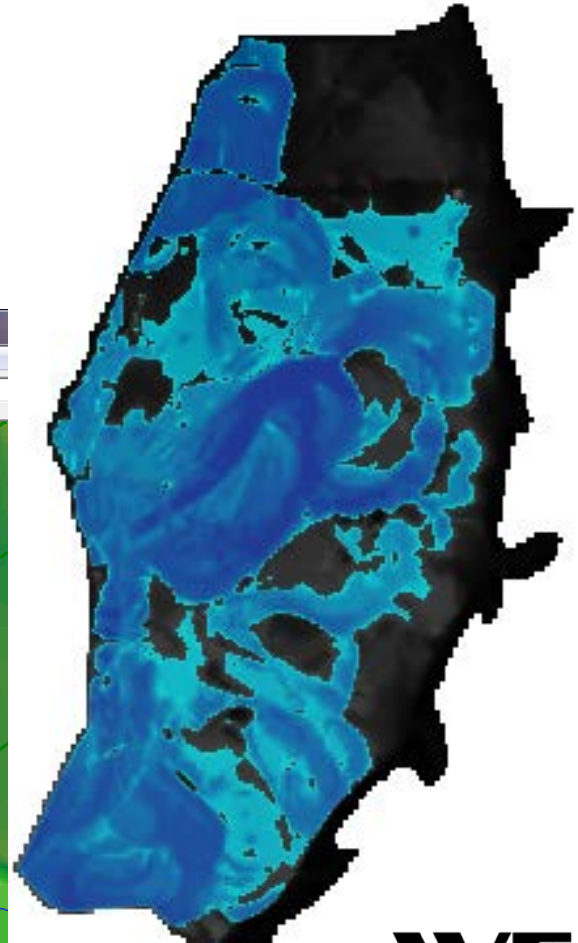
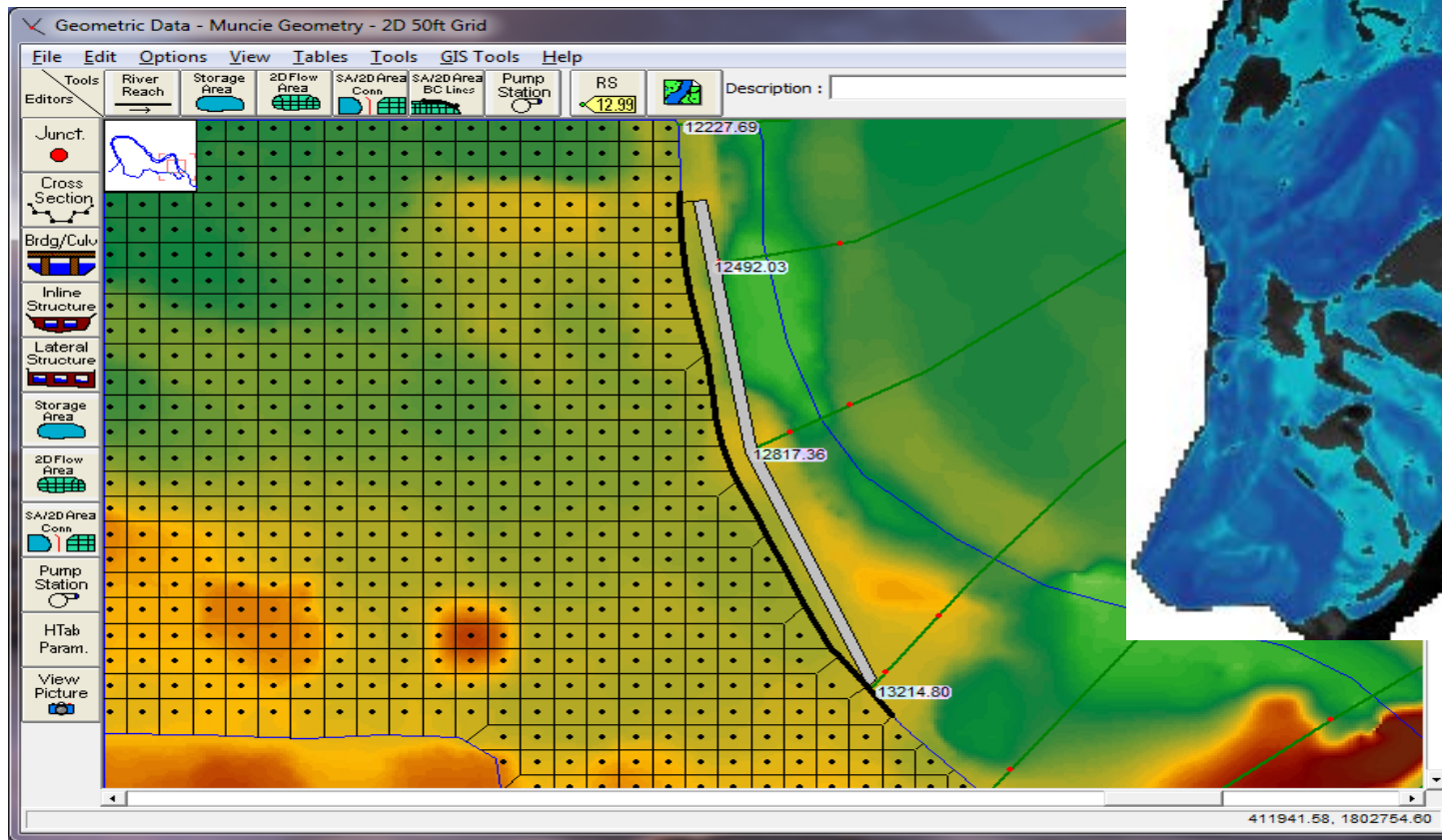


TWO-DIMENSIONAL CAPABILITIES OF HEC-RAS

Kevin Denn, P.E.
NHEC 2014



ACKNOWLEDGEMENTS

Gary Brunner, P.E., D.WRE
Hydrologic Engineering Center
(HEC)



OUTLINE

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

DEVELOPMENT IMPETUS

- **Dam and Levee Breaches**

- USACE Mapping, Modeling, & Consequence Production Center
- USACE Risk Management Center

- **USACE I**

- Integrated
- I

- **HEC was**

- Poor model stability
- Relatively long model run time

**Build 2D Component
into HEC-RAS!**

EXAMPLE APPLICATIONS

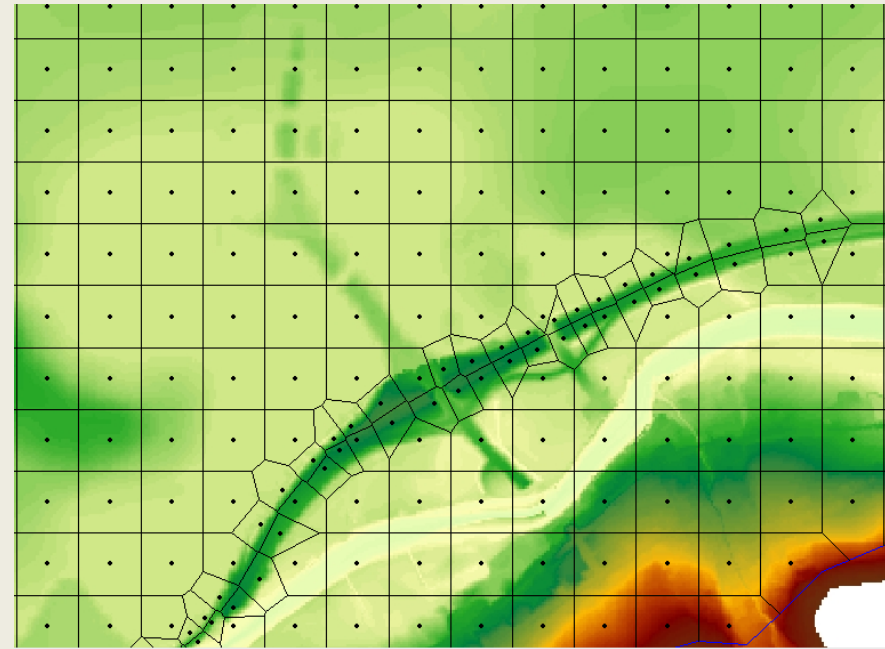
- Detailed 2D channel modeling
- Detailed 2D channel and floodplain modeling
- Combined 1D channels with 2D floodplain areas
- Subcritical and supercritical areas

OUTLINE

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

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

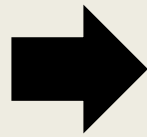


COMPUTATIONAL SCHEME



COMPUTATIONAL SCHEME

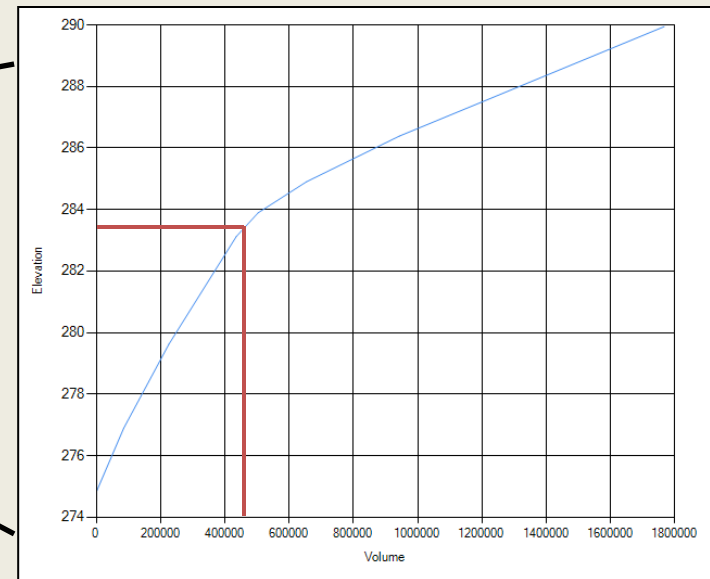
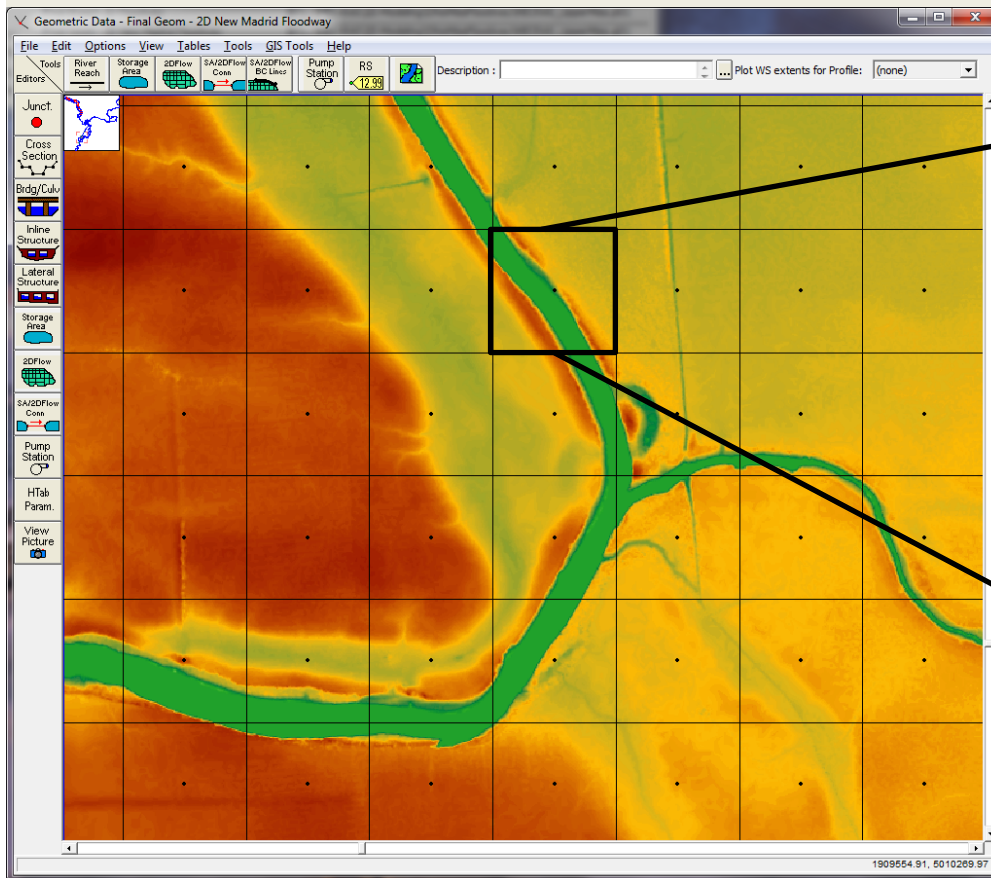
- **Typical 2D Model:**
 - Center of element (single average elevation)
 - Element boundary points (sloped element)



**Masks detail of
underlying terrain**

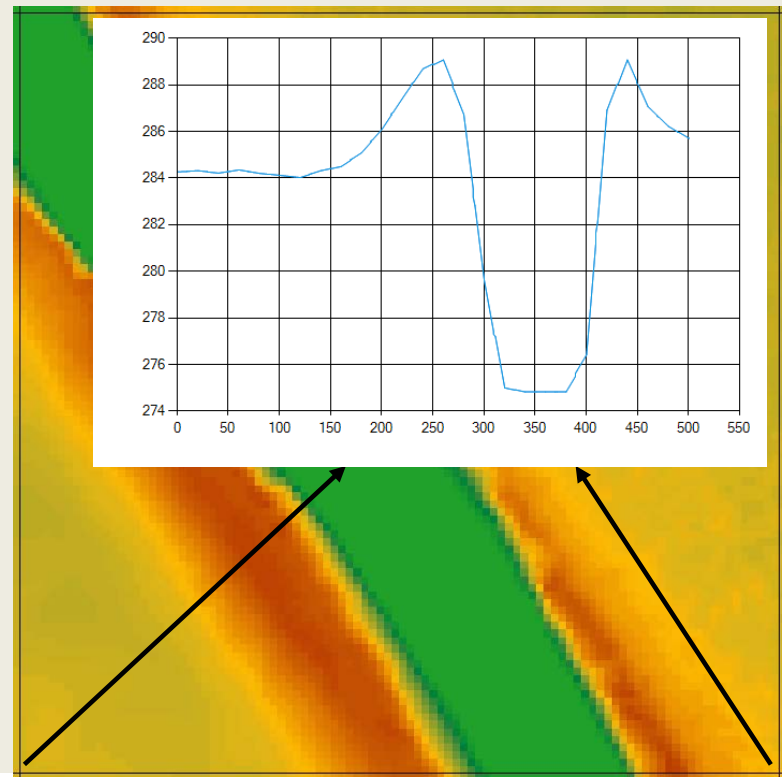
COMPUTATIONAL SCHEME

- 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



COMPUTATIONAL SCHEME

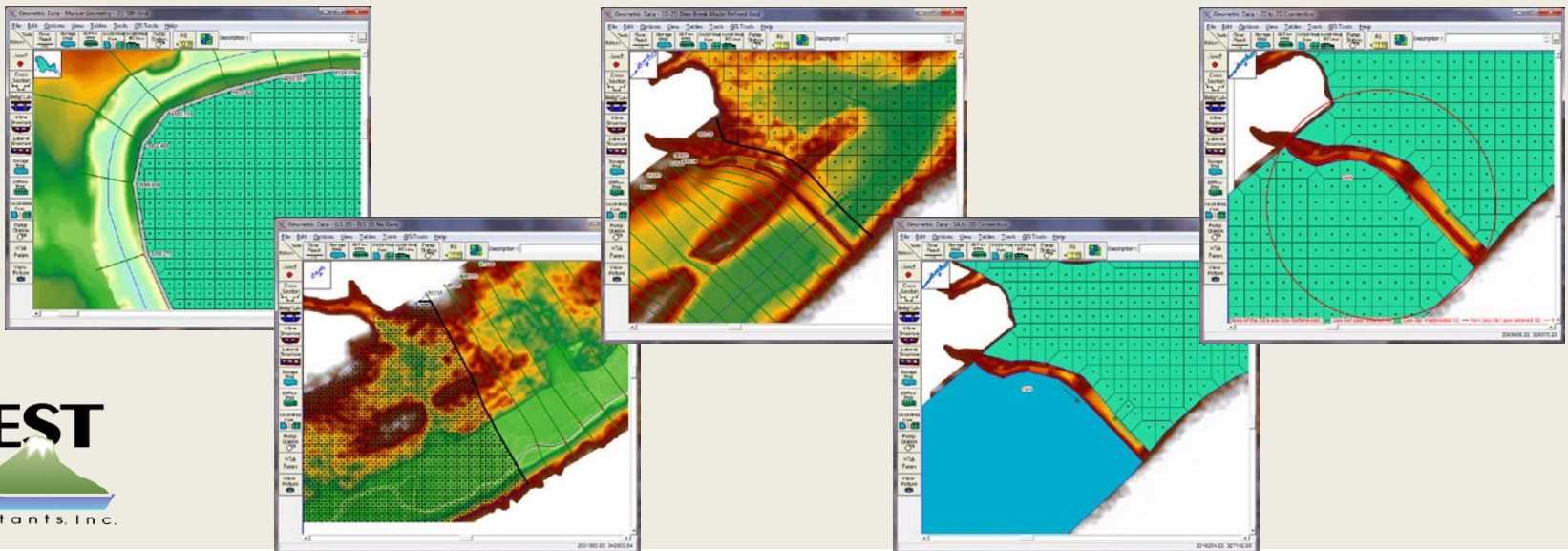
- **What Does This Mean?**
 - Cell can be 'partially wet'
 - More detailed results
 - *Potentially* larger cell sizes can be used compared to models that solely use a node-based approach
 - Faster model run times
- **Does not mean you can use infinitely large cells**
 - Water surface slope
 - Terrain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

OUTLINE

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

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



OUTLINE

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

EXTERNAL BOUNDARIES

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

Unsteady Flow Data - 1972 Flood Event - SA to 2D Run

File Options Help

Boundary Conditions Initial Conditions Apply Data

Boundary Condition Types

Stage Hydrograph	Flow Hydrograph	Stage/Flow Hydr.	Rating Curve
Normal Depth	Lateral Inflow Hydr.	Uniform Lateral Inflow	Groundwater Interflow
T.S. Gate Openings	Elev Controlled Gates	Navigation Dams	IB Stage/Flow
Rules			

Add Boundary Condition Location

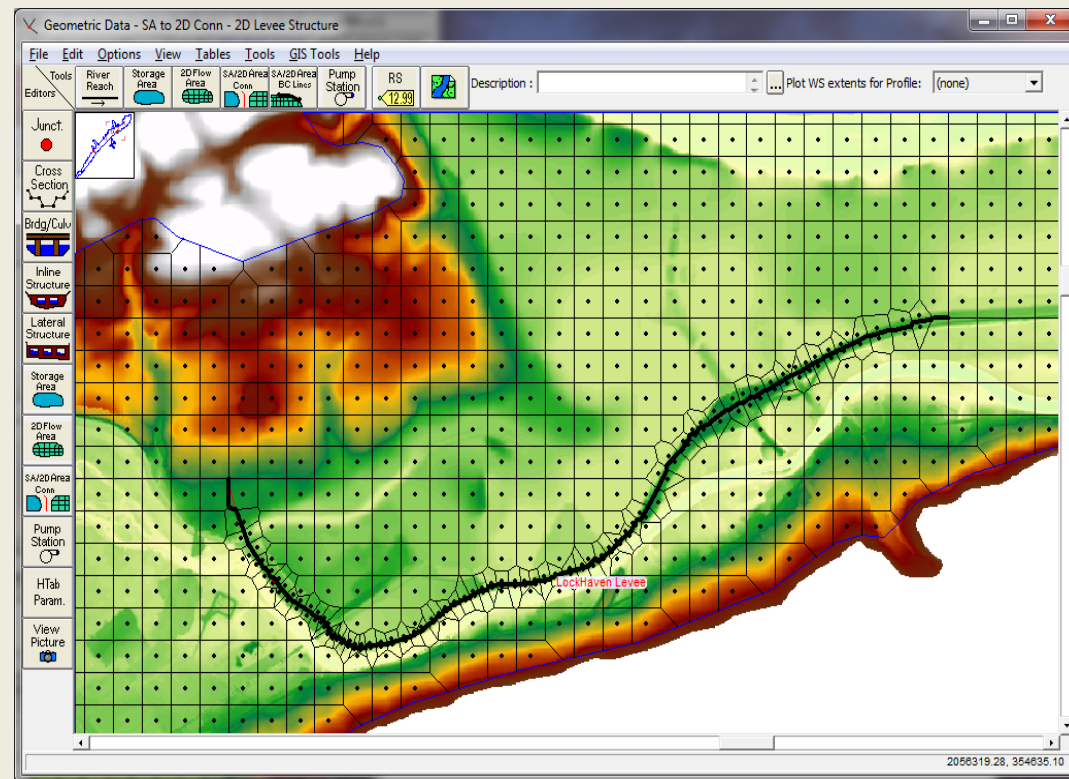
Add RS ... Add Storage Area ... Add SA Connection ... Add Pump Station ...

Select Location in table then select Boundary Condition Type

River	Reach	RS	Boundary Condition
Storage/2D Flow Areas			
1	BaldEagleCr	BCLine: DS2NormalD	Normal Depth
2	BaldEagleCr	BCLine: DSNormalDepth	Normal Depth
3	Reservoir Pool		Lateral Inflow Hydr.
SA Connections			
1	Dam		T.S. Gate Openings

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



OUTLINE

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

MODELING PROCEDURE: INITIAL CONDITIONS

- Dry
- Single WSE
- Restart File

Unsteady Flow Data - 1972 Flood Event - 2D to 2D Run

File Options Help

Boundary Conditions Initial Conditions Apply Data

Initial Flow Distribution Method

☐ Use a Restart File Filename:

☒ Enter Initial flow distribution (Optional - leave blank to use boundary conditions)

Add RS...

User specified fixed flows (Optional) [?]

	River	Reach	RS	Initial Flow
1				

Initial Elevation of Storage Areas/2D Flow Areas (Optional) Import Min SA Elevation(s)

☐ Keep initial elevations constant during warmup [?]

	Storage Area/2D Flow Area	Initial Elevation
1	BaldEagleCr	
2	Upper 2D Area	630

OUTLINE

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

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.

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**

THANK YOU!

www.TheRASSolution.com

Email: kdenn@westconsultants.com

Phone: (503) 485-5490