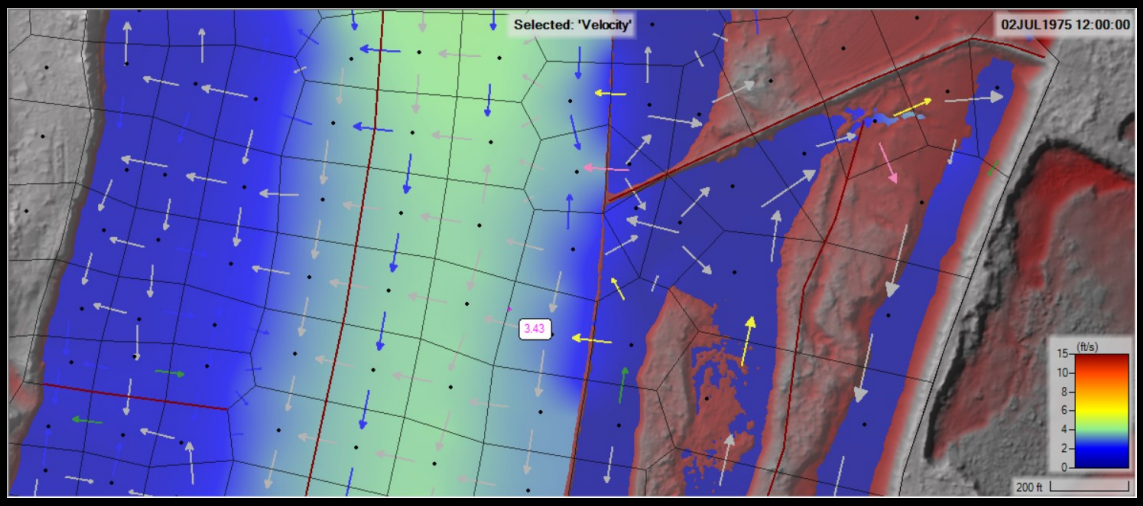
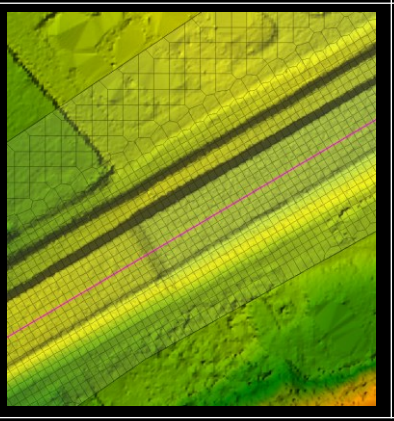
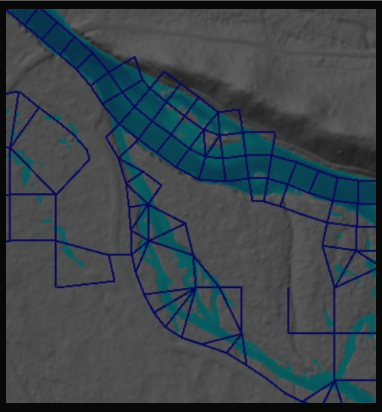
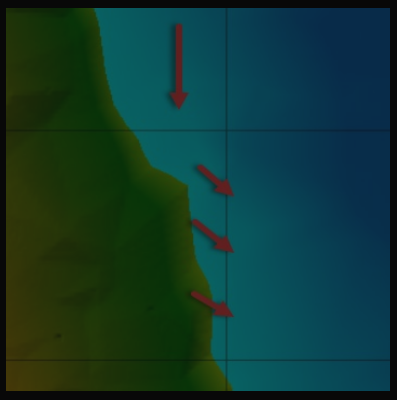
Mesh Development, Best Practices, and Troubleshooting for HEC-RAS 2D Sediment Models



Stanford Gibson
Alex Sánchez, Cameron Ackerman

1

Mesh Quality Trouble Shooting

Mesh Best Practices	Diagnostics	Common Mesh Fixes
		

2

Mesh Best Practices for 2D Sediment Modeling

1. Align Cell Faces with High Ground/Structures
2. Align Cell Faces with Flow Direction
3. Defining an Irregular 2D Channel
4. Connectivity
   - Diagnostics
   - Best Practices

3

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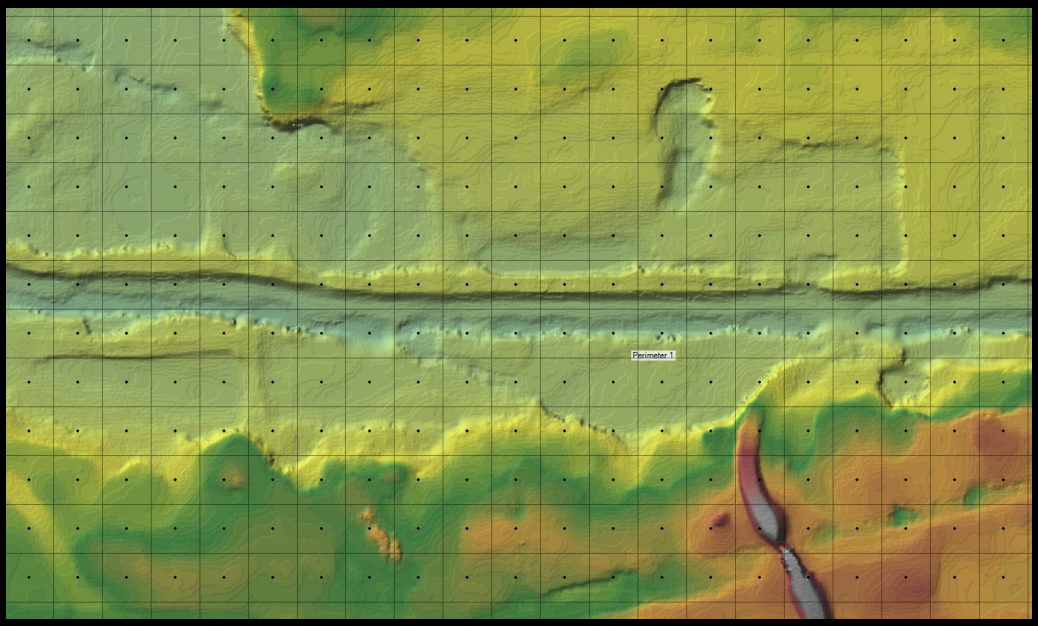
What is the biggest problem with this mesh?



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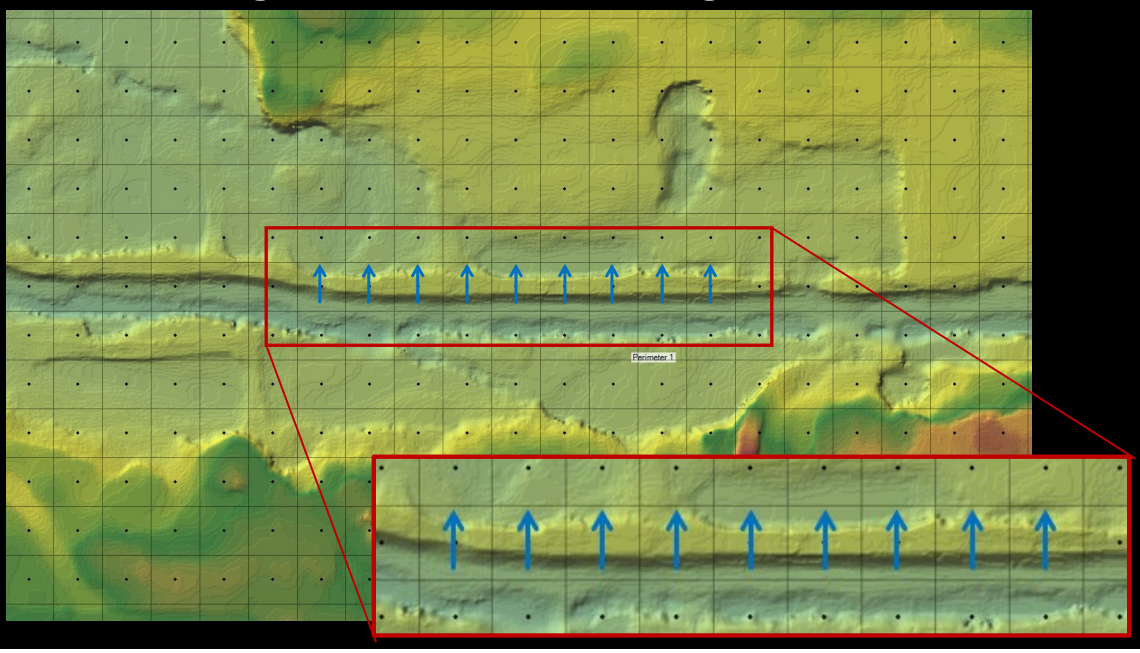
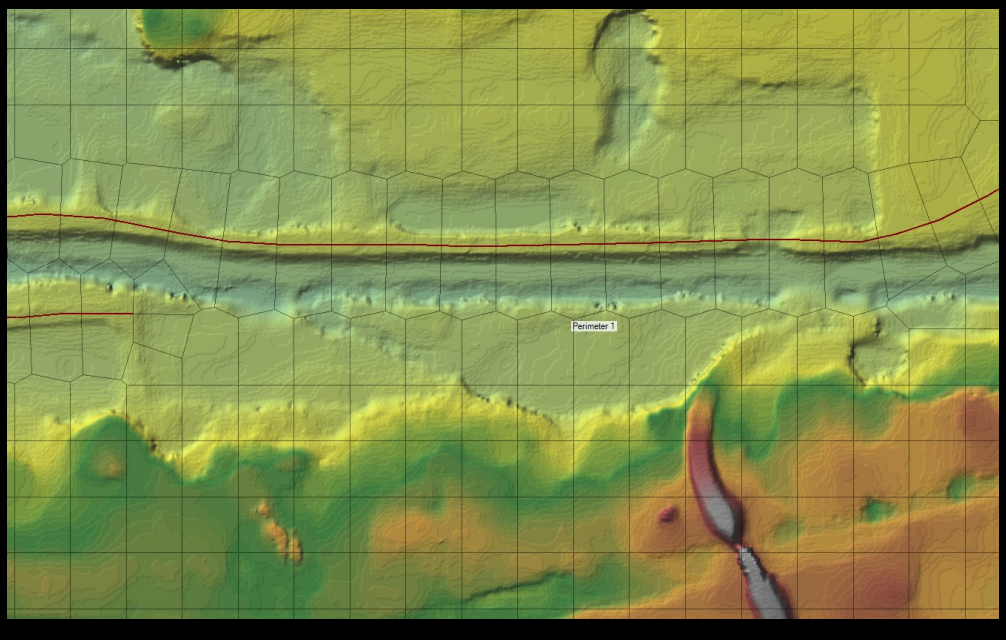
Cell Edges Do Not Follow High Ground



6

Add a Breakline (or a bunch)



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Take Away: Take Control of the High Ground

8

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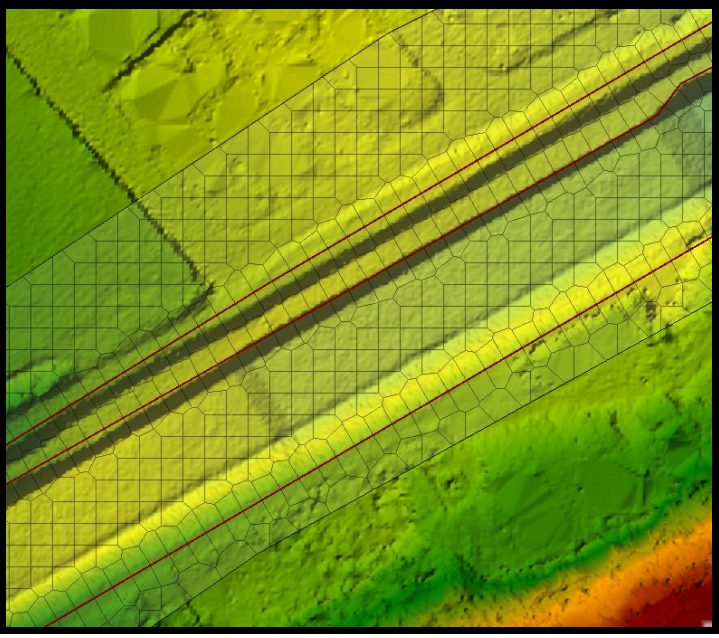
How Could We Improve This Mesh?



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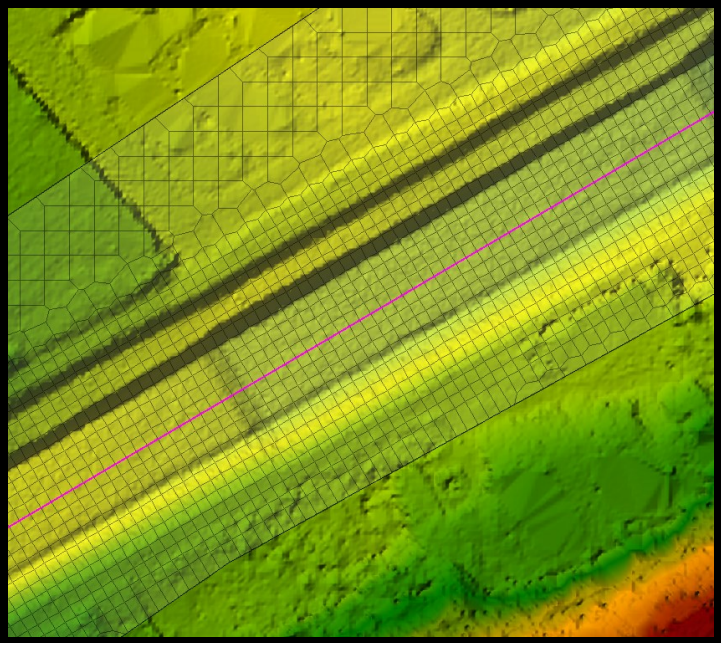
Align the Mesh with the Flow



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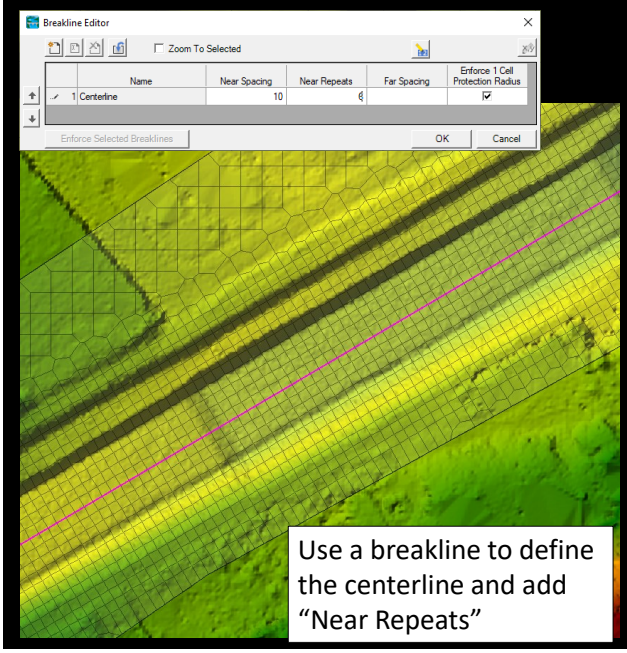
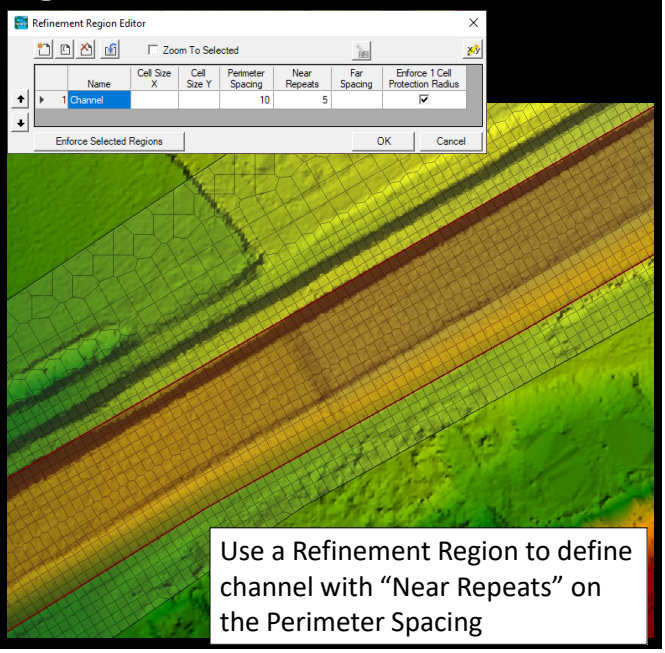
Two Methods to Align Cells with Flow



Use a breakline to define the centerline and add “Near Repeats”



Use a Refinement Region to define channel with “Near Repeats” on the Perimeter Spacing

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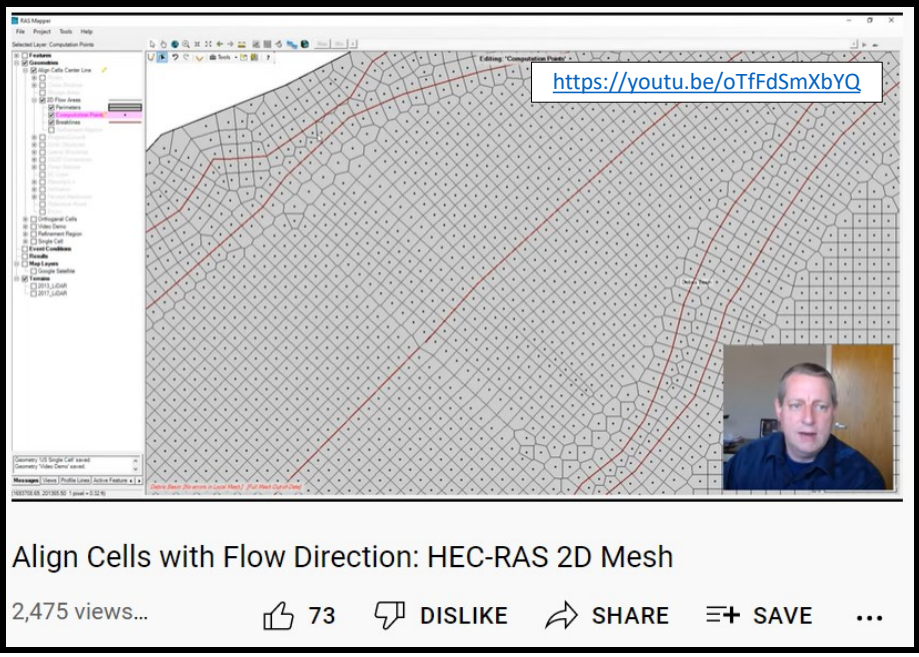
Alignment Video Tutorial



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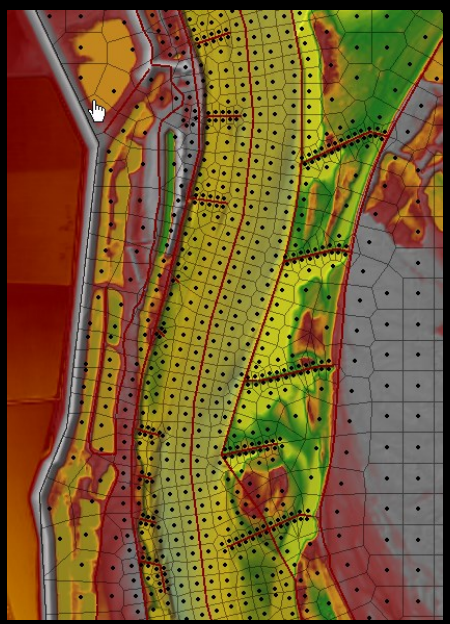
Mesh Best Practices for 2D Sediment Modeling

1. Align Cell Faces with High Ground/Structures
2. Align Cell Faces with Flow Direction
3. Defining an Irregular 2D Channel
4. Connectivity
   - Diagnostics
   - Best Practices



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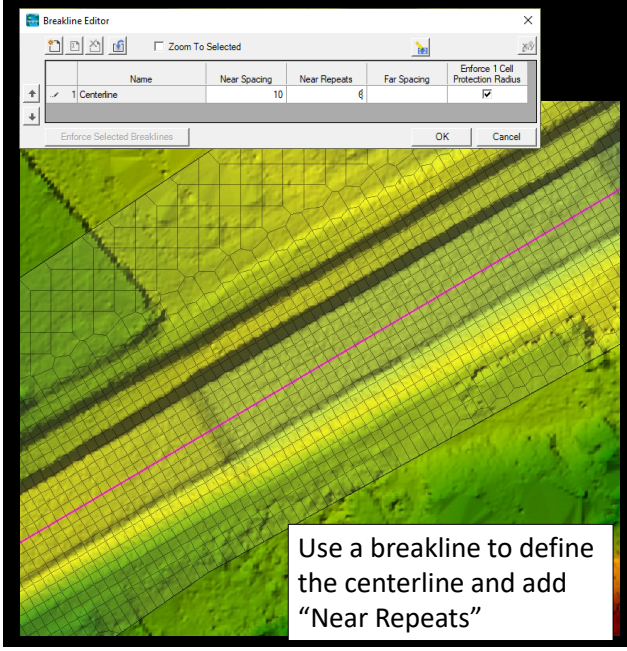
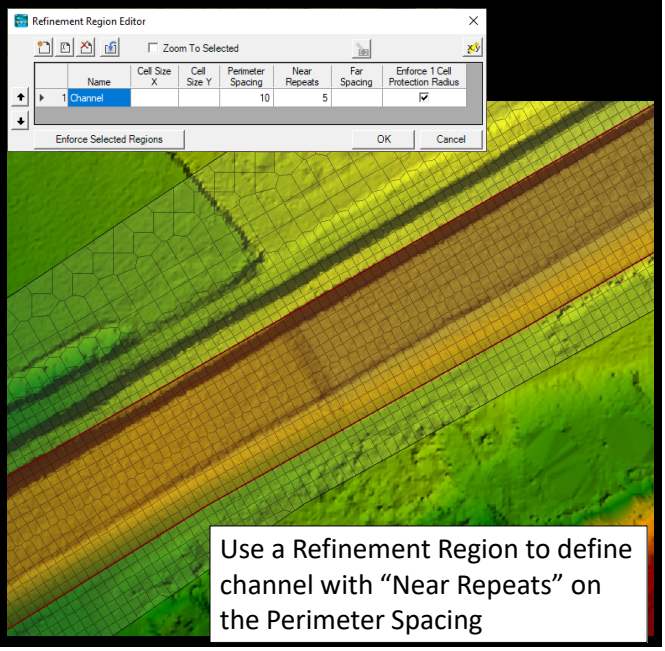
Two Methods to Align Cells with Flow



Use a breakline to define the centerline and add "Near Repeats"



Use a Refinement Region to define channel with "Near Repeats" on the Perimeter Spacing

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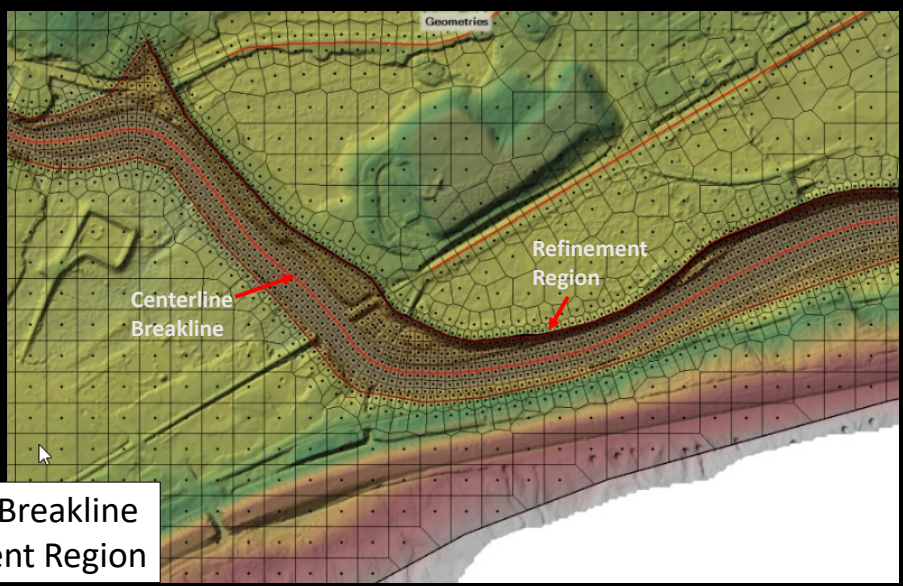
Best Practice – Use Them Together



Centerline Breakline + Refinement Region

https://www.hec.usace.army.mil/confluence/rasdocs/r2dum/latest/development-of-a-2d-or-combined-1d-2d-model/development-of-the-2d-computational-mesh#id-.Developmentofthe2DComputationalMeshv6.0-MakingaChannelMesh

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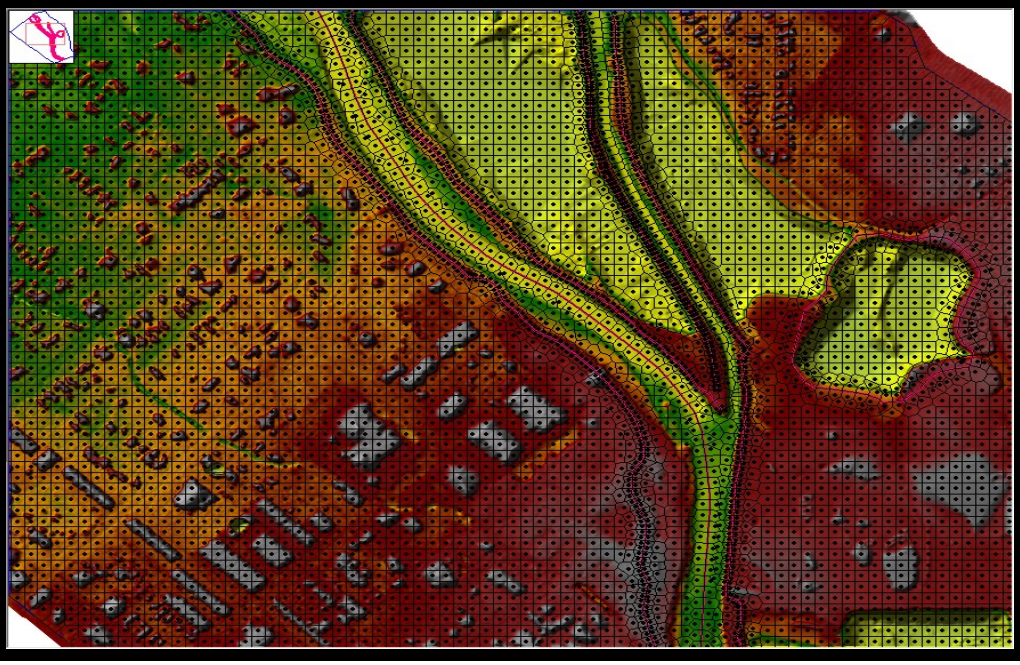
Polygon Refinement for Main Channel



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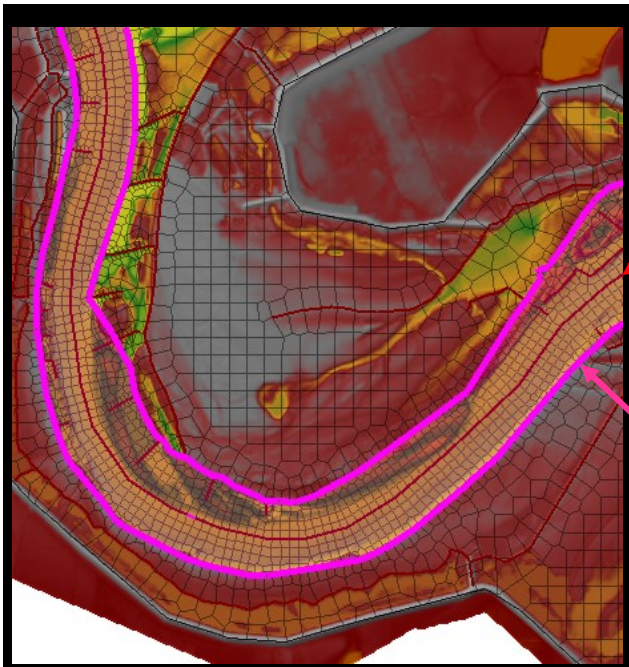
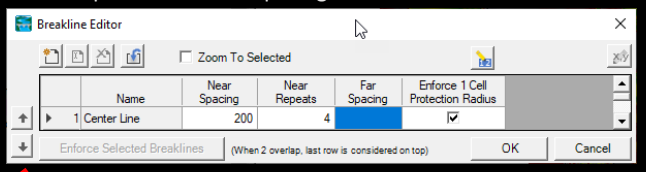


Centerline breakline

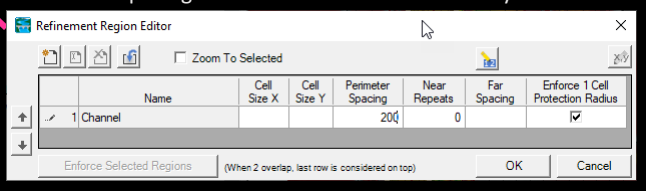
Near Repeats with Near Spacing



Refinement Region

Only Meant to Snap the Outside Cell Faces to Banks

Perimeter Spacing and Enforce Cell Protection Only



Best practices are still emerging, but at least 6-8 cells across a channel is probably a practical minimum for a 2D sediment model

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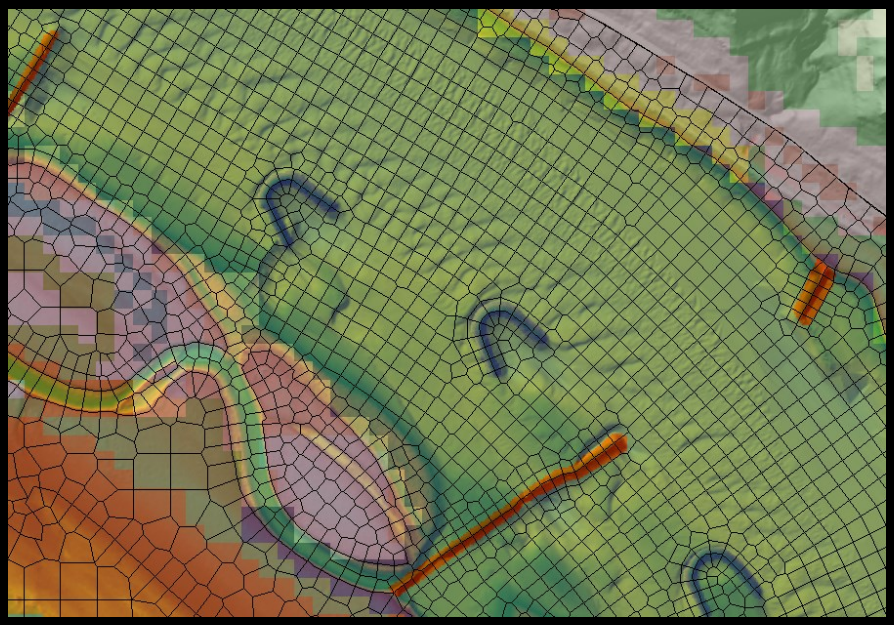
Use Breaklines for Linear Structures



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Developing a Quality, Aligned, Mesh Takes Time

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Mesh Best Practices for 2D Sediment Modeling

1. Align Cell Faces with High Ground/Structures
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   - **Diagnostics**
   - **Common Mesh Fixes**

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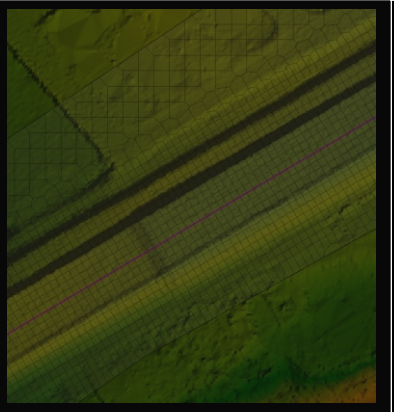
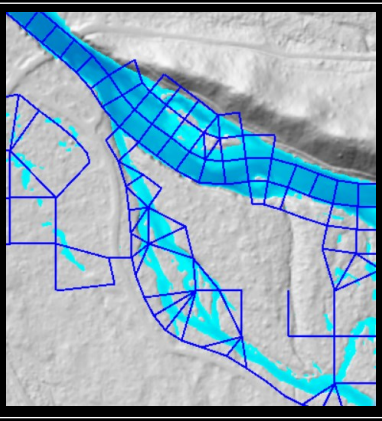
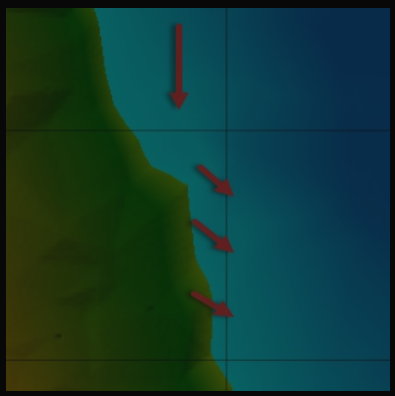
Mesh Quality Trouble Shooting

Mesh Best Practices	Diagnostics	Common Mesh Fixes
		

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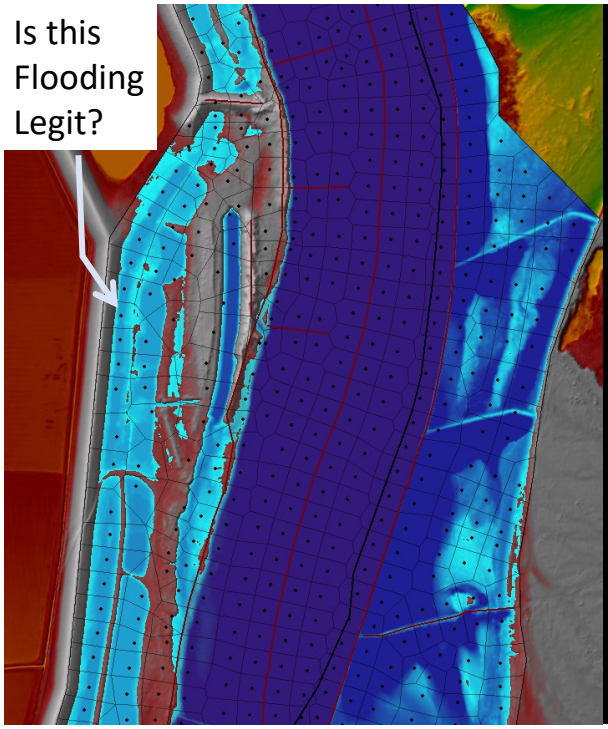
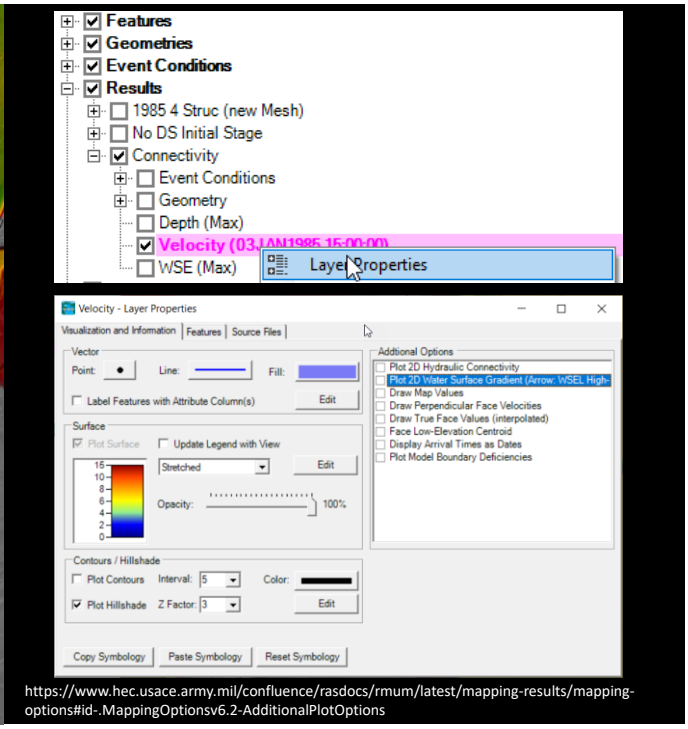
Is this Flooding Legit?

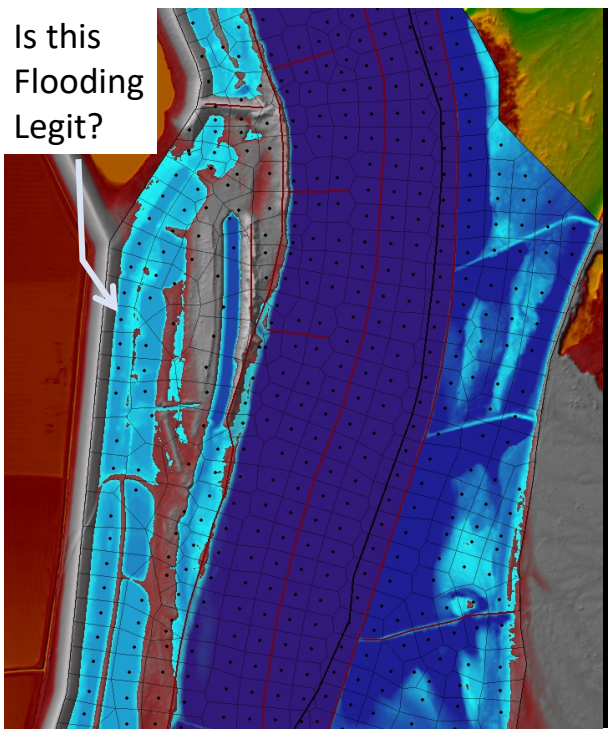


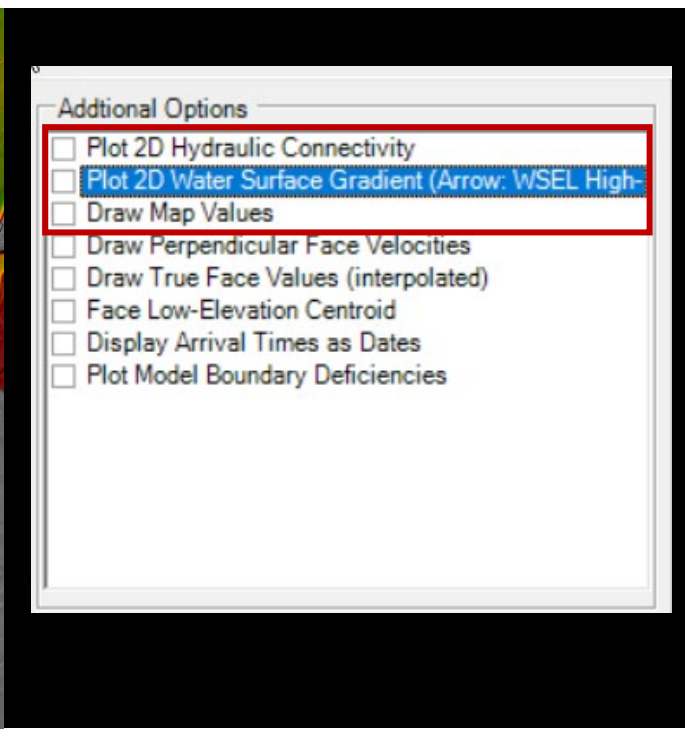


https://www.hec.usace.army.mil/confluence/rasdocs/rmum/latest/mapping-results/mapping-options#id-.MappingOptionsv6.2-AdditionalPlotOptions

23

Is this Flooding Legit?





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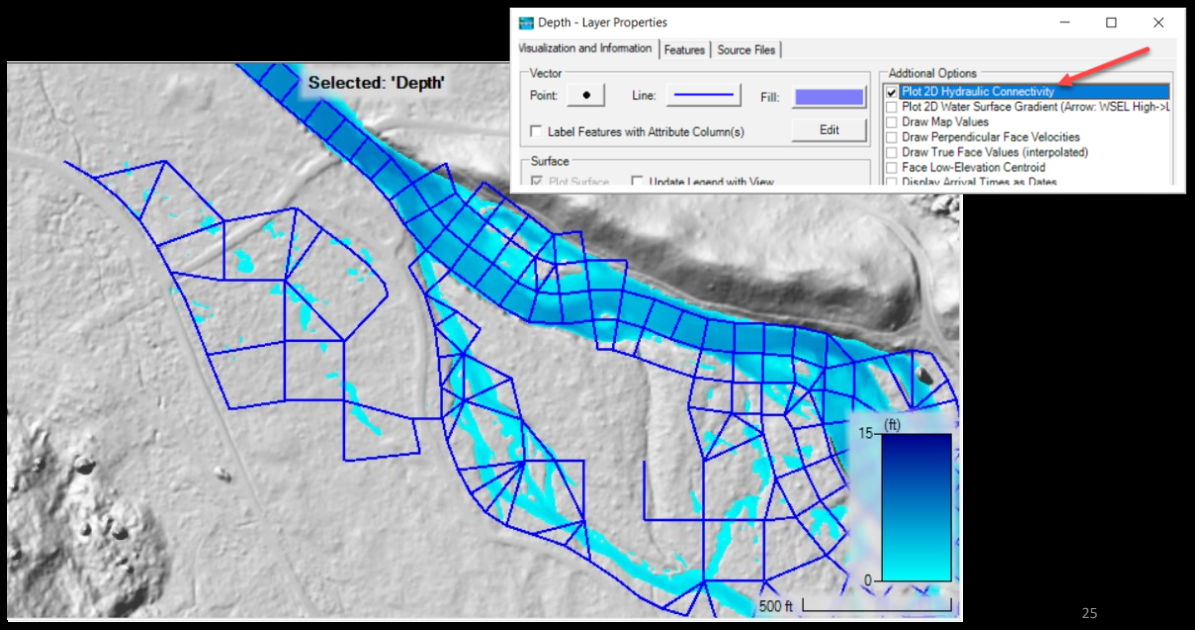
Hydraulic Connectivity



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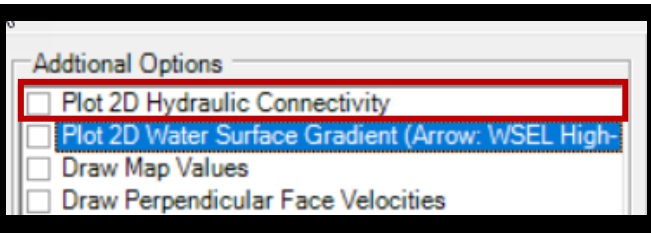

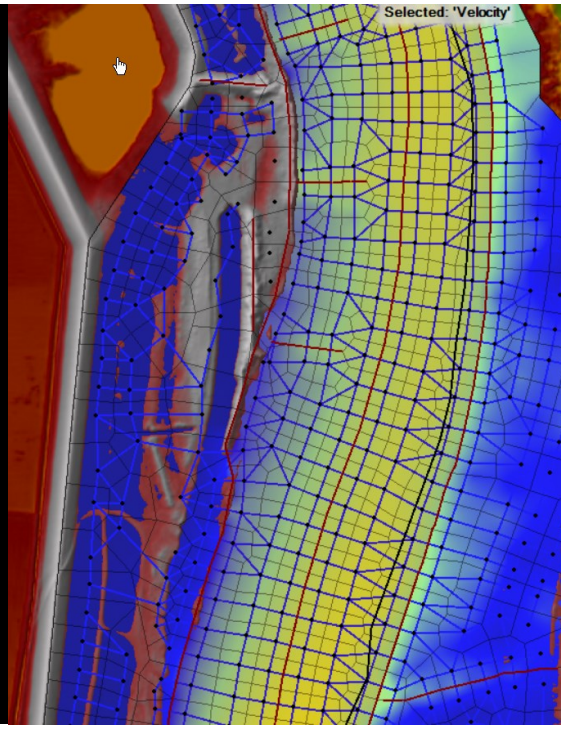

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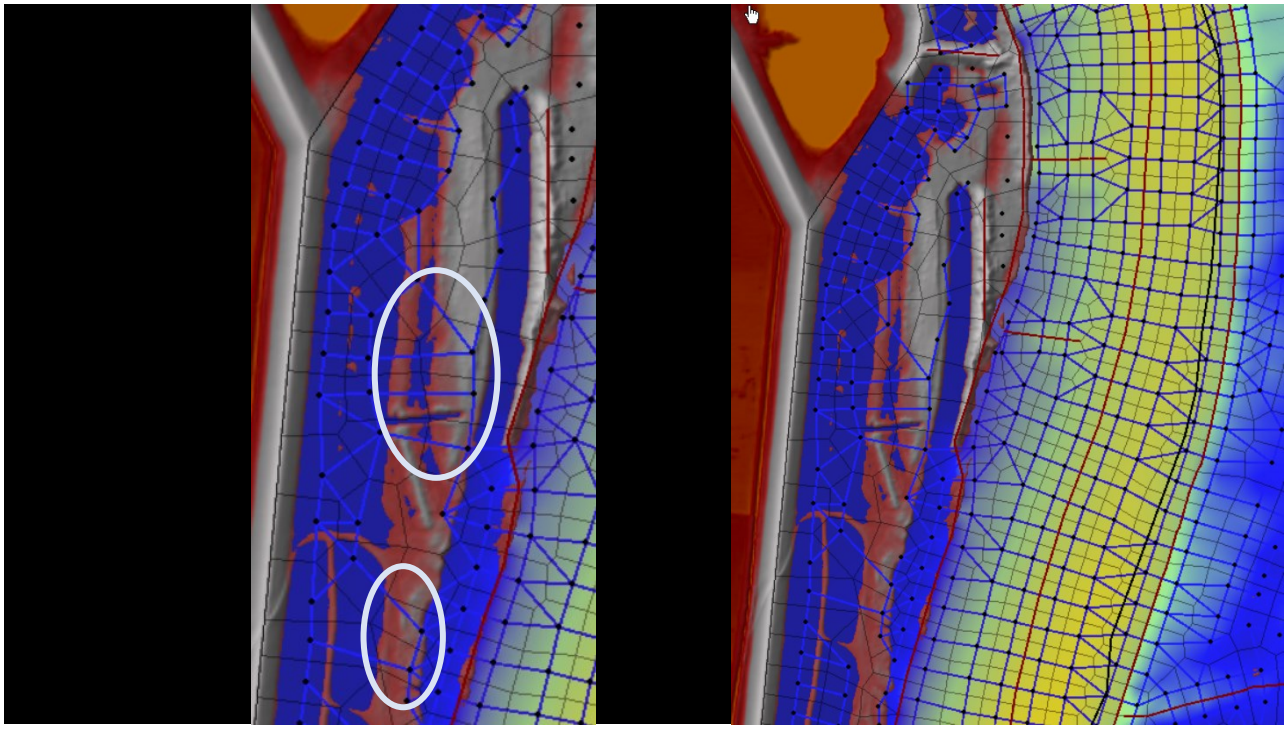

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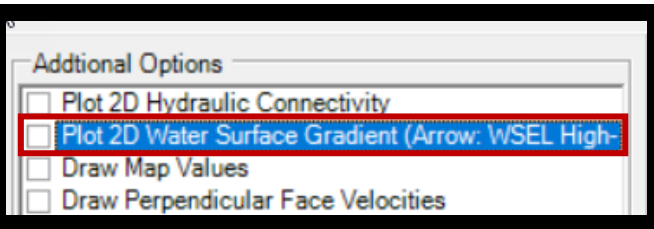
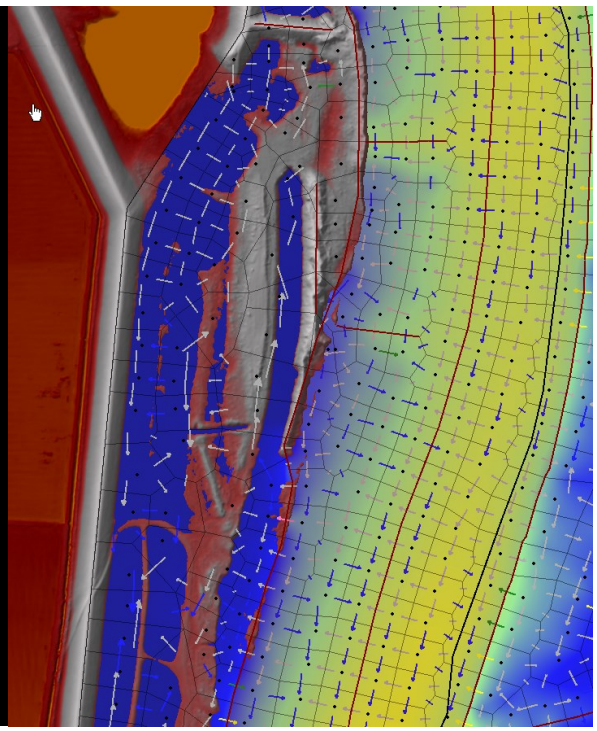


Blue →	Normal flow. Upstream WSE > downstream WSE and flow is with the predominant velocity.
Yellow →	Shallow depth of flow. Water is moving from high ground to low ground. Flow is not of significant depth over the cell face; however, it is expected to be hydraulically connected.
Green →	Intermediate depth of flow. While not deep, flow is expected over the adjacent cell face.
Gray →	Backwater. Downstream WSE > upstream WSE. Cell with the higher water surface elevation usually has lower terrain elevation.
Pink →	Critical. Flow most likely passes through critical depth over a cell face.



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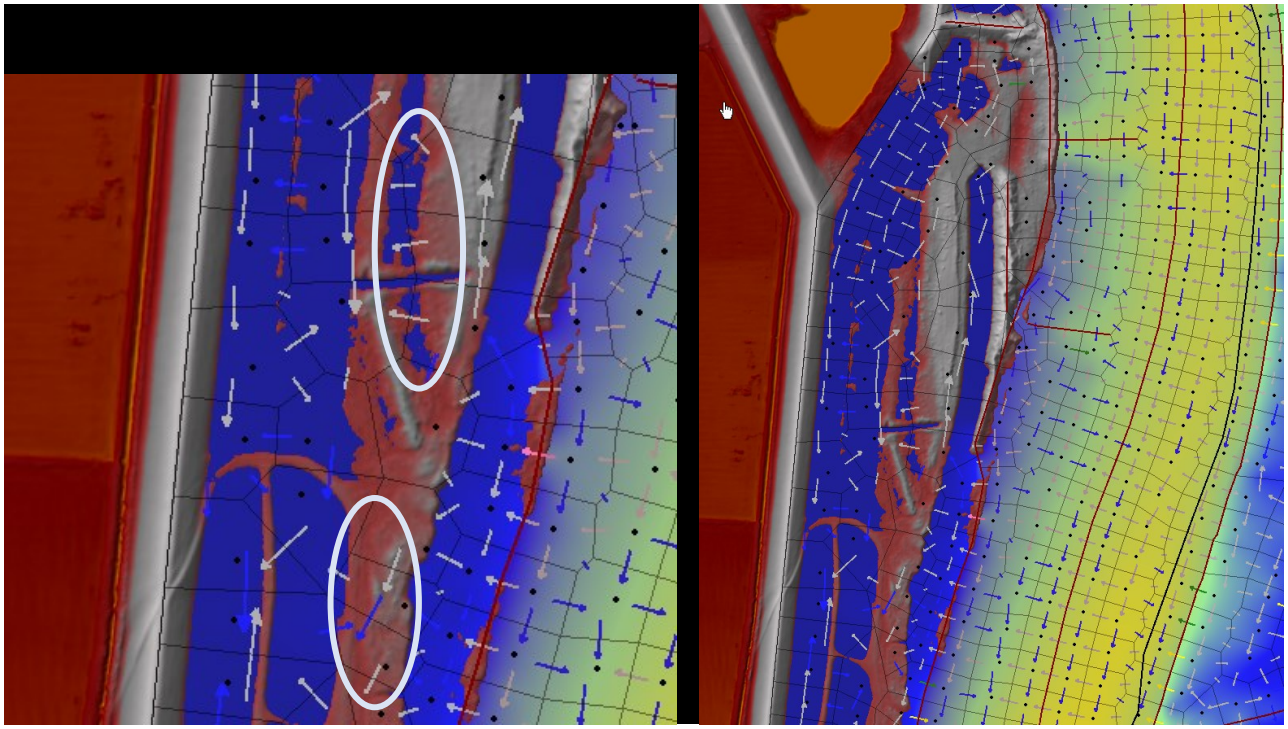

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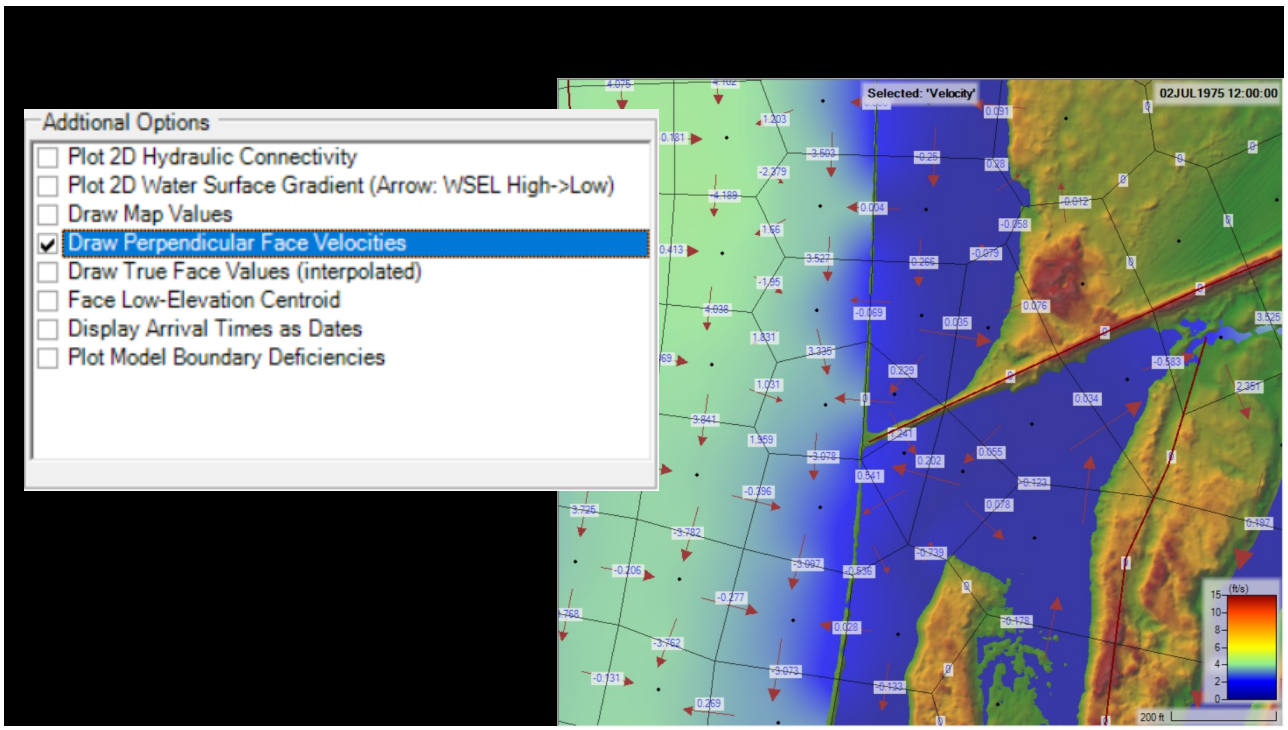
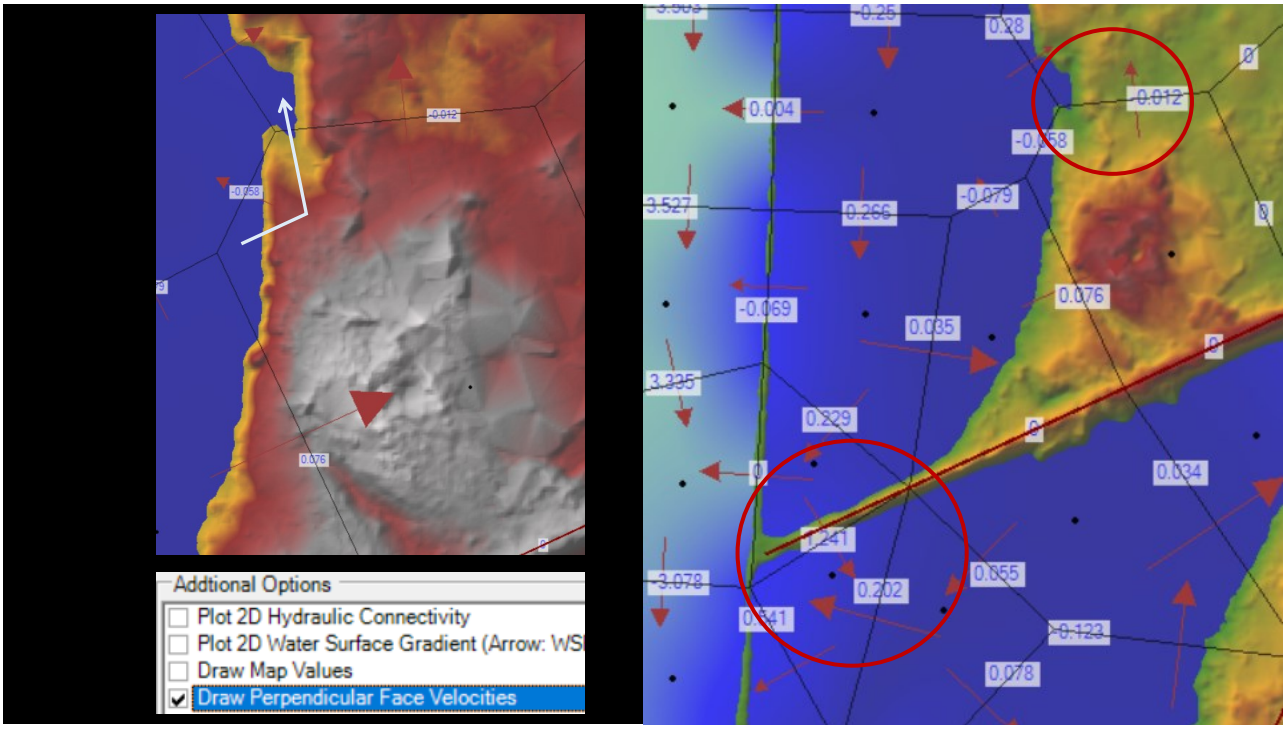

Addtional Options
Plot 2D Hydraulic Connectivity
Plot 2D Water Surface Gradient (Arrow: WSEL High->Low)
Draw Map Values
Draw Perpendicular Face Velocities
Draw True Face Values (interpolated)
Face Low-Elevation Centroid
Display Arrival Times as Dates
Plot Model Boundary Deficiencies
Selected: 'Velocity'
02JUL1975 12:00:00
(ft/s)
200 ft

30



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Mesh Quality Trouble Shooting

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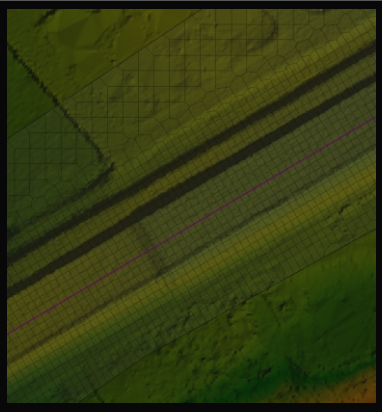	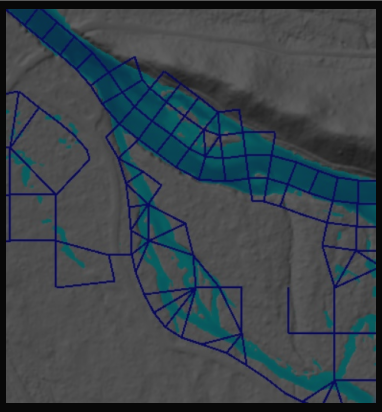	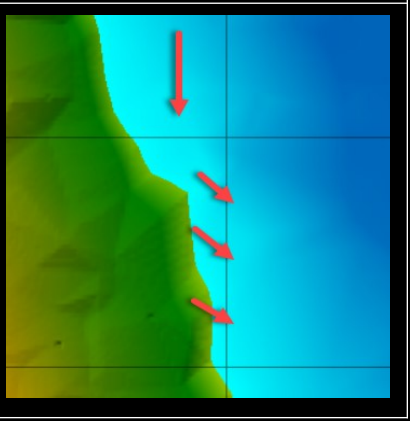

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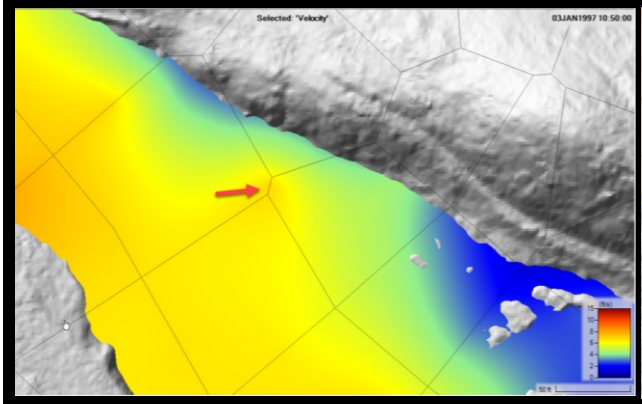
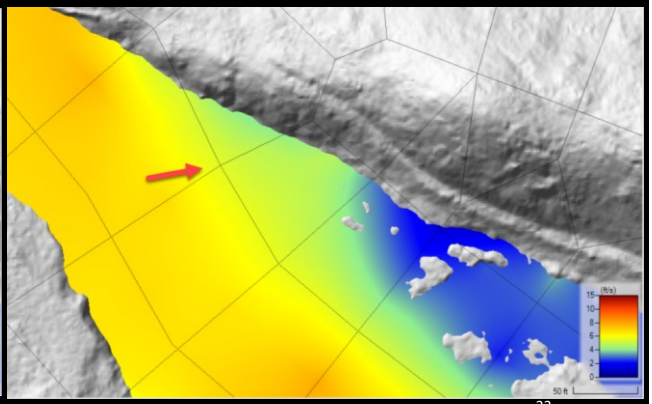
Weird Shaped Cells/Small Faces

- Cells size should transition slowly
  - No more than 50% change in size
- Small cells and short faces compared to other cells and cells
  - This may cause excessive model iterations.





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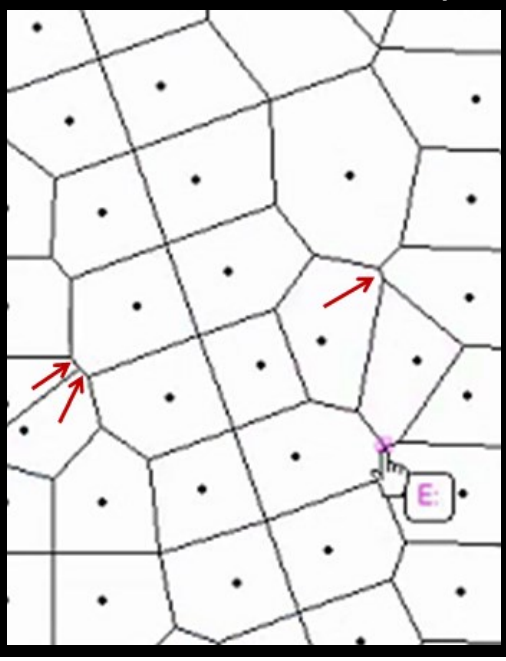
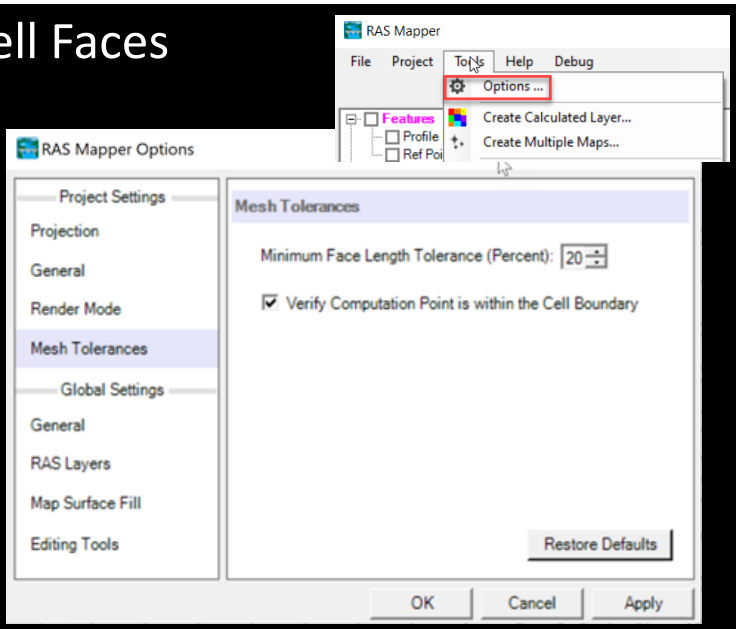
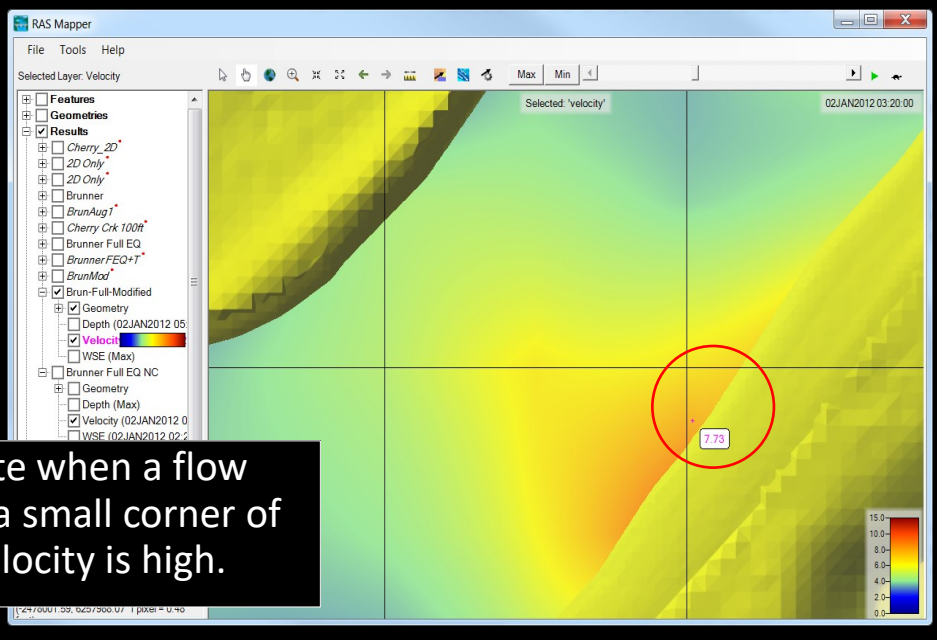
Avoid Tiny Cell Faces





This is much easier to fix in recent versions.
Use the Mesh Tolerances in Mapper Options

Partial Cell Wetting Issue



Model can iterate when a flow passes through a small corner of a cell and the velocity is high.

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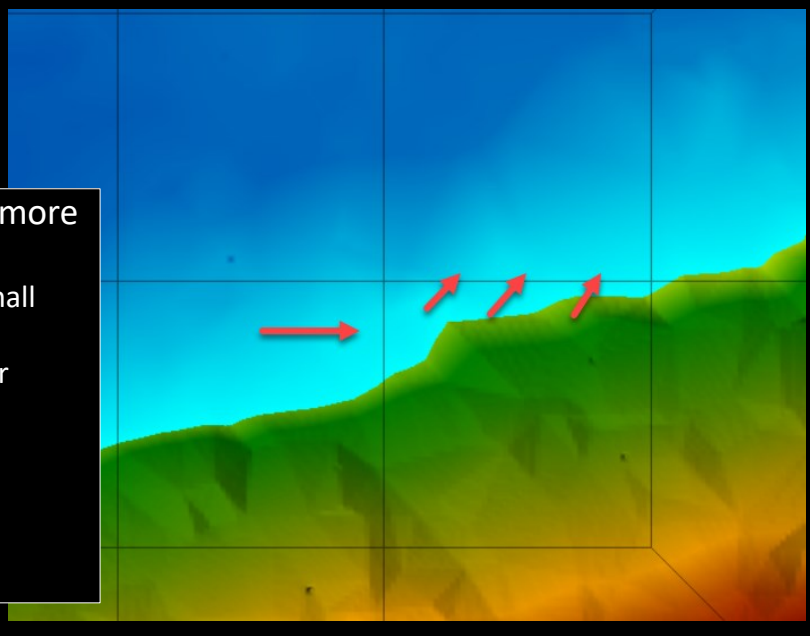
Partial Cell Wetting Issue



- These Cells will be even more unstable when flow:
  - Enters a cell through a small portion of a face but
  - Leaves over a much larger portion of another face
- Adjust cell sizes, use breaklines and polygon refinement tool to fix

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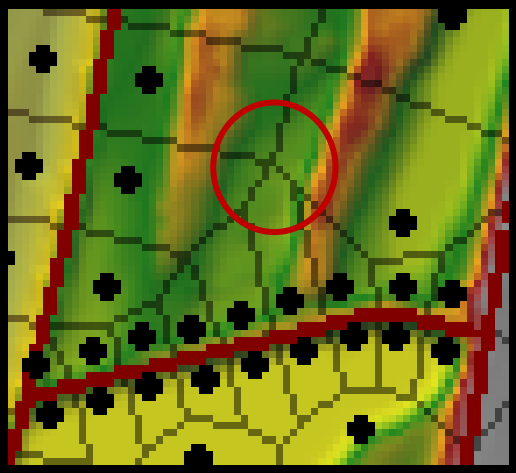
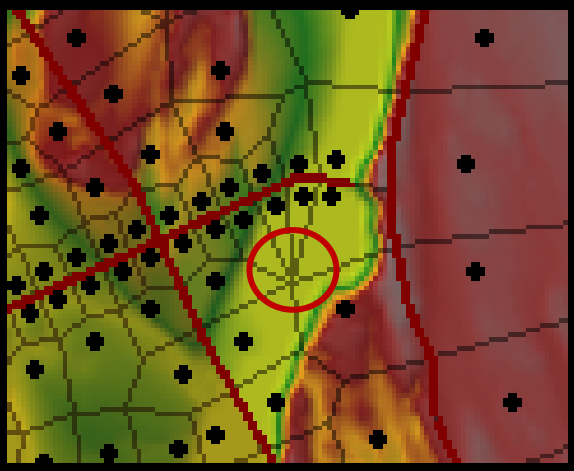
Watch for "Wheel Spokes" Which Indicate Regions Without Nodes





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Internal Hydraulic Structures

- Small cell sizes at invert of culvert or gate.
  - Small cells have less volume
  - Flow/volume for the culvert is computed over the time step as V = Q x DT
- Highly submerged weirs with culverts and gates can have stability issues. "Weir and Gate Flow Submergence decay exponents"
- Flow over the embankment can be computed as weir flow or 2D Flow Equations
  - Use Weir options when the is a high embankment
  - Use 2D flow option for non-weir flow situations

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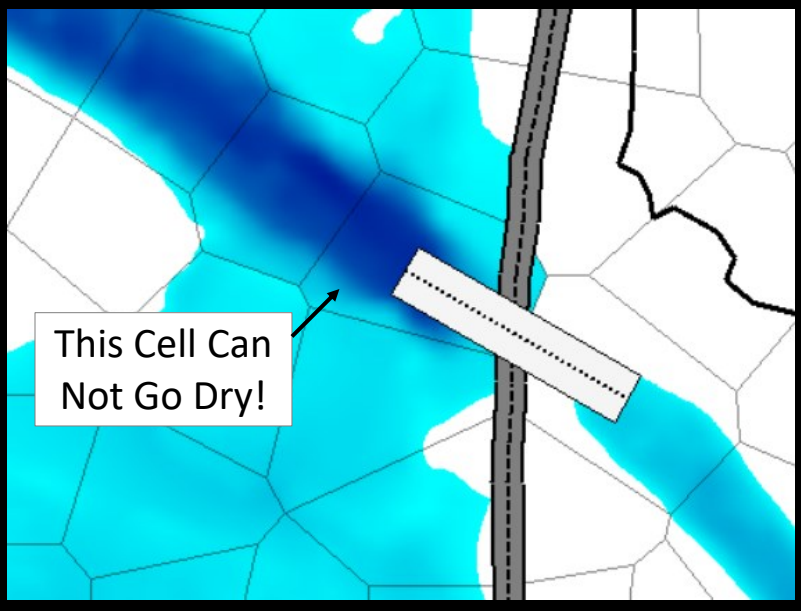
Culverts Modeling Failure Mode

The cell that intersects with the upstream culvert location must be large enough that it will not empty during the time step.

$$Vol_{Cell} > Q_{culvert} * \Delta t$$

Note: Source Cell does not need to be first cell upstream of culvert



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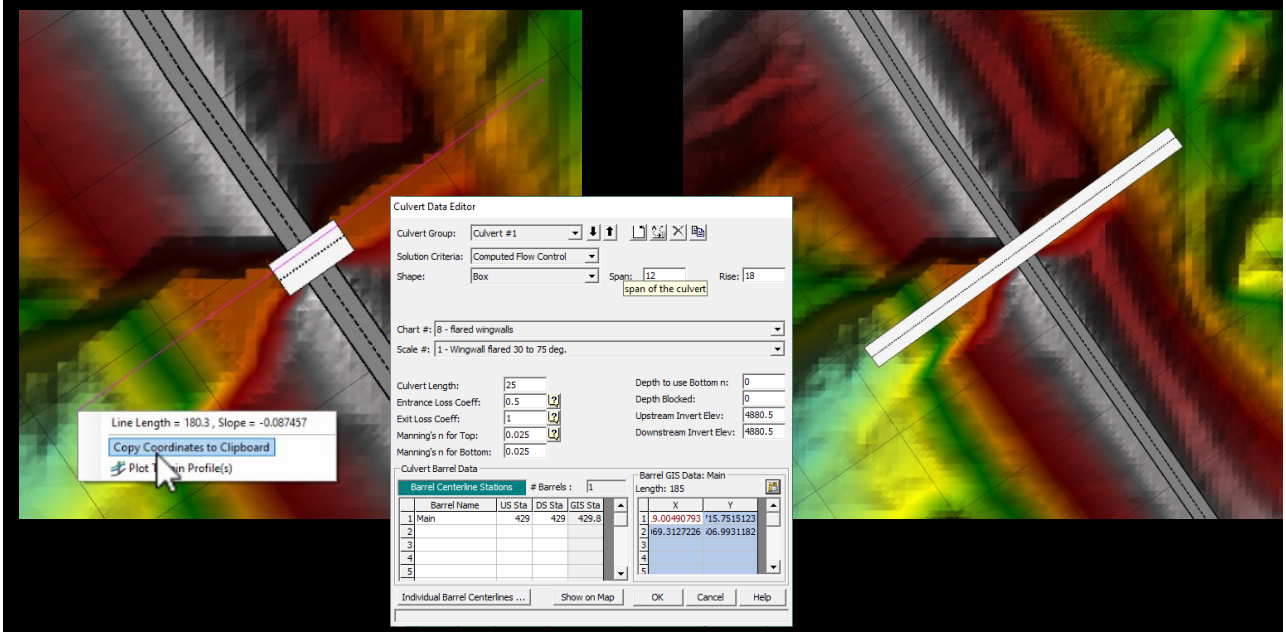
Georeference Culvert Inlet/Outlet



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Mesh Best Practices for 2D Sediment Modeling

1. Align Cell Faces with High Ground/Structures
2. Align Cell Faces with Flow Direction
3. Defining an Irregular 2D Channel
4. Connectivity
   - Diagnostics
   - Best Practices

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