BUREAU OF RECLAMATION

FEMA

A three-tiered approach to assess erosion and deposition on and downstream from unlined spillways with mixed alluvial and bedrock cover

Aaron Hurst and Melissa Foster

Project Background (1)

Project Background (2)

- New Melones Dam is an earth and rock-filled embankment dam, completed in 1978.

- Second-tallest earth filled dam in the US and sixth tallest overall in the US.

Project Background (3)

- New Melones Dam is an earth and rock-filled embankment dam, completed in 1978.
- Second-tallest earth filled dam in the US and sixth tallest overall in the US.
- New Melones Dam has an unlined spillway that has never received flow.

Project Background (4)

- The spillway consists of blasted bedrock that outlets onto a soil-covered hillslope on the left valley wall of Bean Gulch.

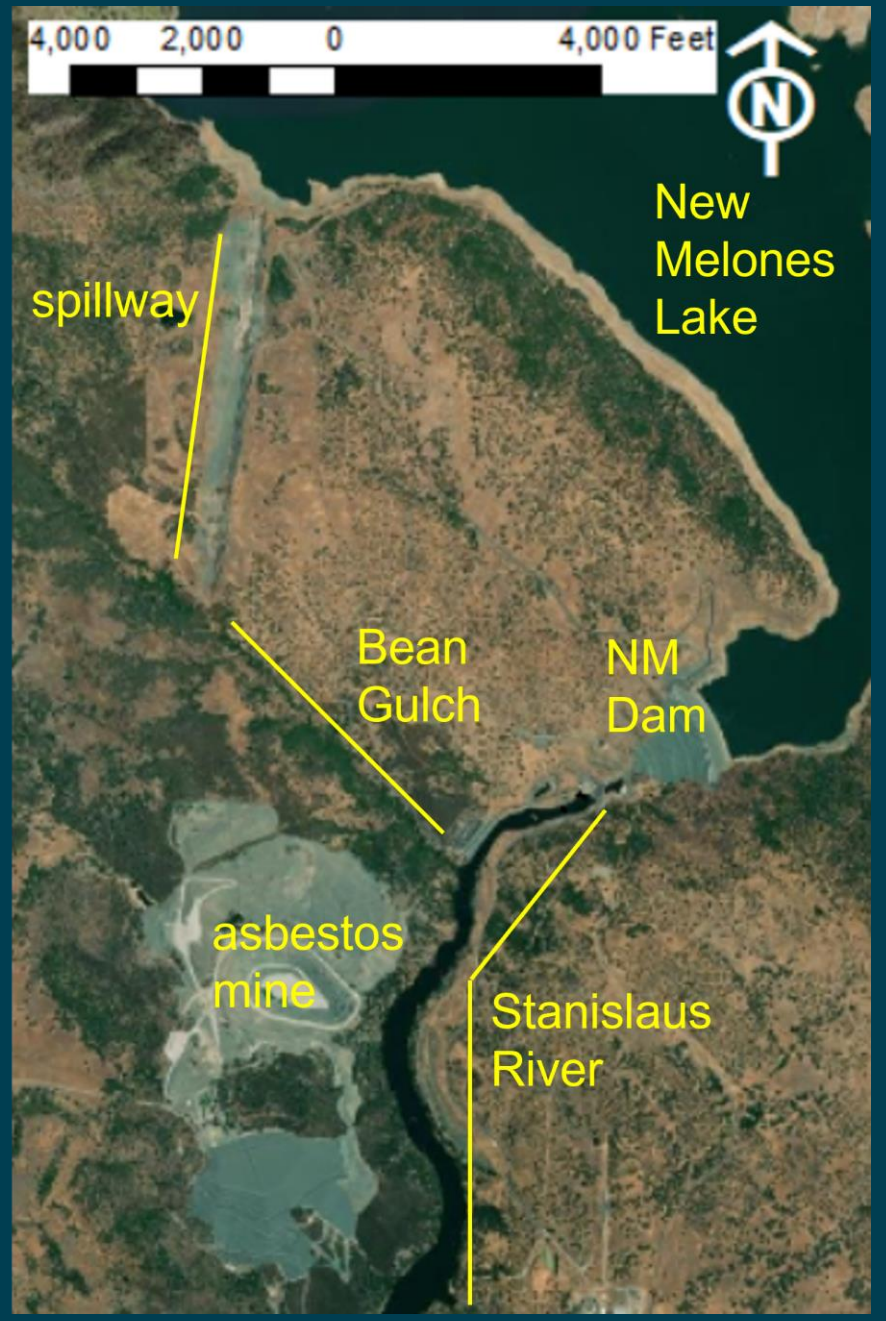
Project Background (5)

- Most of the spillway rock is competent meta-sedimentary and meta-volcanic rocks, but the lower end is underlain by erodible asbestos-laden serpentinite and meta-siltstone.

Project Objectives

We want to understand the magnitude of erosion due to sediment transport and rock erosion for a range of spillway flow events.

This is not a dam failure investigation.



Project Objectives (2)

1. Test the assumption that sediment cover on the spillway is removed, exposing bedrock. Identify areas of sediment deposition.
   - Will Tulloch Reservoir be impacted by sediment deposition?

2. Identify zones of potential bedrock erosion on the spillway for a range of flow events.

3. Constrain vertical incision and potential volume of erosion for a range of flow events.

Three-tiered study approach

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   _____ Sediment transport Model (SRH-2D)

2. Identify zones of potential bedrock erosion on the spillway for a range of flow events.

   _____ 2D erosion model

3. Constrain vertical incision and potential volume of erosion for a range of flow events.

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Three-tiered study approach (2)

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Sedimentation and River Hydraulics 2-Dimensional model (Lai, 2010)

SRH-2D is a hydraulic model that can simulate a mobile bed and sediment transport on a flexible model mesh (triangular and quadrilateral cells to best represent spatial zones).

Sedimentation and River Hydraulics 2-Dimensional model (Lai, 2010) (2)

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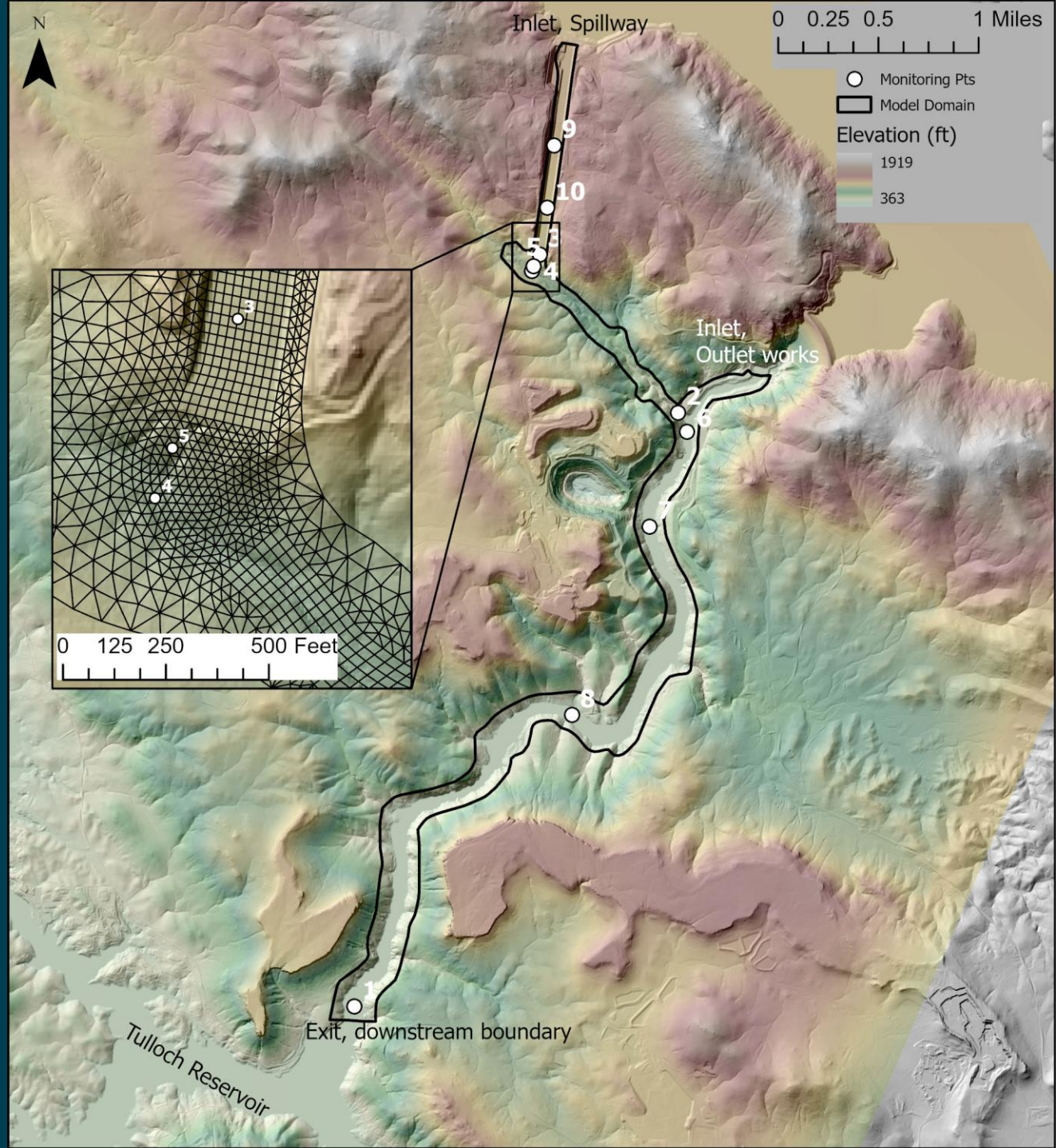


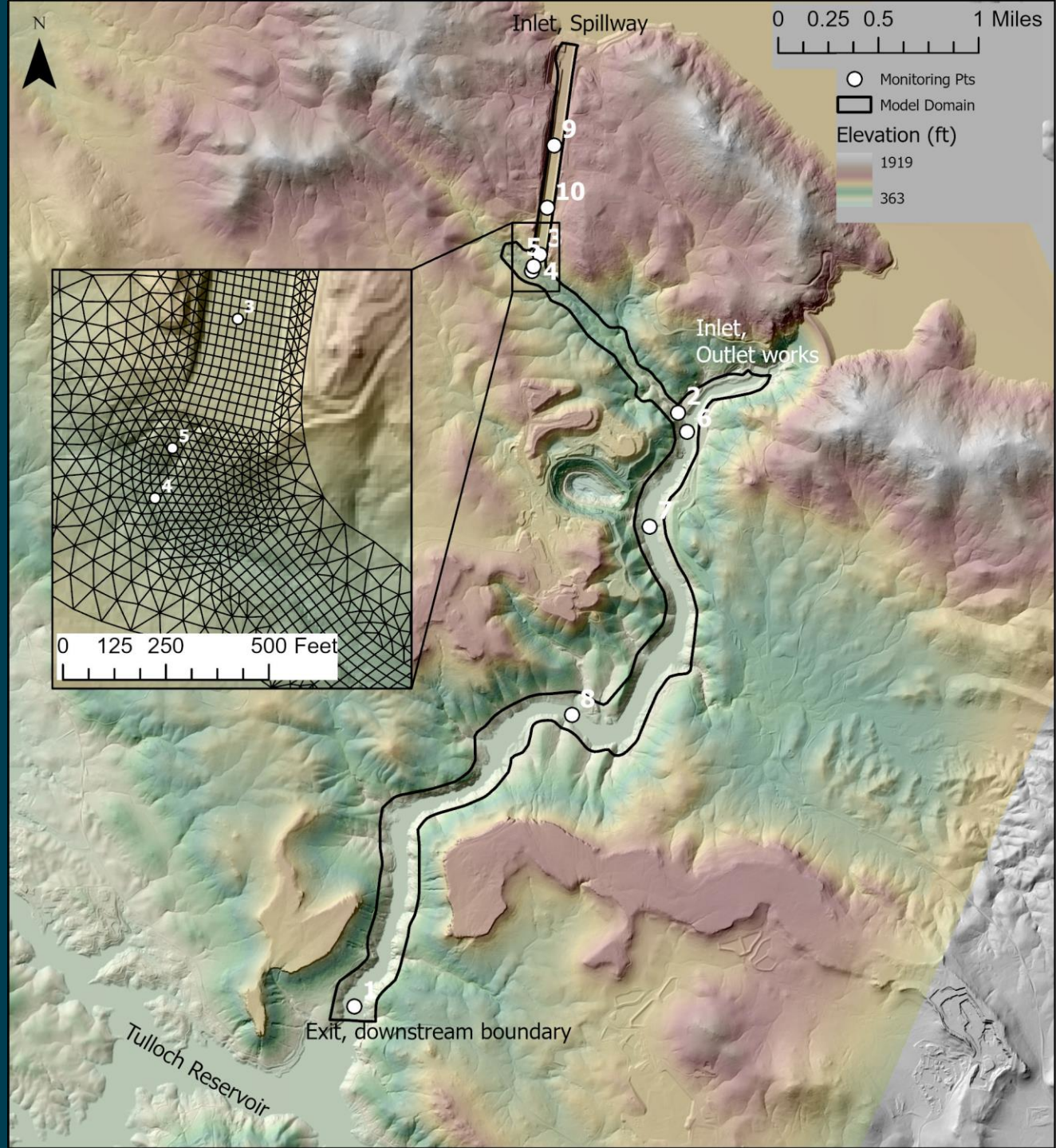
Sedimentation and River Hydraulics 2-Dimensional model (Lai, 2010) (3)

Solved parameters:

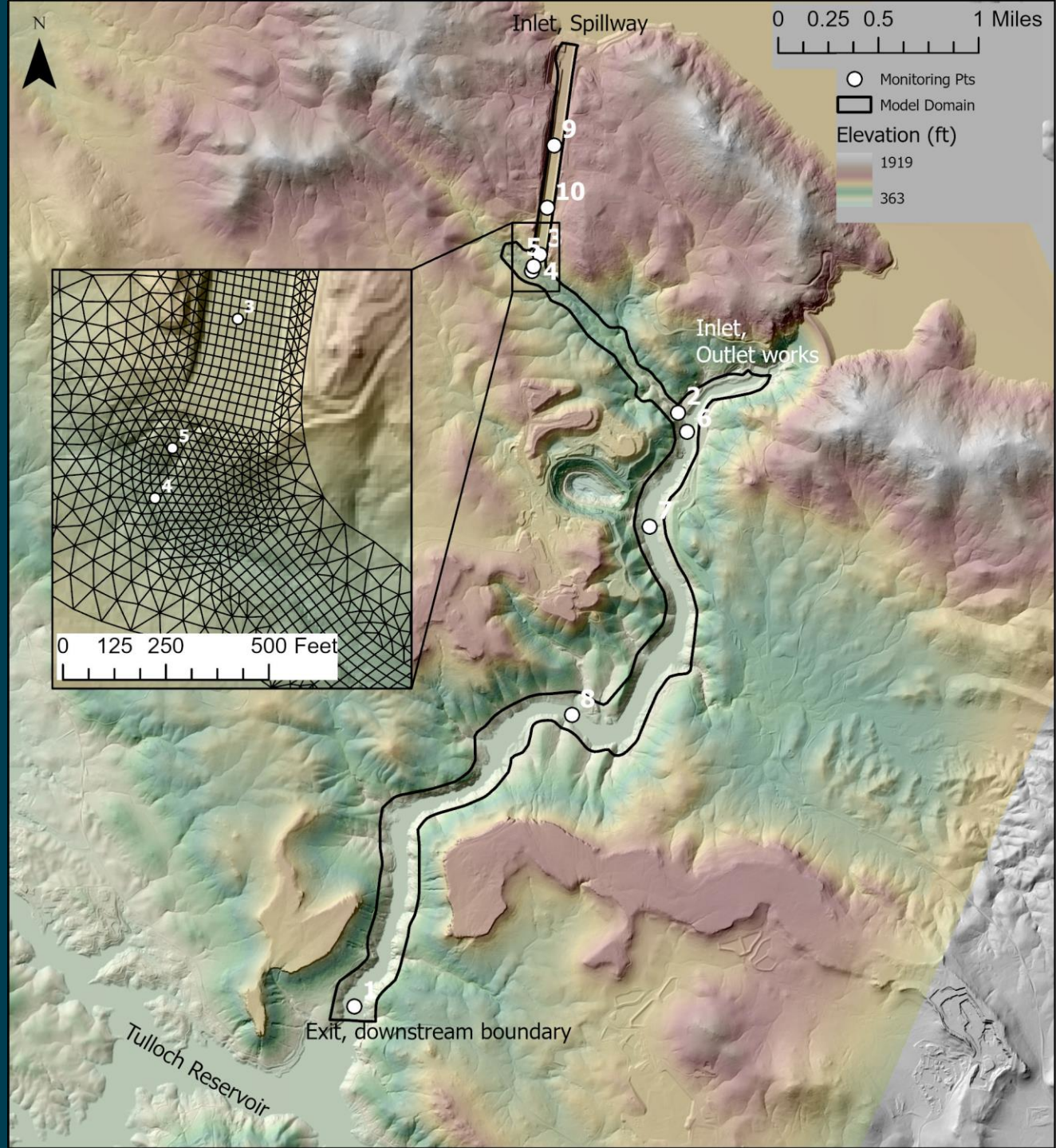
- Water surface elevation
- Depth
- Depth-averaged velocity
- Bed elevation

Additional output:

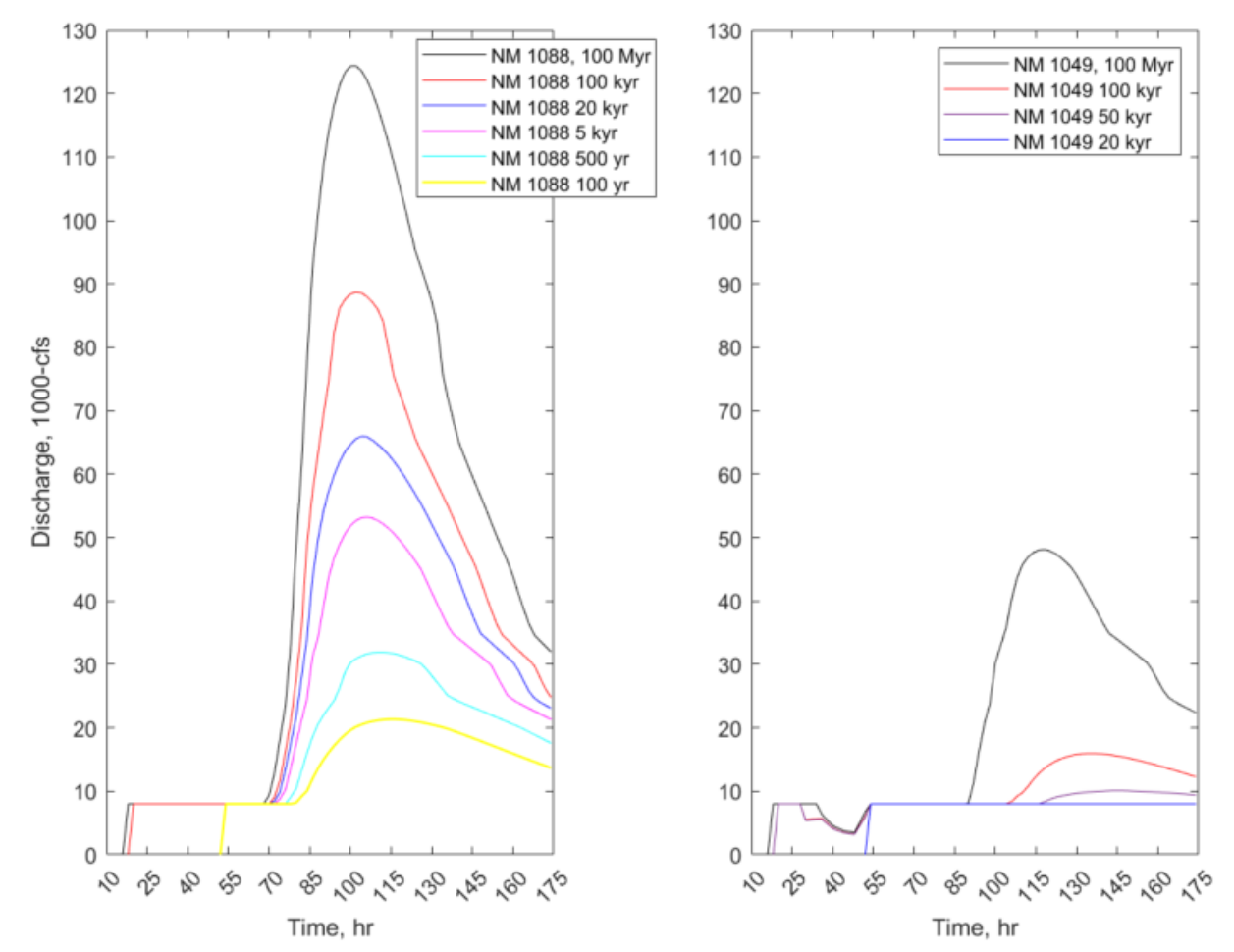
- Froude number
- Shear stress

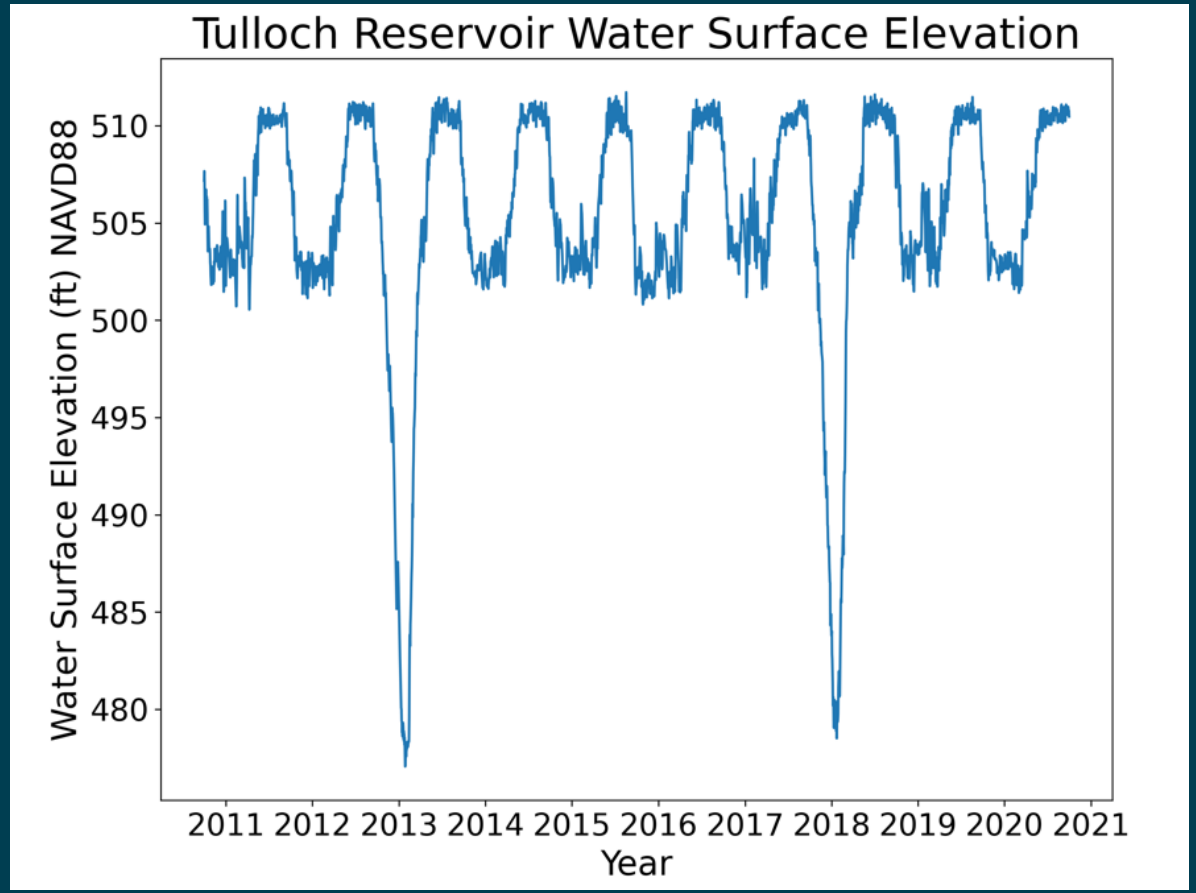


SRH-2D Input Data – Model Mesh

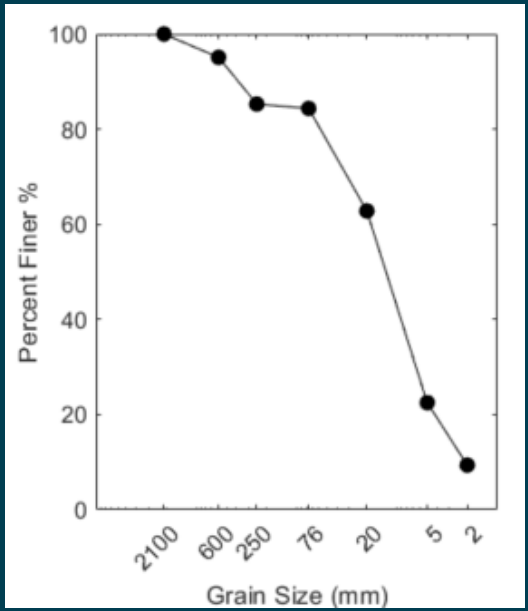


SRH-2D Input Data - Hydrographs

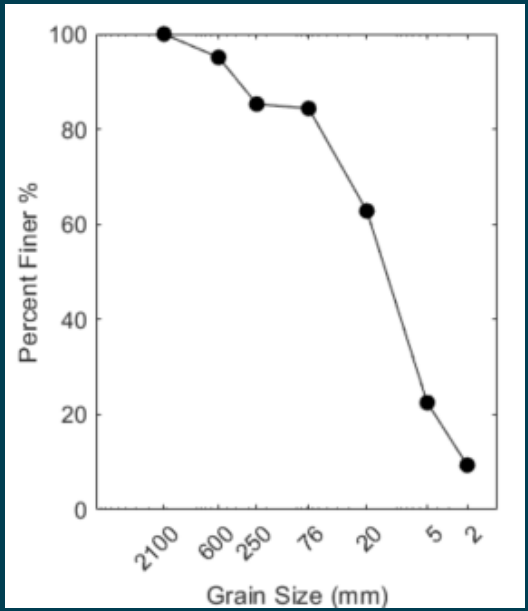


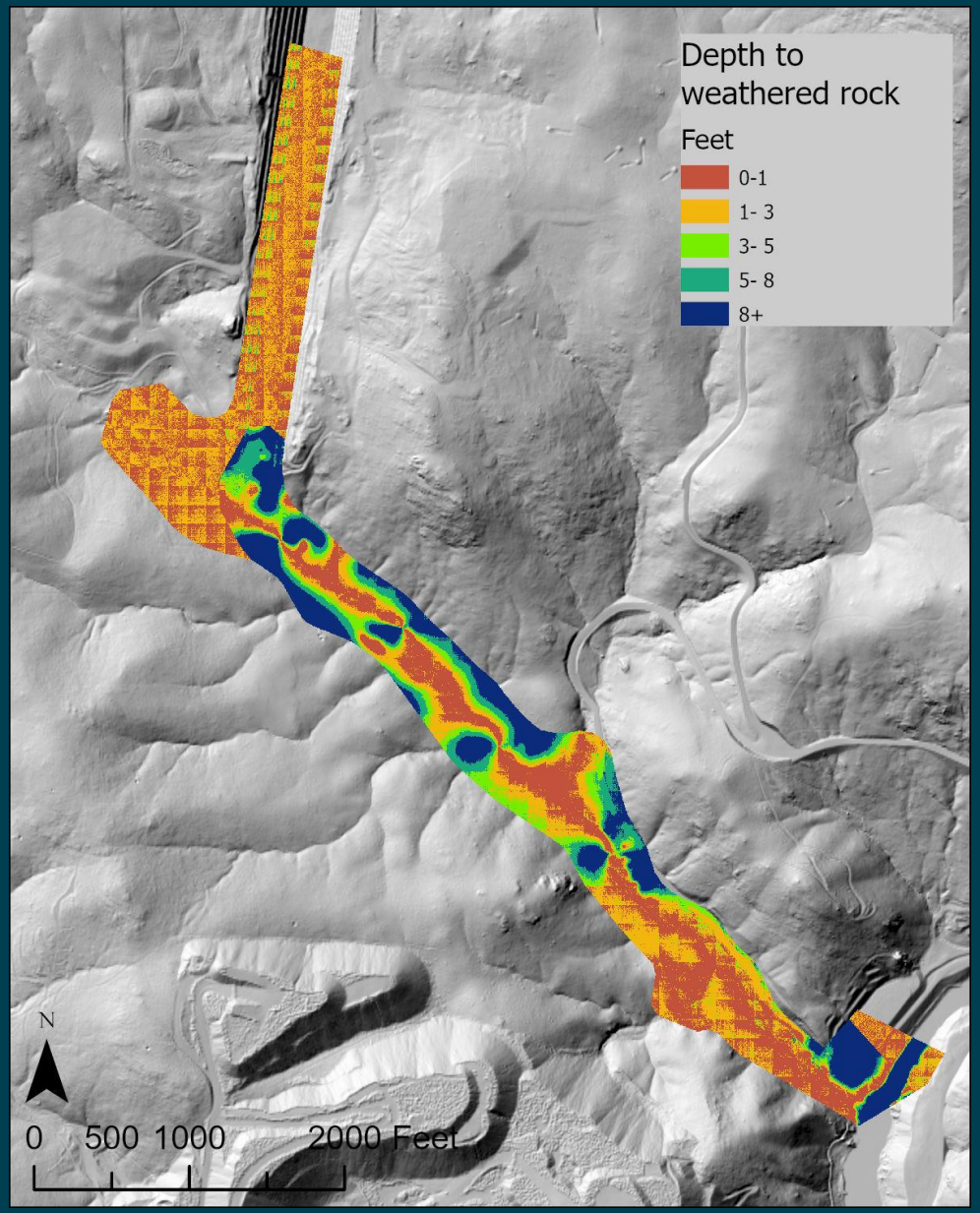


Sediment data

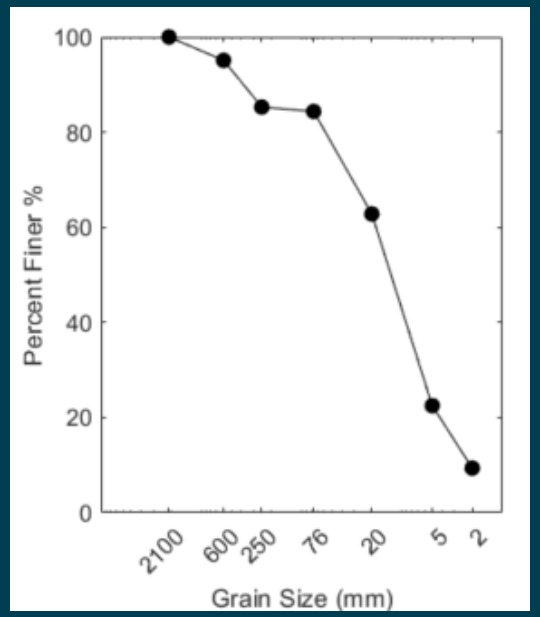


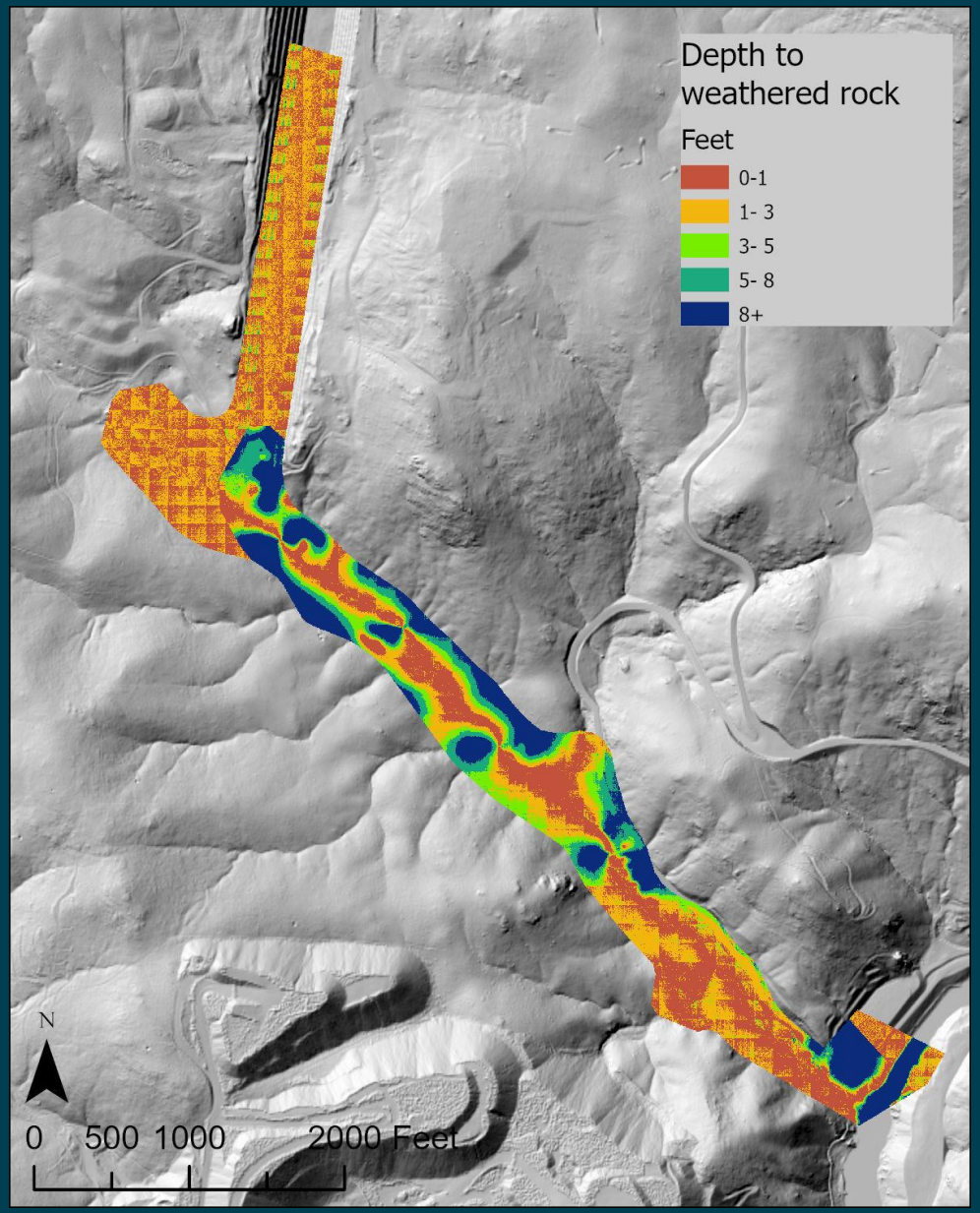
Sediment data (2)

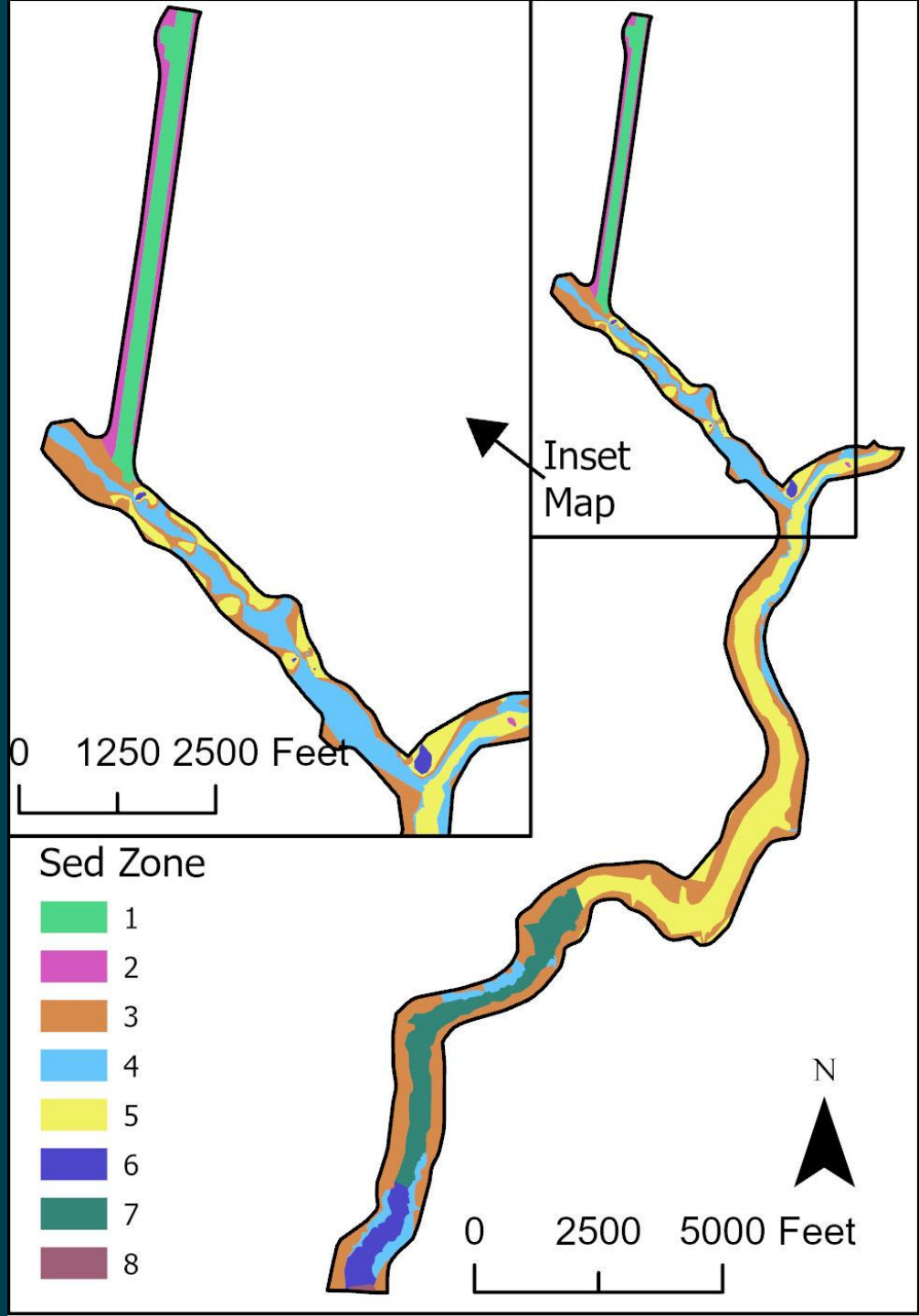




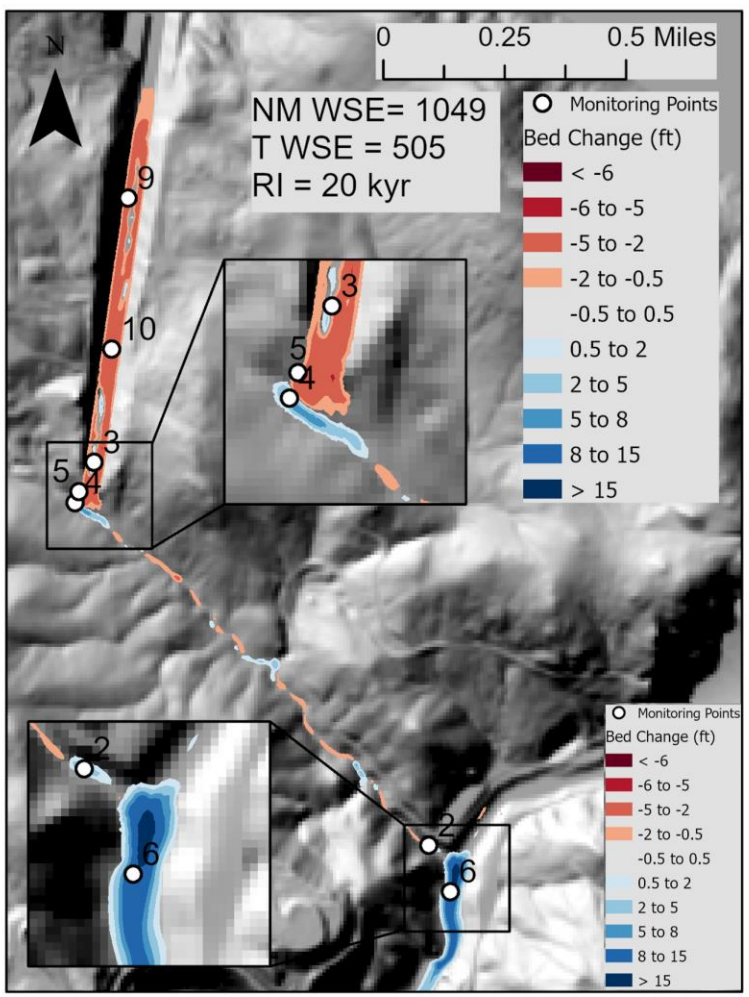
Sediment data (3)

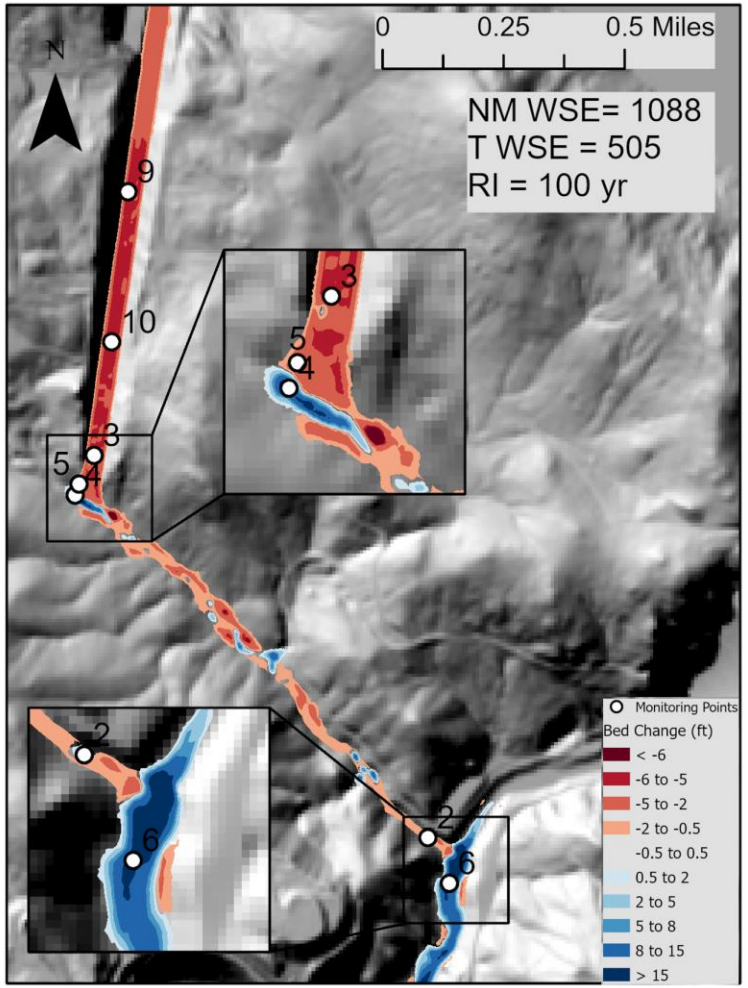


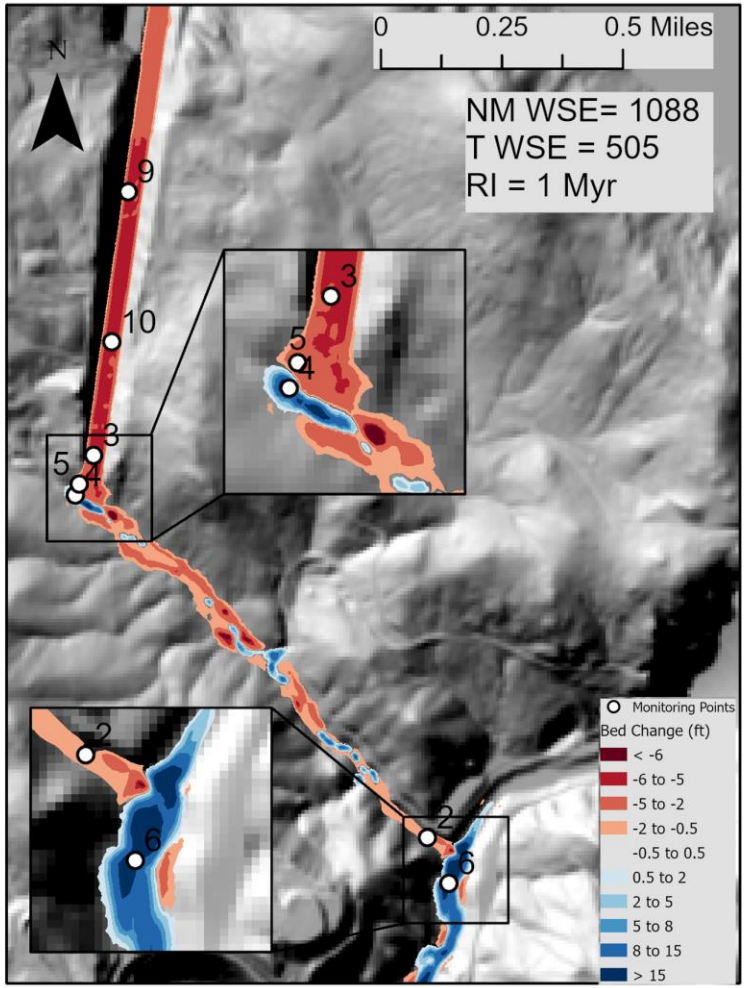




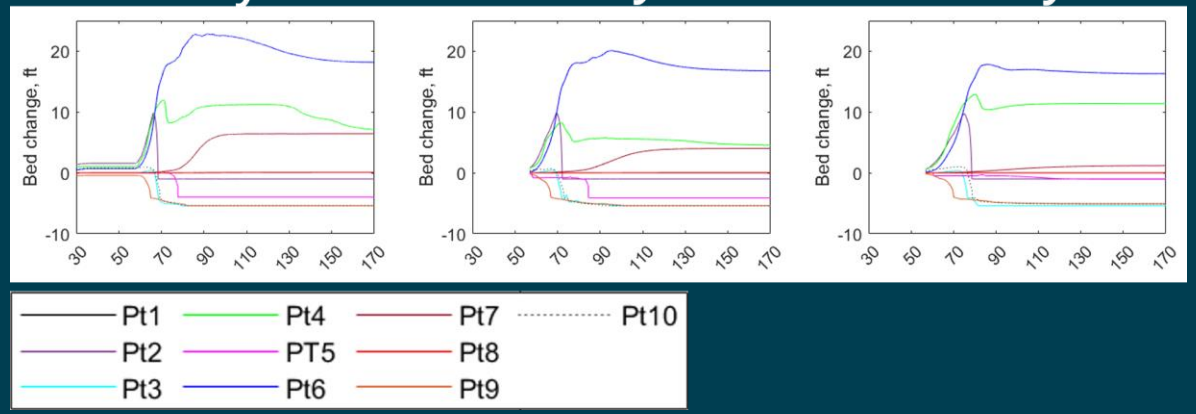
SRH-2D model results



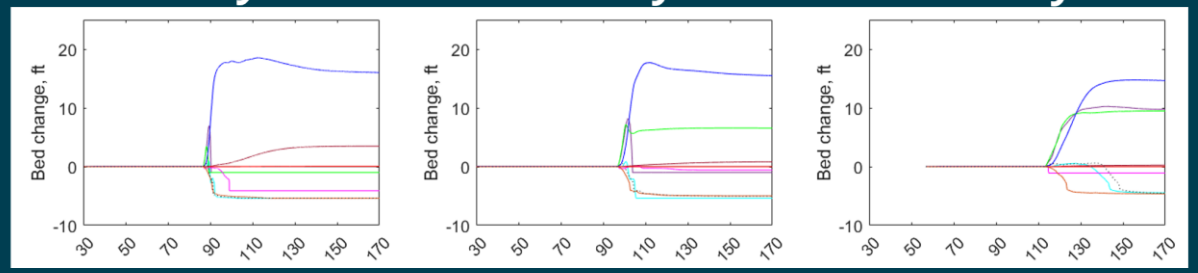




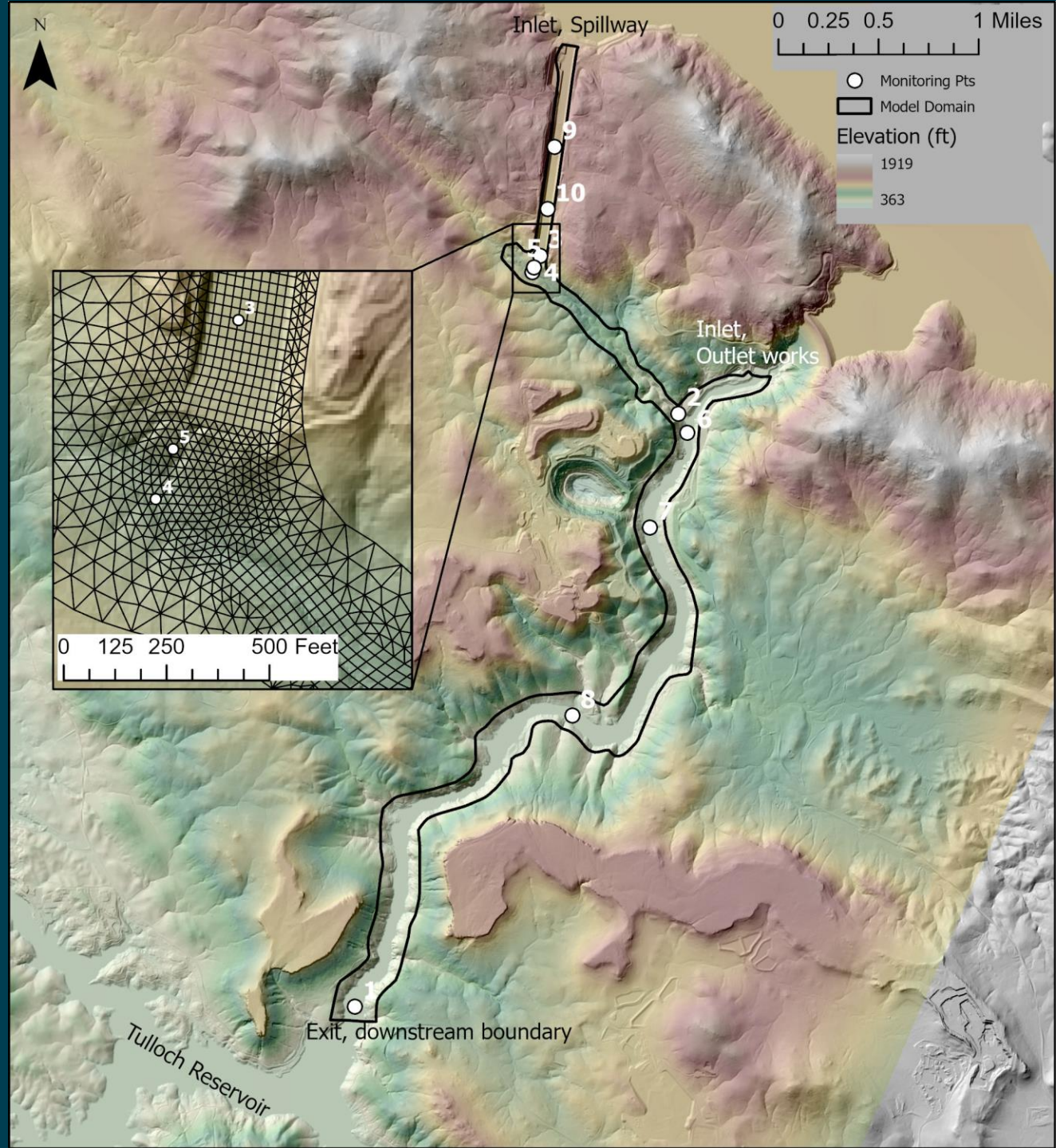
1088 New Melones Starting Elevation



1049 New Melones Starting Elevation



- In the majority of model scenarios, all or most of the sediment is eroded from the spillway.
- Deposition at Tulloch Reservoir is negligible (<0.2 ft). Most of the sediment is deposited just below the confluence between Bean Gulch and Tulloch Reservoir.



Three-tiered study approach (3)

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2D Annandale Erodibility Index model (Annandale, 1995)

- Determine the erodibility of rock using properties of the rock and the flow and relationship derived by Annandale
- Create a map of the probability of erosion for different flows

2D Annandale Erodibility Index model (Annandale, 1995) (2)

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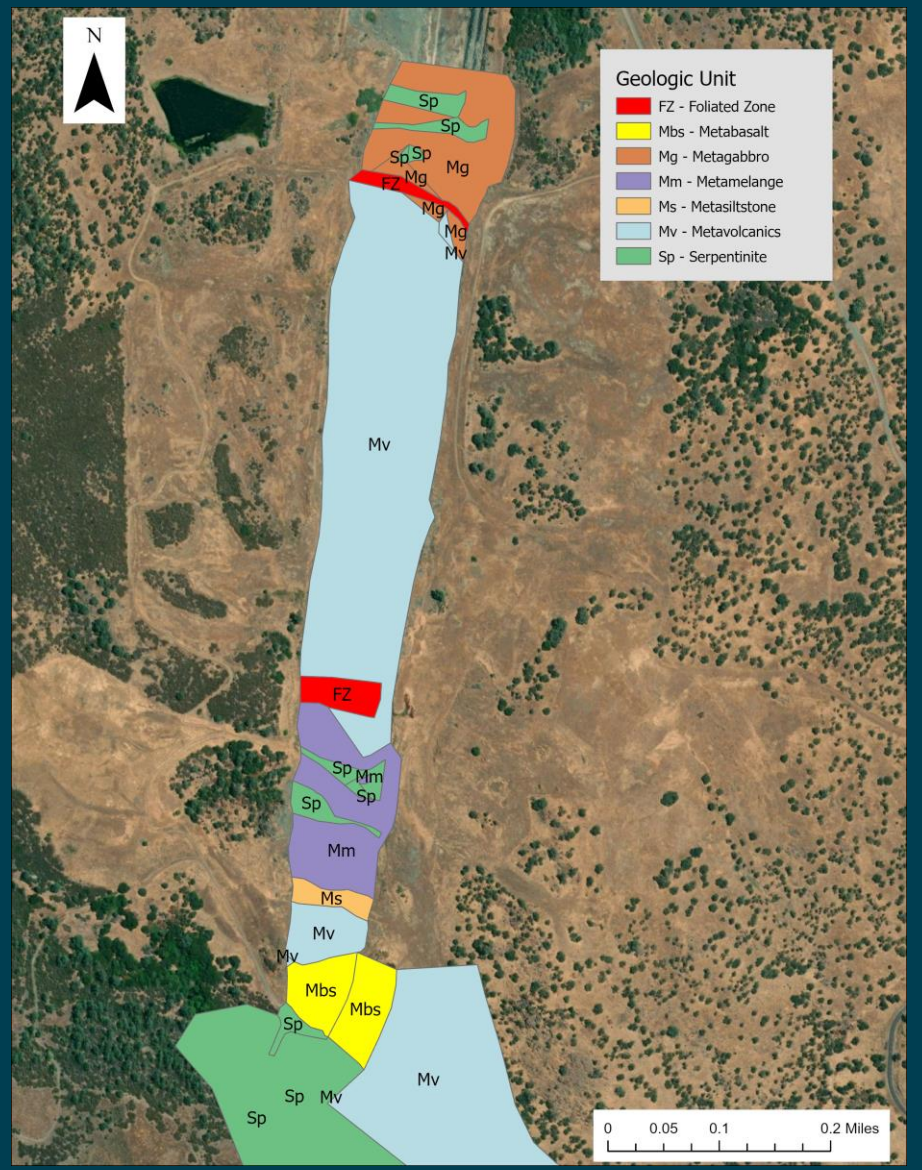
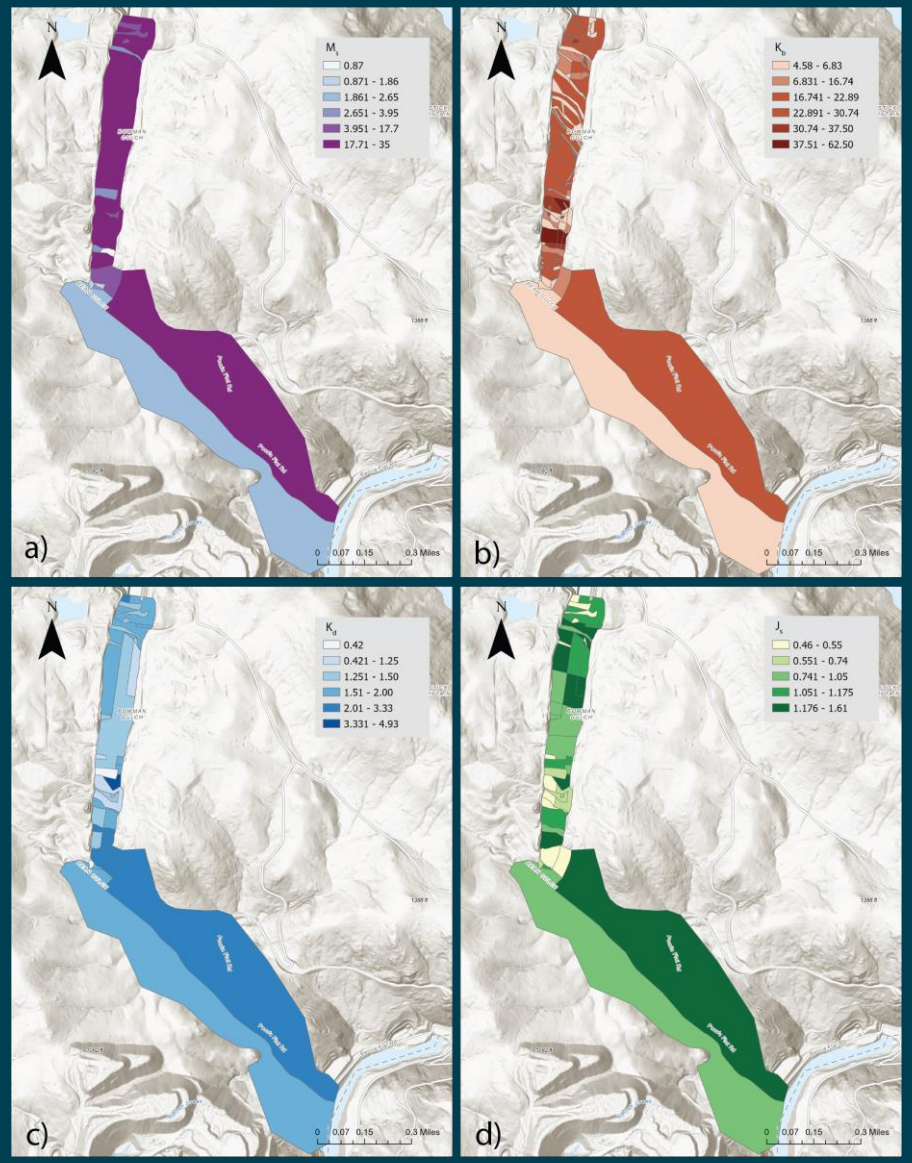
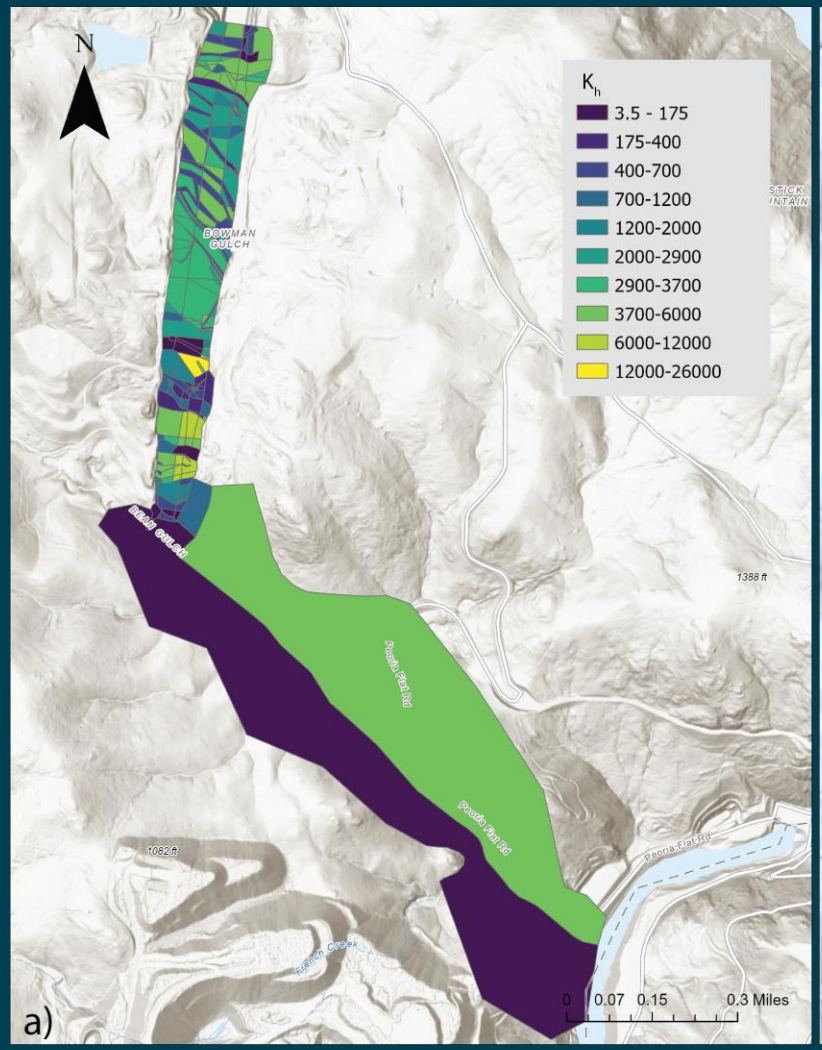
Model Inputs:

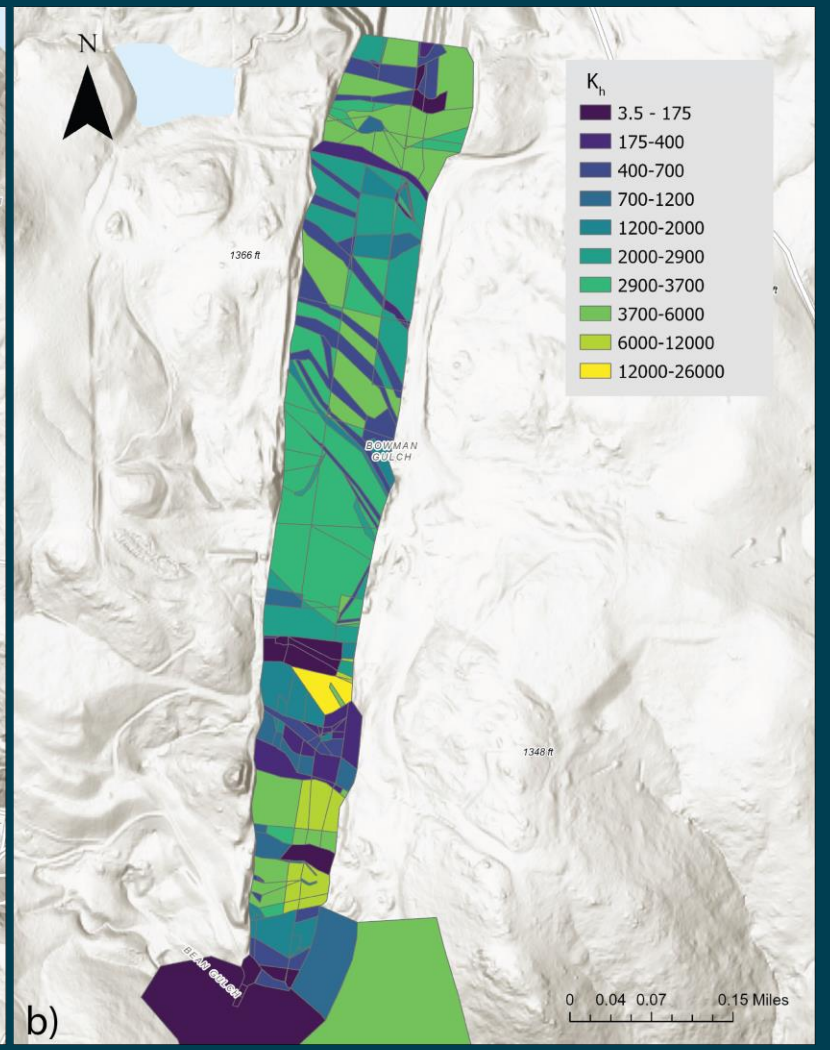
- Geologic data
- Flow data from SRH-2D



Annandale Input – Erodibility Map Data

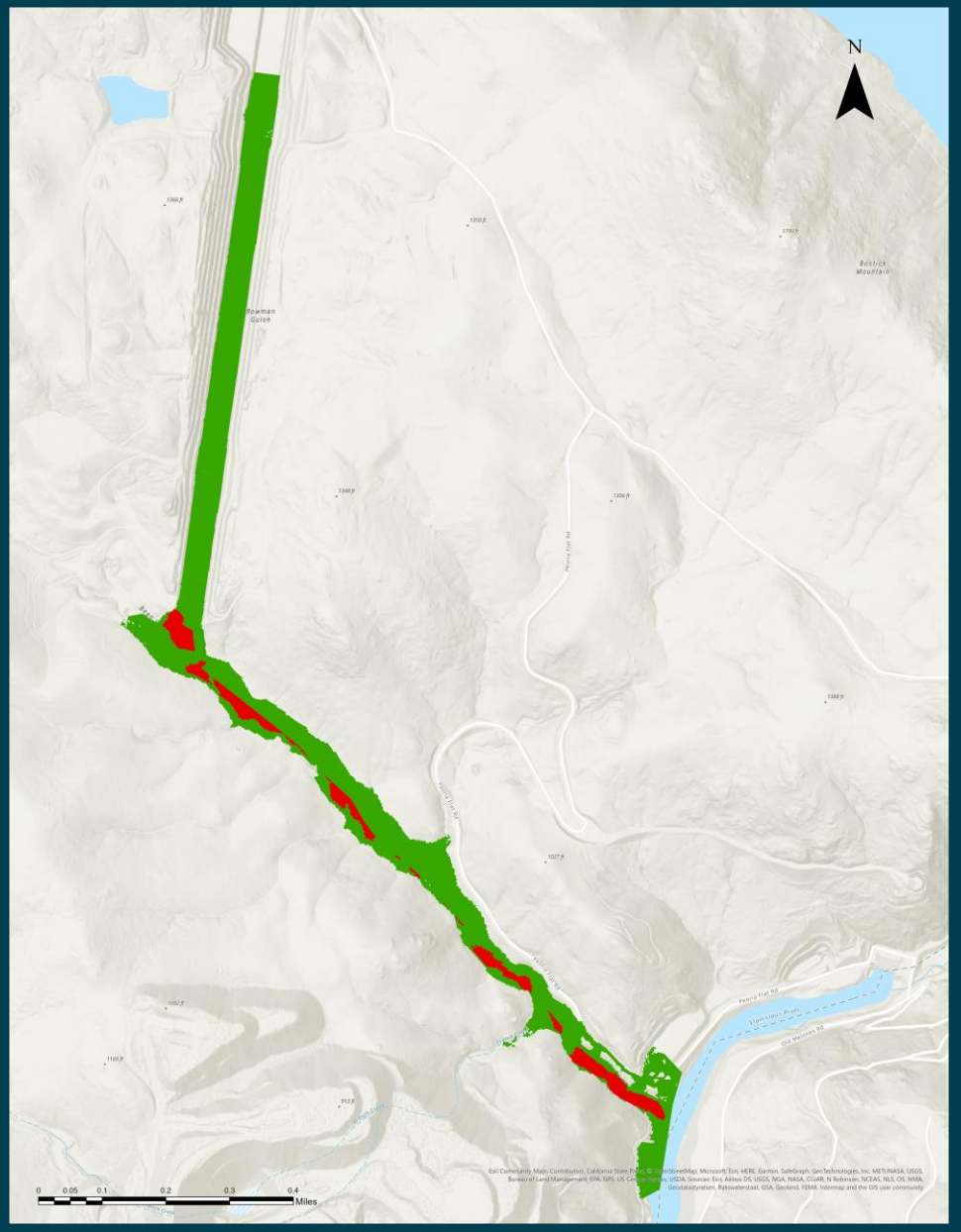




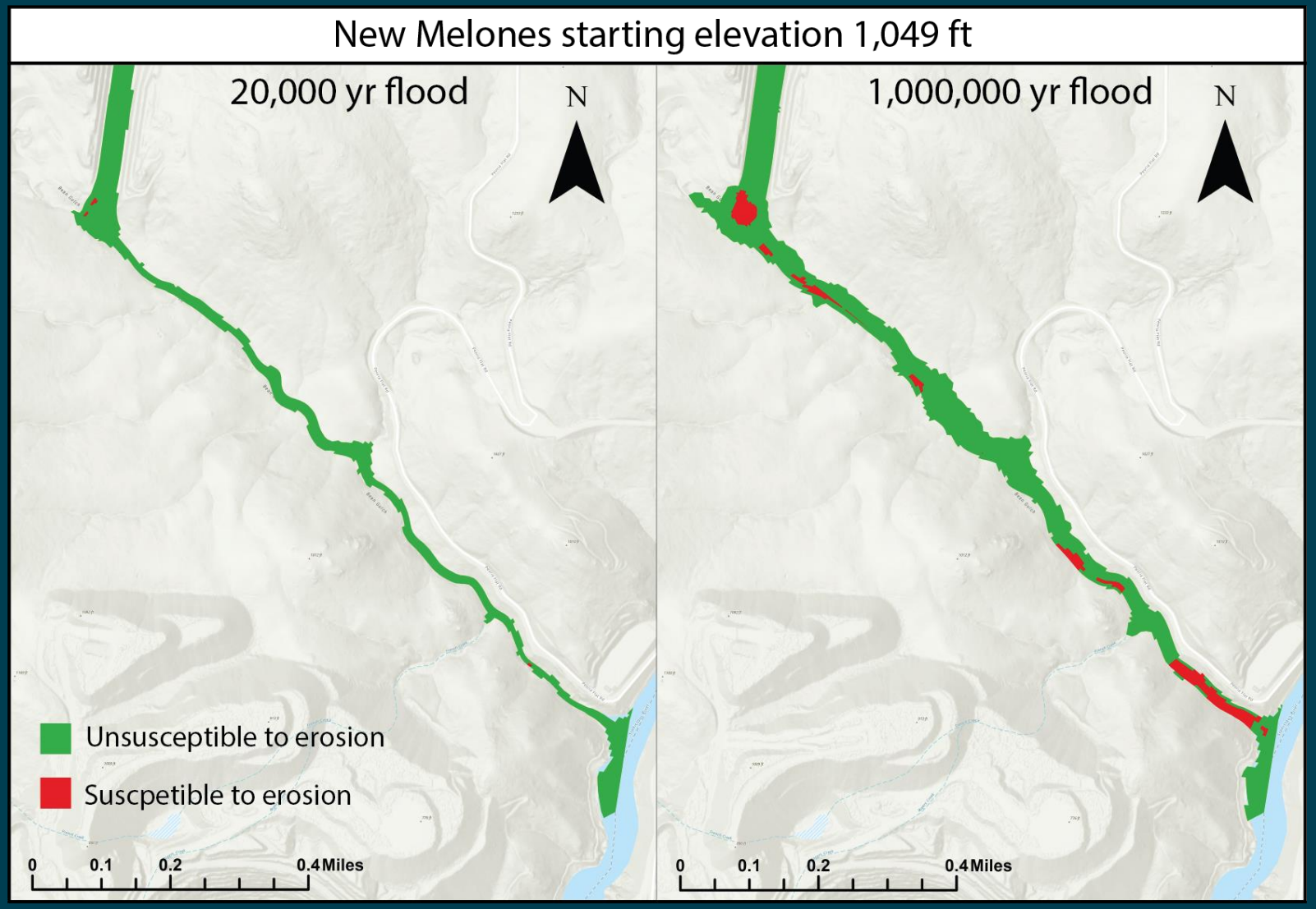


2D Annandale Erosion – Overview

- We calculated the streampower from the steady-state SRH2D results over the entire mesh
- We calculate the threshold streampower needed to erode the bed (Annandale Erodibility Index)
- Green spaces won't erode; Red is likely to erode
- Most erosion is expected to occur at the downstream end of the spillway and into Bean Gulch for all flows



Erosion is confined to the gully downstream of the spillway and Bean Gulch.



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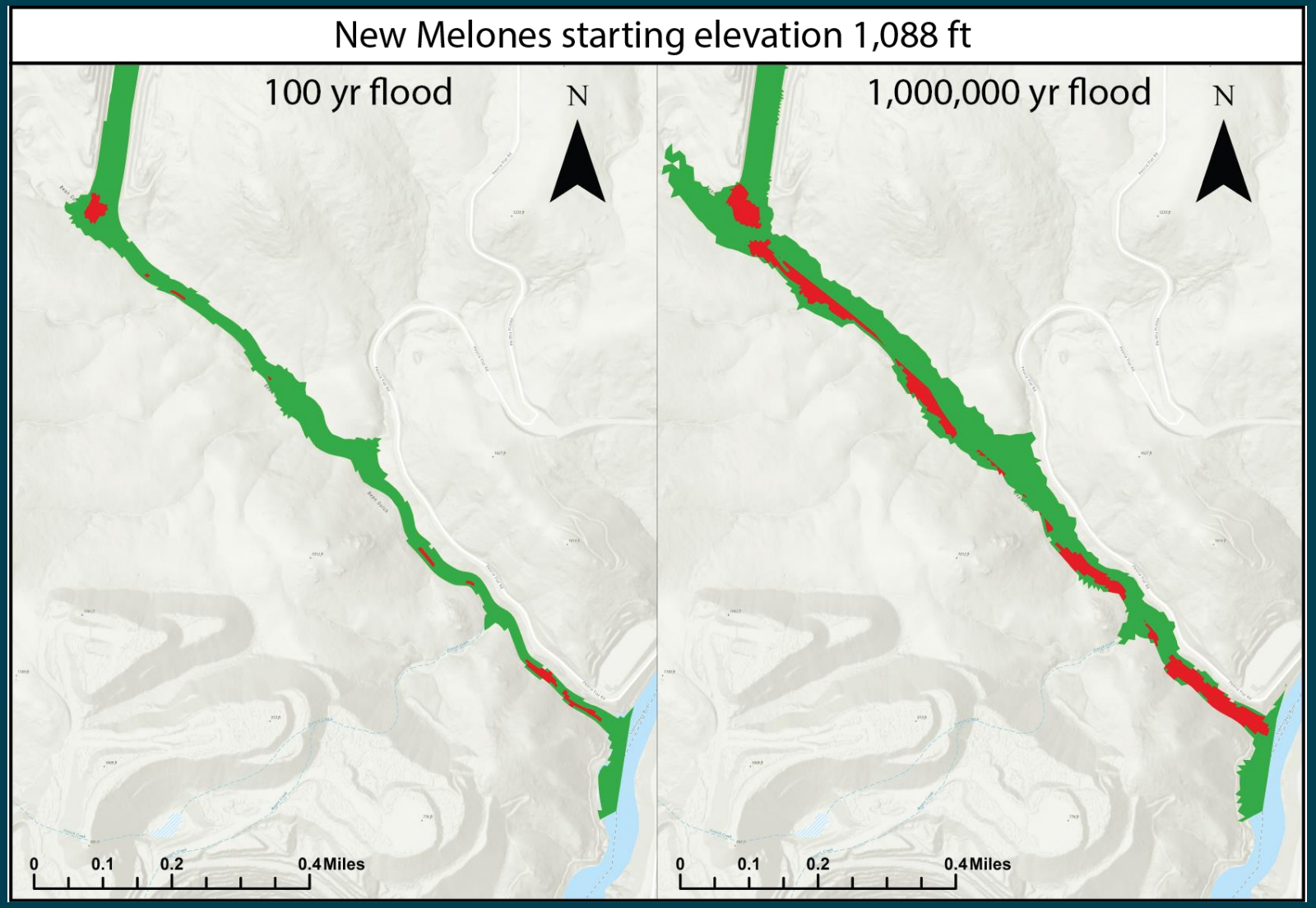

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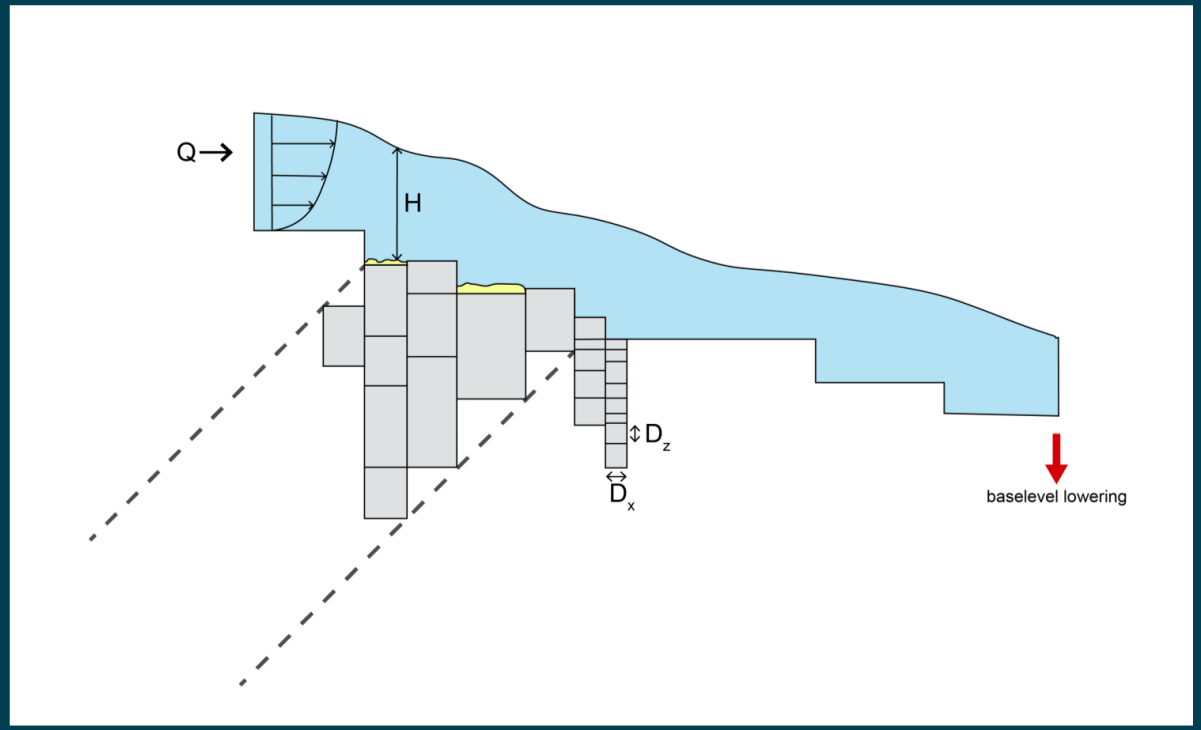
Hurst 1-Dimensional Erosion model (Hurst et al., 2020)

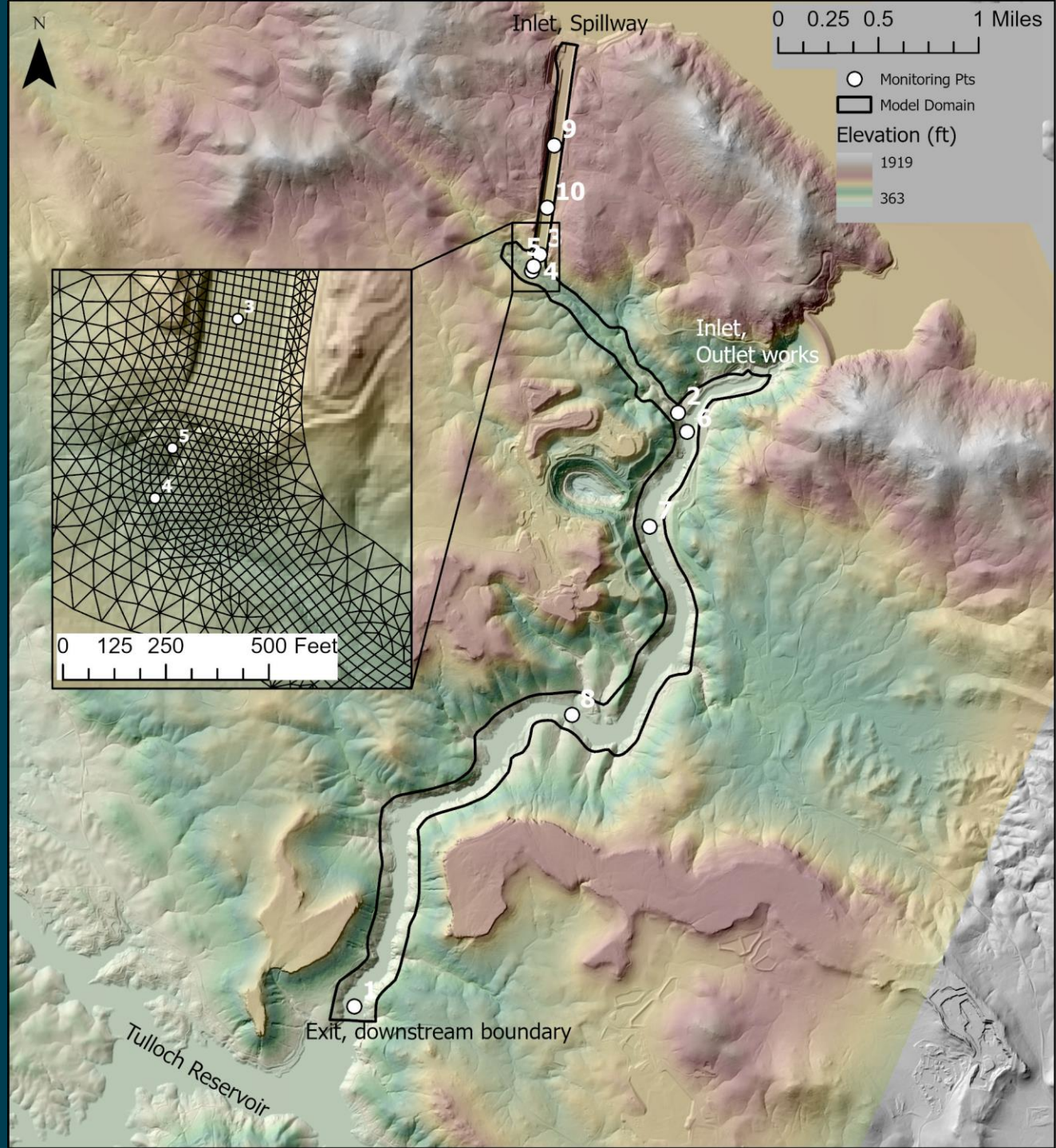
- Time-dependent, probabilistic erosion model that calculates the timing and depth of erosion along a 1D transect
- Utilizes novel physics for block entrainment to erode fractured bedrock material



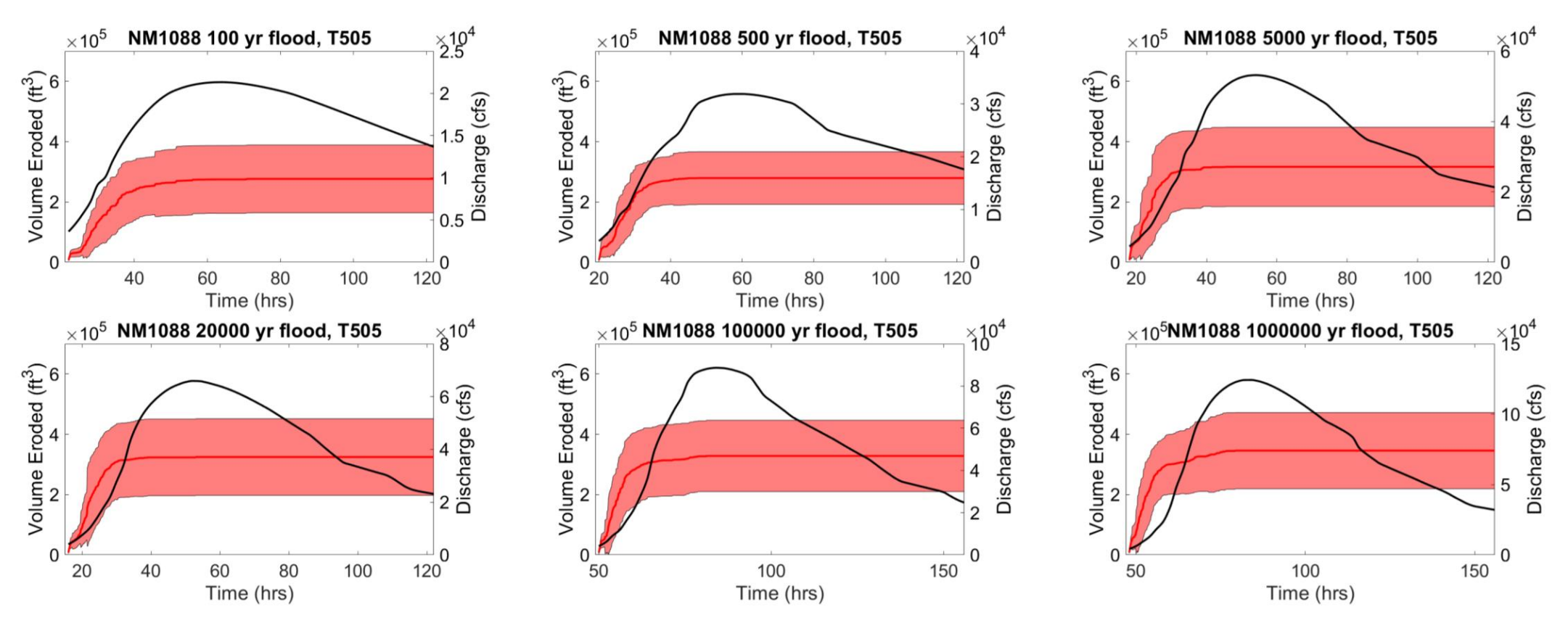
Model Inputs:

- Fracture spacing
- Rock Density

Reminder of point locations:

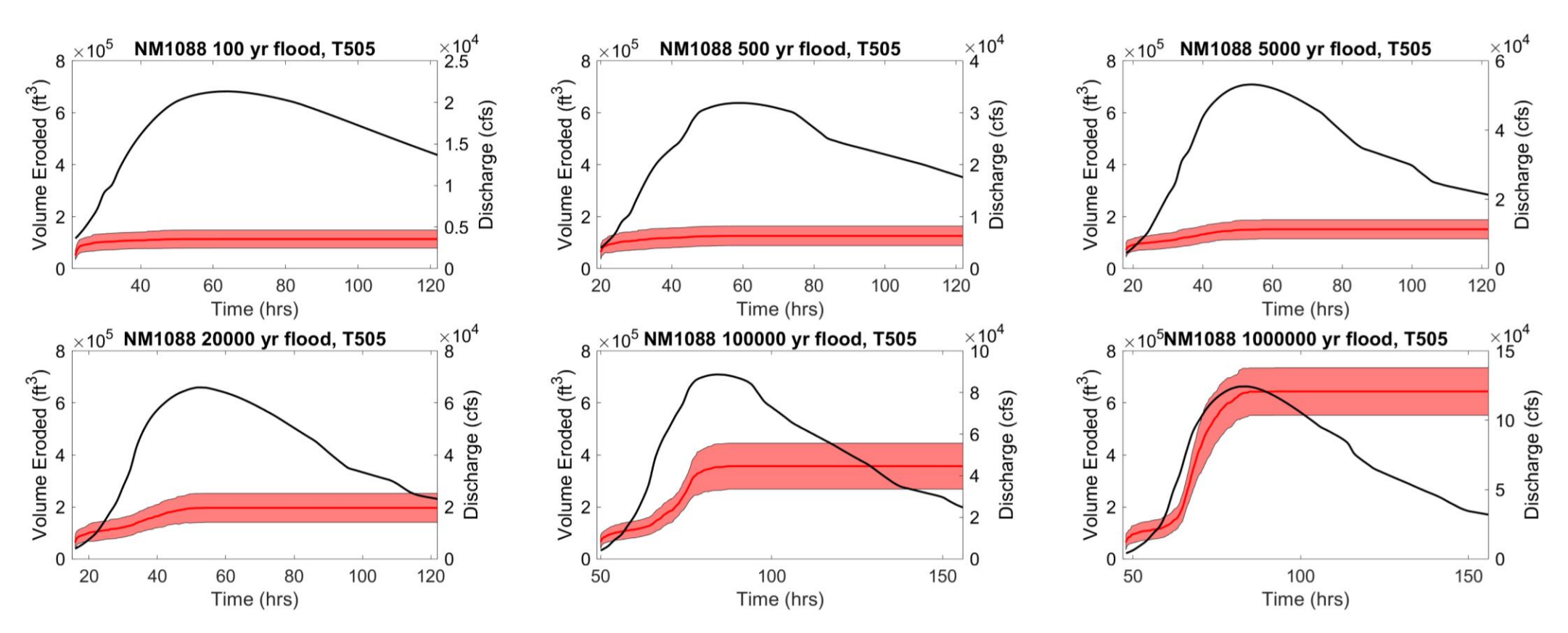


New Melones starting elevation 1,088 ft: Left Spillway



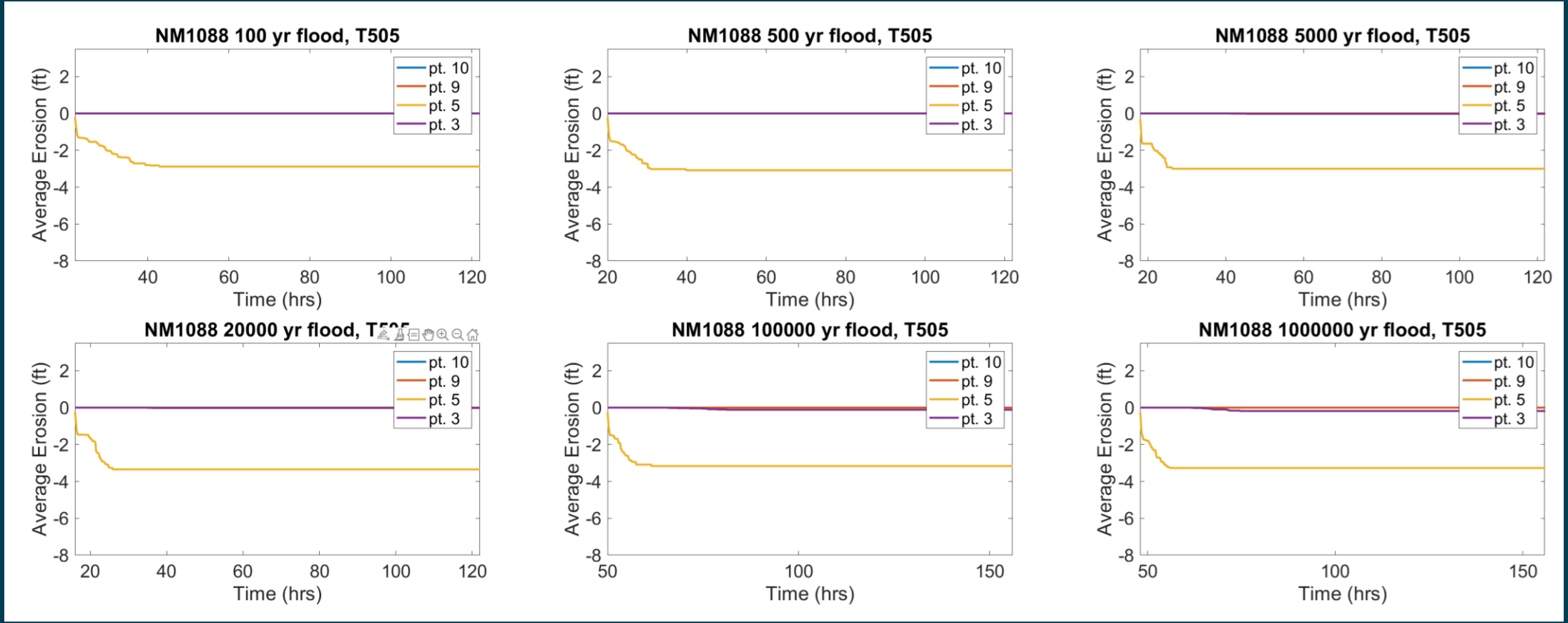
- The 1088 runs erode slightly more than the 1049 runs, but similarly are capped by the maximum gully erosion.

New Melones starting elevation 1,088 ft: Right Spillway



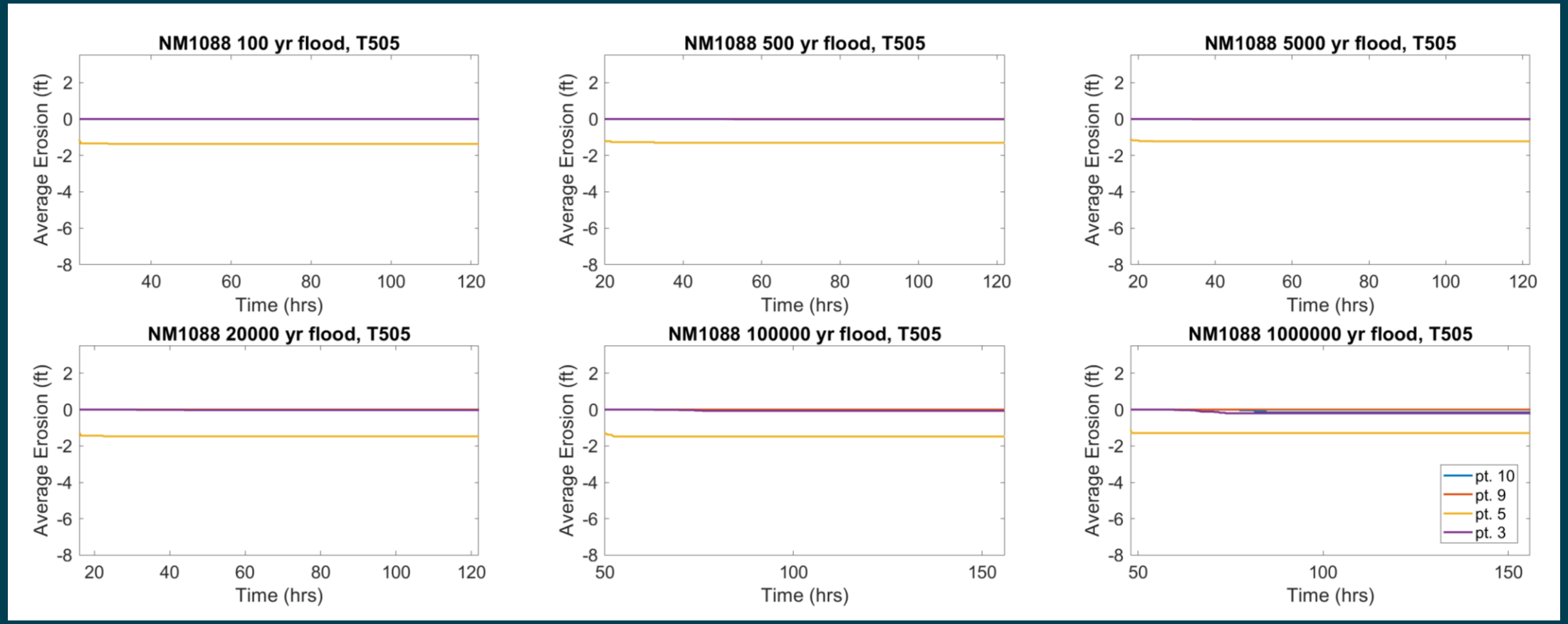
- The right spillway erodes twice as much for the 1 Myr flood as the left spillway. For lower flows it erodes less.

New Melones starting elevation 1,088 ft: Left Spillway (2)



- The gully point erodes to a similar depth for all flows. Pt. 3 (downstream end of the spillway) erodes in the higher discharge runs.

New Melones starting elevation 1,088 ft: Right Spillway (2)



- Right spillway has less erosion than the left spillway for all but the 1 Myr flood. For the 1 Myr flood erosion progresses up to Pt. 10.

Conclusions

1. Test the assumption that sediment cover on the spillway is removed, exposing bedrock. Identify areas of sediment deposition.
   - Will Tulloch Reservoir be impacted by sediment deposition?

Tulloch is not impacted. Most sediment deposited downstream of the confluence with Bean Gulch.

2. Identify zones of potential bedrock erosion on the spillway for a range of flow events.

Downstream end of the spillway into Bean Gulch for all flows. No erosion expected in the majority of the spillway.

3. Constrain vertical incision and potential volume of erosion for a range of flow events.

Worst case shows 0.5 ft of incision in the gully and small amounts of incision in the spillway.

Acknowledgements

- MP Geology team- Bryan Holmes, Steve Dalton, Greg Mongano and team
- Geophysics- Justin Rittgers
- TSC Geology- Austin Reed
- New Melones Power Office
- Cassie Wagner, Blair Greimann, Dom Galic
- Dam Safety
- MP Regional Office

Questions?