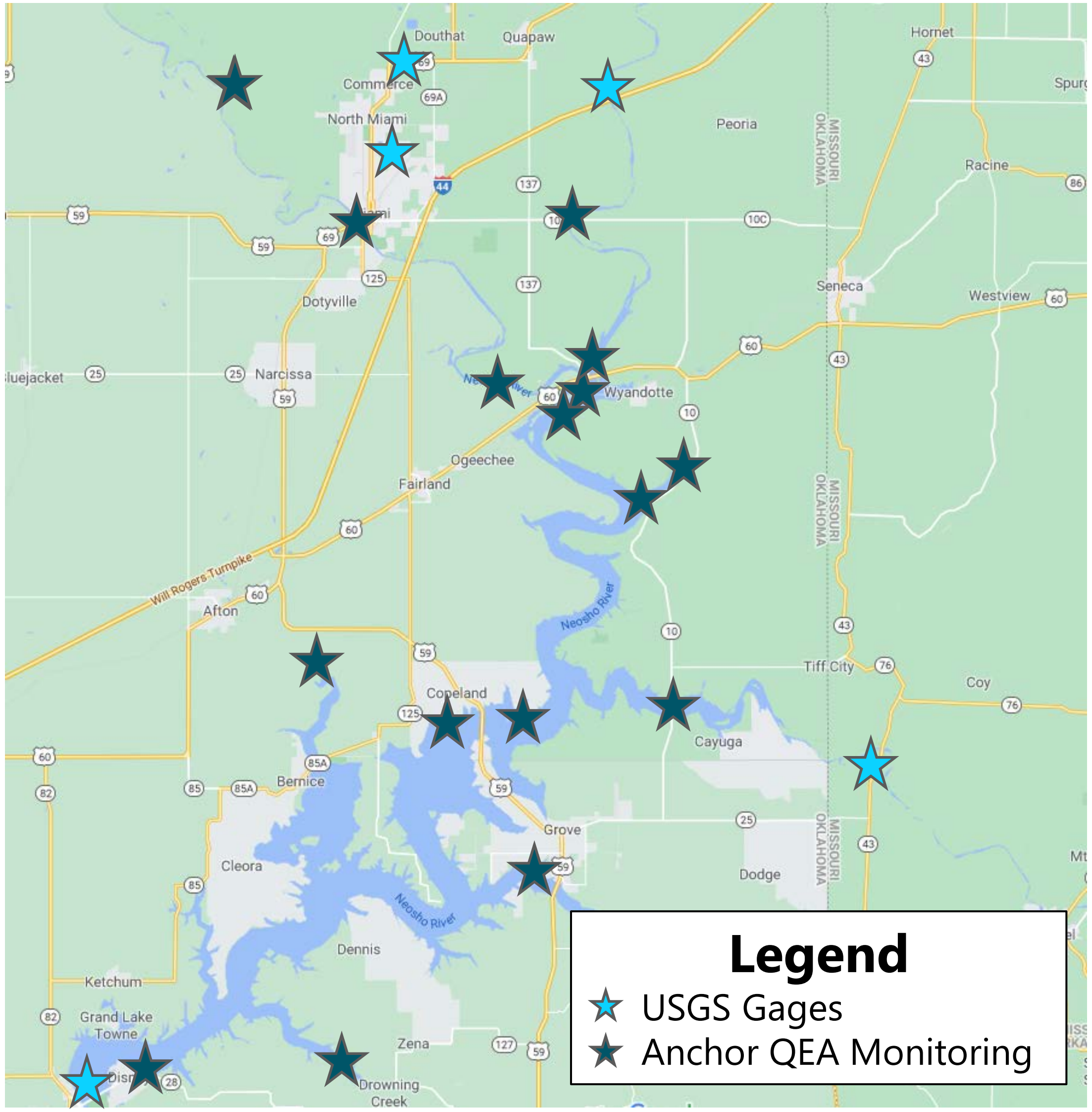
STM Calibration

- 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



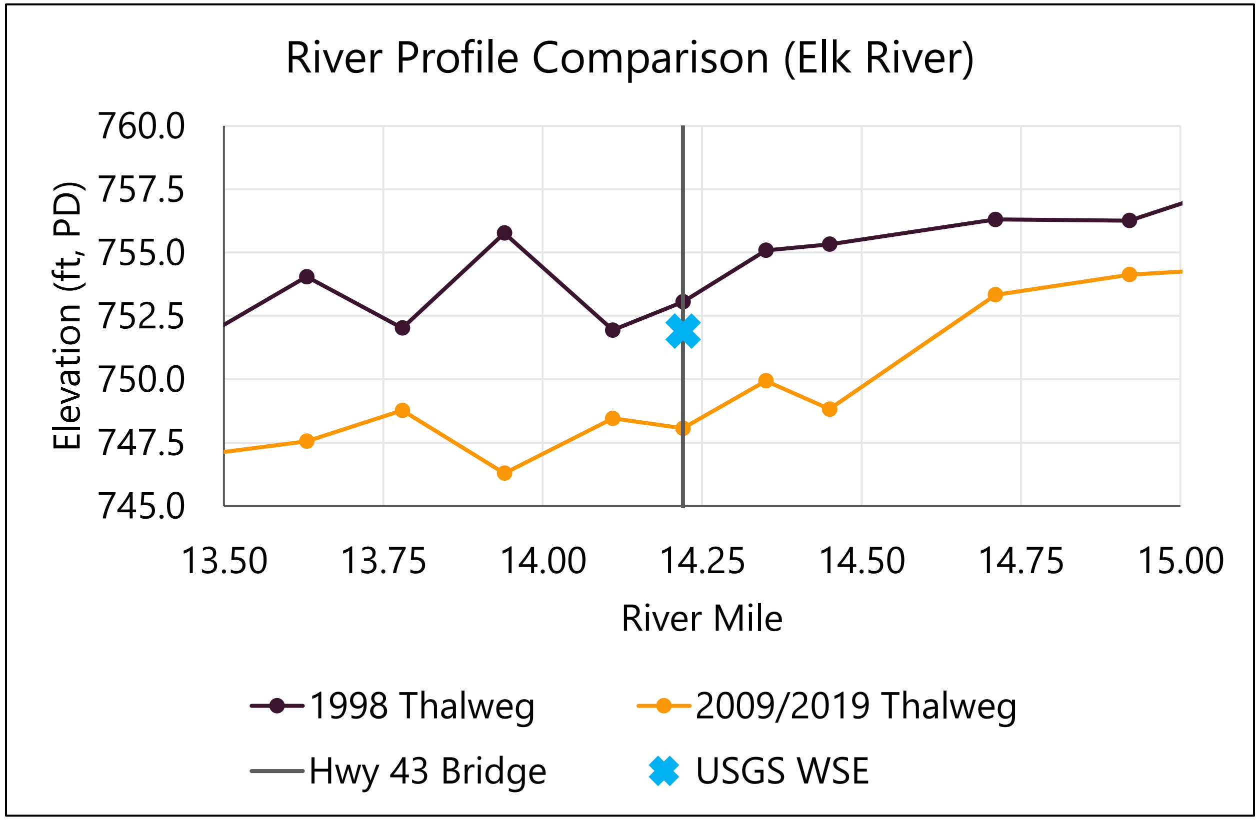
STM Hydraulic Calibration

- 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**



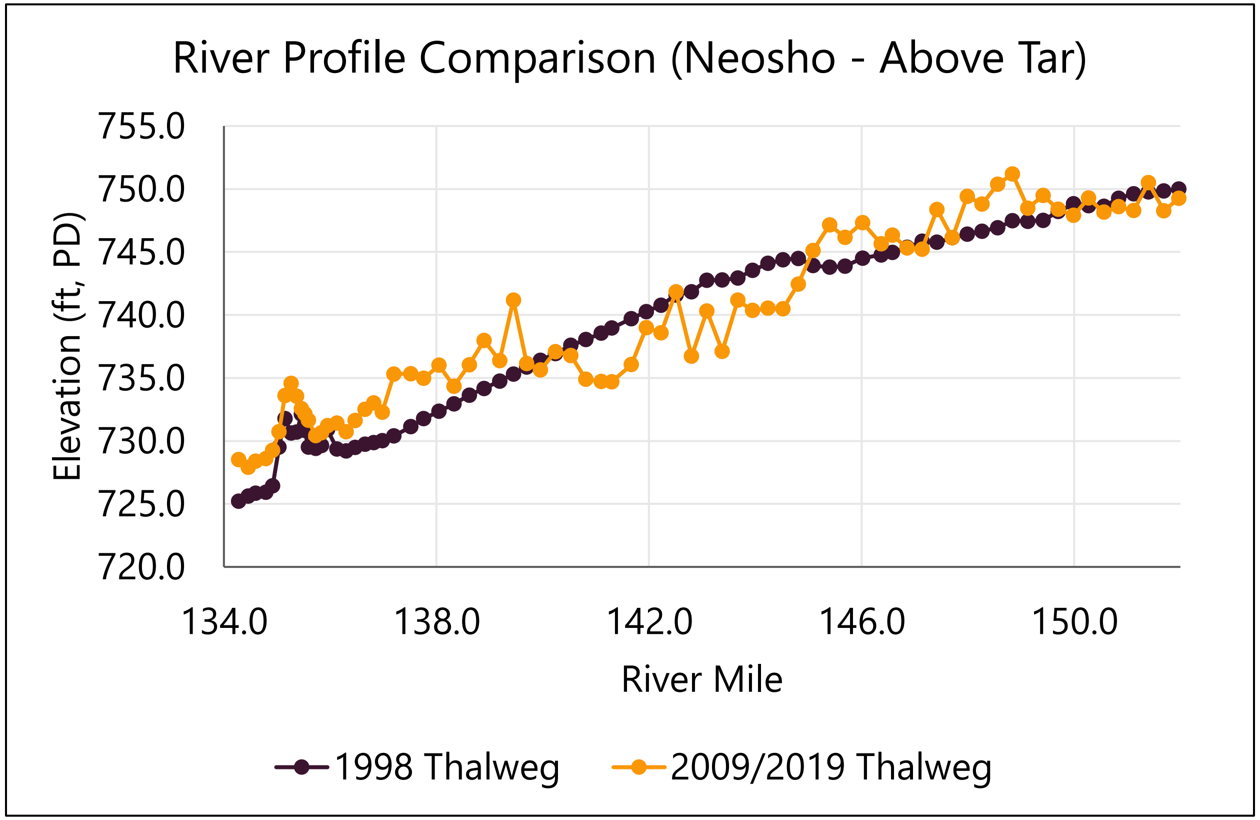
1998 Geometry Inconsistencies

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



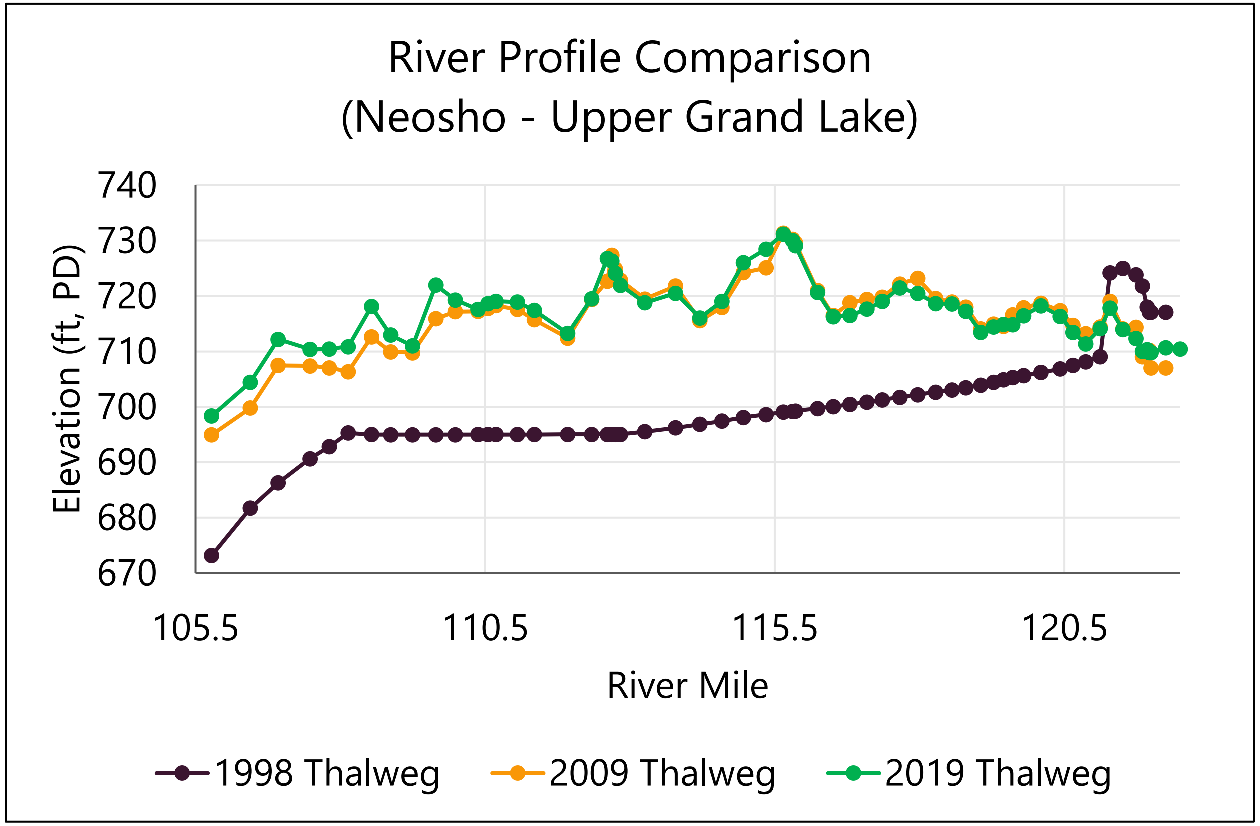
1998 Geometry Inconsistencies

- Neosho River above Tar Creek
  - Artificially smooth profile



1998 Geometry Inconsistencies

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

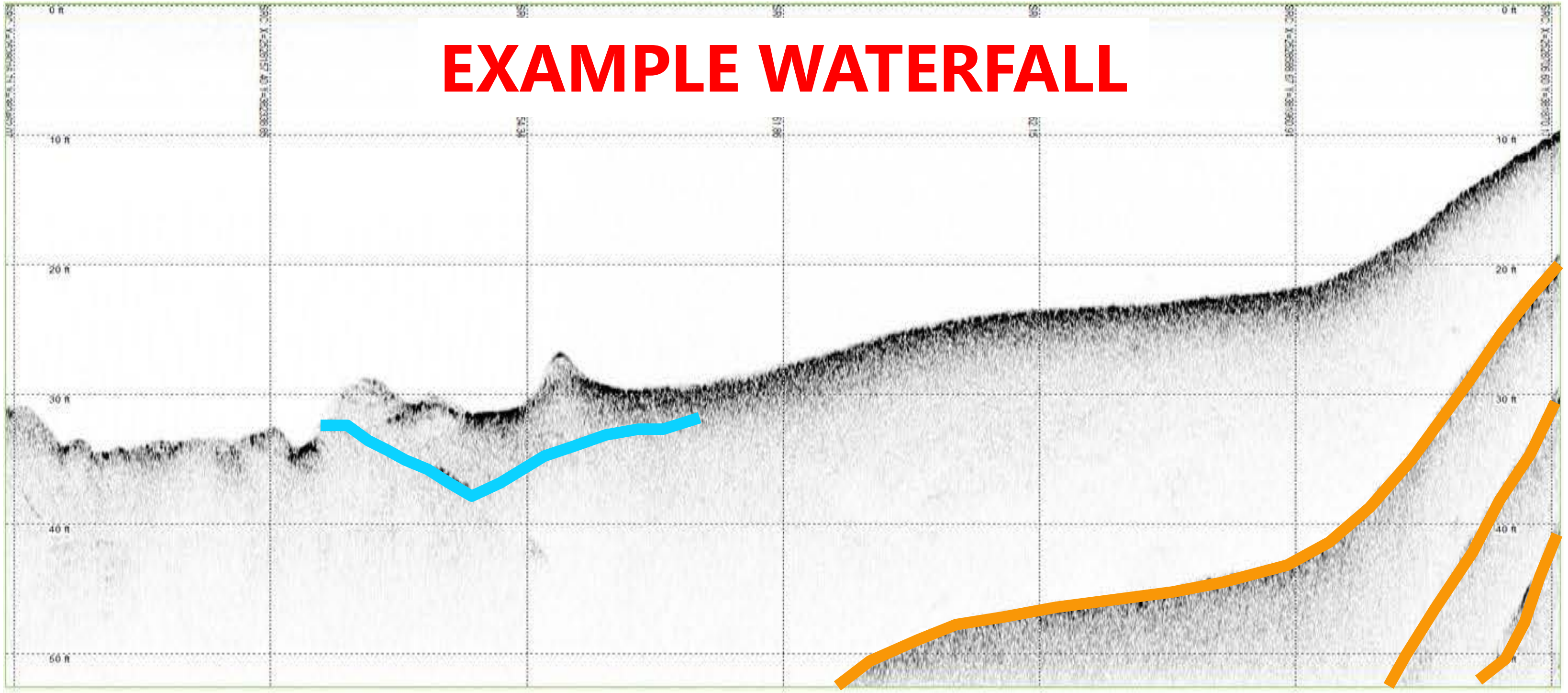


Sub-Bottom Profiling

- Sub-bottom profiler (SBP)
  - Similar to bathymetric surveying sonar systems
  - Higher power allows pulses to penetrate soft bed materials
  - Provides information on sediment layer thickness

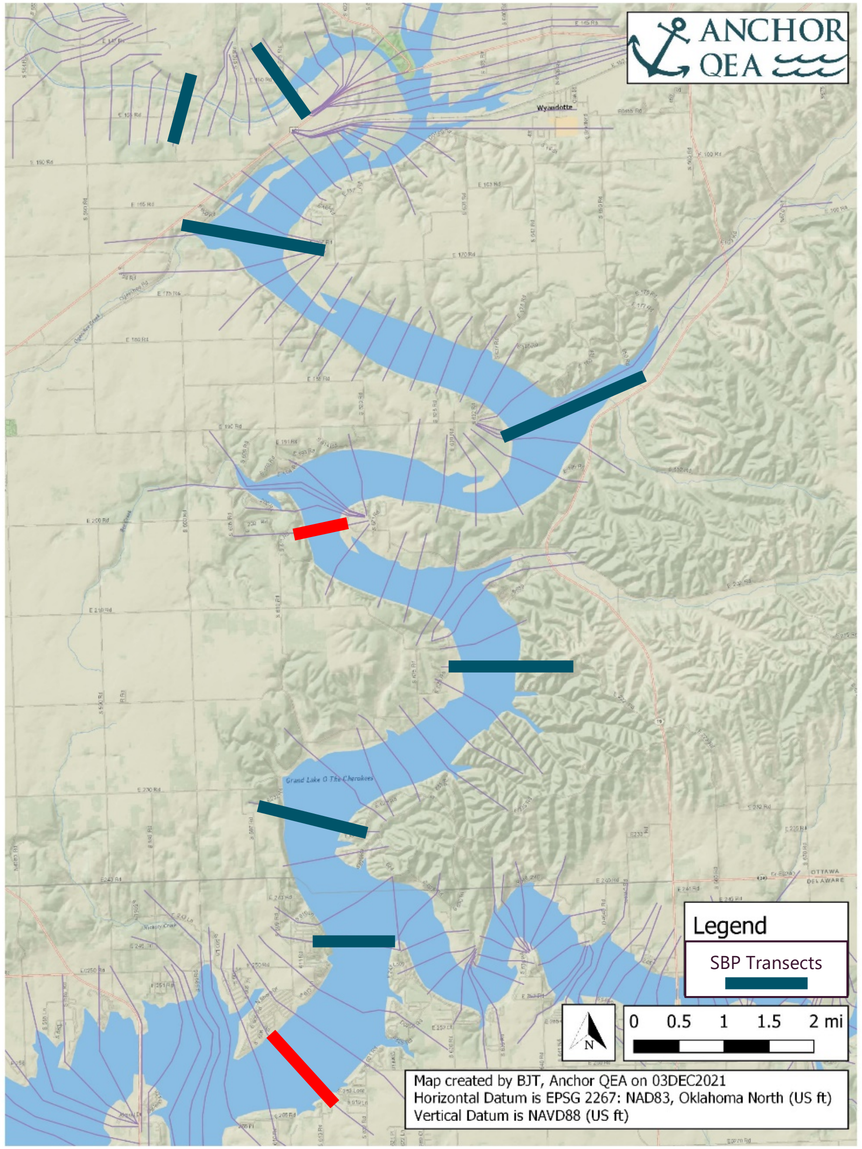
Sub-Bottom Profile Waterfalls

- Graphical outputs show sediment layers
  - **Teal** line is layer transition
  - **Orange** lines are “multiples” or secondary reflections



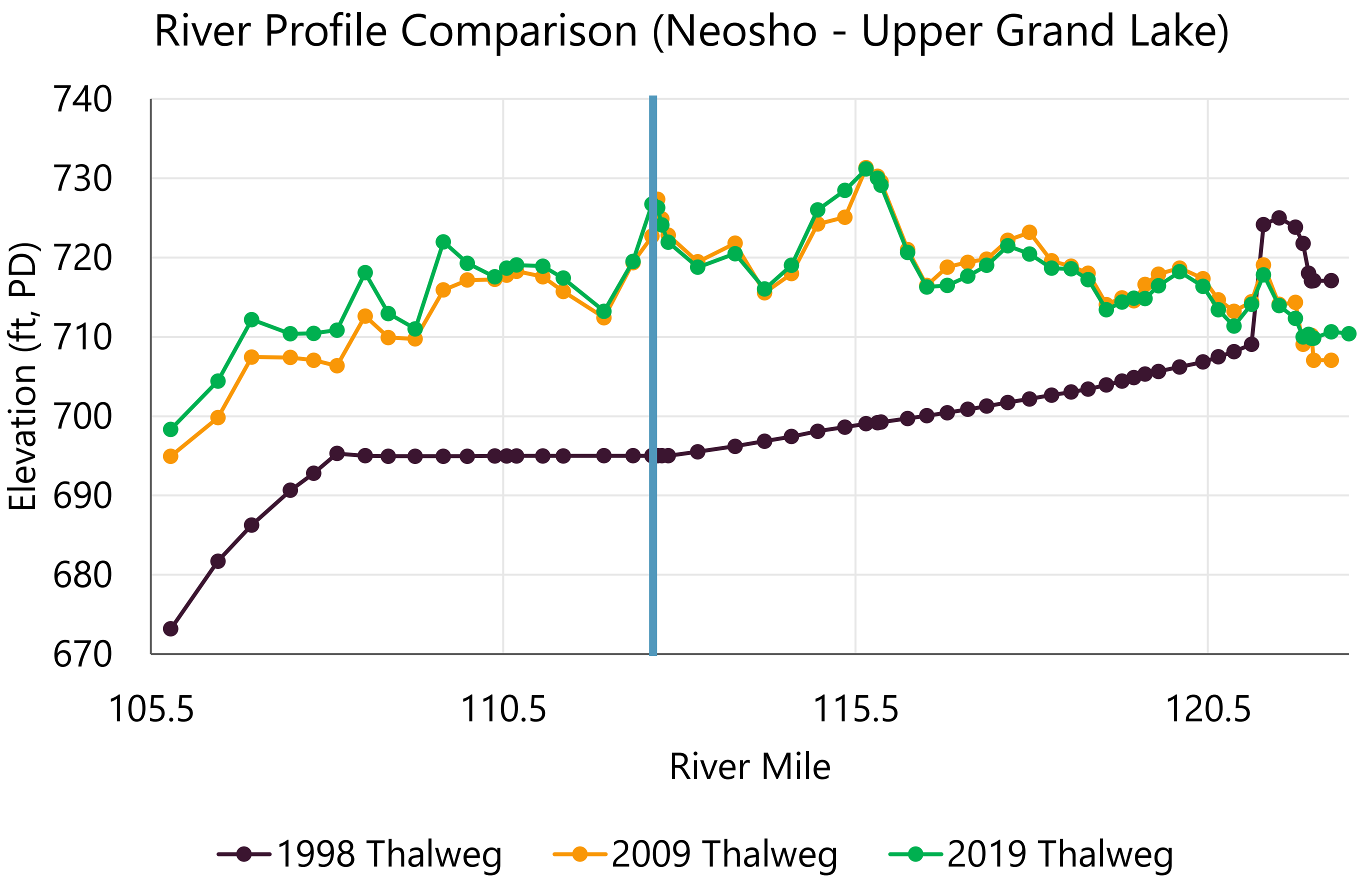
Data Collection

- Collected SBP data at 9 transects
- Presenting data from
  - RM 112.34
  - RM 103.72



Terrain Comparisons

- Cross-section collected at **RM 112.34**
- Profile comparison shows apparent ~30 ft of deposition



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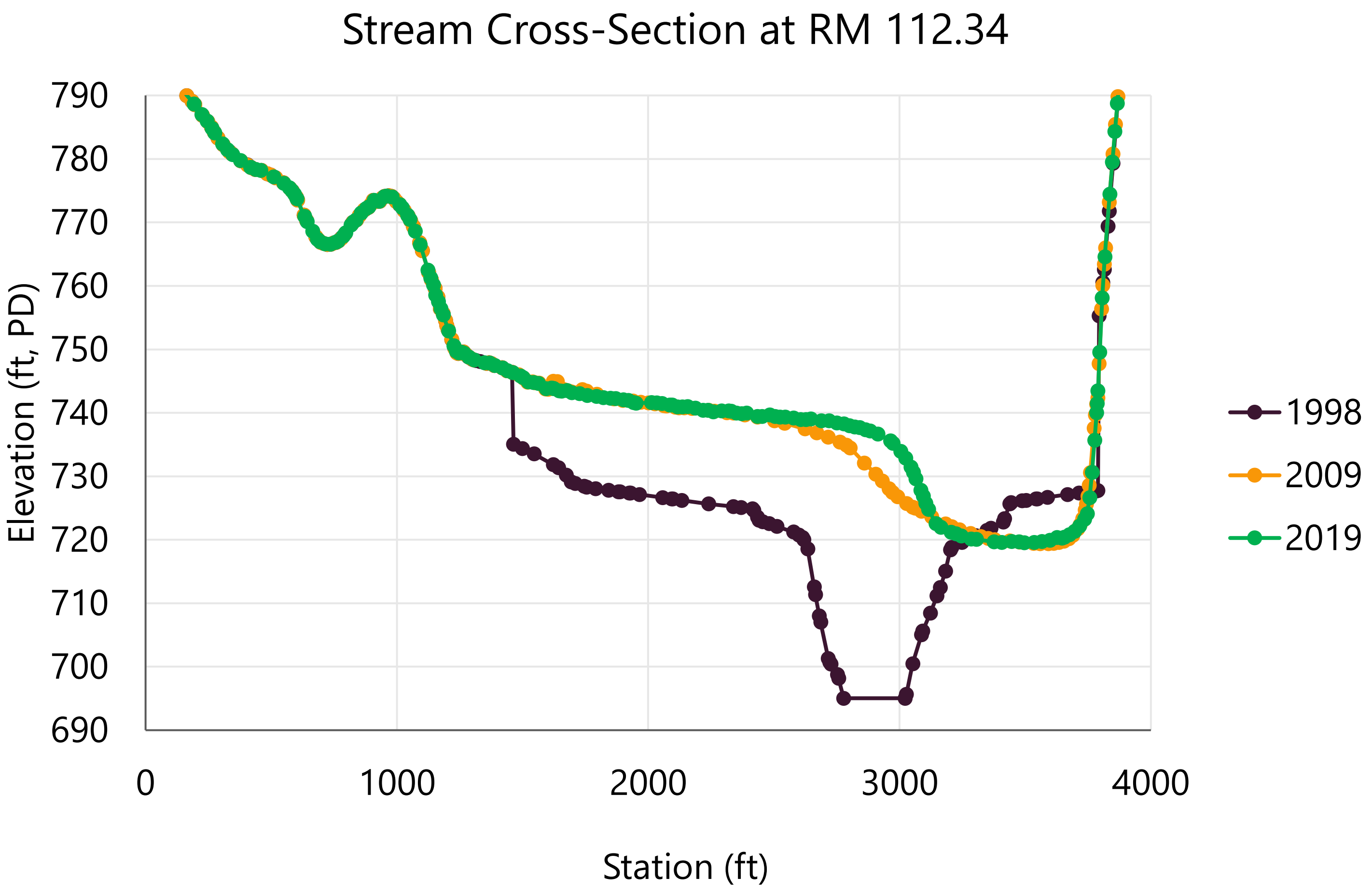
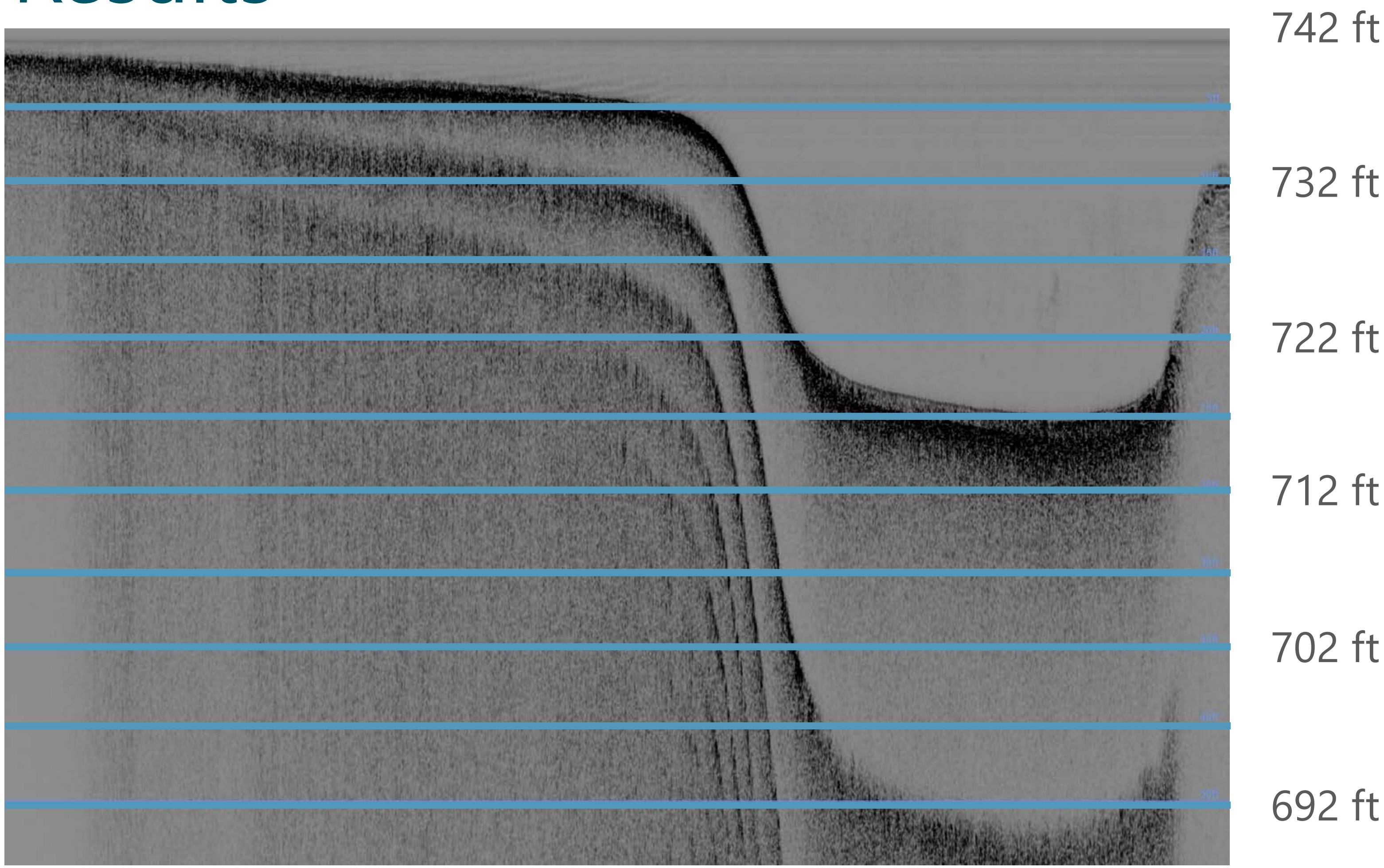


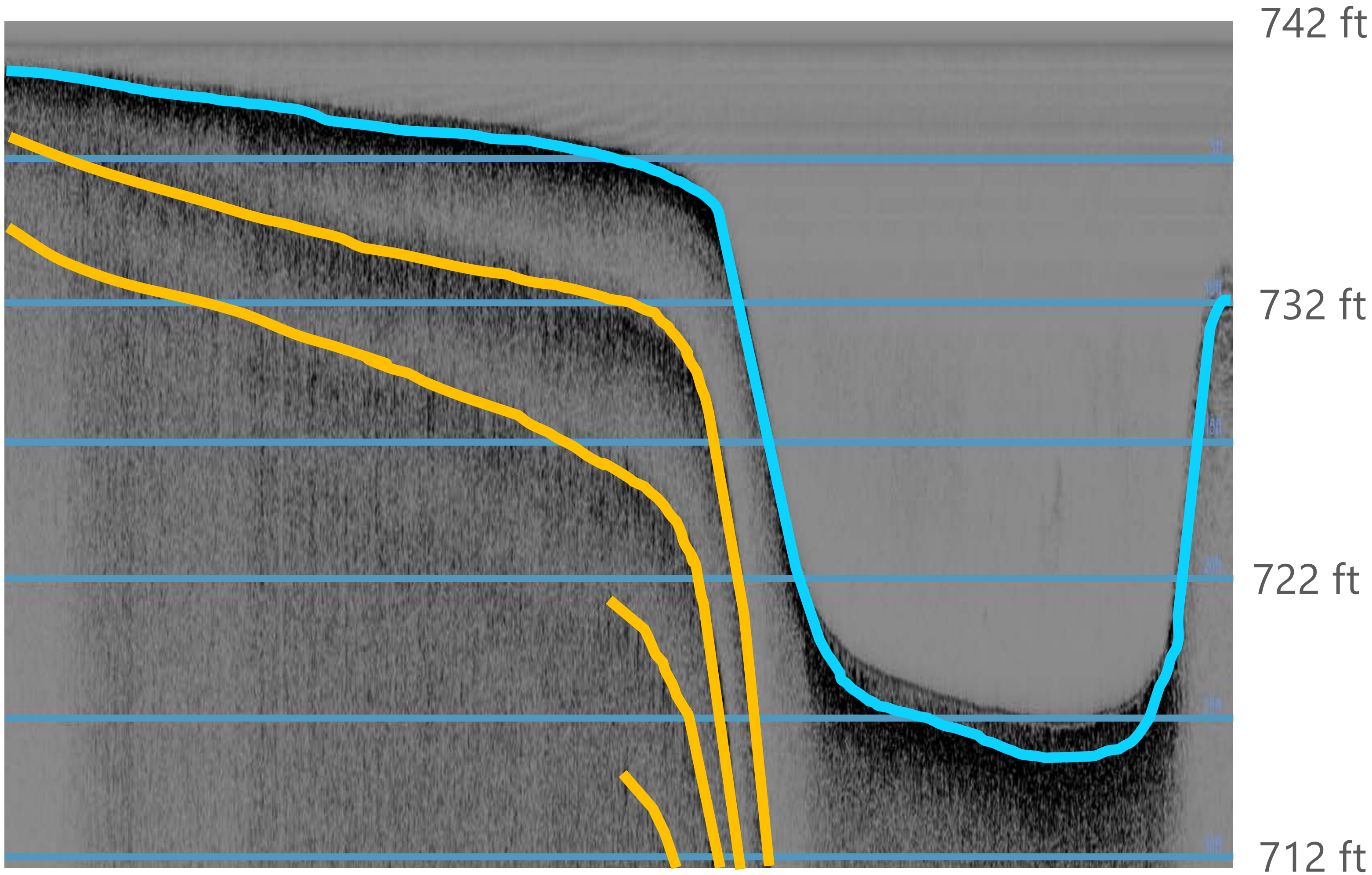
Sub-Bottom Profiler Results

- Cross-section collected at **RM 112.34**
- Profile comparison shows apparent ~30 ft of deposition



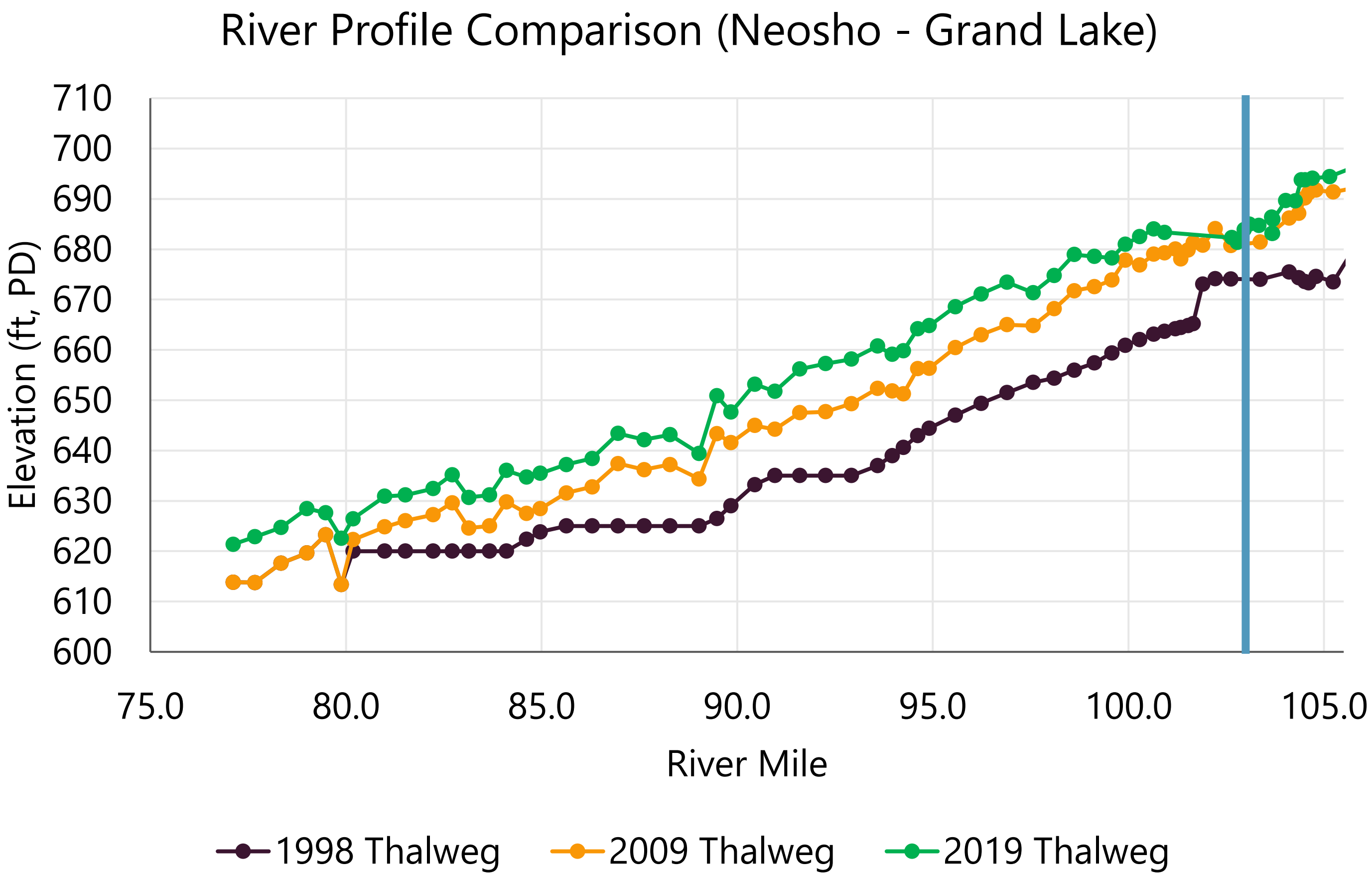
Sub-Bottom Profiler Results

- Cross-section collected at **RM 112.34**
- Profile comparison shows apparent ~30 ft of deposition
- SBP shows small layer of soft material deposition (~2-3 ft)
  - **Layer transition**
  - **Multiples**



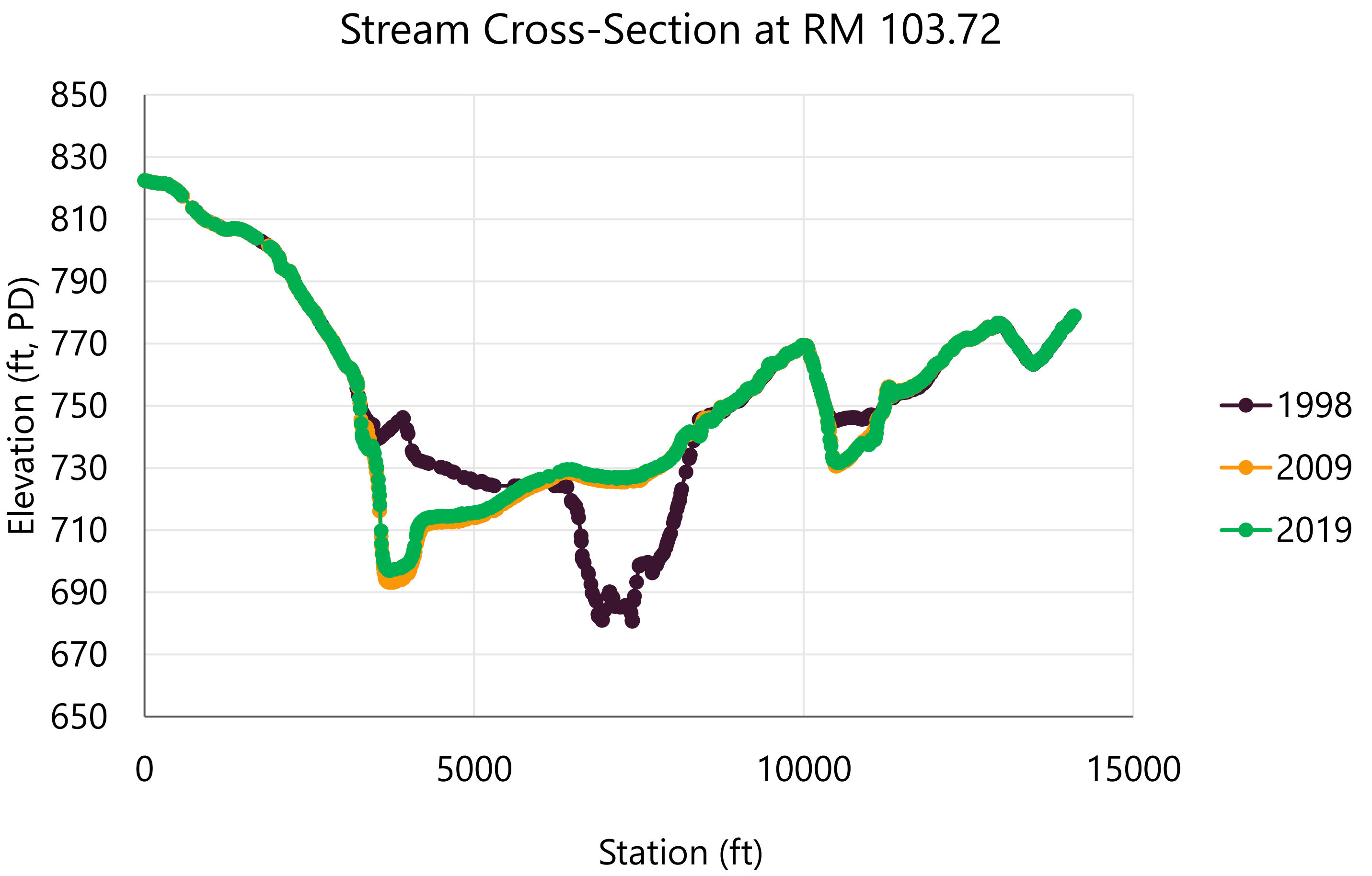
Terrain Comparisons

- Cross-section collected at **RM 103.72**
- Profile comparison shows apparent ~10 ft of deposition



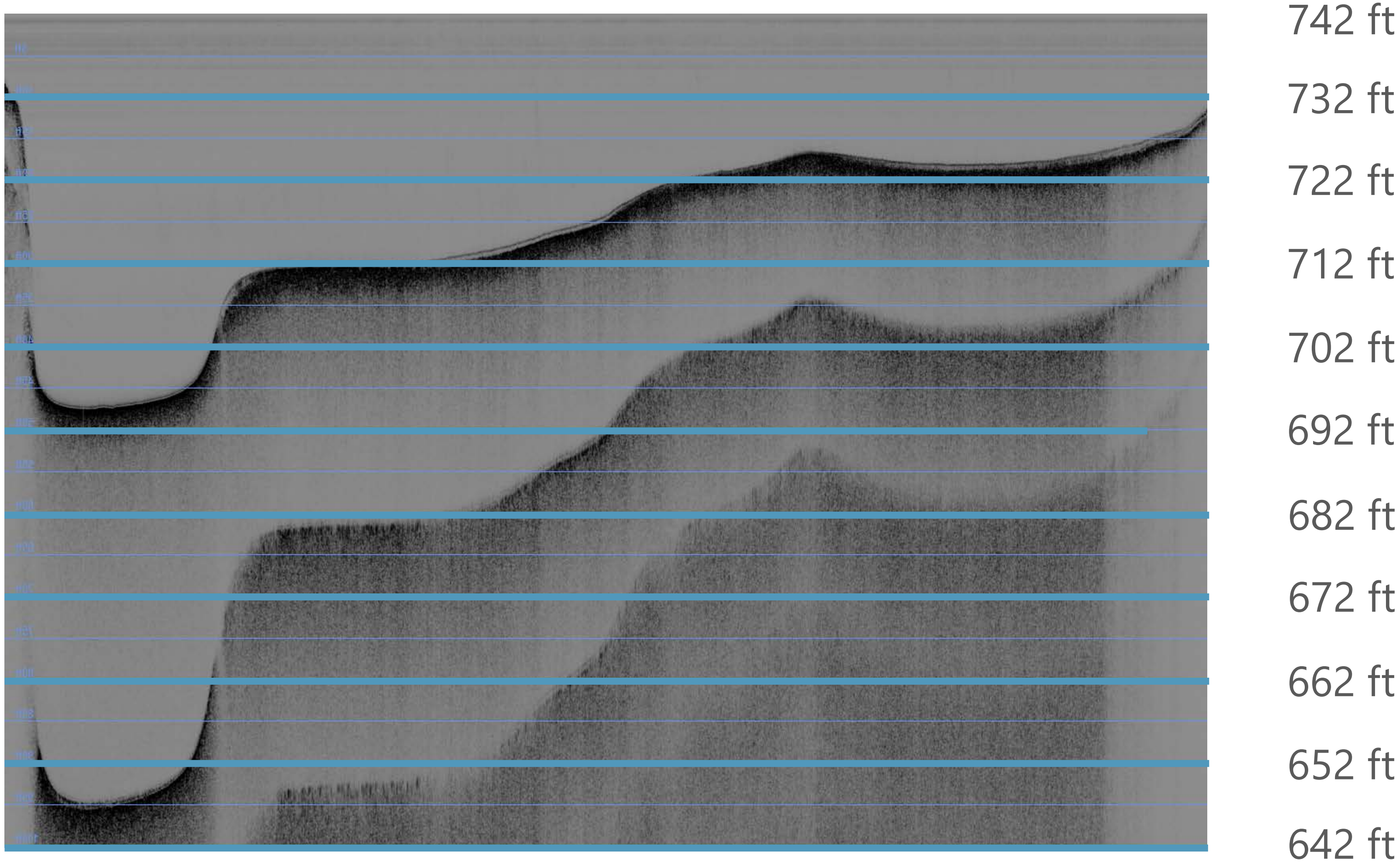
Terrain Comparisons

- Cross-section collected at **RM 103.72**
- Profile comparison shows apparent ~10 ft of deposition



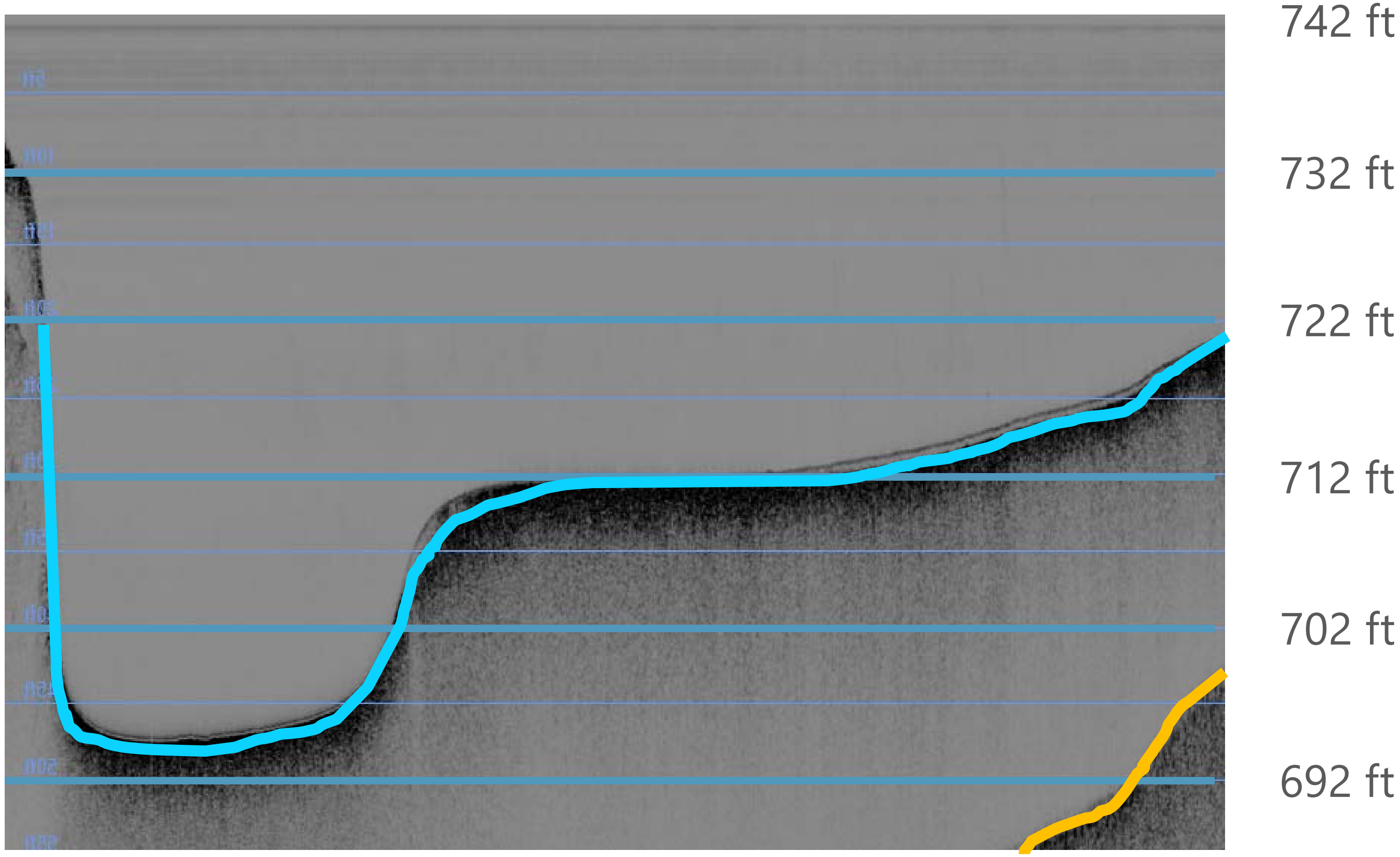
Sub-Bottom Profiler Results

- Cross-section collected at **RM 103.72**
- Profile comparison shows apparent ~10 ft of deposition



Sub-Bottom Profiler Results

- Cross-section collected at **RM 103.72**
- Profile comparison shows apparent ~10 ft of deposition
- SBP shows small layer of soft material deposition (~2-3 ft)
  - **Layer transition**
  - **Multiple**



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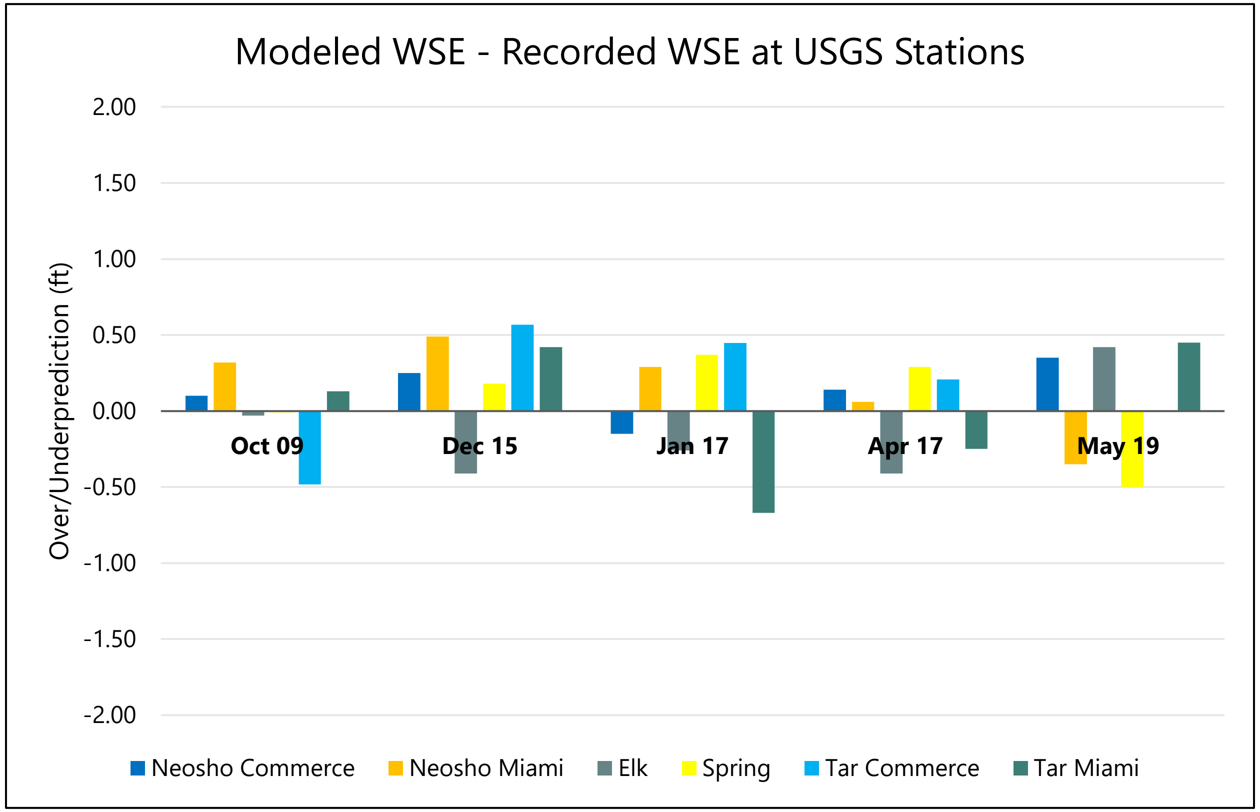
Addressing Inconsistencies

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

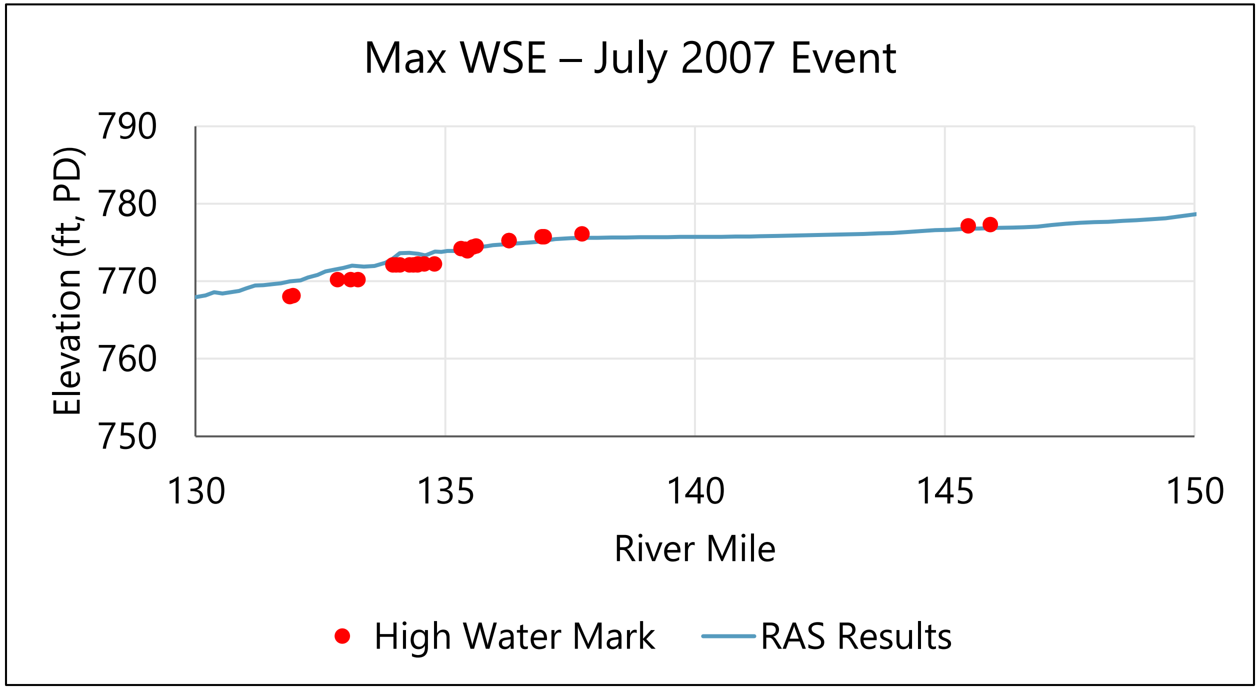
Hydraulic Correlation with USGS Gages

- Model hydraulic calibration shows good agreement with USGS gages
  - Average difference between simulated and recorded WSEs is 0.07 ft (model over-predicts WSE)



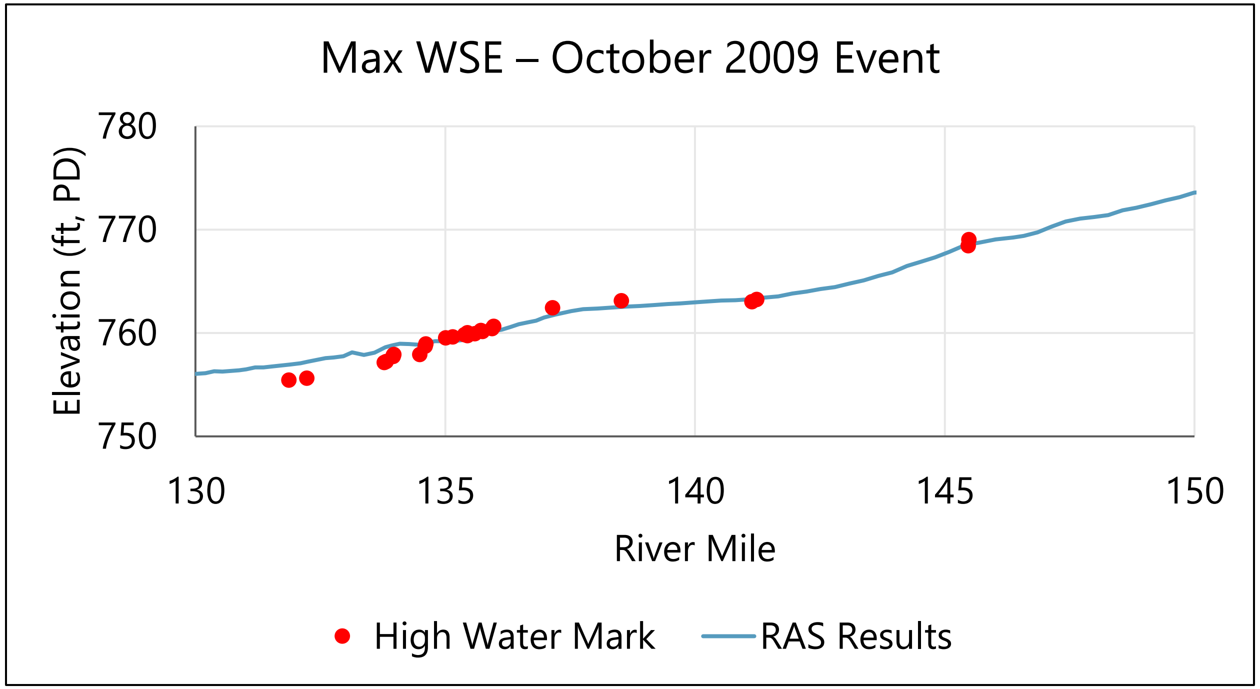
Comparison to measured HWM

- Average differences are:
  +0.6 ft with July 2007 event



Comparison to measured HWM

- Average differences are:
  - +0.6 ft with July 2007 event
  - +0.2 ft for October 2009 event



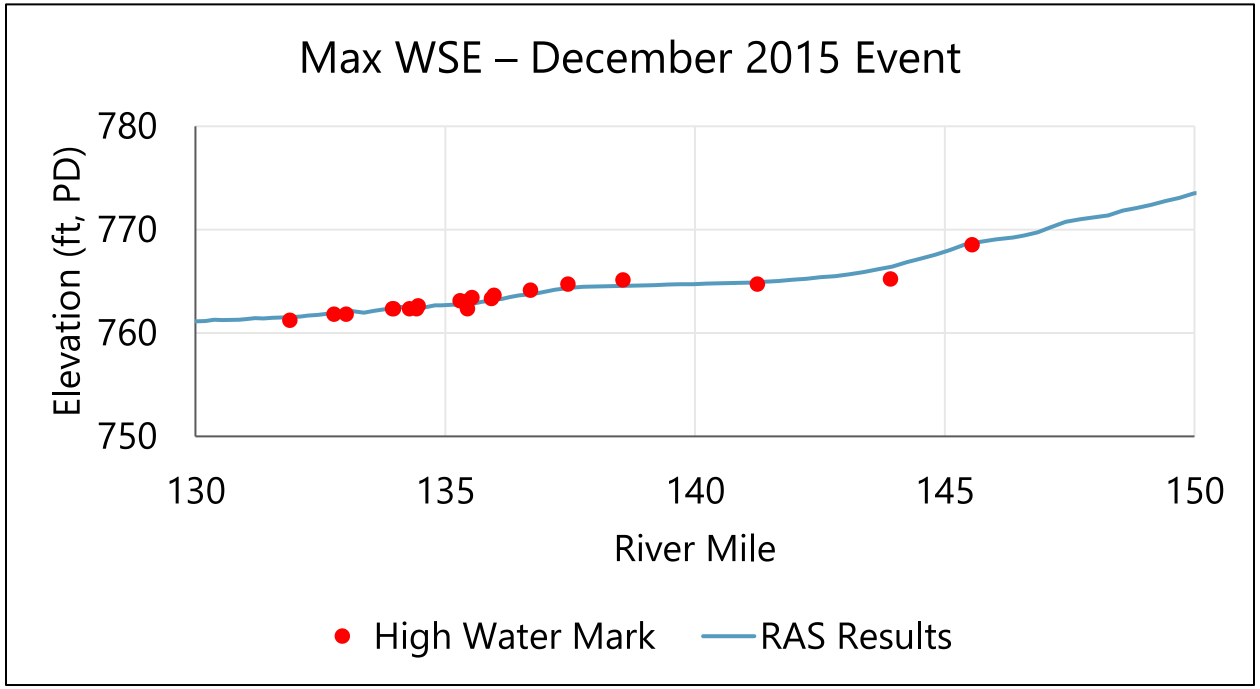
Comparison to measured HWM

- Average differences are:

  +0.6 ft with July 2007 event

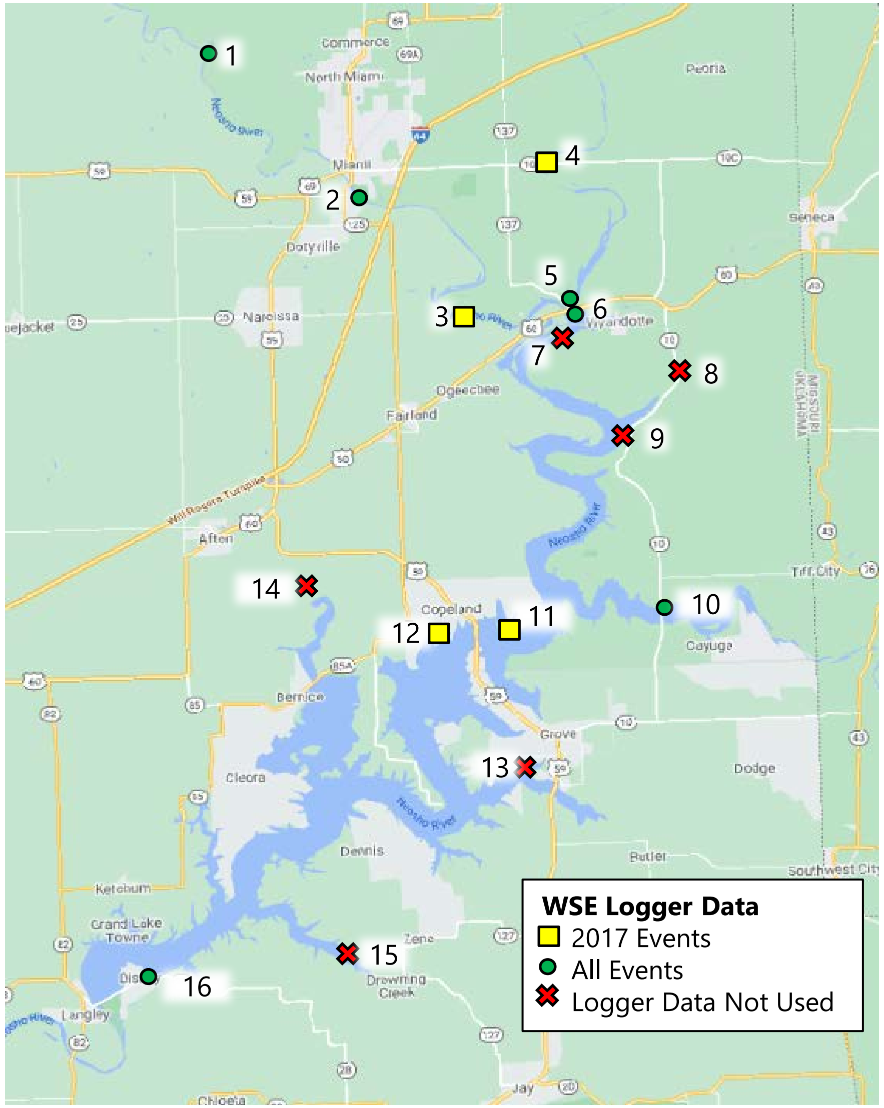
  +0.2 ft for October 2009 event

  -0.01 ft for December 2015 event



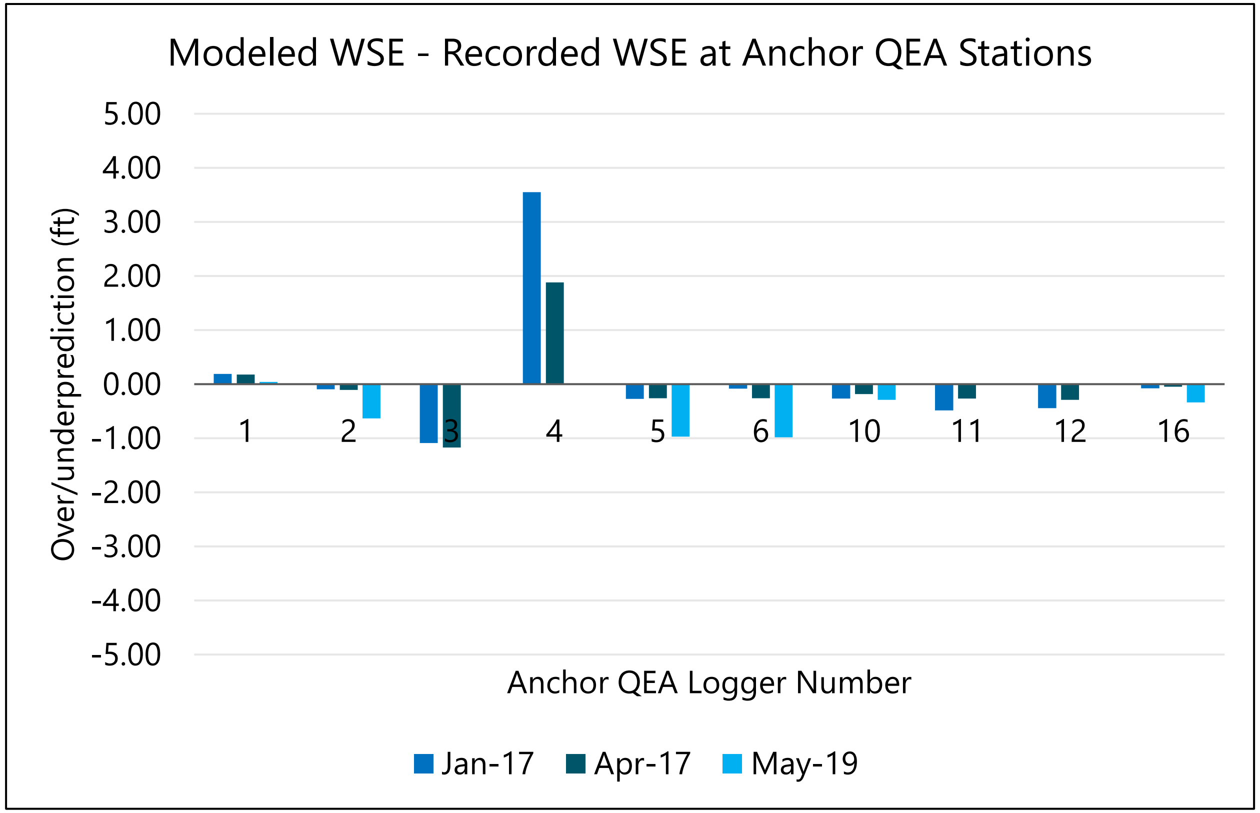
Comparison to Anchor QEA Loggers

- Average differences are:



Comparison to Anchor QEA Loggers

- Average differences are:
  - +0.09 ft for January 2017 event
  - -0.05 ft for April 2017 event
  - -0.53 ft for May 2019 event



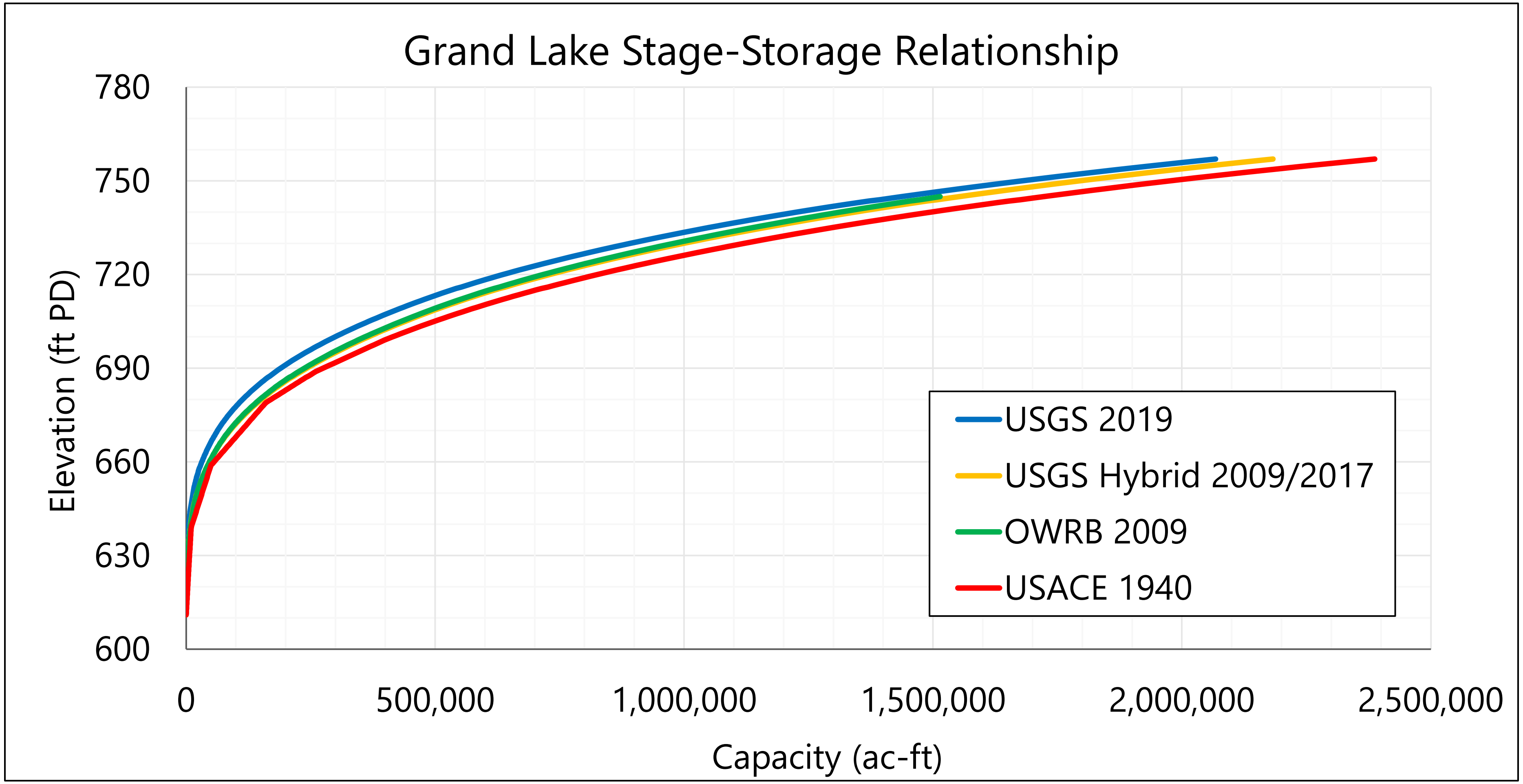
Sediment Calibration

- Sediment calibration based on 2009 – 2019
  - Primarily Grand Lake; lower reaches of Elk, Neosho
  - Known stage-storage curves used to validate accumulation in reservoir

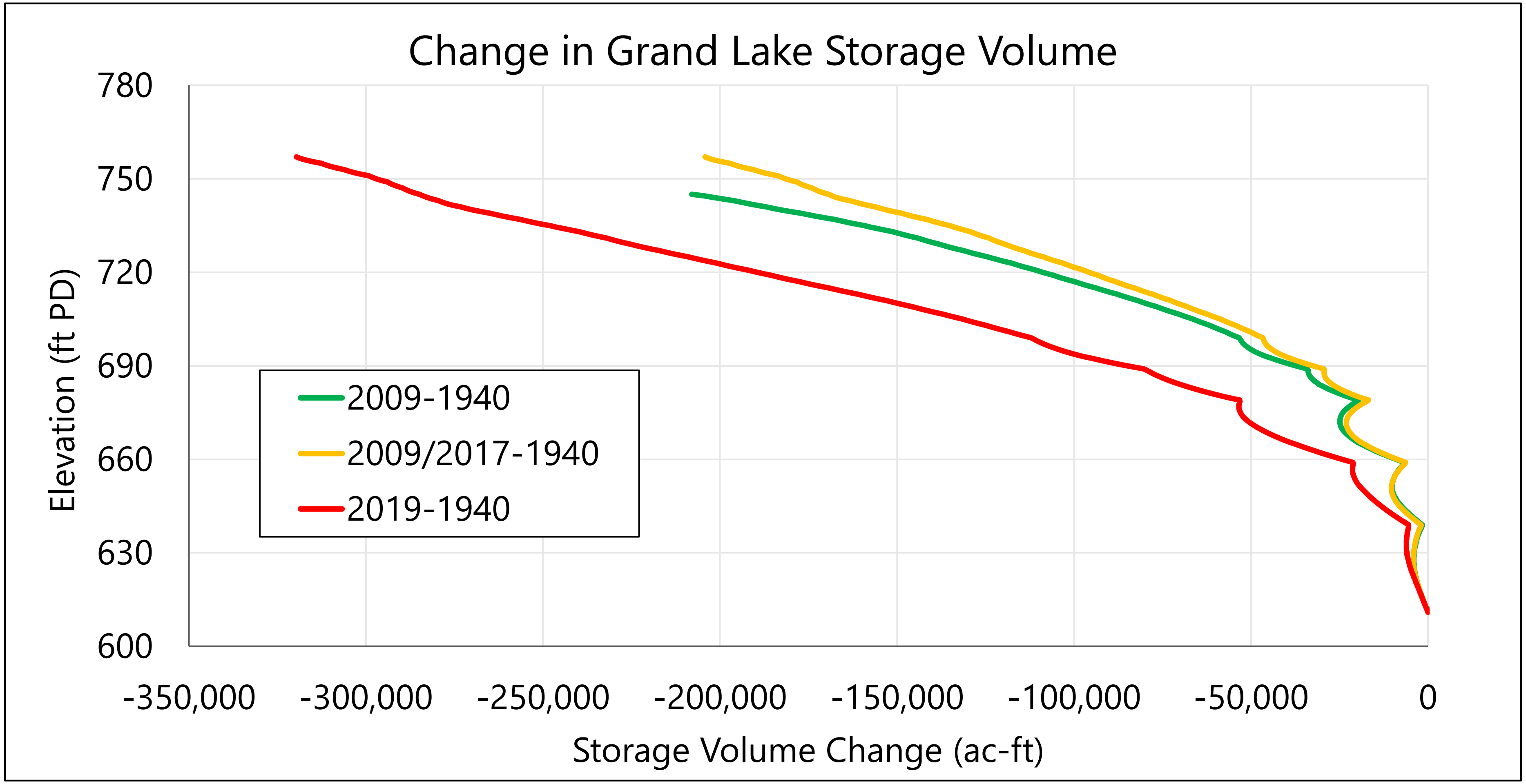
Sediment Transport – Reservoir Storage

- 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)

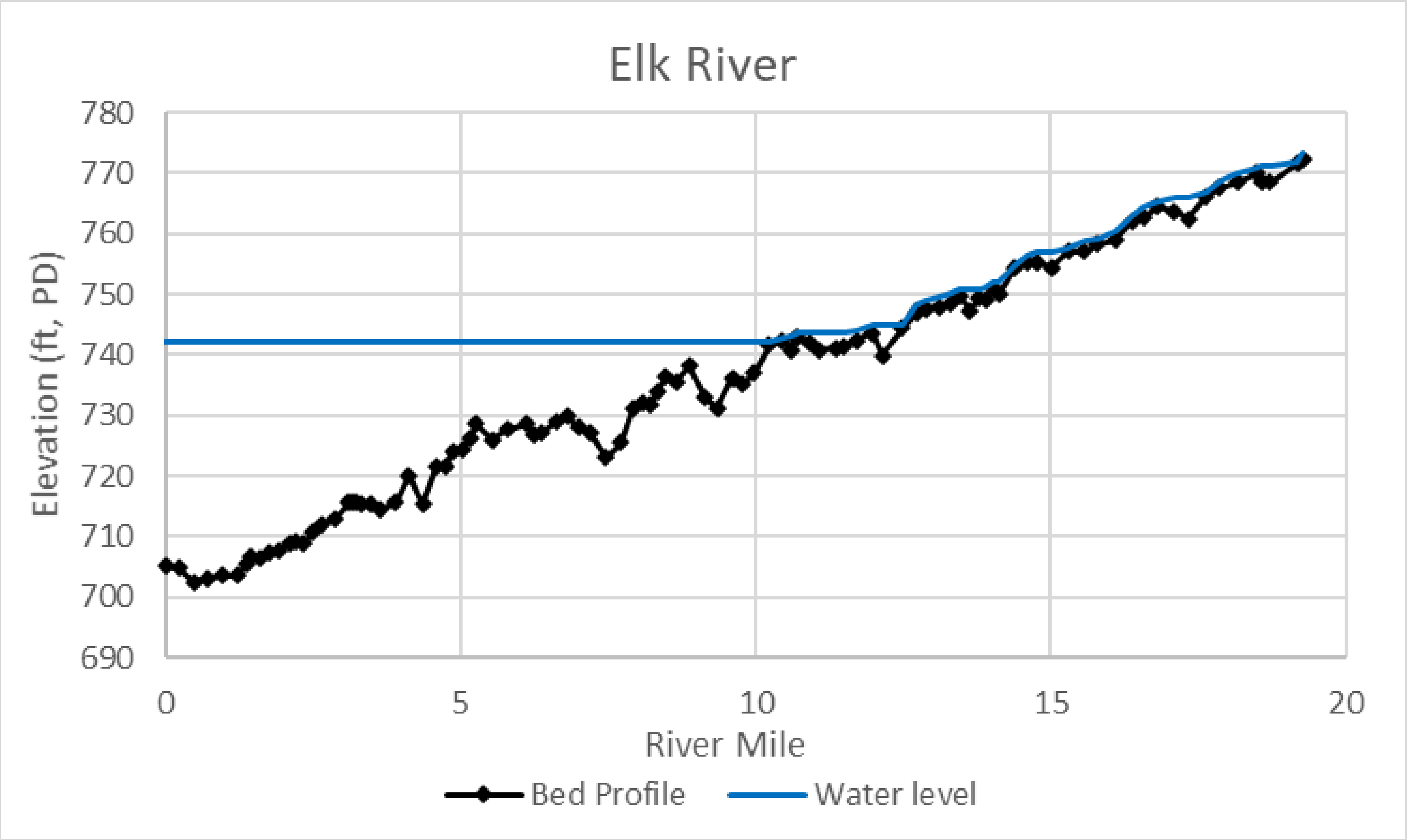
Reservoir Storage Volume Analysis



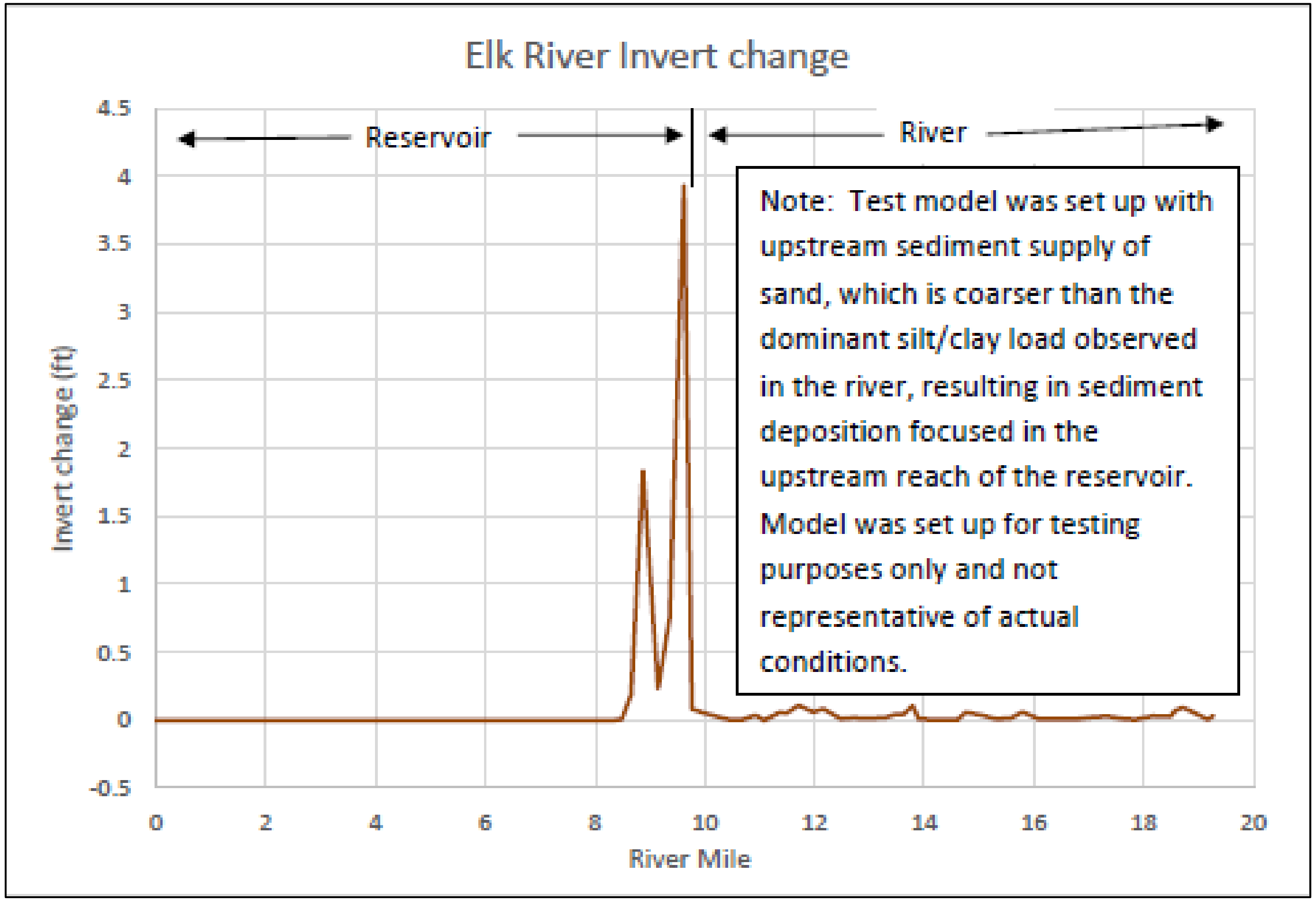
Reservoir Storage Volume Analysis



HEC-RAS Testing



HEC-RAS Testing

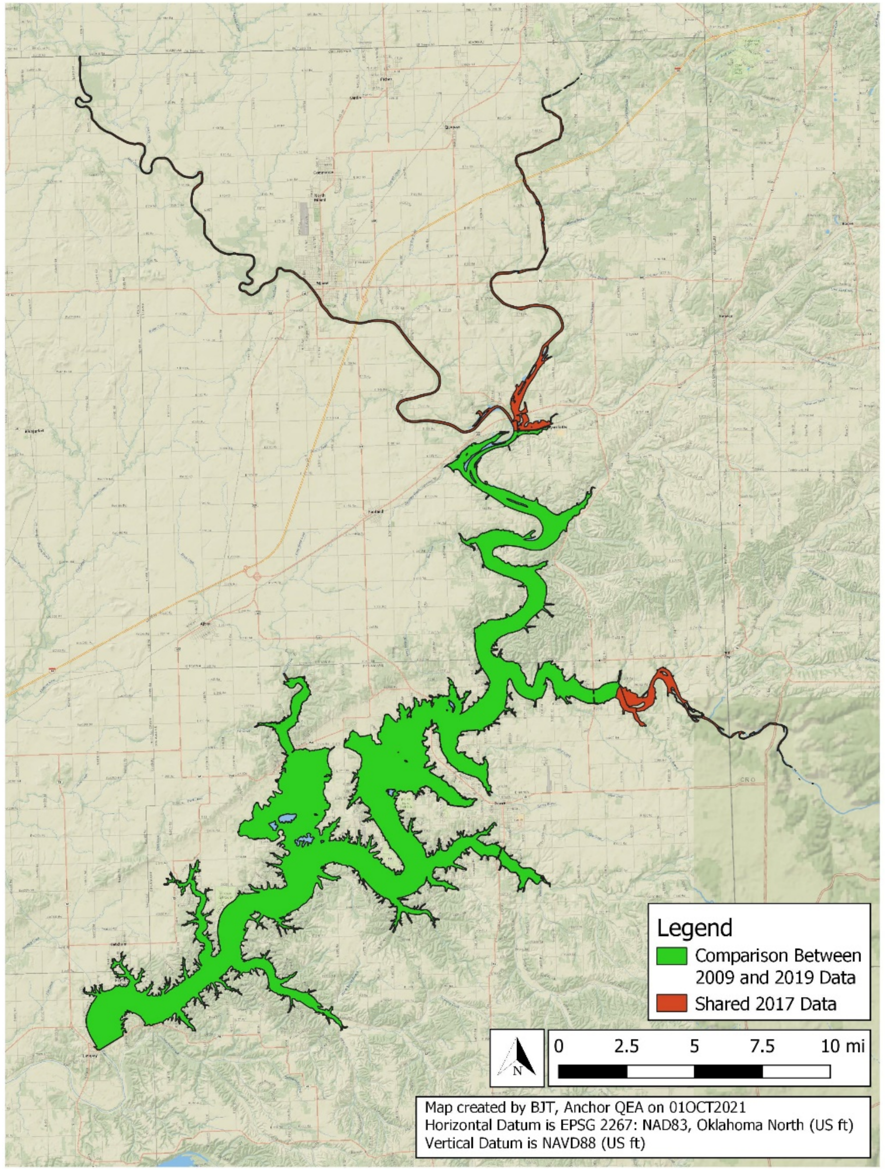


Sediment Calibration

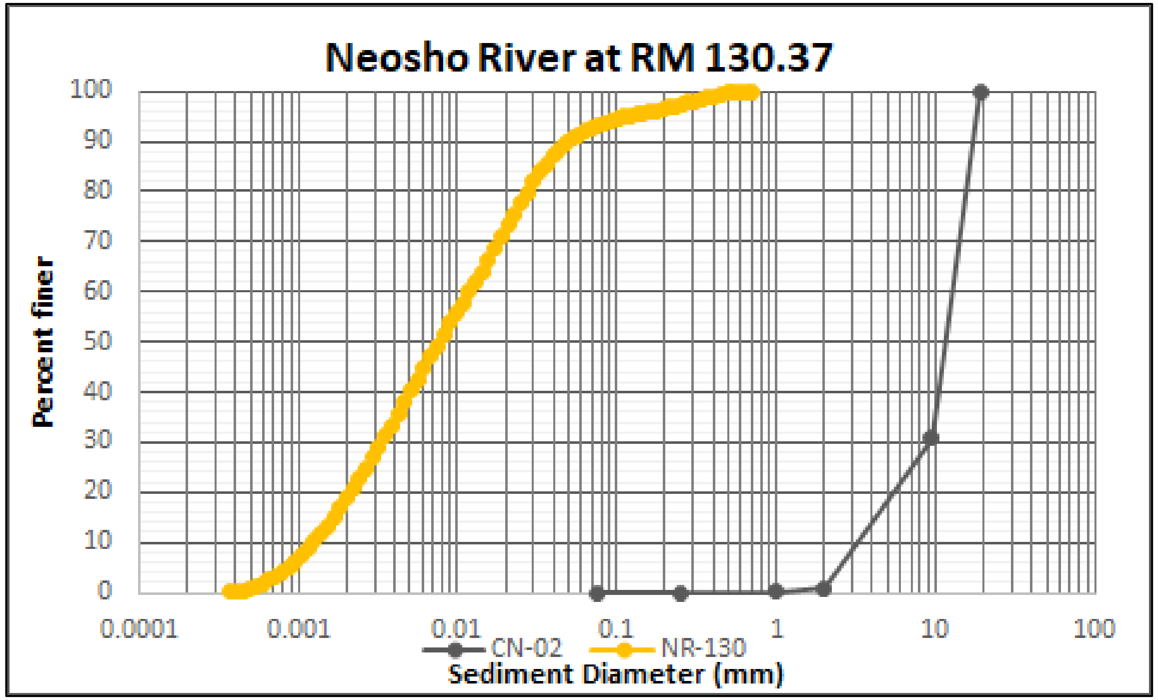
- Sediment calibration was ongoing at the time of the October ISR
  - Upstream hydrology using historic hydrographs 2009 – 2019
  - Downstream boundary uses historic water levels in Grand Lake 2009 - 2019
  - Upstream boundary conditions for sediment inflow developed based on suspended sediment rating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

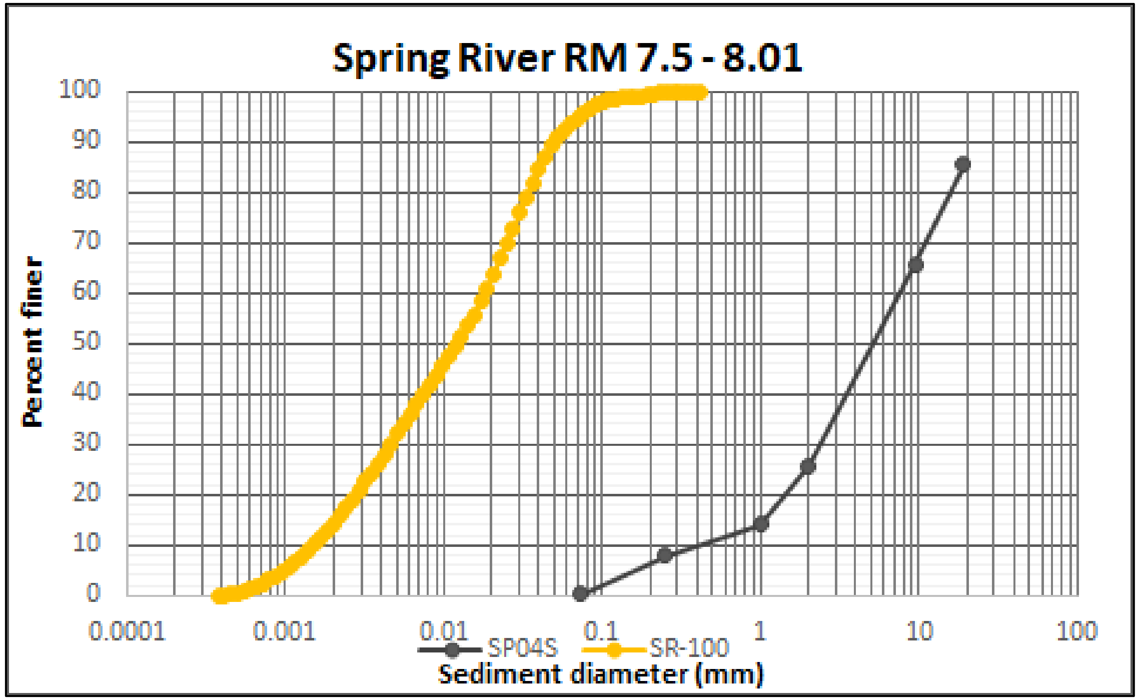
Sediment Calibration

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



Sediment Calibration



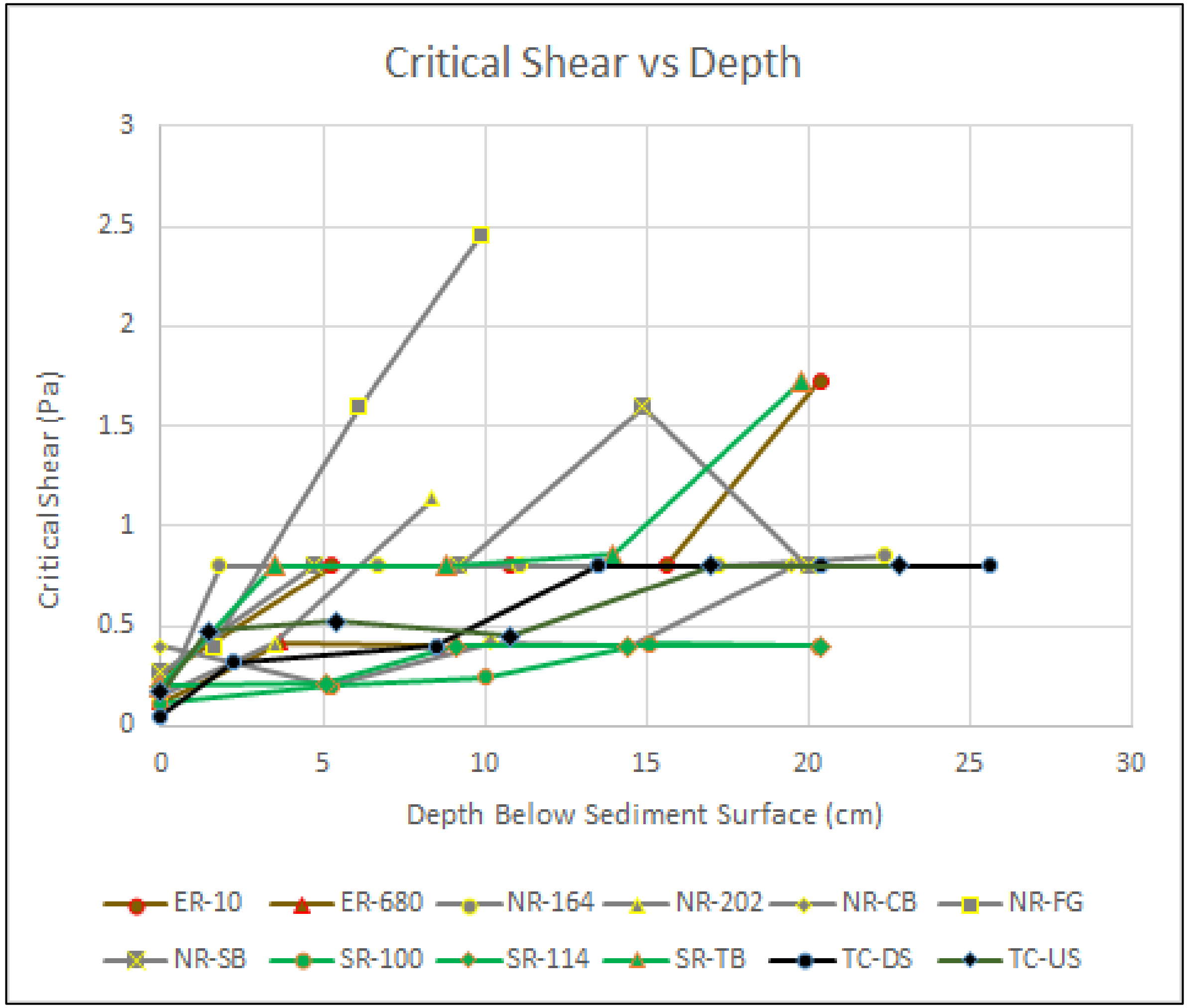


Sediment Calibration

Cohesive Sediment Density Summary:

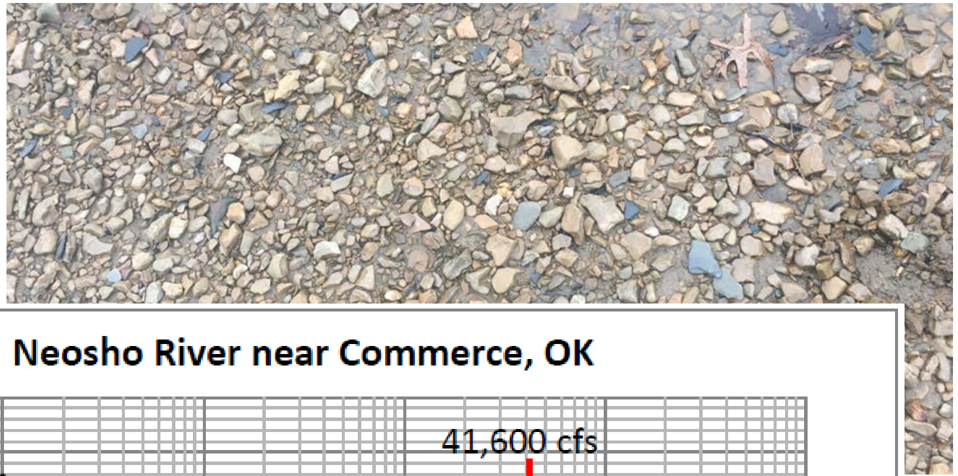
Sediment Core	Min Dry Density		Max Dry Density		Mean Dry Density (lb/ft^3)
	lb/ft^3	% of Mean	lb/ft^3	% of Mean	
Minimum	21.2	56.7%	43.7	105.4%	36.8
Mean	39.4	72.6%	61.7	118.5%	52.7
Maximum	76.2	90.0%	103.0	140.0%	93.0

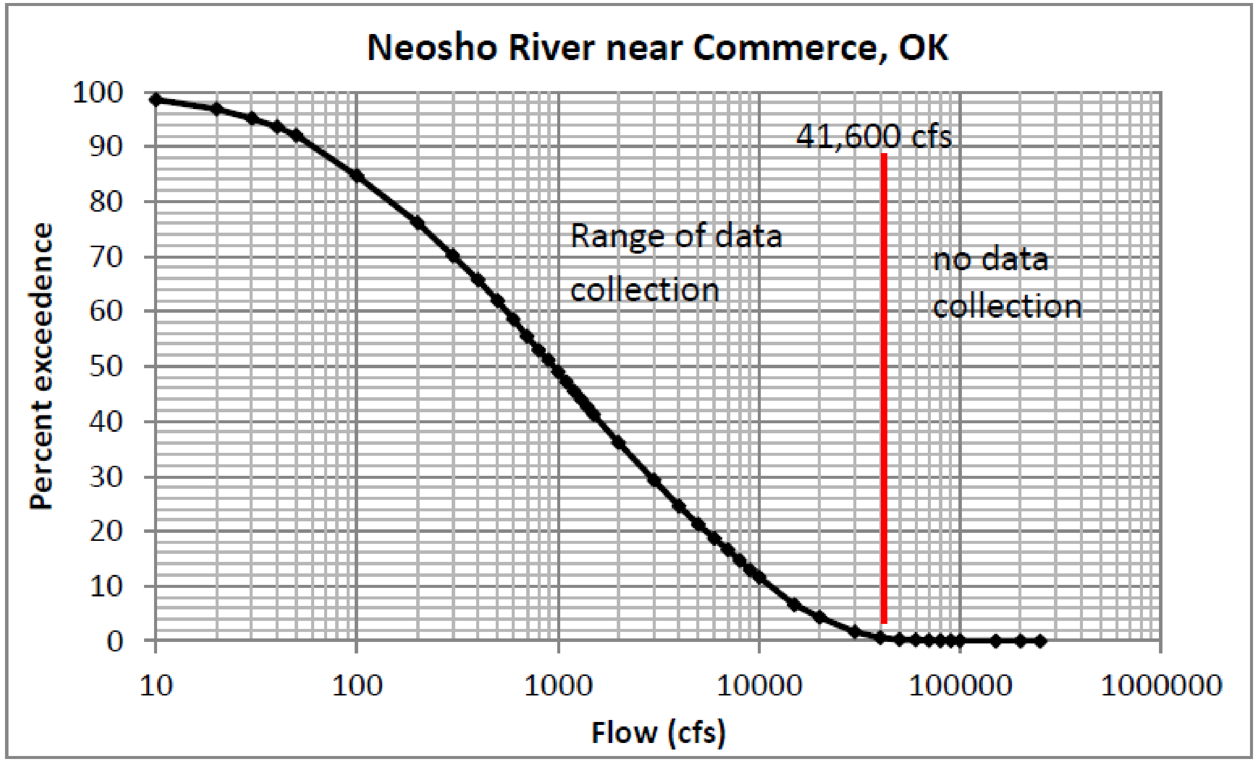
Sediment Calibration



Non-Cohesive Sediment Transport

- Typically transported as bedload
  - Found on beds of most streams
  - Measurements over a wide range of flows found no significant bedload transport



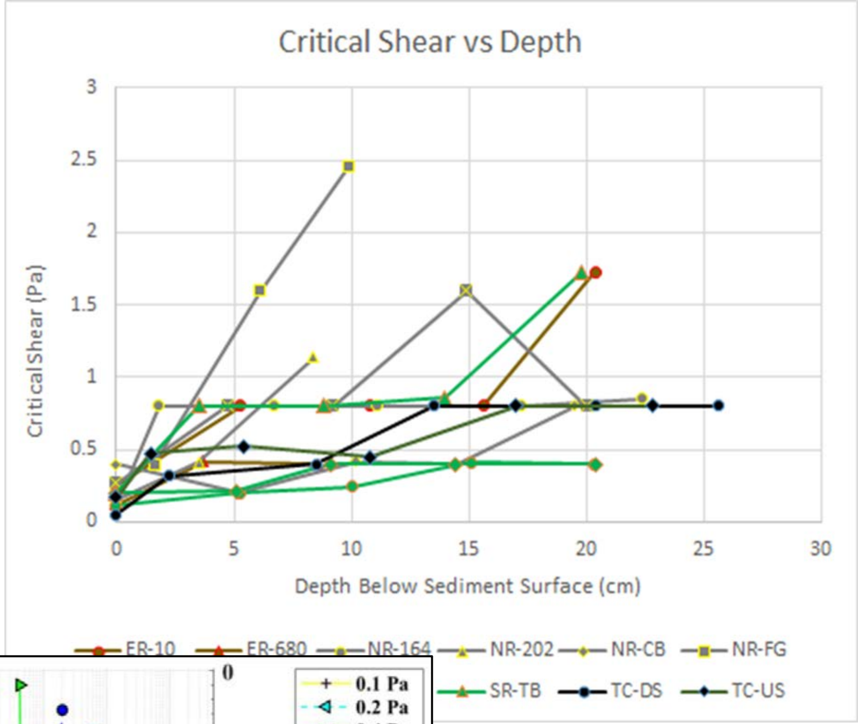


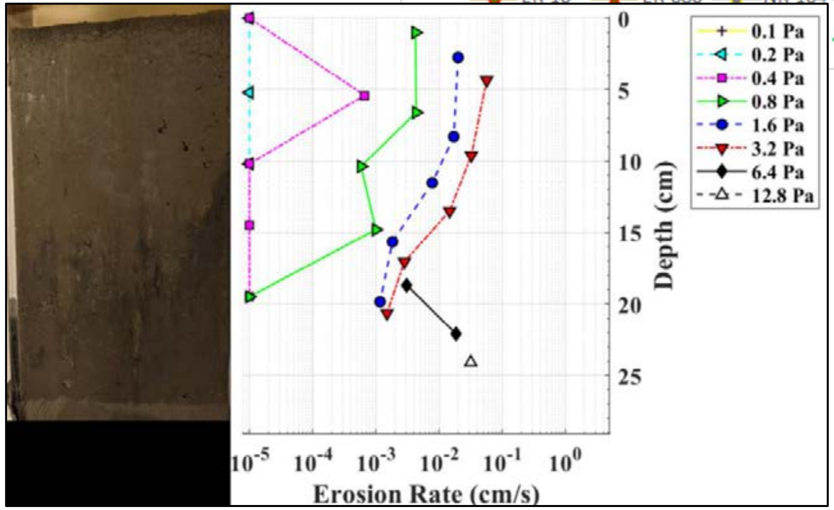
Cohesive Sediment Transport

- Typically transported as suspended load
  - Sampling efforts show virtually all incoming sediment is suspended, cohesive material
- Stream beds consist primarily of non-cohesive material
  - Incoming material must be transported further downstream and deposited in reservoir
  - Confirms City of Miami's assertion that "*cohesive sediment is carried as wash load well downstream into the reservoir, and deposition and re-entrainment of that material has very little, if any effect, on upstream channel capacity and flooding.*" (City of Miami response to RSP 2018)

Cohesive Sediment Characteristics

- Silt and clay compact
  - Properties vary by depth in sediment column
- Layers deposited over time
  - Deeper layers compressed by overburden
  - Higher compression increases density, critical shear stress
  - Higher critical shear stress reduces erosion rates





Ranges of Model Calibration Parameters

Calibration Factor	Hydraulic Model	Cohesive Sediment Model
Resistance to flow	Range: 300%	Range: 300%
Bed material	n/a	Bi-modal distribution Range: 1,000,000%
Critical Shear Stress	n/a	Range: 3,000%
Erosion rate	n/a	Range: 1,000,000%
Bulk density	n/a	Range: 485%

HEC-RAS Sediment Transport Model Capabilities

- Includes non-cohesive sediment transport
  - User-selected standard transport equations
- Includes cohesive sediment transport
  - One critical shear stress value for particle erosion with associated erosion rate
  - One critical shear stress value for mass wasting with associated erosion rate
  - Parameters cannot change with depth or time

Model Complexity Tradeoffs

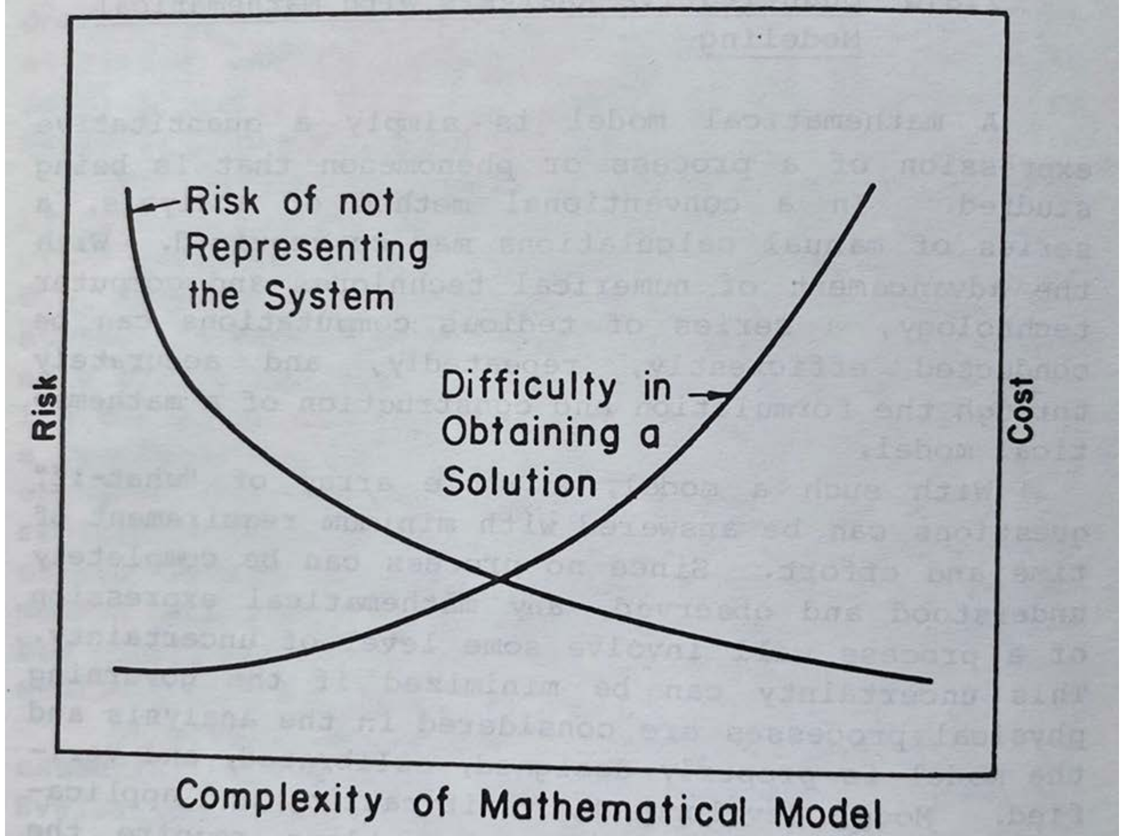


Figure 2.8. The model complexity trade-off diagram (after Overton and Meadows, 1976).

HEC-RAS Sediment Transport Model Capabilities

HEC-RAS is attempting to model a very complex system:

- Bi-modal bed material size distribution covering 5 orders of magnitude
- Cohesive and non-cohesive sediment
- Widely-varying cohesive sediment parameters:
  - Bulk density – 485%
  - Critical shear stress – 3,000%
  - Erosion rate – 1,000,000%

With over-simplified tool:

- One set of cohesive sediment parameters per sample that are fixed with time and depth

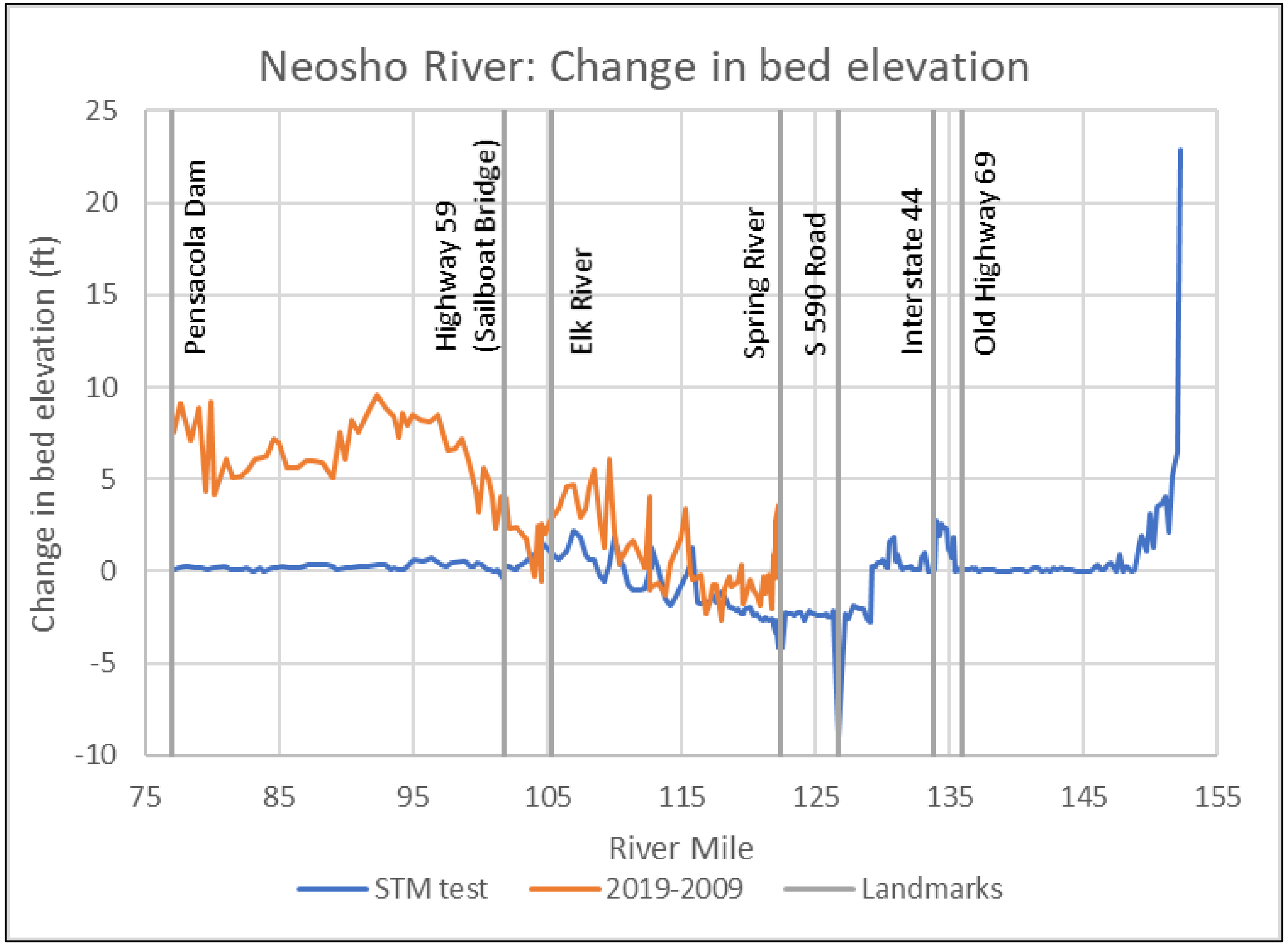
Sediment Transport Evaluation

- City of Miami, in response to RSP, citing ASCE Manual on Sedimentation:
  - "ASCE notes that where full calibration is not possible, 'model tests are devised so that engineering judgment can be used to assess the credibility of the calculated results.'"
- Attempted basic model run
  - Used MPM equation for non-cohesive sediment
    - Showed several feet of erosion
    - Does not match measured bedload transport

Sediment Transport Evaluation

- Basic model test
  - Adjusted parameters to MPM showed zero non-cohesive transport
    - Showed many feet of cohesive deposition in upstream reach
    - Does not match known sediment conditions
  - Adjusting parameters of non-cohesive transport should not affect cohesive transport
    - Appears to be flaw in model

Sediment Transport Evaluation

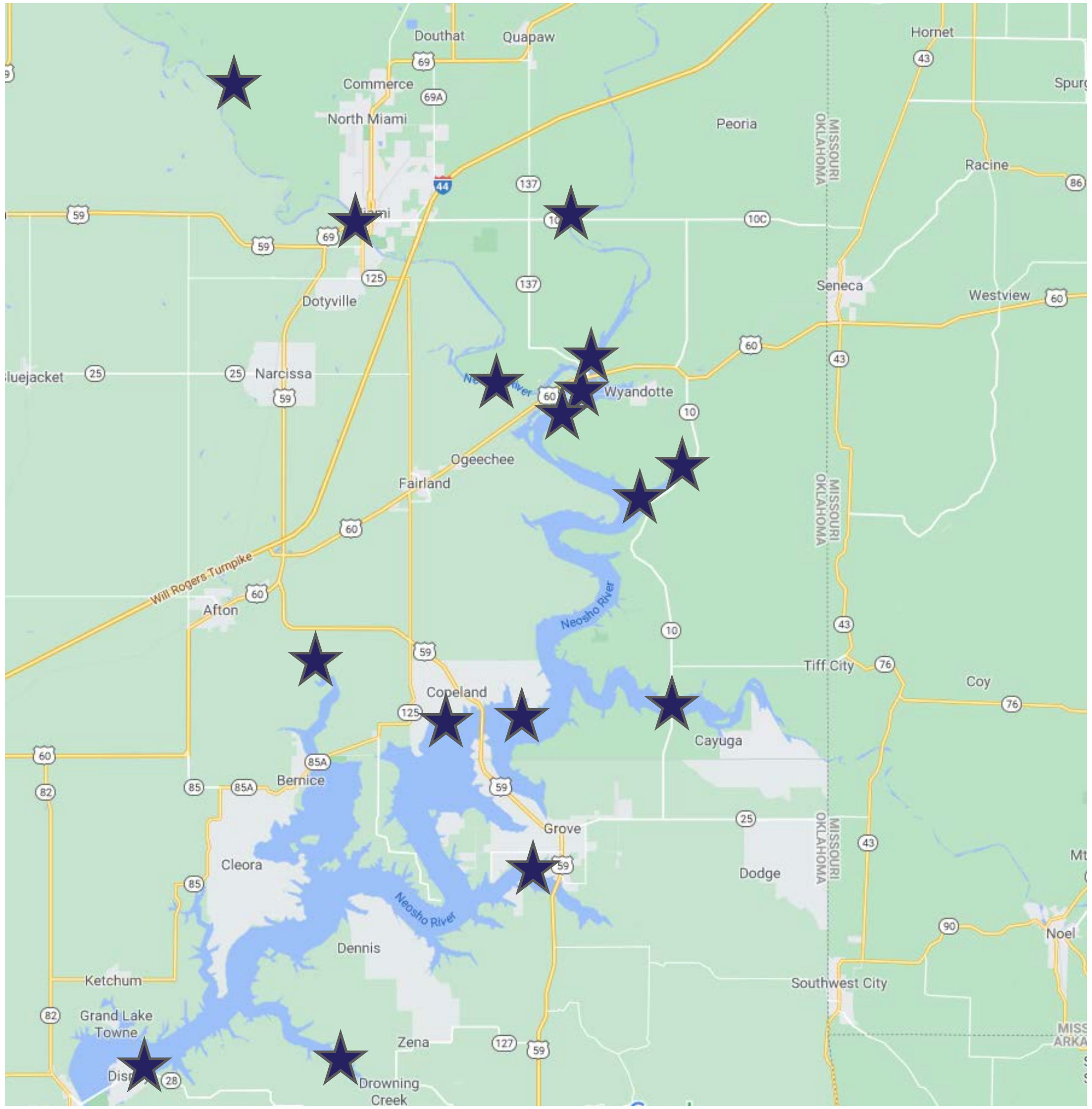


Sediment Transport Evaluation Alternatives

- Engineering judgment suggests that HEC-RAS is incapable of realistically modeling this system
- Will need alternative means of assessing sediment transport in the study area
  - Developed Proposed Modified Study Plan (PMSP)

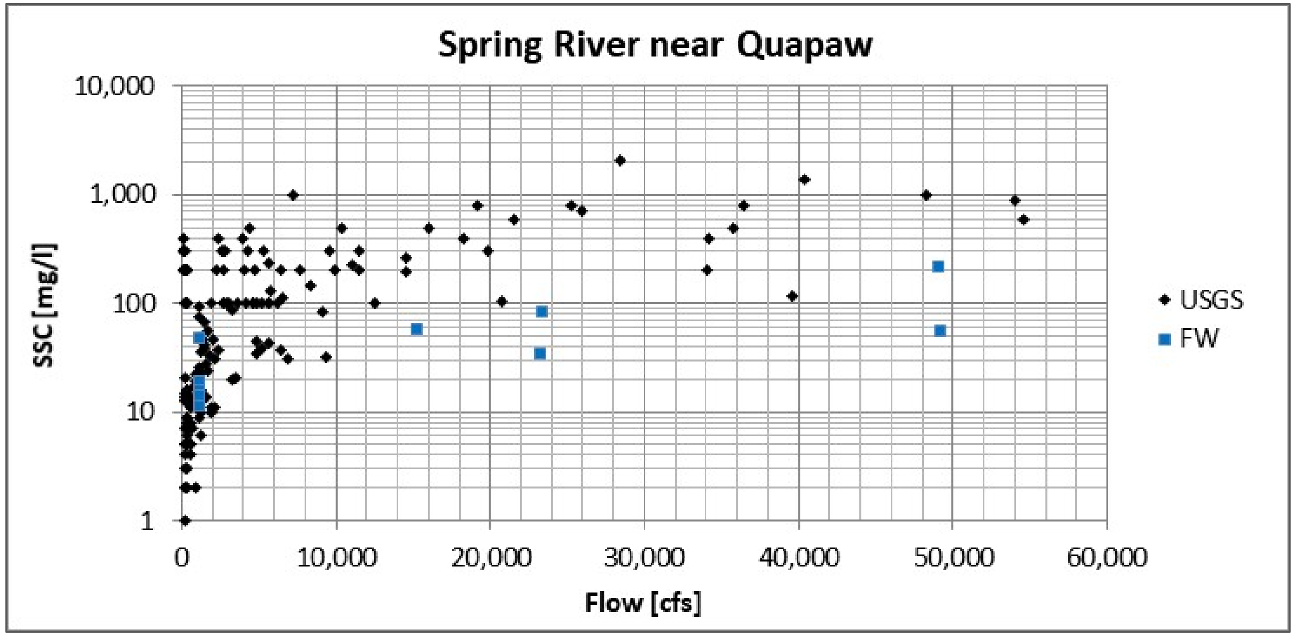
Summary

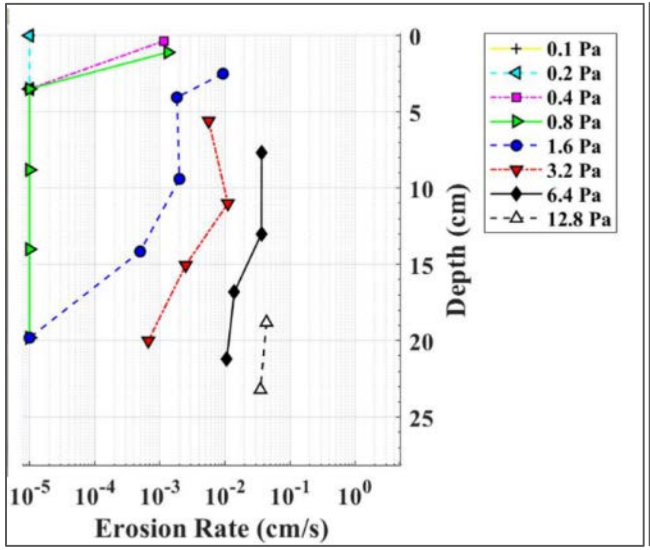
- Water level monitoring



Summary

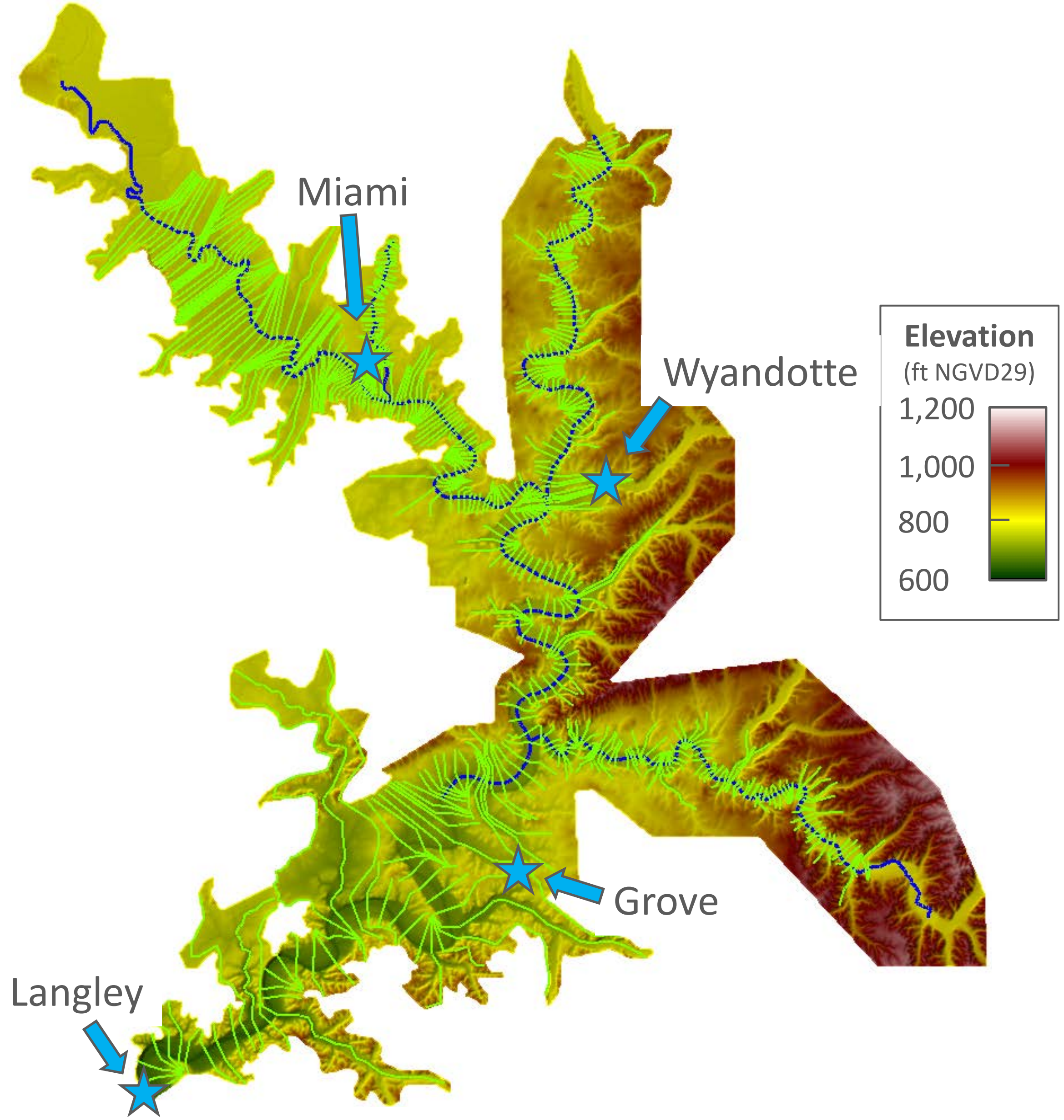
- Water level monitoring
- Sediment sampling
  - Grab samples
  - SEDflume sampling
  - Transport measurements





Summary

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



Grand Lake Sedimentation Study Proposed Modified Study Plan

January 14th, 2022

Anchor QEA
Simons & Associates

Outline

- Need for Proposed Modified Study Plan (PMSP)
- Additional fieldwork
  - Sub-bottom profiling
  - Vibracore sampling
- Sediment transport evaluation
- Characterization of sedimentation impacts
  - Flooding
  - Conservation pool

Outline

- Need for Proposed Modified Study Plan (PMSP)
- Additional fieldwork
  - Sub-bottom profiling
  - Vibracore sampling
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  - Flooding
  - Conservation pool

Need for PMSP

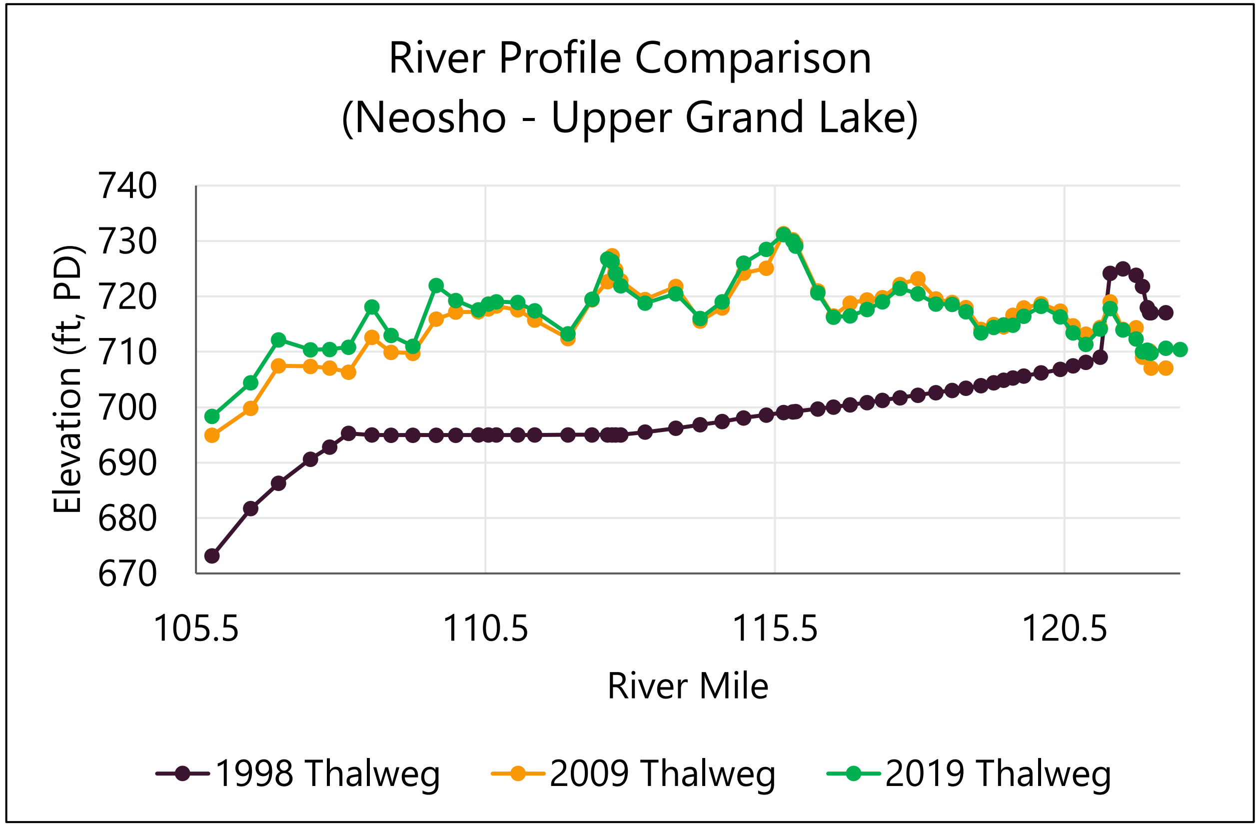
- The 2018 Study Plan Determination (SPD) assumes the 1998 REAS dataset is valid. New evidence shows that it is inaccurate
- The 2018 SPD relies on HEC-RAS to predict sediment erosion and deposition
  - New information indicates existing sediment conditions require complex, detailed model
  - HEC-RAS is overly simplistic, incapable of reliably predicting transport
- Modifications to the existing model methodology are required

Outline

- Need for PMSP
- Additional fieldwork
  - Sub-bottom profiling
  - Vibracore sampling
- Sediment transport evaluation
- Characterization of sedimentation impacts
  - Flooding
  - Conservation pool

Ongoing Fieldwork

- Address questions about deposition from 1998 REAS dataset
- Two primary components
  - Sub-bottom profiling
  - Vibracore sampling

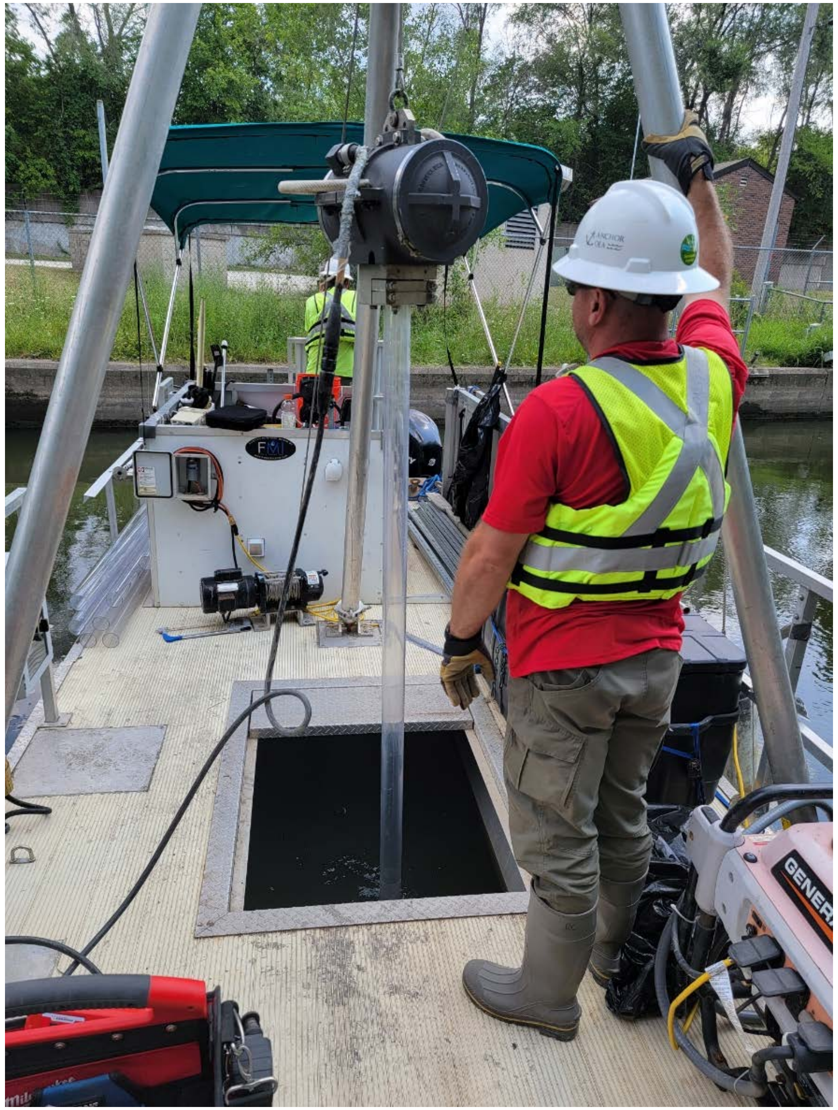


Sub-Bottom Profiling

- Sub-bottom profiler (SBP)
  - Similar to bathymetric surveying sonar systems
  - Higher power allows pulses to penetrate soft bed materials
  - Provides information on sediment layer thickness

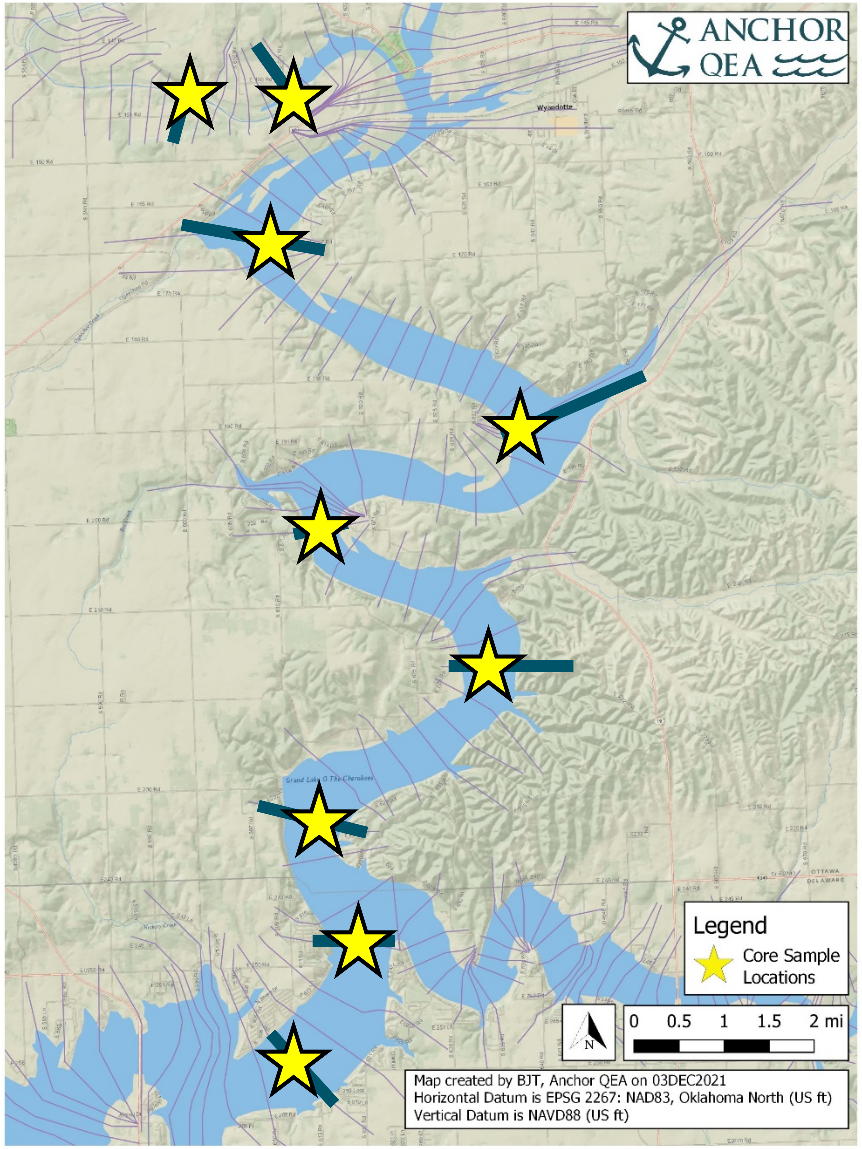
Vibracore Sampling

- Vibracoring used to collect sediment core samples
- 16 ft tubes vibrated into sediment bed
- Samples provide
  - Layer thickness
  - Grain size distribution



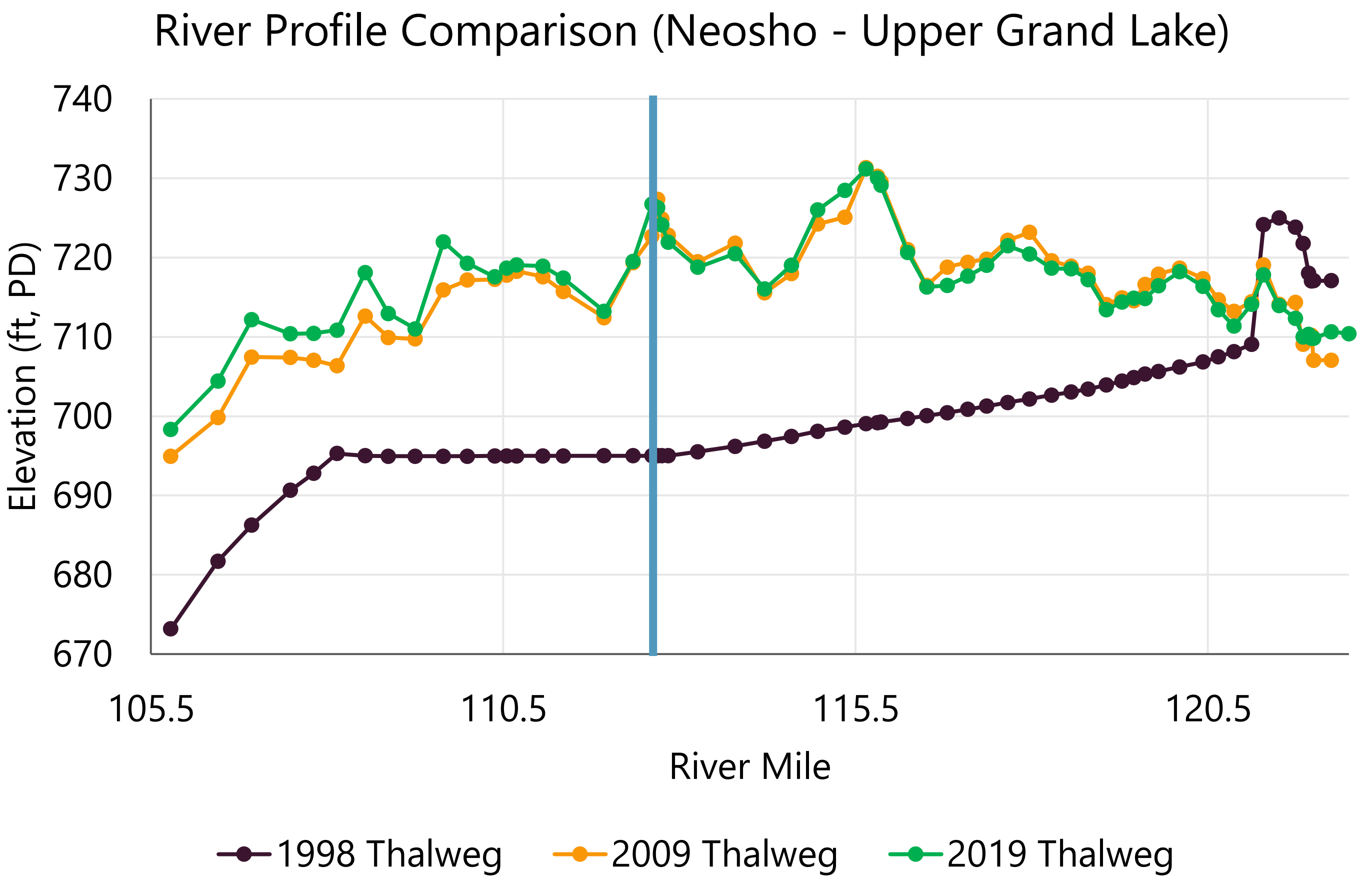
SBP and Vibracore Sampling

- Target areas of reported deposition
- SBP data verified by vibracoring
- Field crew collected 9 SBP transects along Neosho River
  - From RM 103.72 (Hickory Point)
  - To RM 125.56 (~1 mi downstream of Connors Bridge)



Terrain Comparisons

- Cross-section collected at **RM 112.34**
- Profile comparison shows apparent ~30 ft of deposition



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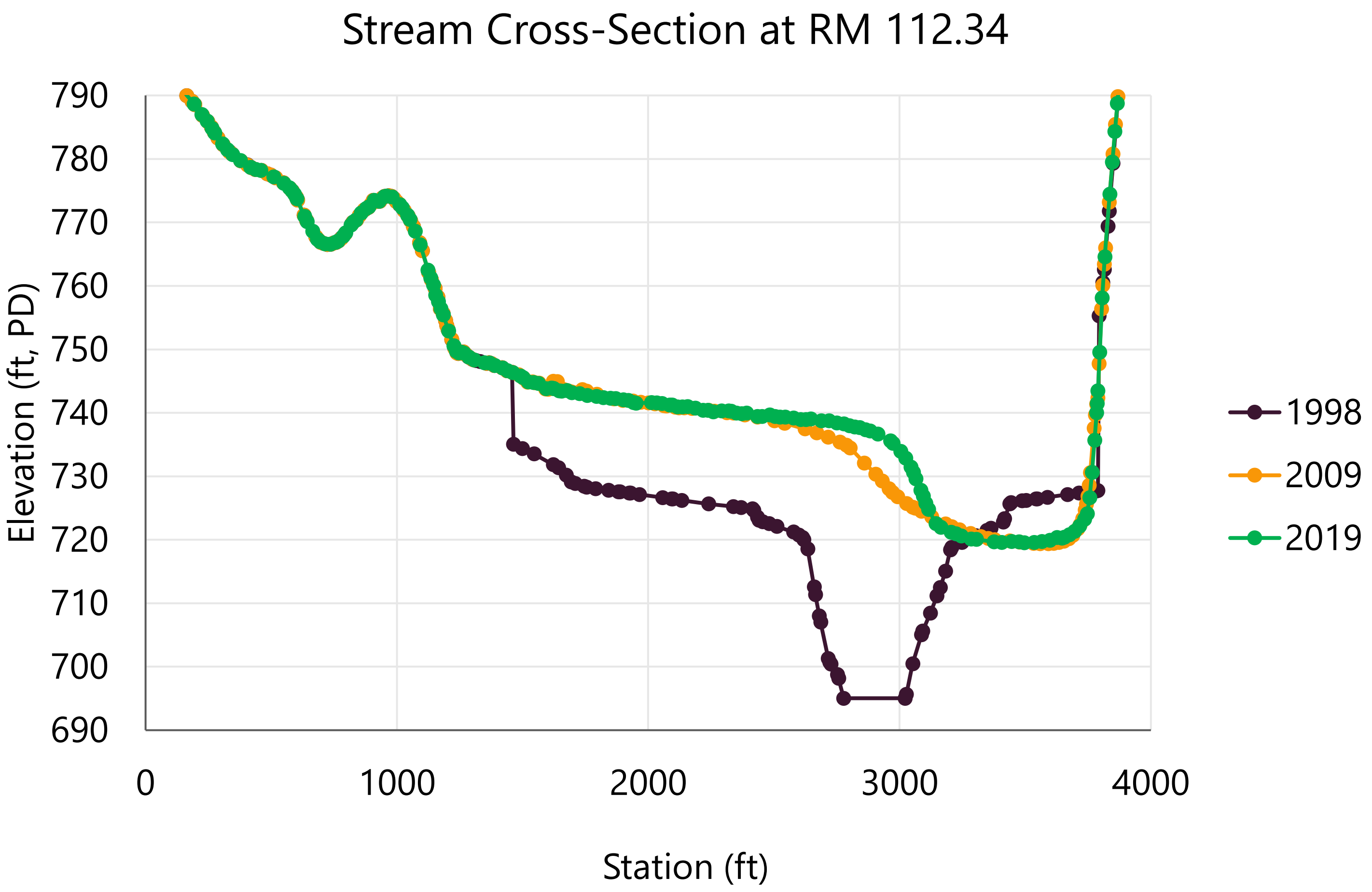
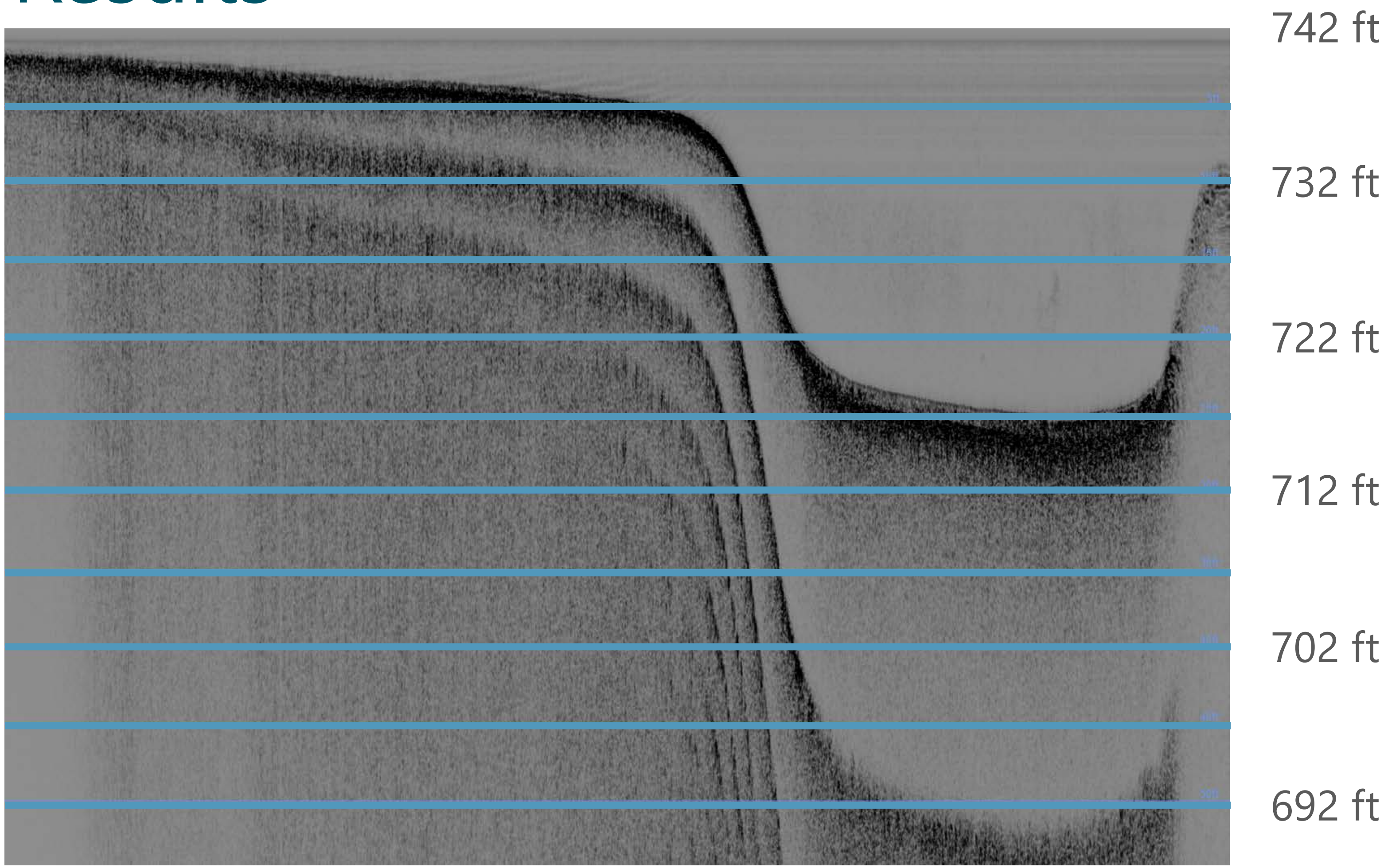


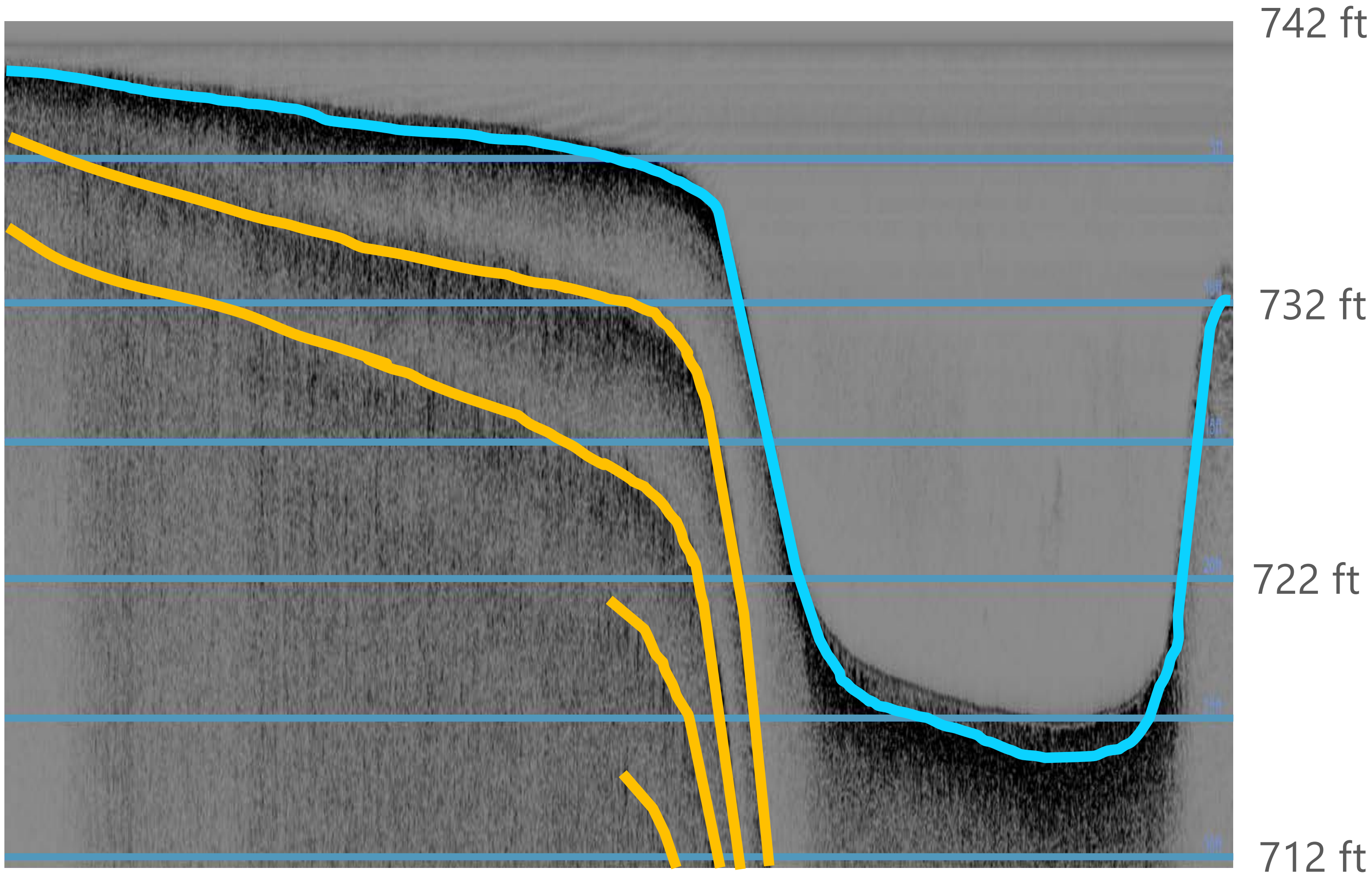
Sub-Bottom Profiler Results

- Cross-section collected at **RM 112.34**
- Profile comparison shows apparent ~30 ft of deposition



Sub-Bottom Profiler Results

- Cross-section collected at **RM 112.34**
- Profile comparison shows apparent ~30 ft of deposition
- SBP shows small layer of soft material deposition (~2-3 ft)
  - **Layer transition**
  - **Multiples**



Outline

- Need for Proposed Modified Study Plan (PMSP)
- Additional fieldwork
  - Sub-bottom profiling
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  - Flooding
  - Conservation pool

Sediment Transport Evaluation Alternatives

- Engineering judgment suggests that HEC-RAS is incapable of modeling this system
- Simons & Simons (1997):
  - "If it is not possible to adequately calibrate and verify a model in a given application, it is appropriate to utilize interpretations of available data, geomorphic and other analysis techniques for prediction purposes. Even when a model can successfully be calibrated and verified, it is appropriate to use these other techniques as an independent check on the modeling results."

Sediment Transport Evaluation Alternatives

- Simons & Simons in *Civil Engineering* (Sept 1996):
  - "Using a computer model to analyze and predict sediment transport only works when the analyst considers the model's limitations and the physical processes involved and conducts adequate calibration and verification."
  - Citing a 1988 FERC document: "*Computer modeling has long been used by scientists and engineers to aid in the design and operation of water resource projects. While models are highly useful tools, they can also be a source of misinformation for users and project reviewers who do not understand all the assumptions, capabilities and limitations of a particular computer model. Such is the case with computerized sedimentation models.*"
  - Citing same 1988 FERC document: "*[A computer model] cannot be a substitute for professional experience.*"

Proposed Approach

Fundamental Relationships:

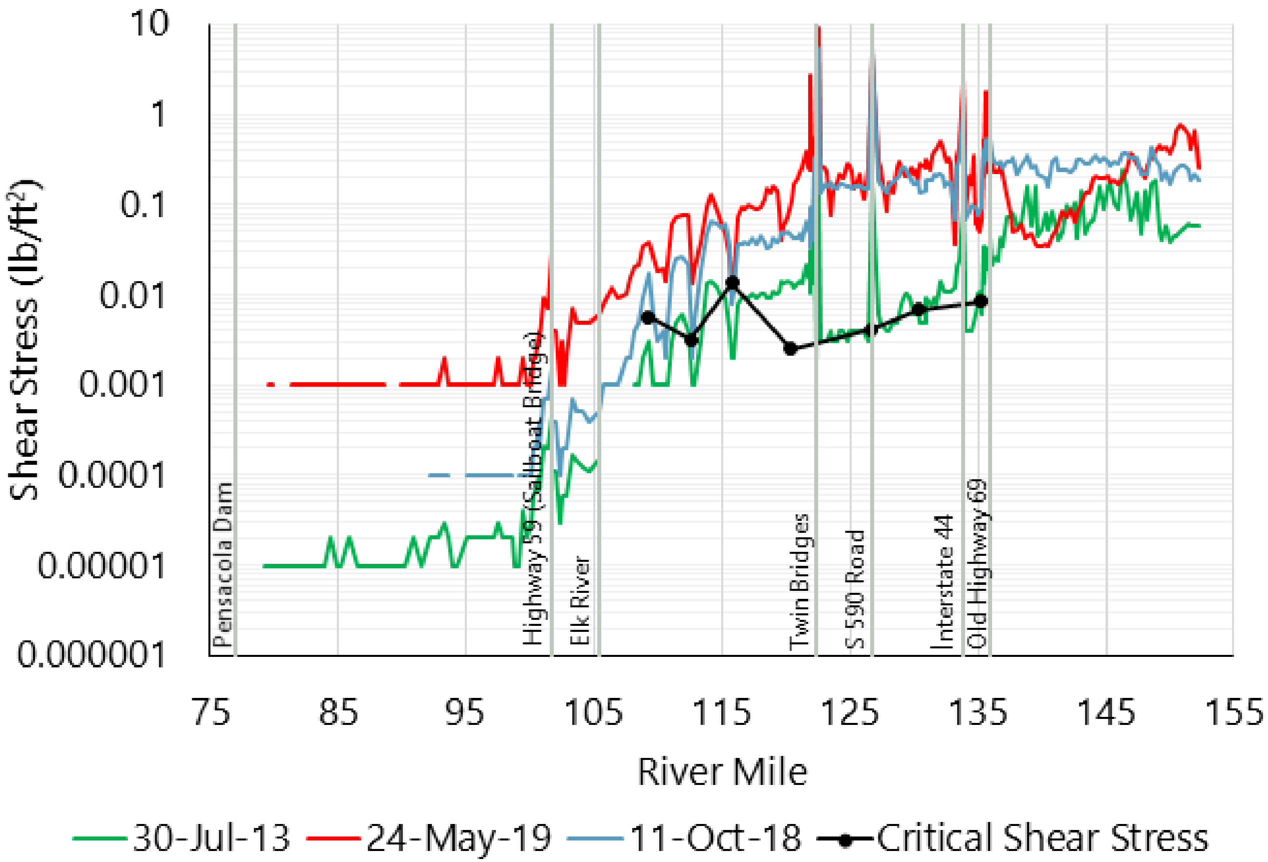
- Sedimentation patterns are function of:
  - Incoming sediment load
  - Longitudinal and temporal distribution of hydraulic shear stress
- Percentage of sediment passing a given cross-section (or depositing upstream) is function of:
  - Distribution of shear stress at given location
- Relationship exists between
  - Shear stress at given location
  - Quantity of sediment passing that location or depositing upstream

Proposed Approach

- Relationships will be developed between:
  - Historic shear stress at specific locations
  - Quantity of sediment passing those locations
  - Quantity of sediment depositing between locations
- Relationships will use:
  - Historic shear stresses from 2009 to 2019 using HEC-RAS
  - Historic incoming sediment loads from measured flow data and sediment rating curves
  - Amount of sediment deposited at various sites within streams and reservoir based on bathymetric changes from 2009 to 2019

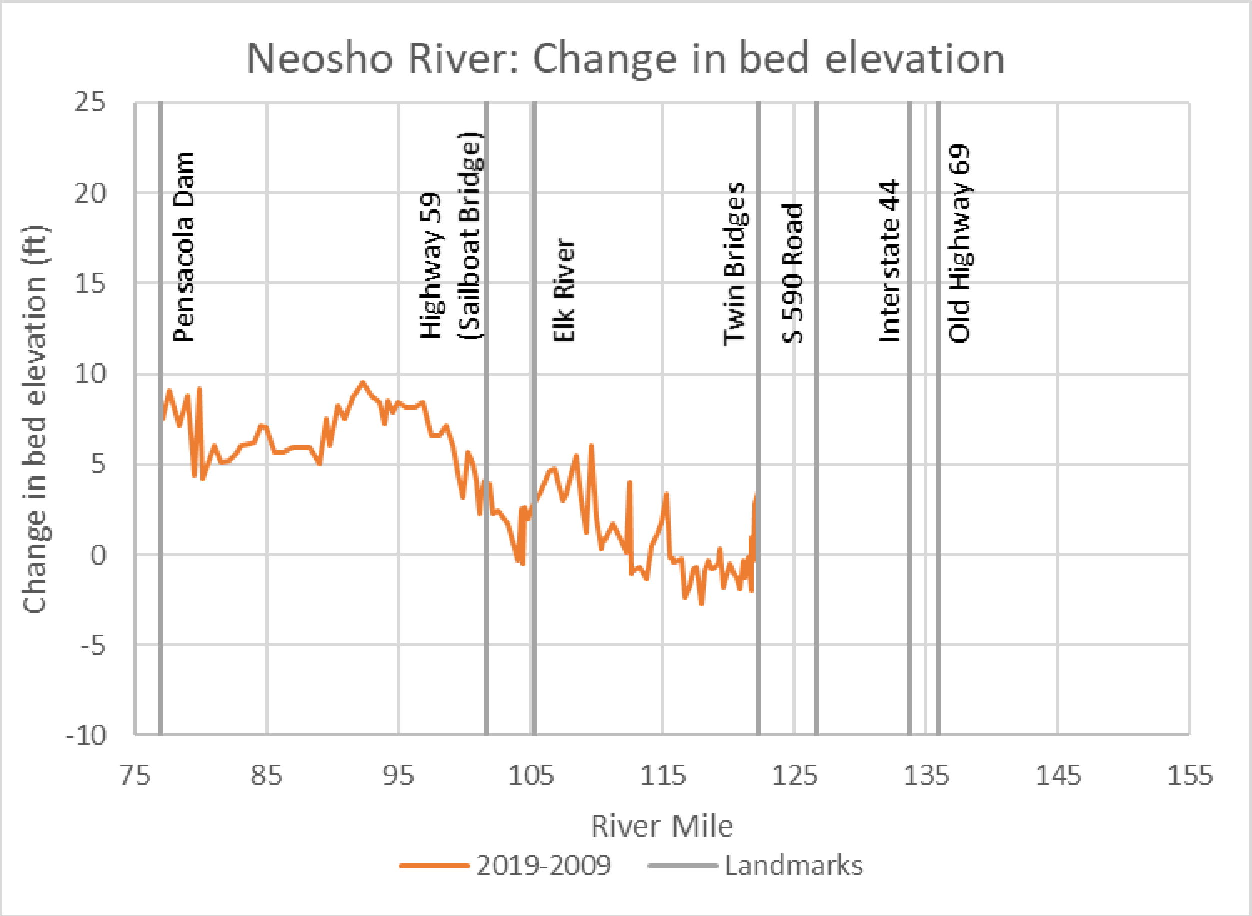
Proposed Approach

Hydraulic shear: example of longitudinal shear profiles



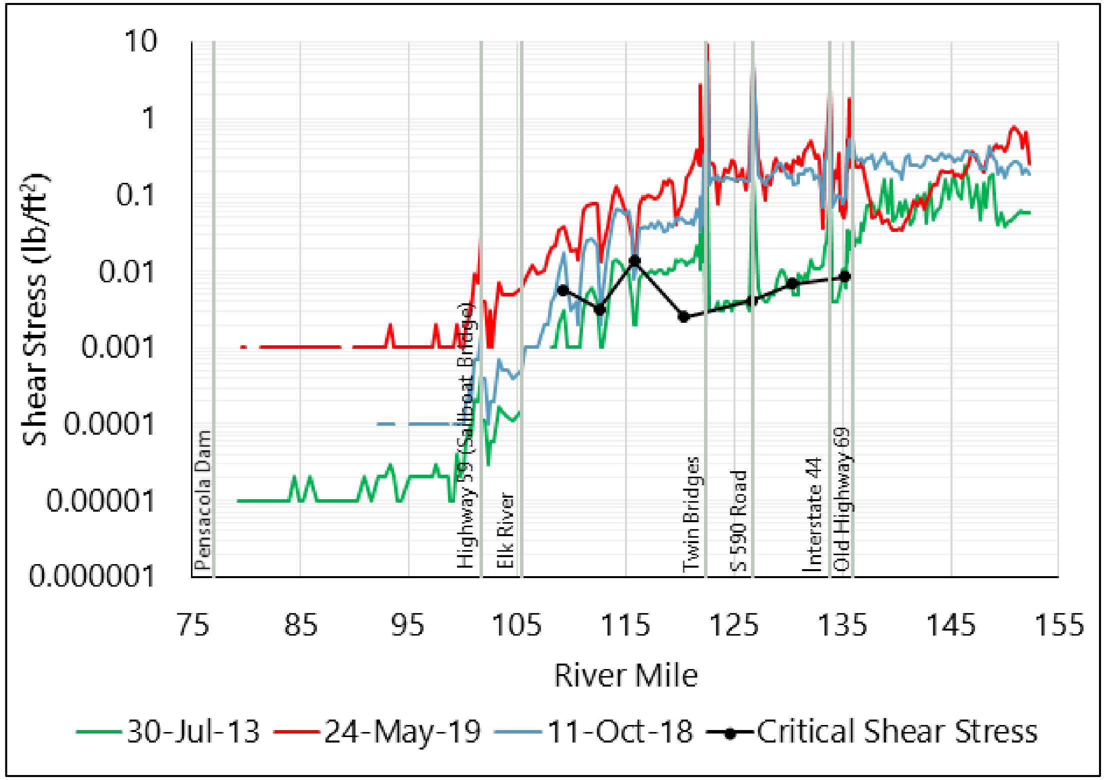
Proposed Approach

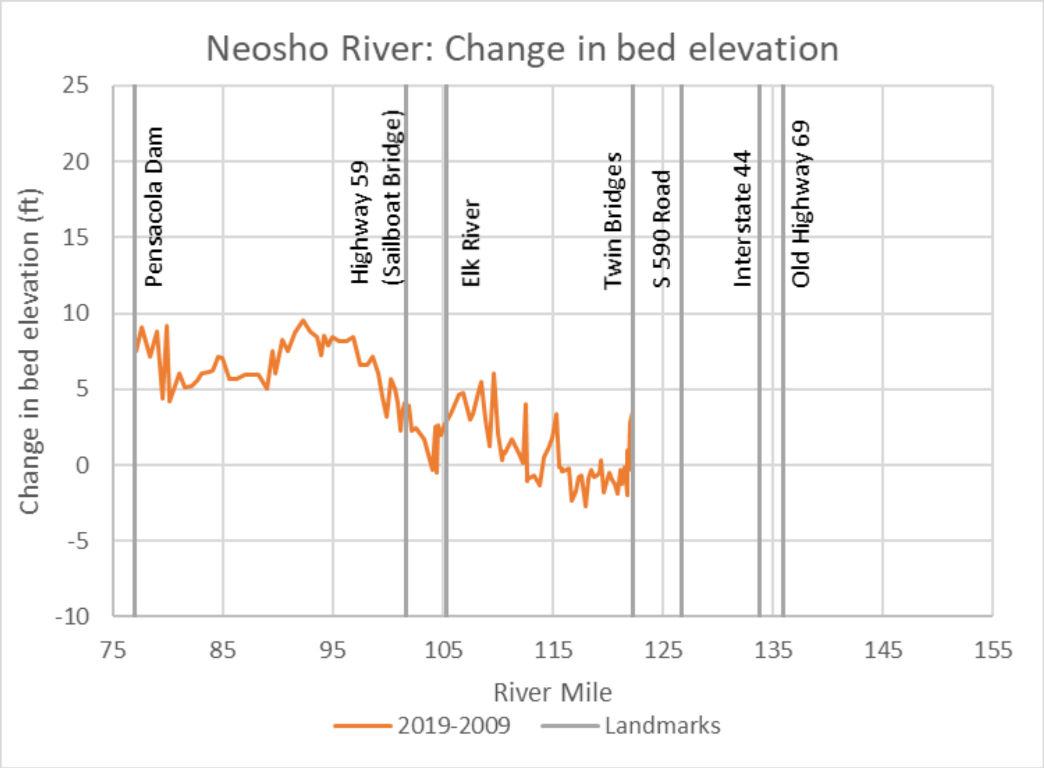
Bed profile change 2009 – 2019



Proposed Approach

Comparison of hydraulic shear to sedimentation pattern





Data and analysis confirm City of Miami's assertion:

"[C]ohesive sediment is carried as wash load well downstream into the reservoir, and deposition and re-entrainment of that material has very little, if any effect, on upstream channel capacity and flooding." (City of Miami response to RSP 2018)

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- Additional fieldwork
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  - Flooding
  - Conservation pool

Proposed Modeling Approach

- Using 2019 cross-sections and bathymetry, run HEC-RAS STM (fixed channel geometry) for proposed flow and operation condition (e.g. 50-year flow/operation scenario) to produce shear values for every time step and location
- Develop shear-duration curves at selected locations (same ones used in developing the shear relation with historic sedimentation from 2009-2019 run, at approximately a 3-5 mile spacing and/or additional points of interest)
- Calculate incoming sediment load from Neosho, Tar, Spring, Elk using 50-year flow regime coupled with sediment rating curves for each river
- Using shear-duration curves at selected locations related to % sediment passing or depositing from 2009-2019, distribute 50-year sediment volume on top of 2019 cross-sections/bathymetry

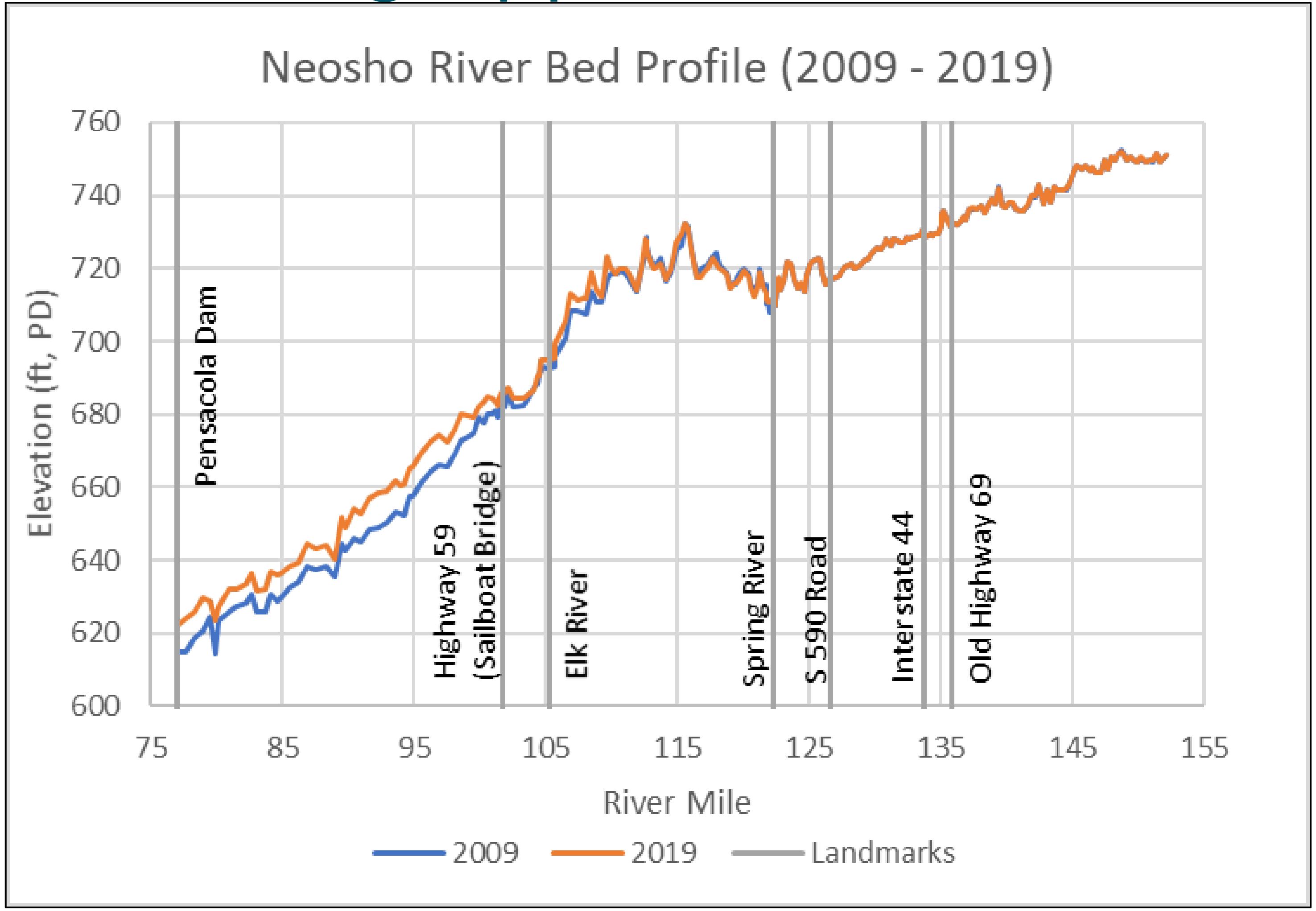
Proposed Modeling Approach

- Adjust sediment deposition pattern based on sediment consolidation over time (e.g. 50 years)
- Based on sedimentation pattern for any given scenario develop new cross-sections to define the channel geometry
- The adjusted sedimentation pattern produces new channel cross-sections which will be used as input geometry
- Using this new channel geometry for a given scenario, the results of the fixed bed STM will then be utilized to analyze flooding by simulating inflow events with the reservoir at 742 and 745 ft PD

Proposed Modeling Approach

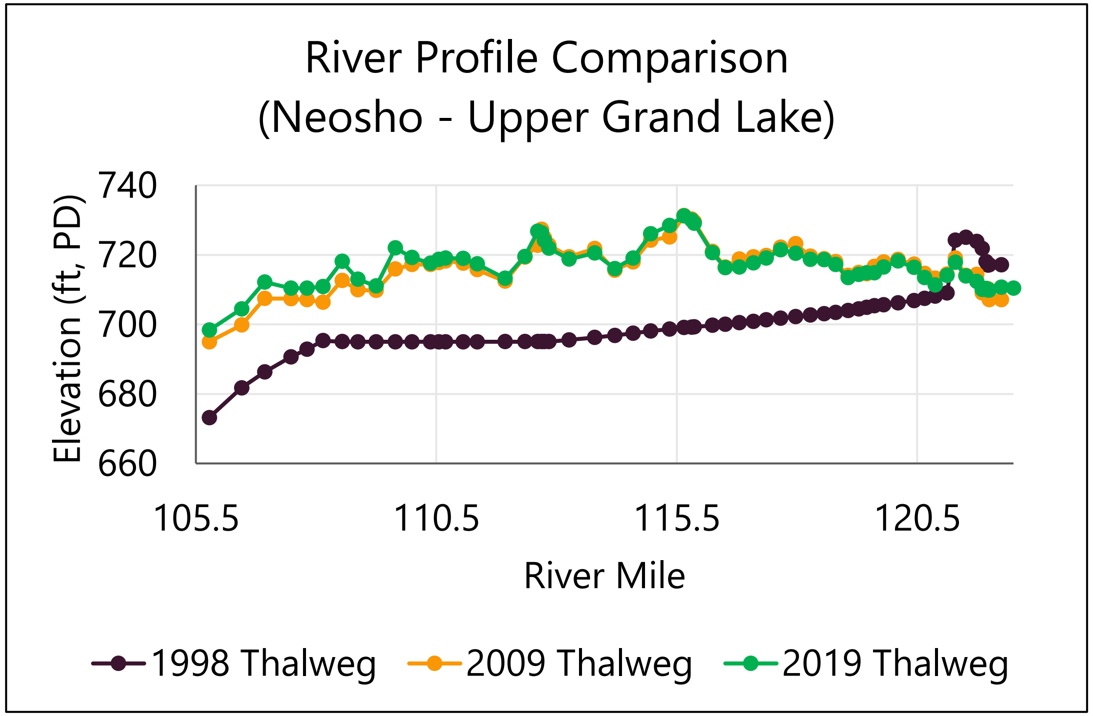
- Neosho River profile shows that from 2009 to 2019, there was little change in bed elevation from approximately RM 109 to 122
  - Most sedimentation occurred downstream of RM 102 (near Sailboat Bridge)
- The reach of primary interest lies between the Elk River and Spring River regarding the potential for sedimentation
  - Analysis will focus most attention here by more closely spacing the locations where hydraulic shear-duration graphs related to percentage of sediment passing each location
- Remaining amount of sediment that passes this reach continues to flow and deposit in the remaining reach towards the dam and cannot present any potential backwater or upstream flooding effect

Proposed Modeling Approach



Summary

- Need for PMSP
  - Questions remain about actual sediment deposition
  - HEC-RAS is incapable of handling necessary modeling tasks



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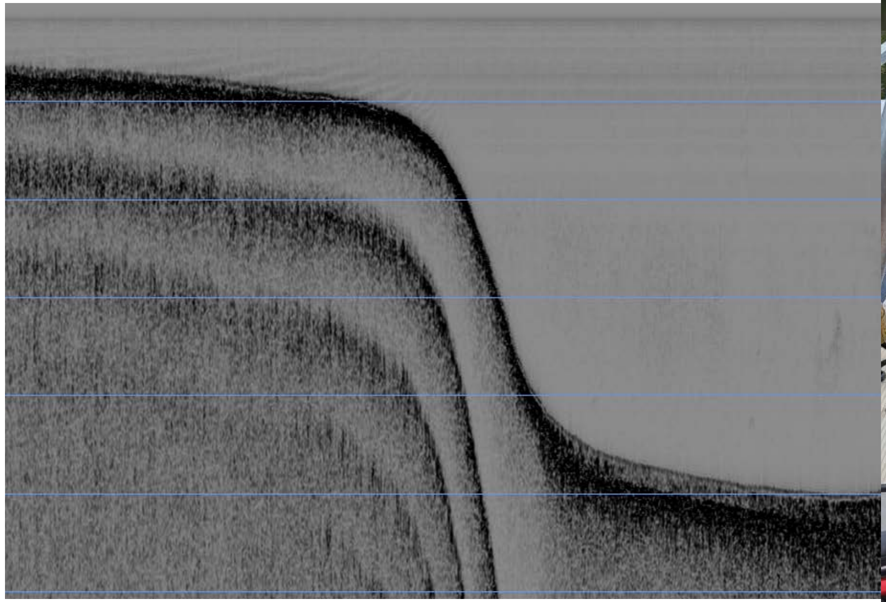

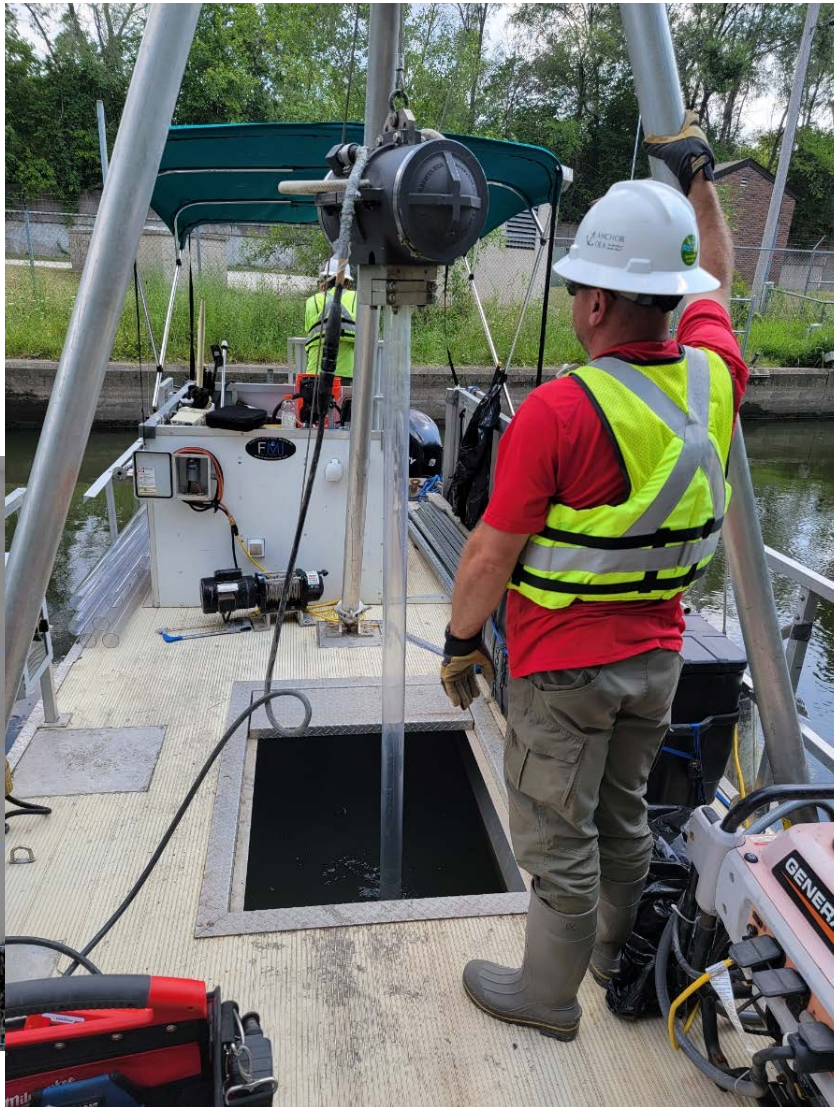

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- Additional fieldwork
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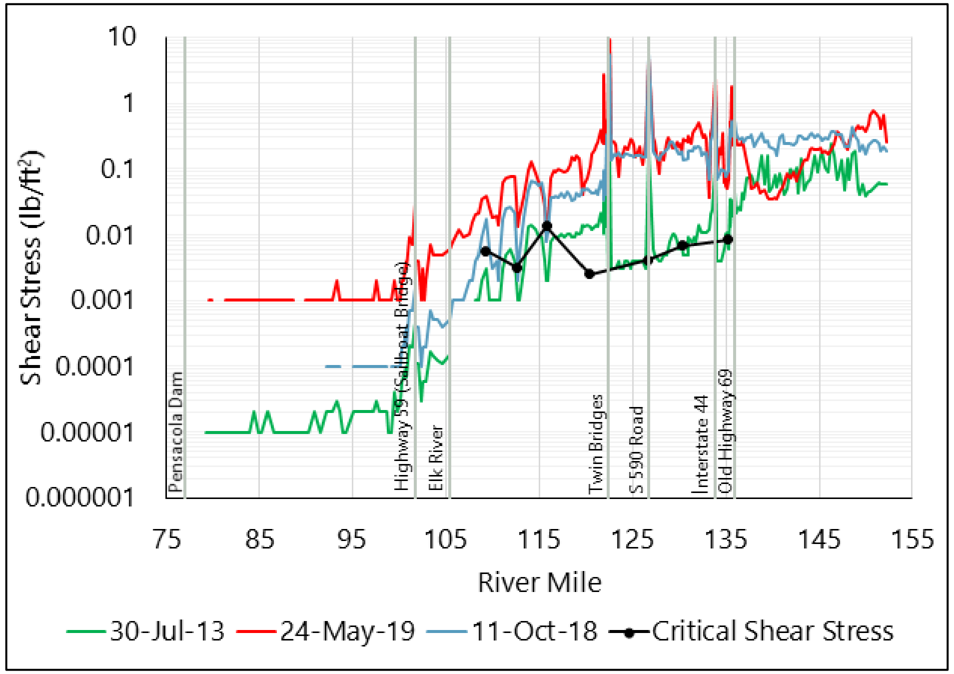
- Sediment transport evaluation
  - Use STM bed shear stress outputs
  - Evaluate sediment deposition/transport over time based on modeled shear stress



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