Mead & Hunt | EXPERIENCE EXCEPTIONAL

H&H Modeling: Downstream Hydraulic Model

Pensacola Hydroelectric Project

Project No. 1494

Grand River Dam Authority

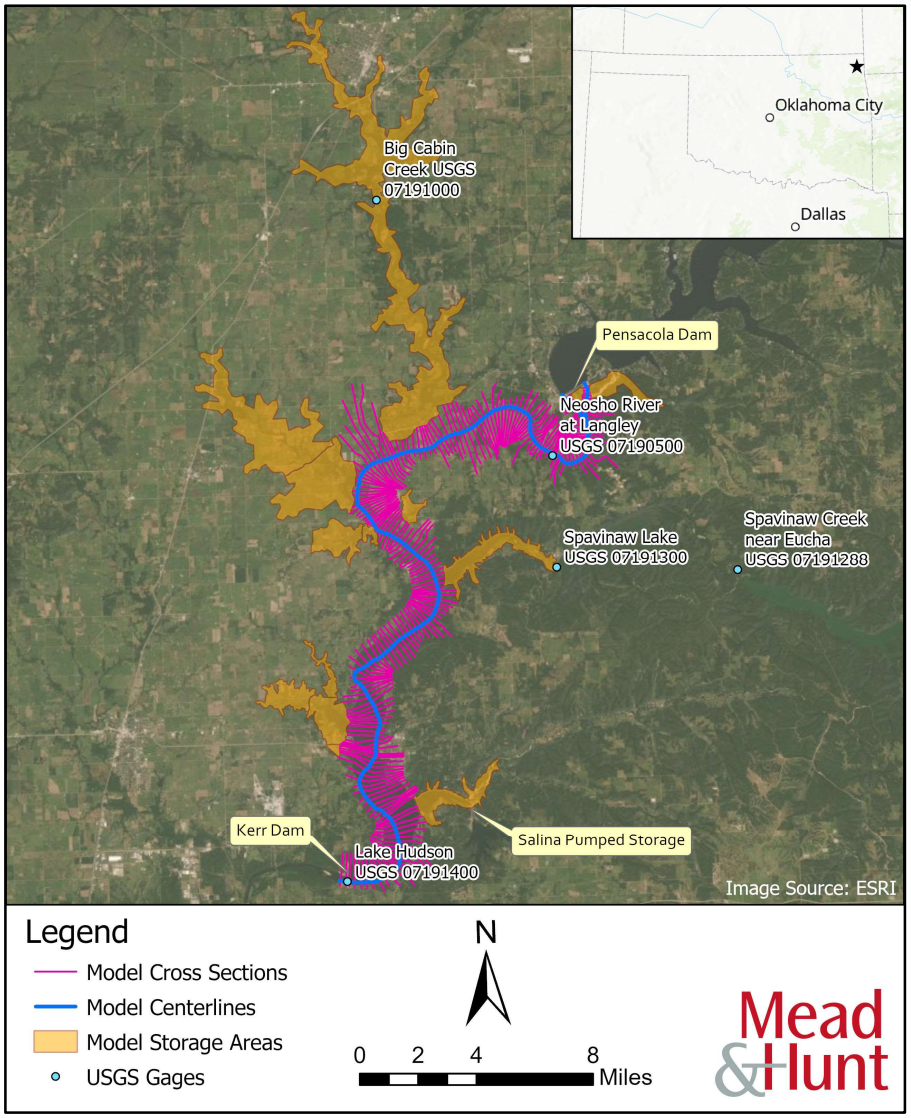
April 21, 2021

Presentation Outline

- Introduction and Background
- Model Development
- Model Calibration

Introduction and Background

Study Area


Oklahoma City
Dallas
Big Cabin Creek USGS 07191000
Pensacola Dam
Neosho River at Langley USGS 07190500
Spavinaw Lake USGS 07191300
Spavinaw Creek near Eucha USGS 07191288
Kerr Dam
Lake Hudson USGS 07191400
Salina Pumped Storage
Image Source: ESRI
Legend
Model Cross Sections
Model Centerlines
Model Storage Areas
USGS Gages
N
0 2 4 8
Miles
Mead & Hunt

Study Plan Proposals and Determination

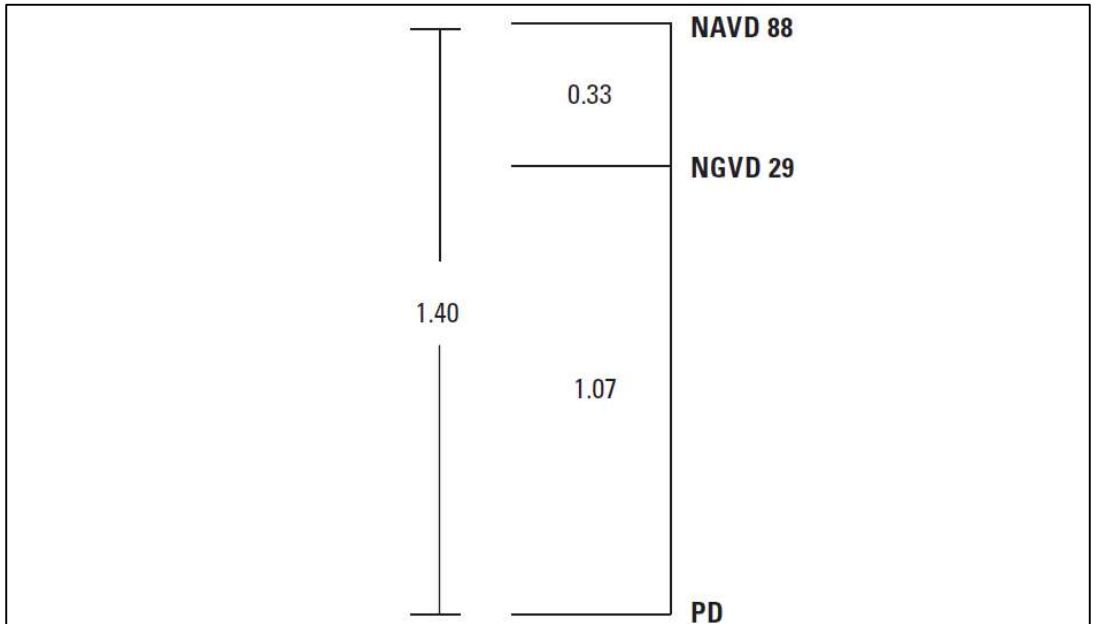
Relicensing Timeline

- April 27, 2018: GRDA filed PSP to address H&H modeling
- September 24, 2018: GRDA filed RSP
- November 8, 2018: FERC issued SPD
- January 23, 2020: FERC issued Order on Request for Clarification and Rehearing

FERC's Recommendations

- Hold conference call on model (Downstream Hydraulic Model) inputs and calibration

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

Source : (Hunter, Trevisan, Villa, & Smith, 2020)

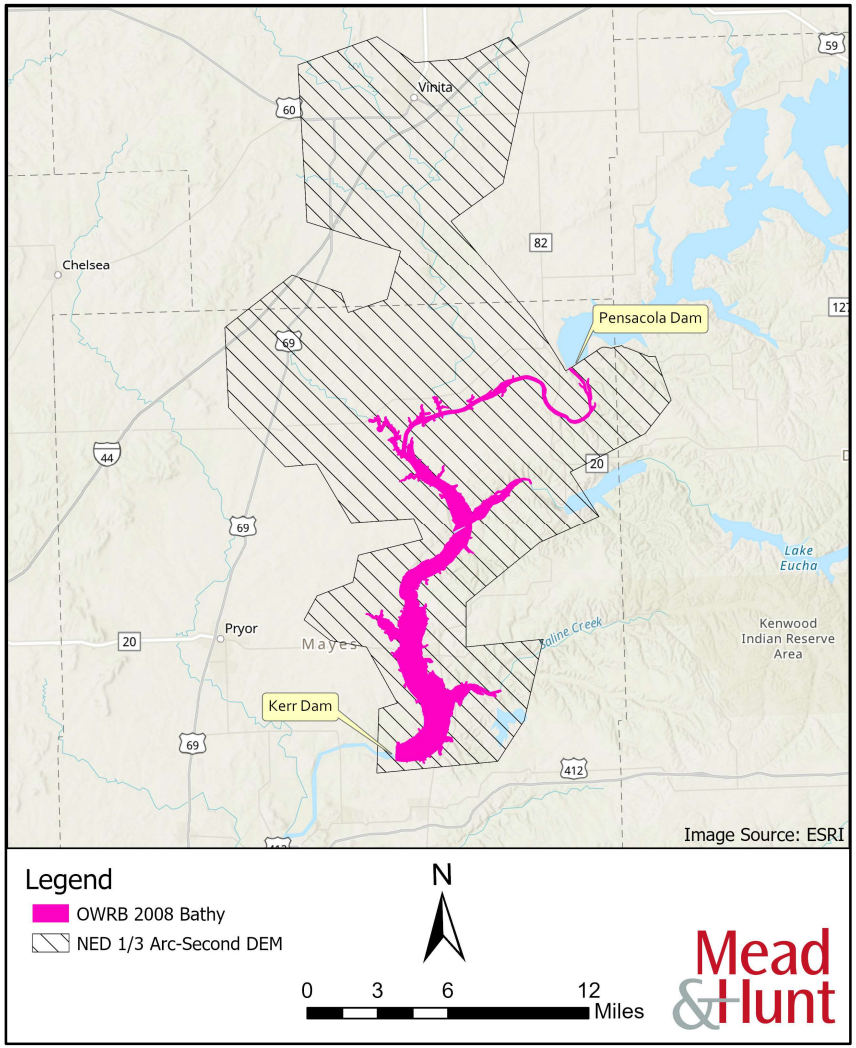
Model Development

Model Development

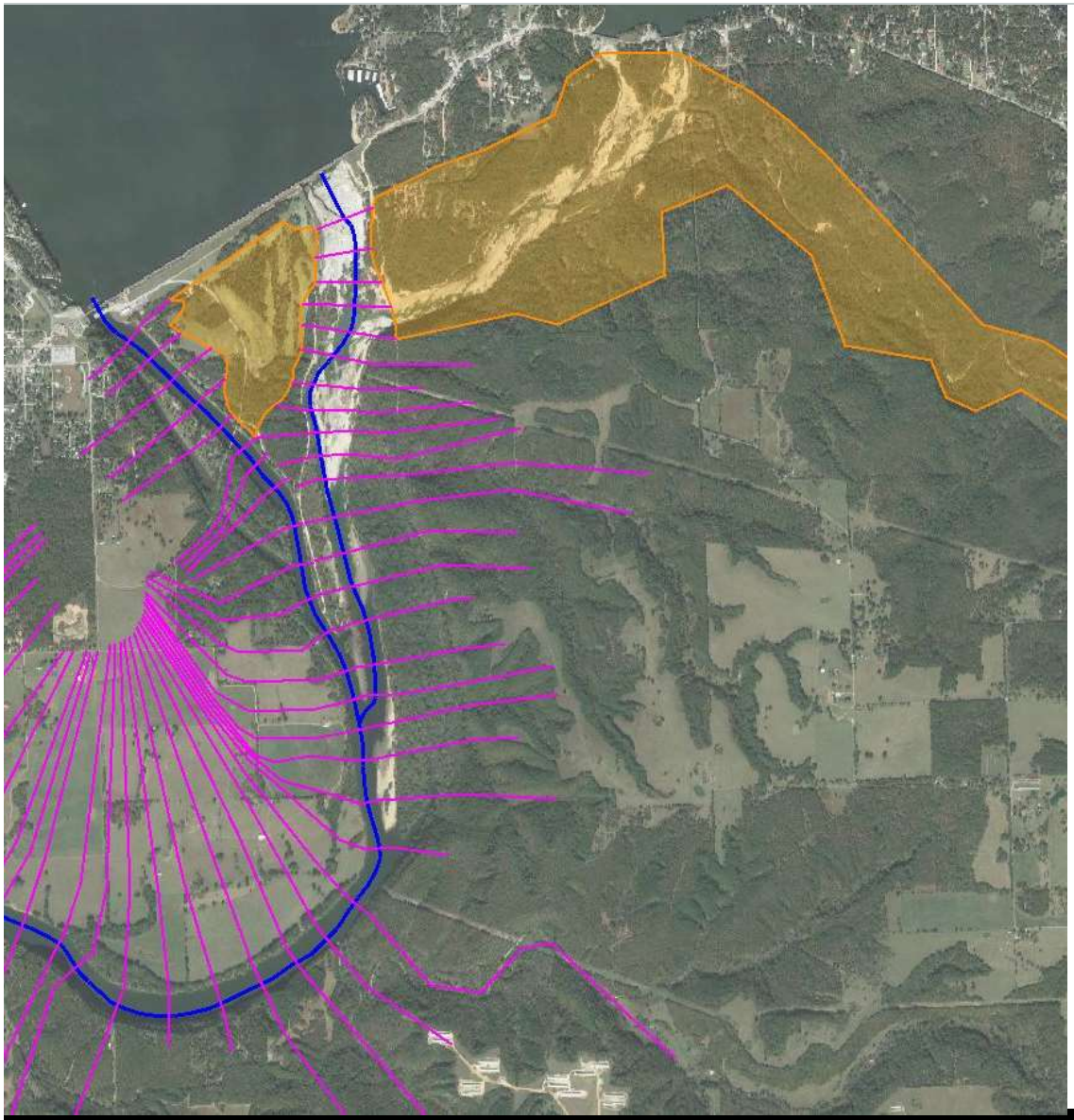
- One dimensional (1D) unsteady-state HEC-RAS model
  - Version 5.0.7

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

Topographic and Bathymetric Data



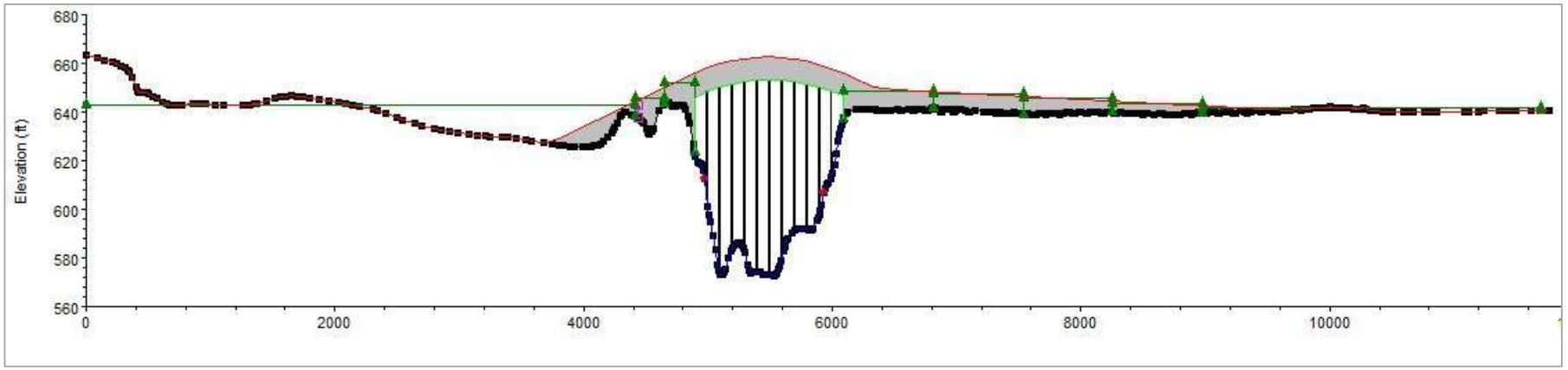
Model Geometry



- 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 river channel and Main Spillway channel

Model Geometry

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



Model Geometry

- Manning's n-values derived from aerial imagery prior to calibration
  - Guidance from HEC-RAS *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

Unsteady Flow Data

- Inflow boundary conditions developed from USGS Gages

USGS Gage No.	Station Name
07190500	Neosho River near Langley, OK
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 time series operations data that is summarized and sent to USACE monthly
  - East spillway as lateral inflow hydrograph

Unsteady Flow Data

- 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

Model Calibration

- Model calibrated using four historic events

Event	Pensacola Dam Peak Outflow	Kerr Dam Peak Outflow
June 10, 2007 – July 23, 2007	106,941 cfs	99,034 cfs
April 7, 2008 – April 17, 2008	82,340 cfs	91,287 cfs
April 20, 2011 – May 15, 2011	80,559 cfs	91,852 cfs
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)

Model Calibration

- Initial model runs showed discrepancies between recorded and observed data at Kerr Dam
  - Volume conservation errors due to ungaged tributaries
- Uniform lateral inflow hydrograph added as additional boundary condition to account for missing inflows
  - 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

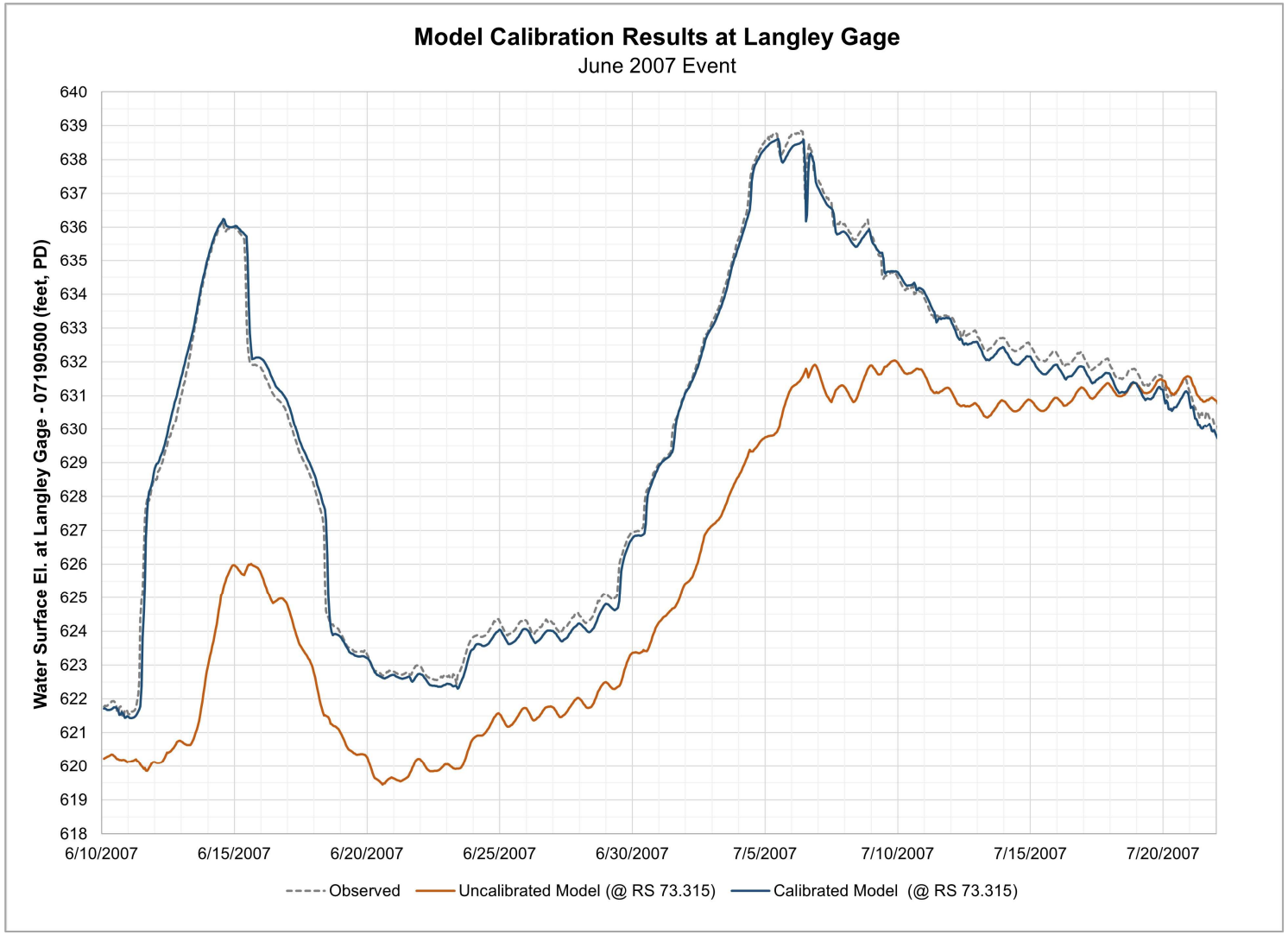
Land Use Category	Calibrated n-value
Channel	0.0324
Pasture high grass or mature row crops	0.0378
Mature field crops	0.0432
Light brush and trees	0.0648
Urban or residential	0.0756
Dense urban or residential	0.0972
Medium to dense brush	0.1080

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)
June 2007	638.9	638.6
April 2008	636.9	636.9
April 2011	635.8	635.9
May 2015	639.5	639.6

Calibration Results



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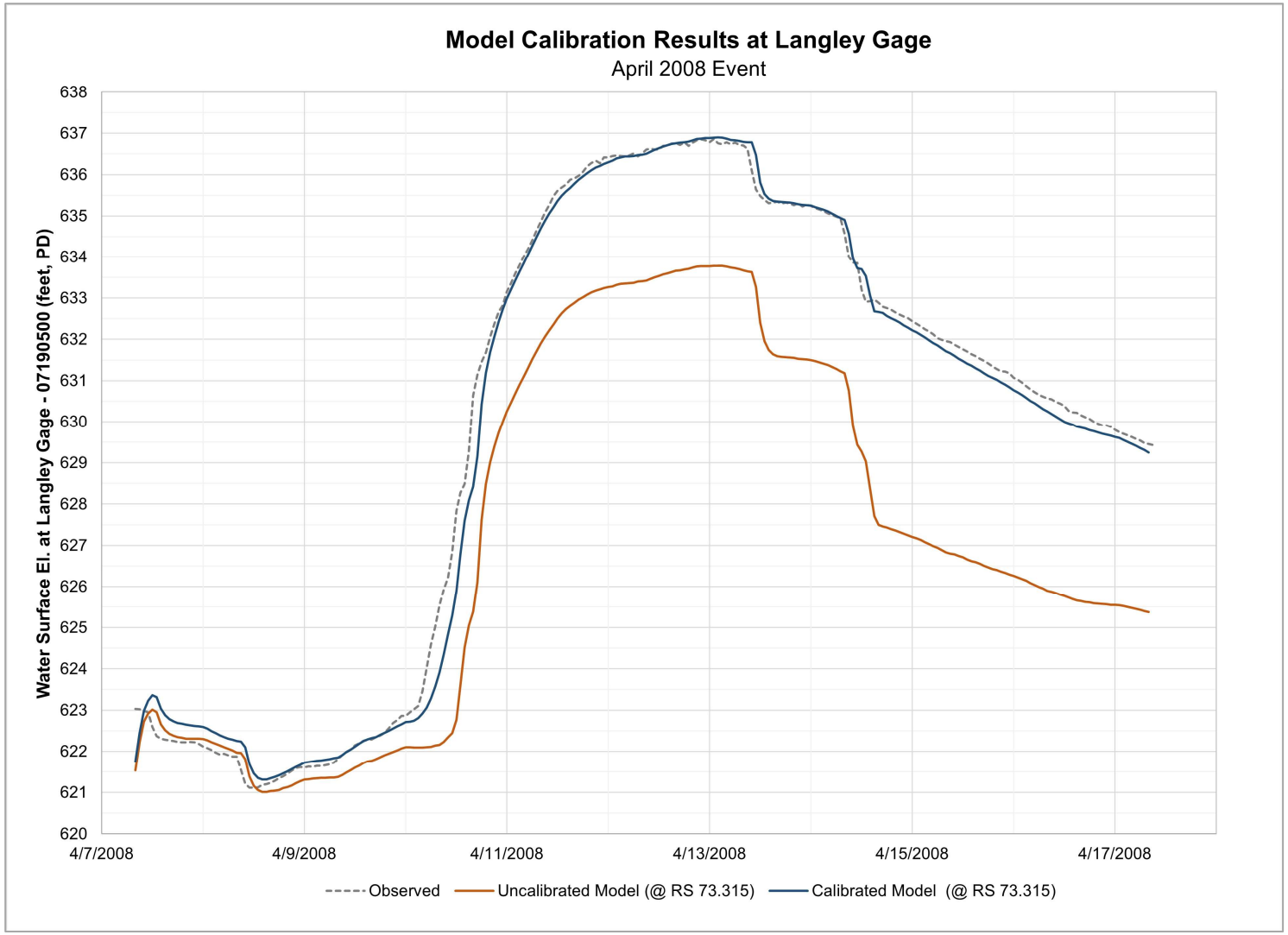

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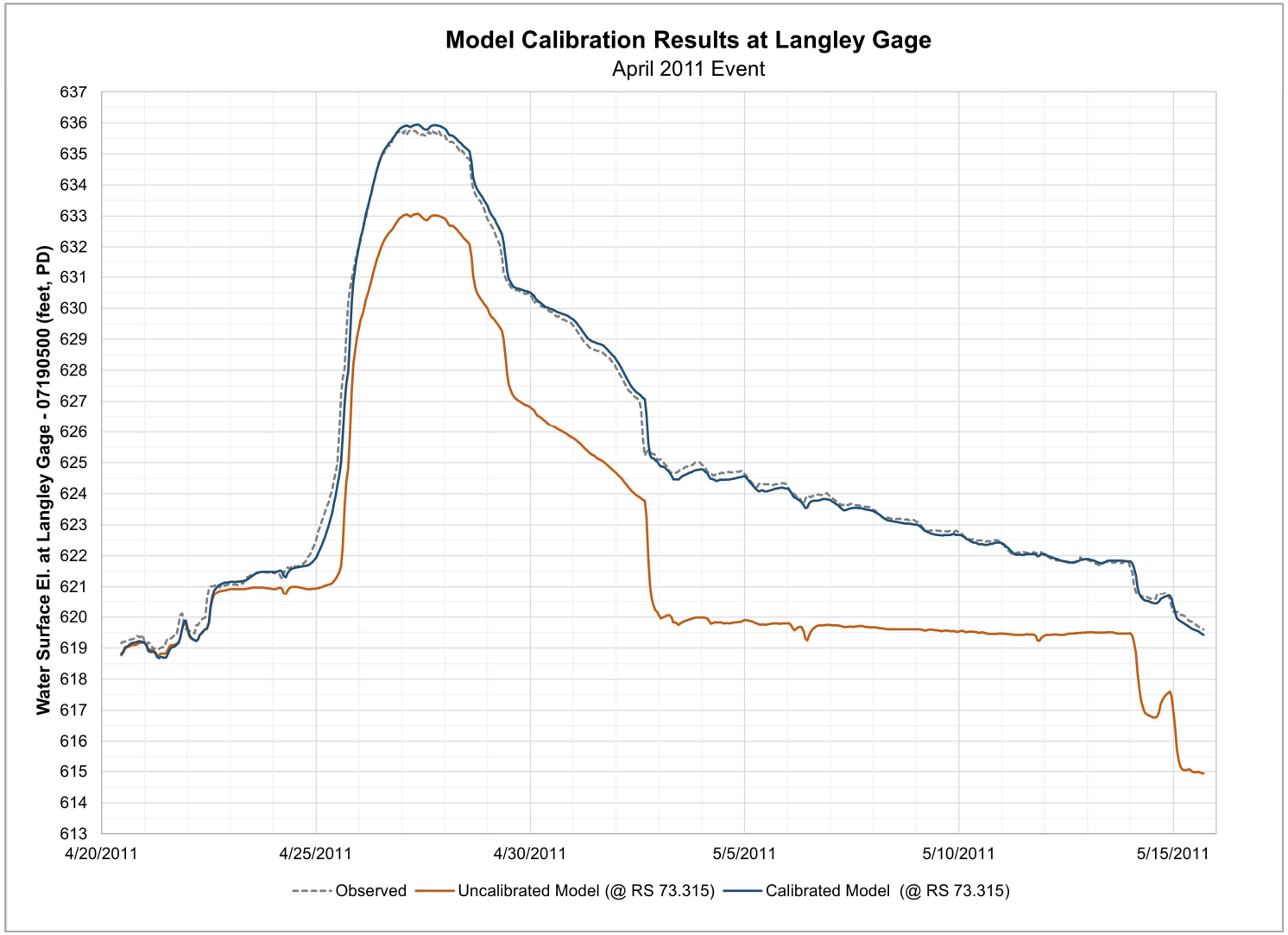

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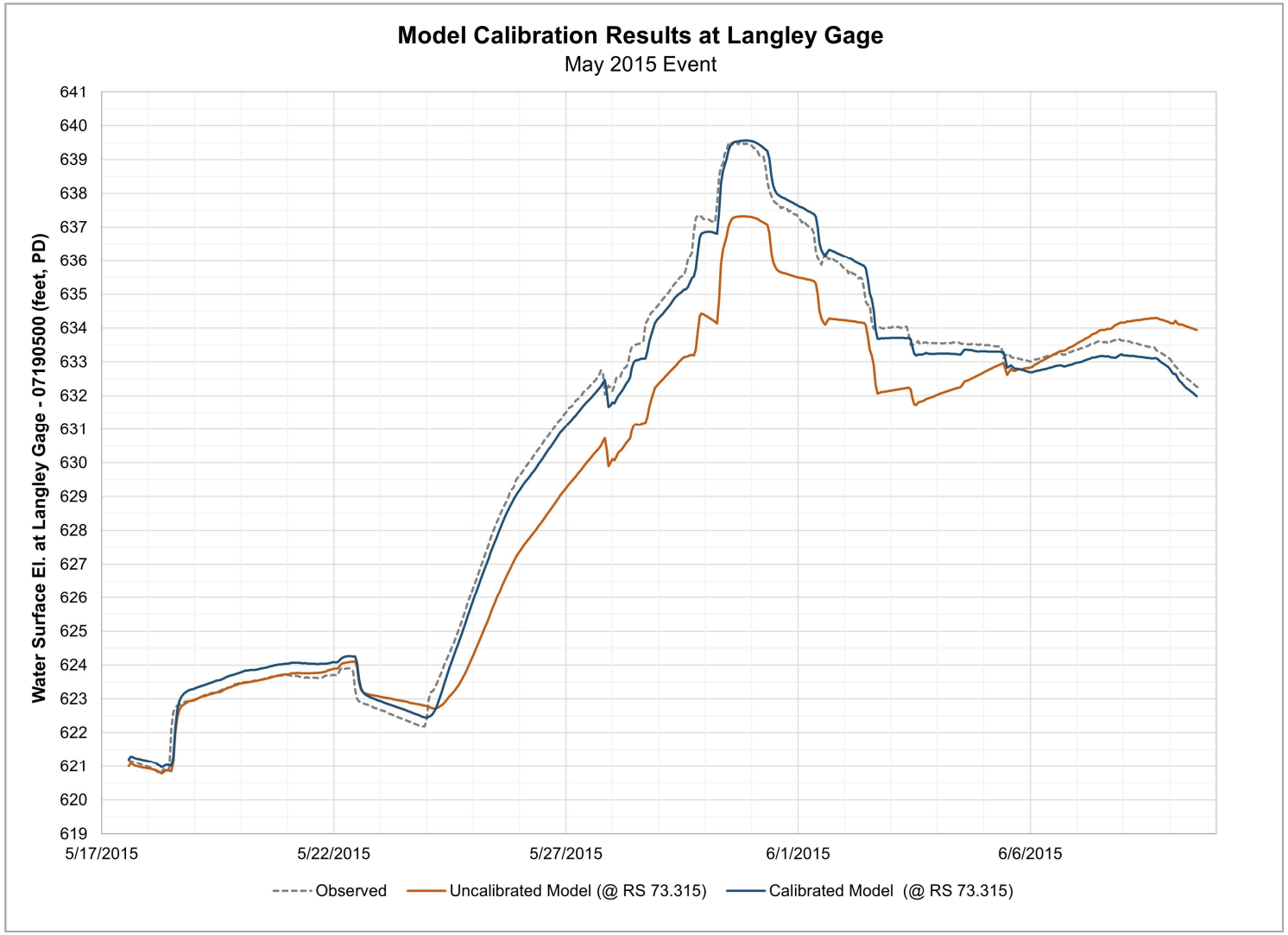

Thank You