Common 2D Model Stability Problems
Troubleshooting Strategies

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2D Flow Area Stability Issues

- Cell size and time step
- Diagnostic Tools
- Flood wave wetting front
- Weird shaped/small cells
- Channel Alignment/cell size
- Partial cell wetting
- Internal hydraulic structures

Cell Size and Time Step

- Too large a time step for the cell size/velocity can cause model instability.
- Diffusion Wave is more forgiving than Shallow Water eqns. But full St. Venant more accurate.
- Use Courant condition pick the best time step.
- The time step you use will also depend on how fast the hydrograph rises:
  - Fast rising = Lower time step/Courant number
  - Slow rising = Higher time step/Courant number

Courant Condition Guidelines

- Shallow Water Equations
  - Experience shows, max C = 3.0

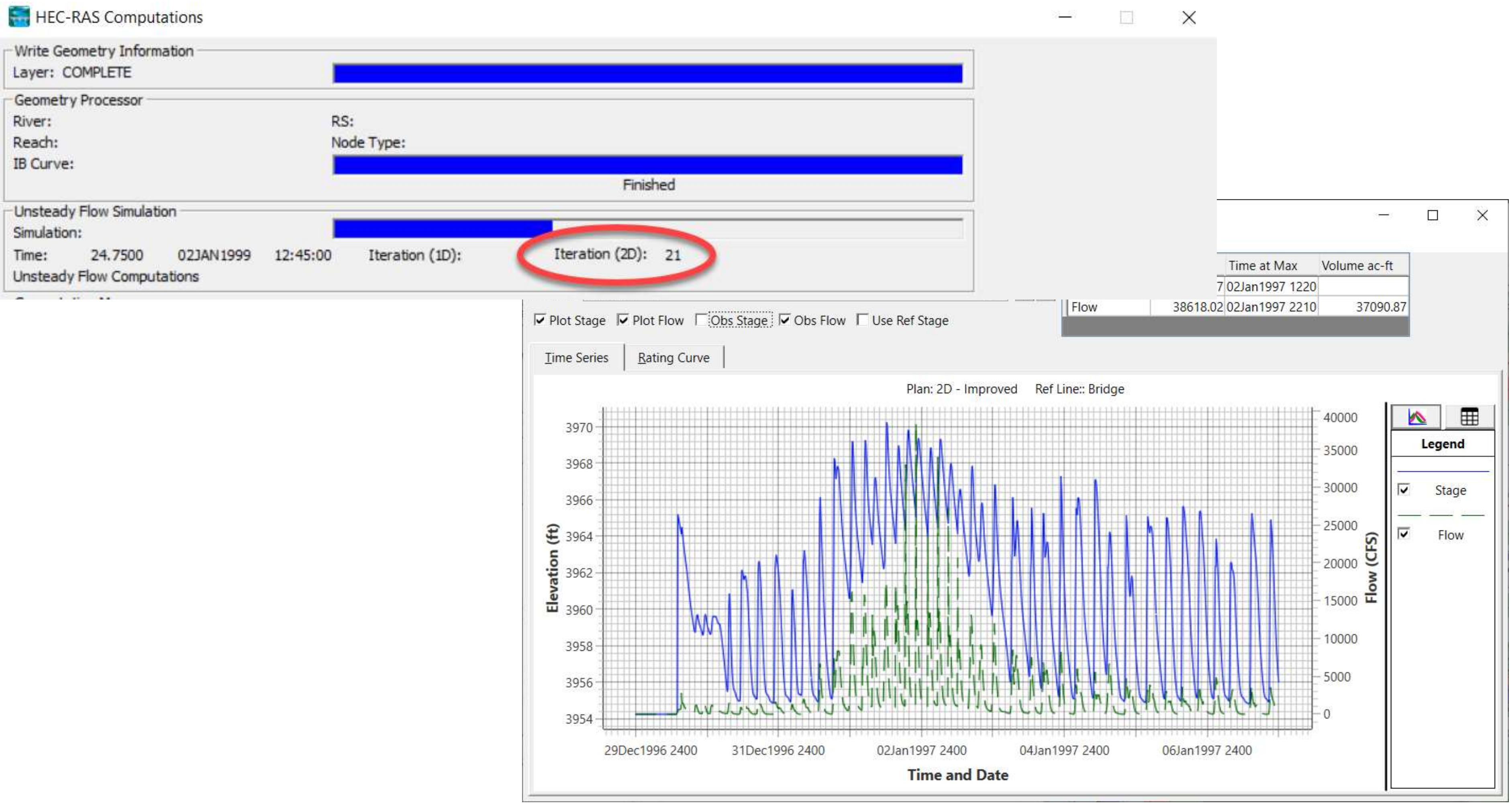
$$C = \frac{V * \Delta T}{\Delta X} \leq 1.0$$

- Diffusion Wave Approximation
  - Experience shows, max C = 5.0

$$C = \frac{V * \Delta T}{\Delta X} \leq 2.0$$

C	=	Courant Number
V	=	Velocity of the Flood Wave (ft/s)
ΔT	=	Computational Time Step (seconds)
ΔX	=	The average Cell size (ft)

Iterations

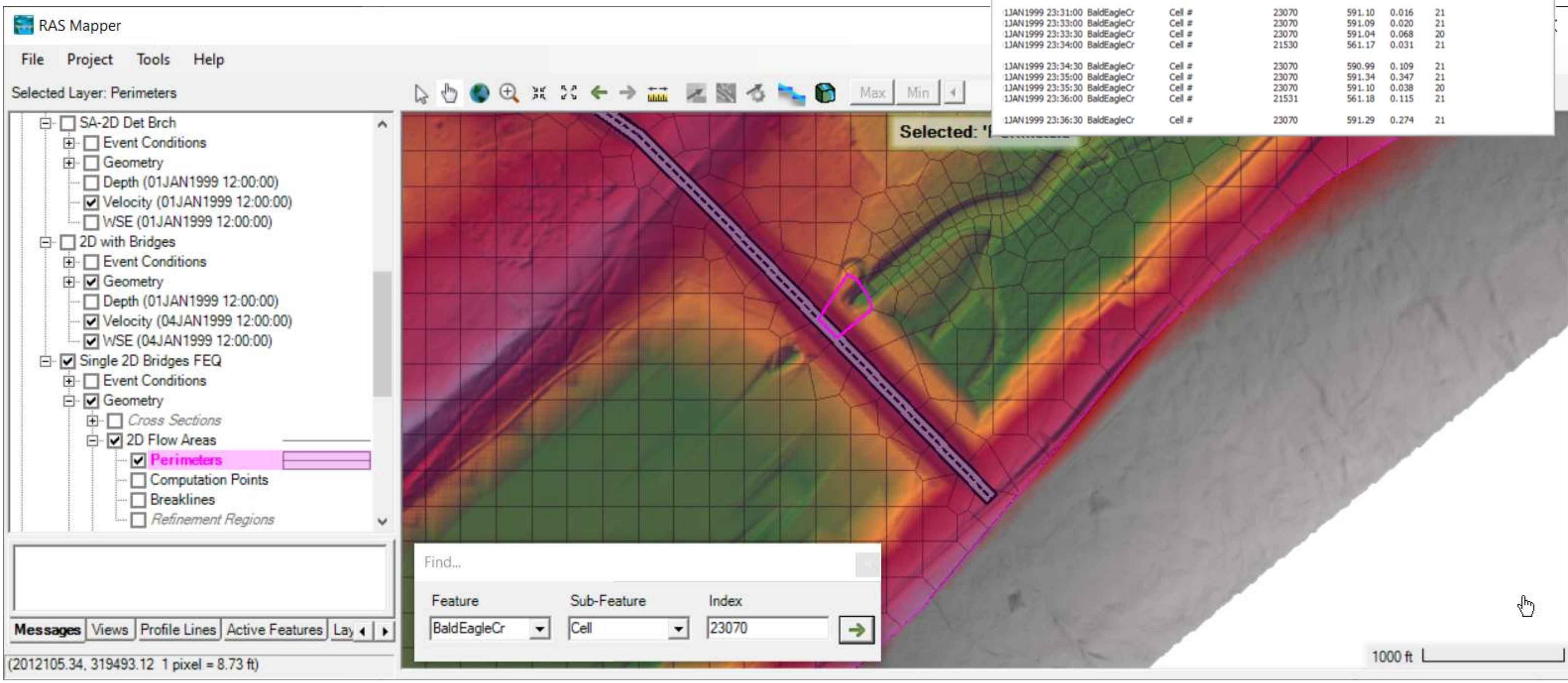


HEC-RAS Computations
Write Geometry Information
Layer: COMPLETE
Geometry Processor
River:
RS:
Reach:
Node Type:
IB Curve:
Finished
Unsteady Flow Simulation
Simulation:
Time: 24.7500 02JAN1999 12:45:00 Iteration (1D): Iteration (2D): 21
Unsteady Flow Computations
Time at Max
Volume ac-ft
02Jan1997 1220
Flow 38618.02 02Jan1997 2210 37090.87
Plot Stage
Plot Flow
Obs Stage
Obs Flow
Use Ref Stage
Time Series
Rating Curve
Plan: 2D - Improved Ref Line:: Bridge
Elevation (ft)
Flow (CFS)
Time and Date
29Dec1996 2400
31Dec1996 2400
02Jan1997 2400
04Jan1997 2400
06Jan1997 2400
Legend
Stage
Flow

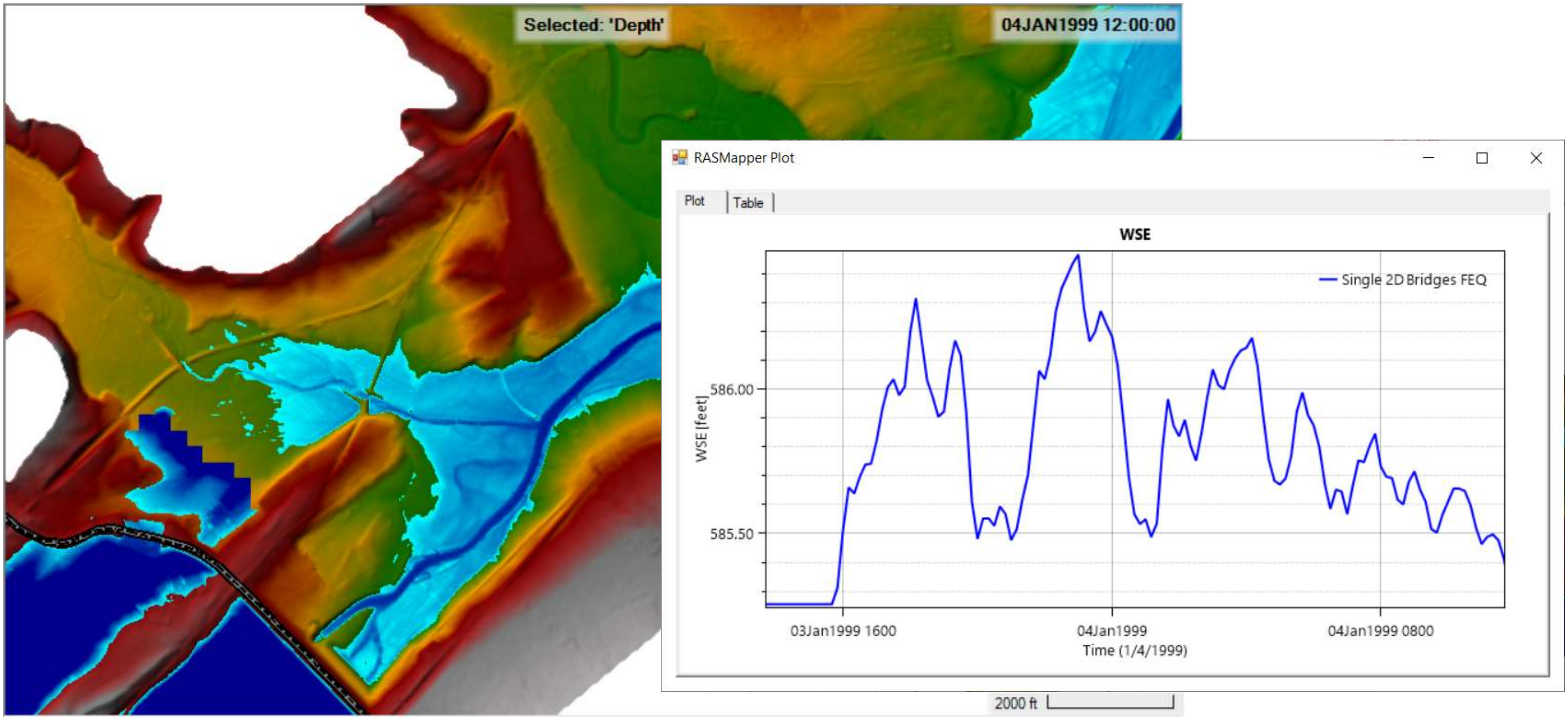
Iterations…. Investigation

- Ctrl+F (Find a Cell)

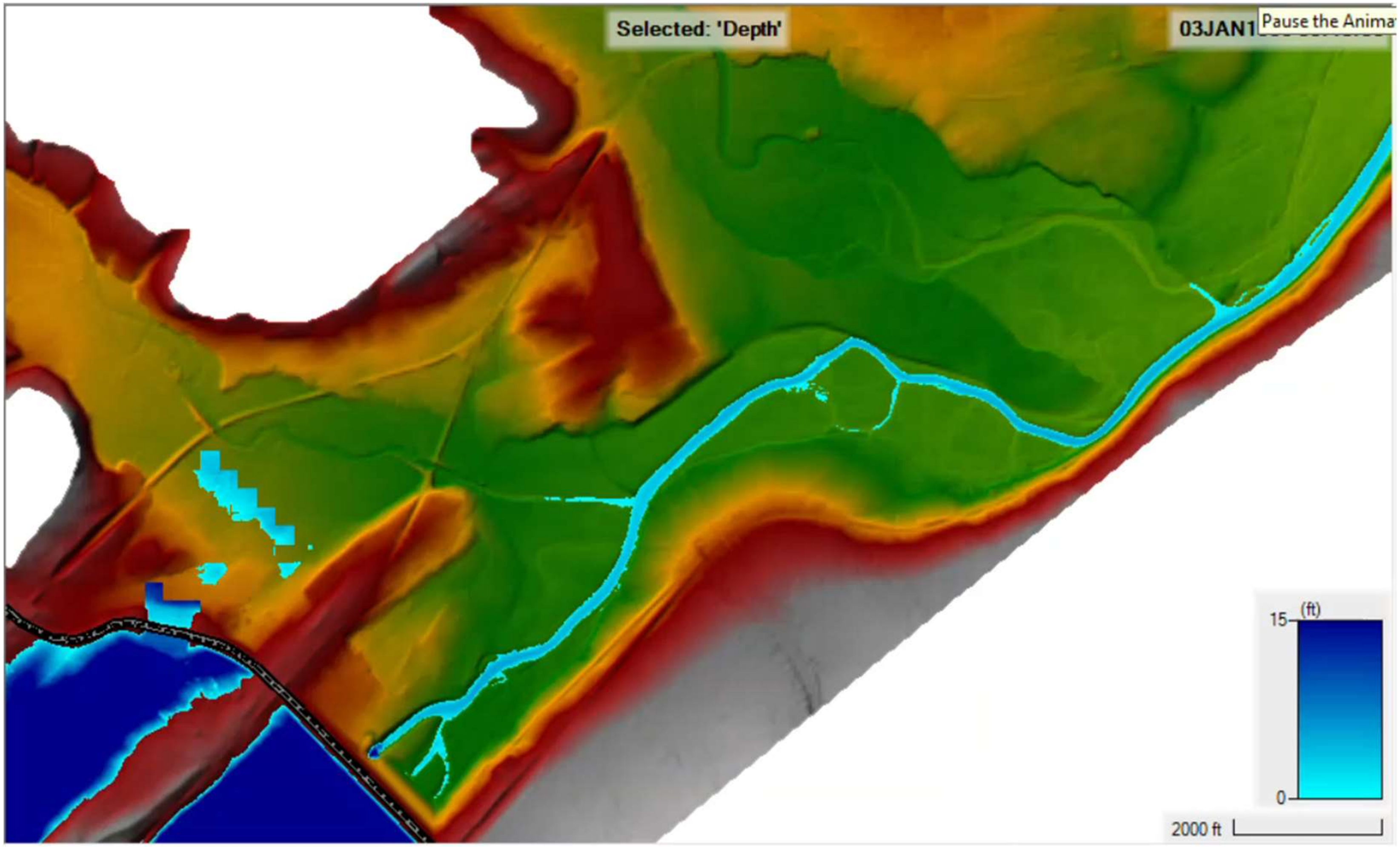
1JAN1999 23:24:30	BaldEagleCr	Cell #	23070	591.23	0.222	21
1JAN1999 23:25:00	BaldEagleCr	Cell #	23070	590.53	0.703	22
1JAN1999 23:25:30	BaldEagleCr	Cell #	23070	590.80	0.667	20
1JAN1999 23:26:00	BaldEagleCr	Cell #	23070	591.77	0.972	20
1JAN1999 23:26:30	BaldEagleCr	Cell #	23070	589.20	2.566	22
1JAN1999 23:27:00	BaldEagleCr	Cell #	23070	589.27	3.414	22
1JAN1999 23:27:30	BaldEagleCr	Cell #	23070	592.73	3.288	20
1JAN1999 23:28:00	BaldEagleCr	Cell #	23070	590.16	1.100	21
1JAN1999 23:28:30	BaldEagleCr	Cell #	23070	592.53	2.369	22
1JAN1999 23:29:00	BaldEagleCr	Cell #	23070	590.61	0.826	21
1JAN1999 23:29:30	BaldEagleCr	Cell #	23070	591.91	1.292	21
1JAN1999 23:30:00	BaldEagleCr	Cell #	23070	590.82	0.453	21
1JAN1999 23:30:30	BaldEagleCr	Cell #	23070	591.58	0.763	22
1JAN1999 23:31:00	BaldEagleCr	Cell #	23070	591.10	0.016	21
1JAN1999 23:33:00	BaldEagleCr	Cell #	23070	591.09	0.020	21
1JAN1999 23:33:30	BaldEagleCr	Cell #	23070	591.04	0.068	20
1JAN1999 23:34:00	BaldEagleCr	Cell #	21530	561.17	0.031	21
1JAN1999 23:34:30	BaldEagleCr	Cell #	23070	590.99	0.109	21
1JAN1999 23:35:00	BaldEagleCr	Cell #	23070	591.34	0.347	21
1JAN1999 23:35:30	BaldEagleCr	Cell #	23070	591.10	0.038	20
1JAN1999 23:36:00	BaldEagleCr	Cell #	21531	561.18	0.115	21
1JAN1999 23:36:30	BaldEagleCr	Cell #	23070	591.29	0.274	21



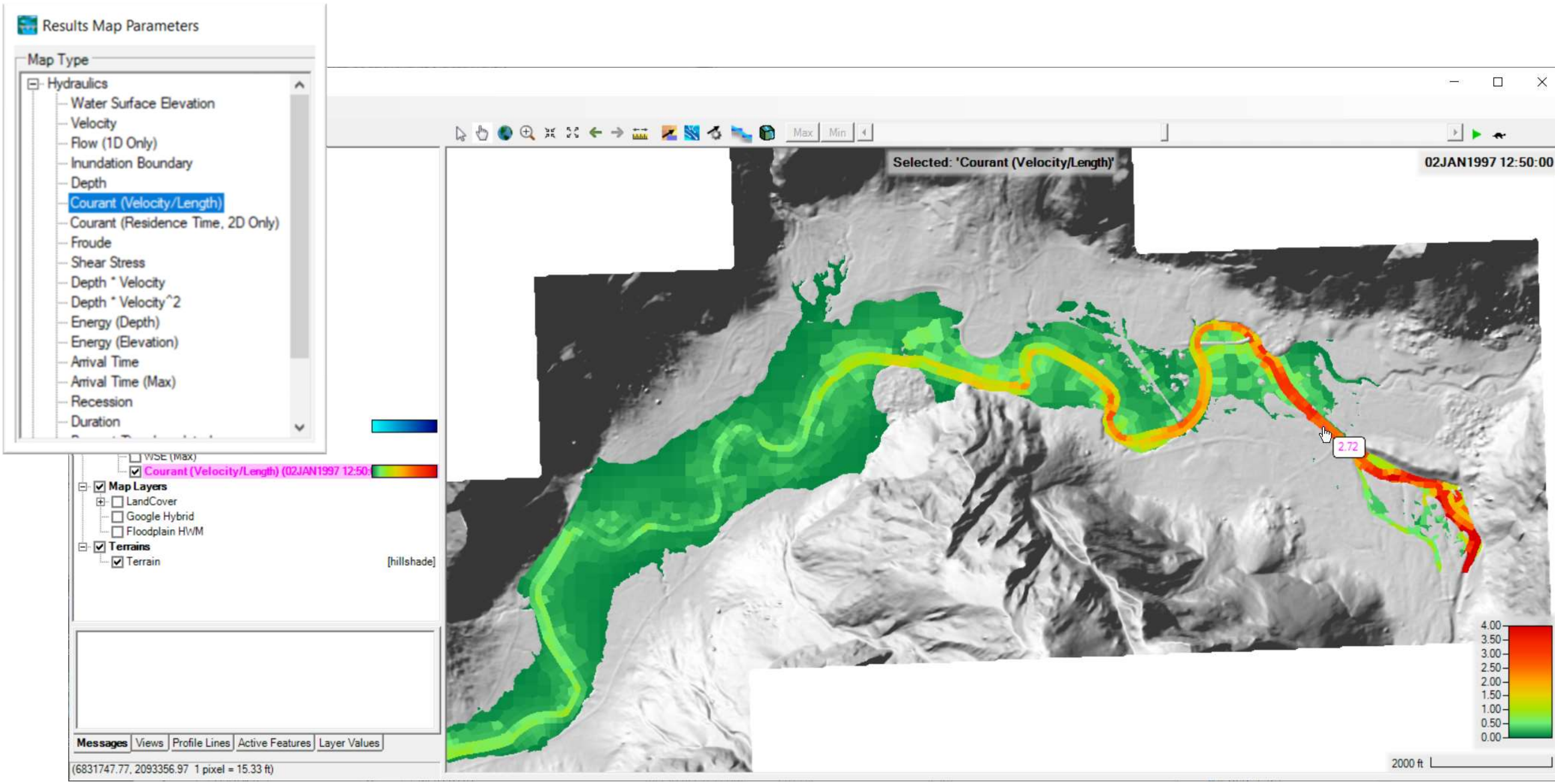
RAS Mapper Visualization



Model Instability



RAS Mapper Courant Number Map



Volume Accounting Check

Runtime Messages

07JAN1997 15:14:00	2DArea	Cell #	1085	4003.97	0.010	20
07JAN1997 15:37:00	2DArea	Cell #	1085	4003.97	0.010	20
07JAN1997 15:39:00	2DArea	Cell #	1085	4003.97	0.012	20
07JAN1997 16:06:00	2DArea	Cell #	1085	4003.96	0.010	20
07JAN1997 16:22:00	2DArea	Cell #	1085	4003.96	0.010	20
07JAN1997 16:24:00	2DArea	Cell #	1085	4003.96	0.011	20
07JAN1997 16:39:00	2DArea	Cell #	1085	4003.96	0.010	20
07JAN1997 16:52:00	2DArea	Cell #	1085	4003.96	0.011	20
07JAN1997 16:54:00	2DArea	Cell #	1085	4003.96	0.012	20
07JAN1997 17:28:00	2DArea	Cell #	1085	4003.96	0.010	20
07JAN1997 17:45:00	2DArea	Cell #	1085	4003.96	0.011	20

Overall Volume Accounting Error in Acre Feet: 0.3240
Overall Volume Accounting Error as percentage: 0.000662
Please review "Computational Log File" output for volume accounting details

Writing Results to DSS

Finished Unsteady Flow Simulation

1D Post Process Skipped (simulation is all 2D)

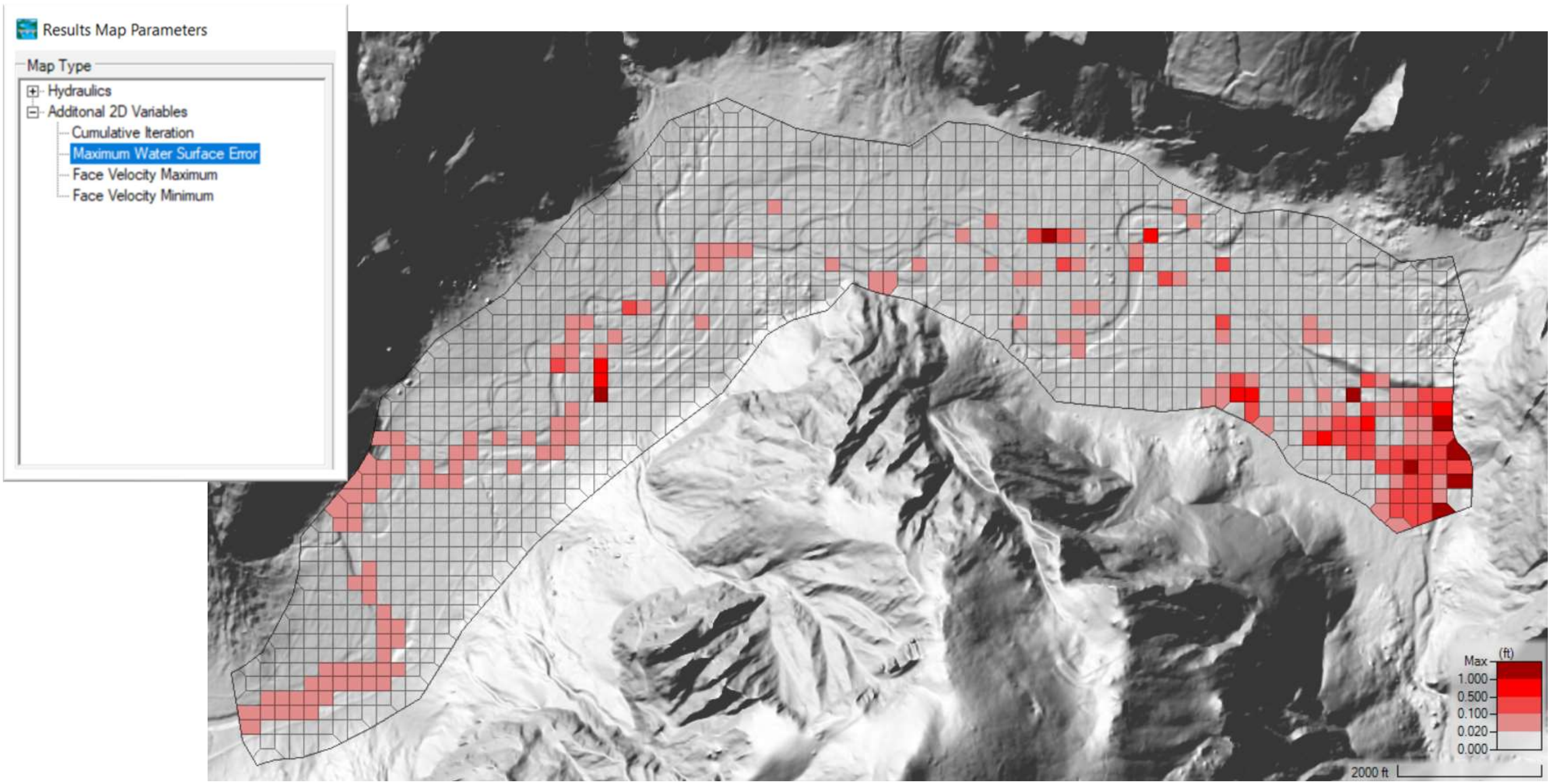
Computations Summary

Computation Task   Time(hh:mm:ss)

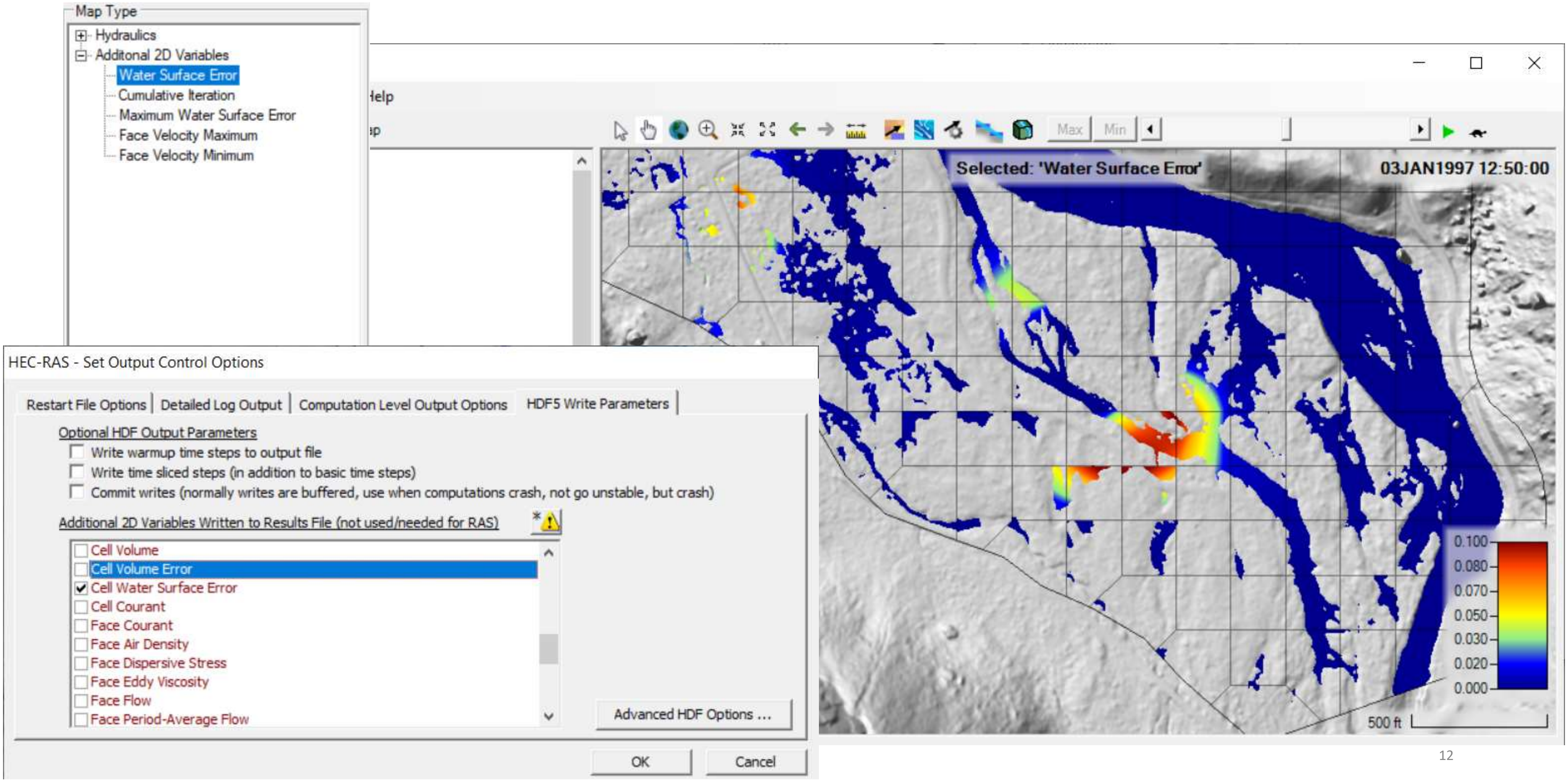
Computation Log File

```
***  Volume Accounting for 2D Flow Area in Acre Feet  ***

2D Area   Starting Vol   Ending Vol   Cum Inflow   Cum Outflow   Error   Percent Error
*******   ************   **********   **********   ***********   *****   *************

2DArea                   401.4        48924.       48523.        0.3240  0.000662

***  Total Volume Accounting (for the entire model) in Acre Feet  ***

Total Boundary Flux of Water In      48924.
Total Boundary Flux of Water Out     48523.

Starting Volume                      0.000000
Ending Volume                        401.4

                  Error    Percent Error
                  *****    *************
                  0.3240   0.000662
```

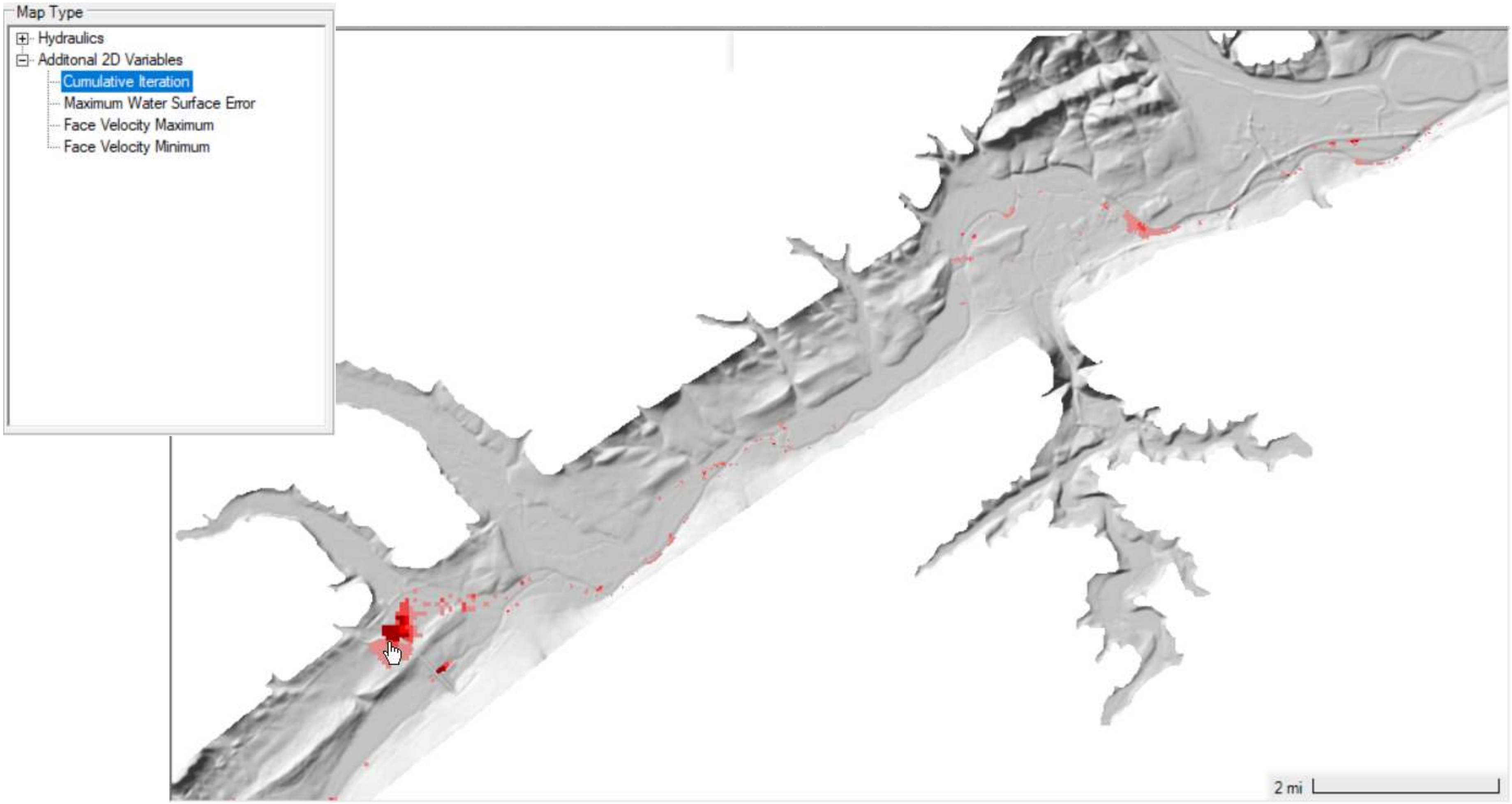
Maximum Water Surface Error



Cell Water Surface Error (For each time step)



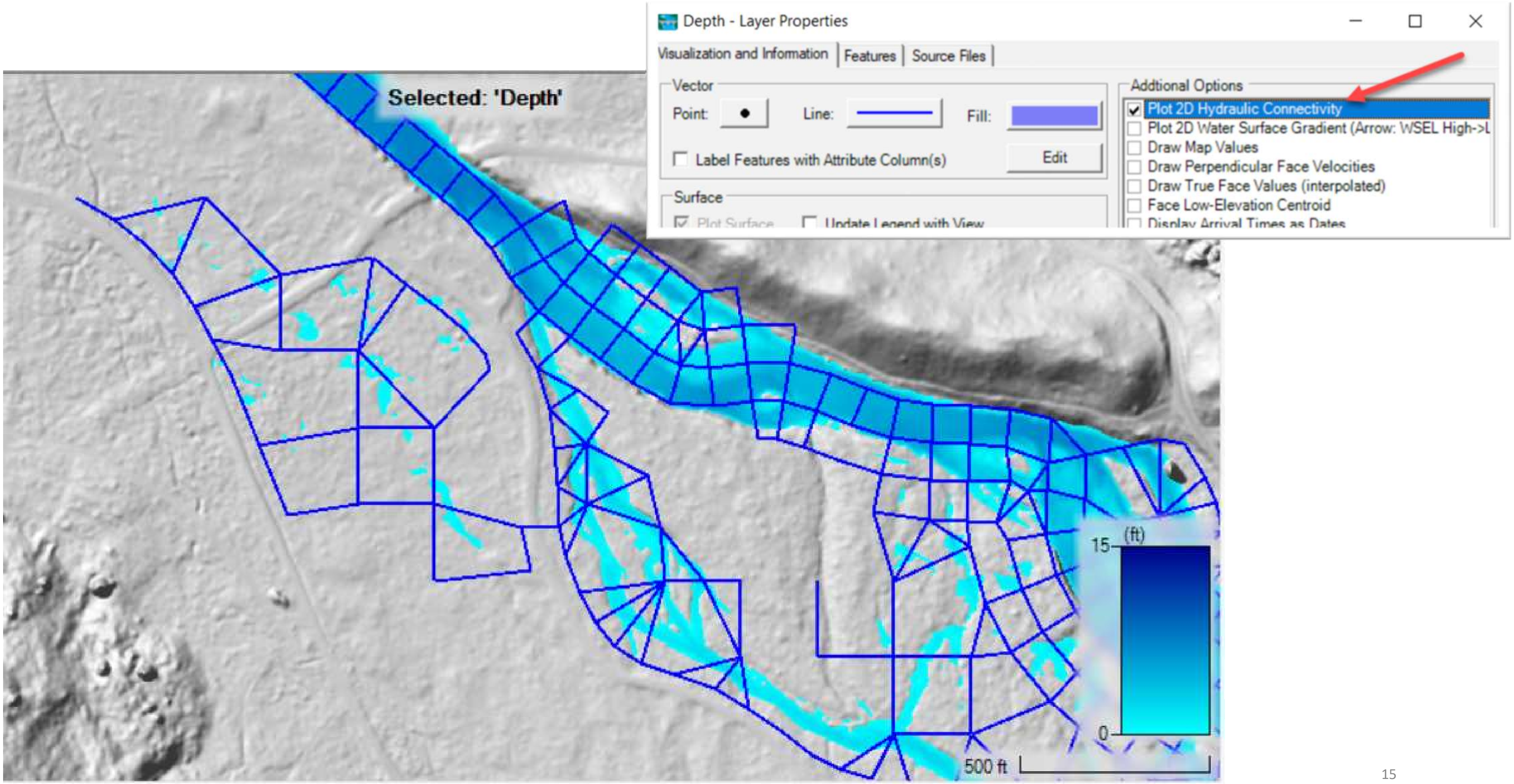
Cumulative Iterations



Floodwave Wetting Front

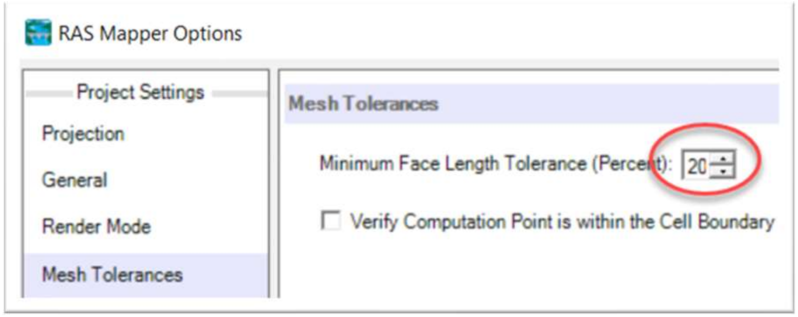
- 2D Models can often go unstable at the wetting front of the floodwave
  - Can cause model iterations
  - Can also cause bad max velocity plots
- Ways to improve this:
  - Reduce Time Step
  - Poor Cell Size – use polygon refinement tool
  - To large of an elevation change across a single cell – make cells smaller or larger
  - Breaklines for high ground barriers

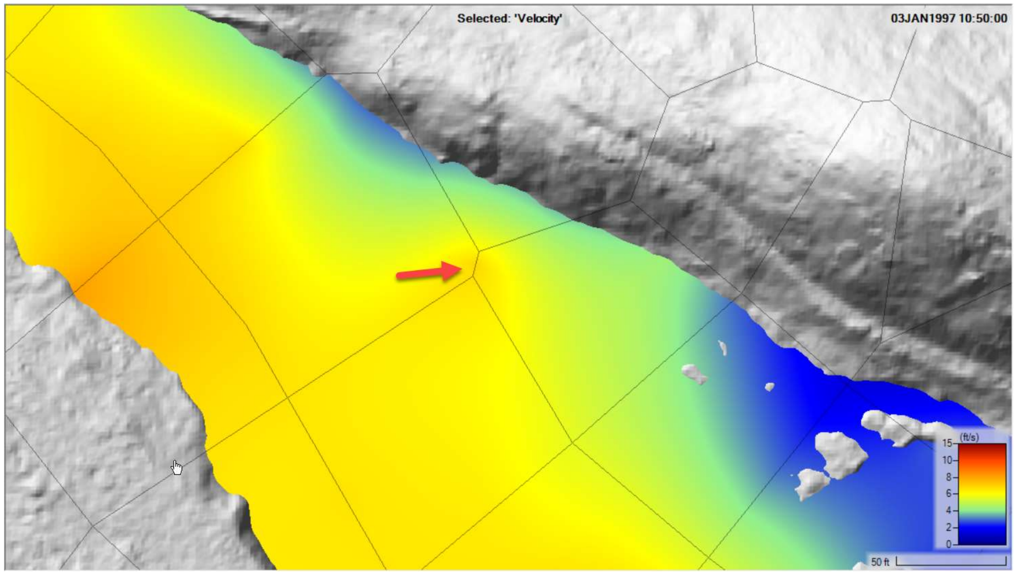
Hydraulic Connectivity

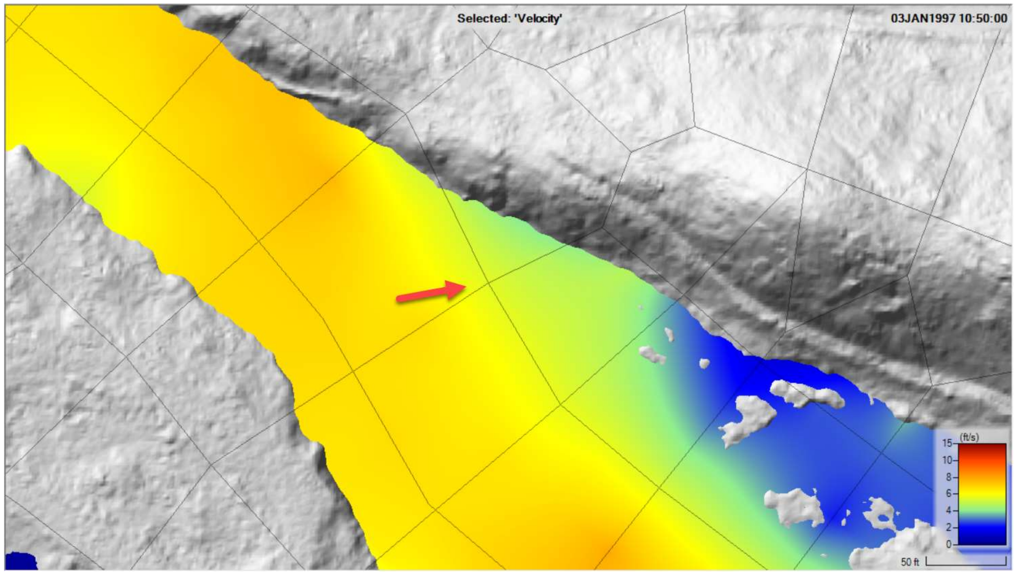


Weird Shaped Cells/Small Faces

- Cells need to transition in size 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.

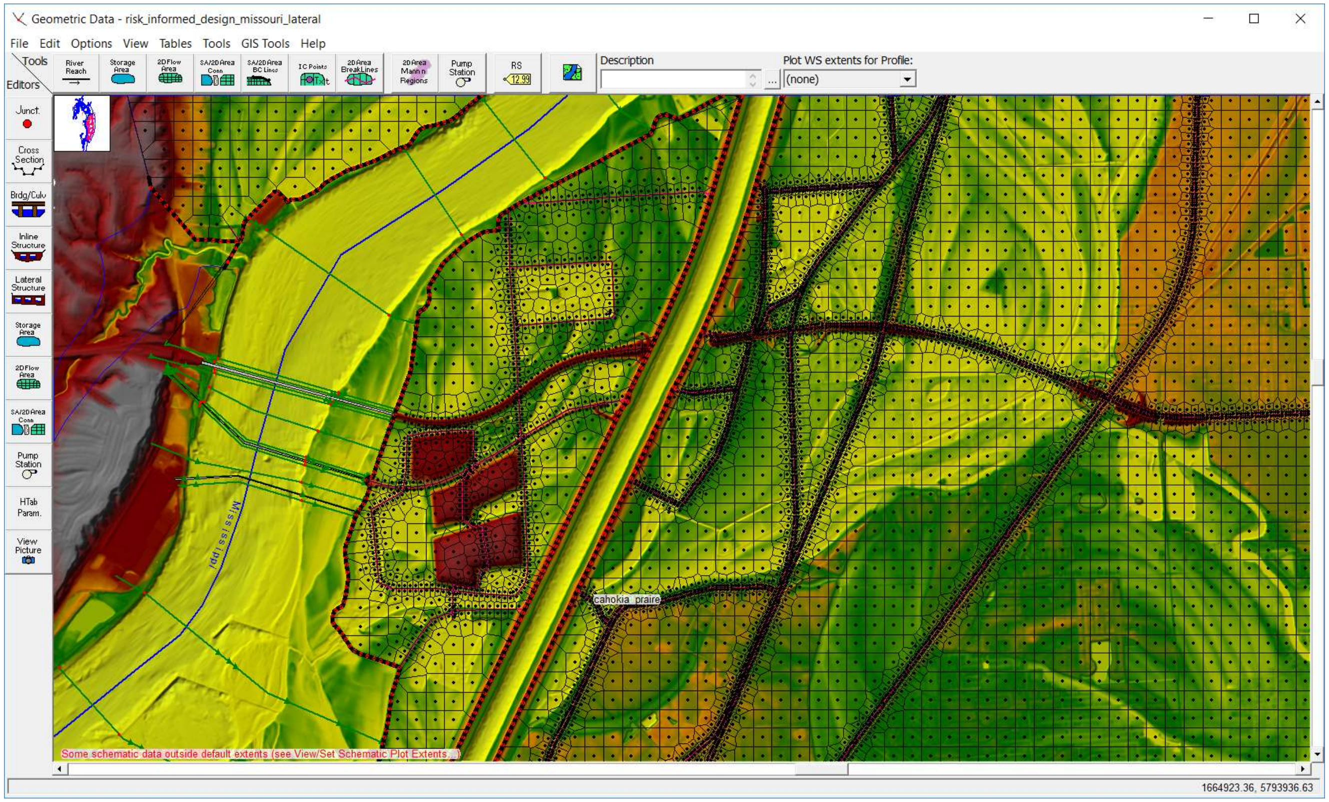






Breaklines

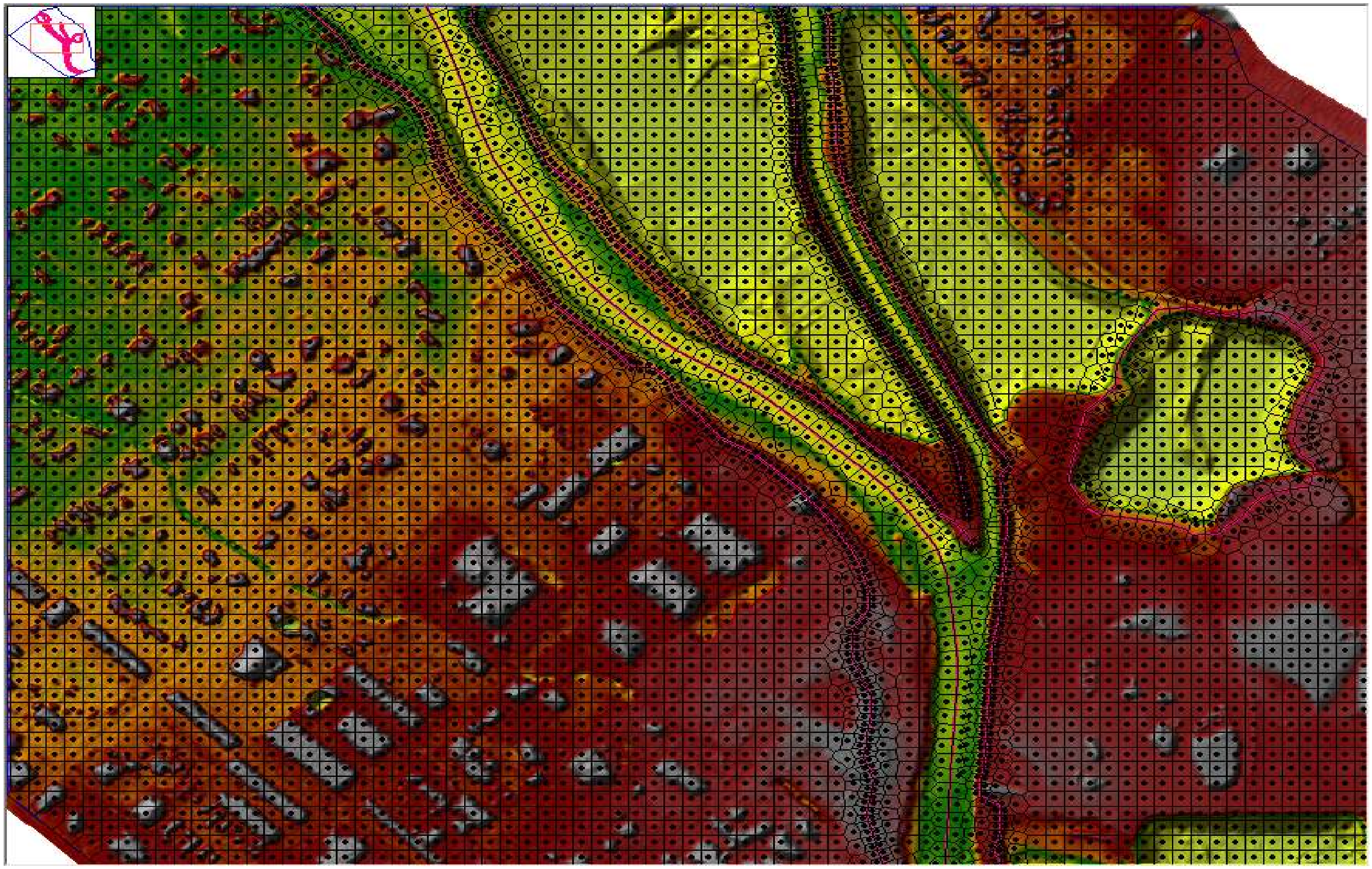
- In general people do not use enough breaklines
- Use breaklines along high ground barriers to flow in order to align faces
  - This will improve accuracy
  - This will improve model stability



Channel Alignment and Cell Size

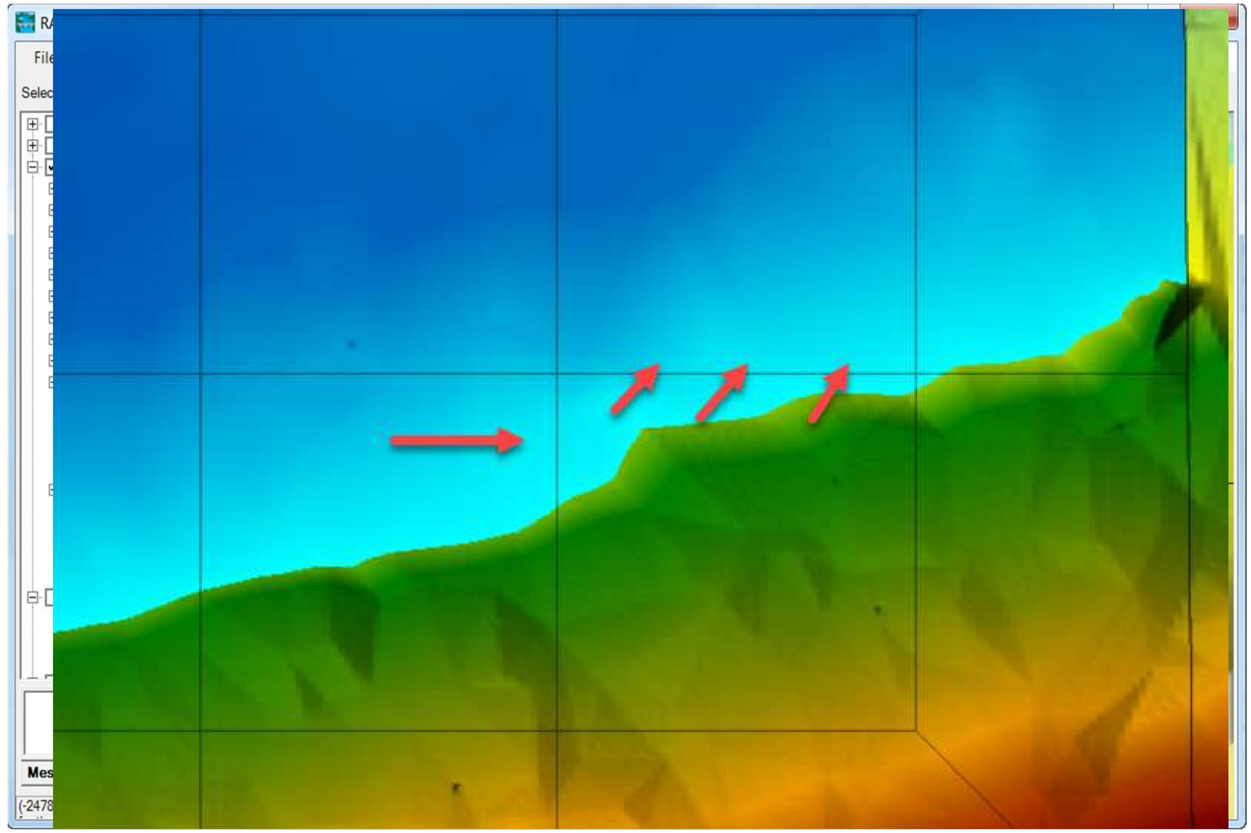
- Need to define the channel portion of the 2D mesh appropriately
- 2D Faces need to be aligned with high ground separating channel from floodplain
- Channel needs to have enough cells across the channel in order to get a good velocity profile. Recommend at least 7 to 10 cells across channel
- Fewer cells ok for water surface only
- Use Breaklines/Refinement Regions to accomplish this

Polygon Refinement for Main Channel



Partial Cell Wetting Issue

- Excessive model iteration can occur when just a corner of a cell has flow and the velocity is high.
- This will be even more unstable when flow comes into a cell through a small portion of a face but can leave over a much larger portion of another face
- Adjust cell sizes, use breaklines and polygon refinement tool to fix



Internal Hydraulic Structures

- To small of 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

Questions?