



# LAR RAS 2D Model Development Flood Model

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# LAR RAS 2D Overview

- Scope:
  - Develop HEC-RAS 2D model for historic conditions
    - Topo/Bathy: 2008 CVFED LiDAR and 2006 USACE bathymetric survey
    - Calibrate/validate model for floods up to 160,000 cfs
    - Calibrate/validate model to low flows down to 500 cfs
  - Build a current conditions DEM and roughness map
    - Bathymetric LiDAR (green and NIR sensors) and singlebeam sonar
  - Finalize model calibration/validation with current conditions DEM
- Objectives:
  - Develop a high resolution current conditions DEM and roughness map
  - Develop an ecological flow model to support habitat analyses
  - Develop a flood flow model to support bank erosion and levee analyses

# Presentation Outline

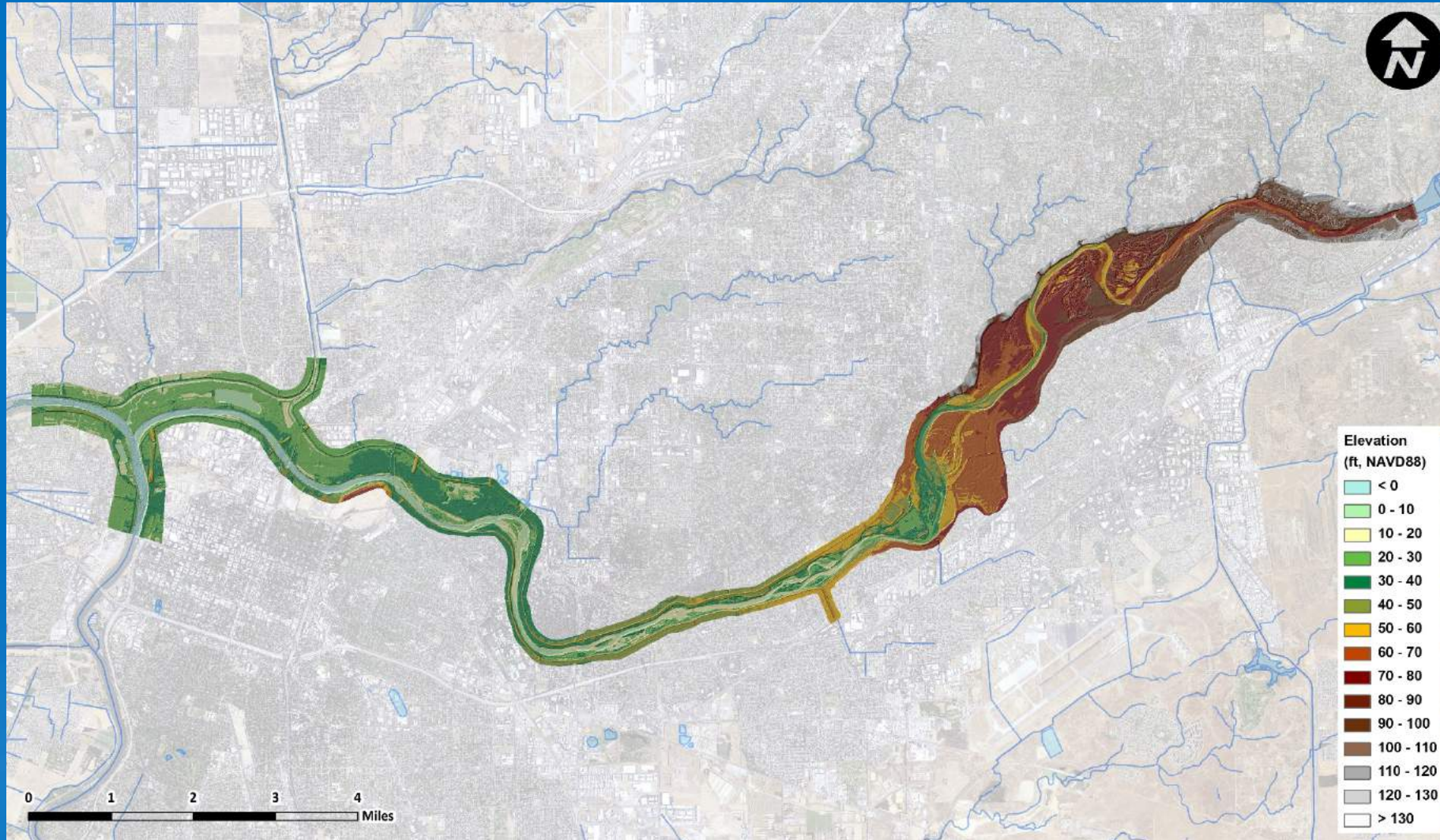
- Flood Model Development
  - Model DEM
  - Model extent
  - Roughness map development
  - Mesh resolution tests
  - Bridge pier modeling tests and approach
  - Mesh breaklines
  - Calibration/Validation results
  - Boundary condition scenarios
  - Bridge clearance results



Source: cbec UAV 2/10/2017



# Flood Model Development – DEM

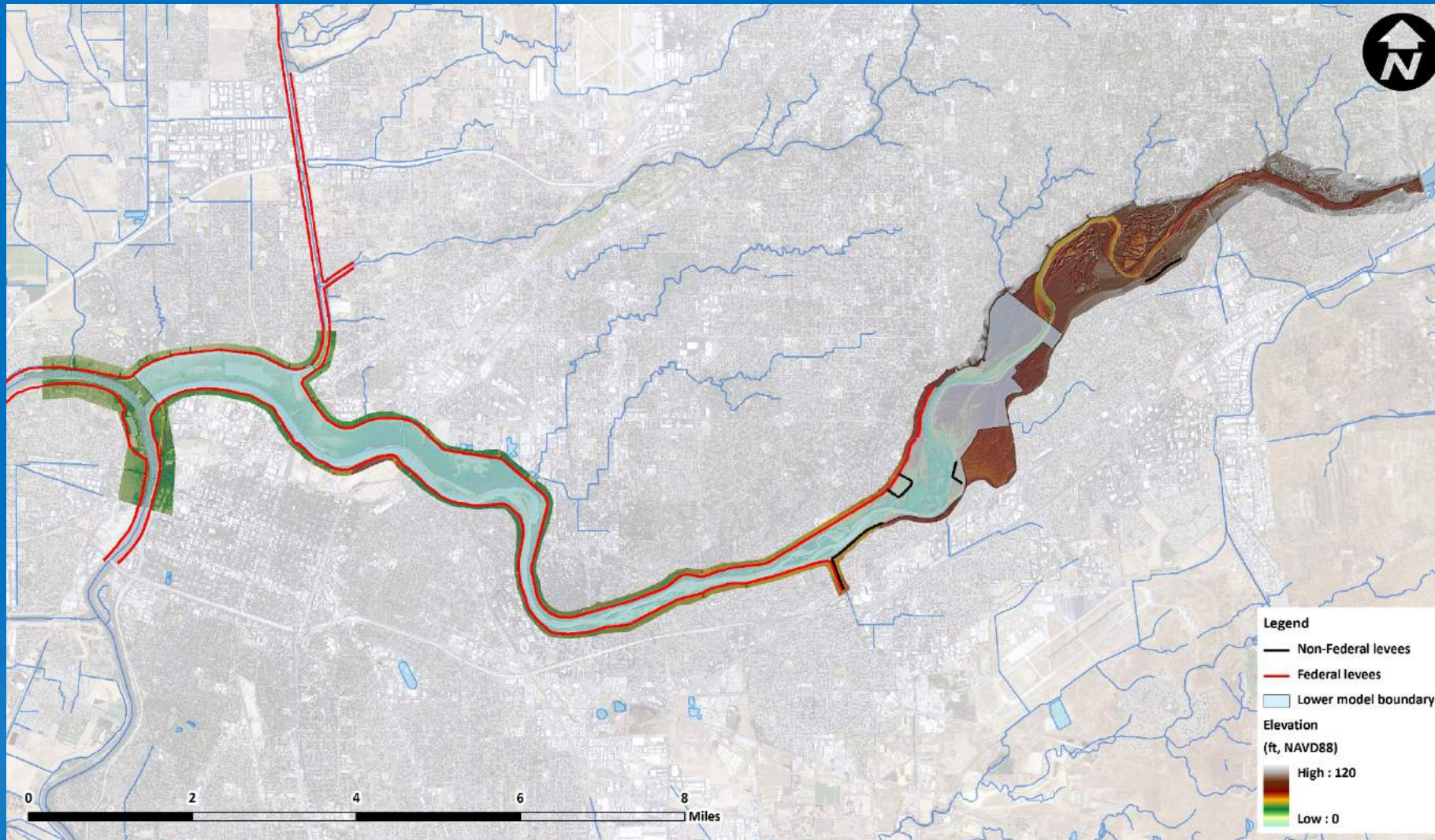


## Sources:

- 2006 USACE singlebeam sonar for LAR
- 2008 CVFED LiDAR topography
- 2008 DWR multibeam sonar for Sacramento River



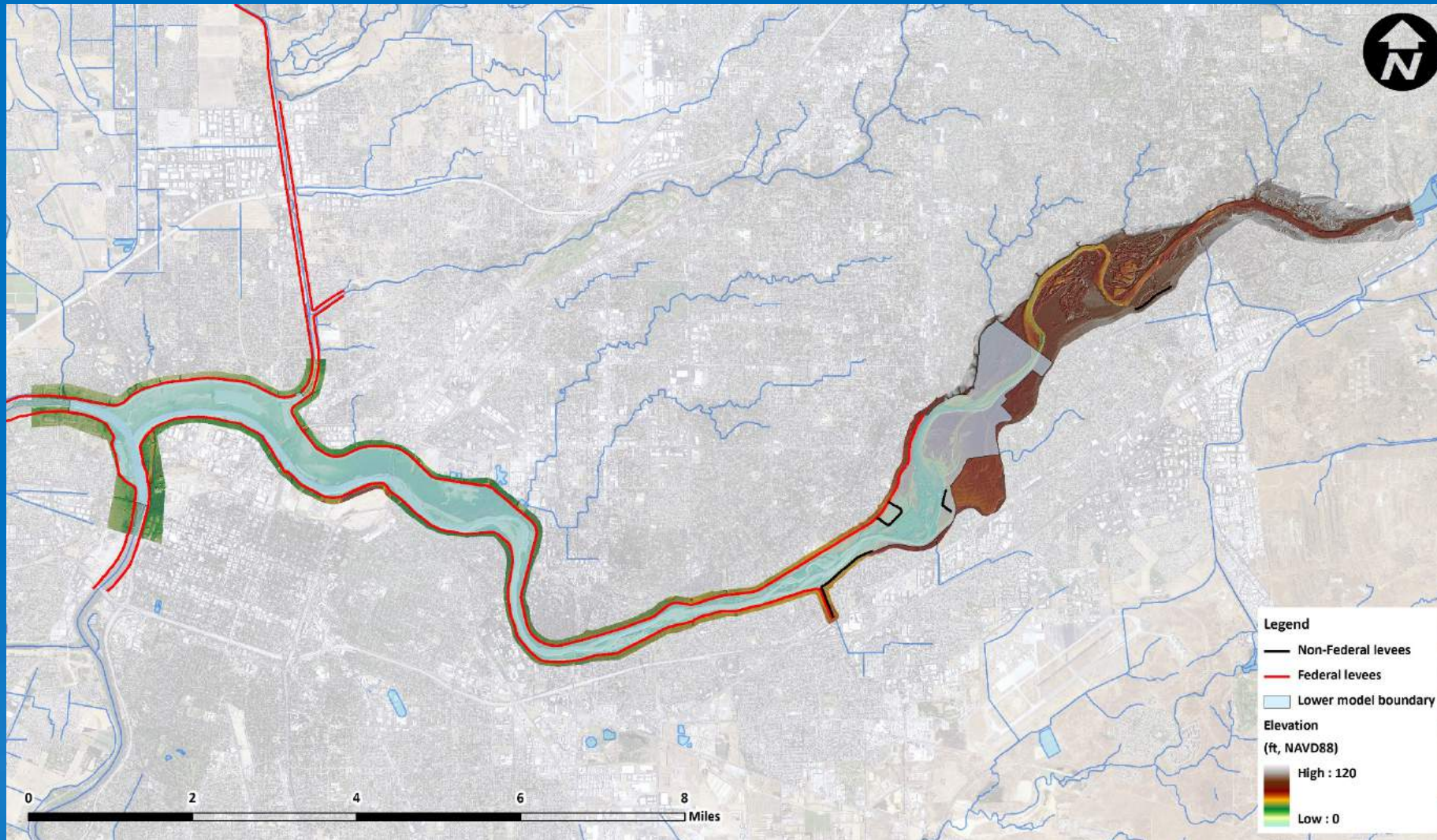
# Flood Model Development – Truncated Lower Domain



- Model domain covers full leveed section of LAR
- Provides for a simple downstream stage boundary condition



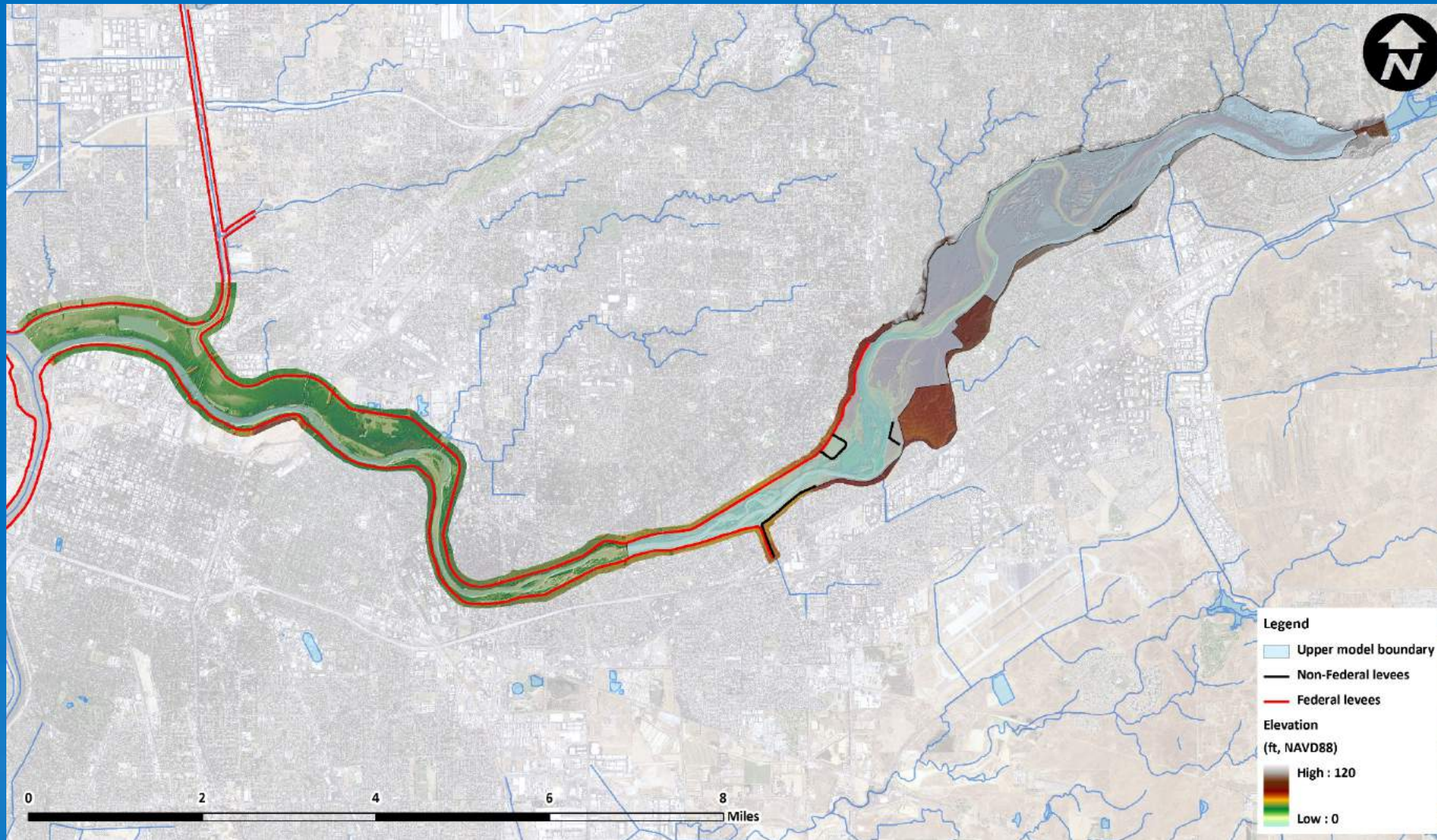
# Flood Model Development – Lower Domain with Confluence



- Model domain covers full leveed section of LAR
- Provides scenario testing with Sacramento Weir operations



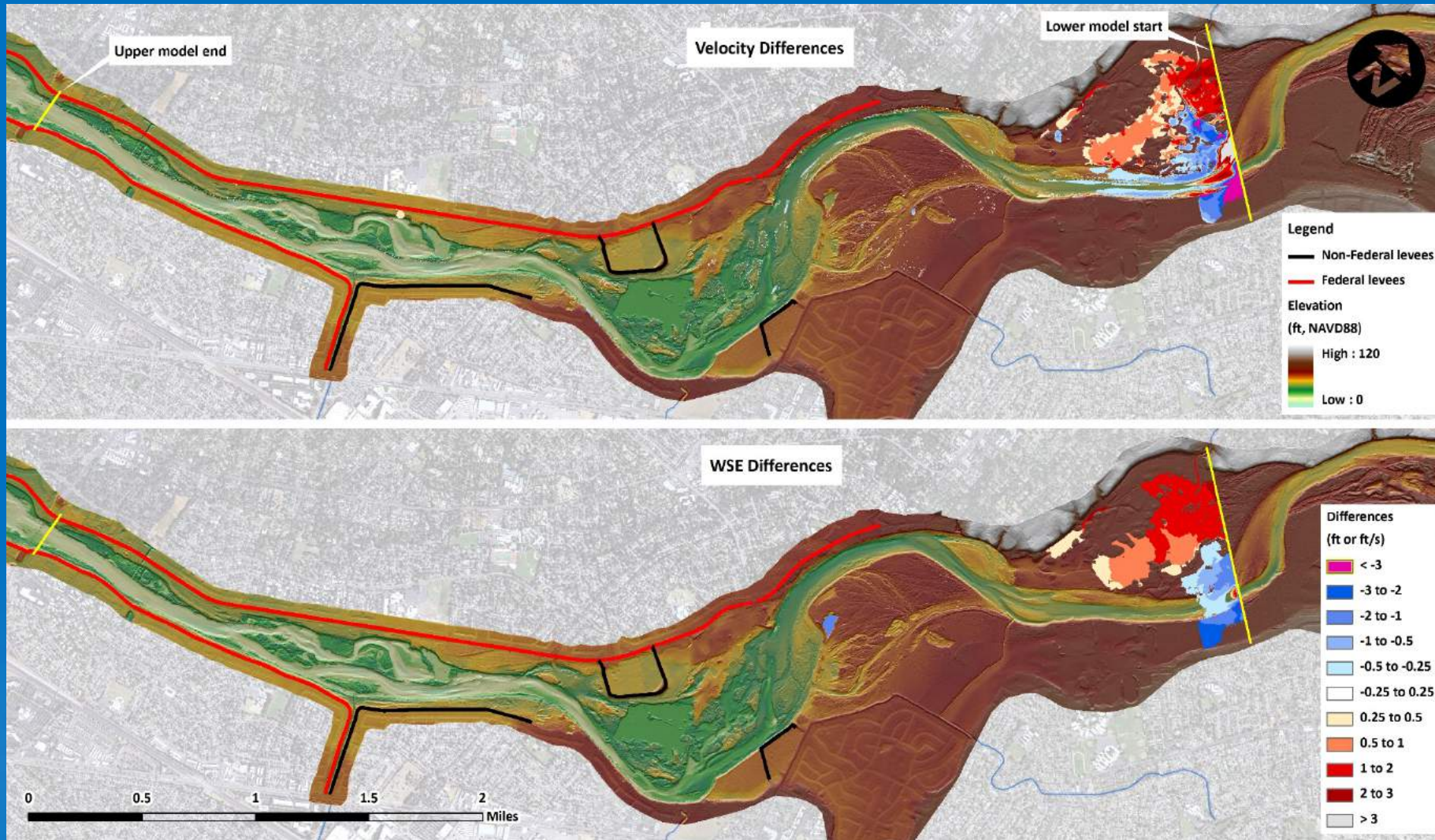
# Flood Model Development – Upper Domain



- Begins below Nimbus fish screens
- Ends at Watt Ave.



# Model Overlap Differences



- Only significant differences between the upper and lower model domain occur within the first  $\sim 3/4$  of a mile
- The leveed portion of the lower model domain is not impacted by the boundary condition



# Roughness Map – Landcover Classification





# Roughness Map – Landcover Classification



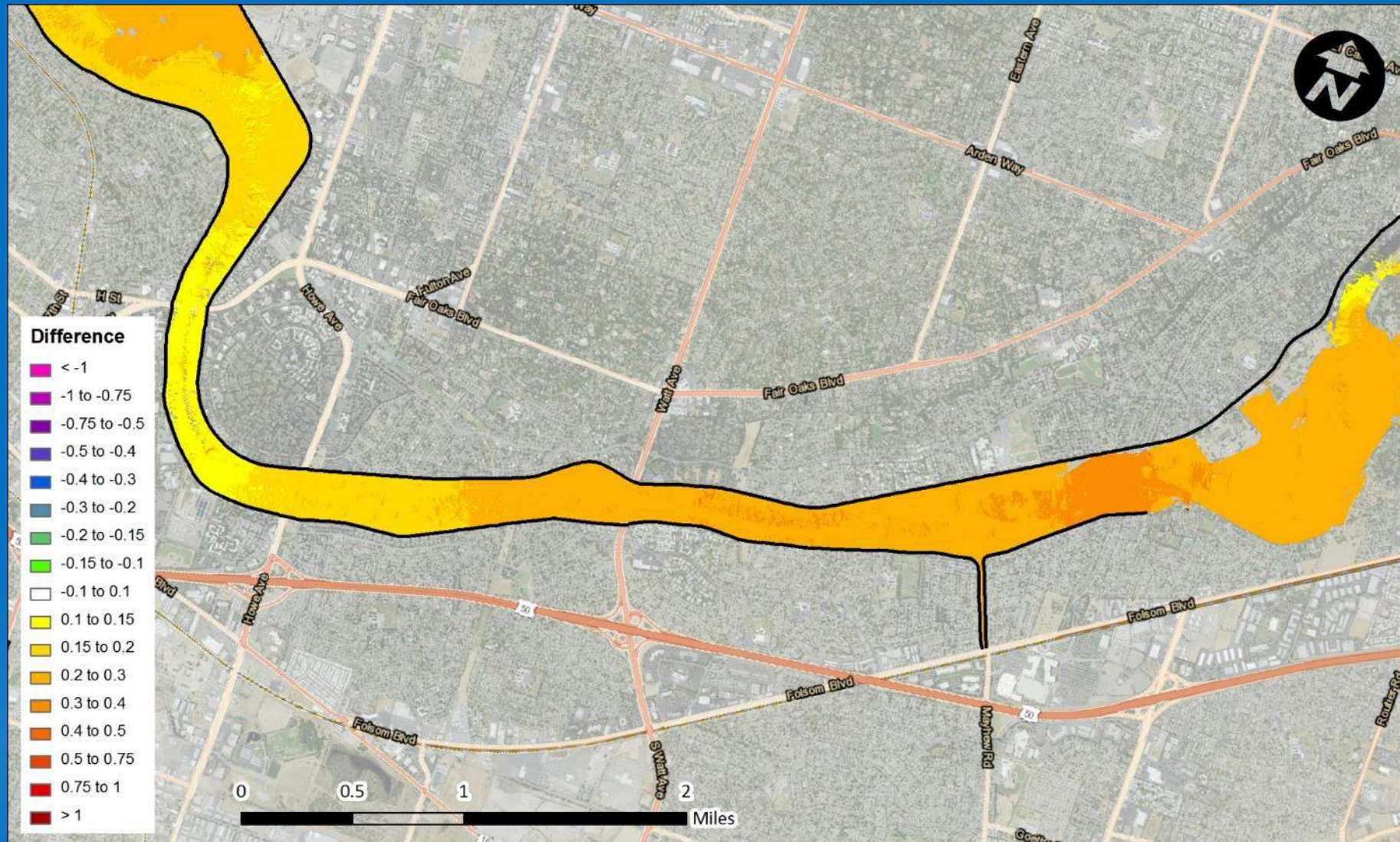


# Flood Model Development – Mesh Resolution

- Tested different mesh resolutions for 130,000 cfs steady inflow
  - 15-ft
  - 20-ft
  - 25-ft
  - 30-ft
  - 40-ft
  - 50-ft
- Concluded that a 20-ft mesh provides balance of model efficiency and accuracy

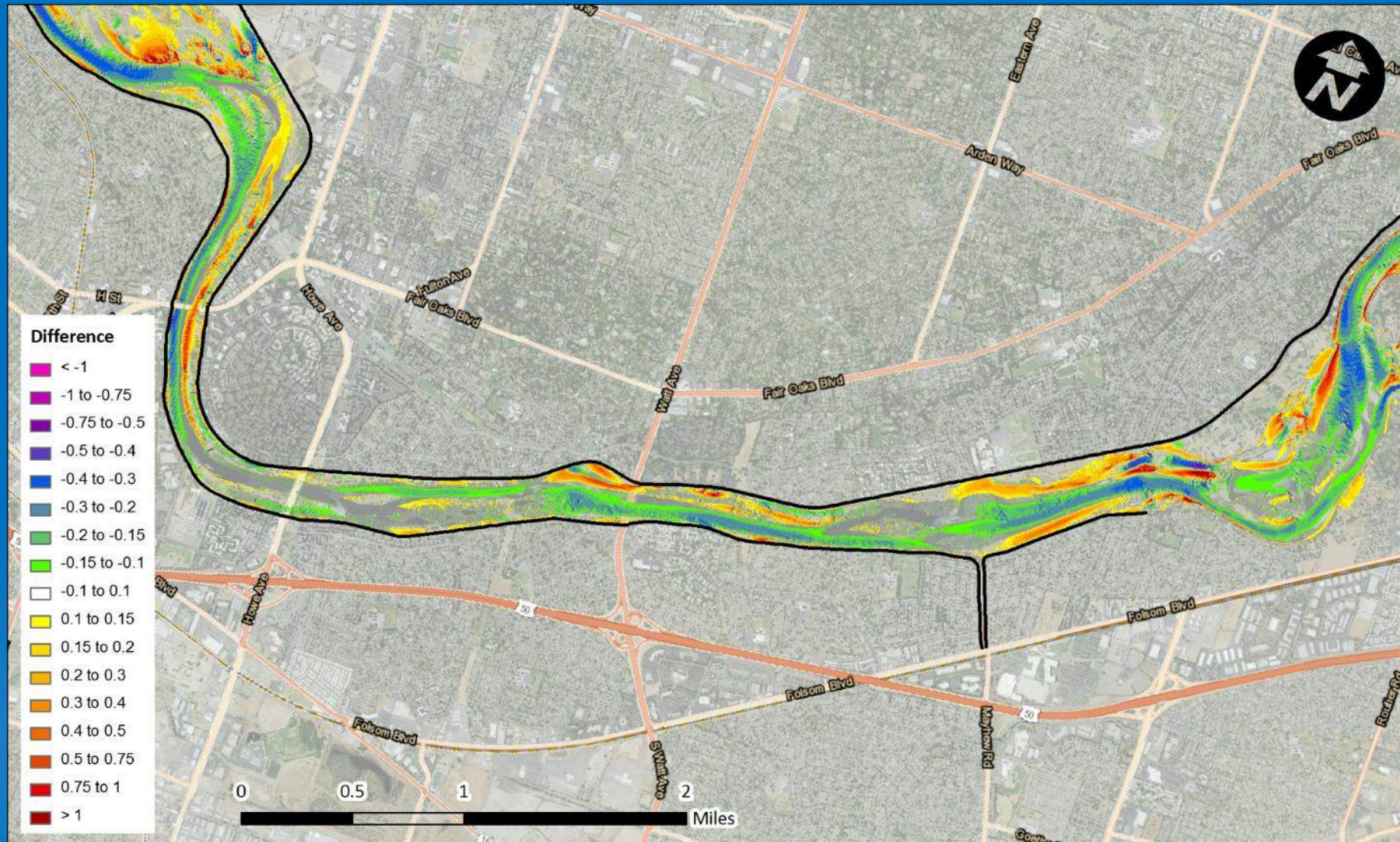


# WSE Difference: 130,000 cfs 30-ft mesh vs. 15-ft mesh





# Velocity Difference: 130,000 cfs 30-ft mesh vs. 15-ft mesh



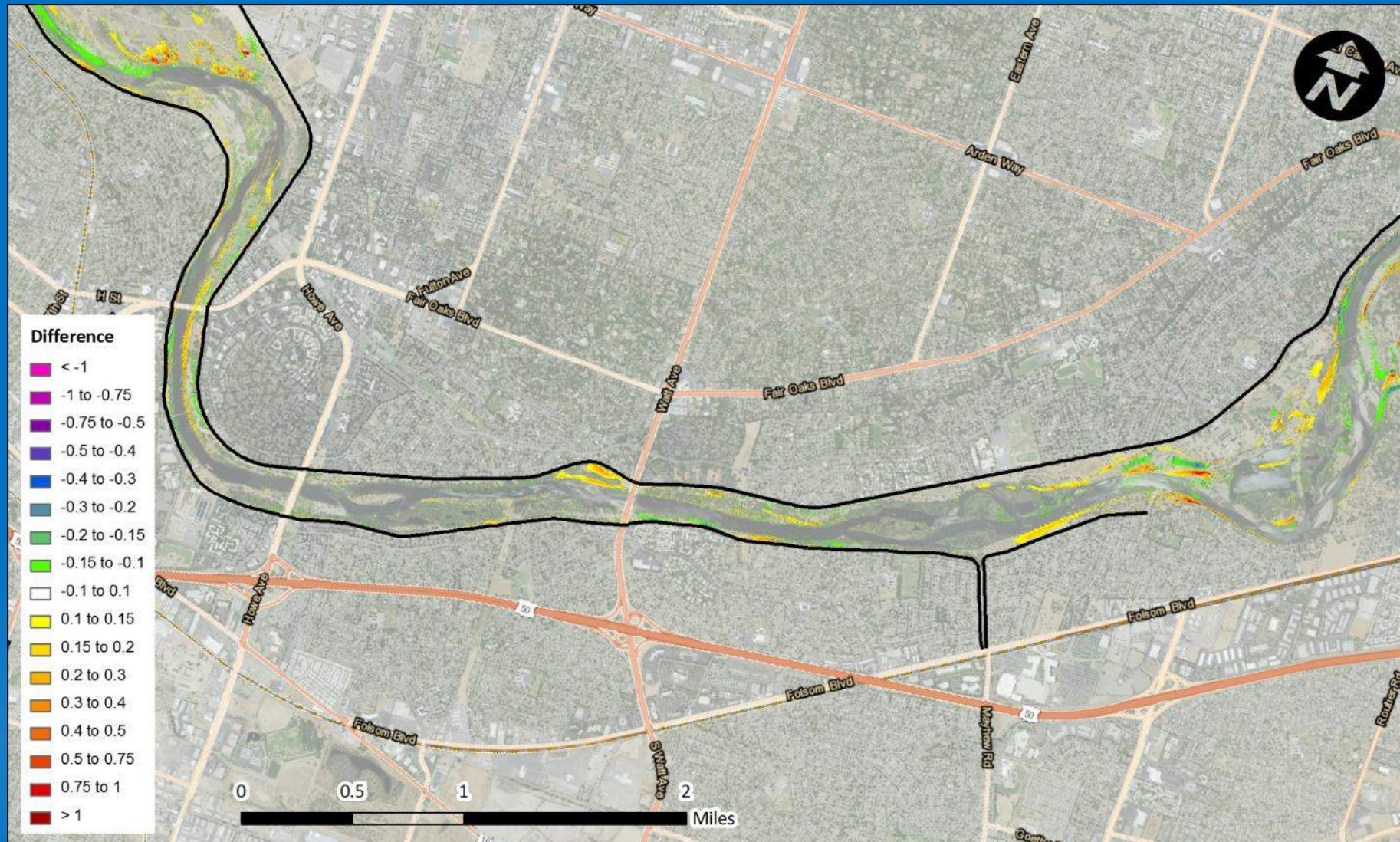


# WSE Difference: 130,000 cfs 20-ft mesh vs. 15-ft mesh





# Velocity Difference: 130,000 cfs 20-ft mesh vs. 15-ft mesh





# Bridge Pier Modeling Tests

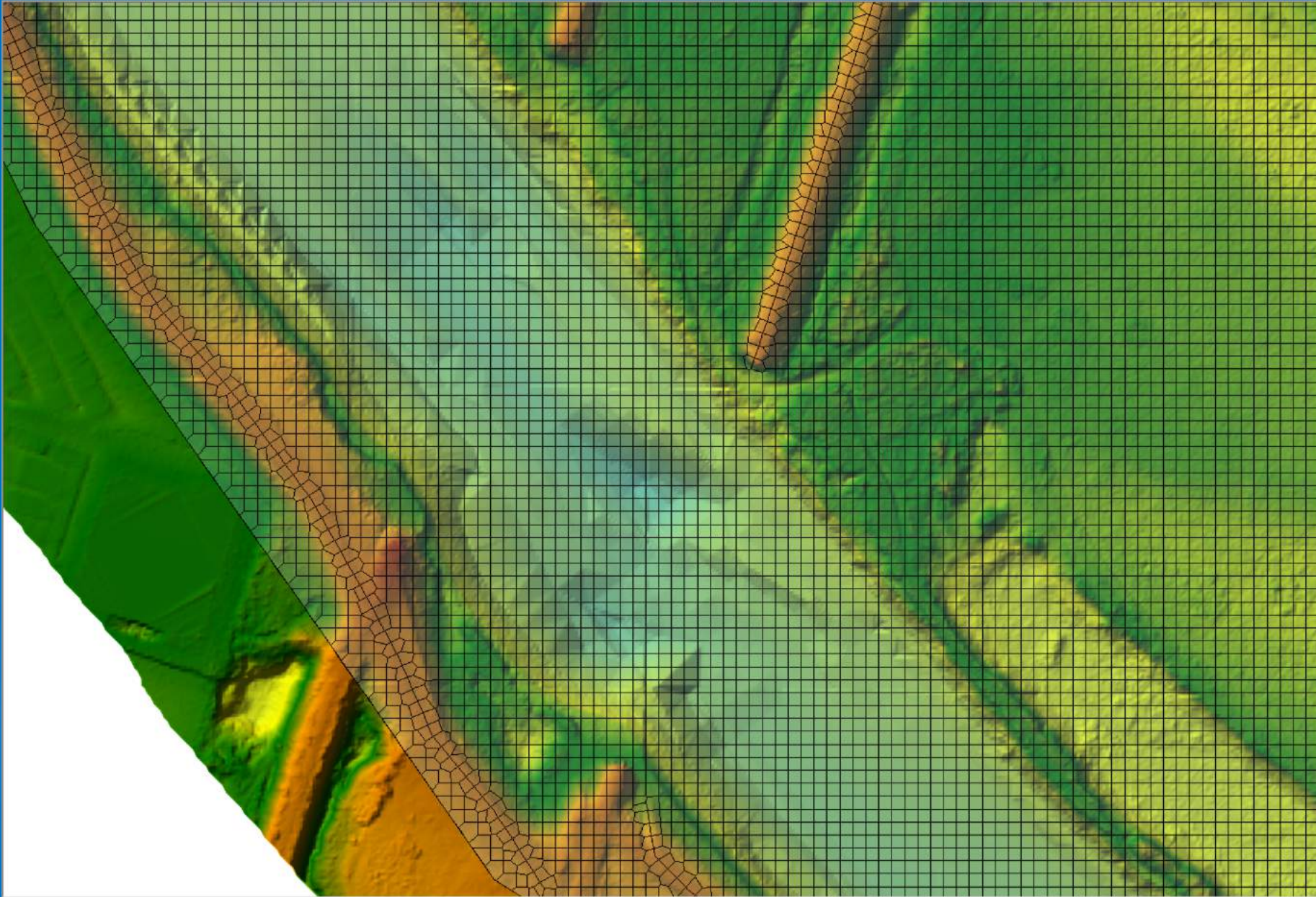
## Three scenarios

- A) No bridge piers; 20-ft mesh
- B) Bridge piers included in the DEM; 20-ft mesh
- C) Bridge piers included in the DEM; 20-ft mesh with refinements (i.e, breaklines and small cells around the piers)

Scenarios are for 134,000 cfs (1986 peak flow)

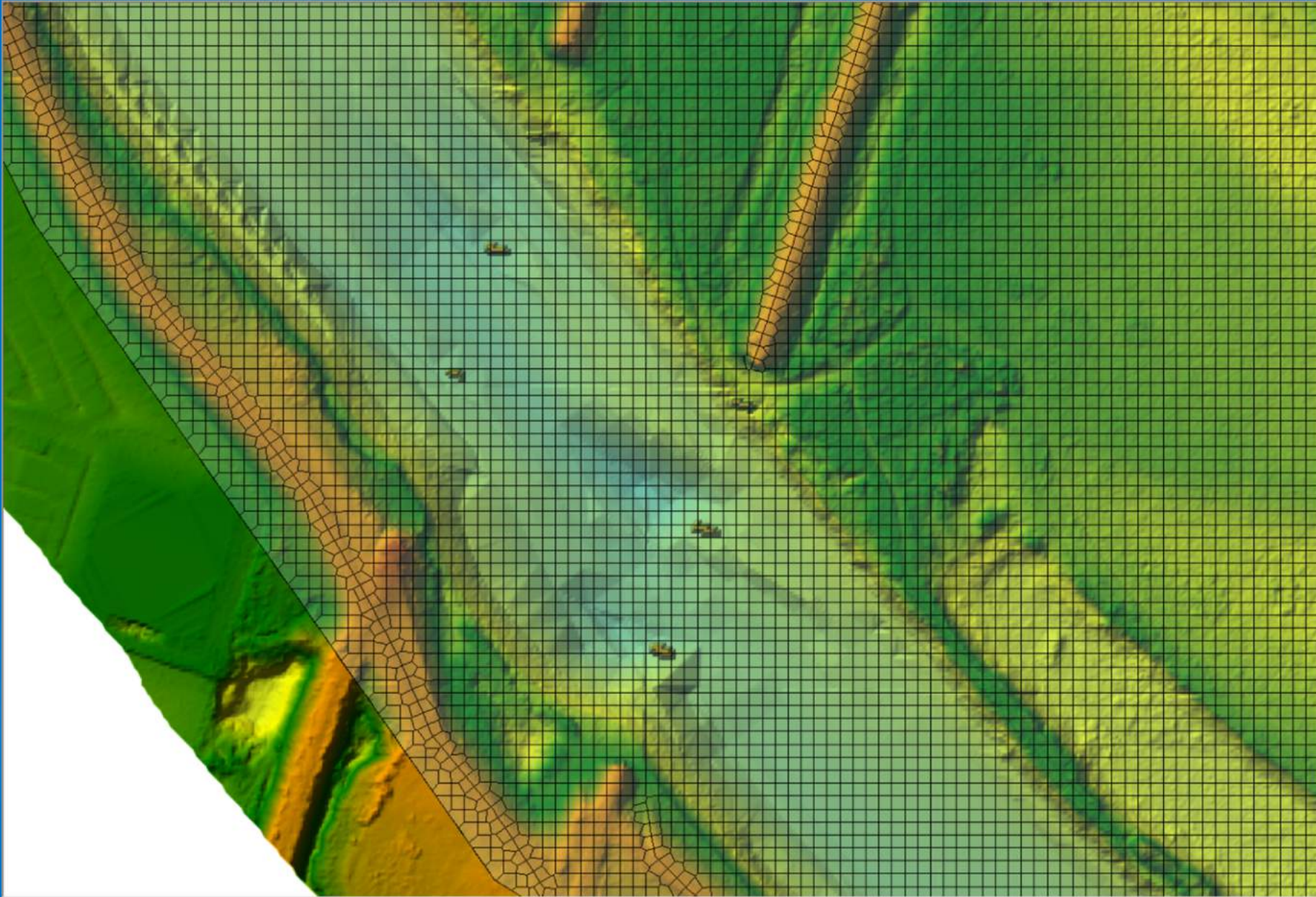


# Scenario A mesh



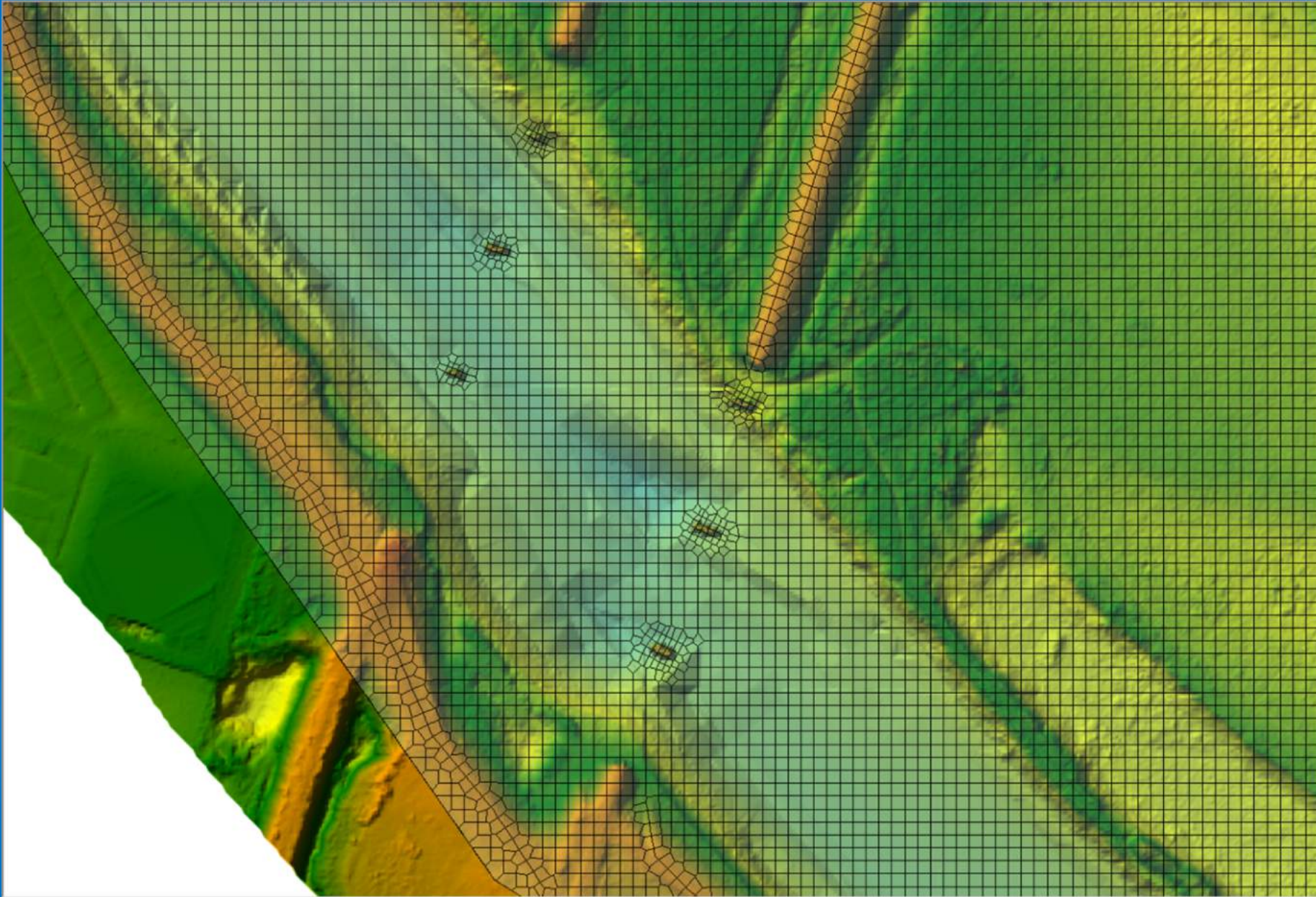


# Scenario B mesh



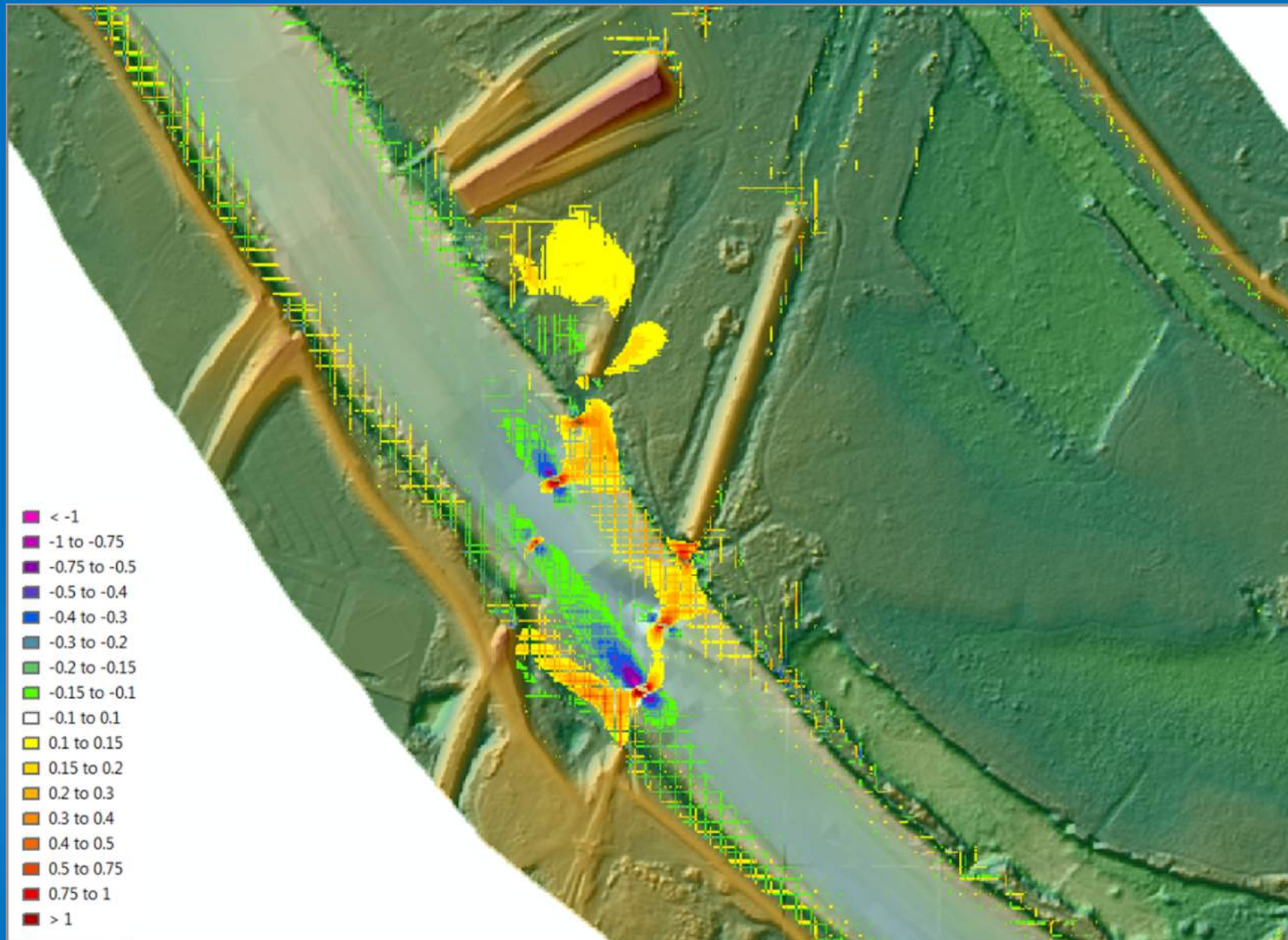


# Scenario C mesh



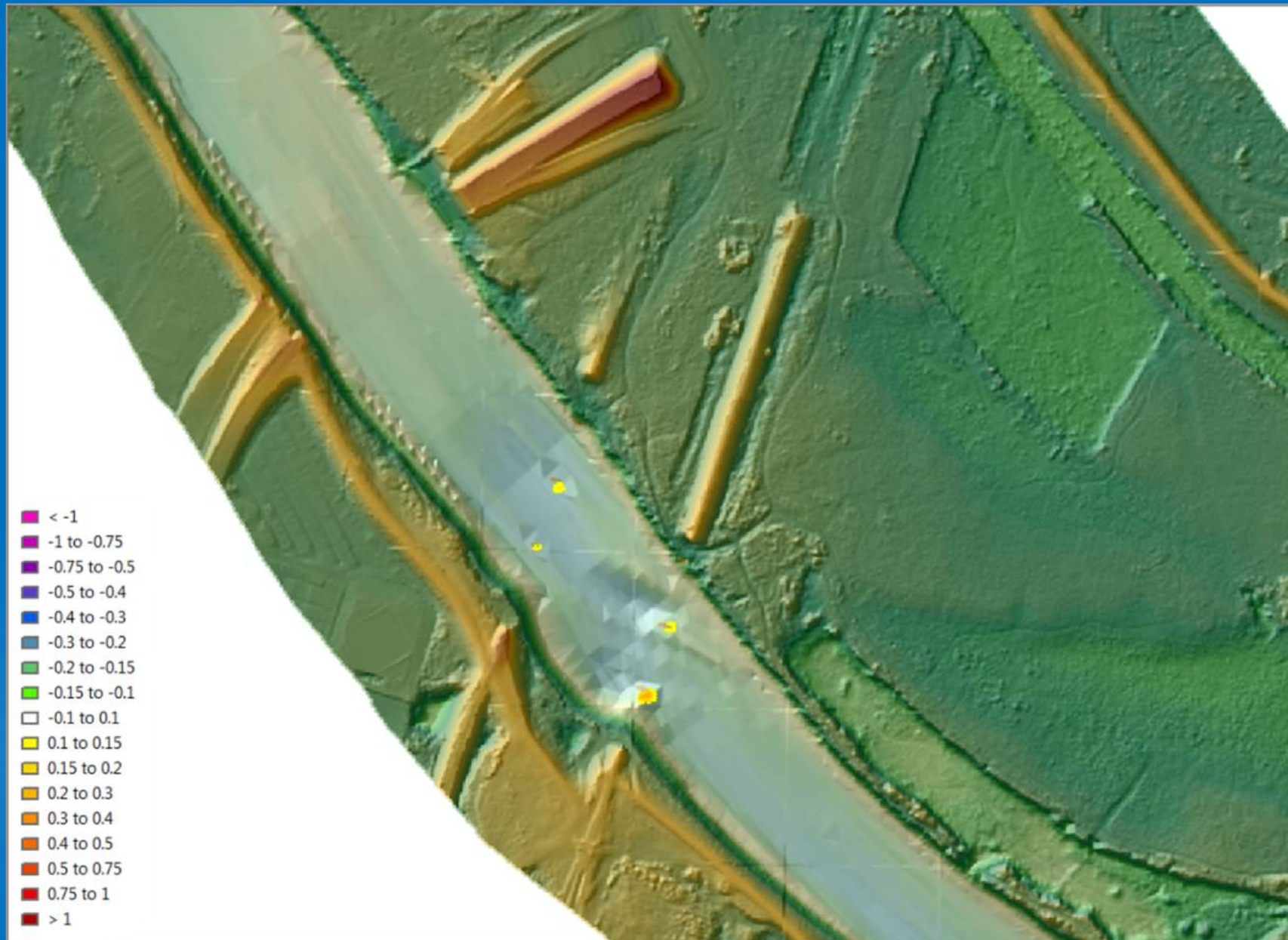


# Velocity Differences: B - A



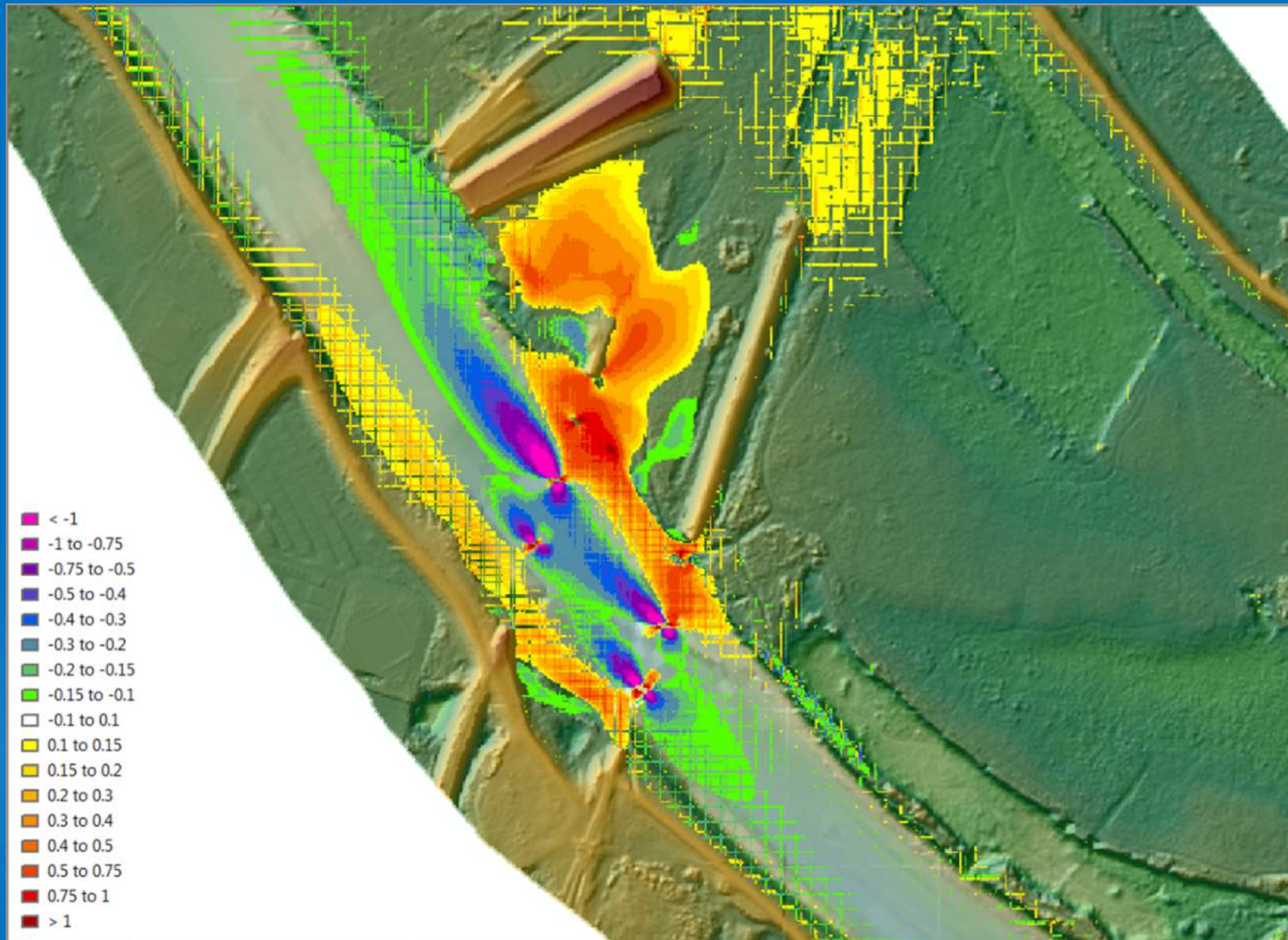


# WSE Differences: B - A



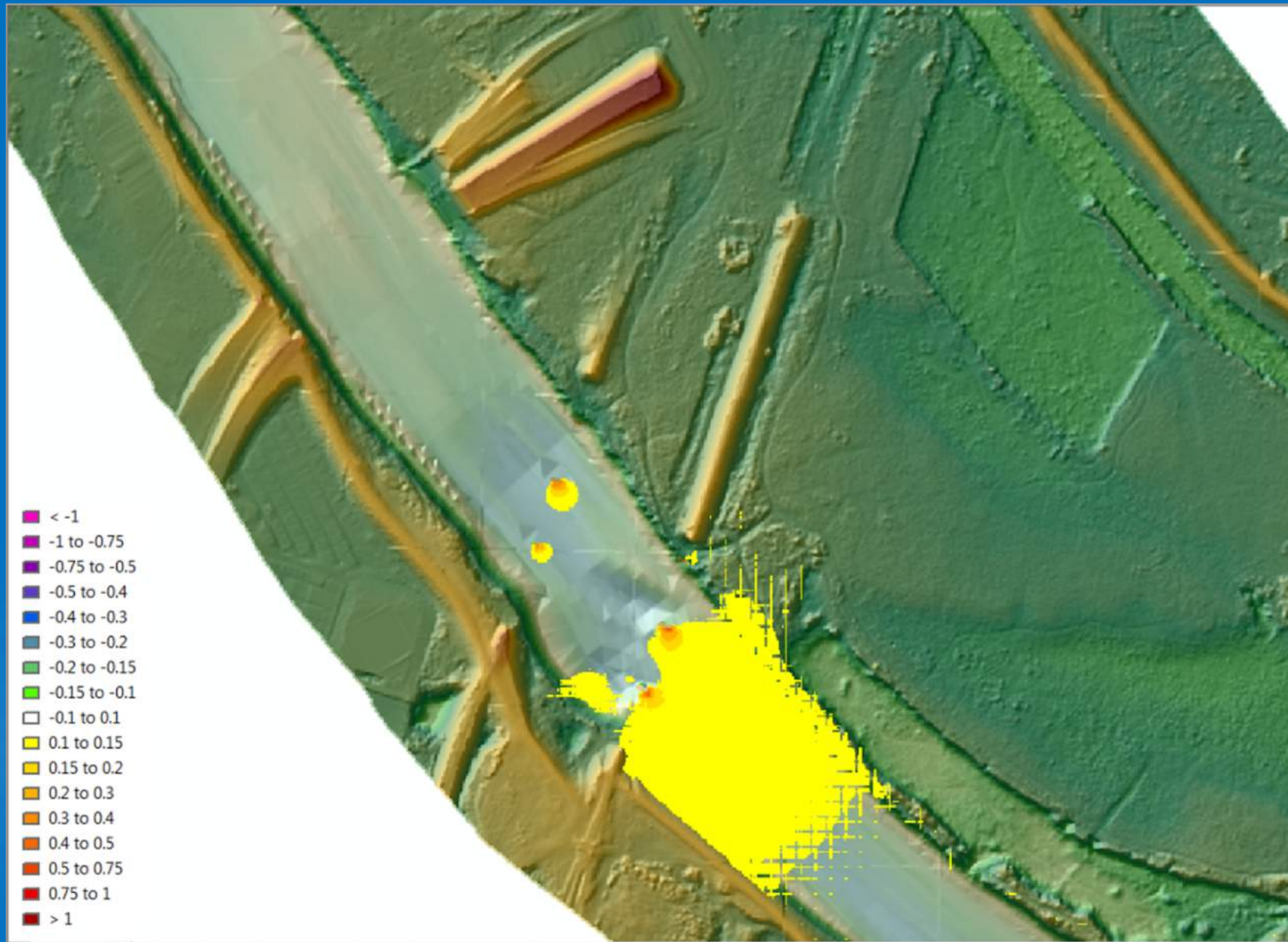


# Velocity Differences: C - A





# WSE Differences: C - A





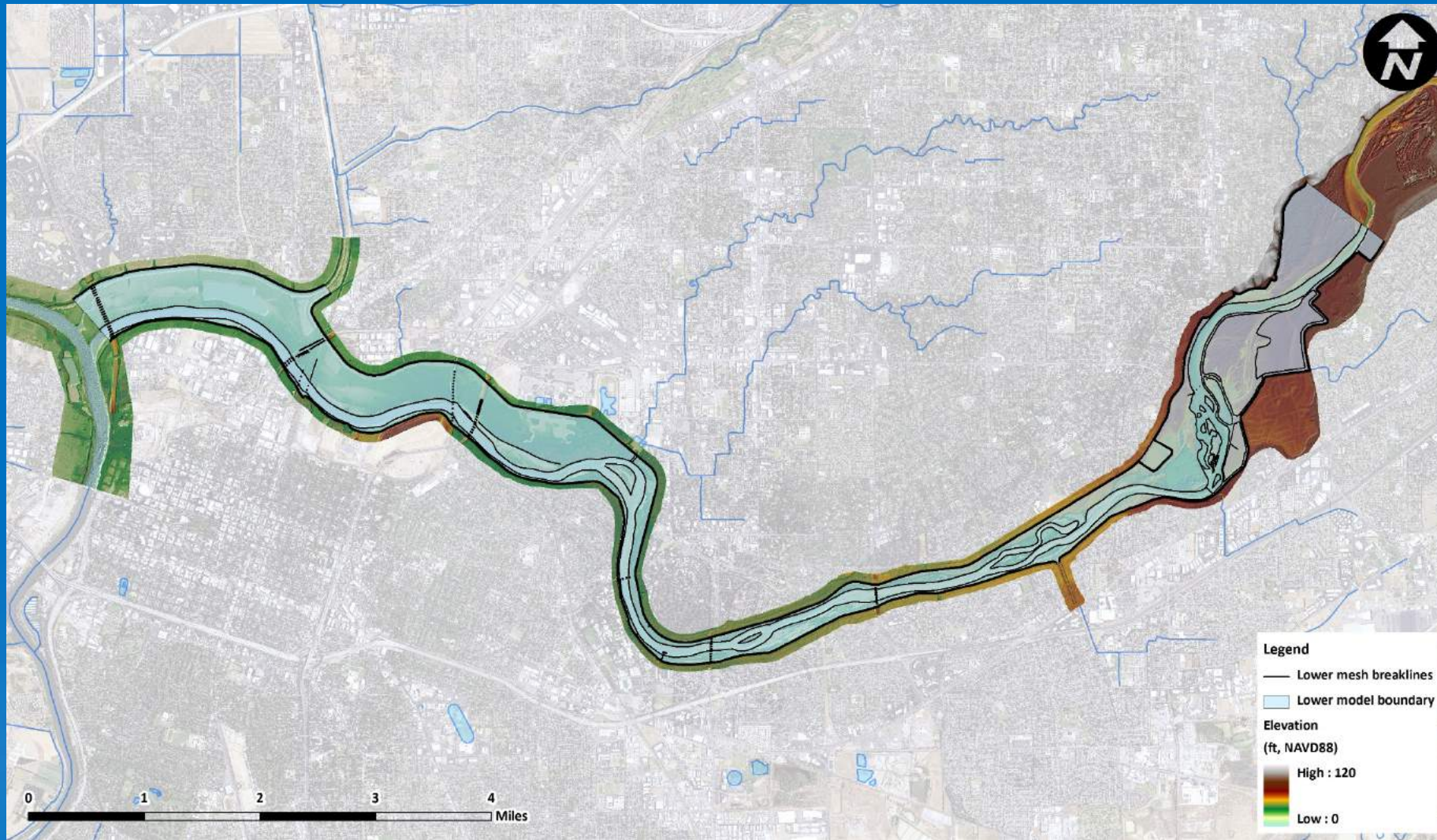
# Conclusion



- Add bridge piers to the DEM and refine mesh with breaklines



# Flood Model Development – Lower Domain Breaklines



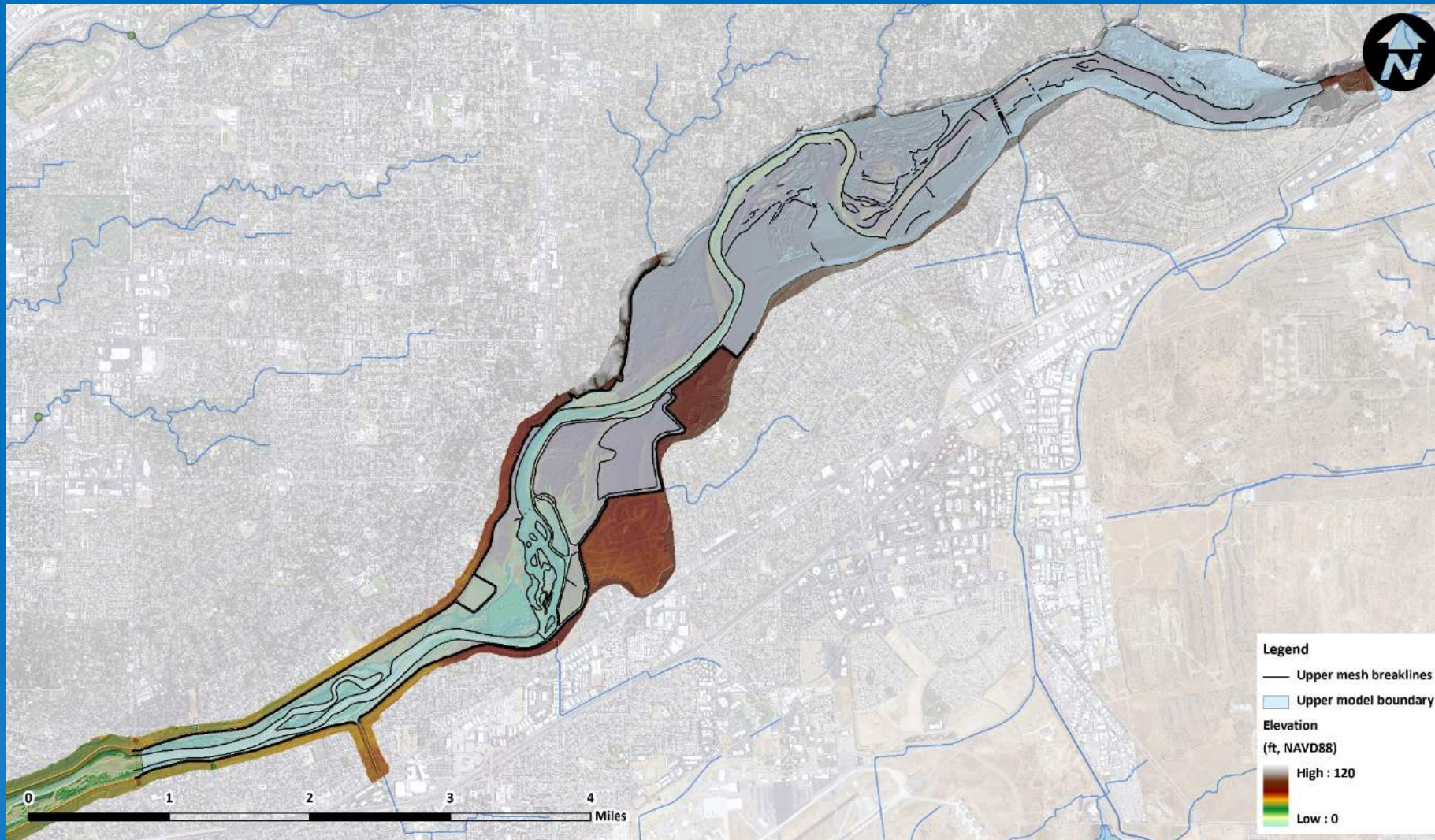
Breaklines include:

- Top of levee
- Toe of levee
- Channel banks
- High ground
- Bridge piers

Breaklines orient the cell faces to enforce features and refine the mesh to provide more detail



# Flood Model Development – Upper Domain Breaklines



Breaklines include:

- Top of levee
- Toe of levee
- Channel banks
- High ground
- Bridge piers

Breaklines orient the cell faces to enforce features and refine the mesh to provide more detail



# Calibration/Validation Data

- HWM's and WSE observations:
  - 02/10/2017: 82,000 cfs RTK-WSEs
  - 02/19/1986: 134,000 cfs HWMs
  - 01/02/1997: 117,000 cfs HWMs
  - 12/16/2016: 34,000 cfs RTK-WSEs
  - 12/20/2016: 20,500 cfs RTK-WSEs
  - 01/11/2017: 60,000 cfs RTK-WSEs
- UAV Imagery:
  - 12/16/2016: 34,000 cfs
  - 01/11/2017: 60,000 cfs
  - 02/10/2017: 82,000 cfs

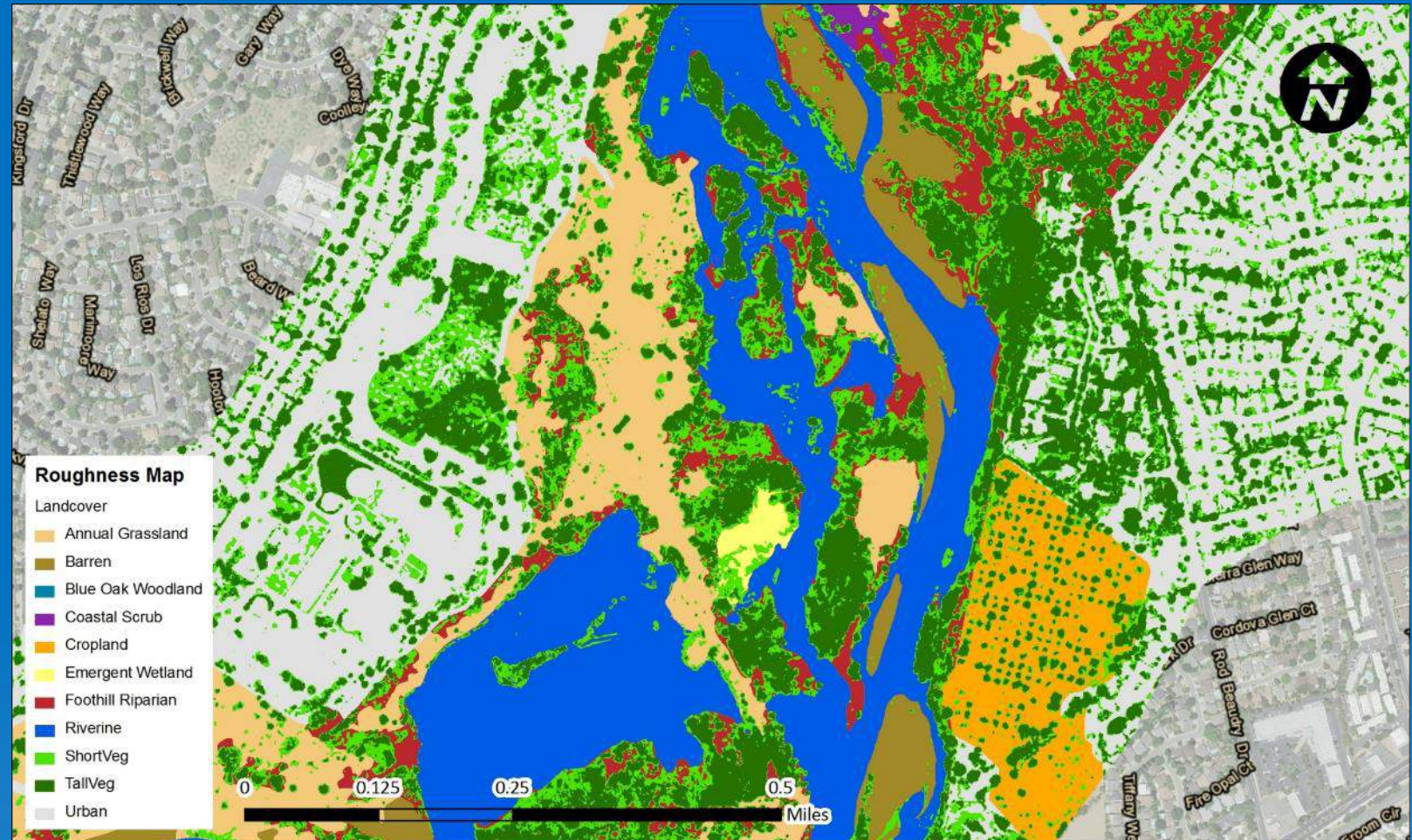


Source: cbec UAV 2/10/2017



# Roughness Map: Manning's n

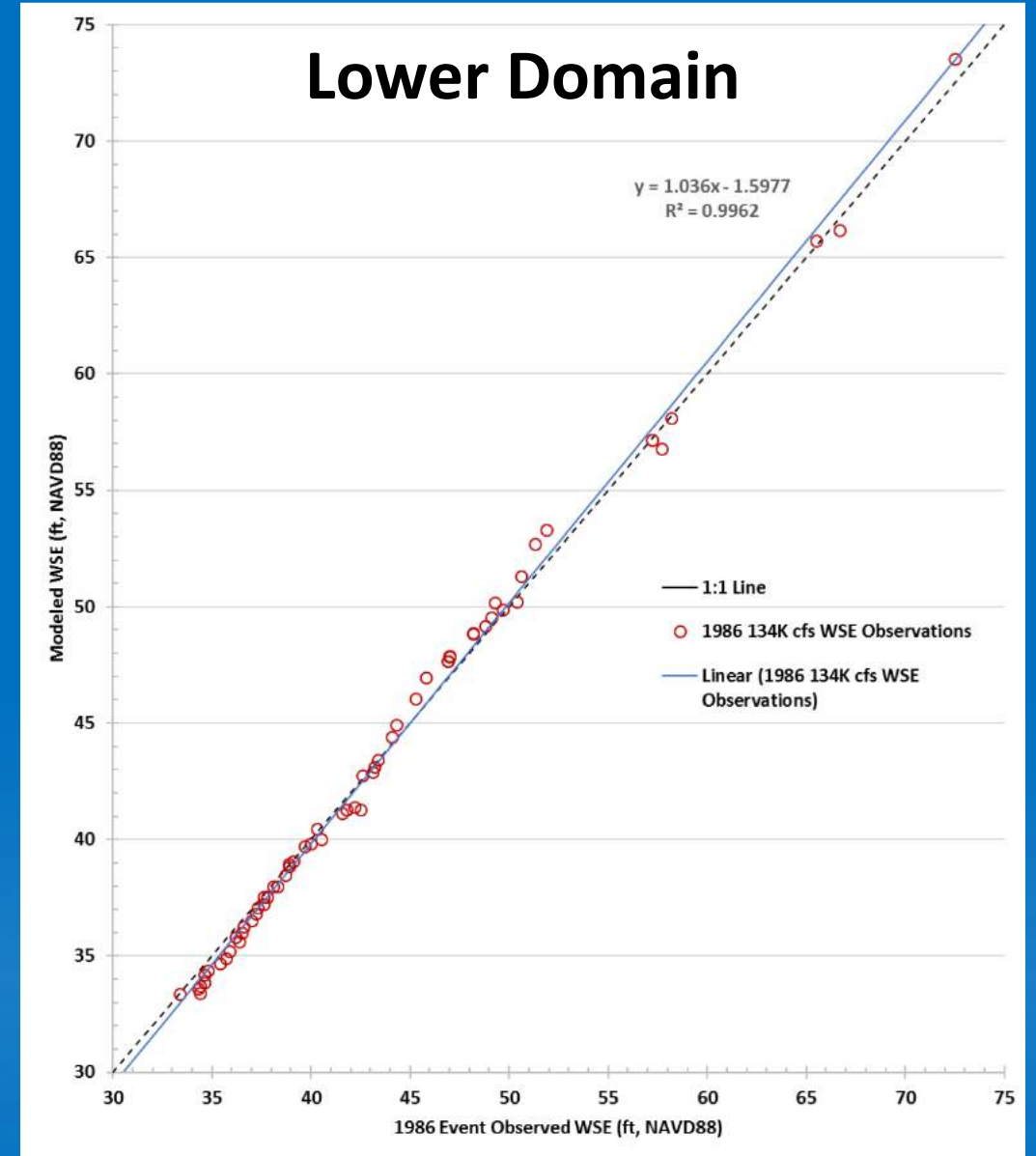
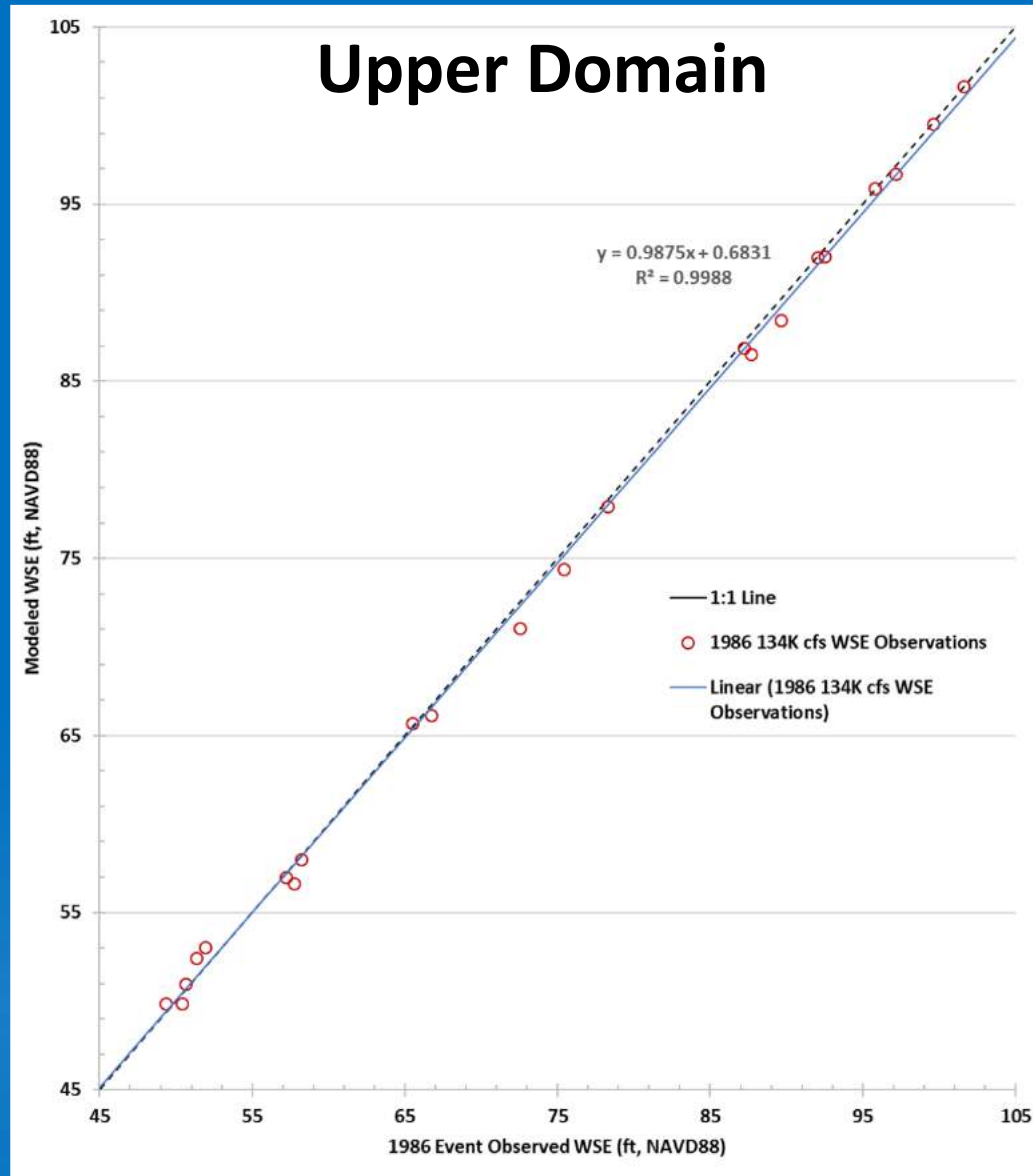
Landcover	Manning's N
Annual grassland	0.035
Barren	0.035
Blue oak woodland	0.04
Coastal scrub	0.04
Cropland	0.035
Emergent wetland	0.035
Foothill riparian	0.04
Water	0.022
Sparse vegetation	0.055
Dense vegetation	0.07
Urban	0.03



Note: the bulk of the vegetation is defined by “sparse vegetation” or “dense vegetation” classes, which come from classifying the NAIP imagery.



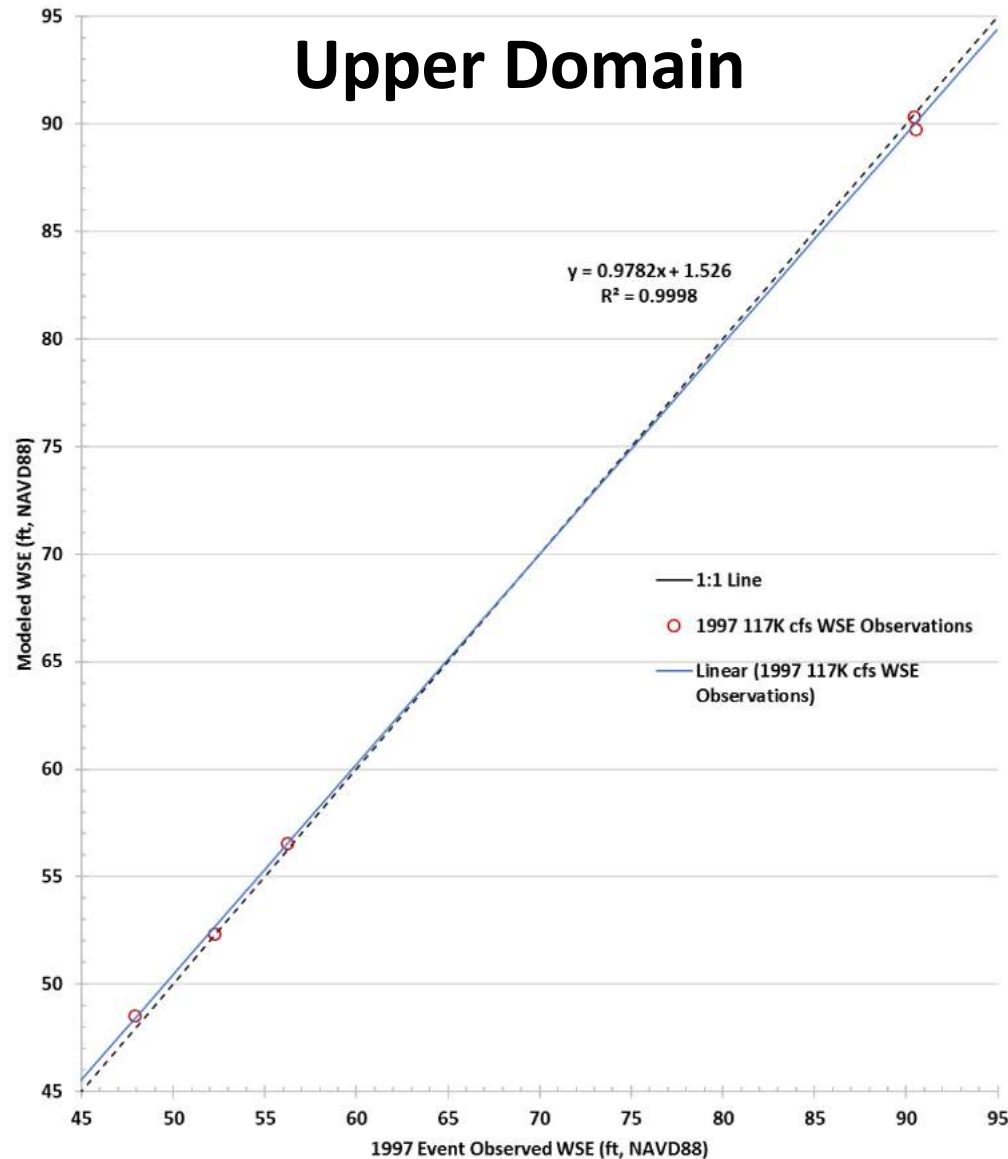
# 1986 event – 134,000 cfs



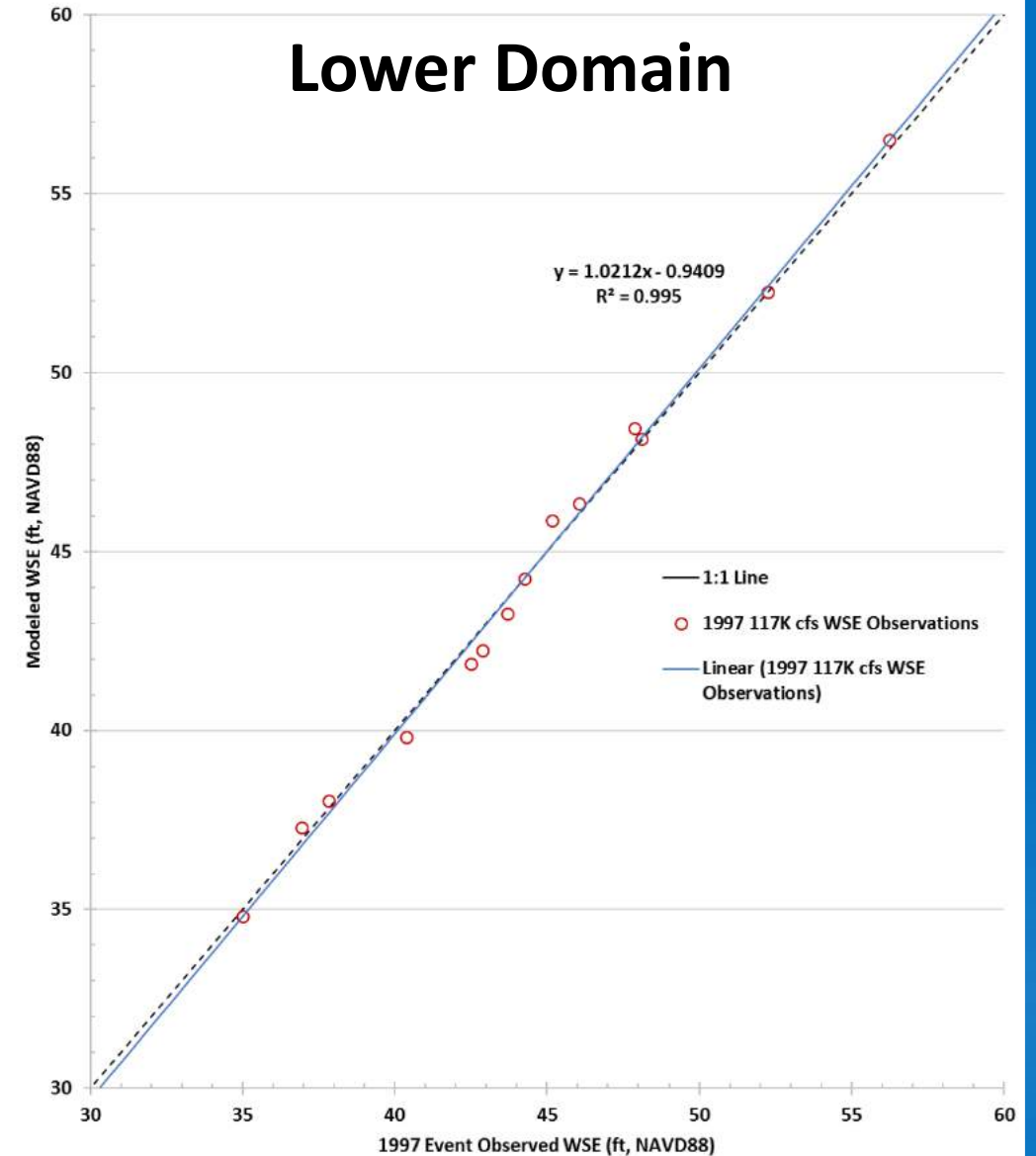


# 1997 event – 117,000 cfs

## Upper Domain

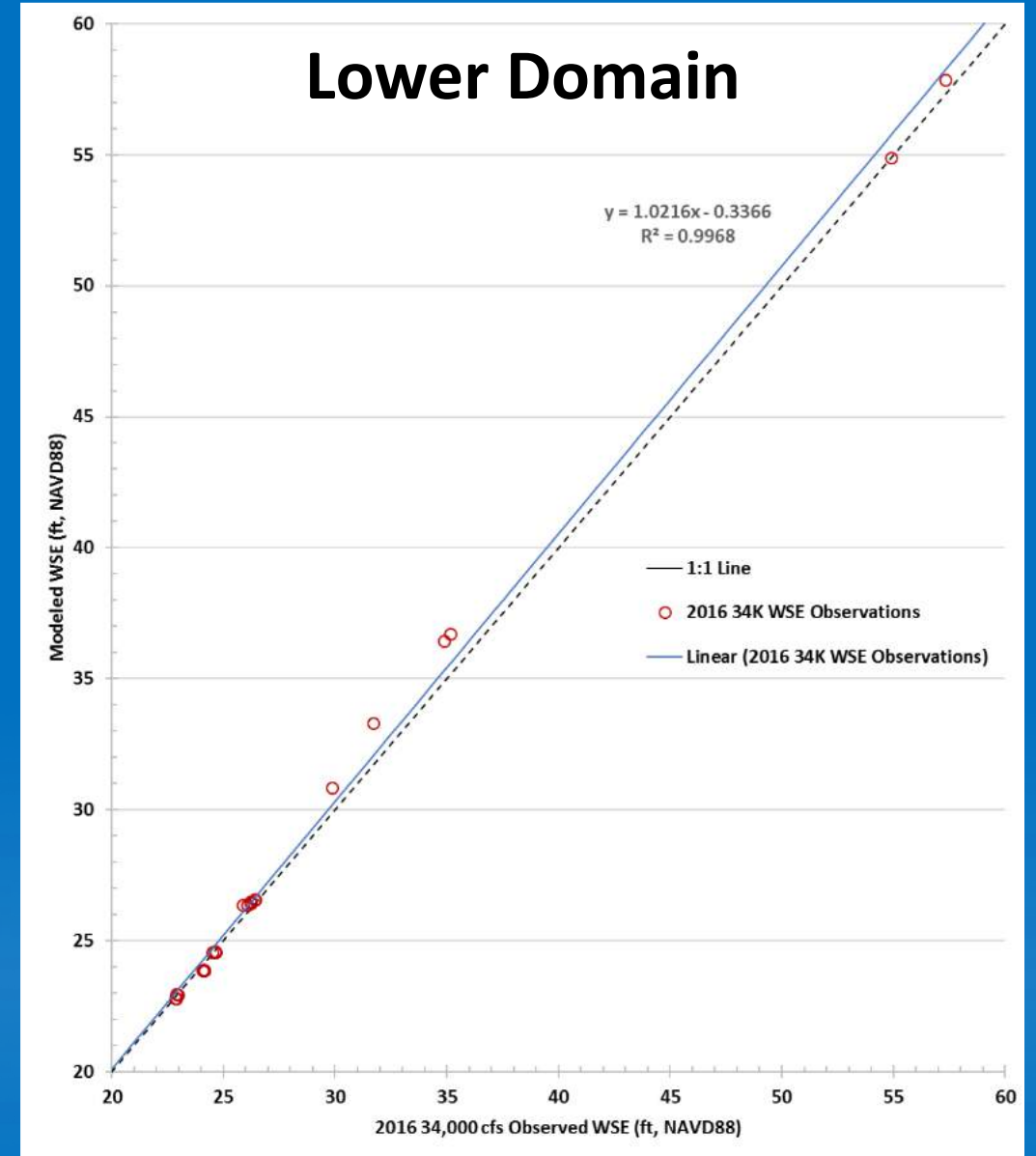
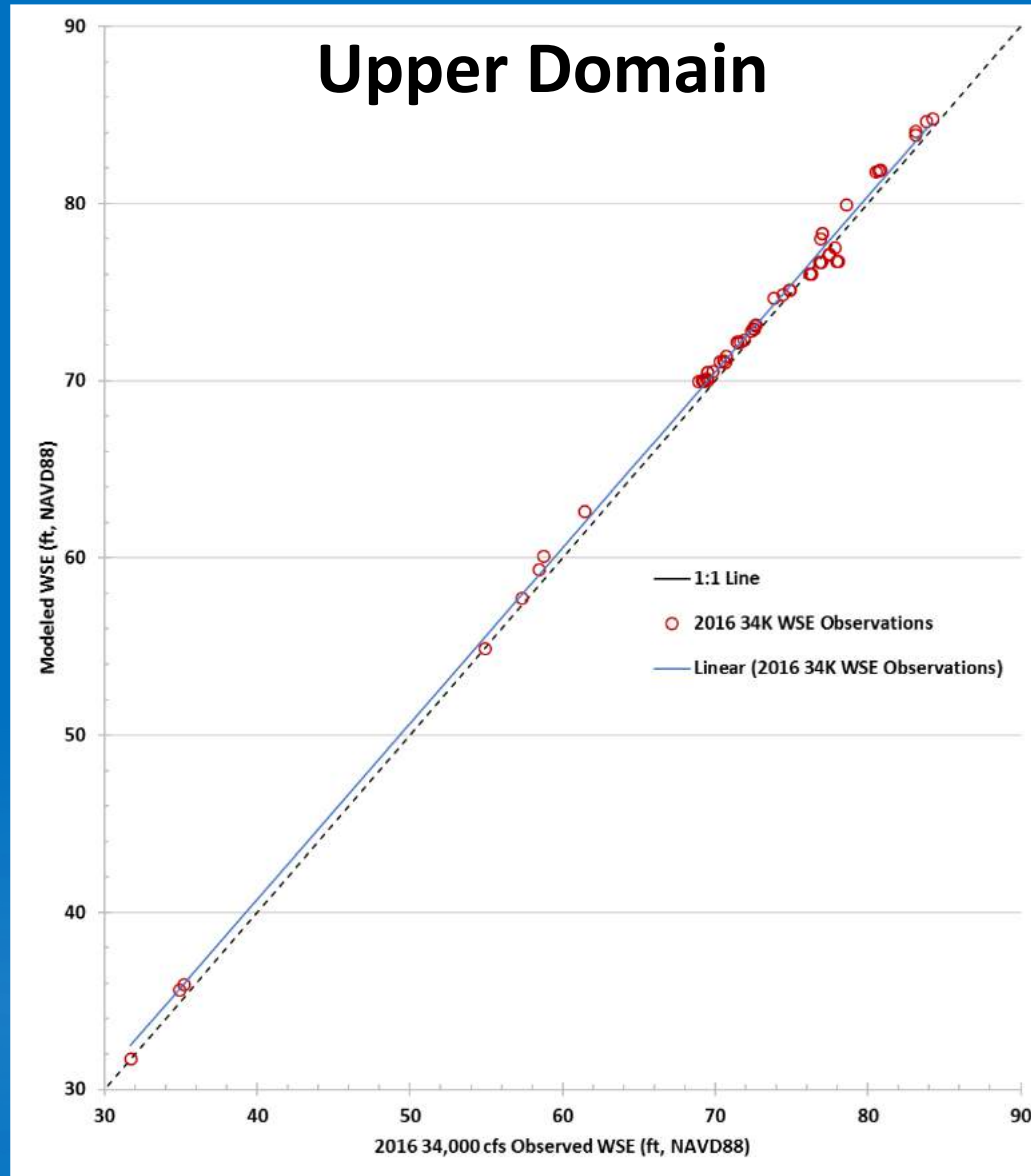


## Lower Domain





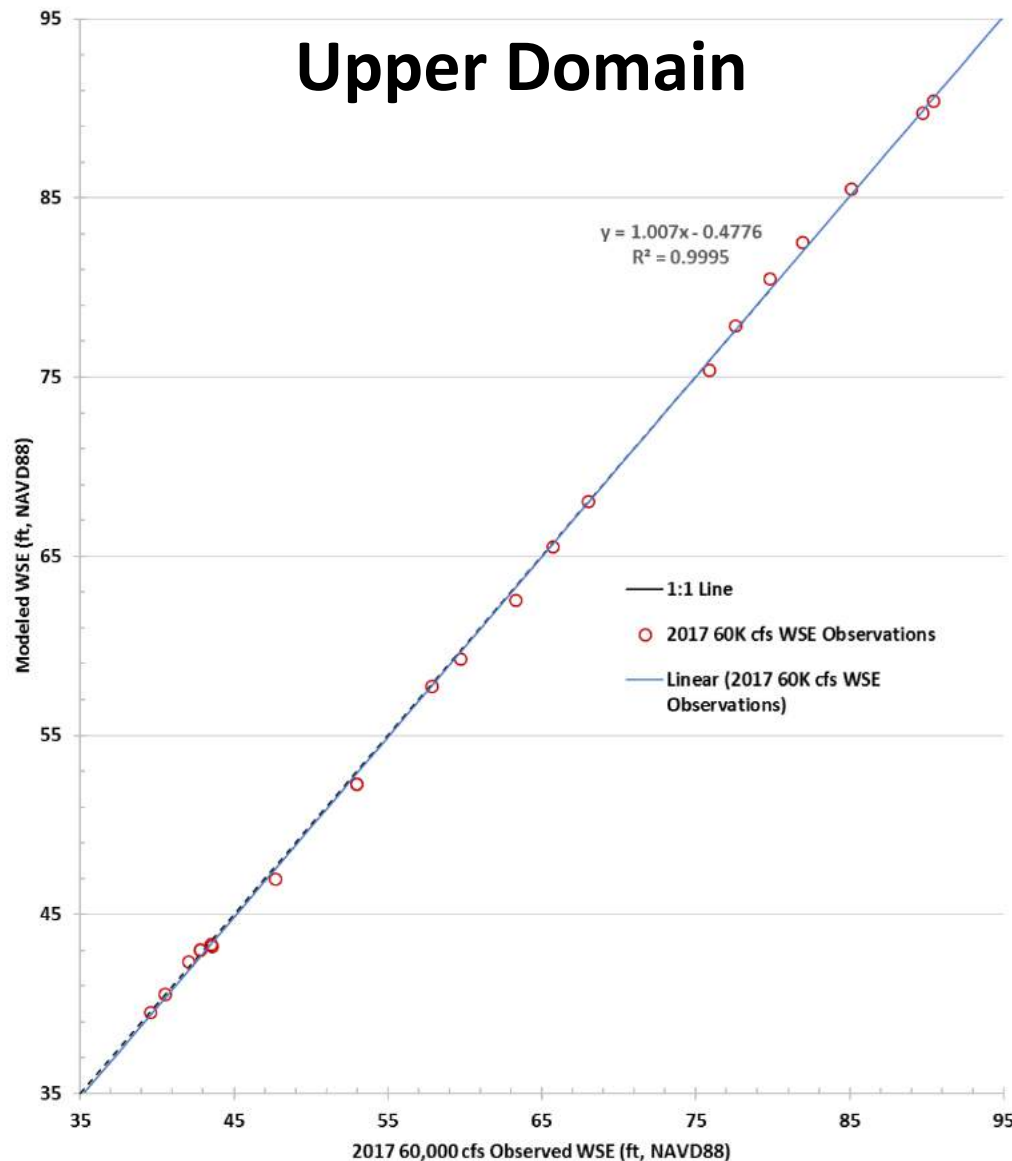
# 2016 event – 34,000 cfs



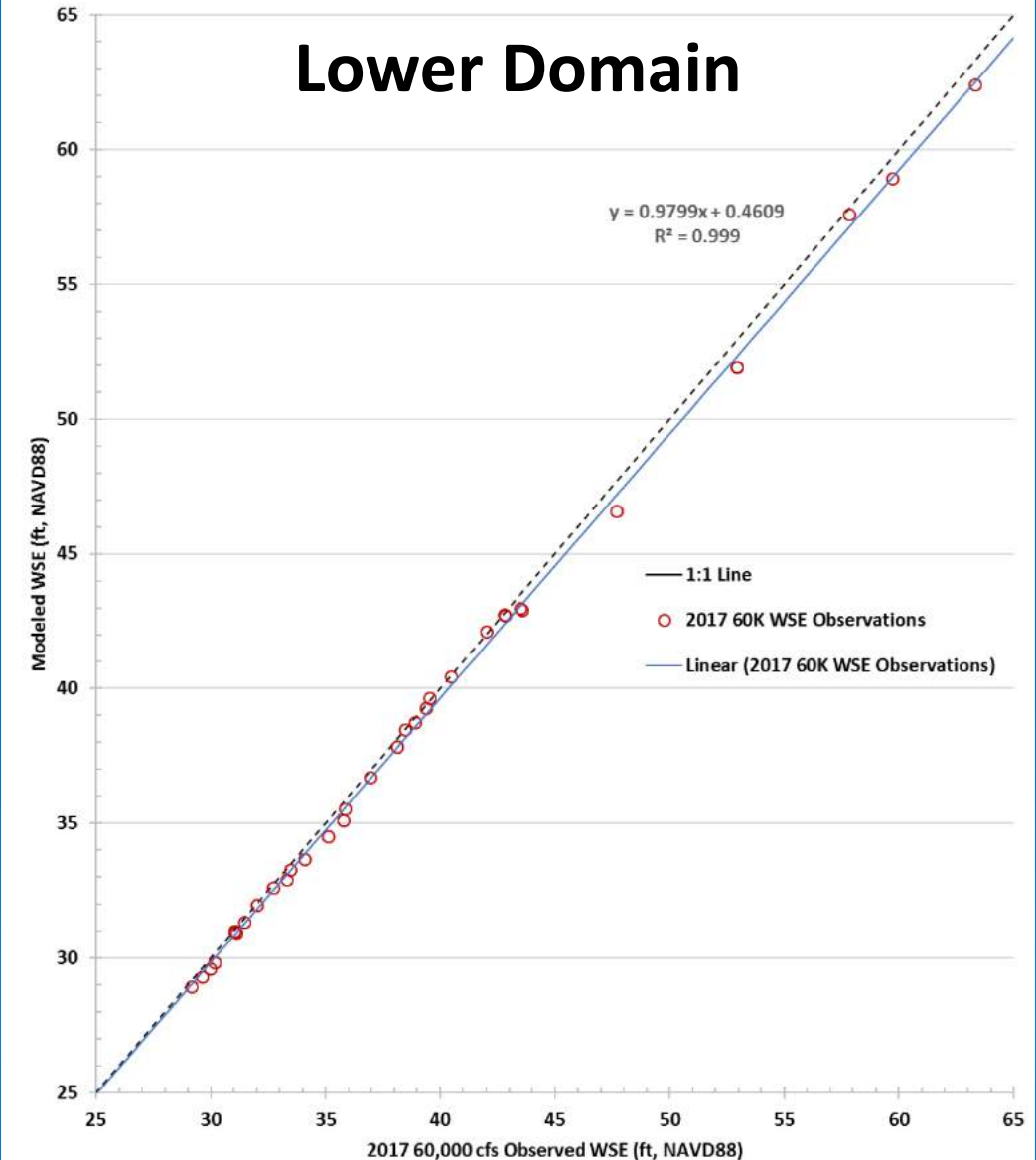


# 2017 event – 60,000 cfs

## Upper Domain

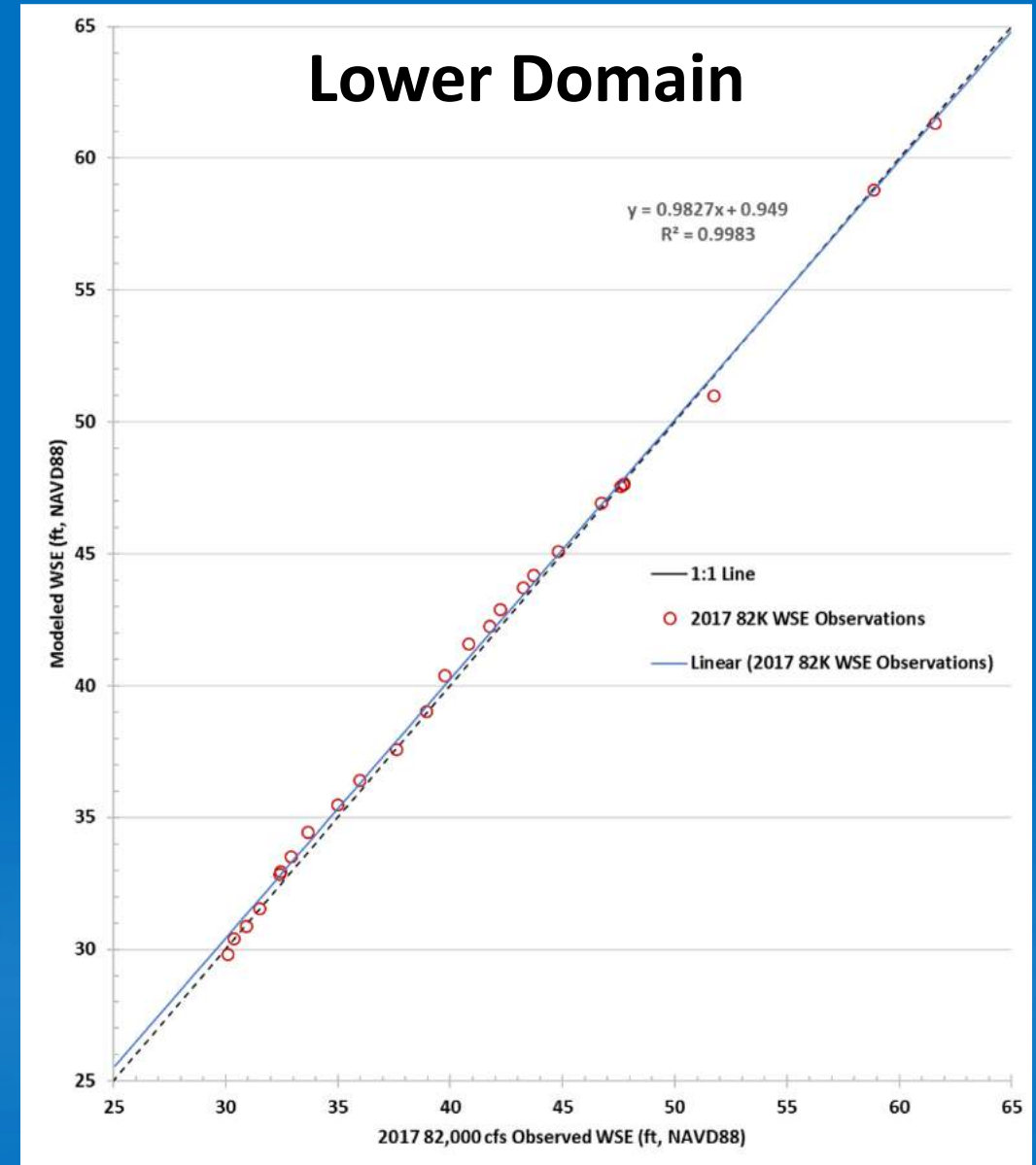
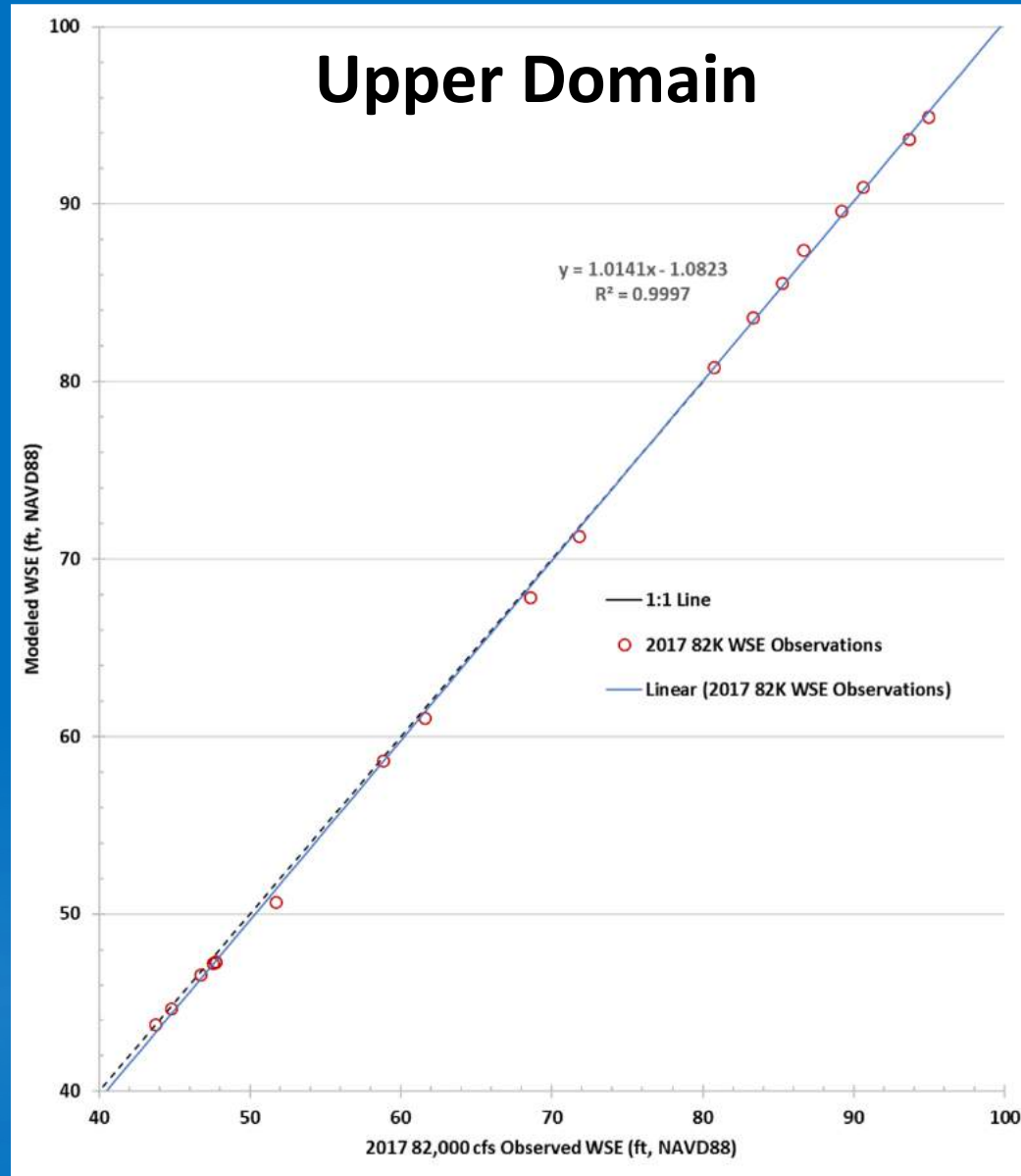


## Lower Domain





# 2017 event – 82,000 cfs





# Calibration and Validation Summary Statistics

**Table 1. Lower model domain statistics**

Date	Discharge (cfs)	# of Obs.	Modeled minus Observed WSE (ft)				
			Min.	Max.	Average	Median	RMSE
2/19/1986	134,000	62	-1.23	1.39	-0.09	-0.04	0.61
1/2/1997	117,000	14	-0.66	0.70	0.00	0.04	0.42
12/16/2016	34,100	24	-0.25	1.61	0.28	0.08	0.56
12/20/2016	20,500	23	-0.44	0.08	0.51	0.56	0.44
1/11/2017	60,300	34	-1.10	0.09	-0.33	-0.24	0.33
2/10/2017	82,20	26	-0.72	-0.02	0.24	0.24	0.37
All Dates	All flows	183	-1.23	1.61	0.06	-0.02	0.56

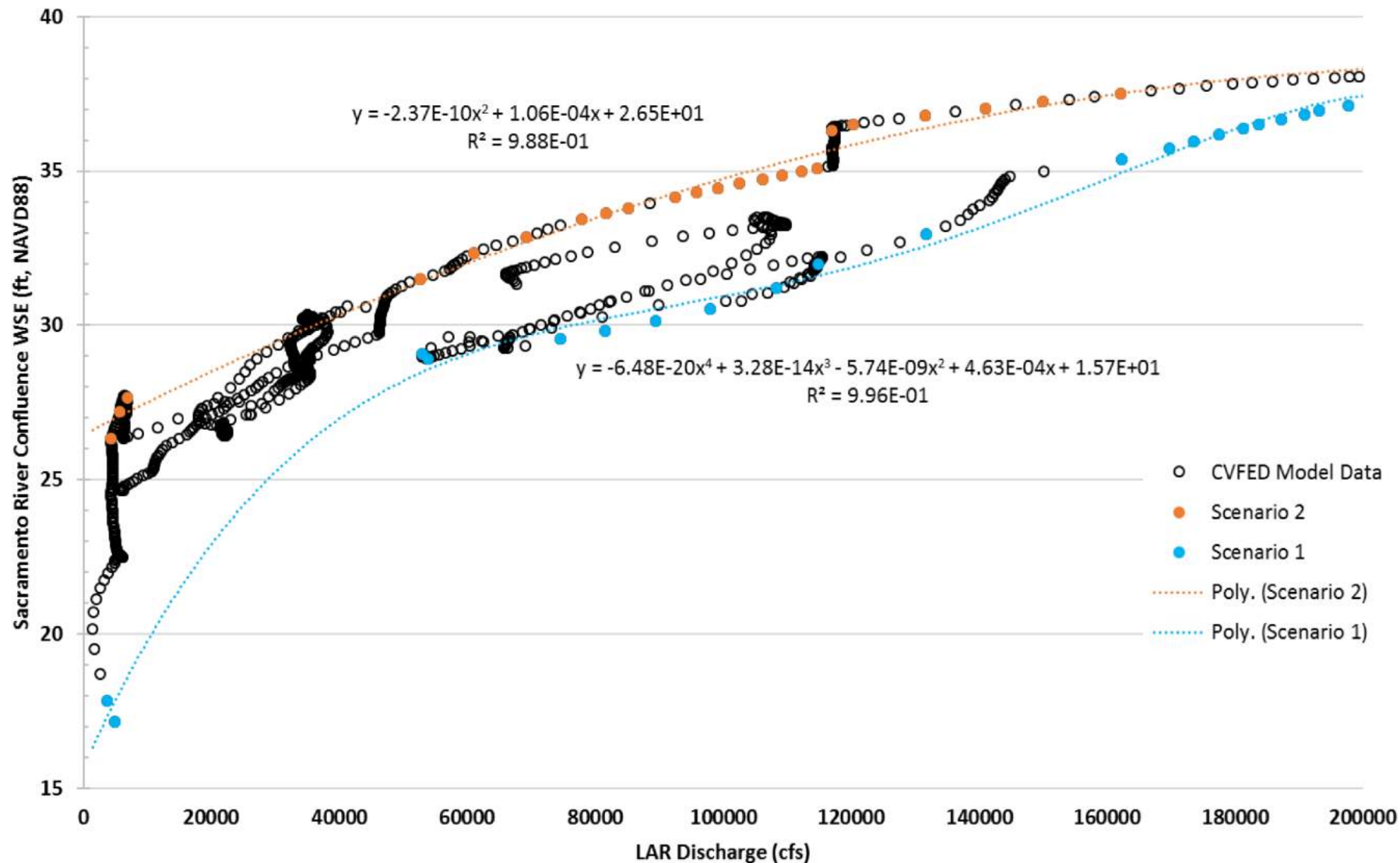
**Table 2. Upper model domain statistics**

Date	Discharge (cfs)	# of Obs.	Modeled minus Observed WSE (ft)				
			Min.	Max.	Average	Median	RMSE
2/19/1986	134,000	22	-1.44	1.16	-0.24	-0.27	0.68
1/2/1997	117,000	5	-0.79	0.70	0.06	0.10	0.50
12/16/2016	34,100	48	-1.27	1.40	0.49	0.61	0.63
12/20/2016	20,500	24	-0.94	0.58	0.10	0.15	0.35
1/11/2017	60,300	22	-0.74	0.75	-0.00	-0.05	0.42
2/10/2017	82,200	19	-1.08	0.79	-0.12	0.14	0.44
All Dates	All flows	127	-1.44	1.40	0.16	0.09	0.66





# Flood Model Boundary Conditions: Two Scenarios



**Applicable range**  
**30,000 – 160,000 cfs**

**Scenario 1:**

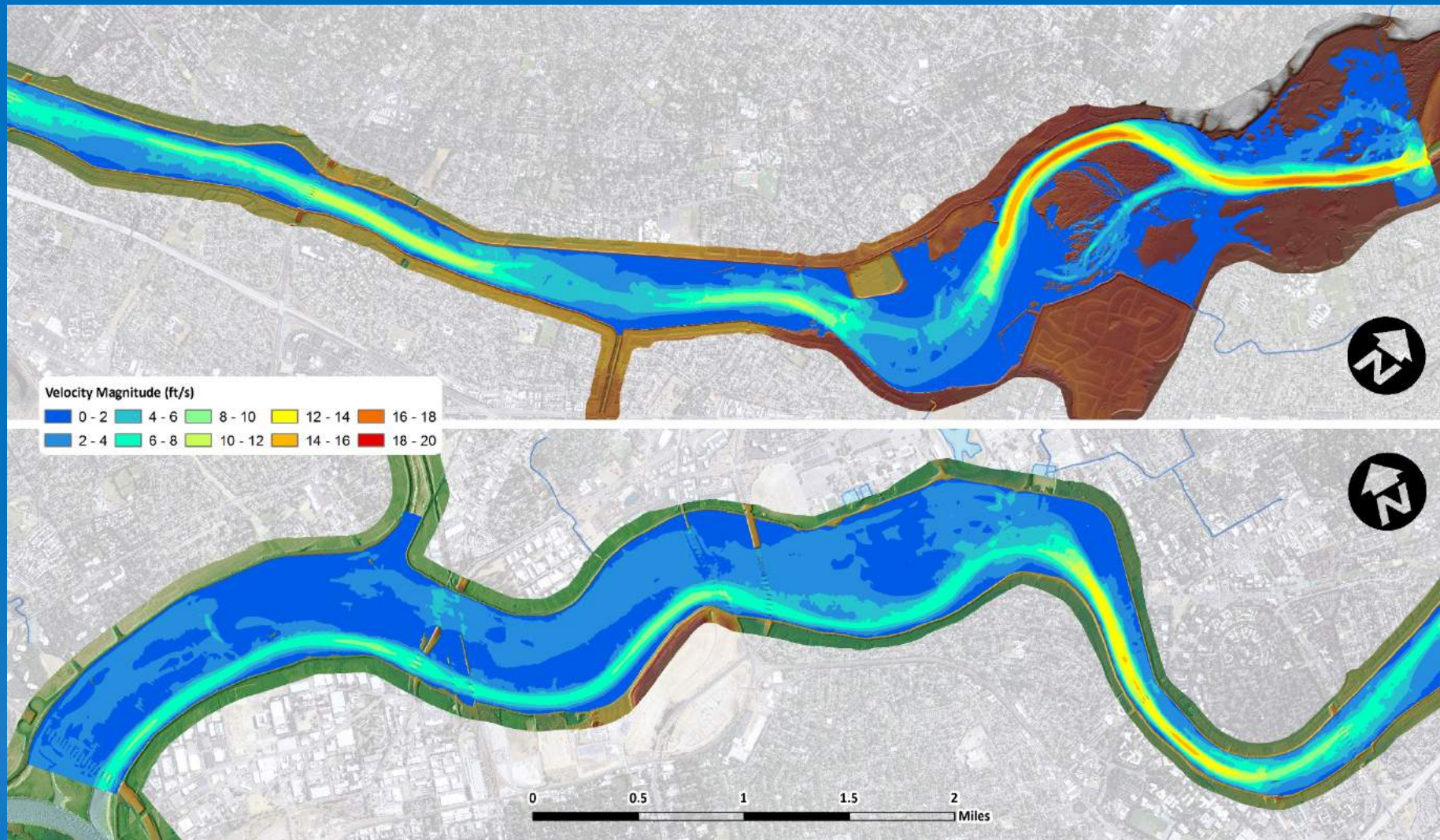
- Lower WSE at the confluence

**Scenario 2:**

- High WSE at the confluence

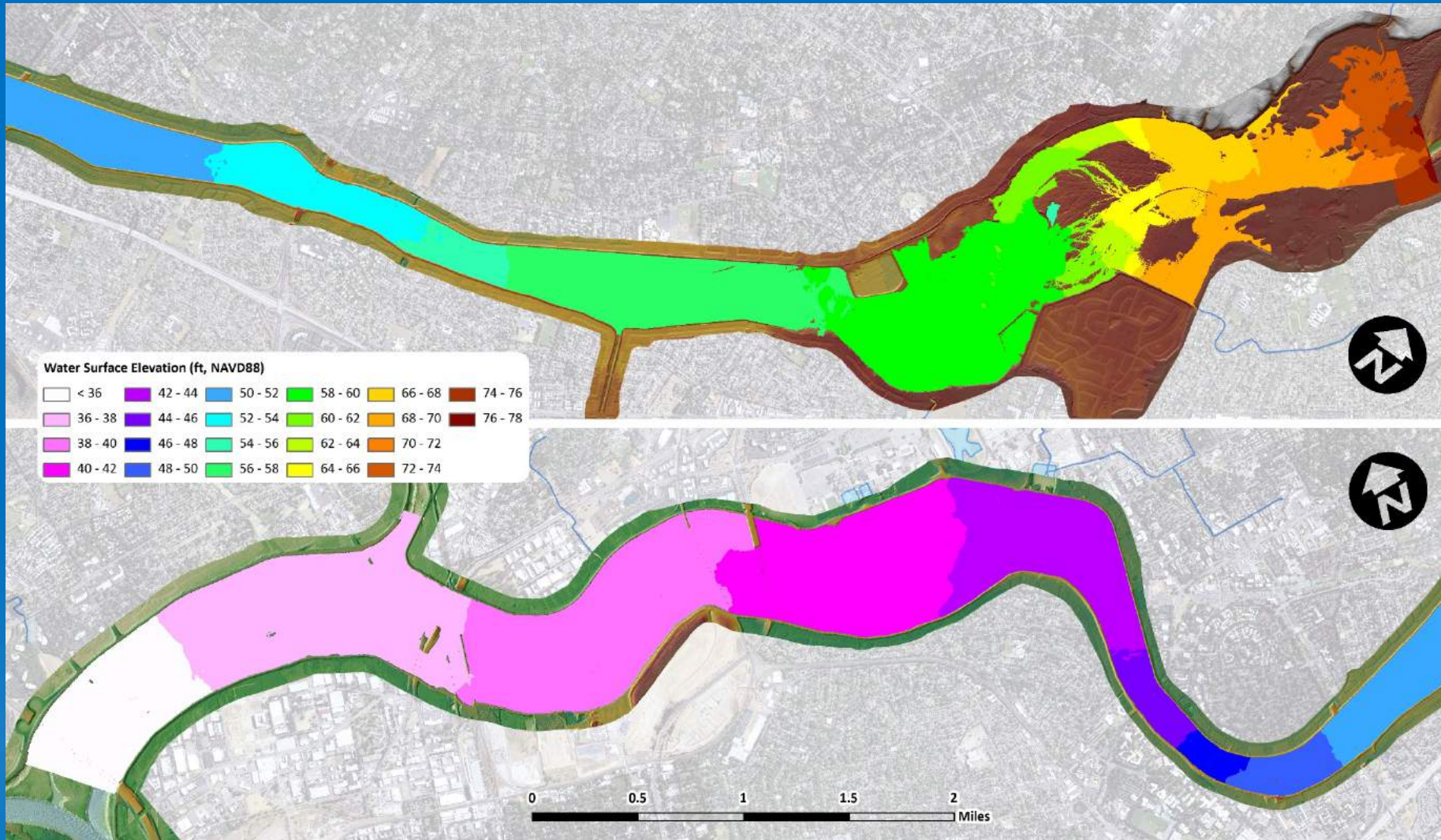


# Scenario 1 – Lower Model – 160,000 cfs Velocity



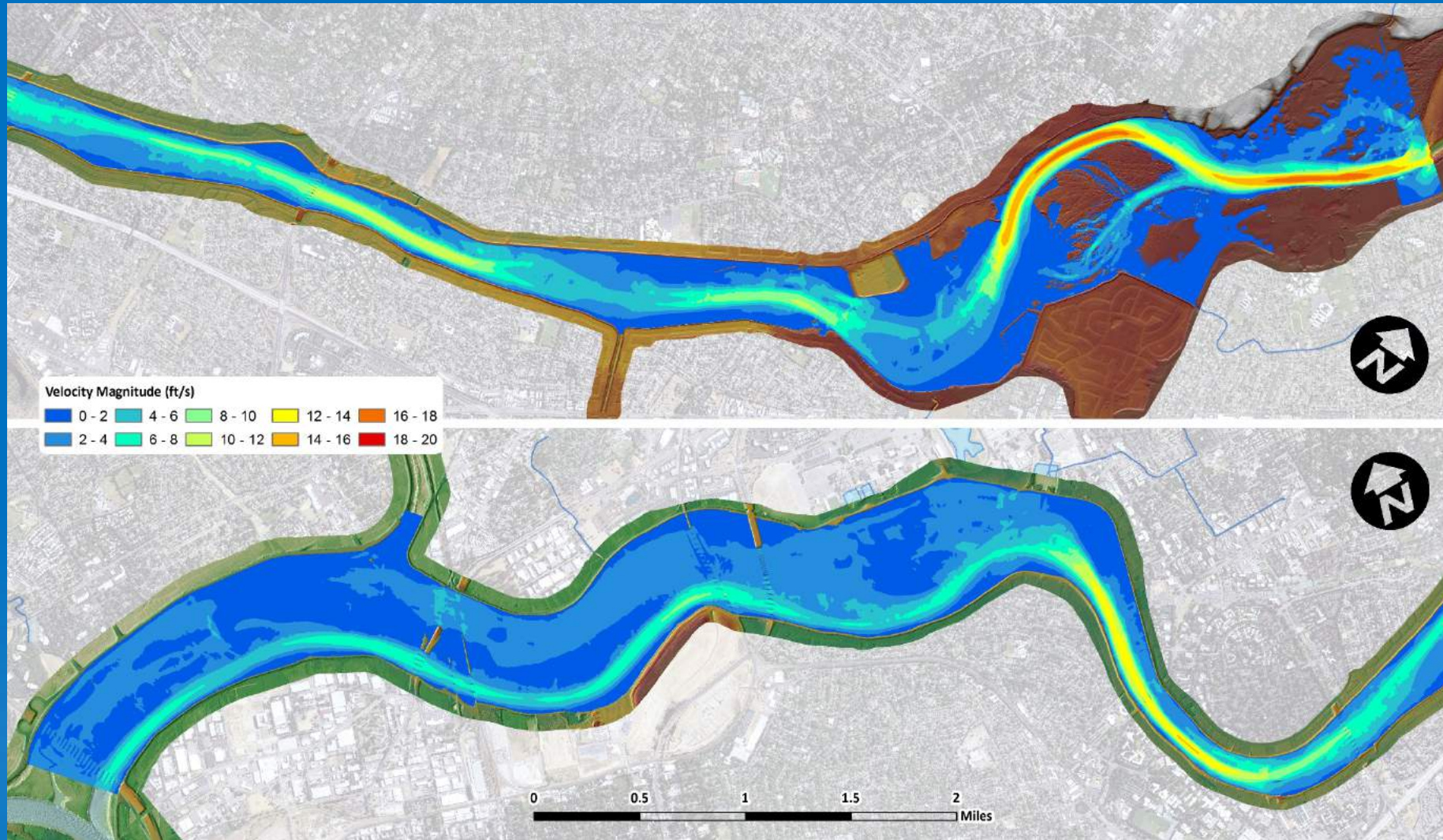


# Scenario 1 – Lower Model – 160,000 cfs WSE



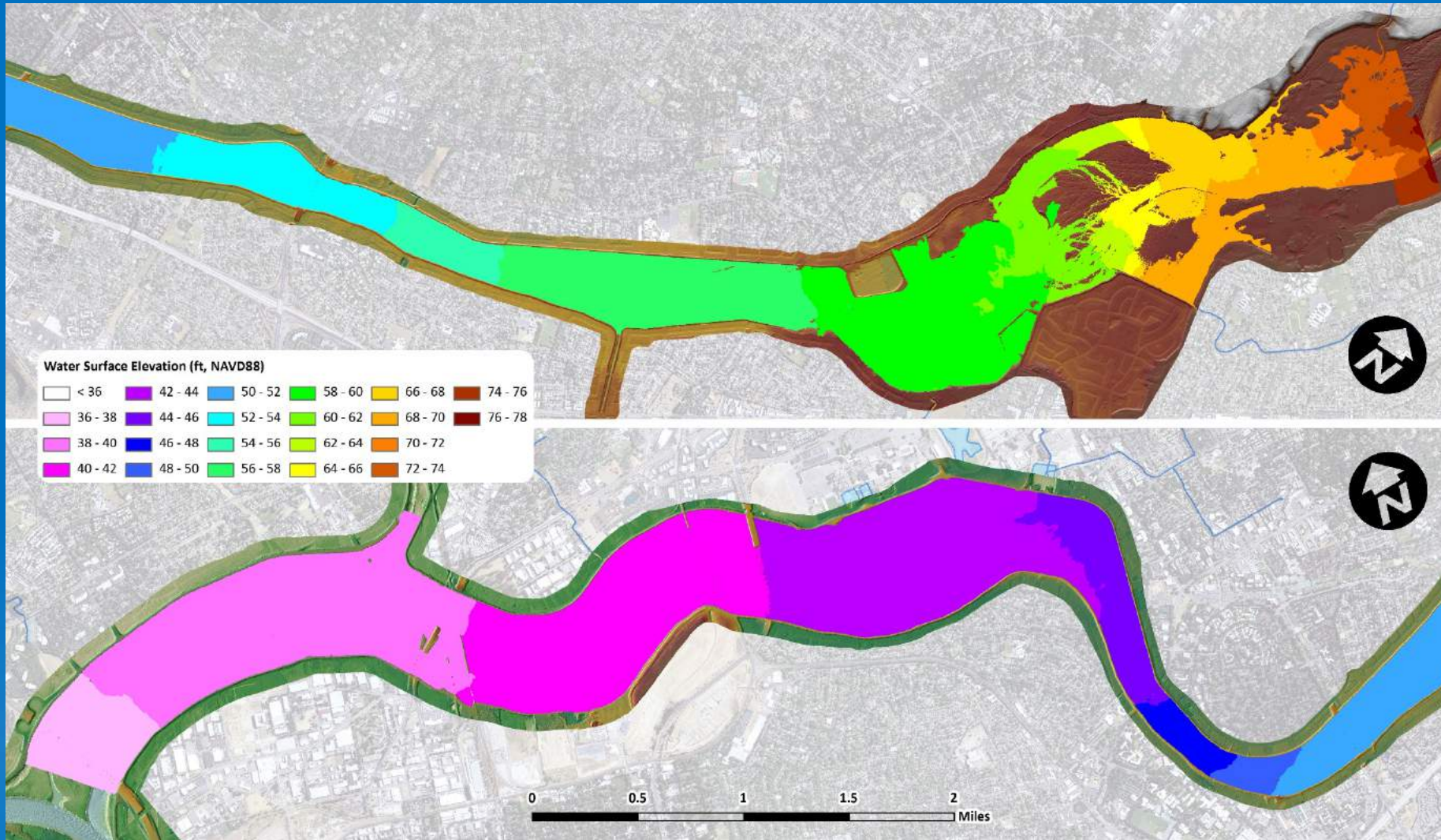


## Scenario 2 – Lower Model – 160,000 cfs Velocity



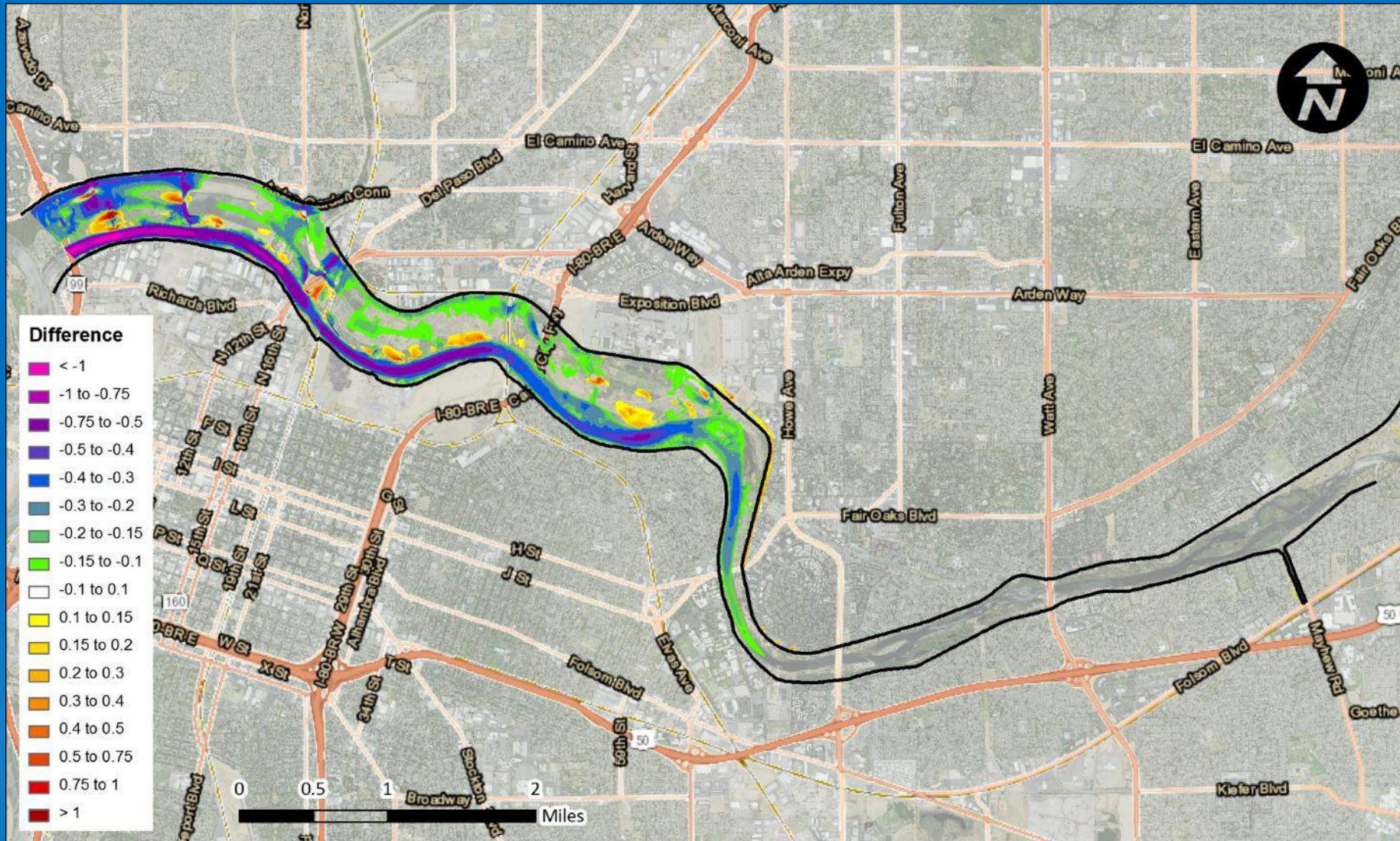


# Scenario 2 – Lower Model – 160,000 cfs WSE



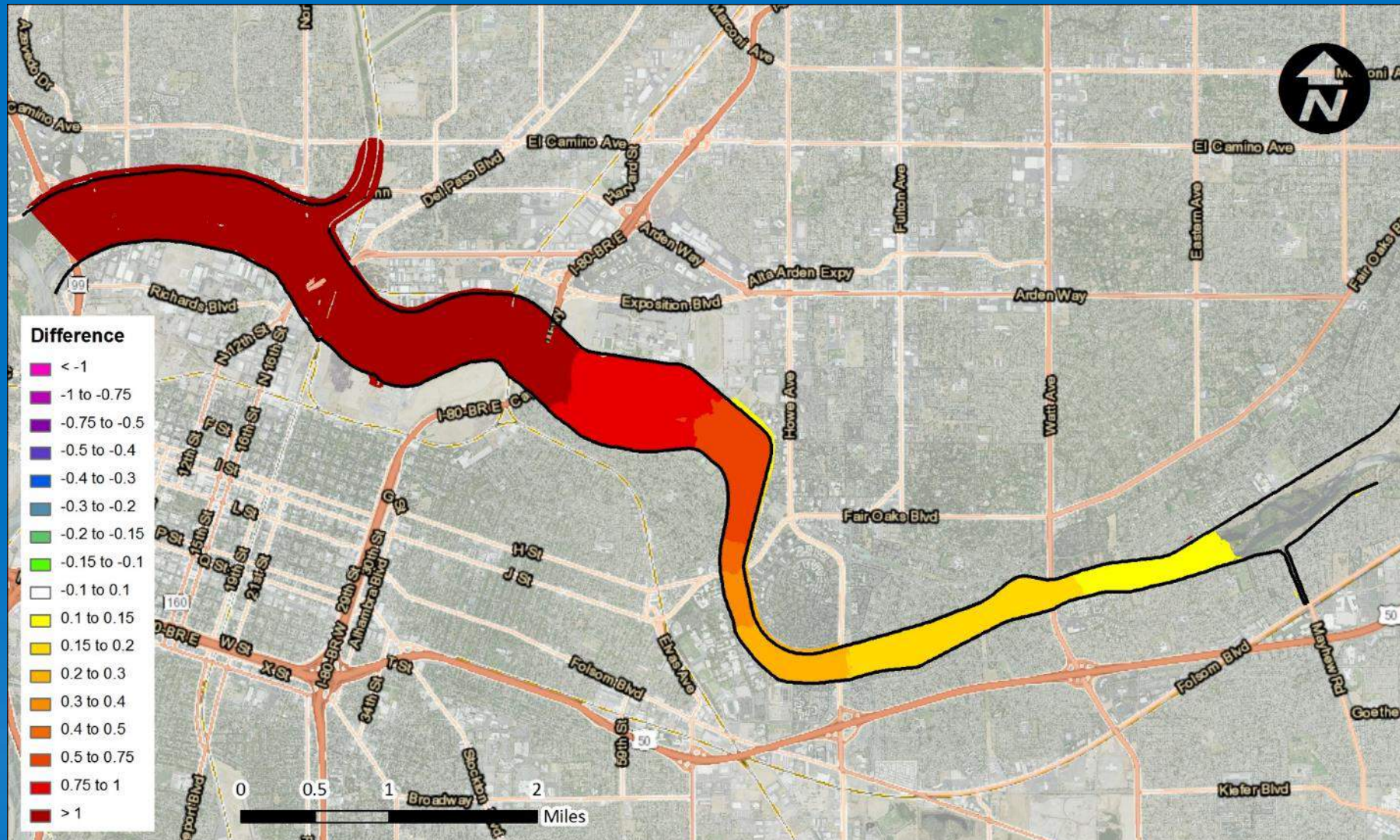


## Scenario Differences: Velocity



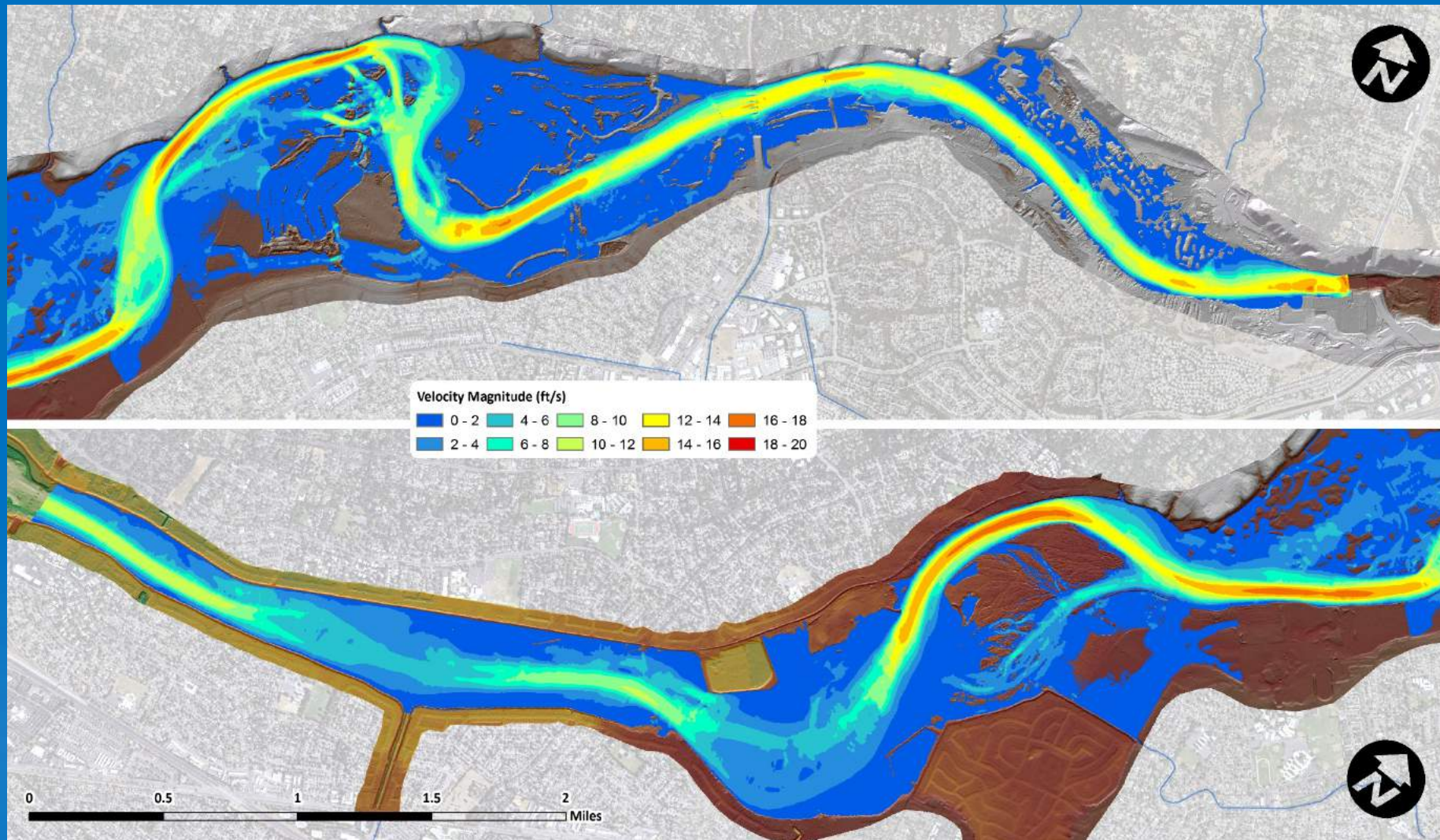


# Scenario Differences: WSE





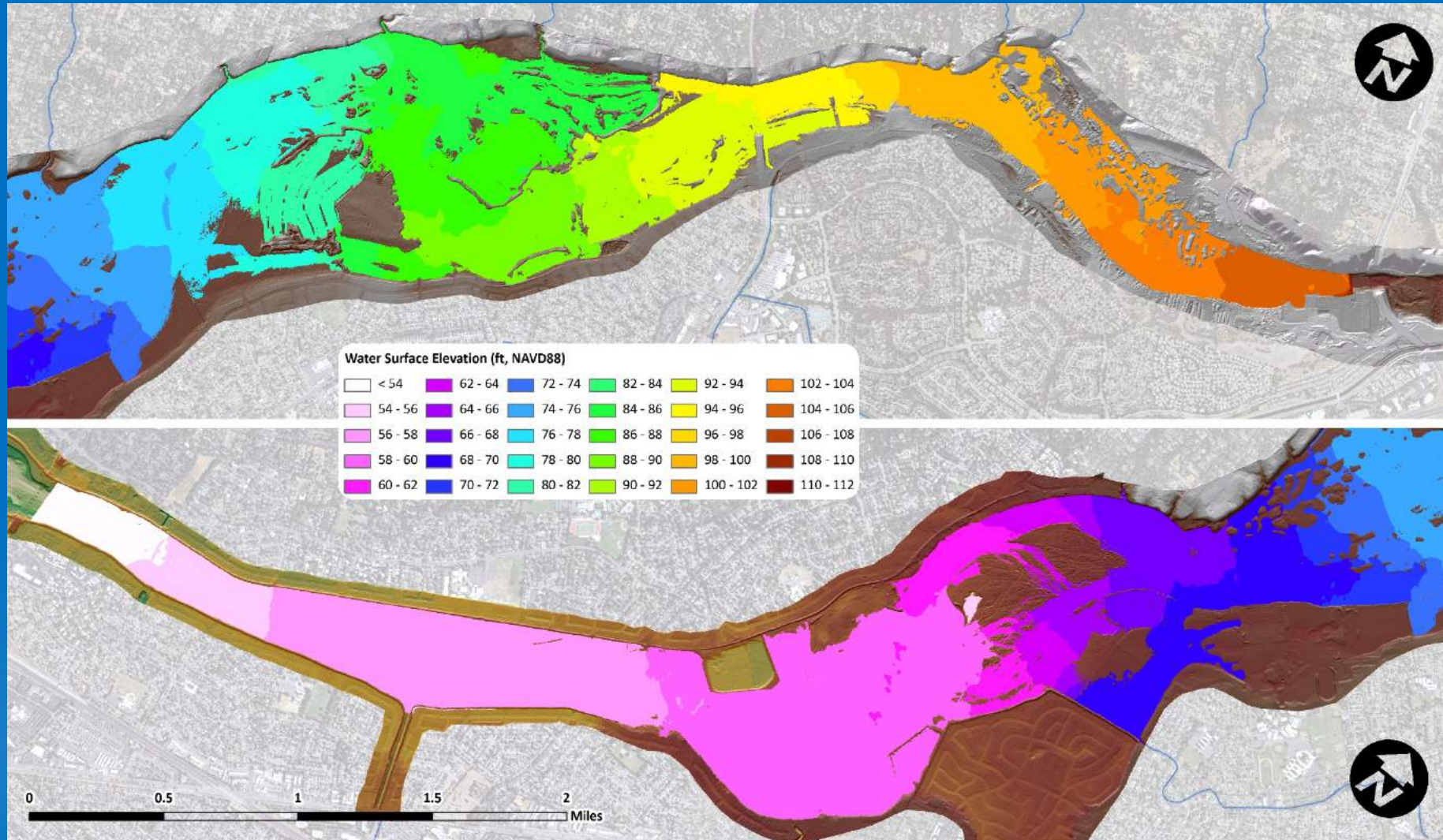
# Scenario 1 – Upper Model – 160,000 cfs Velocity



Note: the upper domain model is insignificantly impacted by Sacramento WSEs; thus, only Scenario 1 results are shown



# Scenario 1 – Upper Model – 160,000 cfs WSE



Note: the upper domain model is insignificantly impacted by Sacramento WSEs; thus, only Scenario 1 results are shown



# 160,000 cfs WSEs at Bridge Locations

**Table 3. Bridge soffit (i.e, low chord) elevations in comparison to modeled WSE**

Bridges / Structures	Bridge Soffit Elevations (NAVD88, ft) <sup>1</sup>					160,000 cfs WSE (NAVD88, ft)		
	Floodplain	Channel			Floodplain	Hydraulic Models		
	Left	Left bank	Middle	Right bank	Right	Scenario 1	Scenario 2	Ayers RMA2
HWY 160 W	-	41.2	30.6 / 43.7 (arch)	41.2	-	37.7	39.5	38.2
HWY 160 E	-	41.2	41.2	41.5	-	37.7	39.5	38.2
Sac N. Bikeway	-	43.0	43.0	43.0	-	38.0	39.9	38.5
RR-1	-	42.0	42.1	42.2	-	38.2	40.1	38.7
RR-2	45.9	44.1	44.0	44.0	43.2	40.1	41.6	40.7
80/51	47.0	46.4	52.3	53.9	53.5	40.7	42.2	41.5
H St./Fair Oaks Blvd	49.7	48.8	48.8	48.8	47.2	45.5	46.2	47.4
Guy West	47.1	50.7	53.1	53.7	47.3	47.8	48.2	48.7
Water Intake	53.0	53.2	-	-	-	49.7	50.1	50.6
Howe Ave	52.8	-	51.5	50.2	50.0	50.5	50.9	51.5
Watt Ave	-	55.3	55.4	55.5	55.4	53.0	53.3	54.4



# Summary

- Developed three flood model meshes with two overall domains (i.e., upper and lower domain)
- The end user has two options for placing the downstream boundary condition for the lower model domain
- Constructed a detailed roughness map
- Conducted a sensitivity analyses to choose the best mesh resolution (20-ft) and bridge pier modeling approach
- Incorporated bridge piers into a 2-ft DEM
- Calibrated to the 2017 82,000 cfs peak flow and 1986 134,000 cfs peak flow
- Validated results from other observed high flows in 1997, 2016, and 2017 (30,000 – 117,00 cfs)
- Created a two-scenario rating curve for the Sacramento River and LAR confluence
- Tested the scenarios with a 160,000 cfs flow to understand velocity and water surface elevation impacts
- Checked bridge soffit clearances for both scenarios



# Next Steps

- Process LiDAR data and bathymetric survey data
- QA/QC current conditions DEM
- Receive feedback on flood model development
- Finalize flood model calibration with new DEM
- Finalize ecological flow model calibration with new DEM