Glen Canyon Dam Adaptive Management Work Group
Agenda Item Information
August 24-25, 2016

Agenda Item

Sandbar Modeling Project Update

Purpose of Agenda Item

Provide update on recent findings of sandbar-related research including the variability of eddy sandbar response during two decades of controlled flooding along the Colorado River in Marble Canyon and Grand Canyon

Action Requested

Information item only; we will answer questions but no action is requested.

Presenters

Erich R. Mueller, Research Hydrologist, U.S. Geological Survey, GCMRC

Previous Action Taken

N/A

Relevant Science

N/A

Summary of Presentation and Background Information

Repeat topographic measurements from 45 eddy sandbars throughout the Marble Canyon and Grand Canyon has demonstrated that high-flow experiments (HFEs) cause deposition of sand and increase average bar size. However, the magnitude of sandbar deposition has varied from eddy to eddy, even over short distances where flow and suspended-sediment properties were similar. We have characterized temporal trends in sandbar size and sediment storage as a function of flow, channel, and vegetation characteristics that reflect the hydraulic environment. The variability in response between sites reflects, in part, the geomorphic setting of individual fan-eddy complexes. This variability also corresponds to the degree of vegetation establishment since the 1980s when most sandbars were cleared of vegetation. Sandbars in narrow eddies are less-vegetated, water surface elevation (stage) changes rapidly with discharge, and sandbars are more dynamic. In wider settings, where stage change during floods is less, HFE deposits have become stabilized by vegetation and increased in elevation. Bar-building during floods has decreased through time at these sites. Measurements 10 months after floods in 2012, 2013, and 2014 show that average sandbar volumes may increase when floods are more frequent, especially on the high-elevation parts of bars. This likely reflects deceased erosion between HFEs at narrow, dynamic sites and continued deposition on stabilized parts of bars at wider, lower energy sites. Ideally, a geomorphic-grouping framework can be used to assess whether the long-term monitoring sites are representative and to anticipate long-term sandbar change along the 400 km river corridor.

Sandbar Modeling Update:

Geomorphic and vegetation controls on sandbar dynamics

Erich R. Mueller, Paul E. Grams, Joseph E. Hazel, Jr., and John C. Schmidt

USGS science for a changing world

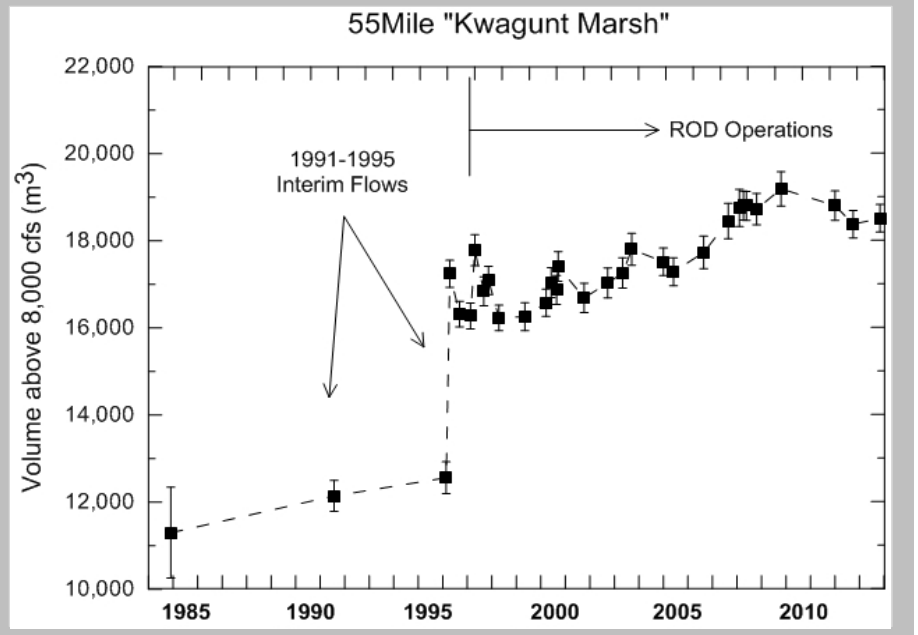
NORTHERN ARIZONA UNIVERSITY

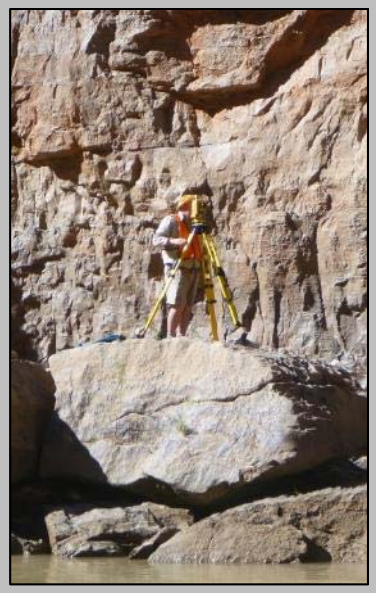
UtahState University

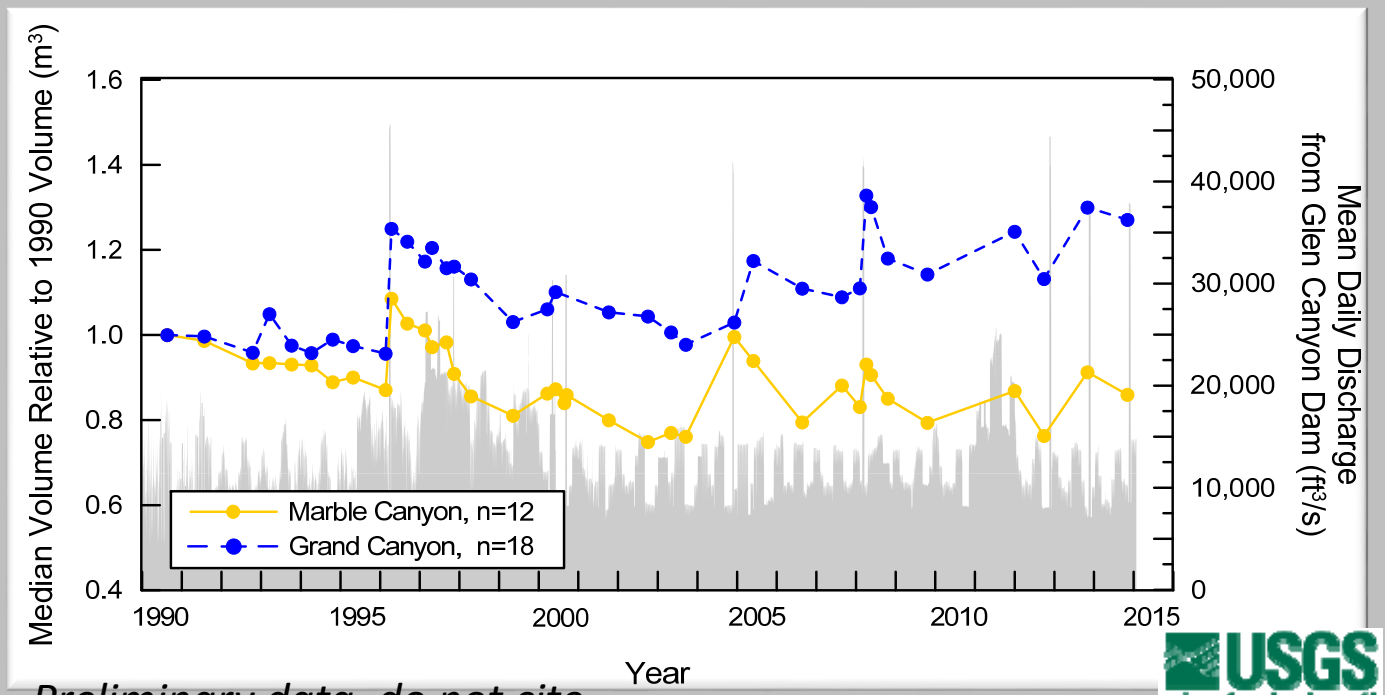
Sandbars: *Where to monitor?*

- **45 sites in 2-week trip**
- **Variable histories and trajectories**
- **No real "average"**
- **Criteria for grouping:**

I. Distance from dam
II. Eddy/Channel characteristics
III. Vegetation encroachment
IV. Narrow/wide



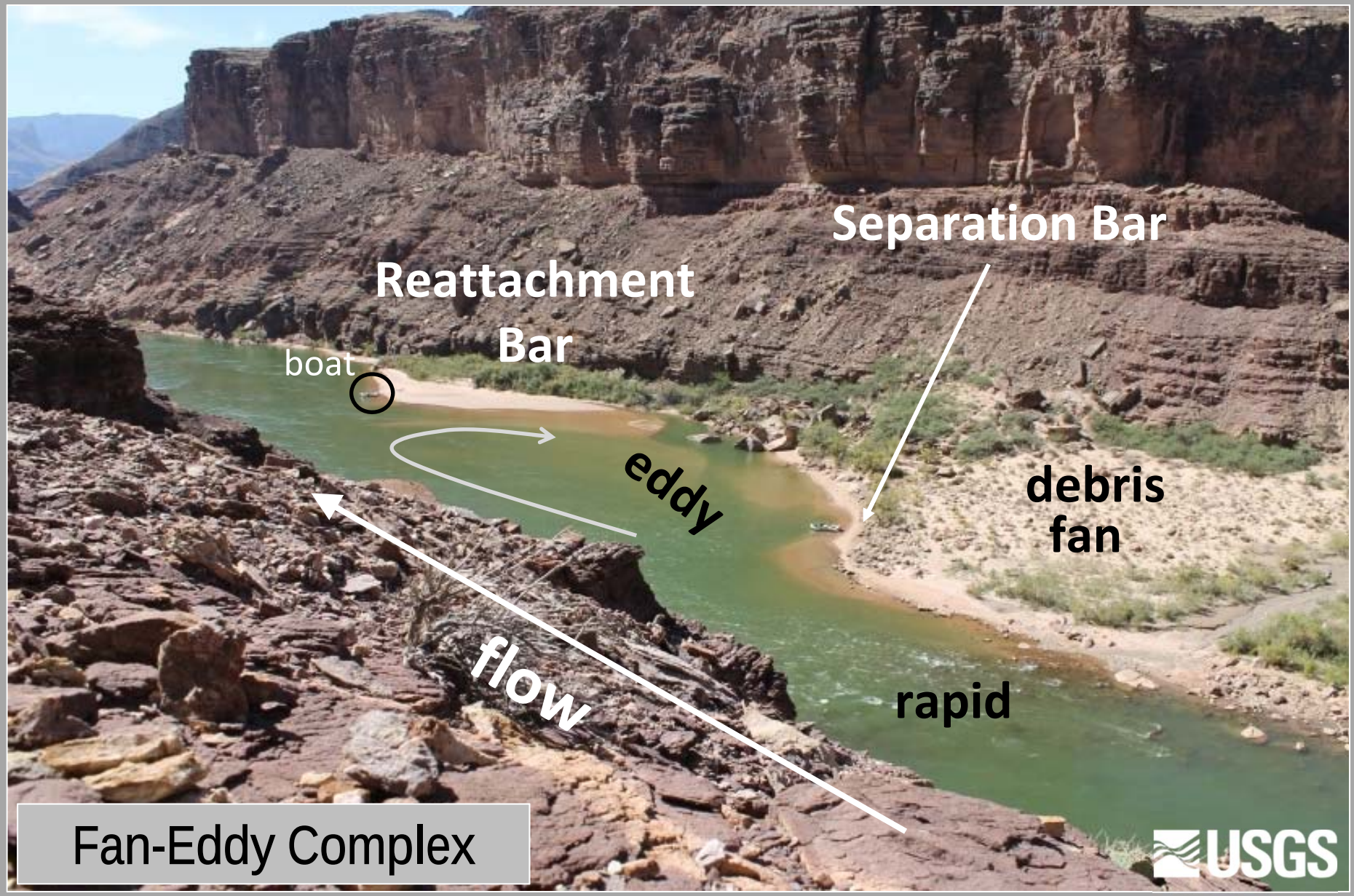




Preliminary data, do not cite

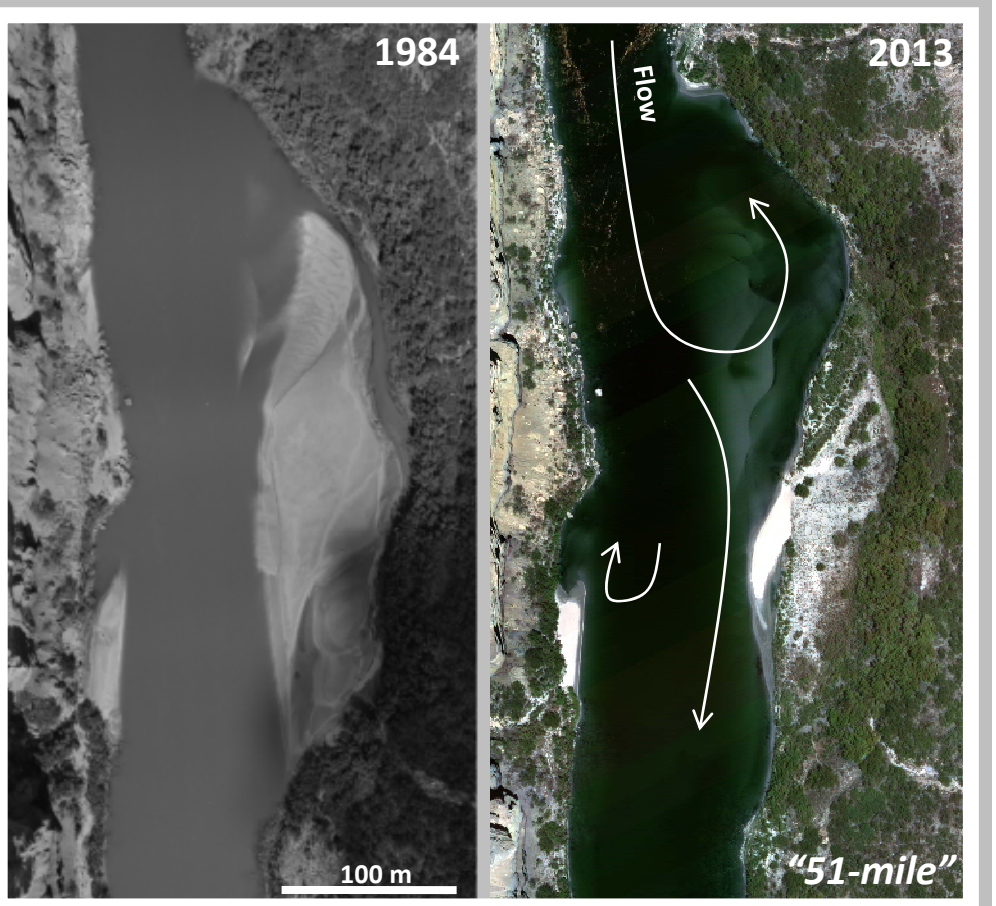
Grand Canyon is a “debris fan-dominated” canyon river

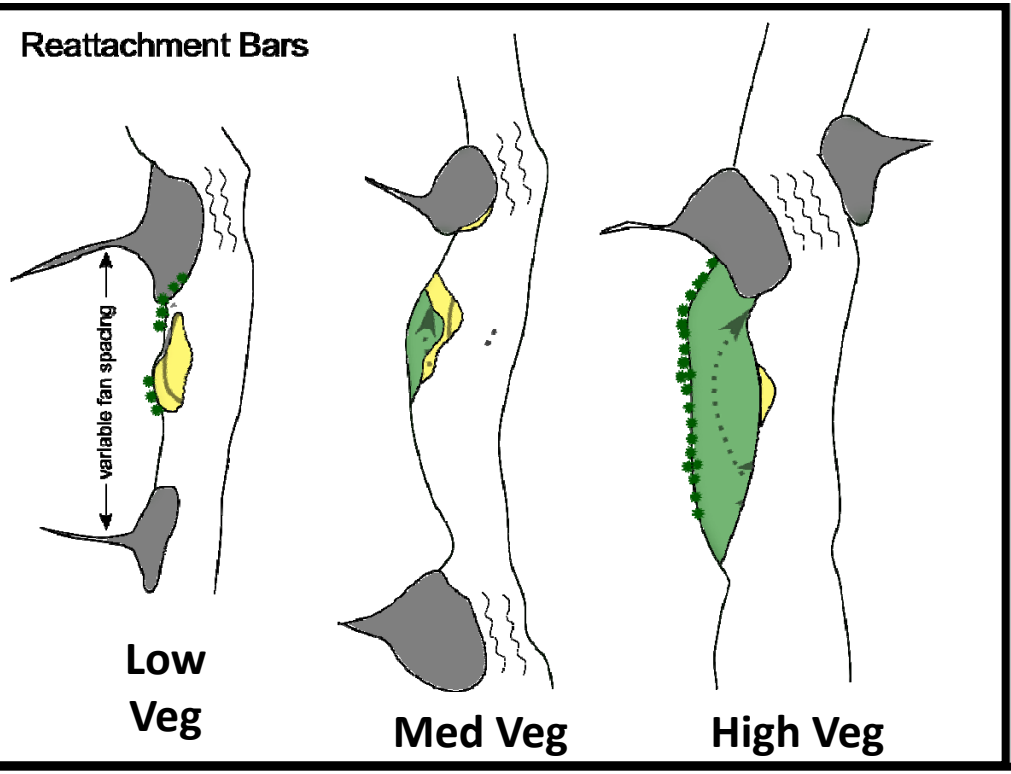
- River Morphology is strongly controlled by hydraulic interactions with debris fans



Background

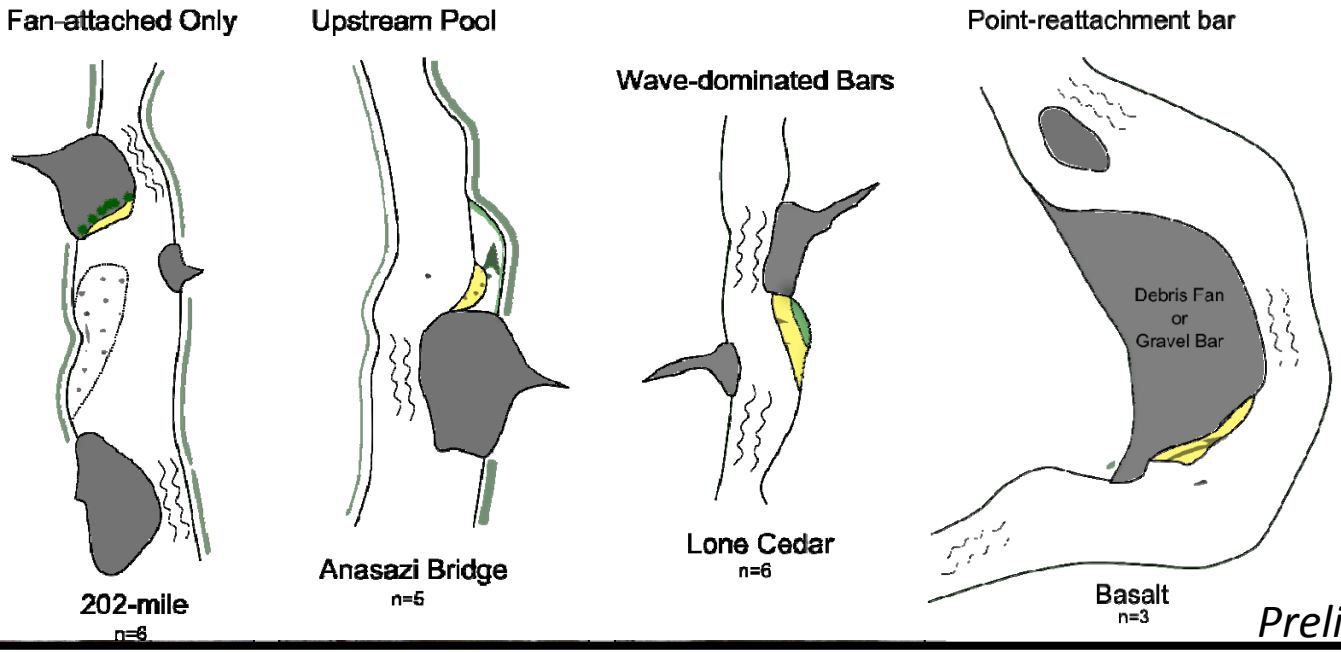
- The 1980s floods were the largest post-dam floods, approximately double recent controlled floods, and cleared vegetation from many bars
- HFEs have occurred during a period of increasing vegetation establishment
- The degree of vegetation encroachment reflects the hydraulics of longer reaches
- *What about the sandbars?*





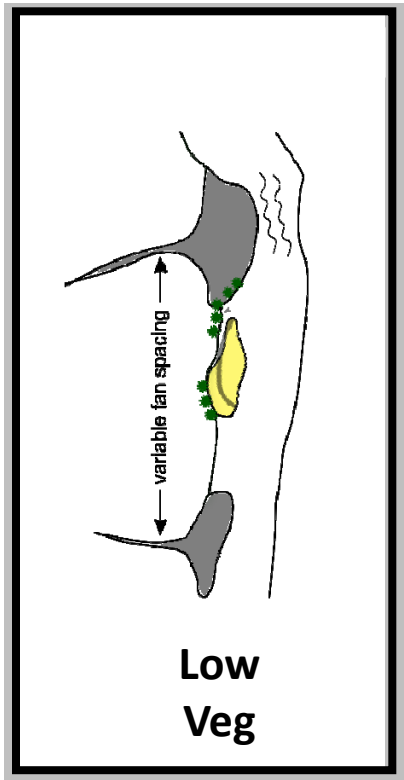
Sandbar Groupings

More than half of the long-term monitoring sites contain "typical" reattachment bars with varying degrees of vegetation encroachment

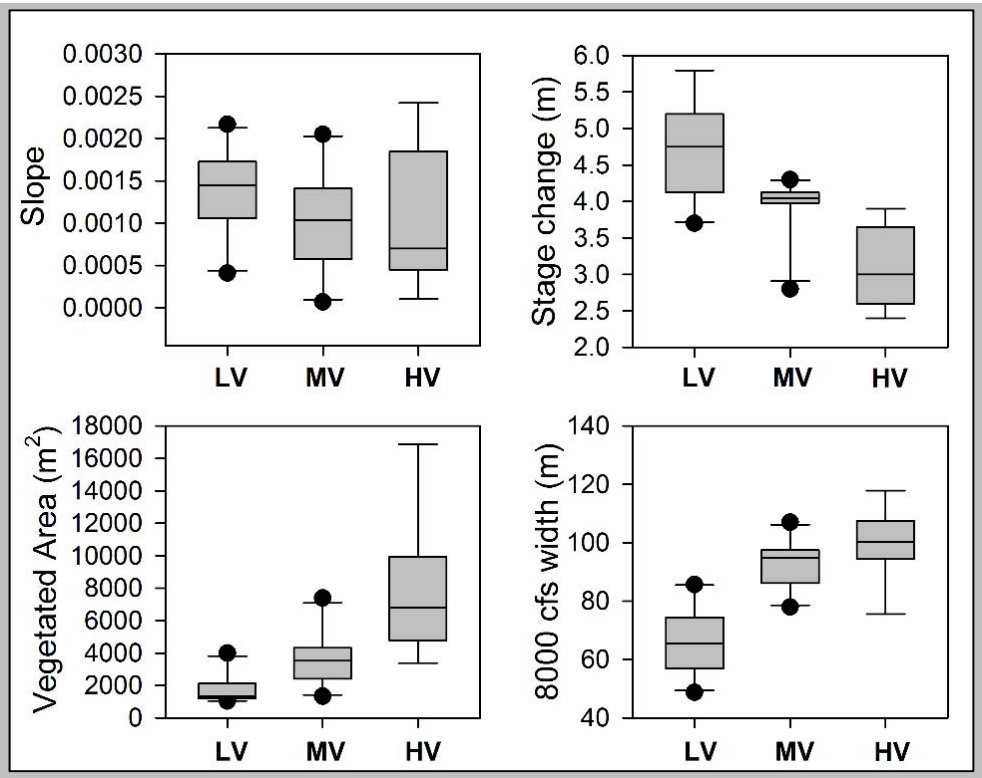


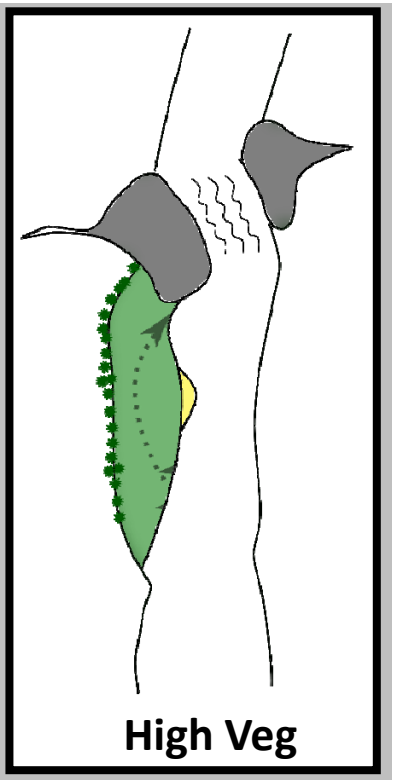
Other sandbar deposition zones common in the canyon

Preliminary data, do not cite



Low Veg





High Veg

Preliminary data, do not cite

- **Smaller bars**
- **Narrow reaches**
- **Large range in stage**

Minimal vegetation encroachment and narrowing

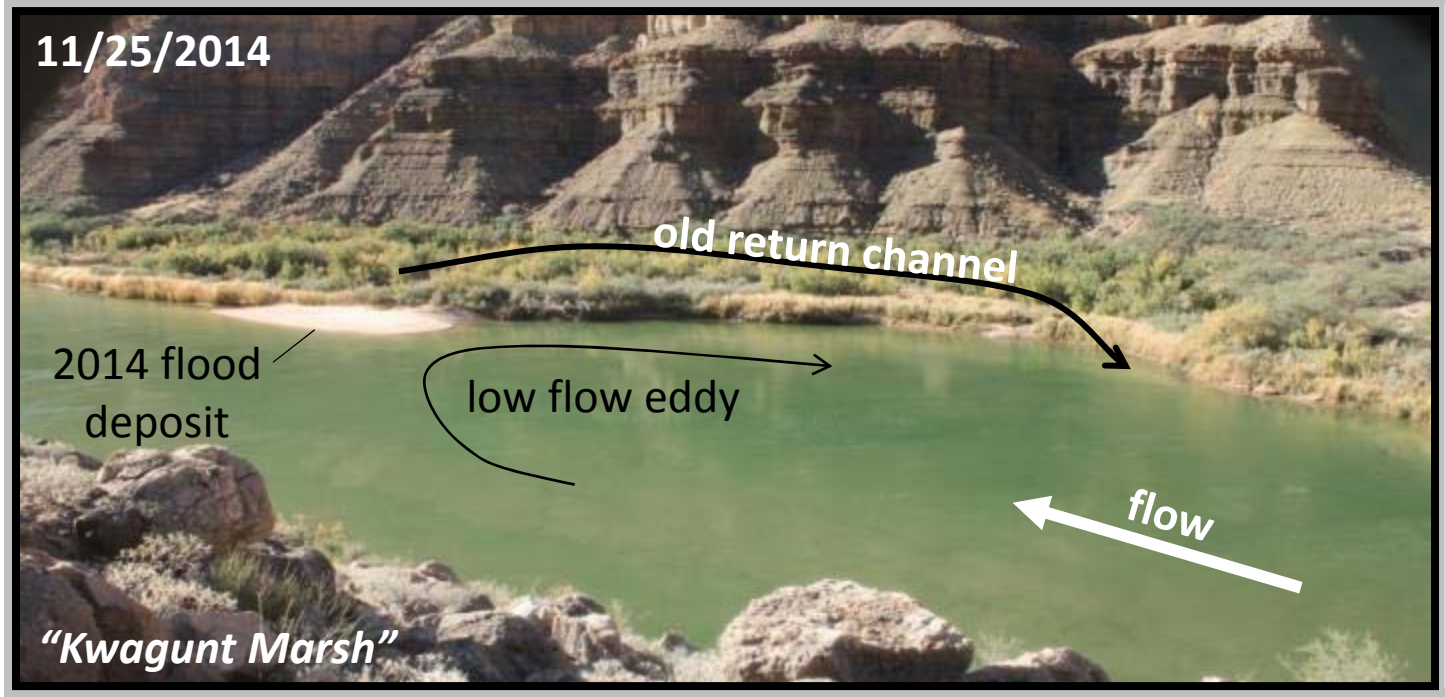
Smaller total bar area?

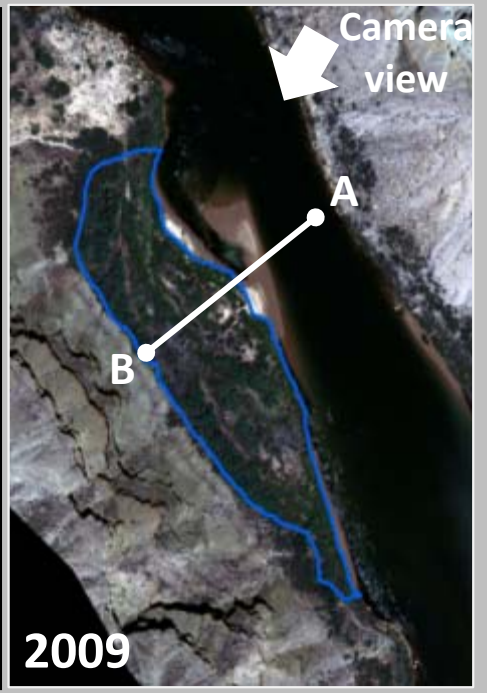
- **Larger bars**
- **Wider reaches**
- **Small range in stage**

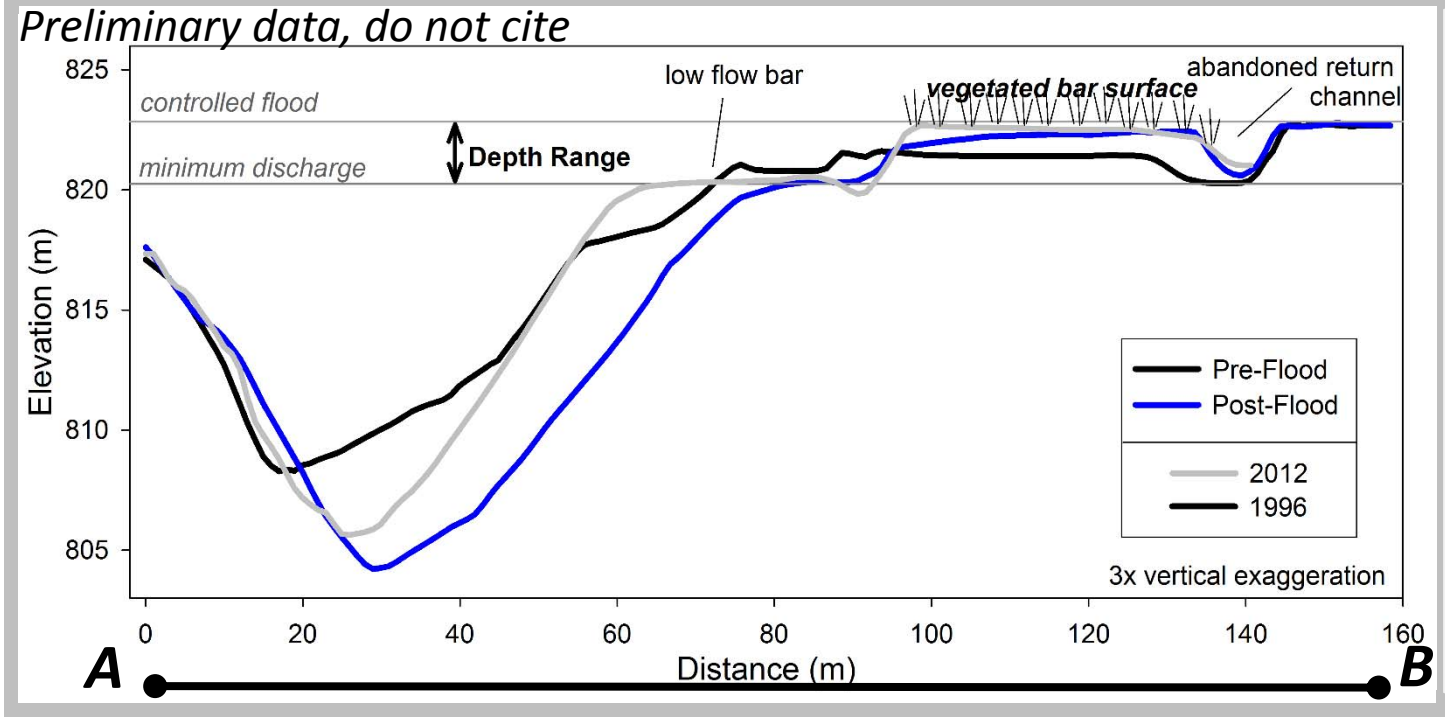
Significant vegetation encroachment and narrowing

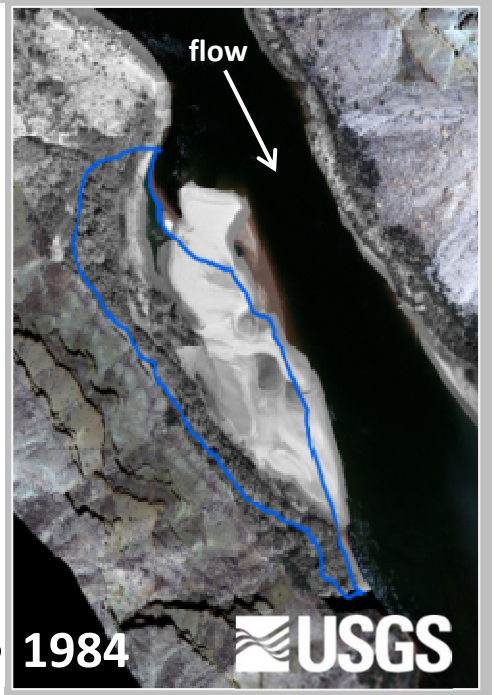
Greater total bar area?

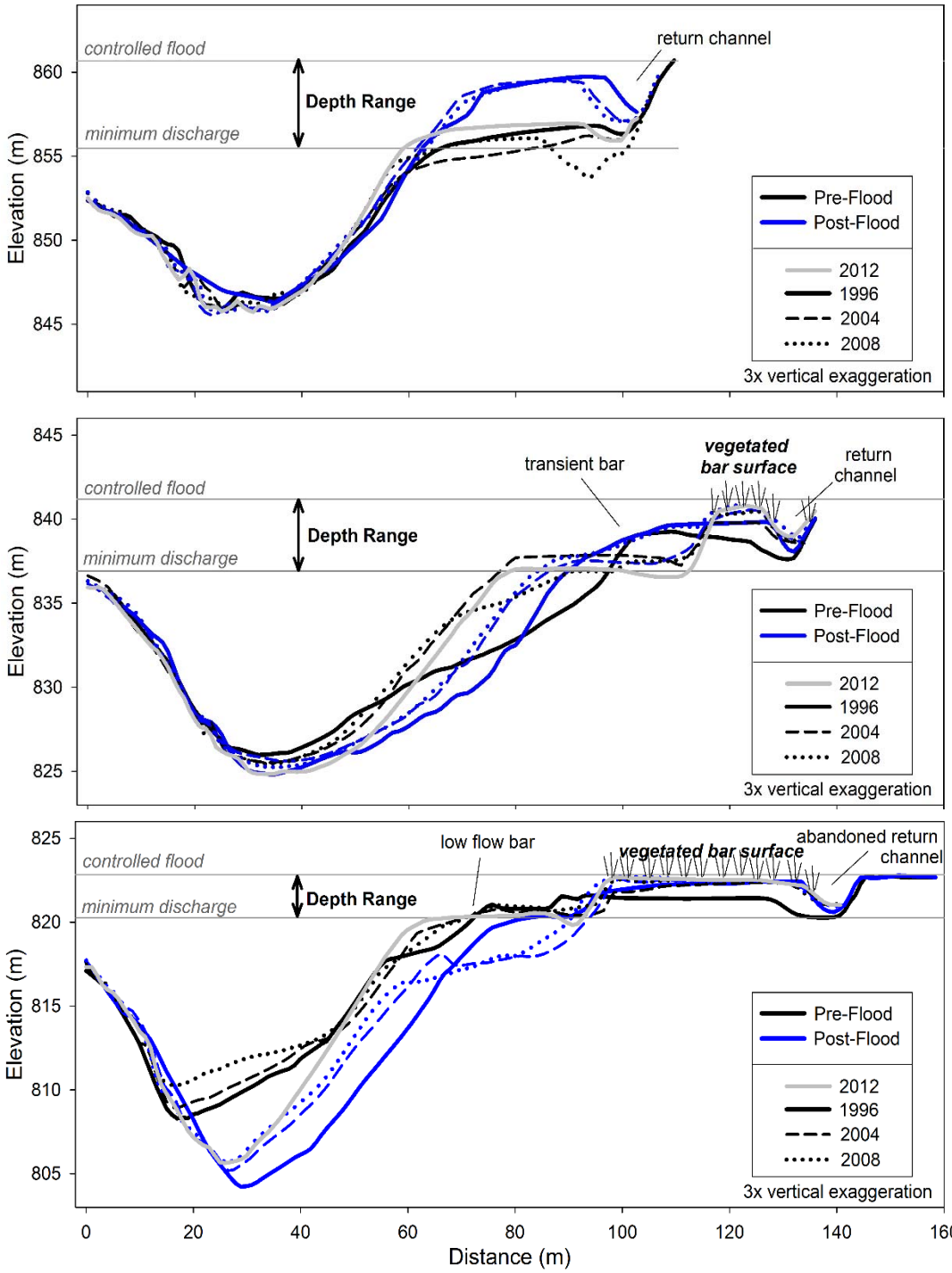
USGS

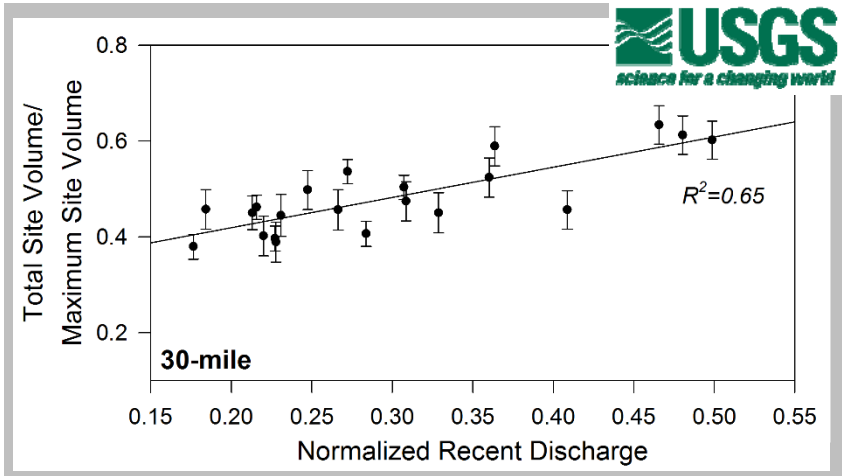

11/25/2014
old return channel
2014 flood deposit
low flow eddy
flow
"Kwagunt Marsh"

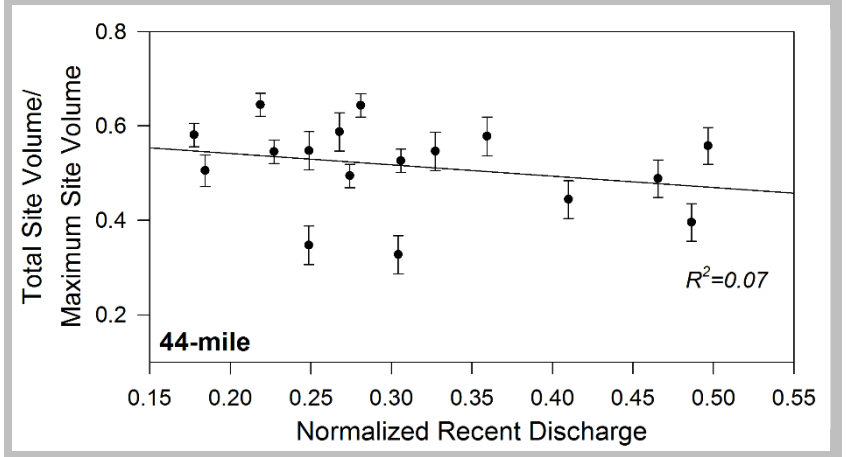

Camera view
A
B
2009

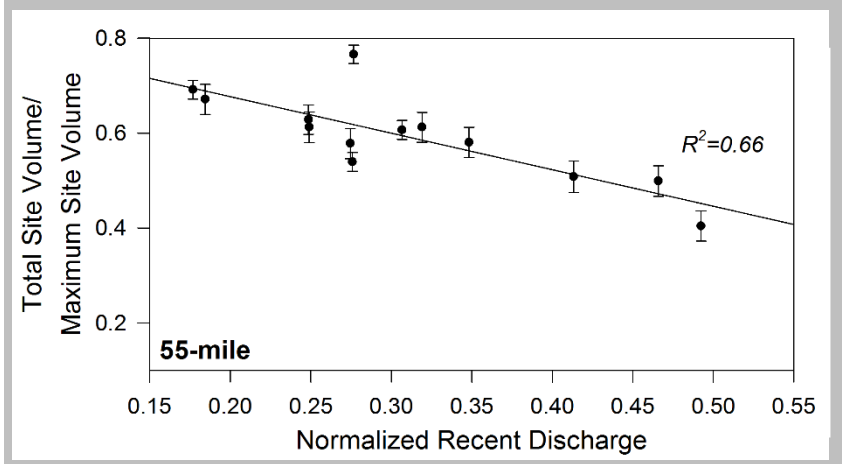

Preliminary data, do not cite
825
820
815
810
805
Elevation (m)
controlled flood
minimum discharge
Depth Range
low flow bar
vegetated bar surface
abandoned return channel
Pre-Flood
Post-Flood
2012
1996
3x vertical exaggeration
0
20
40
60
80
100
120
140
160
Distance (m)
A
B


flow
1984
USGS









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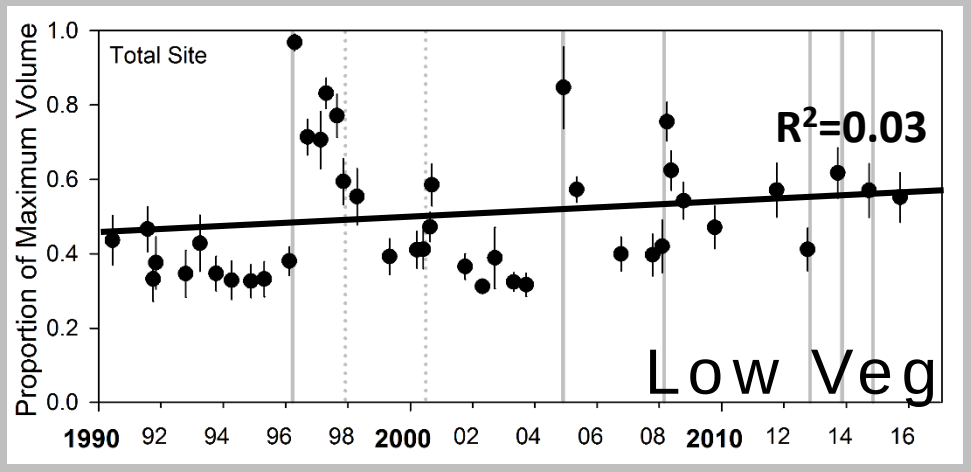
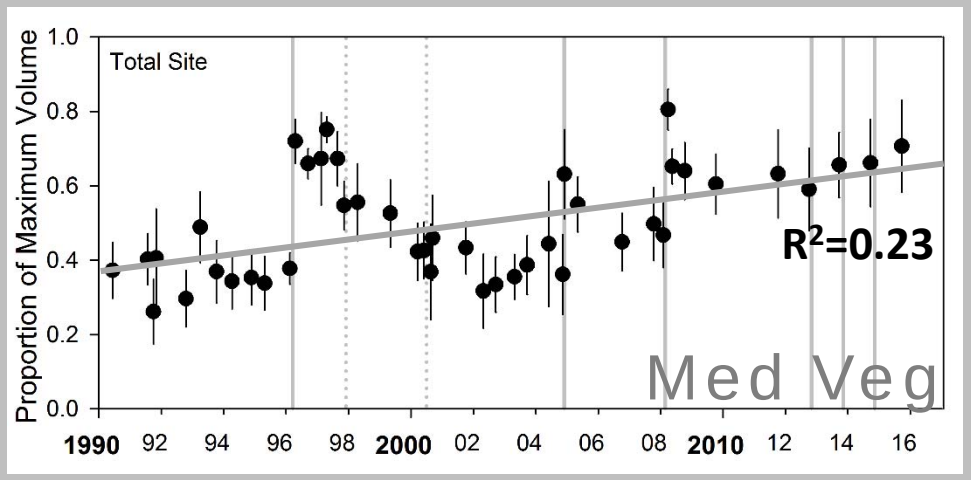
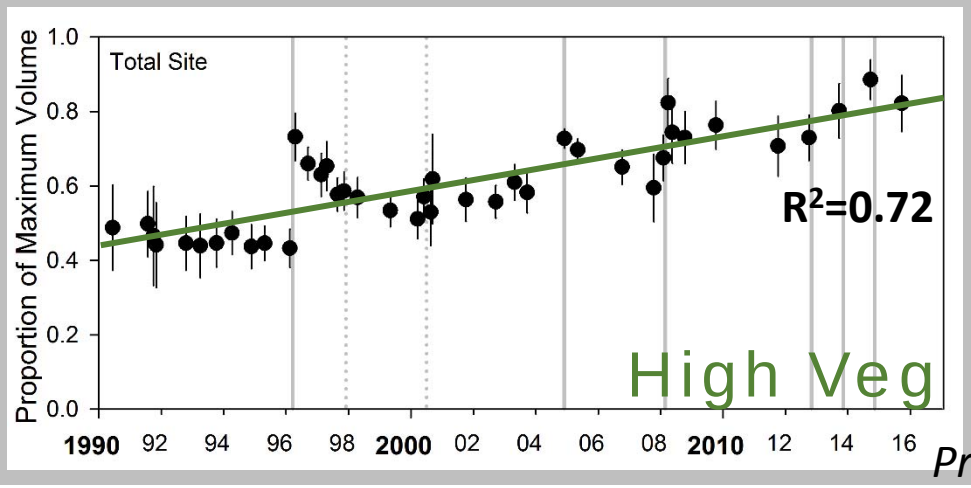




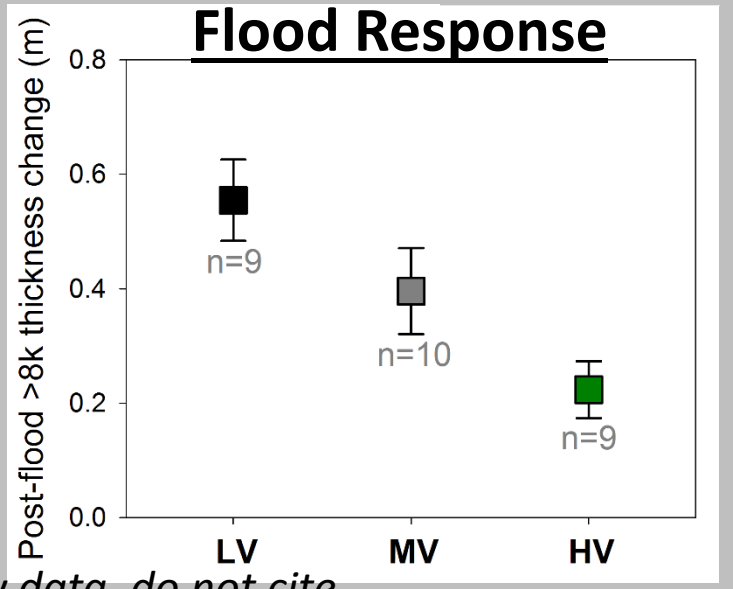


Time Series above 8000 cfs

Less-vegetated sites have little temporal trend, but show a larger response to controlled floods

Bar volume increases more steadily as vegetation establishes, but individual flood effects are muted

USGS



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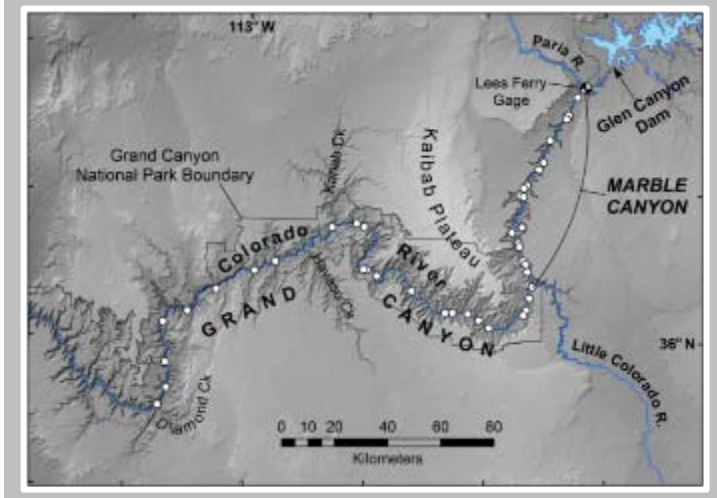
Can we scale observations from monitoring sites to entire canyon?

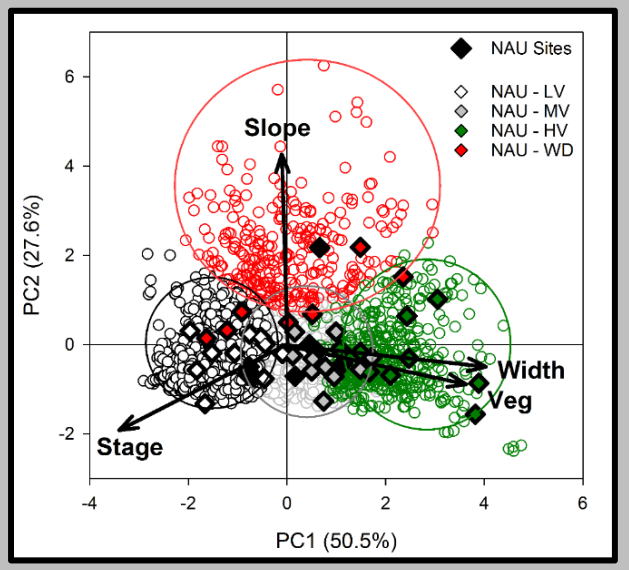
Preliminary data, do not cite



Remote Sensing

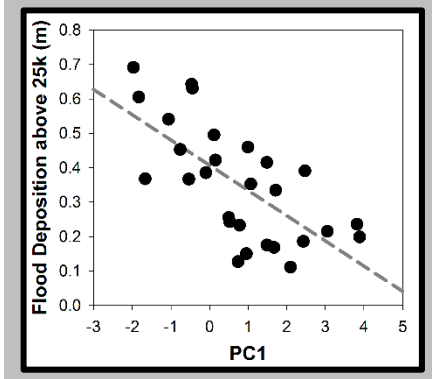
of geomorphic metrics

Site characterization

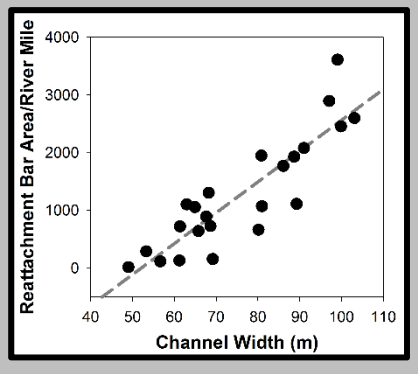


statistical classification

Sandbar Groupings



Bar Response and Occurrence

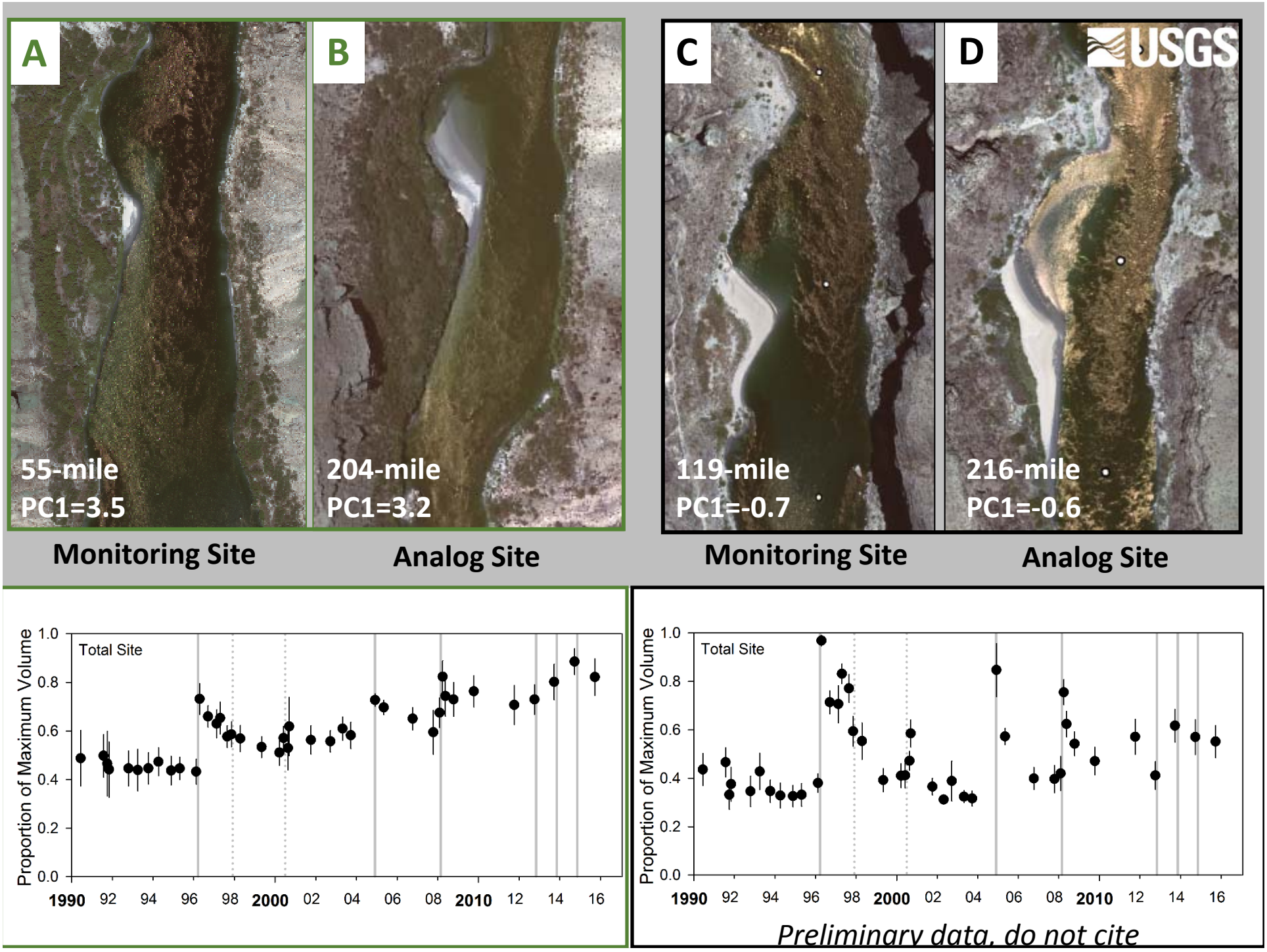


Empirical or modeled functional relationships

Better Spatial understanding of:

- **Bar response and representation by NAU sites** (local site response a different but related problem)
- **Sandbar-vegetation feedbacks**
- **Fluvial-aeolian sand linkages**

USGS


A
B
C
D
USGS
55-mile
PC1=3.5
204-mile
PC1=3.2
119-mile
PC1=-0.7
216-mile
PC1=-0.6
Monitoring Site
Analog Site
Monitoring Site
Analog Site
Total Site
Proportion of Maximum Volume
1.0
0.8
0.6
0.4
0.2
0.0
1990
92
94
96
98
2000
02
04
06
08
2010
12
14
16
Total Site
Proportion of Maximum Volume
Preliminary data, do not cite

Conclusions

- Vegetation stabilization of bars causes vertical accretion and channel narrowing, especially in wider parts of the river corridor
- More dynamic bars tend to be in higher energy settings where the channel is narrower and stage changes rapidly with discharge
- Trends at long-term monitoring sites are better understood by grouping like-bars, and may provide an analog for understanding canyon-wide bar behavior

Acknowledgements

This work was supported by the Glen Canyon Adaptive Management Program.

Many scientists, field technicians, and boat operators assisted in data collection during more than two decades of monitoring, including Matt Kaplinski, Rob Ross, Bob Tusso, Dan Buscombe, Tom Gushue, Barbara Ralston, Emily Palmquist, Daniel Sarr and many more.