IAFSM 2023 Annual Conference
Tinley Park, IL.
Session 3C:Modeling and Regulations

Value Added 3-D Modeling – Eagle Creek Flood Risk Reduction Project

Stantec

Agenda

- Project Background
- Project Goals
- Project Components
- CFD (3D) Modeling Background
- CFD Modeling Results
- Lessons Learned
- Project Benefits
- Q&A

Project Location

Project Location

Marathon Petroleum Corporation

COOPER TIRES

Historic Flooding Issues

Historic Flooding Issues

Flood Categories (in feet)

Major Flood Stage:	13.5
Moderate Flood Stage:	12
Flood Stage:	11
Action Stage:	8

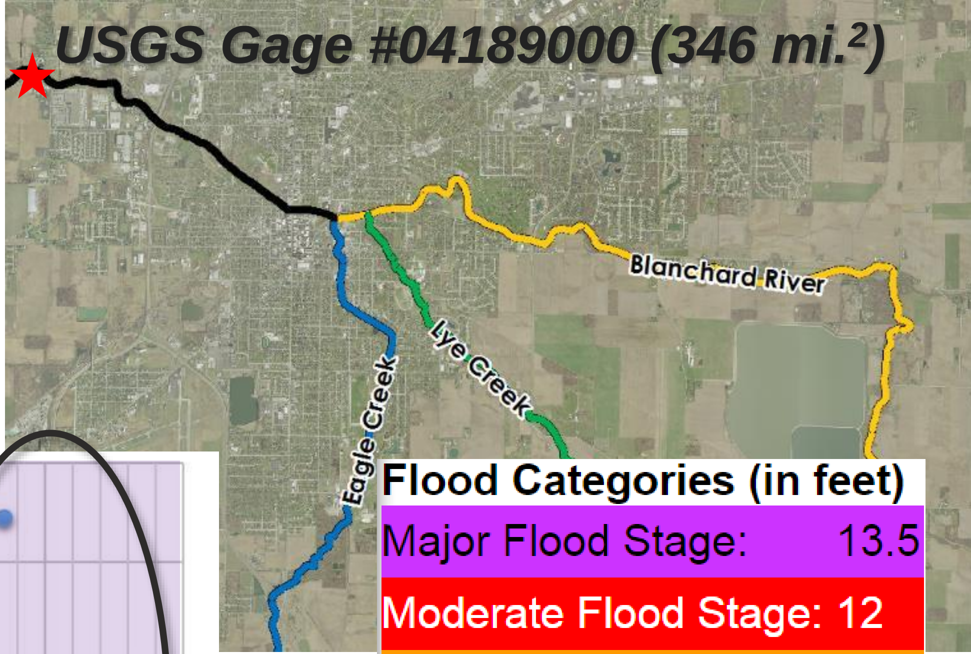
Historic Crests

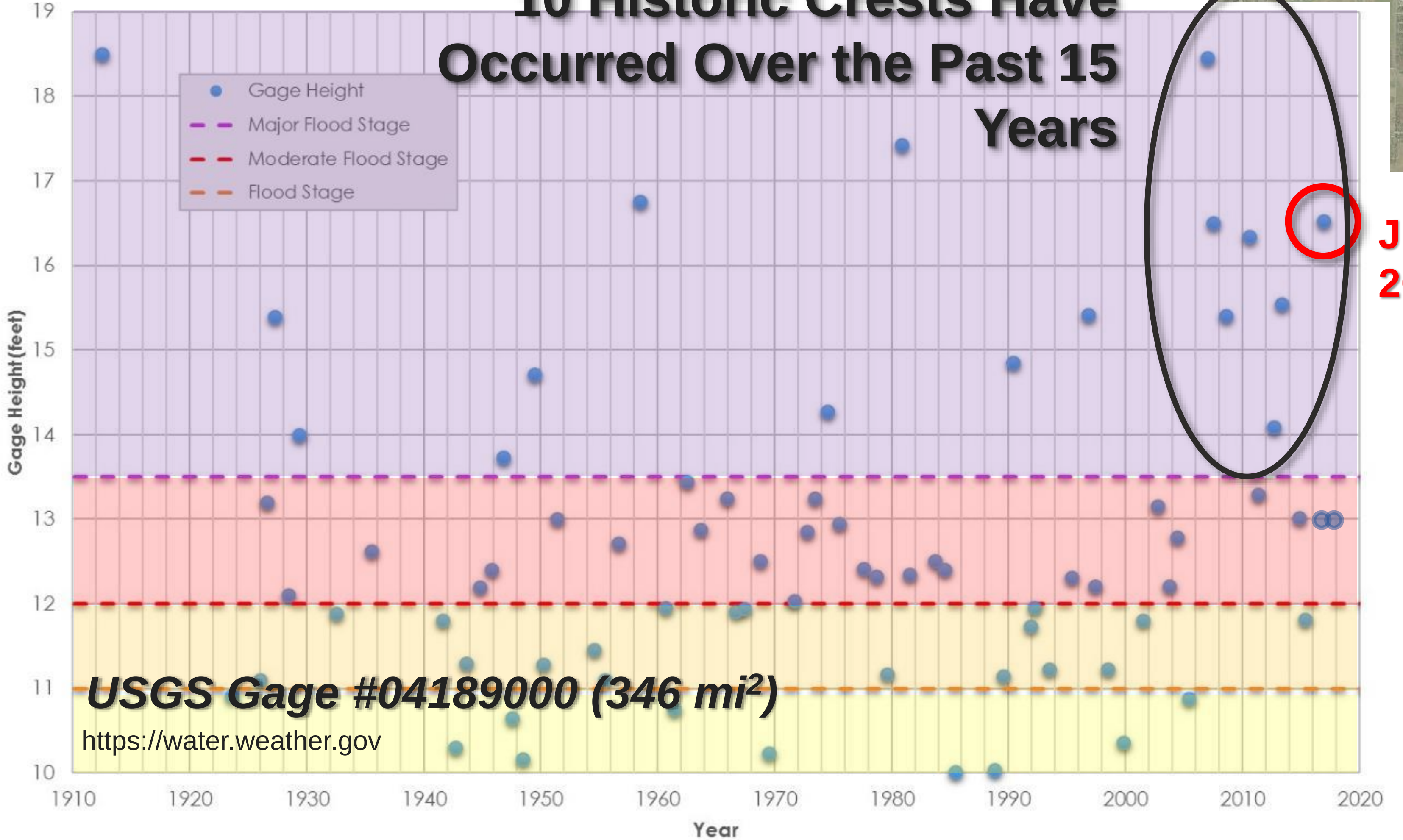
(1) 18.50 ft on 03/25/1913
(2) 18.46 ft on 08/22/2007
(3) 17.43 ft on 06/14/1981
(4) 16.76 ft on 02/11/1959
(5) 16.53 ft on 07/14/2017
(6) 16.50 ft on 02/07/2008
(7) 16.42 ft on 03/01/2011
(8) 16.10 ft on 01/22/1959
(9) 15.58 ft on 12/22/2013
(10) 15.42 ft on 06/02/1997

Historic Flooding Issues

Historic Flooding Issues

7 Major Floods and 5 of the Top 10 Historic Crests Have Occurred Over the Past 15 Years





Flood Categories (in feet)	
Major Flood Stage:	13.5
Moderate Flood Stage:	12
Flood Stage:	11
Action Stage:	8

Historic Crests

(1) 18.50 ft on 03/25/1913
(2) 18.46 ft on 08/22/2007
(3) 17.43 ft on 06/14/1981
(4) 16.76 ft on 02/11/1959
(5) 16.53 ft on 07/14/2017
(6) 16.50 ft on 02/07/2008
(7) 16.42 ft on 03/01/2011
(8) 16.10 ft on 01/22/1959
(9) 15.58 ft on 12/22/2013
(10) 15.42 ft on 06/02/1997

Key
Stakeholders

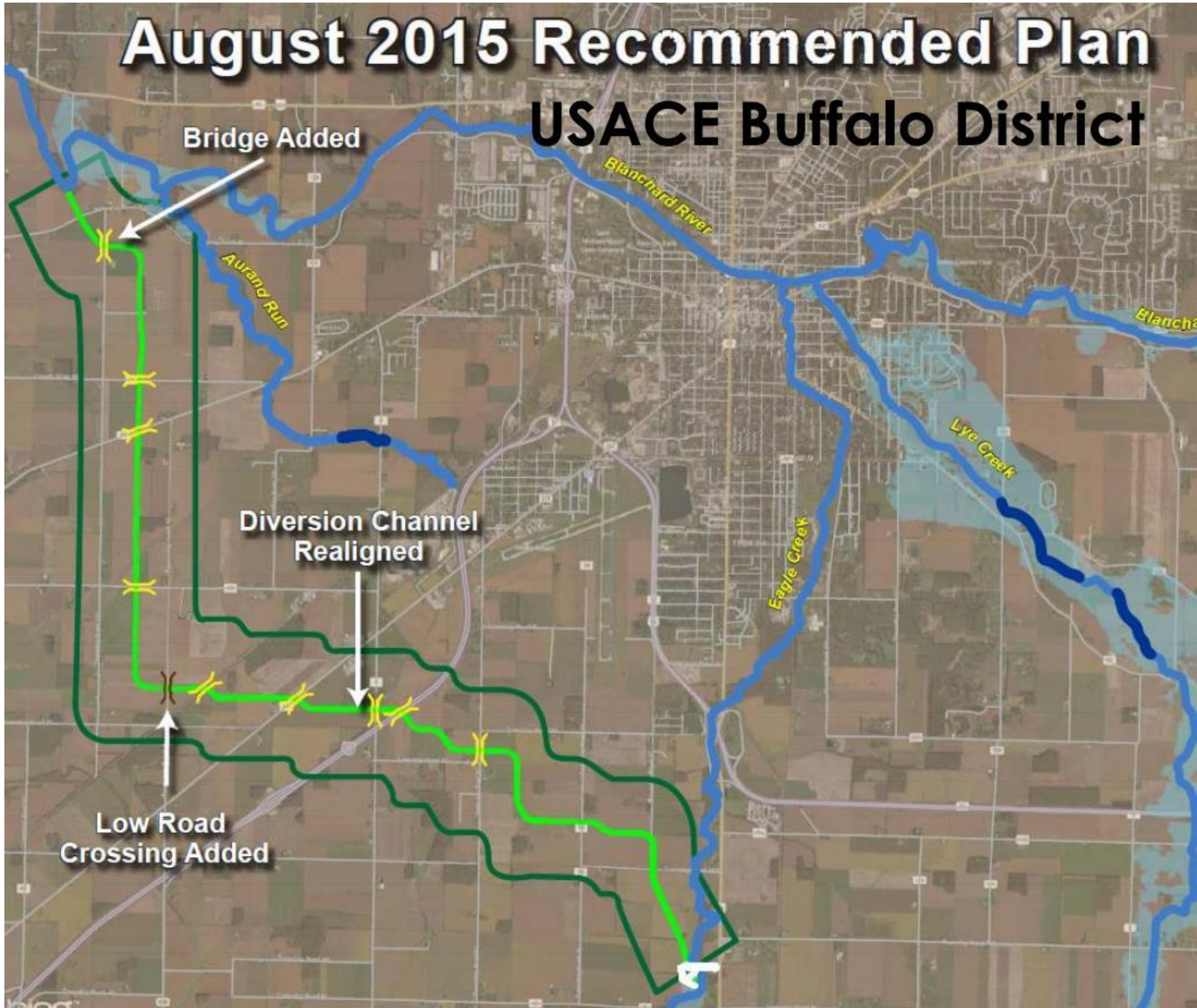
Key Stakeholders

- **Hancock County, Ohio Board of Commissioners**
- **City of Findlay, Ohio**
- **Maumee Watershed Conservancy District (MWCD)**
- U.S. Environmental Protection Agency (USEPA)
- Ohio Department of Natural Resources, Division of Water Resources (ODNR-DWR)
- Federal Emergency Management Agency (FEMA)
- **U.S. Army Corps of Engineers, Buffalo District (USACE)**
- Ohio State Historic Preservation Office (SHPO)
- Ohio Environmental Protection Agency (OEPA)
- **Stantec Consulting Services Inc.**

Flood Reduction Options

Flood Reduction Options

- **Studies Conducted by the USACE from 2007-2015 Following 2007 Event**
  - Recommended **9.2-mile Flood Diversion Channel** Located to the South and West of City (a.k.a. The Western Diversion)
  - Designed for 4% AEP
- **USACE Feasibility Report Presented to Stakeholders in 2015**
  - Deemed Unlikely to Meet Federal Funding Requirements Due to <1.0 CBR and Low Community Support

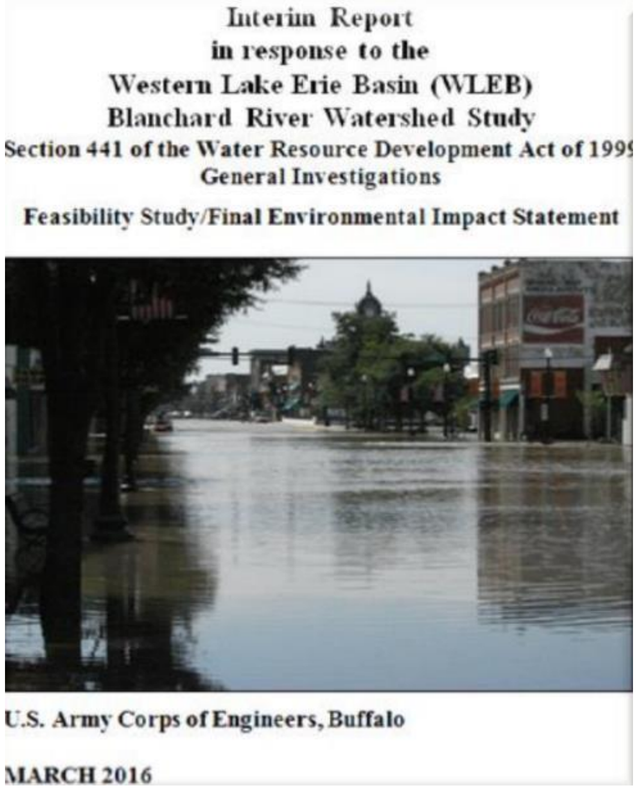


Flood Reduction Options

Flood Reduction Options

- **City and County Took Over Ownership of the Project in Early 2016**
  - Stantec Hired to Perform a Gap Analysis and Continue Forward with the Western Diversion of Eagle Creek
- Results of the Analysis Shifted the Focus from the USACE Diversion Plan to a Risk- Based Review and Alternatives Analysis
  - Formation of the **Hancock County Flood Risk Reduction Program (HCFRP)**

https://hancockcountyflooding.com/

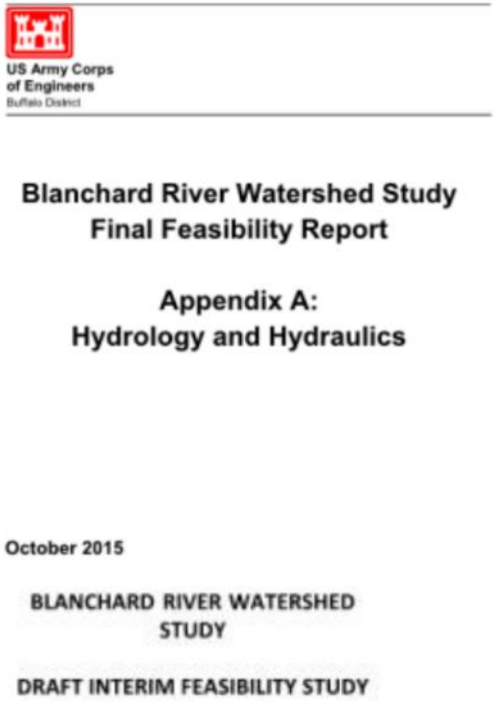


Interim Report
in response to the
Western Lake Erie Basin (WLEB)
Blanchard River Watershed Study
Section 441 of the Water Resource Development Act of 199
General Investigations

Feasibility Study/Final Environmental Impact Statement

U.S. Army Corps of Engineers, Buffalo

MARCH 2016



US Army Corps of Engineers
Buffalo District

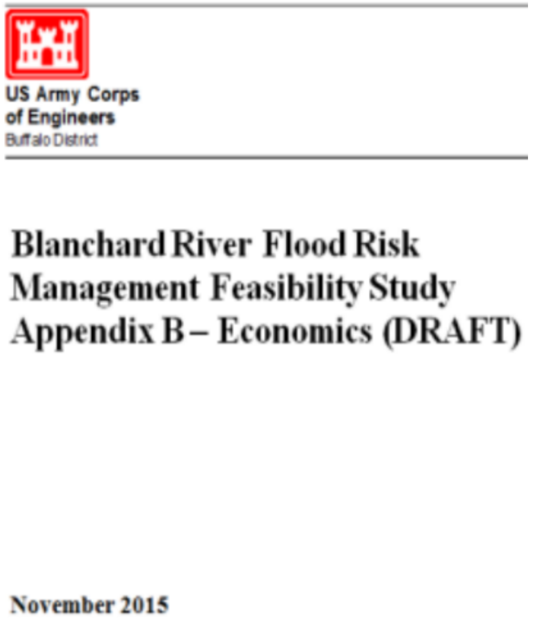
Blanchard River Watershed Study
Final Feasibility Report

Appendix A:
Hydrology and Hydraulics

October 2015

BLANCHARD RIVER WATERSHED STUDY

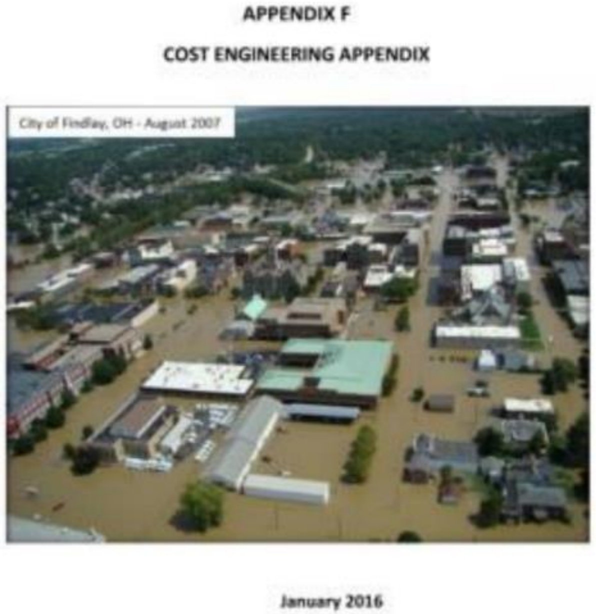
DRAFT INTERIM FEASIBILITY STUDY



US Army Corps of Engineers
Buffalo District

Blanchard River Flood Risk Management Feasibility Study
Appendix B – Economics (DRAFT)

November 2015



APPENDIX F

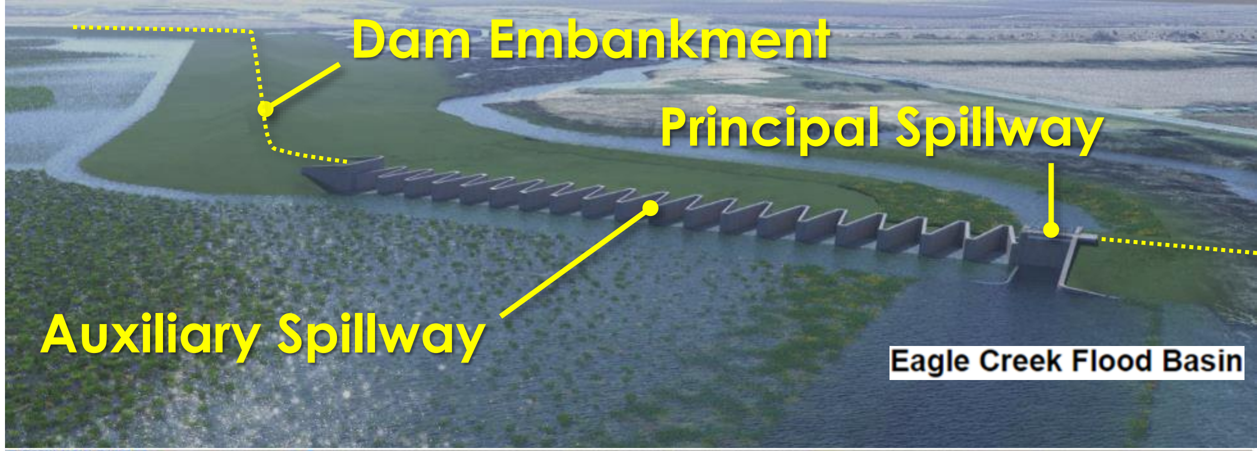
COST ENGINEERING APPENDIX

City of Findlay, OH - August 2007

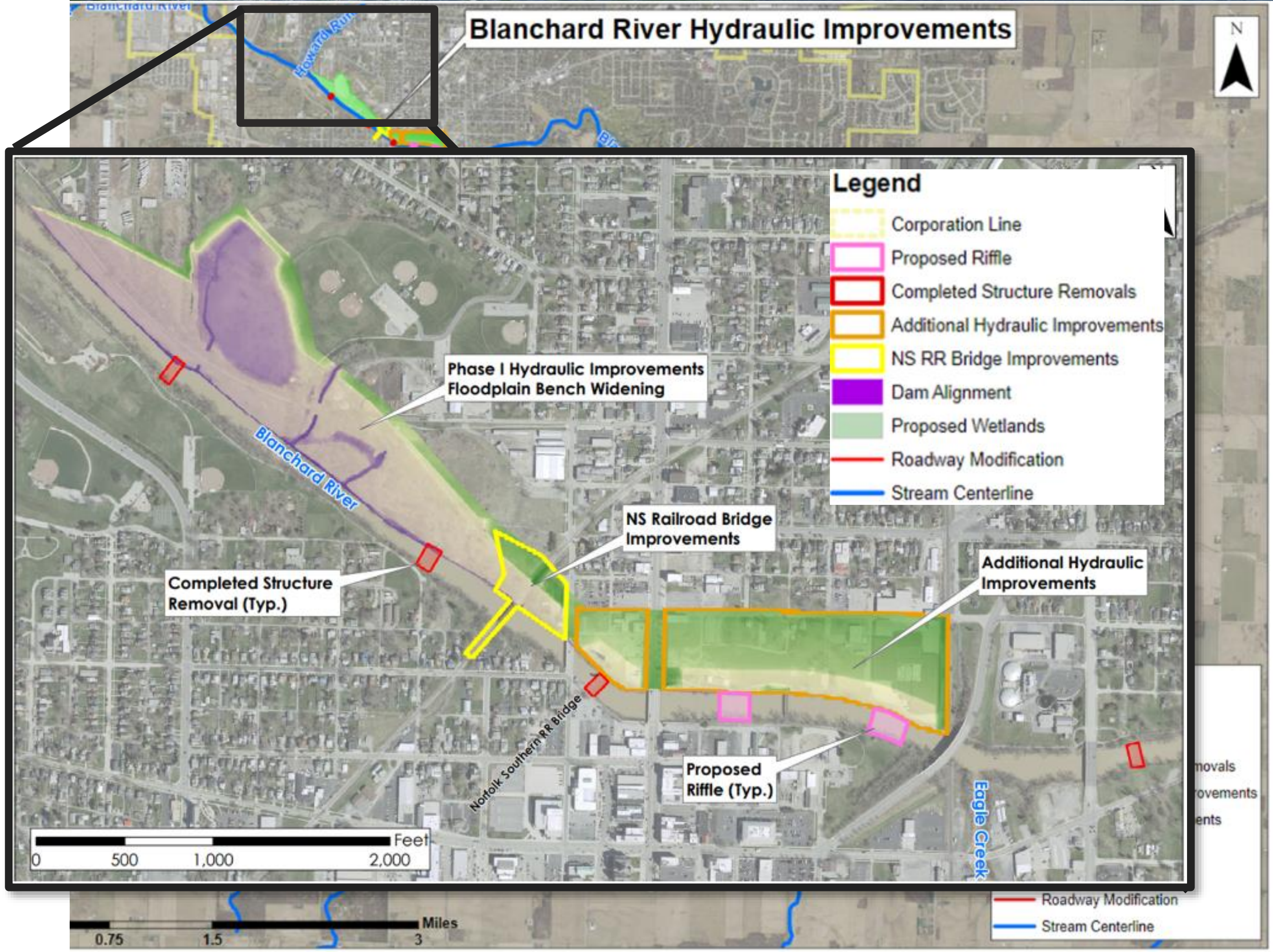
January 2016

Hancock County Flood Risk Reduction Program (HCFRP)

HCFRP Goals

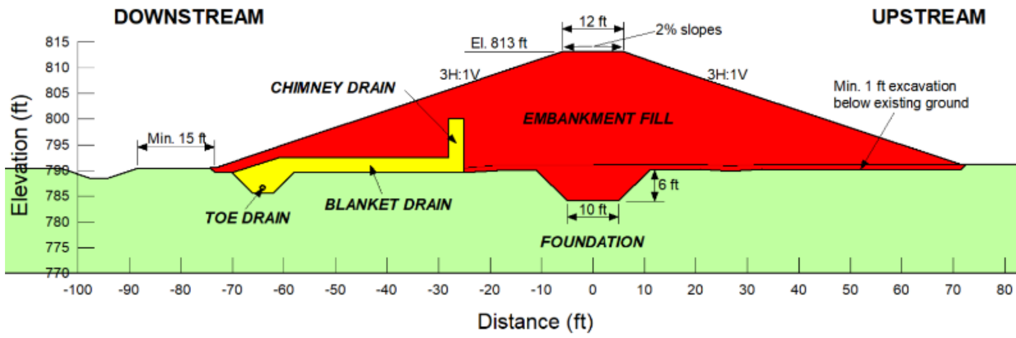


- **Included Improvements to Eagle Creek (ECFB) and Blanchard River**
- **Primary Goal**
  - Reduce Peak Flows, and WSEL's Through the City to Mitigate the Ongoing Structural, Social, and Environmental Damages
- **Secondary Goals**
  - Water Quality (Add Wetlands/Buffers),
  - Stream Stability (Floodplain Benching and Widening to Control Erosion/ Deposition)
  - Fish Passage (Structure Removals)
- **Tertiary Goal**
  - Provide Enhanced Recreational Opportunities (Trail Systems)

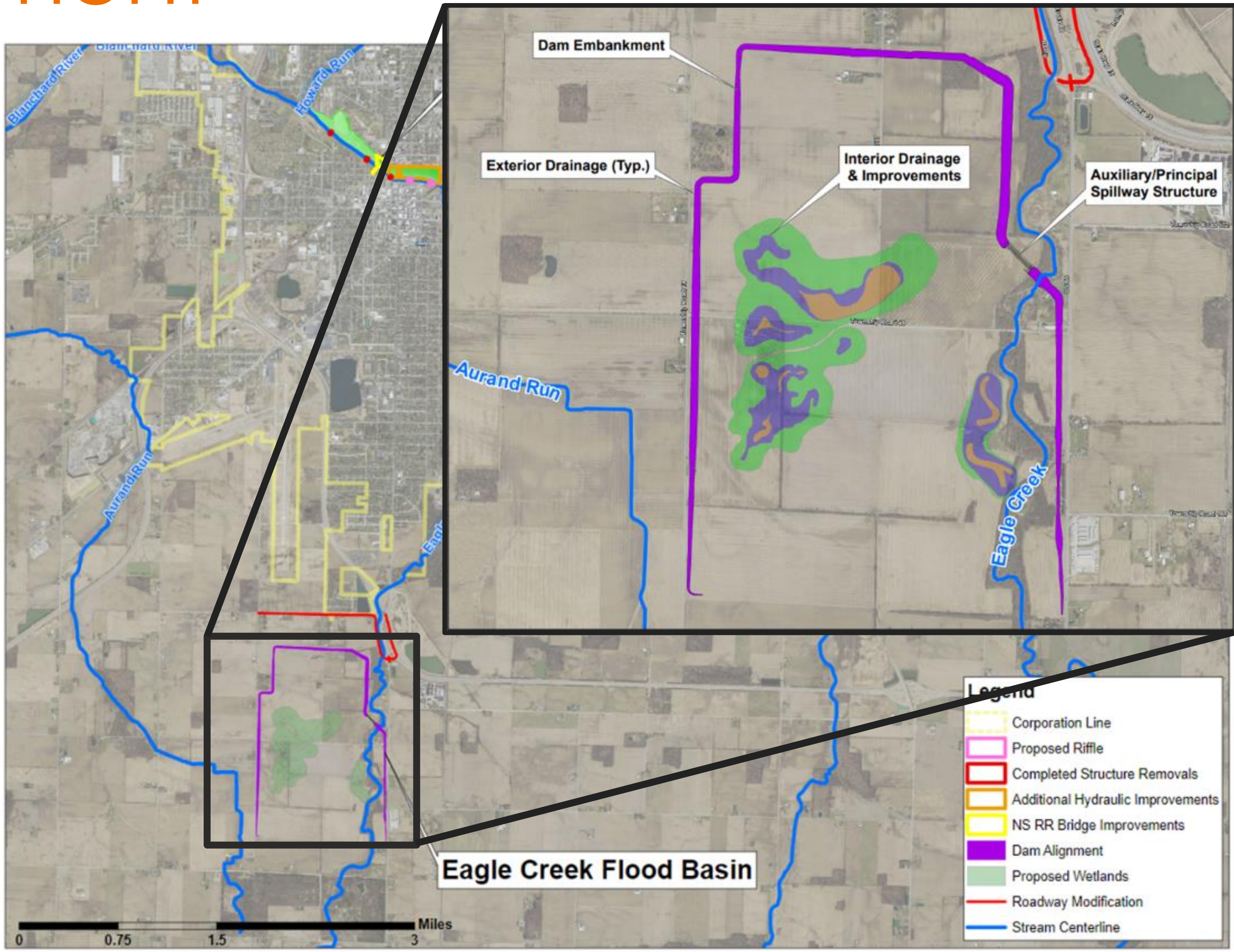


Hancock County Flood Risk Reduction Program (HCFRP)

HCFRP – ECFB Dam Embankment

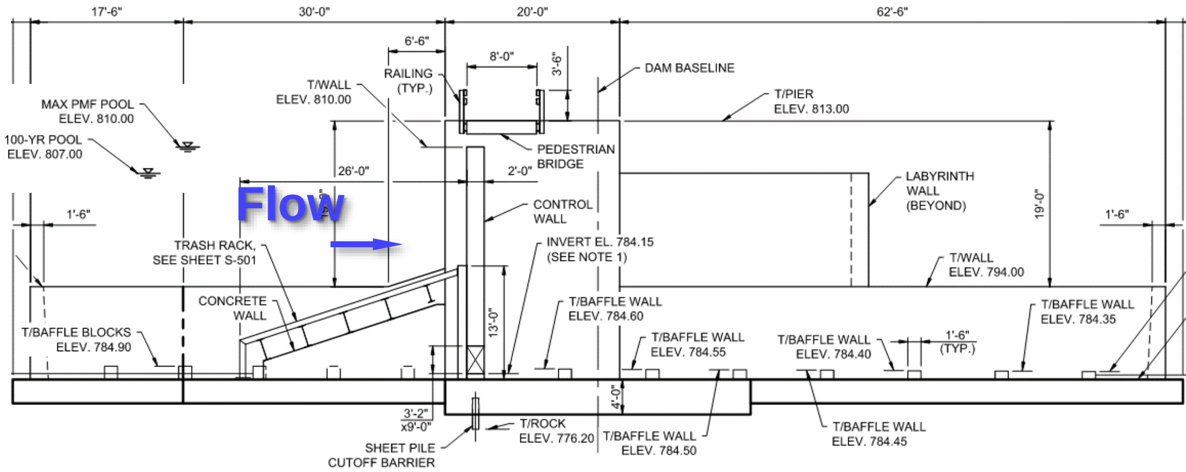


- **Embankment Details**
  - **Dry Detention Basin** (Uses Existing Topography – No Major Excavation)
  - 16 Total Footprints Evaluated
  - Embankment Length **3.8 mi.**
  - Avg. Embankment Height **12.5 ft**
  - Max. Embankment Height **29.0 ft**
  - Storage Footprint **900 acres**
  - Storage Capacity **7,000 ac-ft**
  - Class I Dam Per ODNR-DWR

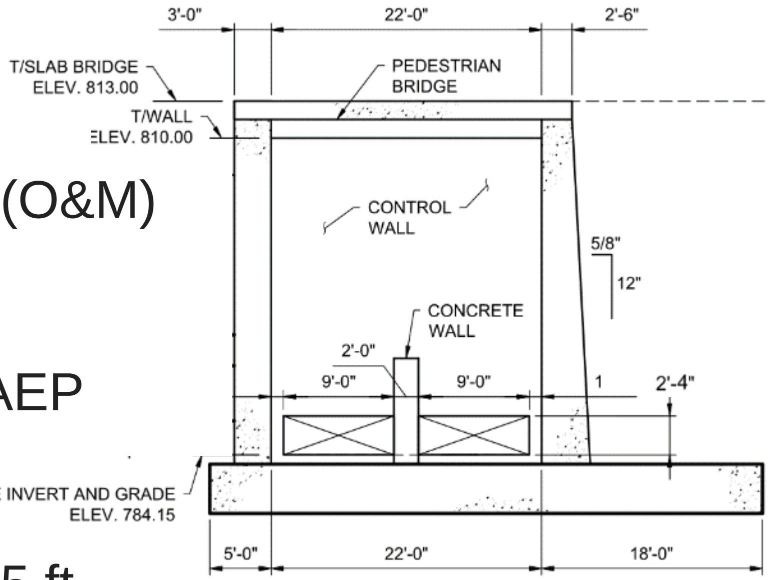


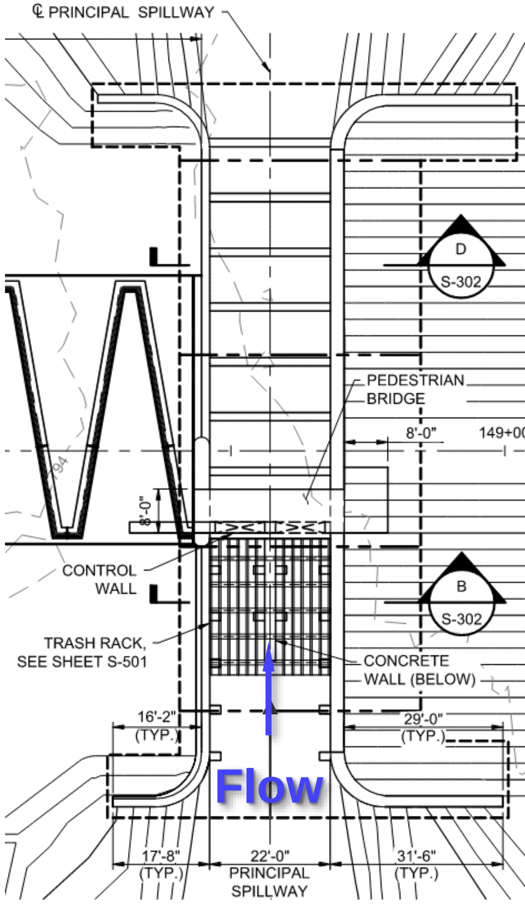
Hancock County Flood Risk Reduction Program (HCFRP)

HCFRP – ECFB Principal Spillway



- **Spillway Details**
  - Ported Baffle/Control Wall
  - 3 Variations Evaluated
  - Only Considered Passive Control Options (O&M)
  - Target Discharge of **1,250 cfs** for 1% AEP
  - Target Basin WSEL at **El. 807.0 ft** for 1% AEP
  - Spillway Width **22.0 ft**
  - Twin **2.3 x 9.0 ft Orifice Ports** at El. 784.15 ft
  - **80.0 ft-Long** Baffled Discharge and Fish Passage Channel

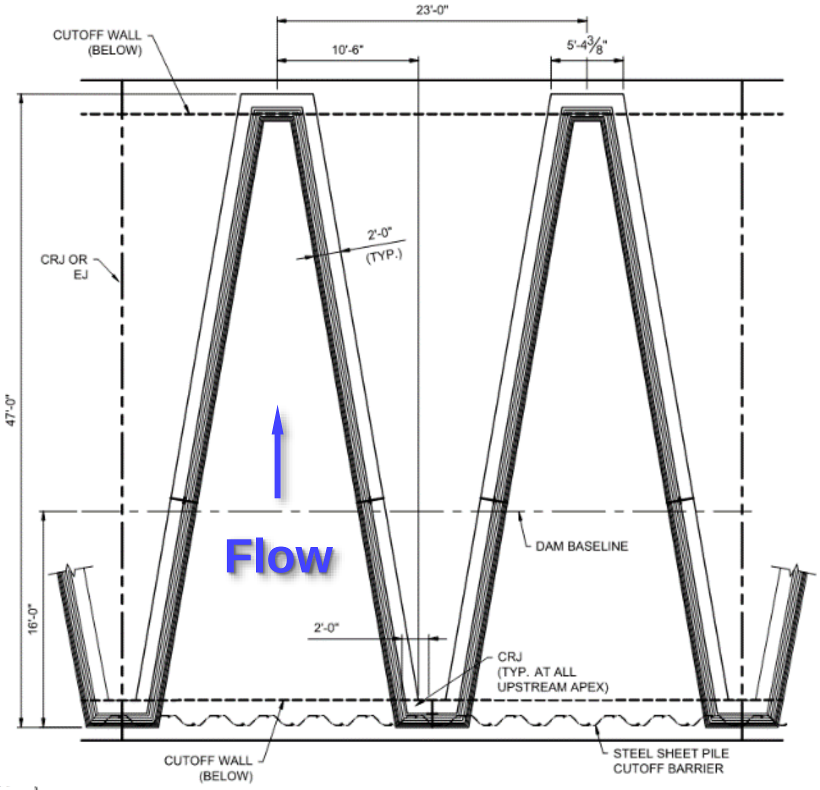


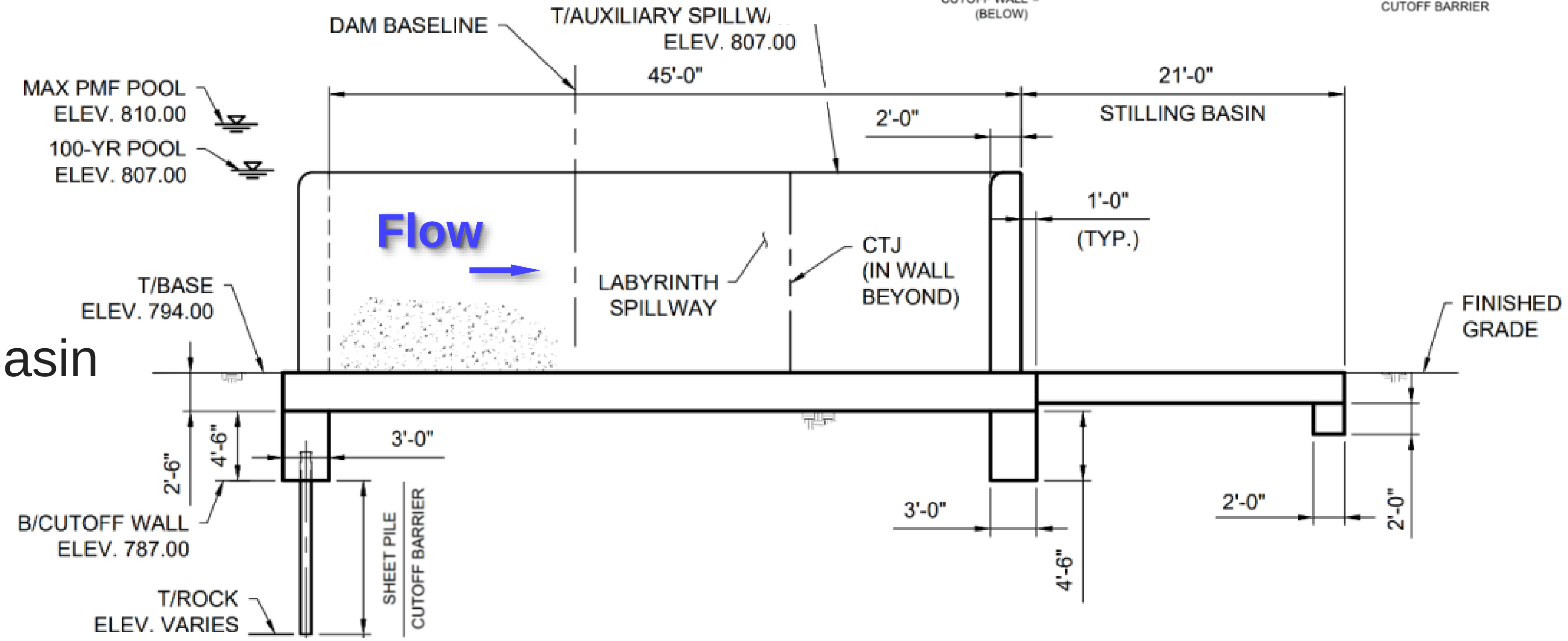


Hancock County Flood Risk Reduction Program (HCFRP)

HCFRP – ECFB Auxiliary Spillway

- **Spillway Details**
  - 3 Variations Evaluated
  - Maximum Discharge **27,400 cfs** for PMF
  - Total Spillway Length **437.0 ft**
  - Number of Cycles **19**
  - Cycles Each **47.0 ft x 23.0 ft**
  - Crest at **El. 807.0 ft** (Target Basin WSEL for 1% AEP)
  - USBR Type 1 Stilling Basin

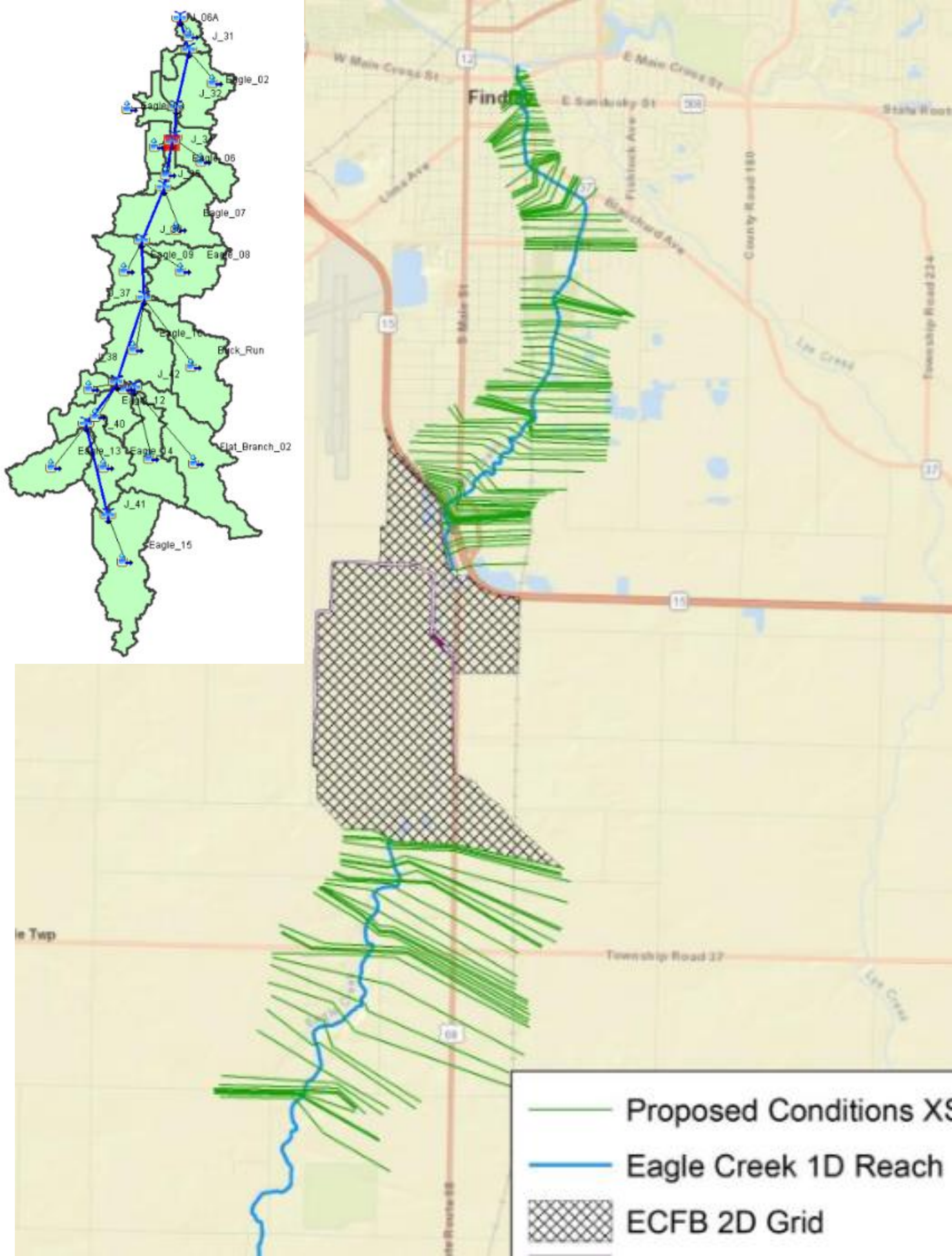




HCFRP
Hydraulic Model
Development

H&H Model Development

- **Effective Model**
  - Defines Current Flood Hazards on the Effective FIRMs
- **Pre-Project Models (Proof of Concept)**
  - Baseline Model to Assess Effects of Project
    - Leveraged USACE Models
    - Updated Project LiDAR
    - Supplemented with Recent Field Surveys
- **Post-Project Models (Used for CLOMR)**
  - Incorporates the HCFRP Features
  - Combines 1D and 2D HEC-RAS models w/ CFD



HCFRP
Hydraulic Model
Design Process

Pre- and Post-Project Hydraulic Model Design Process

Pre-Project Design Originally Modeled as a Culvert Using HY-8 and 1D HEC-RAS

At Start of Post-Project Design, Changed to Orifice Configuration Using 1D and 2D HEC-RAS

At Start of Post-Project Design, Principal Spillway Switched to be Fully modeled in 1D and 2D HEC-RAS as an Inline Structure w/ Gates

During Post-Project Design, CFD Modeling Performed to Confirm Hydraulic Performance and “Calibrate” the 1D/2D HEC-RAS Models to Produce Final Rating Curves

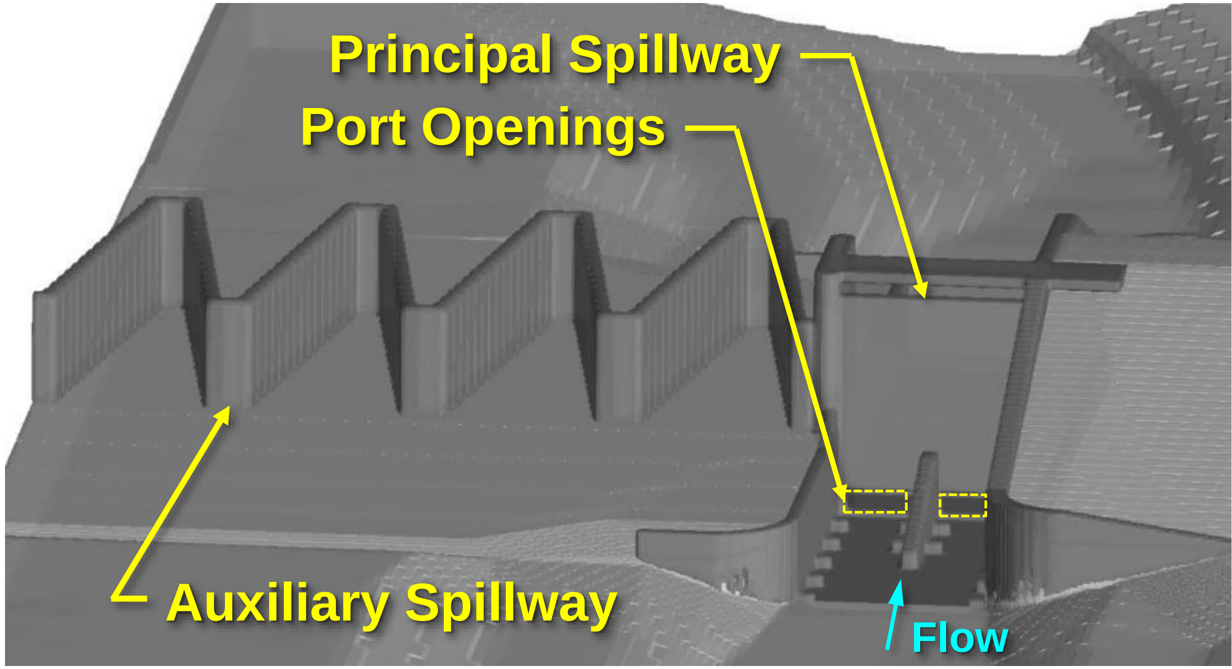
Computational Fluid Dynamics (CFD)

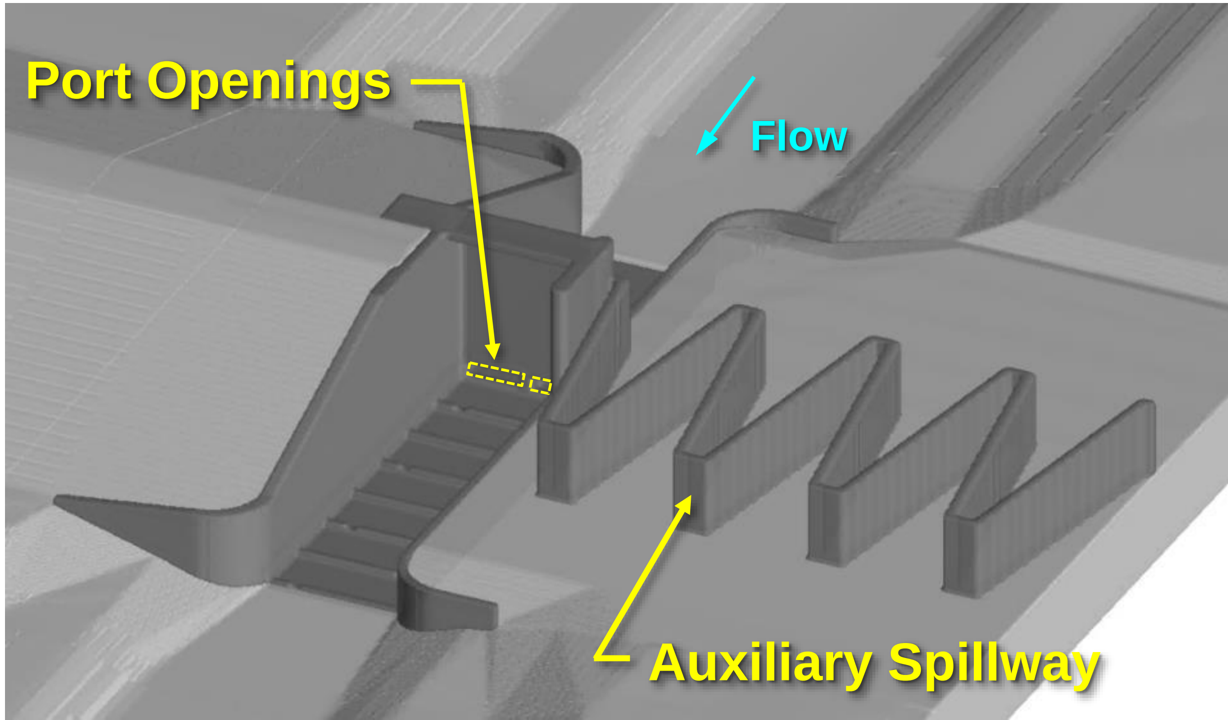
FLOW-3D®

- **CFD Uses**
  - Test Designs to Identify Need for Improvements to Hydraulic Performance Before Final Designs and Construction are Undertaken (Risk Mitigation)
  - Evaluate Flow and Velocity Distribution Patterns, Pressures, Energy Dissipation, Vorticity, etc.
- **CFD Benefits**
  - Visualize Hydraulic Designs
  - Provide Comprehensive Information of the Modeled System to Aide in Design
- **Stantec Experience**
  - Have Been Incorporating CFD into Our Hydraulic Structure Designs Since 2005
  - Provide Mechanism to Allow for Iterative Discussions Between Design Discipline Leads and Design Partners Throughout the Design Process

HCFRP CFD Modeling

- **Primary Objective**
  - Confirm Overall Hydraulic Performance of the Project
  - Validate and “Calibrate” 1D / 2D HEC-RAS Rating Curves for the Principal and Auxiliary Spillways
- **Added Value**
  - Fish Passage Design
  - Energy Dissipation
  - Hydrodynamic Loading for Use by the Structural Design Team

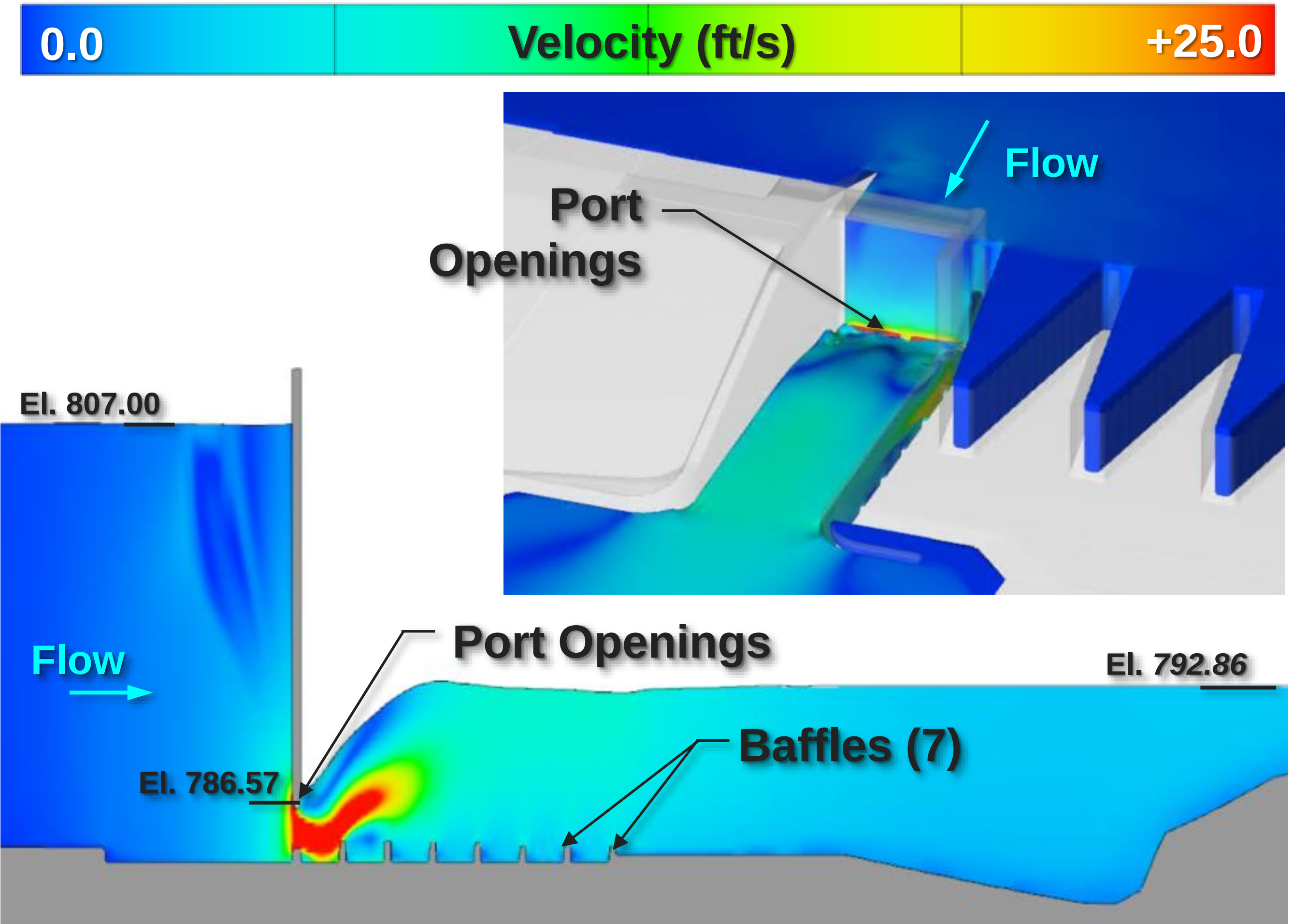




HCFRP CFD Model Results

Principal and Auxiliary Spillways

HCFRP CFD Results
Principal and Auxiliary Spillways



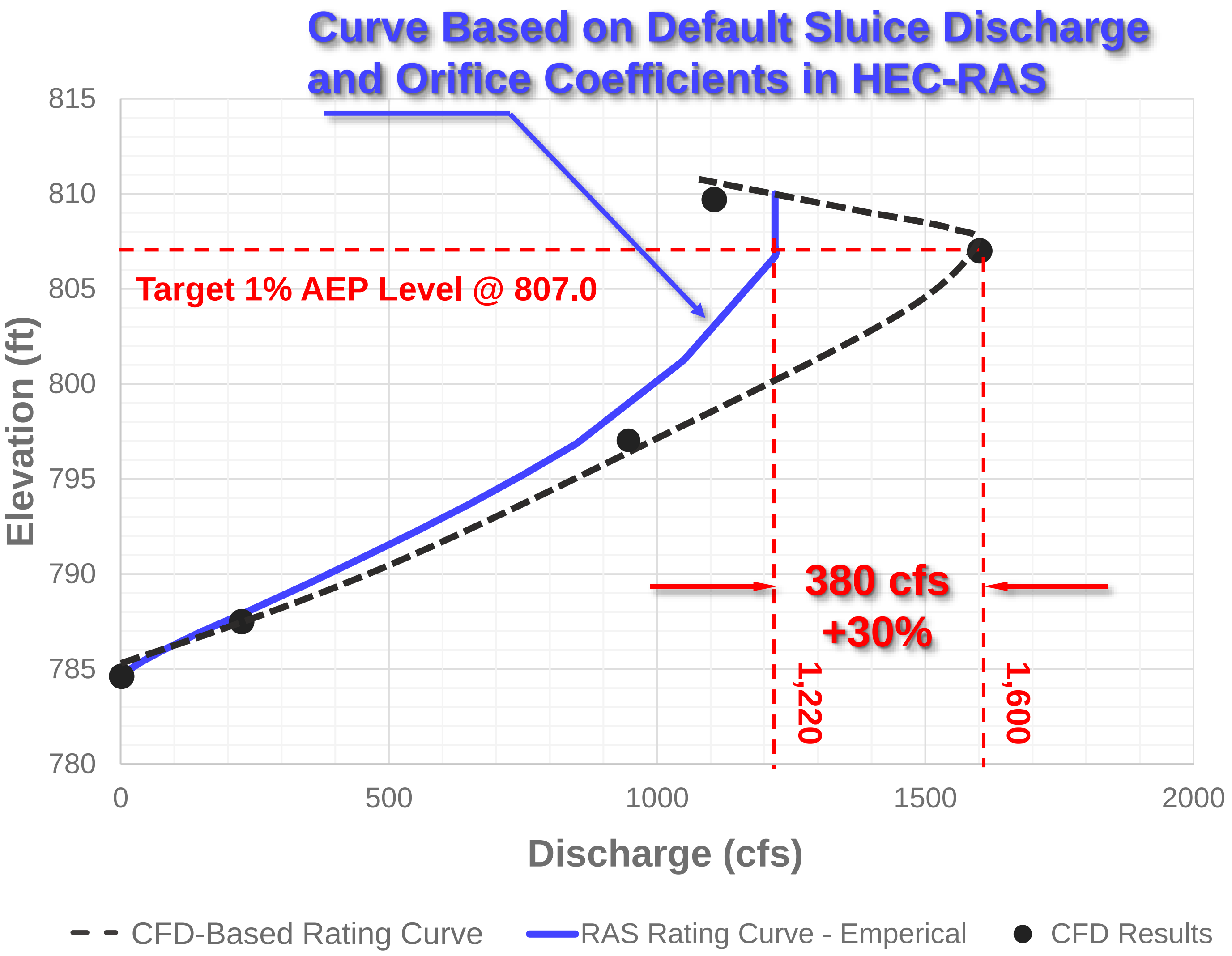
- **HW / TW Combinations Set Using 1D / 2D HEC-RAS Model Results**
  - Stage/Discharge Curve or Individual Set Points (Auxiliary Spillway Active)
- **Compared Results Against Pre-Project Design Models**
  - Flow Bias Observed Between the Ports
  - High Hydrodynamic Forces on U/S Baffle
  - Principal Spillway Discharges Higher Flows than Initially Estimated

HCFRP CFD Model Results

Initial Rating Curve

HCFRP CFD Results – Principal Spillway Design Updates Based on Initial CFD

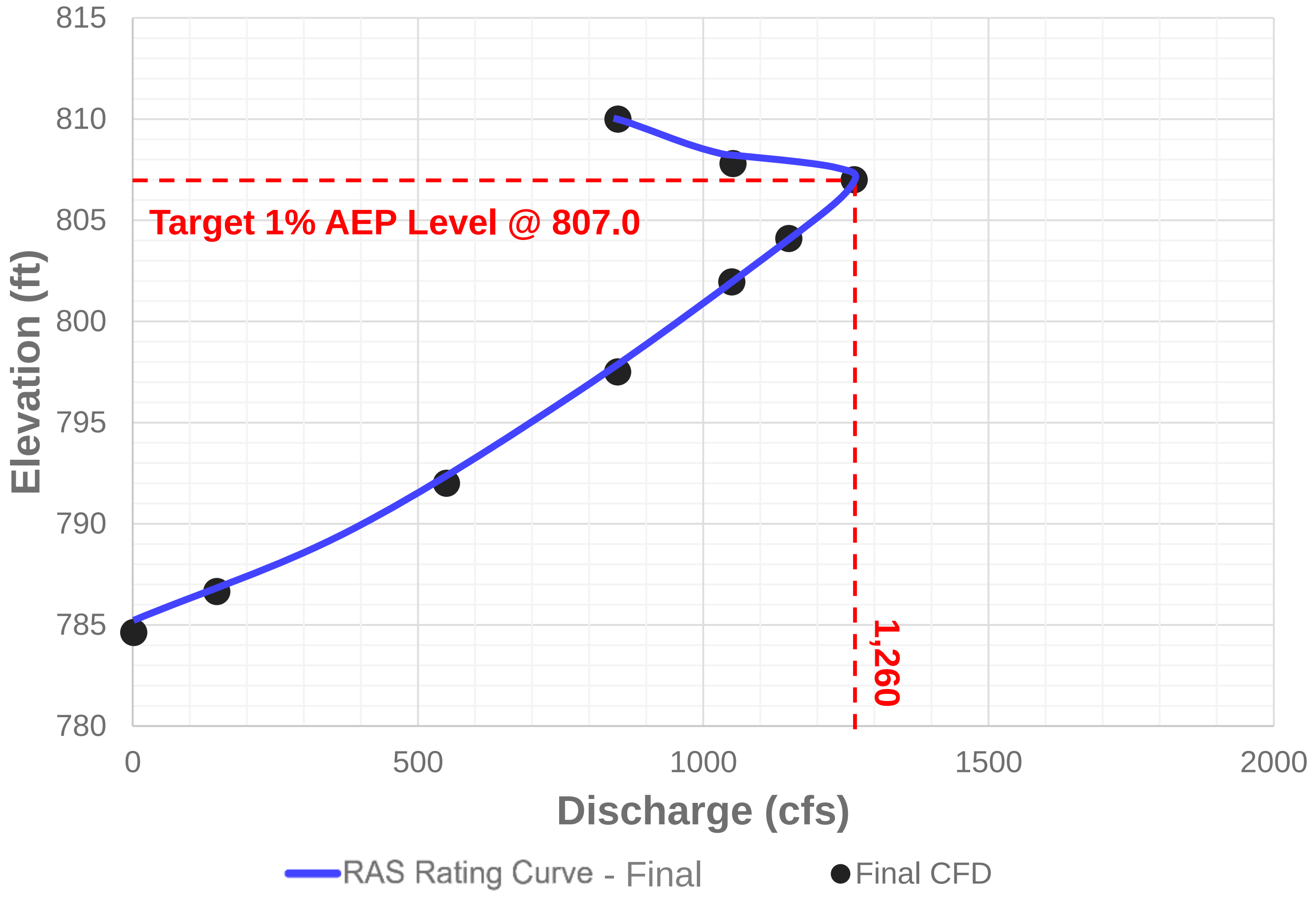
- **Comparison Between Empirical and CFD Results**
    - 30% More Flow Passed D/S at Target 1% AEP Level for 3'-2" Port Opening Heights (57 ft^2)
- **Ports Heights Revised in 1D / 2D HEC-RAS Models**
    - Developed New Rating Curve for Port Heights of 2'-5" (43 ft^2), a 24% Reduction in Open Area



HCFRP CFD Model Results
Final Rating Curve

HCFRP CFD Results – Principal Spillway Design Updates Based on Final CFD

- Comparison Between 1D / 2D HEC-RAS and Final CFD Results Matched Well
- No Further Changes to Spillway Design or 1D / 2D HEC-RAS Model Parameters Required
- "Recalibrated" 1D / 2D HEC-RAS Coefficients Using 43 ft^2 Port Opening

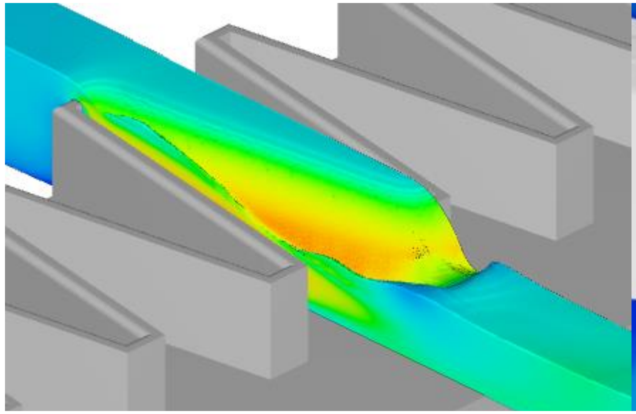


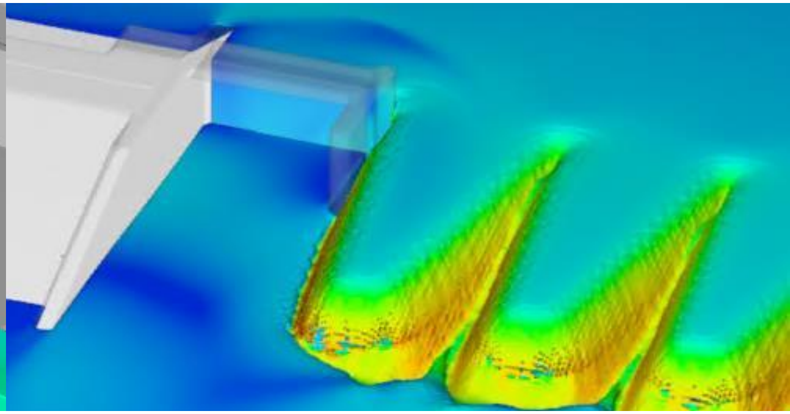
HCFRP CFD
Model Results

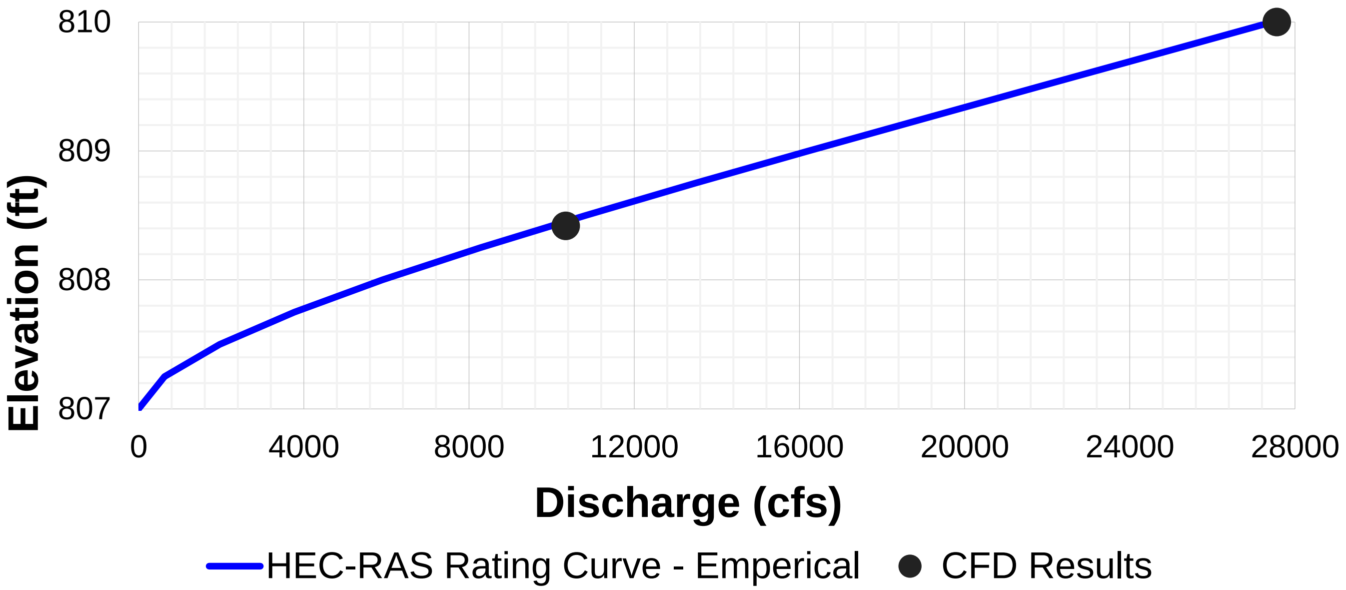
Auxiliary
Spillway

HCFRP CFD Results – Auxiliary Spillway Design Updates Based on Initial CFD

- Comparison Between 1D / 2D HEC-RAS and CFD Results Matched Well
- No Changes to Spillway Design or 1D / 2D HEC-RAS Model Parameters Required
- Increased Riprap Sizing D/S of Spilling Basin Based on Overlay of 1D / 2D HEC-RAS and CFD Model Results



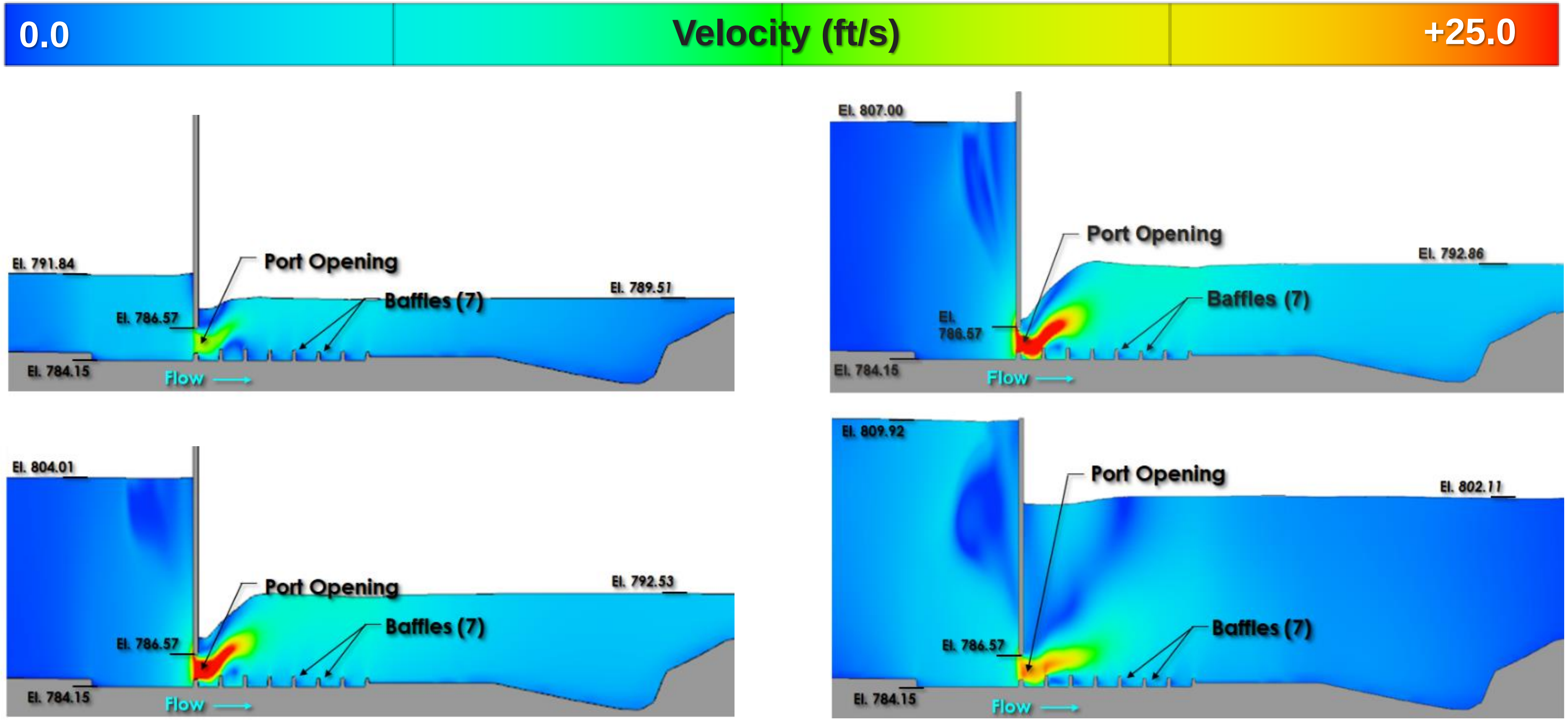




HCFRP CFD Model Results

Energy Dissipation

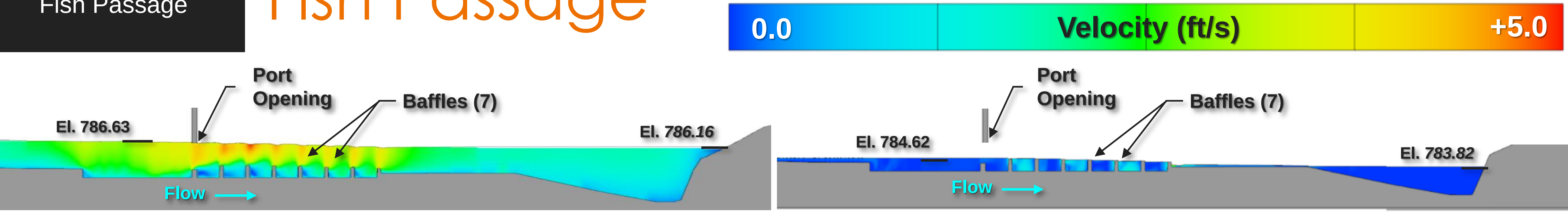
HCFRP CFD Results – Added Value Energy Dissipation D/S Principal Spillway



HCFRP CFD Model Results

Fish Passage

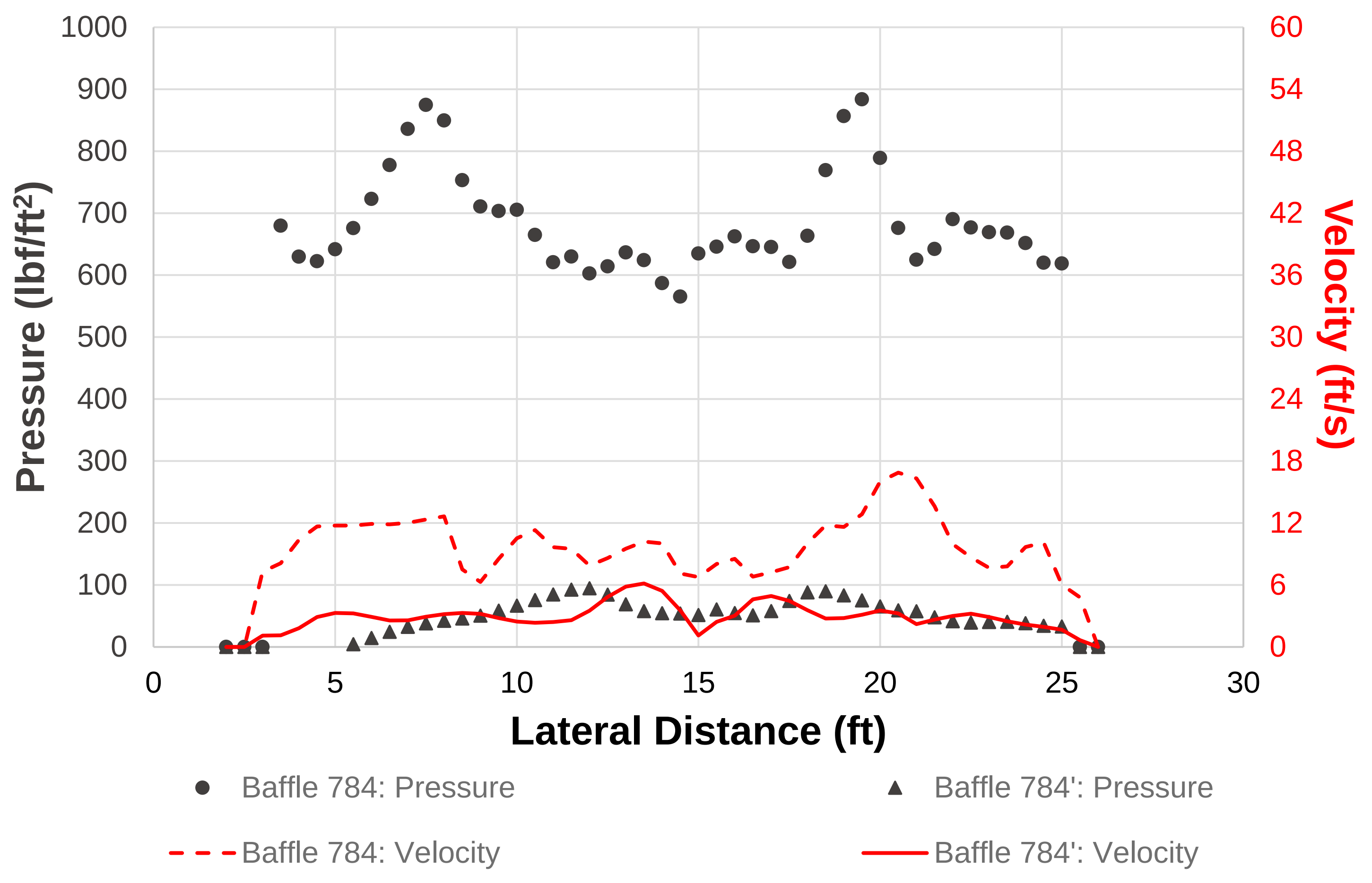
HCFRP CFD Results – Added Value
Fish Passage

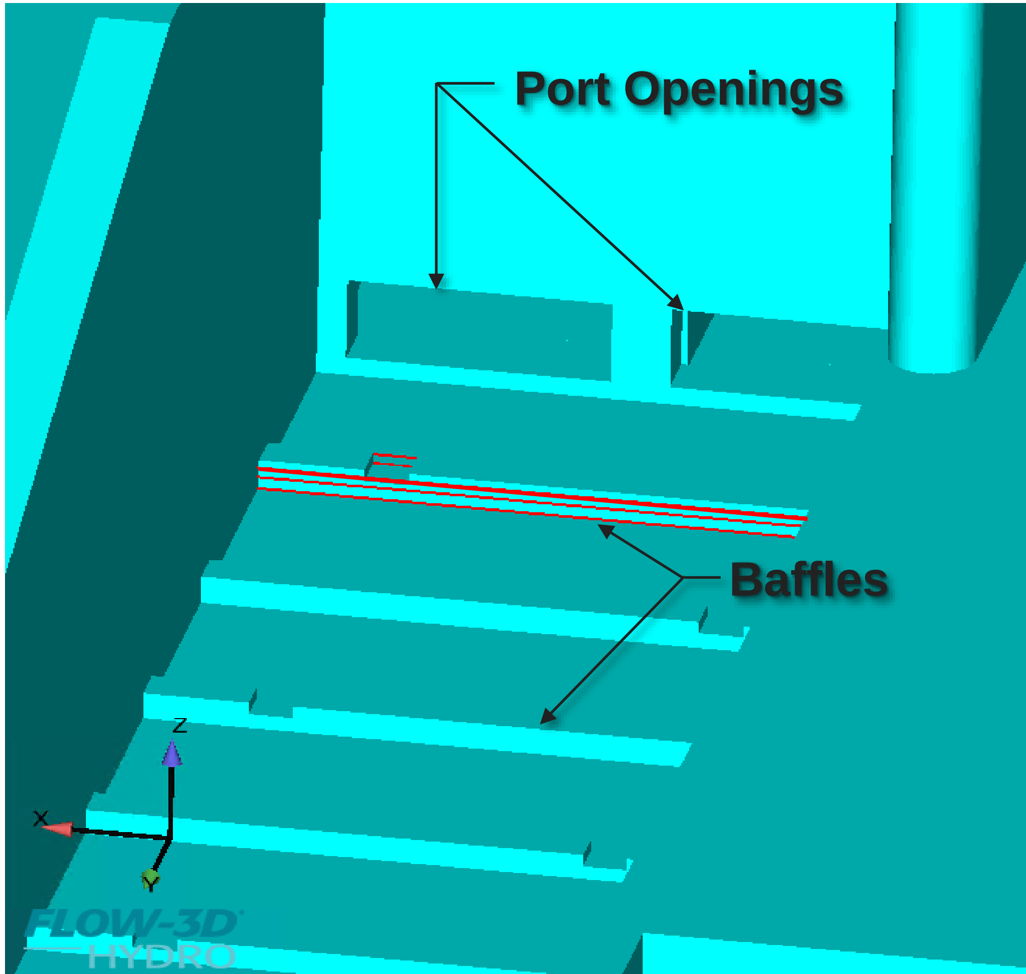


- **Target Species**
  - Channel Catfish
  - White Sucker
  - Smallmouth Bass

HCFRP CFD
Model Results
Hydrodynamic
Pressures

HCFRP CFD Results – Added Value
Hydrodynamic Pressures





HCFRP Modeling Lessons Learned

HCFRP Modeling - Lessons Learned

HEC-RAS Models Will Not Always Accurately Model Hydraulic Jumps Downstream of Sluice Gates

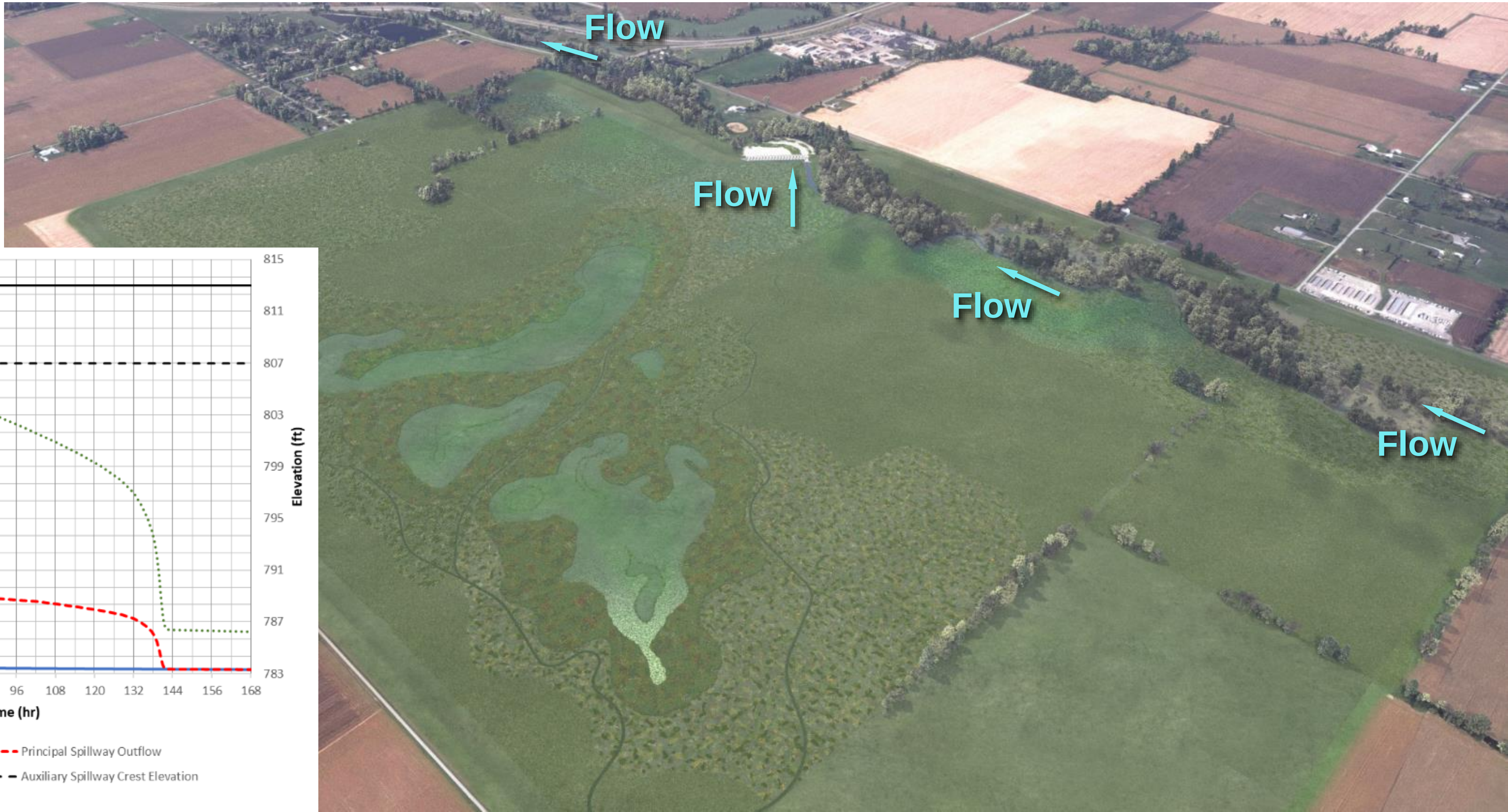
This Can Impact Results, Designs and Performance if a Hydraulic Jumps Form Downstream of the Prototype Installation

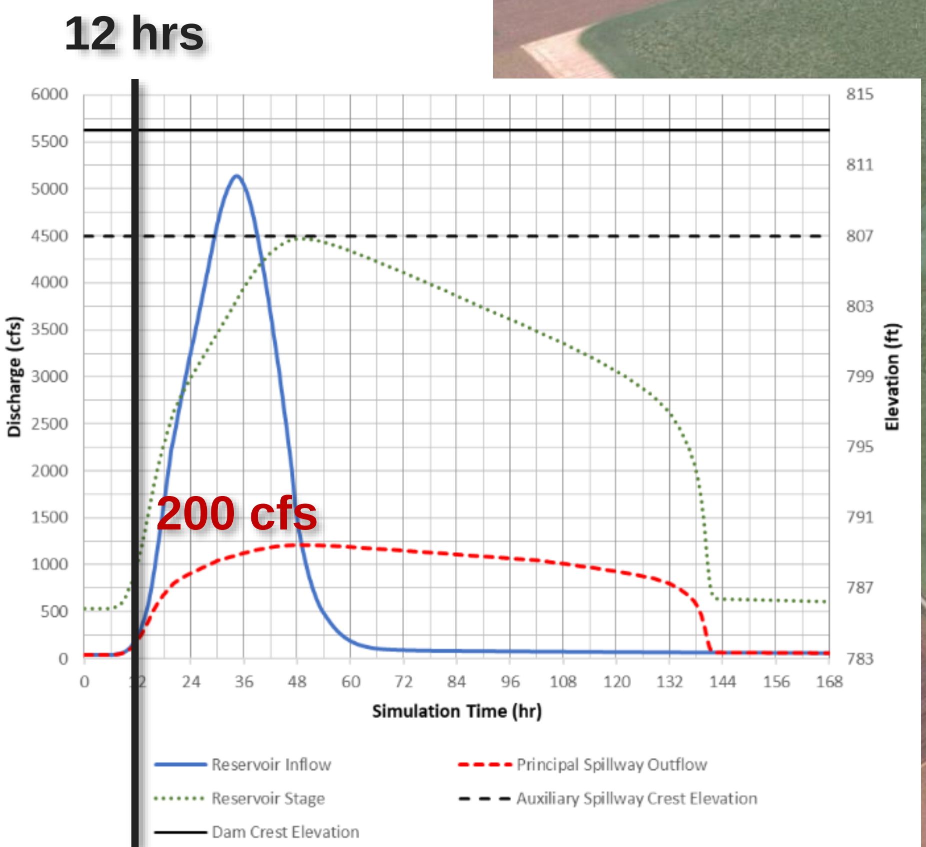
Don’t Assume Default Sluice Discharge and Orifice Coefficients in 1D / 2D HEC-RAS are Appropriate for all Structures or HW /TW Combinations

Always Make Sure to Validate Results in a Design Project Against Other Methodologies When Possible (Empirical, 1D, 2D, CFD, Physical Modeling, etc.)

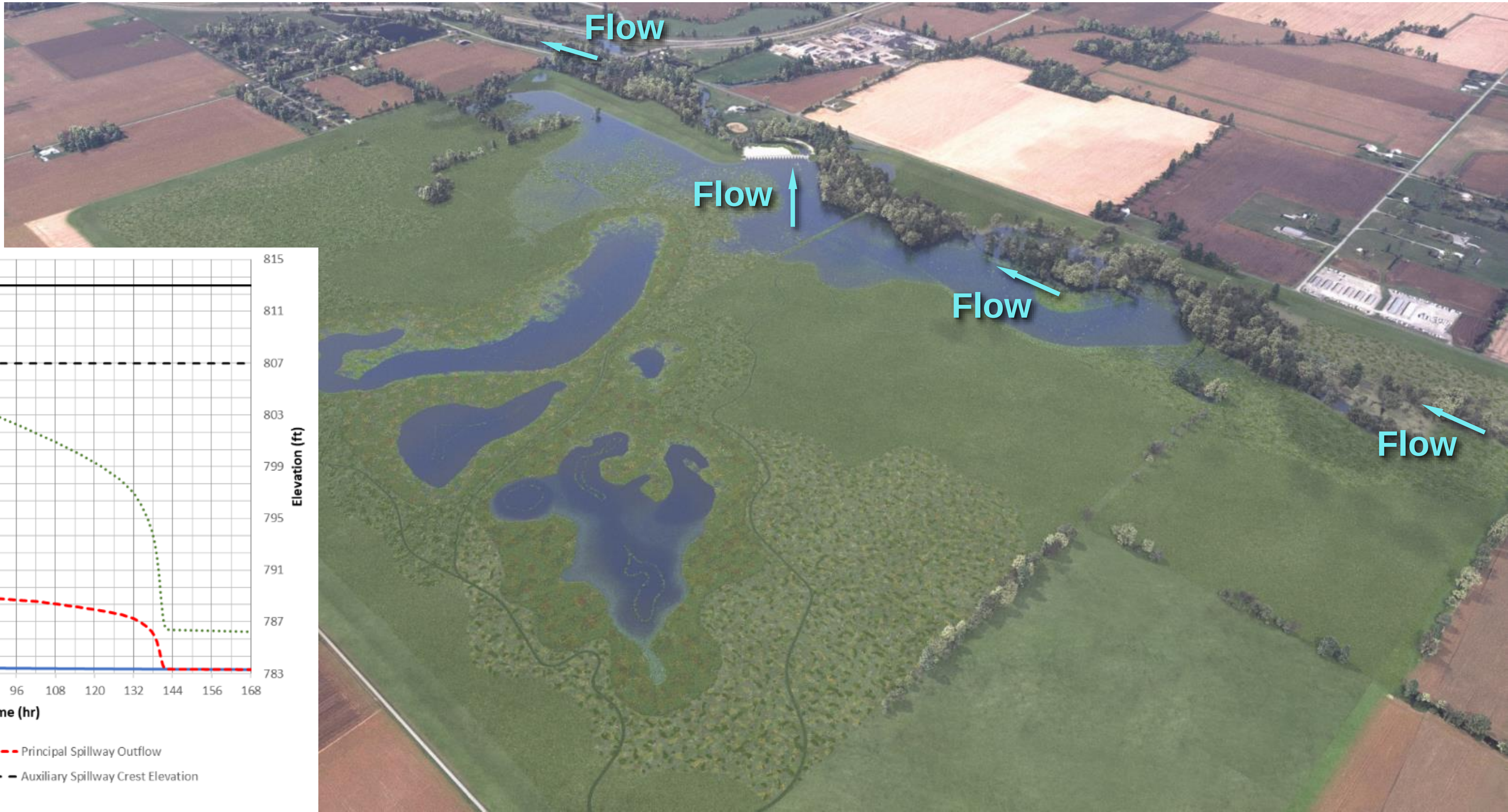
HCFRP Project Benefits

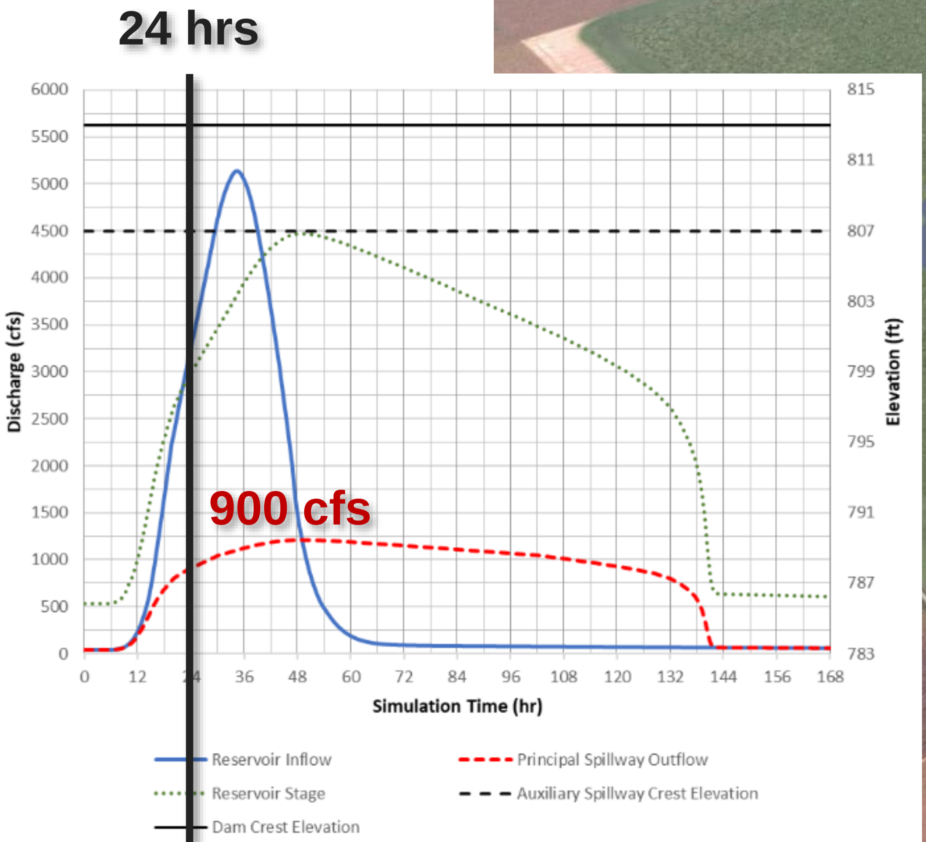
HCFRP Project Benefits
Flood Routing Simulation – 1% AEP





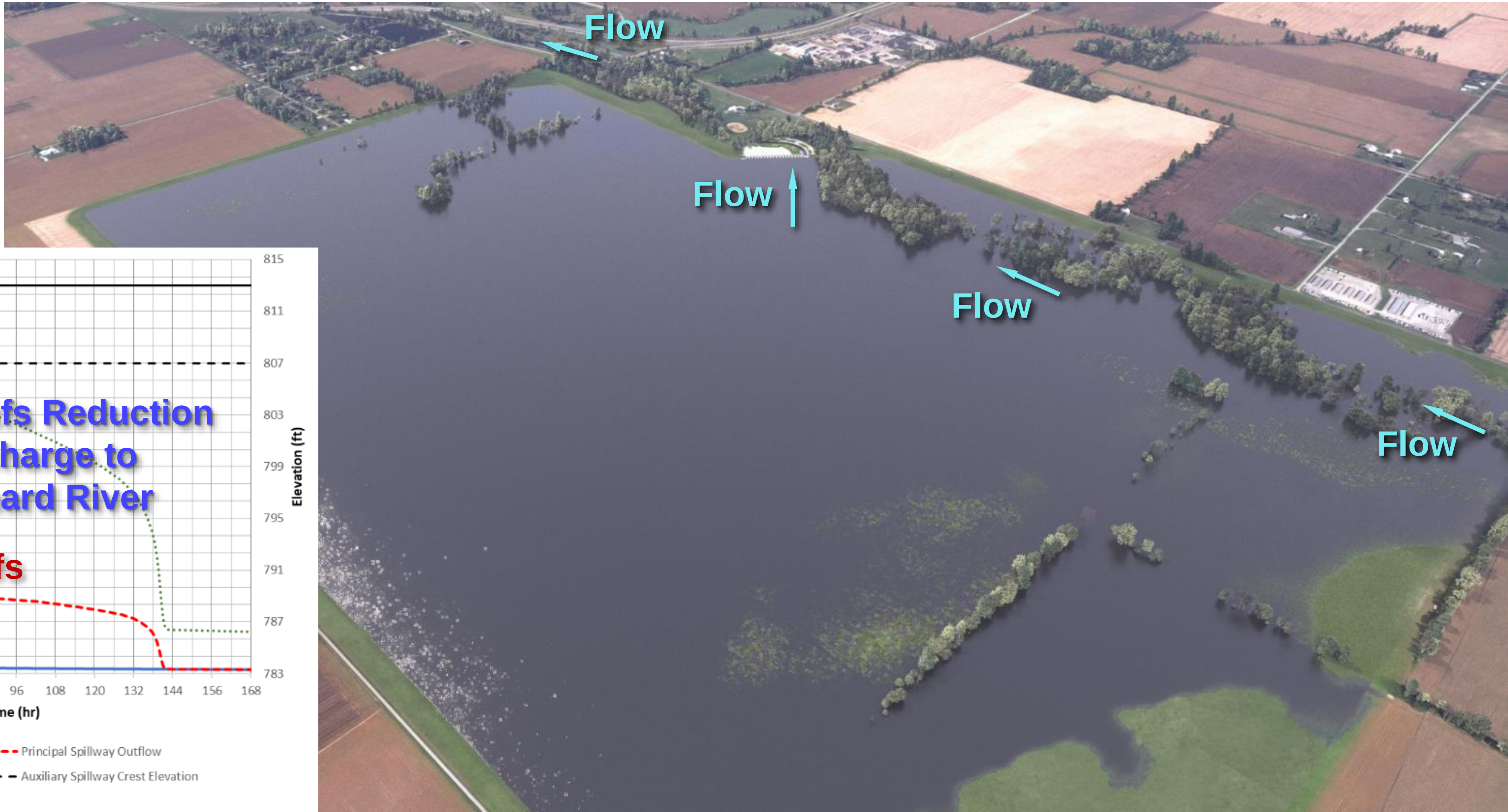
HCFRP Project Benefits
Flood Routing Simulation – 1% AEP

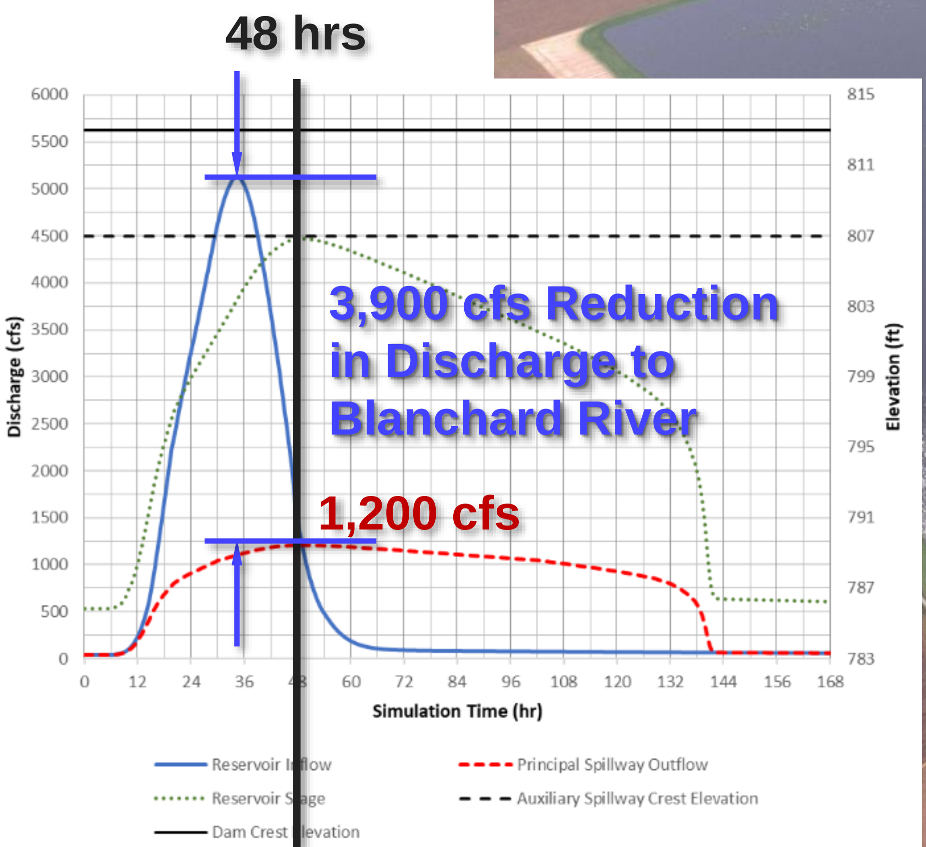




HCFRP Project Benefits

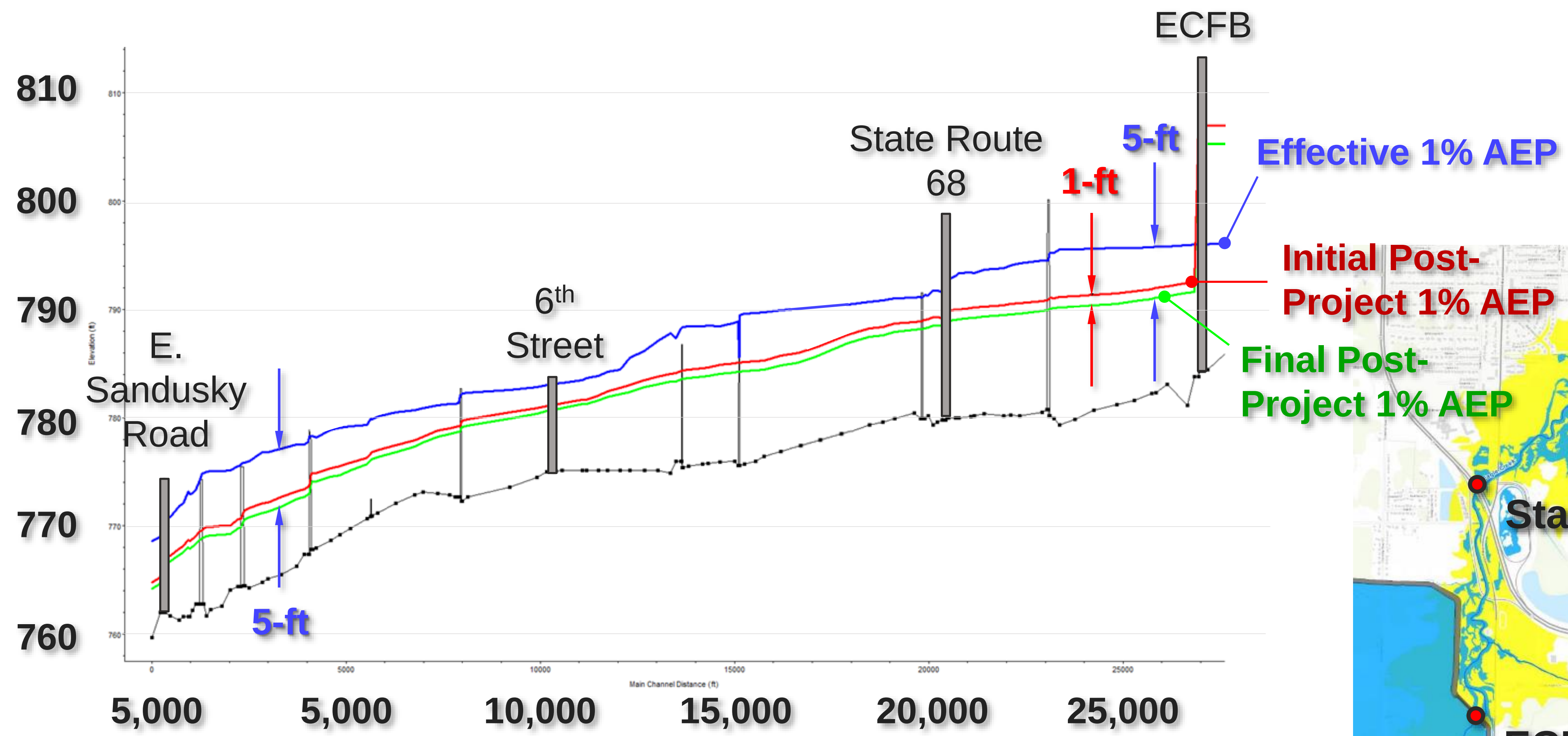
HCFRP Project Benefits
Flood Routing Simulation – 1% AEP

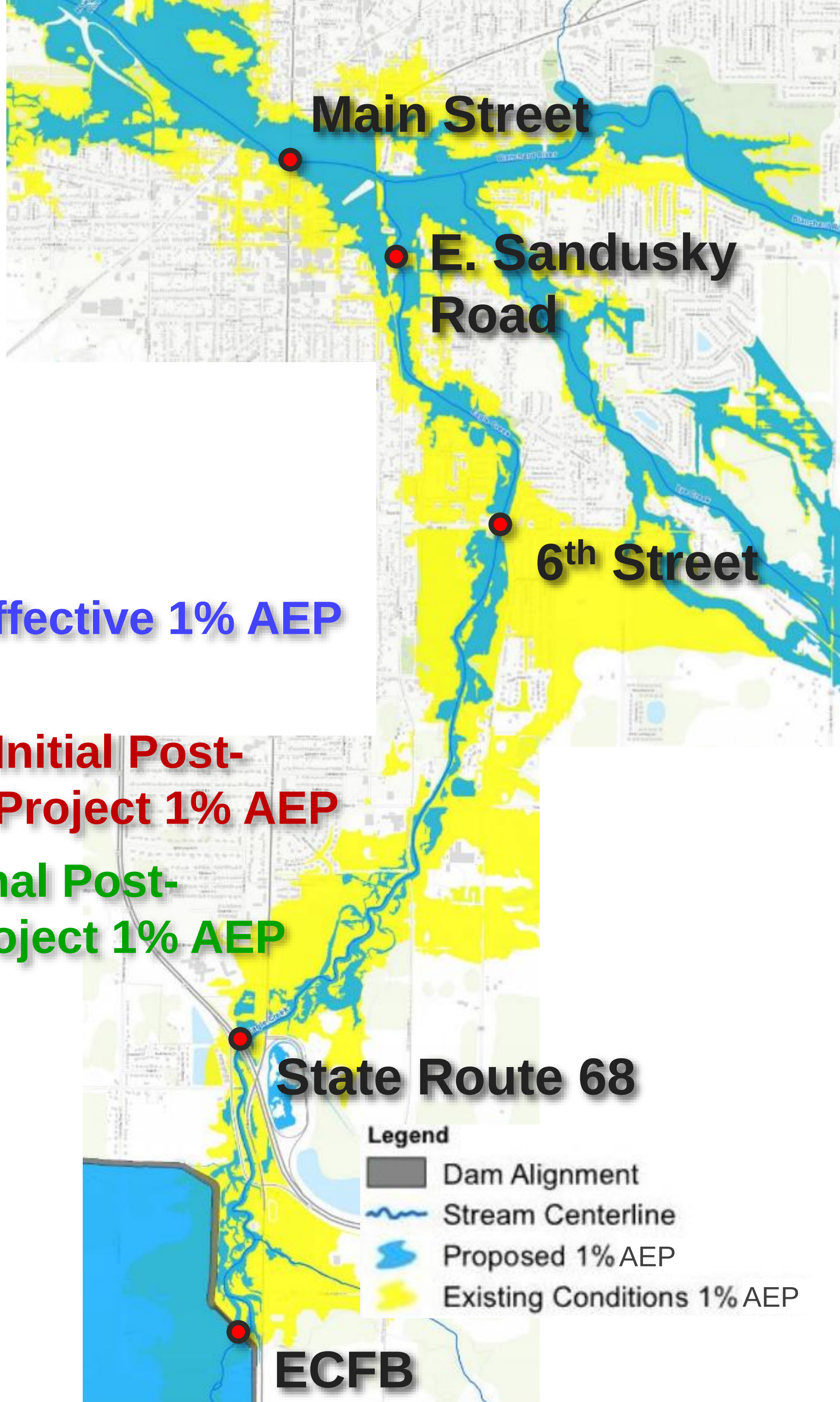




HCFRP Project Benefits

HCFRP Project Benefits 1% AEP Comparisons





HCFRP Project Benefits

HCFRP Project Benefits

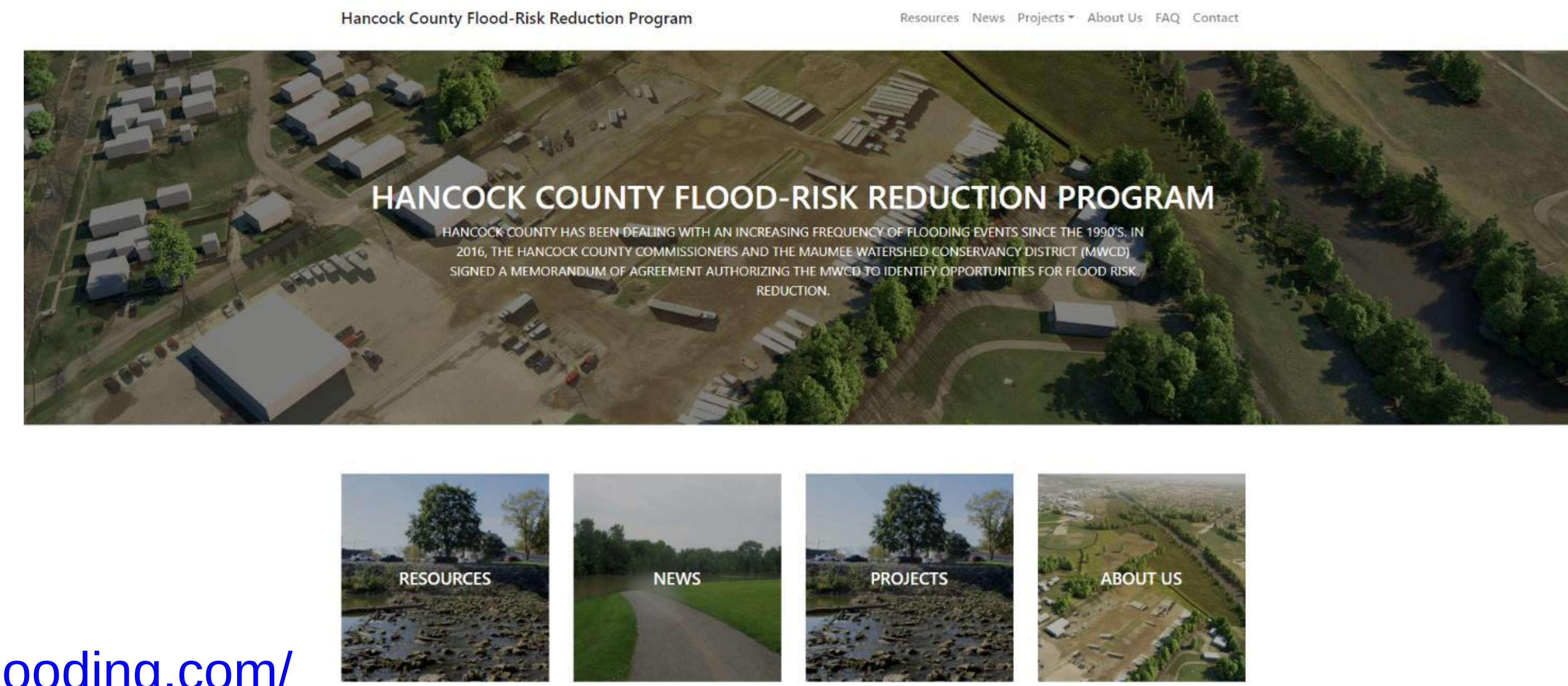
- Overall Project Projected to Lower Flood Levels in Downtown Findlay by 1 to 2 ft During the 1% AEP
- Projected Removal of 1,740 Parcels from Current FEMA Floodplain
- Projected Removal of 1,680 acres from Current FEMA Floodplain
- BCR Increased from Less than 1.0 to 2.2
- US 68 & SR 15 Will Remain Open to Traffic During Flood Events

Questions

Questions?

- Justin Bartels, PE, CFM
- justin.bartels@stantec.com
- (312) 831-3267

- Lila Fehr, PE
- lila.fehr@stantec.com
- (312) 831-3044



https://hancockcountyflooding.com/