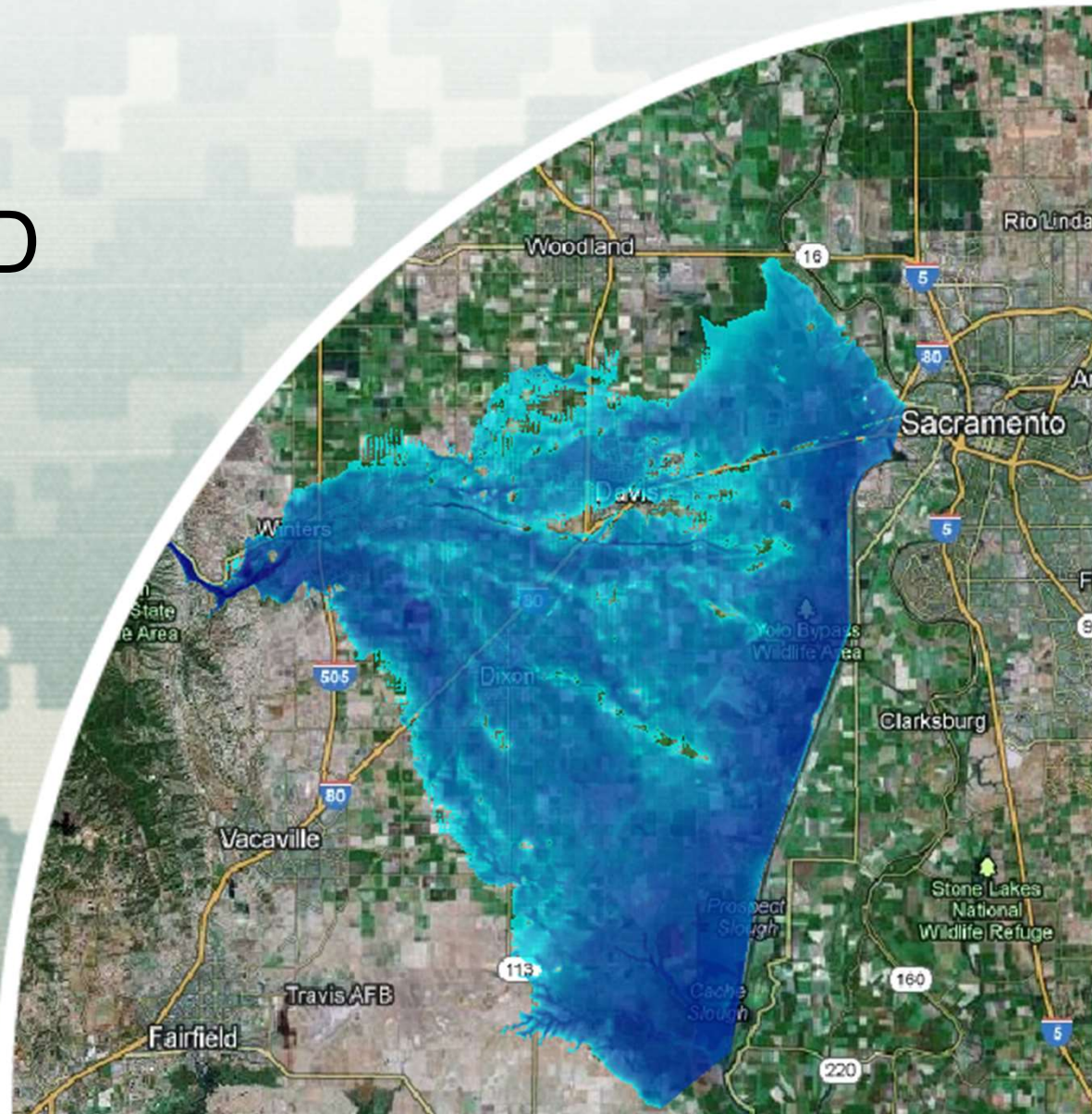


Dam Breaching Analysis with Combined 1D and 2D Elements



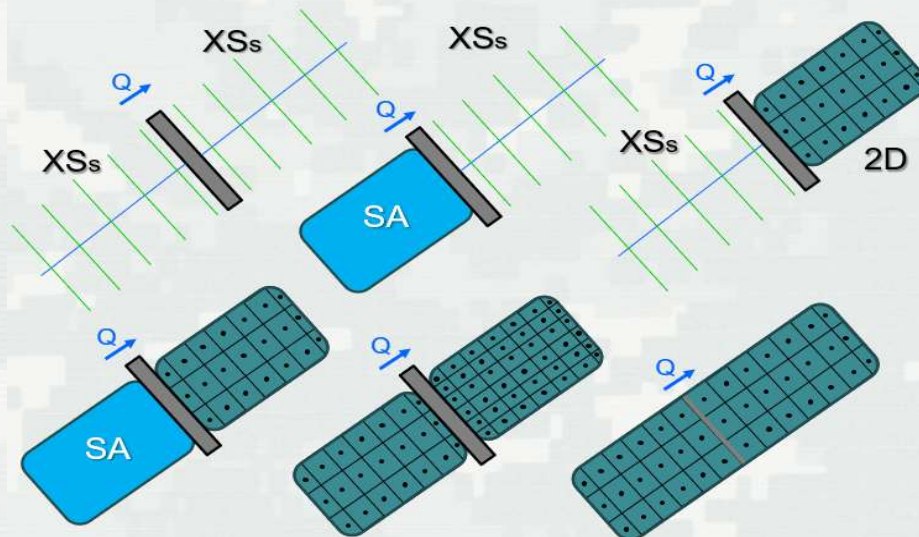
Stanford Gibson, PhD

Includes slides by
Gary Brunner, P.E.

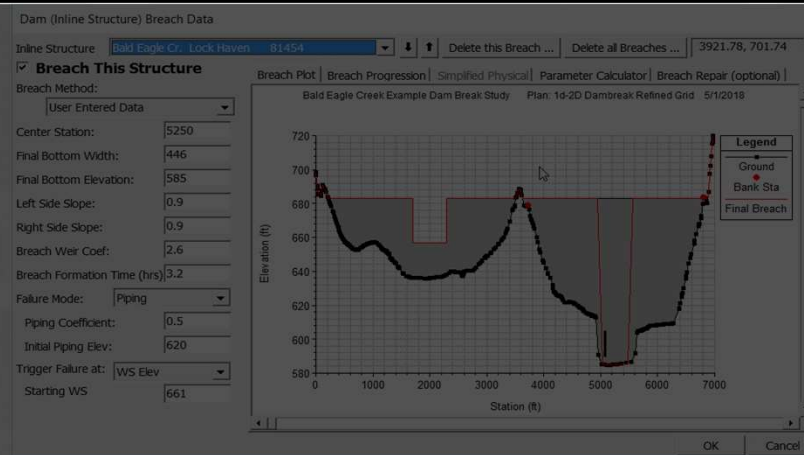


US Army Corps of Engineers
BUILDING STRONG®

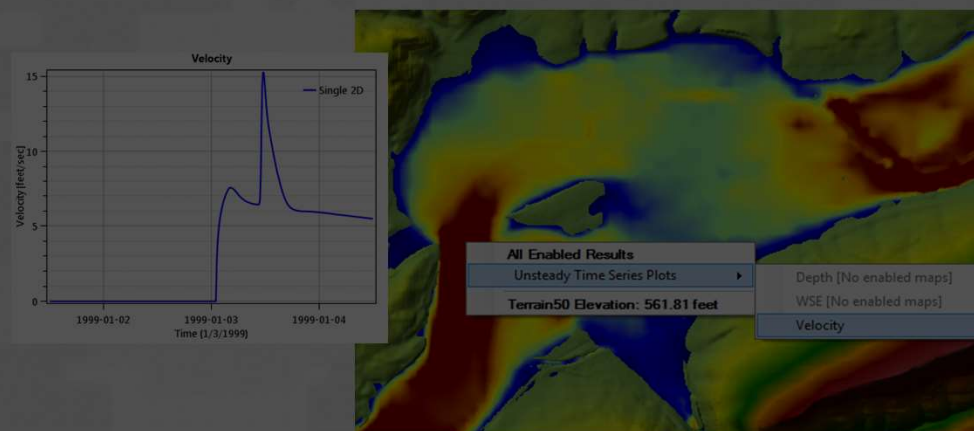
1. Six Dam Breach Model Configurations



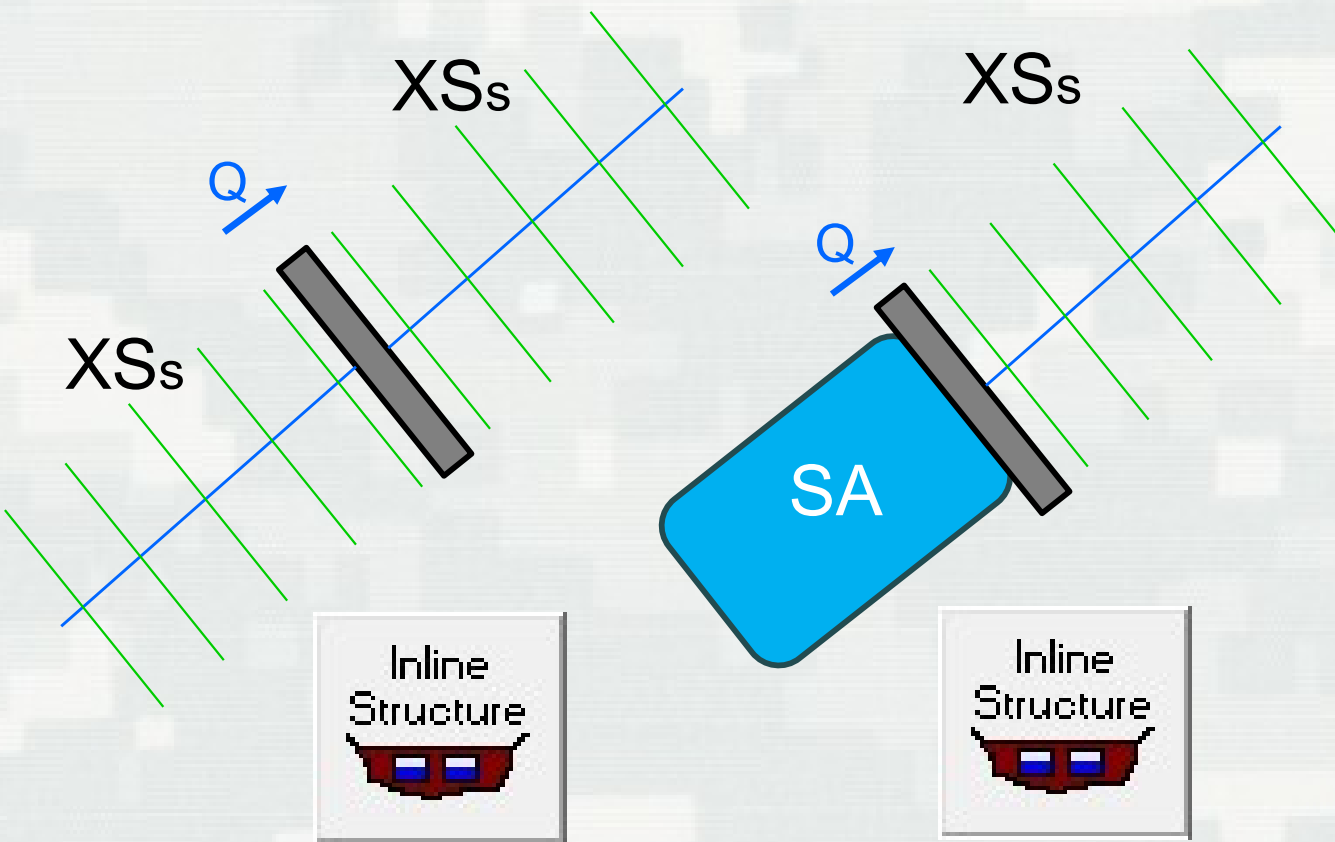
2. Breaching Options and Parameters



3. Breach Results and Visualization



Breach Model Configuration Options



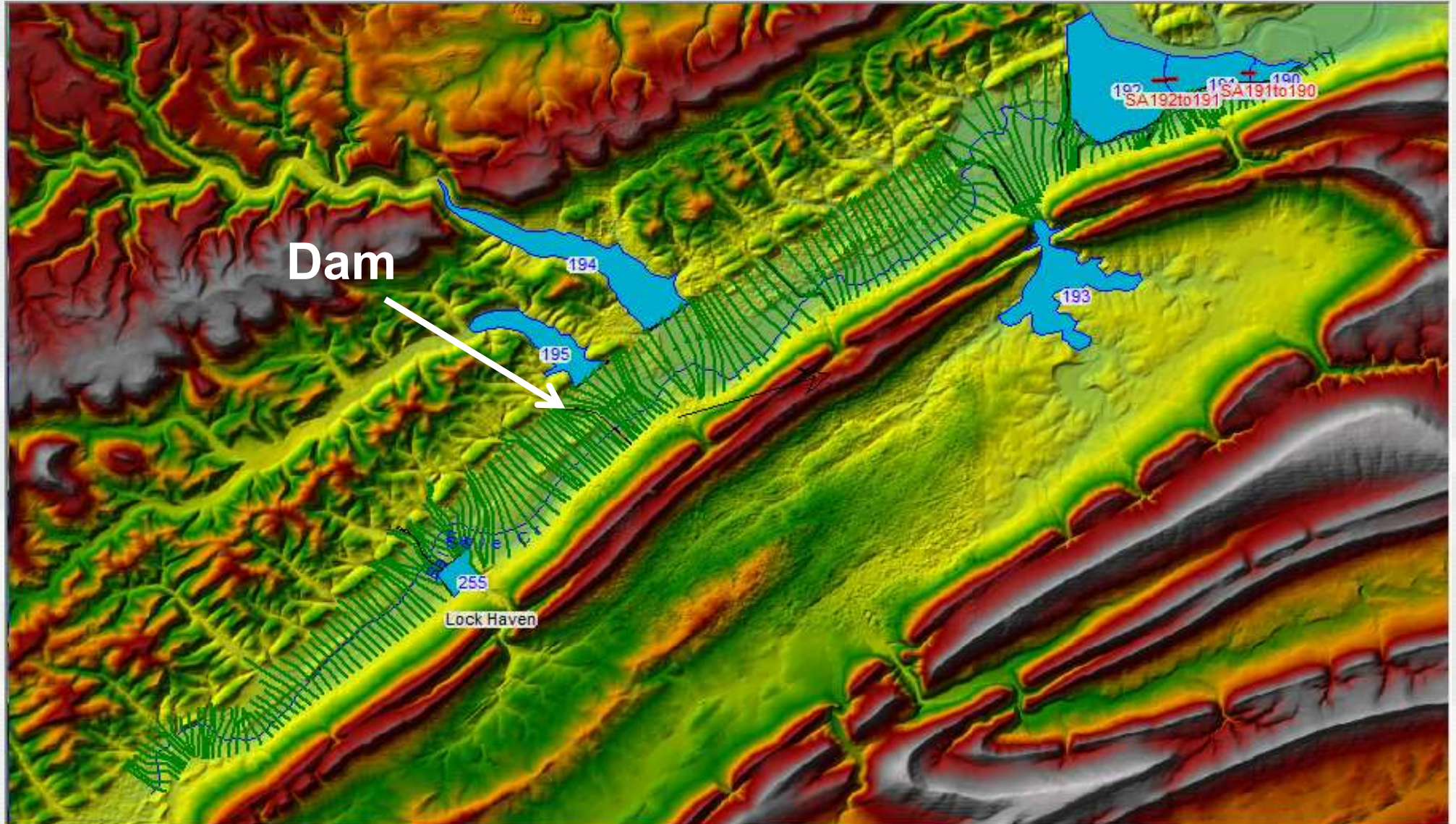
Pre-2D
Options





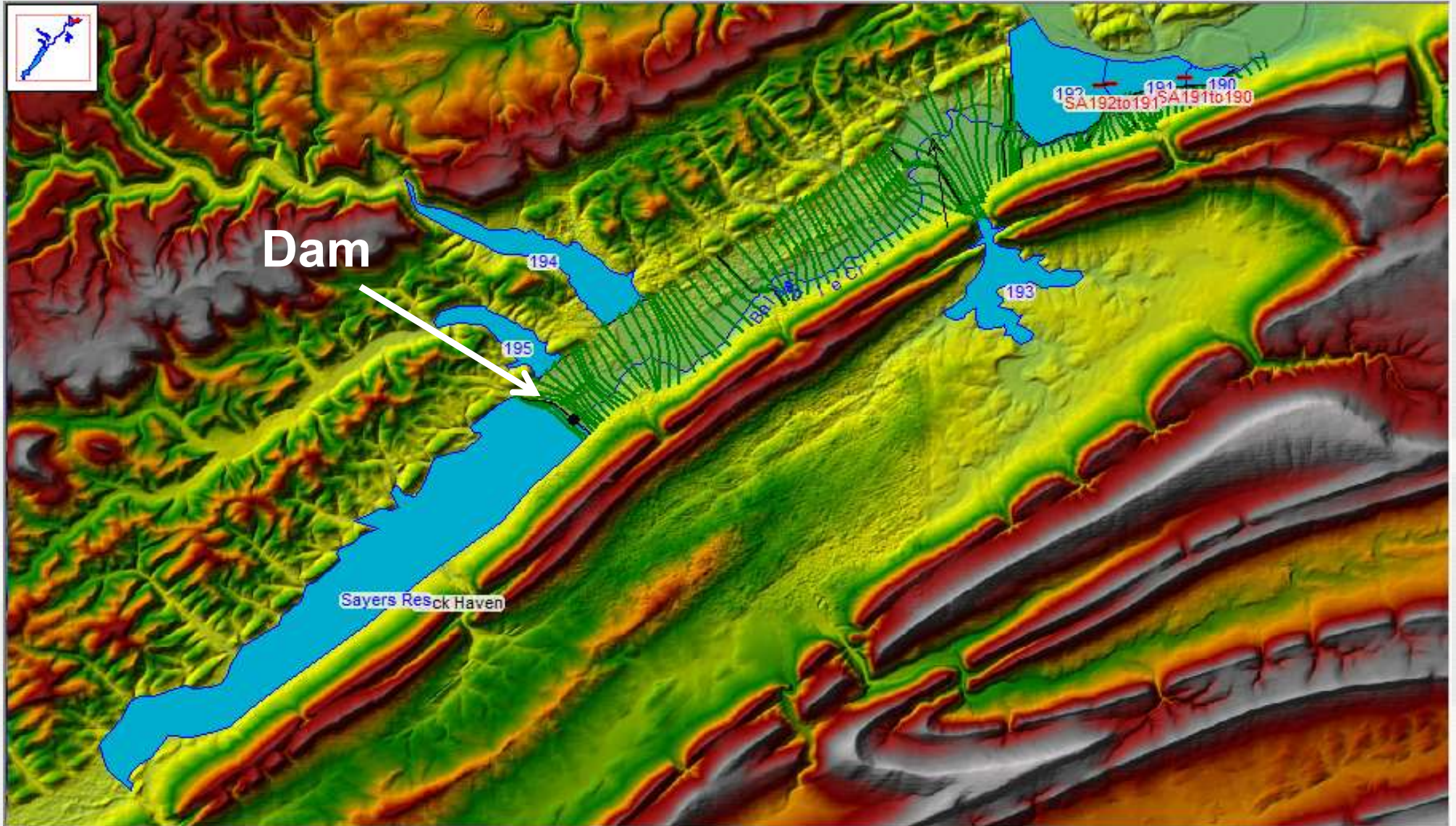
1D Dam Breaching Analysis

Cross Section for Pool and Downstream

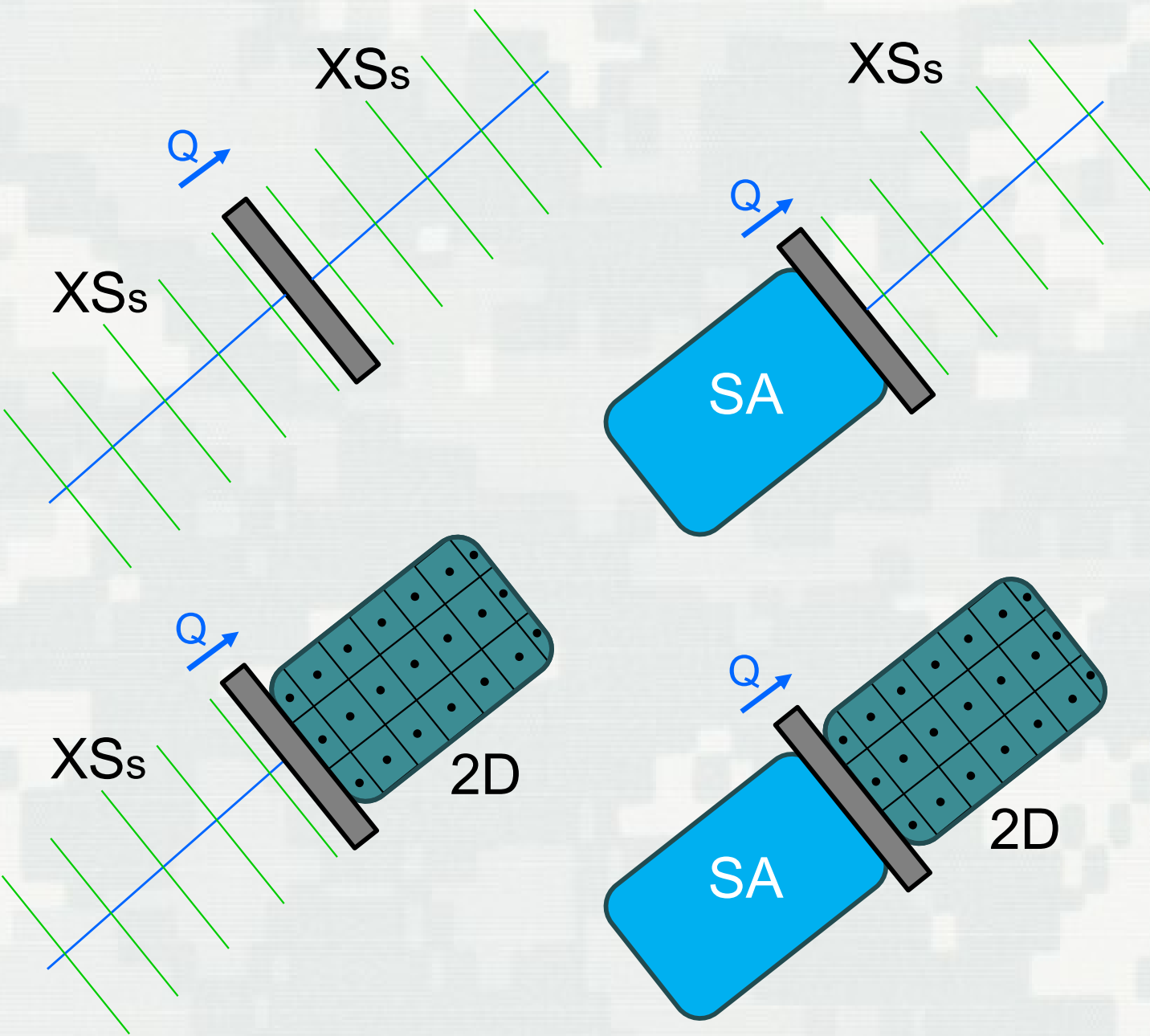




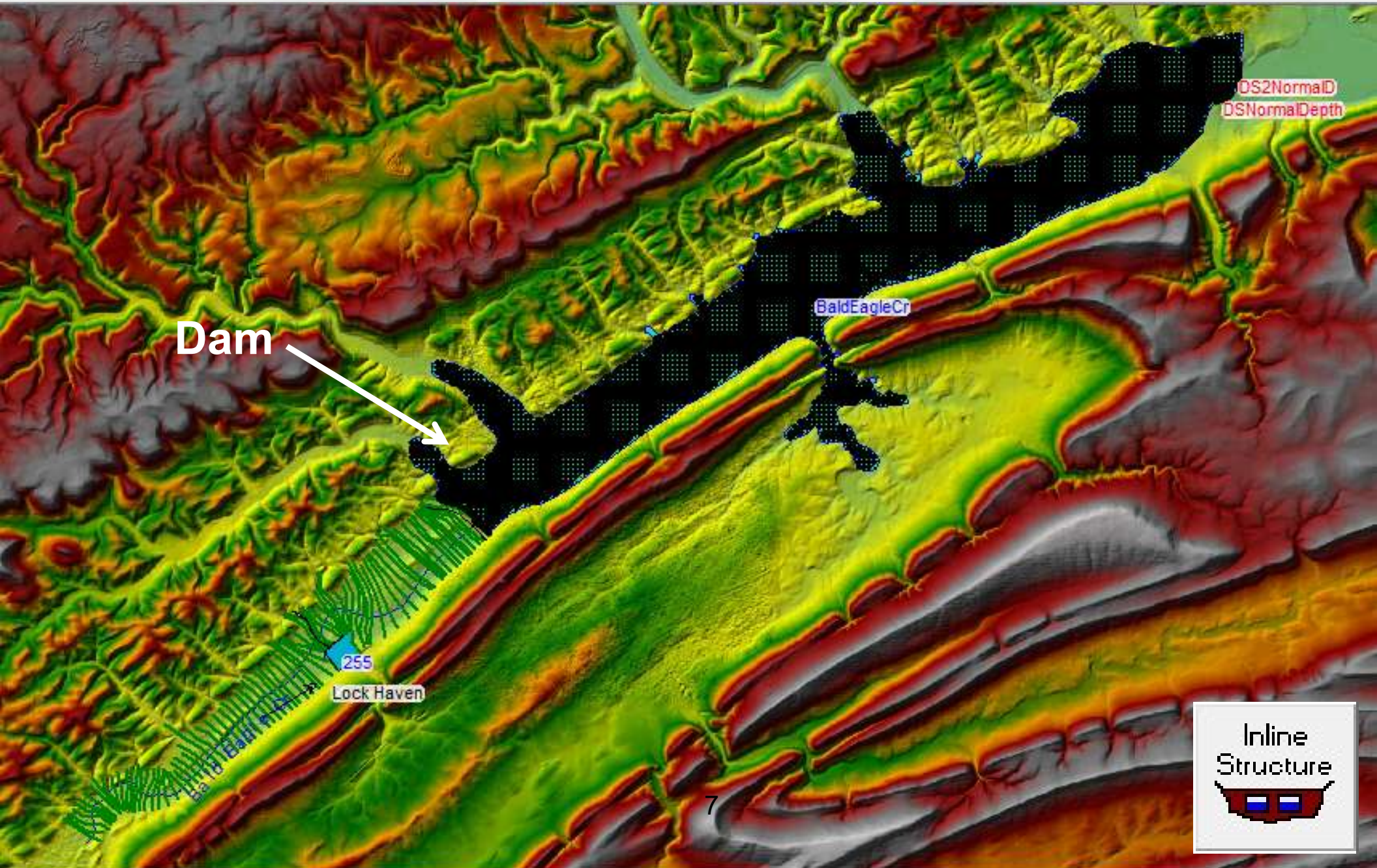
1D Dam Breaching Analysis Storage Area Pool and XS Downstream



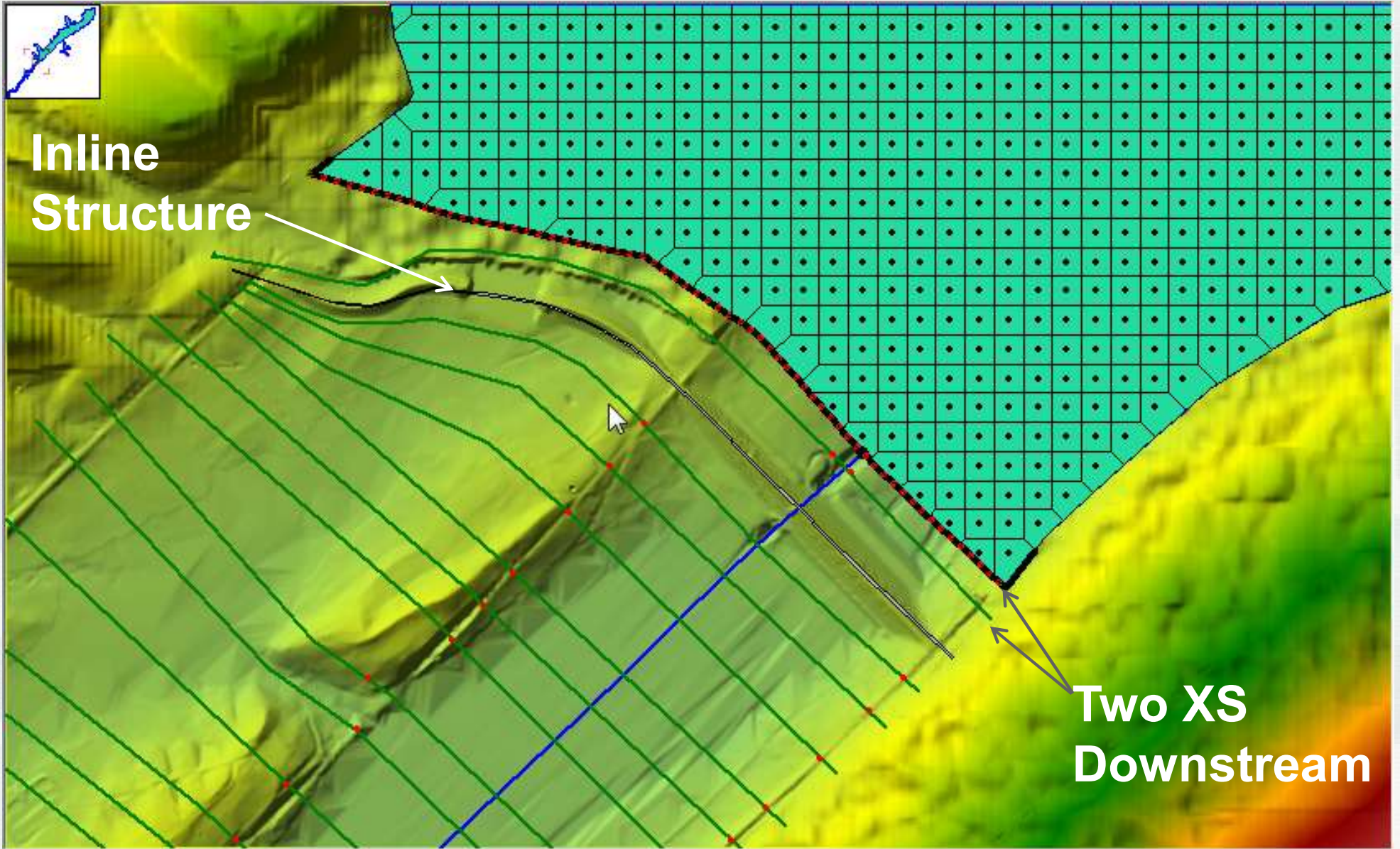
Breach Model Configuration Options



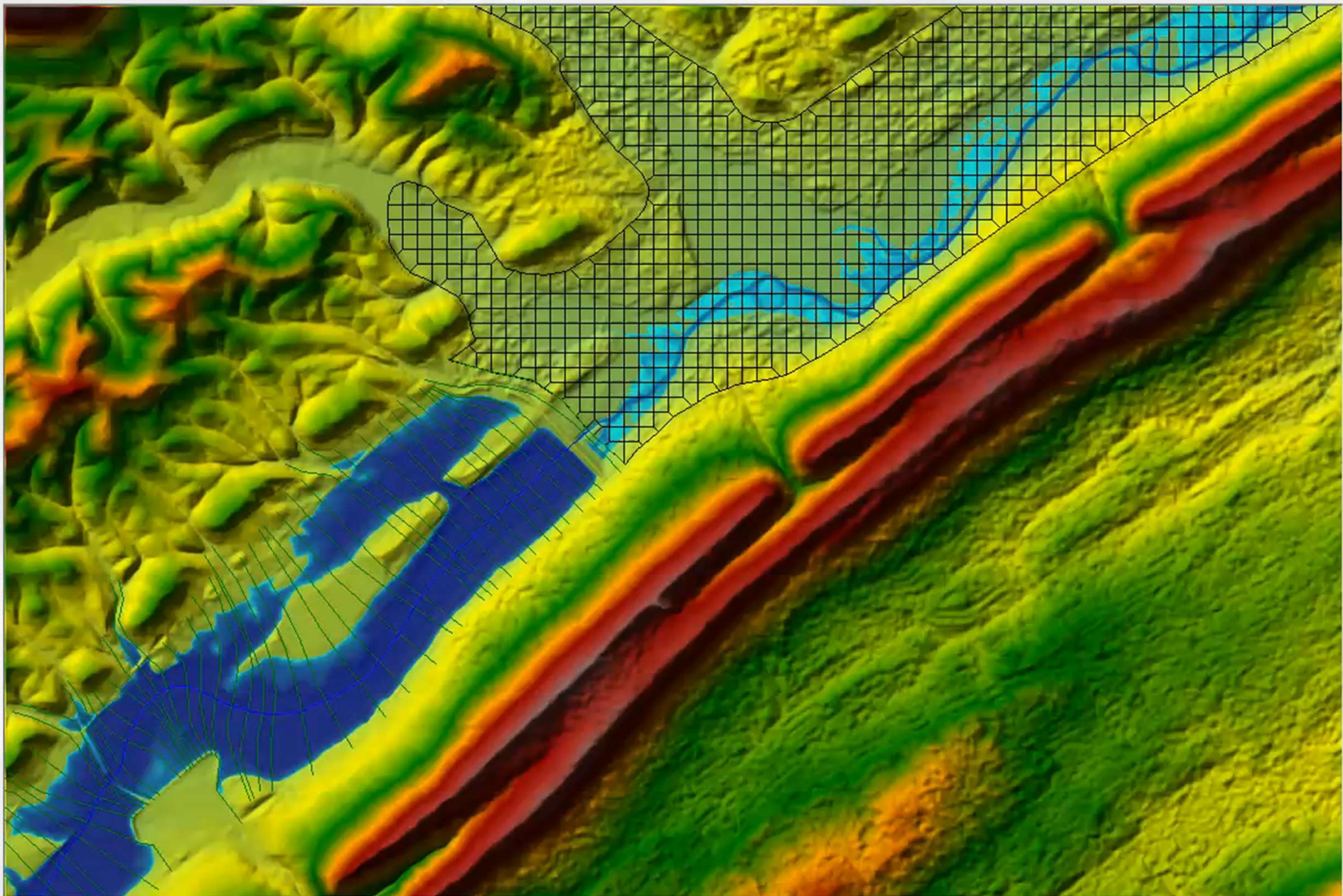
1D River Reach Pool and 2D Downstream



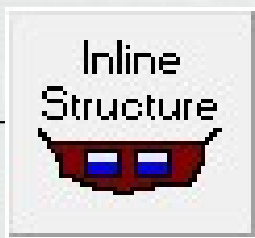
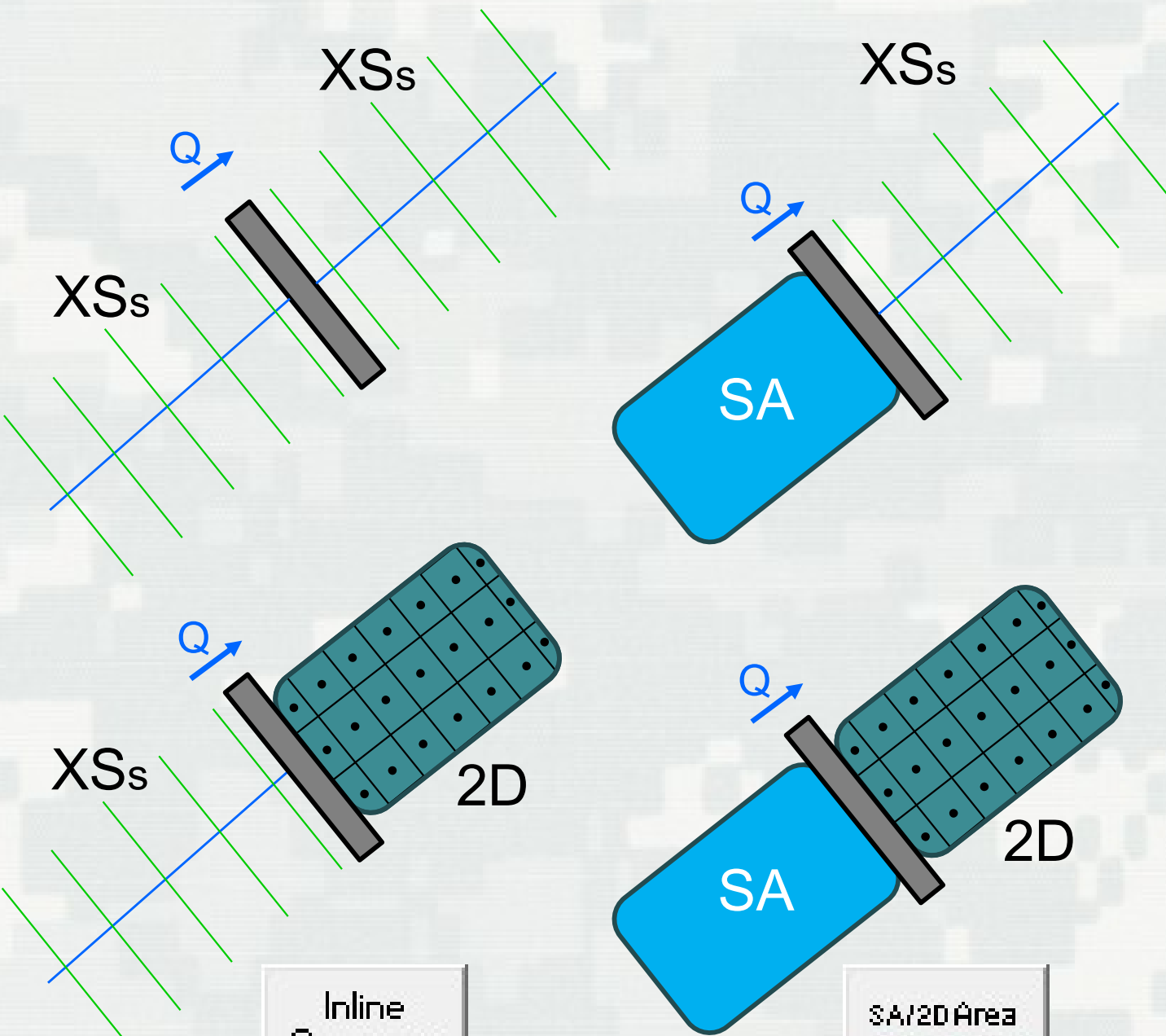
1D River Reach Pool and 2D Downstream



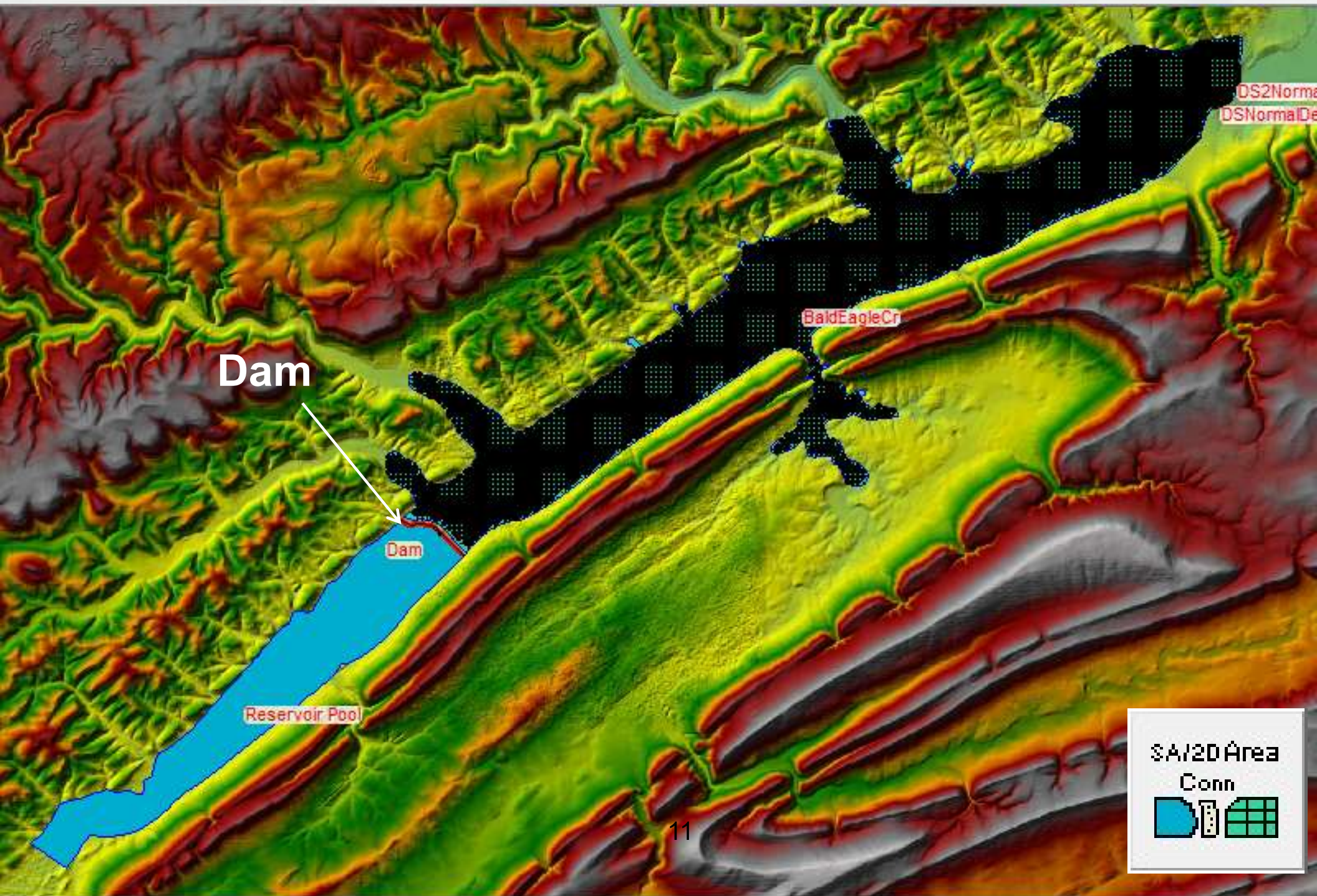
Animation 1D River Reach Pool and 2D Downstream



Breach Model Configuration Options



1D Storage Area Pool and 2D Downstream



1D Storage Area Pool and 2D Downstream

Geometric Data - SA to 2D Flow Area - Detailed

File Edit Options View Tables Tools GIS Tools Help

Tools

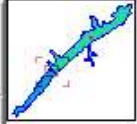


Description

Plot WS extents for Profile:

(none)

Editors



Dam



Dam

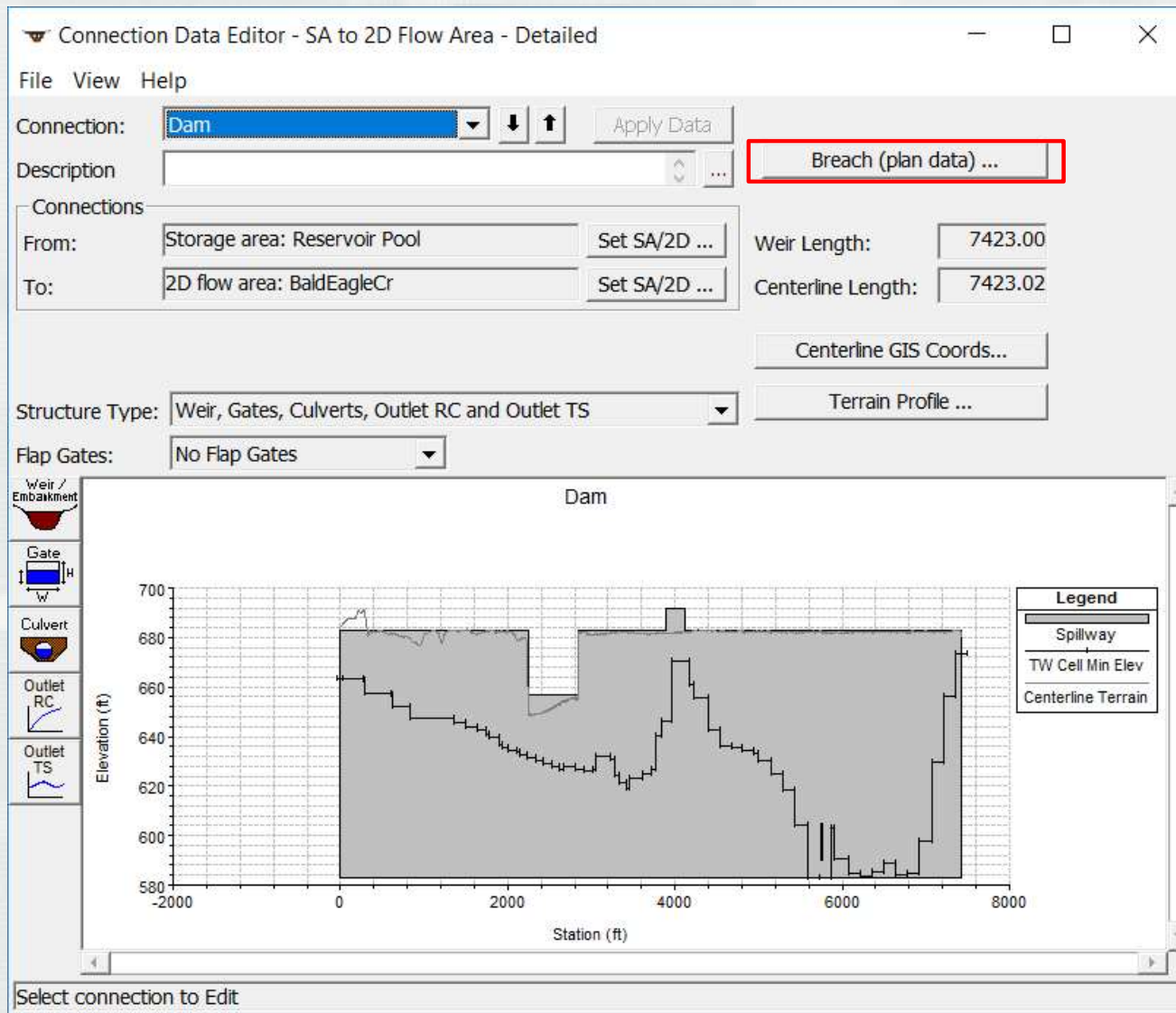
12

Steps to Connect a SA to a 2D Flow Area with a SA/2D Area Hydraulic Connection

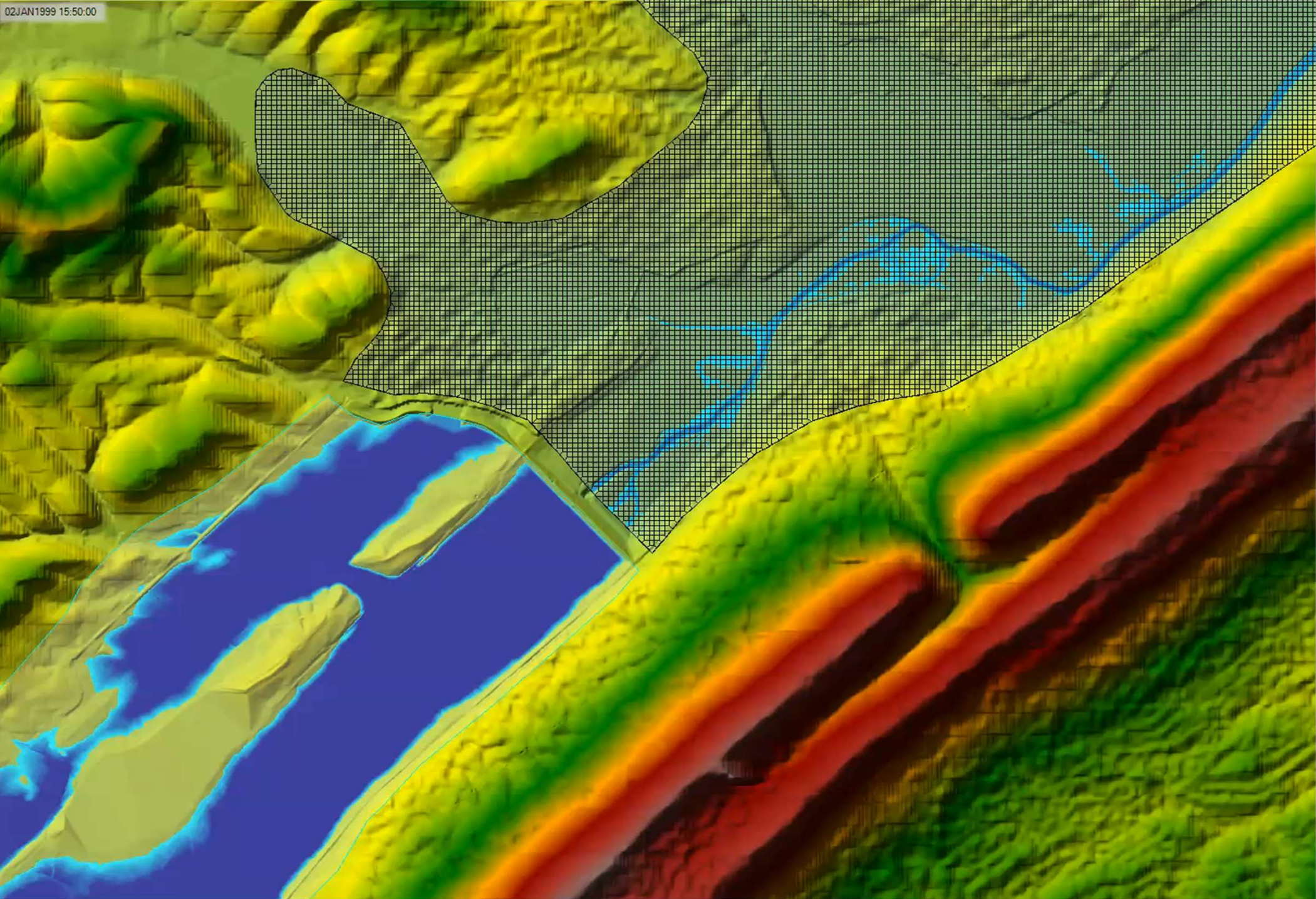
- Draw the Storage Area and enter its data
- Draw the 2D Flow Area and create Mesh
- Using the **SA/2D Area Conn** drawing tool
 - ▶ draw the line that represents the hydraulic Structure from left to right looking downstream
- Select the **SA/2d Area Conn** data editor
 - ▶ Enter the “From” and “To” connections
 - ▶ Enter the top of dam and spillway profile
 - ▶ Enter any gate data, etc...



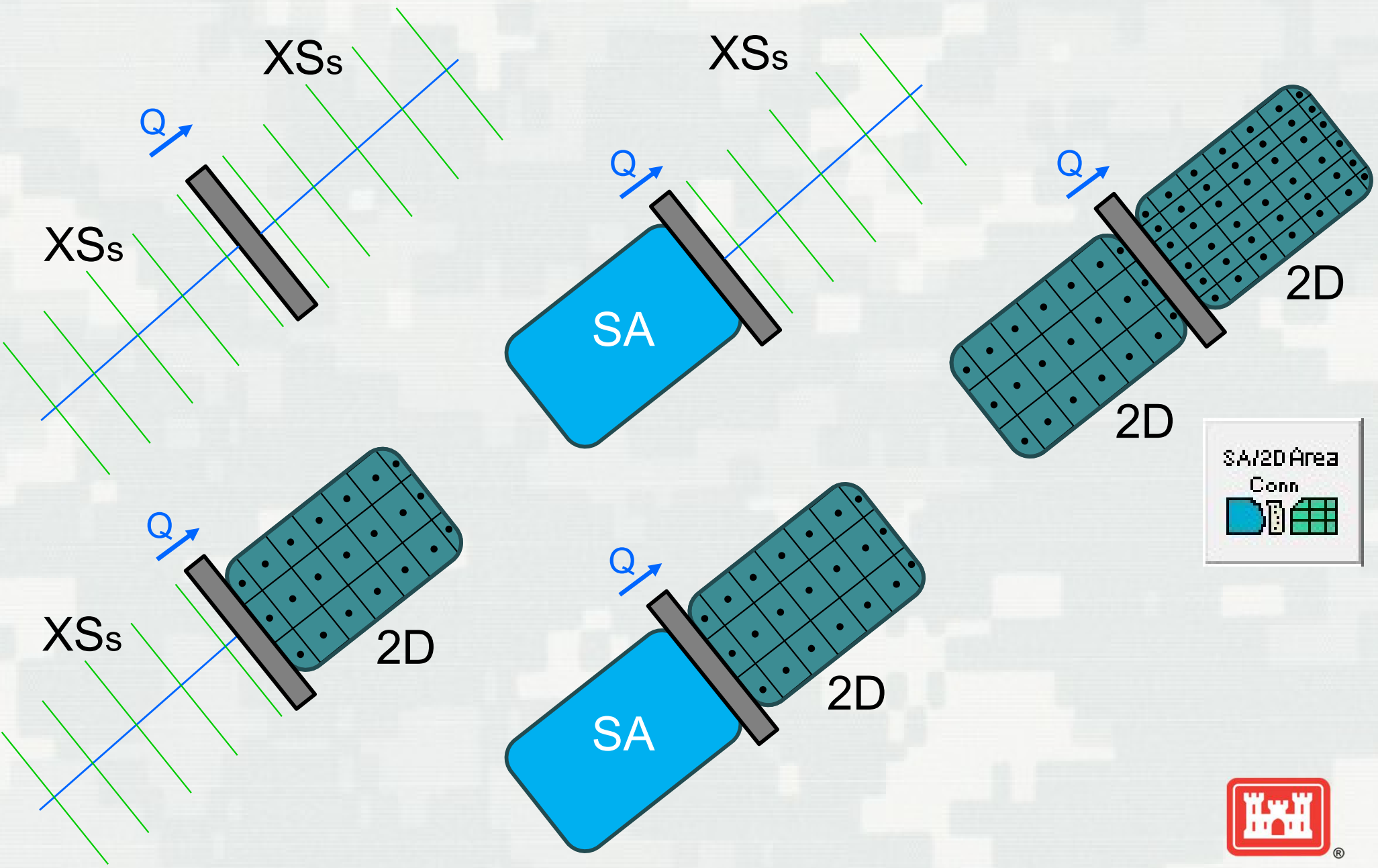
Modeling the Dam with a SA/2D Area Hydraulic Connection



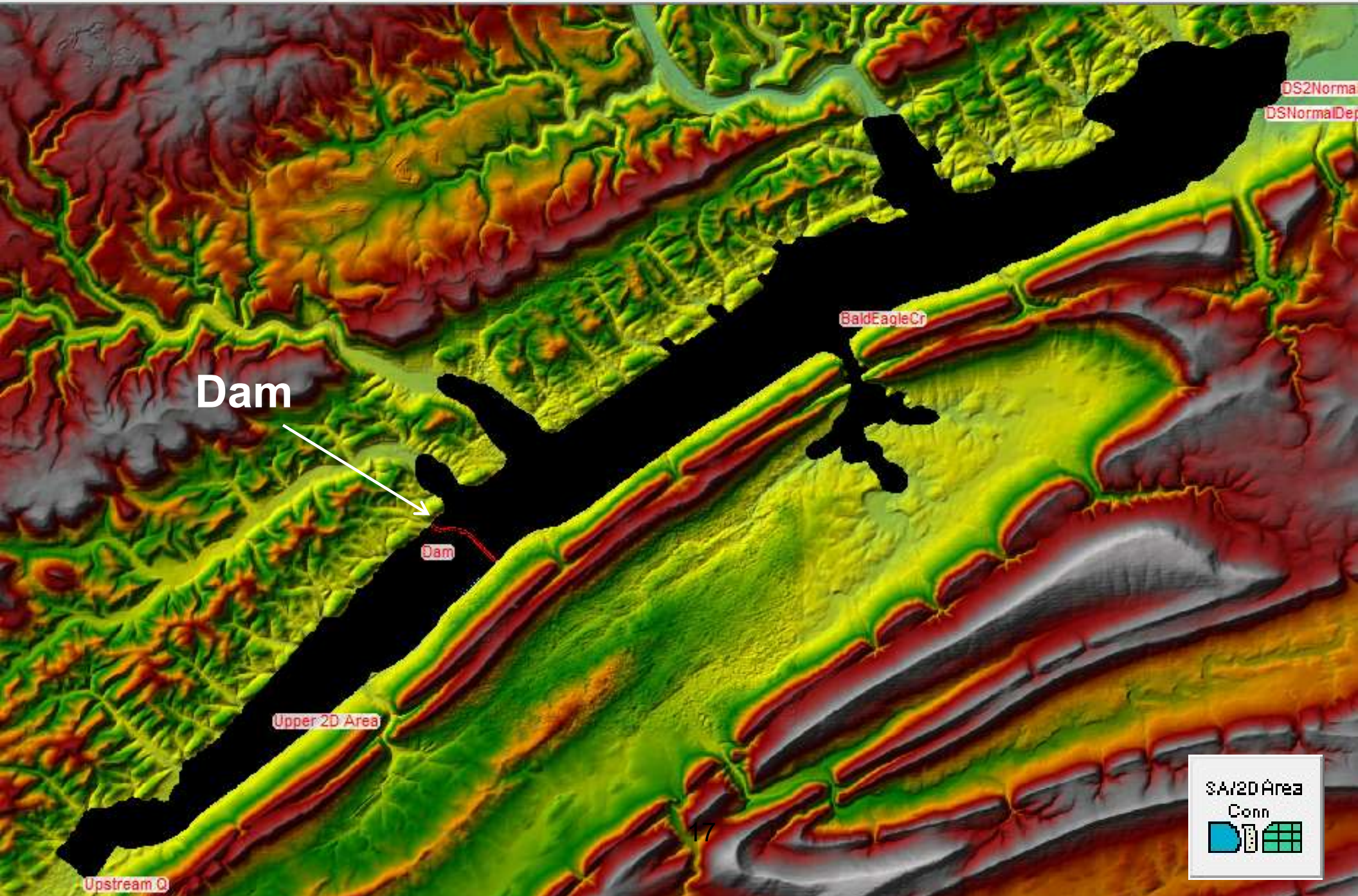
1D Storage Area Pool → 2D Area Downstream



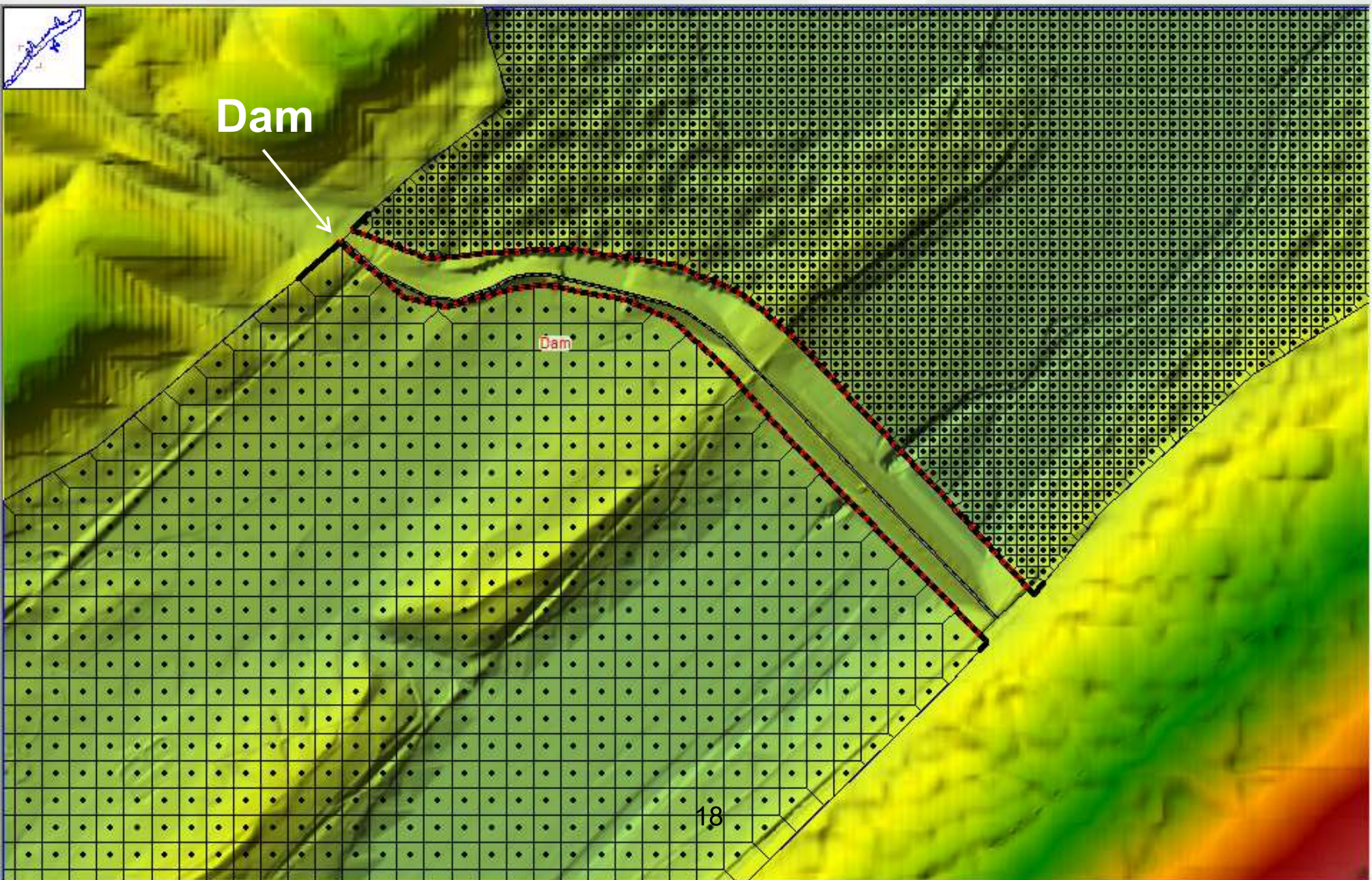
Breach Model Configuration Options



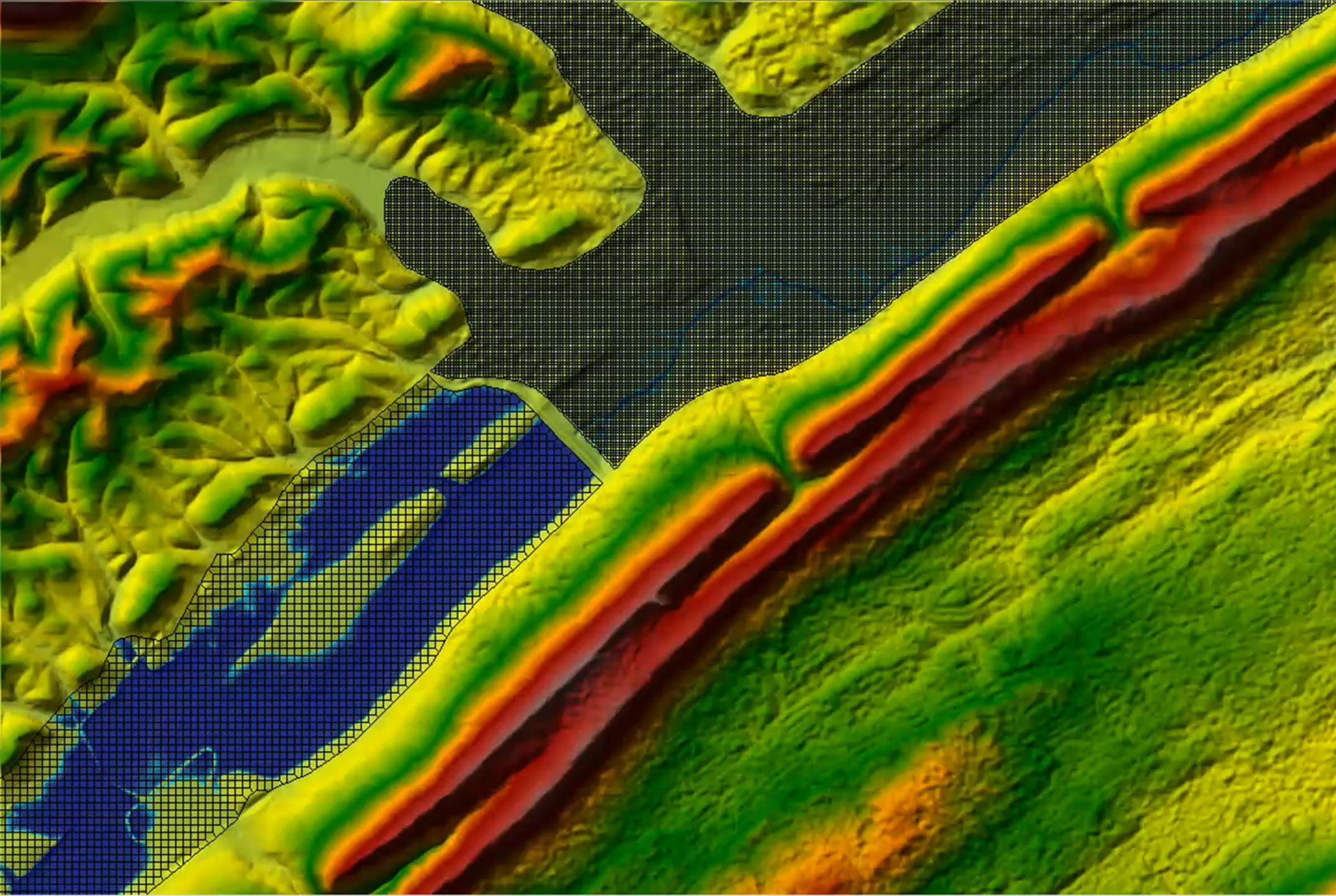
2D Reservoir Pool and 2D Downstream



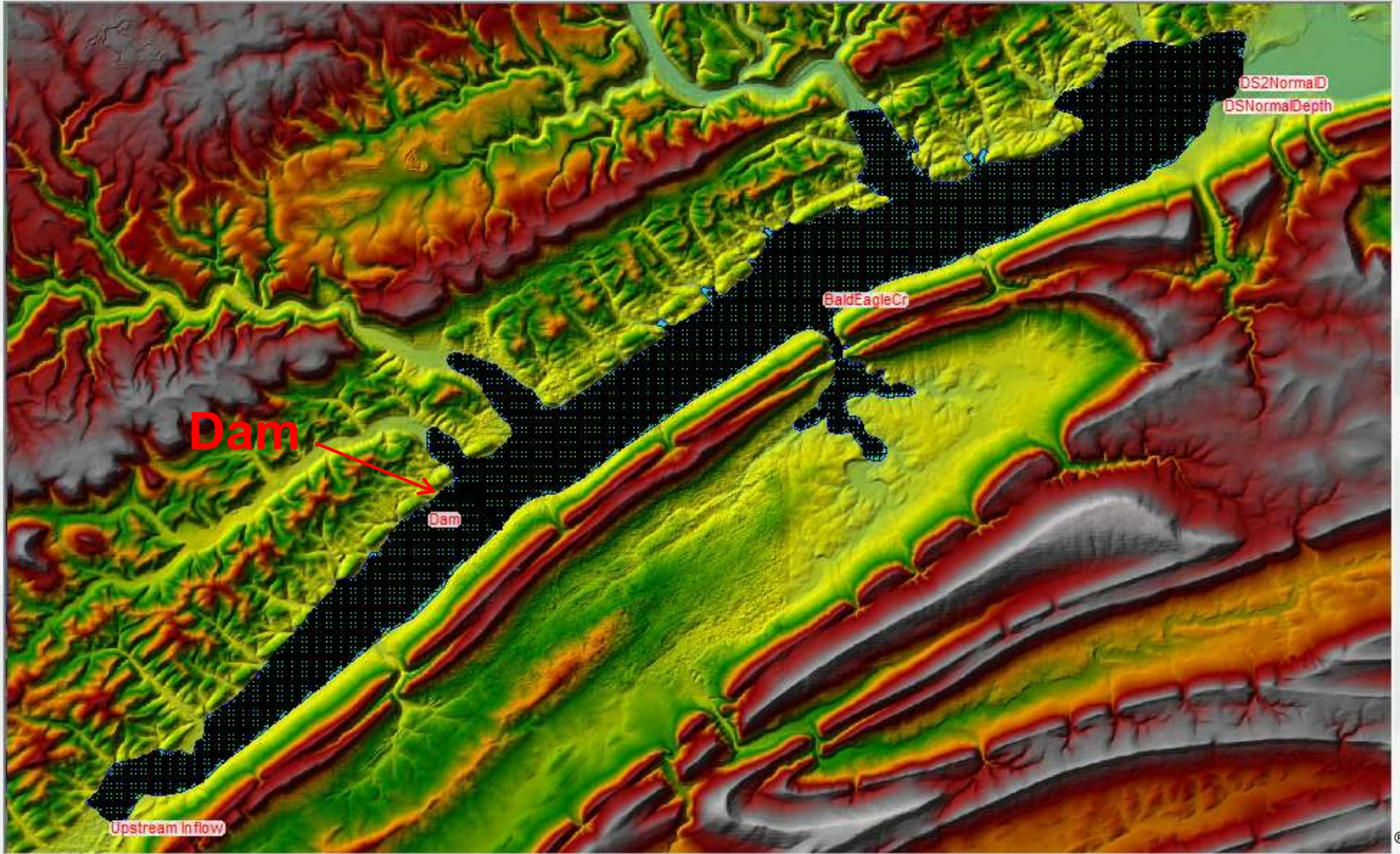
2D Reservoir Pool and 2D Downstream



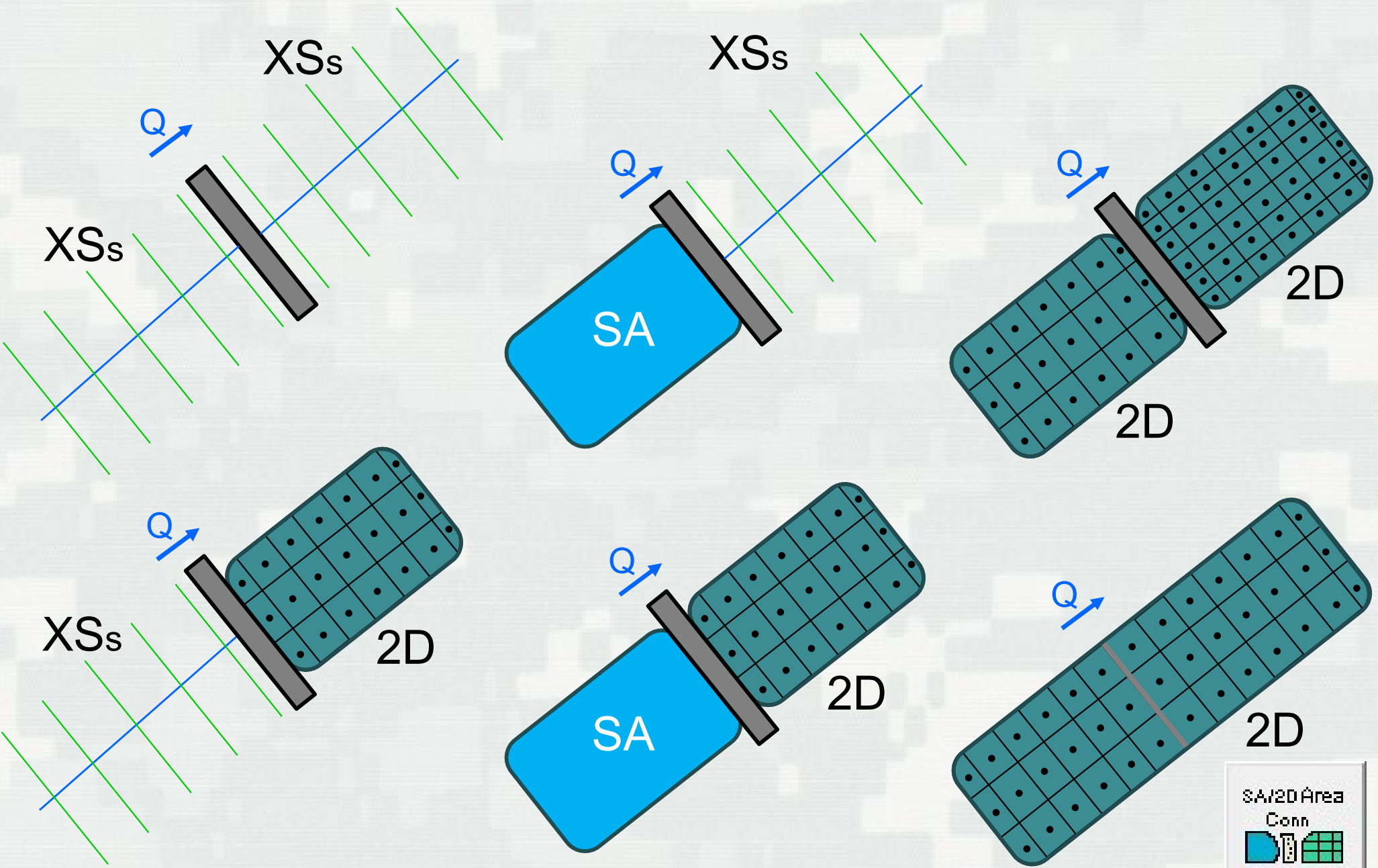
Animation of 2D Reservoir Pool and 2D Downstream



Single 2D Flow Area with Internal Hydraulic Structure for the Dam



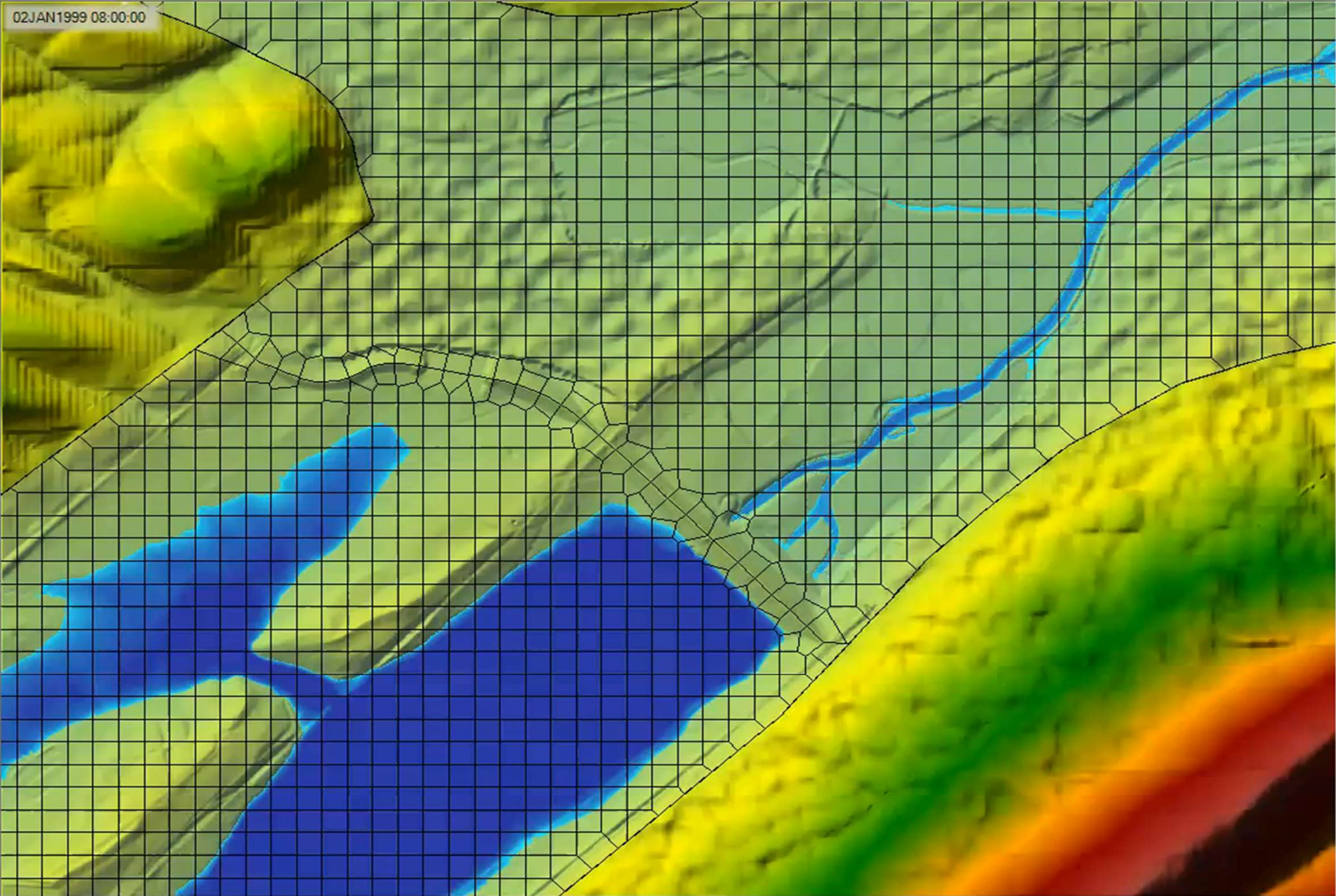
Breach Model Configuration Options



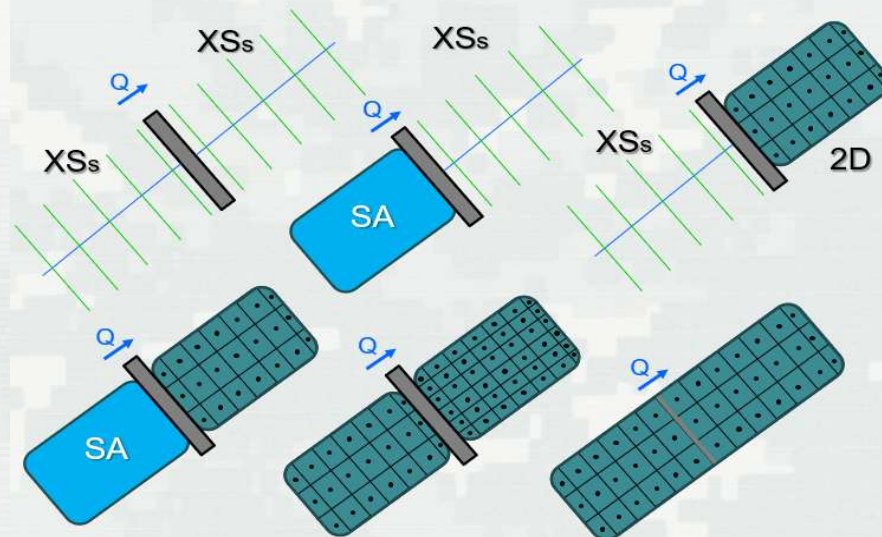
Single 2D Flow Area with Internal Hydraulic Structure for the Dam



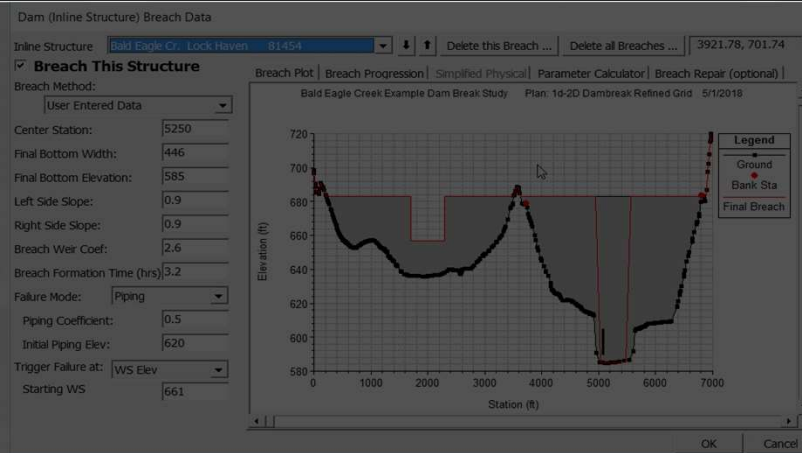
Animation of Single 2D Flow Area with Internal Hydraulic Structure for the Dam



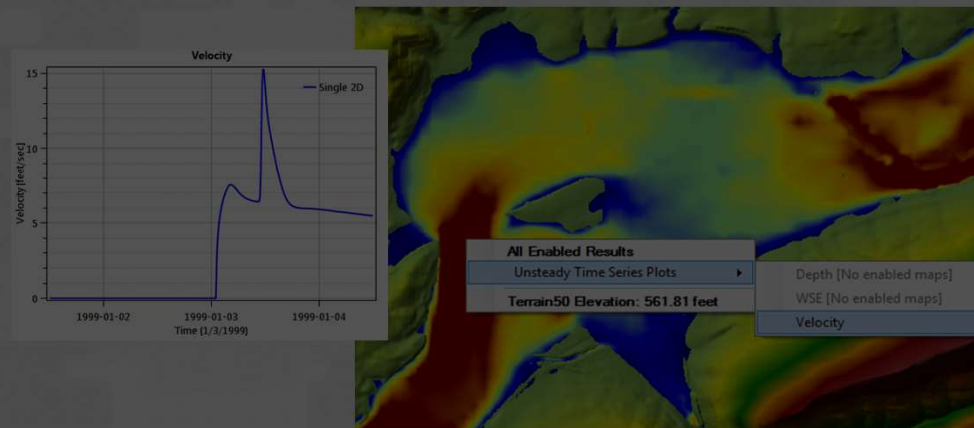
1. Six Dam Breach Model Configurations



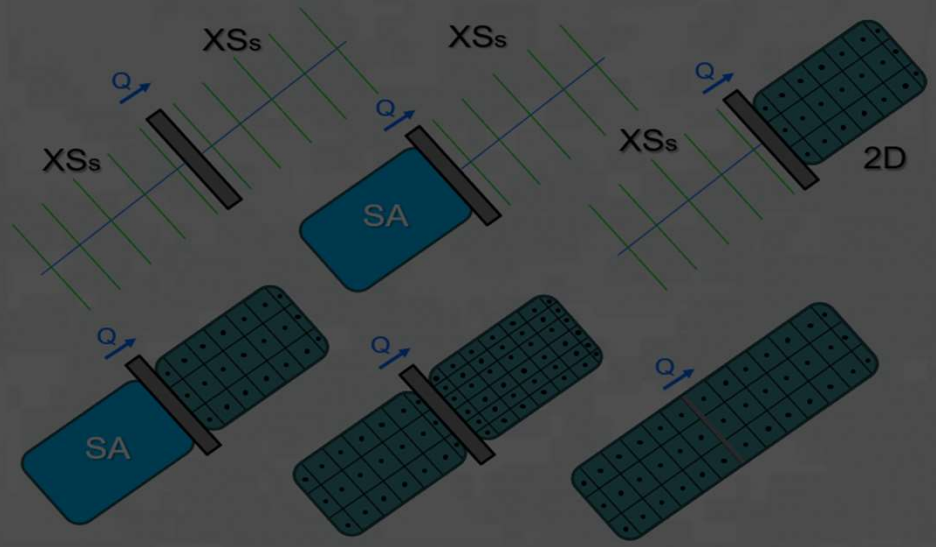
2. Breaching Options and Parameters



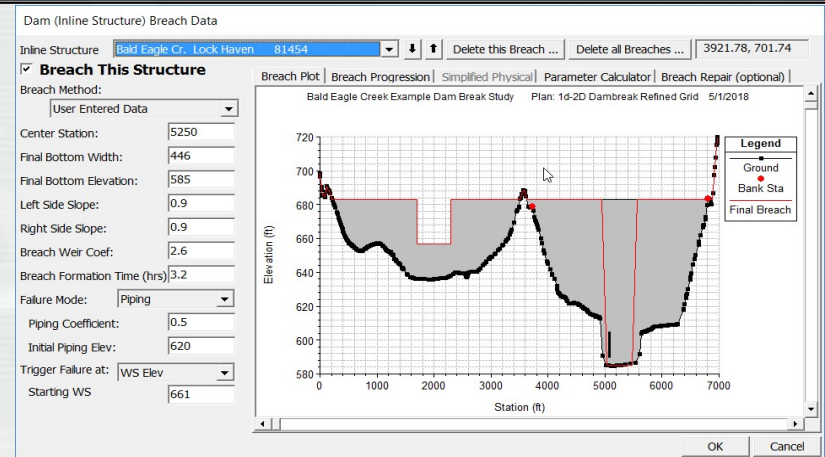
3. Breach Results and Visualization



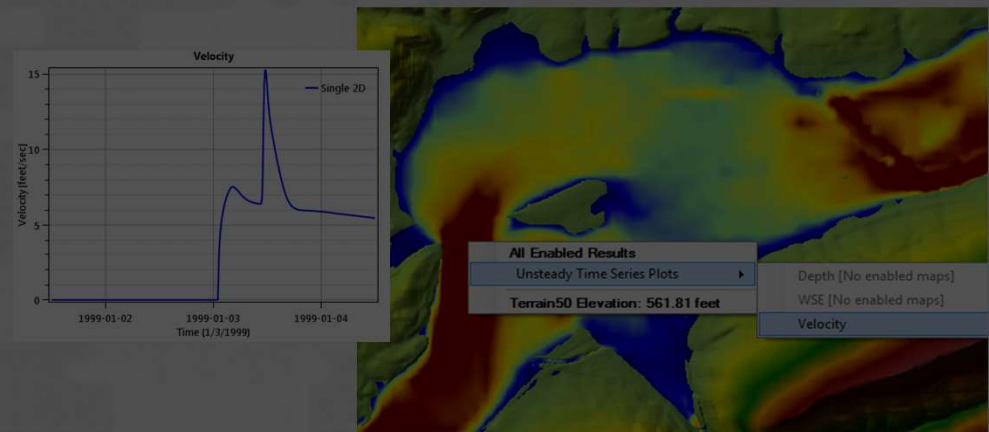
1. Six Dam Breach Model Configurations



2. Breaching Options and Parameters



3. Breach Results and Visualization



Dam Break Analysis in HEC-RAS

- Failure Modes
 - Overtopping and Piping

- Failure Initiation based on:
 - stage
 - simulation time
 - stage + duration, and immediate initiation stage.

- Breach progression
 - linear or nonlinear (user specified)
 - Simplified Physical Breaching Option
 - DL Breach



Modeling the Dam with a SA/2D Area Hydraulic Connection

Connection Data Editor - SA to 2D Flow Area - Detailed

File View Help

Connection: **Dam** [Apply Data]

Description: [Breach (plan data) ...]

Connections

From: Storage area: Reservoir Pool [Set SA/2D ...]

To: 2D flow area: BaldEagleCr [Set SA/2D ...]

Weir Length: 7423.00

Centerline Length: 7423.02

[Centerline GIS Coords...]

Structure Type: Weir, Gates, Culverts, Outlet RC and Outlet TS [Terrain Profile ...]

Flap Gates: No Flap Gates

Dam

Elevation (ft)

Station (ft)

Legend

- Spillway
- TW Cell Min Elev
- Centerline Terrain

27

Select connection to Edit



Inline Structure Dam Break Control

Inline Structure Data - 1D-2D Dam Break Model Refin...

File View Options Help

River: **Bald Eagle Cr.** Apply Data

Reach: Lock Haven River Sta.: 81454 Joseph Sayers Da

Upstream XS: 81914 Upstream channel length: 998.163 (ft)

Description: Foster Joseph Sayers Dam and Reservoir

Pilot Flow: 0 **Breach (plan data) ...** Rules (unsteady data) ...

All Culverts: No Flap Gates

Bald Eagle Creek Example Dam Break Study Plan: 1d-2D Dambreak Refined Grid 5/1/2018

Select the river for inline structure editing

Unsteady Flow Analysis

File Options Help

- Stage and Flow Output Locations ...
- Flow Distribution Locations ...
- Flow Roughness Factors ...
- Seasonal Roughness Factors ...
- Automated Roughness Calibration ...
- Dam (Inline Structure) Breach ...**
- Levee (Lateral Structure) Breach ...
- SA Connection Breach ...
- Calculation Options and Tolerances ...
- Output Options ...
- Friction Slope Method for Cross Sections ...
- Friction Slope Method for Bridges ...
- Initial Backwater Flow Optimizations ...
- Sediment Computation Options and Tolerances ...
- Sediment Output Options ...
- Sediment Dredging Options ...
- Check Data Before Execution
- View Computation Log File ...
- View Runtime Messages ...

1D-2D Refined Grid

1200

1200

Interval: 5 Minute

Interval: 1 Hour

sets\2D Unsteady



Dam Breach Data

Dam (Inline Structure) Breach Data

Inline Structure **Bald Eagle Cr. Lock Haven 81454** 3921.78, 701.74

Breach This Structure

Breach Method:

User Entered Data

Center Station: 5250

Final Bottom Width: 446

Final Bottom Elevation: 585

Left Side Slope: 0.9

Right Side Slope: 0.9

Breach Weir Coef: 2.6

Breach Formation Time (hrs) 3.2

Failure Mode: Piping

Piping Coefficient: 0.5

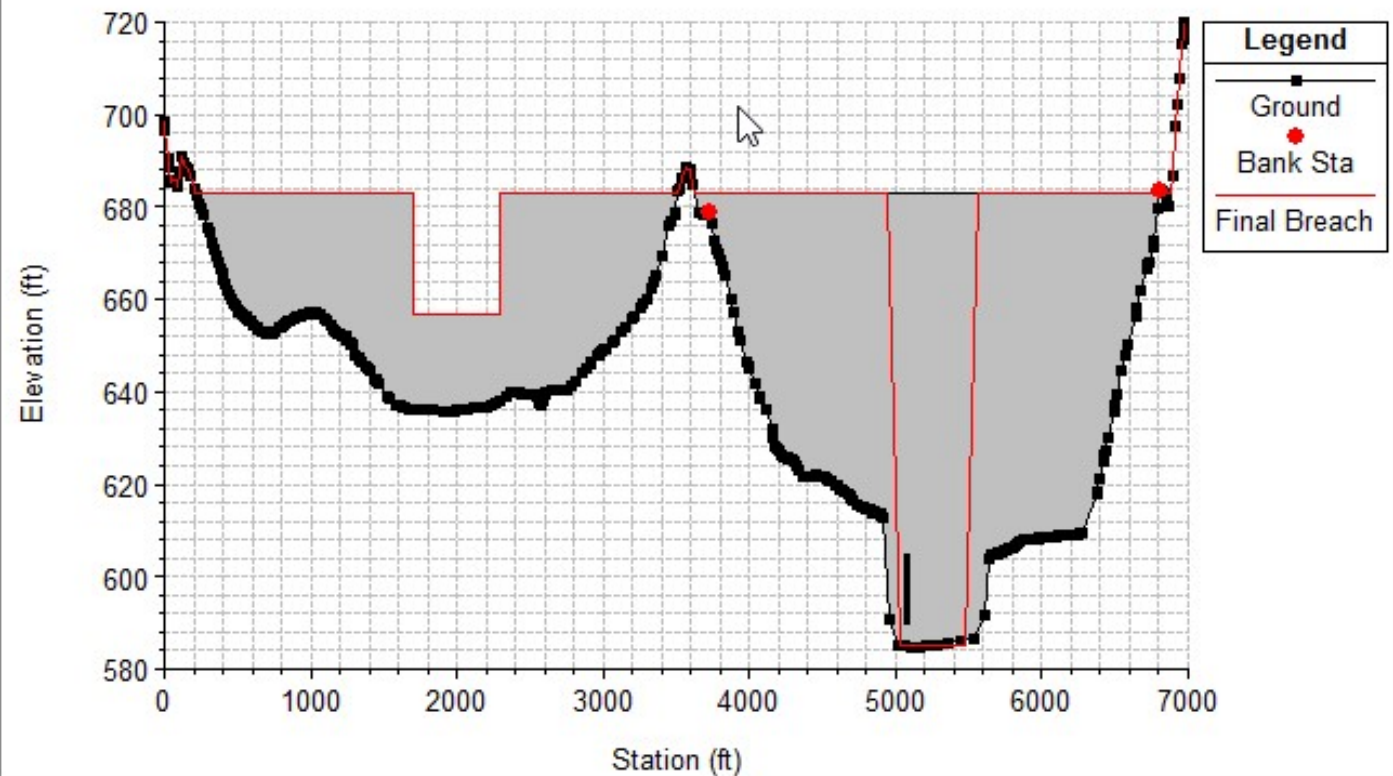
Initial Piping Elev: 620

Trigger Failure at: WS Elev

Starting WS 661

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

Bald Eagle Creek Example Dam Break Study Plan: 1d-2D Dambreak Refined Grid 5/1/2018



OK

Cancel

Non-Linear Breach Growth

Dam (Inline Structure) Breach Data

Inline Structure: Bald Eagle Cr. Lock Haven 81454

Delete this Breach ...

Delete all Breaches ...

Breach This Structure

Breach Method:

User Entered Data

Center Station: 5250

Final Bottom Width: 446

Final Bottom Elevation: 585

Left Side Slope: 0.9

Right Side Slope: 0.9

Breach Weir Coef: 2.6

Breach Formation Time (hrs): 3.2

Failure Mode: Piping

Piping Coefficient: 0.5

Initial Piping Elev: 620

Trigger Failure at: WS Elev

Starting WS: 661

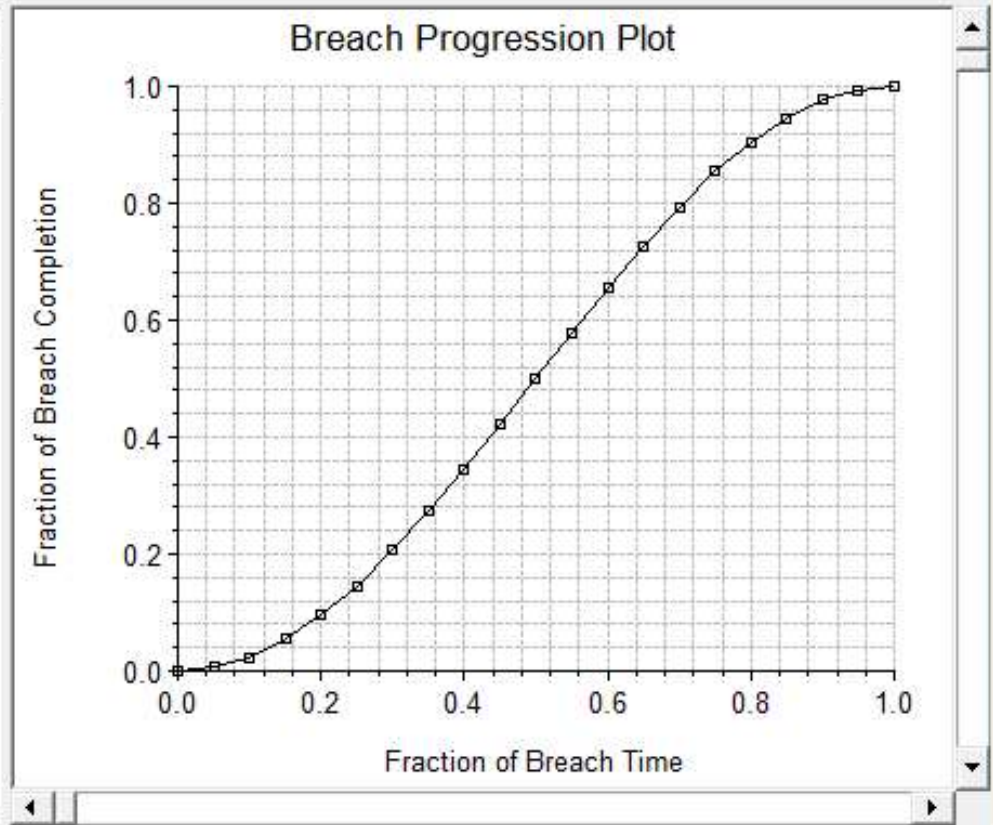
Breach Plot | Breach Progression | Simplified Physical | Parameter Calculator | Breach Repair (optional)

Set to Linear ... | Sine Wave ...

Use equal vertical and horizontal growth rate

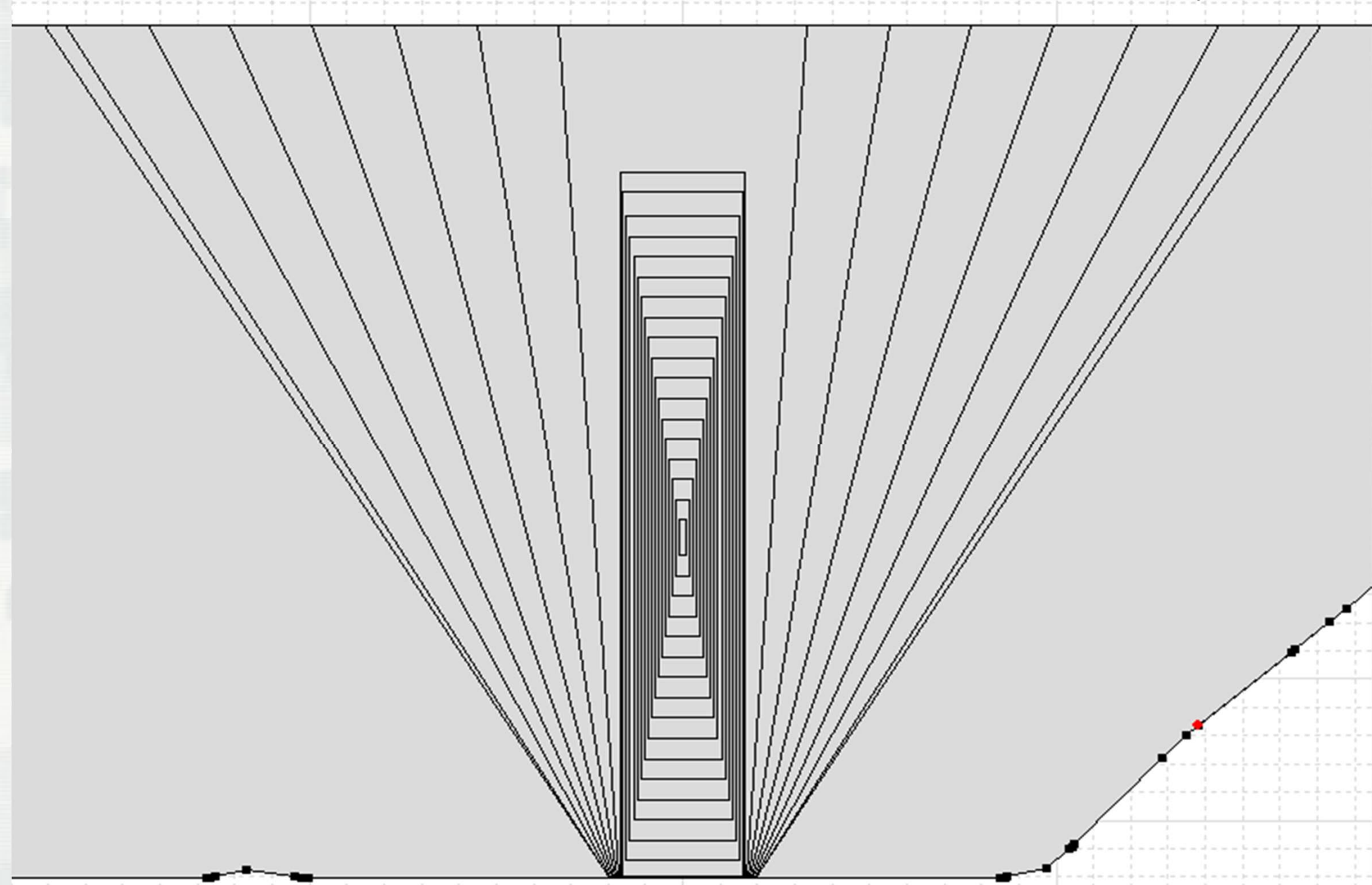
User specified vertical/horizontal growth ratio: 1

	Time	Breach
	Fraction	Fraction
1	0	0
2	0.05	0.006
3	0.1	0.024
4	0.15	0.054
5	0.2	0.095
6	0.25	0.146
7	0.3	0.206
8	0.35	0.273
9	0.4	0.345
10	0.45	0.422
11	0.5	0.5
12	0.55	0.578
13	0.6	0.655
14	0.65	0.727
15	0.7	0.794
16	0.75	0.854
17	0.8	0.905



OK Cancel

Piping Failure Breach Growth Geometry



Breach Repair Option

Dam (Inline Structure) Breach Data

Inline Structure Bald Eagle Cr. Lock Haven 81454

Delete this Breach ...

Delete all Breaches ...

Breach This Structure

Breach Method:

User Entered Data

Center Station: 5250

Final Bottom Width: 446

Final Bottom Elevation: 585

Left Side Slope: 0.9

Right Side Slope: 0.9

Breach Weir Coef: 2.6

Breach Formation Time (hrs) 3.2

Failure Mode: Piping

Piping Coefficient: 0.5

Initial Piping Elev: 620

Trigger Failure at: WS Elev

Starting WS 661

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

Number of hours after full breach to start repair:

Total repair time (hours):

Final filled in elevation:

OK

Cancel

Breach Regression Equation Calculator

Dam (Inline Structure) Breach Data

Inline Structure

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:

Starting WS

Input Data

Top of Dam Elevation (ft): Breach Bottom Elevation (ft):

Pool Elevation at Failure (ft): Pool Volume at Failure (acre-ft):

Failure mode:

MacDonald

Dam Crest Width (ft): Slope of US Dam Face Z1 (H:V):

Earth Fill Type: Slope of DS Dam Face Z2 (H:V):

Xu Zhang (and Von Thun)

Dam Type: Dam Erodibility:

Method	Breach Bottom Width (ft)	Side Slopes (H:V)	Breach Development Time (hrs)	
MacDonald et al	743	0.5	2.51	<input type="button" value="Select"/>
Froehlich (1995)	447	0.9	3.23	<input type="button" value="Select"/>
Froehlich (2008)	413	0.7	2.85	<input type="button" value="Select"/>
Von Thun & Gillete	361	0.5	0.81	<input type="button" value="Select"/>
Xu & Zhang	297	0.62	4.88 *	<input type="button" value="Select"/>

Simplified Physical Breaching

Levee (Lateral Structure) Breach Data

Lateral: Bald Eagle Cr. Lock Haven 23100

Breach This Structure

Breach Method: **Simplified Physical**

Center Station: 1000

Max Possible Bottom Width: 1000

Min Possible Bottom Elev: 566

Left Side Slope: 0.1

Right Side Slope: 0.1

Breach Weir Coef: 2.6

Breach Formation Time (hrs):

Failure Mode: **Overtopping**

Piping Coefficient: 0.5

Initial Piping Elev:

Mass Wasting Feature:

Trigger Failure at: **WS Elev+Duration**

Threshold WS: 577.6

Duration Above Threshold: 1

Immediate Initiation WS: 580.6

Accumulate Duration

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

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

OK Cancel

Performing the Computations

Unsteady Flow Analysis

File Options Help

Plan : Single 2D Area - Internal Dam Structure Short ID: Single 2D

Geometry File : Single 2D Area - Internal Dam Structure

Unsteady Flow File : Single 2D Area

Programs to Run

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

Plan Description

In this example a single 2D flow area is used to model the entire system, including the Dam. The computational mesh was modified in the area of the dam to align the cell faces along the top of the dam. A SA/2D Connection was added inside of the 2D flow area to represent the Dam, including the top of dam, overflow spillway, and low flow gates. This internal hydraulic structure will control flow from the cells upstream to the cells downstream.

Simulation Time Window

Starting Date: 01JAN1999 Starting Time: 1200

Ending Date: 04JAN1999 Ending Time: 1200

Computation Settings

Computation Interval: 30 Second Hydrograph Output Interval: 1 Minute

Mapping Output Interval: 10 Minute Detailed Output Interval: 1 Hour

DSS Output Filename: d:\HEC Data\HEC-RAS\Automated Test Datasets\2D Unsteady

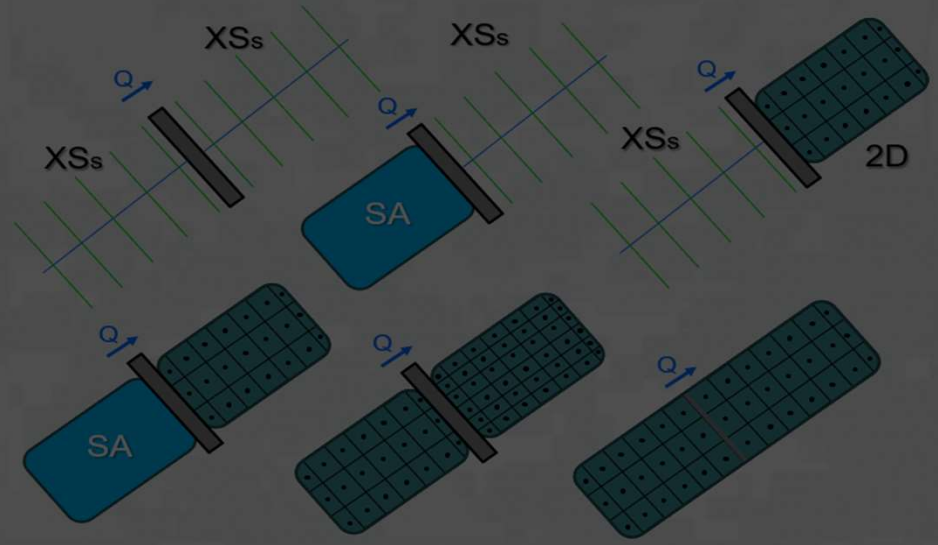
1 Storage Area Connection with breach data. 1 set to breach.

Compute

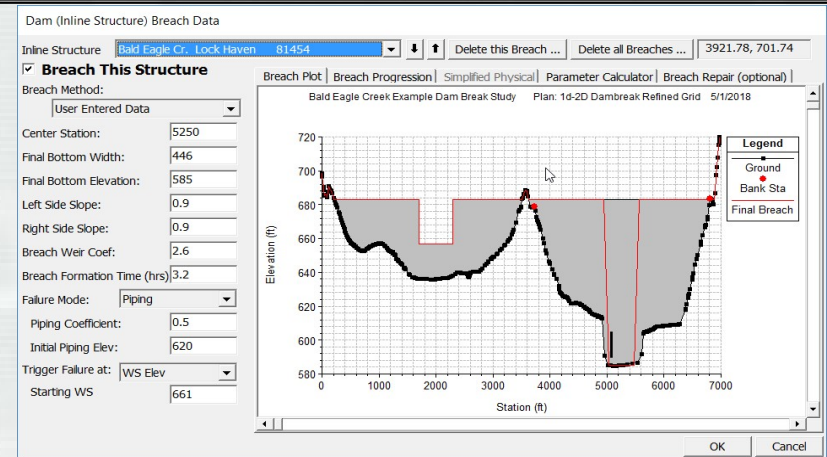
Important
Computational
Settings →



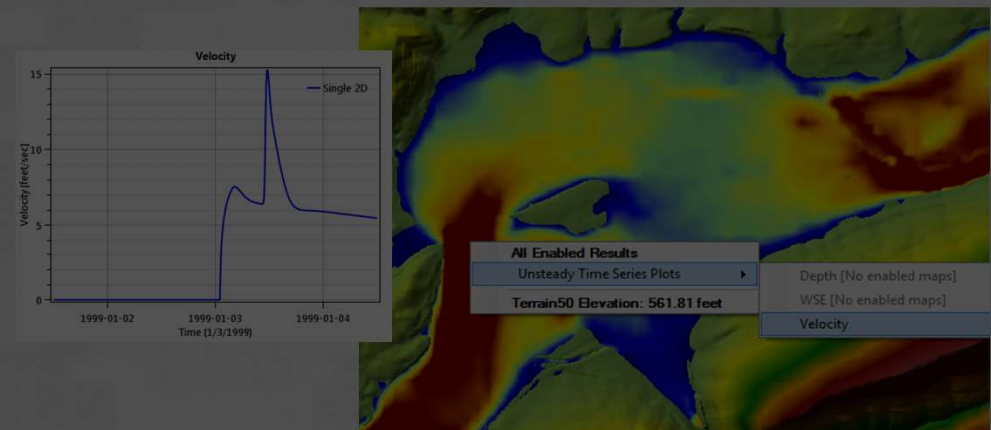
1. Six Dam Breach Model Configurations



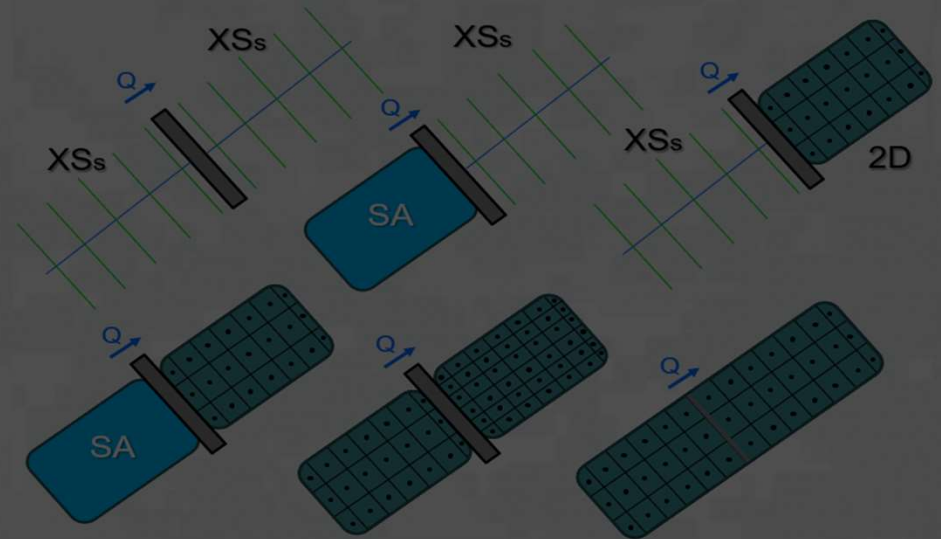
2. Breaching Options and Parameters



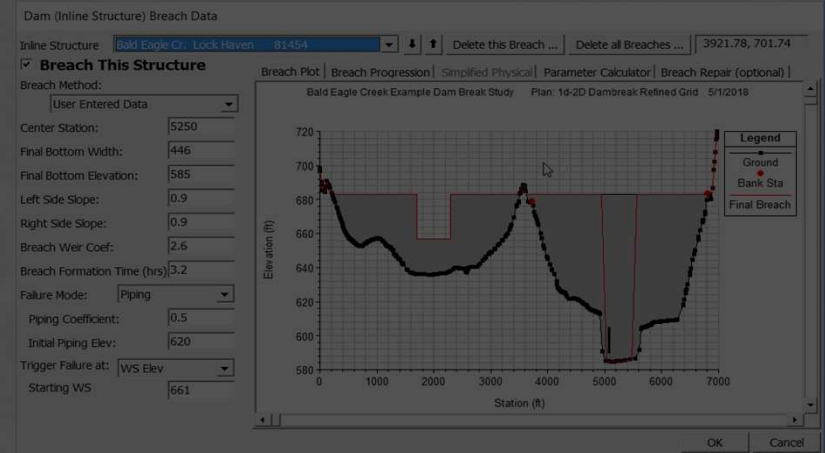
3. Breach Results and Visualization



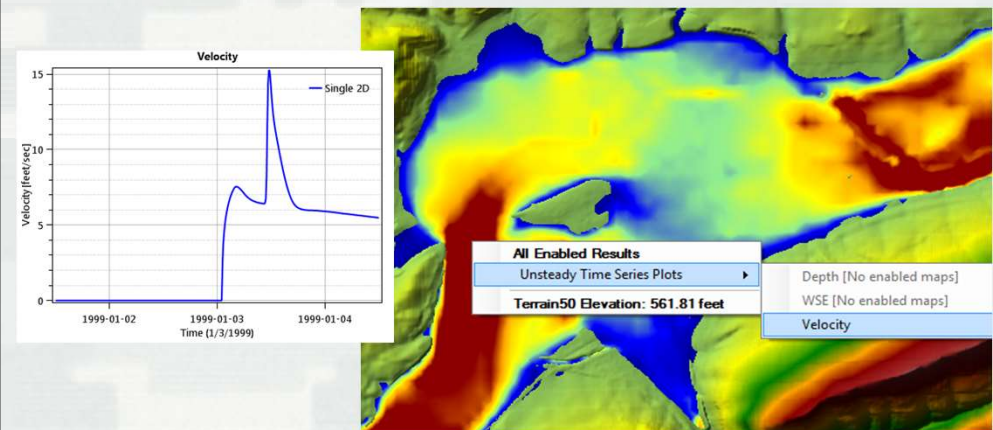
1. Six Dam Breach Model Configurations



2. Breaching Options and Parameters



3. Breach Results and Visualization

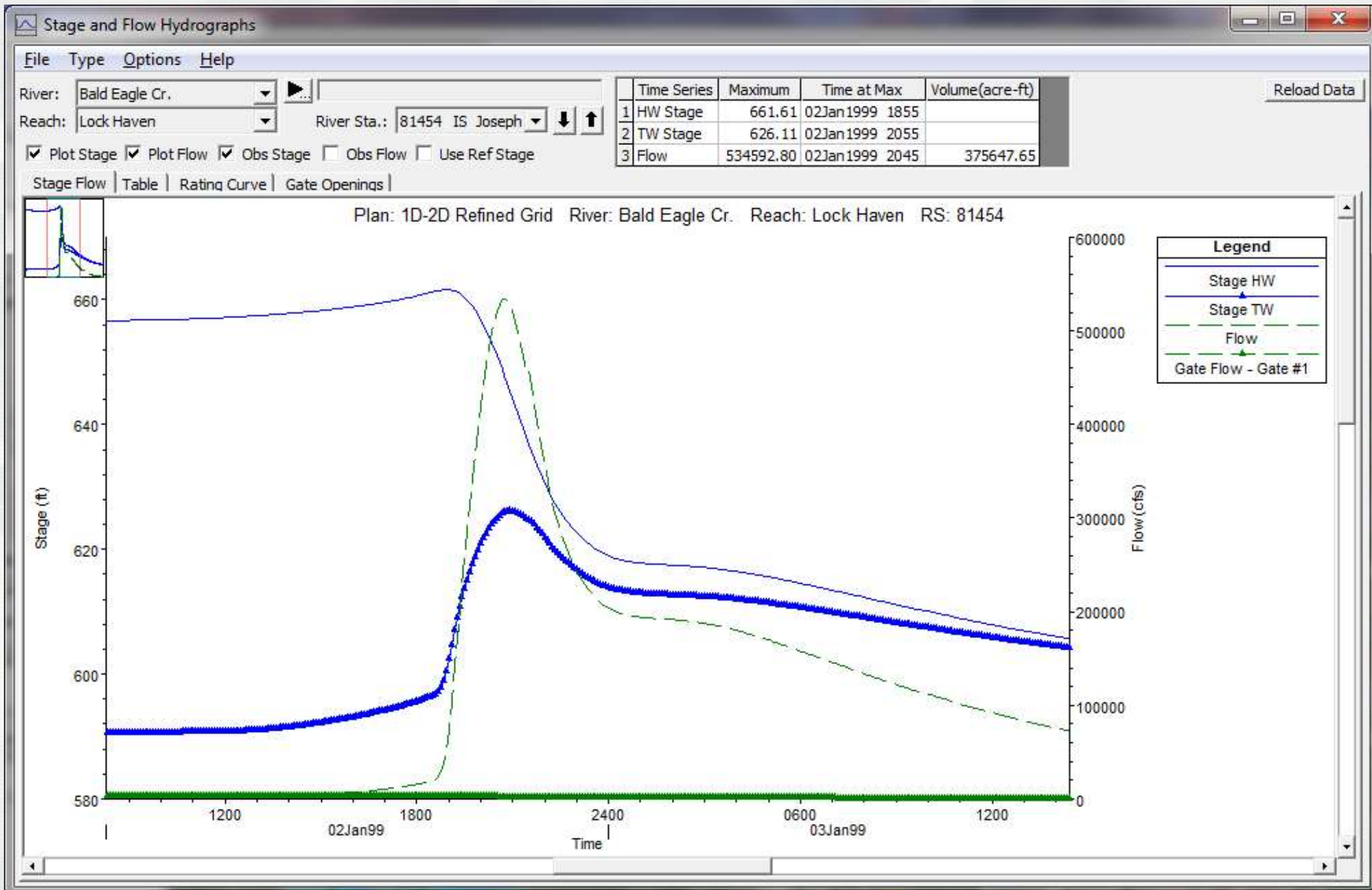


Breach Results and Visualization

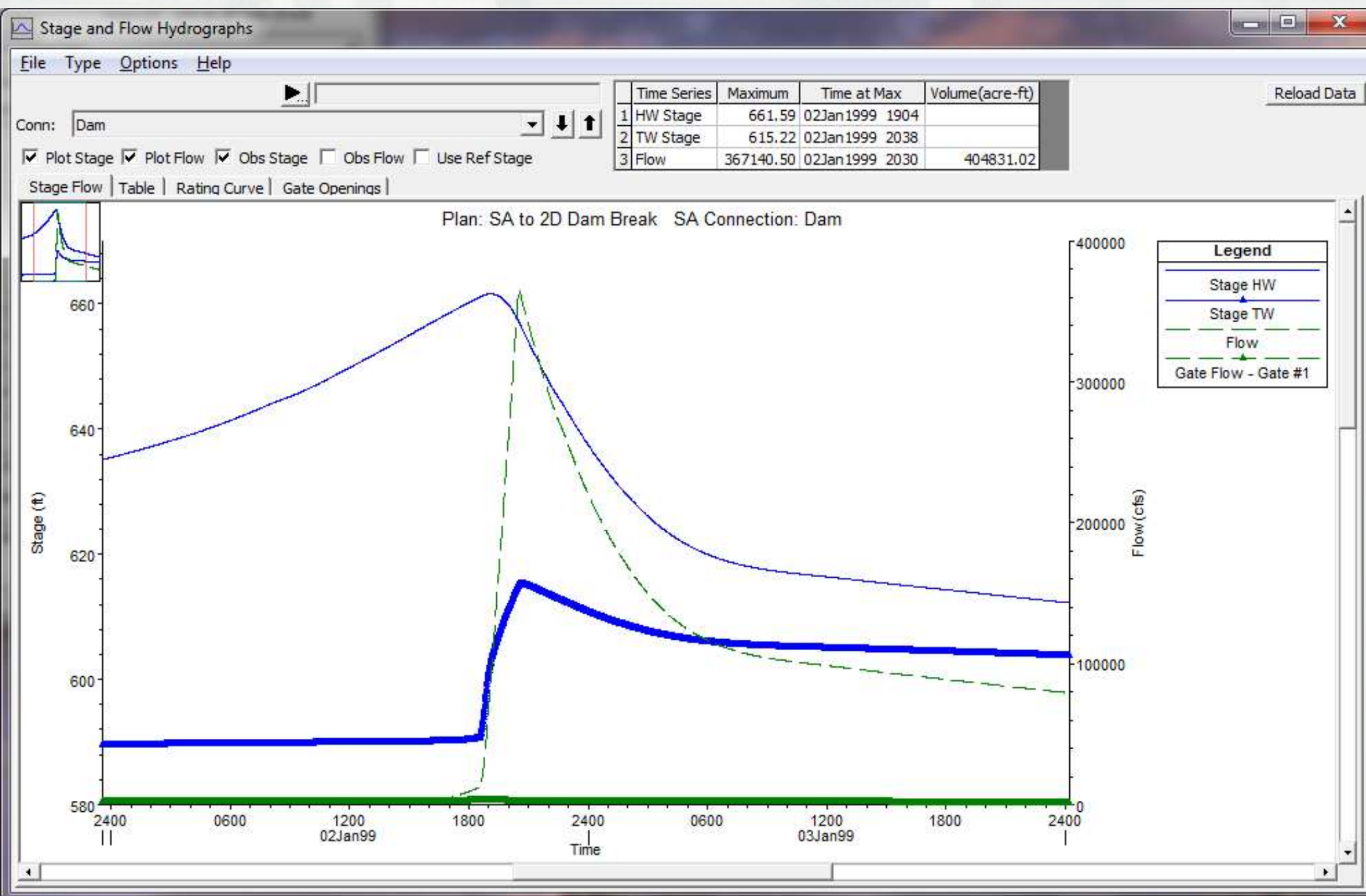
- Hydrographs at Inline Structures, SA/2D Hydraulic Connections, and Storage Areas
- Profile Plots for 1D Reaches
- Flow Hydrographs at 2D Area Boundaries
- Inundation Maps/Animations in RAS-Mapper
- Stage Hydrograph Plots in RAS-Mapper
- Velocity Time Series in RAS-Mapper



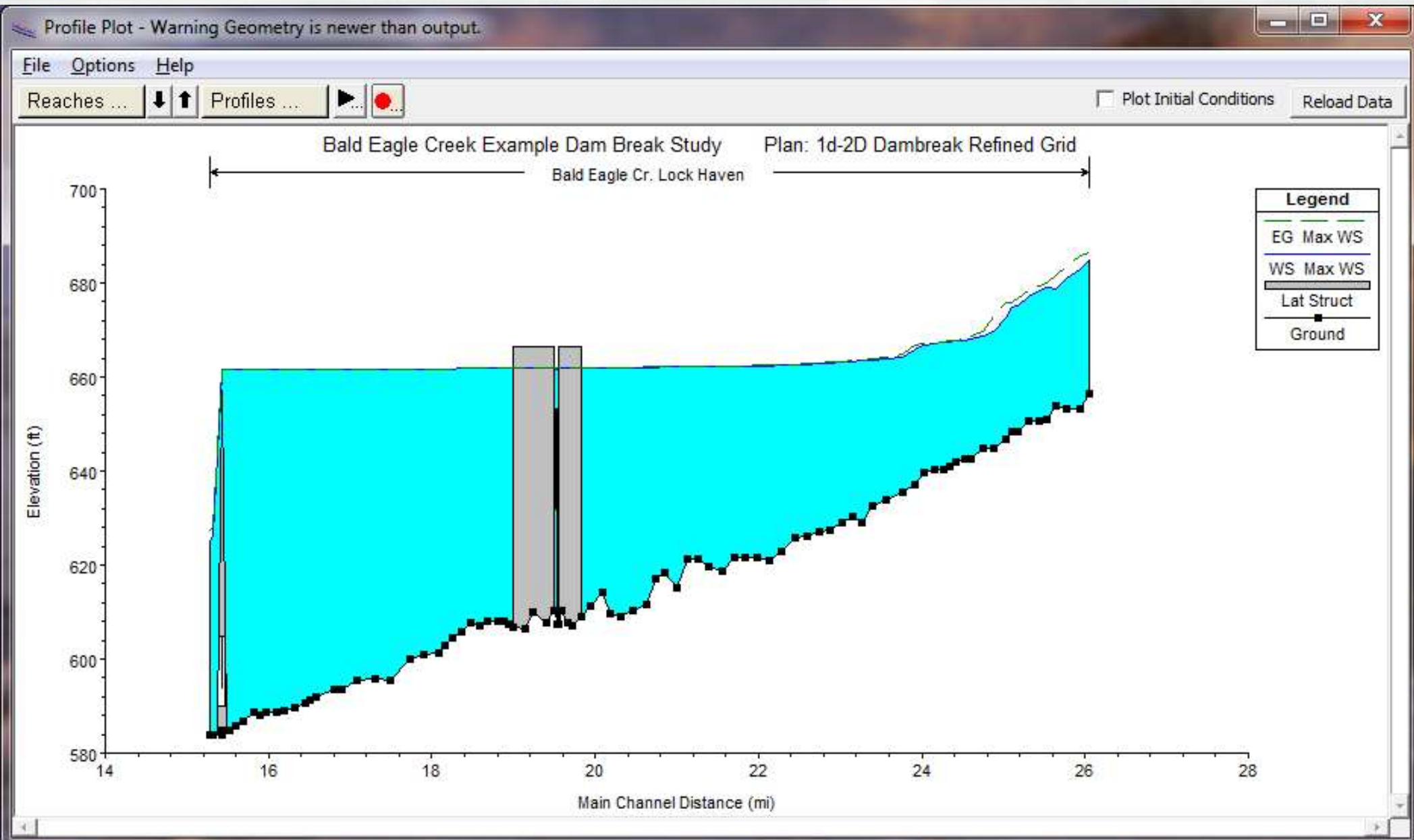
Inline Structure Hydrograph



SA/2D Conn Hydrograph



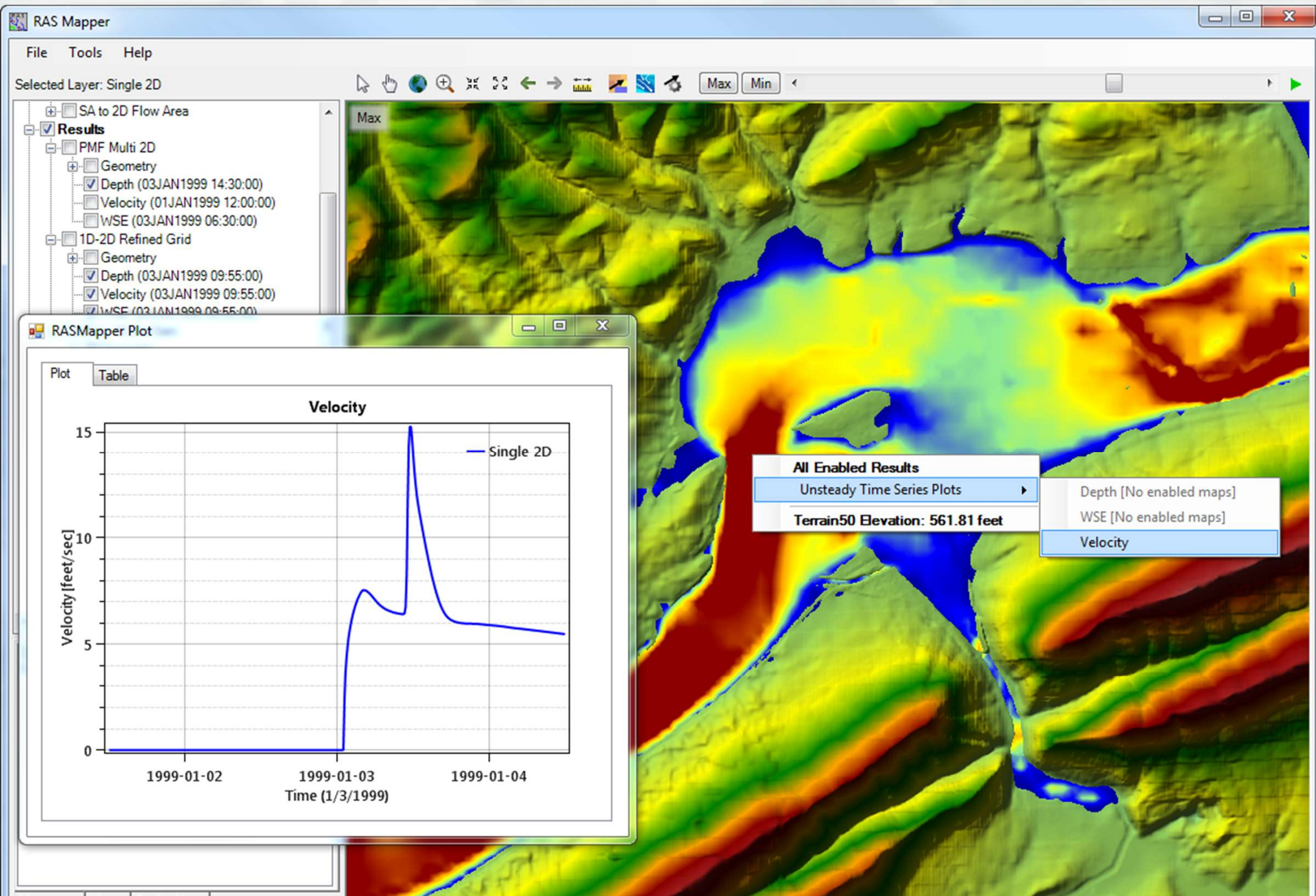
1D River Reach W.S Profile Plots



Stage Hydrographs – RAS-Mapper



Velocity Time Series – RAS-Mapper



Profile Lines – RAS-Mapper

