2D Hydraulic Modeling User's Forum

How To Generate An Accurate and Efficient Mesh

January 19, 2023

Federal Highway Administration
RESOURCE CENTER
Office of Innovation Implementation

U.S. Department of Transportation
Federal Highway Administration

Agenda

- Housekeeping stuff
- Training Opportunities
- Current Software Versions and Licensing
- Helpful Resources
- Mesh Development Best Practices
- Recommended Mesh Development Steps
- Tips and Tricks

Housekeeping

- Please post any questions in the Chat Pod
- PDF file of presentation slides (posted in the chat pod)
- PDH certificate (posted in chat pod)
- Recording link will be sent out tomorrow to all members of the 2D forum (with the slides and certificate)
- Participants may subscribe or unsubscribe using the link in the email
- Upcoming 2D Hydraulic Modeling User's Forum webinars

Training Opportunities

- In-person training (NHI Course 135095)
- Virtual training available (NHI Course 135095V)
- Virtual Training (NHI Course 135095A) SRH-2D Model Data files, Diagnostics & Verifying 2D Model Results
- Virtual Training (NHI Course 135095B) Model Terrain Development with Various Data Sources

Current Software Versions and Licensing

- SMS 13.2.14 (January 6, 2023) / SRH-3.5
- Community license (free to all)
  - No license code needed
- Pro version free to all DOTs/FHWA and anyone whose role is to review models
  - License renewal / update required annually or with new computer
  - DOT/FHWA staff contact *scott.hogan@dot.gov* *or* *laura.Girard@dot.gov*
  - All others contact *support@Aquaveo.com*

Helpful References and Resources

Click links for information:

- 2D Hydraulic Modeling for Highways in the River Environment
- Training, Reference Documents, and Other Resources
- Step-by-step instructions (SMS wiki)
- Table of SRH-2D Errors and Solutions
- Tutorials and videos
- FHWA Bridge Scour Workshop

Mesh Development Guidelines / Best Practices

- Well-thought-out domain
- Element length generally > flow depth
- Start with course mesh and add detail where needed
- Run test simulations during development
- Align element faces with hydraulic controls
- Review mesh accuracy

Mesh Development Tools

SMS wiki links:

- Dataset to Raster
- Extracting Features
- Source Arc Vertex Redistribution
- Arcs to polygons
- Bridge meshing
- Dataset to Raster
- Raster Difference

Tutorials:

- Mesh Generation
- Extract Features
- Extract Features for Mesh Generation
- Mesh Generation from Extracted Features
- Bridge Meshing

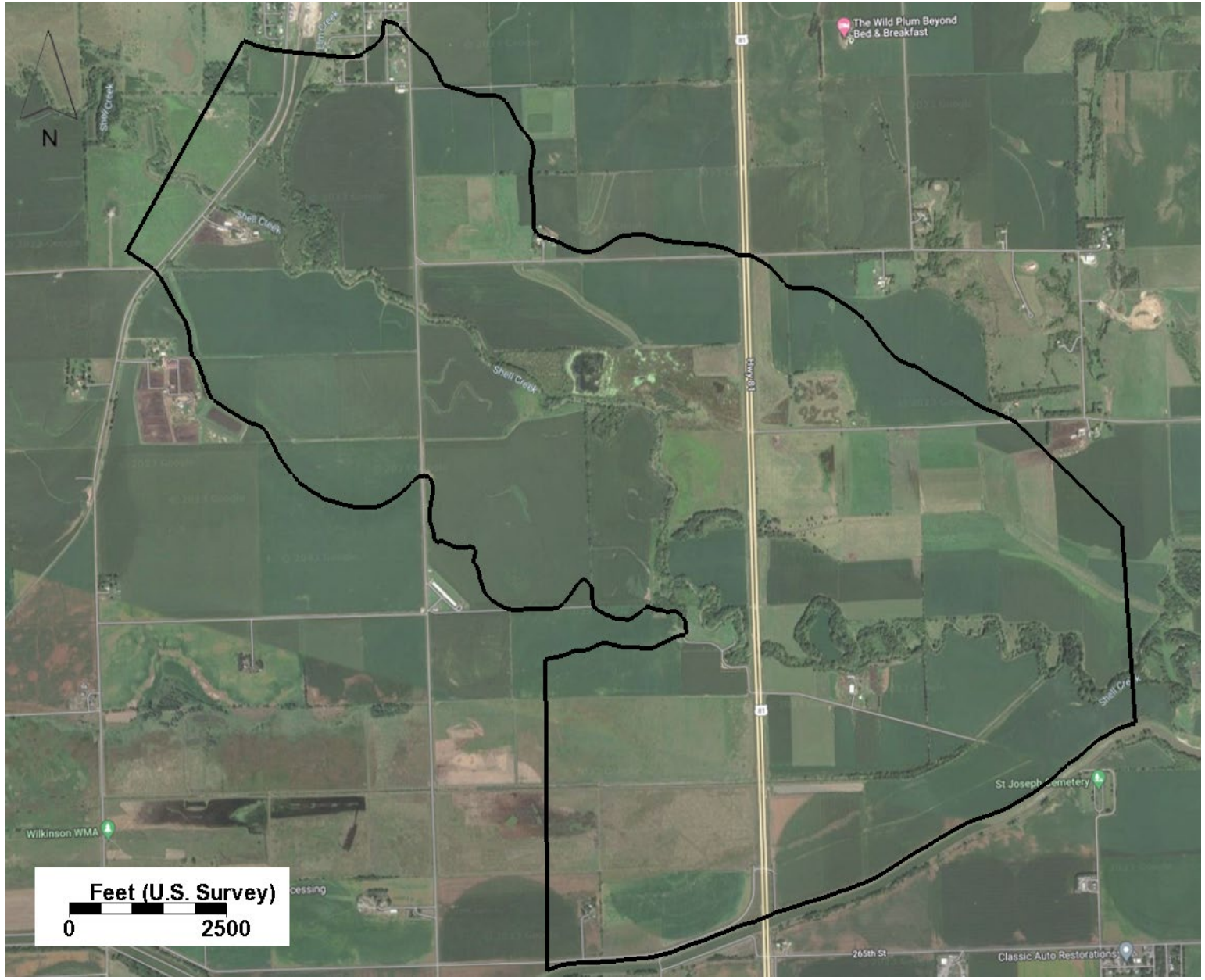
Recommended Mesh Development Steps

1. Define model domain
2. Generate initial coarse mesh
3. Run test simulation
4. Adjust domain limits as needed
5. Delineate channel centerline and channel banklines (if needed)
6. Add mesh breaklines to capture hydraulic controls and secondary streams
7. Refine mesh along hydraulic controls and streams
8. Define mesh at bridges with piers
9. Set mesh for large areas to use 'Constant Paving Density'
10. Generate mesh
11. Evaluate mesh quality and accuracy
12. Revise mesh to improve terrain representation as needed

Mesh Development:

Define Model Domain

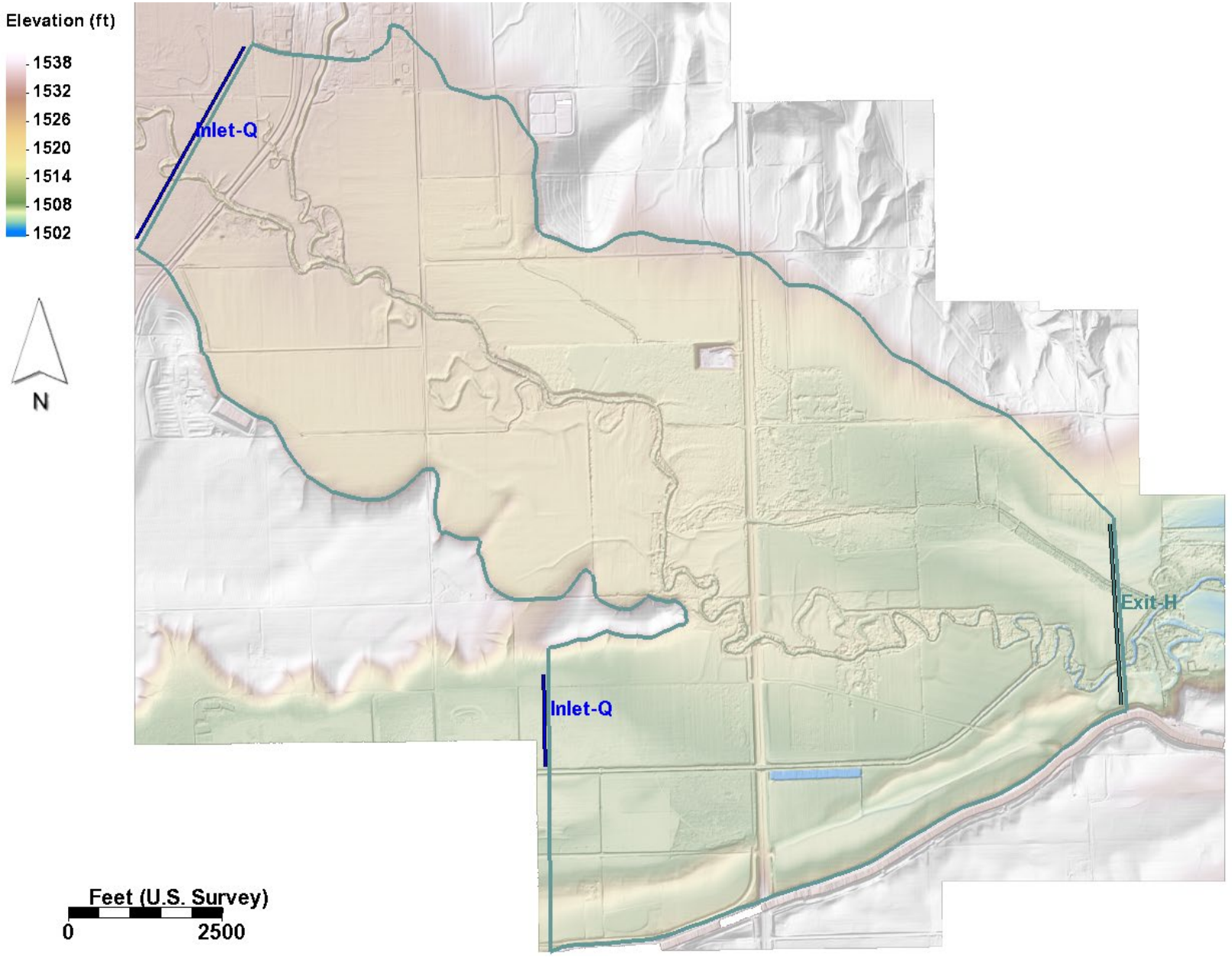
- Wide enough to capture floodplain limits (avoid wet boundaries)
- ~2 floodplain widths up and downstream of project area to avoid boundary condition impacts



Mesh Development:

Define Model Domain

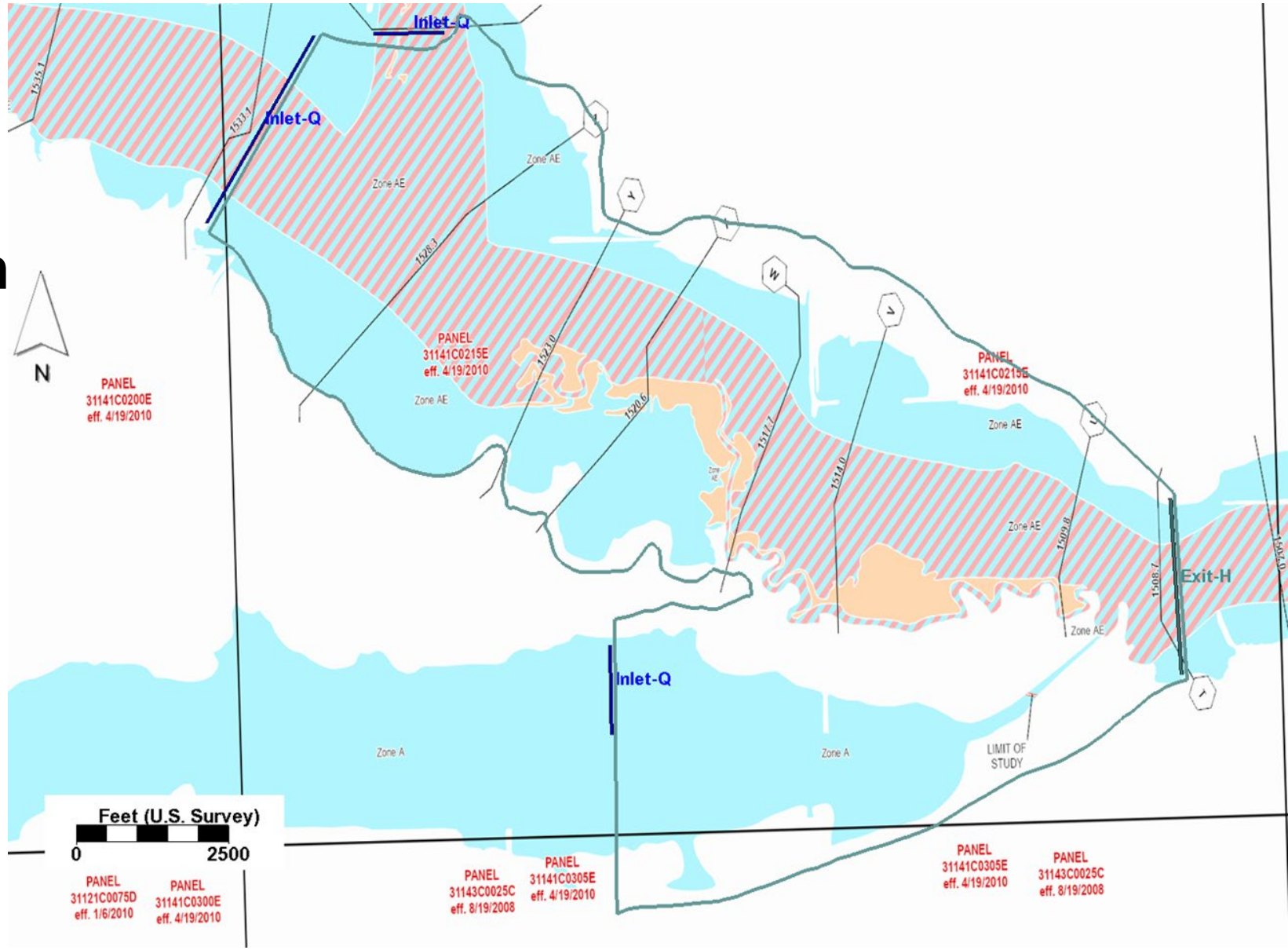
- Terrain contours are a helpful reference when setting lateral limits
- Confined flow / constrictions work best for boundary condition locations



Mesh Development:

Define Model Domain

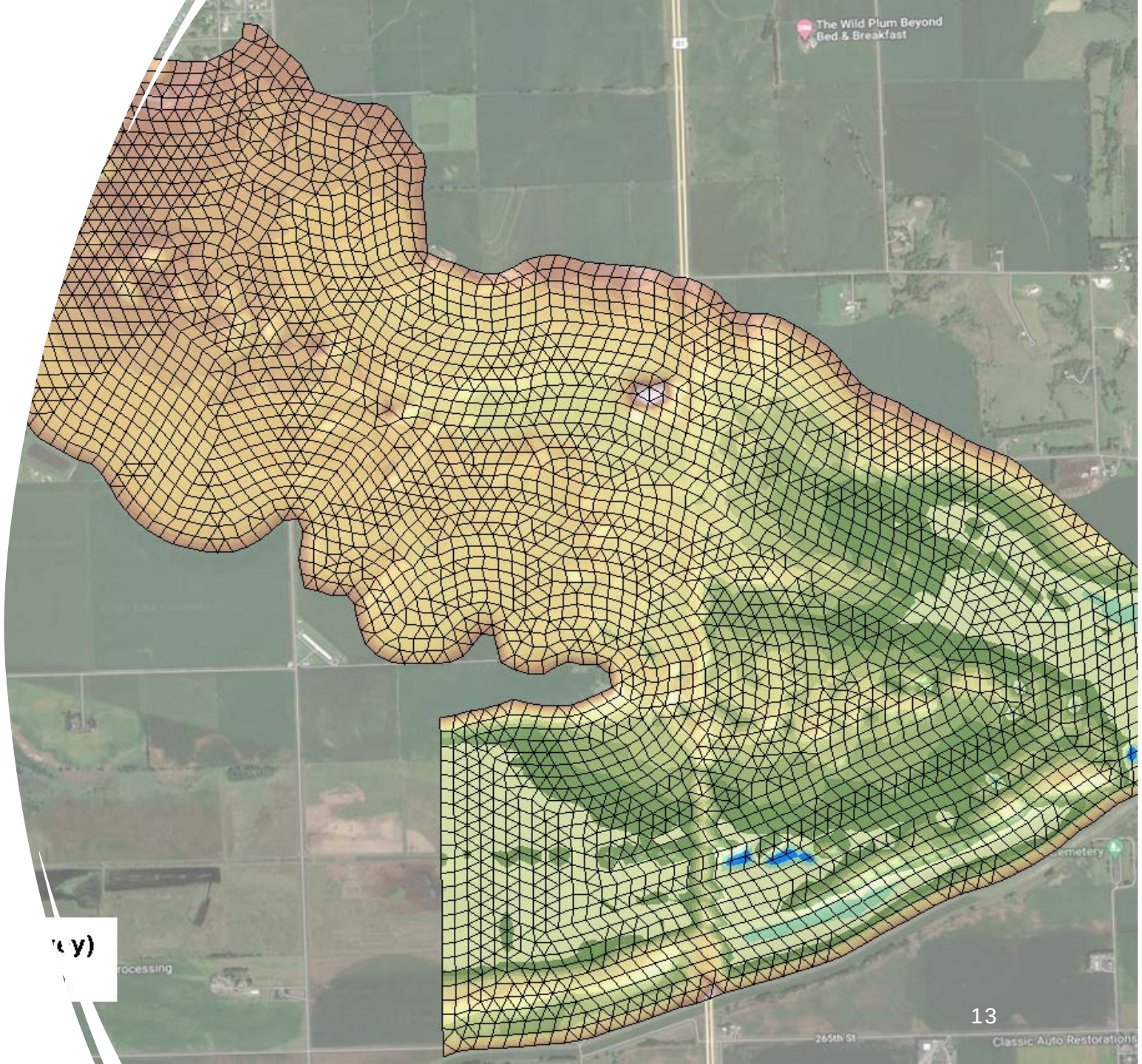
- FEMA Floodplain limits are also a good resource (*USA Flood Hazard Zones* map in SMS)
- Add boundary conditions for largest event to be modeled



Mesh Development:

Generate Initial Course Mesh

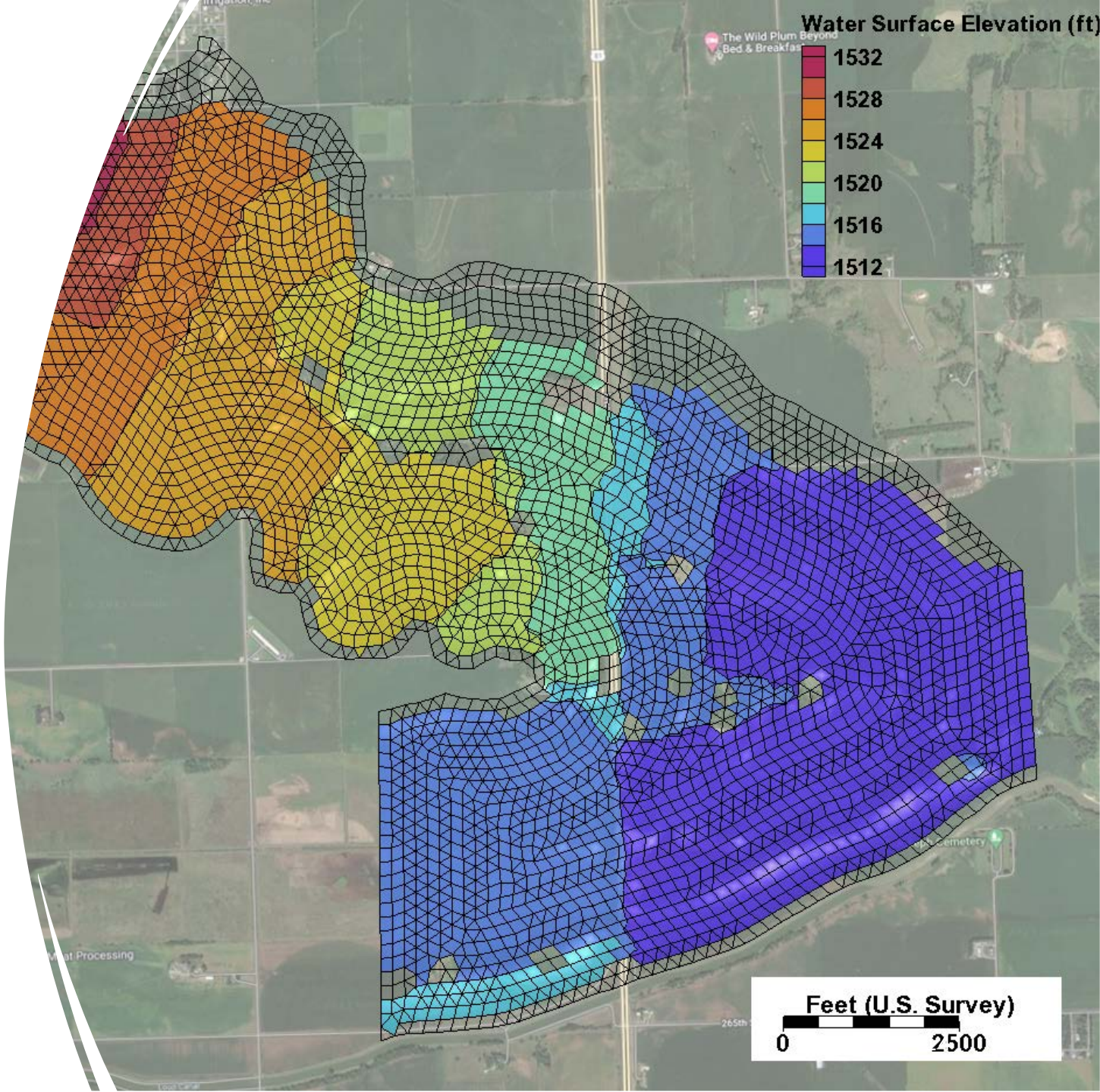
- Start with large elements (~100 ft)
- Merge triangles (and renumber nodes)



Mesh Development:

Test Simulation

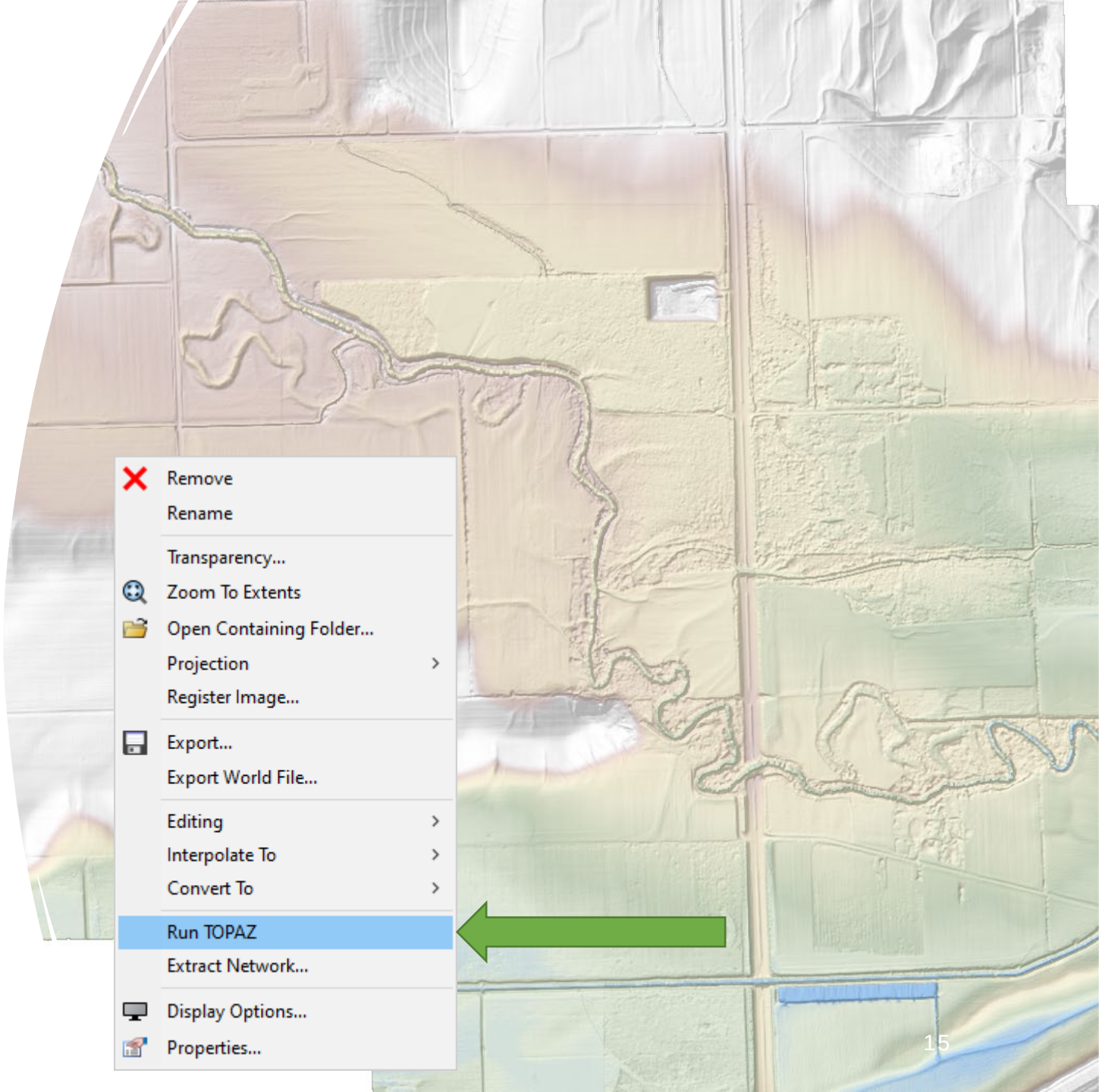
- Run initial simulation
- Review results
- Adjust domain limits as needed



Mesh Development:

Raster Image Data

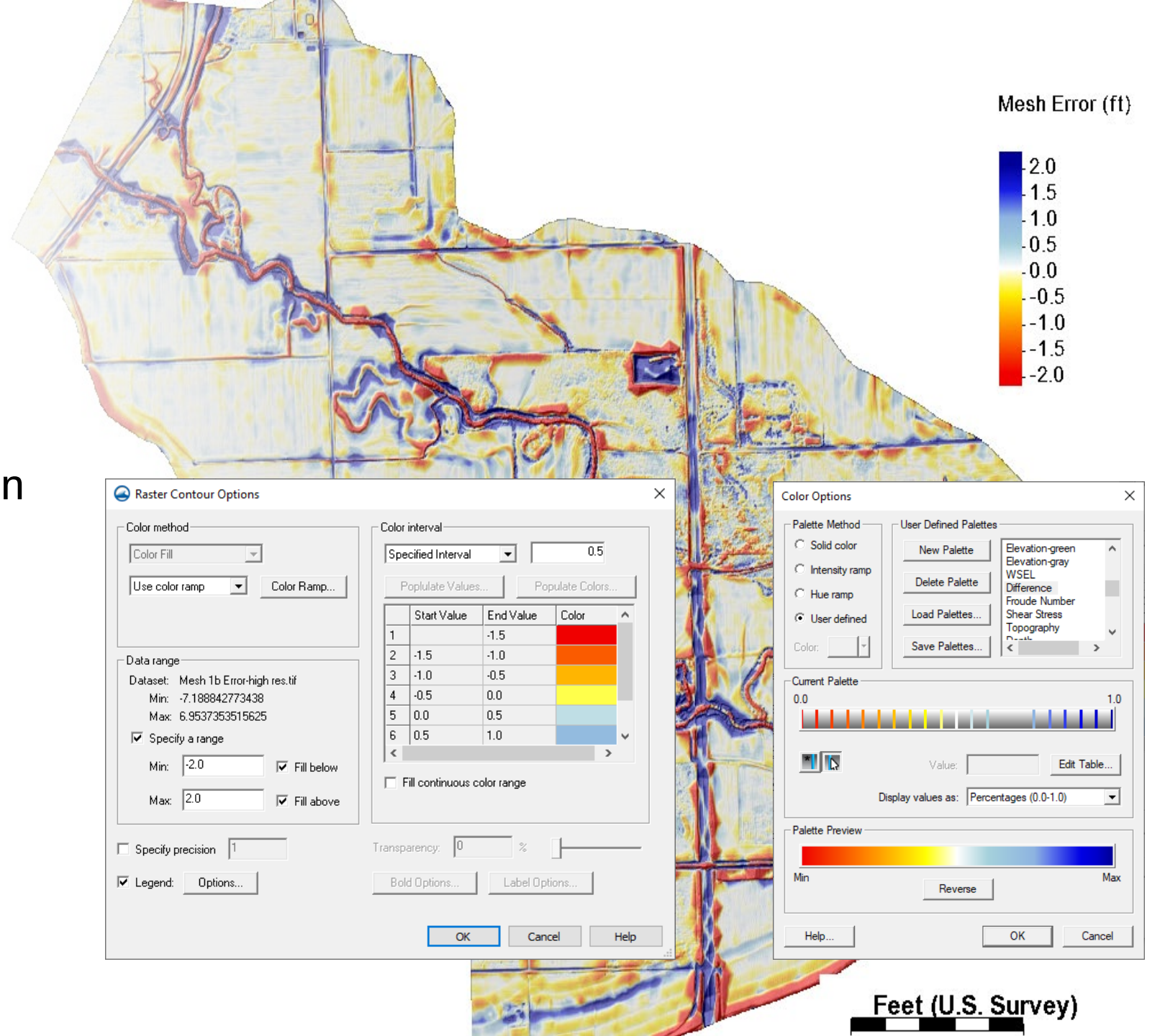
- Terrain raster image is used for terrain comparison and delineation of channel centerlines, banklines, ridges, and streams
- If terrain is scatter data, convert to Raster (rt click on scatter data, convert to raster)
- Rt click on Raster image and Run TOPAZ (can run for 20-30 minutes in the background)



Mesh Development:

Evaluating Mesh Accuracy

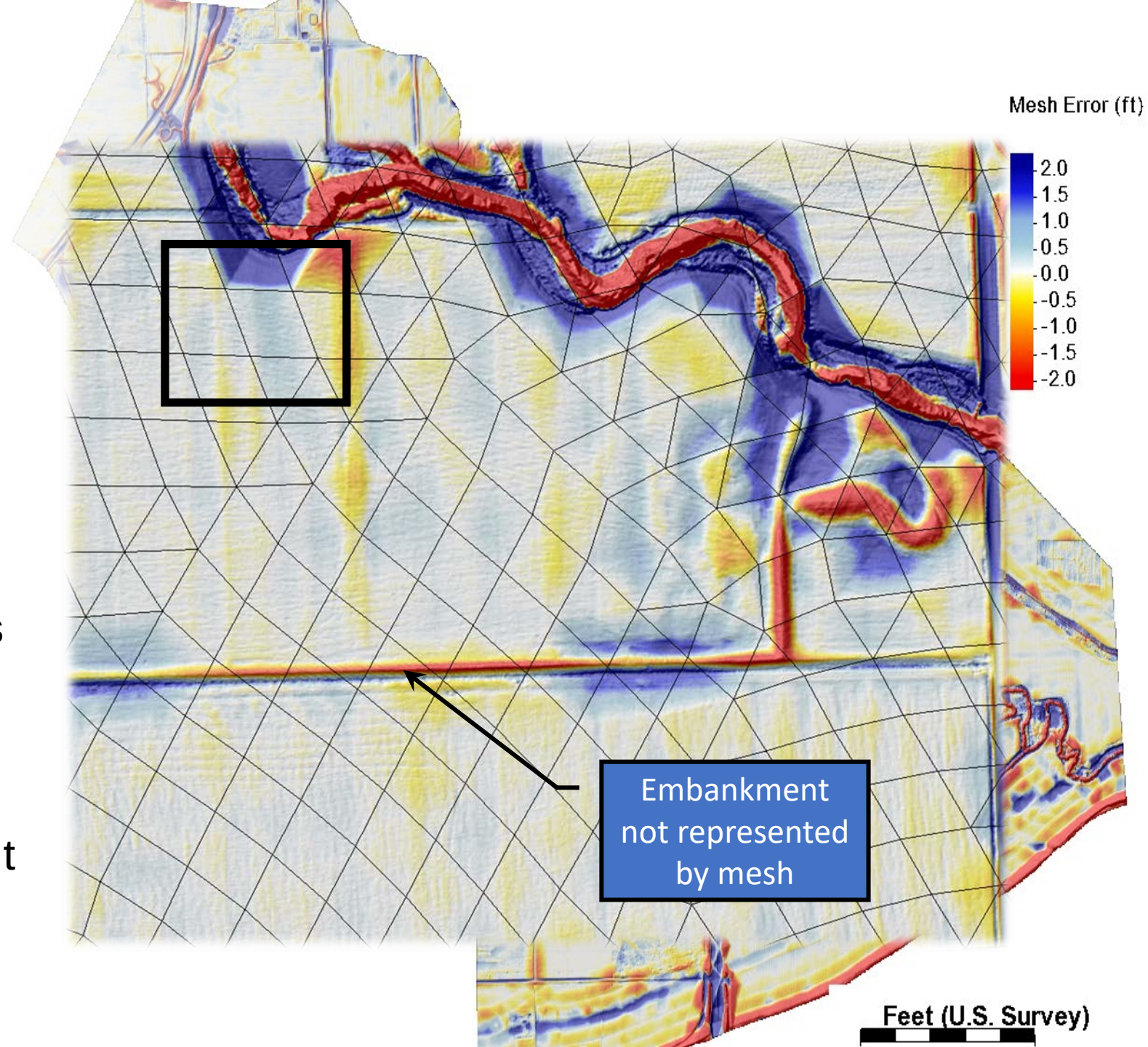
- Convert mesh to raster
- Compare mesh elevation raster to terrain raster
- Review differences



Mesh Development:

Evaluating Mesh Accuracy

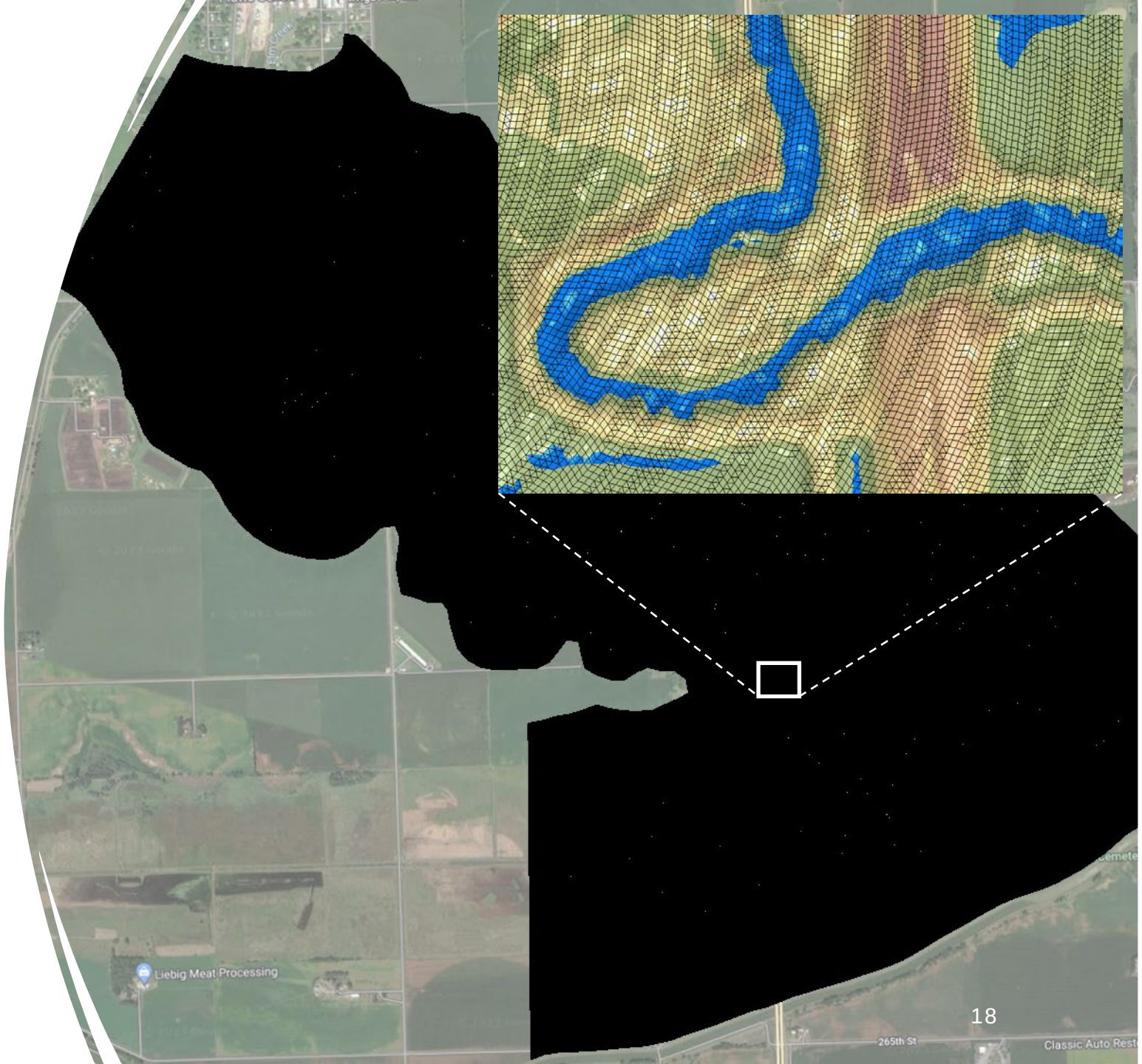
- Assess potential hydraulic controls that need to be represented
- Add mesh breaklines along hydraulic controls to align element faces
- Refine mesh as needed to improve representation of abrupt changes in terrain



Mesh Development:

High Resolution Mesh Option

- Elements size roughly equal to 0.5-1x width of features to be represented (e.g. road embankment top width 10-20 ft)
- Captures all predominant features/controls
- Accurate representation of terrain with less development time
- Long simulation times



Mesh Development:

Evaluating Mesh Accuracy- High Resolution Mesh Option

Recommended Mesh Development Steps

1. Define model domain
2. Generate initial coarse mesh
3. Run test simulation
4. Adjust domain limits as needed
5. Delineate channel centerline and channel banklines
6. Add mesh breaklines to capture hydraulic controls and secondary streams
7. Refine mesh along hydraulic controls and streams
8. Define mesh at bridges with piers
9. Set mesh for large areas to use 'Constant Paving Density'
10. Generate mesh
11. Evaluate mesh quality and accuracy
12. Revise mesh to improve terrain representation as needed

Mesh Development:

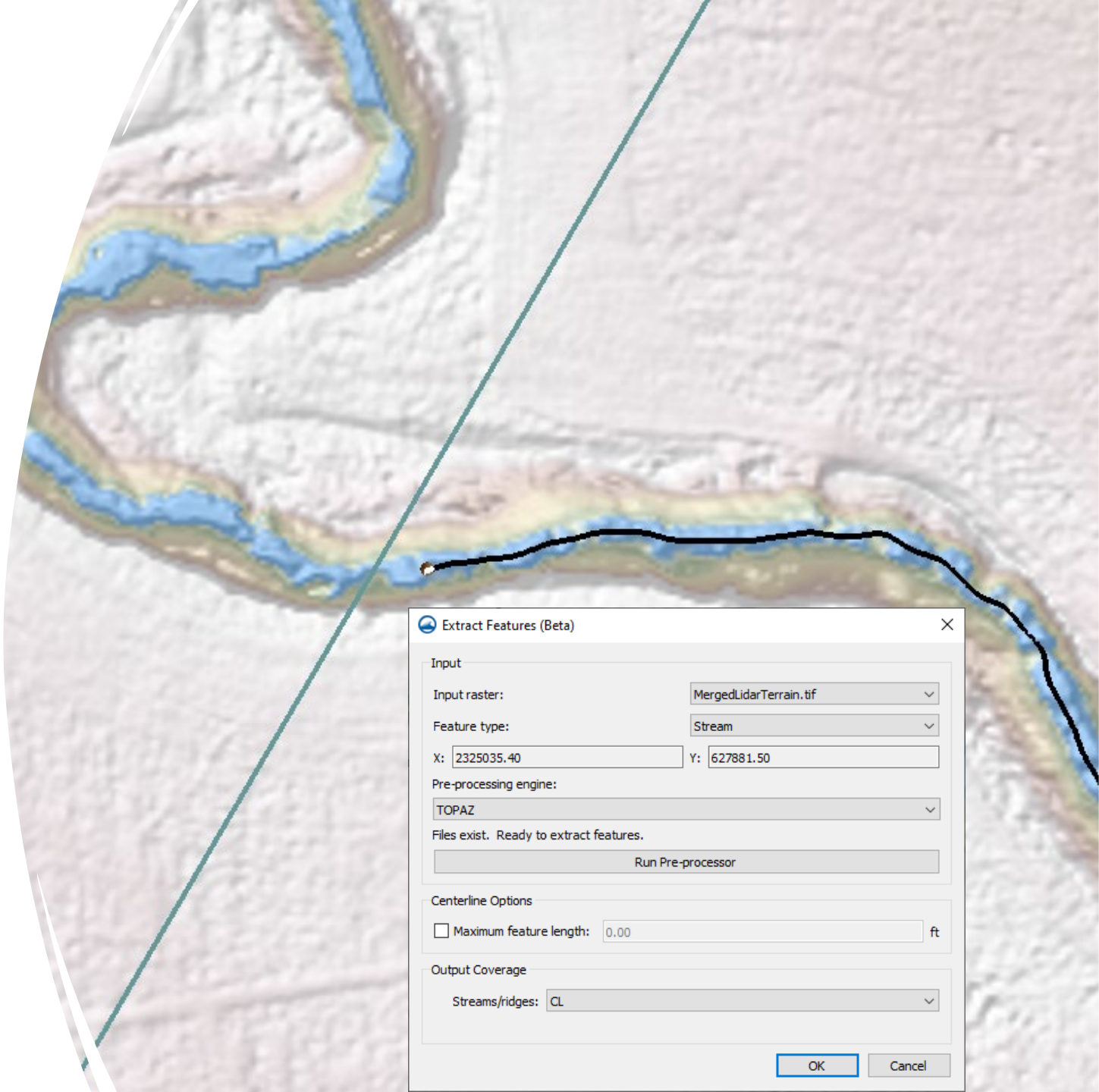
Add Channel Centerline

- Create new general coverage (CL) in SMS
- Add a point/node in the channel
- Select the node, rt click, select ***Extract Feature***

Mesh Development:

Add Channel Centerline

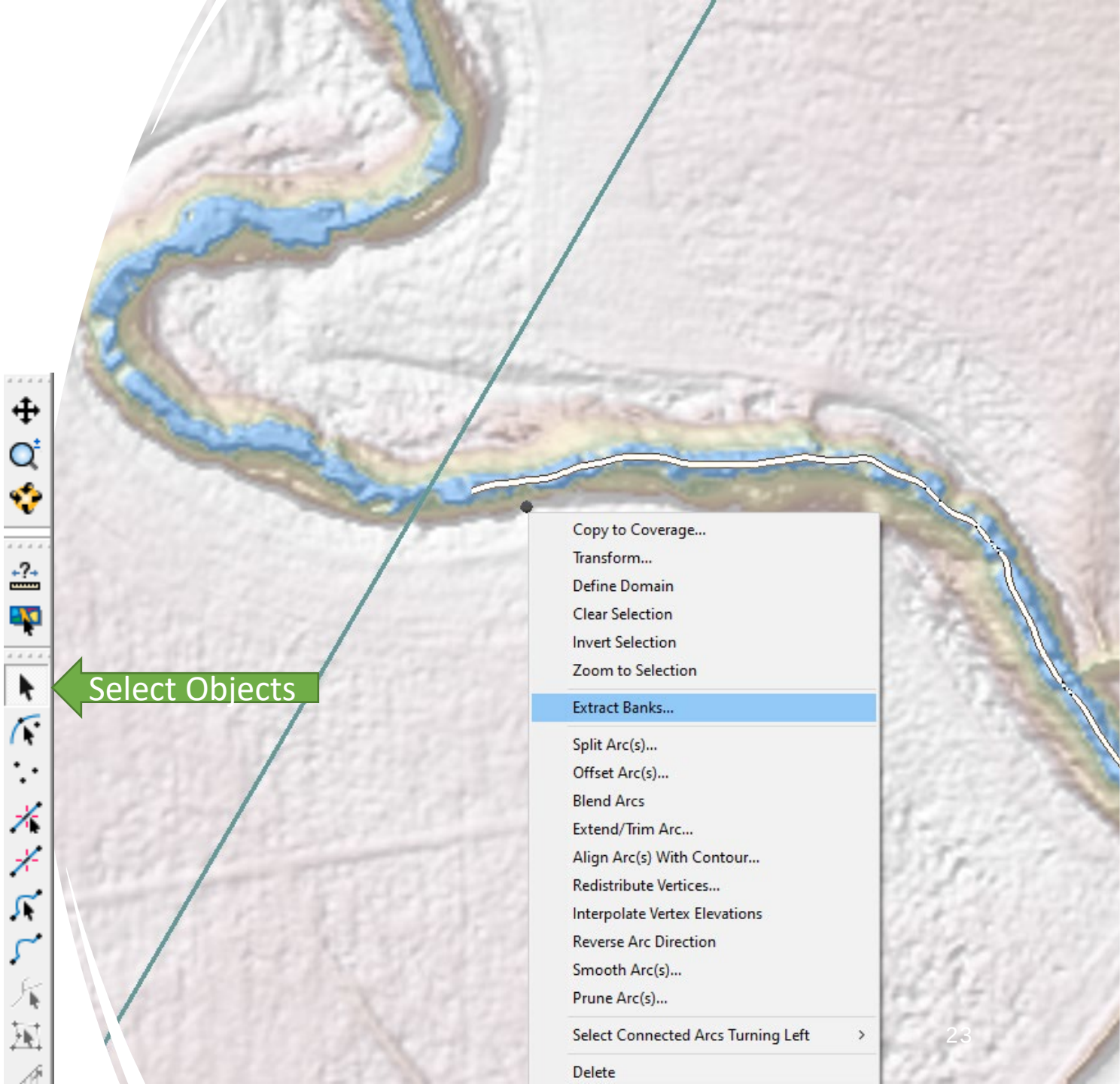
- Use ***Extract Feature*** preset options
- Set Output Coverage to the new coverage (CL)
- Generate CL



Mesh Development:

Add Channel Banklines

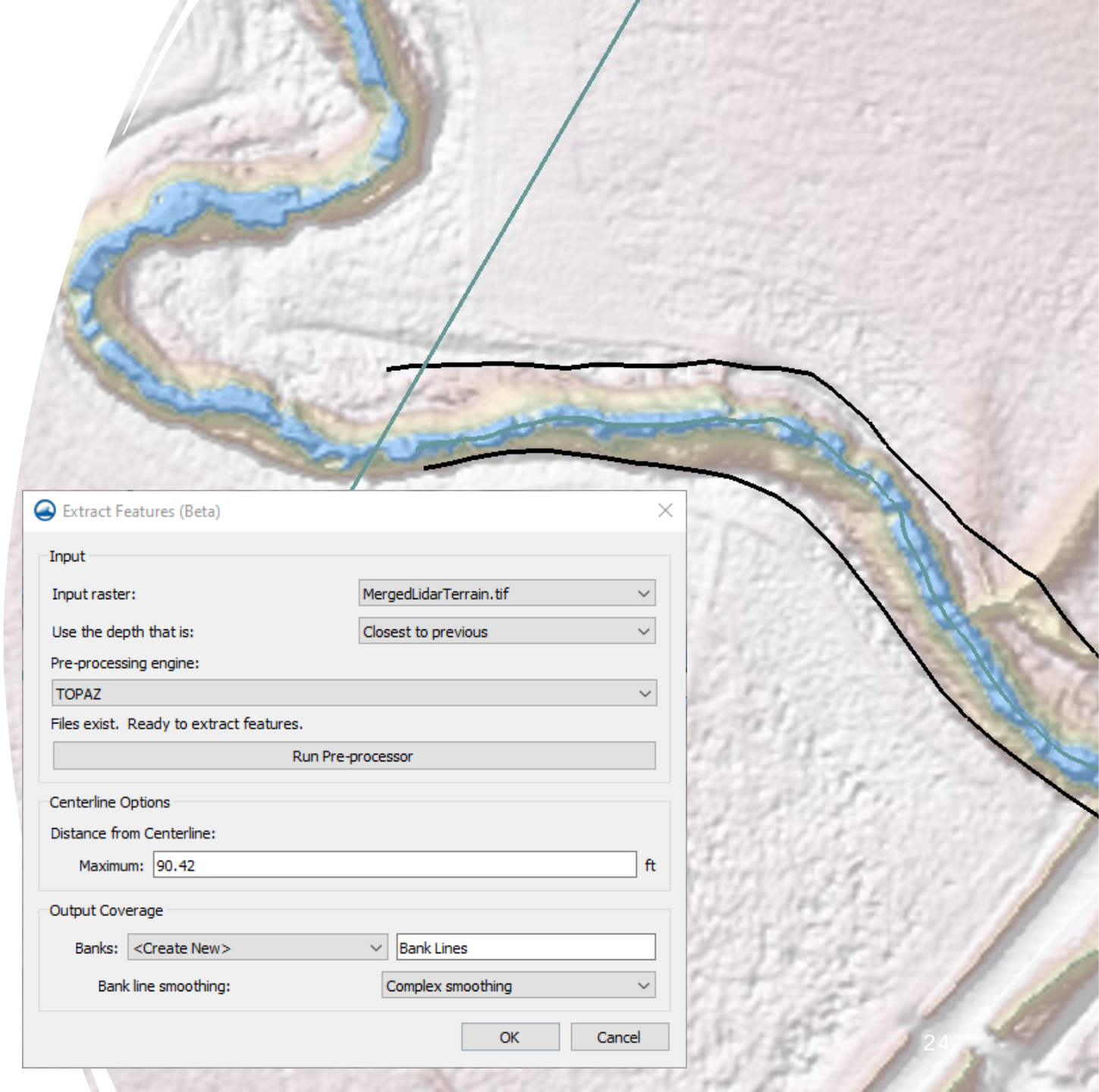
- Add a node in the vicinity of one of the channel banks
- Select the node and the centerline using the ***Select Objects Tool*** and Shift key
- Select the ***Extract Banks*** option (rt click)



Mesh Development:

Add Channel Banklines

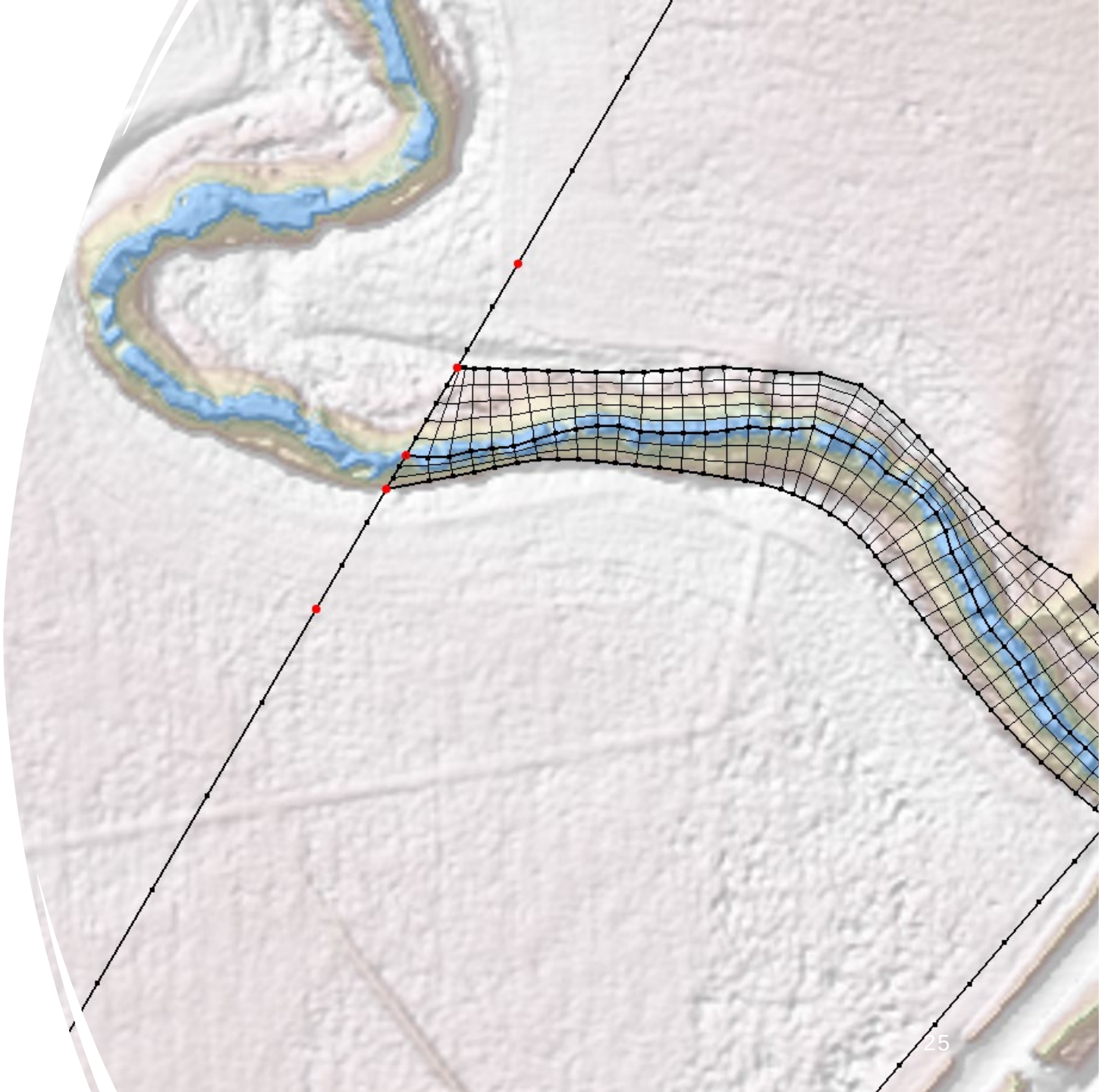
- Start with default options and adjust as needed
- Several bank line scenarios can be generated by varying the bank point location
- Merge with the CL coverage and edit arcs to form a closed polygon



Mesh Development:

Set Mesh Parameters for Main Channel

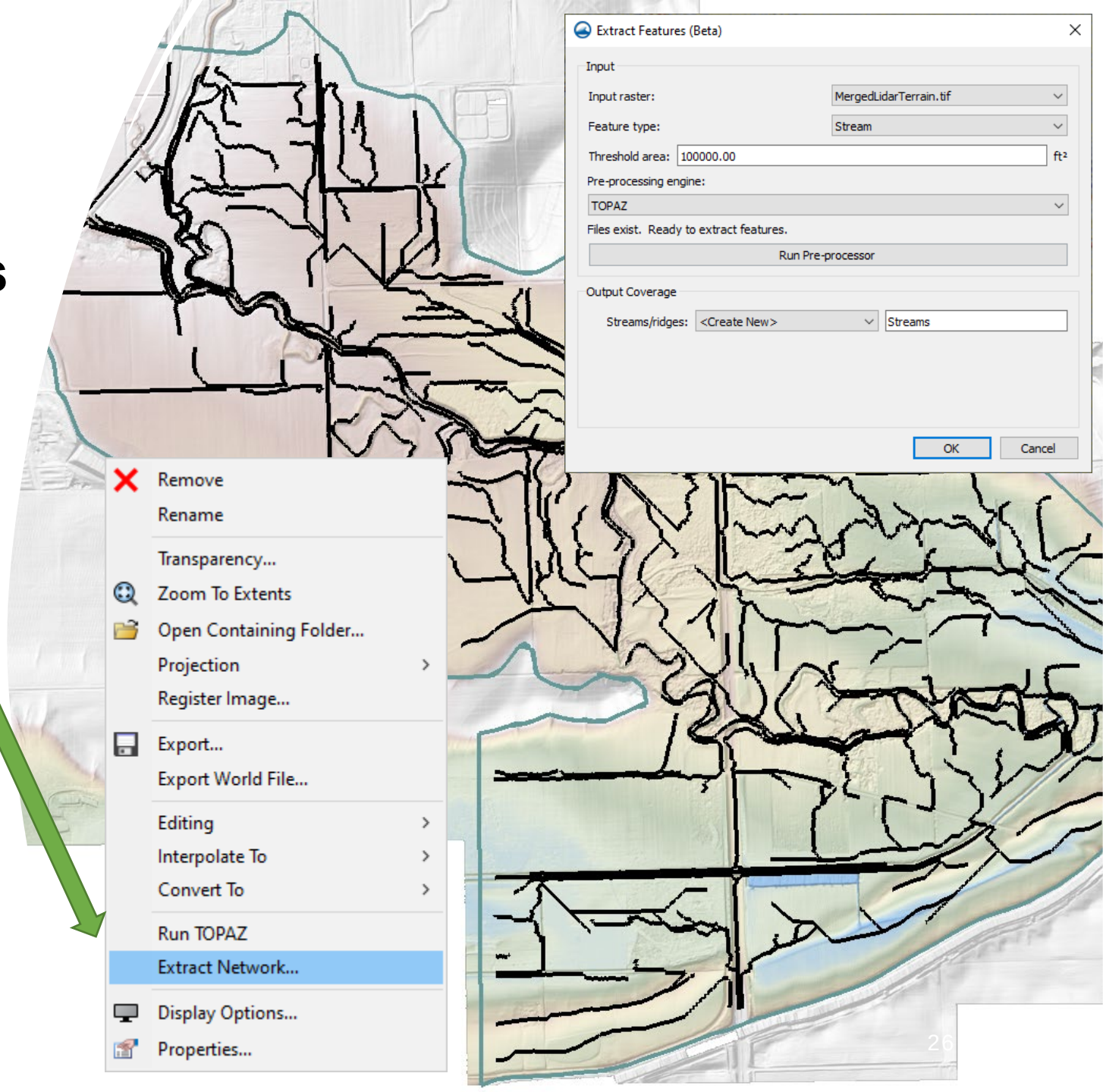
- Set desired vertex distribution along the CL arc
- Use source arc distribution to project CL vertices to the bank arcs
- Set mesh preferences



Mesh Development:

Add Breaklines for Ridges and Secondary Channels

- Rt click on Terrain Raster and select ***Extract Network***
- Run tool for *Stream* and then *Ridge* Feature Types
- Start with default Threshold area and adjust to desired level of detail (Threshold area =drainage area)



Mesh Development:

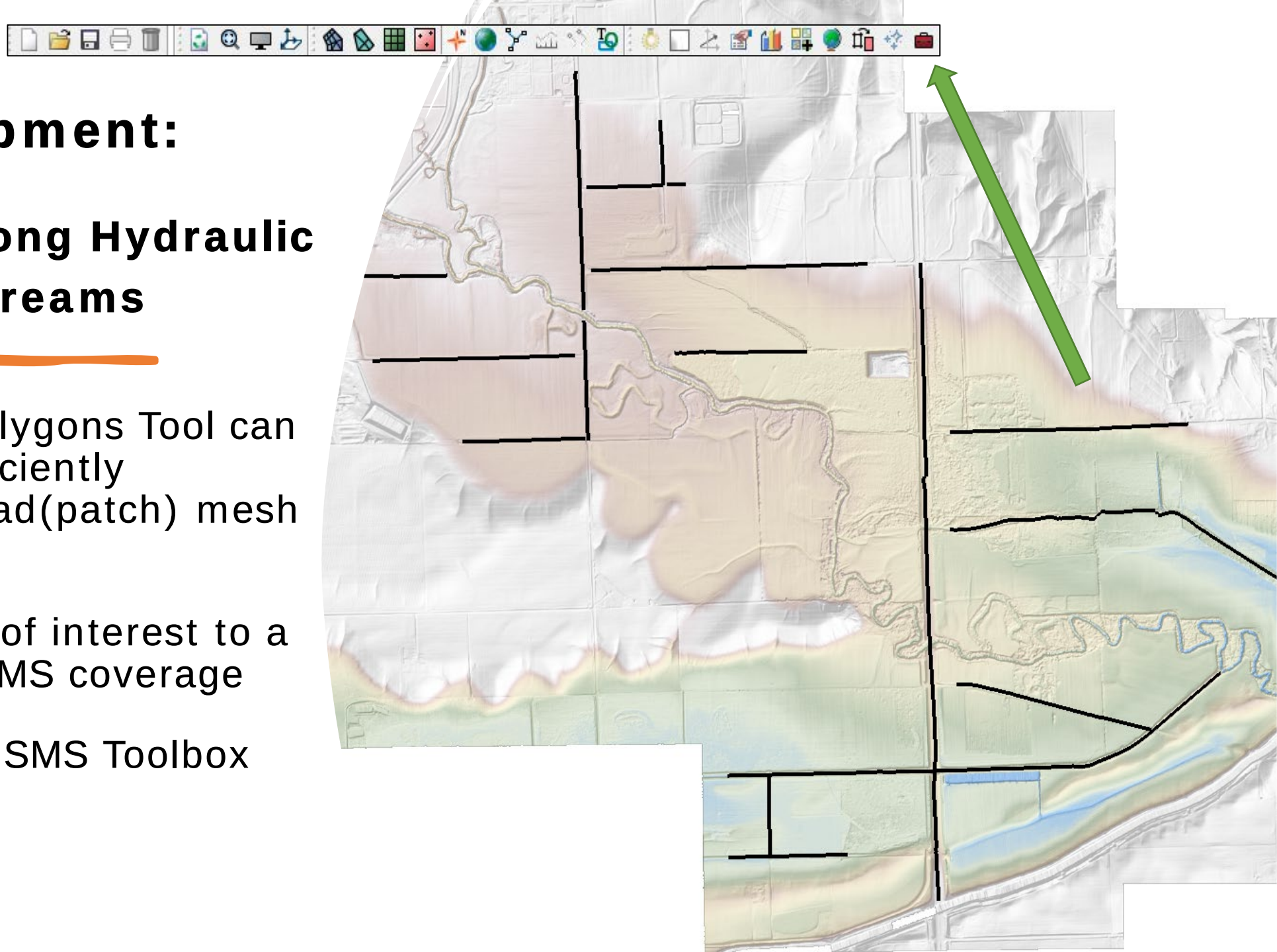
Add Breaklines for Ridges and Secondary Channels

- Thin arcs to the desired level of detail (manually select & delete)
- Merge ridge and stream coverages

Mesh Development:

Refine Mesh Along Hydraulic Controls and Streams

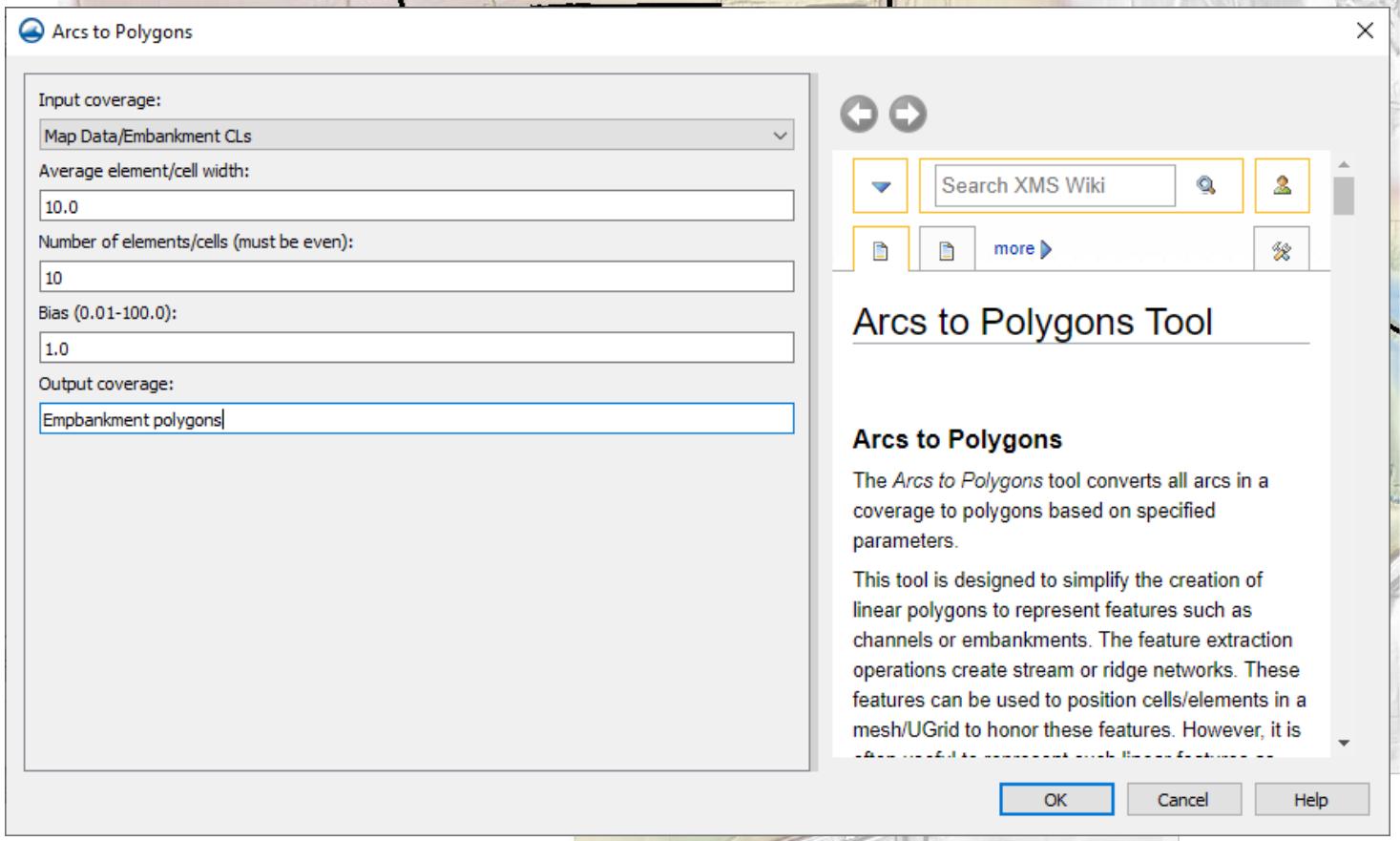
- The Arcs to Polygons Tool can be used to efficiently generate a quad(patch) mesh along an arc
- Copy the arcs of interest to a new general SMS coverage
- Open the new SMS Toolbox



Mesh Development:

Refine Mesh Along Hydraulic Controls and Streams

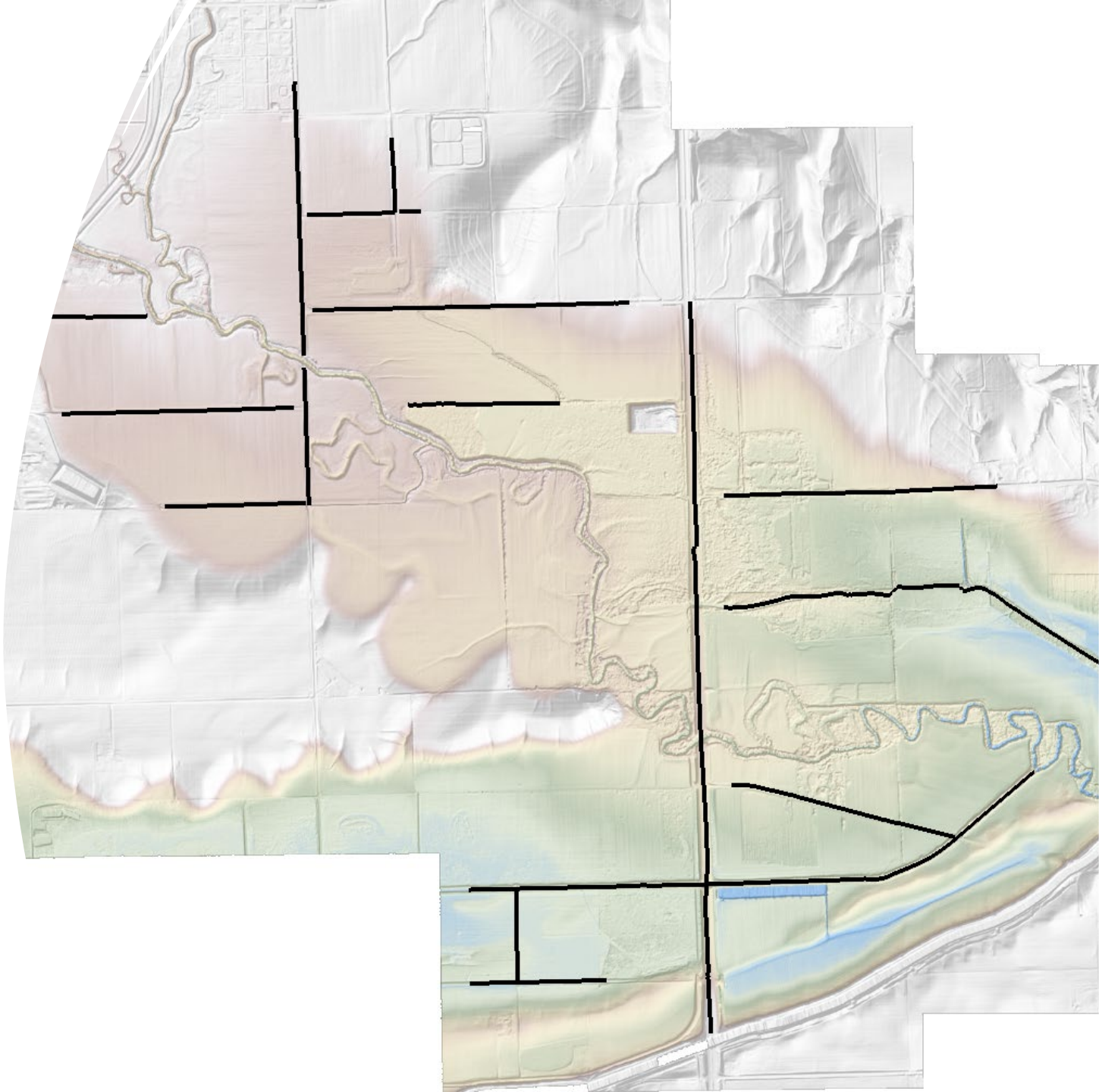
- Under the Coverages folder, select ***Arcs to Polygons***
- Select input coverage with CL arcs and specify preferences



Mesh Development:

Refine Mesh Along Hydraulic Controls and Streams

- Under the Coverages folder, select ***Arcs to Polygons***
- Select input coverage with CL arcs and specify preferences
- For variable preferences for different arcs, use multiple coverages and run the Arcs to Polygon Tool for each one



Mesh Development:

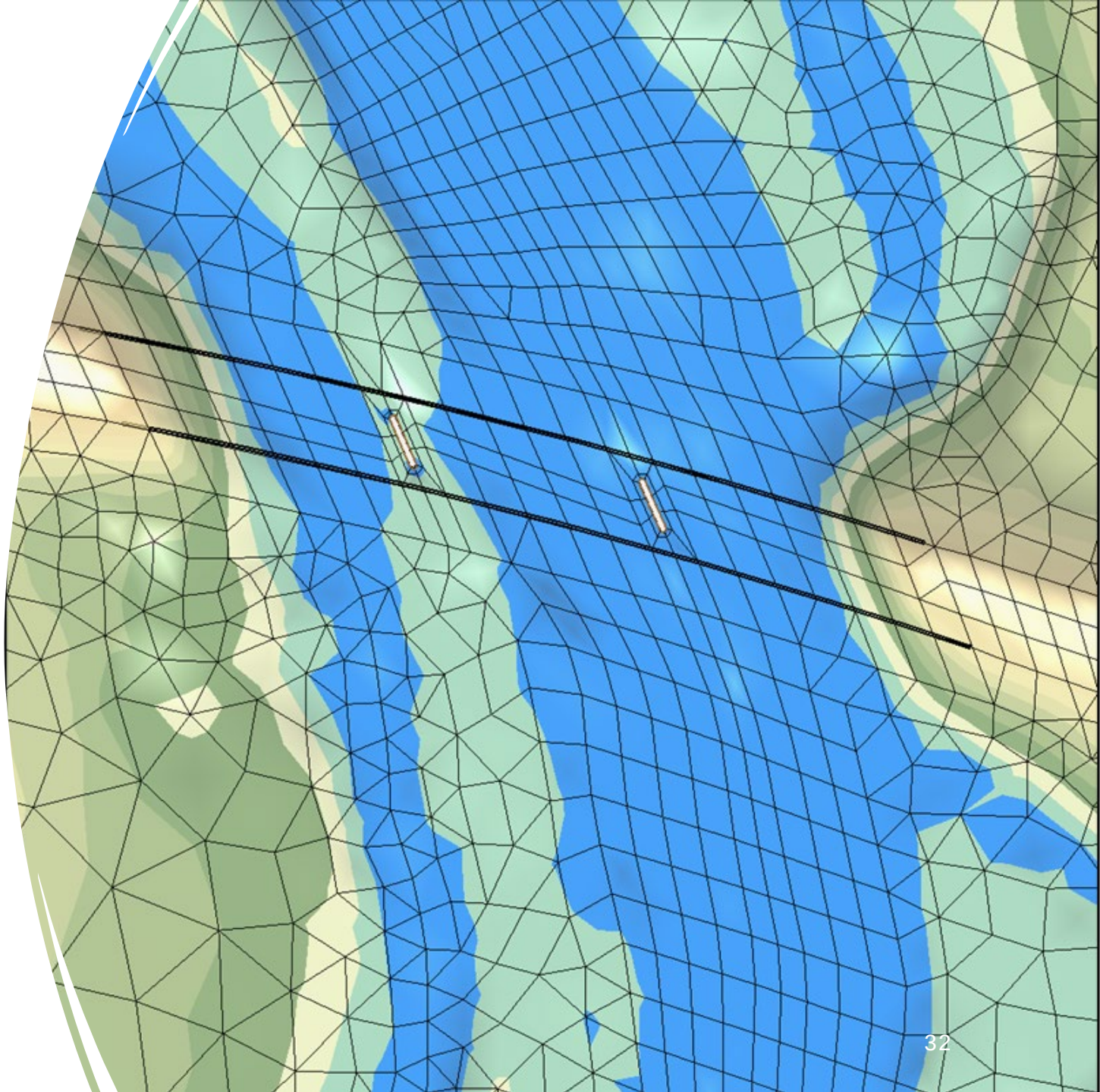
Refine Mesh Along Hydraulic Controls and Streams

- Each polygon has vertices set to support the specified element size
- Minor editing can be needed for more complex arc configurations
- Copy polygons into the master mesh generator coverage

Mesh Development:

Define Mesh at Bridges

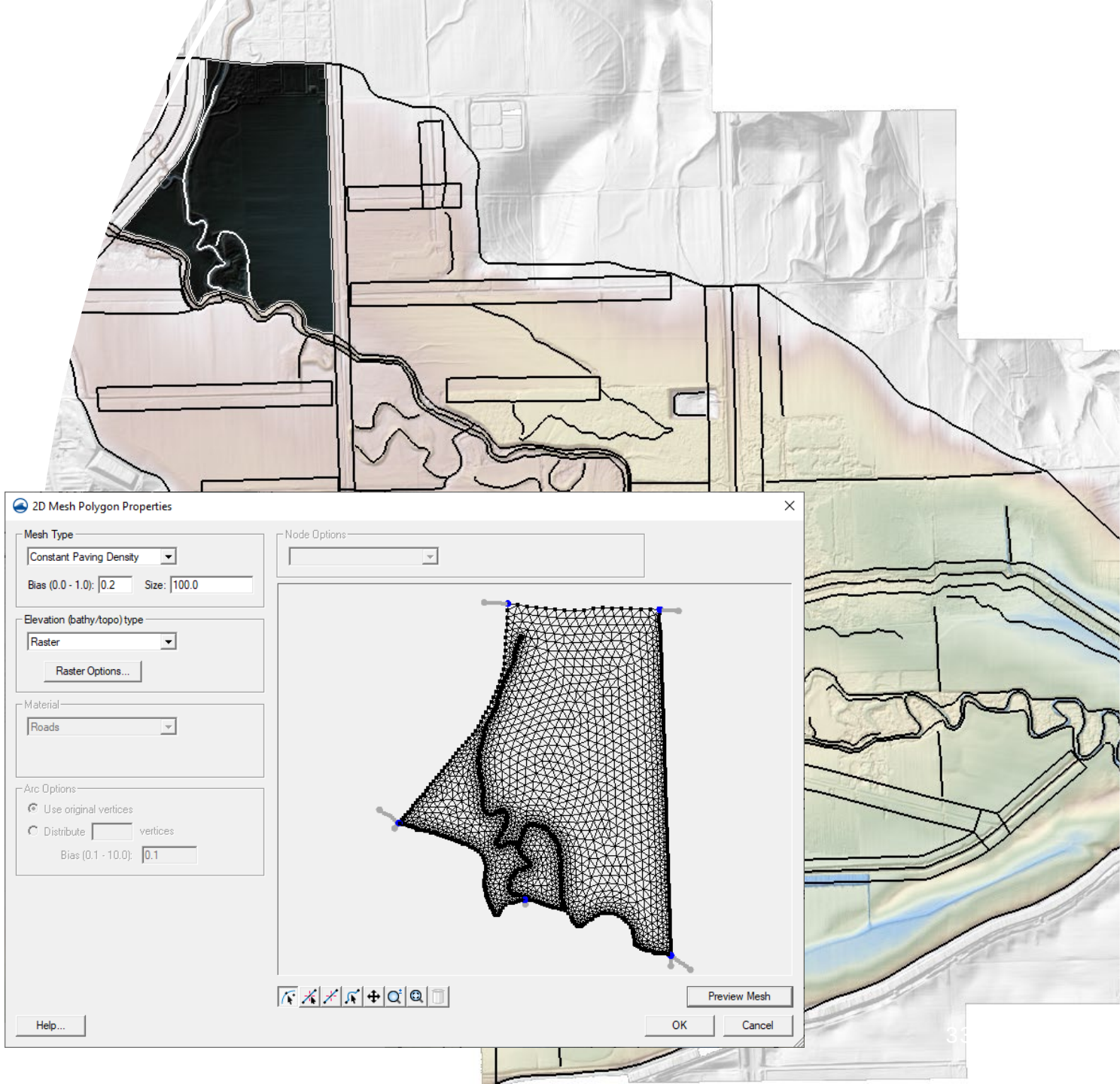
- Review November 16, 2022 web meeting recording and demo
- Copy bridge footprints to master mesh generator coverage



Mesh Development:

Set Variable Mesh Sizing

- Use the ***SMS Constant Paving Density*** option for large areas
- Specify target element size and a rate of transition (bias)
- Multiple polygons can be selected and edited at the same time by holding the Shift Key while selecting each one



Mesh Development:

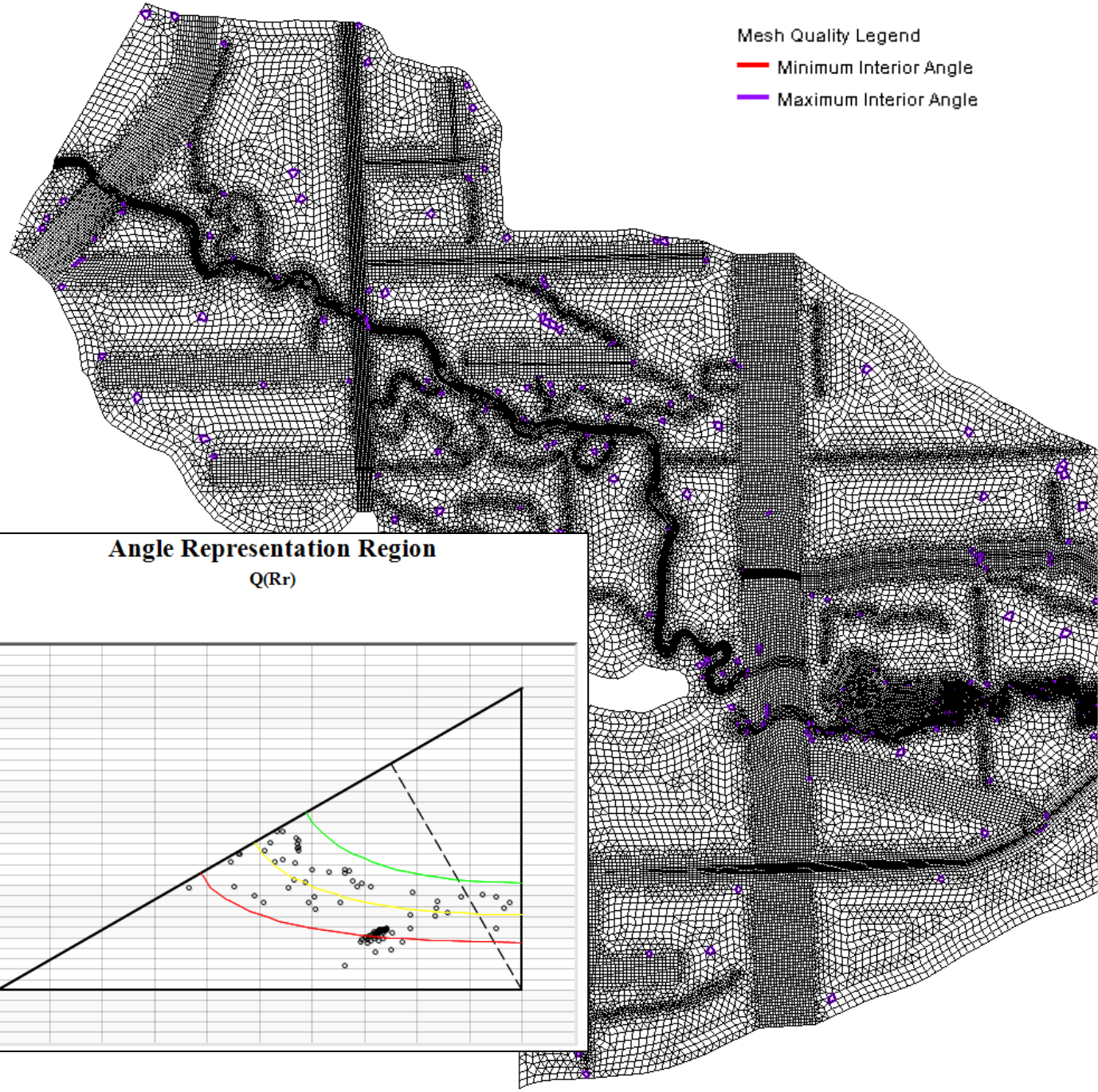
Generate Final Mesh

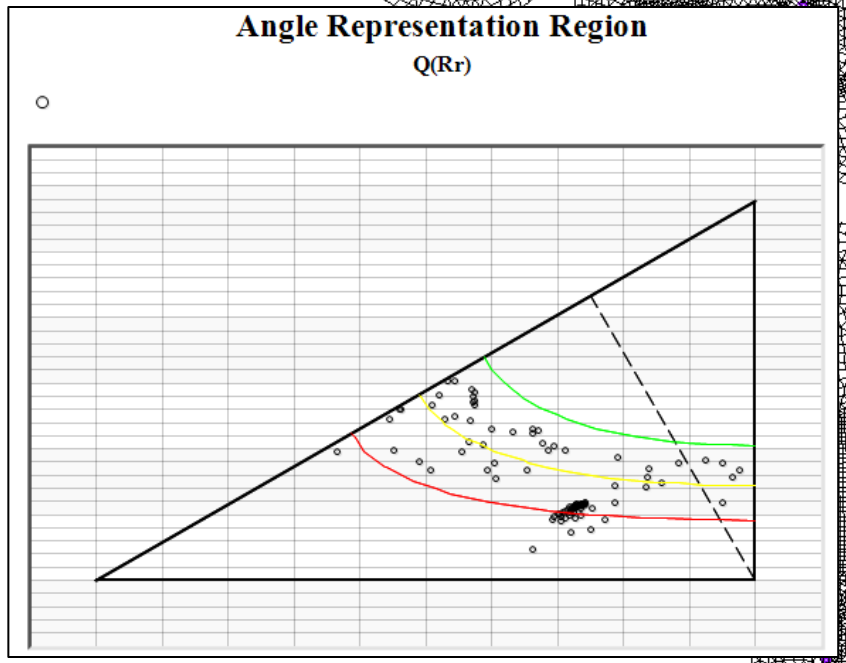
- Set terrain data source for all polygons
- Generate the mesh
- Merge Elements to optimize the mesh

Mesh Development:

Review Mesh Quality

- Turn on Mesh Quality options in SMS Display Options
- Focus primarily on minimum interior angles
- Review the ARR Mesh Quality Plot under the SMS Plot Wizard

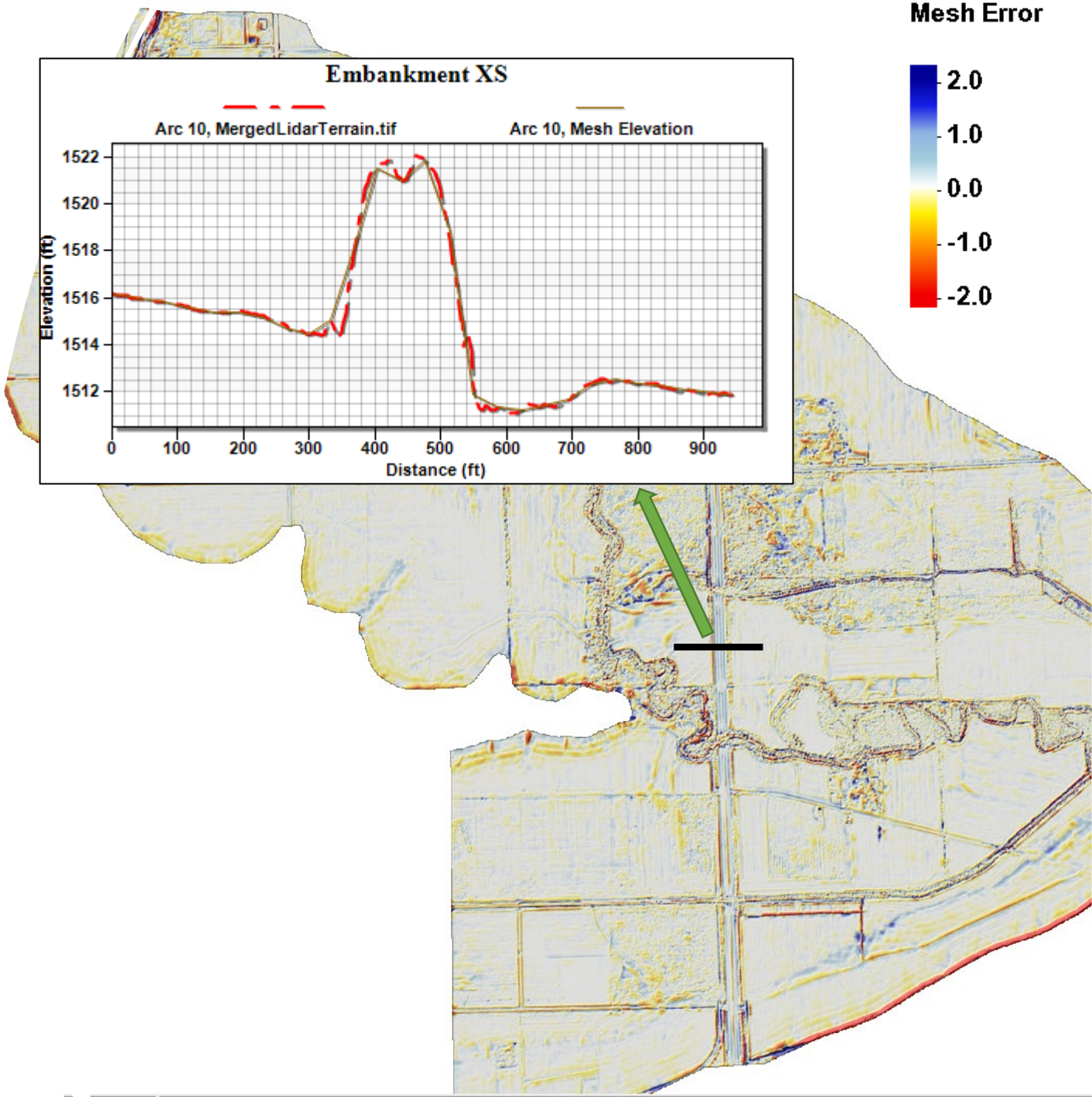




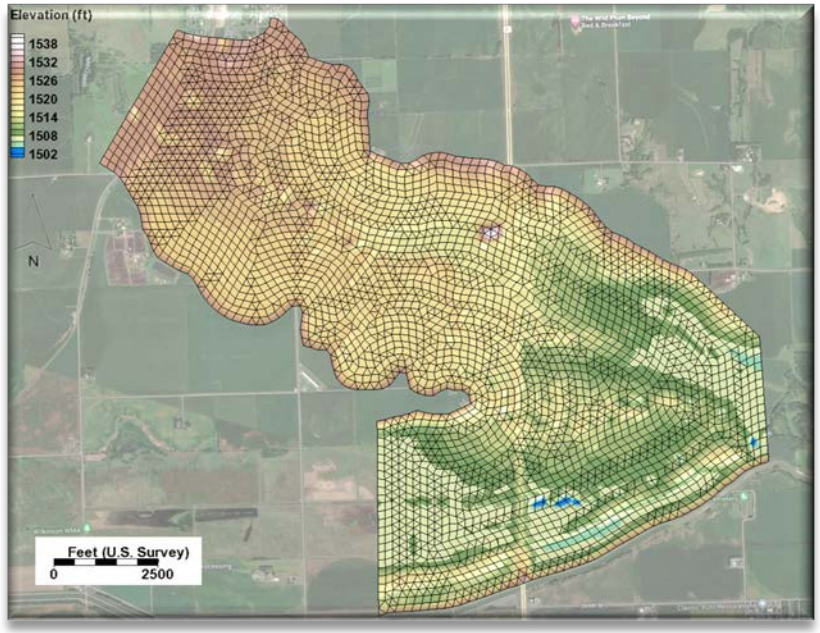
Mesh Development:

Review Mesh Accuracy

- Convert Final Mesh to a raster using the SMS Toolbox ***Dataset to Raster*** tool
- Compare Final Mesh Raster with Terrain Raster using the SMS Toolbox ***Raster Difference*** tool
- Use SMS ***Observation Plots*** to spot check primary features
- Revise mesh as needed



Mesh Development Recap:



- 100 ft elements
- No mesh breaklines
- 4680 total elements
- Simulation time = 10 sec
- Solution accuracy - low

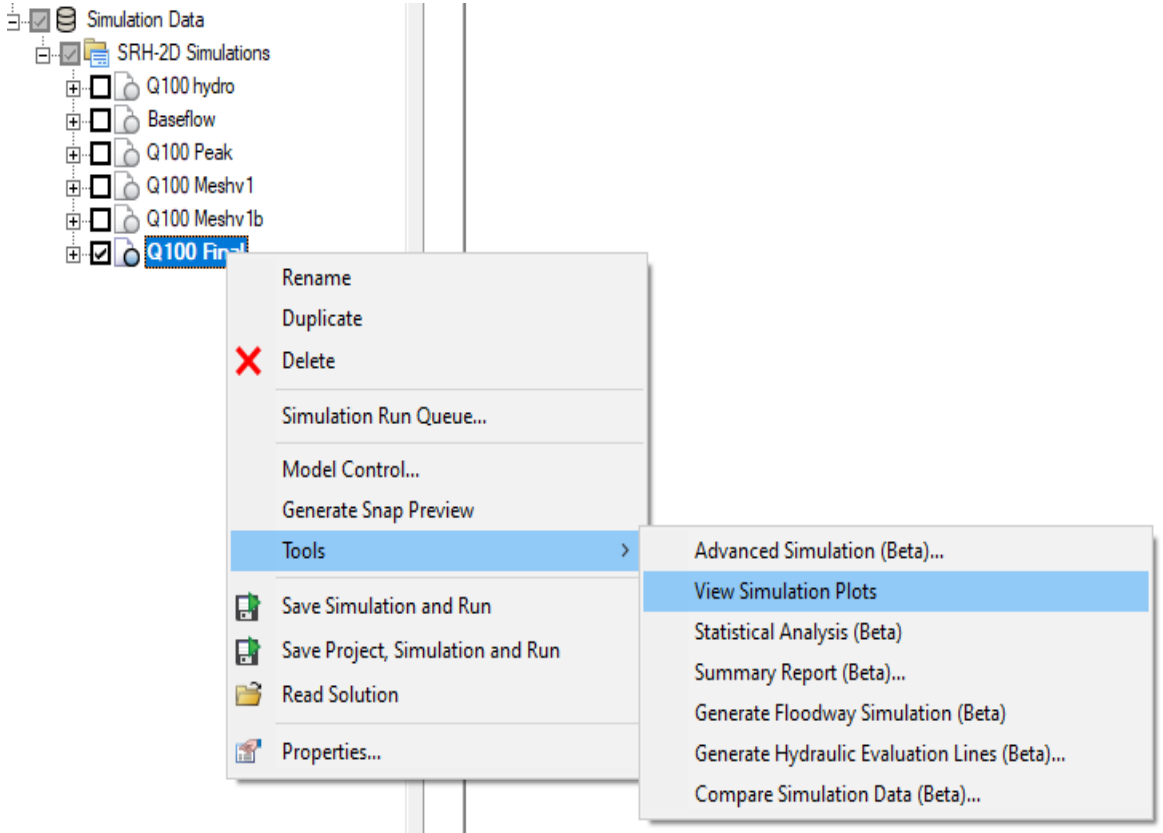
- 10 ft elements
- No mesh breaklines
- 1.7M total elements
- Simulation time = 9.5 hrs
- Solution accuracy - high

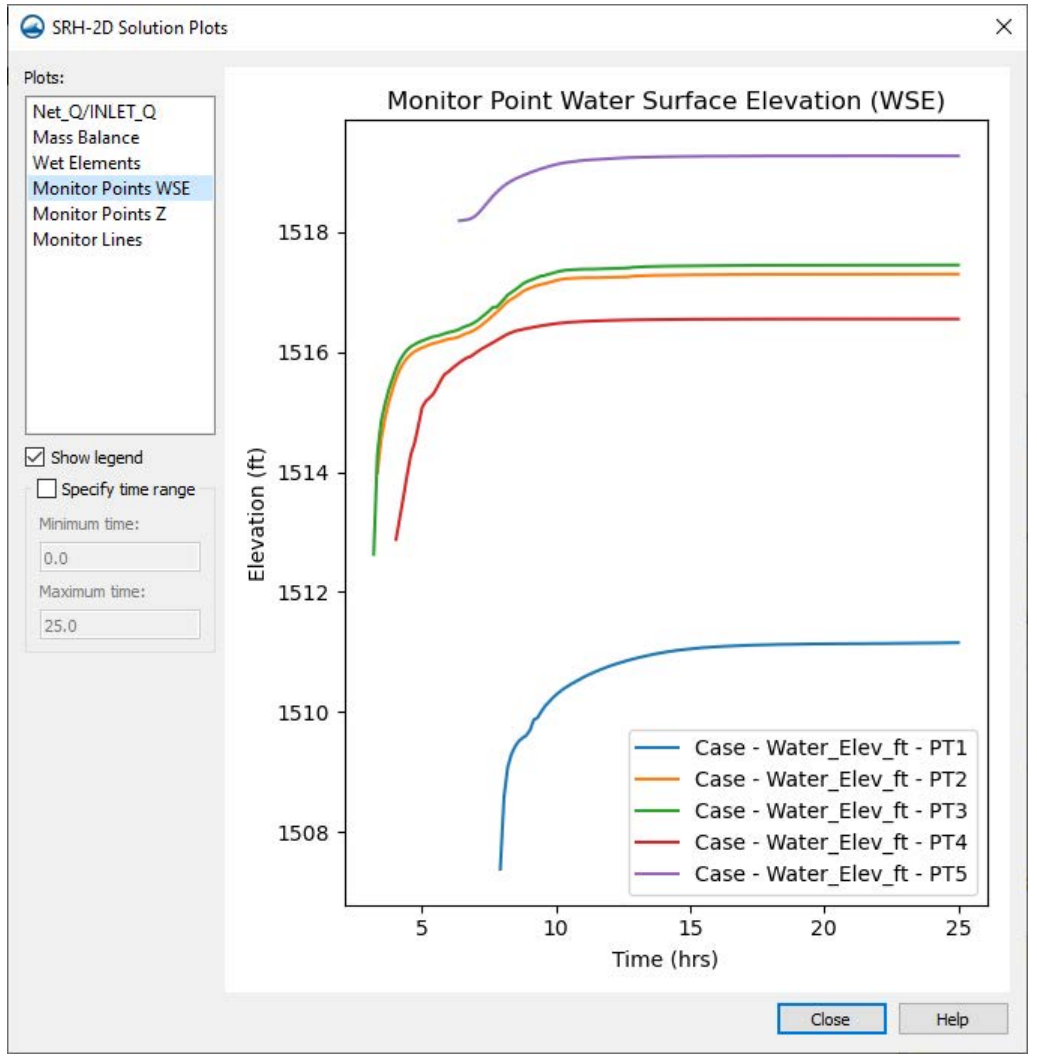
- 20-100 ft elements
- Detailed mesh breaklines
- 68,488 total elements
- Simulation time = 12 min
- Solution accuracy - high

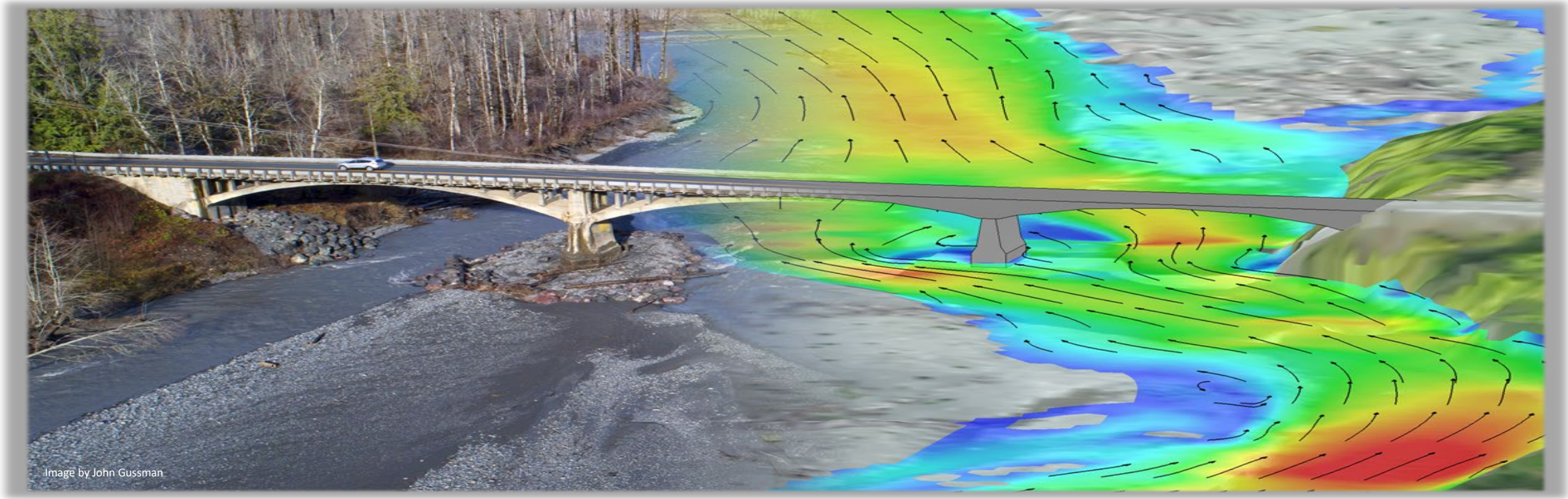
Recommended Mesh Development Steps

1. Define model domain
2. Generate initial coarse mesh
3. Run test simulation
4. Adjust domain limits as needed
5. Delineate channel centerline and channel banklines (if needed)
6. Add mesh breaklines to capture hydraulic controls and secondary streams
7. Refine mesh along hydraulic controls and streams
8. Define mesh at bridges with piers
9. Set mesh for large areas to use 'Constant Paving Density'
10. Generate mesh
11. Evaluate mesh quality and accuracy
12. Revise mesh to improve terrain representation as needed

Tips and Tricks – View Simulation Plots







THANK YOU!

Please contact us with any questions

Scott Hogan
FHWA Resource Center
Scott.hogan@dot.gov
(720) 576-6026

Laura Girard
FHWA Resource Center
laura.girard@dot.gov
(970) 217-3894