2017 Montana Floodplain Resource Seminar: Lecture 4
2D Geometry Setup

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compass

Identify Hazards, Interpret Risks, Integrate Mitigation

Lecture 4 Overview

- Important buttons and functions
- 2D mesh development and resolution
- Grid cell parameters and alignment
- Breaklines and mesh refinement
- Inline structures and bridge applications
- Basic rules, common pitfalls, and trouble shooting

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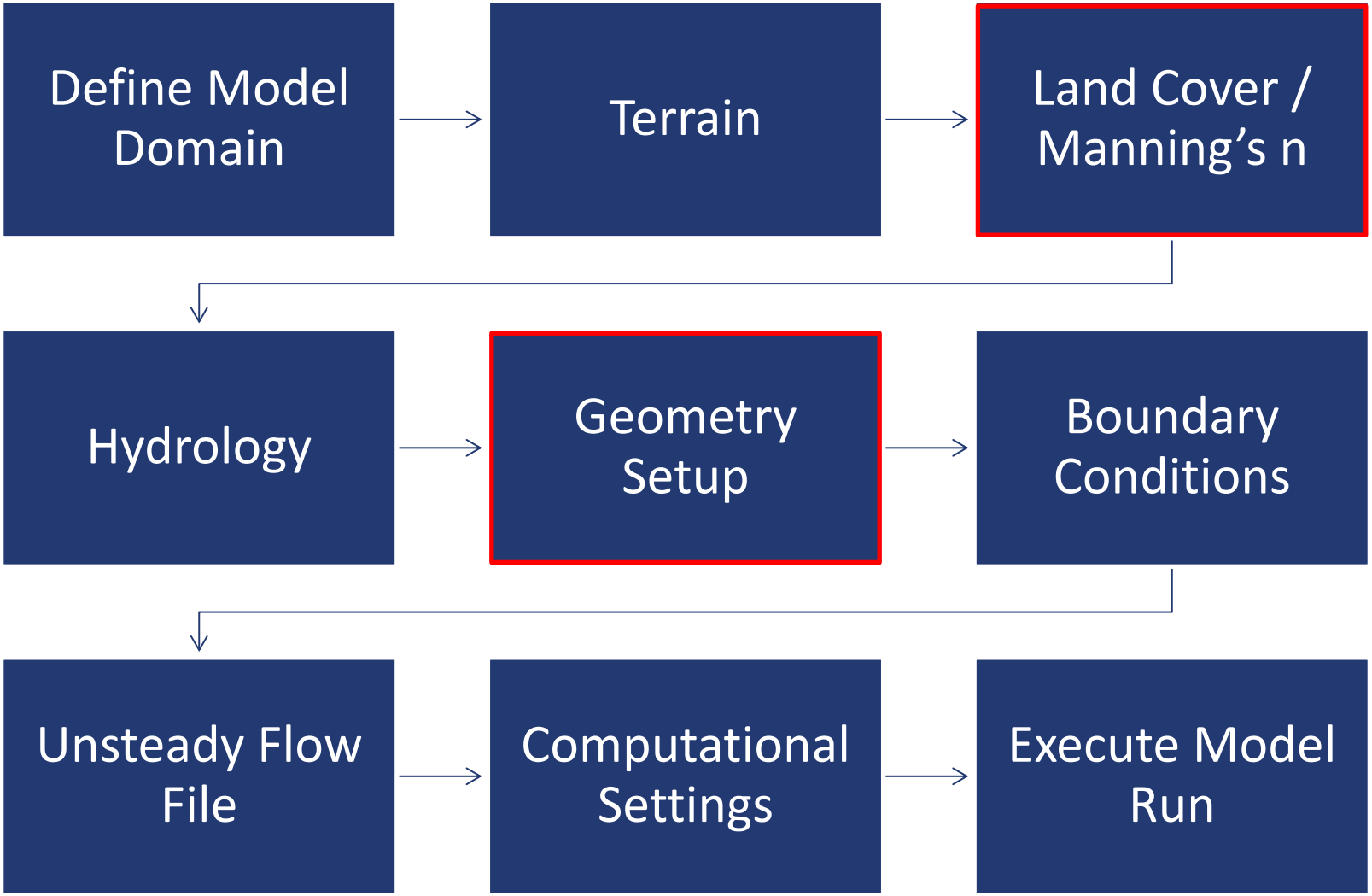
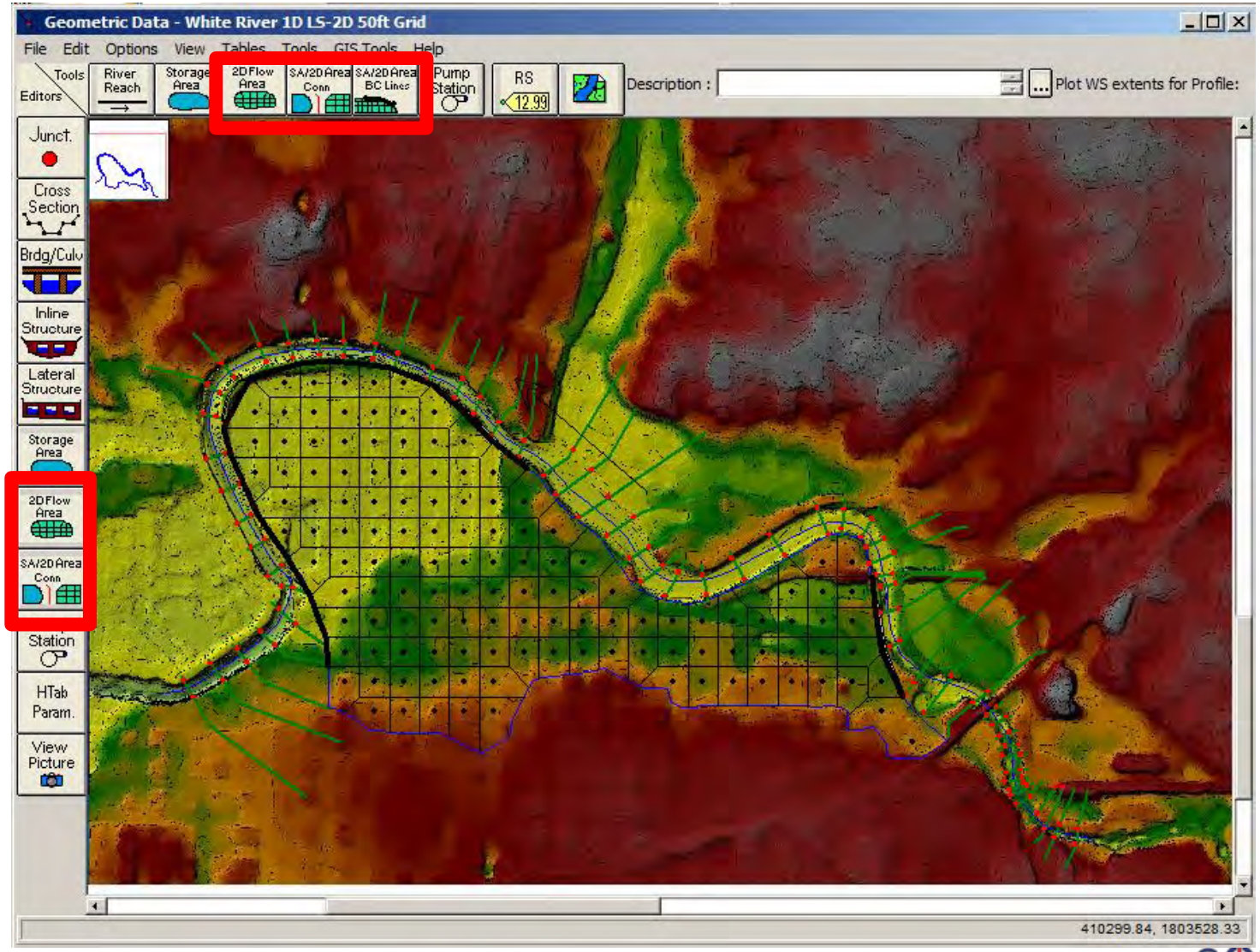
HEC-RAS 5.0 Process



Geometry Editor Tools



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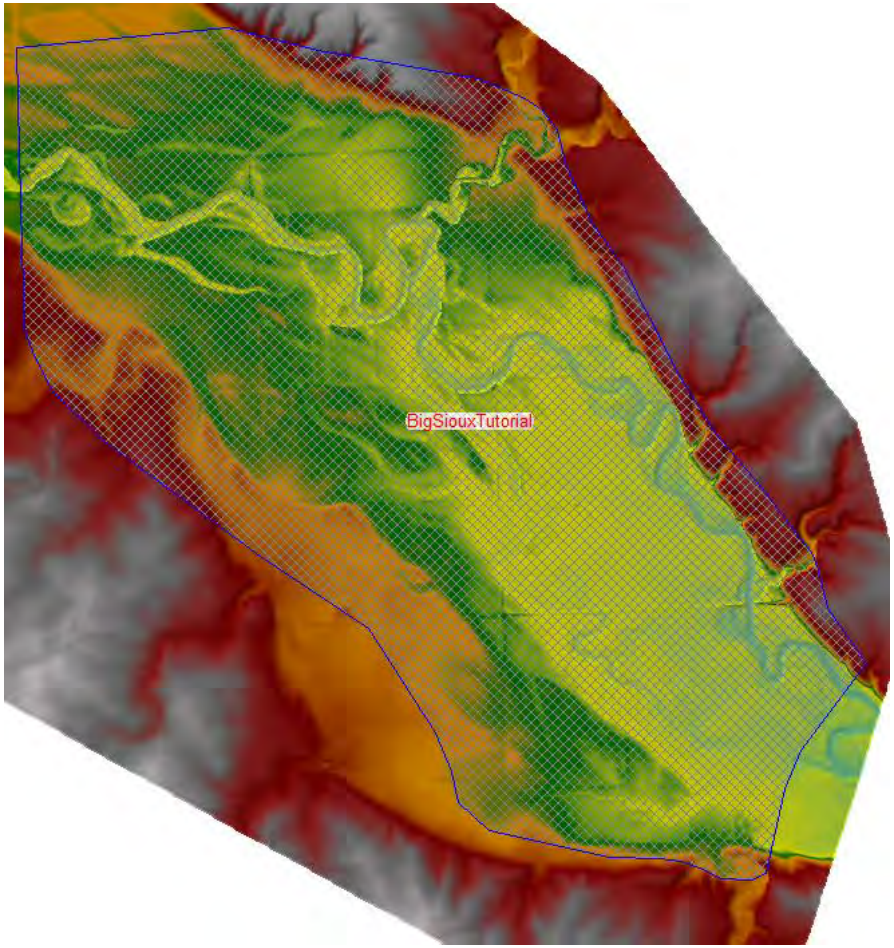
2D Flow Area (Computational Mesh)

- Defines area where 2D computations are performed
- Composed of a gridded mesh (structured or unstructured) with user defined cell size
  - Nominal cell size specified
  - Modified locally with breaklines or manual tools



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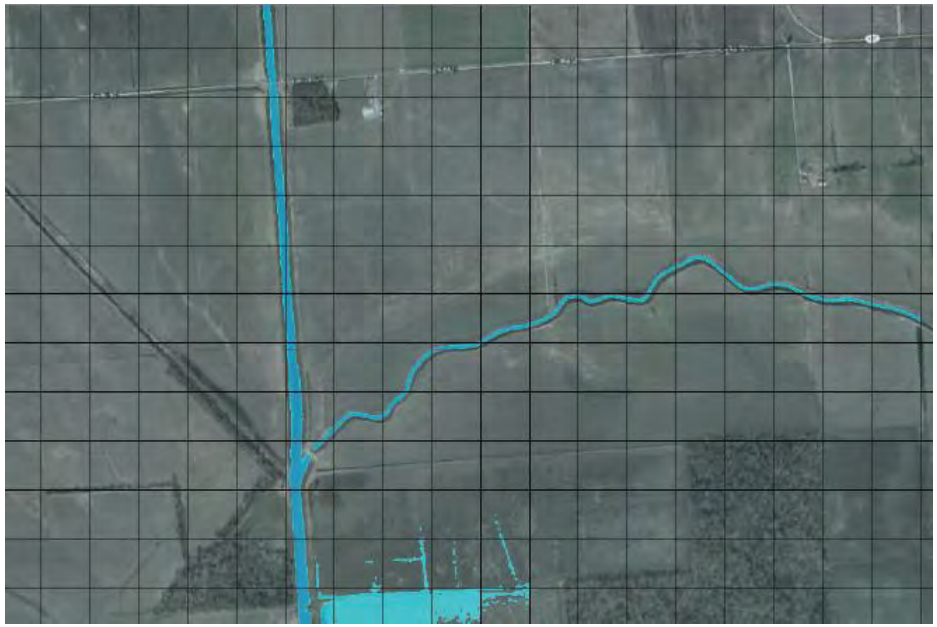
High Resolution Subgrid Model

- "Subgrid" means it uses detailed underlying terrain to develop geometric and hydraulic property tables that represent cells and cell faces
- Maintain resolution of terrain data with larger grid cells



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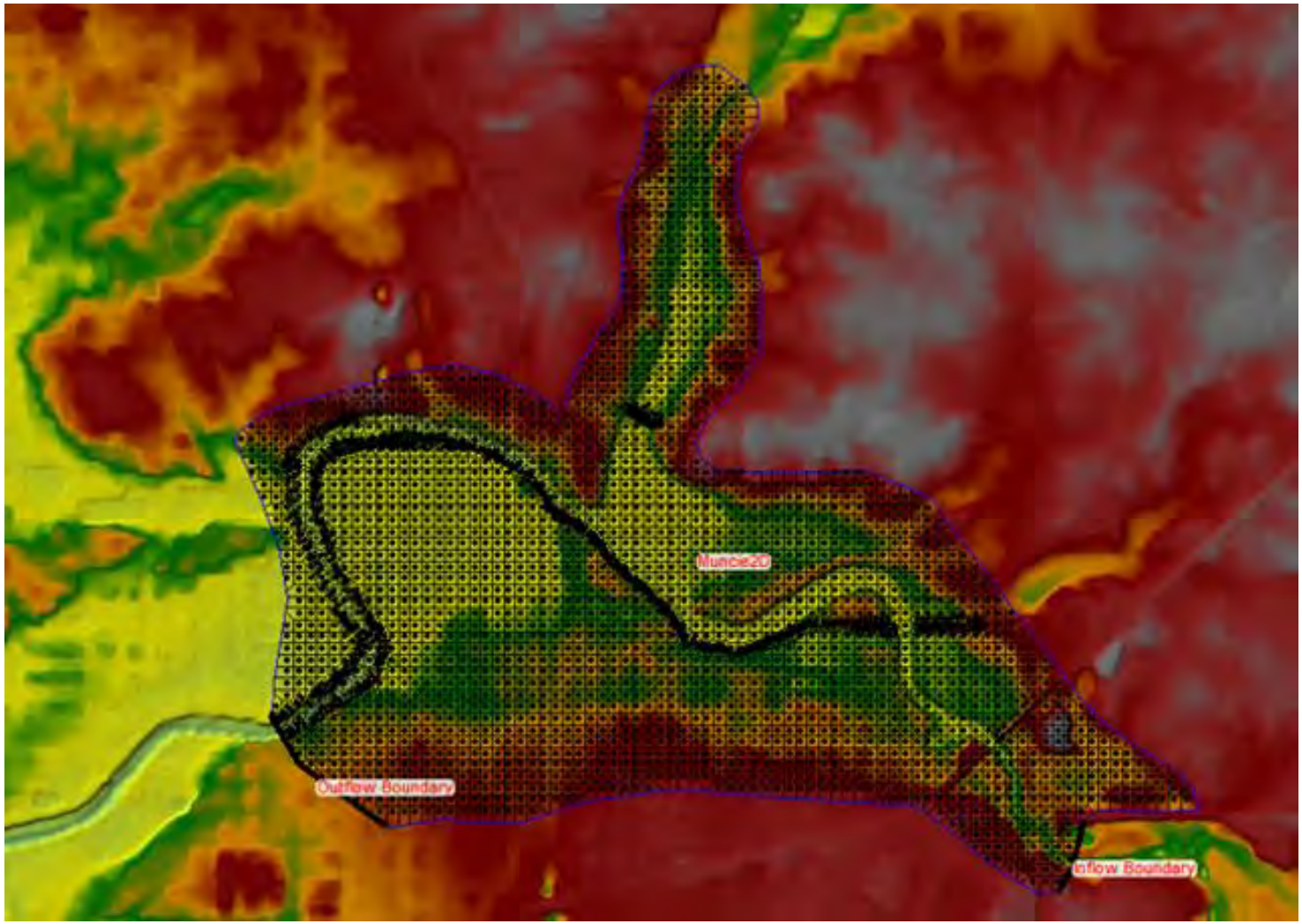
2D Only Mesh



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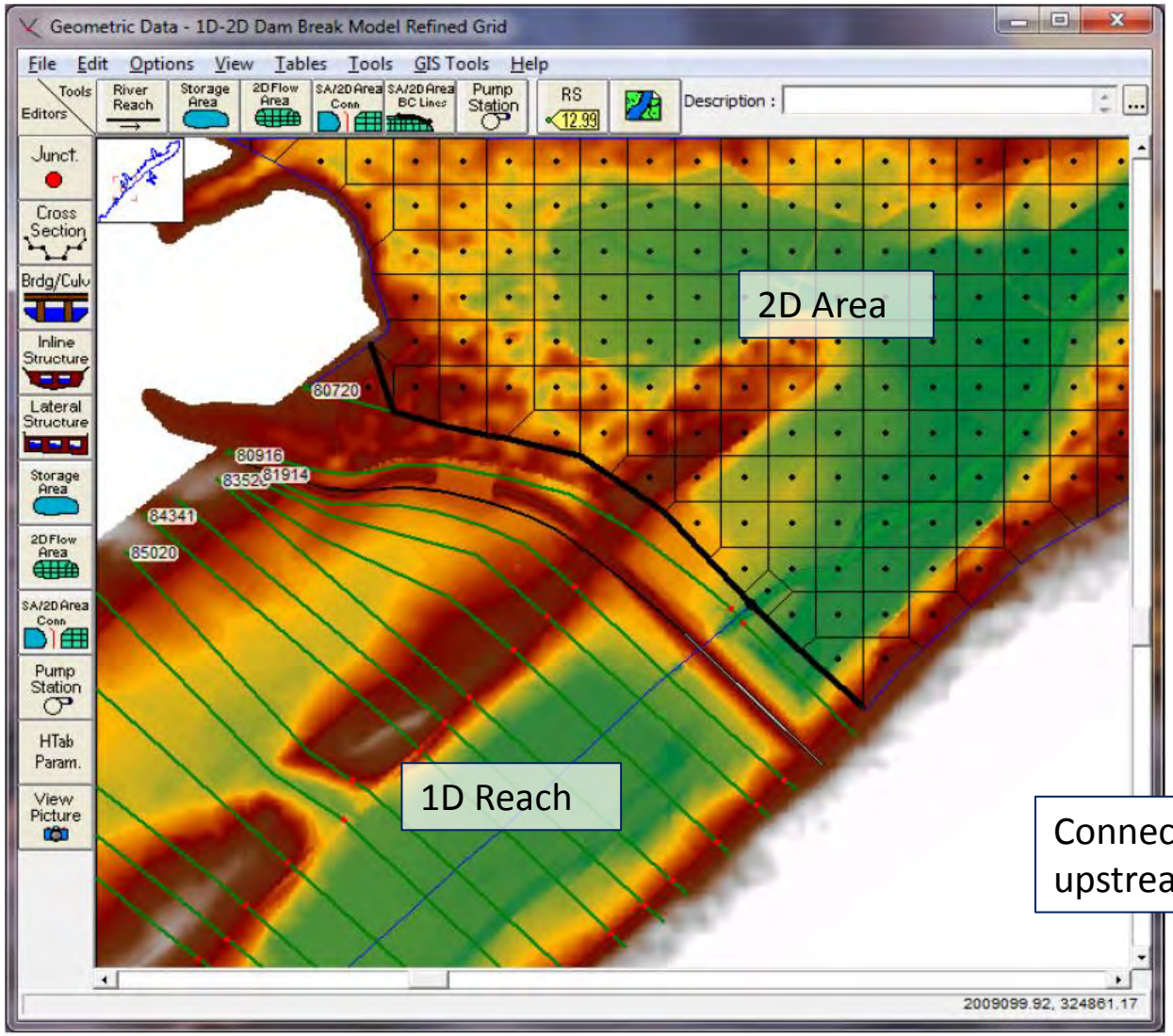
Inline Connection



Connection between a 2D Area and the upstream BC of a 1D reach

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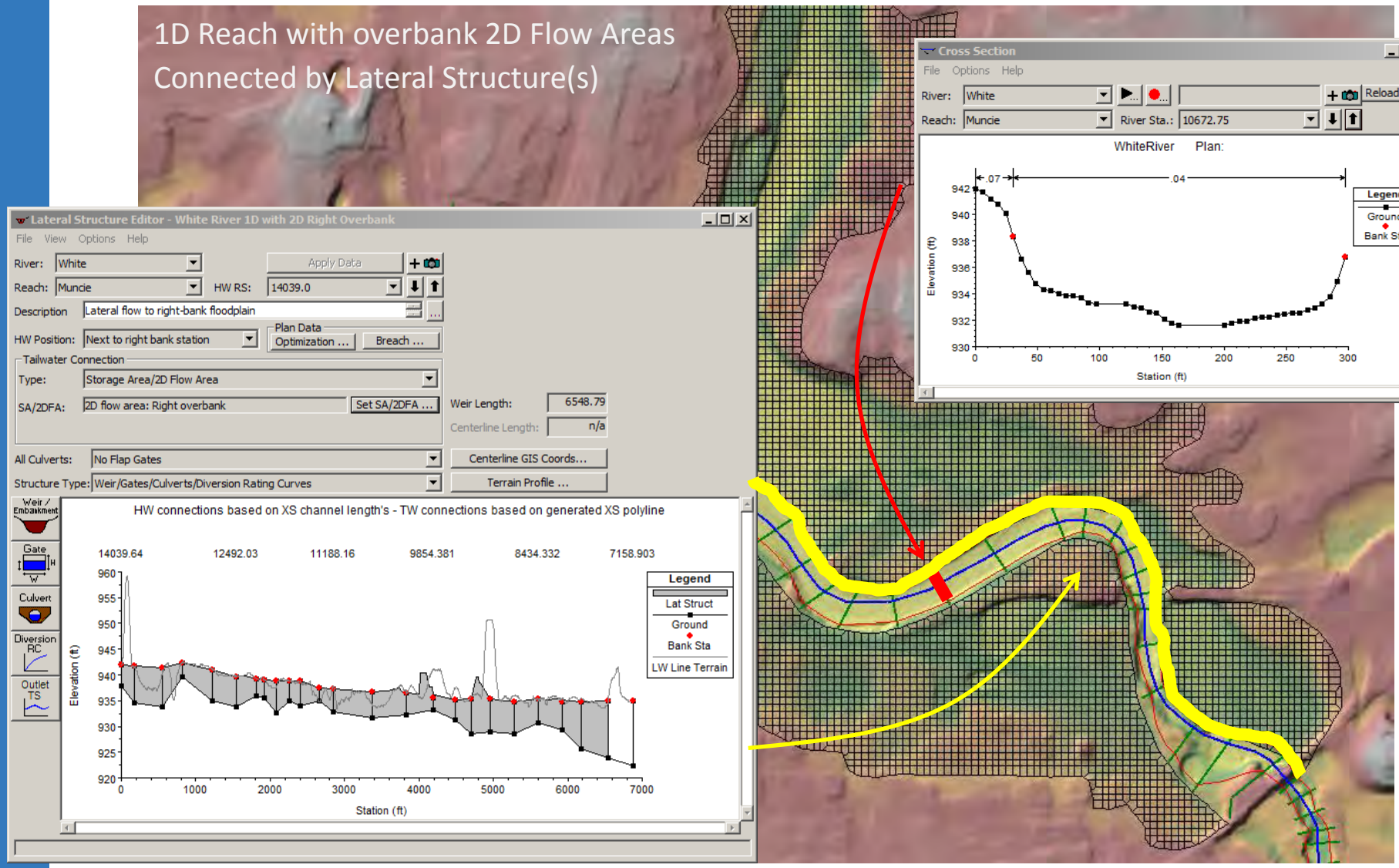
Overbank Connection

1D Reach with overbank 2D Flow Areas Connected by Lateral Structure(s)



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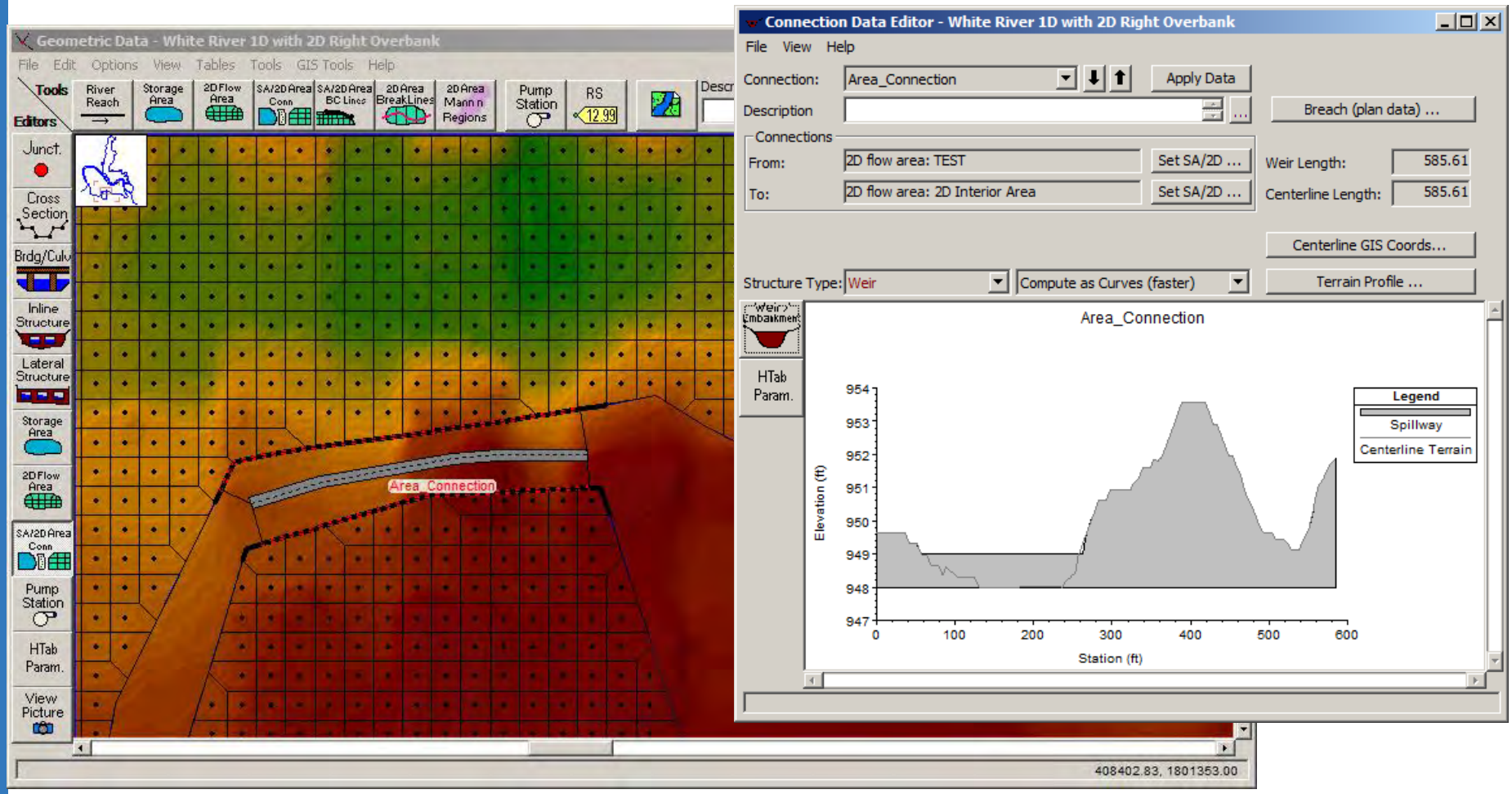
2D to 2D Connection



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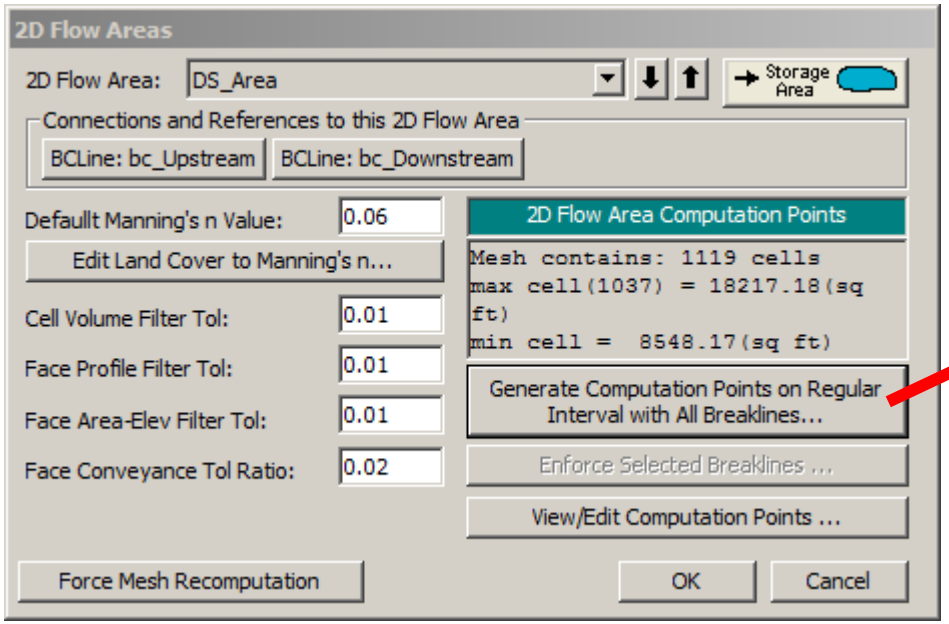
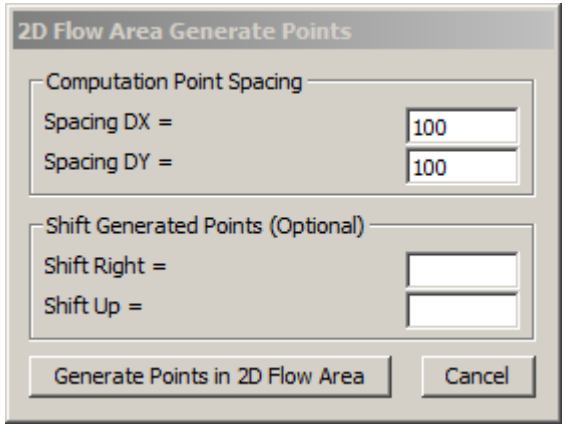
Delineating 2D Flow Area

- Two Options
  1. Use ***2D Flow Area*** tool in geometry editor
     - Delineate extents inside of HEC-RAS
     - Use background imagery or terrain to guide boundaries
  2. Delineate features in GIS → Import to RAS
     - Imported as a points file to define vertices
     - Use ***Features to Vertices*** tool in GIS to convert polygon to points file (***Data Management*** → ***Features***)

Generating Mesh

- 2D Area is defined, time to generate a grid cell mesh
- Define grid cell parameters with 2D Flow Area Editor





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Grid Cell Size Considerations

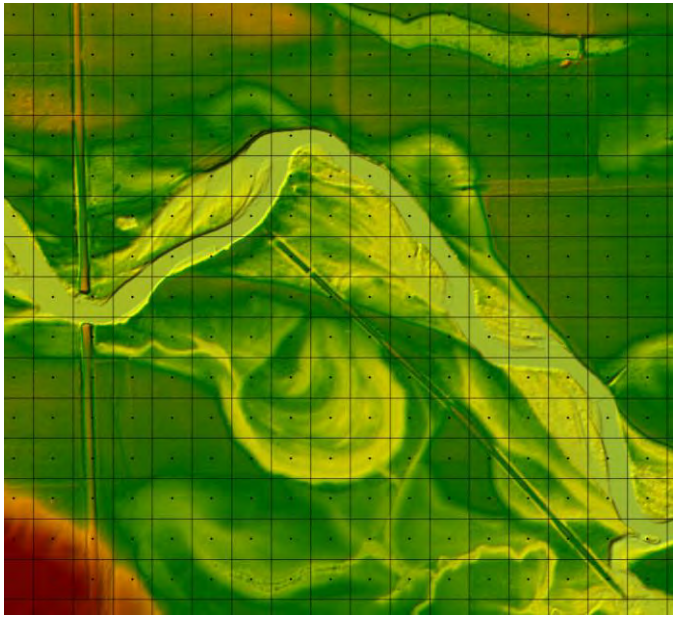
- Subgrid resolution allows for larger cells, <u>but model still only calculates one depth at each cell</u>
- Need to consider the system being represented
  - Rapid water surface changes, smaller cells
  - Gradual water surface changes, larger cells
- Application is also important
  - Detailed channel study → smaller cells
  - Large scale flood inundation study → larger cells

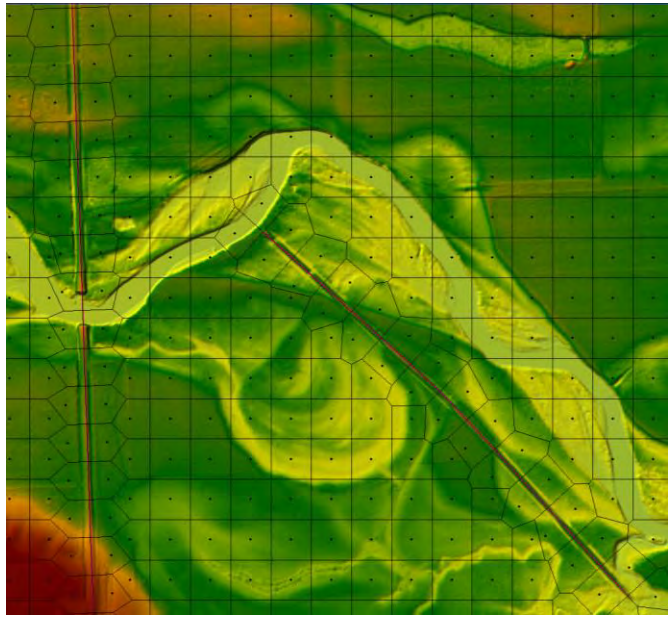
Mesh Refinement

- Must refine mesh initial generation to capture terrain details and appropriately model features in the channel and floodplain
- Two tools:
  - Breaklines
  - Manual mesh adjustments

Breaklines

- Force the alignment of cell faces along line
- Critical to realistic flood routing through 2D flow area
- Define topographic features in channel and floodplain
- Cell face determines how adjacent cells exchange water
  - Think cross sections





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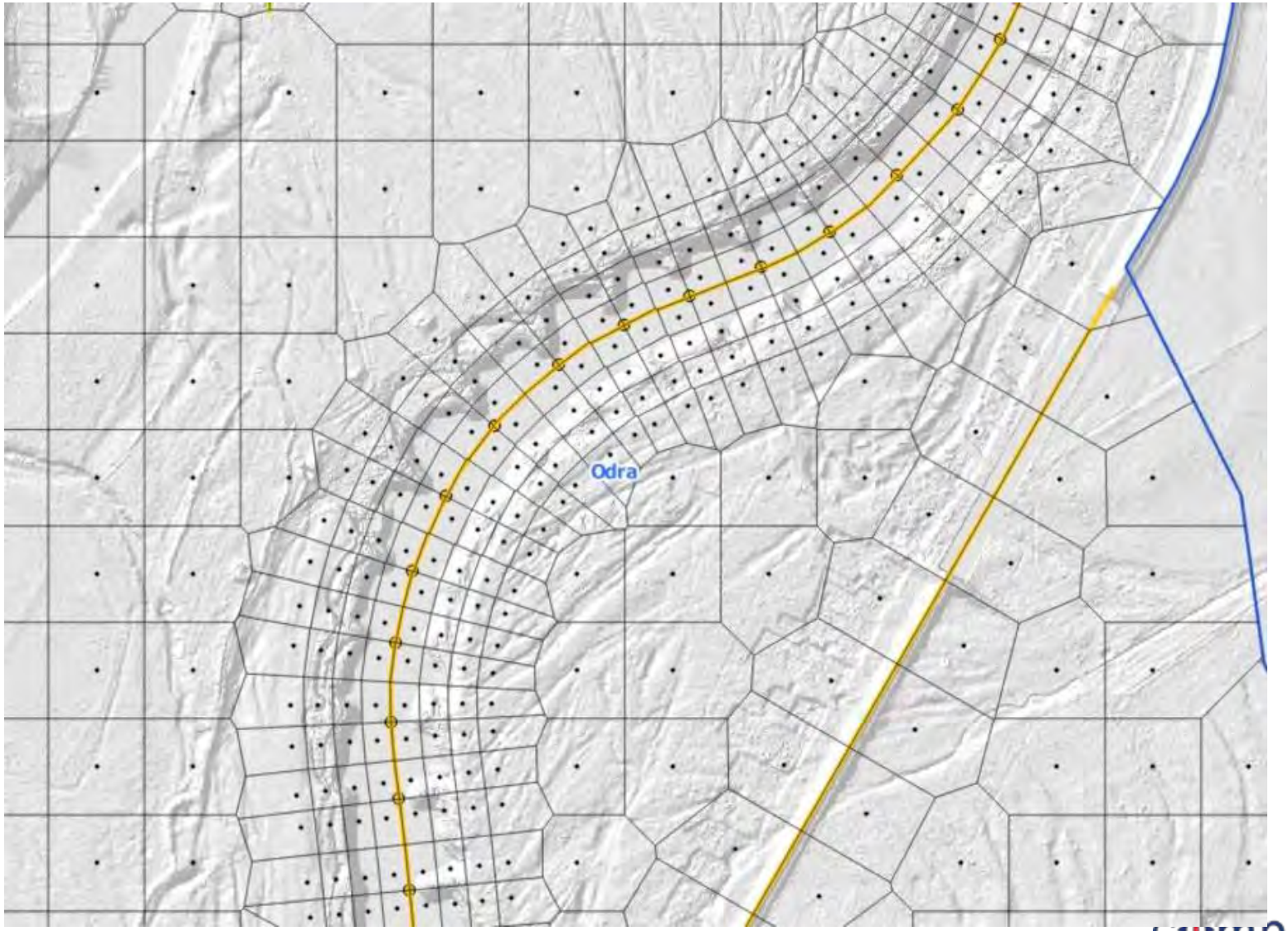
Variable Cell Sizes



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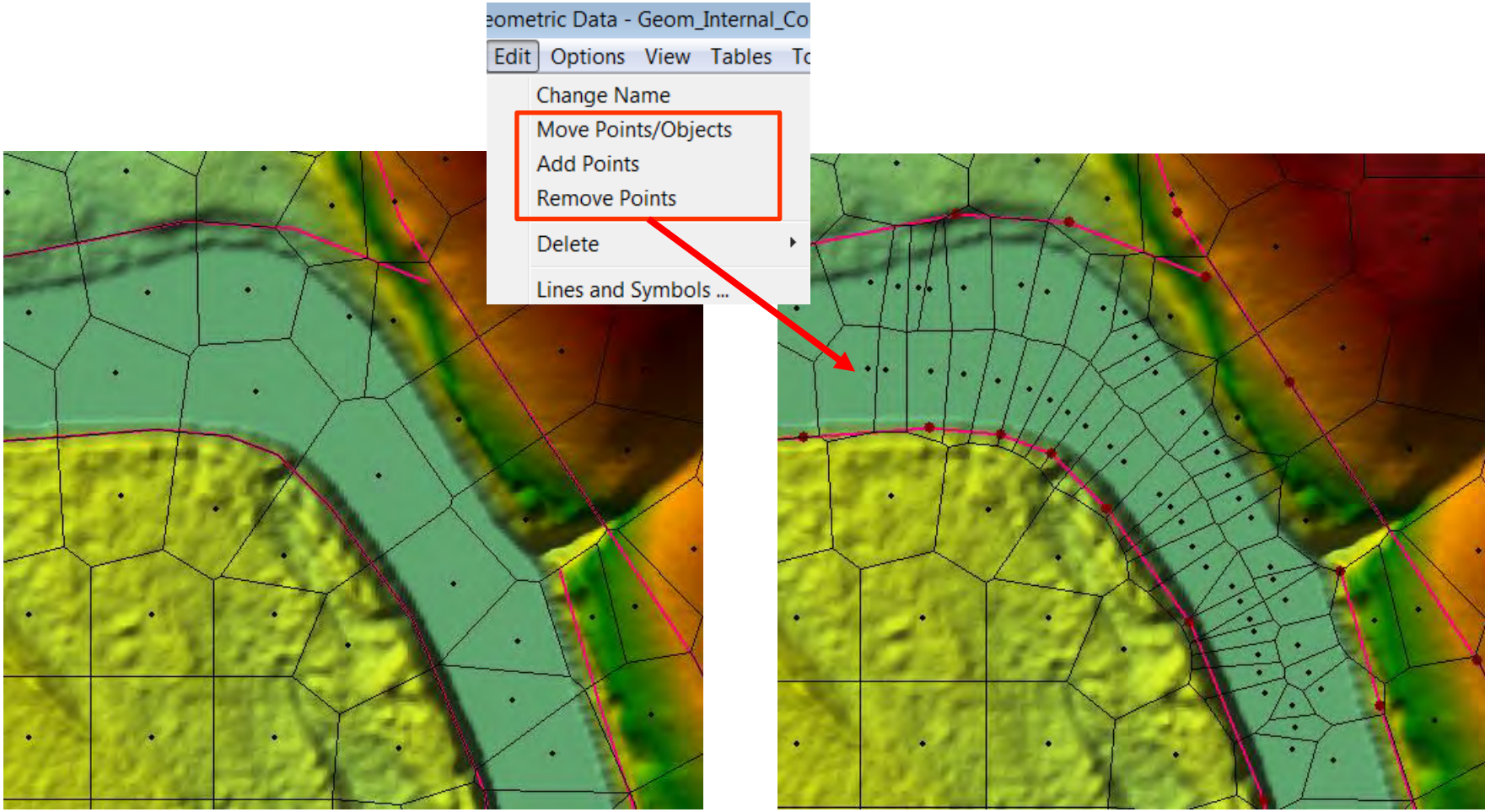
Manual Adjustments

If mesh is recomputed, all manual changes will be lost!!



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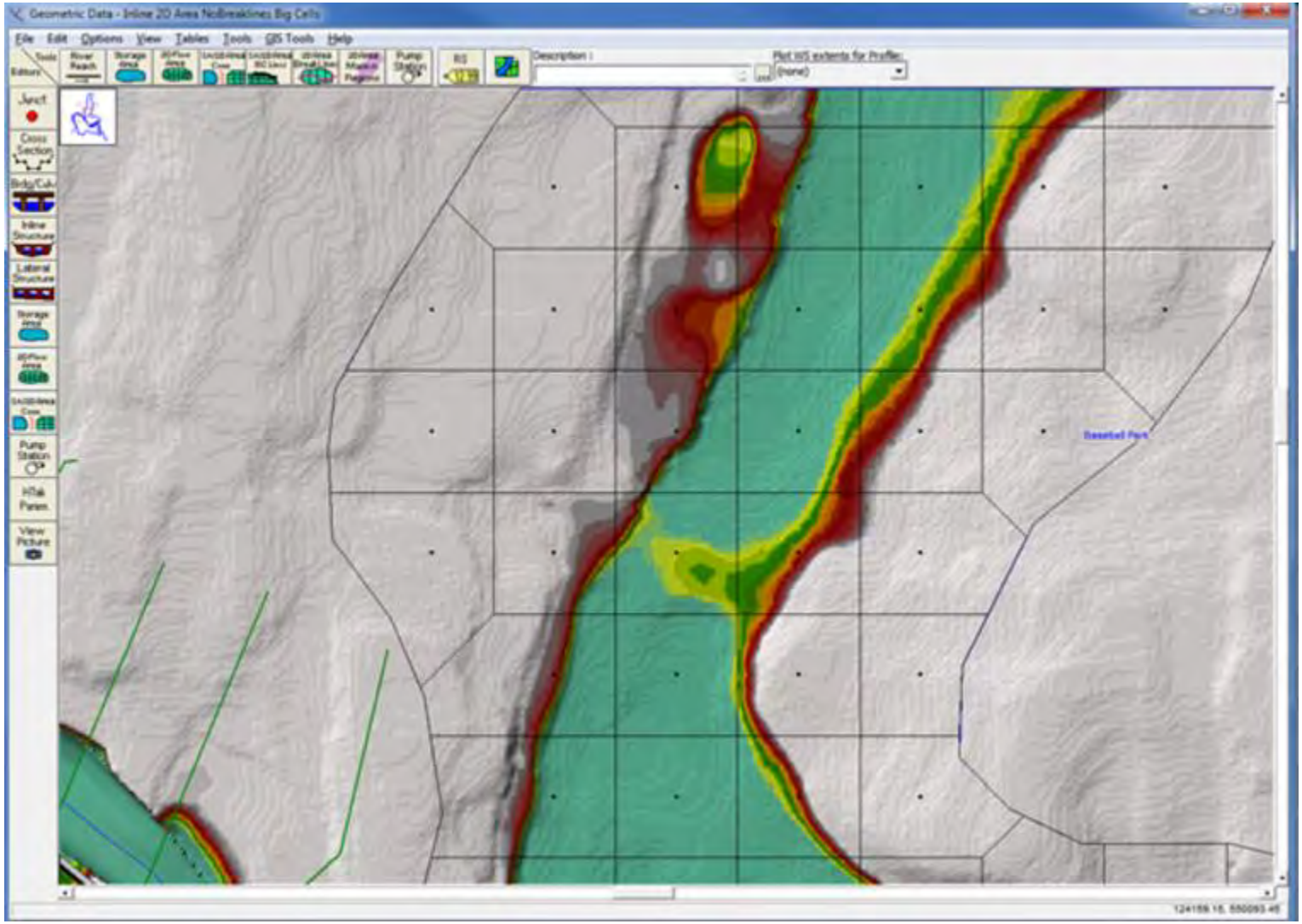
Leakage Across Grid Cells



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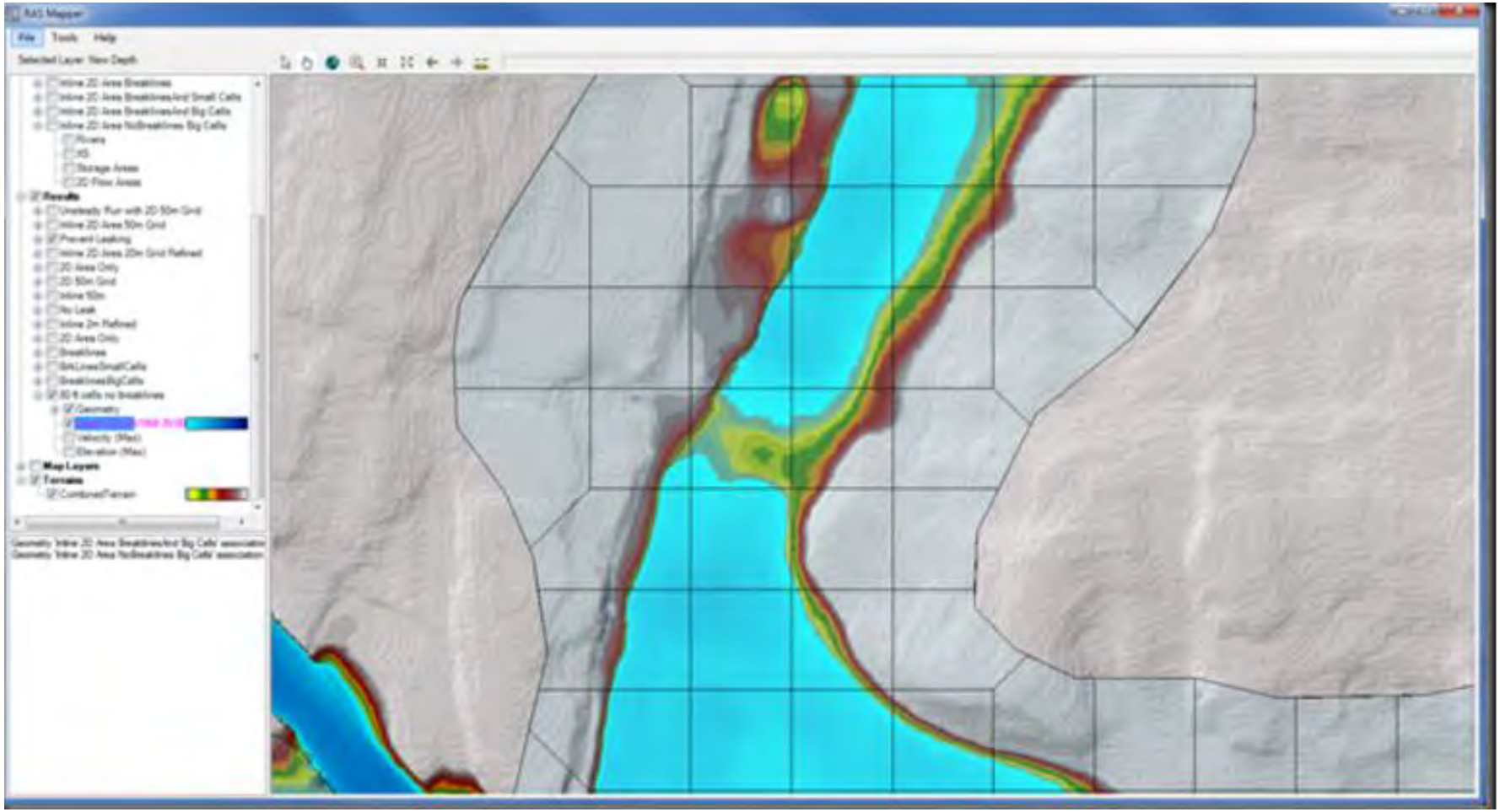

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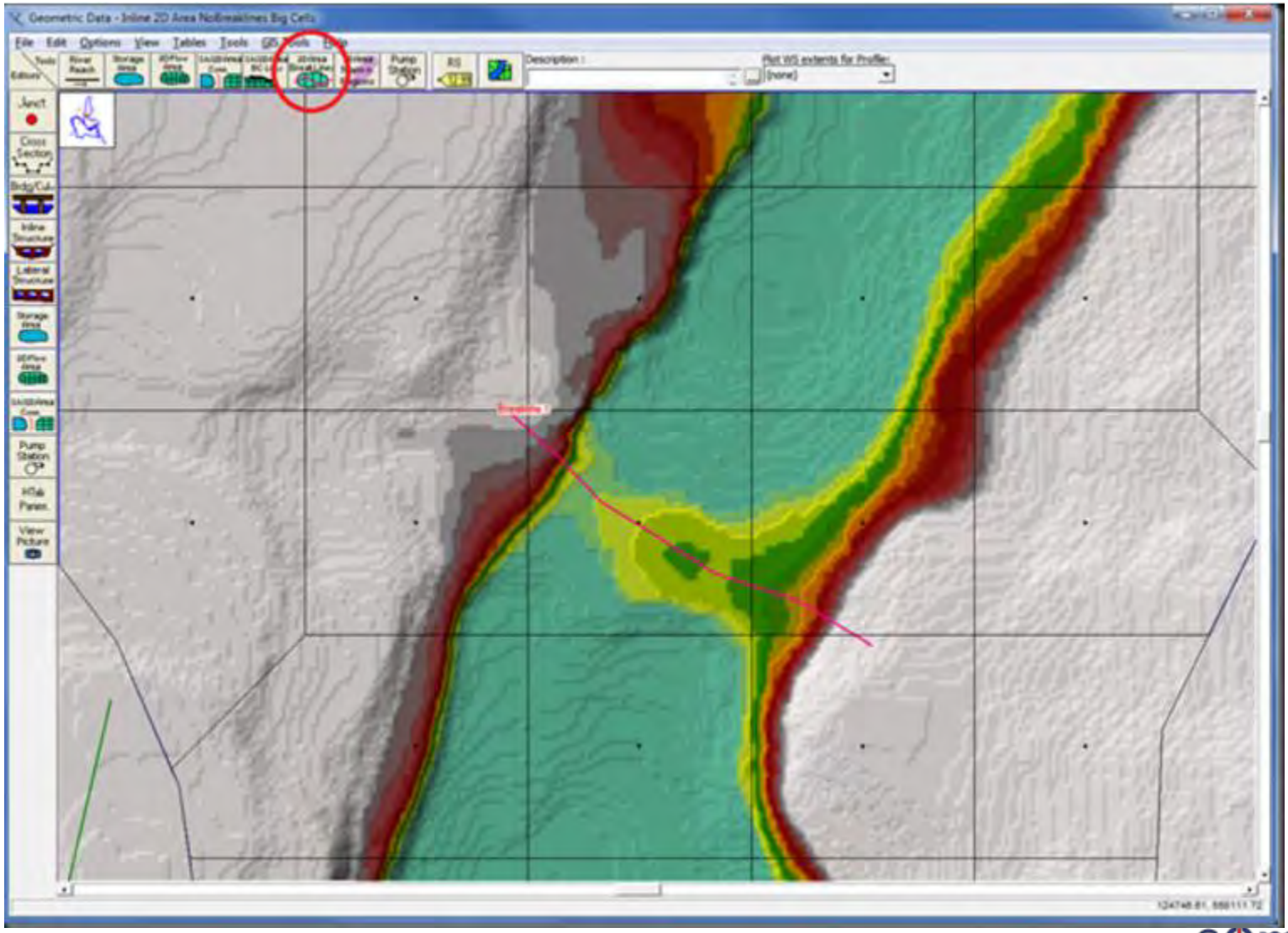

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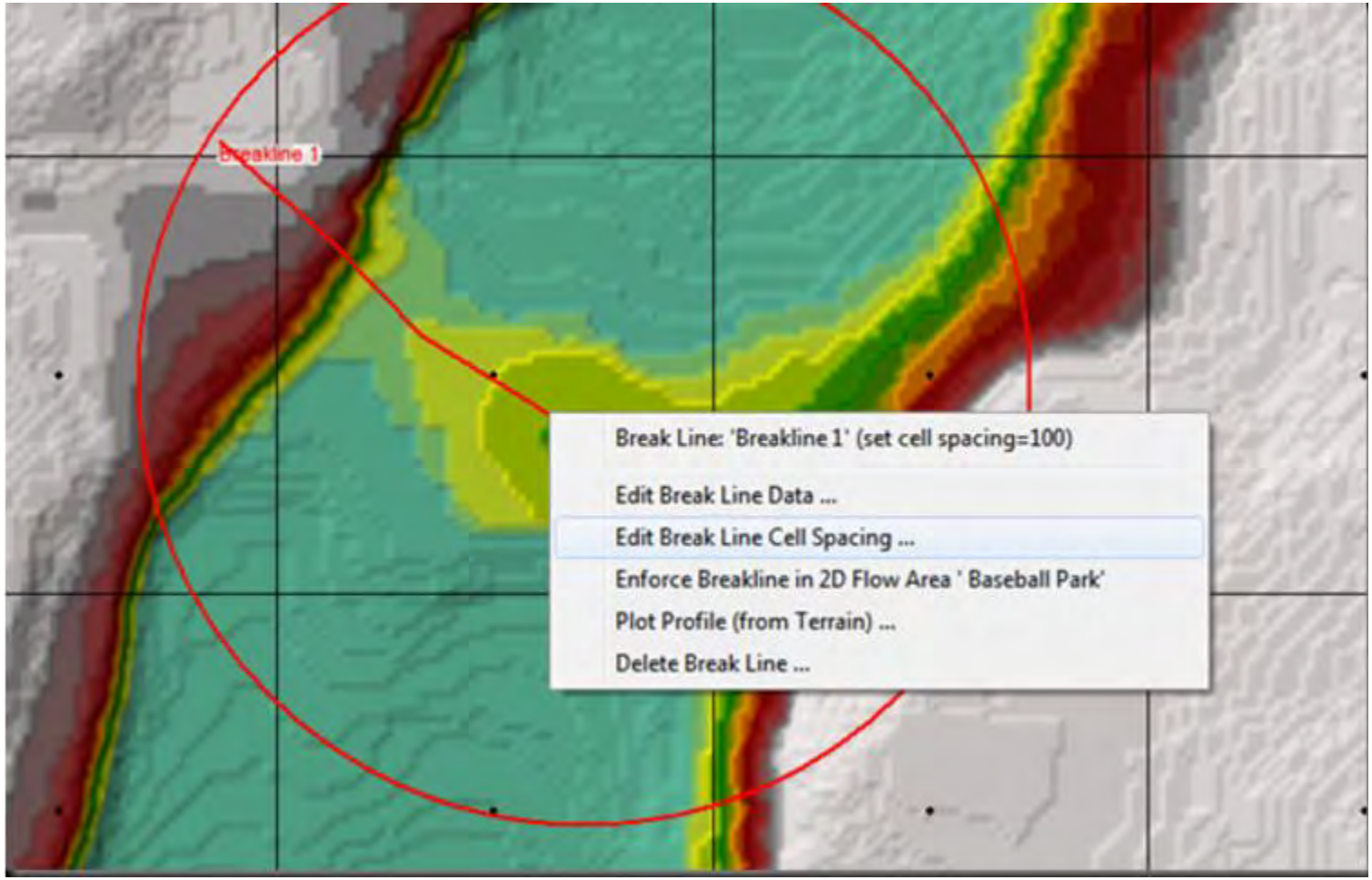

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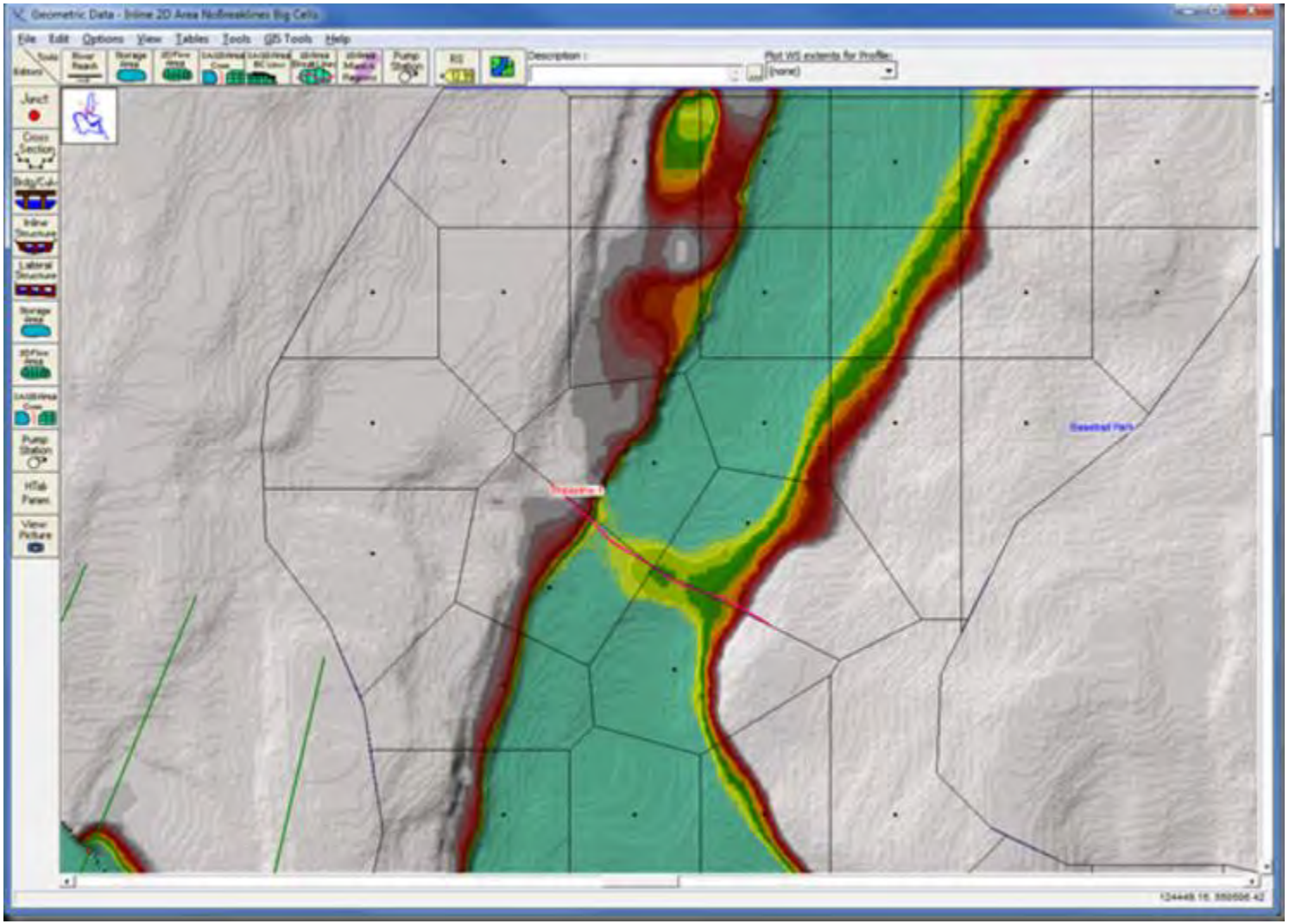

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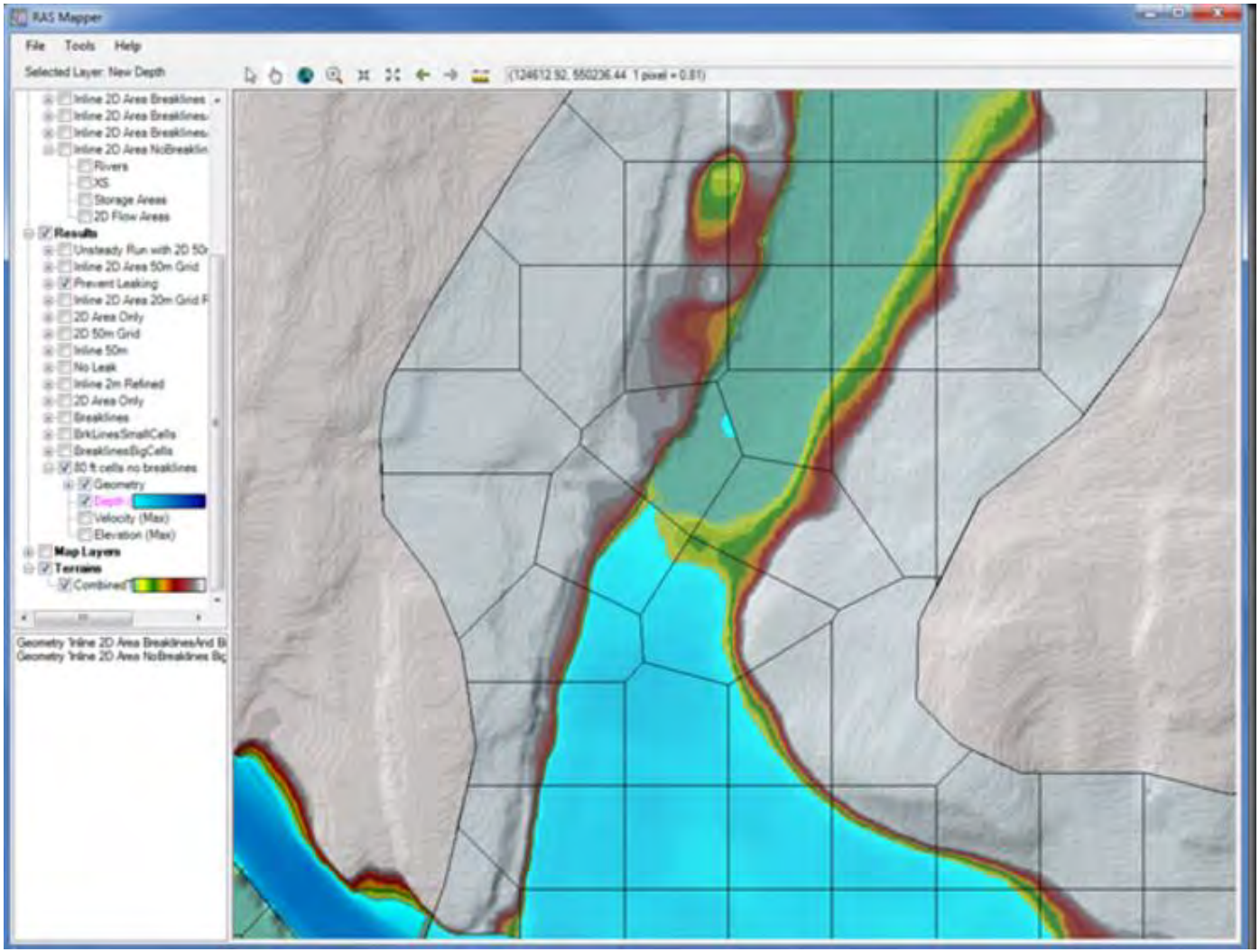
Leakage Across Grid Cells



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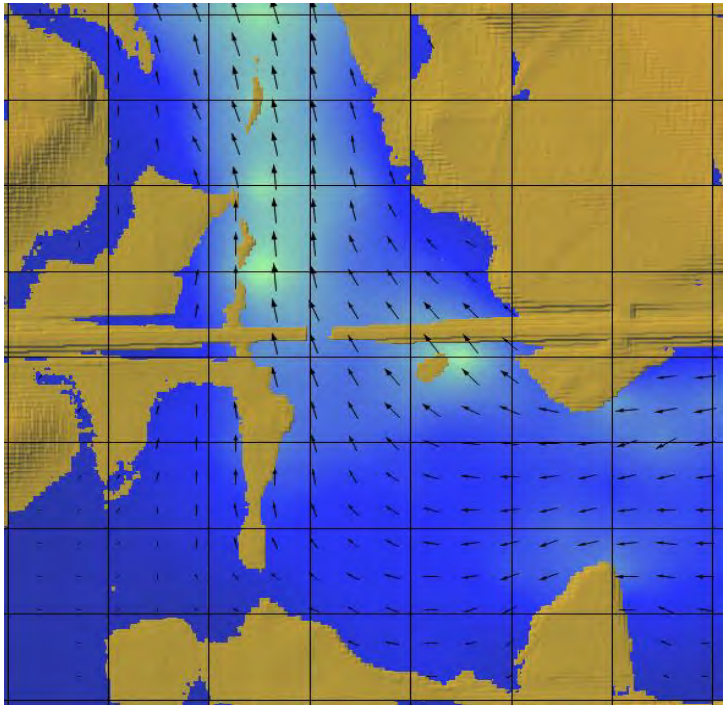
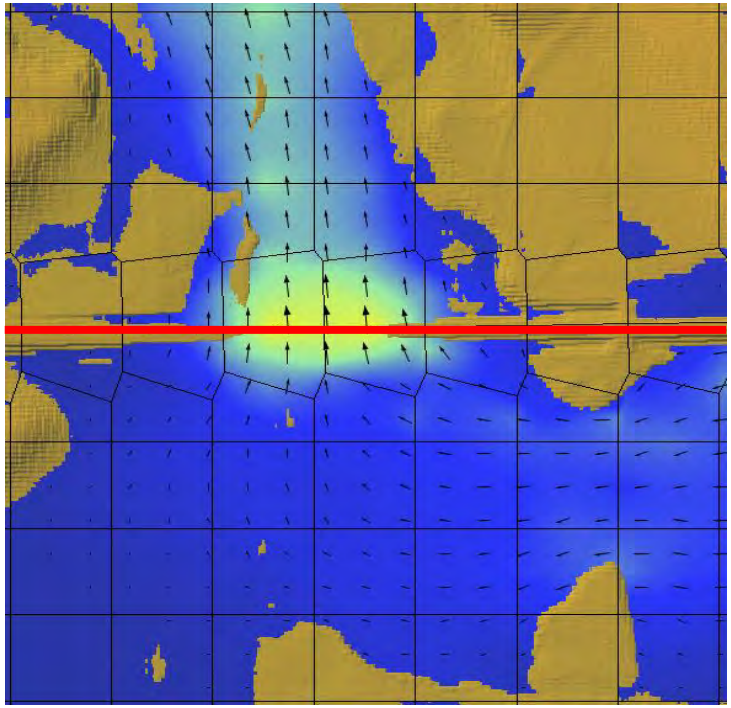
Embankments at Crossings

No Breakline



With Breakline



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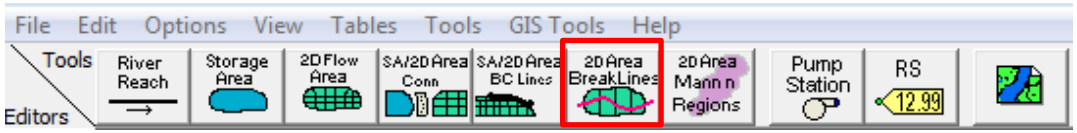
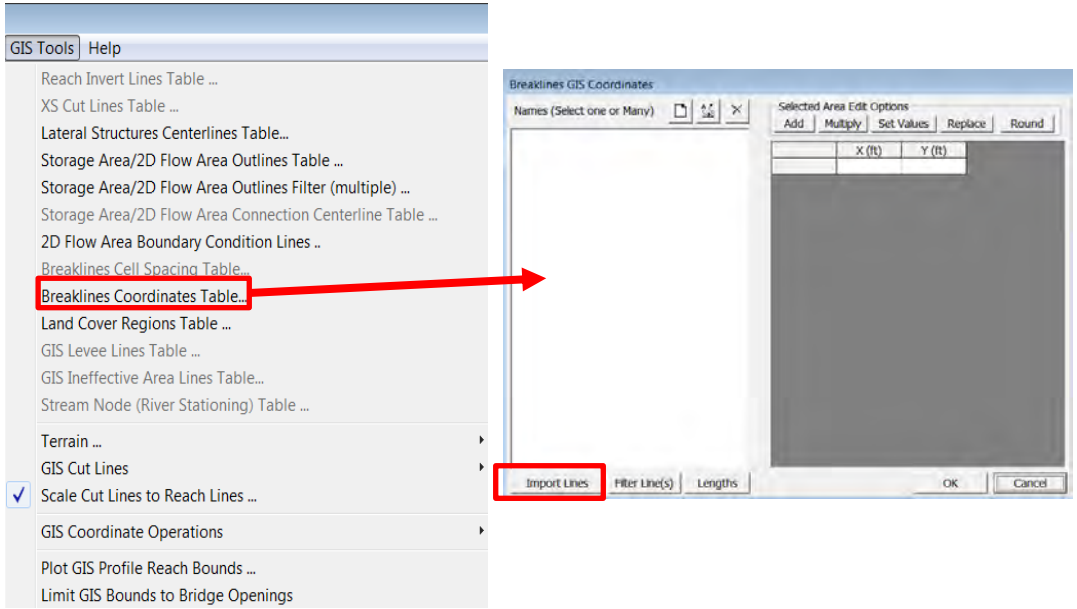
Implementing Breaklines

- Draw in Geometry Editor
- Import line shapefile
  - Delineate in GIS
  - Start with available data
    - Roads
    - Channel banks





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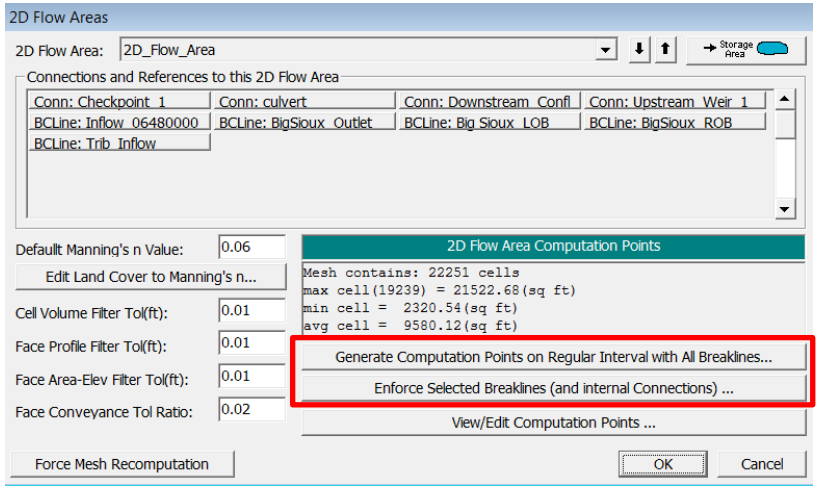
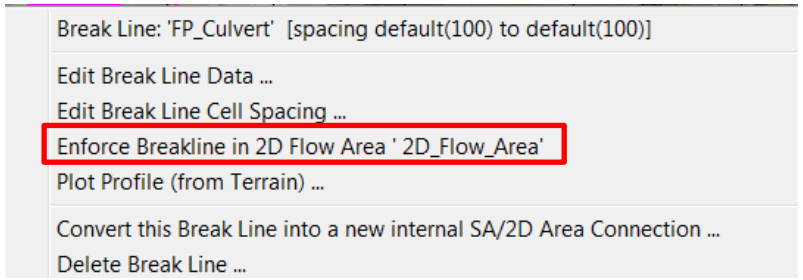
Enforcing Breaklines

- Enforce all breaklines in 2D Flow Area Editor



- Or one at a time by selecting the breakline



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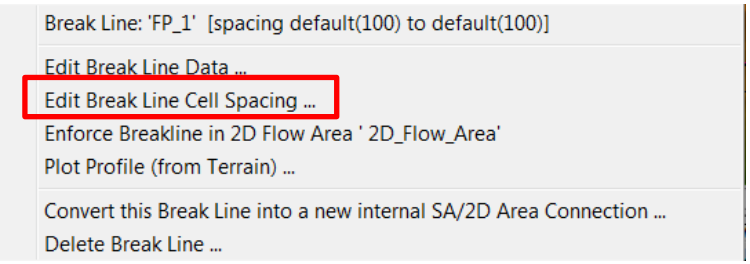
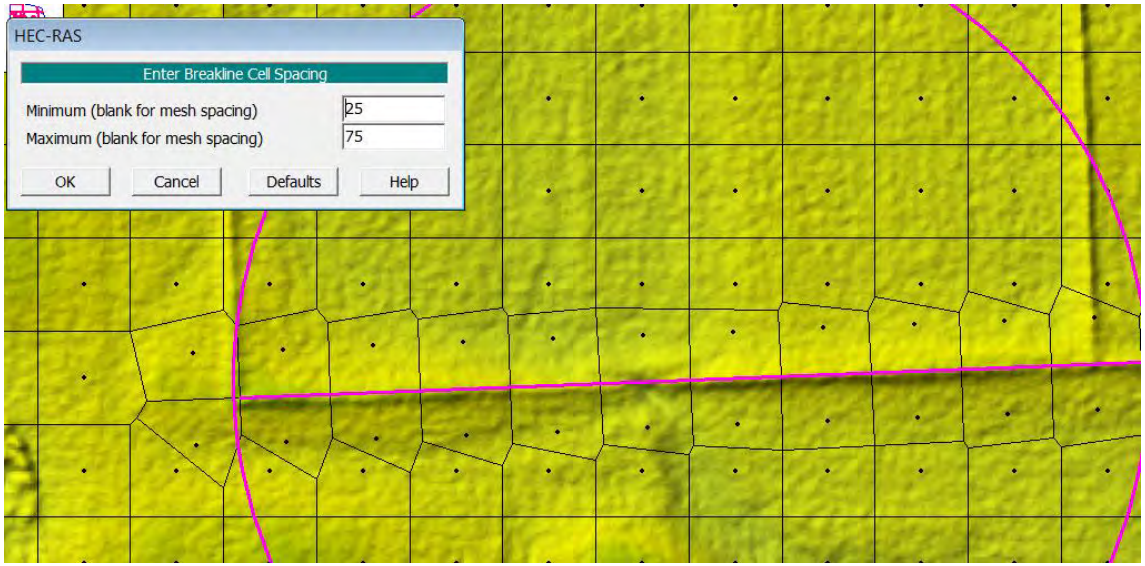
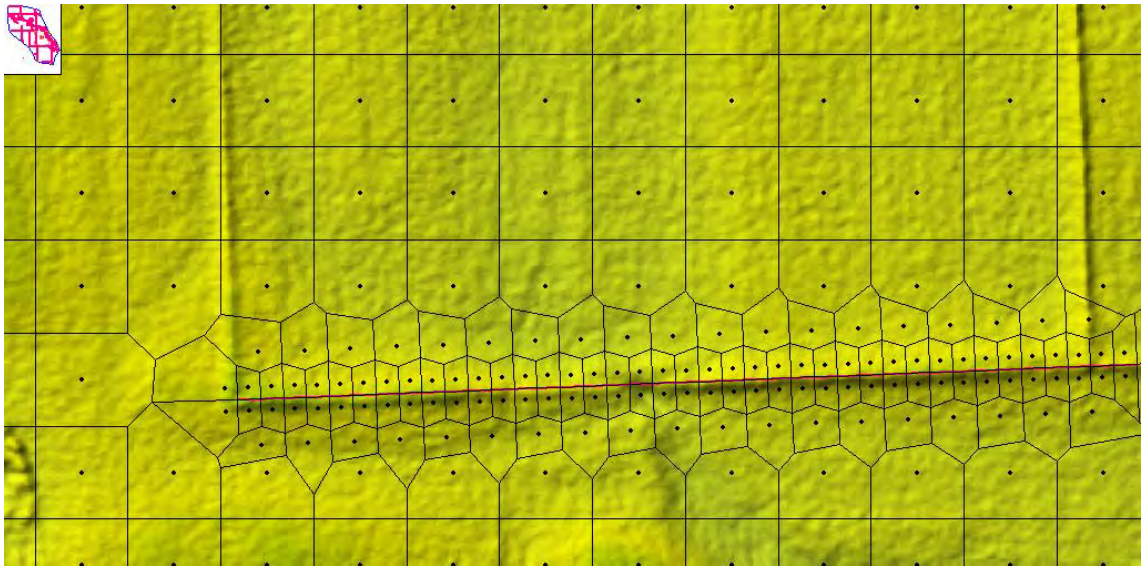
Cell Spacing







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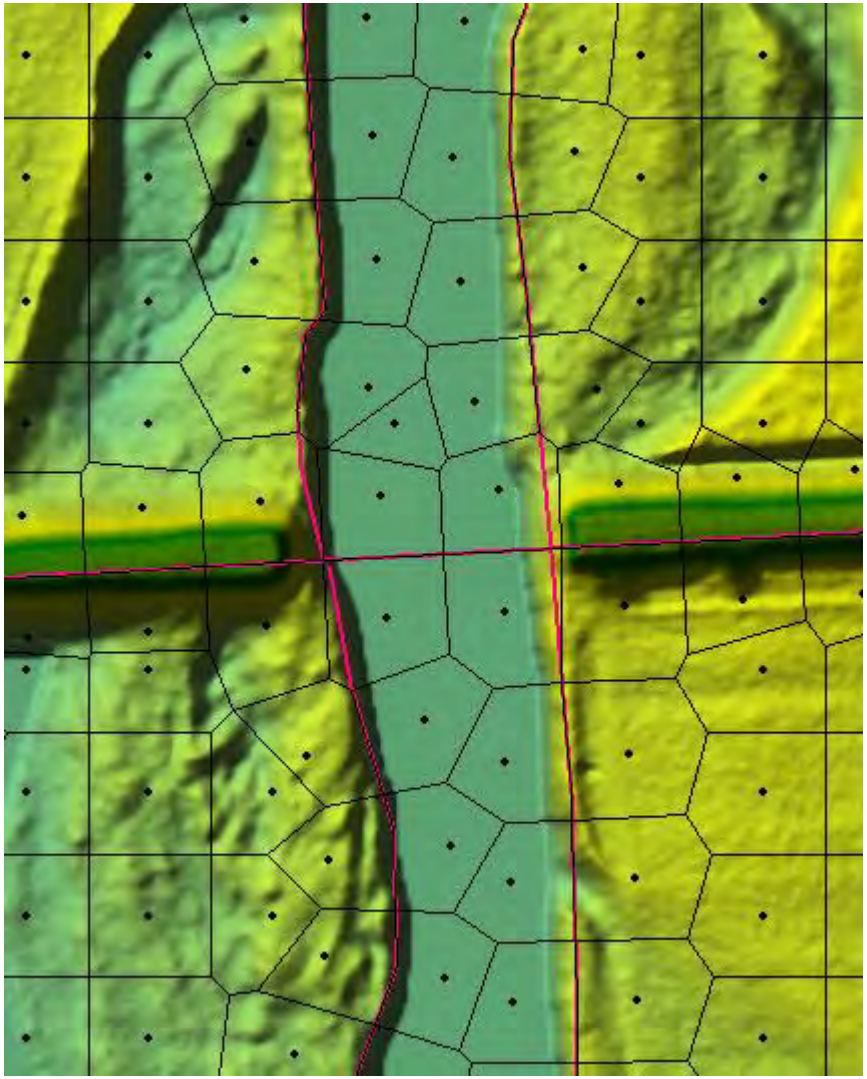
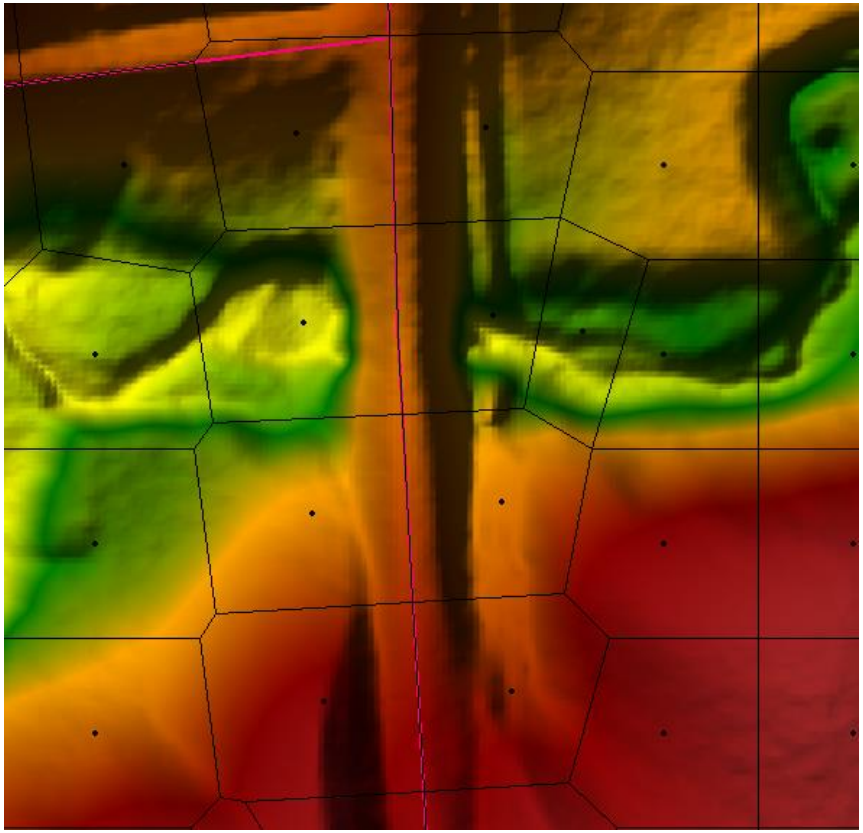
Breaklines at Crossings





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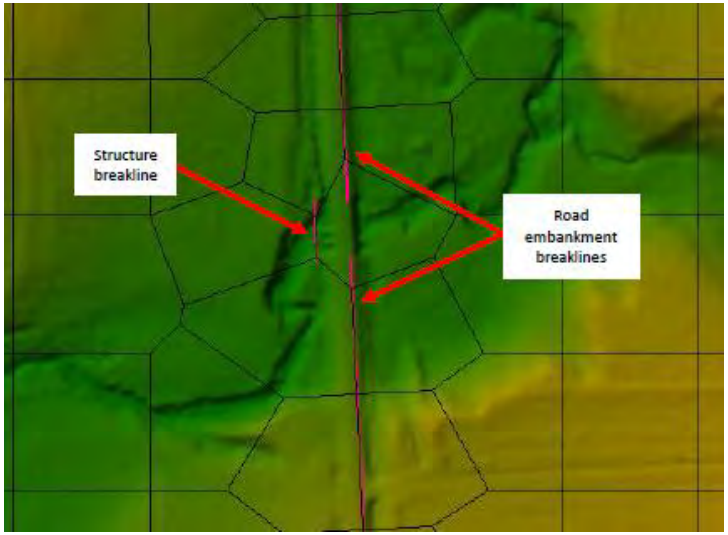
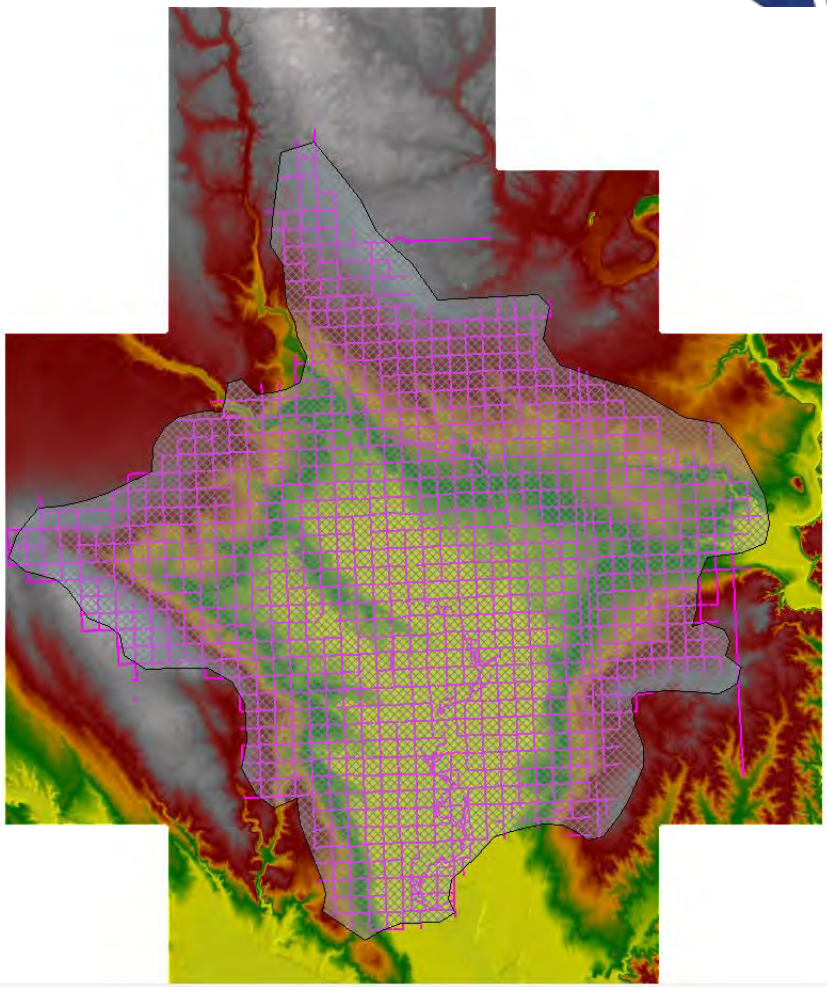
Large Scale Breaklines

- Tedious process, but extremely important
- Roads are a good starting point
- Structures are a challenge
- “Offset” breaklines





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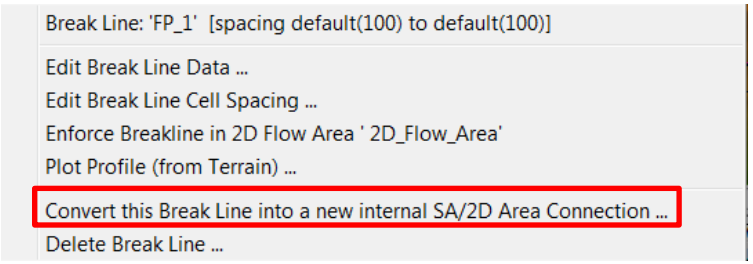
Adding Internal Structures

- Draw breakline at structure
  - Orient on top of embankment
  - Extend beyond culvert or bridge on each side
  - Enforce breakline; convert to internal structure



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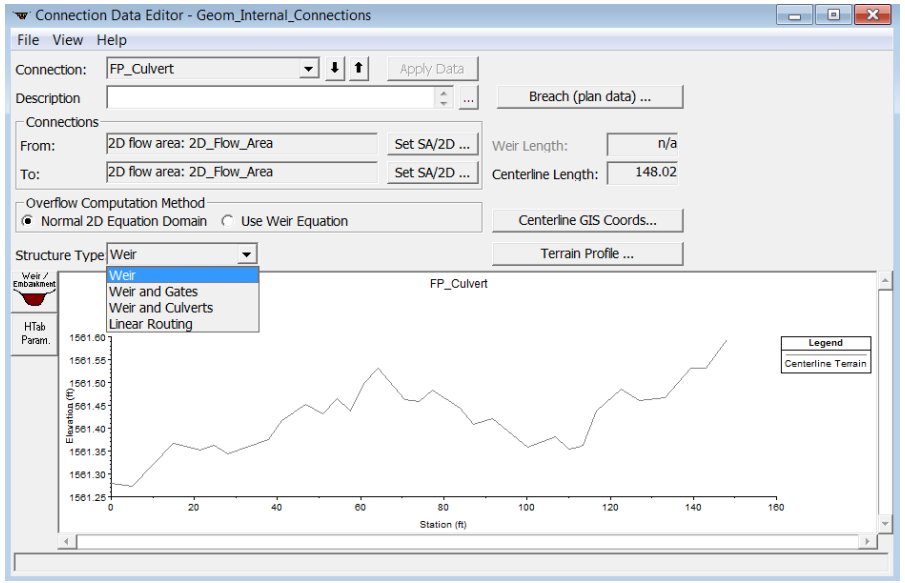
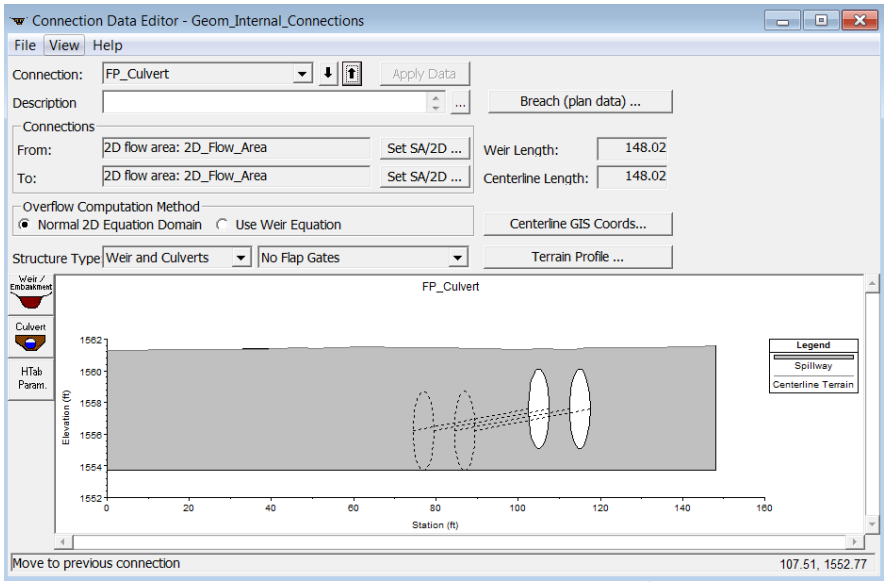
Editing Internal Structures

- Edit connection
  - Select structure type
  - Define weir profile and properties
  - Define culvert or gate dimensions and properties





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Structure Errors

- Errors in structure data will generate an error when trying to run simulation
- Structure stationing not aligned with cell face
  - Must enforce as breakline
  - Adjacent breaklines may cause cell face at structure to shift
  - Provide buffer and/or enforce structures as breaklines after surrounding structures

More Structure Errors

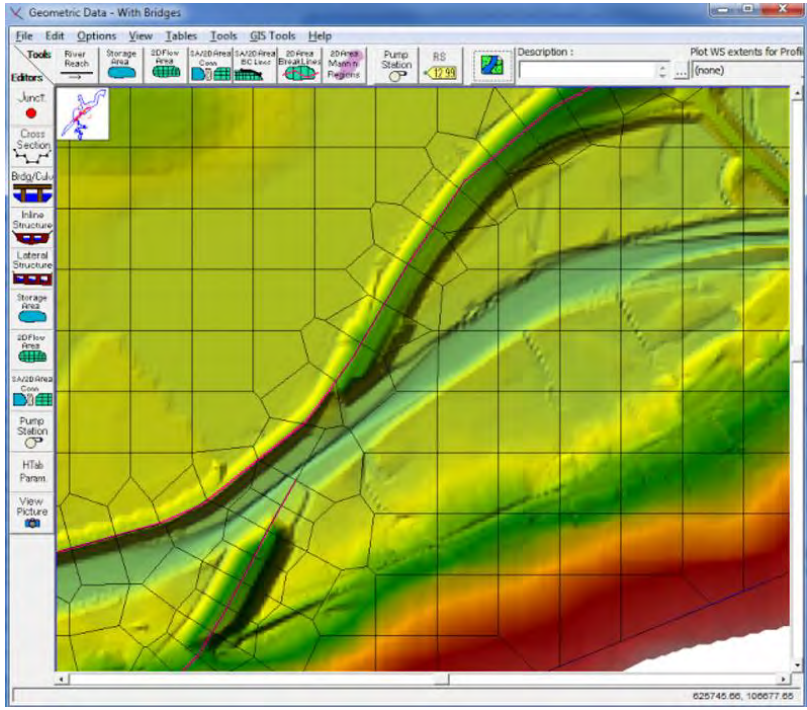
- Weir height lower than terrain profile
  - Weir profile limited to 500 points
  - If longer, have to filter points resulting in deviation from underlying terrain profile
  - May need to draw separate, contiguous structures to cover length of structure
- Culvert invert below terrain profile

Bridges

- Currently can't include the bridge routine inside of a 2D flow area
- Four Options
  1. Use the terrain to represent the bridge opening
  2. Use internal connection with culvert
  3. Use internal connection with gates
  4. Inline 1D/2D coupling at bridge

Bridge Option 1: Terrain

- Deck must be processed out of terrain
- Can modify terrain to include piers
- Simply uses 2D St. Venant equations
  - Need to use Full Momentum Equation to represent detailed bridge hydraulics
- Not a good option for piers
- Can't simulate impact from deck



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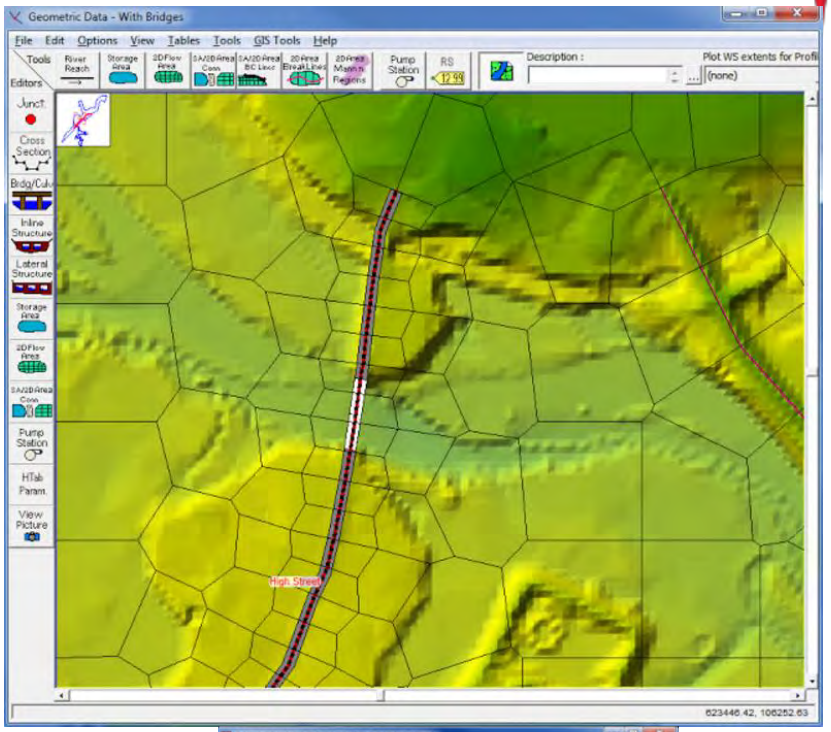
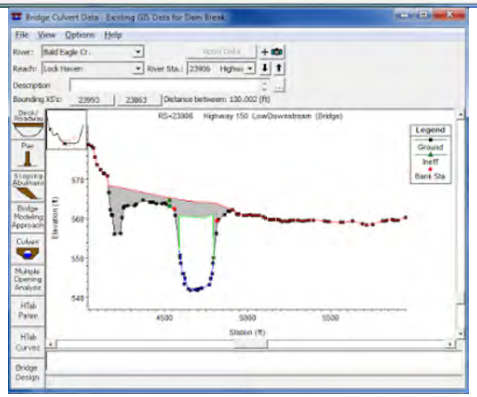
Bridge Option 2: Culvert

- Use an internal connection with culvert
- Can use multiple culverts to simulate piers
- Simulates low and high flow
- Uses 1D culvert equations so must be calibrated using a standalone 1D HEC-RAS model of the bridge





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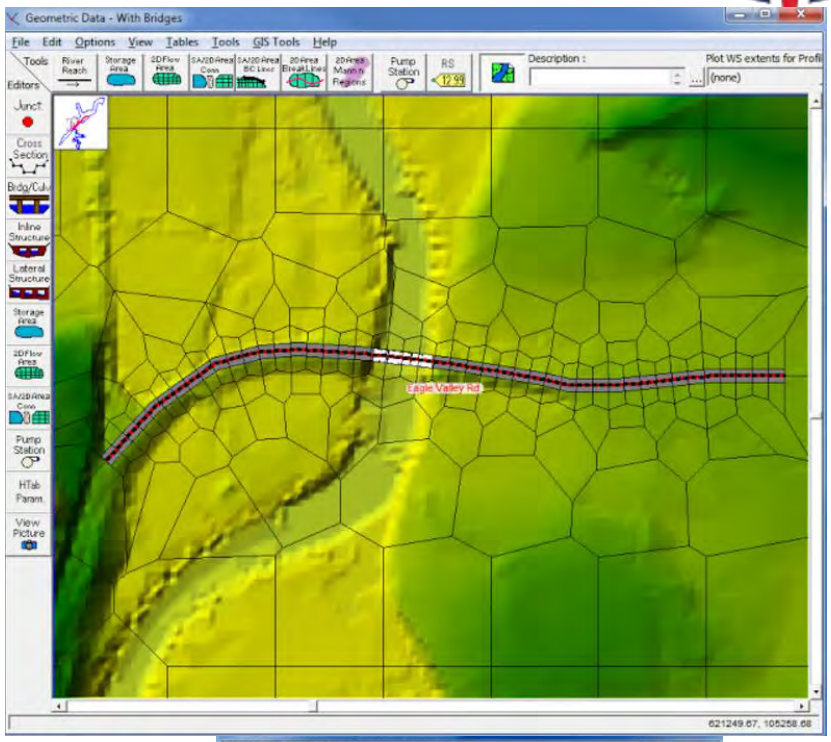
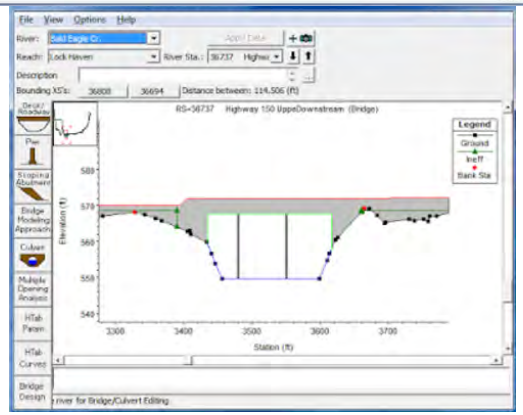
Bridge Option 3: Gates

- Same considerations as culvert option apply here
- Better for narrow bridges – uses a single invert
- Must also include a time-series boundary condition for gates





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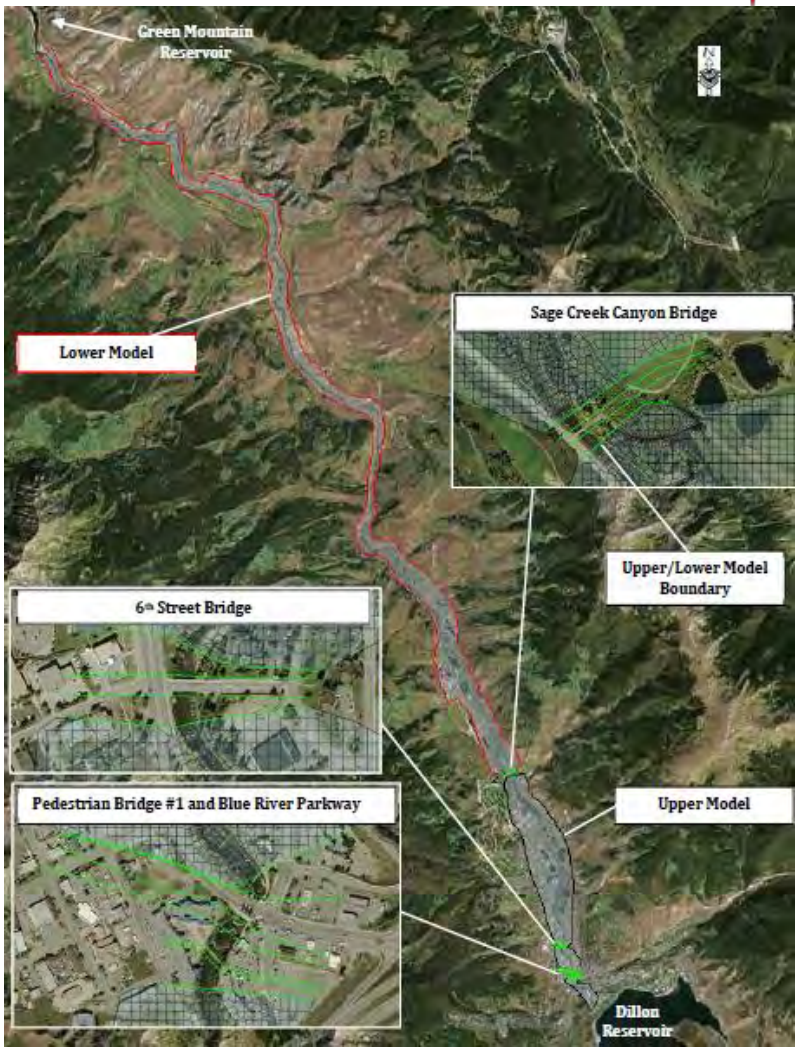
Bridge Option 4: 1D/2D Couple

- No calibration required
- Can create a stand-alone model with 1D and 2D elements
- Stability issues at 1D/2D connections
- Cross sections can't start dry in unsteady flow simulation
- Requires multiple 2D areas (upstream and downstream)



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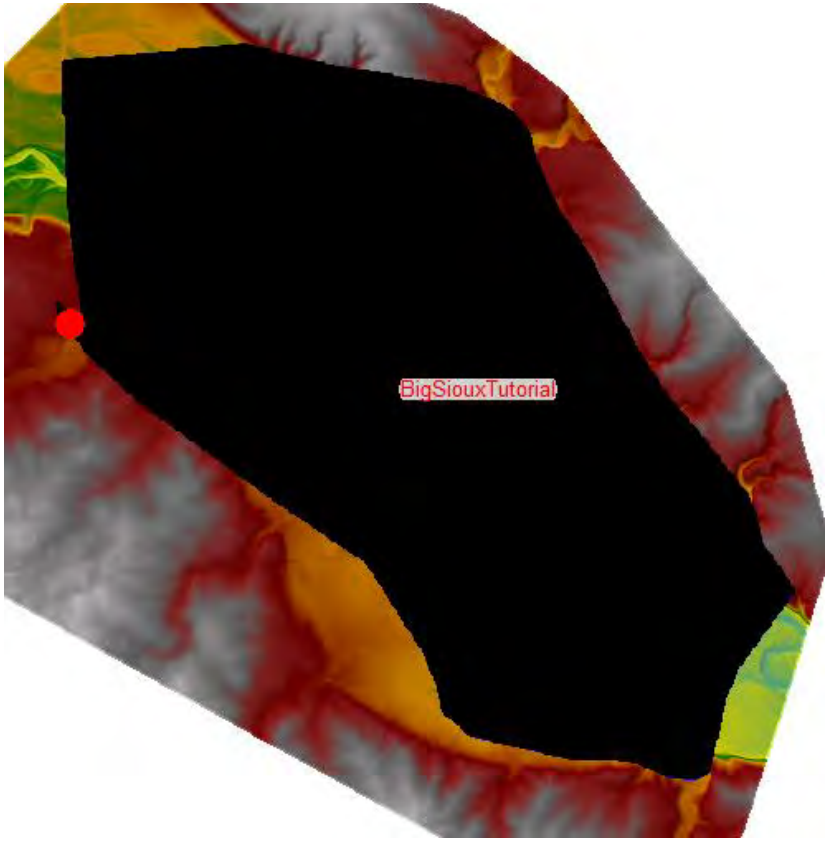
Mesh Errors??

Mesh 'BigSiouxTutorial': FATAL ERROR: 1 face errors detected on the perimeter of the mesh.

- Possible errors
  - Boundary errors
  - Too many faces
  - Duplicate cell centers
  - Cell centers outside of the 2D area
  - Collinear faces



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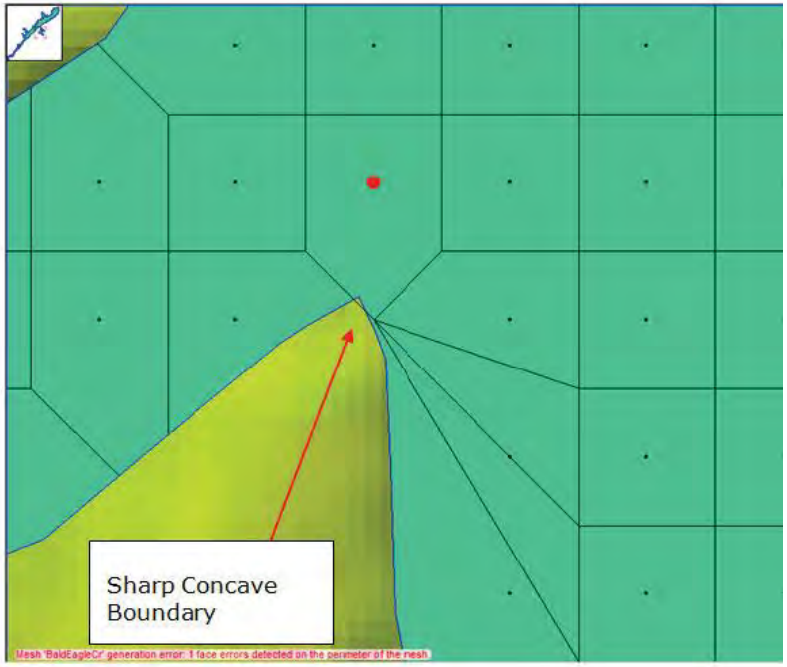
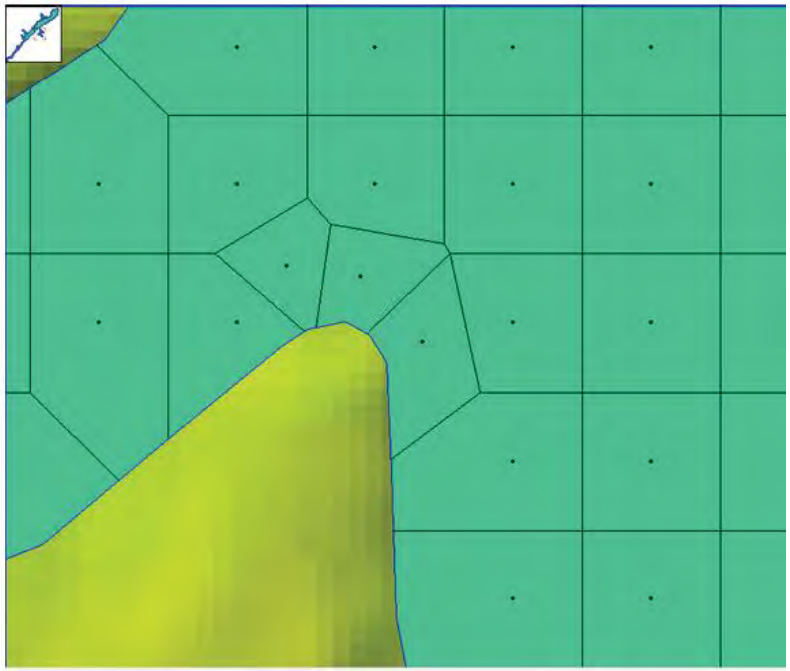
Boundary Errors

Boundary error

Smooth edge boundary, regenerate mesh





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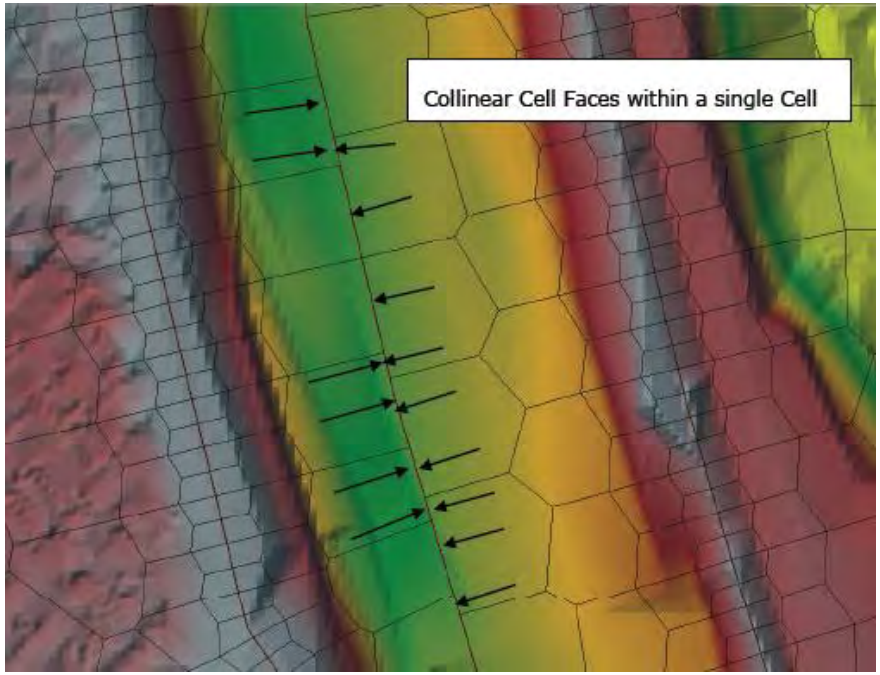
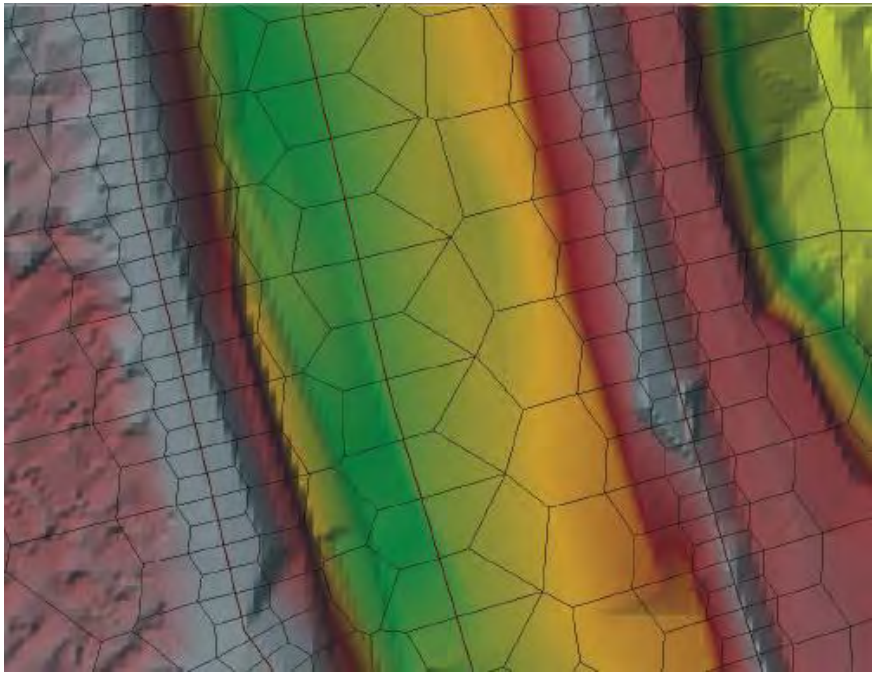
Collinear Faces

Collinear face due to adjacent breaklines

Adjust breakline cell size or breakline location





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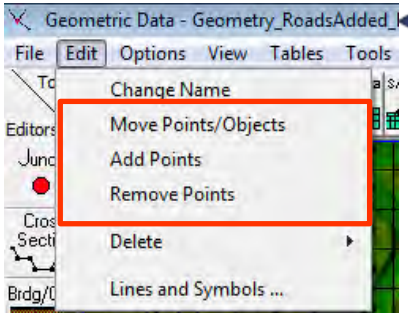
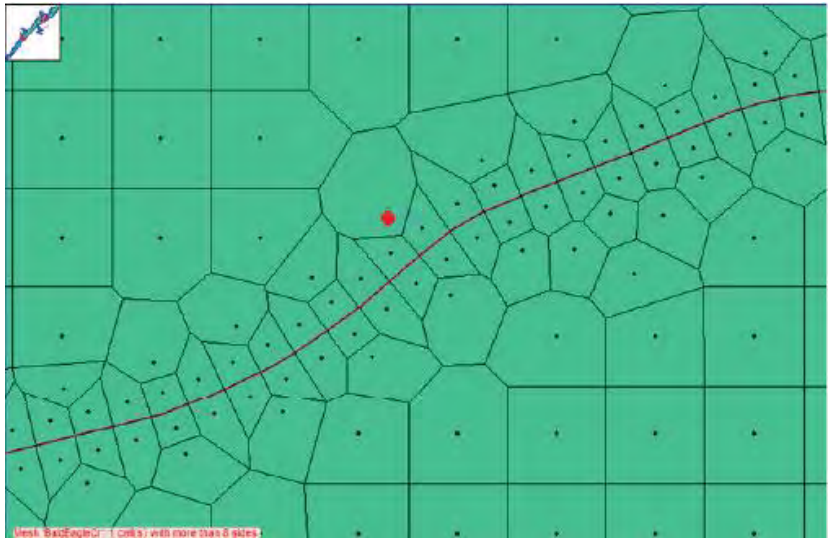
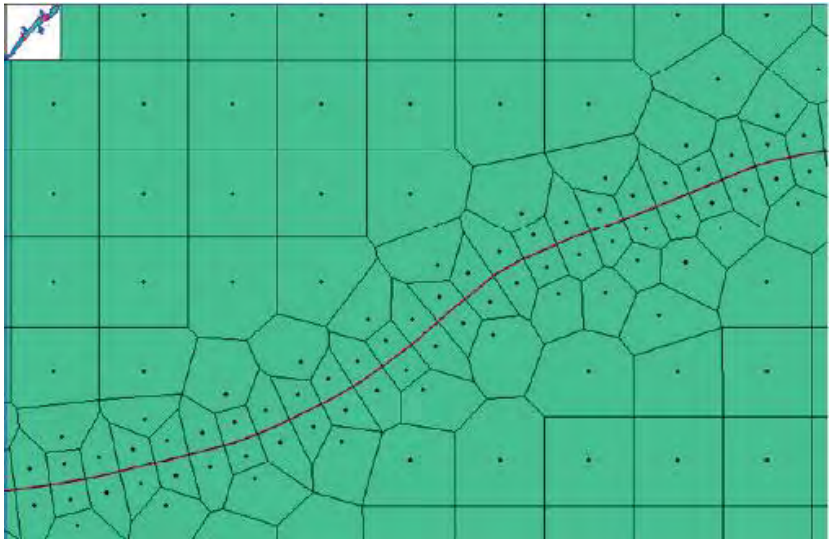
Face Errors



Too many faces

Manual edits: add / remove / move points (cell centers)





Note: If there are a significant amount of errors, manual edits may be overly tedious; recommend evaluating mesh boundaries and breaklines to fix

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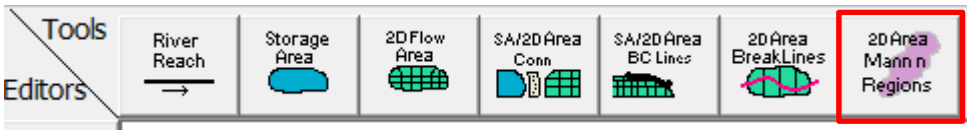
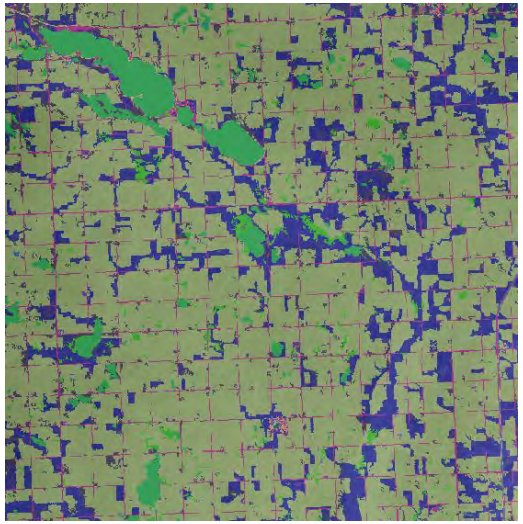
Manning's Roughness

- Default values for entire mesh
- Import land cover layer via RAS Mapper
  - NLCD 2011
  - Manually delineated regions
- 2D Area Manning's n regions in geometry editor
  - Override values in specific regions





Color	Value	Name	Default Manning's n
	0	nodata	
	1	11	0.033
	2	21	0.035
	3	22	0.063
	4	23	0.094
	5	24	0.125
	6	31	0.035
	7	41	0.16
	8	42	0.16
	9	43	0.16
	10	52	0.07
	11	71	0.035
	12	81	0.05
	13	82	0.045
	14	90	0.12
	15	95	0.15

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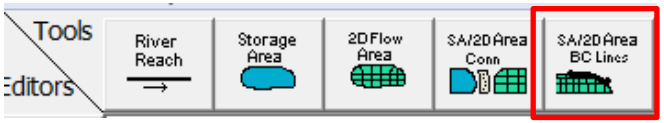
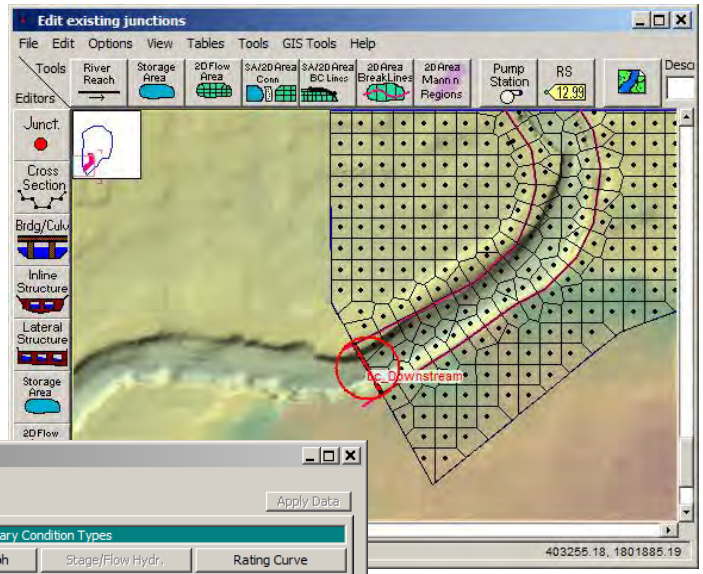
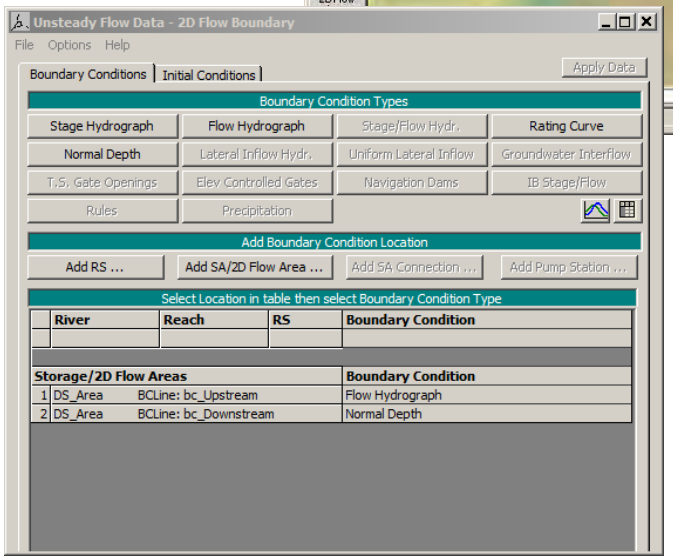
Defining Boundary Conditions

- Define inflows and outflows
- Draw in geometry editor
  - Snaps to closest mesh boundary
  - Apply data in unsteady flow editor (Lecture 5)







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Questions

Photo from FEMA

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