2-D Floodplain and Low Flow Bridge Modeling Using HEC-RAS 5.0

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PURPOSE

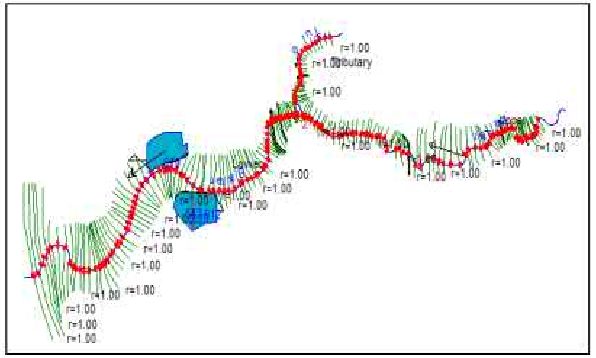
Illustrate how a HEC-RAS 2-D hydraulic modeling can help:

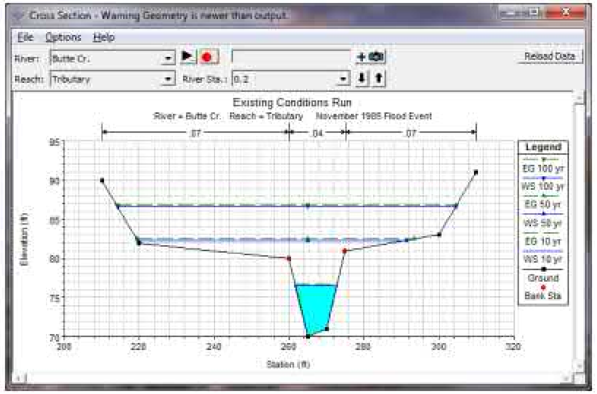
1. Identify changes of flow direction in a floodplain

2. Quantify flow distribution across multiple bridges under low flow (non-pressure flow) conditions

1-D HYDRAULIC MODELS

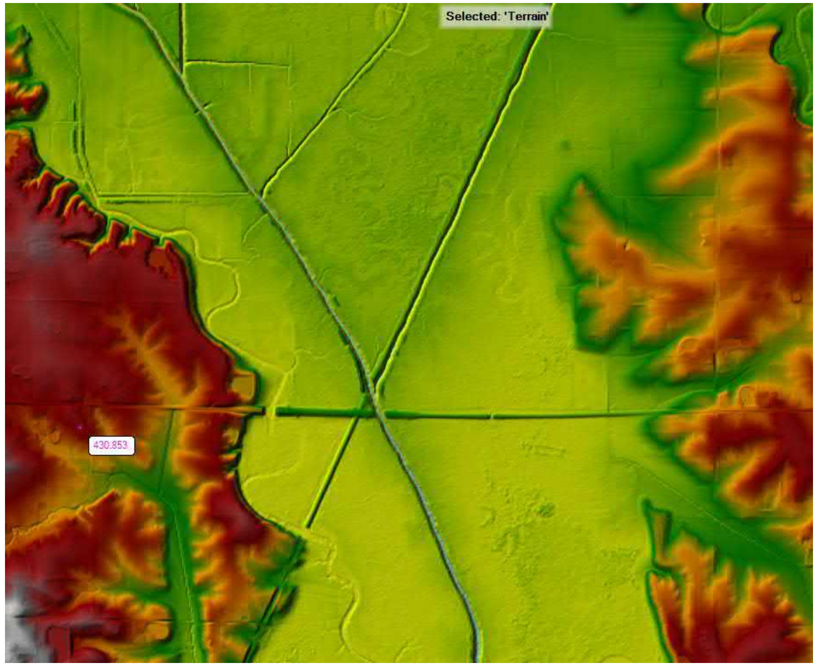
- Most flood hazard mapping hydraulic models (e.g. FEMA FIS)
- Average conveyance of cross sections along stream
- On directional flow, perpendicular to cross section line.
- Steady flow for gradually varied flow, unsteady flow for rapidly varied flow (e.g. dam break)
- Reliable for well defined channels, but not so much in very wide flat areas.





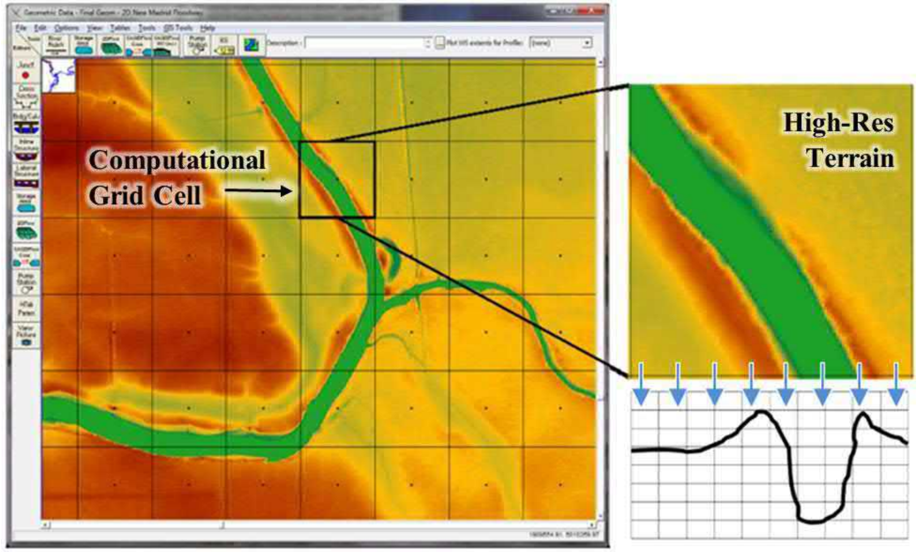
2-D HYDRAULIC MODELS

- Different approach to modeling flow.
- Considers entire terrain, down to the cell size of the representative elevation model
- Accounts for change in flow direction between computational cells.
- Unsteady state. Accounts for storage



DATA INPUT

- Terrain:
  - ✓ 1-m cells preferred for detailed studies, 5-ft cells may be OK, 10-ft cells for approximate studies
  - ✓ GeoTIFF (.tif) format is recommended
  - ✓ Use best available elevation data (smallest cell size) regardless of computational mesh cell size.
- 2-D Mesh Area:
  - ✓ Boundary can be defined in HEC-RAS or imported from GIS.
  - ✓ Nominal 2-D Mesh Cell Size: start with 100ft and adjust if necessary to achieve model stability. Smaller streams may require smaller cells.

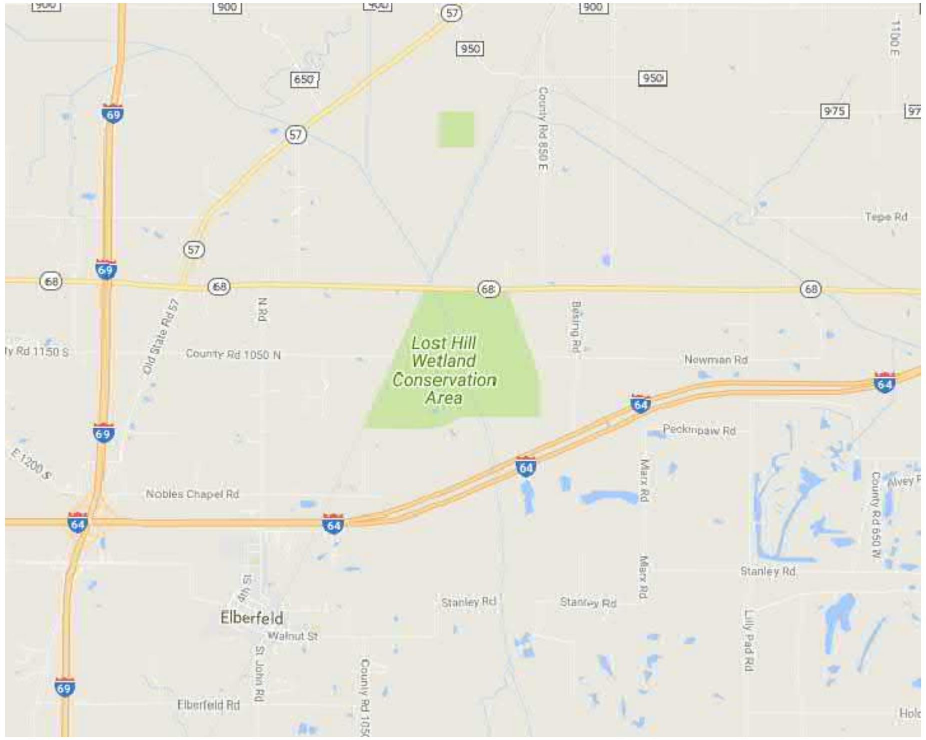


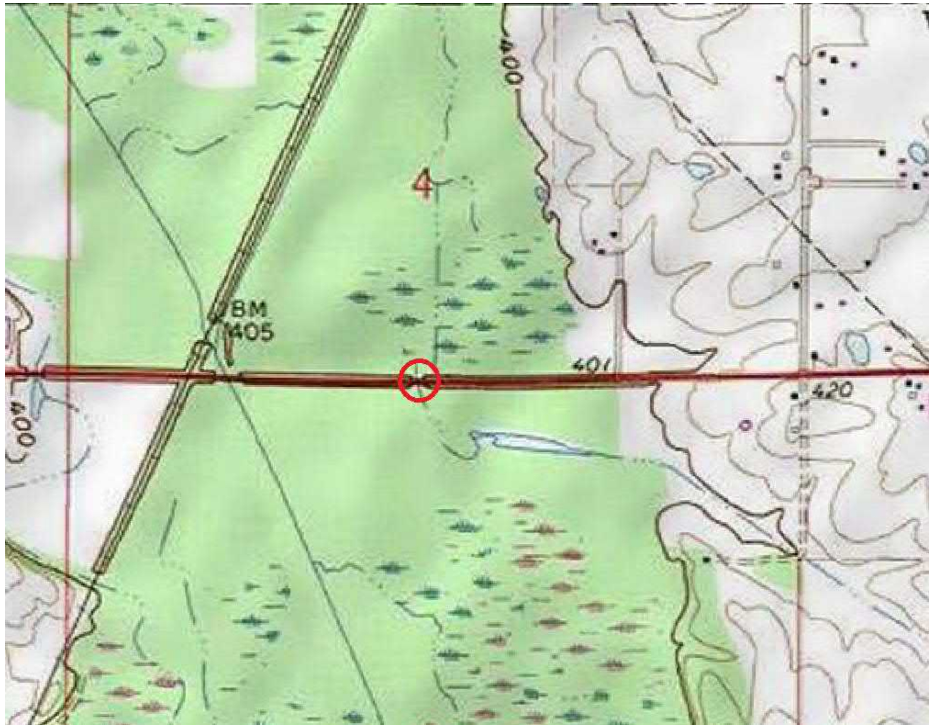
2D mesh cell faces are treated as cross-sections, with hydraulic tables (HTab) computed and stored for each cell. The WSEL calculated across each mesh cell face, and the mapped output, are based on the underlying geometry of the high resolution terrain data, not mesh computational cell size.

DATA INPUT

- ❑ Roughness Coefficients - Manning n values
  - ✓ A GIS layer of n values can be created based on the NLCD or manually from aerial photography.

PIGEON CREEK OVERFLOW





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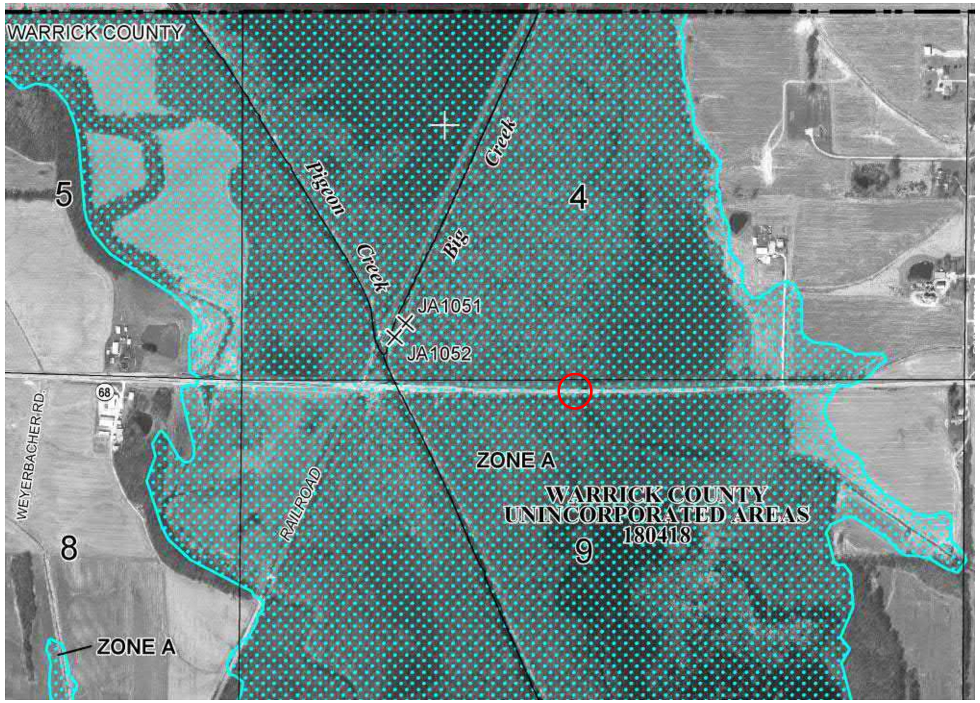

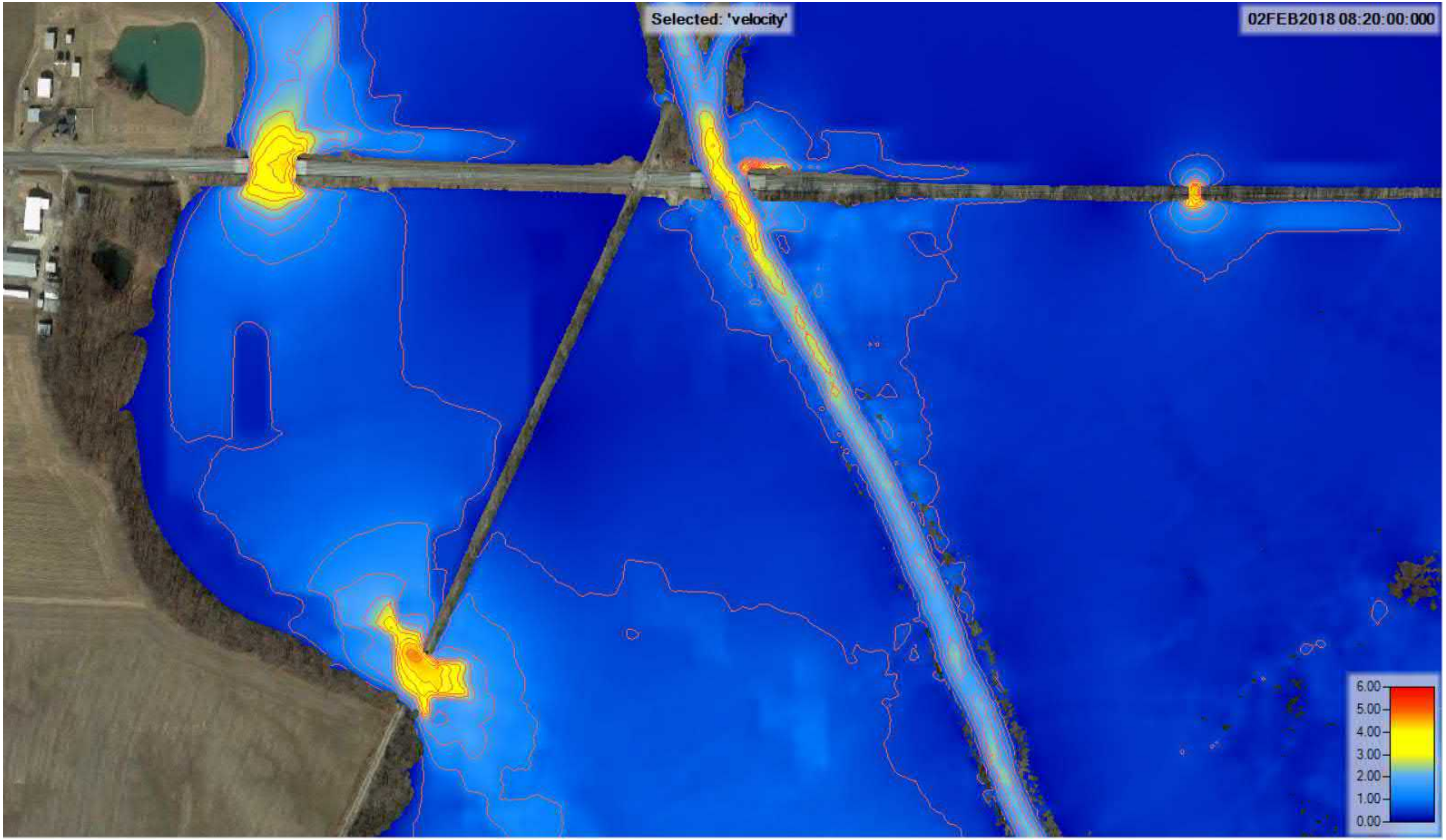
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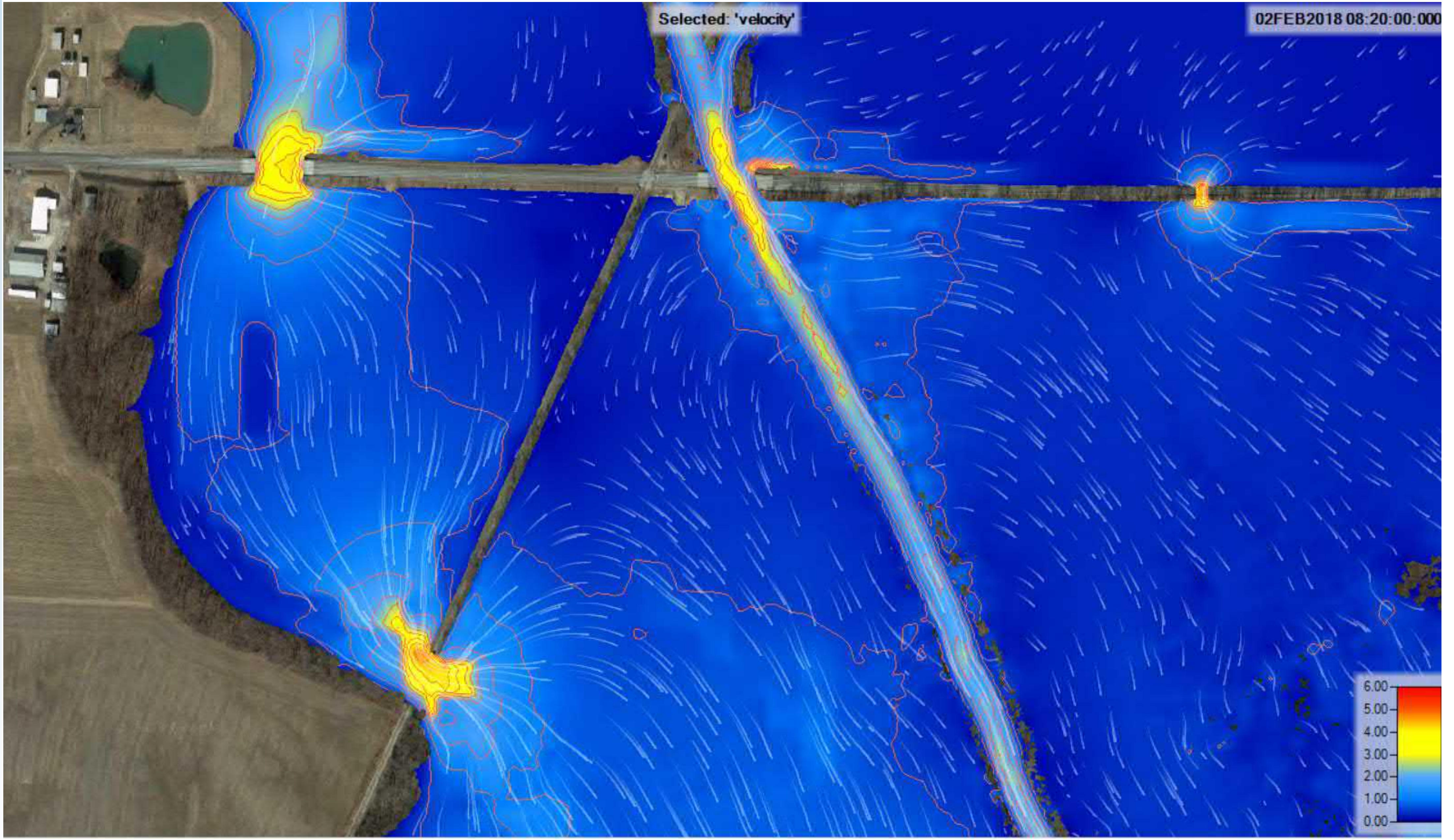
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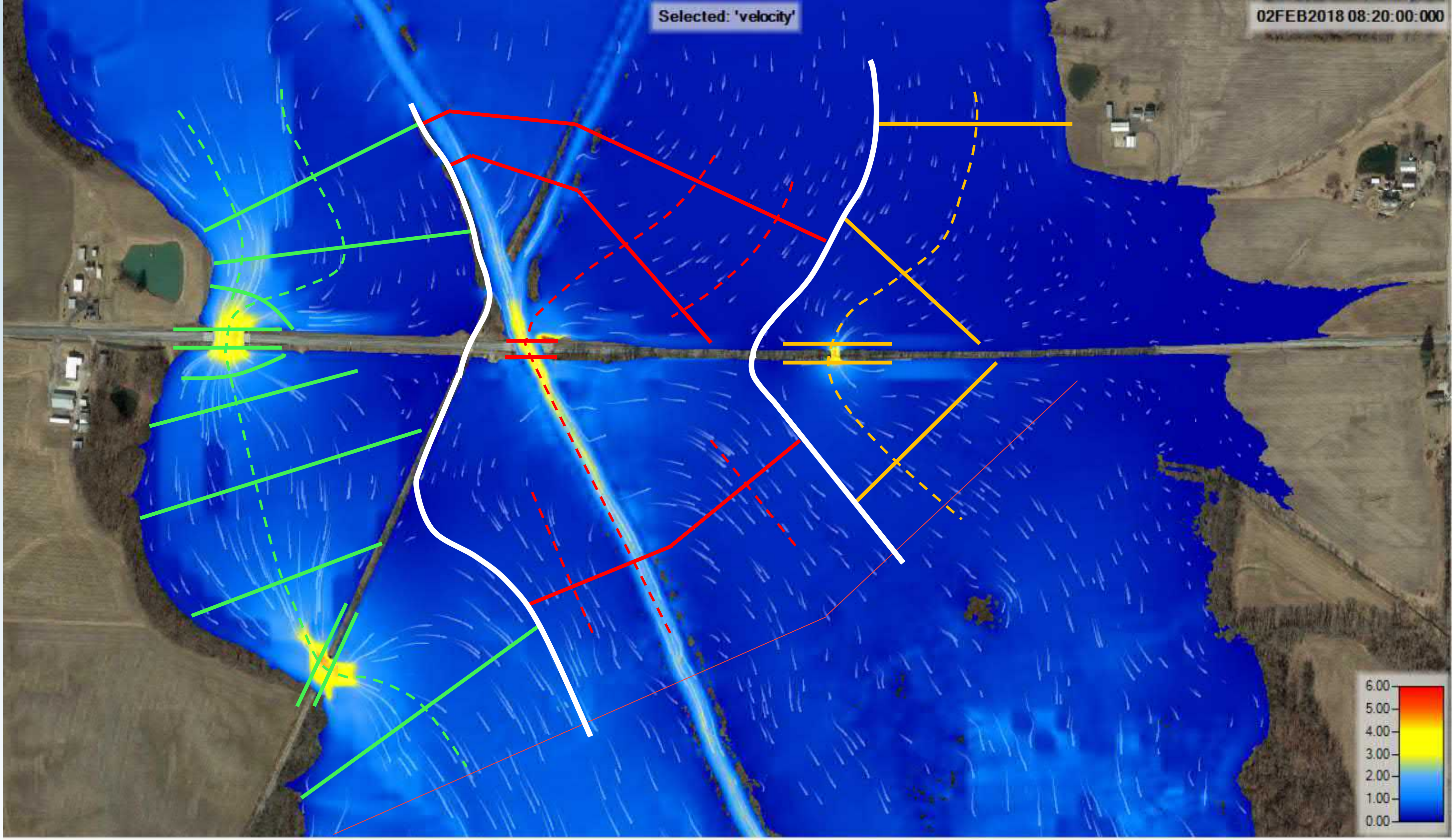

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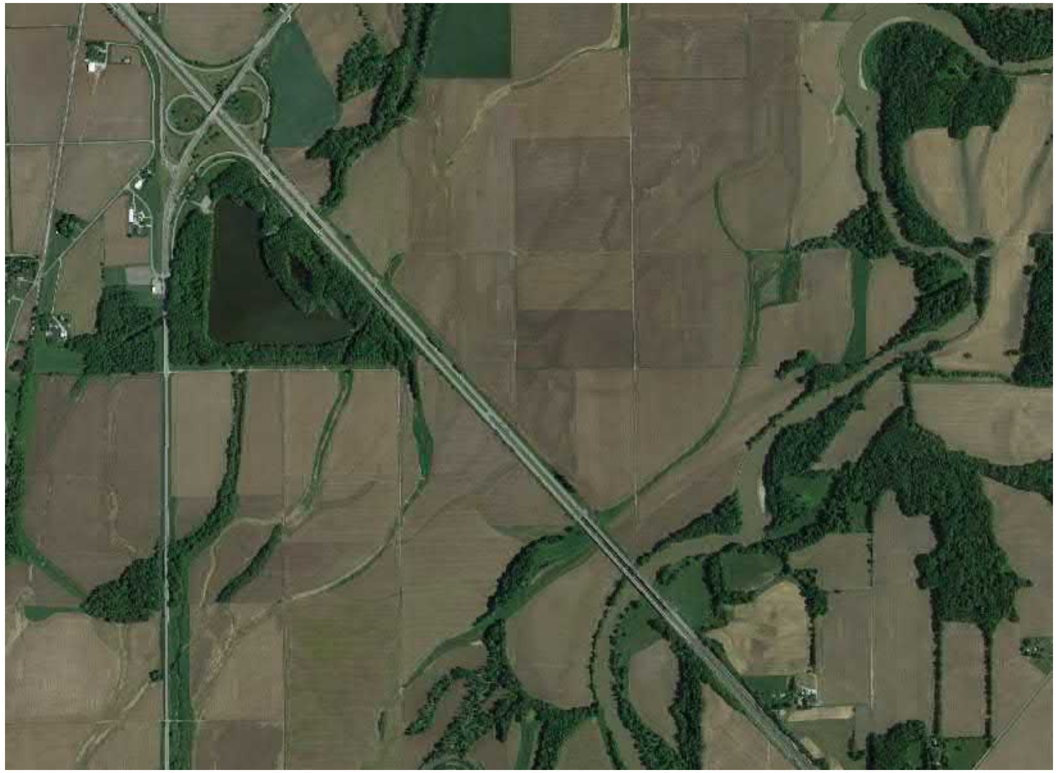
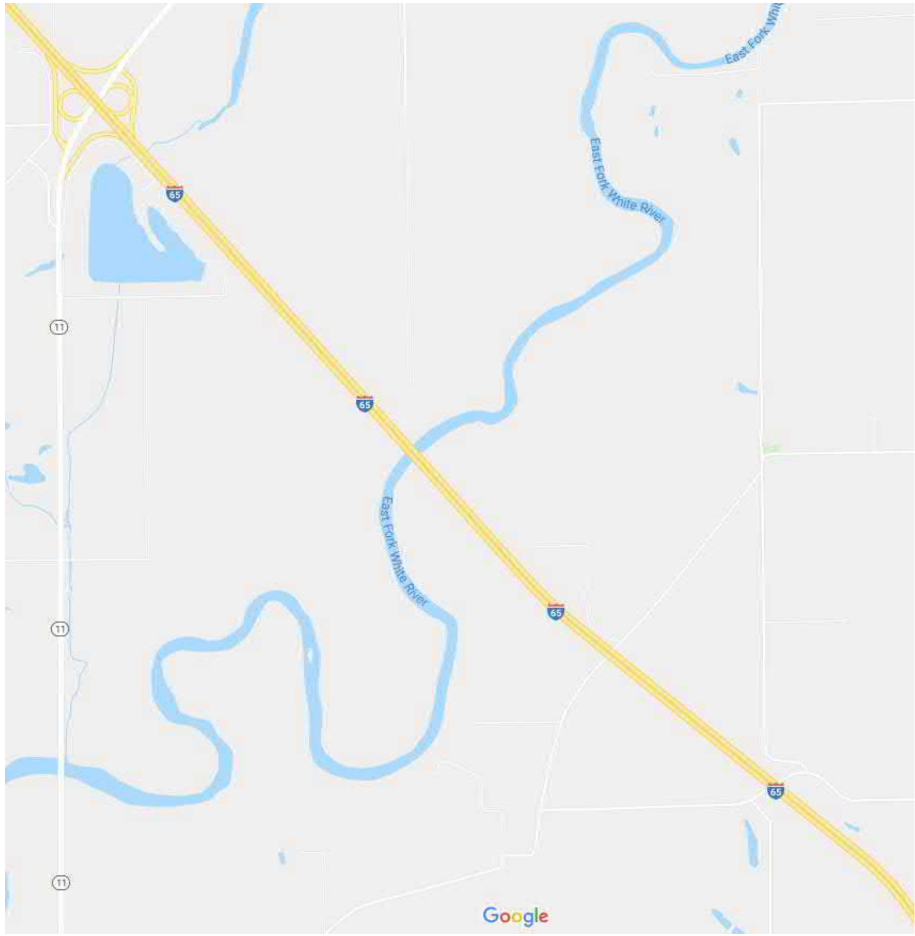
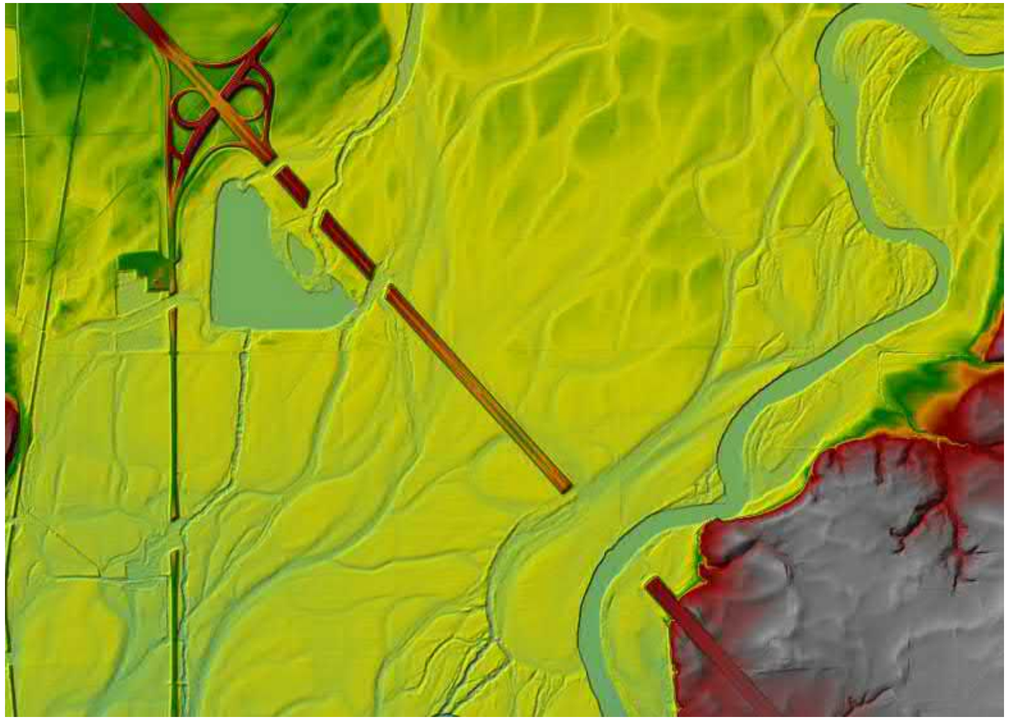
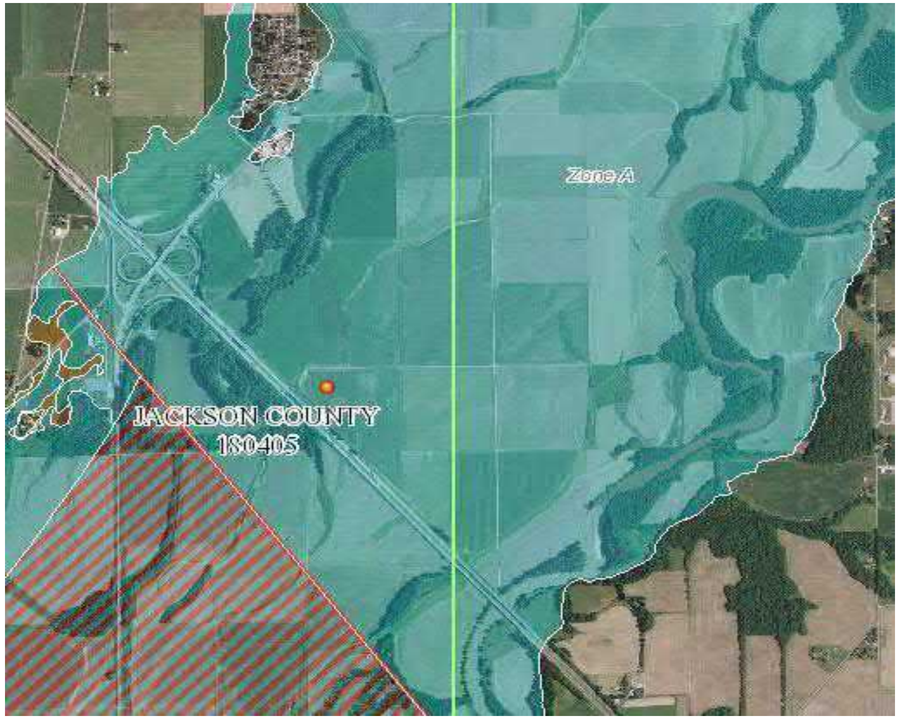
East Fork White River



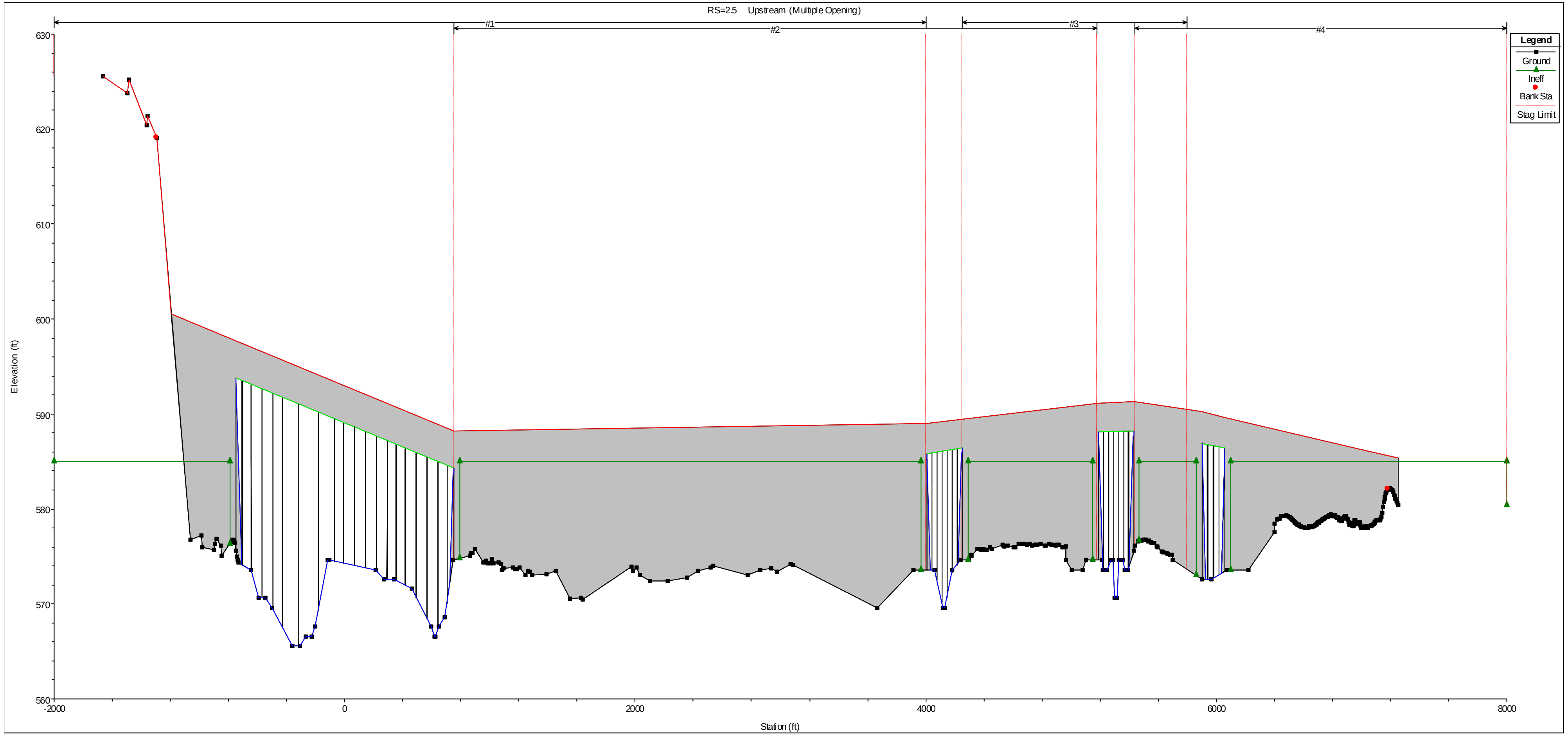


East Fork White River

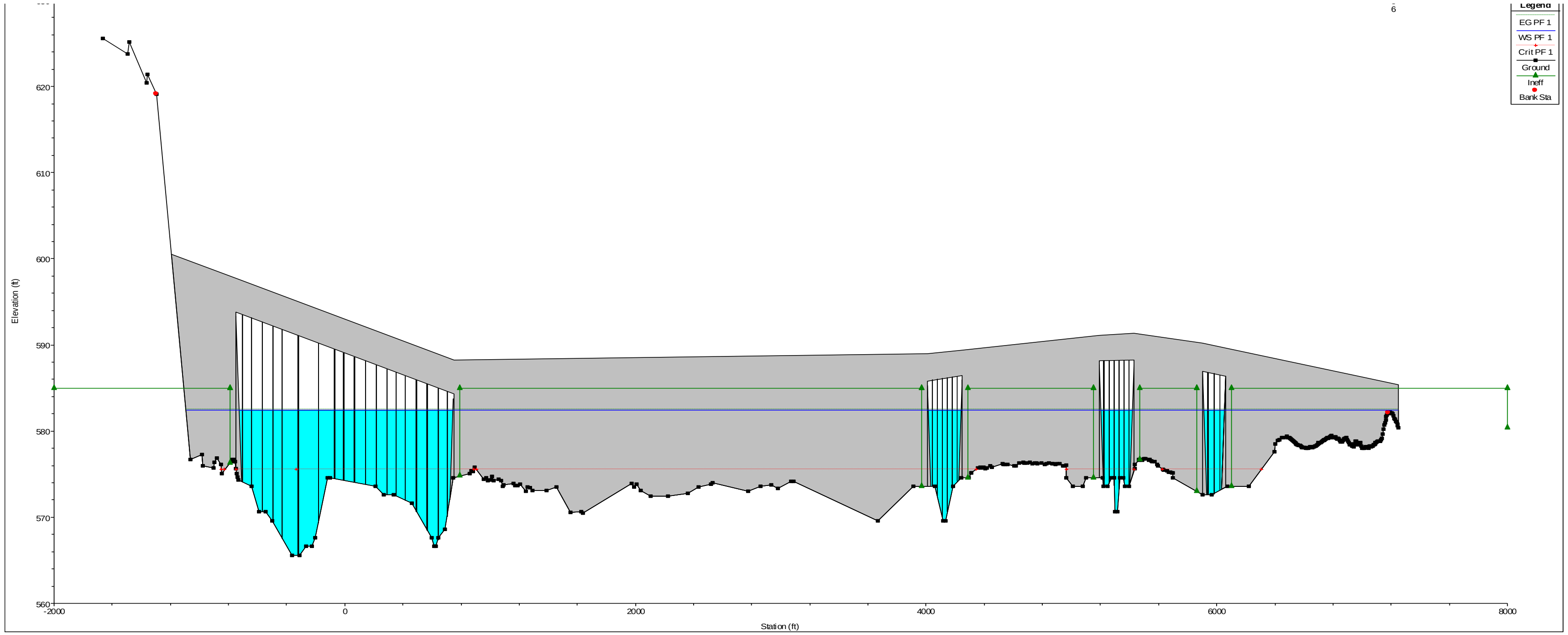




Multiple Bridge Opening in HEC-RAS 1D



Flow Distribution in HEC-RAS 1D



Profile Output Table - Multiple Opening

File Options Std. Tables Locations Help

HEC-RAS Plan: existing River: EFWR Reach: 1 Profile: PF 1

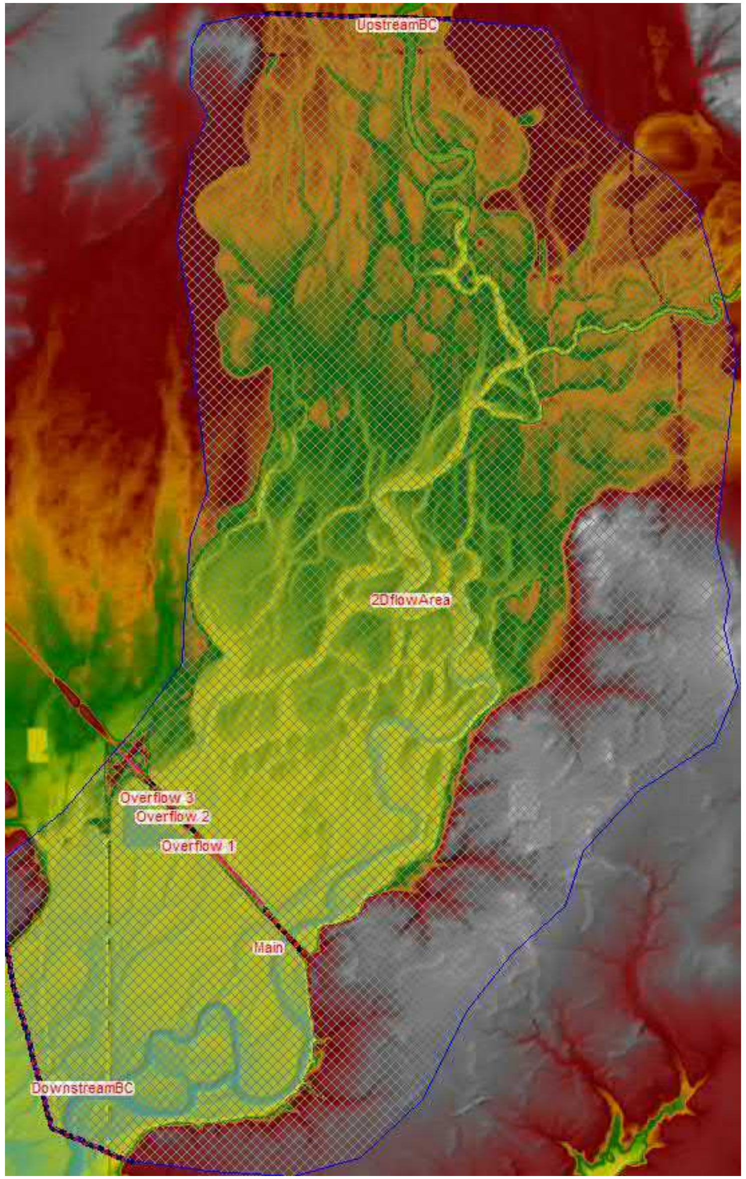
Reload Data

Reach	River Sta	Profile	Q Total (cfs)	Flow Area (sq ft)	E.G. US. (ft)	W.S. US. (ft)	Top Wdth Act (ft)	Vel Total (ft/s)	Crit W.S. (ft)	Left Stagn (ft)	Right Stagn (ft)
1	2.5 Bridge #1	PF 1	81409.21	17705.31	582.61	582.28	1613.00	4.60	575.52	-1092.46	4000.00
1	2.5 Bridge #2	PF 1	5949.36	2448.83	582.58	582.49	250.00	2.43	575.30	4000.00	4250.00
1	2.5 Bridge #3	PF 1	5679.47	2789.10	582.57	582.50	331.00	2.04	576.17	4250.00	5440.00
1	2.5 Bridge #4	PF 1	4161.96	2481.30	582.57	582.53	271.00	1.68	575.08	5440.00	7251.36

Total flow in cross section.

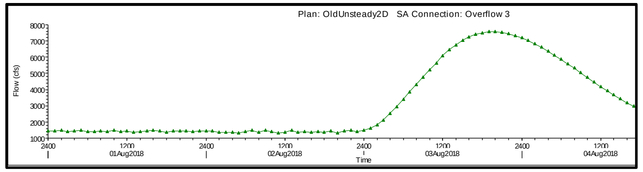
Multiple Bridge Opening in HEC-RAS 2D

- Hydrograph as the upstream boundary condition of the 2D Flow Area
- Normal Depth is used as the downstream end boundary condition of the 2D Flow Area
- Bridges are modeled as connections inside the 2D Flow Area
- A cell size of 100 ft is used for Mesh Computation

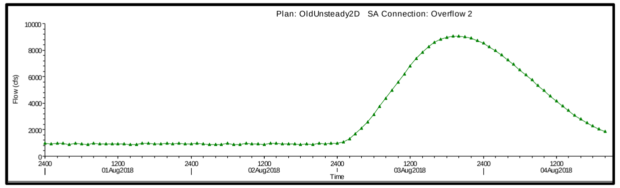


Flow Distribution in HEC-RAS 2D

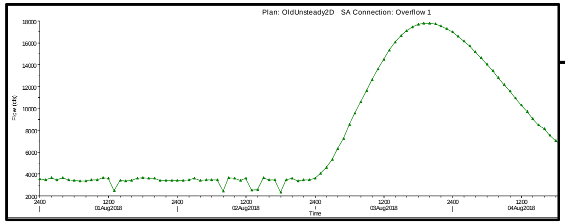
$Q_{\text{Overflow 3}}$ = 7,500 cfs



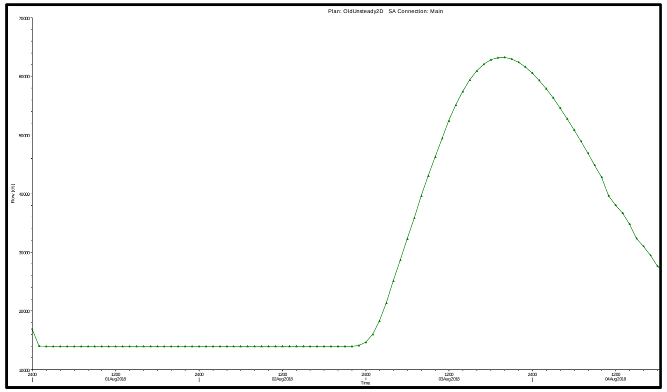
$Q_{\text{Overflow 2}}$ = 9,000 cfs

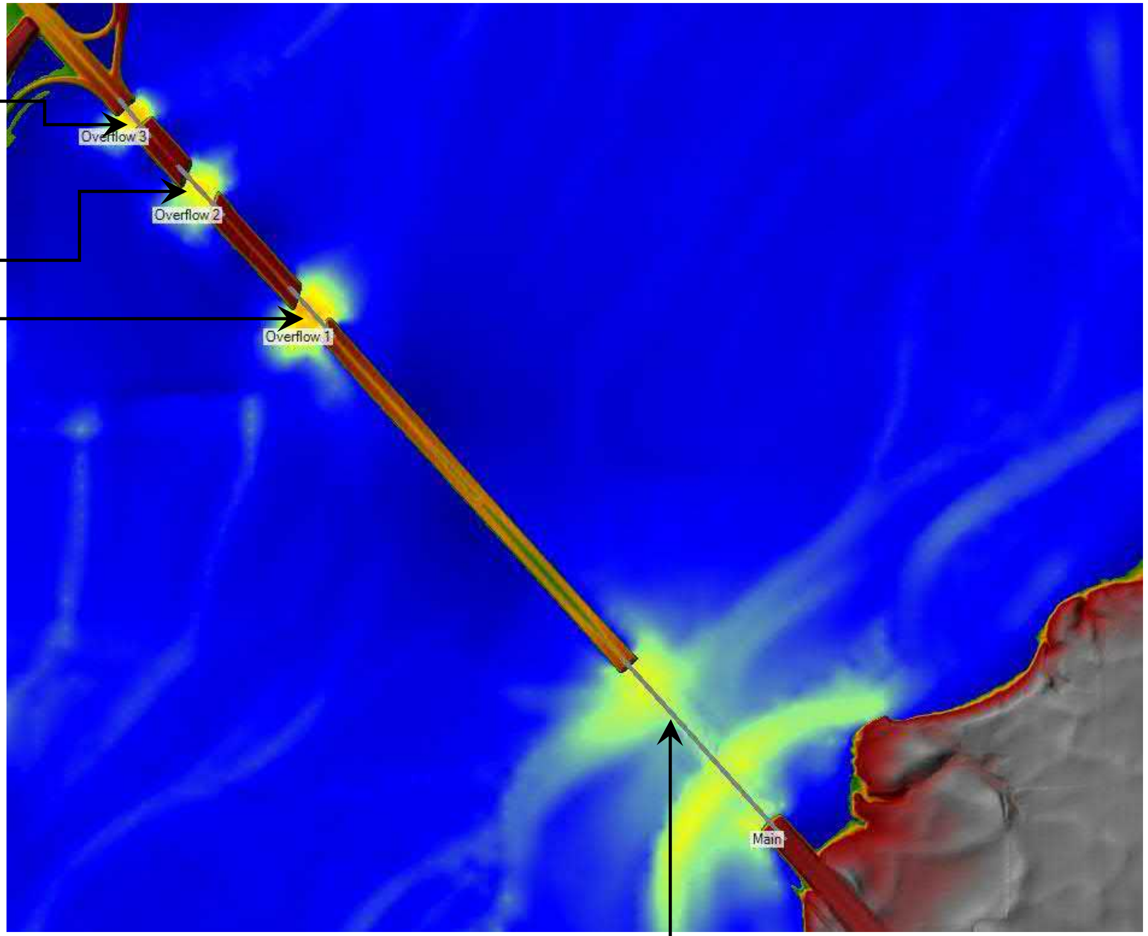


$Q_{\text{Overflow 1}}$ = 17,800 cfs

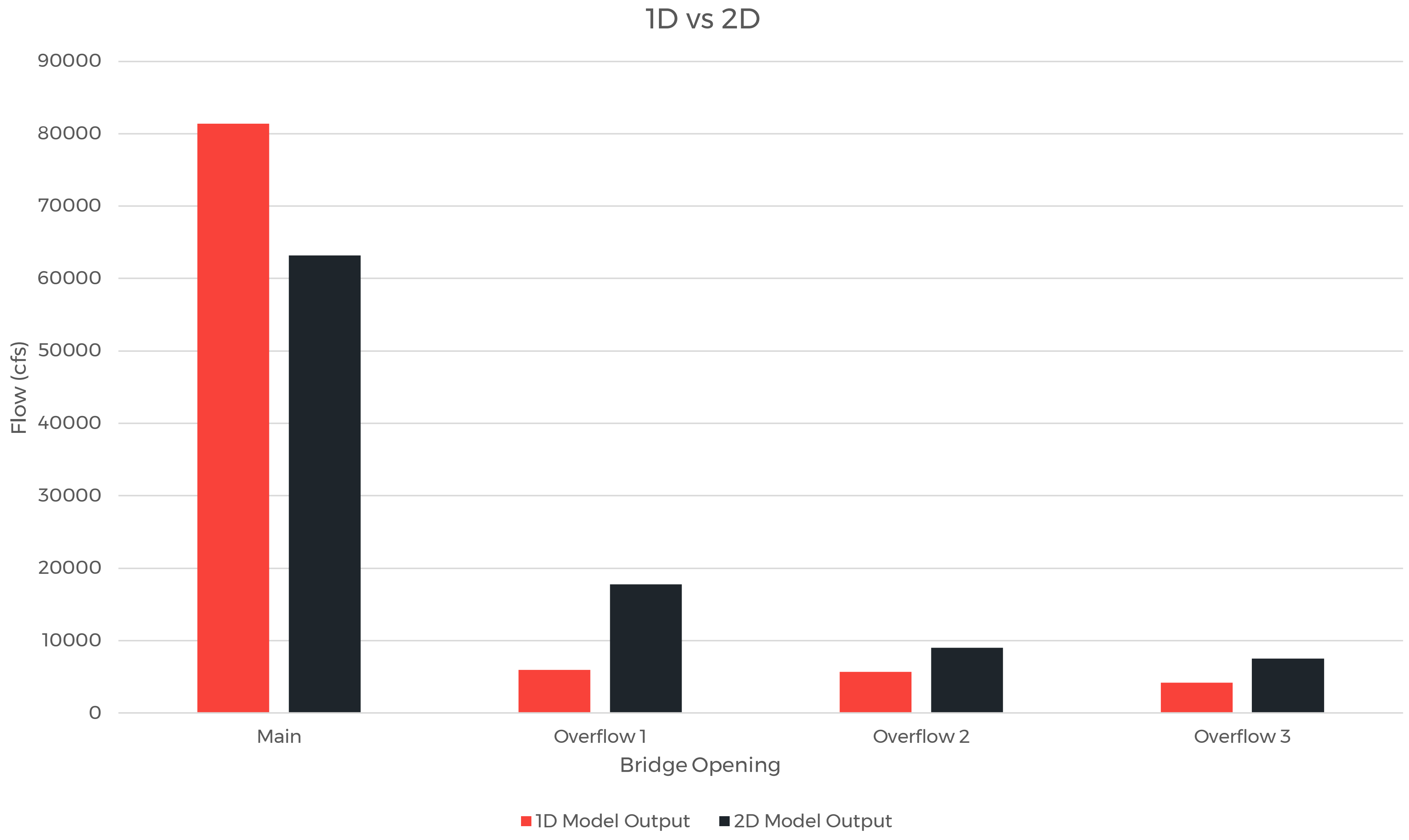


Q_{Main} = 63,200 cfs

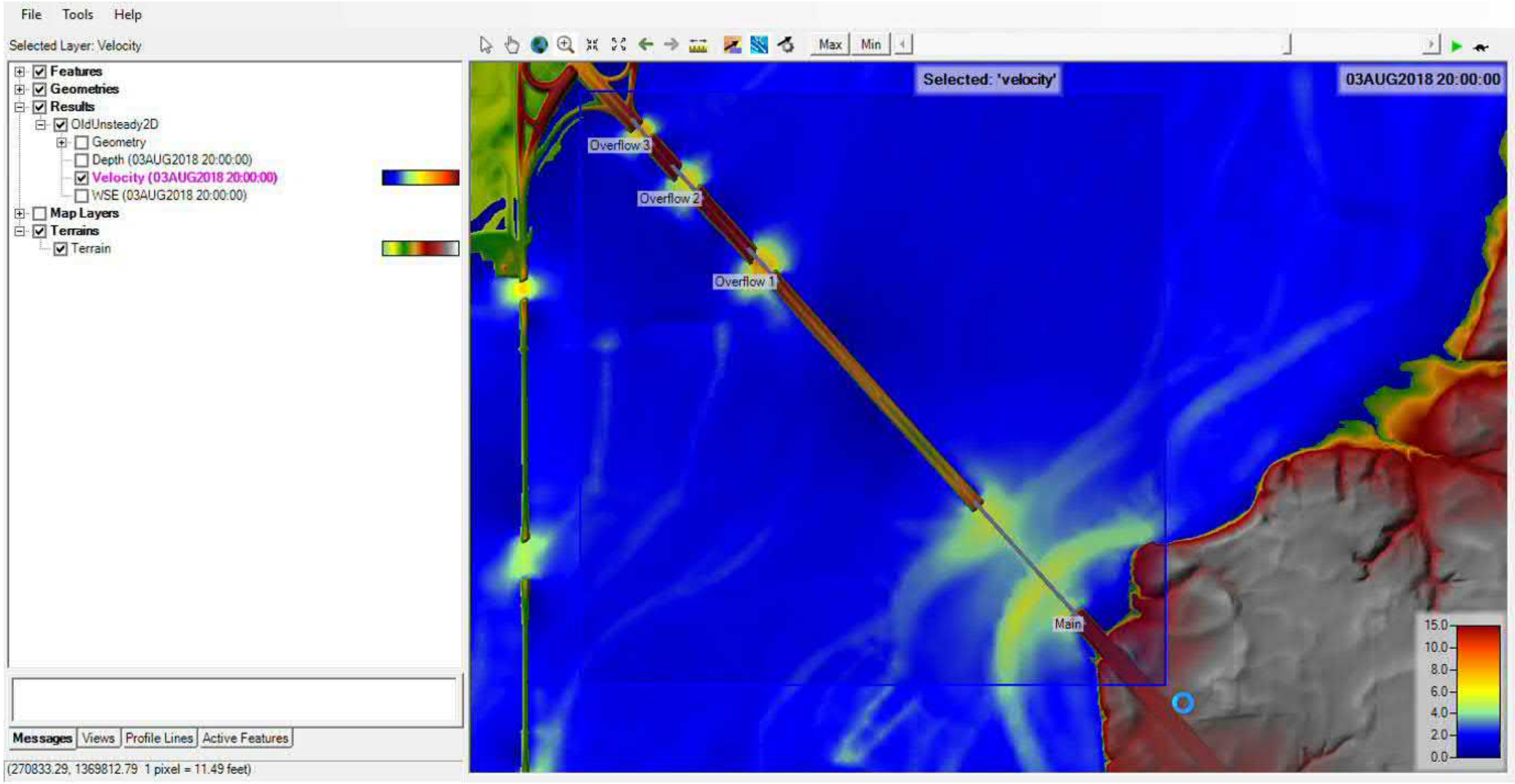




1D vs 2D Flow Distribution



Flow Distribution in HEC-RAS 2D



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Final Thoughts

- 1-D and 2-D HEC-RAS models produced significantly different results at multiple bridge floodplains.
- Flow distribution results should be compared to river gage water level time series data, where available, to calibrate and validate the models.
- Flow paths are not likely to change significantly with calibration, so uncalibrated models are OK for informing cross section orientation and stagnation points.
- We expect the 2-D models to better represent multiple bridges and very wide flat floodplains, and to more easily calibrate to river gage data than 1-D models.