2022 Fish Passage and Stream Restoration Training

Module 6: Modeling with SRH-2D

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- Olympic Region

- **Current Duties:** Fish passage project design & management in the Olympic region.

- **Background & Experience:** 2 years in consulting and ~6 months at WSDOT

- **Education:** B.S. in Civil and Environmental Engineering, UU; B.A. in Anthropology, GSU; M.A. International Relations, AMU

- **Personal Interests:** Hiking, the humanities, hugging trees, and playing in the water

Agenda

- Brief overview of SRH-2D
- Documentation required for PHD/FHD reports and appendices
- Special topics

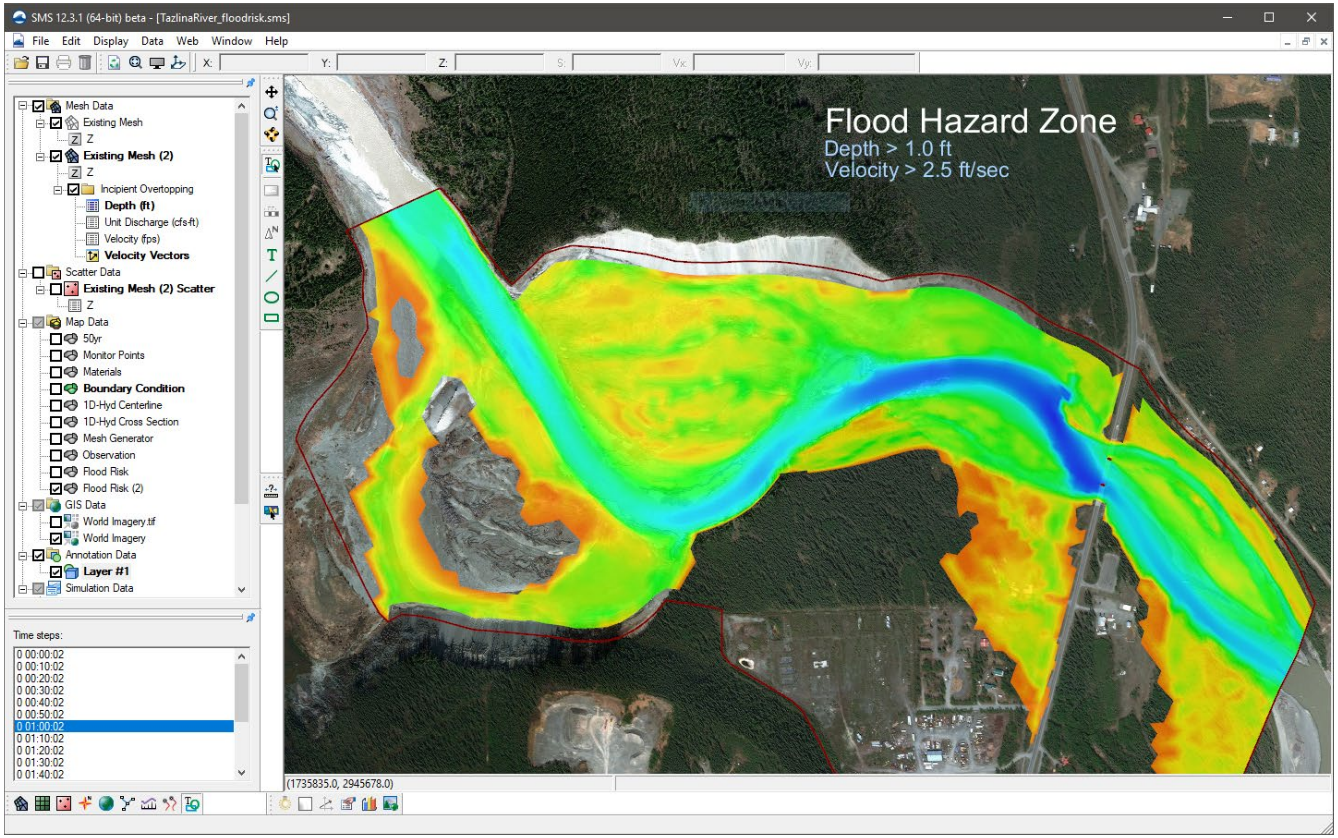
Learning Objectives

- Understand
  - What is SRH-2D and why we use it
  - What modeling and results documentation is required per the hydraulic design templates
  - What level of detail is required
  - How to conduct model review and packaging for submittal

- NOTE: This module is *NOT* a how-to guide for SRH-2D
  - Resources:
    - Aquaveo tutorials
    - NHI Training Course
    - 2D Hydraulic Modeling for Highways in the River Environment Reference Document
    - FHWA SRH-2D User's Meetings
    - WSDOT SRH-2D User's Meetings (*Hannah Morsch: morschh@wsdot.wa.gov*)

What is SRH-2D?

- SRH-2D is a 2-dimensional numerical hydraulic model run through SMS (GUI)
- Developed at the USBR
- FHWA-approved model and required by WSDOT



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Why Use 2D Models & SRH-2D?

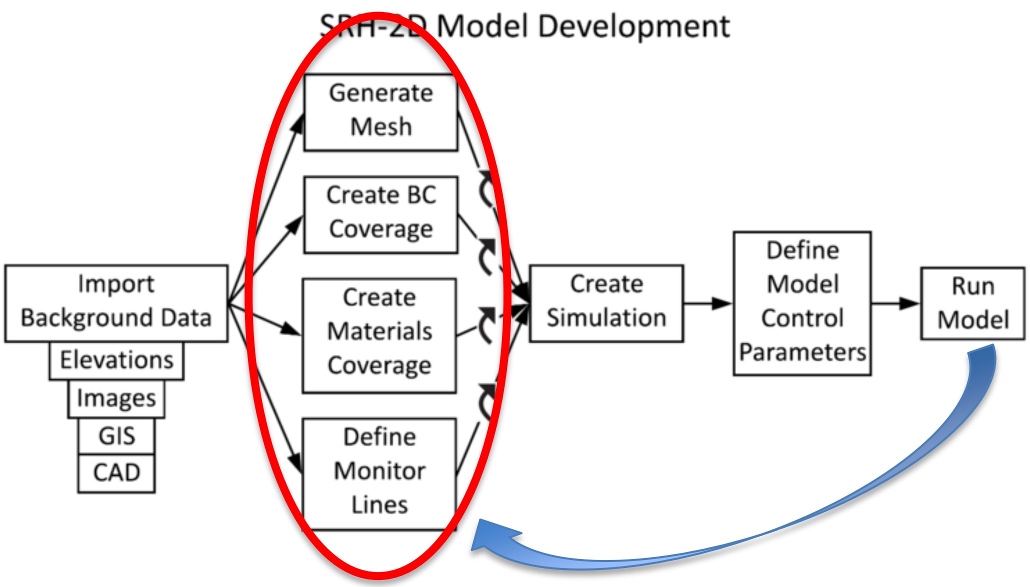
- 1D vs 2D – more detailed channel hydraulics and floodplain impacts
- Focused on transportation projects
- Flexibility – multiple ways to represent structures and other controlling features
- Depth-averaged flow – generally a safe assumption
- Robustness and stability
- Relatively user-friendly

- Limitations
  - Precision of results (tenths of a foot)
  - Depth-averaged flow
  - Time-consuming

1D vs 2D MODELING		
Variables	**1D Modeling**	**2D Modeling**
Flow direction and paths	Modeler's assumption	Computed by model
Ineffective flow areas	Modeler's assumption	Computed by model
Flow contraction/ expansion through structures	Modeler's assumption	Computed by model
Water surface elevation (WSE)	Assumed to be constant across XS	Discrete WSE at each element across XS
Velocity	Computed as average across cross-sections AND assumed to be perpendicular to XS	Discrete velocity at each element across XS (magnitude AND direction)
Roughness values	Assumed to be constant between XS	Discrete roughness values at each element in model

Model Development

- Consider project scope, level of detail required (PHD vs FHD)
- Import background data
- Create input files (coverages) and set controls
- Calibrate (if possible)/validate model



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Import Background Data

- Survey data
- LiDAR (validated)
- Coordinate system
- Key topographic features
- Reference reach vs proposed reach

Create Input Files (Coverages) and Set Controls

- Coverages
  - Mesh geometry for existing, natural (if required), and proposed conditions
    - Rectangular vs triangular (patch vs paving)
    - Element size
    - Feature/hydraulic controls representation
    - Domain limits
  - Materials
  - Boundary conditions
  - Monitor lines and monitor points

- Model control parameters
  - Start/end times
  - Time step
  - Initial conditions (dry, auto, etc.)
  - Flow (steady vs unsteady)

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Create Input Files (Coverages) and Set Controls

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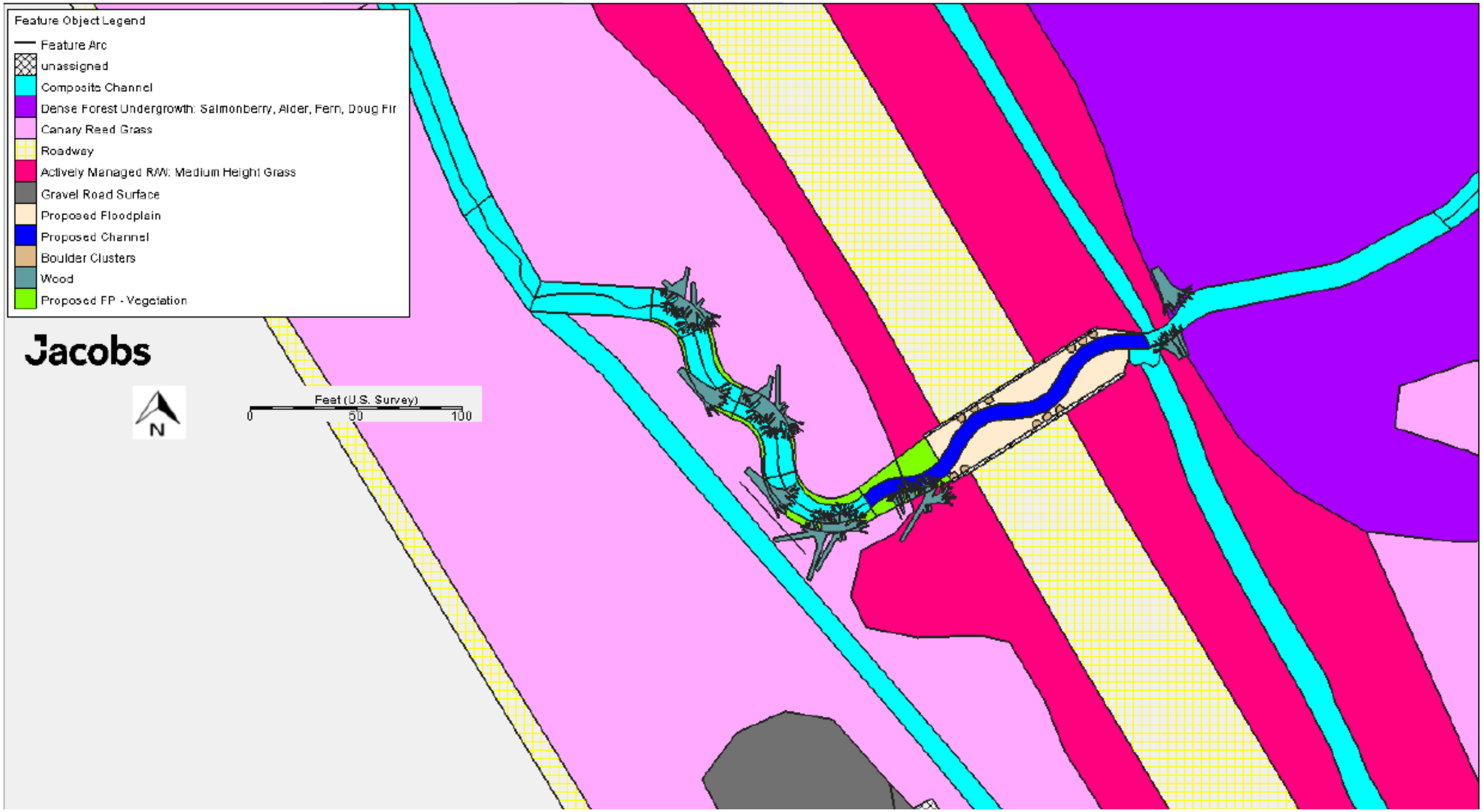

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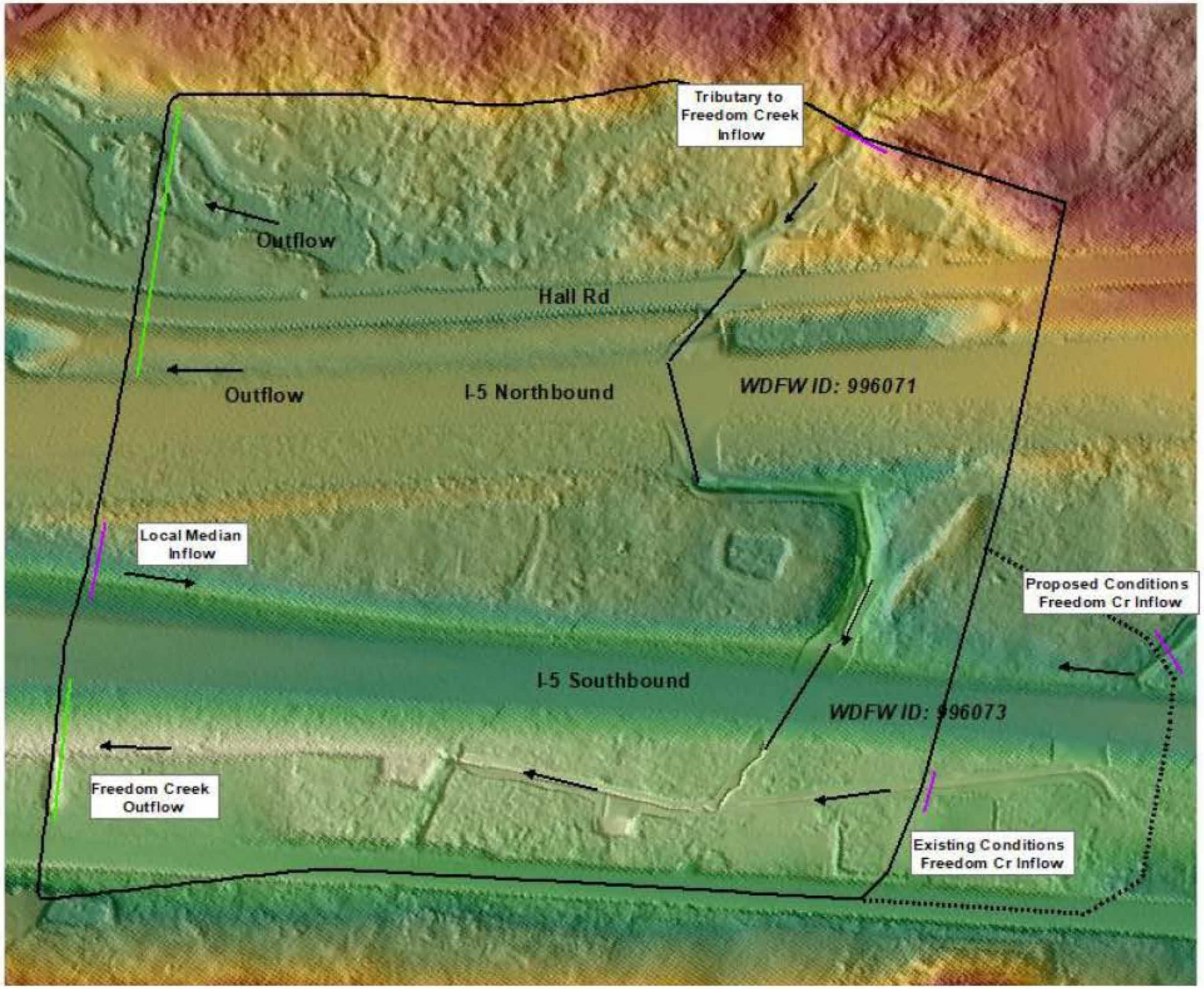

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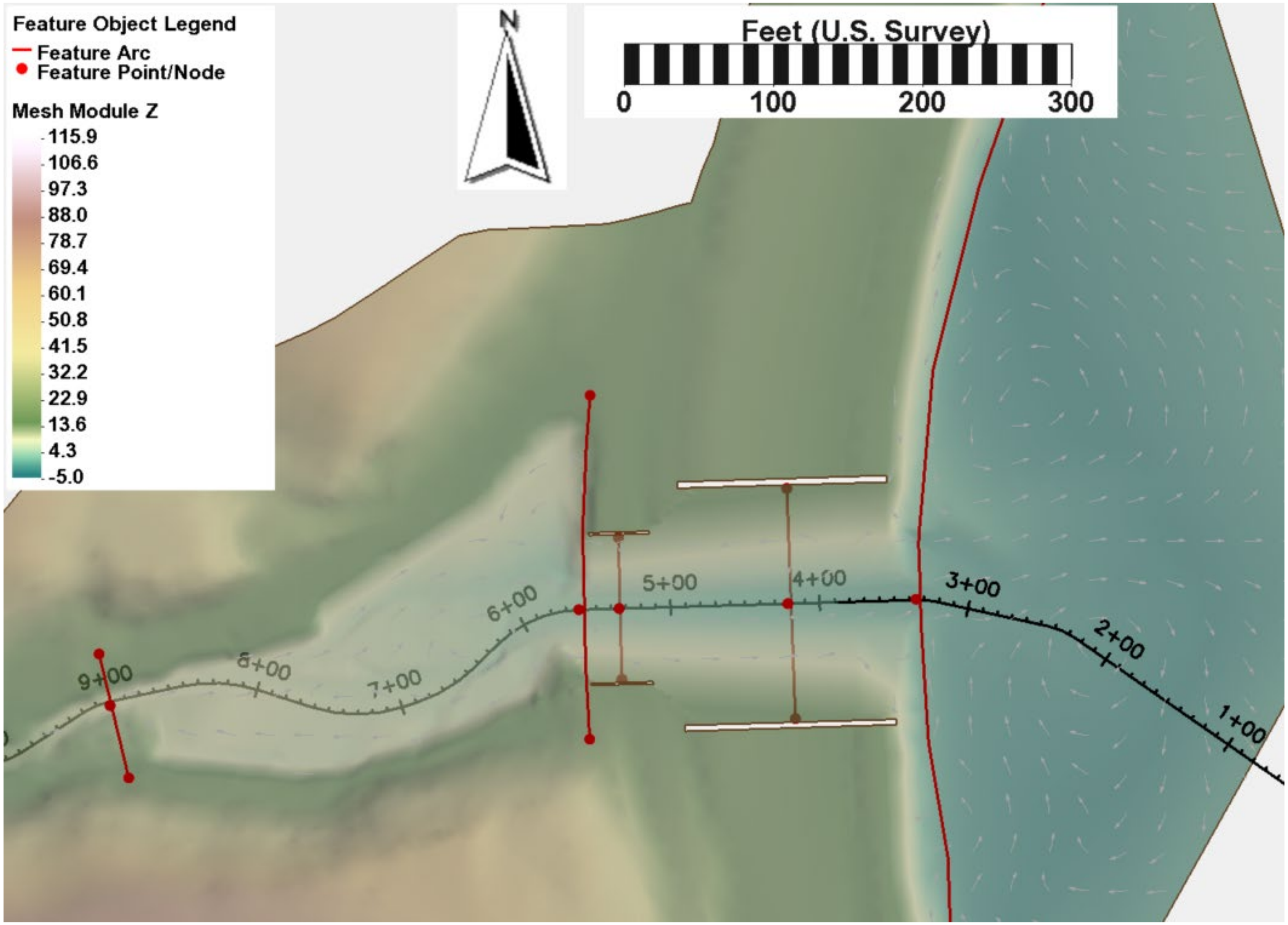

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- **Model control parameters**
  - **Start/end times**
  - **Time step**
  - **Initial conditions (dry, auto, etc.)**
  - **Flow (steady vs unsteady)**

Calibrate/Validate Model

- Bankfull depth and flow extents
- Observed high water marks vs modeled depth
- Is the model stable?
- Do the results make sense?

Model Results - PHD

- Main outputs: WSE, depth, velocity, and shear
- Confined vs unconfined (FUR)
- Structure size: velocity ratios; sensitivity to width, length, and freeboard requirements
- WSE changes (for FRA)
- Preliminary scour analysis: check flood and design flood
- Sediment sizing based on shear and velocity

Model Results - FHD

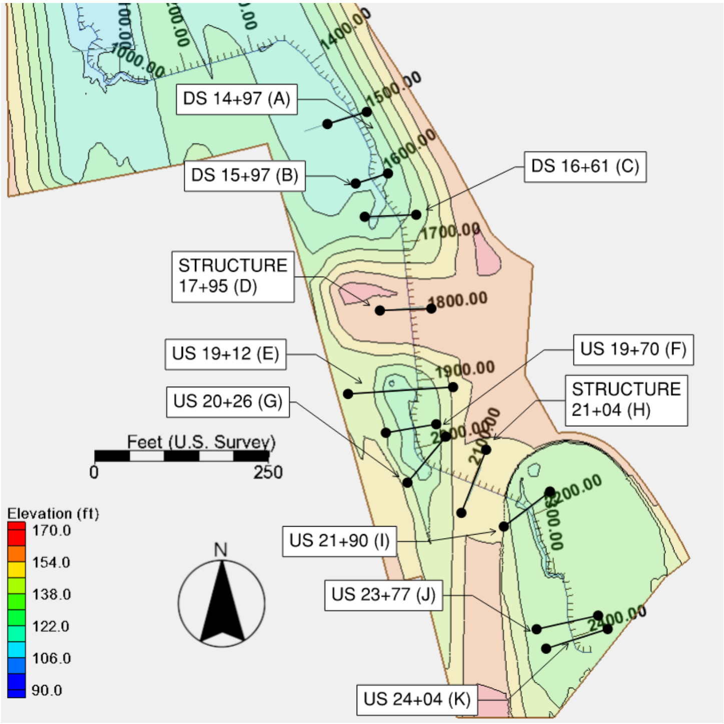
- Hydraulics surrounding structure, how structure interacts with surrounding environment
- Habitat utility at all flows (depths, velocities)
- Stability (LWM design)
- Final scour analysis
- Finalize sediment sizing

Model Outputs and Results Presentation

- For existing, natural (required for unconfined streams), and proposed conditions:
  - 2, 100, 500, predicted 2080 100-year flows
  - Note:
    - Model intermediate flows (10, 25, 50) for scour, sediment sizing, etc., but not for figures and tables
    - May need to run intermediate/future conditions (future compatibility) in addition to proposed conditions and present results
- Produce main channel and overbank values for tables
- Figures in the PHD/FHD may be printed from SMS, GIS, etc.
- Ensure results reporting locations are representative

Model Outputs and Results Presentation

Hydraulic parameter	Cross section	2-year	100-year	Projected 2080 100-year	500-year
Average WSE (ft)	DS XX+XX (A)				
	DS XX+XX (B)				
	DS XX+XX (C)				
	Structure XX+XX (D)				
	US XX+XX (E)				
	US XX+XX (F)				
	US XX+XX (G)				
Max depth (ft)	DS XX+XX (A)				
	DS XX+XX (B)				
	DS XX+XX (C)				
	Structure XX+XX (D)				
	US XX+XX (E)				
	US XX+XX (F)				
	US XX+XX (G)				
Average velocity (ft/s)	DS XX+XX (A)				
	DS XX+XX (B)				
	DS XX+XX (C)				
	Structure XX+XX (D)				
	US XX+XX (E)				
	US XX+XX (F)				
	US XX+XX (G)				
Average shear (lb/SF)	DS XX+XX (A)				
	DS XX+XX (B)				
	DS XX+XX (C)				
	Structure XX+XX (D)				
	US XX+XX (E)				
	US XX+XX (F)				
	US XX+XX (G)				



Cross-section location	Q100 average velocities (ft/s)			2080 Q100 average velocity (ft/s)		
	LOB[a]	Main channel	ROB[a]	LOB[a]	Main channel	ROB[a]
DS XX+XX (A)						
DS XX+XX (B)						
DS XX+XX (C)						
Structure XX+XX (D)						
US XX+XX (E)						
US XX+XX (F)						
US XX+XX (G)						

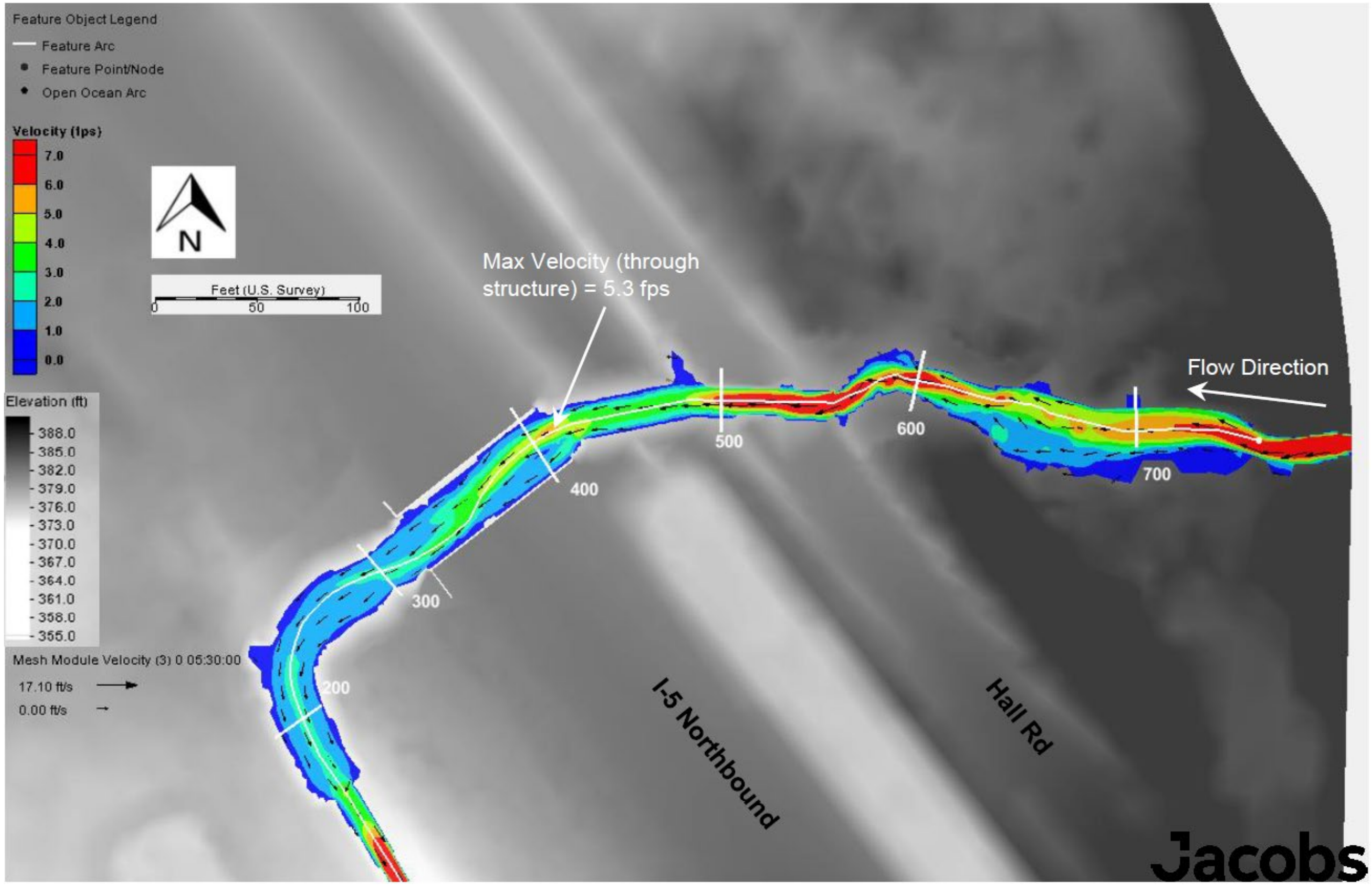
Model Outputs and Results Presentation - Figures

- Plan views of domain extent with stationing and all XS locations
- Plan views of WSE, depth, velocity, and shear
- Longitudinal profiles
- Cross sections
- Floodplain impacts
  - Changes in WSE upstream/downstream
  - Extents

- Readability note: Figures shown here and in the template are just examples. Focus on conveying the necessary information, not mimicking these figures!
  - Minimum components for all plan figures: north arrow, flow direction, scale bar
  - Do not hesitate to exceed the minimum requirements

Model Outputs and Results Presentation - Figures

- 100-yr velocity in proposed conditions
- Use of hillshade provides context for adjacent topography
- Note use of color bins and labels
- Good figure, but what can we improve?



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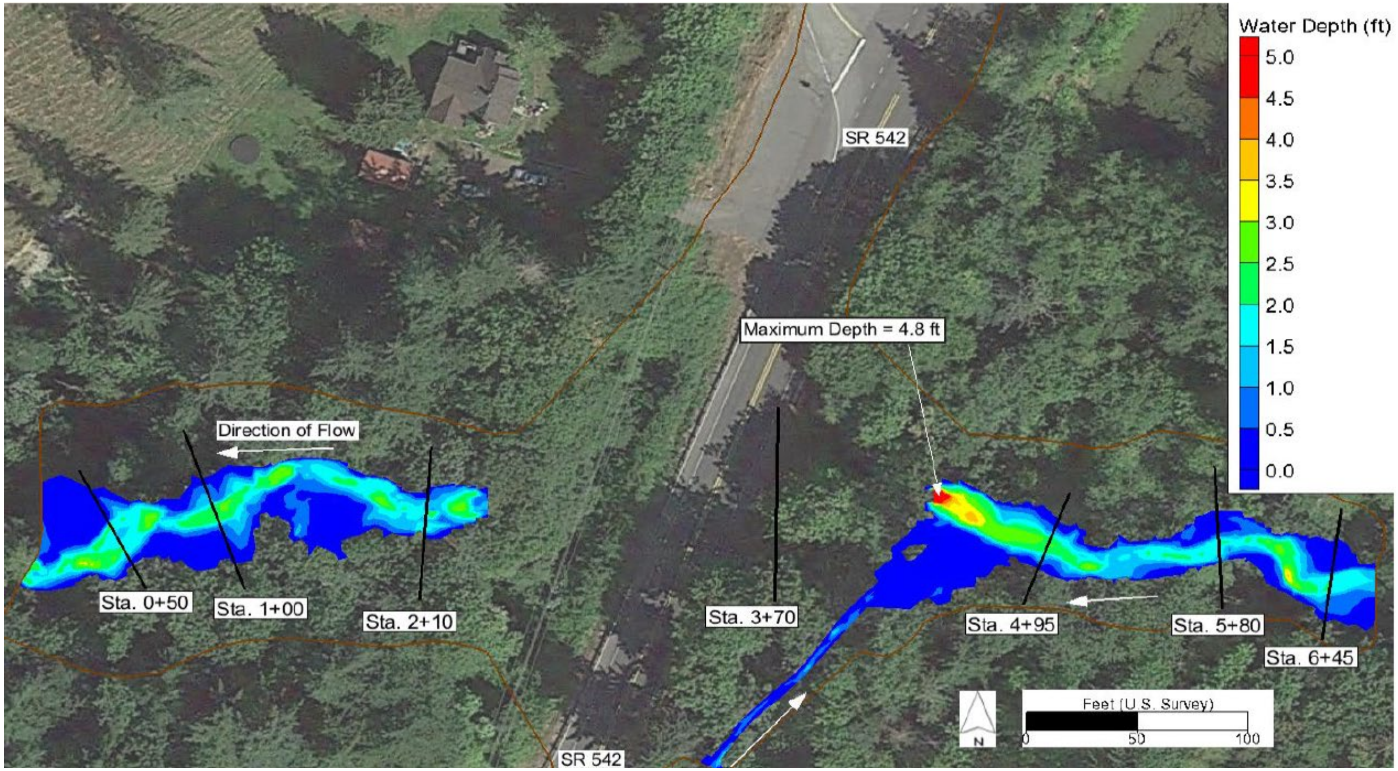
Model Outputs and Results Presentation - Figures

- 100-yr depth in existing conditions
- Use of imagery provides context for nearby constraints
- Note use of color bins and labels
- Okay figure, but what can we improve?



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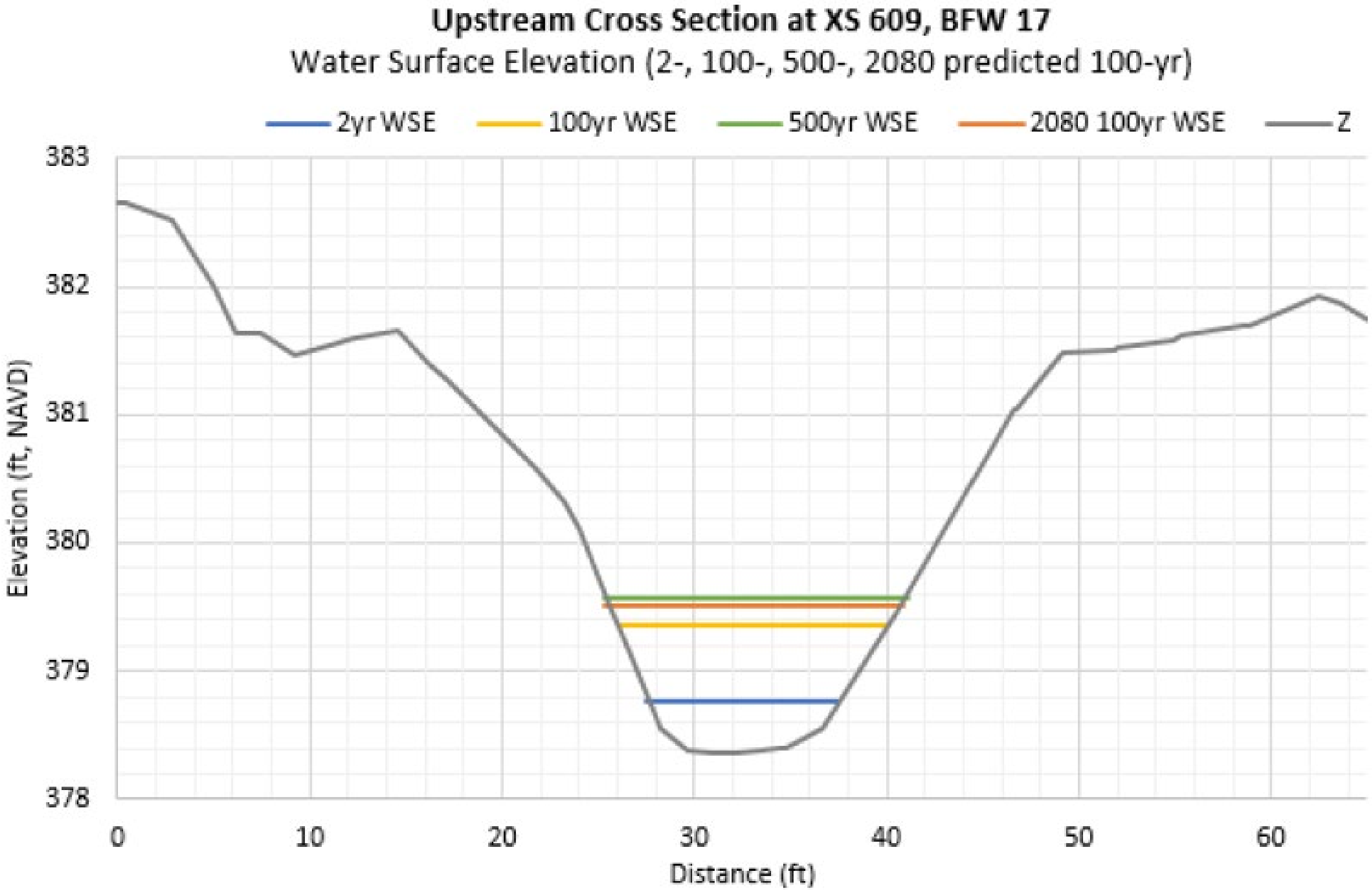
Model Outputs and Results Presentation - Figures



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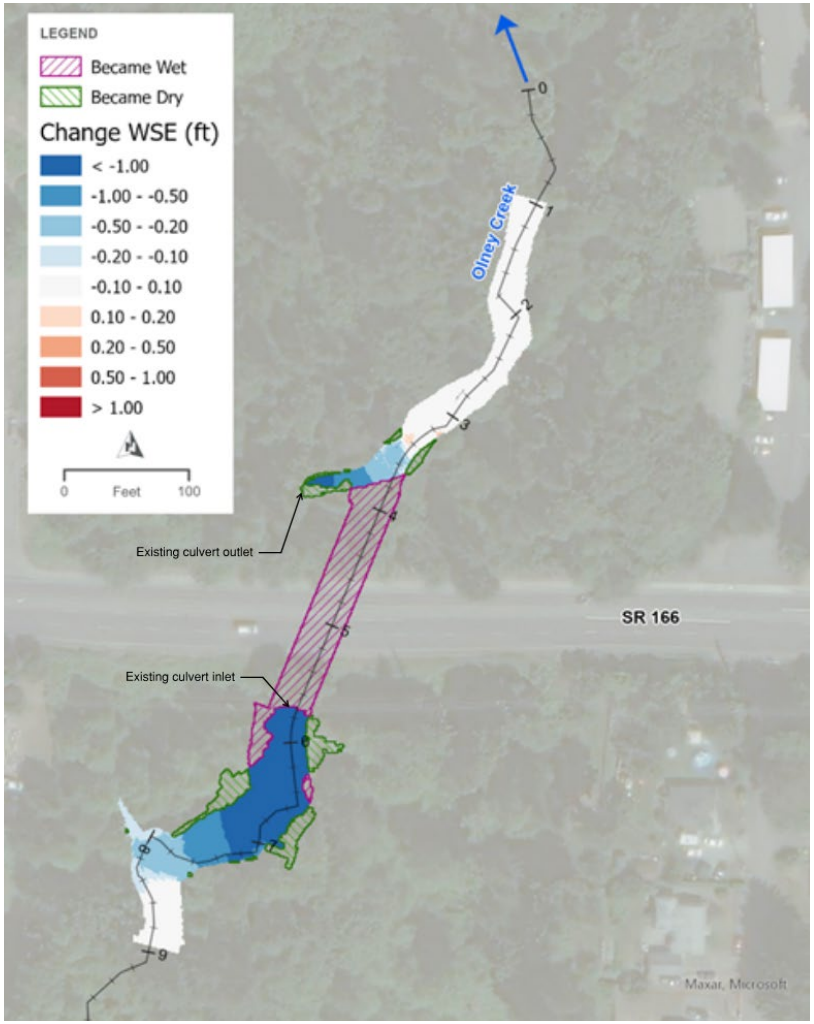
Model Outputs and Results Presentation - Figures

- 100-yr WSE change from existing to proposed conditions
- Figure includes FEMA zone extents (can import in SMS or use GIS)
- Note use of color bins, stationing on proposed alignment, and labels



Model Outputs and Results Presentation - Appendices

- Appendix H: SRH-2D Model Results
  - Plan views of WSE, depth, velocity, and shear results
  - Profile of existing, natural (if required), and proposed WSE
  - Cross sections of existing, natural (if required) and proposed WSE for modeled flows at ALL cross sections used in Sections 5.2, 5.3, and 5.4.

- Appendix I: SRH-2D Model Stability and Continuity
  - Plan view of monitor line and point locations
  - Monitor line plots
  - Monitor point plots
  - Note: If using SMS to generate plots instead of pulling raw data, remember that monitor line plots default to showing flux (Q) unless you toggle the checked boxes to show WSE (ft). Point plots show WSE (ft).

Special Topics – Modeling Obstructions

- Creates obstruction objects that reduce flow in the channel
- Assign attributes such as width, diameter, or radius
- Assign drag coefficients, porosity
  - Note: Porosity function generally not recommended

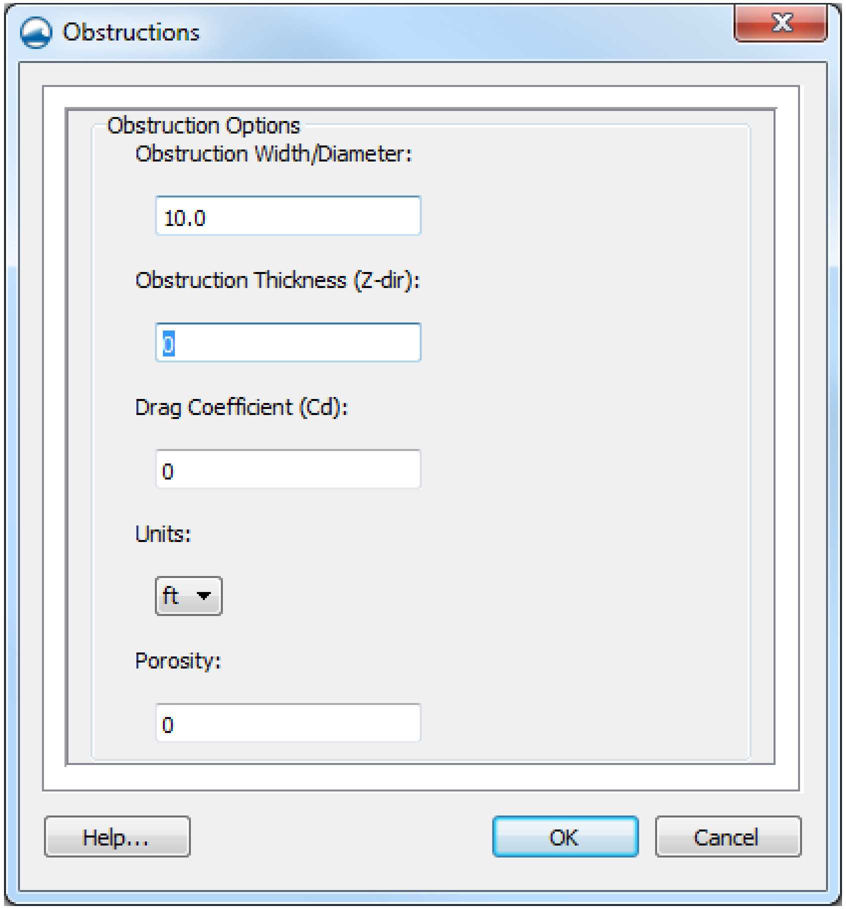
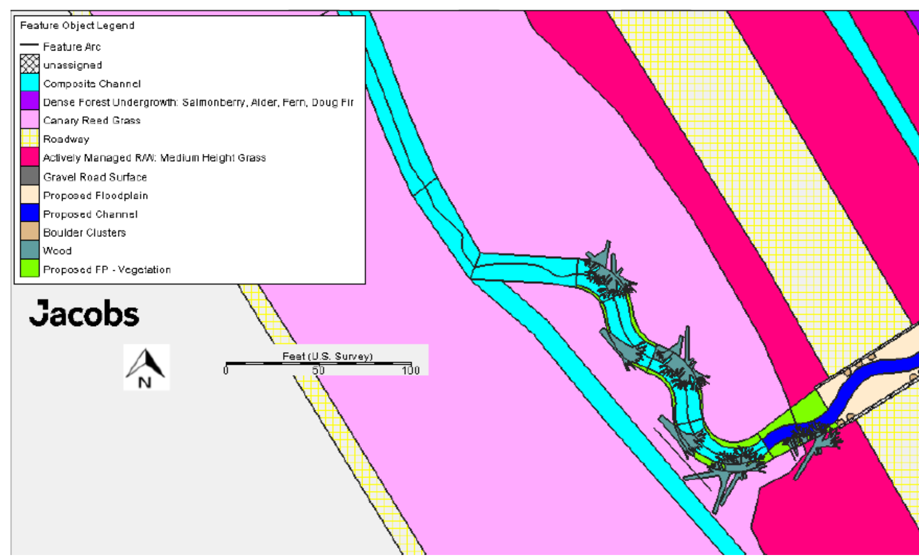


Image Source: Aquaveo. https://www.xmswiki.com/wiki/SMS:SRH-2D_Coverages_13.0

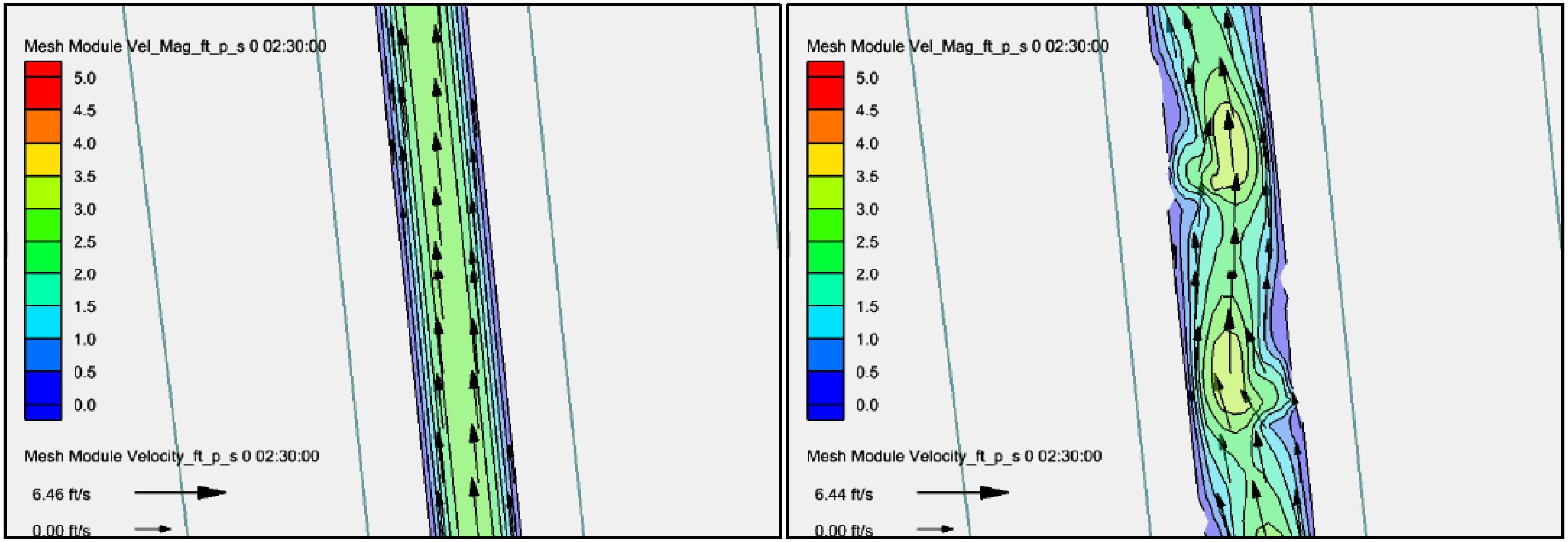
Special Topics – LWM

- For PHD – composite roughness
- For FHD – obstruction or other discrete method, or composite roughness
- Risks:
  - Significant variation between PHD and FHD
  - Variability in construction
  - Inefficient use of time



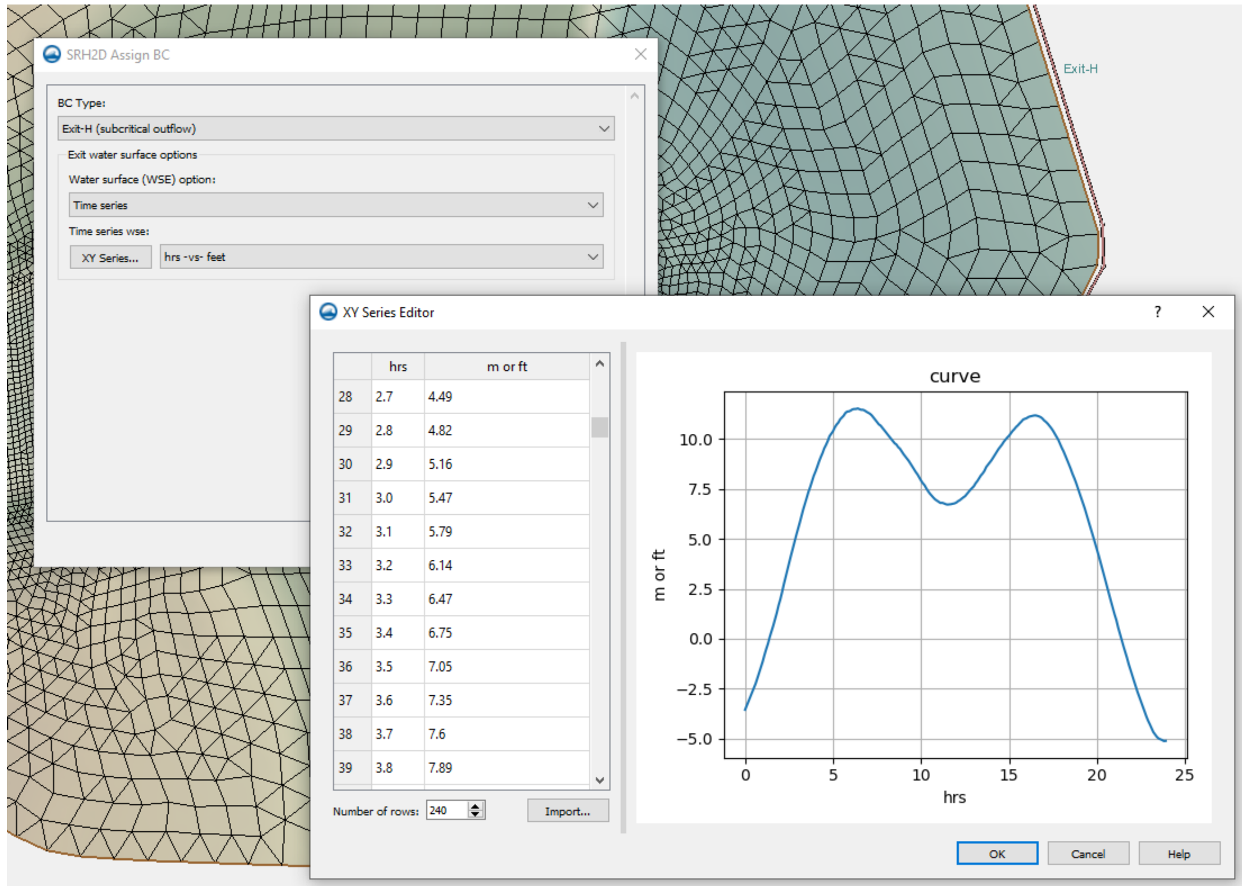
Special Topics – Complexity Features

- Step pools, meander bars, etc.
- For PHD – composite roughness in most cases
- For FHD – incorporate into surface
  - Note: Think about your breaklines and mesh element size vs feature size.
- Same risks as LWM

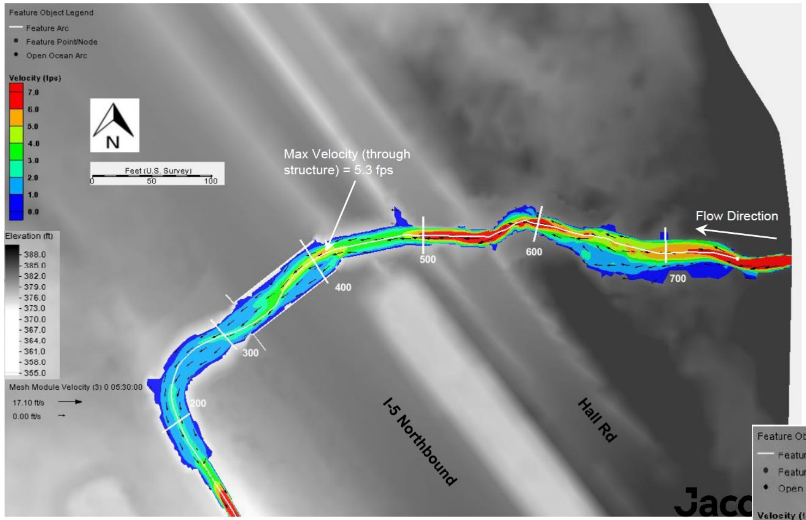


Special Topics – Tidally-Influenced Crossings

- Time series vs constant WSE
- Report results from tide/event ranges (low, high)
- Method doesn't apply only to tidal sites (think sites with nearby downstream confluences in flood zones).

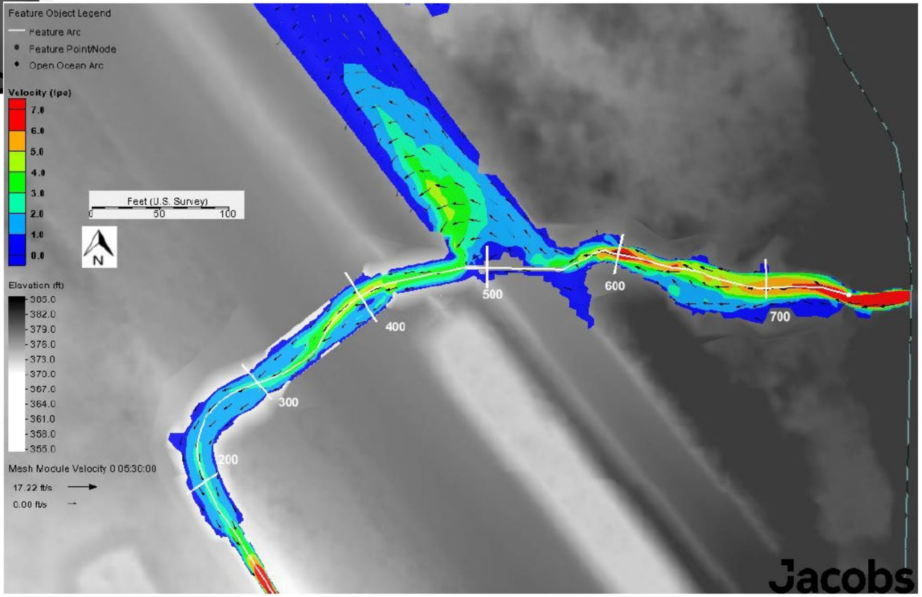


Special Topics – Intermediate Conditions



Upstream barrier removed

Upstream barrier still in place



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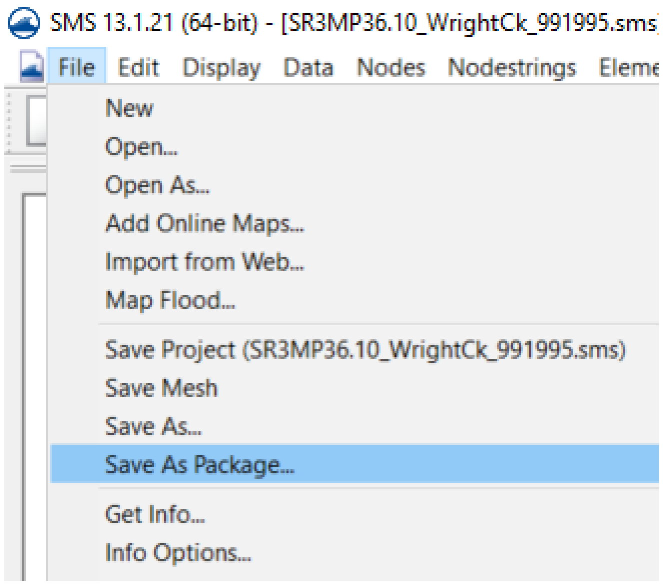
Special Topics

- Keep your goals in mind. There is no cookie-cutter approach to modeling. Always ask yourself:
  - What
  - Why
  - How
- When possible, use built-in tools to simplify work and provide consistency in reporting. These include (but are not limited to):
  - Results extraction
  - Scour coverages and data extraction
  - Importing CAD and raster data

Model Review and Packaging

- Confirm model stability, validate results if possible
- Perform internal QC/QA – model review checklist
- Packaging:
  - Make sure things are labeled intuitively/appropriately
  - Save as package
    - Tip: Unzip and reopen the model to make sure it works and that links aren't broken
  - Must have all relevant documentation and files, including
    - Terrain (survey, LiDAR, graded, merged scatter data)
    - All coverages (mesh, materials, BC, monitor)
    - HY-8 file
    - Results and metadata
    - prj file
  - Remove working extraneous data and results



Summary

- SRH-2D is required by WSDOT.
- Model development is an iterative process using multiple inputs.
- Inputs will be determined by model goals (PHD/FHD).
- Results must be presented in a digestible manner – figures and tables should readable and provide meaningful information.
- Models should be carefully reviewed and packaged appropriately before delivery to WSDOT.

Remember:
This is guidance; it is not prescriptive.

There is no cookie cutter approach to modeling!

Questions?