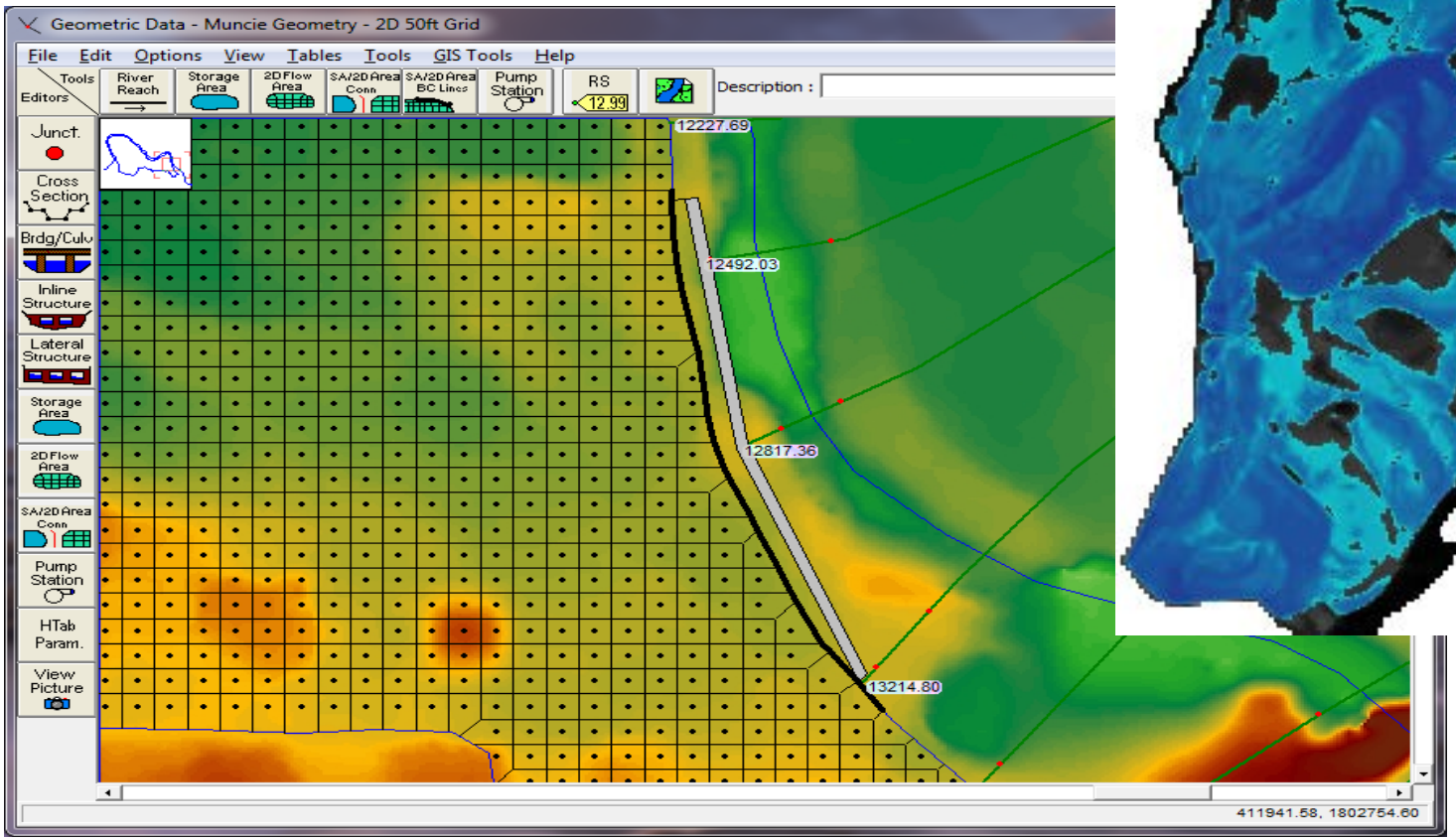
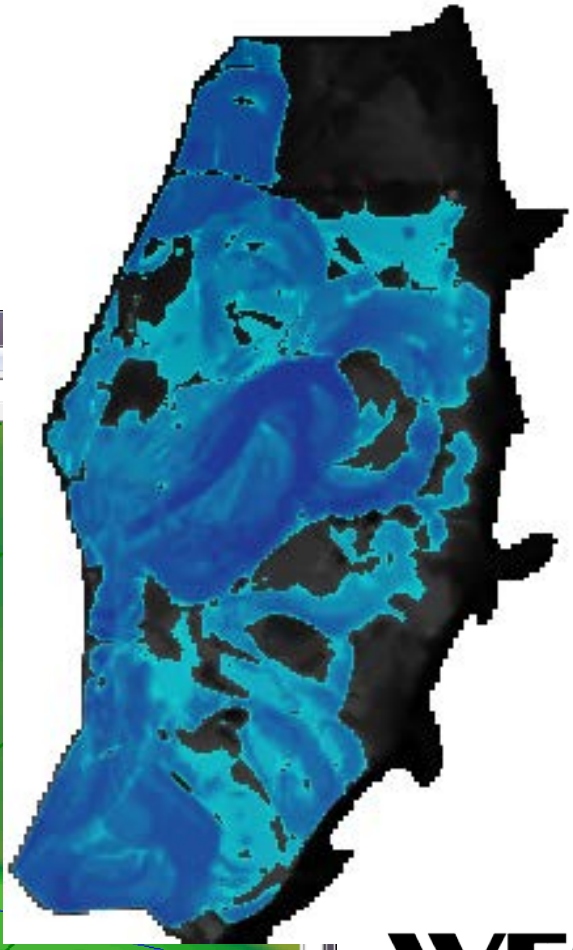
TWO-DIMENSIONAL CAPABILITIES OF HEC-RAS

Kevin Denn, P.E.
NHEC 2014





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ACKNOWLEDGEMENTS

Gary Brunner, P.E., D.WRE

Hydrologic Engineering Center (HEC)

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OUTLINE

- Development Impetus
- Computational Scheme
- 2D Area Connections
- 2D Boundaries
- Initial Conditions
- Current 2D Limitations

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DEVELOPMENT IMPETUS

- **Dam and Levee Breaches**
  - USACE Mapping, Modeling, & Consequence Production Center
  - USACE Risk Management Center
- **USACE N… …m**
  - Integra…
  - …
- **HEC was…**
  - Poor model stability
  - Relatively long model run time

Build 2D Component into HEC-RAS!

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EXAMPLE APPLICATIONS

- Detailed 2D channel modeling
- Detailed 2D channel and floodplain modeling
- Combined 1D channels with 2D floodplain areas
- Subcritical and supercritical areas

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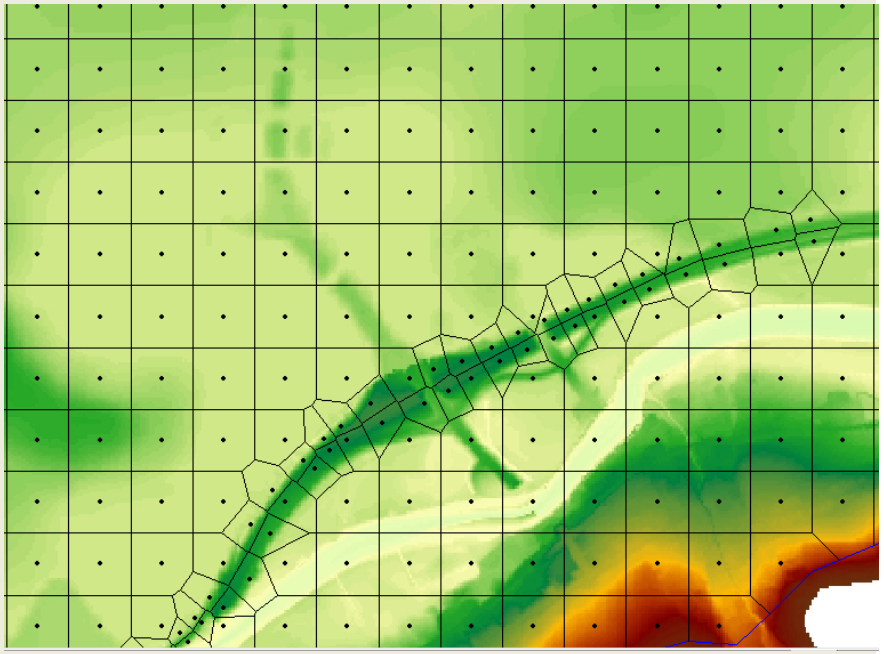
COMPUTATIONAL SCHEME

- **Equations**
  - Full 2D Saint Venant
  - Diffusive Wave Approximation
- **Solutions**
  - Implicit Finite Volume
  - Coupled 1D and 2D
- **Computational Engine**
  - 32-bit
  - 64-bit
- **Multiple Processors**
- **Mesh**
  - Structured
  - Unstructured (3 to 8 sides)
  - Combination



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COMPUTATIONAL SCHEME

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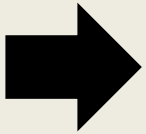
COMPUTATIONAL SCHEME

- **Typical 2D Model:**
  - **Center of element (single average elevation)**
  - **Element boundary points (sloped element)**



Masks detail of underlying terrain

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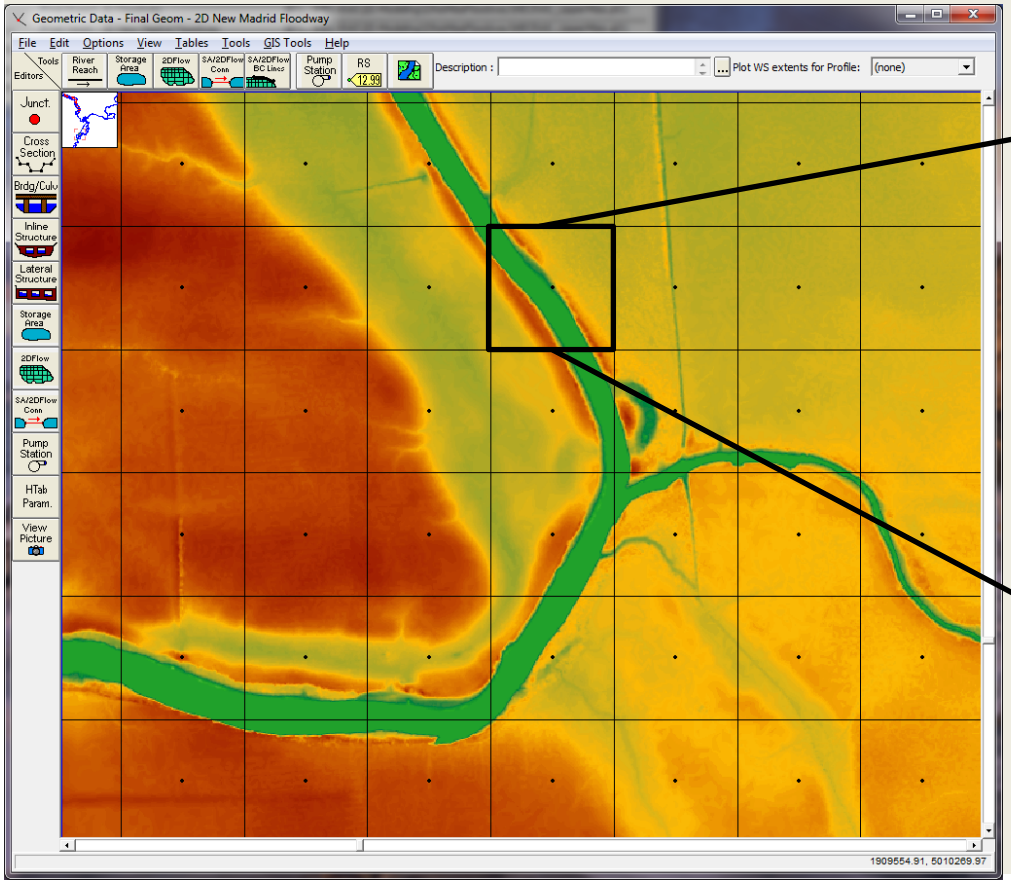
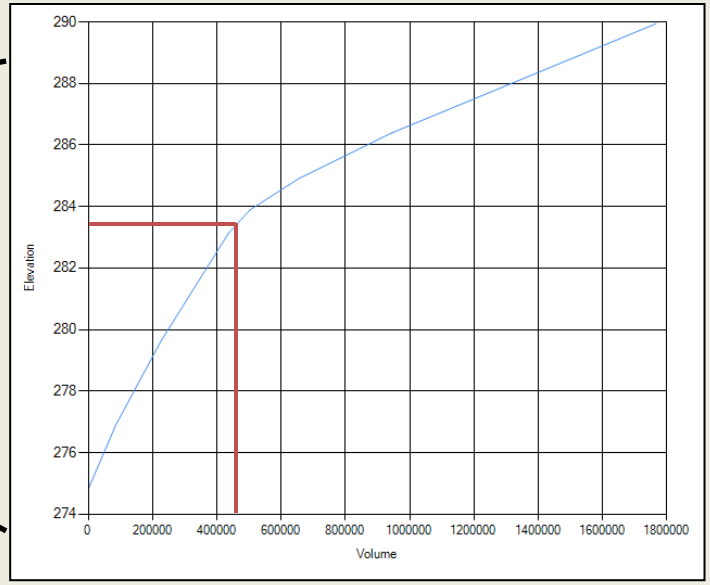
COMPUTATIONAL SCHEME

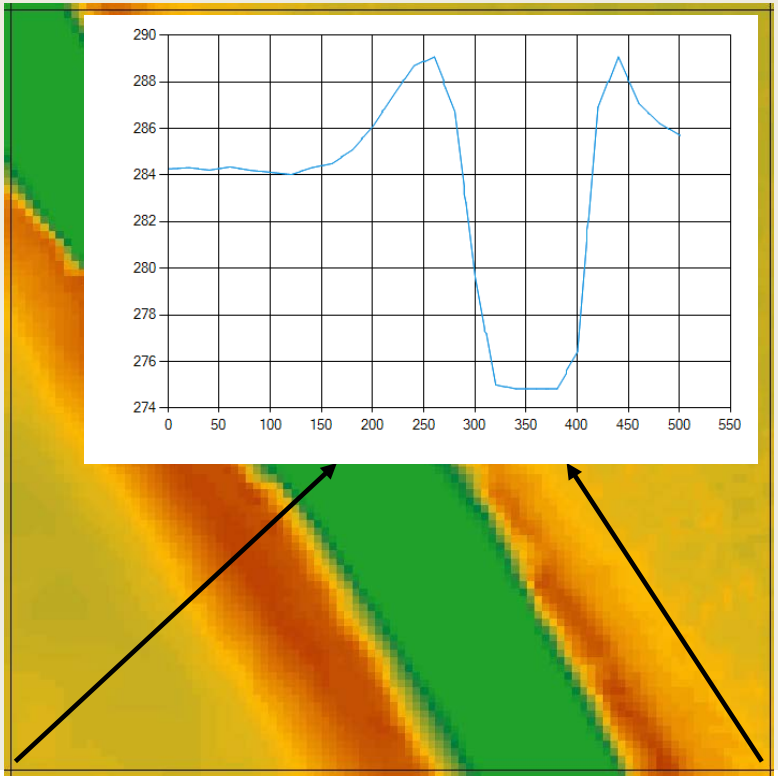
- **Elevation-volume relationship is created for each cell (analogous to HEC-RAS storage areas)**





COMPUTATIONAL SCHEME

- Elevation versus wetted perimeter, area, top width, roughness, etc. curves for each cell face
- Similar to hydraulic property table computations in unsteady HEC-RAS



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COMPUTATIONAL SCHEME

- **What Does This Mean?**
  - **Cell can be 'partially wet'**
    - **More detailed results**
  - ***Potentially* larger cell sizes can be used compared to models that solely use a node-based approach**
    - **Faster model run times**
- **Does not mean you can use infinitely large cells**
  - **Water surface slope**
  - **Terrain changes and hydraulic controls**

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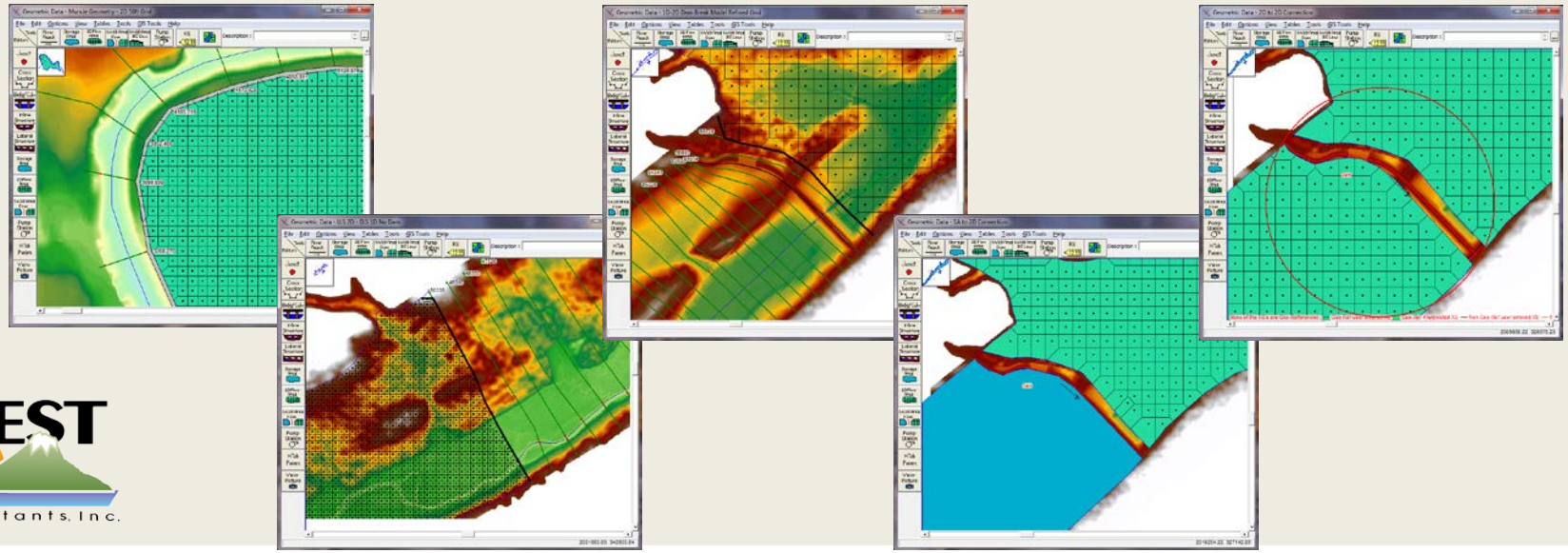
2D AREA CONNECTIONS

- Connect with 1D Reach via Lateral Structure
- Connect with 1D Reach at U/S End of Reach
- Connect with 1D Reach at D/S End of Reach
- Connect with Storage Area via Inline Structure
- Connect with another 2D via Hydraulic Structure



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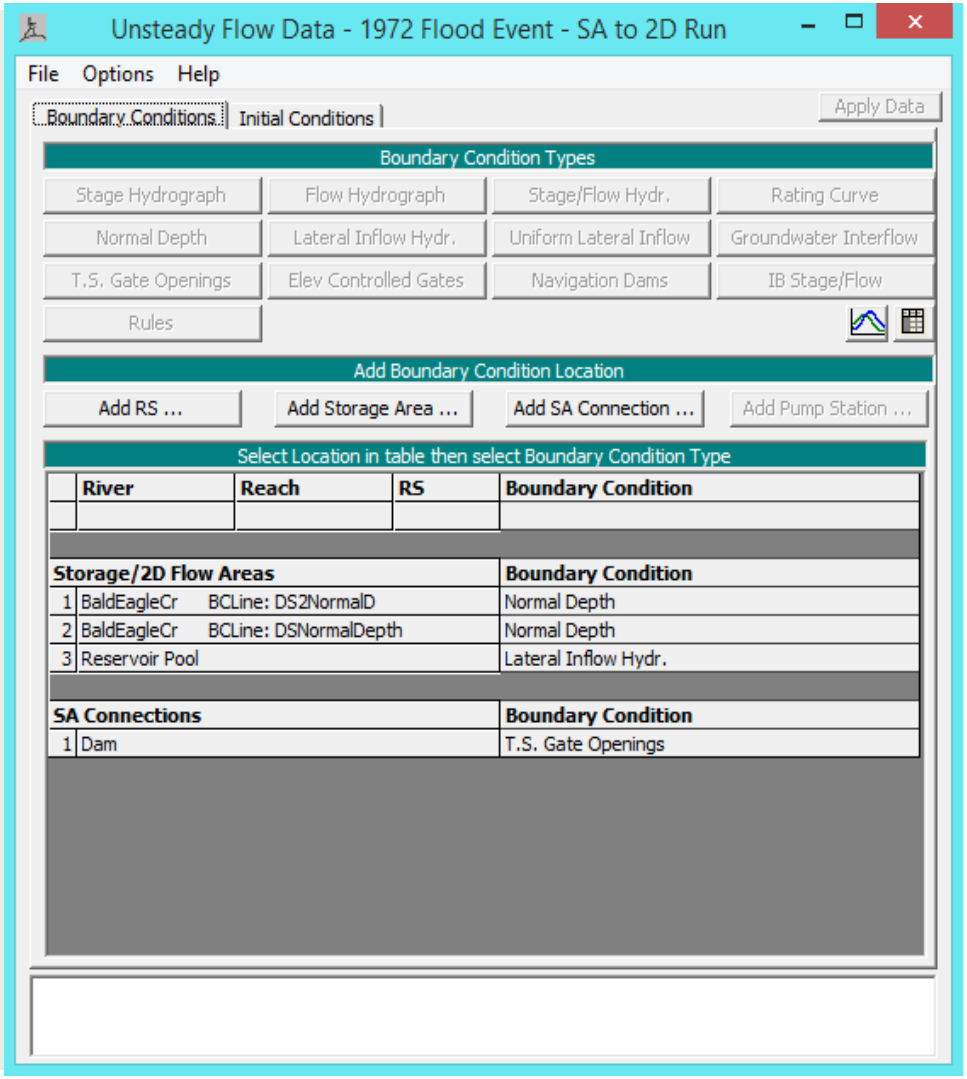
EXTERNAL BOUNDARIES

- Flow hydrograph
- Stage hydrograph
- Normal depth (at downstream end)
- Rating curve (at downstream end)



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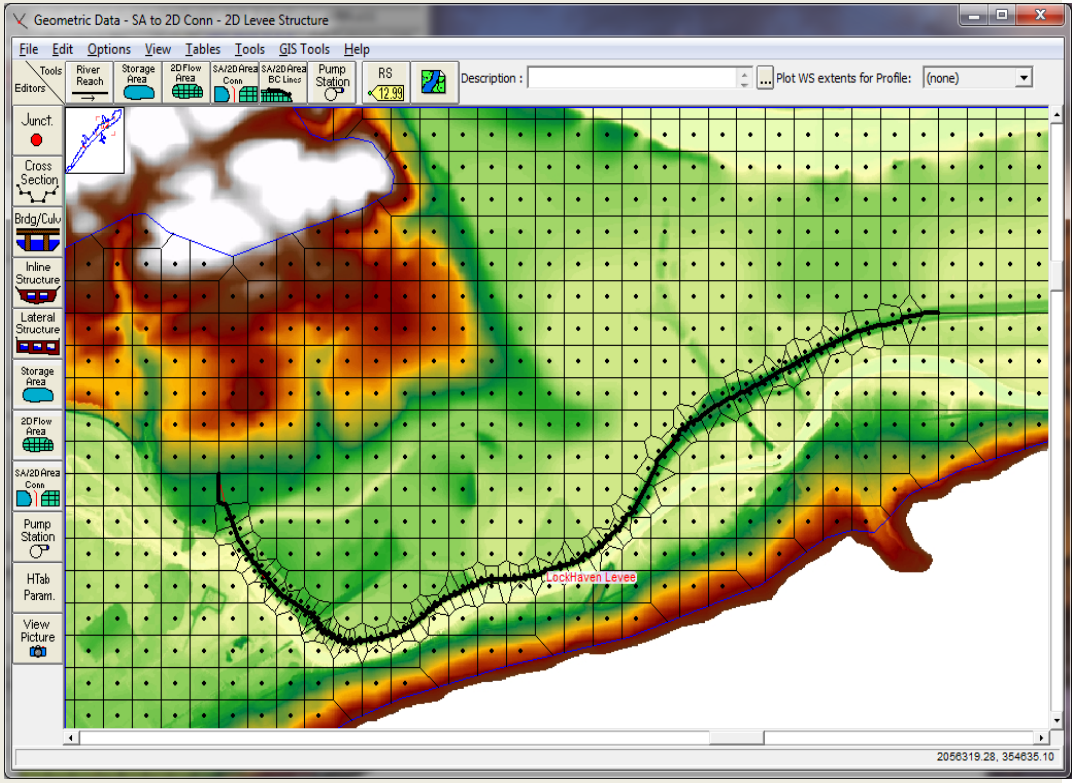
INTERNAL BOUNDARIES/STRUCTURES

- Ensure that the faces of the cells are oriented along the centerline of the boundary or structure
- Flow can be calculated using either weir equation or the 2D equation domain



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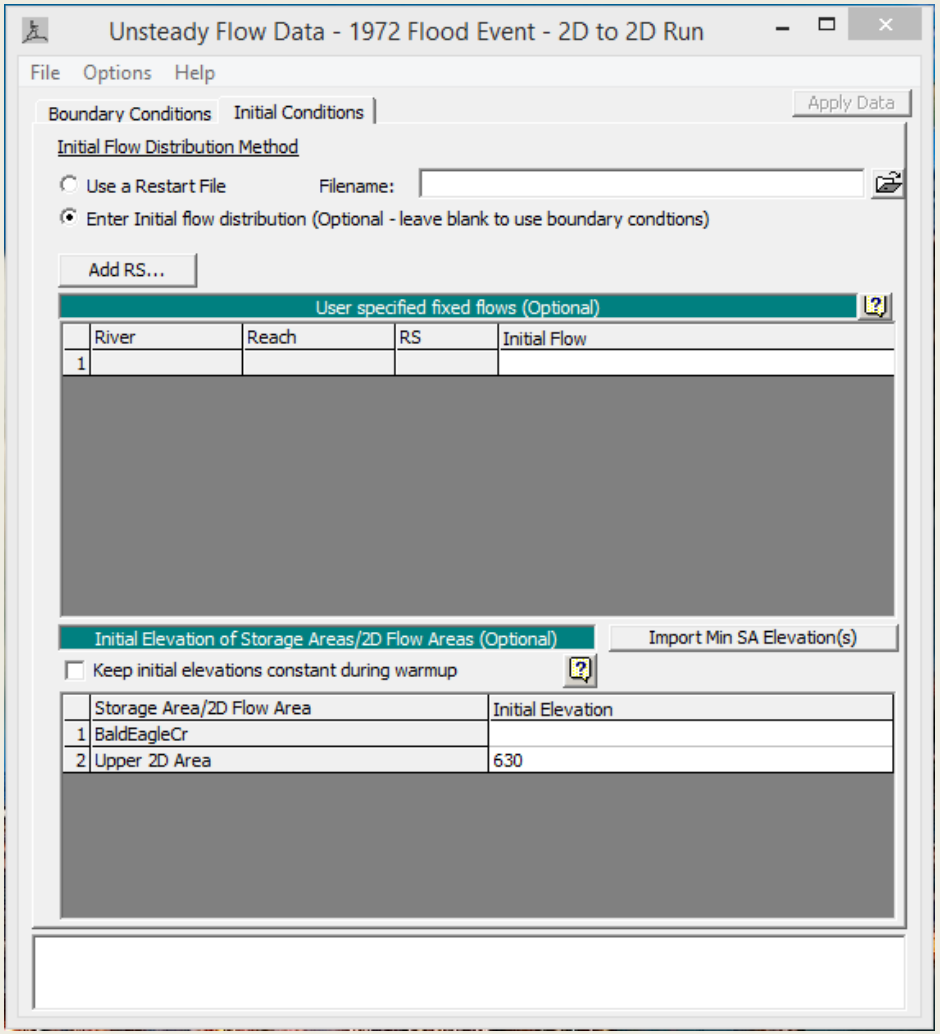
MODELING PROCEDURE: INITIAL CONDITIONS

- Dry
- Single WSE
- Restart File



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CURRENT 2D LIMITATIONS

- Only one n-value for each 2D flow area.
- Limited computational mesh setup toolbox.
- Cannot have “dry” 1D cross sections when connecting directly to a 2D area.
- Cannot have varied WSEs as initial conditions.
- Cannot model pressure flow under bridges in 2D areas.
- Hydraulic property tables are more accurate with high-resolution elevation data (e.g., LiDAR). Without this data, larger grid sizes are not appropriate.

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TAKEAWAYS

- **Unique and Robust Approach to Incorporating Terrain Data in Computations**
  - **Elevation-Volume Relationship for Each Element**
  - **Hydraulic Parameters for Each Element Face**
- **Strong Ability to Model Coupled 1D and 2D Areas**

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THANK YOU!

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