

Combined 1D River and 2D Floodplain/Levee Areas

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Overview

- Using a 2D Flow Area to model inside of Levees
 - Saint Paul Levee Breach Example
- Using 2D Flow Areas to model overbank areas (i.e. 1D Channels and 2D Floodplains)
 - Carson River Example

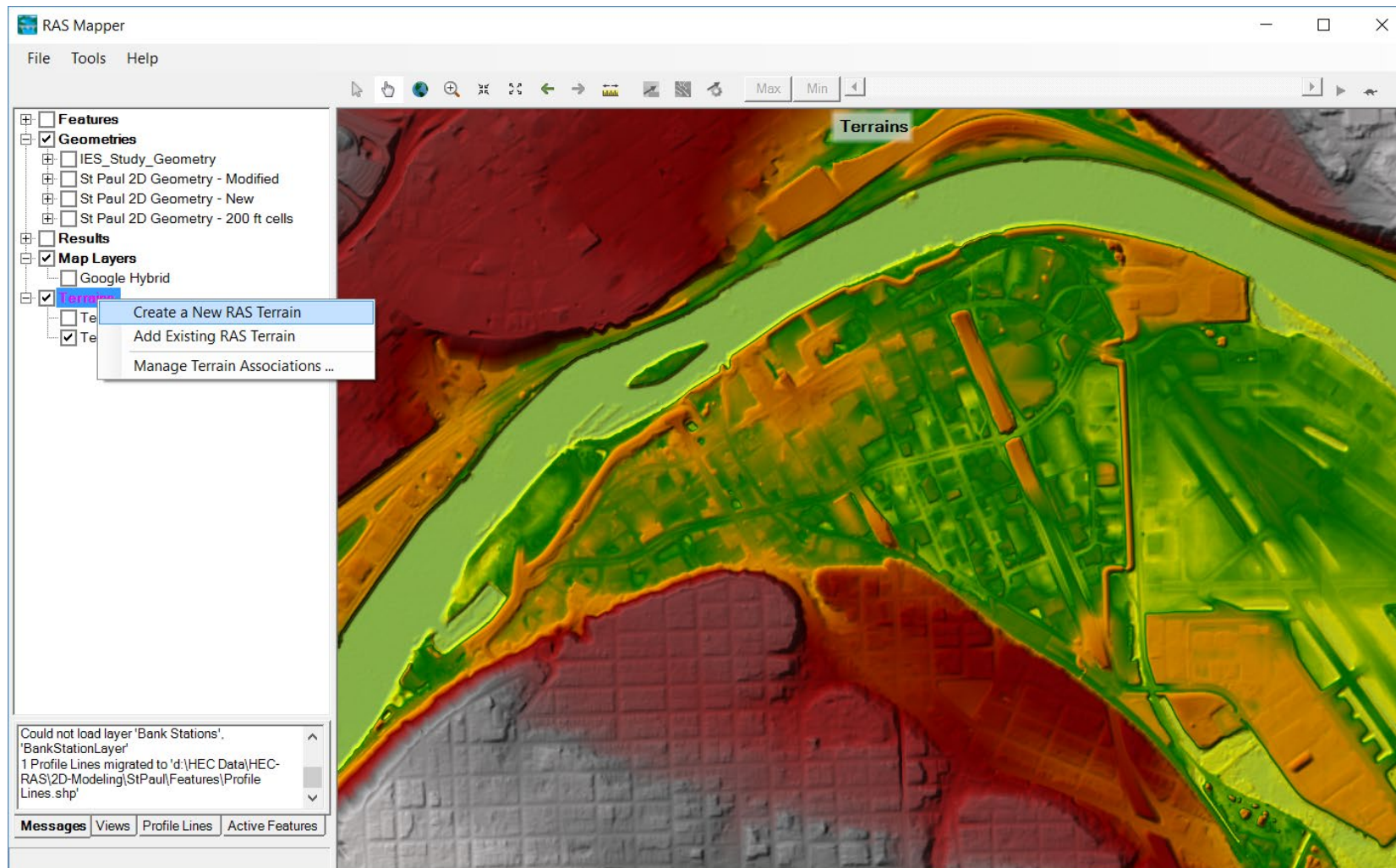


Using a 2D Flow Area to model inside of a Levee system

- Bring in terrain and background map layers into RAS Mapper
- Draw a Polygon for the 2D Flow Area Boundary Inside of the Levee
- Create the 2D Computational Mesh
- View the Mesh Boundary Cells to ensure there are no Mesh Problems
- Modify The Mesh if Needed (add break lines for roads, high ground, etc. Use mesh refinement regions to refine or coarsen areas of the mesh)
- Hook up the 2D Flow Area to a 1D River Reach with Lateral Structures
- Weir Coefficients for Lateral Structures
- Levee Breaching
- Weir and Levee Breach Submergence Issues

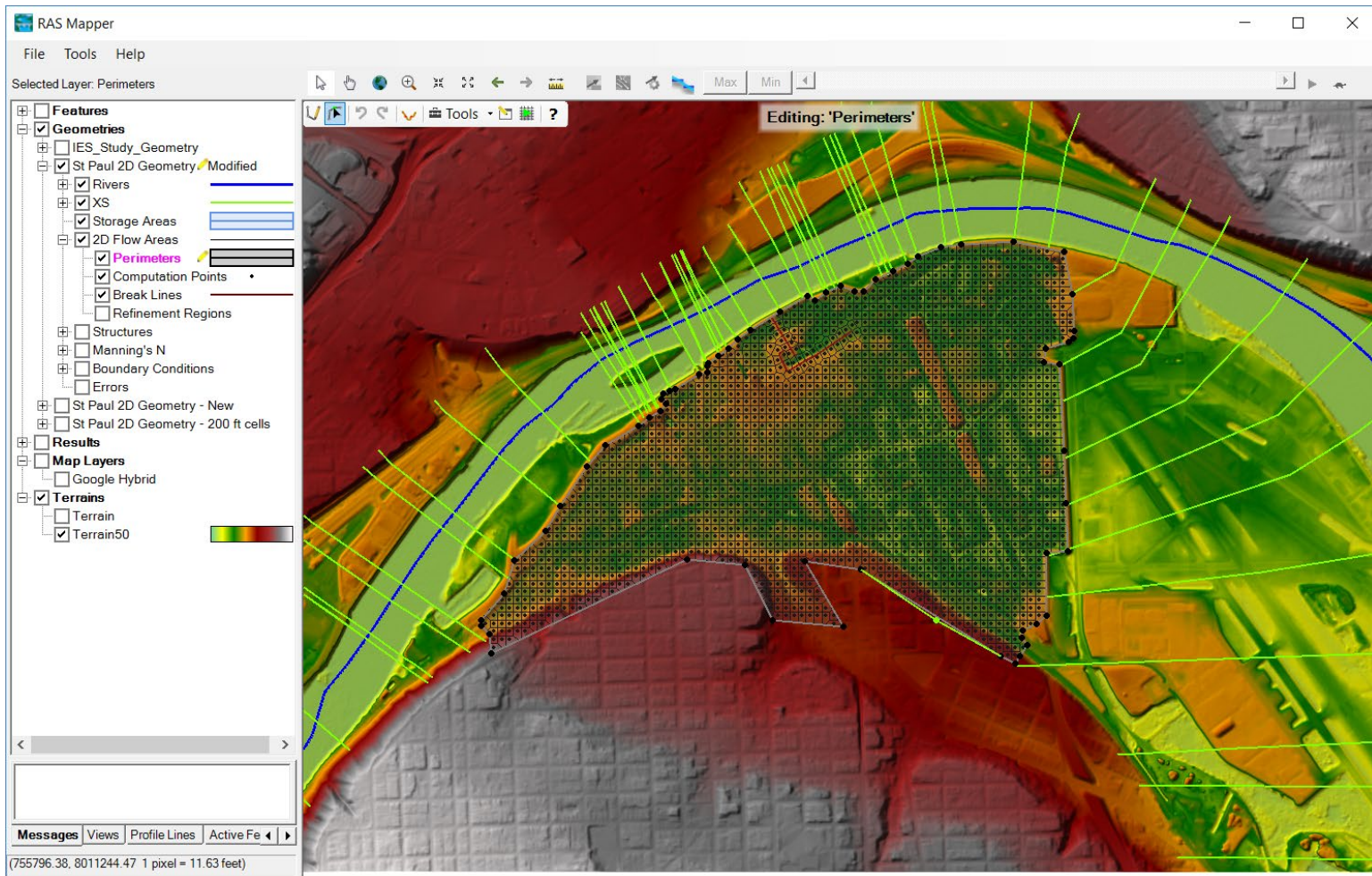


From HEC-RAS Mapper Create a Terrain Model and Map Layers



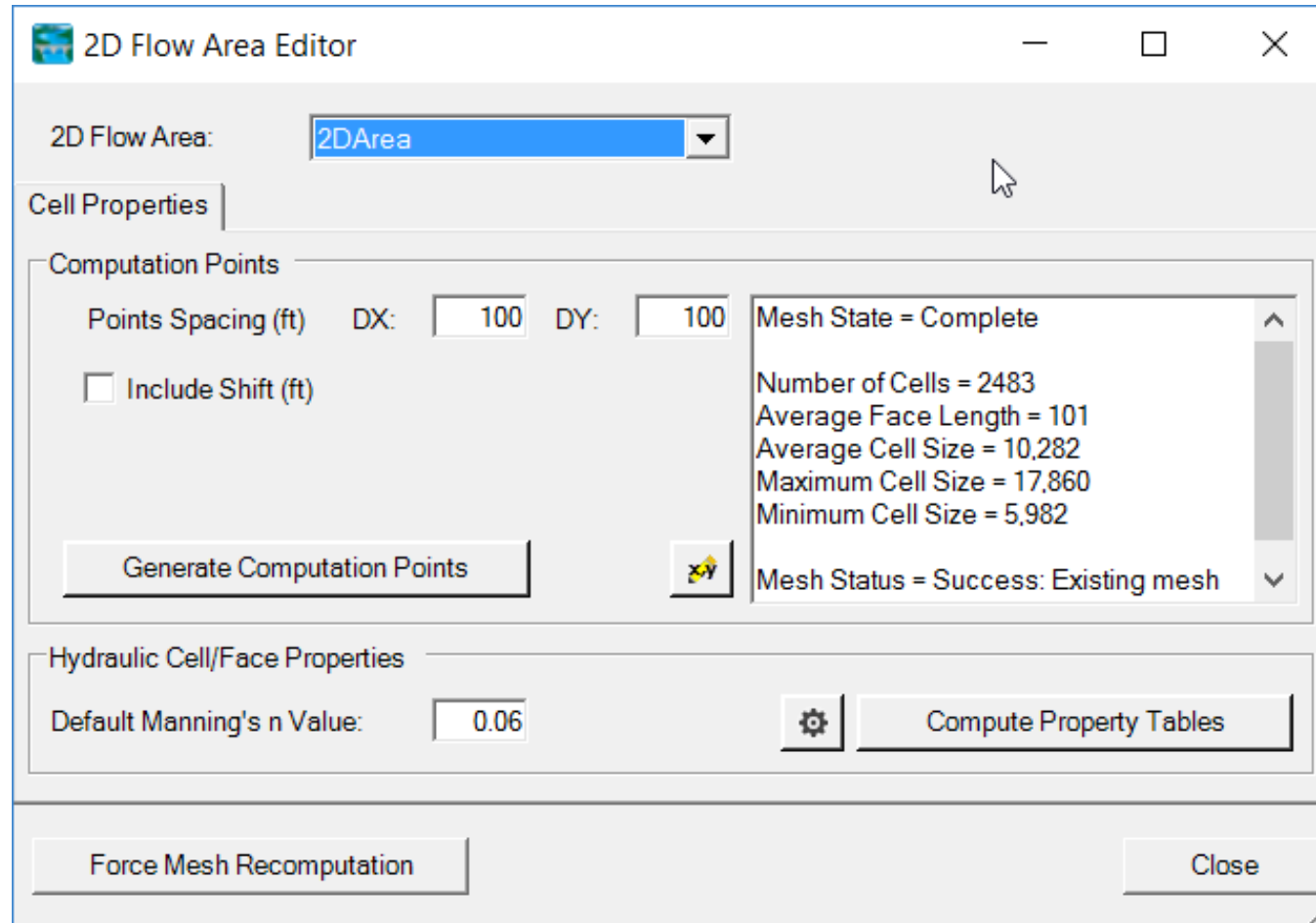


Draw a Polygon for the 2D Flow Area Boundary Inside of the Levee





Create the 2D Computational Mesh using the 2D Flow Area Editor





View the Mesh to ensure there are no Mesh Problems

The screenshot shows the RAS Mapper application window. The title bar reads "RAS Mapper". Below the title bar is a menu bar with "File", "Tools", and "Help". A toolbar with various icons is located below the menu bar. The main window area displays a 2D flow area with a mesh overlay. The mesh is a grid of points and lines, with a blue line indicating the boundary of the selected "Storage Areas". The terrain is shown in shades of green and brown. The layer list on the left is expanded to show "Storage Areas" selected. The status bar at the bottom shows "Messages", "Views", "Profile Lines", and "Active Features".

Selected Layer: Storage Areas

Selected: 'Storage Areas'

Features

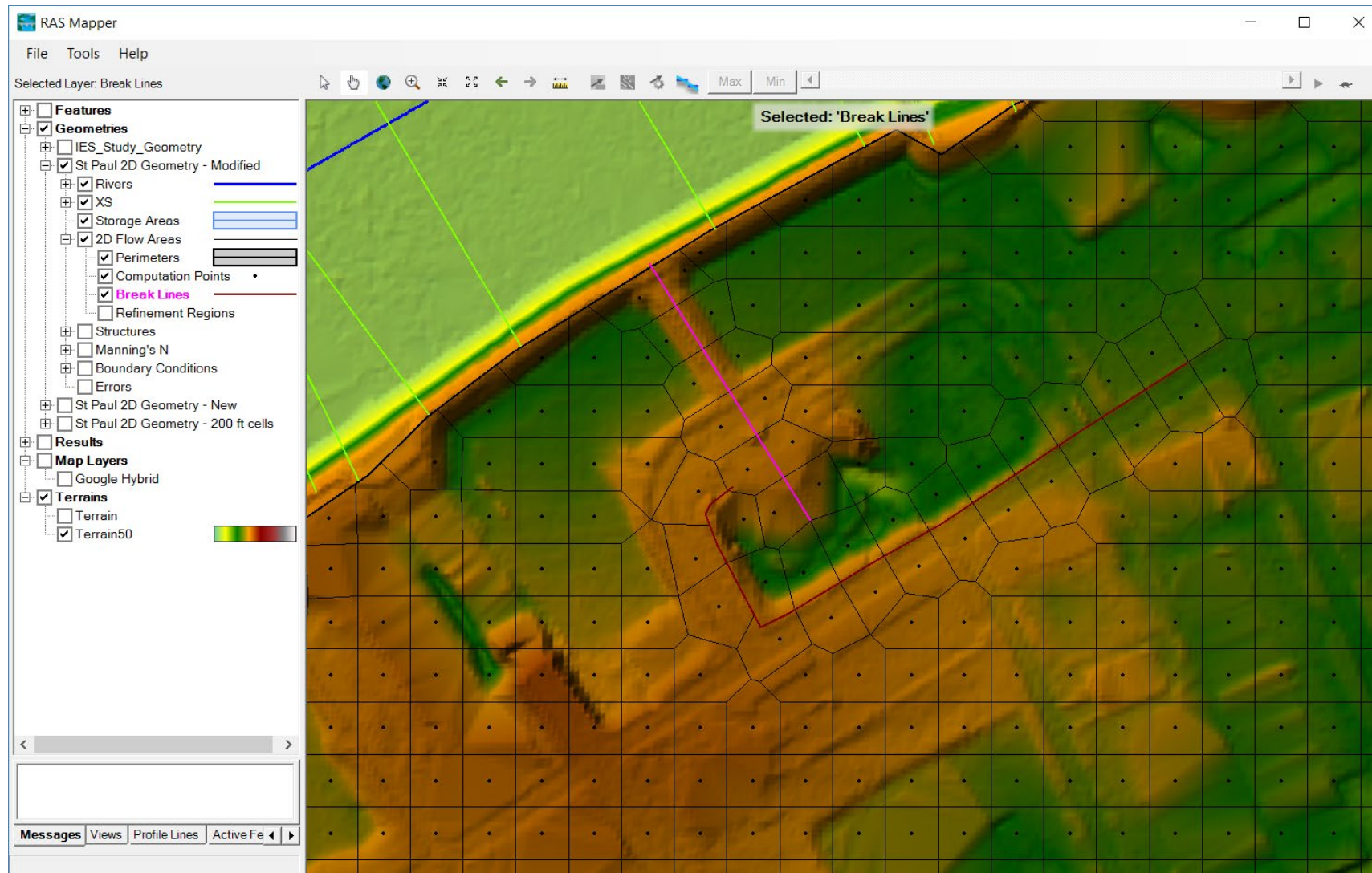
- Geometries
 - IES_Study_Geometry
 - St Paul 2D Geometry - Modified
 - Rivers
 - XS
 - Storage Areas
 - 2D Flow Areas
 - Mesh Perimeters
 - Mesh Points
 - Break Lines
 - Refinement Regions
 - Structures
 - Manning's N
 - Boundary Conditions
 - Errors
 - St Paul 2D Geometry - New
 - St Paul 2D Geometry - 200 ft cells
- Results
- Map Layers
 - Google Hybrid
- Terrains
 - Terrain
 - Terrain50

Could not load layer 'Bank Stations'.
'BankStationLayer'
1 Profile Lines migrated to 'd:\HEC Data\HEC-RAS\2D-Modeling\StPaul\Features\Profile Lines.shp'

Messages Views Profile Lines Active Features

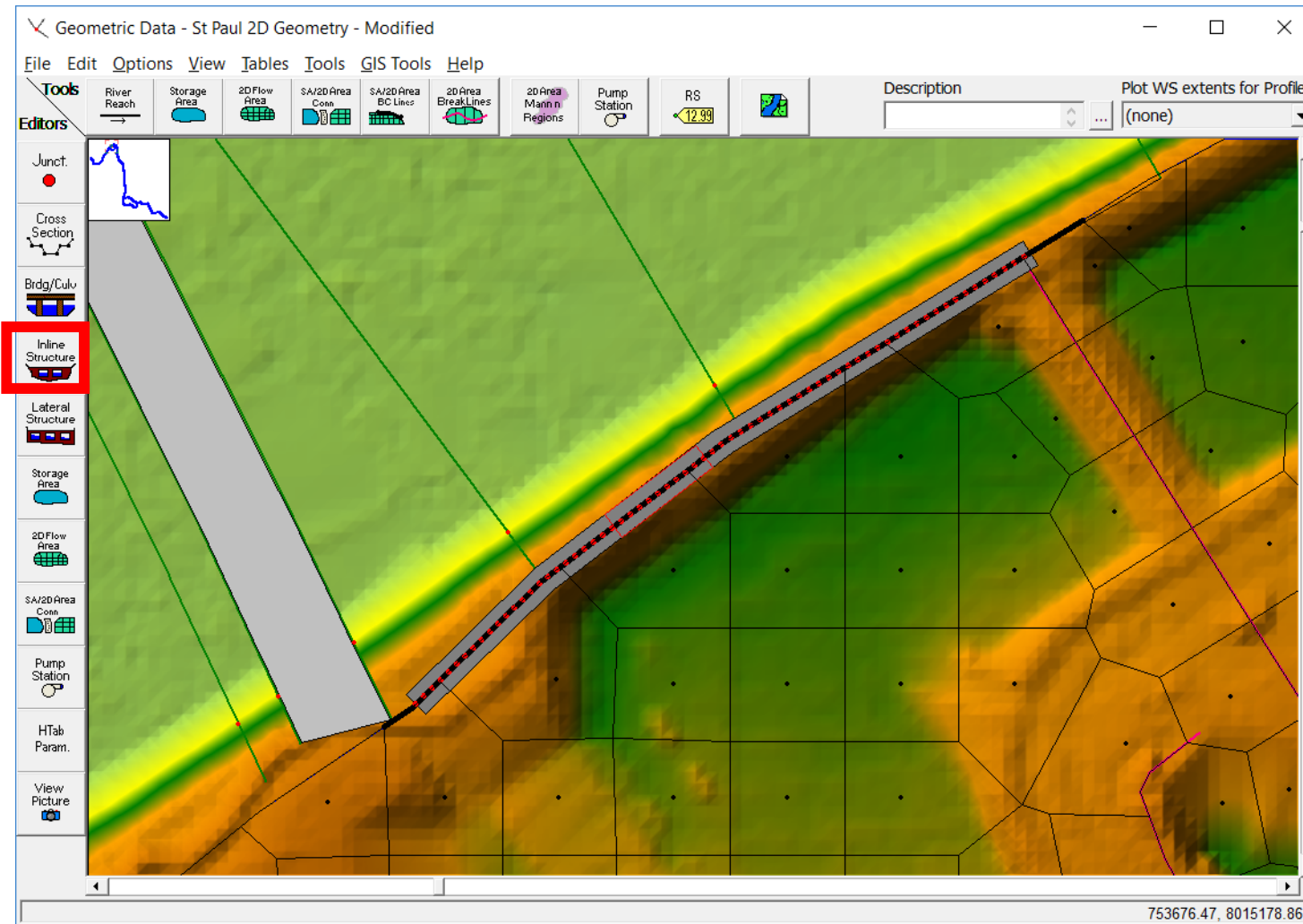


Modify The Mesh as Needed





Hooking up a 2D Flow Area to a 1D River Reach with Lateral Structures





Lateral Structure editor

Lateral Structure Editor - St Paul 2D Geometry - Modified

File View Options Help

River: MissRiver Apply Data + [Icon]

Reach: thru_St_Paul HW RS: 151400 [Down Arrow] [Up Arrow]

Description [Text Box]

HW Position: Right overbank Plan Data Optimization ... Breach ...

Tailwater Connection

Type: Storage Area/2D Flow Area

SA/2DFA: 2D flow area: 2DArea Set SA/2DFA ...

Weir Length: 671.42

Centerline Length: 671.42

Overflow Computation Method

Normal 2D Equation Domain Use Weir Equation 2D Boundary Use Velocity

Centerline GIS Coords...

All Culverts: No Flap Gates Terrain Profile ...

Structure Type: Weir/Gates/Culverts/Diversion Rating Curves Clip Weir Profile to 2D Cells...

Weir / Embankment

Gate [Icon]

Culvert [Icon]

Diversion RC [Icon]

Outlet TS [Icon]

HW and TW Connections Determined Geo-Spatially

Elevation (ft)

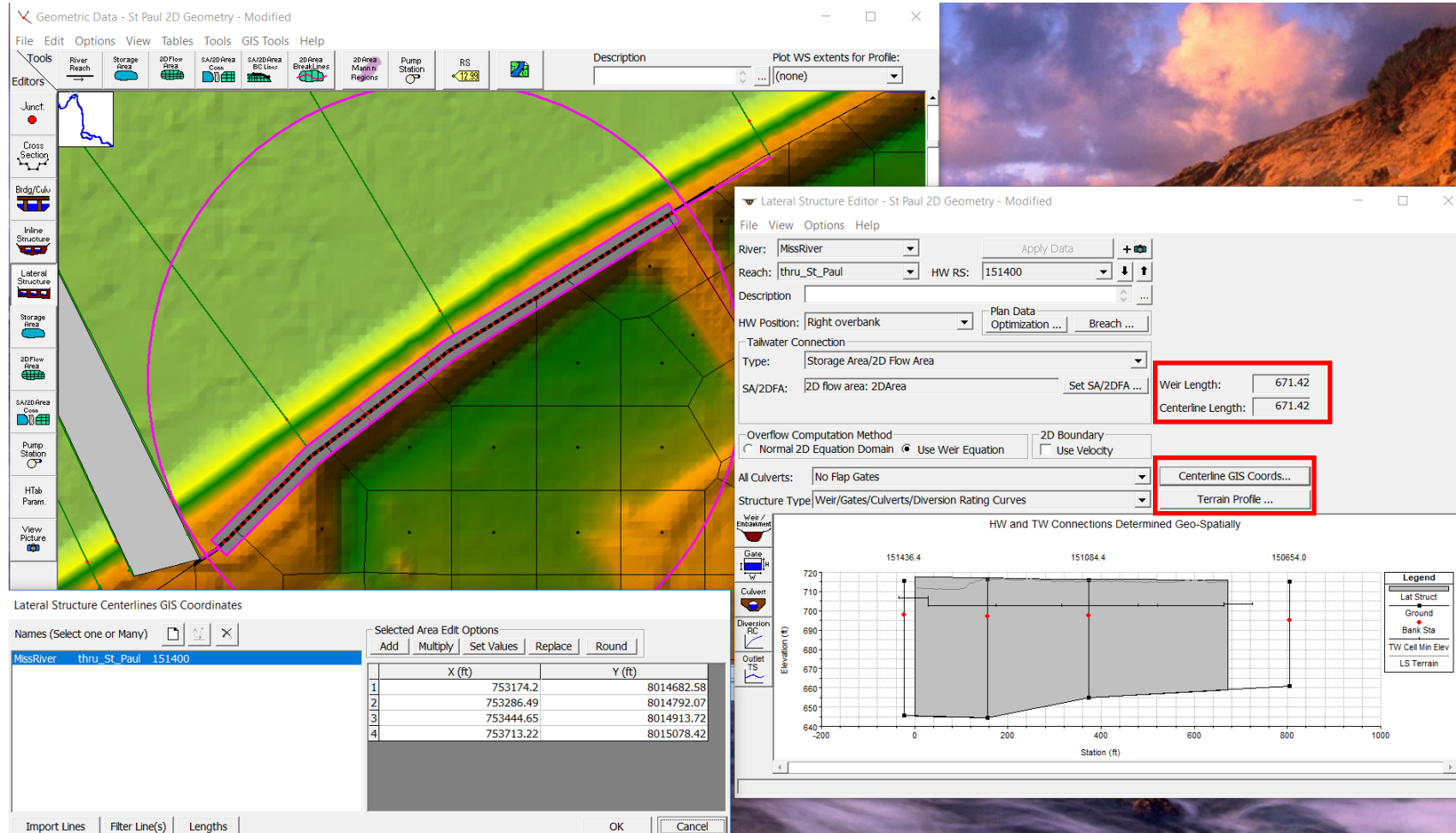
Station (ft)

Legend

- Lat Struct
- Ground
- Bank Sta
- TW Cell Min Elev
- LS Terrain

Edit lateral structure description

Using Geospatial Coordinates for Lateral Structures



The screenshot displays the HEC-RAS software interface. The main window shows a 2D plan view of a river reach with a lateral structure. The **Lateral Structure Editor** window is open, showing the following settings:

- River: MissRiver
- Reach: thru_St_Paul
- HW RS: 151400
- HW Position: Right overbank
- Type: Storage Area/2D Flow Area
- SA/2DFA: 2D flow area: 2DArea
- Weir Length: 671.42
- Centerline Length: 671.42
- Overflow Computation Method: Normal 2D Equation Domain, Use Weir Equation
- Structure Type: Weir/Gates/Culverts/Diversion Rating Curves

The **Lateral Structure Centerlines GIS Coordinates** dialog box is also open, showing the following data:

Names (Select one or Many)	X (ft)	Y (ft)
MissRiver thru_St_Paul 151400		
1	753174.2	8014682.58
2	753286.49	8014792.07
3	753444.65	8014913.72
4	753713.22	8015078.42

Below the dialog box, a graph titled "HW and TW Connections Determined Geo-Spatially" shows the elevation profile of the structure. The x-axis represents Station (ft) from -200 to 1000, and the y-axis represents Elevation (ft) from 640 to 720. The graph shows the structure's profile and the water surface elevation (WSE) and tailwater elevation (TWE) connections.



Lateral Weir/Embankment Editor

Lateral Weir Embankment

Weir Data

Weir Width:

Weir Computations:

Standard Weir Equation Parameters

Weir flow reference:

Weir Coefficient (Cd):

Weir Crest Shape:

Weir Stationing Reference

HW - Distance to Upstream XS:

HW Connections ... TW Connections ...

Embankment Station/Elevation Table

	Station	Elevation	
1	0	717.52	▲
2	160.9	717.328	
3	217.23	716.861	
4	239.07	716.825	
5	297.36	716.253	
6	477.08	716.183	
7	556.99	716.042	
8	671.42	716.046	
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			▼



Lateral Weir Headwater Connections (HW)

HW Lateral Structure Connections

Computed Default Weir Stationing User Defined Weir Stationing

Default Computed Weir Stationing		
	XS RSs	Weir Station
1	151436.4	-22.92
2	151354.9	156.84
3	151084.4	373.92
4	150654.0	803.62
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		

User Defined Weir Stationing		
	XS RSs	Weir Station
1	151354.9	5692
2	151084.4	5909
3	150654.0	6435
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		

User Specified Connections
Option will not be used
because the lateral structure
has a geo-referenced
centerline.

OK Cancel



Lateral Weir Tailwater Connections (TW)

TW Lateral Structure Connections

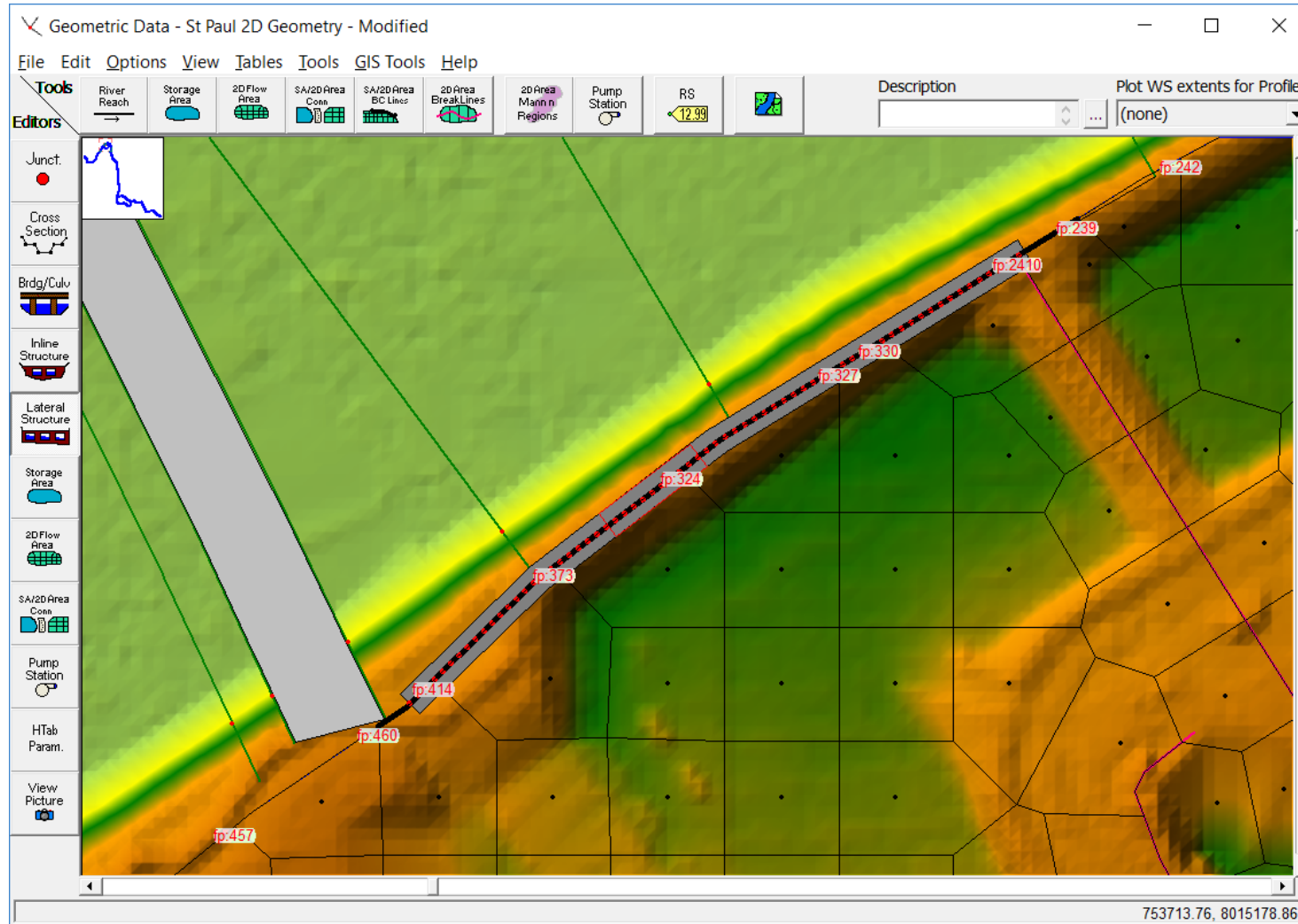
Computed Default Weir Stationing User Defined Weir Stationing

Default Computed Weir Stationing		
	2D Face Points	Weir Station
1	456	-34.3083
2	412	28.59606
3	368	174.9681
4	319	314.8326
5	322	479.7218
6	325	521.3957
7	2408	663.5559
8	239	725.6677
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		

User Defined Weir Stationing		
	2D Face Points	Weir Station
1	454	5470.98
2	411	5537.3
3	368	5703.08
4	319	5861.57
5	322	6048.15
6	325	6095.38
7	User Specified Connections	
8	Option will not be used	
9	because the lateral structure	
10	has a geo-referenced	
11	centerline.	
12		
13		
14		
15		
16		
17		
18		
19		

OK Cancel

Connected 1D River to 2D Flow Area with Lateral Structure





Weir Coefficients for Lateral Structures

What is being modeled with the Lateral Structure	Description	Range of Weir Coefficients
Levee/Roadway – 3ft or higher above natural ground	Broad crested weir shape, flow over Levee/road acts like weir flow	1.5 to 2.6 (2.0 default) SI Units: 0.83 to 1.43
Levee/Roadway – 1 to 3 ft elevated above ground	Broad Crested weir shape, flow over levee/road acts like weir flow, but becomes submerged easily.	1.0 to 2.0 SI Units: 0.55 to 1.1
Natural high ground barrier – 1 to 3 ft high	Does not really act like a weir, but water must flow over high ground to get into 2D area.	0.5 to 1.0 SI Units: 0.28 to 0.55
Non elevated overbank terrain. Lat Structure not elevated above ground	Overland flow escaping the main river.	0.2 to 0.5 SI Units: 0.11 to 0.28



Levee Breaching

Levee (Lateral Structure) Breach Data

Lateral: [Down Arrow] [Up Arrow] [Delete this Breach ...] [Delete all Breaches ...]

Breach This Structure

Breach Method:

Center Station:

Final Bottom Width:

Final Bottom Elevation:

Left Side Slope:

Right Side Slope:

Breach Weir Coef:

Breach Formation Time (hrs):

Failure Mode:

Piping Coefficient:

Initial Piping Elev:

Trigger Failure at:

Start Date:

Start Time:

Breach Plot | Breach Progression | Simplified Physical | Parameter Calculator | Breach Repair (optional)

StPaulIES Plan: Fail Middle - 2D Run Modified FEQ Jan17 7/17/2018

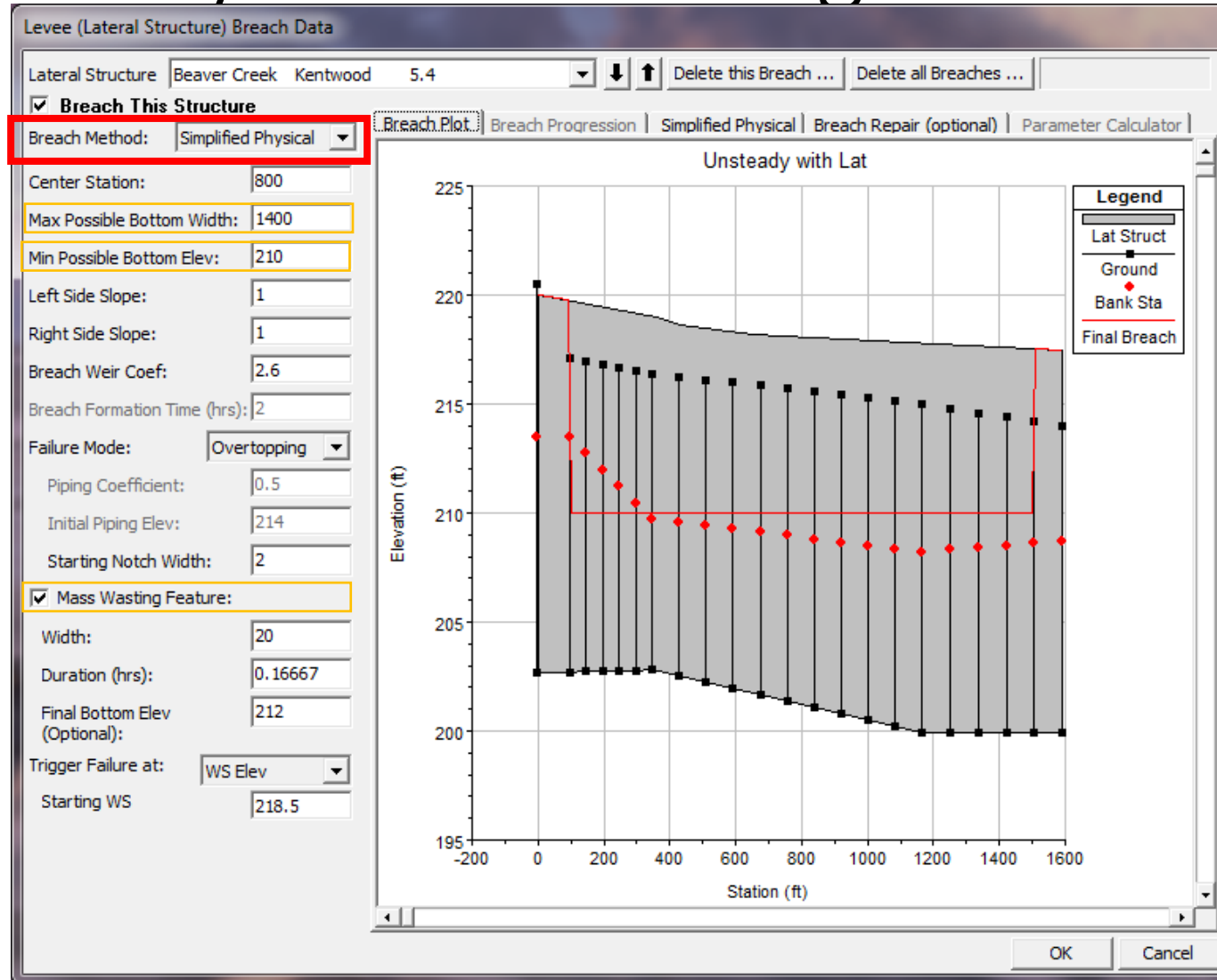
Legend

- Lat Struct
- Centerline Terrain
- Final Breach

OK Cancel



Simplified Physical Breaching





Velocity vs. Downcutting and Widening

Levee (Lateral Structure) Breach Data

Lateral Structure: Beaver Creek Kentwood 5.4

Breach This Structure

Breach Method: Simplified Physical

Center Station: 800

Max Possible Bottom Width: 1400

Min Possible Bottom Elev: 210

Left Side Slope: 1

Right Side Slope: 1

Breach Weir Coef: 2.6

Breach Formation Time (hrs): 2

Failure Mode: Overtopping

Piping Coefficient: 0.5

Initial Piping Elev: 214

Starting Notch Width: 2

Mass Wasting Feature:

Width: 20

Duration (hrs): 0.16667

Final Bottom Elev (Optional): 212

Trigger Failure at: WS Elev

Starting WS: 218.5

Breach Plot | Breach Progression | **Simplified Physical** | Breach Repair (optional) | Parameter Calculator

Overtopping Downcutting

	Velocity (ft/s)	Downcutting Rate (ft/hr)
1	0	0
2	2	0
3	3	5
4	4	10
5	5	20
6	7	30
7	10	40
8	20	50
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
25		

Widening Relationship

	Velocity (ft/s)	Widening Rate (ft/hr)
1	0	0
2	2	0
3	3	20
4	4	50
5	5	100
6	7	150
7	10	200
8	20	300
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
25		

OK Cancel

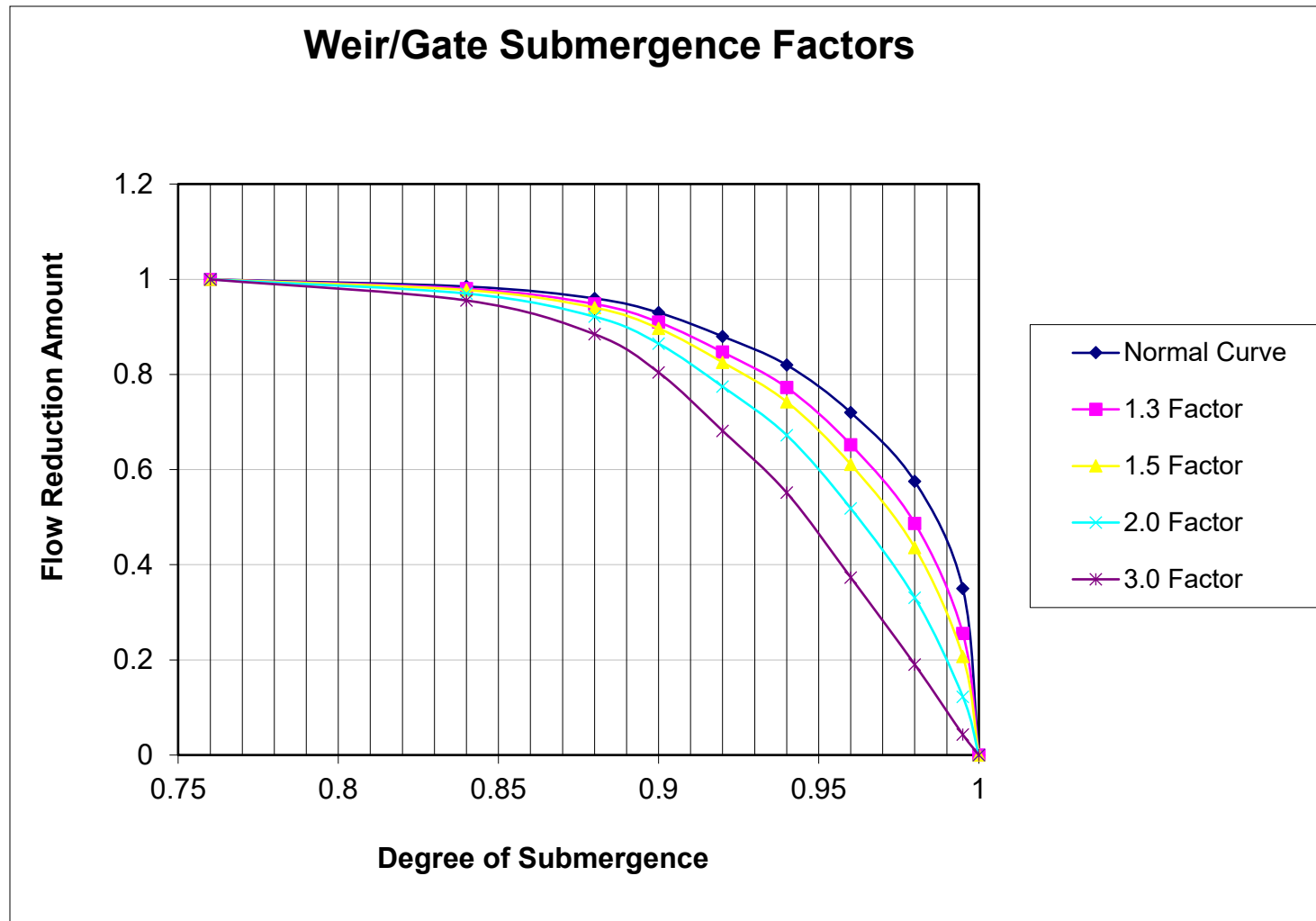


Weir and Levee Breach Submergence Issues

- When a lateral structure gets highly submerged, HEC-RAS uses a weir submergence curve to compute the flow reduction over the weir. The curve is very steep (i.e. the flow reduction changes dramatically) between 95% and 100% submergence. This can cause oscillations and possible model stability issues. To reduce these oscillations, user can have HEC-RAS use a milder sloping submergence curve by going to the 1D “Computational Options and Tolerances” and setting the field labeled “**Weir flow submergence decay exponent**” to 3.0.



Weir Submergence Curves





Unsteady Flow Computational Options and Tolerances

HEC-RAS Unsteady Computation Options and Tolerances

General | 2D Flow Options | 1D/2D Options | Advanced Time Step Control | 1D Mixed Flow Options

1D Unsteady Flow Options

Theta [implicit weighting factor] (0.6-1.0):	1.
Theta for warm up [implicit weighting factor] (0.6-1.0):	1.
Water surface calculation tolerance [max=0.2](ft):	0.02
Storage Area elevation tolerance [max=0.2](ft):	0.05
Flow calculation tolerance [optional] (cfs):	
Max error in water surface solution (Abort Tolerance)(ft):	100.
Maximum number of iterations (0-40):	20
Maximum iterations without improvement (0-40):	

1D/2D Unsteady Flow Options

Number of warm up time steps (0 - 100,000):	0
Time step during warm up period (hrs):	0.05
Minimum time step for time slicing (hrs):	0
Maximum number of time slices:	20
Lateral Structure flow stability factor (1.0-3.0):	3.
Inline Structure flow stability factor (1.0-3.0):	1.
Weir flow submergence decay exponent (1.0-3.0):	3.
Gate flow submergence decay exponent (1.0-3.0):	1.
DSS Messaging Level (1 to 10, Default = 4)	4

Geometry Preprocessor Options

Family of Rating Curves for Internal Boundaries

- Use existing internal boundary tables when possible.
- Recompute at all internal boundaries

1D Numerical Solution

- Finite Difference (classic HEC-RAS methodology)
 - Finite Difference Matrix Solver
 - Skyline/Gaussian (Default: faster for dendritic systems)
 - Pardiso (Optional: may be faster for large interconnected systems)
- Finite Volume (new approach)

Number of cores to use with Pardiso solver: All Available

OK Cancel Defaults ...



Using RAS Mapper Associate the Terrain to the Geometry

The screenshot displays the RAS Mapper interface. The 'RAS Geometry Properties' dialog box is open, showing the following details:

- Filename: d:\HEC Data\HEC-RAS\2D-Modeling\StPaul\StPaulIES.g03.hdf
- Title: St Paul 2D Geometry - Modified
- Associated Layers: Terrain: Terrain50, Manning's n: (None)

The 'Manage Geometry Associations' dialog box is also open, showing a table of associations:

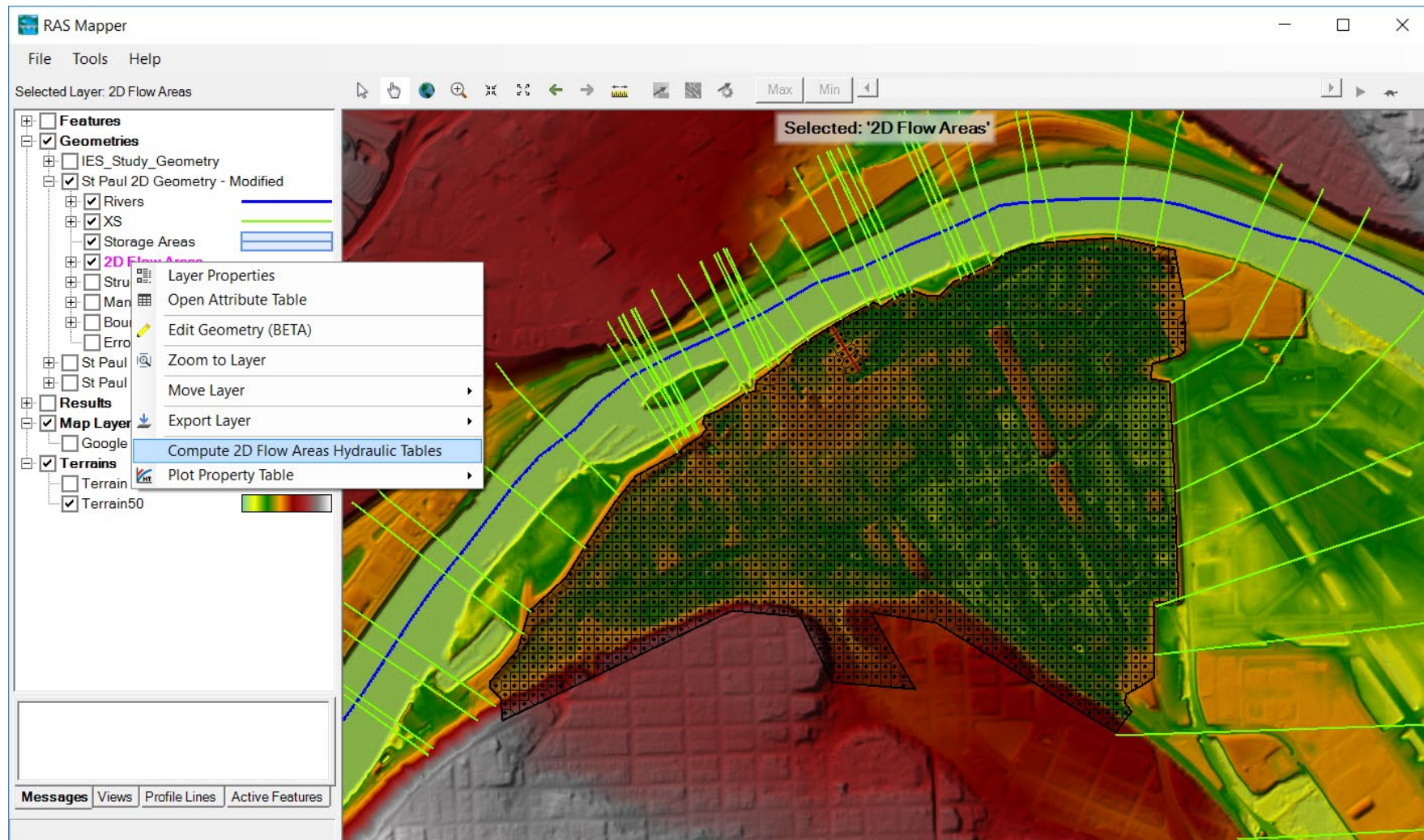
Type	RAS Geometry Layers	Terrain	Manning's n
Geom...	IES_Study_Geometry	Terrain50	(None)
Geom...	St Paul 2D Geometry - Modified	Terrain50	(None)
Geom...	St Paul 2D Geometry - New	Terrain50	(None)
Geom...	St Paul 2D Geometry - 200 ft cells	Terrain50	(None)
Results	2D Run Modified	Terrain50	(None)

The background shows a 2D model of a river channel with a grid overlay. The 'RAS Mapper' window title is visible at the top, and the 'Selected Layer: St Paul 2D Geometry - Modified' is shown in the top toolbar. The 'RAS Geometry Properties' dialog box has a 'Manage Associations' button. The 'Manage Geometry Associations' dialog box has a 'Close' button. The 'RAS Mapper' window has a 'Messages' tab at the bottom left.



RAS-Mapper

Running the 2D Pre-Processor





Run the Model and View the Results

Unsteady Flow Analysis

File Options Help

Plan : Fail Middle - 2D Run Modified FEQ Jan17 Short ID: 2D Run FEQ Jan17

Geometry File : St Paul 2D Geometry - Modified

Unsteady Flow File : TopOfLevee

Programs to Run

- Geometry Preprocessor
- Unsteady Flow Simulation
 - Sediment
- Post Processor
- Floodplain Mapping

Plan Description

Simulation Time Window

Starting Date: 02feb2099 Starting Time: 0000

Ending Date: 18feb2099 Ending Time: 0000

Computation Settings

Computation Interval: 30 Second Hydrograph Output Interval: 5 Minute

Mapping Output Interval: 5 Minute Detailed Output Interval: 6 Hour

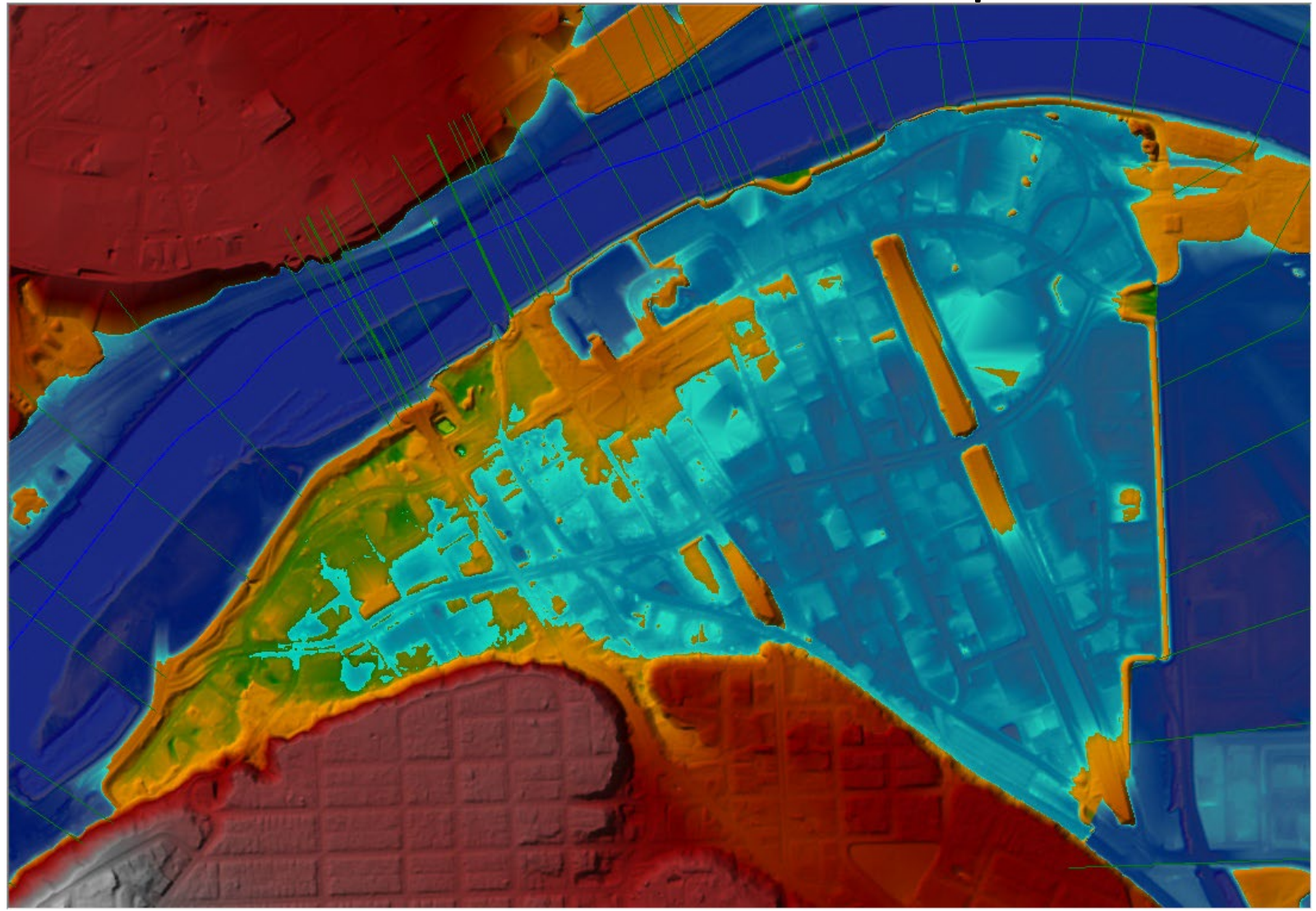
DSS Output Filename: d:\HEC Data\HEC-RAS\2D-Modeling\StPaul\StPaulIES.dss

1 Levee (Lateral Structure) with breach data. 1 set to breach.

Compute

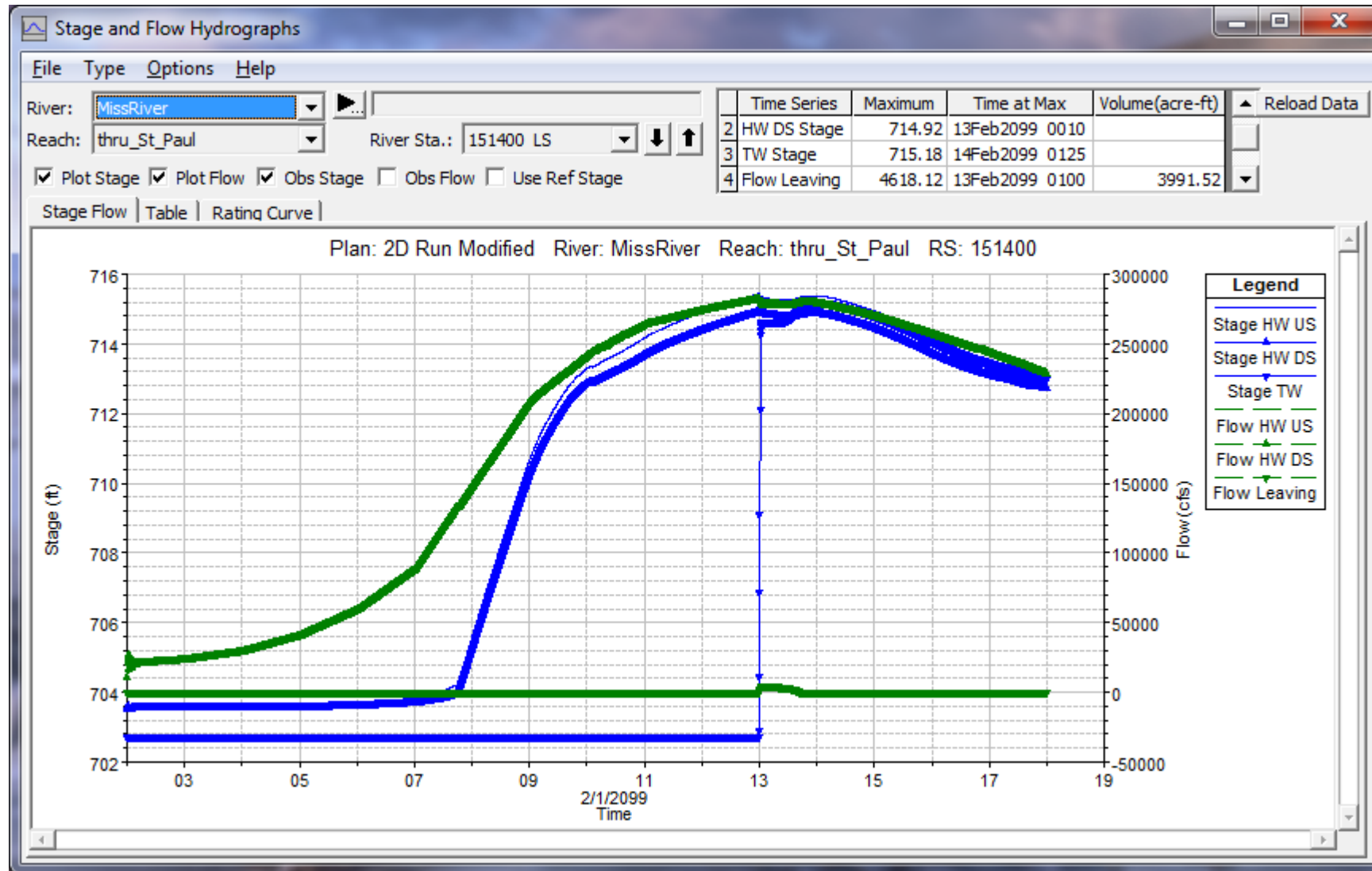


Saint Paul Levee Breach Example





Lateral Structure Time Series Output





Lateral Structure Detailed Output

Lateral Structure Output

File Type Options Help

River: MissRiver Profile: 13FEB2099 0600 Lateral Structure

Reach thru_St_Paul RS: 151400 Plan: 2D Run Modified

Plan: 2D Run Modified MissRiver thru_St_Paul RS: 151400 Lateral Structure Profile: 13FEB2099 0600

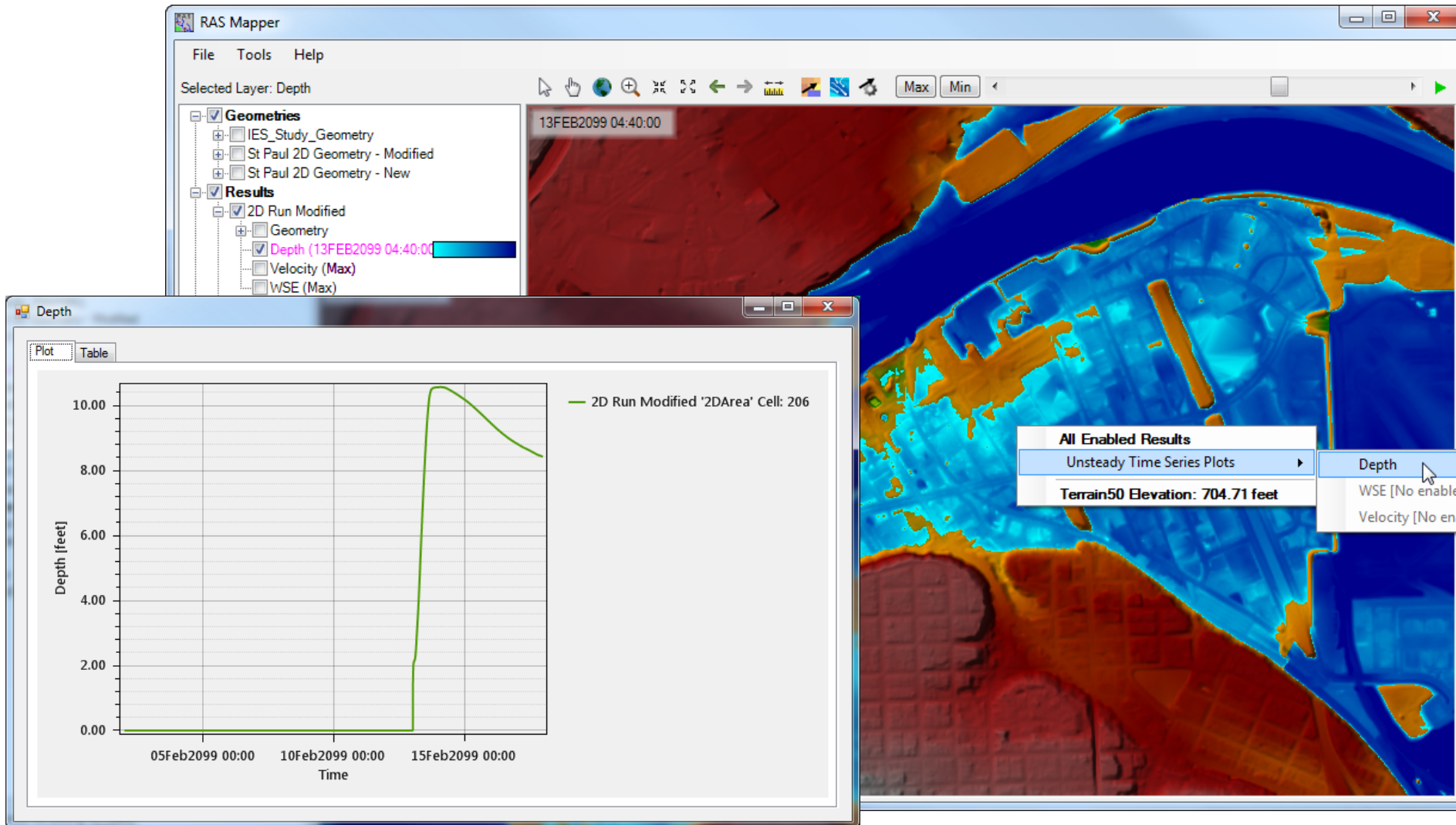
E.G. US. (ft)	716.10	Weir Sta US (ft)	5750.00
W.S. US. (ft)	715.28	Weir Sta DS (ft)	5850.00
E.G. DS (ft)	716.08	Min El Weir Flow (ft)	704.00
W.S. DS (ft)	714.80	Wr Top Wdth (ft)	100.00
Q US (cfs)	281458.70	Weir Max Depth (ft)	11.22
Q Leaving Total (cfs)	4332.12	Weir Avg Depth (ft)	11.14
Q DS (cfs)	277159.10	Weir Flow Area (sq ft)	1113.82
Perc Q Leaving	1.54	Weir Coef (ft ^{1/2})	2.600
Q Weir (cfs)	4332.12	Weir Submerg	0.95
Q Gates (cfs)		Q Gate Group (cfs)	
Q Culv (cfs)		Gate Open Ht (ft)	
Q Lat RC (cfs)		Gate #Open	
Q Outlet TS (cfs)	0.00	Gate Area (sq ft)	
Q Breach (cfs)	4332.12	Gate Submerg	
Breach Avg Velocity (ft/s)	3.89	Gate Invert (ft)	
Breach Flow Area (sq ft)	1113.82	Gate Weir Coef	
Breach WD (ft)	100.00		
Breach Top El (ft)			
Breach Bottom El (ft)	704.00		
Breach SSL (ft)	0.00		
Breach SSR (ft)	0.00		

Errors, Warnings and Notes

Average flow velocity through a breach.

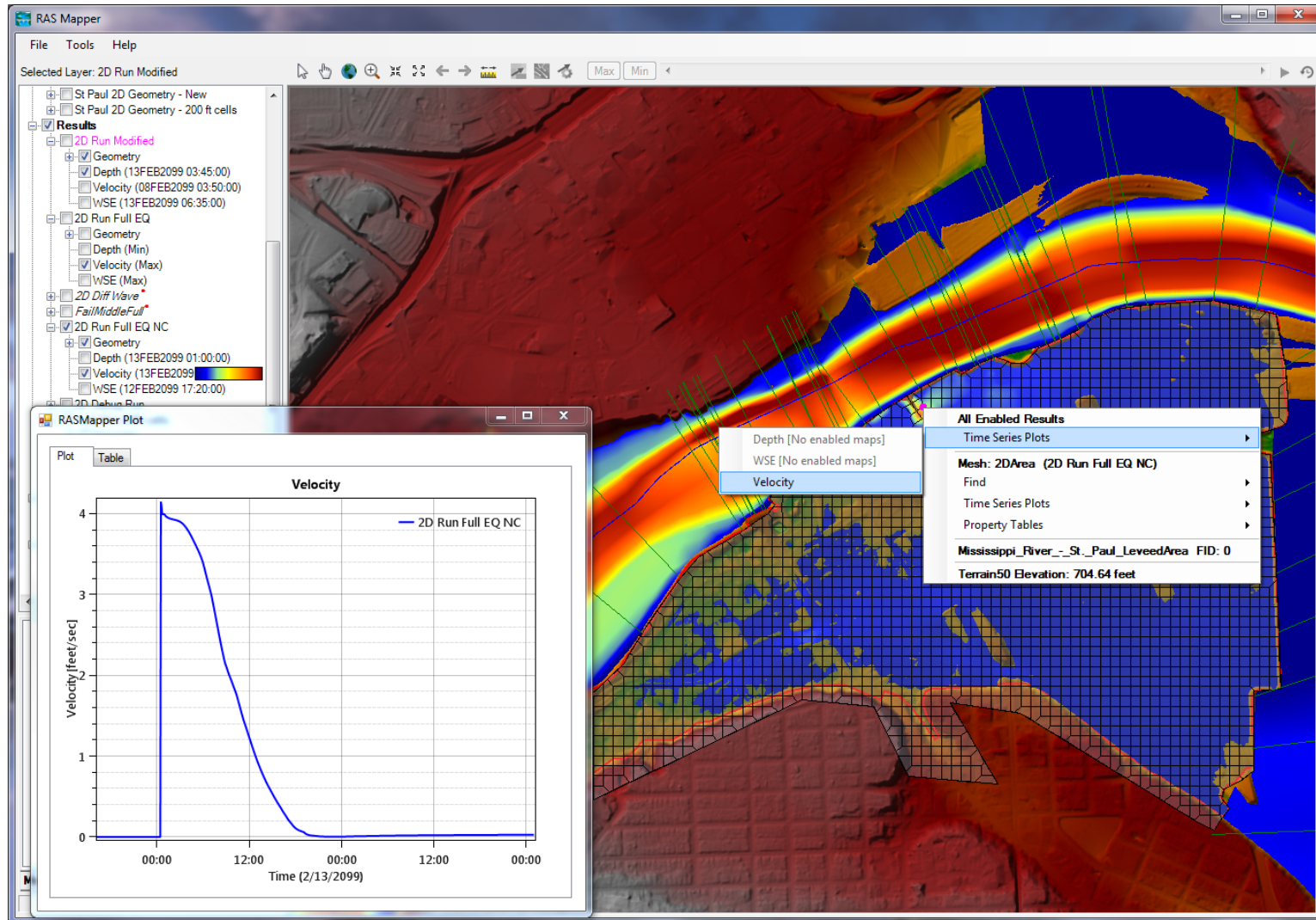


Stage Hydrograph Plots from RAS Mapper





Velocity Hydrograph Plots from RAS-Mapper



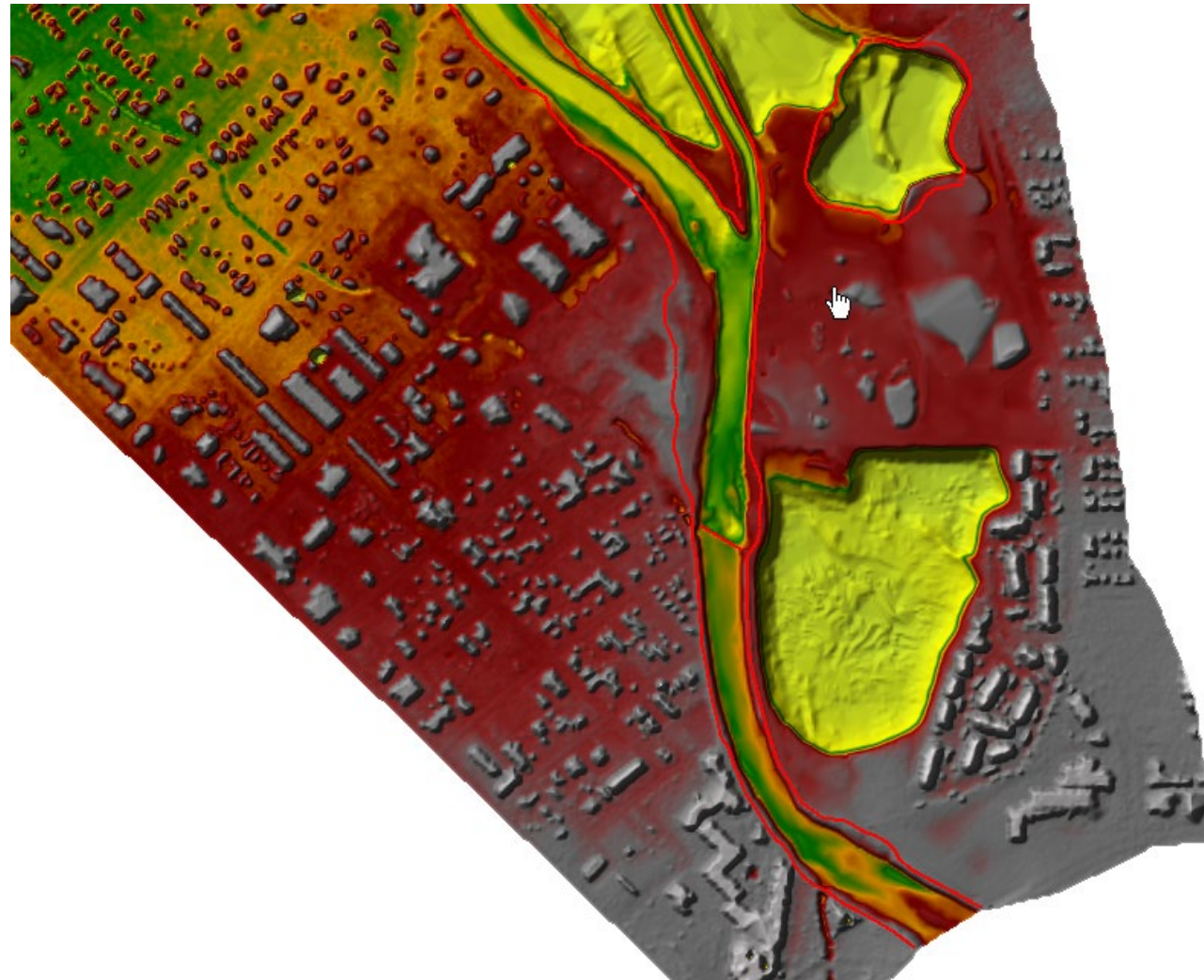


Using 2D Flow Areas to model Overbank Areas (floodplains)

- Draw a Polygon for the Overbank/Floodplain Area
 - The 2D Flow Area boundary should be drawn at a High Ground Separation between the 1D Main Channel and 2D Floodplain
- Create the 2D Computational Mesh
- View the Mesh to ensure there are no Mesh Problems
- Modify The Mesh if Needed (add break lines, points, etc...)
- Hooking up a 2D Flow Area to a 1D River Reach with Lateral Structures
- Overflow Computation Method
- Weir Coefficients for Lateral Structures
- Weir Submergence Issues

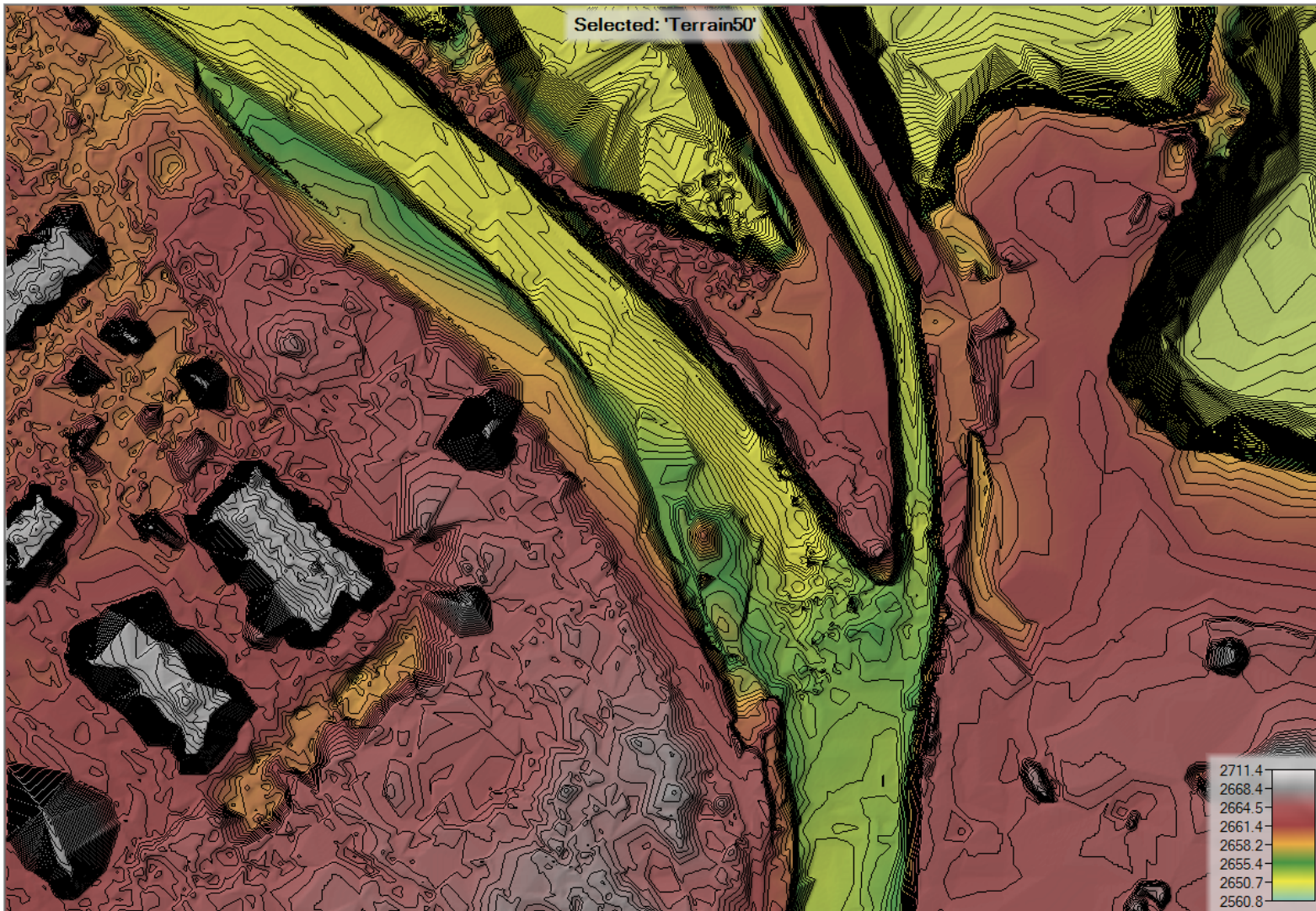


1D Channel to 2D Interface Should be at High Ground
Separating the two



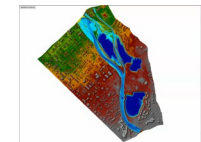
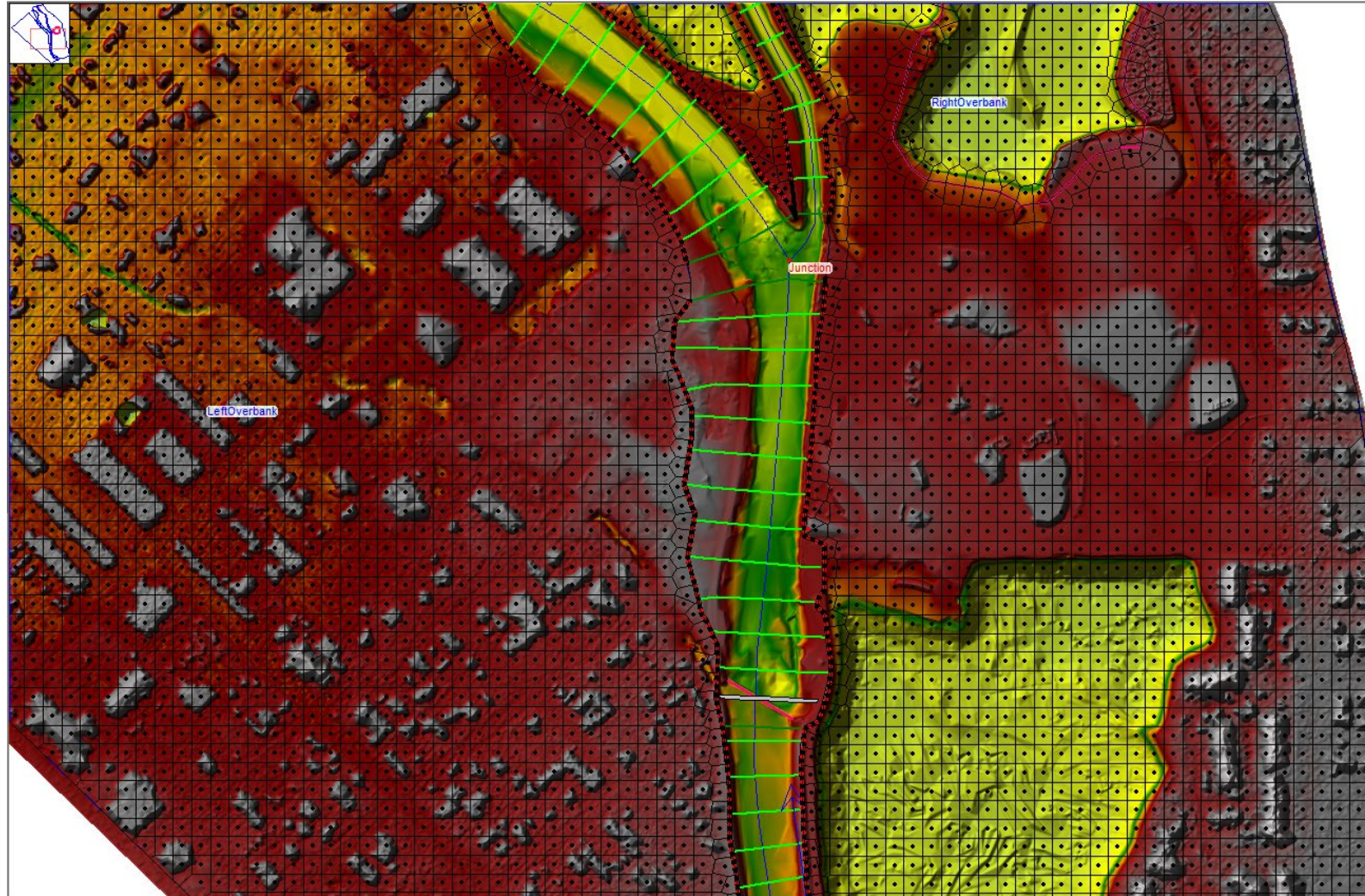


Terrain Contours





Lateral Structure to connect 1D river to 2D overbank areas





Overflow Computation Method

Lateral Structure Editor - Detailed 1D-2D Stage to Stage

File View Options Help

River: BoiseRiver Apply Data + [Camera Icon]

Reach: Lower HW RS: 3749 3749 LS [Down Arrow] [Up Arrow]

Description [Text Box]

HW Position: Left overbank [Plan Data Optimization ... Breach ...]

Tailwater Connection
Type: Storage Area/2D Flow Area
SA/2DFA: 2D flow area: LeftOverbank [Set SA/2DFA ...]

Weir Length: 3388.30
Centerline Length: 3388.30

Overflow Computation Method
 Normal 2D Equation Domain Use Weir Equation 2D Boundary Use Velocity

All Culverts: No Flap Gates [Centerline GIS Coords...]

Structure Type: Weir/Gates/Culverts/Diversion Rating Curves [Terrain Profile ...]

HW and TW Connections Determined Geo-Spatially

Legend
Lat Struct
Ground
Bank Sta
TW Cell Min Elev
LS Terrain



Weir Coefficients for Lateral Structures

What is being modeled with the Lateral Structure	Description	Range of Weir Coefficients
Levee/Roadway – 3ft or higher above natural ground	Broad crested weir shape, flow over Levee/road acts like weir flow	1.5 to 2.6 (2.0 default) SI Units: 0.83 to 1.43
Levee/Roadway – 1 to 3 ft elevated above ground	Broad Crested weir shape, flow over levee/road acts like weir flow, but becomes submerged easily.	1.0 to 2.0 SI Units: 0.55 to 1.1
Natural high ground barrier – 1 to 3 ft high	Does not really act like a weir, but water must flow over high ground to get into 2D area.	0.5 to 1.0 SI Units: 0.28 to 0.55
Non elevated overbank terrain. Lat Structure not elevated above ground	Overland flow escaping the main river.	0.2 to 0.5 SI Units: 0.11 to 0.28

Questions?