

1D/2D Direct Connections: Transitioning between 1D and 2D Channels

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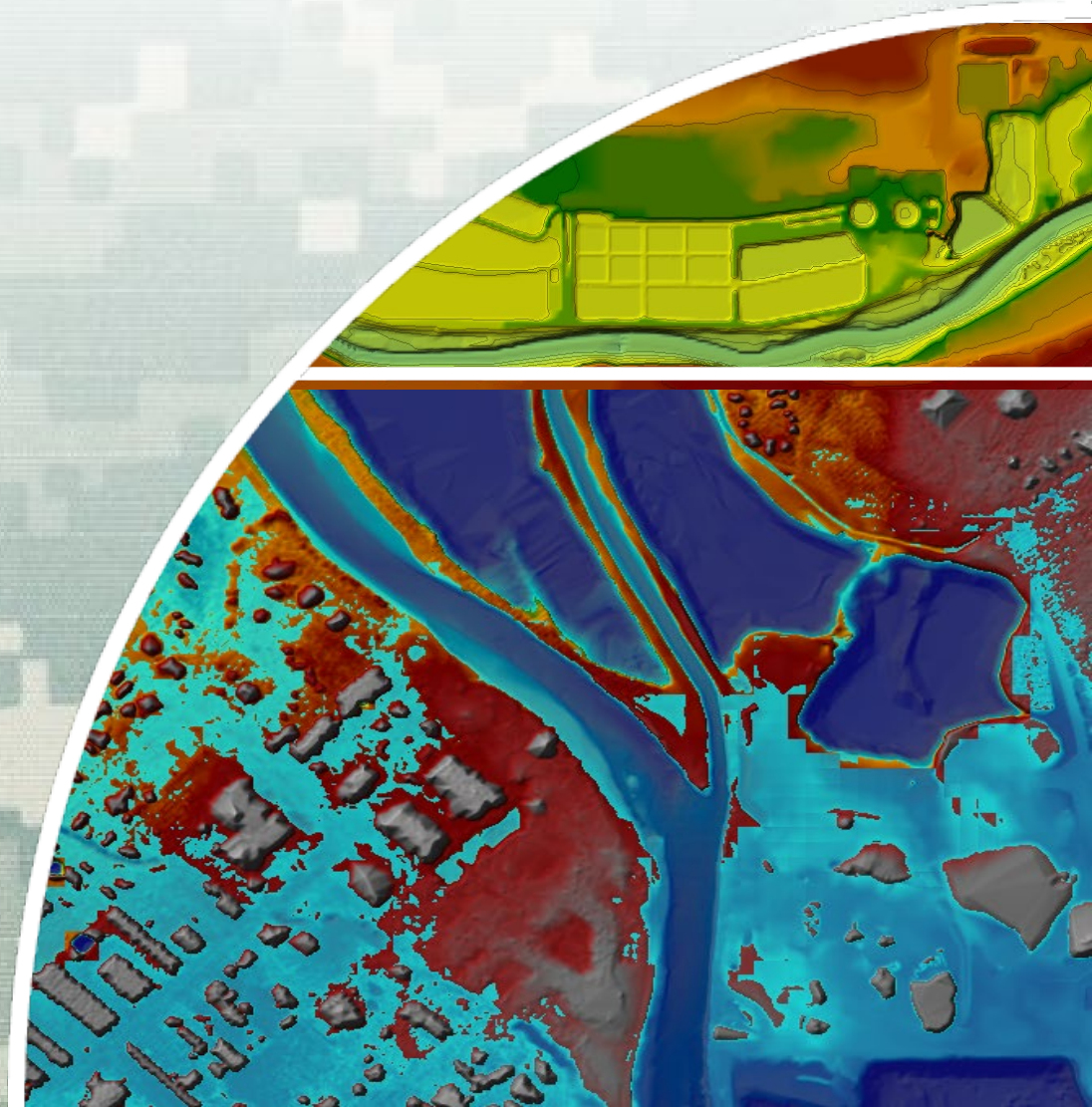
Cameron Ackerman, PE, D.WRE



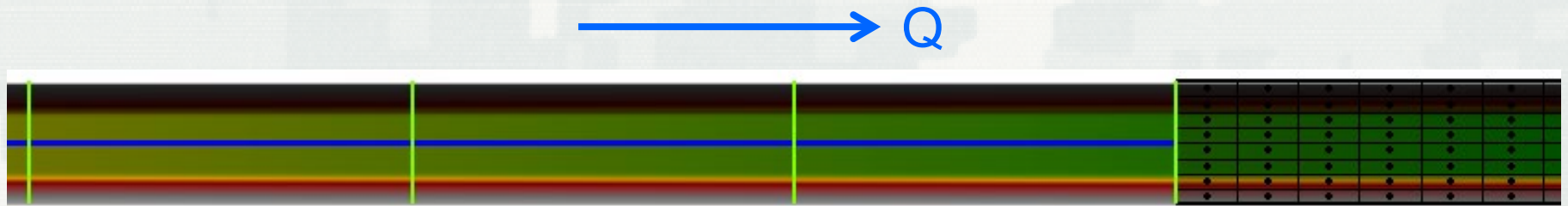
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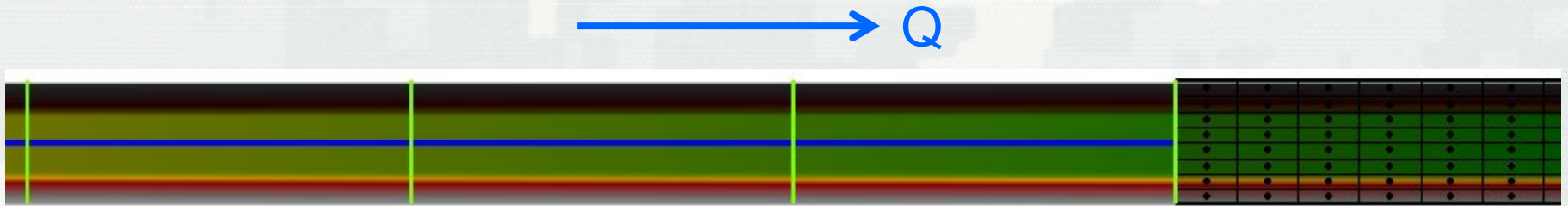
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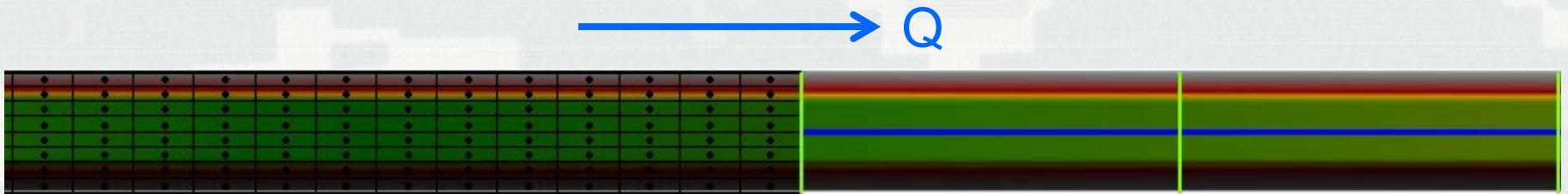
1D-2D Connection



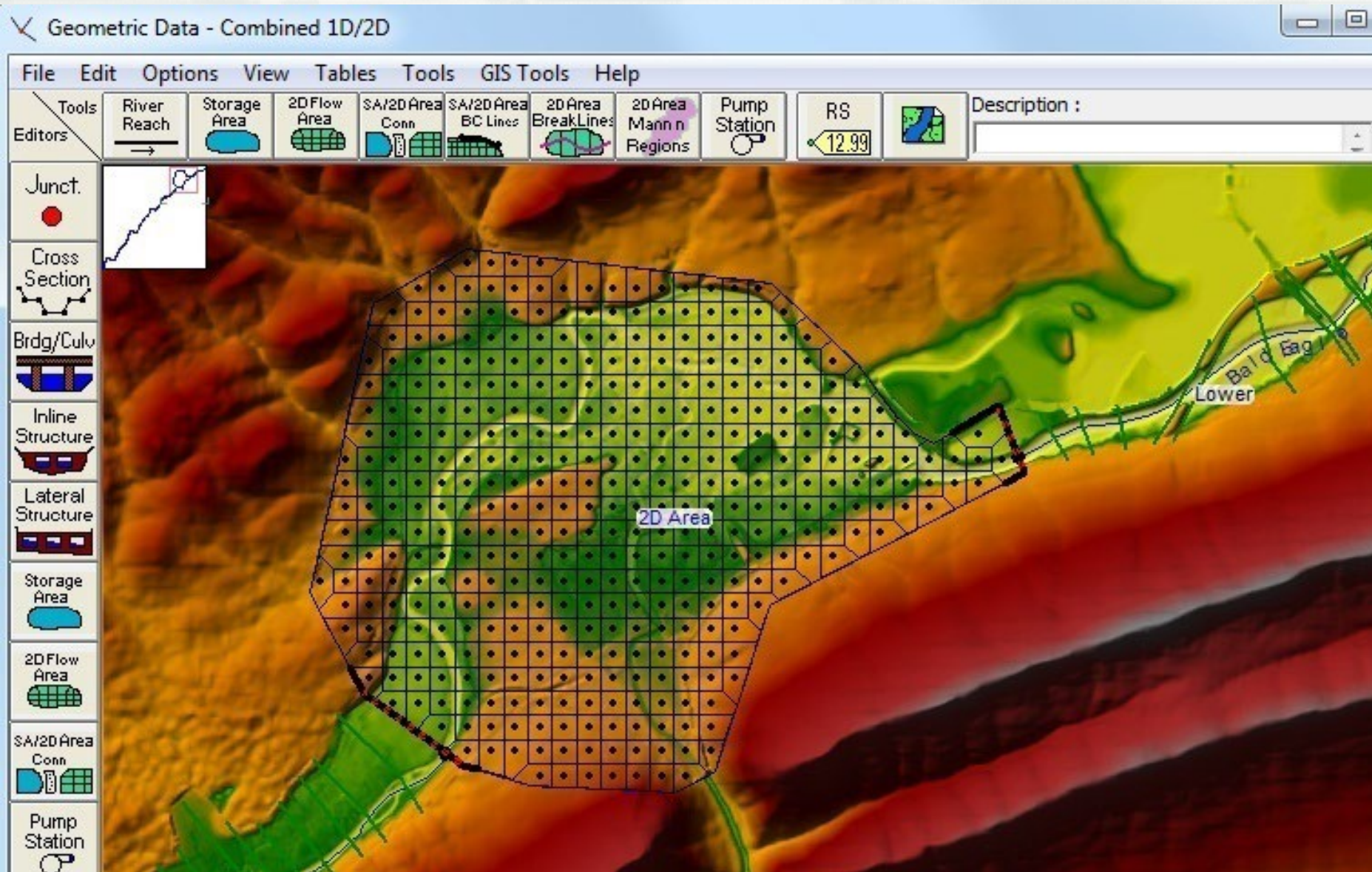
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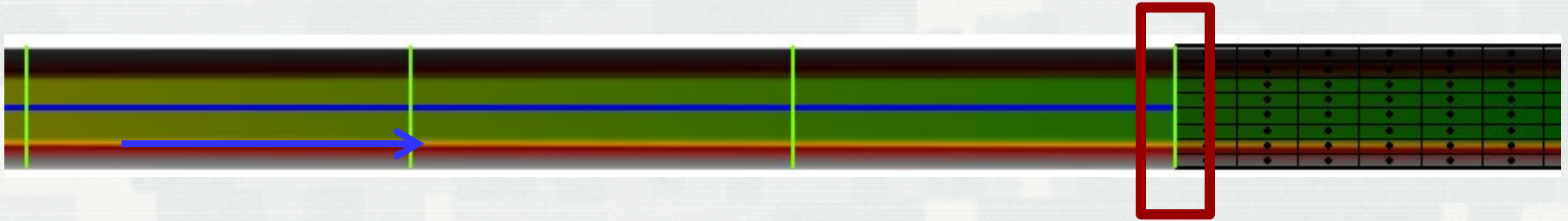
2D-1D Connection



1D to 2D to 1D Connection



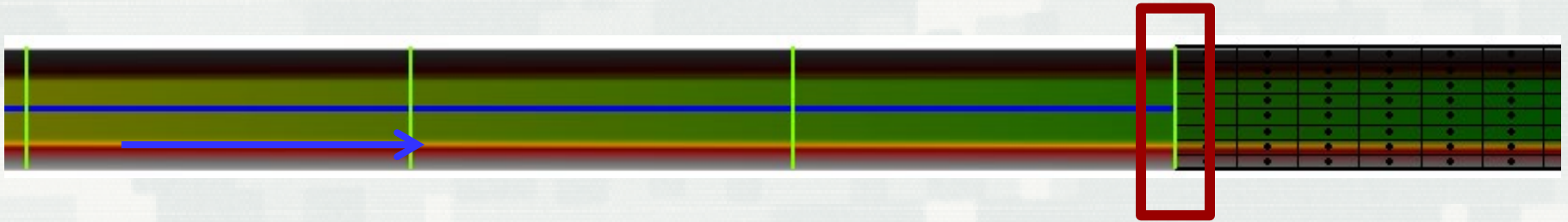
Three Critical Take-Aways: Managing Instabilities at 1D-2D Transitions



1. Cross section and mesh boundary must be identical at the connection.
2. 1D First → 2D Second.
1D uses lagged 2D result, which can cause instability.
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Requirements for Connecting 1D to 2D Channels Directly

1. Choose a 1D Flow Location
2. Carefully align 1D XS with 2D area boundary
3. 1D XS Station/Elevation must be exactly the same as 2D area terrain.
4. Same Manning's n at the 1D-2D boundary.



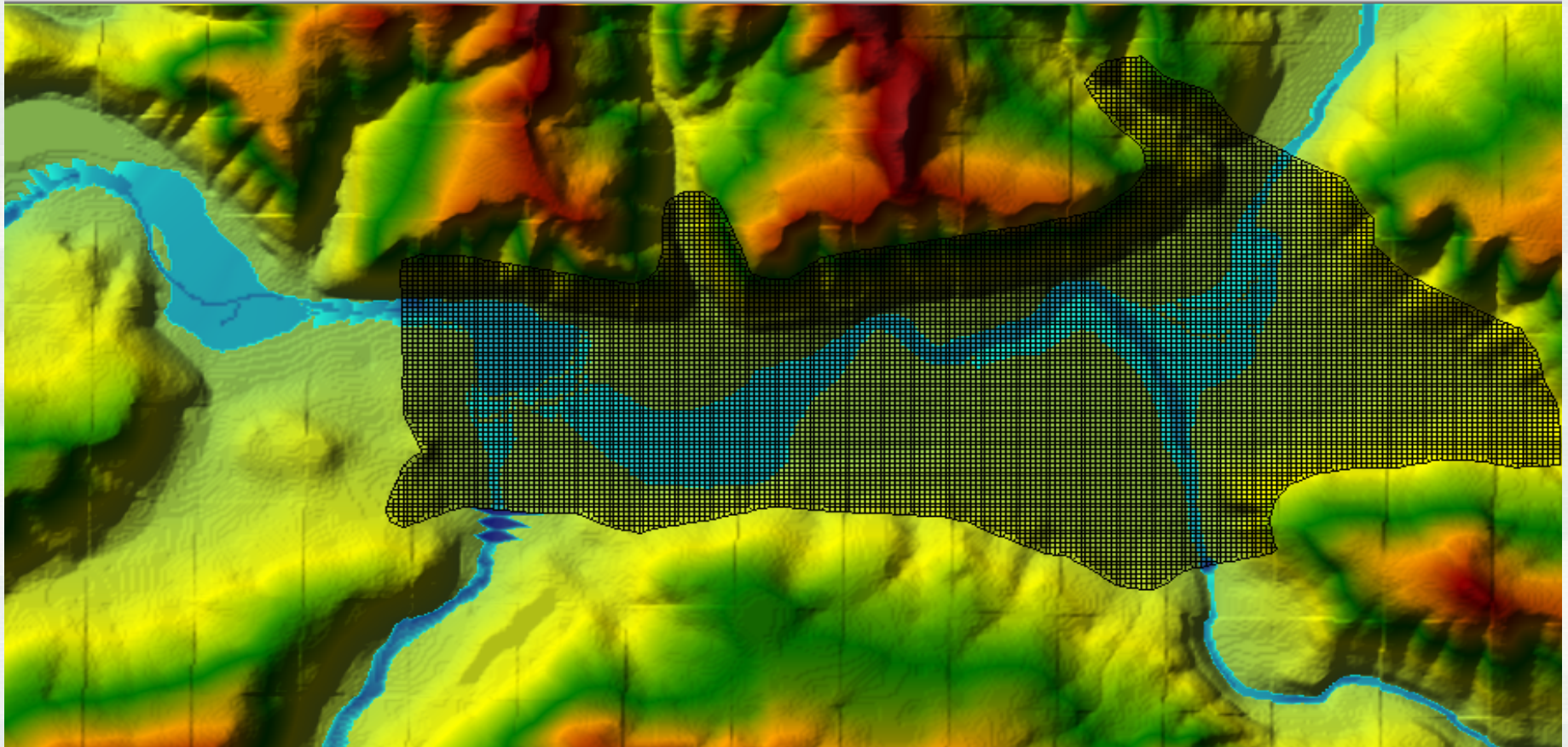
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1D/2D Locations

- 1D to bay estuary or alluvial fan

- 1D river with regions of 2D river
 - ▶ Complicated bridge/multiple opening
 - ▶ Complex junction
 - ▶ Detailed WSEs (e.g. sharp bend)
 - ▶ Detailed Velocities



Requirements for Connecting 1D to 2D Channels Directly

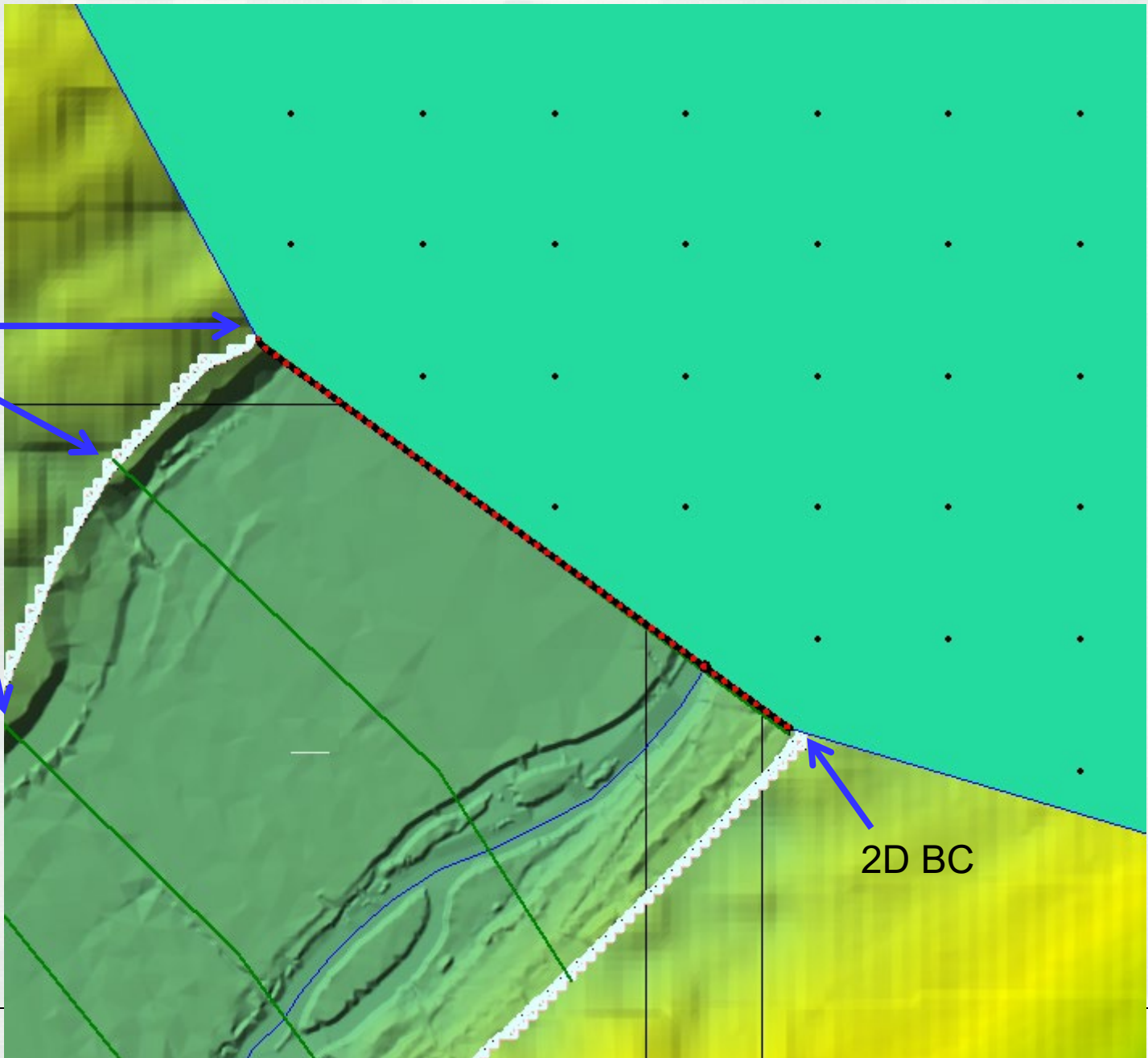
1. Choose a 1D Flow Location...
...or move connection away from the area of interest.
2. Carefully align 1D XS with 2D area boundary
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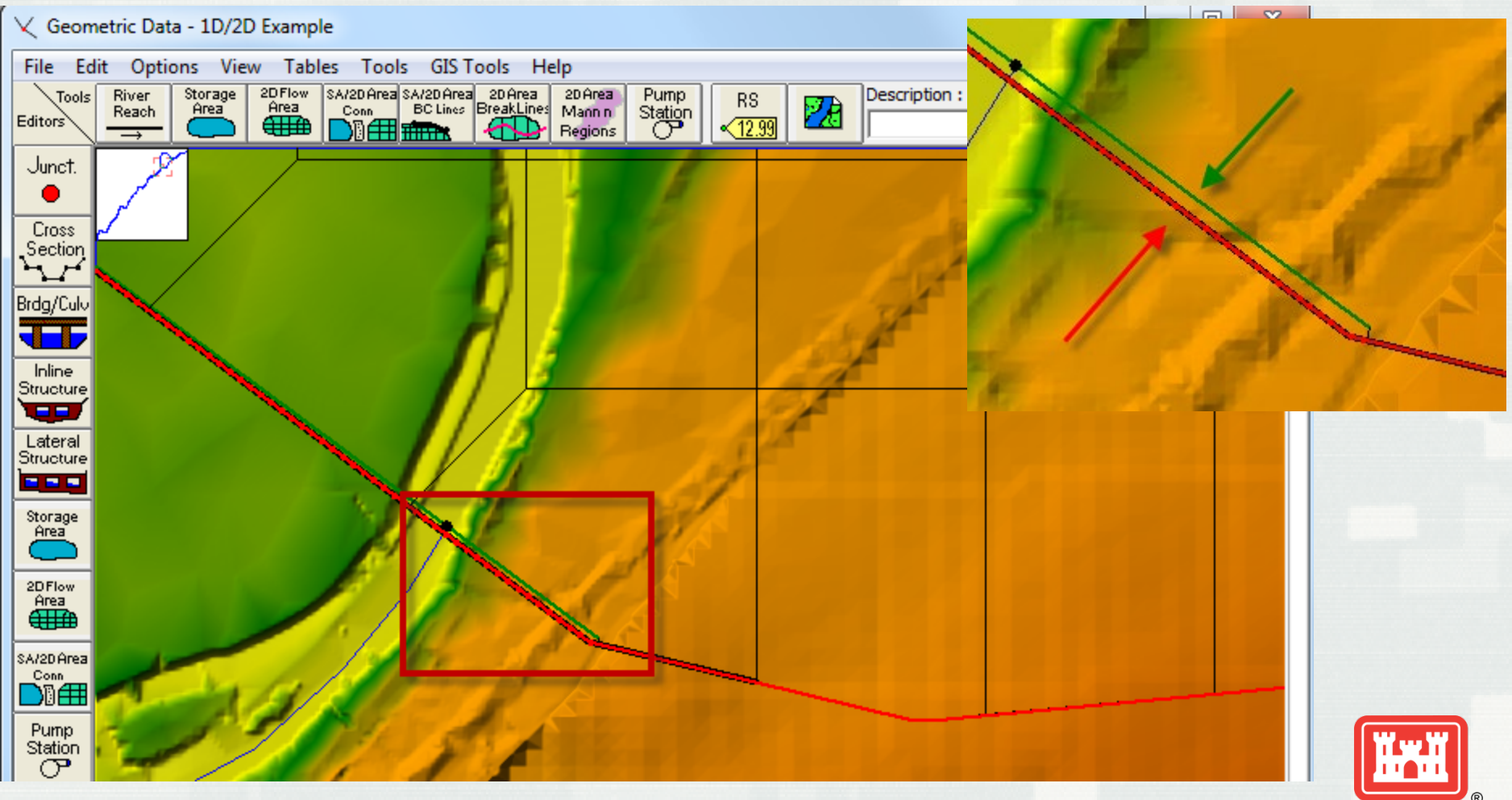
1D XSs

2D BC



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Checking 1D/2D Boundary



Requirements for Connecting 1D to 2D Channels Directly

1. Choose a 1D Flow Location
2. Carefully align 1D XS with 2D area boundary

Why is this so important?

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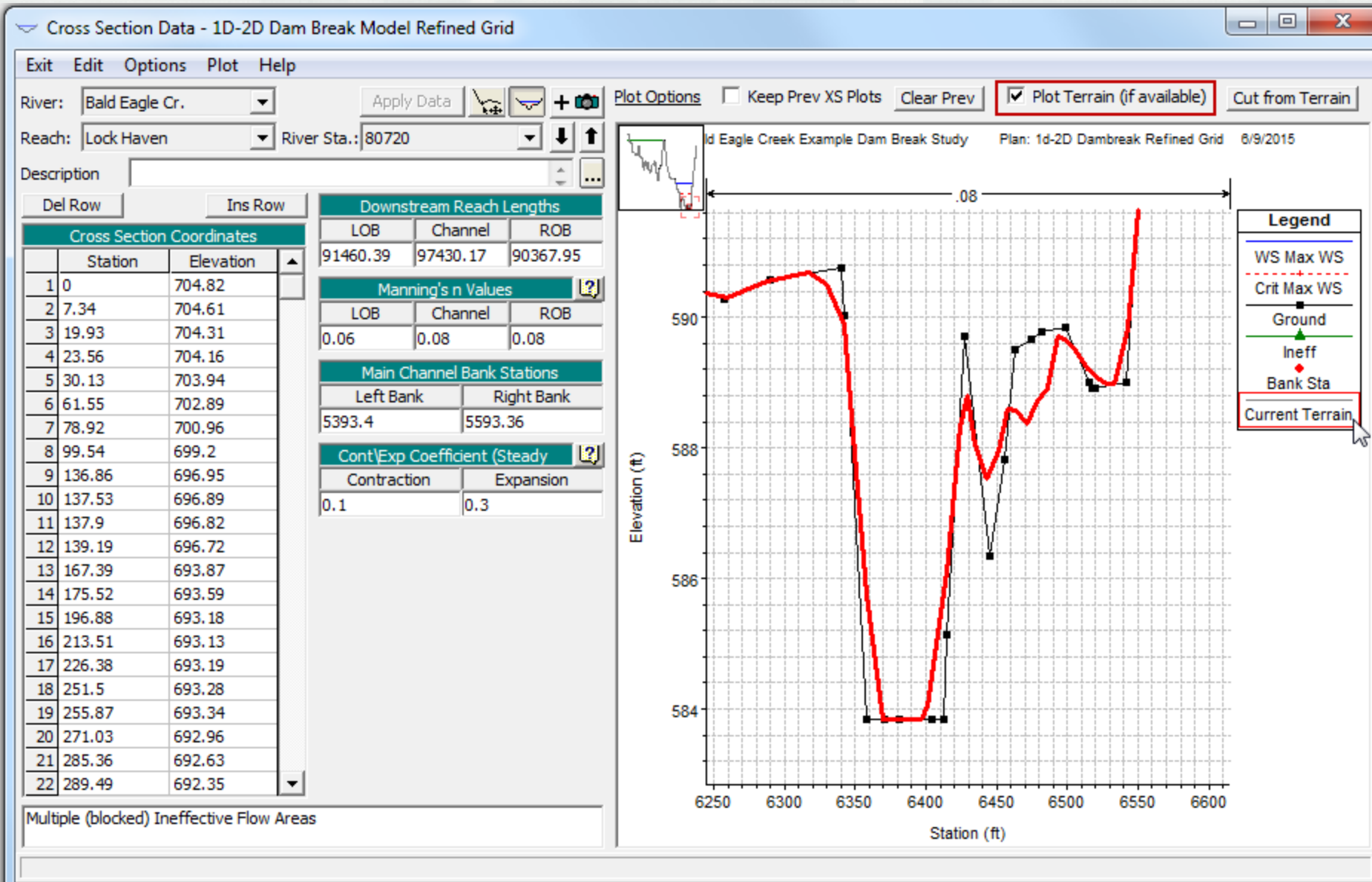


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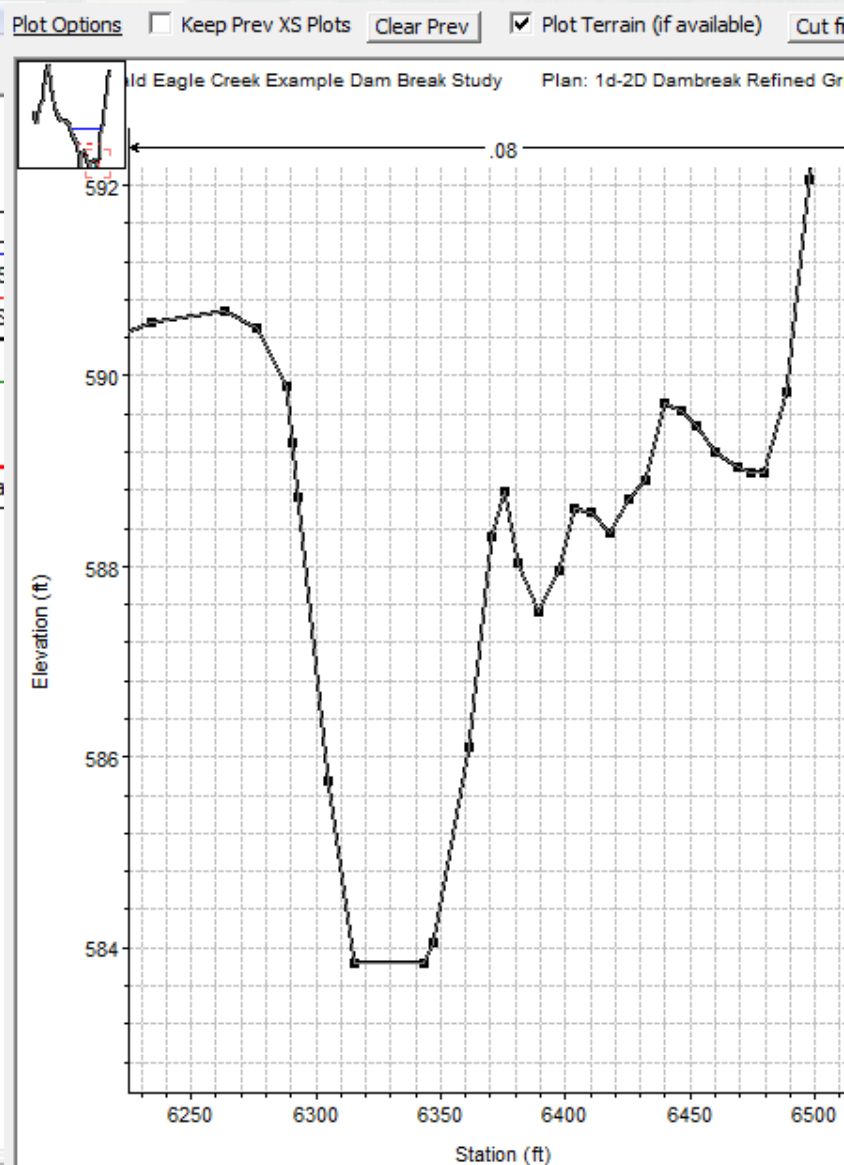
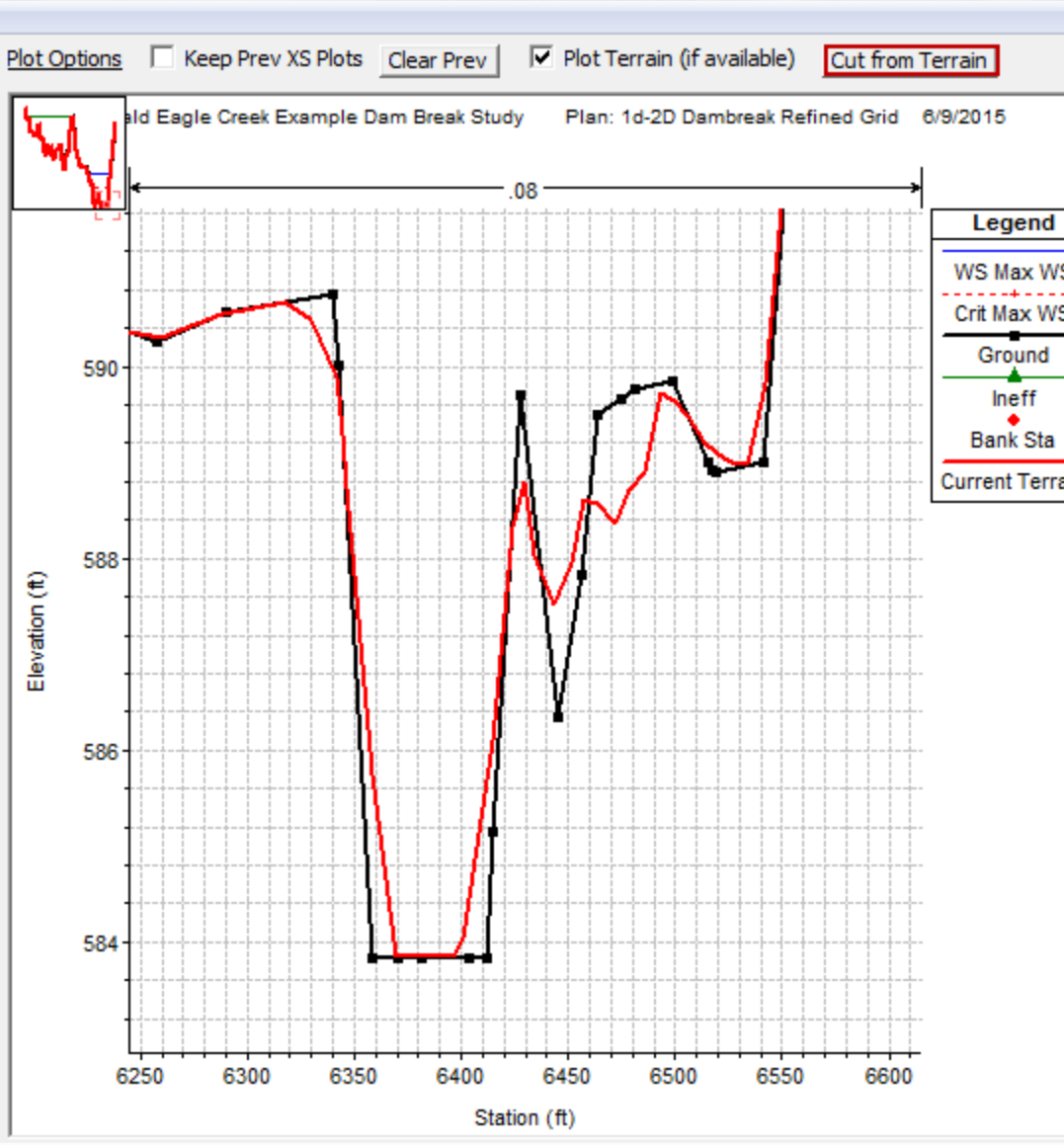
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1D Sta/Elev vs Terrain



Update 1D Sta/Elev

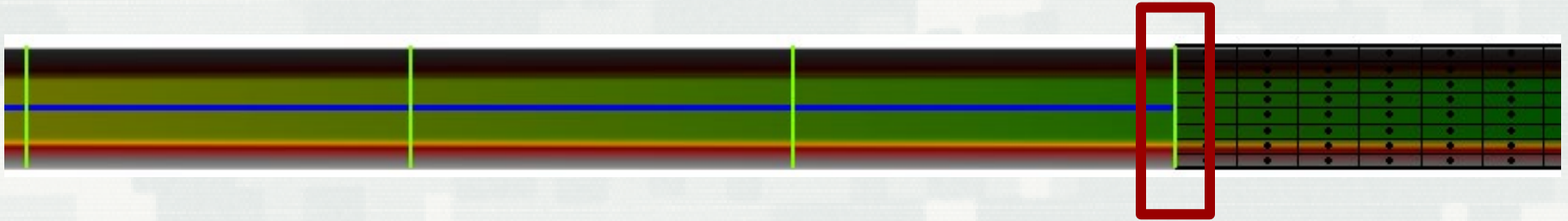


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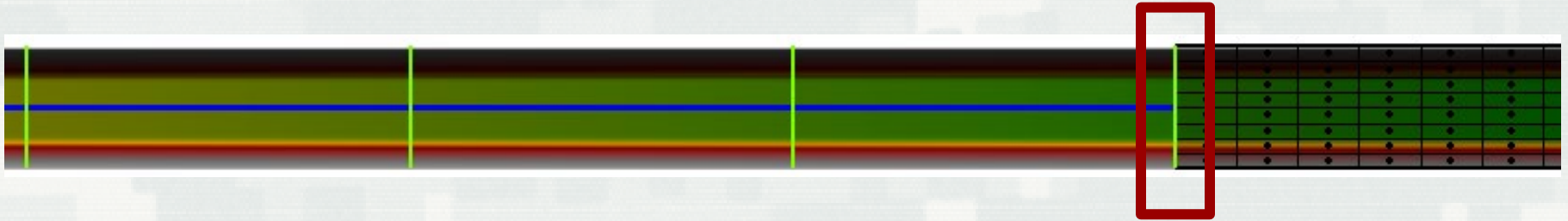
Three Critical Take-Aways: Managing Instabilities at 1D-2D Transitions



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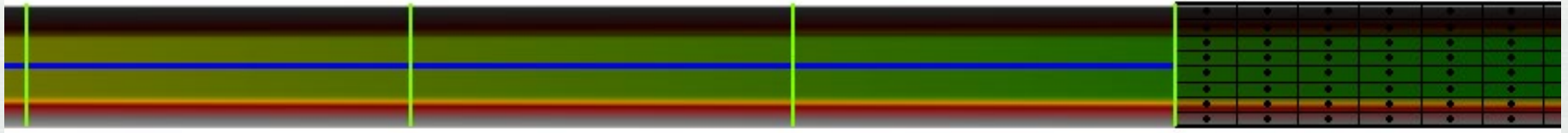
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1D/2D Solution Overview



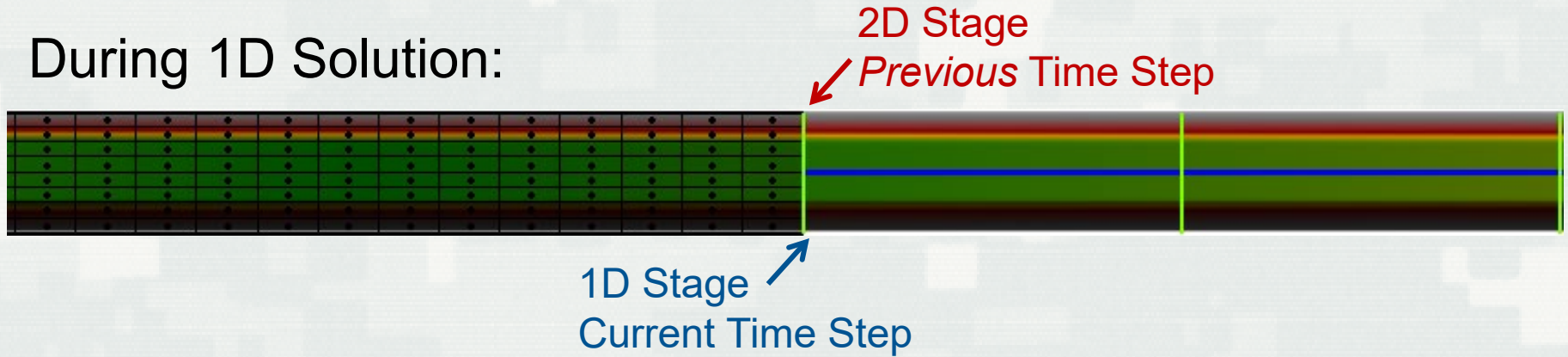
For each time step:

- **1D is computed first, then 2D**
- 2D has latest boundary conditions from 1D
- 1D gets “lagged” boundary conditions from 2D
- Upstream region uses the downstream WSE
- Downstream region uses upstream flow

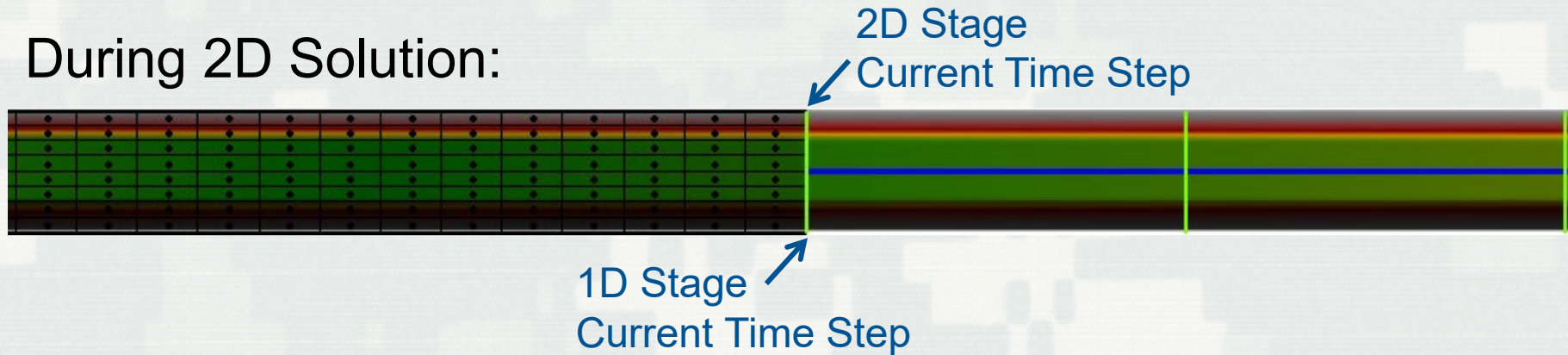


1D/2D Solution Overview

During 1D Solution:



During 2D Solution:

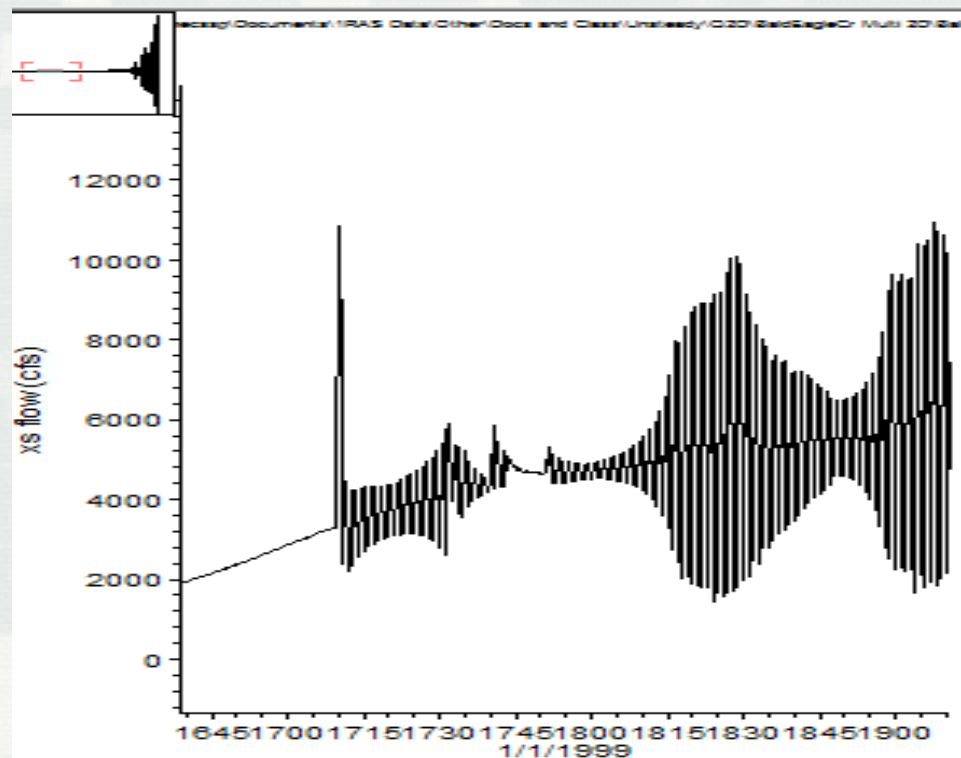
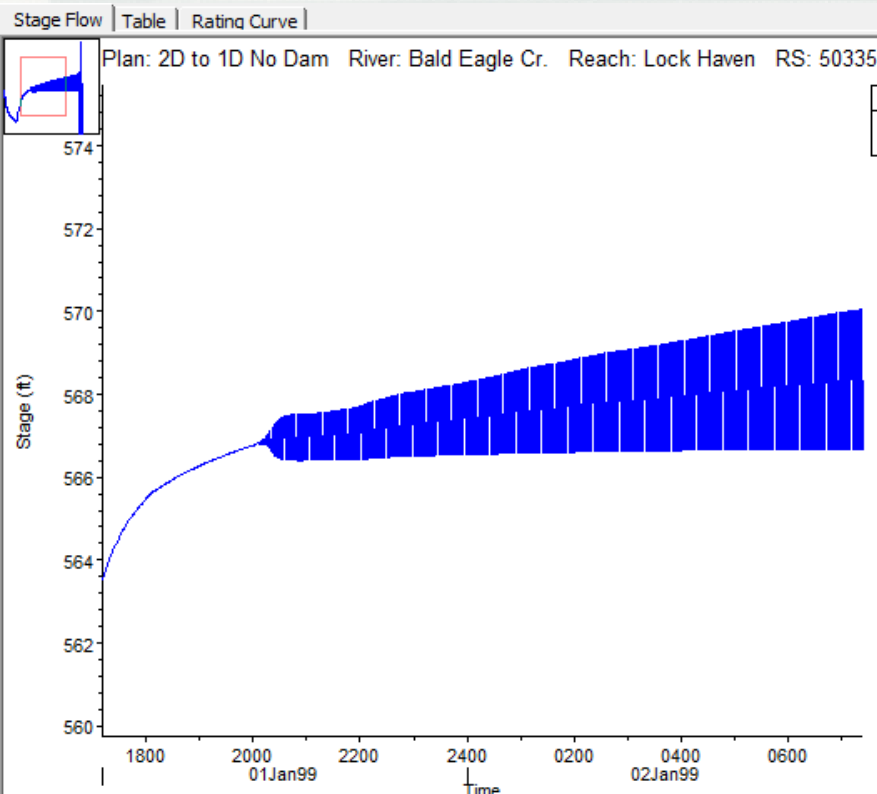


Large differences between **current 1D stage** and **previous 2D stage**, at the shared transition transect, can cause instabilities at the boundaries.



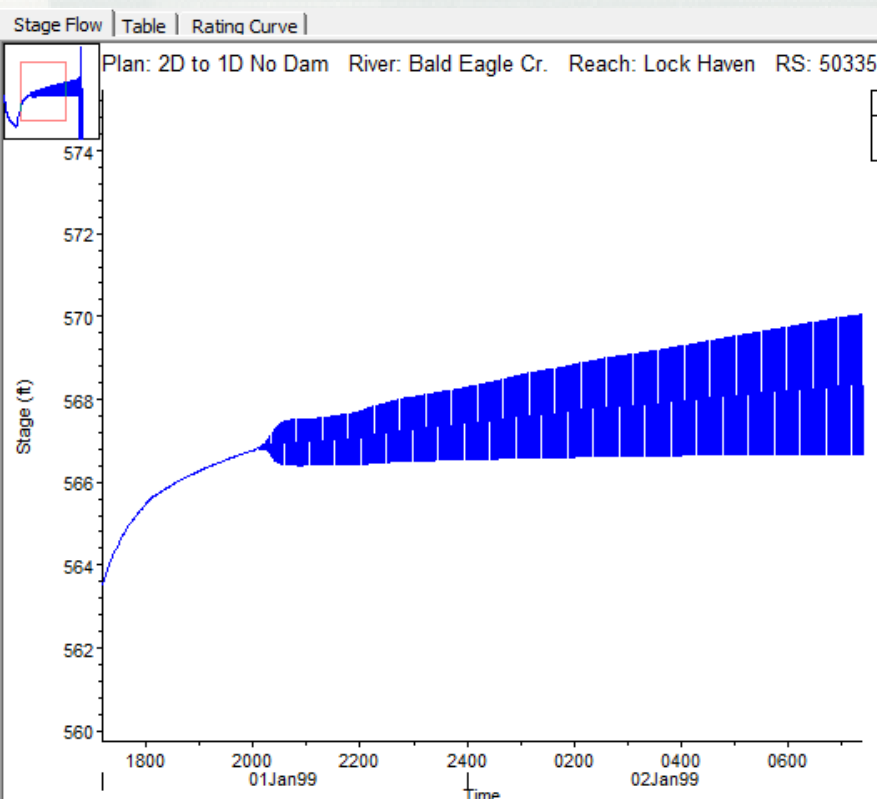
Discontinuity between 1D and 2D results at the transition can cause instabilities:

Boundary instabilities can cause oscillate



That's fascinating...

...How do you fix it?



- 1D/2D Iterations
- Smaller Time Step



1D/2D Iterations

The image shows a screenshot of the HEC-RAS Unsteady Flow Analysis software interface. The main window is titled "Unsteady Flow Analysis" and has a menu bar with "File", "Options", and "Help". The "Options" menu is open, showing various settings. The "Calculation Options and Tolerances ..." option is highlighted, and a mouse cursor is pointing at it. A secondary dialog box, titled "HEC-RAS Unsteady Computation Options and Tolerances", is open over the main window. This dialog has three tabs: "General (1D Options)", "2D Flow Options", and "1D/2D Options". The "1D/2D Options" tab is selected and circled in red. It contains four input fields:

- Maximum iterations between 1D and 2D (0=off, 1 to 20): 4
- Water surface tolerance (ft): 0.01
- Flow Tolerance (%): 0.1
- Minimum flow tolerance (cfs): 1

Below the input fields, there are two dropdown menus for "1 Minute" and "1 Hour", and two buttons labeled "Parameters" and "Close".

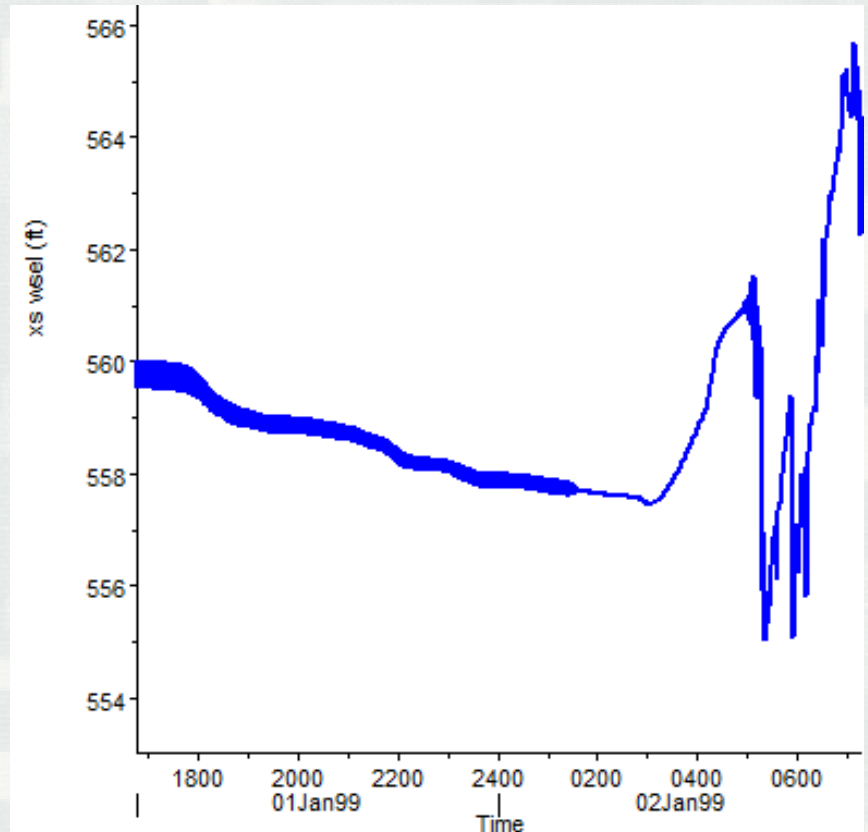
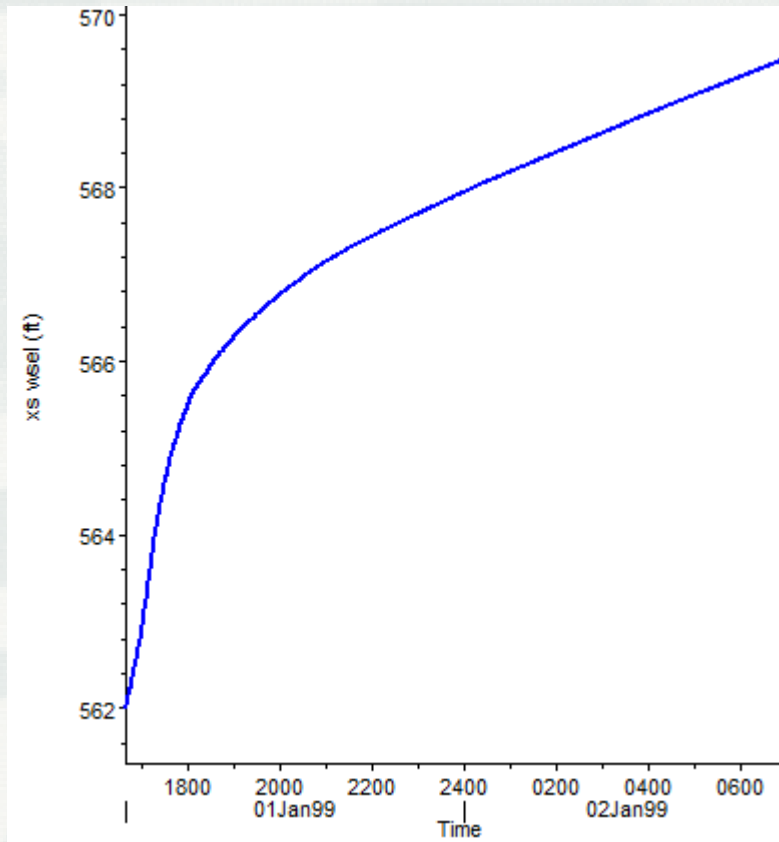


1D/2D Iterations

- For each time step: 1D is computed, then 2D
- Every 1D/2D boundary is checked for convergence
 - ▶ 1D to 2D WSE is checked
 - ▶ 2D to 1D Flow is checked
 - ▶ Lat Struct or SA Conn, Flow checked
 - Flow is based on “assumed” WSE
 - Flow is re-computed from “computed” WSE



2D to 1D Instability

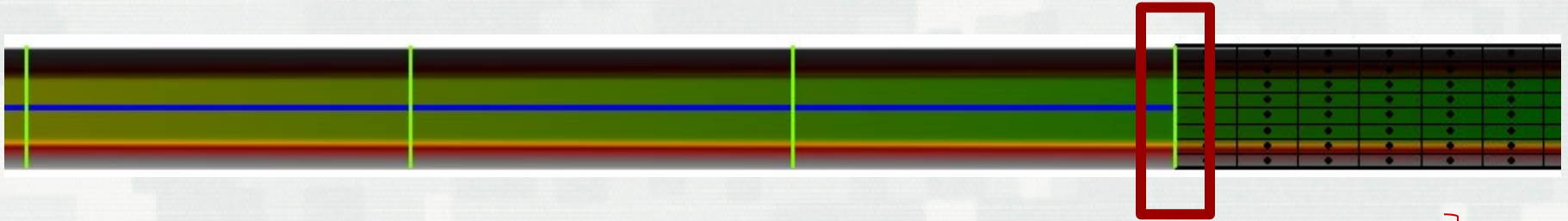


- 1 Minute time step
- 4 Iterations Max

- 15 Second time step
- 0 Iterations



Three Critical Take-Aways: Managing Instabilities at 1D-2D Transitions

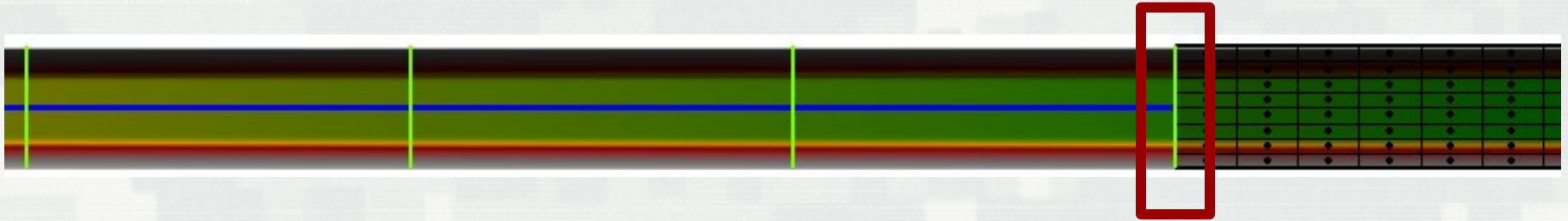


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Causes



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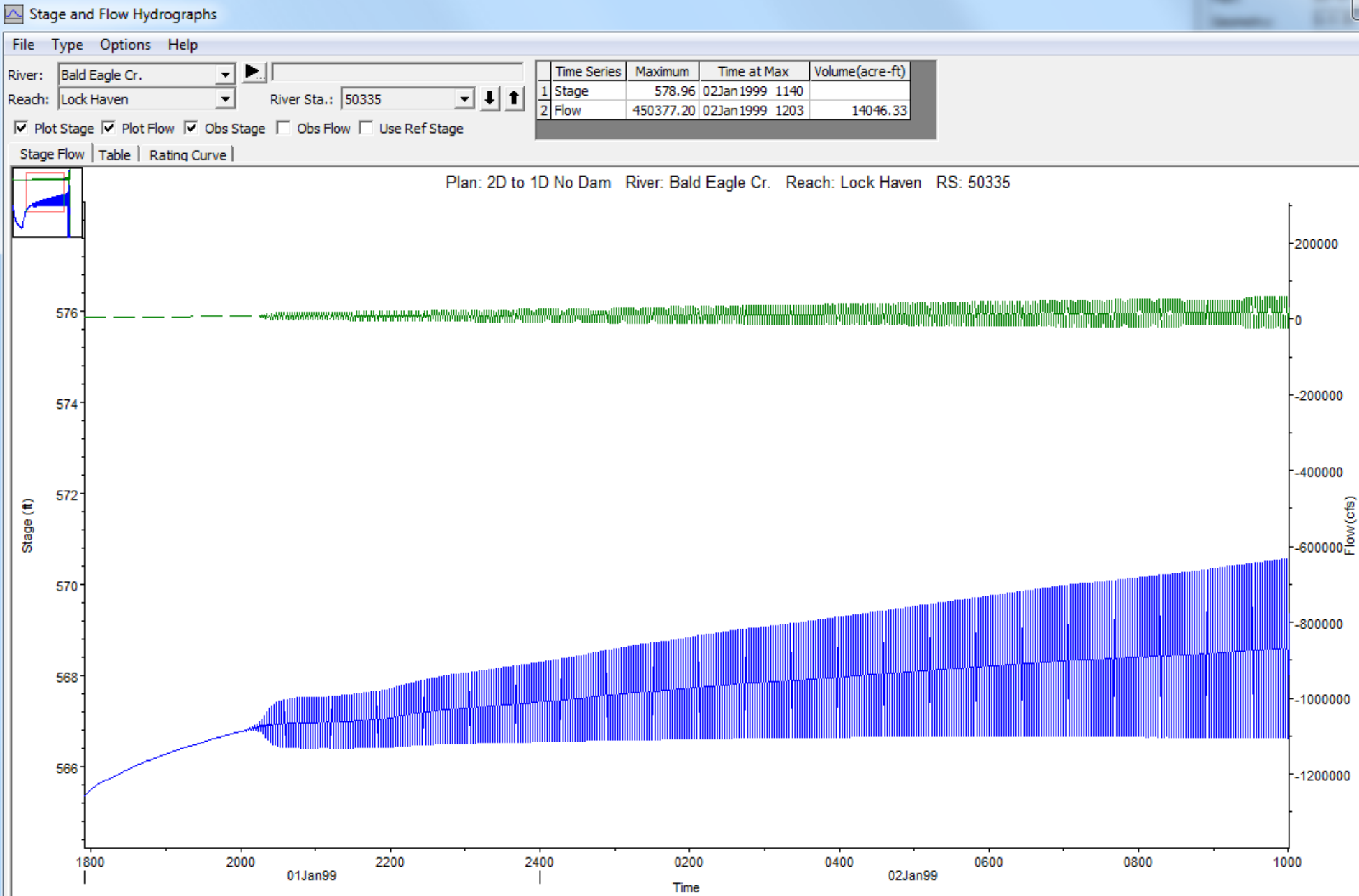


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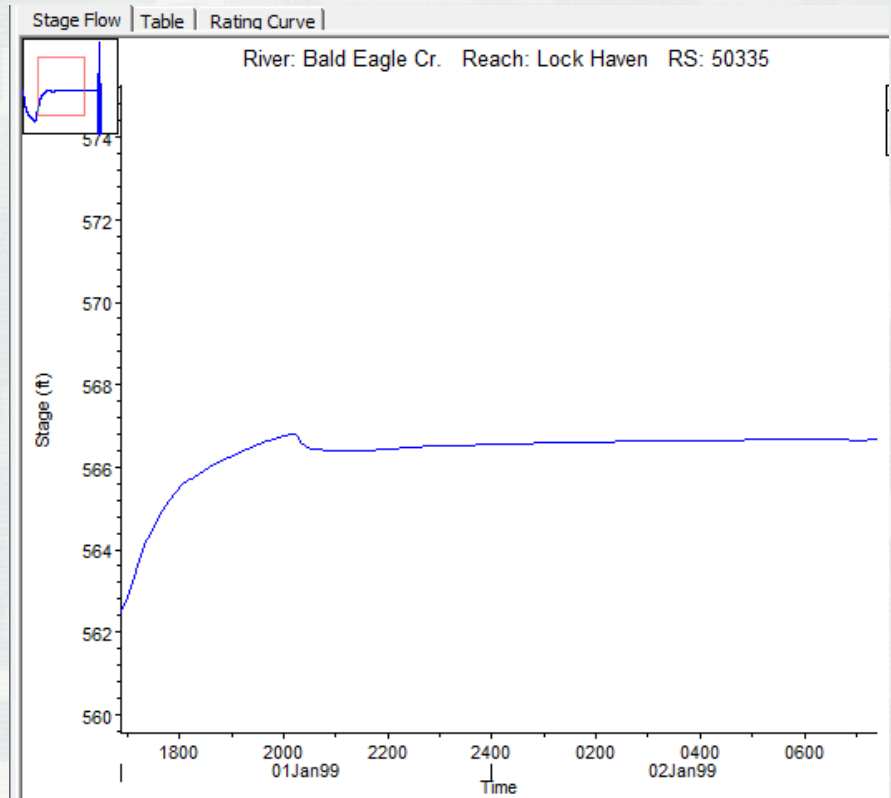
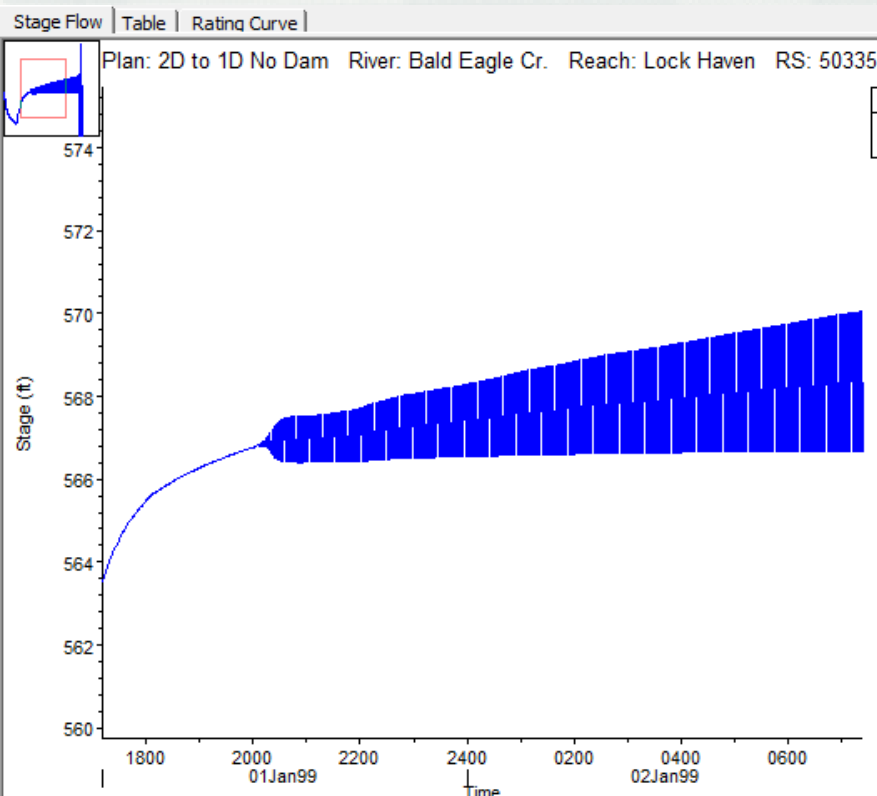
D diagnostic



2D to 1D Instability



2D to 1D Instability



Computation Settings

Computation Interval: 1 Minute Hydrograph Output Interval: 1 Minute

Mapping Output Interval: 5 Minute Detailed Output Interval: 1 Minute

Computation Level Output

DSS Output Filename: C:\Users\q0hecsp\Documents\1RAS Data\Other\Docs and Cl

Mixed Flow Regime (see menu: "Options/Mixed Flow Options ...") debug parameters

Computation Settings

Computation Interval: 1 Minute Hydrograph Output Interval: 2 Minute

Mapping Output Interval: 5 Minute Detailed Output Interval: Max Prof.

Computation Level Output

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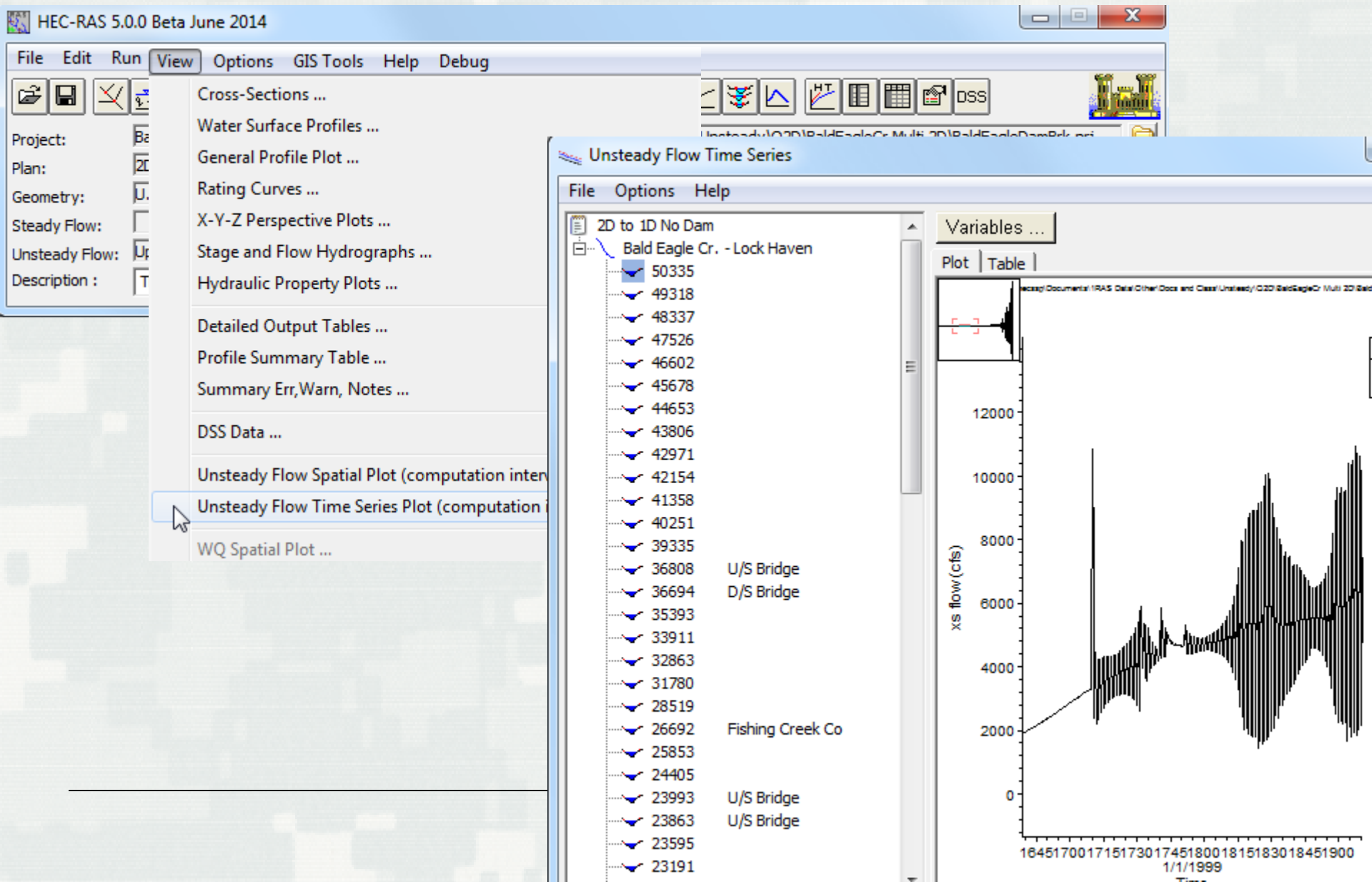
Output Options

The screenshot shows the 'Unsteady Flow Analysis' software interface. The 'Plan' is set to '2D to 1D No Dam'. The 'Geometry File' is 'U.S 2D - D.S 1D No Dam' and the 'Unsteady Flow File' is 'Upstream 2D'. The 'Simulation Time Window' shows a starting date of 01JAN1999 and an ending date of 03JAN1999, both at 1200. The 'Computation Settings' section includes a 'Computation Interval' of 30 Second, a 'Hydrograph Output Interval' of 1 Minute, a 'Mapping Output Interval' of 30 Second, and a 'Detailed Output Interval' of 1 Minute. The 'Computation Level Output' checkbox is checked. The 'DSS Output Filename' is set to 'C:\Users\q0hecsp\Documents\1RAS Data\Other\Docs and Cl'. The 'Mixed Flow Regime' checkbox is unchecked. The 'Compute' button is visible at the bottom.

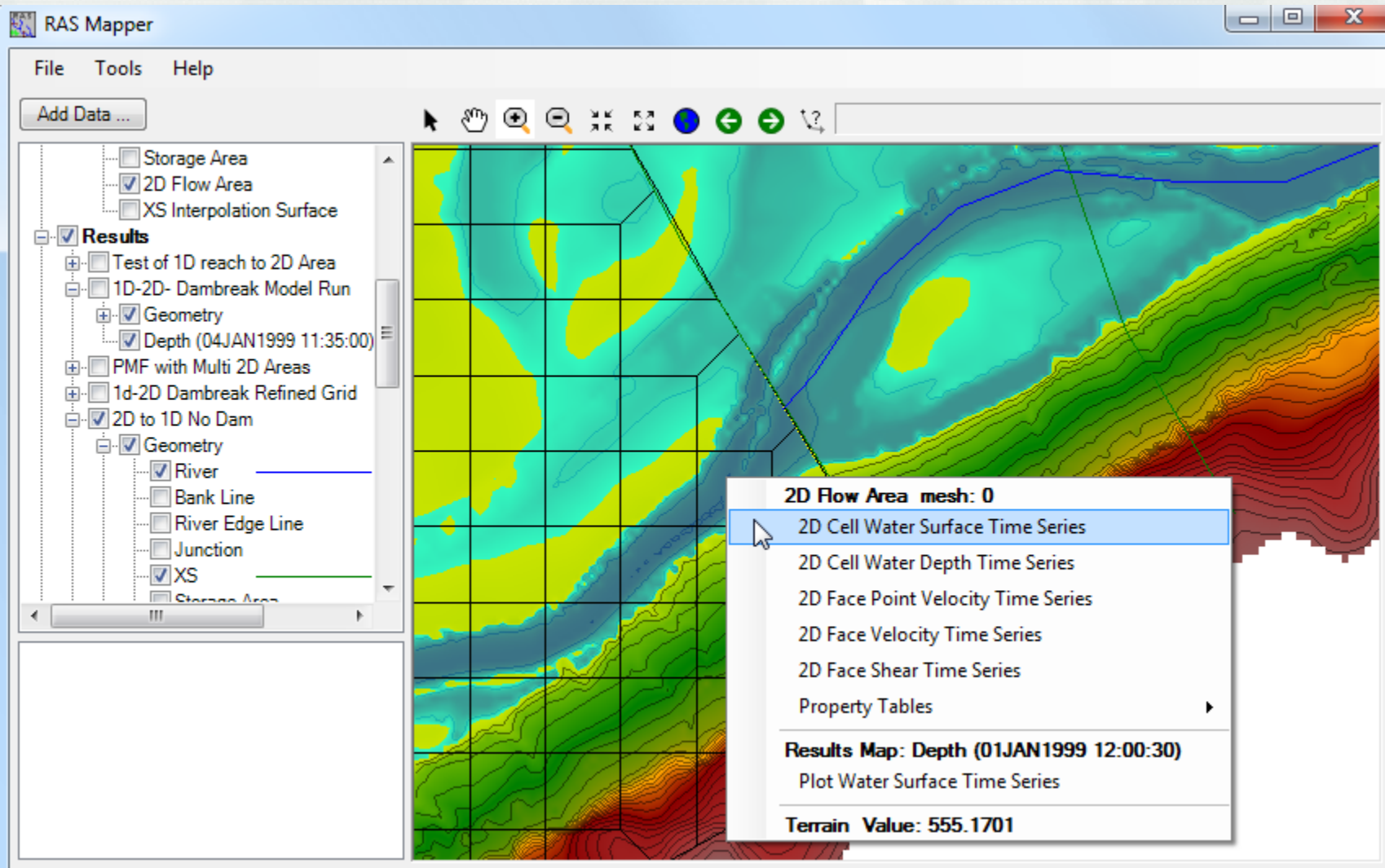
- 30 Sec Time Step
- Hydrograph [DSS] limited to 1 Minute
- Mapping Output Interval [HDF5] can be same as computation
- Use Computation Level Output



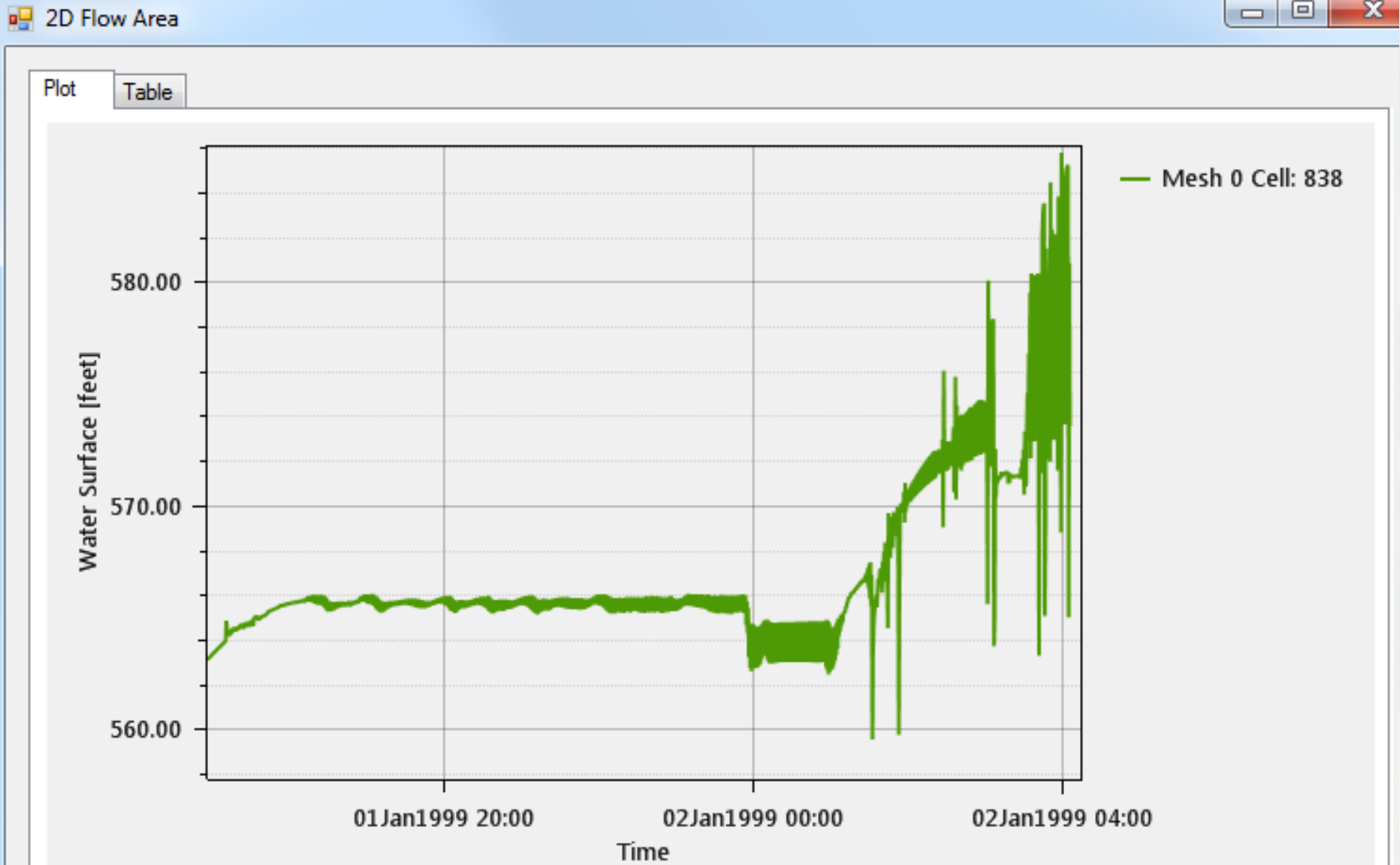
Computation Level Output



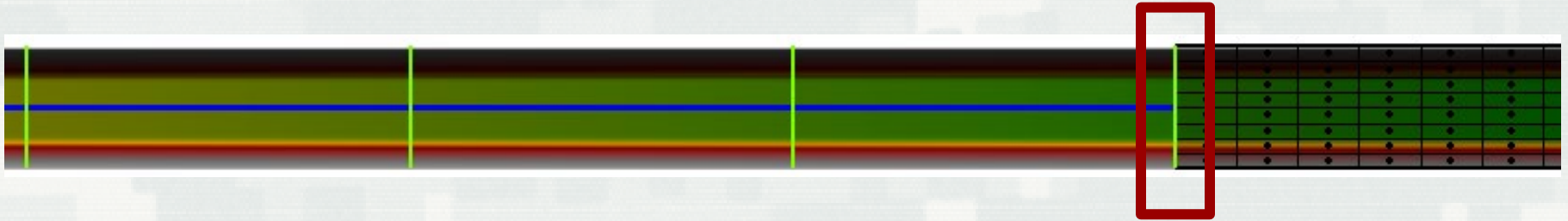
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