# Channel Response to High Flows in Western Grand Canyon

GCDAMP Annual Reporting Meeting
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**Matt Kaplinski**
U.S. Geological Survey
Southwest Biological Science Center
Grand Canyon Monitoring and Research Center

USGS

# Acknowledgments


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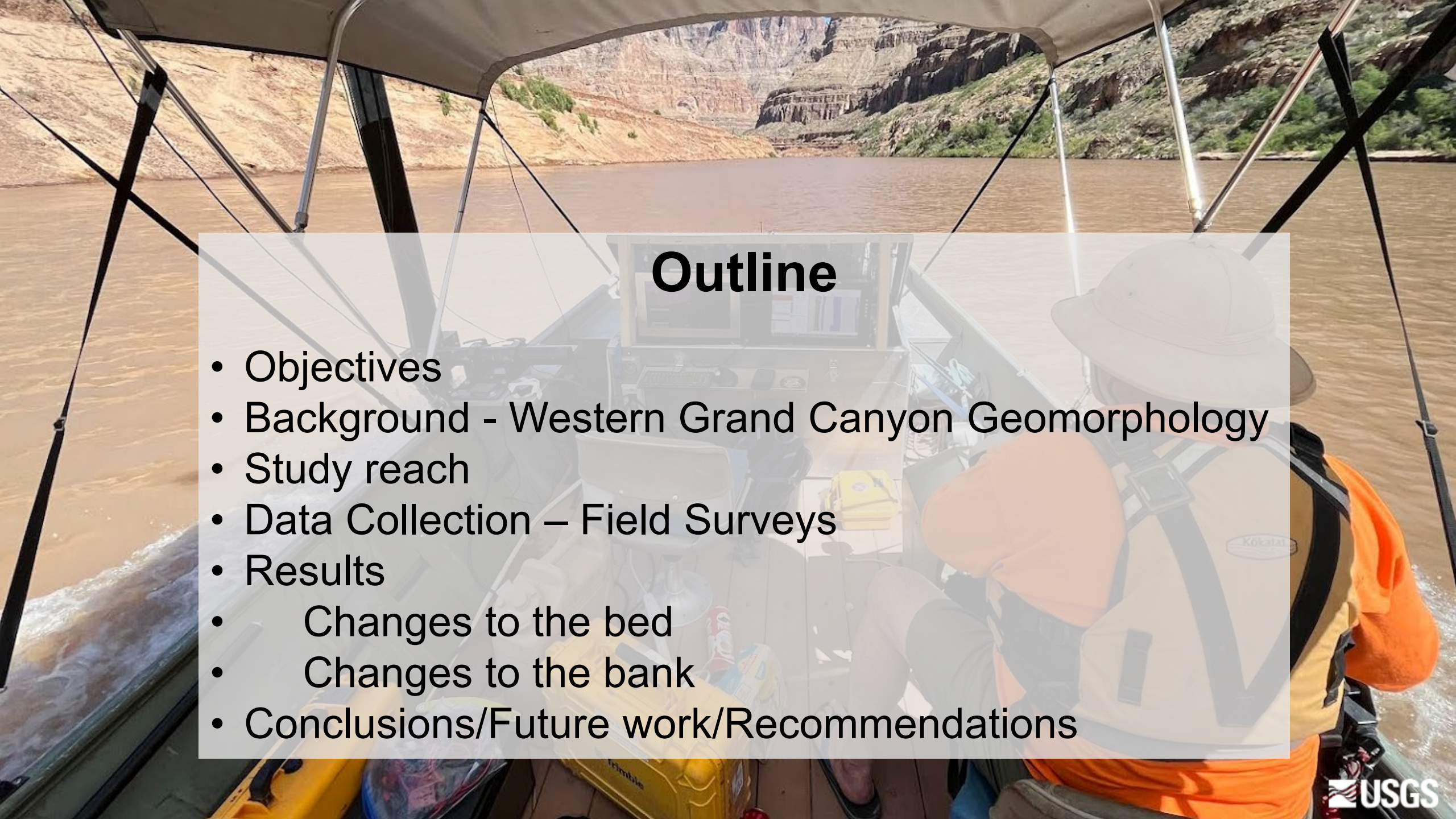
- Corey Sannes: U.S. Geological Survey, Arizona Water Science Center

- U.S. Geological Survey, Grand Canyon Monitoring and Research Center Logistics Staff

- Thanks to the Hualapai tribe and National Park Service for their support, cooperation, and shared interest in the sediment dynamics of the western Grand Canyon



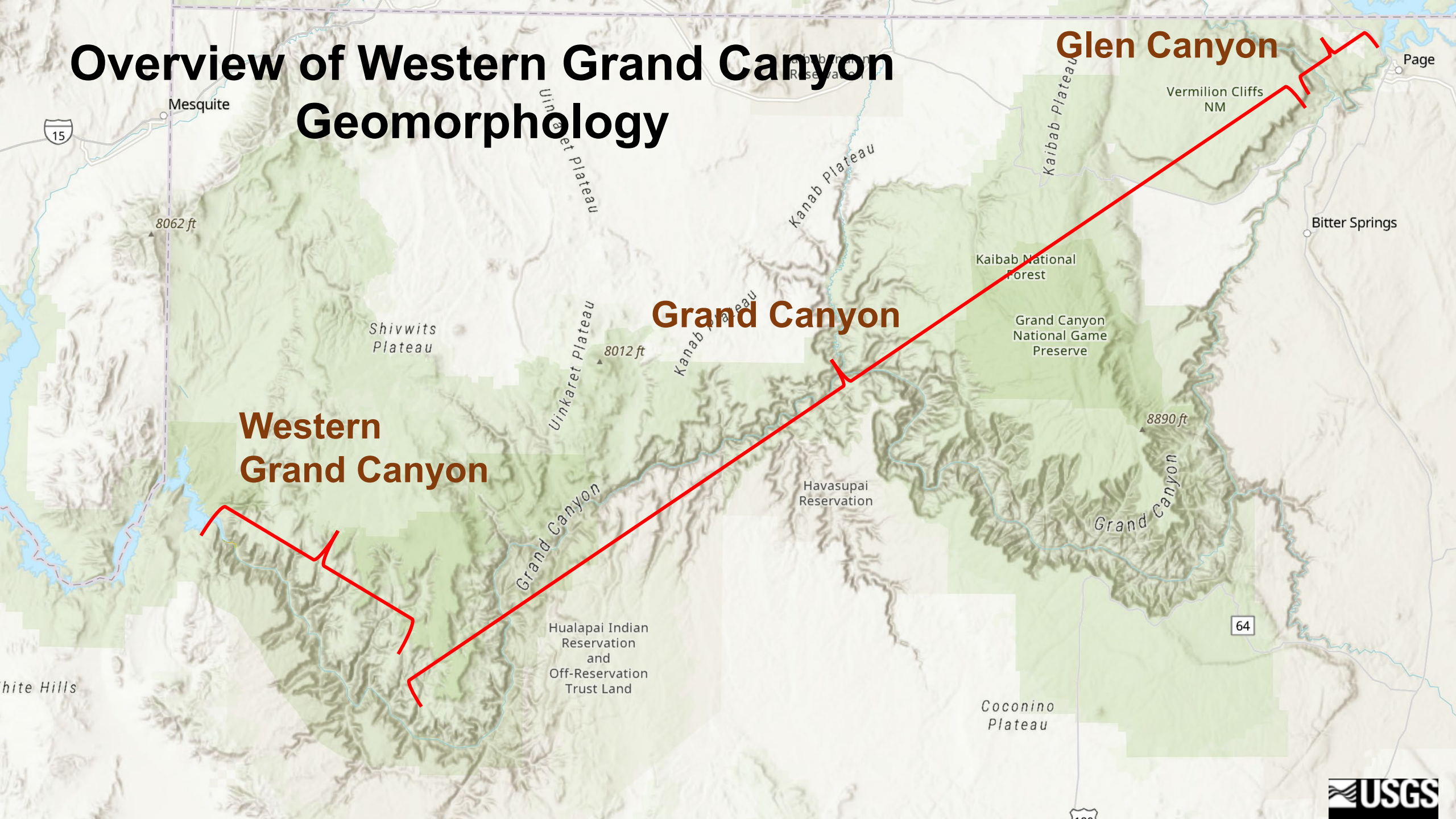
# Outline

- Objectives
- Background - Western Grand Canyon Geomorphology
- Study reach
- Data Collection – Field Surveys
- Results
- Changes to the bed
- Changes to the bank
- Conclusions/Future work/Recommendations

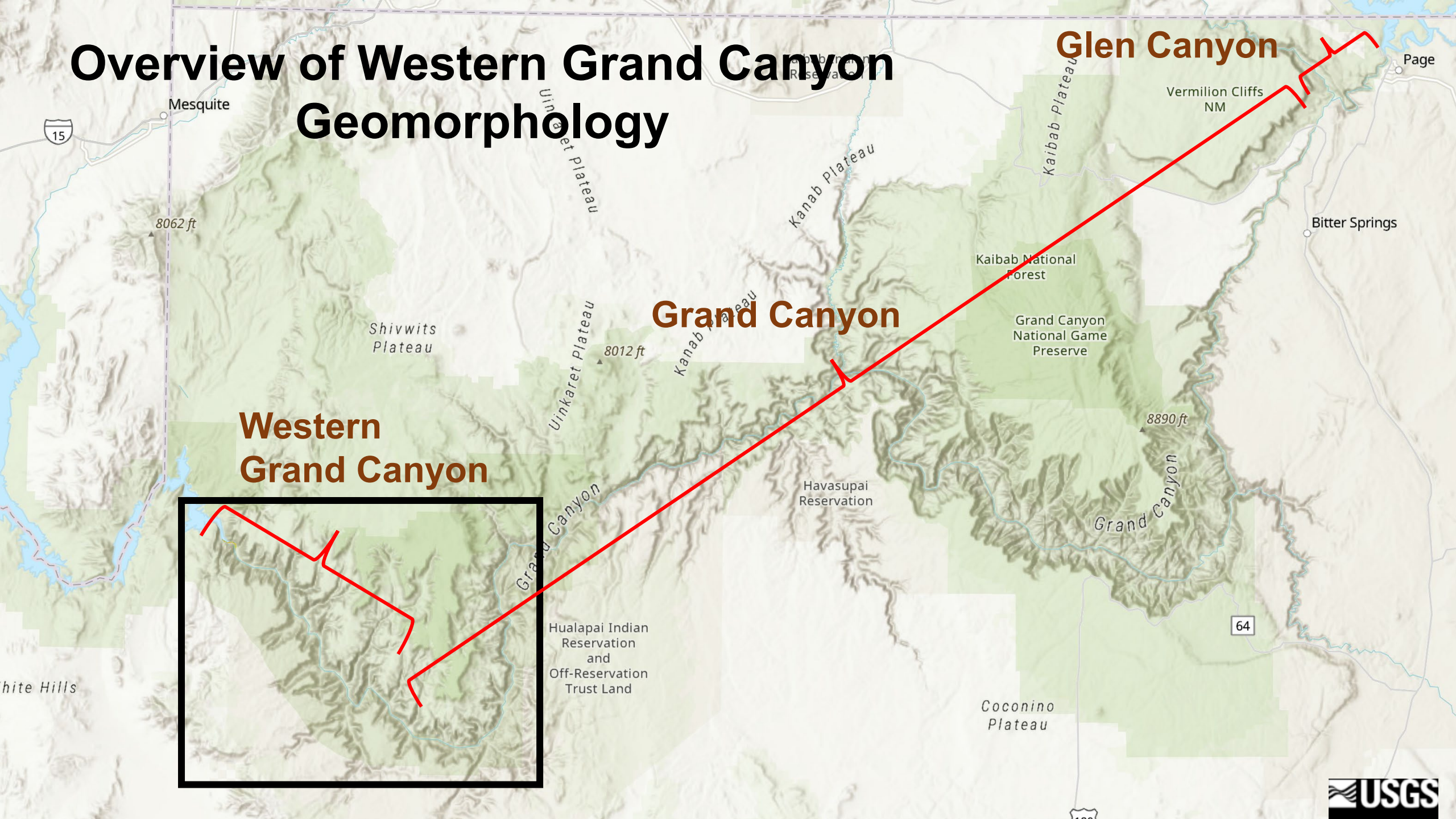
*Objective:* Understand and quantify relation between **changes in bed configuration** in Western Grand Canyon and **dam releases**.

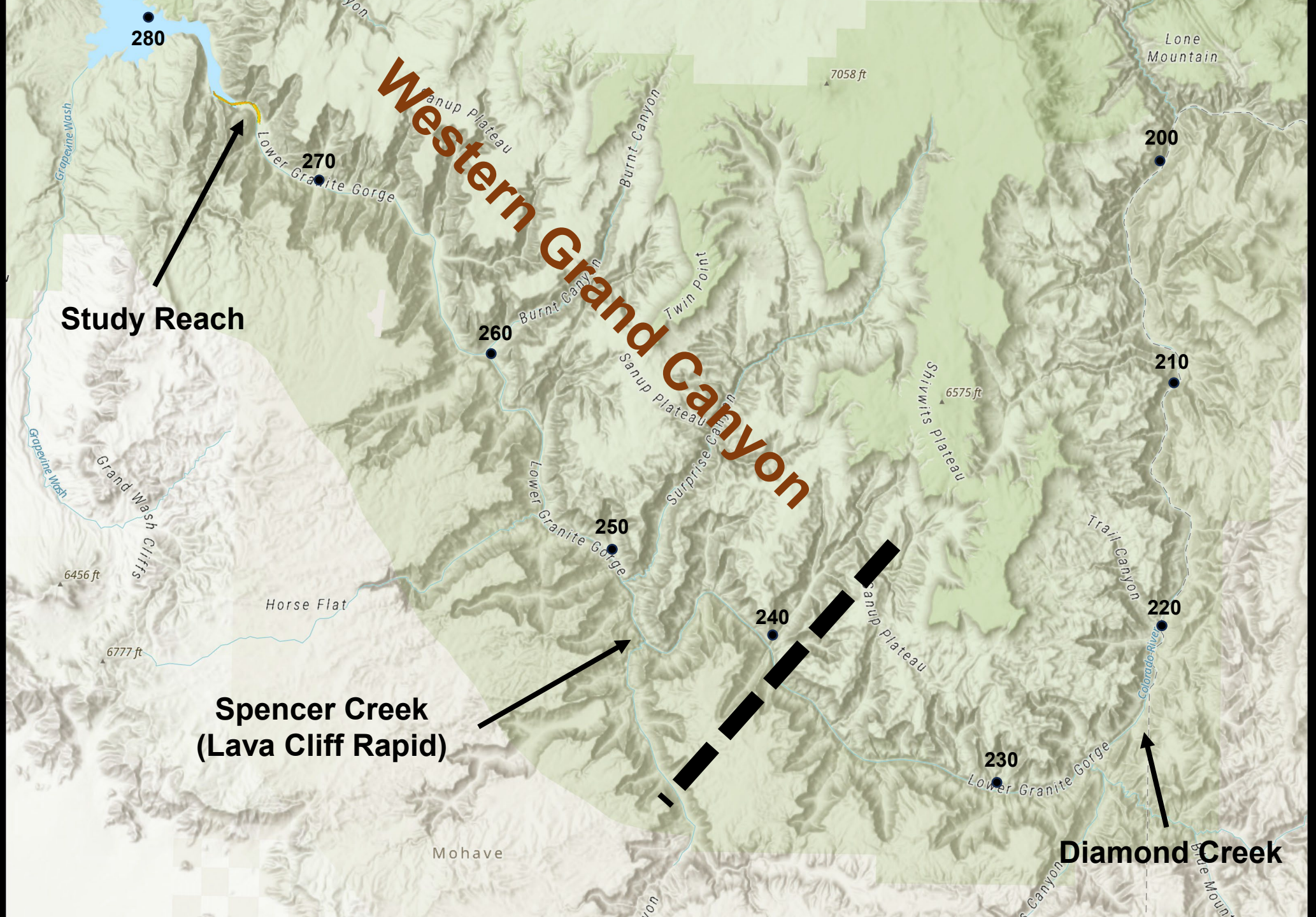
*Do certain dam operations reduce, exacerbate or mitigate sediment accumulation in this reach?*

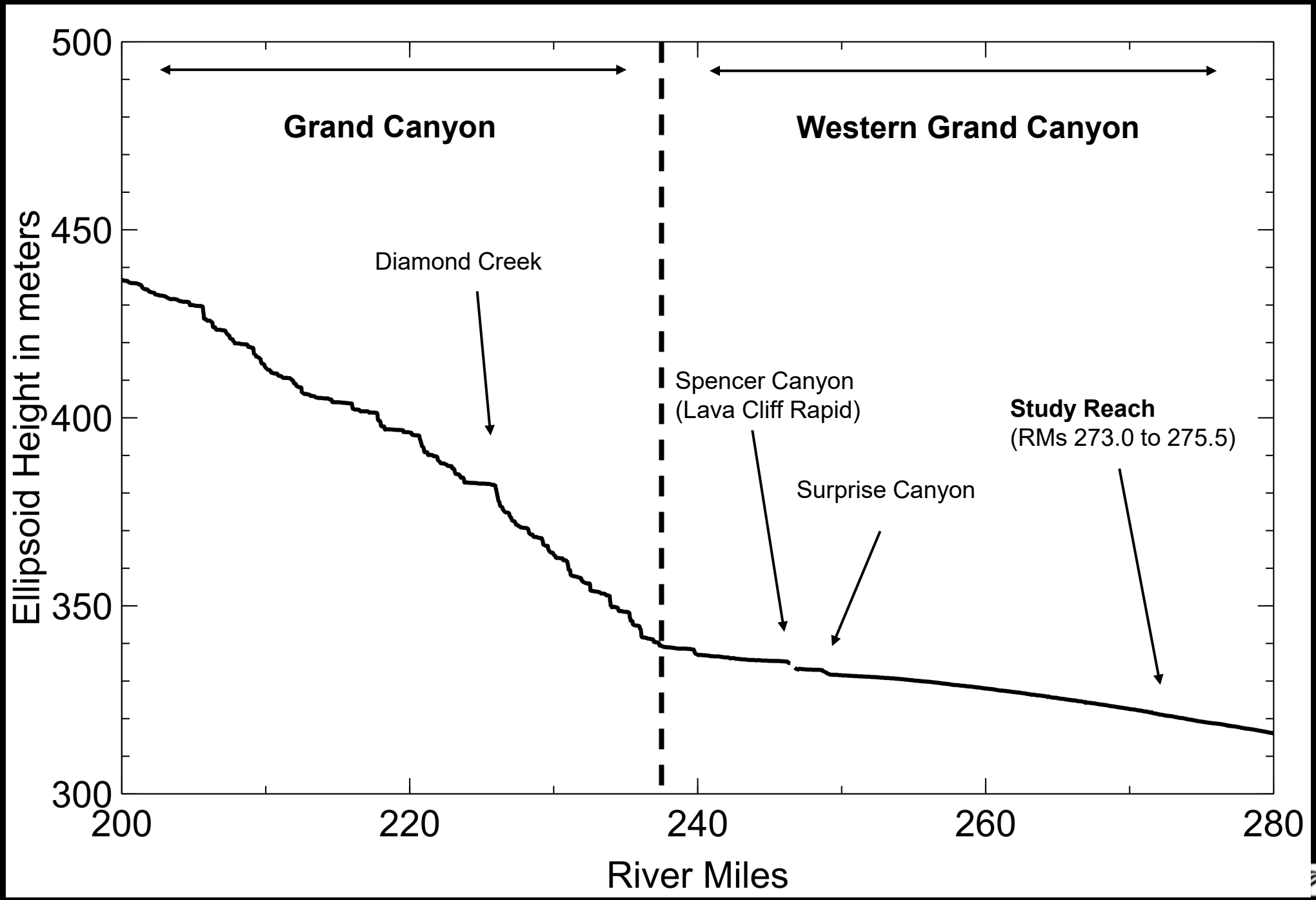
# Overview of Western Grand Canyon Geomorphology

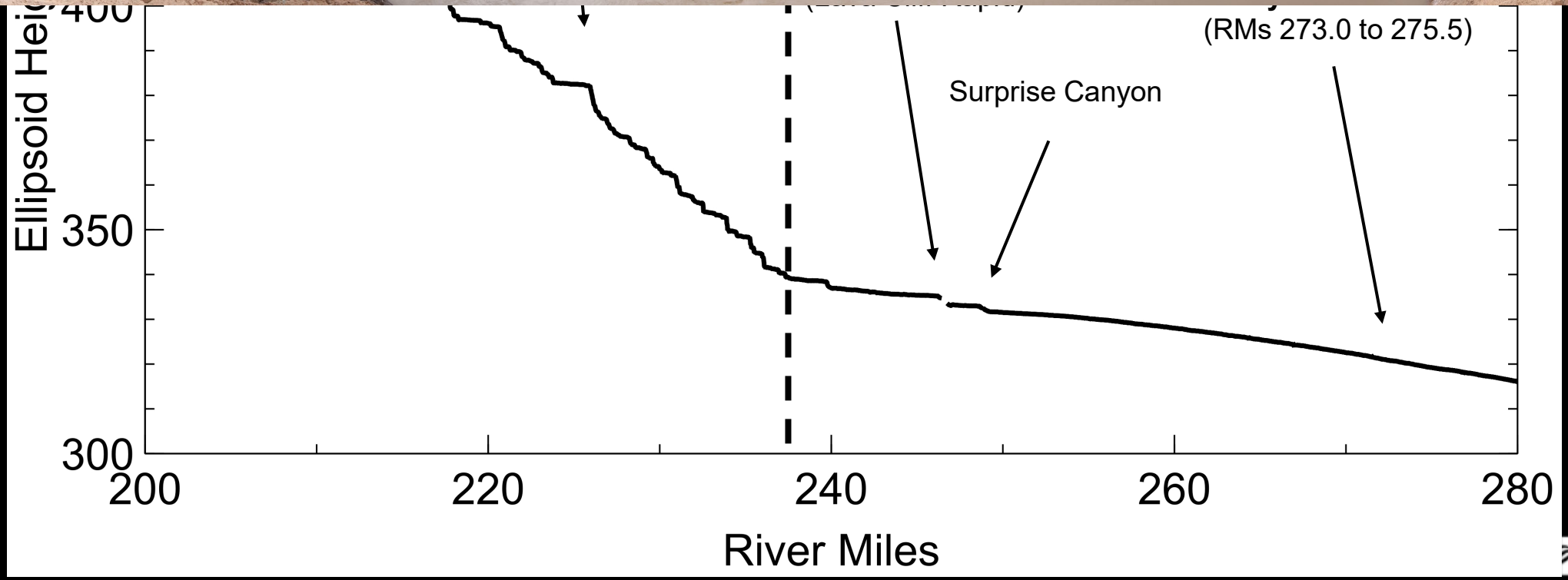


# Overview of Western Grand Canyon Geomorphology




Western Grand Canyon
Study Reach
Spencer Creek
(Lava Cliff Rapid)
Diamond Creek
280
270
260
250
240
230
220
210
200
Lone Mountain
7058 ft
6575 ft
6456 ft
6777 ft
Horse Flat
Mohave
Grapevine Wash
Grand Wash Cliffs
Lower Granite Gorge
Burnt Canyon
Twin Point
Surprise Canyon
Shivwits Plateau
Sanup Plateau
Trail Canyon
Colorado River
USGS


Grand Canyon
Western Grand Canyon
Diamond Creek
Spencer Canyon
(Lava Cliff Rapid)
Surprise Canyon
Study Reach
(RMs 273.0 to 275.5)
Ellipsoid Height in meters
500
450
400
350
300
200
220
240
260
280
River Miles


Ellipsoid Hei
400
350
300
200
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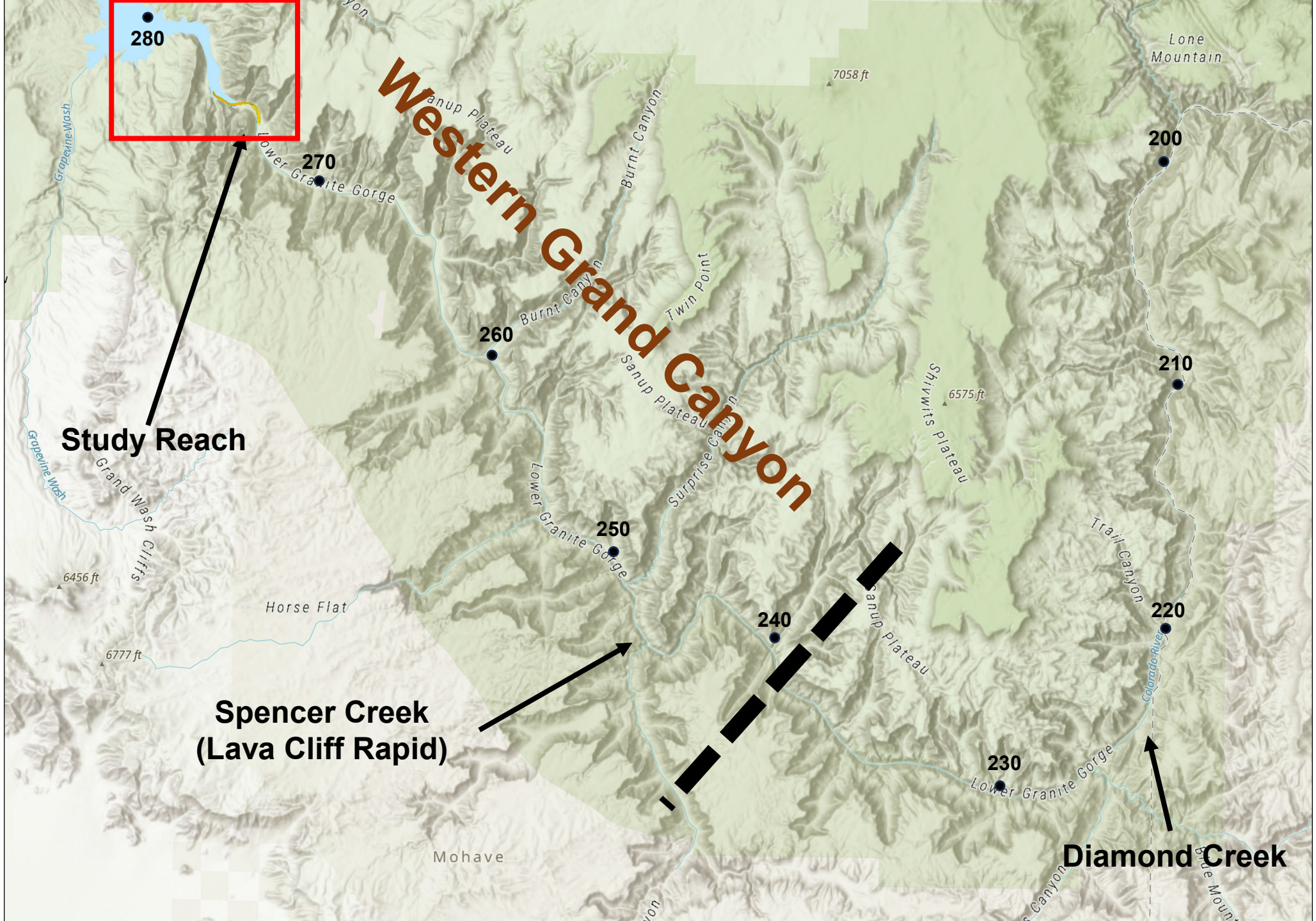
240
260
280
River Miles
(RMs 273.0 to 275.5)
Surprise Canyon

USGS


Western Grand Canyon
Study Reach
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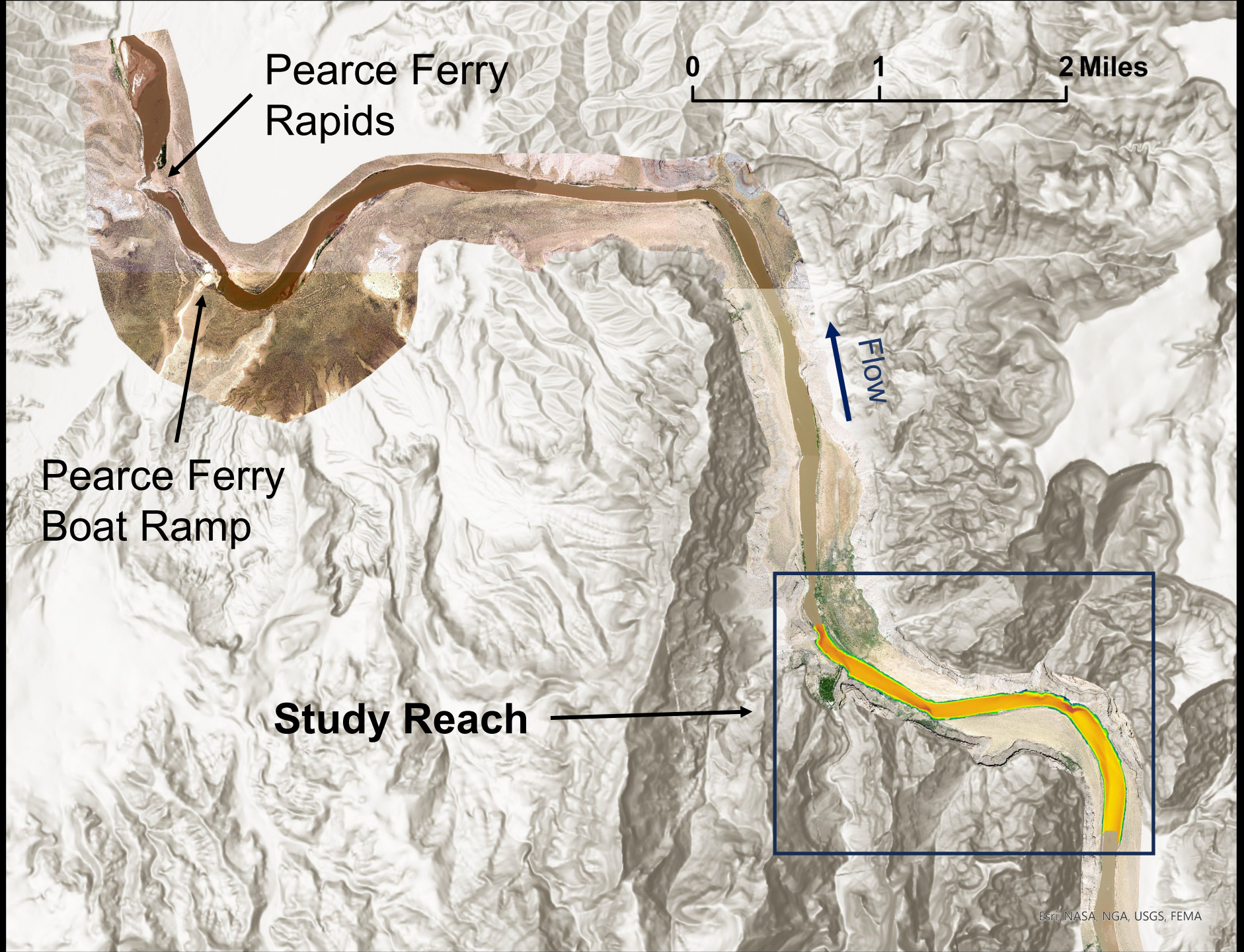
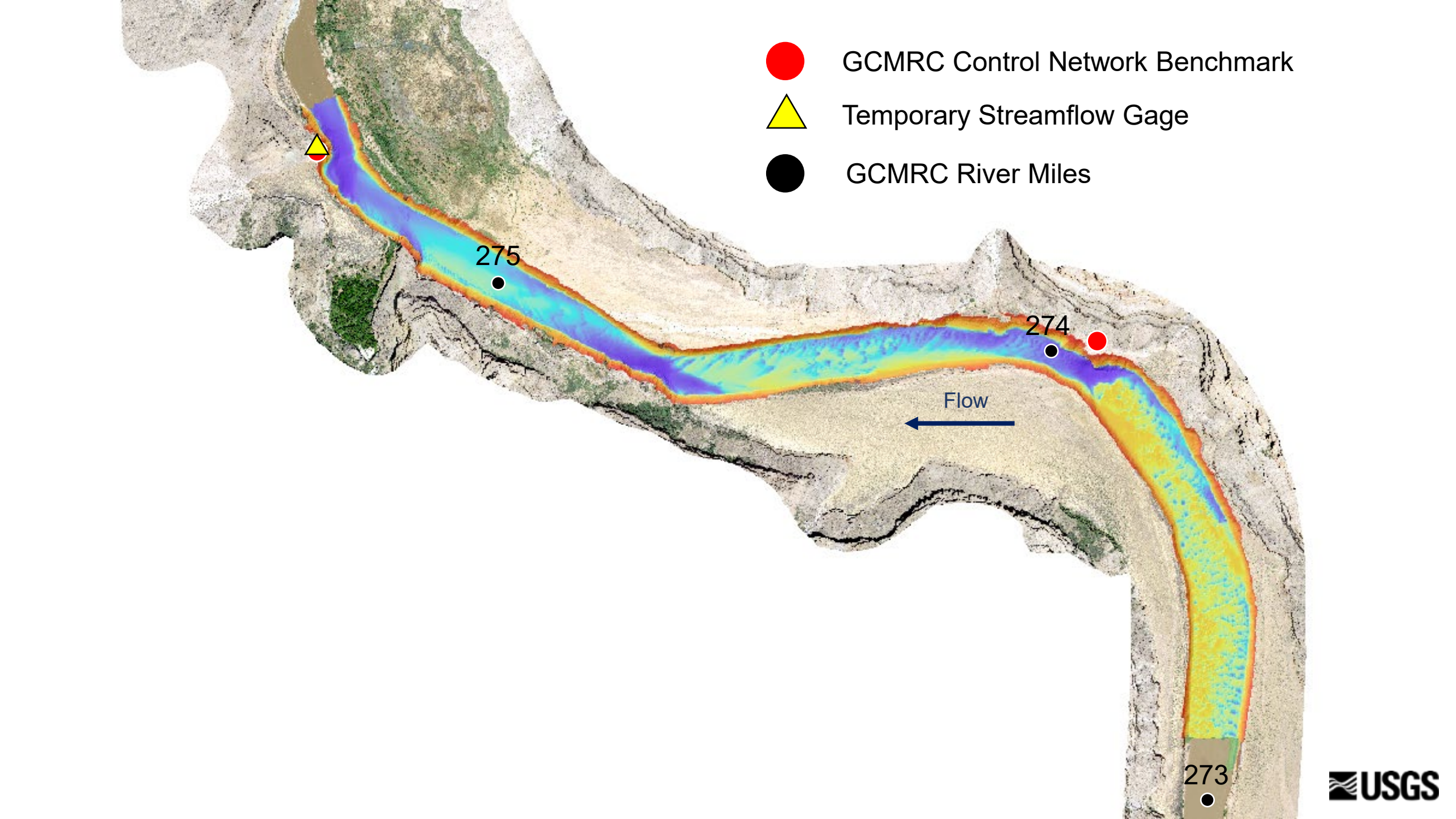
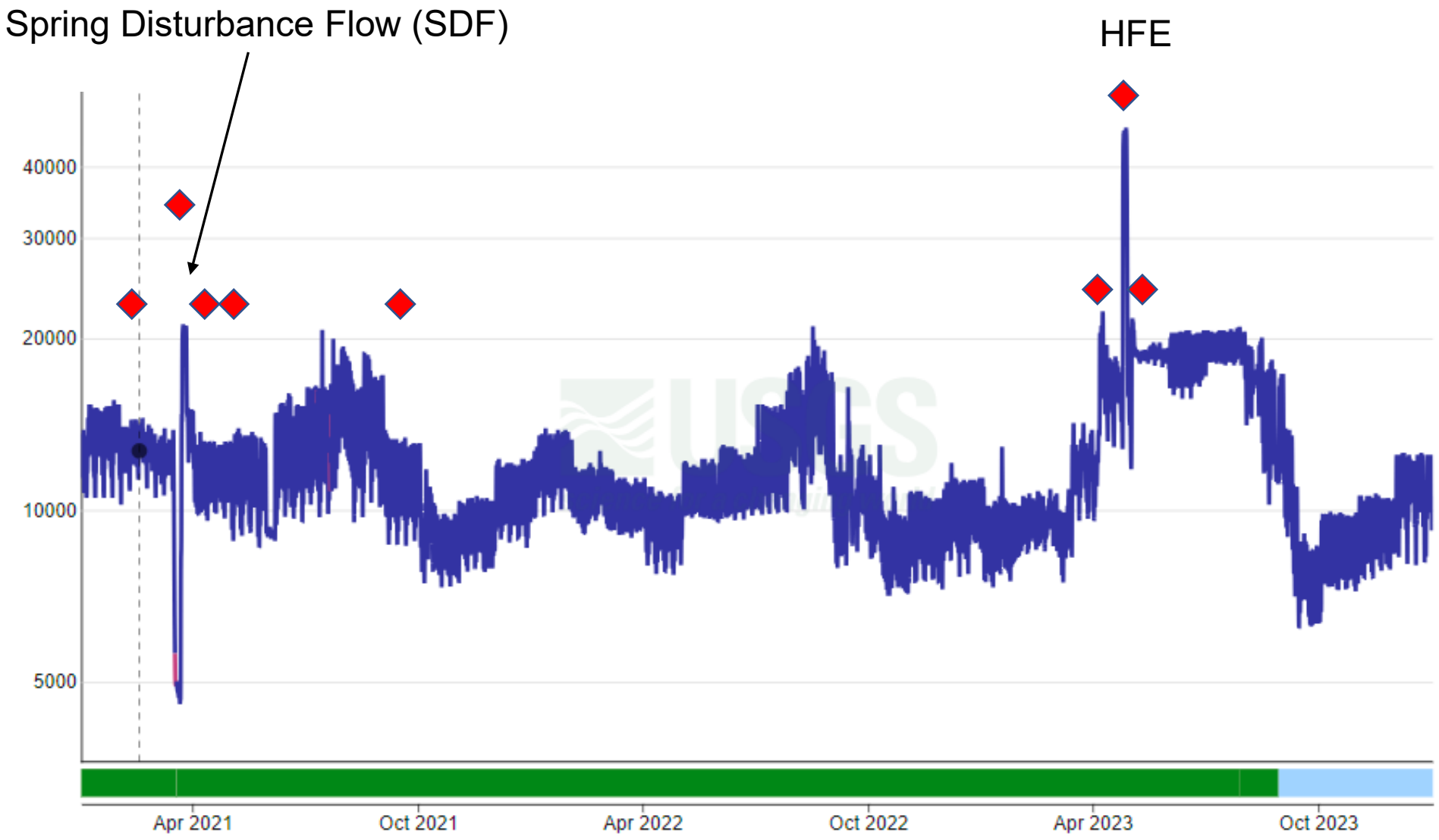

Pearce Ferry
Rapids
0
1
2 Miles
Flow
Pearce Ferry
Boat Ramp
Study Reach
Esri, NASA, NGA, USGS, FEMA

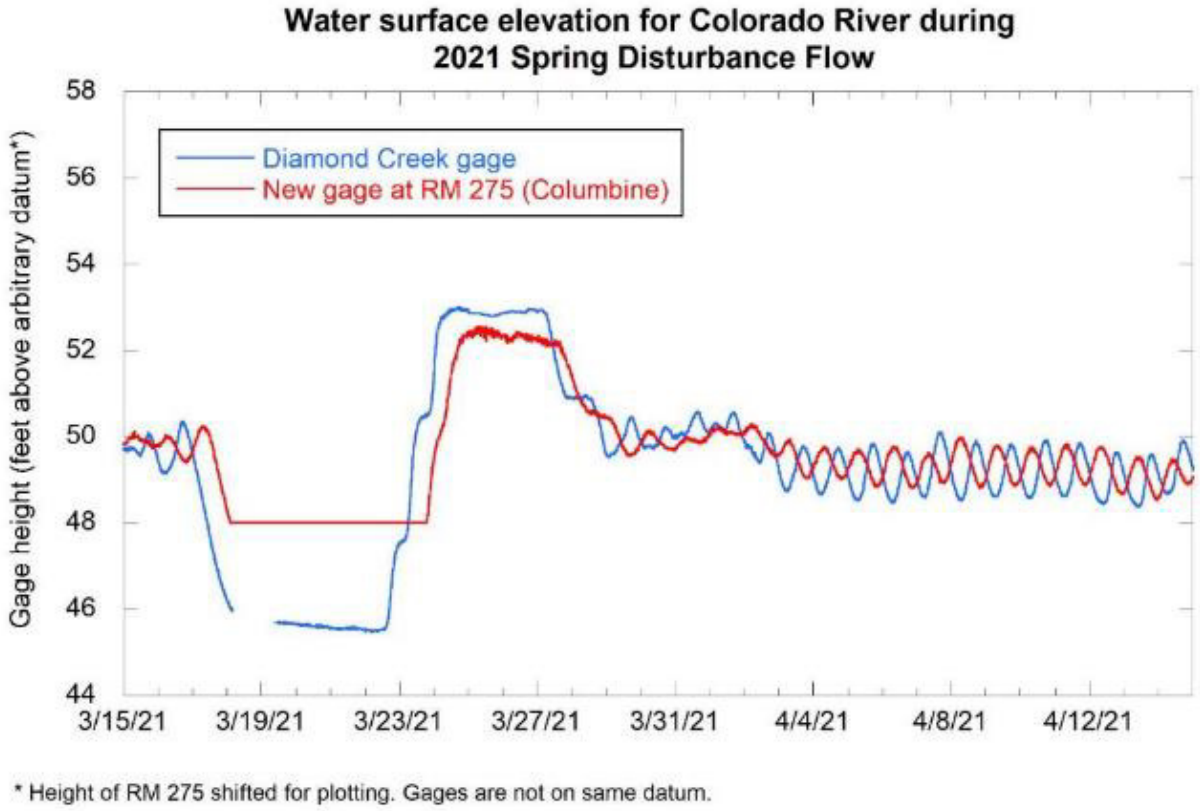

GCMRC Control Network Benchmark
Temporary Streamflow Gage
GCMRC River Miles
275
274
273
Flow

# Dates of Field Surveys



# Temporary Gage at RM 275

- This gage measures water surface elevation
- It is used to calculate travel time between the Colorado River gage at Diamond Creek (RM 226) and the study reach




*Preliminary results, subject to review, do not cite*

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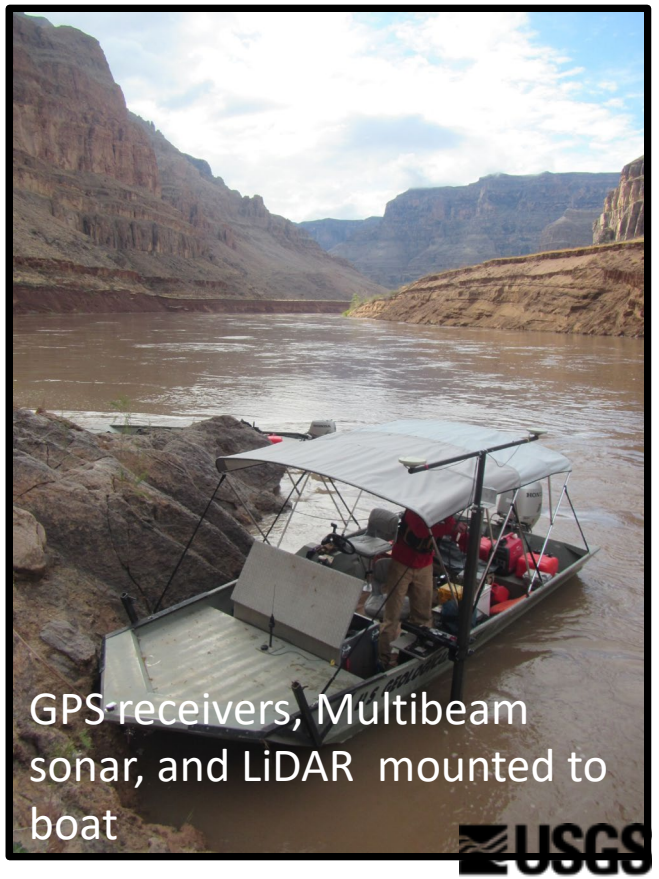
# Field Surveys: Data Collected

- GPS observations of benchmarks
- Multibeam sonar survey of riverbed
- Boat-based lidar survey of banks
- Ground-based RTK-GPS survey of water's edge, topography, and check points
- Time-lapse cameras to show bars during low-flow and bank erosion


RTK-GPS collection of water's edge


GPS receiver on benchmark


Multibeam sonar survey display showing live soundings of the bed


GPS receivers, Multibeam sonar, and LiDAR mounted to boat

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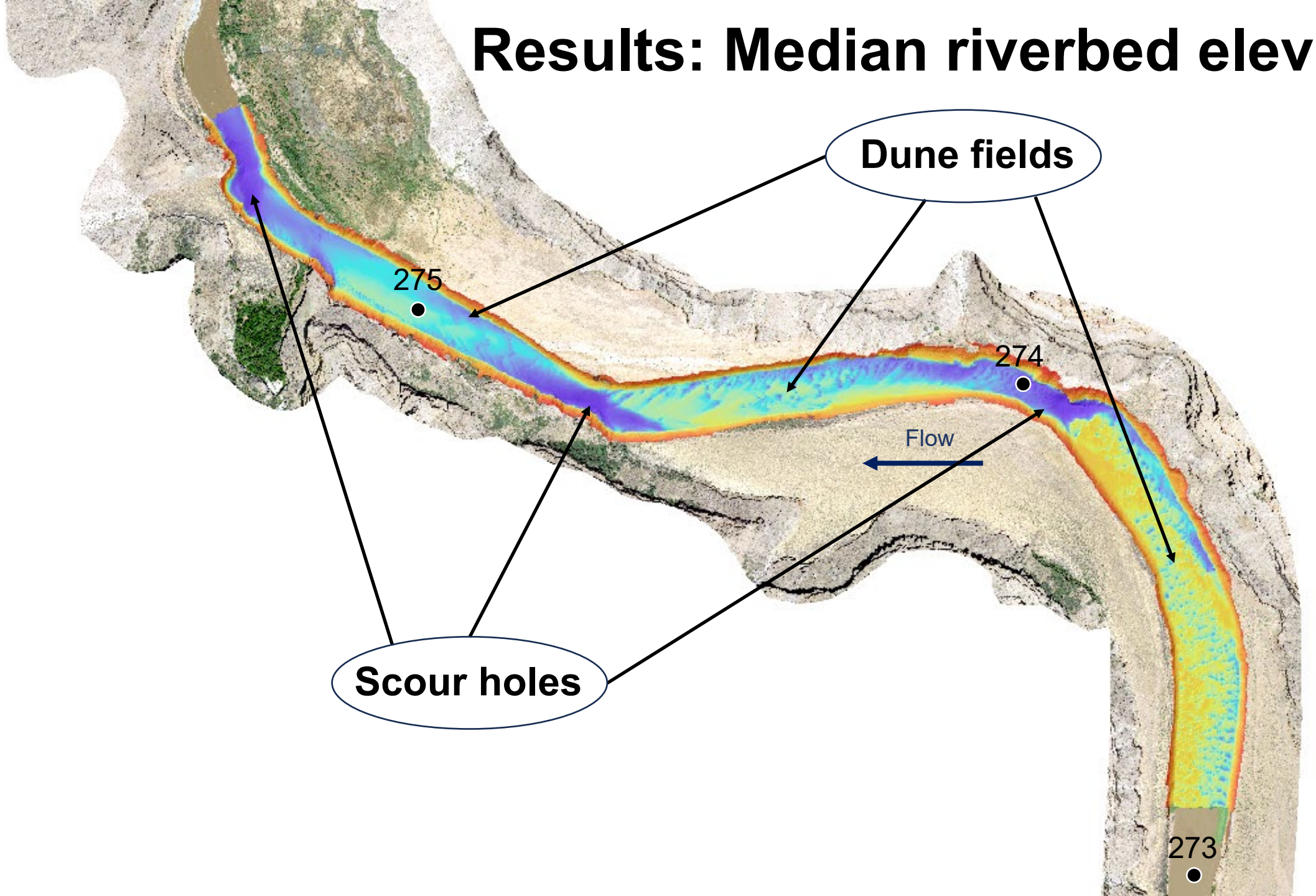
# Results: Median riverbed elevation

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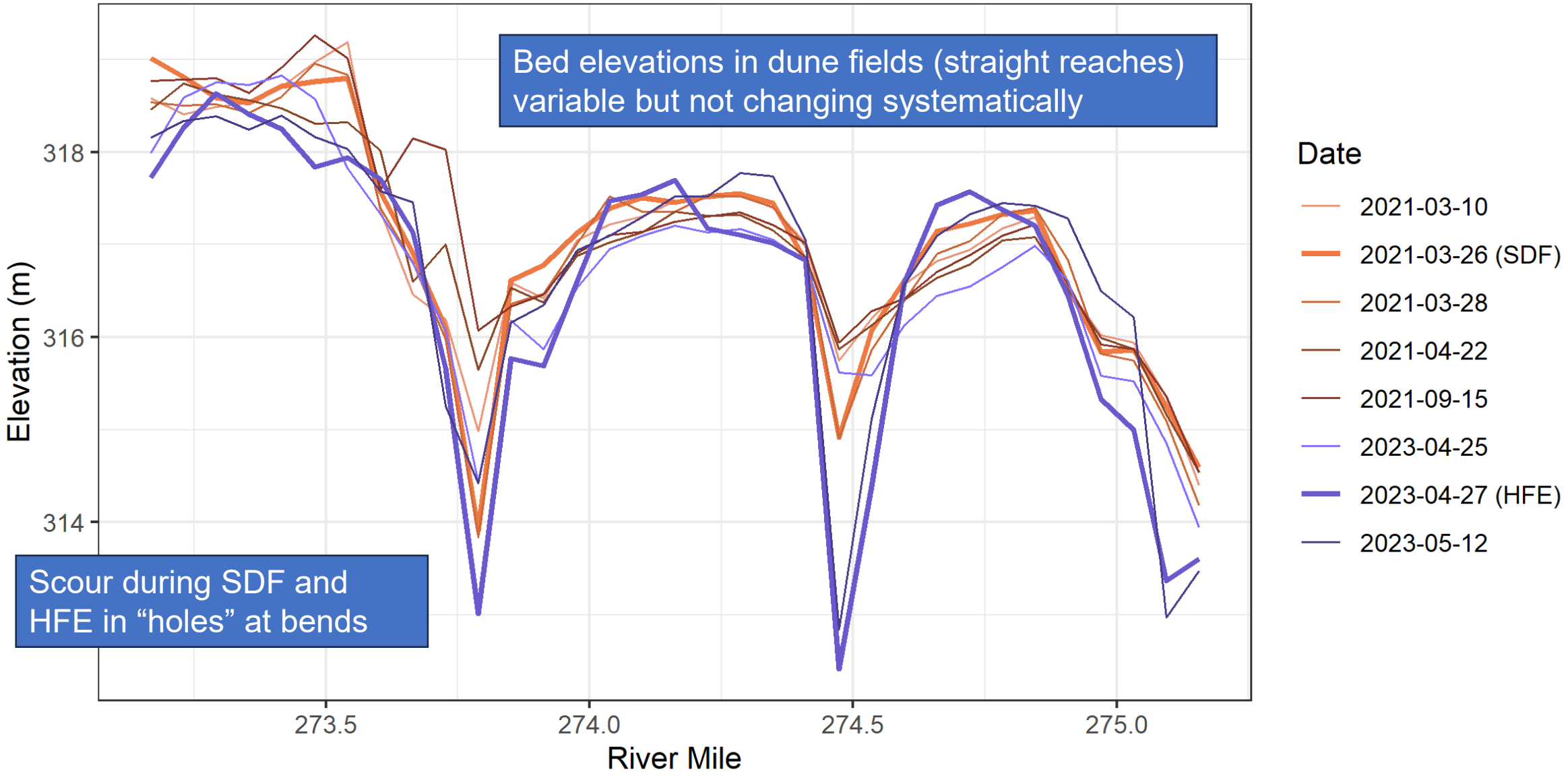
# Median bed elevation

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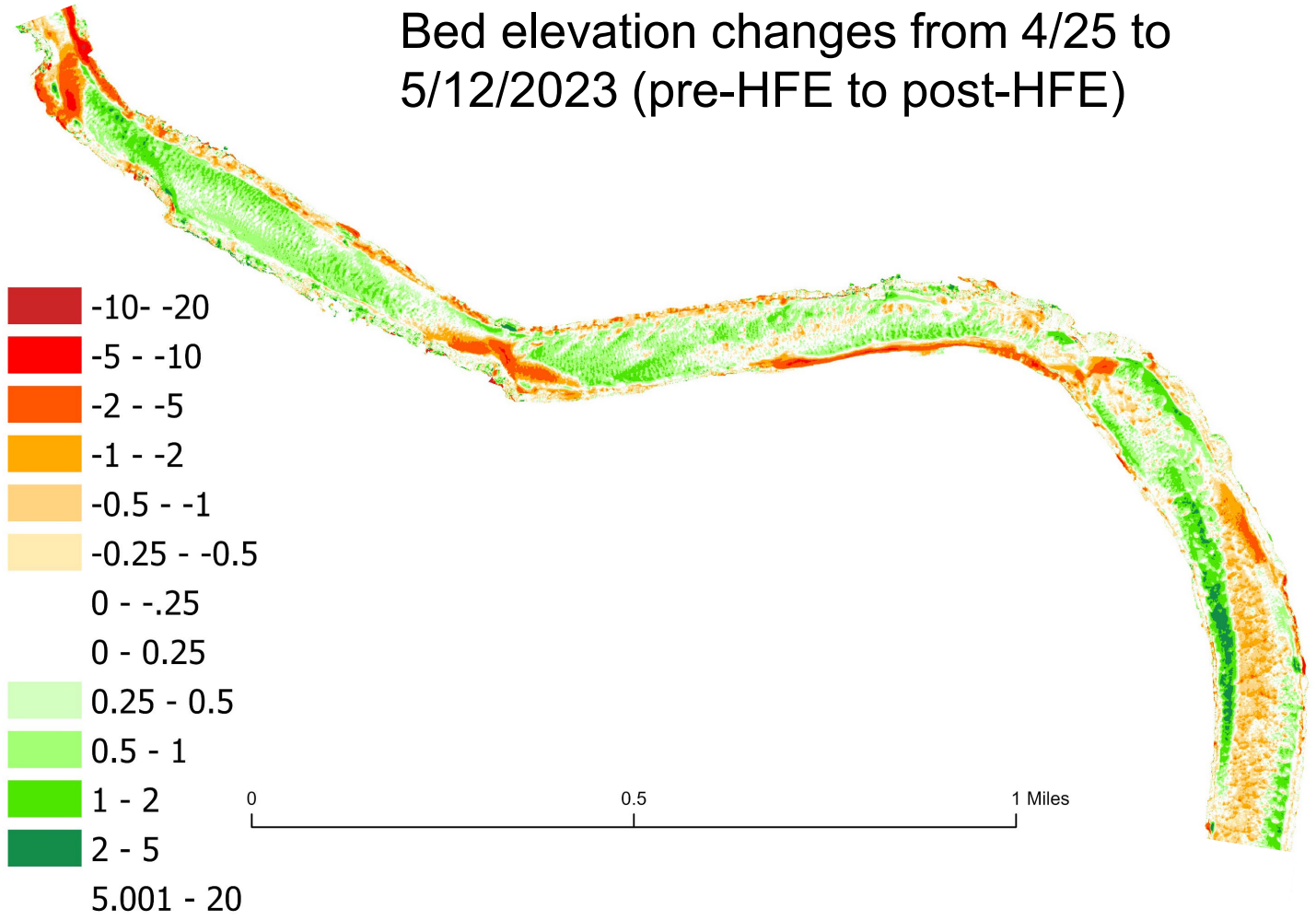
# Changes in the Riverbed

- Scour in scour holes
- No change to slight deposition or slight erosion in dune fields

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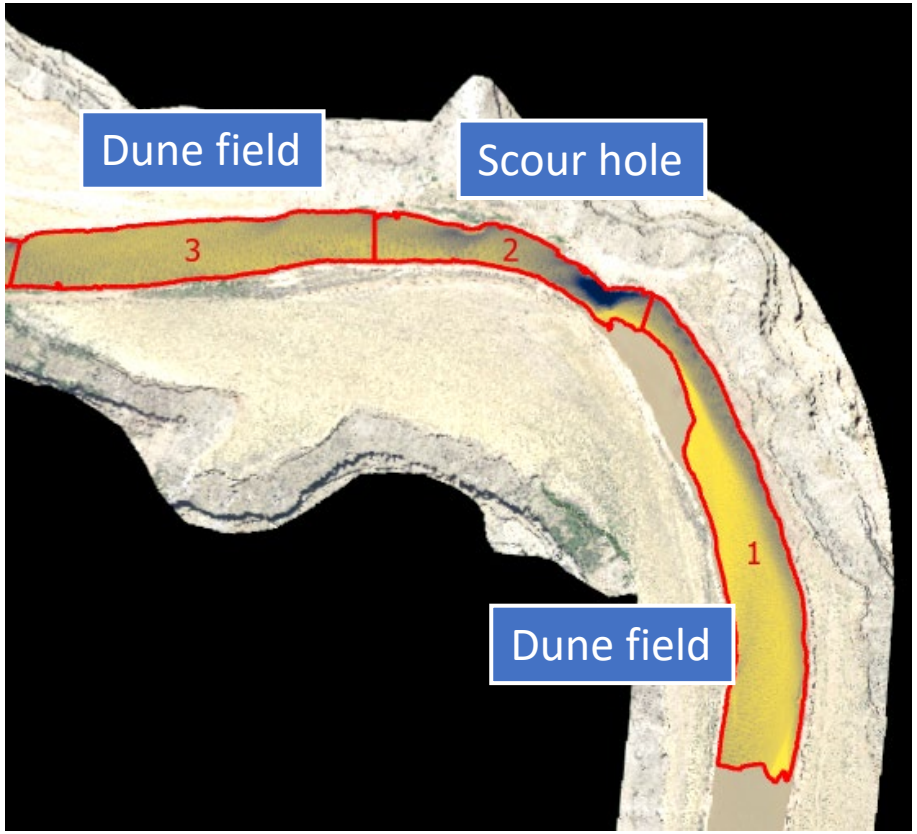
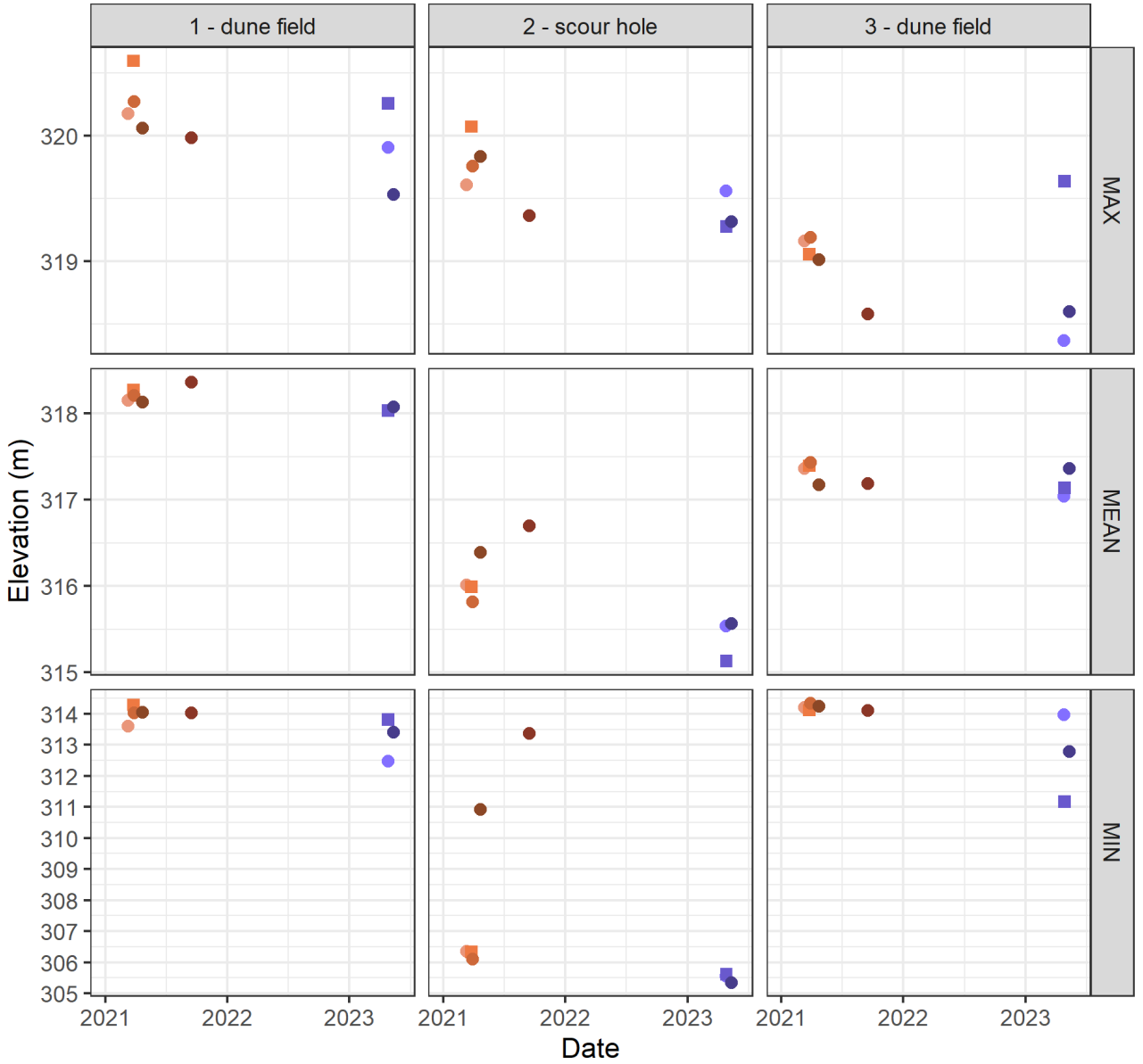
# Changes in the Riverbed by Sub-reach




*Preliminary results, subject to review, do not cite*

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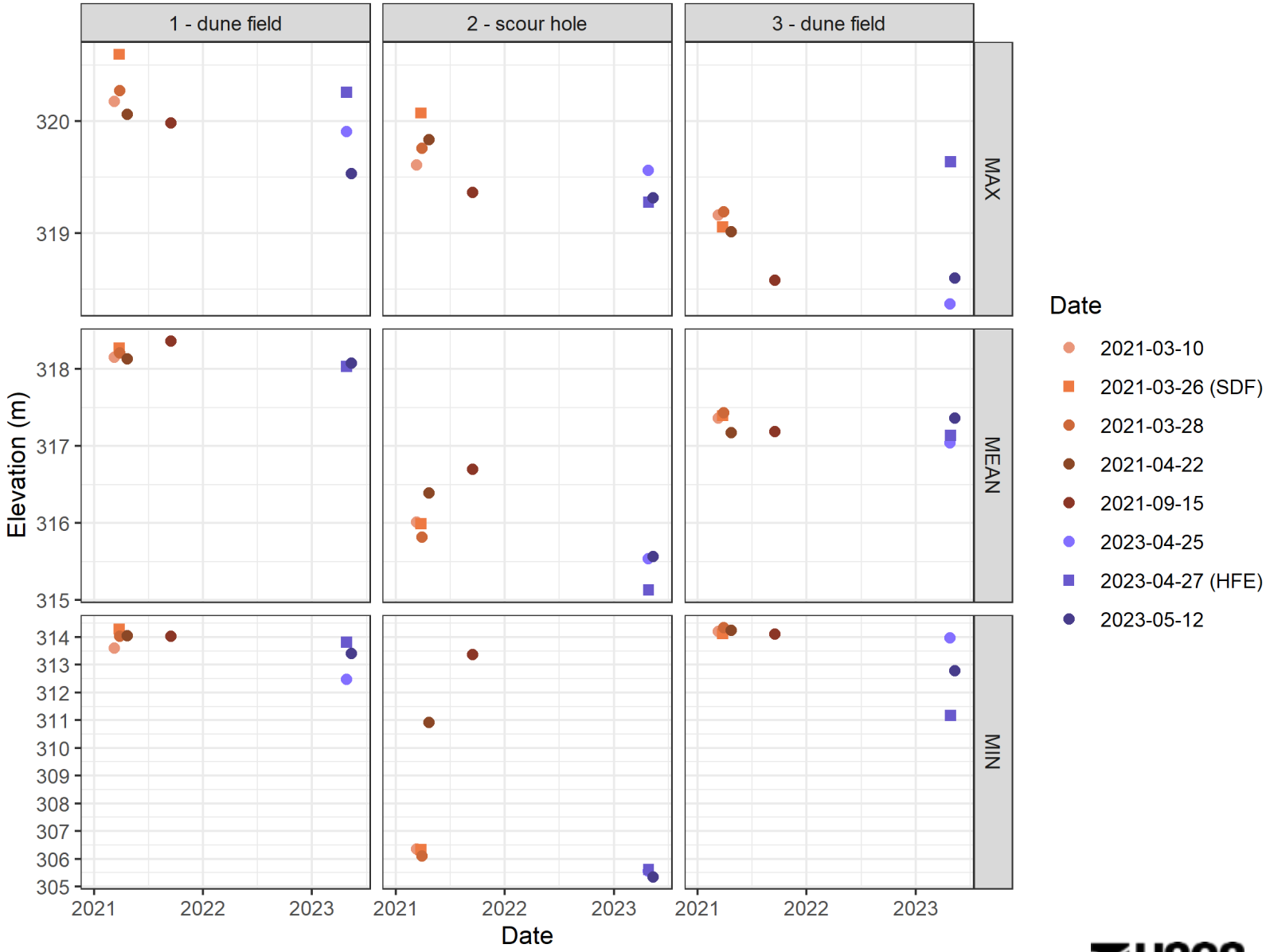
# Changes in the Riverbed by Sub-reach

Dune fields

- No systematic change in bed elevation as function of discharge.
- Max, min and mean bed elevations are similar pre- and post-SDF or HFE

Scour holes

- Scour with increasing discharge (fill back in when discharge drops)

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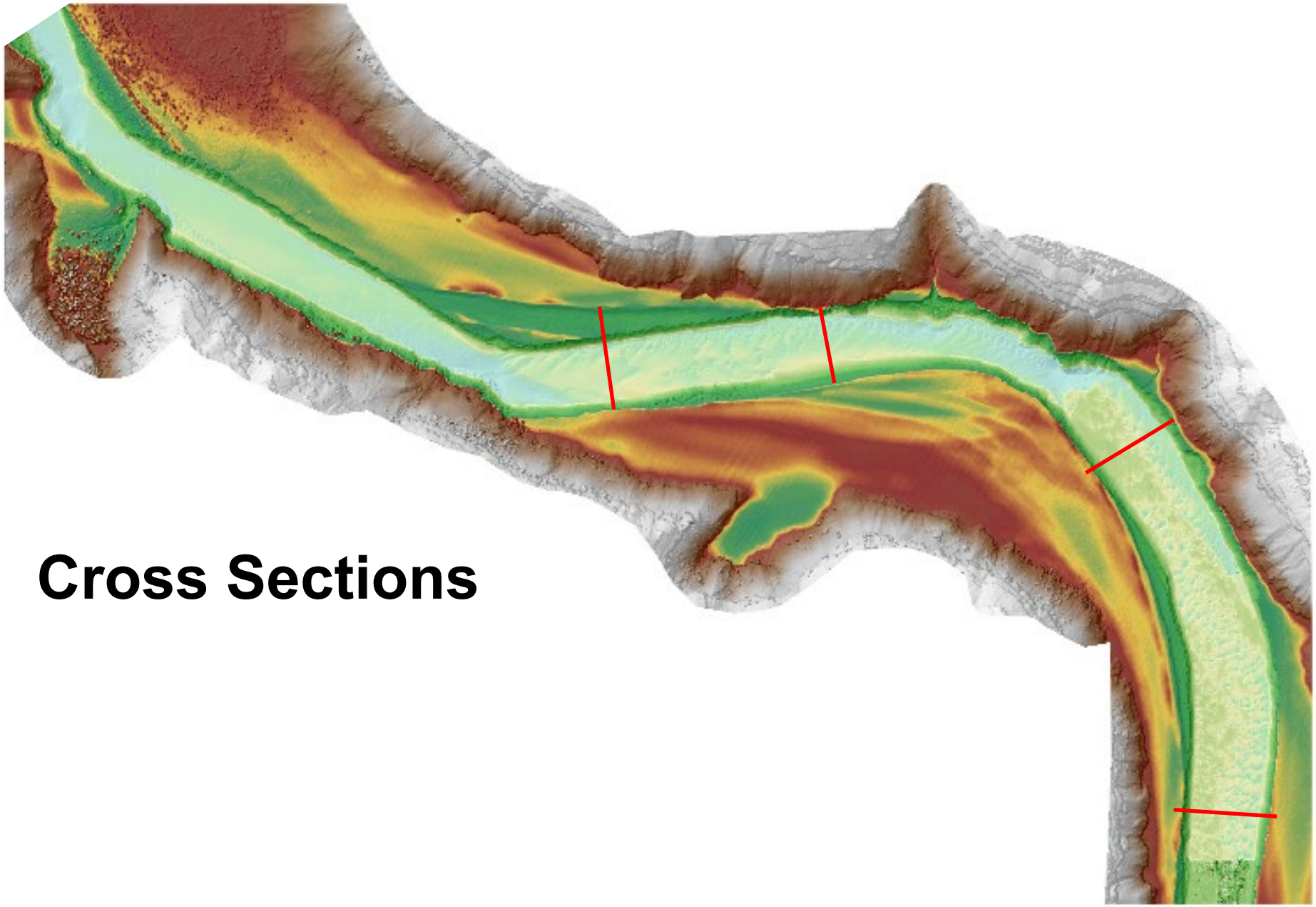
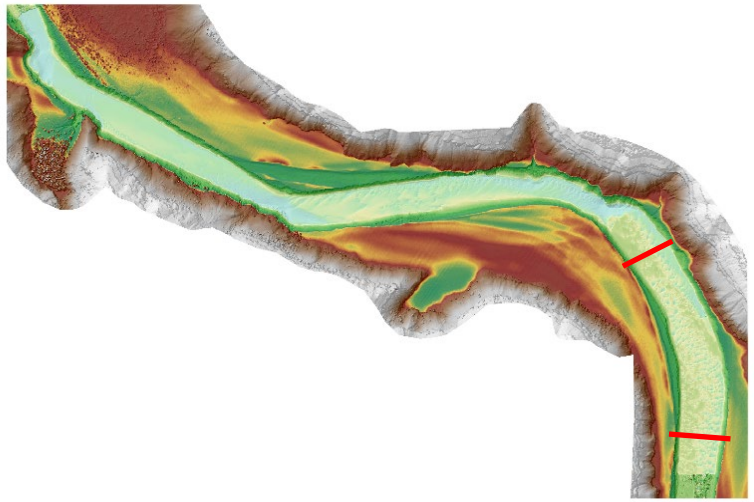
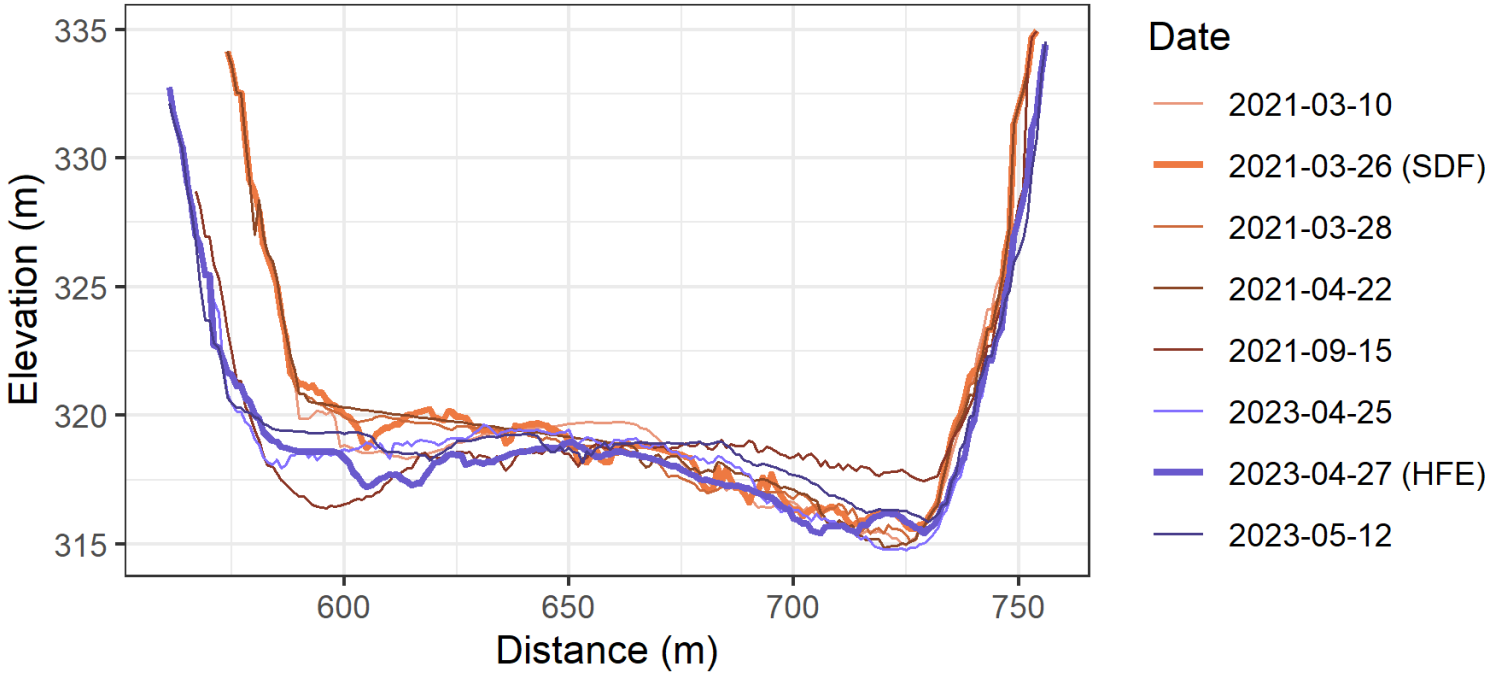


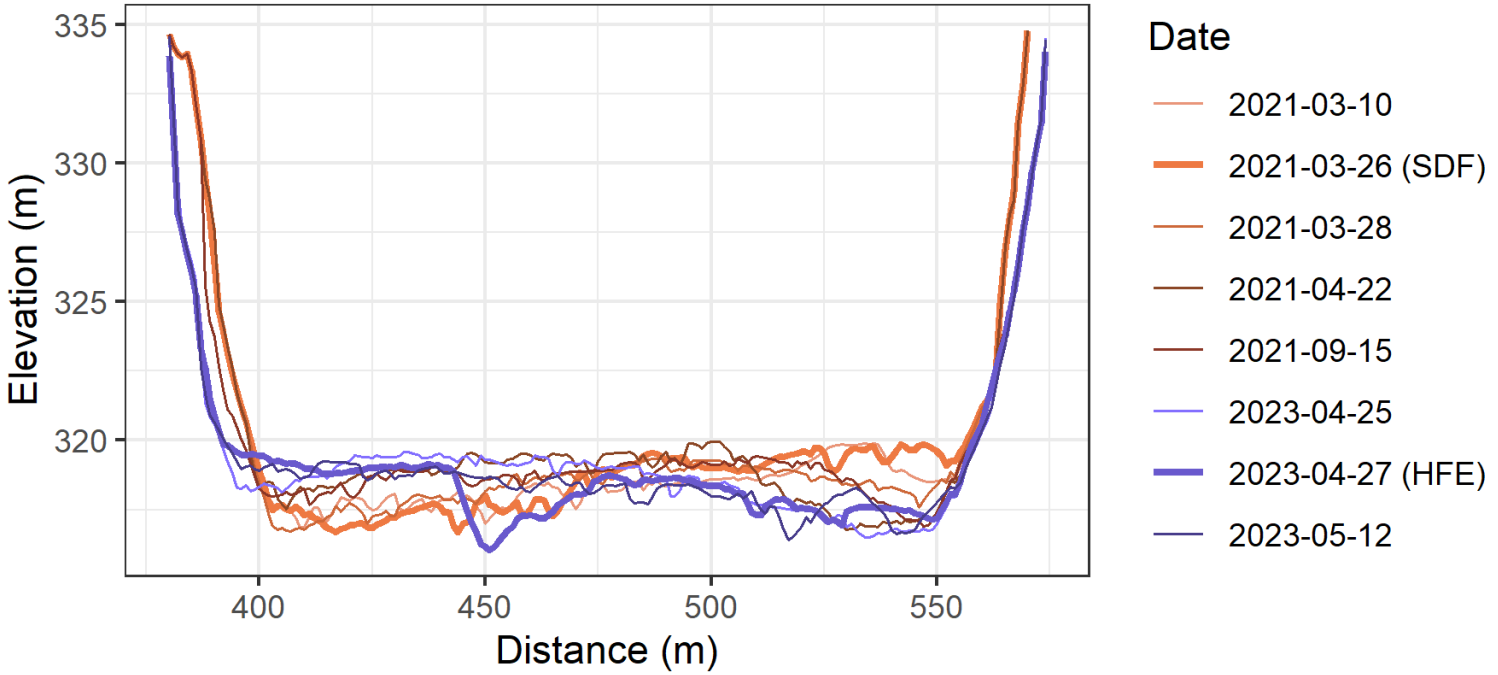
# Cross Sections

**Bank retreat in the 10's of meters over 2 years**

**Majority of bank erosion NOT associated with high flows & occurred between 2021 and 2023 surveys**



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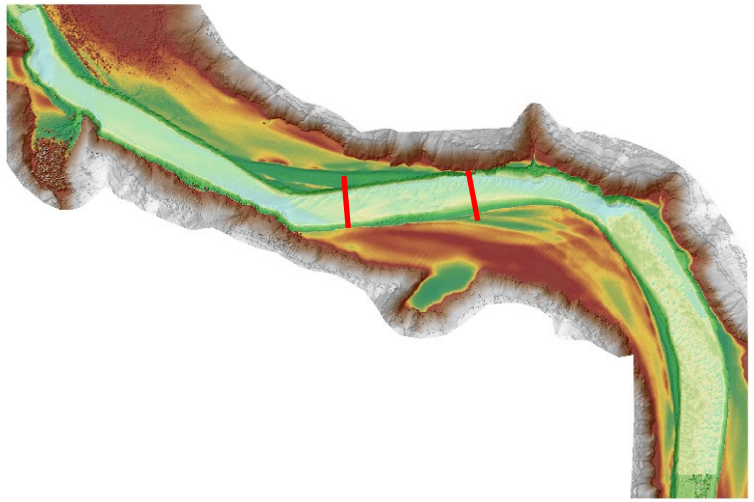
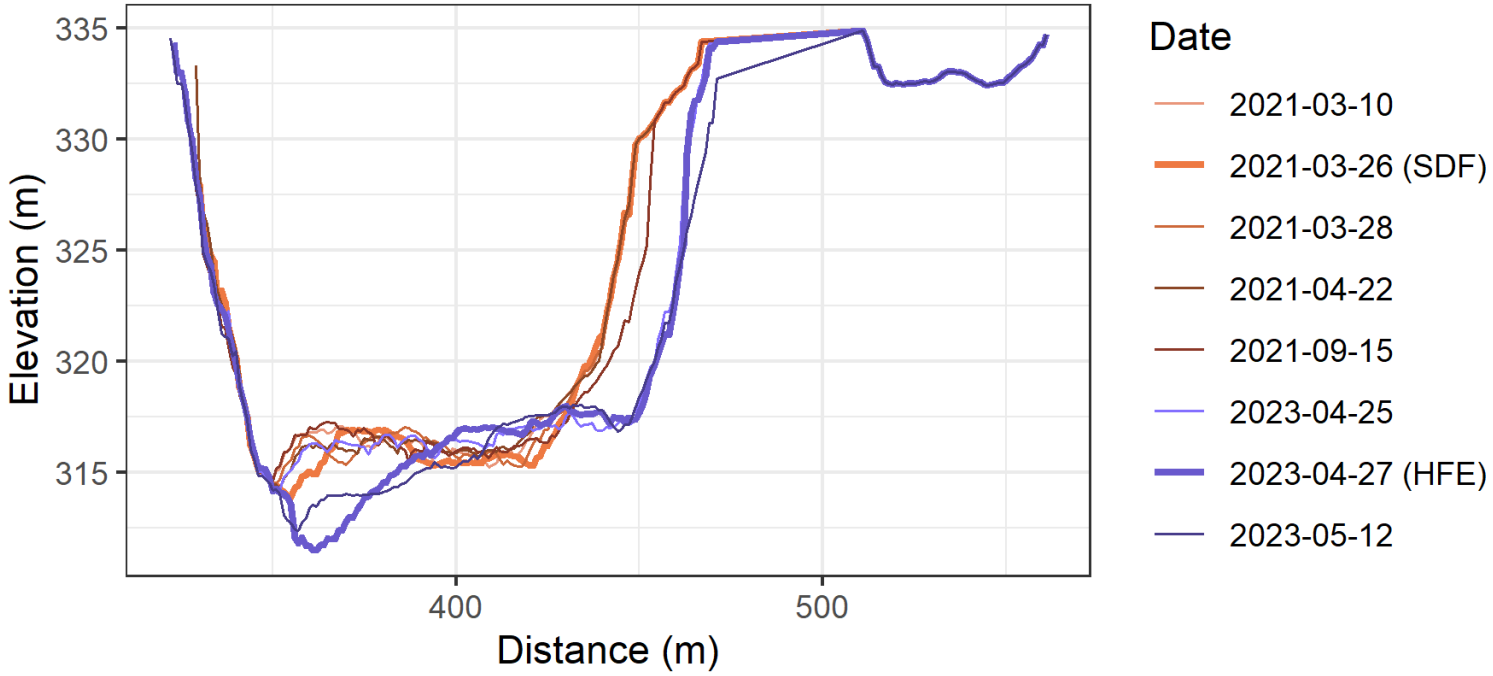
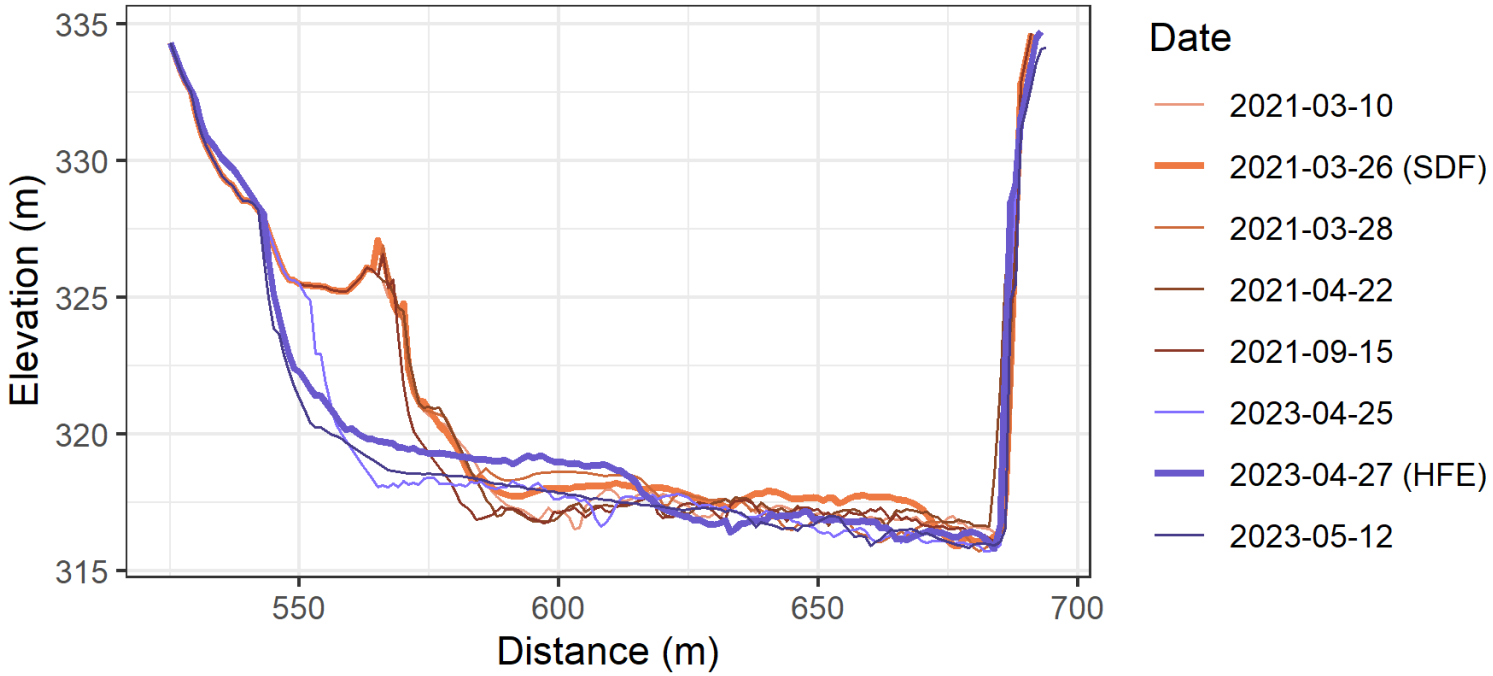
**River is getting wider, but not incising vertically – at least between 2021 & 2023**



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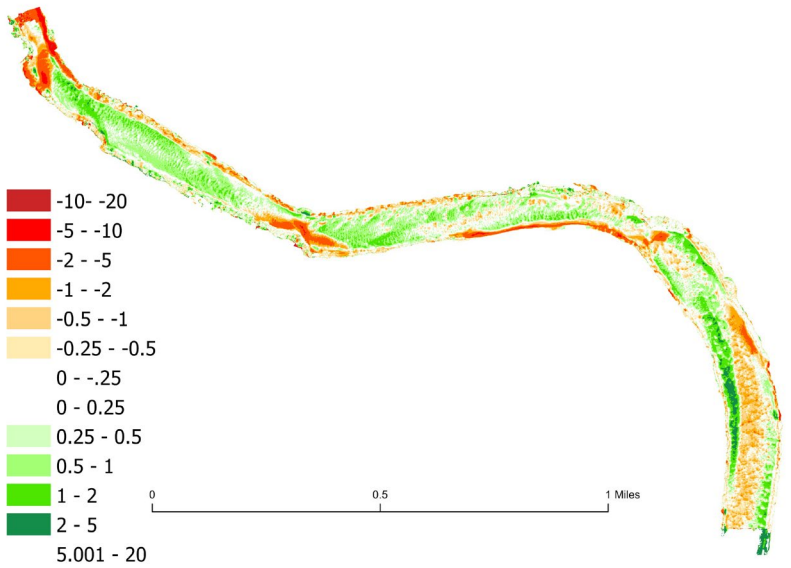
# Conclusions

- The bed in the reach is dynamic
  - 2 to 3 m of scour and fill in scour holes during high flows (SDF and HFE)
  - ~ 0.5 m of bed variability in dune fields across all flows
  - Slight aggradation of dunes during high flows, but followed by slight erosion after high flows
  - No systematic correlation between bar heights and discharge.
- Mean condition of the channel is relatively stable
  - Likely controlled by downstream Pearce Ferry Rapid
- Banks are eroding



# Future Work and Recommendations

- Complete analysis of changes in Columbine study reach.
  - Error analysis
  - Segment volume/area change
- Complete analysis of bedload sediment transport
  - Repeat surveys
- Develop Stage Discharge relationship in study reach
- Develop sediment budget for Western Grand Canyon based on transport measurements (CR at Diamond Creek) and estimates of sediment input from banks.
- Develop and calibrate numerical flow model for study reach.
- Use model to predict response to different dam operations.
- Permanent install of streamflow gage? (currently funded through FY 2024)

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# Thank You

# Questions?

Matt Kaplinski - mkaplinski@usgs.gov

Paul Grams - pgrams@usgs.gov

# Columbine Reach Bank erosion

- Time-lapse cameras capture bank erosion
- This bank eroded on July 14 and 15, 2021