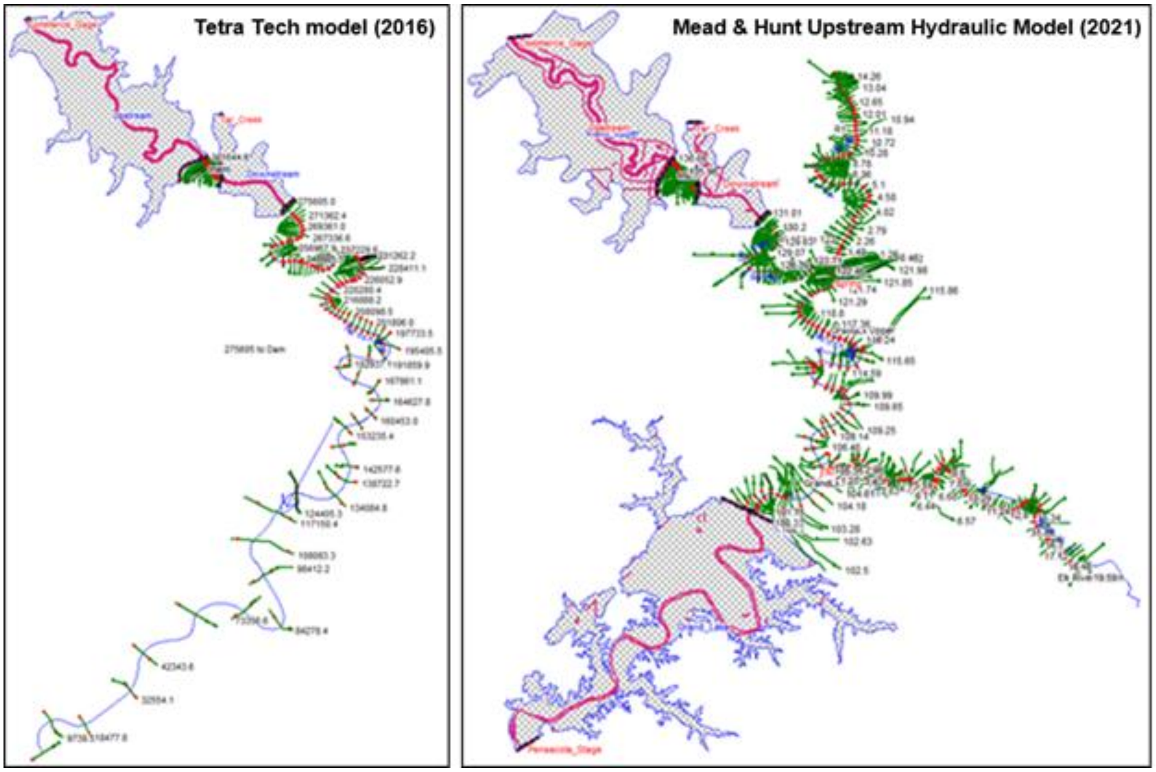
H&H Modeling: Upstream Hydraulic Model – Model Input Status Report
Pensacola Hydroelectric Project (Project No. 1494)
Expanded Executive Summary

This Expanded Executive Summary presents a brief summary of the model input status report, which will be filed with FERC by March 30, 2021. This document assumes the reader is familiar with the Pensacola Hydroelectric Project (FERC Project No. 1494) and the ongoing relicensing process.

Mead & Hunt used a Hydrologic Engineering Center River Analysis System (HEC-RAS) model, previously developed by Tetra Tech, as the base for model development. Mead & Hunt conducted a detailed review of Tetra Tech's model and identified ways in which the model should be improved. Mead & Hunt transformed the model in the following ways, resulting in an improved comprehensive hydraulic model of Grand Lake and the river system upstream of Pensacola Dam.

1. Model was converted from a beta version of HEC-RAS to version 5.0.7.
2. Two-dimensional (2D) flow area (2DFA) was added for the lower portion of Grand Lake, replacing cross-sections.
3. 2DFAs in the vicinity of Miami, Oklahoma were expanded to fully contain inundation from larger flow events.
4. Mesh cell centers within 2DFAs were reviewed and adjusted in accordance with best practices.
5. Cross-sections were extended to fully contain the inundation from larger flow events.
6. 1D/2D flow boundaries were reviewed and adjusted in accordance with best practices.
7. Bridge geometries were updated to reflect current conditions.
8. Bank stations and ineffective flow areas were reviewed and adjusted in accordance with best practices.
9. Elk River was added to the model.
10. Spring River was added to the model.
11. Recently published USGS Grand Lake bathymetry data were incorporated into model geometry.
12. Computational parameters were reviewed and adjusted in accordance with best practices.

The figure below displays a comparison of the model geometries.



Mead & Hunt calibrated the model using measured data. Measured data included USGS gage elevations, high water marks, and recorded data from loggers installed by the project team. For calibration, stream gage data from the USGS were used for upstream inflow boundary conditions and Grand Lake stage data were used as the downstream boundary condition. Six historic events were used to calibrate the model.

1. July 2007. Peak WSEL at the Miami gage and high-water marks were used for calibration. Of the selected events, the July 2007 event had the highest recorded flow on the Neosho River.
2. October 2009. Peak WSELs at the Commerce, Miami, Elk (Tiff City), and Spring (Quapaw) gages, along with high-water marks, were used for calibration.
3. December 2015. Peak WSELs at the Commerce, Miami, Elk (Tiff City), and Spring (Quapaw) gages, along with high-water marks, were used for calibration. Of the selected calibration events, the December 2015 event had the highest recorded flow on the Spring River and was tied with the April 2017 event for the highest recorded flow on the Elk River.
4. January 2017. Peak WSELs at the Commerce, Miami, Elk (Tiff City), and Spring (Quapaw) gages, along with peak WSELs from loggers deployed throughout the study area, were used for calibration. Of the selected calibration events, the January 2017 event had the lowest recorded flow on all gages.
5. April 2017. Peak WSELs at the Commerce, Miami, Elk (Tiff City), and Spring (Quapaw) gages, along with peak WSELs from loggers deployed throughout the study area, were used for calibration. Of the selected calibration events the April 2017 event was tied with the December 2015 event for the highest recorded flow on the Elk River.
6. May 2019. Peak WSELs at the Commerce, Miami, Elk (Tiff City), and Spring (Quapaw) gages, along with peak WSELs from loggers deployed throughout the study area, were used for calibration. Of the selected calibration events the May 2019 event had the highest recorded flow on Tar Creek.

Manning's n-values were adjusted until simulated water surface elevations reasonably matched measured data. Flow roughness factors were used to fine-tune the model. The calibrated model is a very robust tool that accurately simulates water surface elevations for a range of inflow events.

A flood frequency analysis was performed for the study area using data from USACE. Data from 1940 (dam construction date) to 2017 (latest available data at time of data delivery from USACE) were used and a graphical frequency analysis of peak inflows was performed. The analysis estimated the 100-year event flow to Grand Lake is approximately 300,000 cubic feet per second (cfs).

The largest events of recent record did not meet or exceed the 100-year event threshold at Pensacola Dam. The September 1993 event represents a 44-year flood, the July 2007 event represents a 4-year flood, the December 2015 event represents a 15-year flood, and the May 2019 event represents a 9-year flood. Mead & Hunt iteratively scaled these events until the total peak inflow to Grand Lake was approximately 300,000 cfs, or a 100-year event. The scaling factors were 1.17 for the September 1993 event, 2.15 for the July 2007 event, 1.50 for the December 2015 event, and 1.70 for the May 2019 event.

GRDA's Revised Study Plan proposed a study area that encompasses the areas that experience a "material difference" in water surface elevation due to changes in project operation. FERC recommended GRDA include a proposed definition of material difference in the Model Input Status Report. To propose a definition of material difference, Mead & Hunt reviewed how government agencies approach differences in WSEL.

1. FEMA requires base flood elevations to match within 0.5 feet at the transition between a revised study and the study it is replacing.
2. USACE's engineering manual for the Hydrologic Engineering Requirements for Reservoirs dictates the point of intersection between pre-project and post-project WSEL profiles is established where the profiles are within 1.0 feet of each other.
3. USGS defines field measurements of discharge as "excellent" if the flow measurement is within 2% of the actual value and as "good" if the measurement is within 5% of the actual value. Mead & Hunt ran all the calibrated simulations with the gage inflows increased and decreased by 2%. WSELs between the two sets of simulations were compared at the USGS gages within the study area. There was a difference in WSEL of approximately 0.5 feet between the simulation results.

Based on Mead & Hunt's review of how government agencies approach differences in WSEL and understanding that material difference represents expected precision when comparing model results, Mead & Hunt recommends material difference in WSEL be quantified as 0.5 feet for out of bank events for the sole purpose of determining areas to be included in the model.