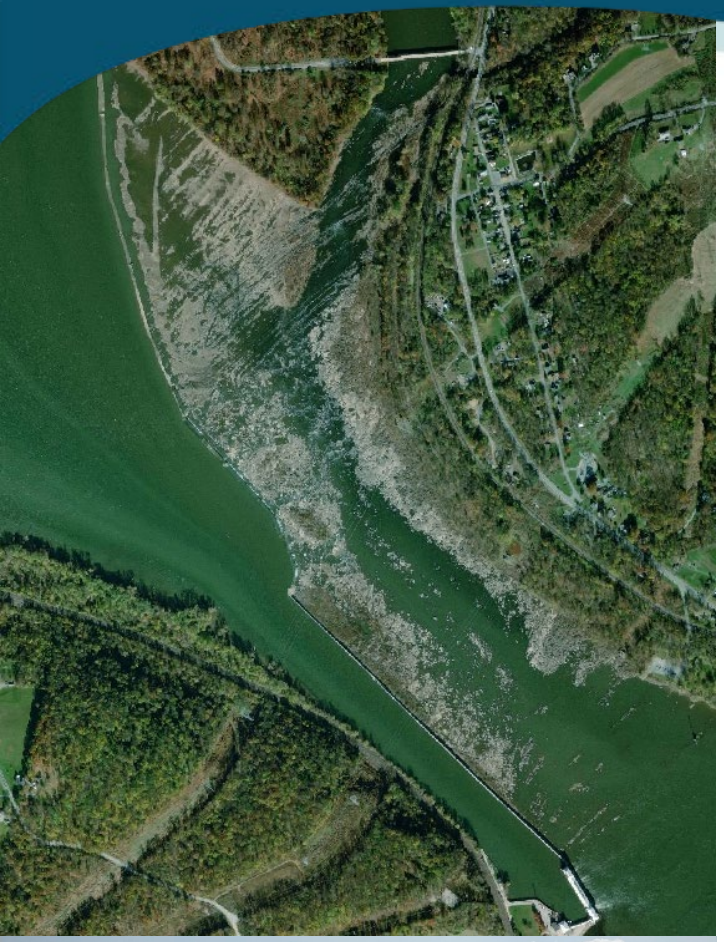

Kleinschmidt

2D Hydraulic Modeling of a Nature-Like Fishway using HEC-RAS

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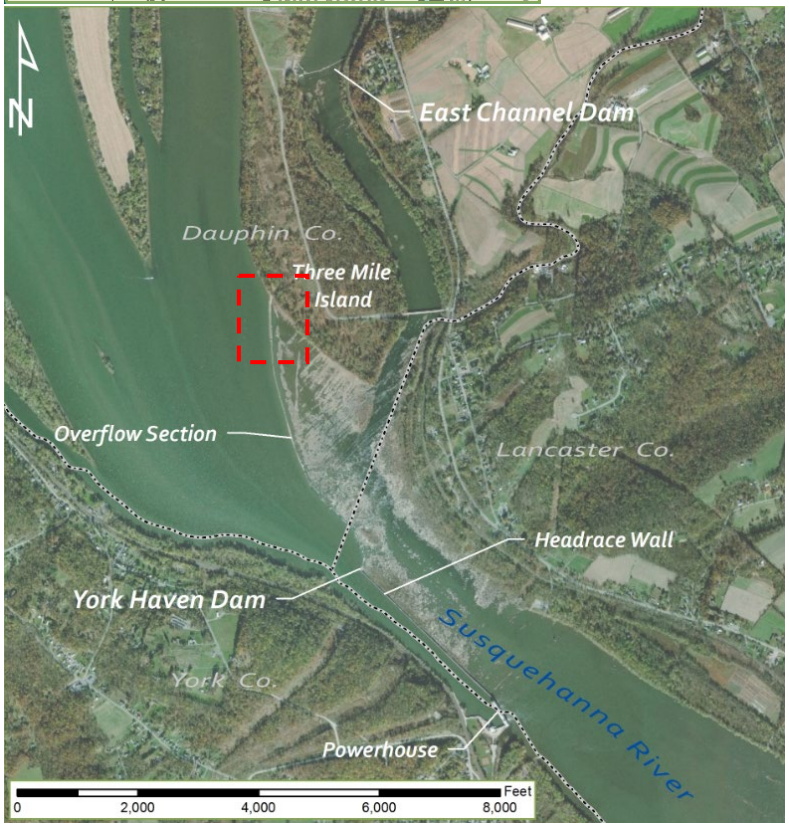
Project Background and Objectives

- Located on Susquehanna River in southeast Pennsylvania
- FERC License agreement to provide fish passage upstream of York Haven Dam using a Nature-Like Fishway (NLF)
- NLF design developed in 2016 by previous consultant

<u>Primary Objective</u> – Develop a 2D model to inform hydraulics of 2016 Design and help inform alternative design

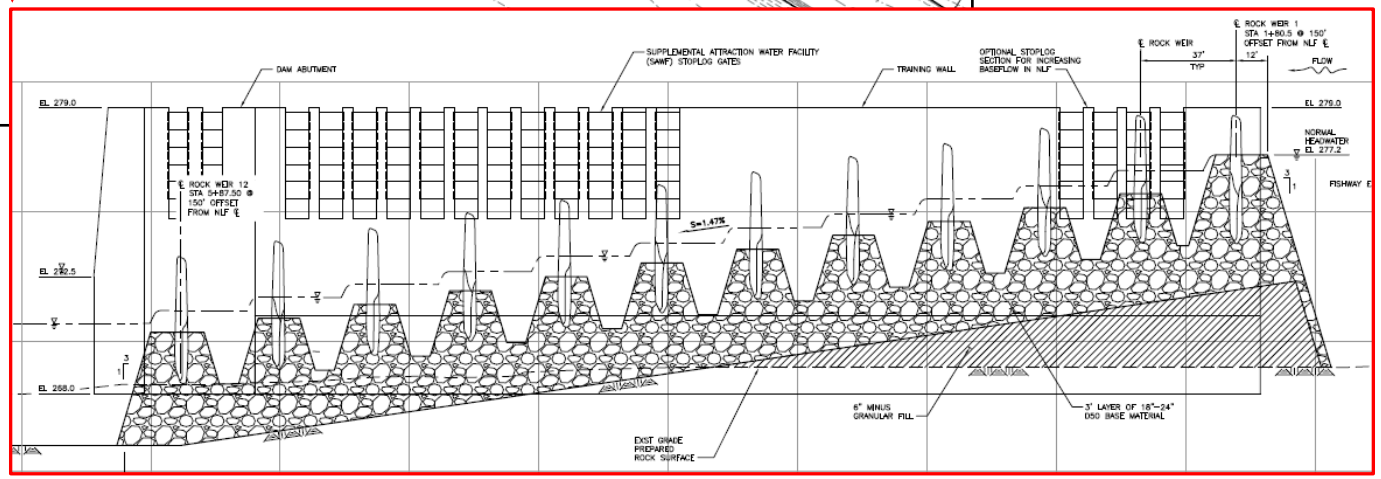


Fish Passage Criteria

- Target species
  - American shad
  - American eel
  - Alewife
  - Blueback herring
  - Various resident species
- Flow Capacity – 5% of total river flow (5,000 to 150,000 cfs river flow)
- Depth – Minimum 1 foot through weir notches
- Velocity – < 6 feet/second

Original 2016 NLF Design

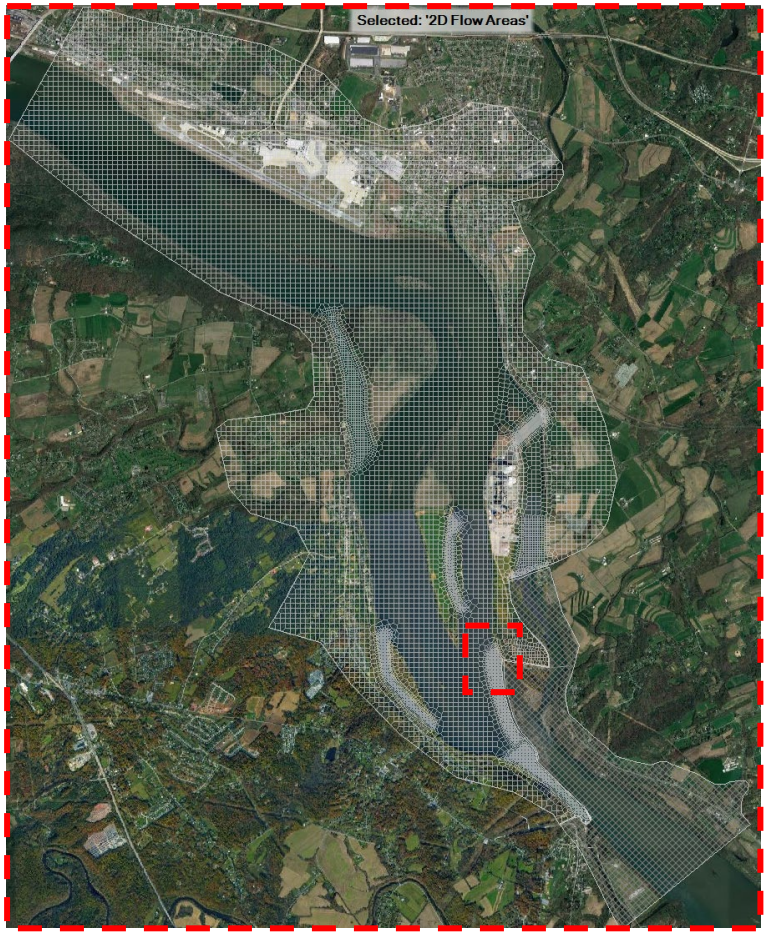
NLF



Supplemental Attraction Water System

Our Modeling Approach

- Step 1 -Develop 2D model of section of Susquehanna River Existing Conditions – "coarse" Scale model; informs "fine" scale boundary conditions
- Step 2 – Calibrate to available data (flow distribution; stage-discharge)
- Step 3 – Develop Proposed Conditions model with 2016 Design at "coarse" scale from Existing Conditions Model—informs boundary conditions
- Step 4 – Develop "fine" scale model of NLF



Coarse Scale Model Development and Calibration

1 – Flow Distribution West+Middle vs East Channel

2 – Tri-County Marina

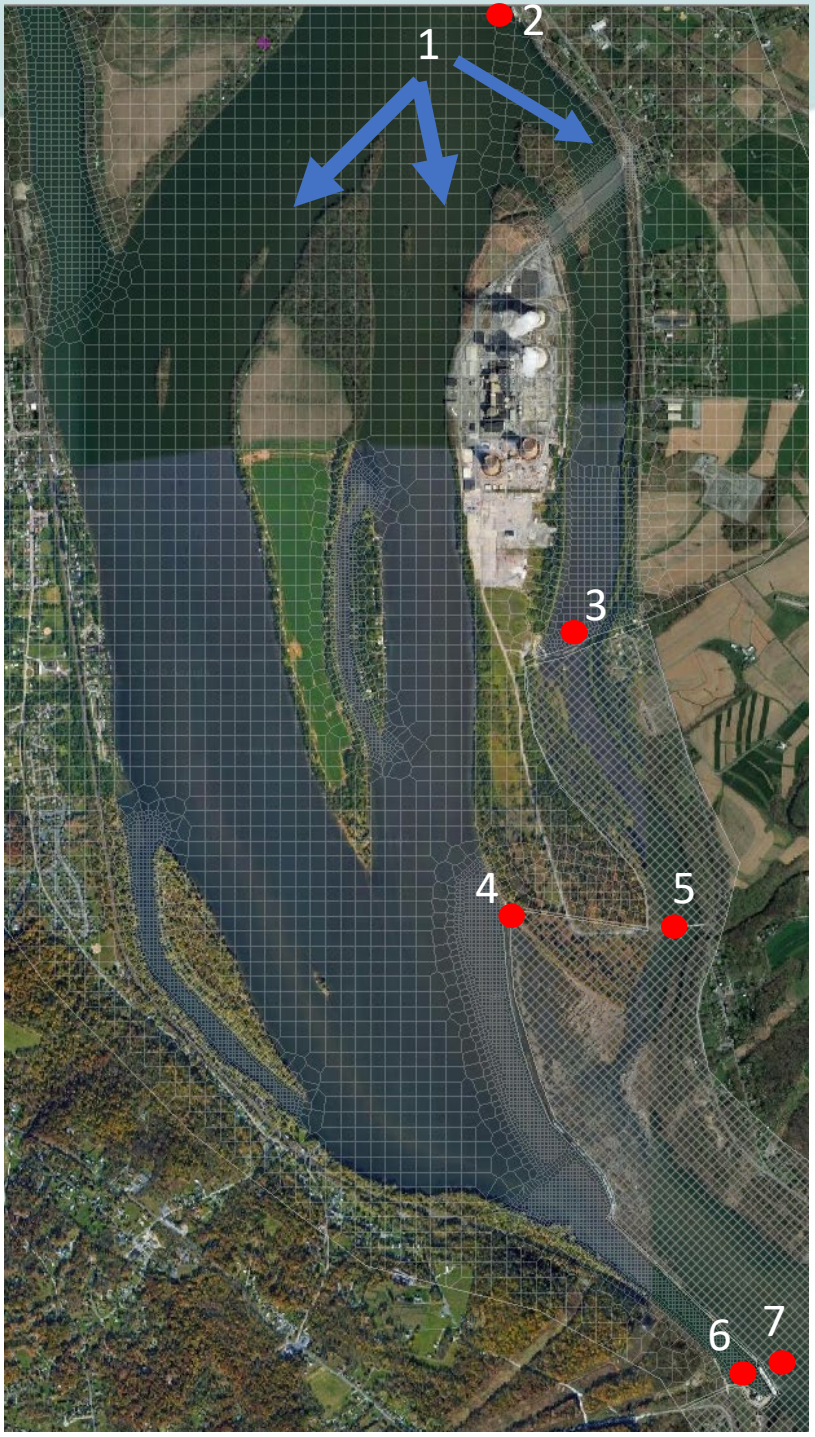
3 – East Channel Dam Headpond

4 – Dam Headpond at Three Mile Island

5 – Three Mile Island South Bridge

6 – York Haven Dam Powerhouse headpond

7 – York Haven Dam Powerhouse tailwater



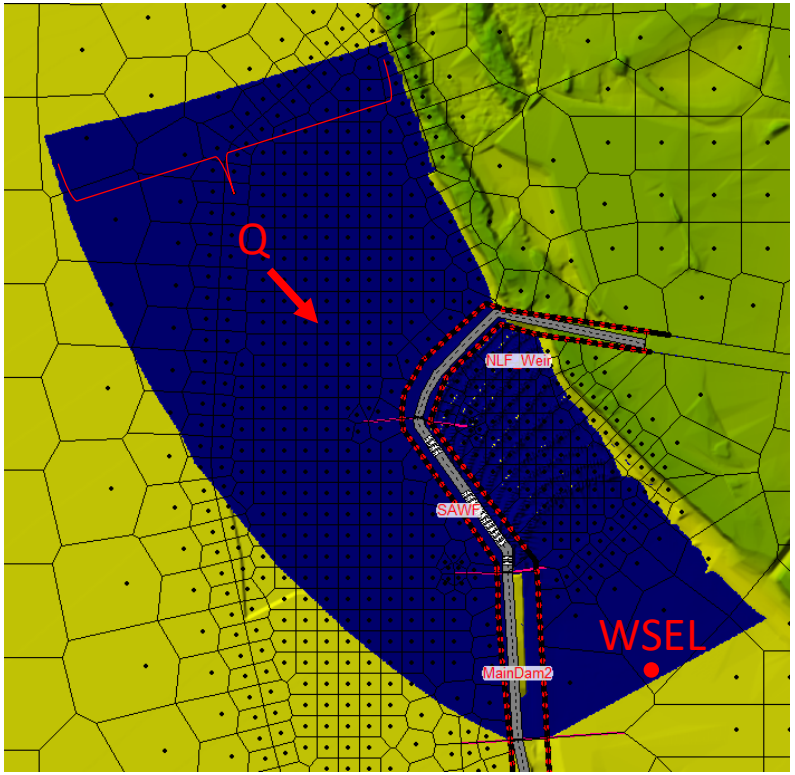
Fine Scale Model Boundary Conditions

Upstream Boundary

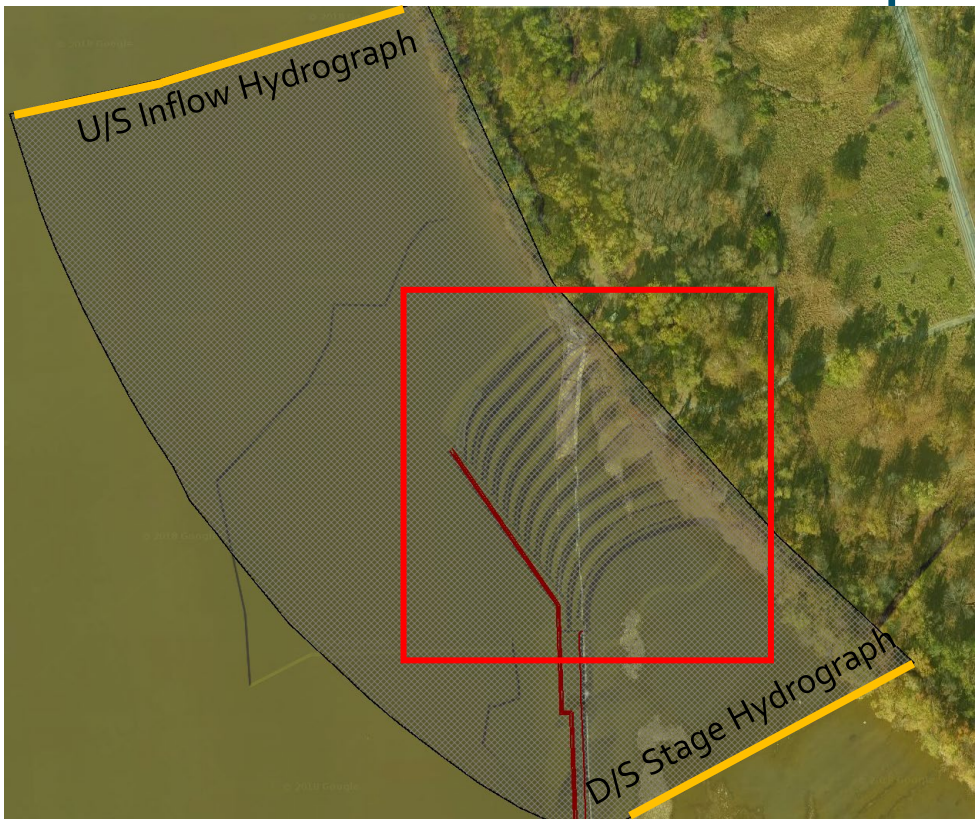
- Inflow Hydrograph
- Amount of flow determined by measured by determining inflow to Fine Scale domain at the Coarse Scale
  - Flow passing over 1D structure elements (NLF upstream weir + Supplemental Attraction Flow Structure+ section of York Haven Dam spillway)

Downstream Boundary

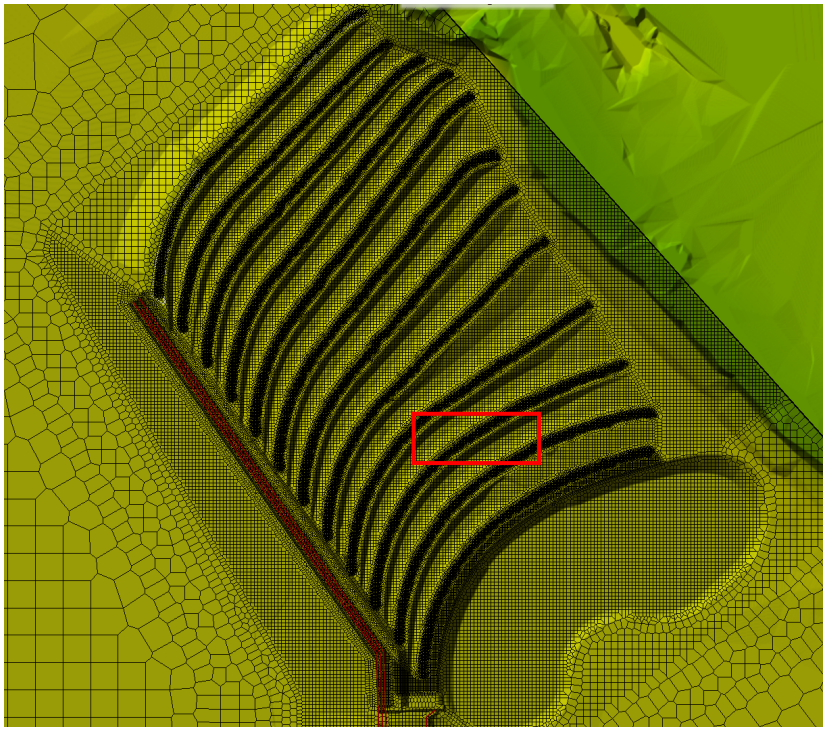
- Stage Hydrograph
- WSEL measured at model domain terminus on downstream side



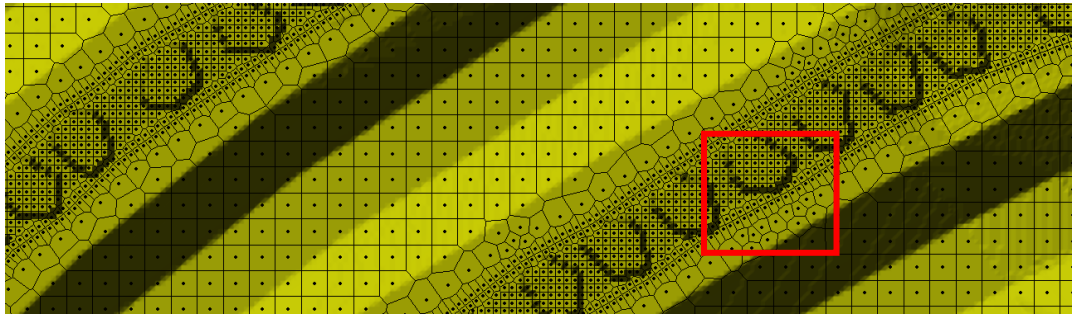
Fine Scale Model Development

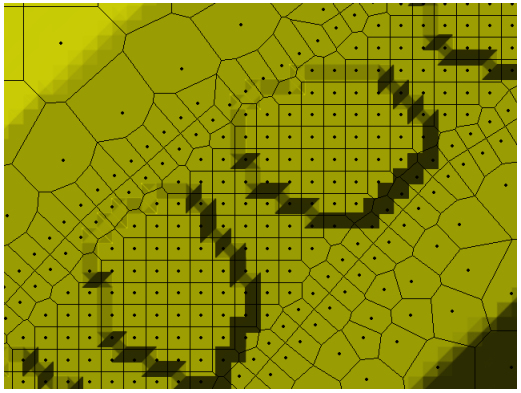


3 feet (generally) cells up to 96 feet



0.75 foot spacing between boulders



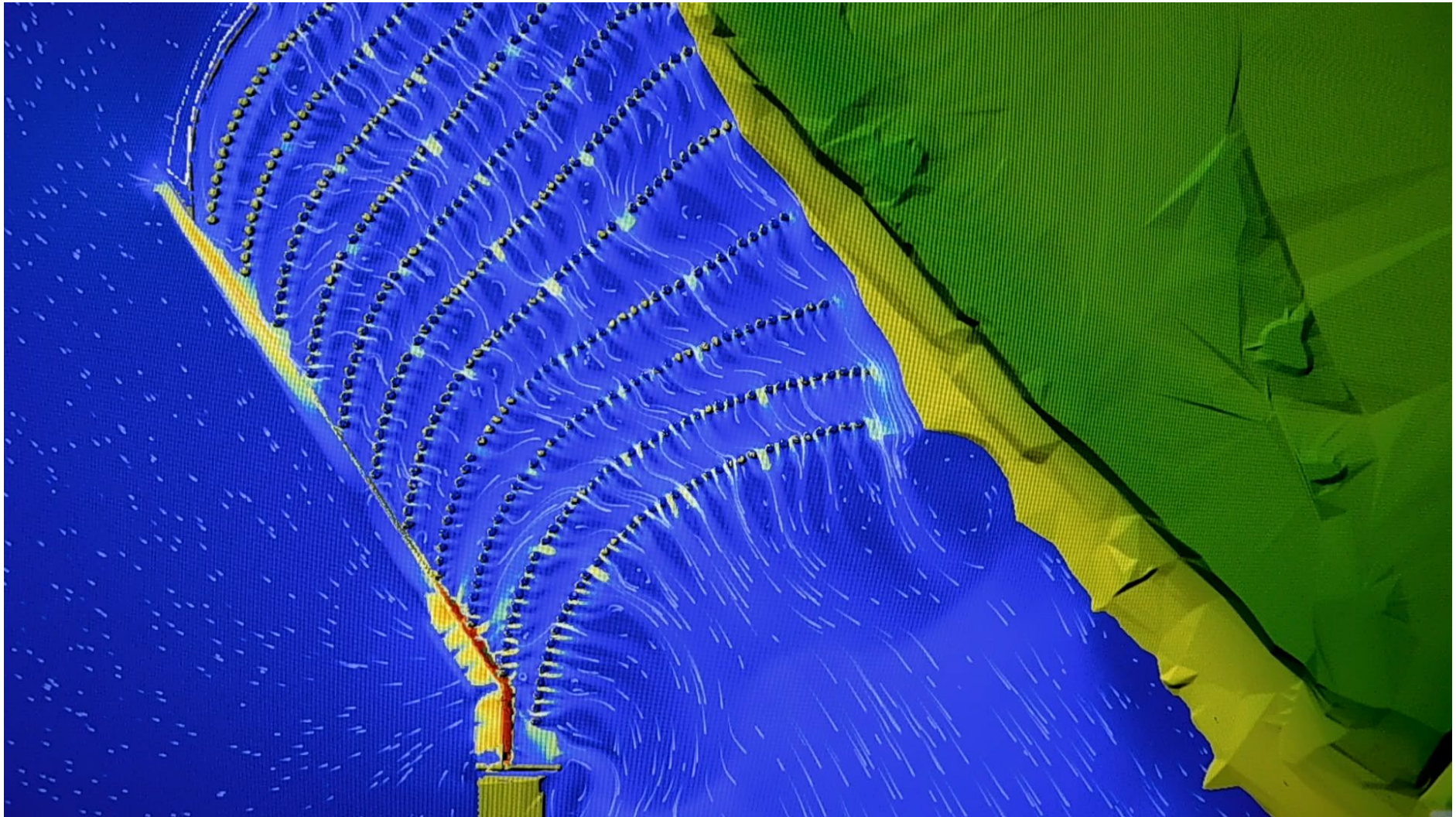


Modeling Challenges

- Cell Size – effects Courant Number, numerical errors
  - Solution – Reduced as velocity ↑; Increased in placid areas; reduced in NLF (to capture hydraulics)
- Timestep – effects Courant Number, numerical errors, ability to complete simulation iterations
  - Solution – Reduced to keep Courant ≤ 1.0; Reduced total simulated time
- Cell Orientation – Across internal 1D structures
  - Solution – Break lines along structures
- Boundary Locations – avoiding boundary effects
  - Solution – increased total grid area; used TW Check in RAS
- Initial Conditions – single 2D area with constant WSEL initially
  - constant water elevation of U/S used, fishway "drained" with time

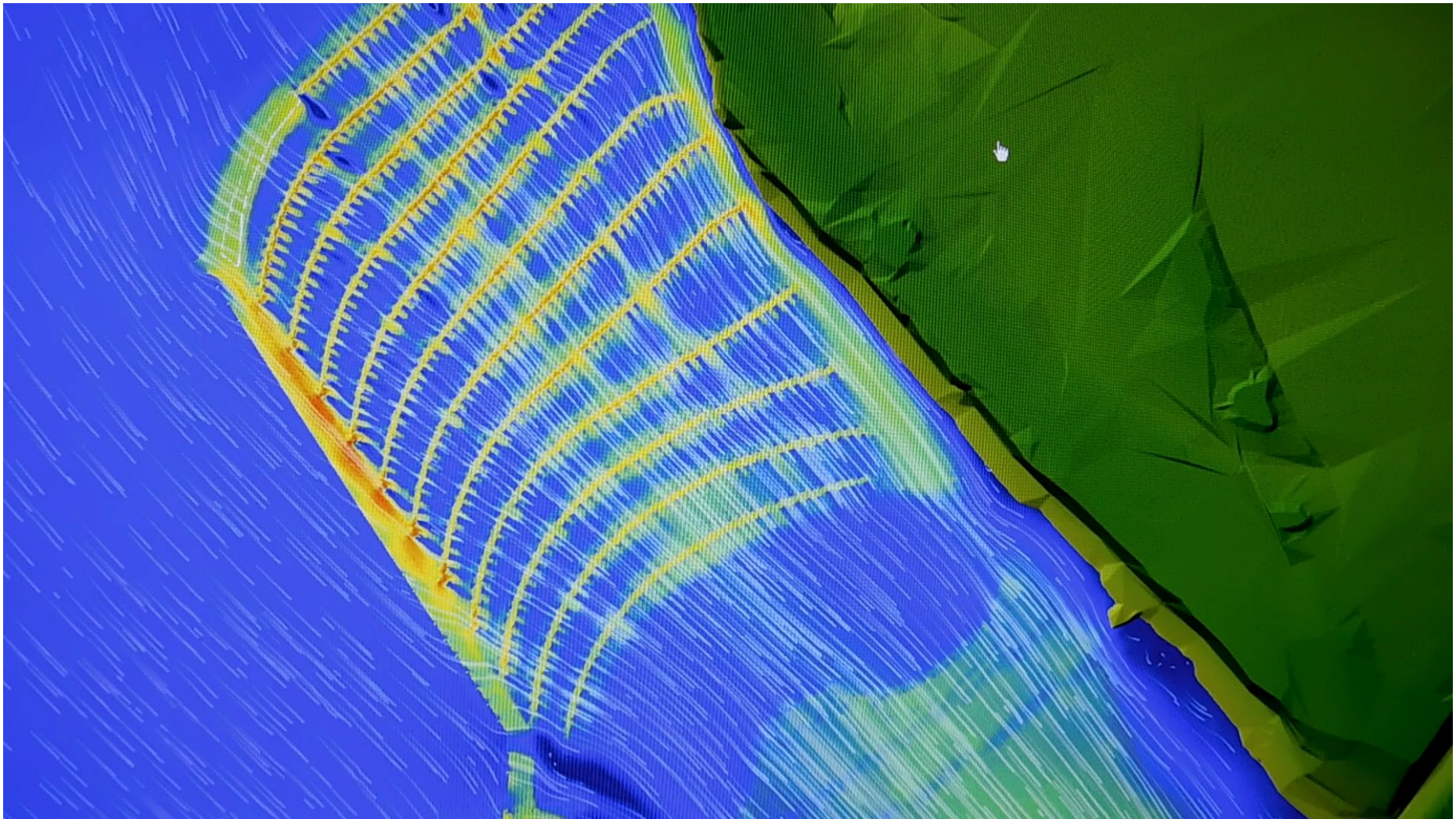
Fine Scale Model Results – Low Flow

95 % Fish Passage Season Exceedance Flow (12,400 cfs River Flow)



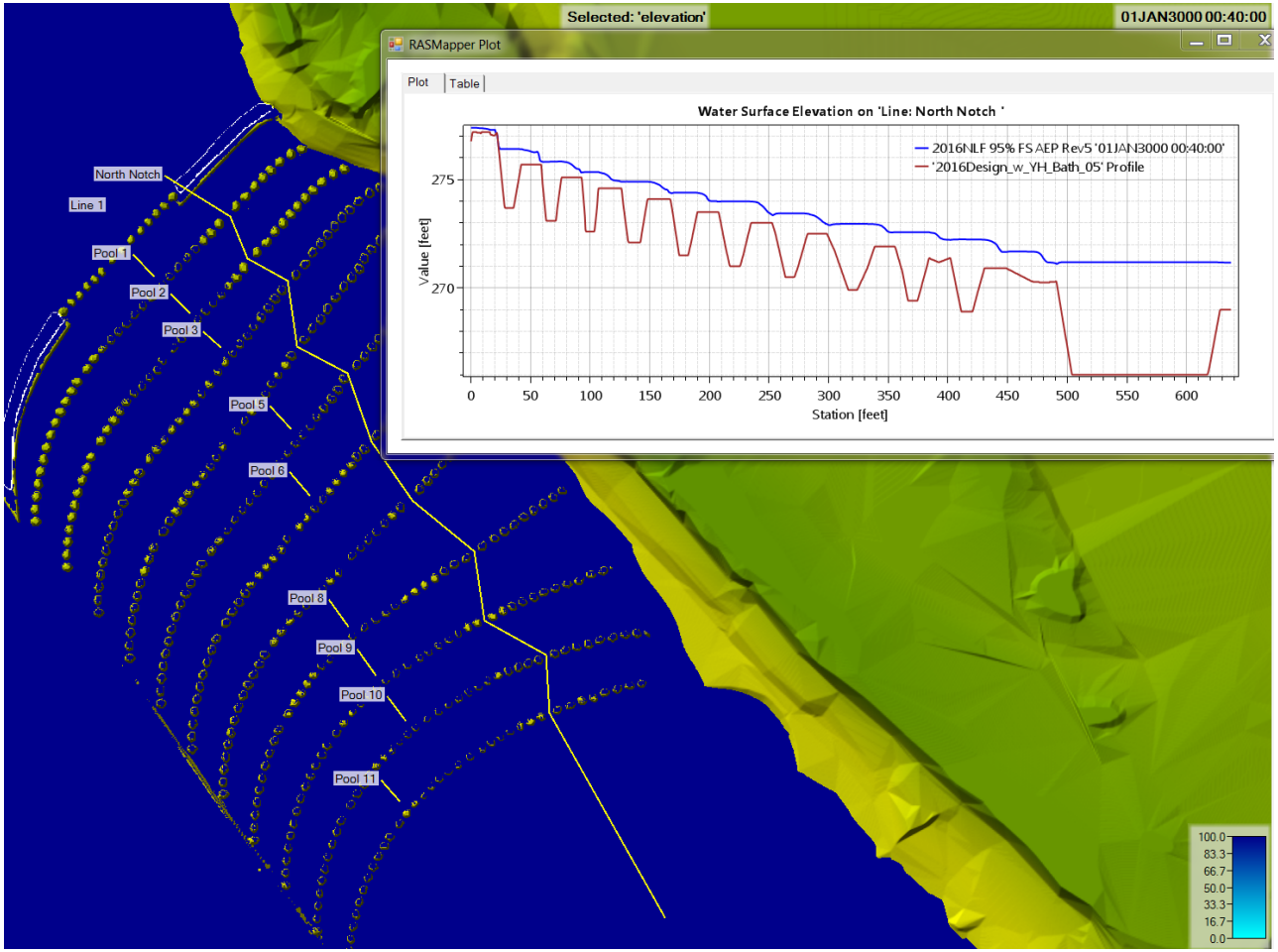
Fine Scale Model Results – High Flow

5 % Fish Passage Season Exceedance Flow (119,800 cfs River Flow)

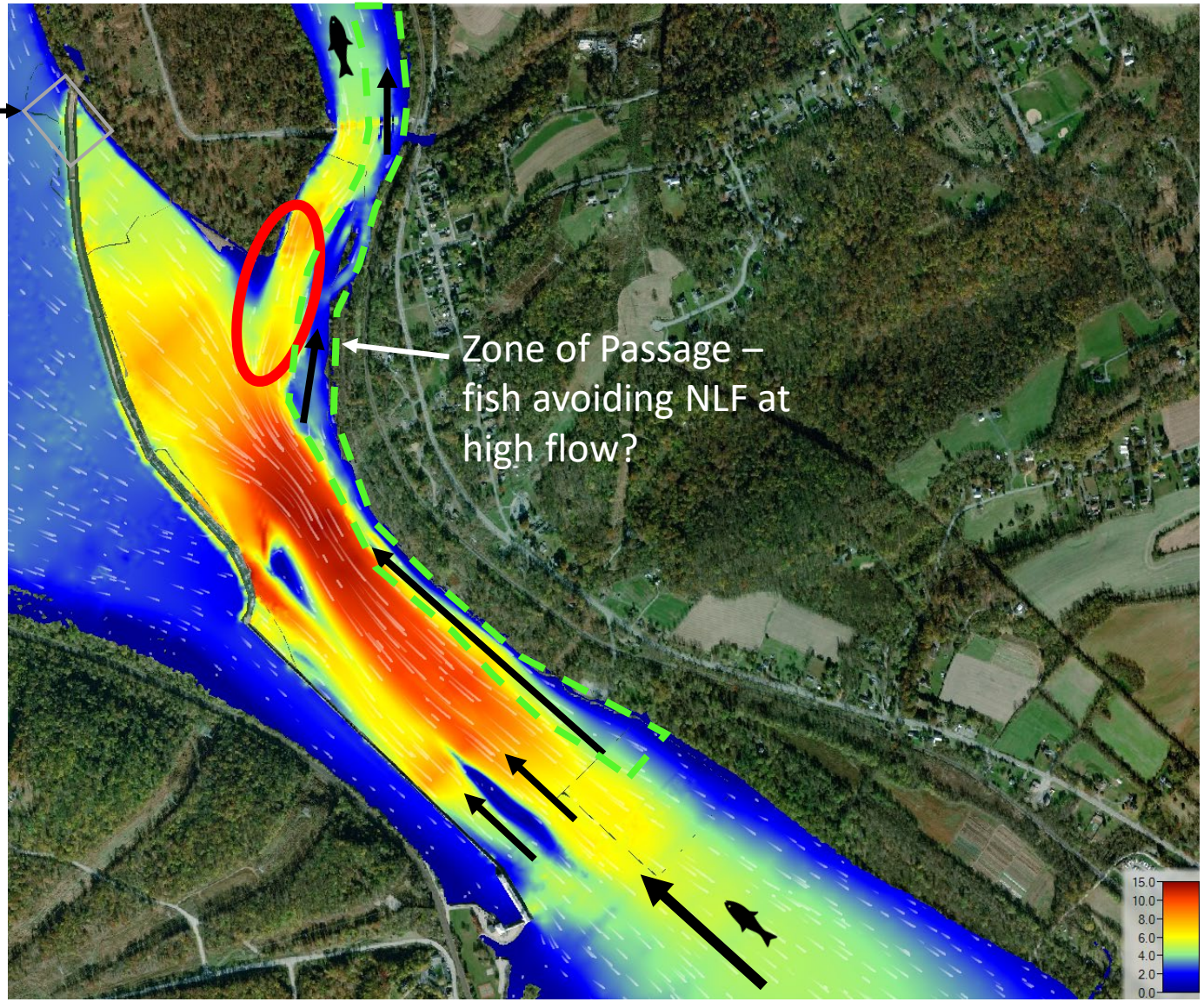


HEC-RAS Mapper Data Viewing

- Ability to draw profile lines, retrieve hydraulic data (depth, velocity, flow, etc.) along a profile and over time.
- Provide customer detailed data to inform stakeholders
  - Low flow notch depth/velocity
  - Flow through NLF vs rest of river



Hydraulic Issue Identified by Model



Design Moving Forward

- Leverage the model to optimize the overall model footprint of the NLF
- Compare results with physical data at site.
- Continue to develop model
- Using model to assess/compare Alternative Designs
- Model validation/verification with aid of Penn State University 3D (OpenFOAM) and Physical Model

Conclusions

- HEC-RAS a powerful tool for assessing NLF hydraulics at small scales
- HEC-RAS Mapper allows retrieval/assessment of detailed hydraulic data (velocity, depth, etc.)
- Model results show opportunities for fish passage optimization.