# HEC-RAS 2D
# Mesh Generation and Refinement

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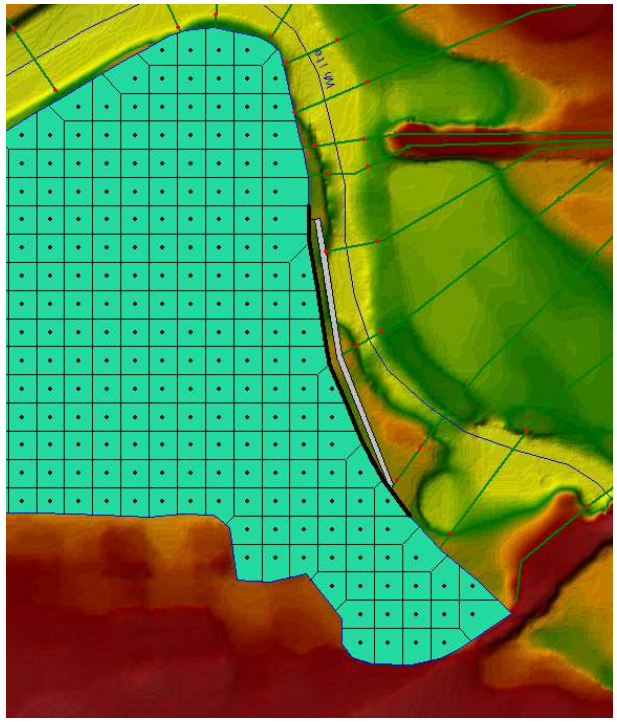
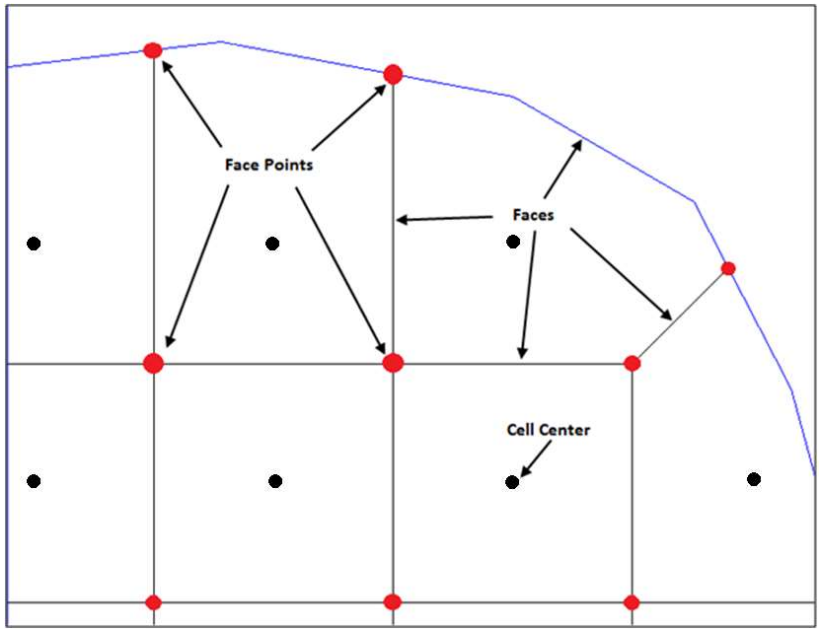
# Overview

- Common Terms
- How to Create a Mesh
- Limitations
- Fixing Mesh Problems
- Hydraulic Property Tables



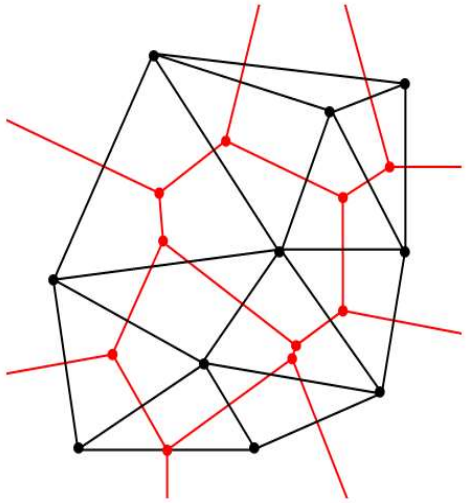
# Finite Volume Mesh

- Naming Convention
  - Cells
  - Face Points
  - Faces
  - Computation Points (center)



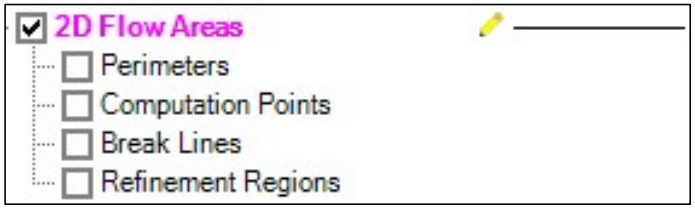
# Mesh Generation

- Define mesh boundary and triangulate Computation Points (black dots)
- Face Points (red dots) are triangle circumcircle centers
- Faces (red lines) connect face points
- Faces are also “Enforced” with internal breaklines



# Create 2D Flow Area Mesh in RAS Mapper

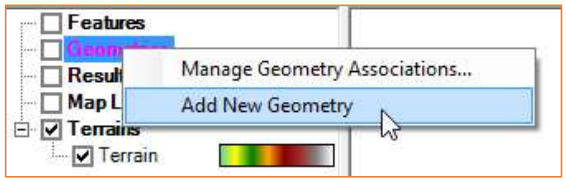
- Meshes are generated from a set of computation points with consideration to polygons and breaklines.
- Steps/Features used to create a mesh:
  - Perimeter Polygon
  - Computation Points
  - Breaklines (Optional)
  - Refinement Regions (Optional)

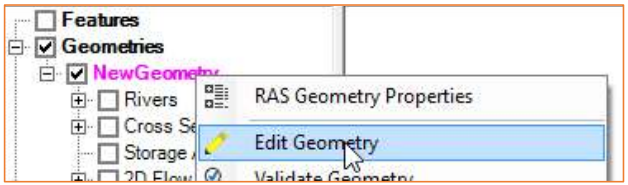


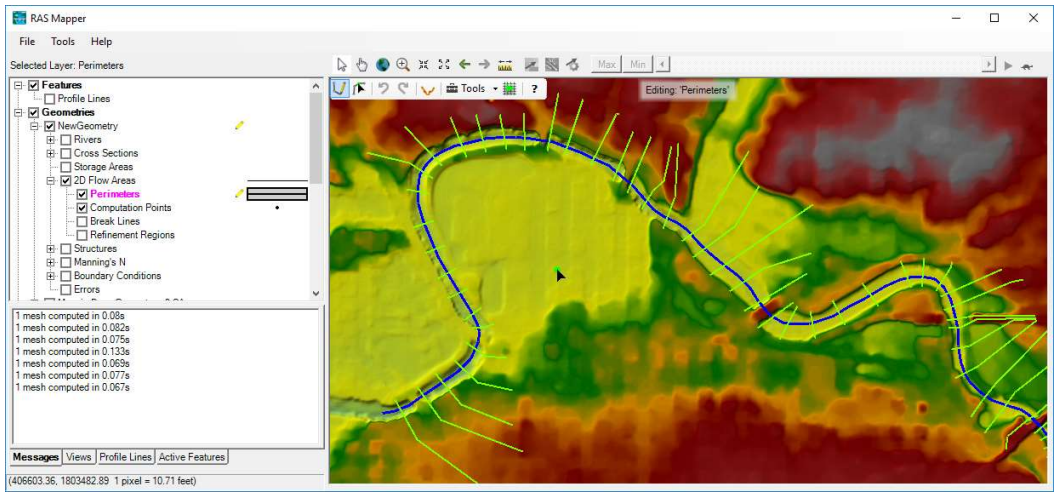

- Creating a good mesh is an iterative process!

# Editor Access

- Create a New Geometry
- Edit Geometry
- Edit Toolbar
- Select Layer

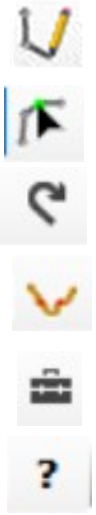


# Editing

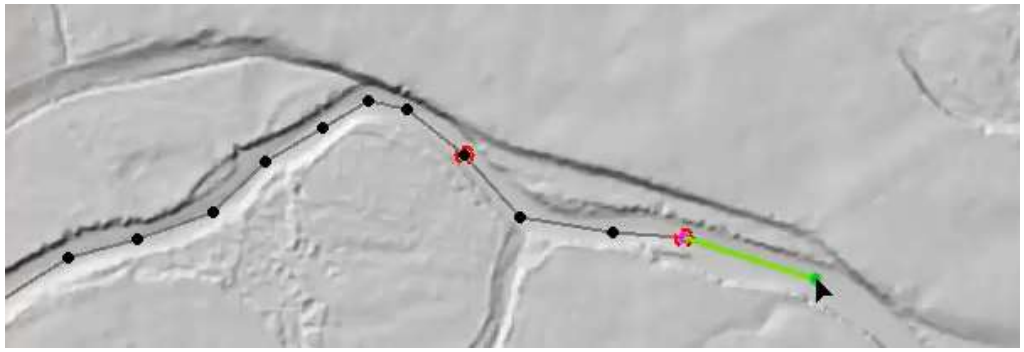

- Add New Feature
- Select/Edit Feature
- Undo/Redo
- Plot Profile
- Tools
- Help



# Add New Feature

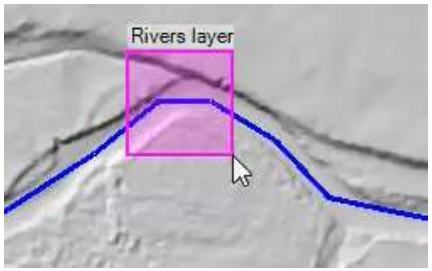
- Left-click to start adding a new point, line, or polygon
- Double-click to end a line or polygon

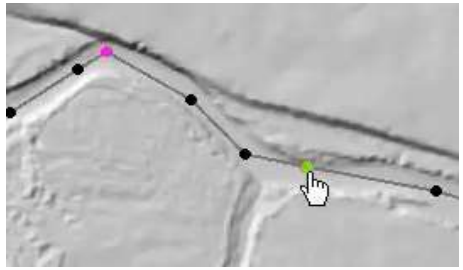
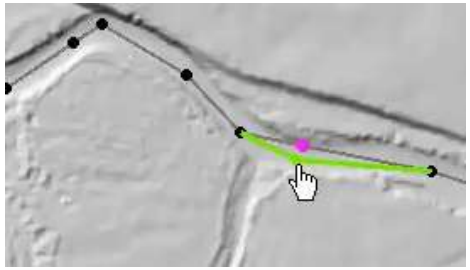
- Pan by switching to Pan tool, Shift key, Middle Mouse, or right-click to re-center.



# Select / Edit

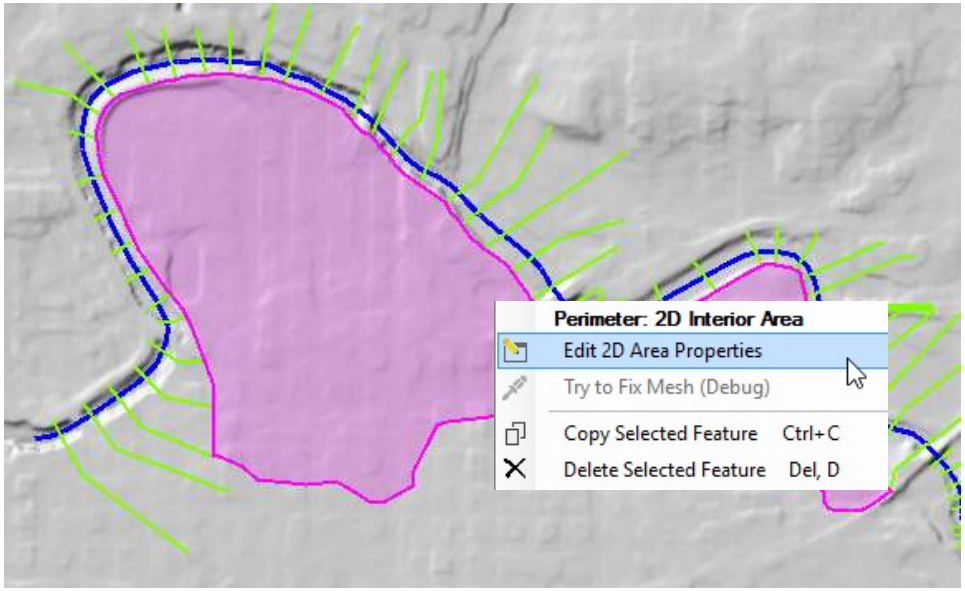
- Select / Edit tool is used to select feature(s) and then begin editing (move, add points, delete, etc).
  - Double-click to Start Editing (Open feature)
  - Double-click to End Editing (Close feature)
- Mouse hover indicates action
  - Green point indicates: Move, Insert, Delete point



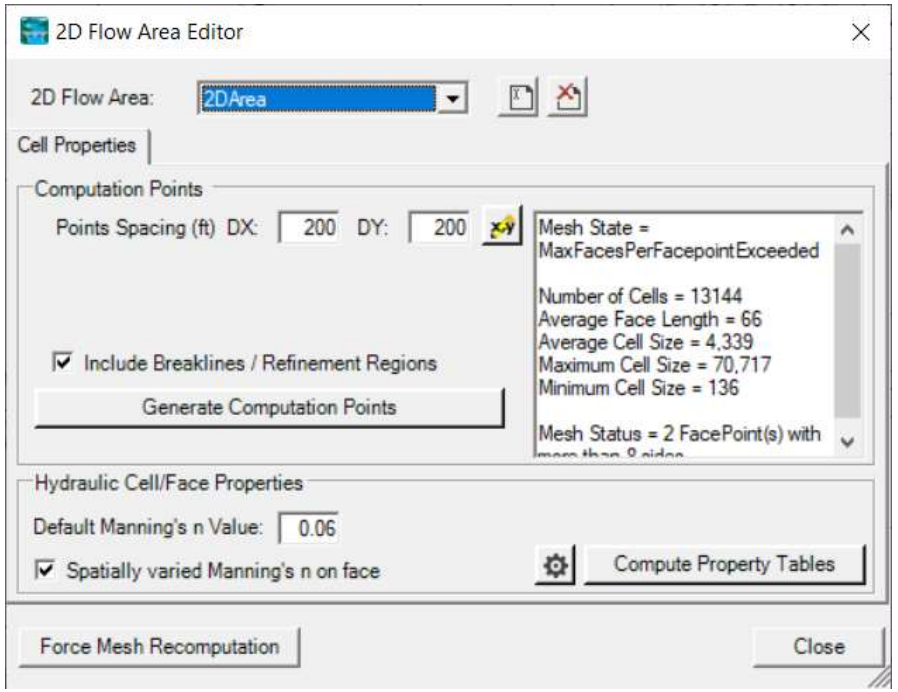




# 2D Flow Area

- Draw Perimeter

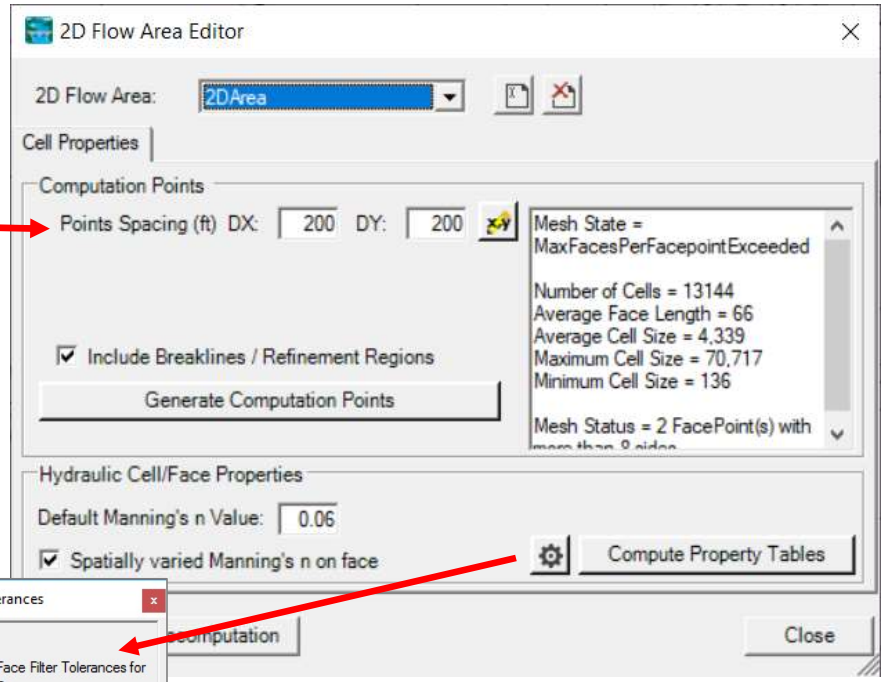


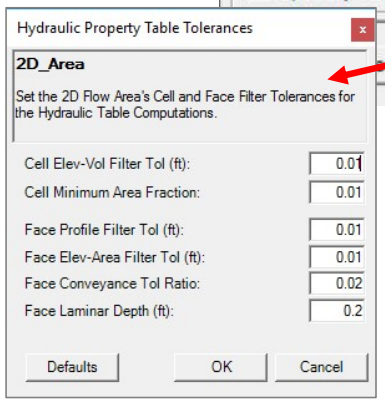

- 2D Flow Area Editor



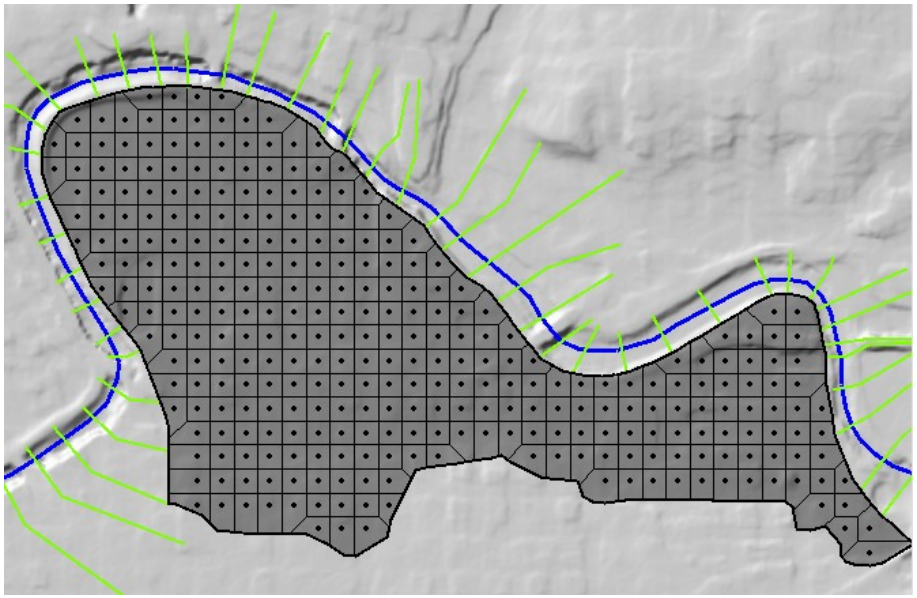
# Computation Points

- Generate Computation Points at an even interval
  - Breaklines and Refinement Regions area enforced
- N Value (Default or Spatially Varied)
- Hydraulic Table Property Tolerances

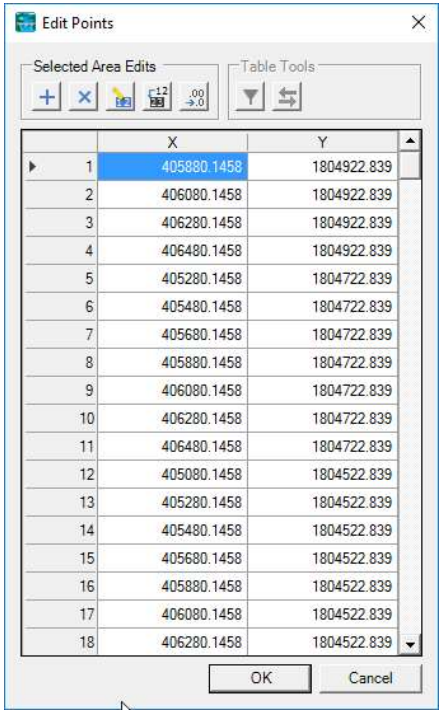



# Computation Points



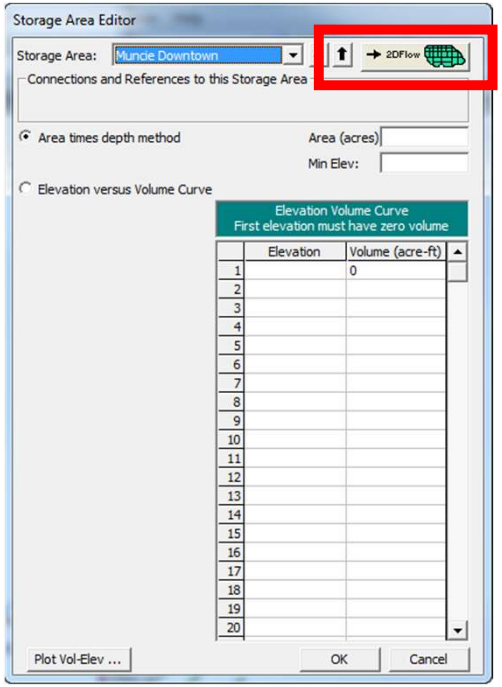
- Mesh is generated from resultant set of computation points.


| | X | Y |
|---|---|---|
| 1 | 405880.1458 | 1804922.839 |
| 2 | 406080.1458 | 1804922.839 |
| 3 | 406280.1458 | 1804922.839 |
| 4 | 406480.1458 | 1804922.839 |
| 5 | 405280.1458 | 1804722.839 |
| 6 | 405480.1458 | 1804722.839 |
| 7 | 405680.1458 | 1804722.839 |
| 8 | 405880.1458 | 1804722.839 |
| 9 | 406080.1458 | 1804722.839 |
| 10 | 406280.1458 | 1804722.839 |
| 11 | 406480.1458 | 1804722.839 |
| 12 | 405080.1458 | 1804522.839 |
| 13 | 405280.1458 | 1804522.839 |
| 14 | 405480.1458 | 1804522.839 |
| 15 | 405680.1458 | 1804522.839 |
| 16 | 405880.1458 | 1804522.839 |
| 17 | 406080.1458 | 1804522.839 |
| 18 | 406280.1458 | 1804522.839 |

# Create 2D Flow Area Mesh from an existing Storage Area

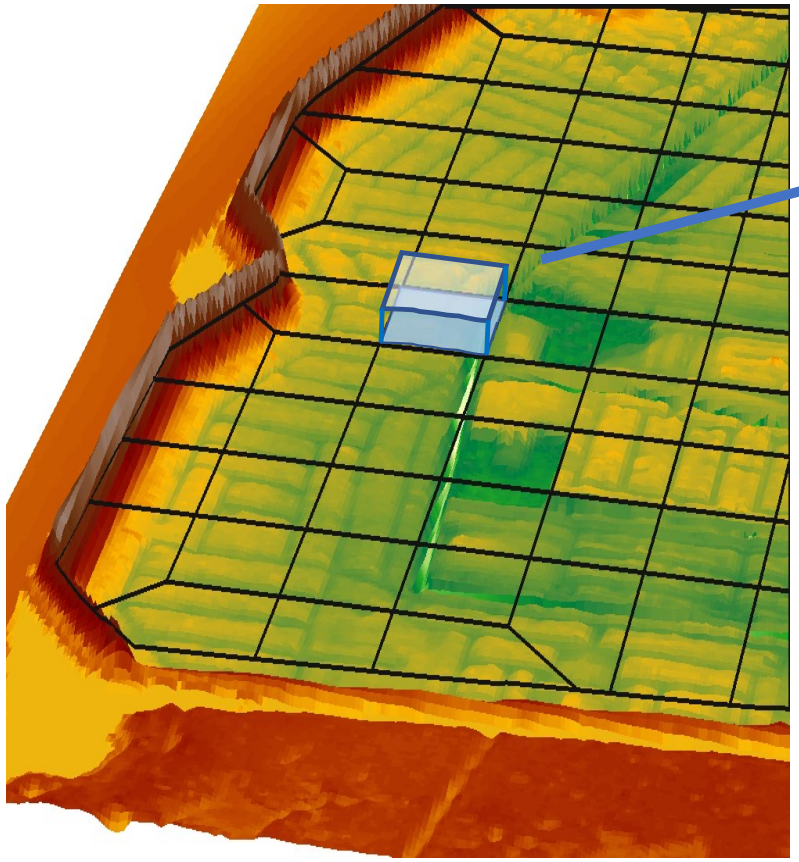
- Converting Existing Storage Area
  - Click convert button

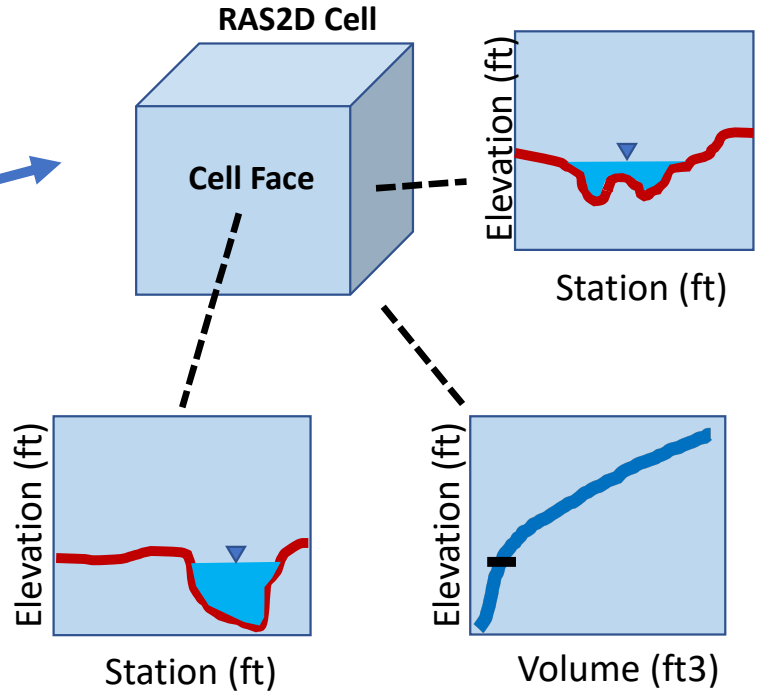


# Hydraulic Property Tables

- Computation engine uses hydraulic property tables to represent the geometry of the system
- Cells
  - Elevation/Volume
- Faces
  - Elevation/Area
  - Elevation/Wetter Perimeter
  - Elevation/Manning's n
  - (all from station elevation profile)

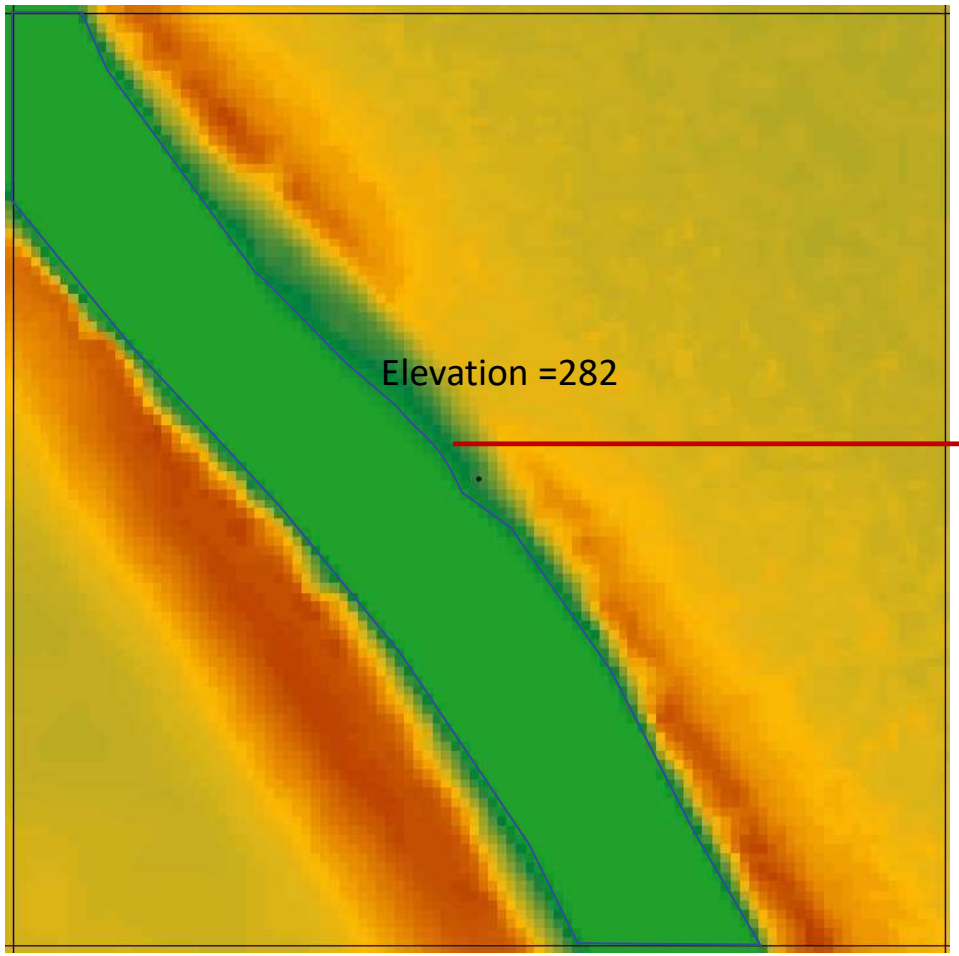
# 2D Computational Mesh Sub-grid Terrain

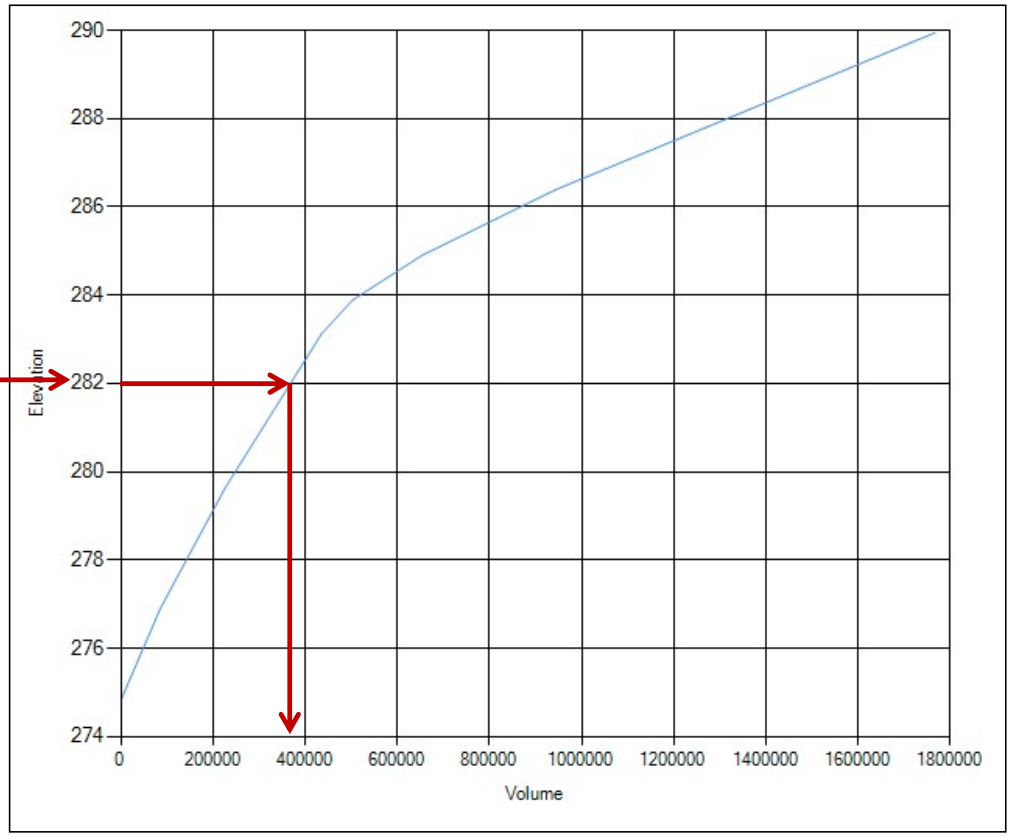




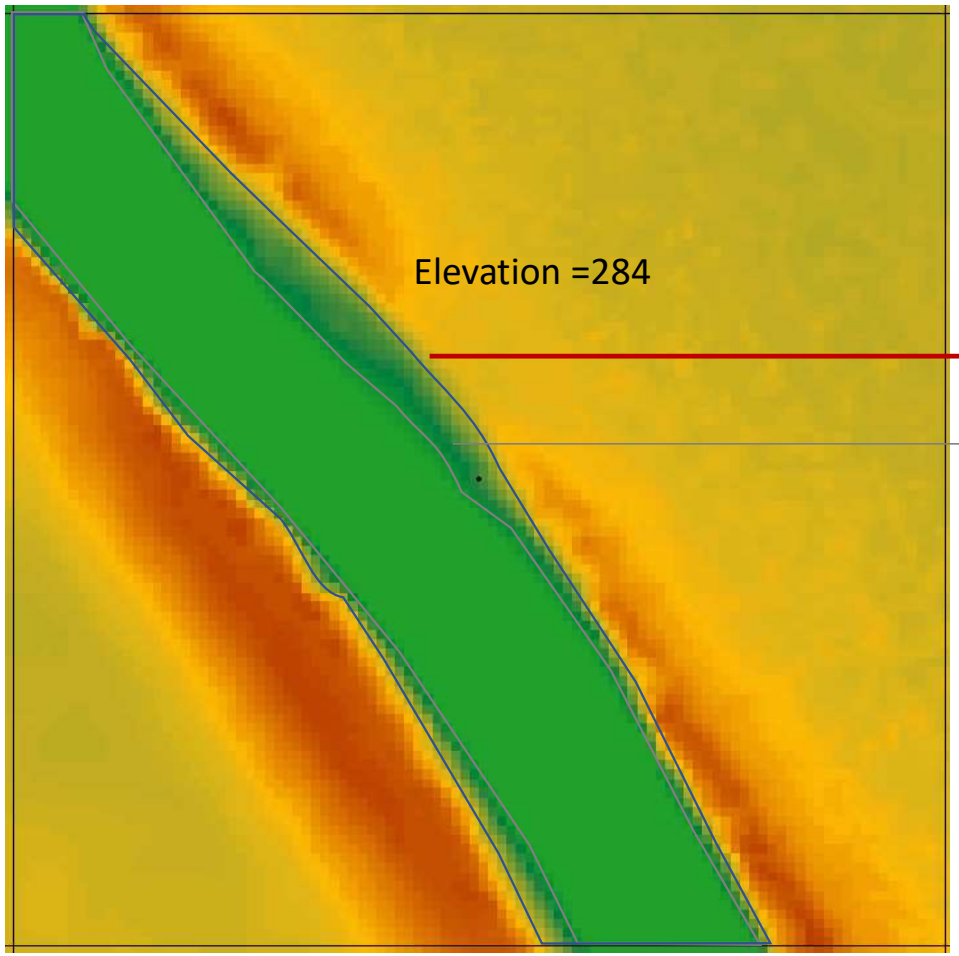

**Each cell face profile and stage-volume curve is based on hundreds to thousands topo-bathymetric data-points, depending of resolution of underlying terrain raster.**
**Cell approach very efficiently discretizes space including complex terrain & surface roughness.**

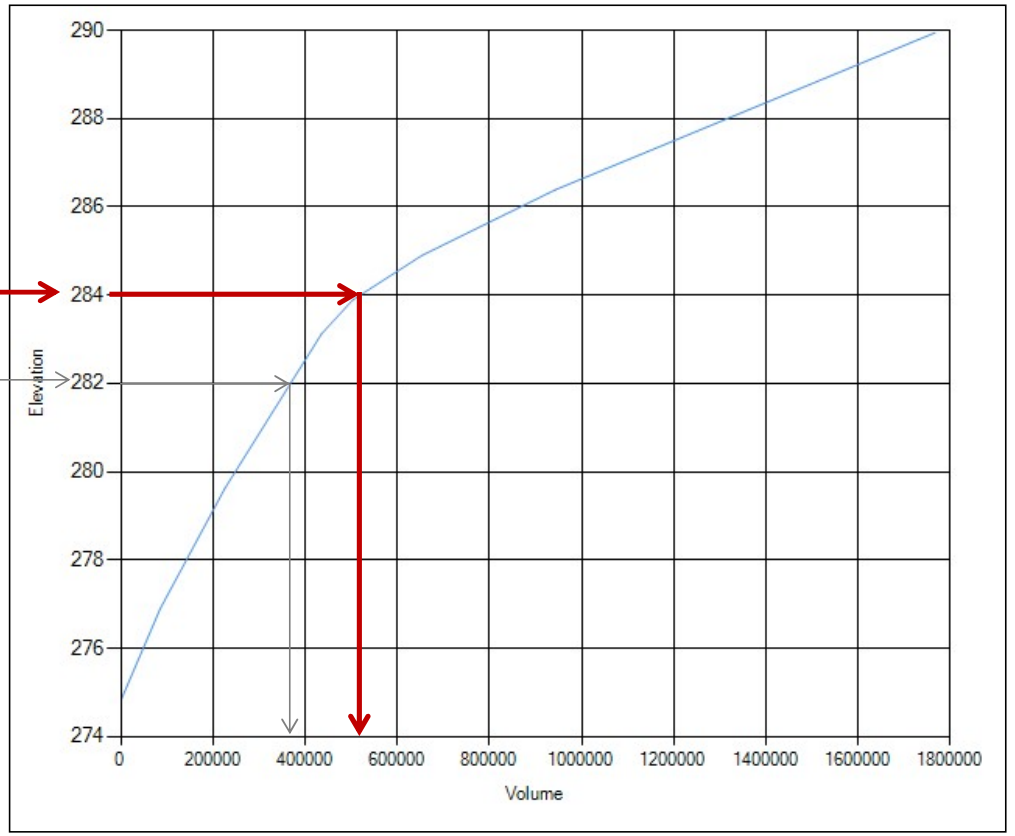
# Computational Cells - Elevation vs. Volume



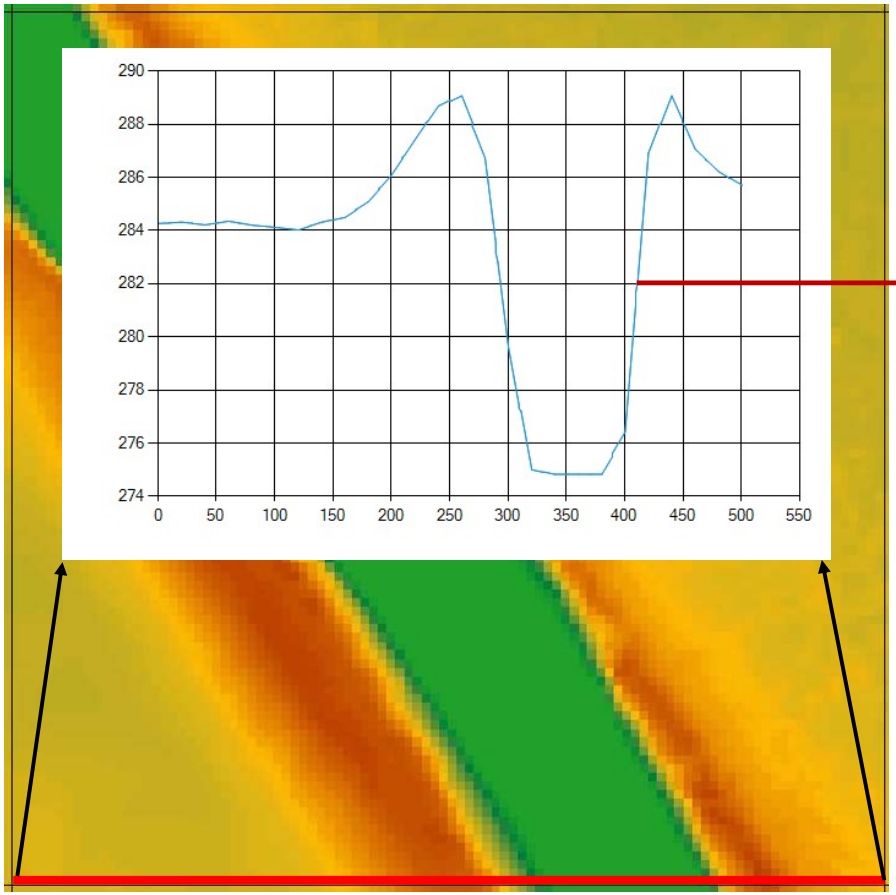
# Computational Cells - Elevation vs. Volume

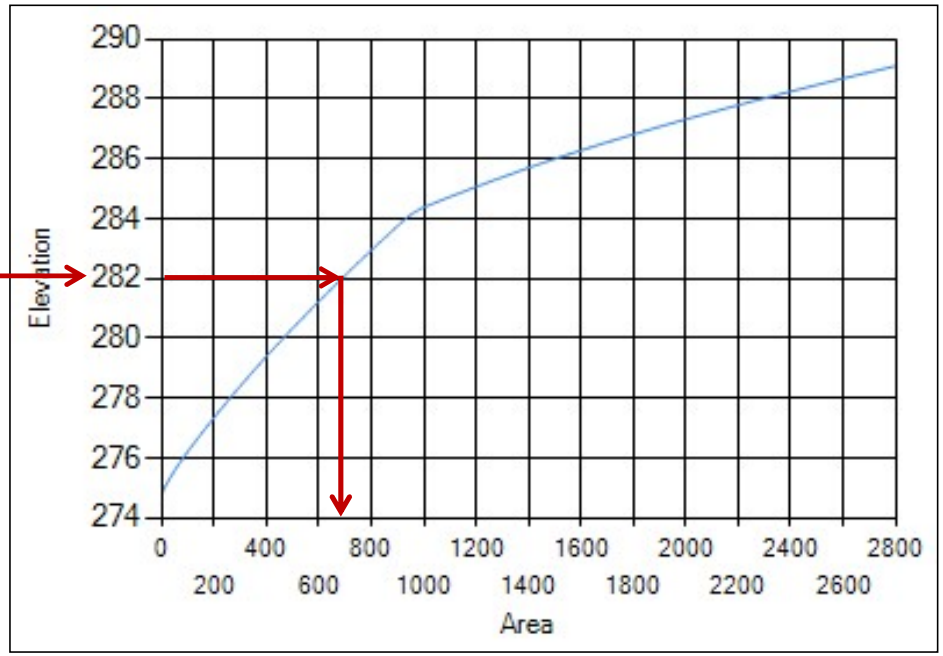



Subgrid = Higher fidelity cell volume tracking

# Computational Faces - Elevation vs. Area

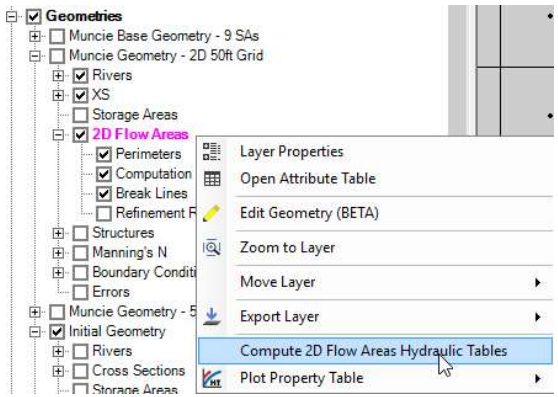


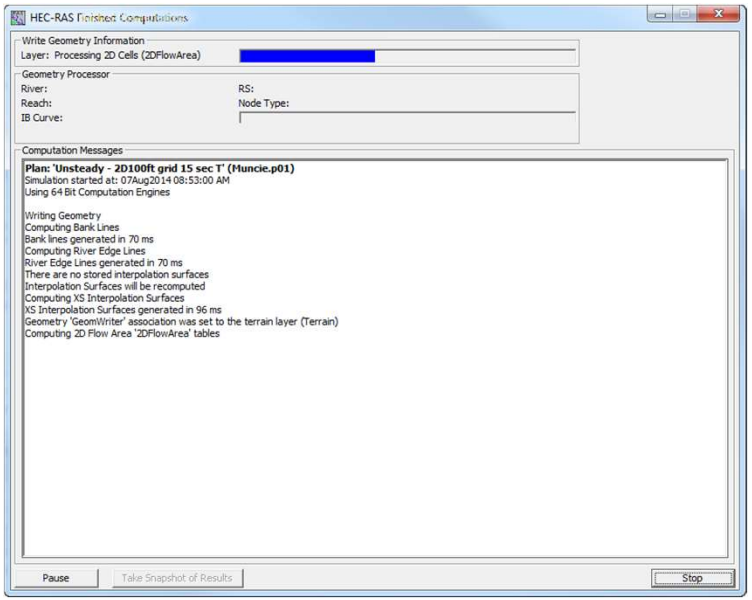




**Faces = Control flow into and out of cell**
**Can model small channels in with large cells**

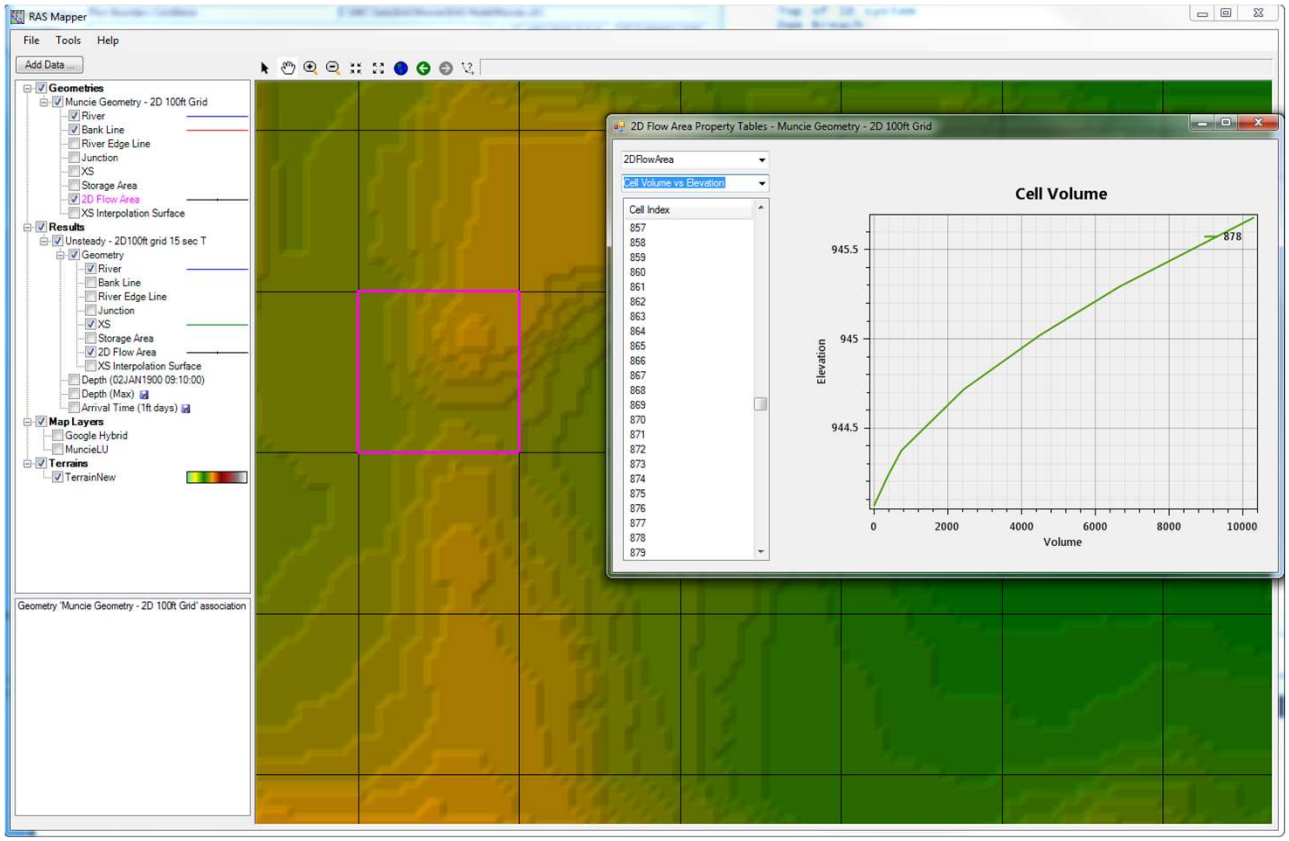
# Hydraulic Property Tables

- Computed (once and stored in geometry *.hdf)
  - From RAS Mapper
  - Before unsteady-flow simulation

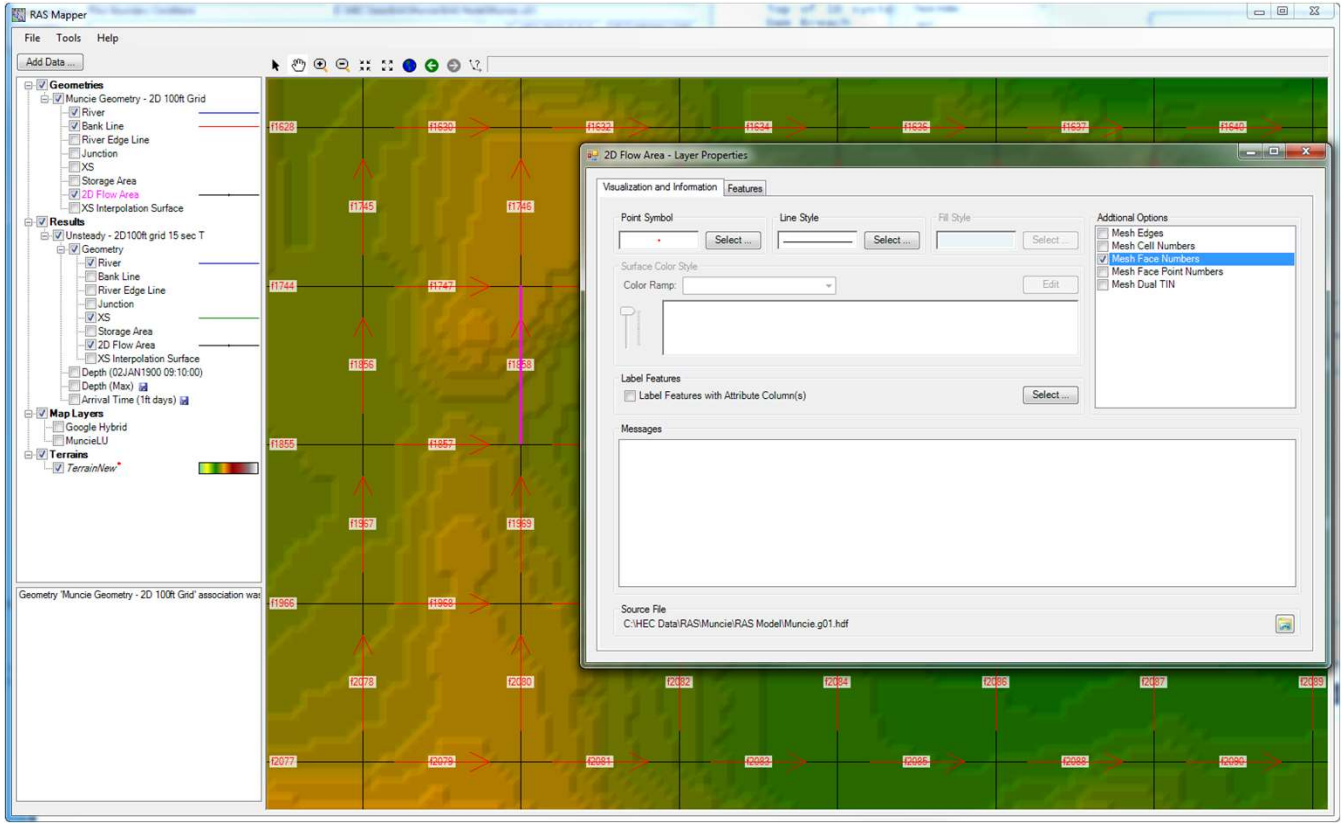


# Cells


RAS Mapper
File Tools Help
Add Data ...
Geometries
Muncie Geometry - 2D 100ft Grid
River
Bank Line
River Edge Line
Junction
XS
Storage Area
2D Flow Area
XS Interpolation Surface
Results
Unsteady - 2D100ft grid 15 sec T
Geometry
River
Bank Line
River Edge Line
Junction
XS
Storage Area
2D Flow Area
XS Interpolation Surface
Depth (02JAN1900 09:10:00)
Depth (Max)
Arrival Time (1ft days)
Map Layers
Google Hybrid
MuncieLU
Terrains
TerrainNew
Geometry 'Muncie Geometry - 2D 100ft Grid' association
2D Flow Area Property Tables - Muncie Geometry - 2D 100ft Grid
2DFlowArea
Cell Volume vs Elevation
Cell Index
857
858
859
860
861
862
863
864
865
866
867
868
869
870
871
872
873
874
875
876
877
878
879
Cell Volume
878
945.5
945
944.5
Elevation
0
2000
4000
6000
8000
10000
Volume

# Faces


RAS Mapper
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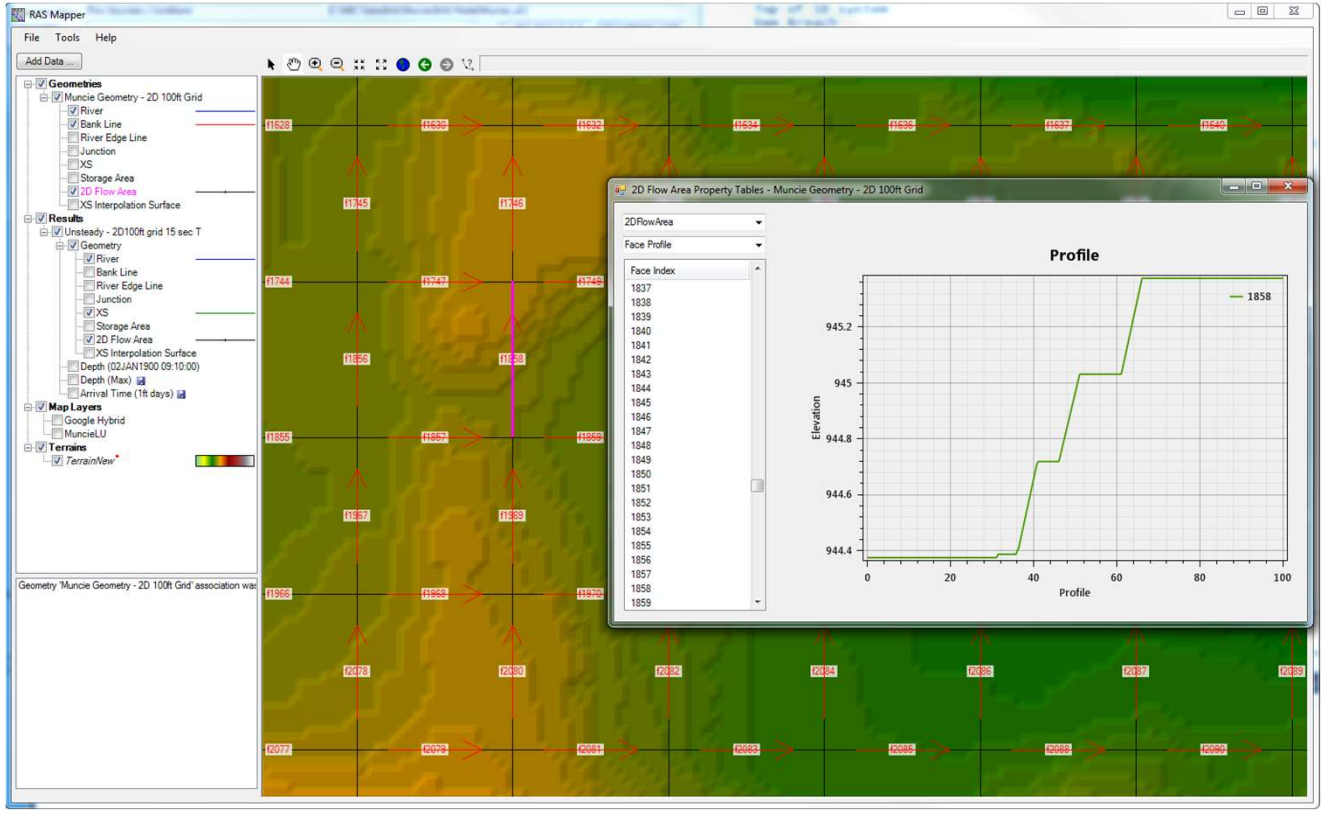
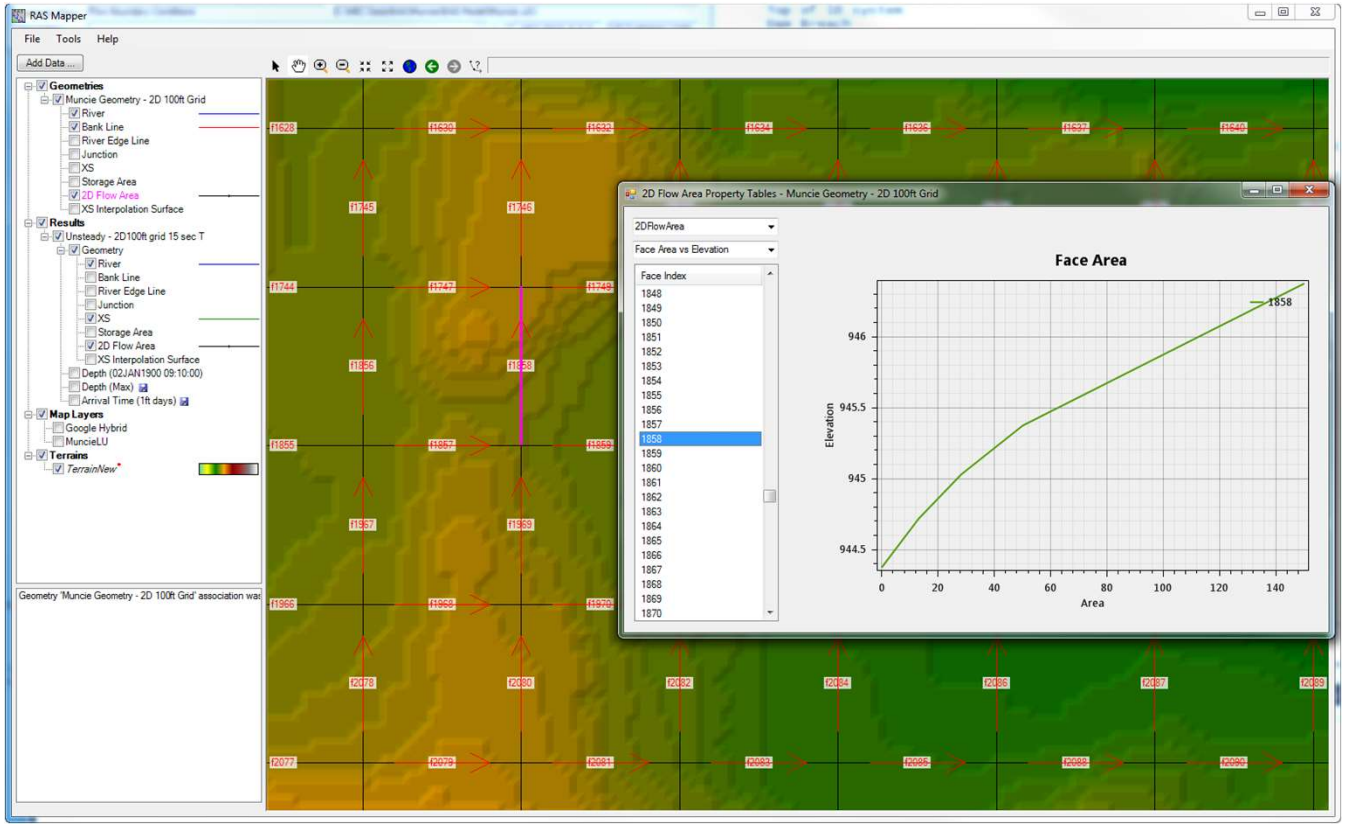
2D Flow Area
XS Interpolation Surface
Depth (02JAN1900 09:10:00)
Depth (Max)
Arrival Time (1ft days)
Map Layers
Google Hybrid
MuncieLU
Terrains
TerrainNew*
Geometry 'Muncie Geometry - 2D 100ft Grid' association wa
2D Flow Area - Layer Properties
Visualization and Information
Features
Point Symbol
Select ...
Line Style
Select ...
Fill Style
Select ...
Additional Options
Mesh Edges
Mesh Cell Numbers
Mesh Face Numbers
Mesh Face Point Numbers
Mesh Dual TIN
Surface Color Style
Color Ramp:
Edit
Label Features
Label Features with Attribute Column(s)
Select ...
Messages
Source File
C:\HEC Data\RAS\Muncie\RAS Model\Muncie.g01.hdf

# Face Profile

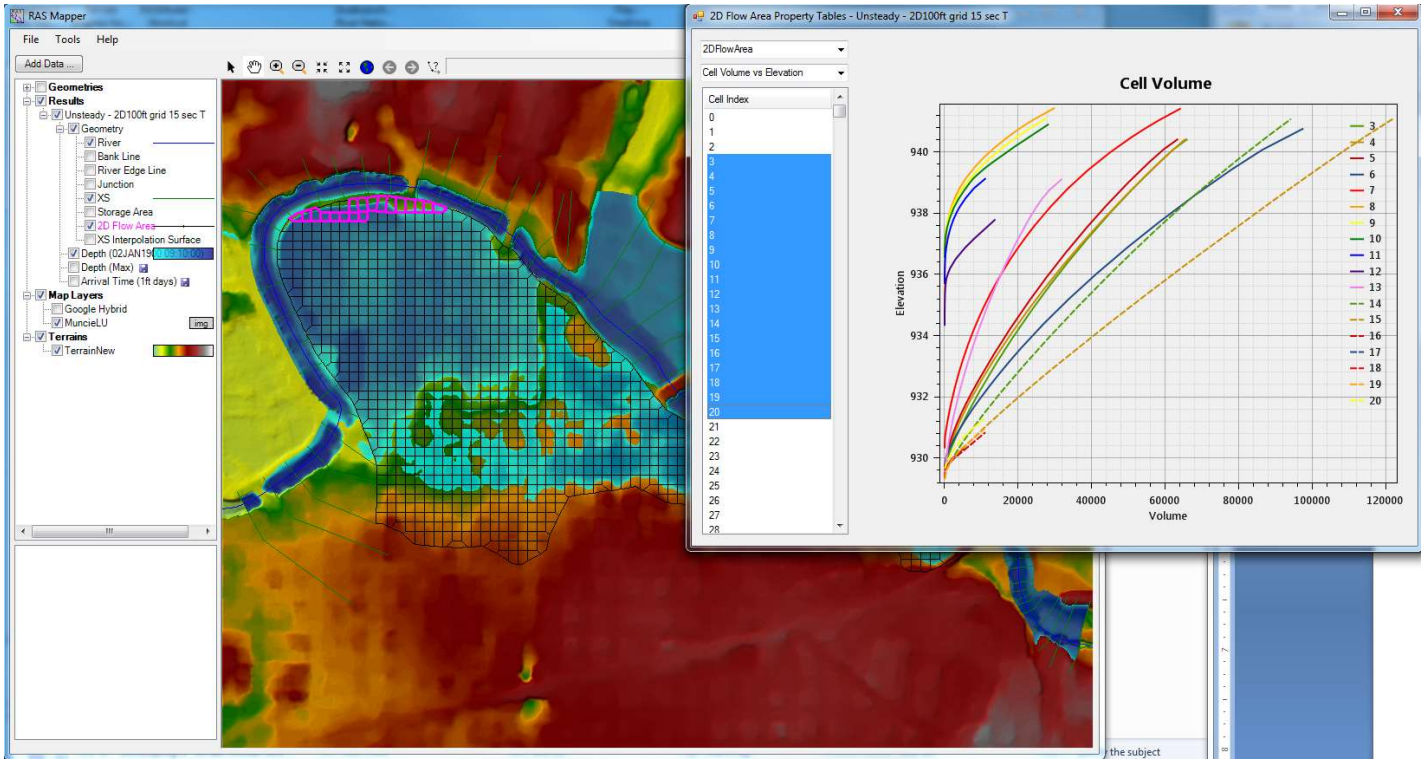


# Face Elevation vs Area



# Hydraulic Property Tables

- View from RAS Mapper - ‘2DFlow Area’ in ‘Geometry’ or ‘Results’

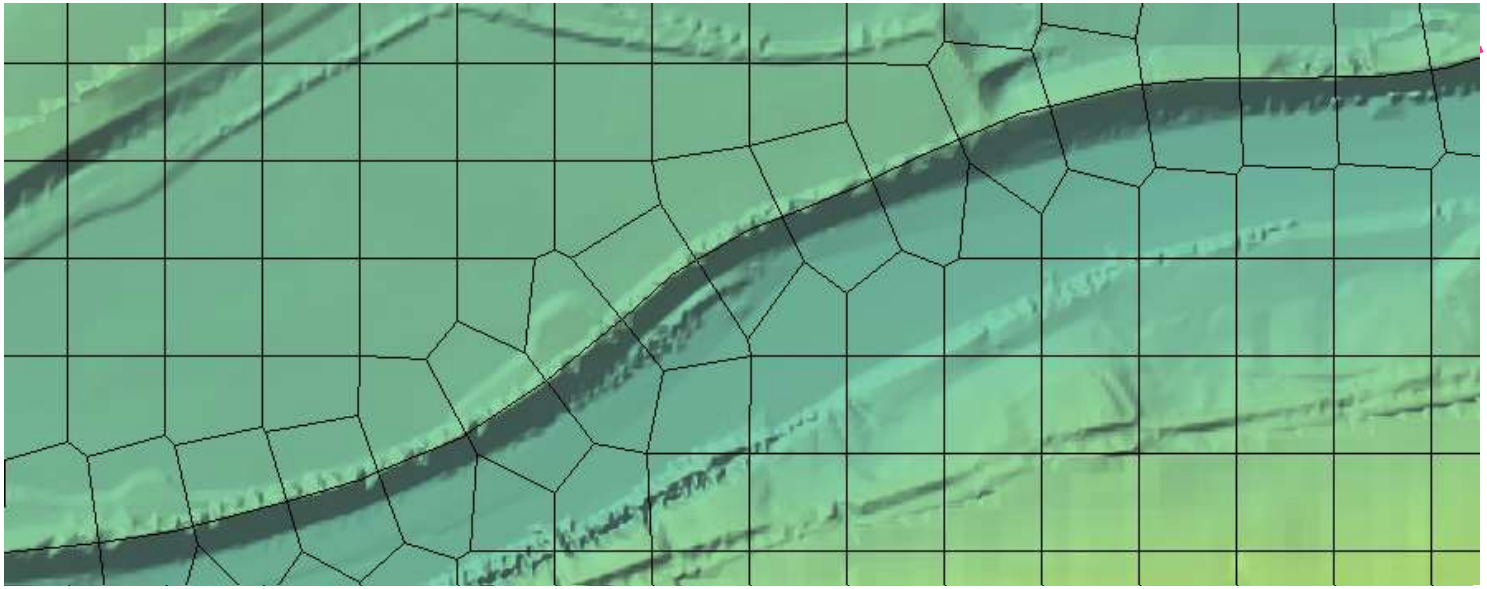


# Mesh Limitations

- One face between cells – even on perimeter
- Only one boundary condition per Face
- Except for Lateral structures
  - Lateral structures can stop and start on the same 2D external Face, when connecting 1D reach to a 2D area.


# Breaklines

- Breaklines enforce Cell Faces inside of the Mesh.
- Place along linear features that control water movement

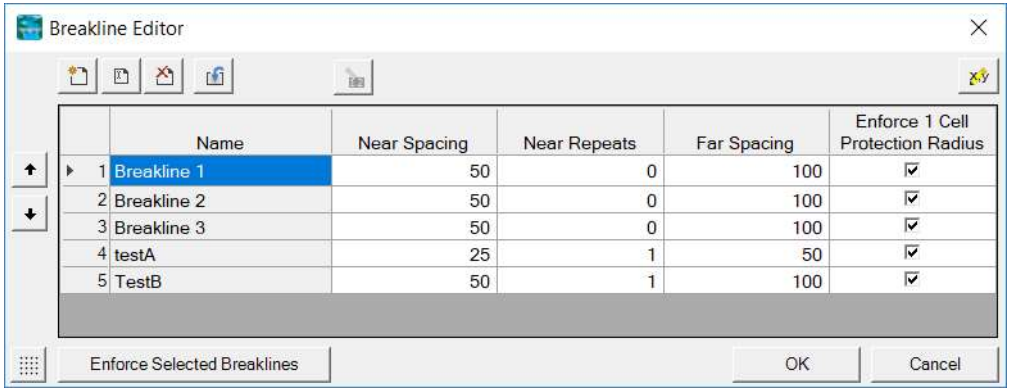


# Breaklines

- “Snapping” is part of mesh generation
  - Faces snap to breaklines if they are close enough
- “Enforcing” changes the cell points around a breakline
  - Improves the snapping of the 2D faces to the breaklines
  - Not perfect, might require tighter cell spacing and/or hand graphical editing

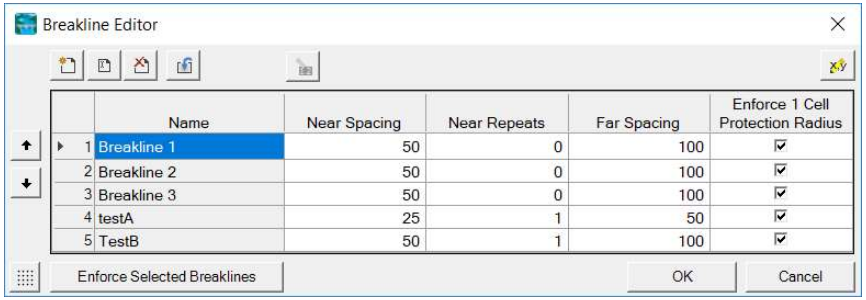
# Breakline Properties

- Near Spacing – Initial cell size (approx.) along the breakline.
  - Default value is 2D Area point spacing
- Near Repeats – Repeats cell insertion using Near Spacing a multiple away from the breakline.
- Far Spacing – Max cell size (approx.) of newly added cells.
  - Default value is 2D Area point spacing
- Enforce 1 Cell Protection Radius – Once enforced cells near to the breakline will not be removed through the enforcement of additional breaklines.
  - Include cells added/edited by hand.



# Breakline Process

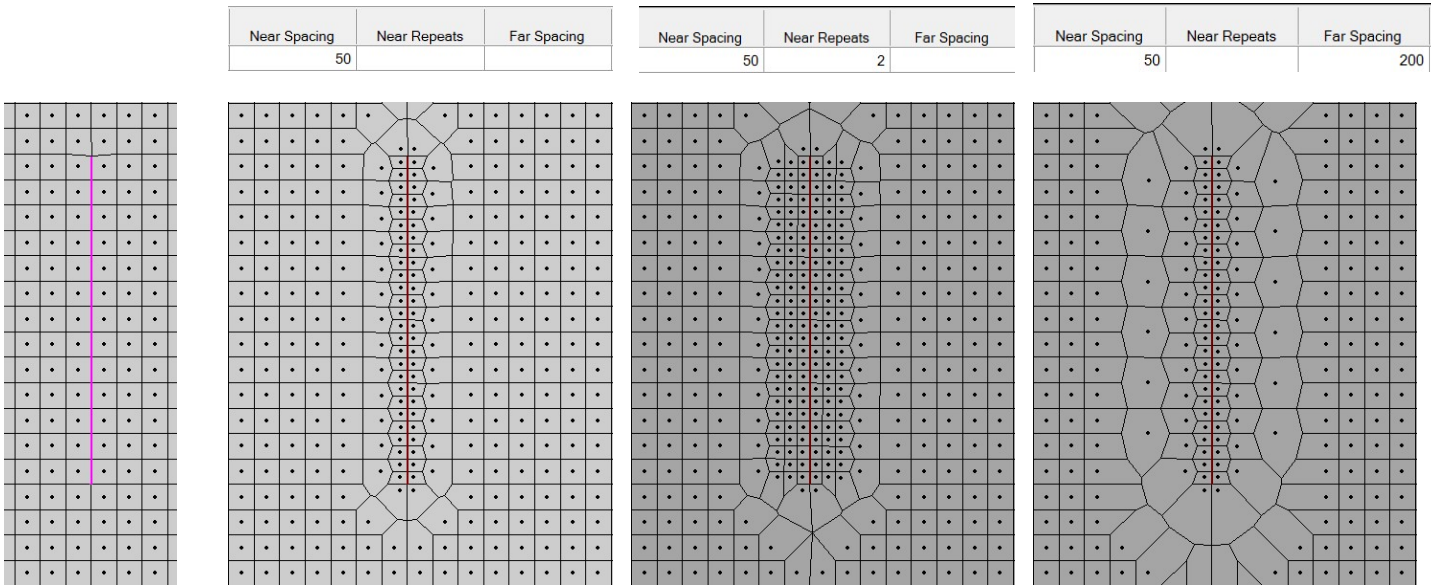
- All points within a computed buffer are removed.
- Cells are added uniformly along the side of breakline.
- Buffer for point removal is computed as:
  Near Spacing * Near Repeats
  + Double Near Spacing size n times until reach Far Spacing size
  (However, take 75% of last cell size so as to not delete too far)




- A breaklines' area of influence is stopped by a neighboring breakline (will not proceed to opposite side).

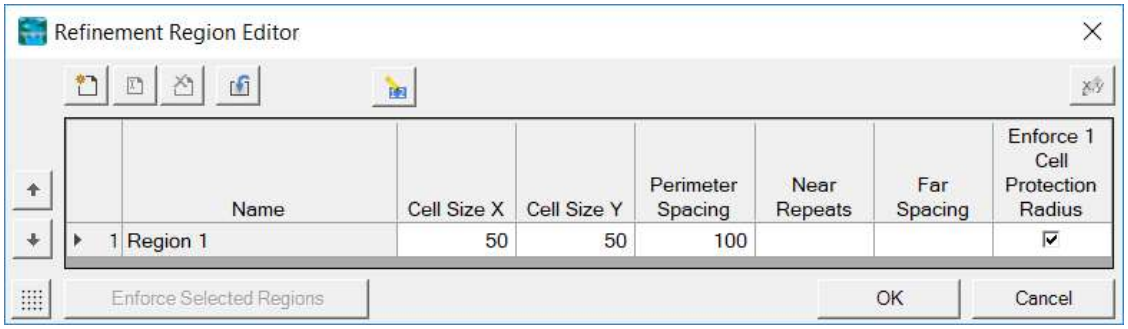
# Breakline Examples

- Grid spacing = 100




# Refinement Regions

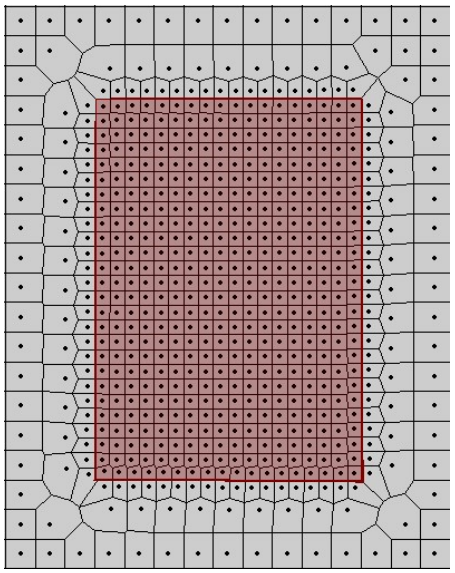
- Cell Size X,Y – Internal cell size dimension
- Perimeter is treated like a breakline
  - Perimeter Spacing, Near Repeats, Far Spacing, Cell Protection same as for breaklines
- Internal cell size used for perimeter spacing, if not defined



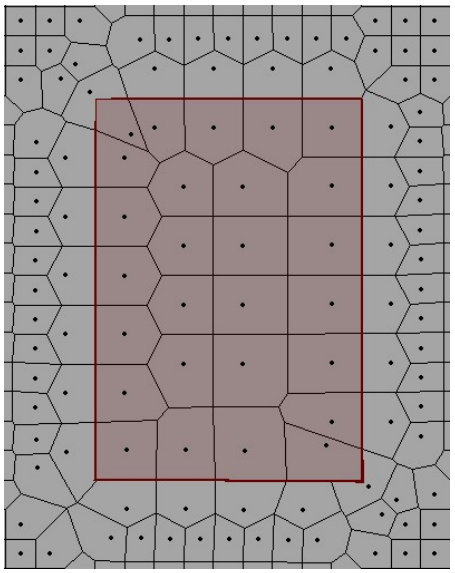
# Refinement Examples

- Grid spacing = 100

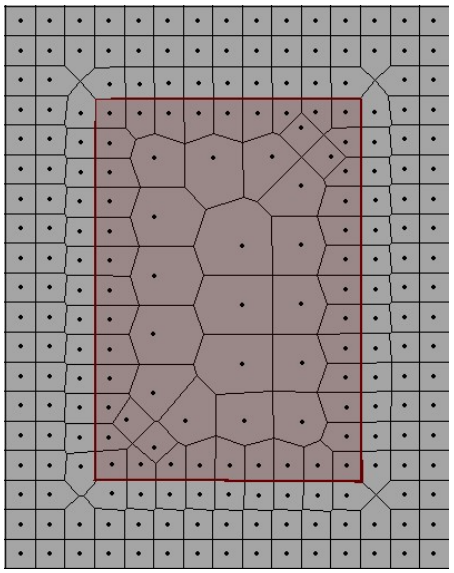
| Cell Size X | Cell Size Y | Perimeter Spacing |
|---|---|---|
| 50 | 50 | |



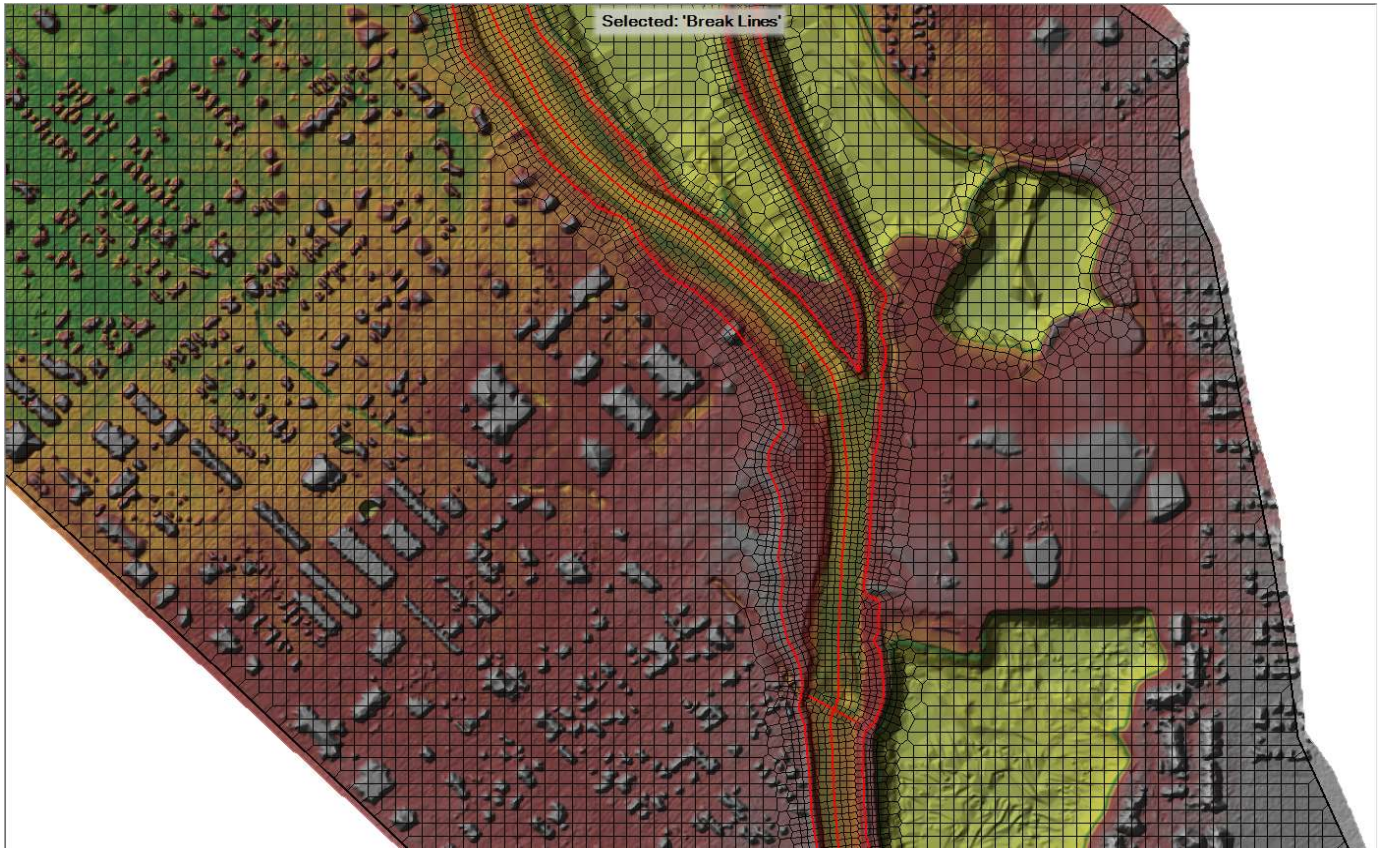
| Cell Size X | Cell Size Y | Perimeter Spacing |
|---|---|---|
| 200 | 200 | |



| Cell Size X | Cell Size Y | Perimeter Spacing |
|---|---|---|
| 200 | 200 | 100 |

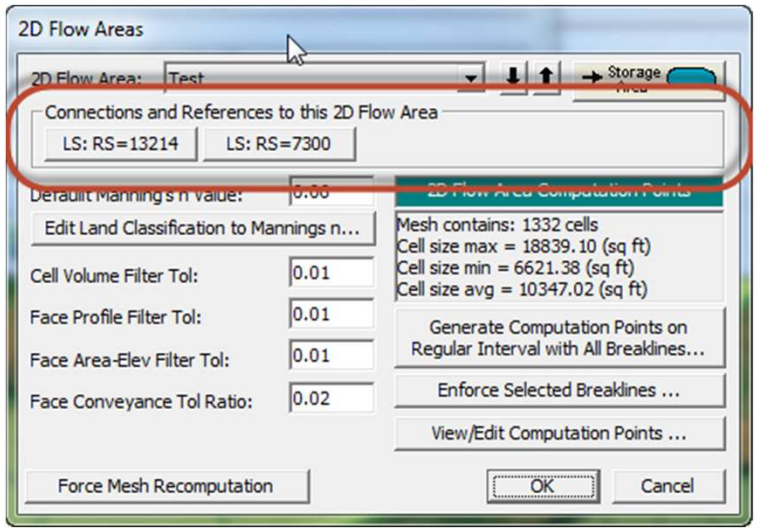


# Refinement Regions and Break Lines to Align Channel Cells



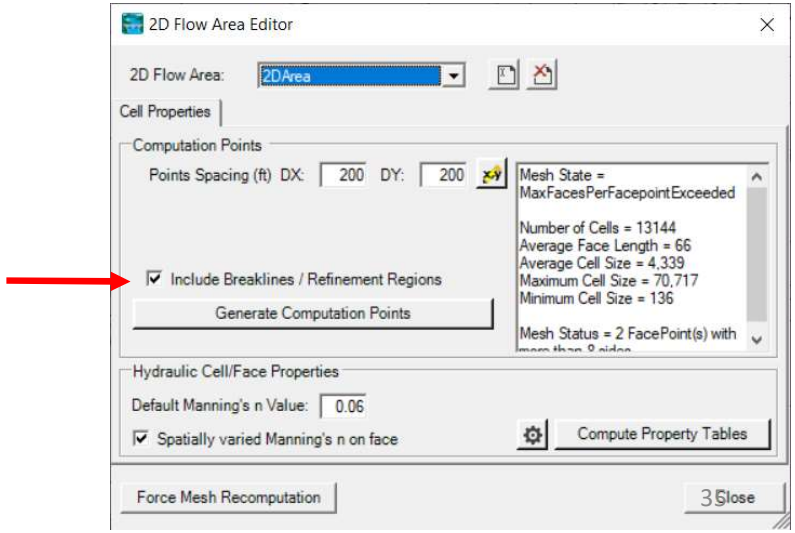
# 2D Flow Area Editor
# Geometry Editor

- Connections
  - Similar to Storage Area
  - Quick Link to Connections



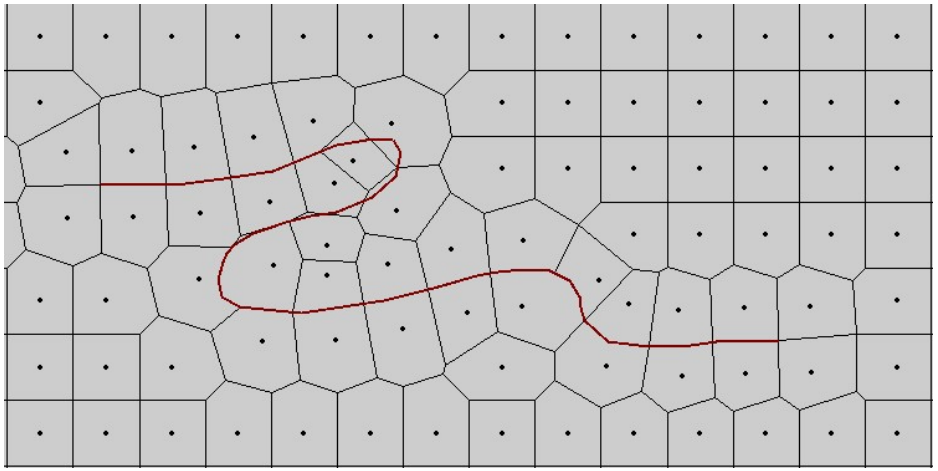
# Computation Points

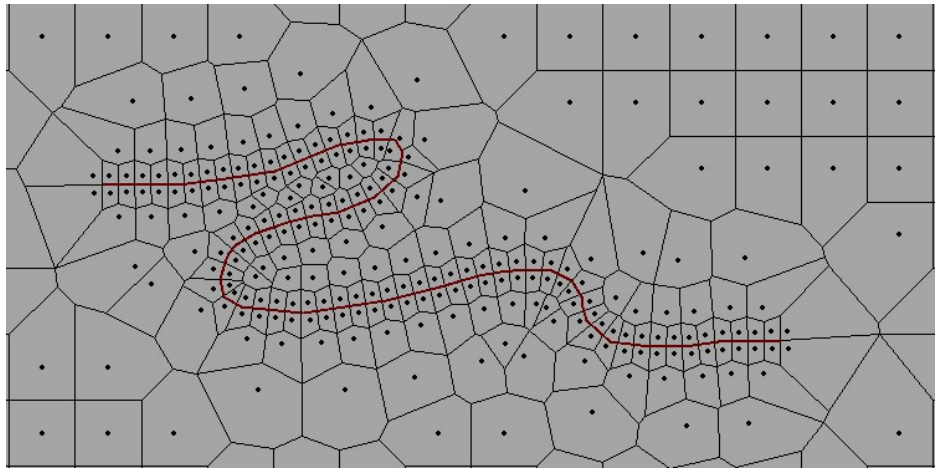
- Final mesh is based on final computation point set.
- Enforcement of Breaklines and Refinement Regions modifies existing computation points.
- Can enforce a breakline once, change parameters and enforce again.
  - Each iteration modifies the previous points.
- Point Regeneration will automatically use Breaklines and Refinement Regions (if included).



# Fixing Problems

- If cell spacing is too large, cell faces may not be enforced

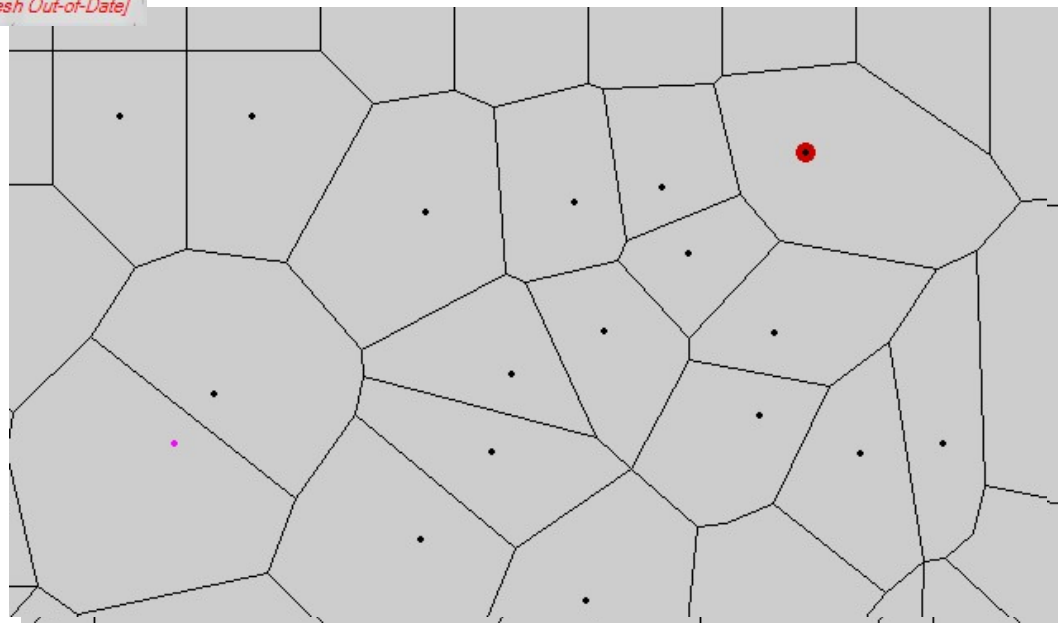




# Fixing Problems

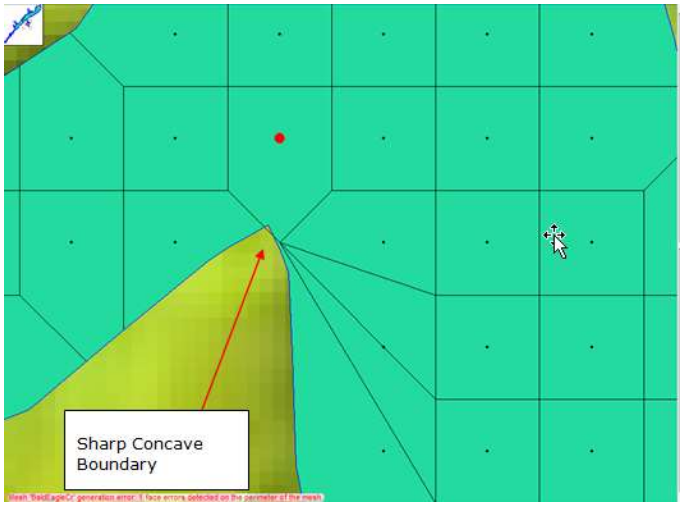
- More than 8 sides on a cell.

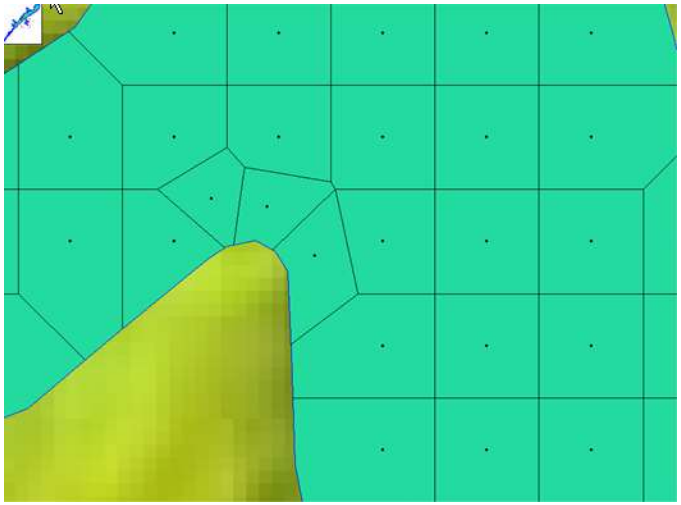

- Fix by Hand
- Auto “Try Fix” menu option



# Fixing Problems

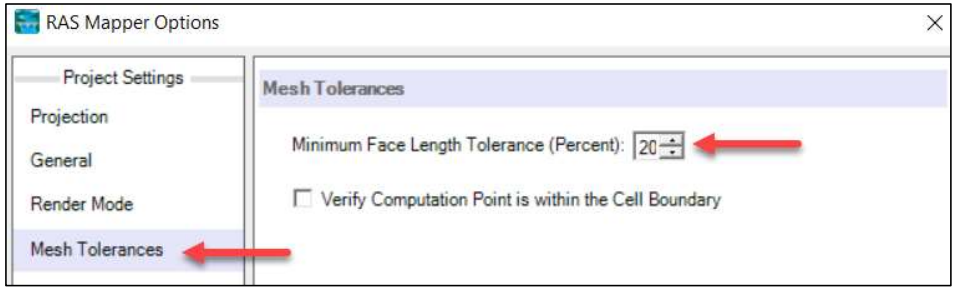
- Cells need to have exactly one Computation Point (Black Dot)
- Fix graphically by adding more points and/or moving points near perimeter

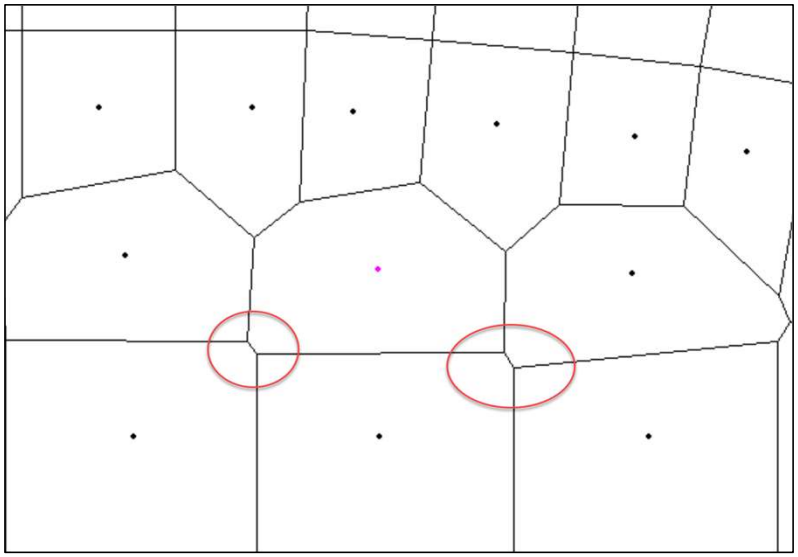


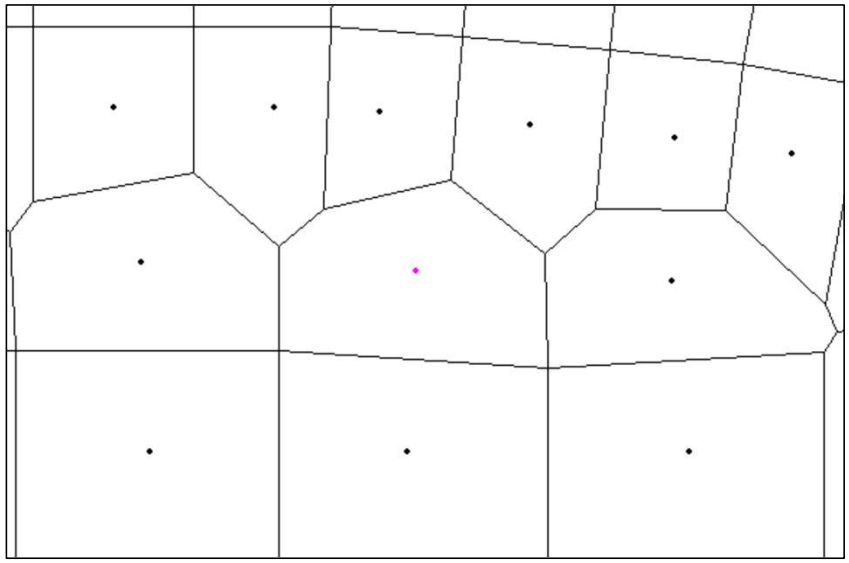



# Mesh Tolerances

- Minimum Face Length (%)
  - 5% is Default, Recommend increasing

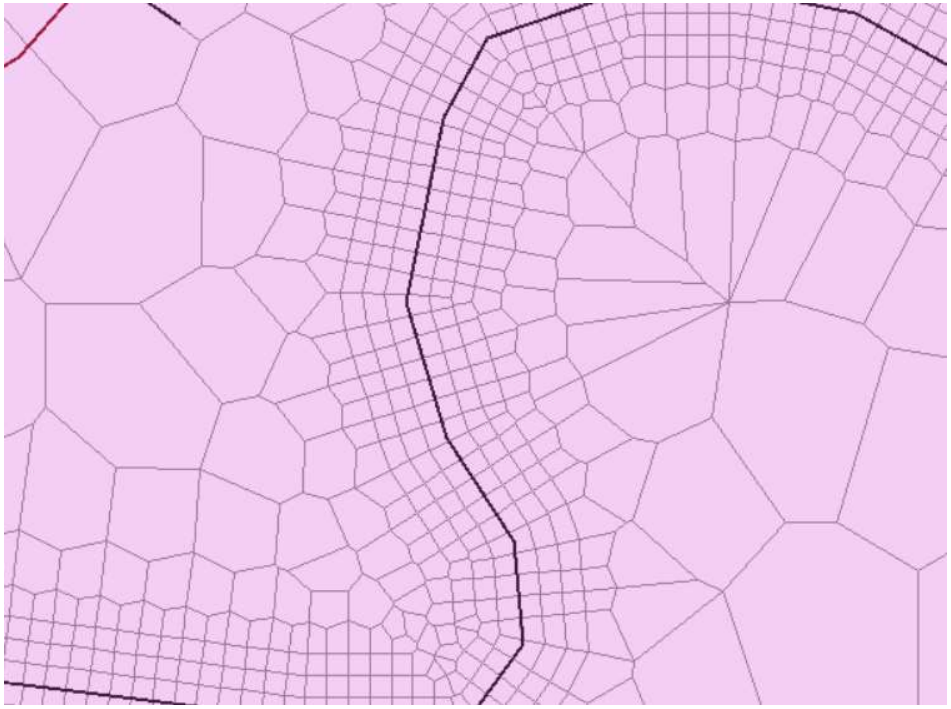


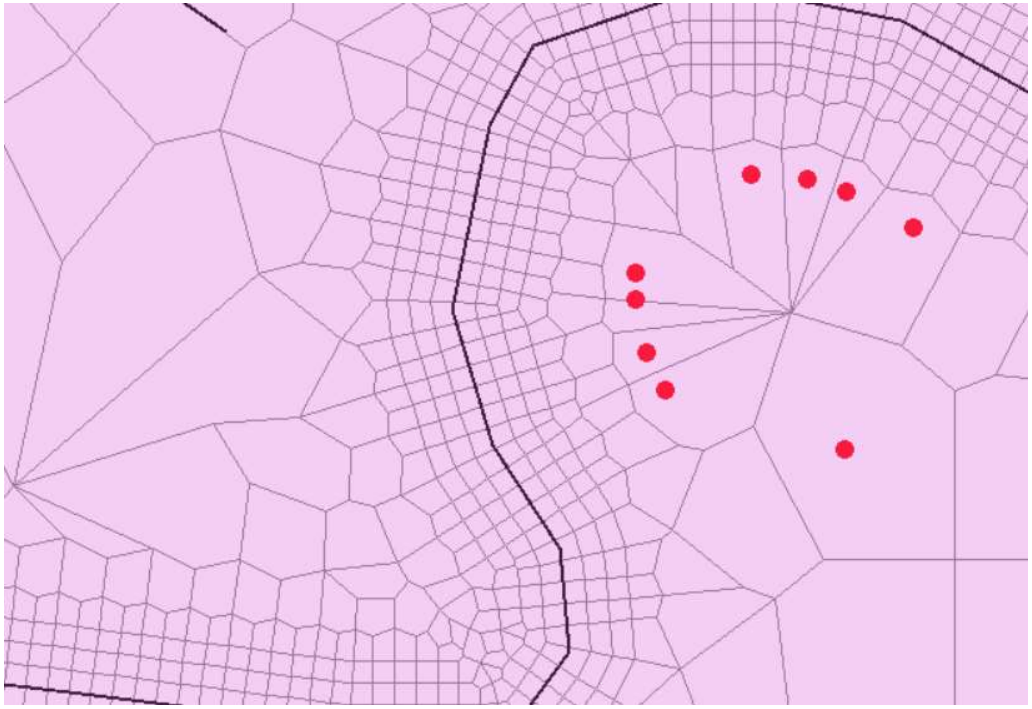


# Face Tolerance

- Small Face Tolerance



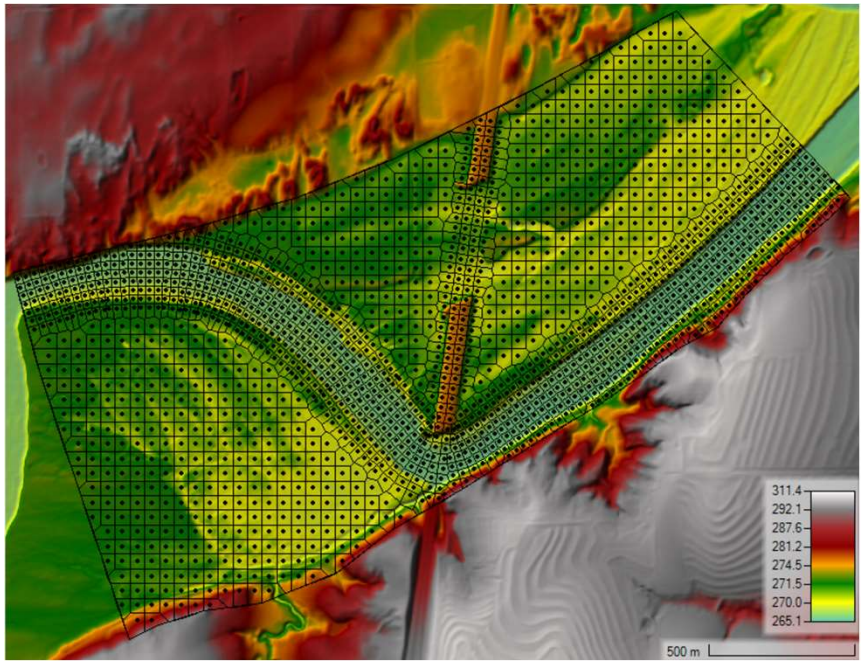
- Larger Face Tolerance

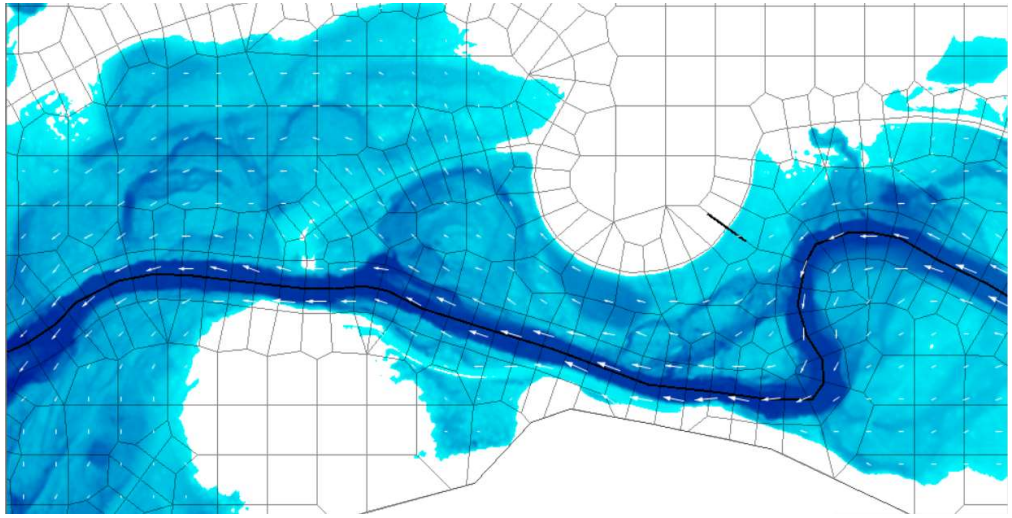


- Fewer faces faster models (less cell face computations).

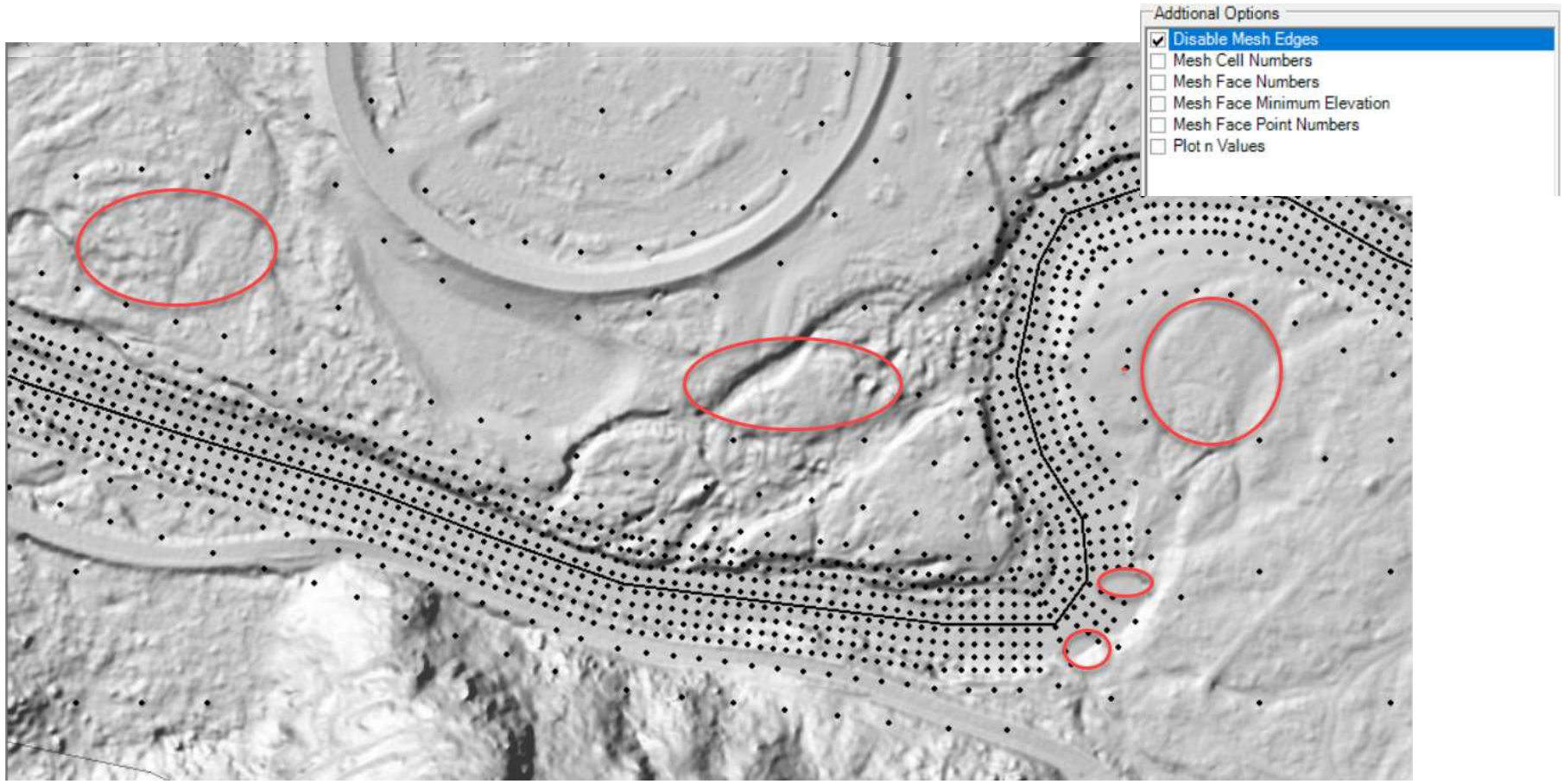
# Face Alignment

- Normal velocities are computed at every face. Tangential velocities are interpolated; therefore, aligning faces with flow more accurate.



# Mesh Evaluation



# Questions?

US Army Corps of Engineers