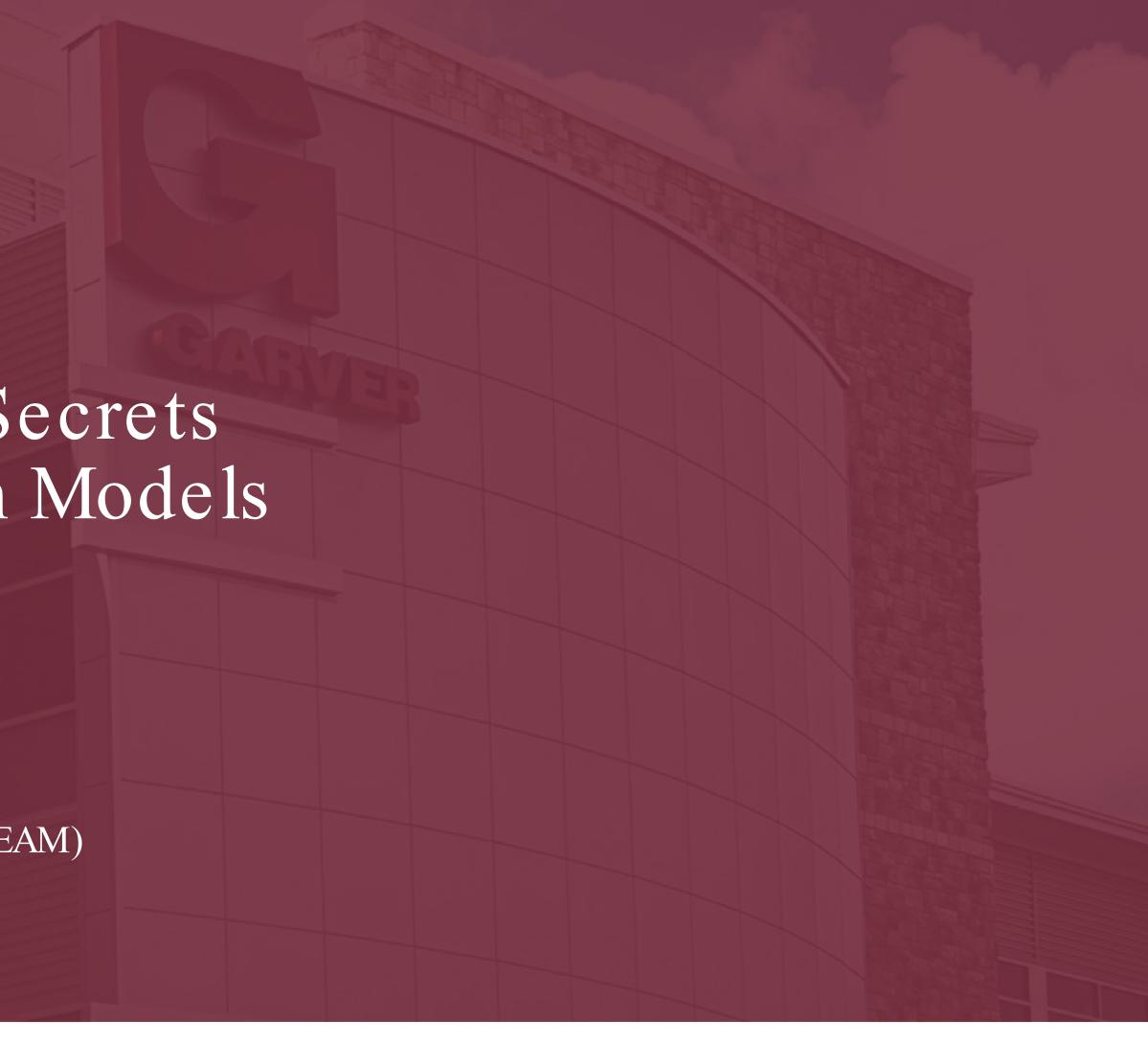
Sherlock Hydro

Unlocking Hydrologic Secrets Using Rain-on-Mesh Models

Alan Dennis March 14, 2024 Transportation Engineers' Association of Missouri (TEAM) 2024 Conference





INTRODUCTION

"The game is afoot"

- Rain on mesh modeling
- Application to roadway corridors





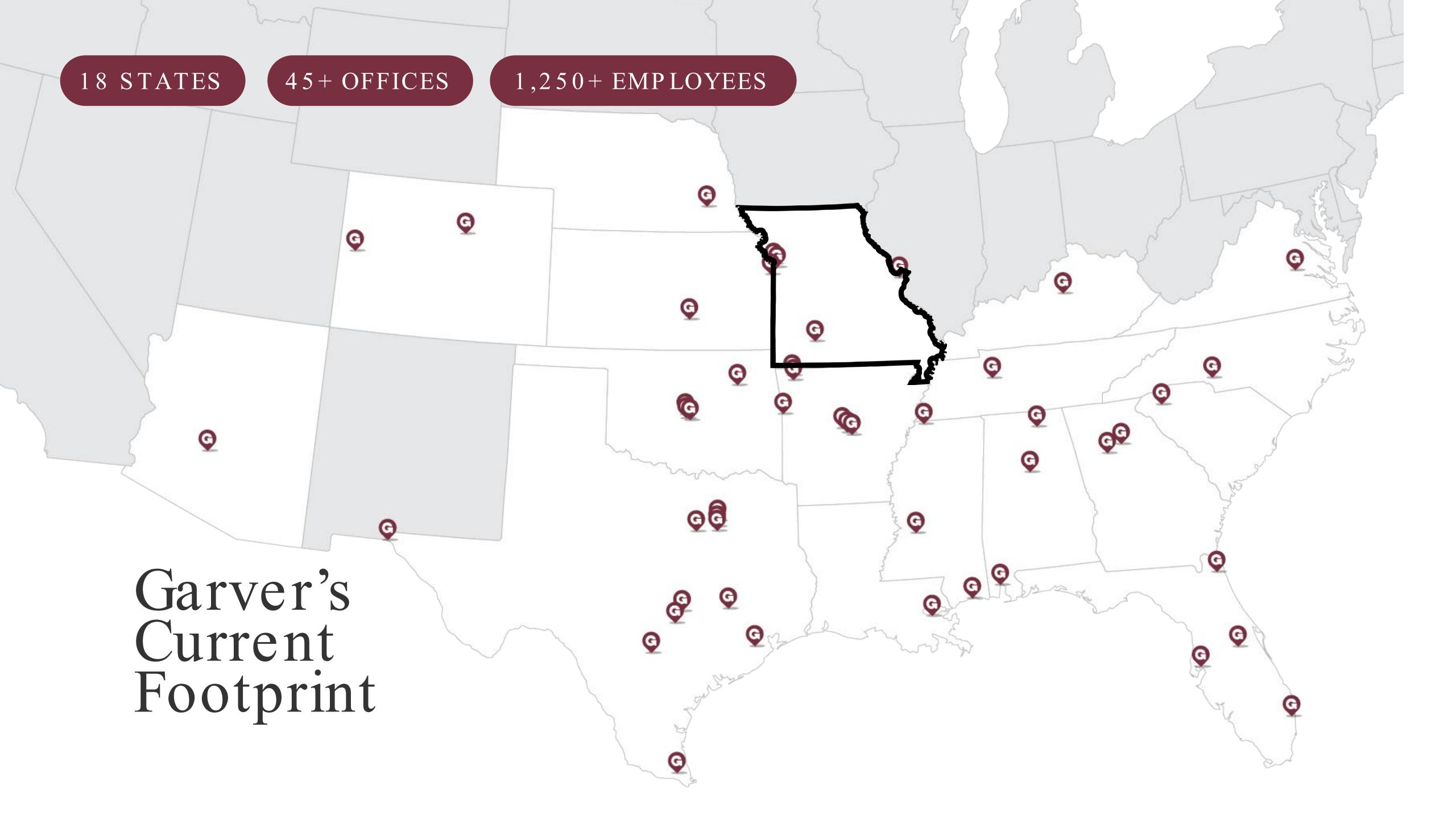


Get to know us

0







Presentation Outline

Topic Introduction

- Methodology
- Technical Details
- Results
- Challenges and Solutions
- Future Work
- Conclusion and Questions

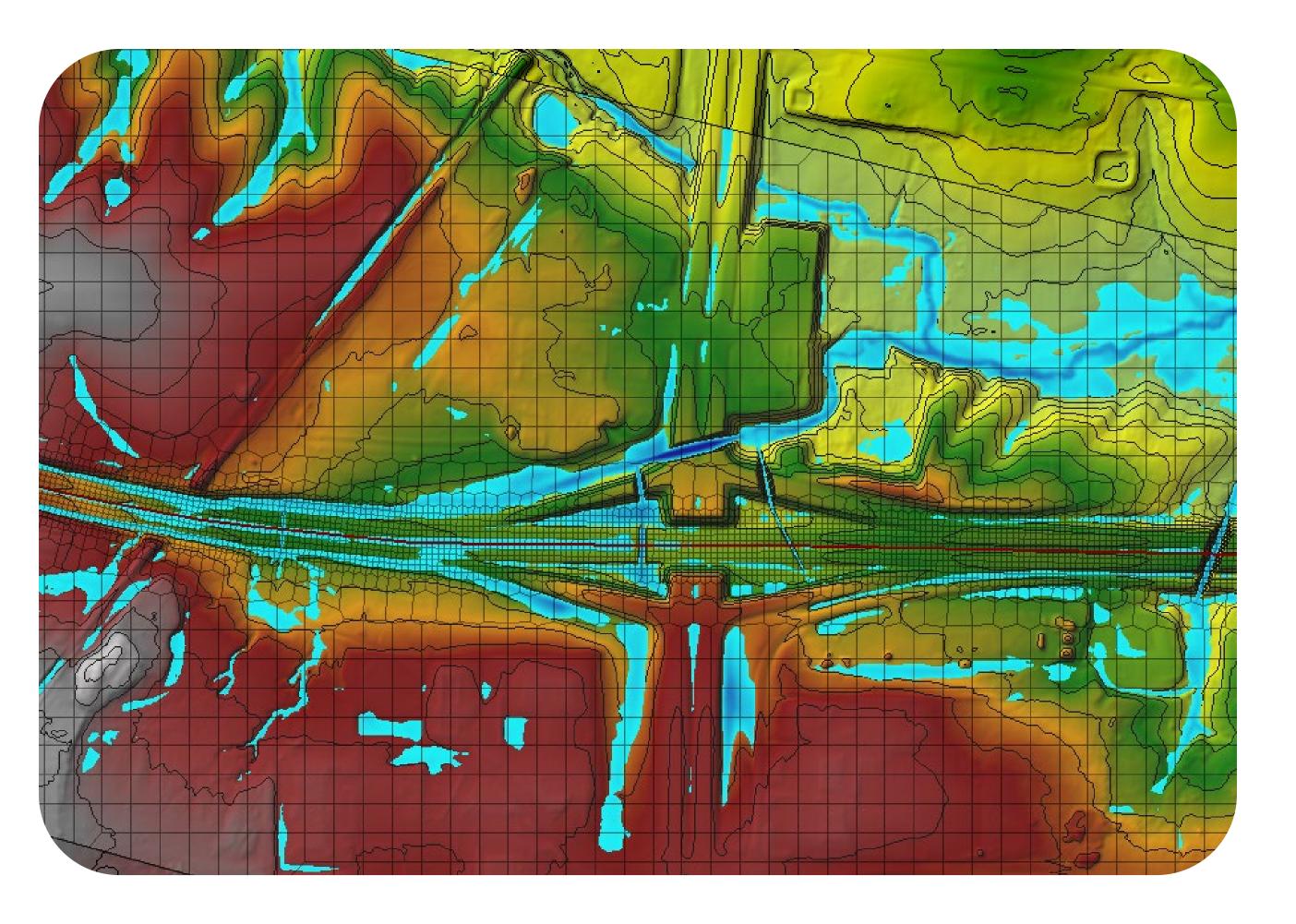




"You see, but you do not observe"

- Objectives:
 - Understand 2D Rain on Mesh Hydraulic Modeling Concepts
 - Understand Application to Roadway Engineering
 - Consider Additional Applications
 Of Methodology





INTRODUCTION

"All models are wrong, but some are useful"

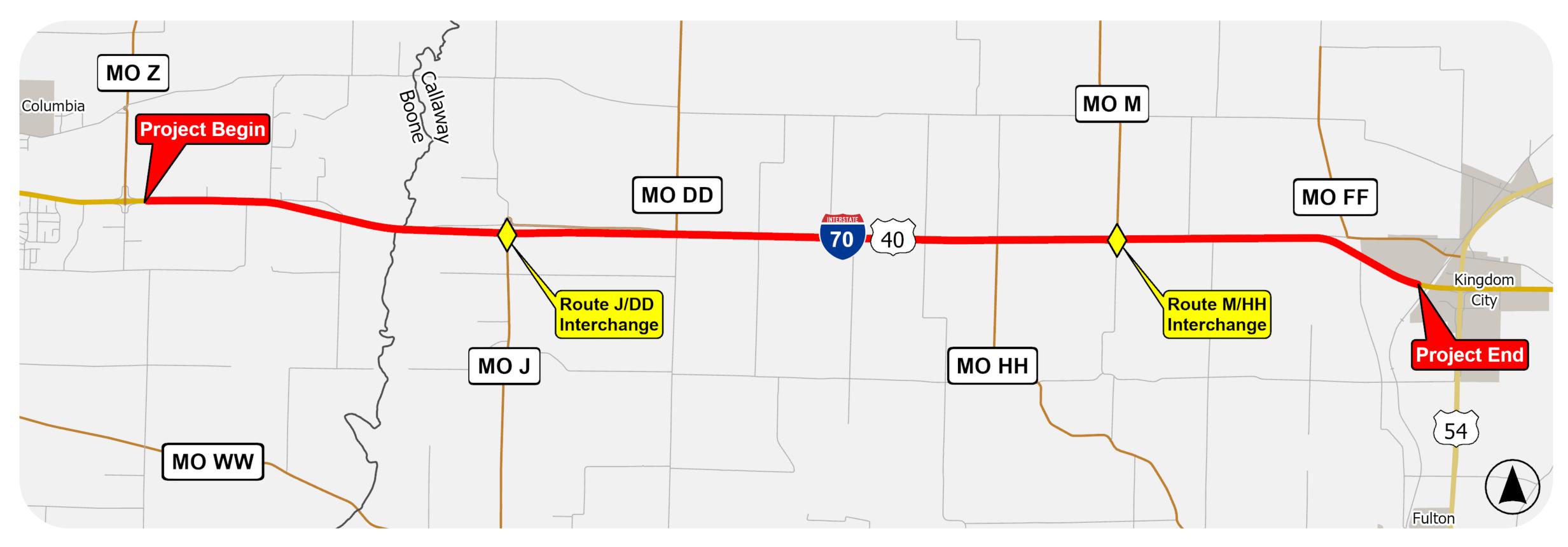




GEORGE P. BOX



I-70 SIU 5 Corridor – Case Study







I-70 SIU 5 Corridor – FEMA Floodplains

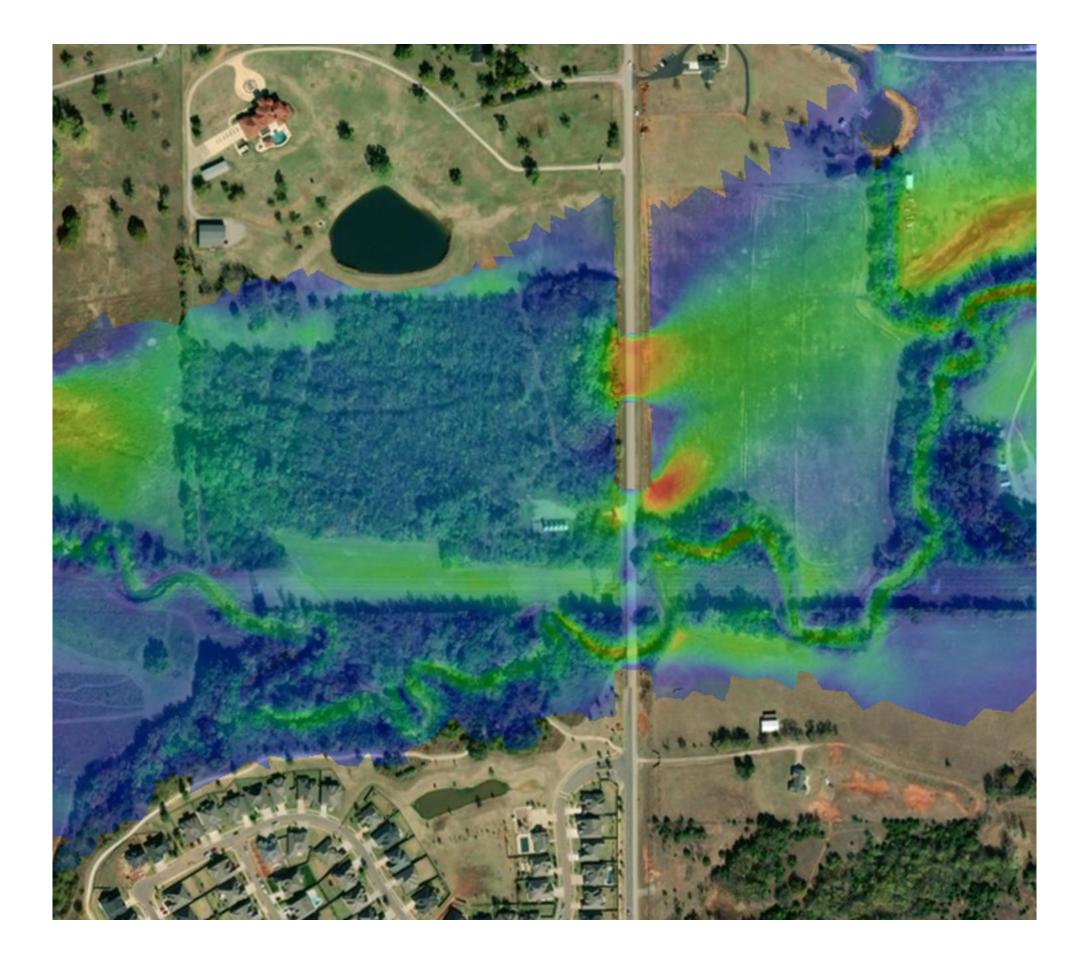




Key Concepts in 2D Hydraulics

- Flow in both X-Y directions
- Depth Averaged velocity at each cell
- More data points
 - WSEL and Velocity/ Shear Stress
- Easy to make something that looks good and means nothing





Key Concepts in Rain-on-Mesh Modeling

- Additional Layers Required:
 - Precipitation
 - Atlas 14
 - Infiltration
 - SCS Curve Number
 - Hydraulic Roughness
 - Manning's *n* Layer





Image courtesy of INTOSAI Journal, 2016



"Data! Data! Data! I can't make bricks without clay."

• Technical Details related to R-O-M Study of I-70 Corridor



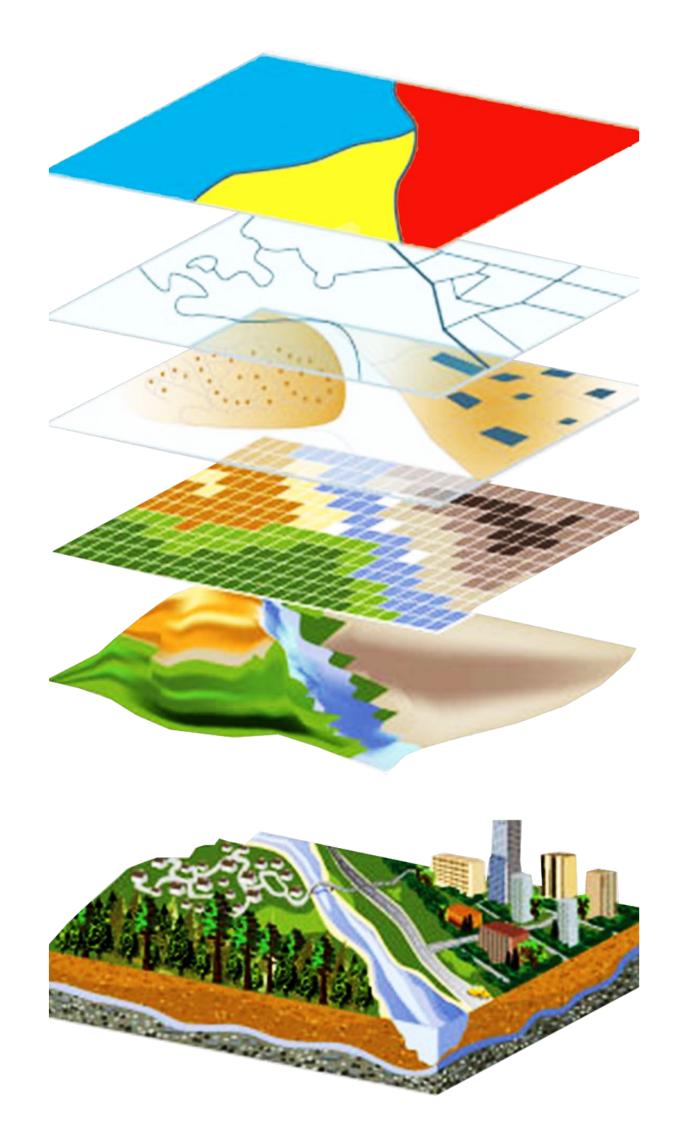


Image courtesy of INTOSAI Journal, 2016



I-70 SIU 5 Corridor – Where Are the Cross Drains?



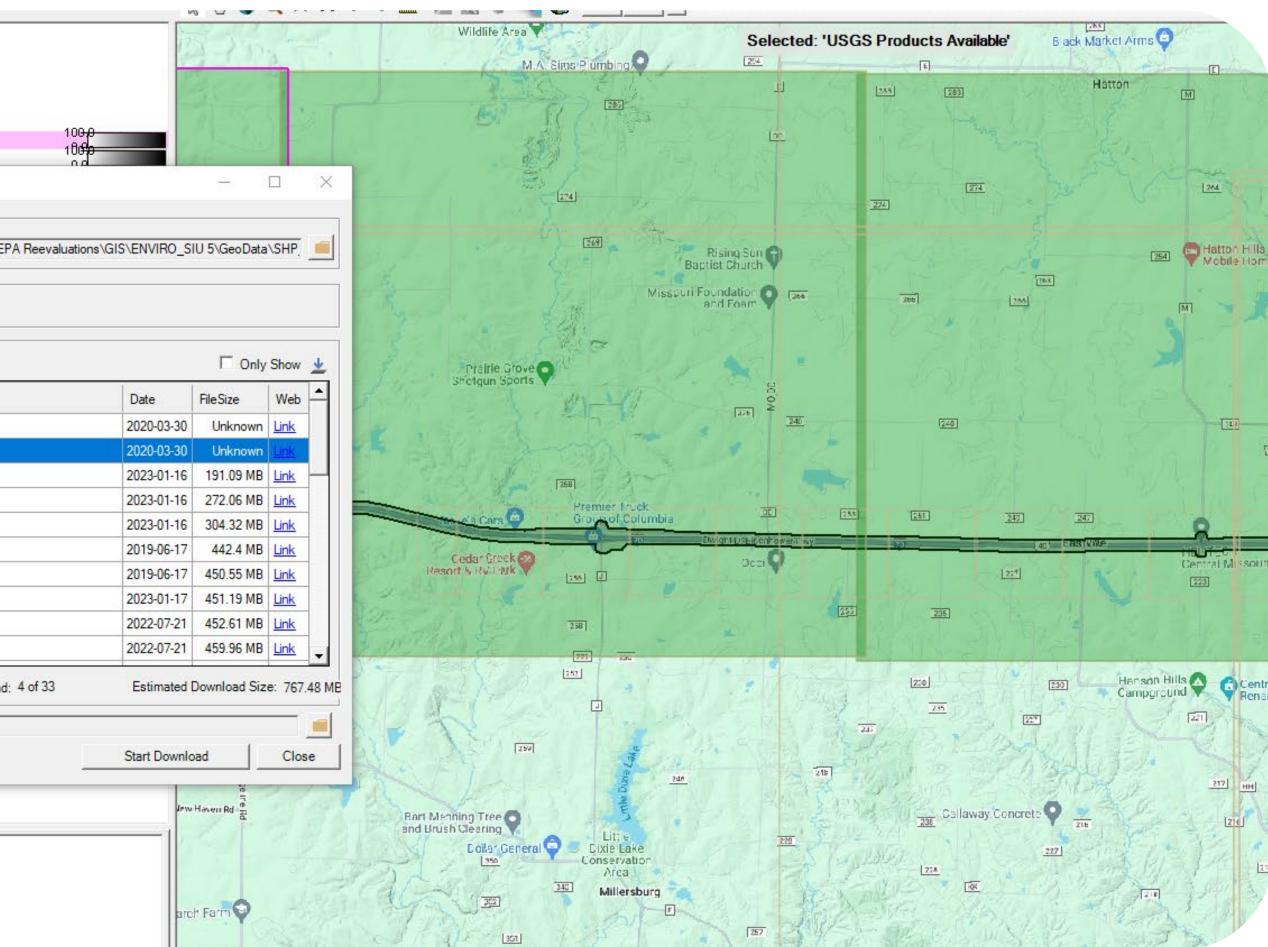


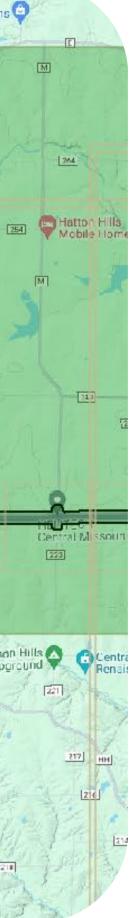
Data Collection

- Topography
 - USGS Lidar
 - Downloaded within RASMapper

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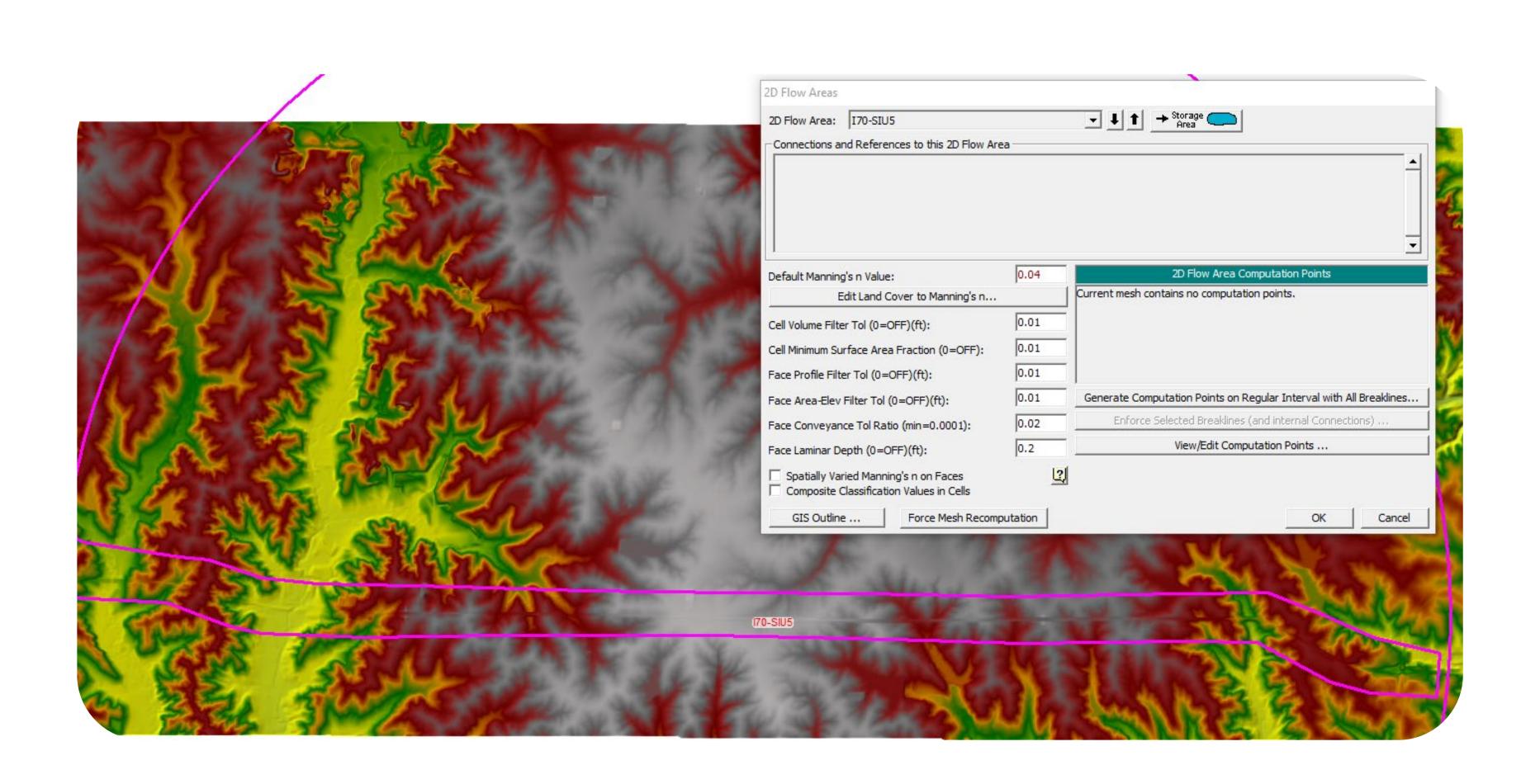






2D Computational Mesh Development

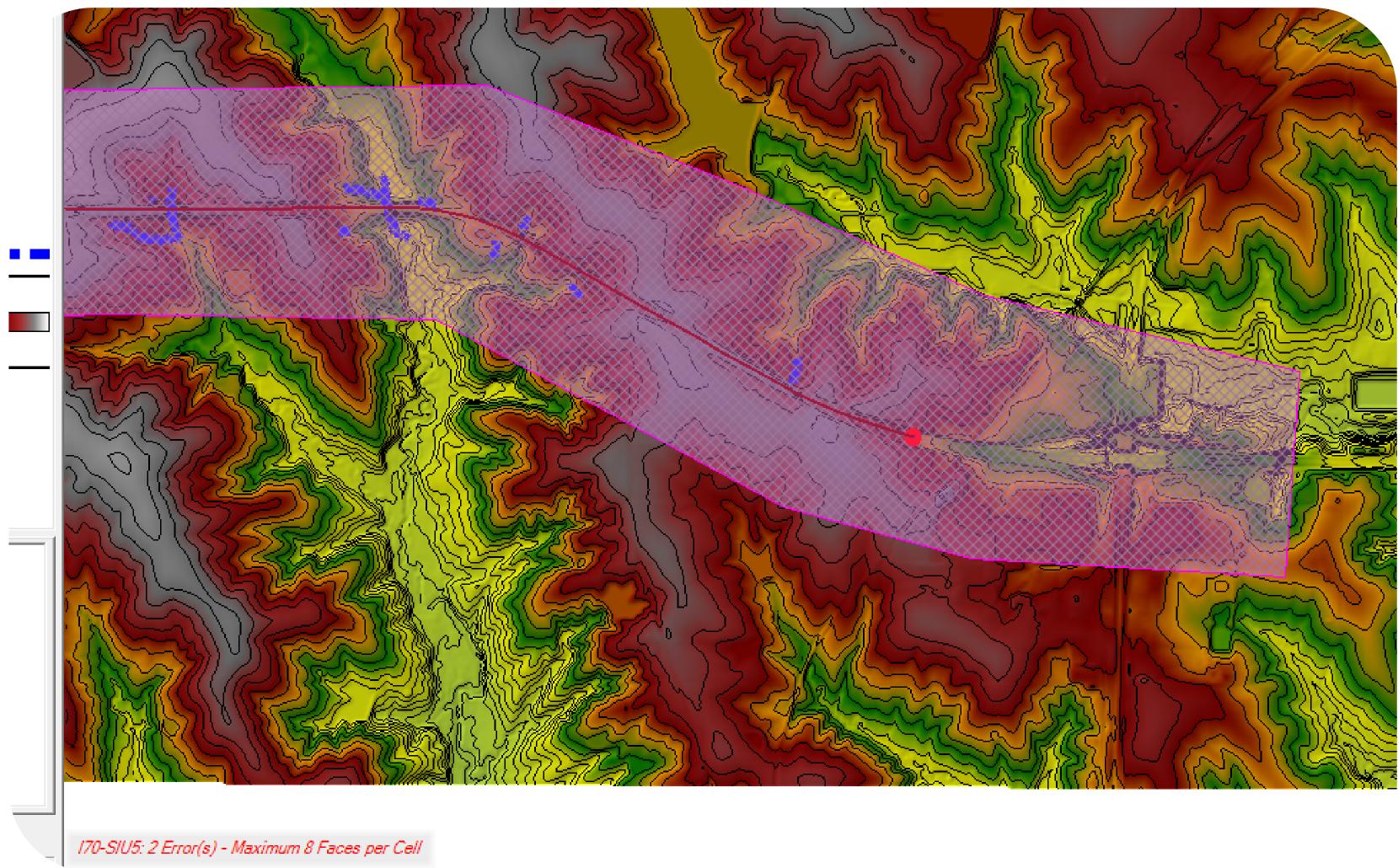
• Includes Entire Corridor





2D Computational Mesh Development

- Add Breaklines
- Address Errors • (See Next Slide)







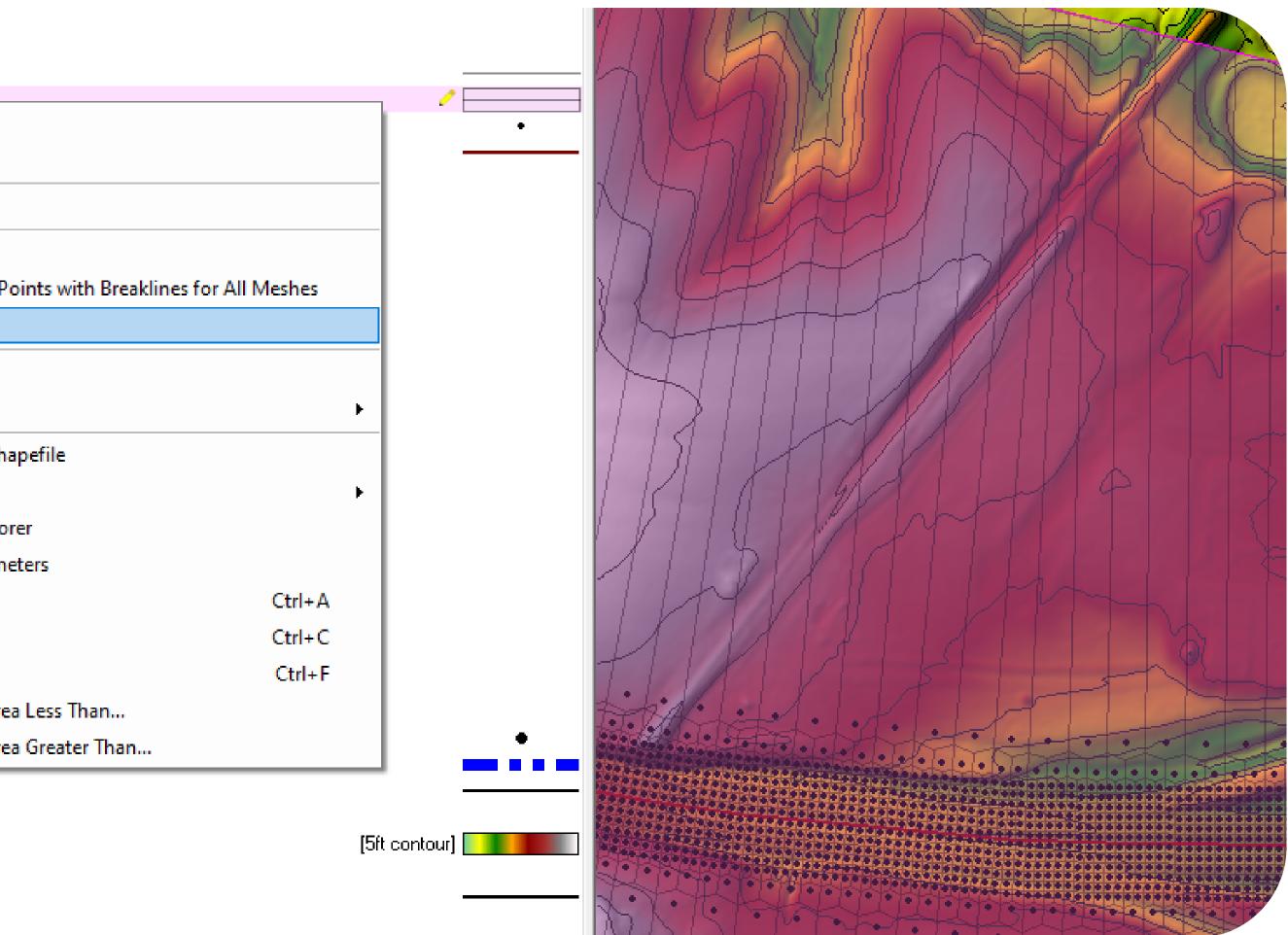
2D Computational Mesh Development

Address Errors

| Juss Sections | |
|--|----------------------------|
| Storage Areas | |
| 🗾 2D Flow Areas 📍 | |
| Perimetere | |
| 🗸 🗸 Computal | Layer Properties |
| ···· ⊡ Breakline ⊞ ···· ⊡ <i>Refineme</i> | Open Attribute Table |
| 🔄 Bridges/Culv 🥥 | Stop Editing |
| 🔄 Inline Structu 🔄 Lateral Struct | Edit 2D Area Properties |
| 🔄 🔄 SA/2D Conn 🚰 | Generate Computation Po |
| Pump Station Boundary Co | Try to Fix All Meshes |
| 🗍 Initial Conditie 词 | Zoom to Layer |
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| - Reference Al 👱 | Import Features From Sha |
| Infiltration | Export Layer |
| 🔄 🗌 Percent Impe 💼 | Open Folder in File Explor |
| Errors | Remove Duplicate Perime |
| nt Conditions | Select All |
| ults 🖸 | Copy Selected Features |
| | Find |
| ilU5_FieldStudyf 🚩 | Select Polygons With Area |
| 70 SIU5 Hydr | |
| IU5_Streams_2L | Select Polygons With Area |
| IU5_CL_20231016 | |
| ains | |
| ull_Terrain_170 | |
| Modifications | |
| ጉ 🔽 Channels | |

Control Points





Precipitation Input

- Atlas 14
 - Precip Depth

| Data description | |
|--|--|
| Data type: Precipitation depth 🗸 Units: English 🗸 Time series type: Partial duration 🗸 | |
| Select location | |
| 1) Manually: | |
| a) By location (decimal degrees, use "-" for S and W): Latitude: Longitude: Submit | |
| b) By station (list of MO stations): Select station | |
| c) By address Search Q | |
| 2) Use map: | |
| n Terrain Iowa St Joseph 3 hattan | a) Select location Move crosshair or double click b) Click on station icon Show stations on map |



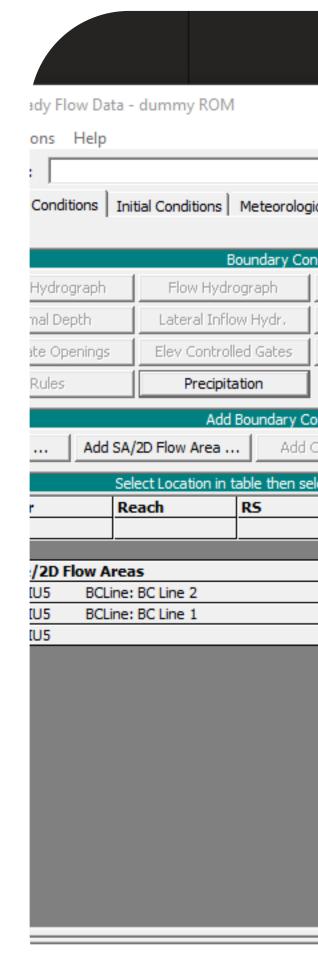


NOAA ATLAS 14 POINT PRECIPITATION FREQUENCY ESTIMATES: MO



Precipitation Input

- Atlas 14
 - Precip Depth







| Data des | scription | | | |
|---|--------------------------------------|------------------------------------|------------|------------|
| — П | ✓ Ipitation depth ♥ Units: English ♥ | Time series type: Partial duration | ~ | |
| | | | | |
| | | | 0.2 | 05 |
| 🚊 … 🛛 Apply D | ata | | _ | × |
| | | | _ | |
| ata Observed Data | 1 | | | |
| | 2D: 170-SIU5 | | | <u>Iri</u> |
| Types | | Select DSS file and Path | | |
| itage/Flow Hydr. Rating Curve | | | ROM.prj | <u> </u> |
| | | | ROM.p01 | |
| form Lateral Inflow Groundwater Interflow | | | ROM.g01 | |
| Javigation Dams IB Stage/Flow | | | | |
| [1] | | Data time interval: 1 Minute | ▼ ROM.u01 | |
| | Reference | | | |
| n Location | | 00 | US Custom | ary Units |
| Add Pump Sta Add Pipe Node | 2: Time: | | | |
| | · , · | | 0.1 | 15 |
| Indary Condition Type | g Values Del Row Ins | Row | (ij | |
| ndary Condition | Hydrograph Data | | | |
| | | Descisitation | | |
| | Simulation Time (hours) | Precipitation (in) | _ _ | |
| ndary Condition | 11:28:00 | 0.02 | | |
| al Depth | 11:29:00 | 0.02 | | |
| al Depth pitation | 11:30:00 | 0.02 | 0.1 | 10 |
| | 11:31:00 | 0.03 | | |
| | 11:32:00 | 0.03 | | |
| | 11:33:00 | 0.03 | | |
| | 11:34:00 | 0.03 | | |
| | 11:35:00 | 0.03 | | |
| | 11:36:00 | 0.03 | | |
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| | 11:38:00 | 0.03 | | |
| | 11:39:00 | 0.03 | | |
| | 11:40:00 | 0.03 | | |
| | 11:41:00 | 0.04 | | |
| | 11:42:00 | 0.04 | | |
| | 11:43:00 | 0.04 | _ | |
| | 11.11.00 | 10.04 | | |
| | 11:44:00 | 0.04 | 0.0 | |
| | 11:44:00 11:45:00 11:46:00 | 0.04 0.04 0.06 | 0.0 | |



Make The Model Useful

- Additional Layers Required:
 - Precipitation
 - Atlas 14
 - - SCS Curve Number
 - Hydraulic Roughness
 - Manning's *n* Layer



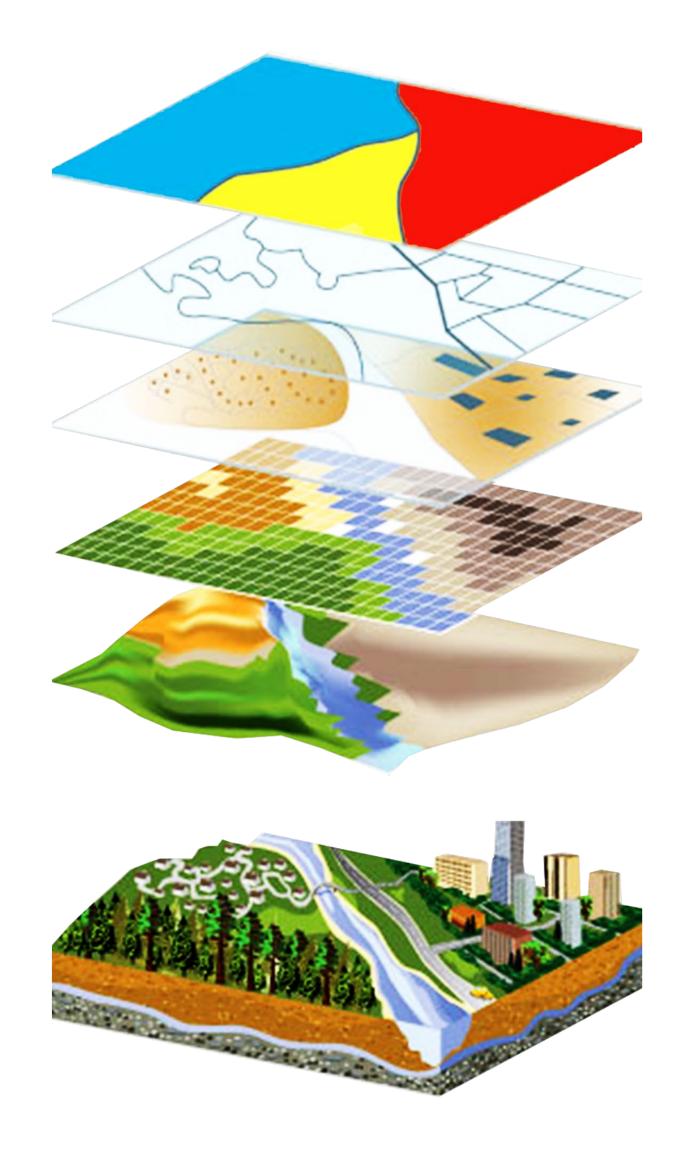


Image courtes y of INTOS AI Journal, 2016



"It's a three-pipe problem"

Results Visualization Case Study at I-70 -- SIU 5



Preliminary Results I-70 SIU 5 Corridor





Preliminary Results I-70 SIU 5 Corridor







Utilize Results

- Make the model useful
- Identify cross culverts
- Identify side drains

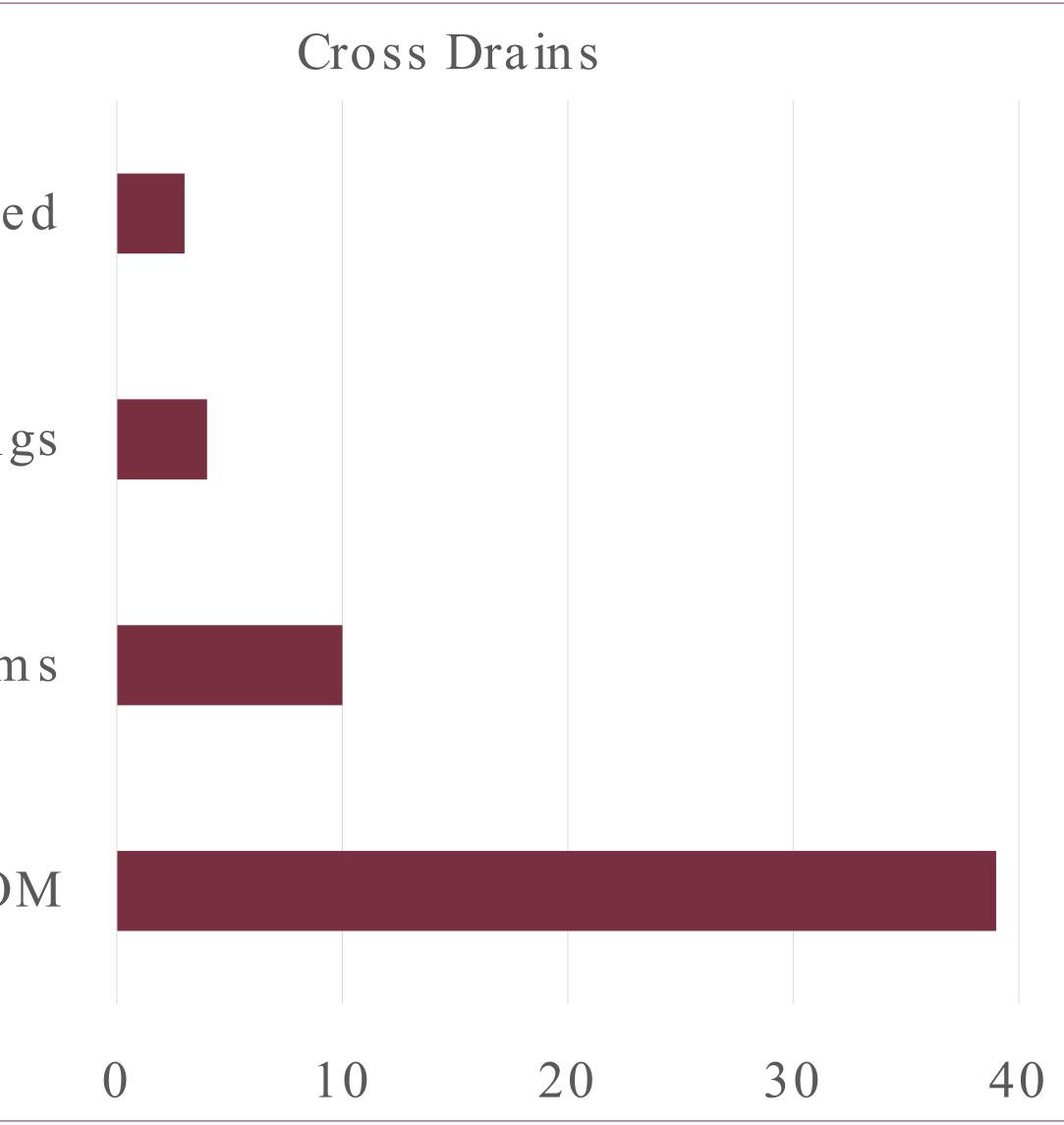
MoDOTNamed

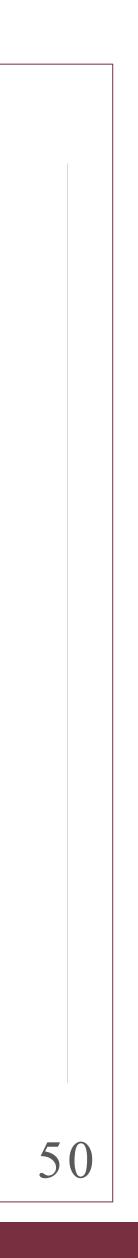
FEMA Crossings

Blue-Line Streams

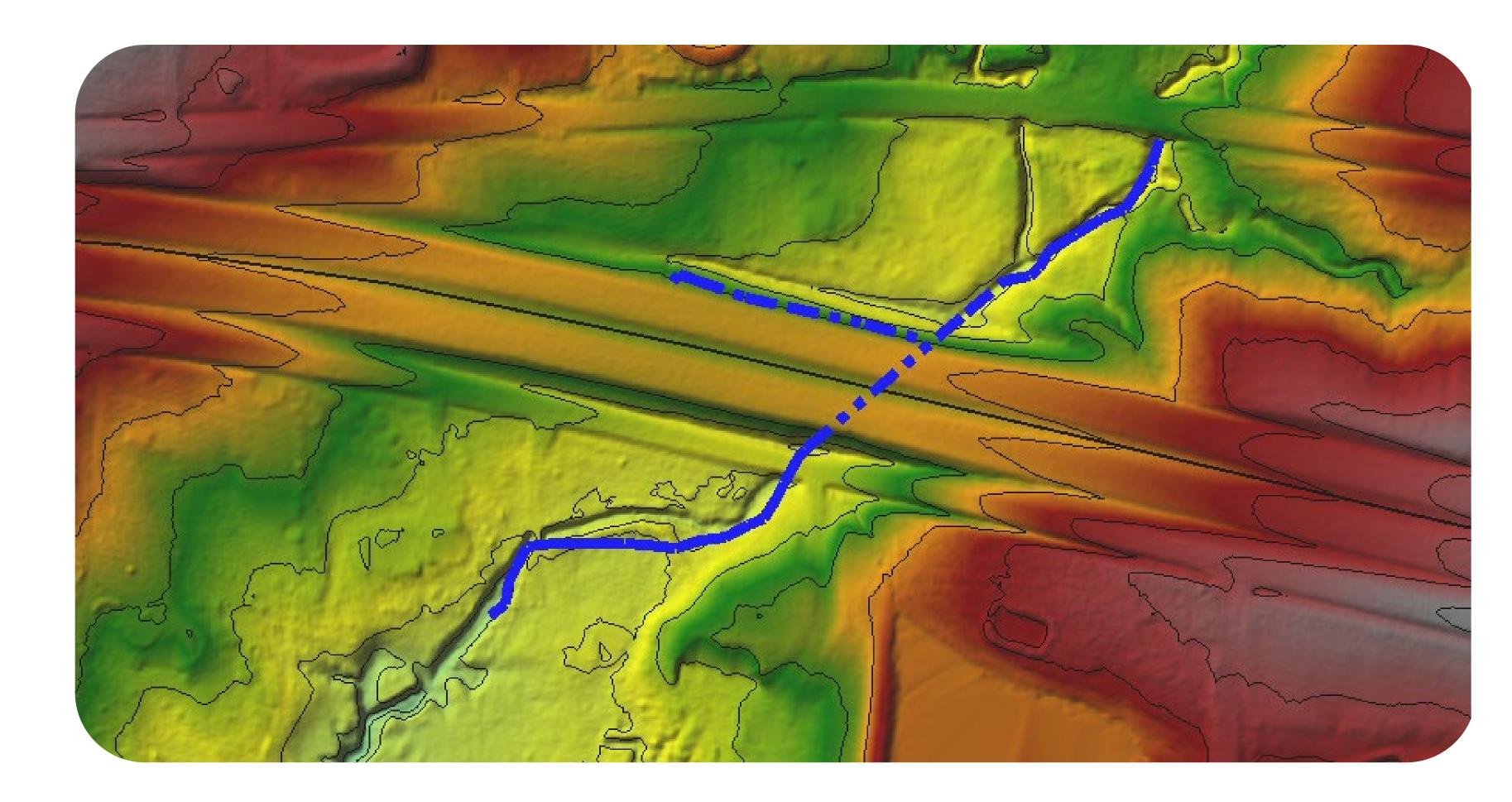
ID'd With ROM







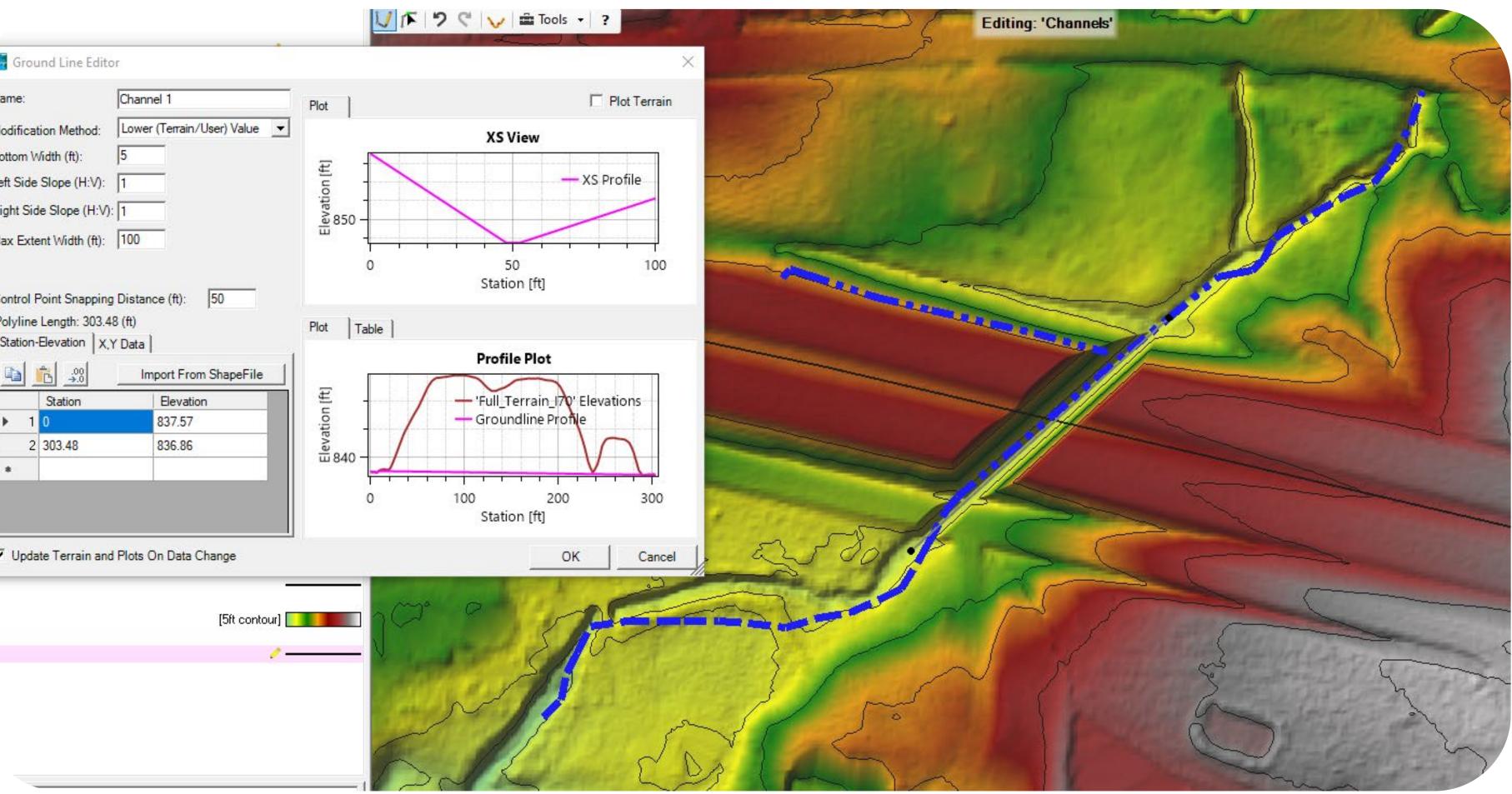
Iterate Hydroconnectors





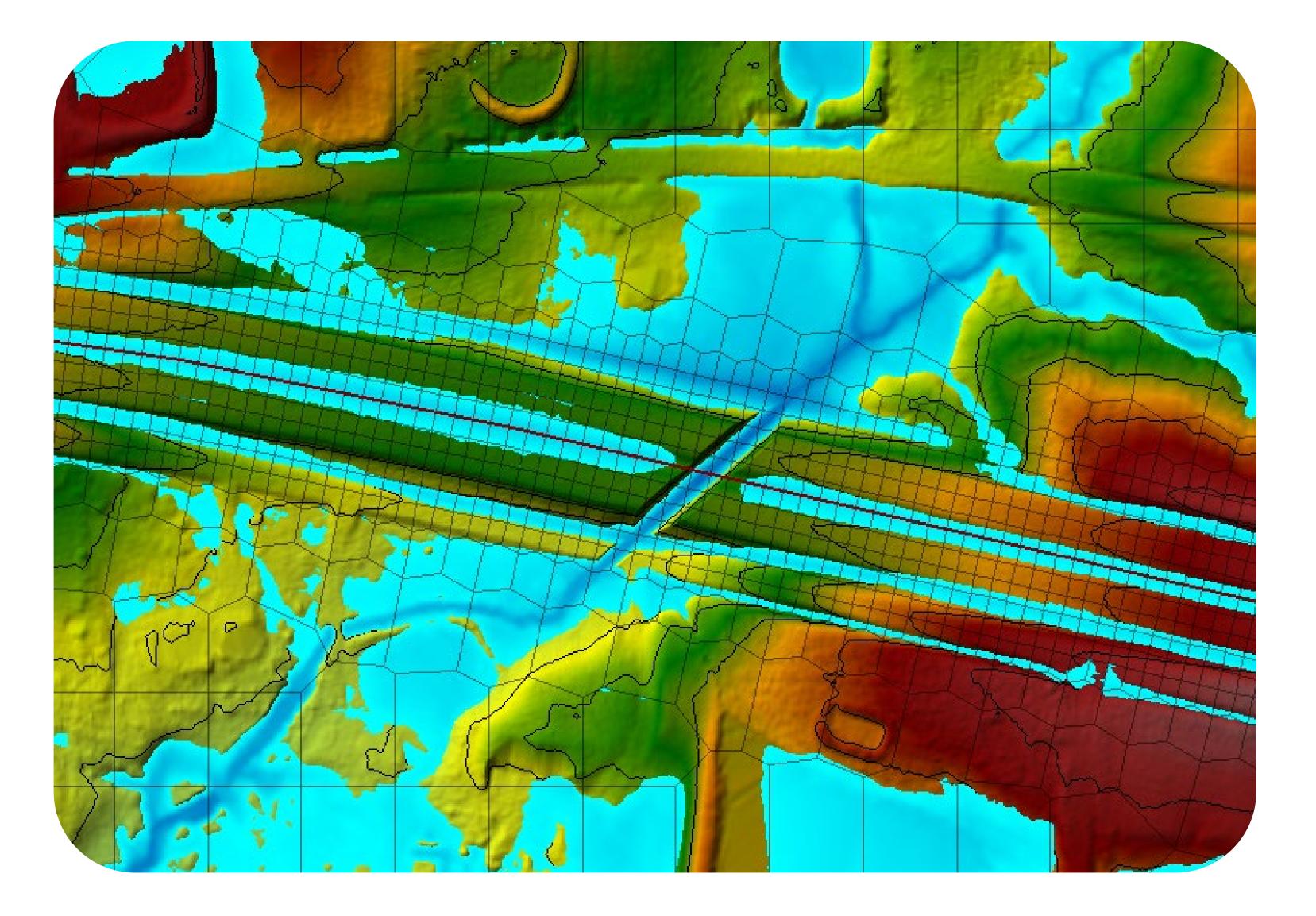
Iterate Hydroconnectors

| ame: | | Channel 1 | Plot |
|--------------------------------|---|---|----------------|
| odifica | tion Method: | Lower (Terrain/User) Value | - ' |
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| ft Side | Slope (H:V): | 1 | n [ft |
| ght Sid | de Slope (H:V |): 1 | Elevation [ft] |
| | | | - UCS U |
| ax Exte | ent Width (ft) | 100 | ш |
| ontrol I | | g Distance (ft): 50 | |
| ontrol I olyline | | g Distance (ft): 50 48 (ft) | Tal |
| ontrol I olyline Station | Point Snappin Length: 303. Elevation X | g Distance (ft): 50 48 (ft) ,Y Data | Plot Tat |
| ontrol I olyline Station | Point Snappin Length: 303. Elevation X | g Distance (ft): 50 48 (ft) ,Y Data Import From ShapeFile | Tal |
| ontrol I olyline Station | Point Snappin Length: 303. Elevation X Station | g Distance (ft): 50 48 (ft) ,Y Data Import From ShapeFile Elevation | |





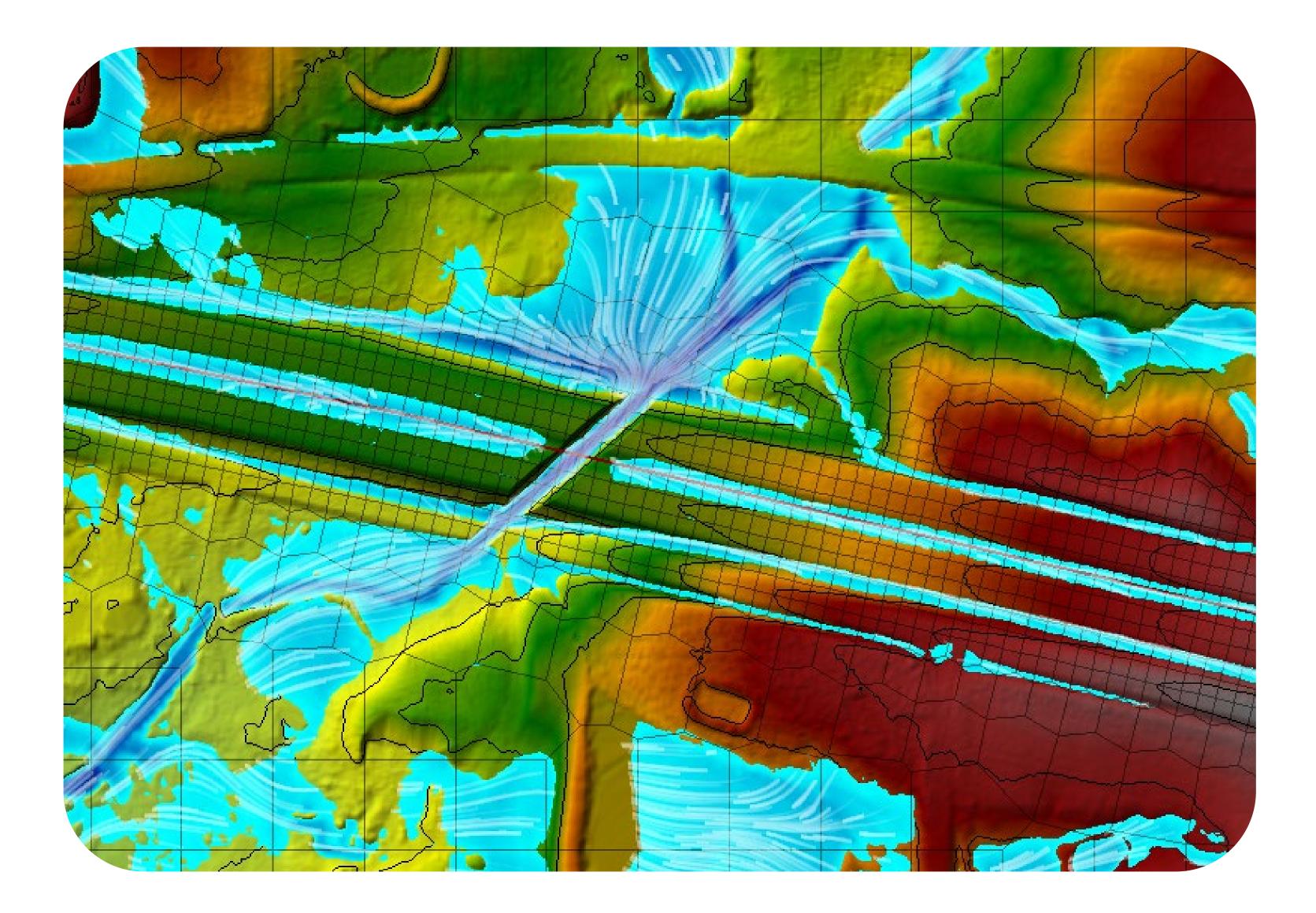
Iterate Hydroconnectors





Visualize Results

"The world is full of obvious things which nobody by any chance ever observes."

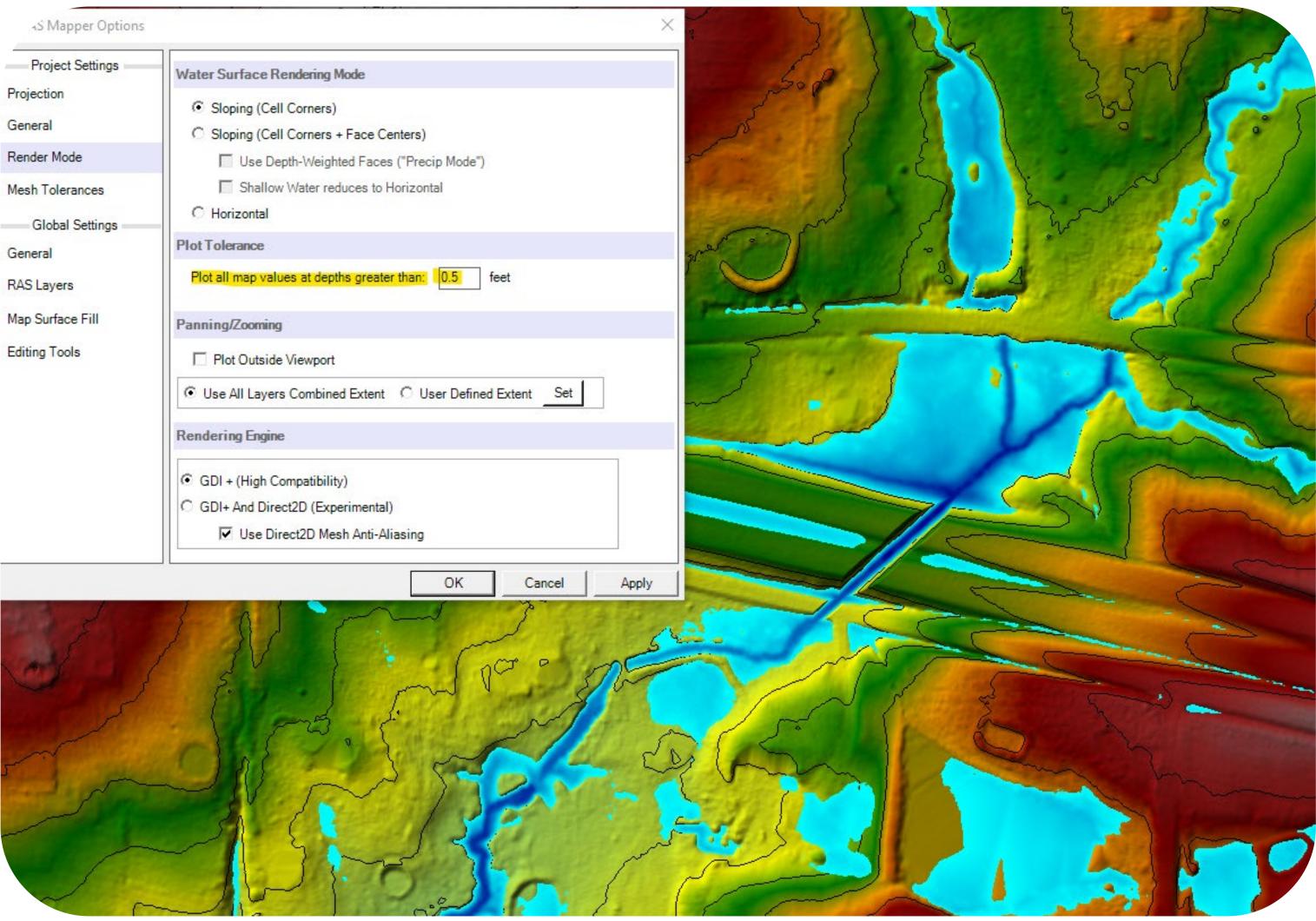




Visualize Results

"The world is full of obvious things which nobody by any chance ever observes."

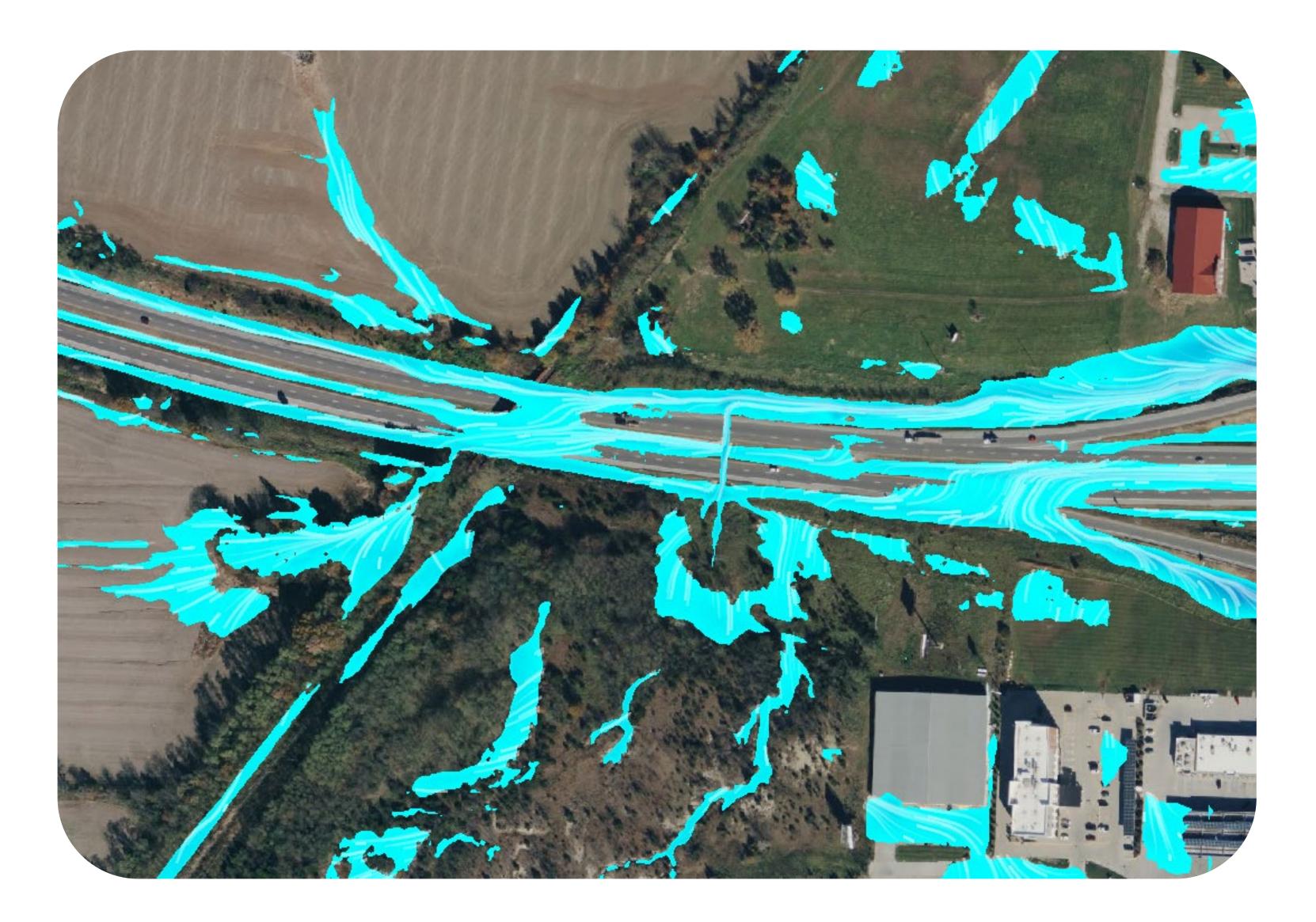
| 45 Mapper Options | |
|-------------------|---|
| Project Settings | Water S |
| jection | • si |
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| nder Mode | 1 |
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| Global Settings | _ C на |
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| S Layers | Plot a |
| p Surface Fill | Panning |
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Virtual Site Visit

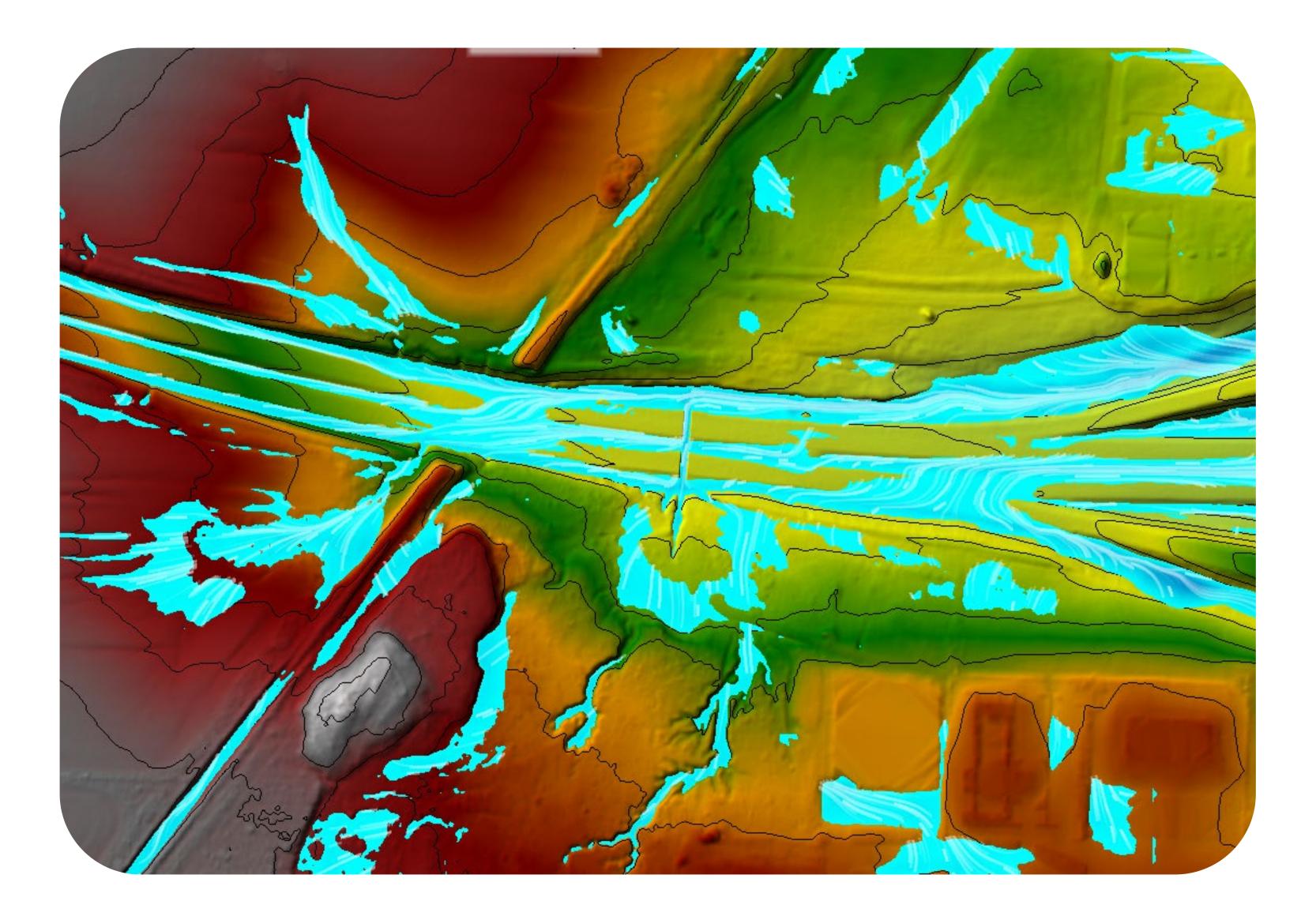
"The world is full of obvious things which nobody by any chance ever observes."





Virtual Site Visit

"The world is full of obvious things which nobody by any chance ever observes."





"My mind rebels against stagnation; give me problems; give me work"

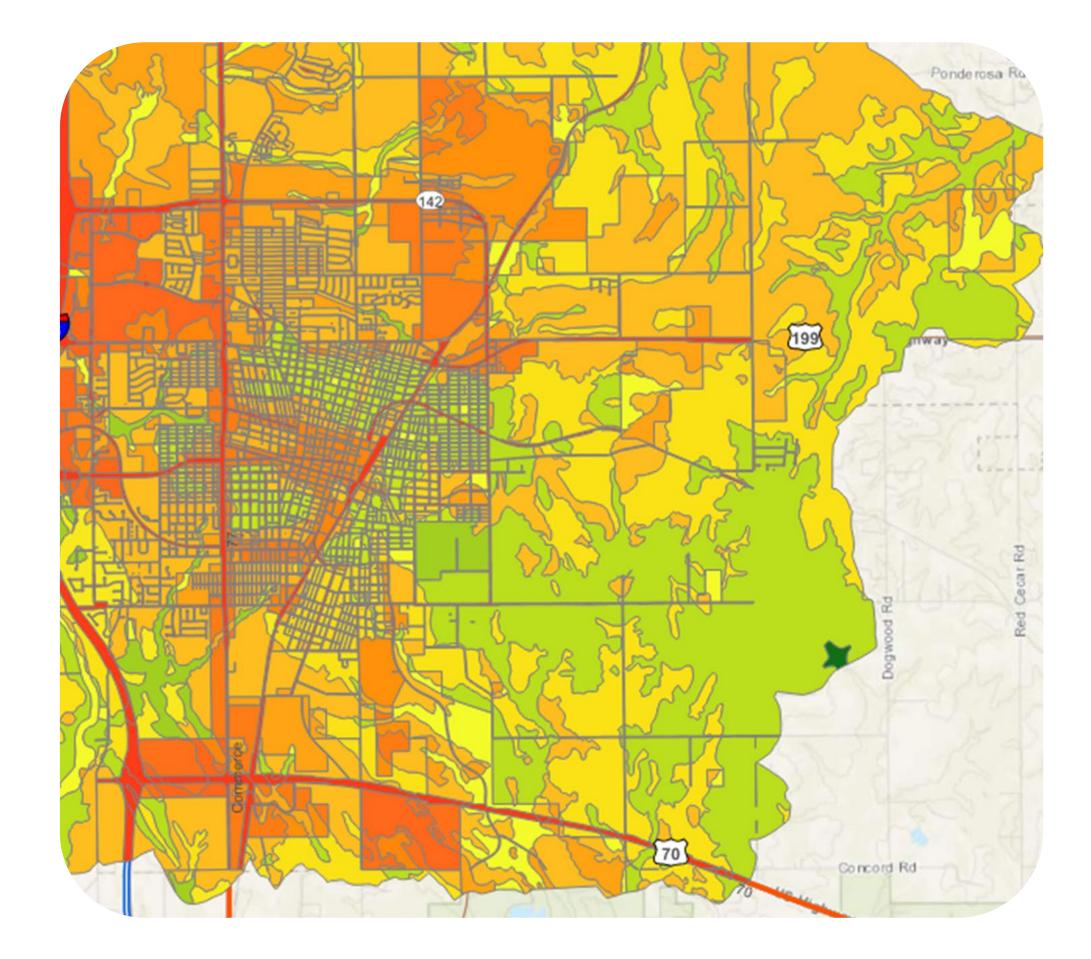
Challenges and Future Improvements Rain on Mesh Modeling



Best Practices in 2D Modeling

- Make all of your input <u>useful</u> for the end goal •
 - **Topography with Hydroconnectors**
 - **Routing Parameters**
 - **Precipitation Input** •
 - **Atlas 14?**
 - What is next?





The Future of Rain-on-Mesh 2D Modeling Is Complex







The Future of 2D Modeling is Exciting

| ocation ID | Drainage Challenge Description | Challenge Area General Location | 100-year Flood Serv. Index | Charge St. | | | CHALLENGE AREA "A" |
|------------|---|--------------------------------------|----------------------------------|------------|-----------|--------|---|
| A | Neighborhood and Street flooding | Maxwell and Washington | 4 | 4 | HARRIS ST | | |
| В | Neighborhood and Street flooding, Roadway overtops | Broadlawn Park Area | 2 | 3 | HA | | |
| с | Neighborhood and Street flooding | 10th Avenue and H Street | 2 | 1 | | 1. | |
| D | Neighborhood and Street flooding | Sam Noble and Washington | 4 | 0 | 1 | | - |
| E | Underpass, Neighborhood and Street flooding | Same Noble Underpass | 3 | 1 | | | EN. |
| F | Neighborhood and Street flooding | 2nd Avenue and K Street | 2 | 4 | | | 1 |
| G | Downtown and Street flooding | Downtown – Depot Area | 3 | 3 | | in the | The second by |
| н | Homes flood, Roadway overtops | Chattanooga Loop to Broadway | 4 | 2 | 1. | | 0.00 |
| 1 | Intersection and Street flooding | Stanley Avenue and Commerce | 1 | 1 | the state | E Cont | |
| 1 | Downtown and Street flooding | Stanley Ave and Washington Street | 2 | 4 | | HALLEI | NGE |
| к | Neighborhood and Street flooding | 6th Avenue and Frisco Lane | 2 | 4 | | AREA " | A CONTRACT OF A |







Questions?

Alan Dennis, PE CFM acdennis@garverusa.com



"Elementary, my dear Watson."





SHERLOCK HOLMES; SIR ARTHUR CONAN DOYLE

Image design by alex.mathews.984 – Threadless.com



Thank you!

Alan Dennis, PE CFM acdennis@garverusa.com



