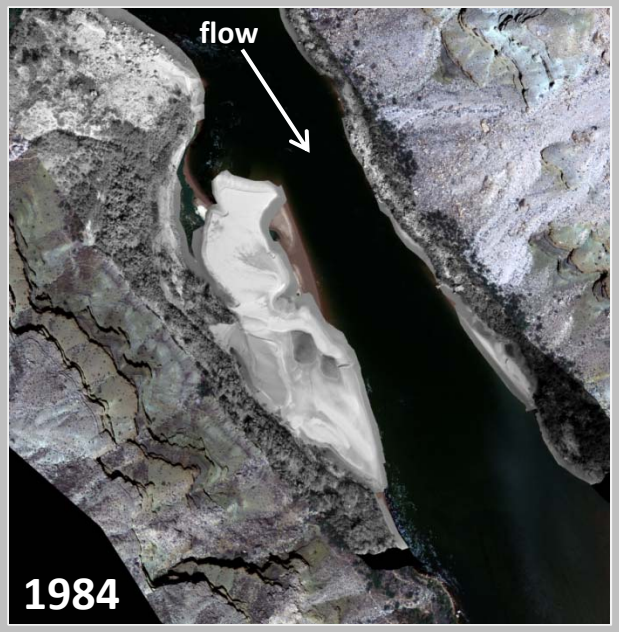
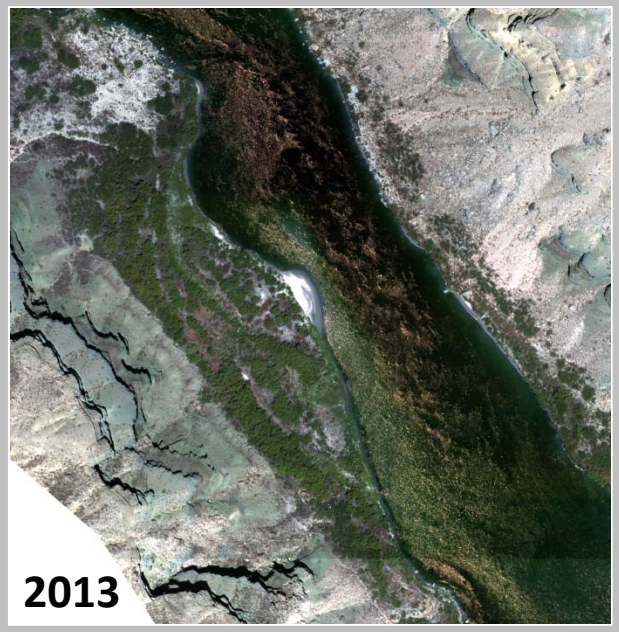
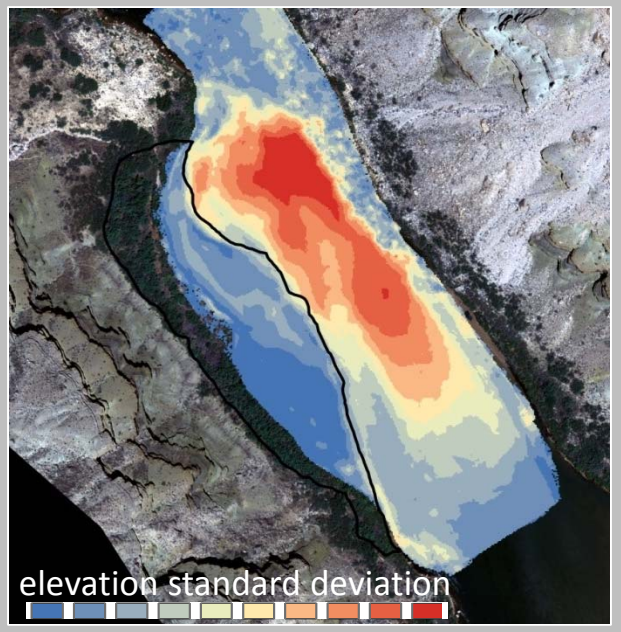
Linkages between controlled floods, eddy sandbar dynamics, and riparian vegetation along the Colorado River in Marble Canyon, Arizona







Erich R. Mueller, Paul E. Grams, Joseph E. Hazel, Jr., Daniel Sarr, and Mark Schmeeckle

USGS science for a changing world

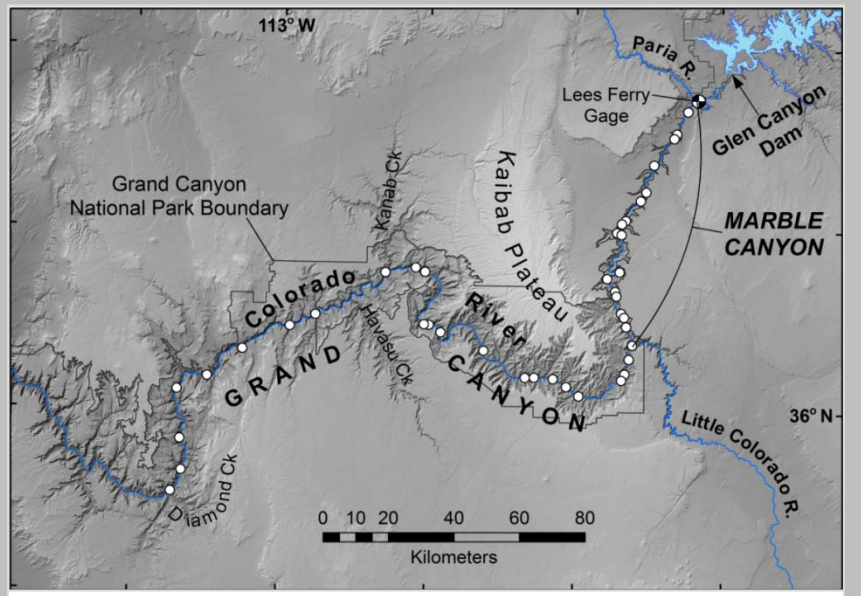
NORTHERN ARIZONA UNIVERSITY

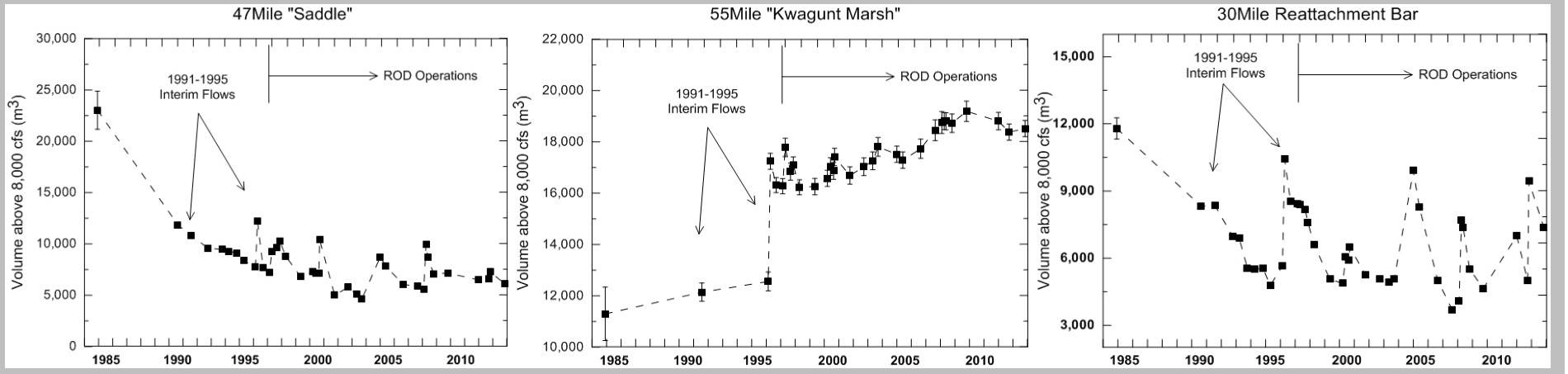
ASU

Sandbars: *Where to monitor?*

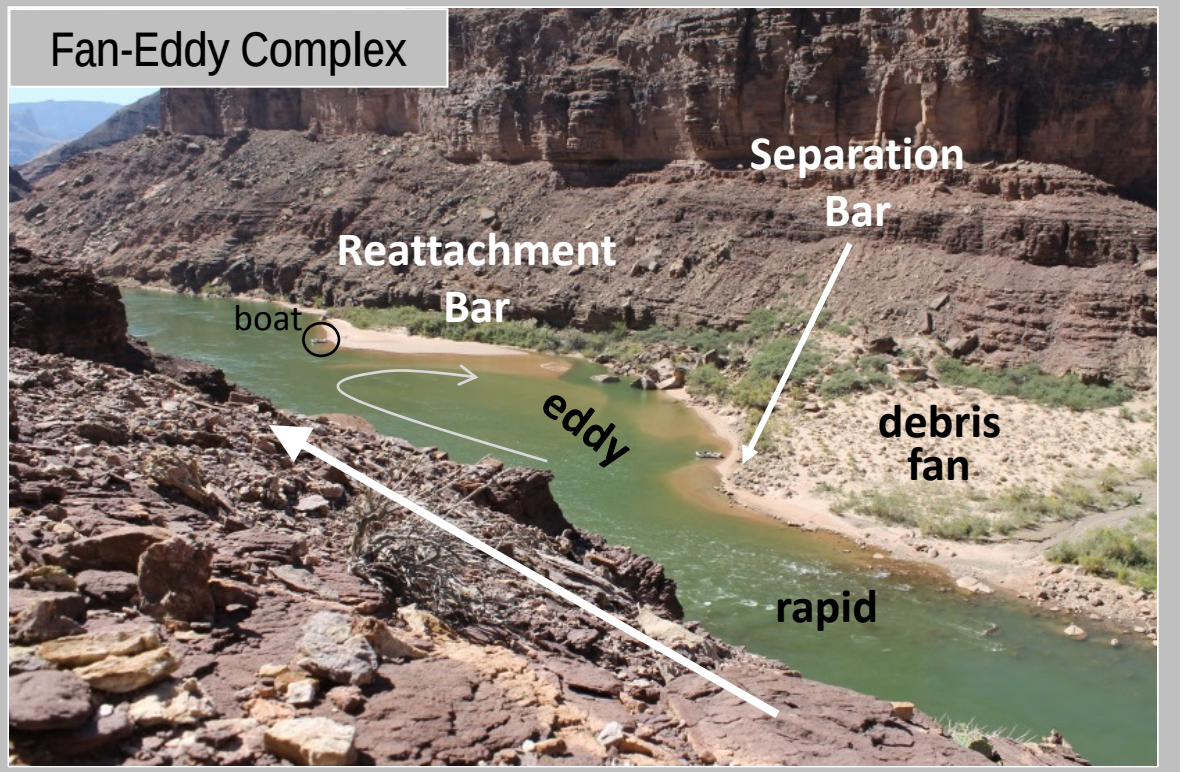
- **Variable histories and trajectories**
- **No real "average"**
- **45 sites in 2-week trip** (must be selective)
- **Criteria for grouping:**

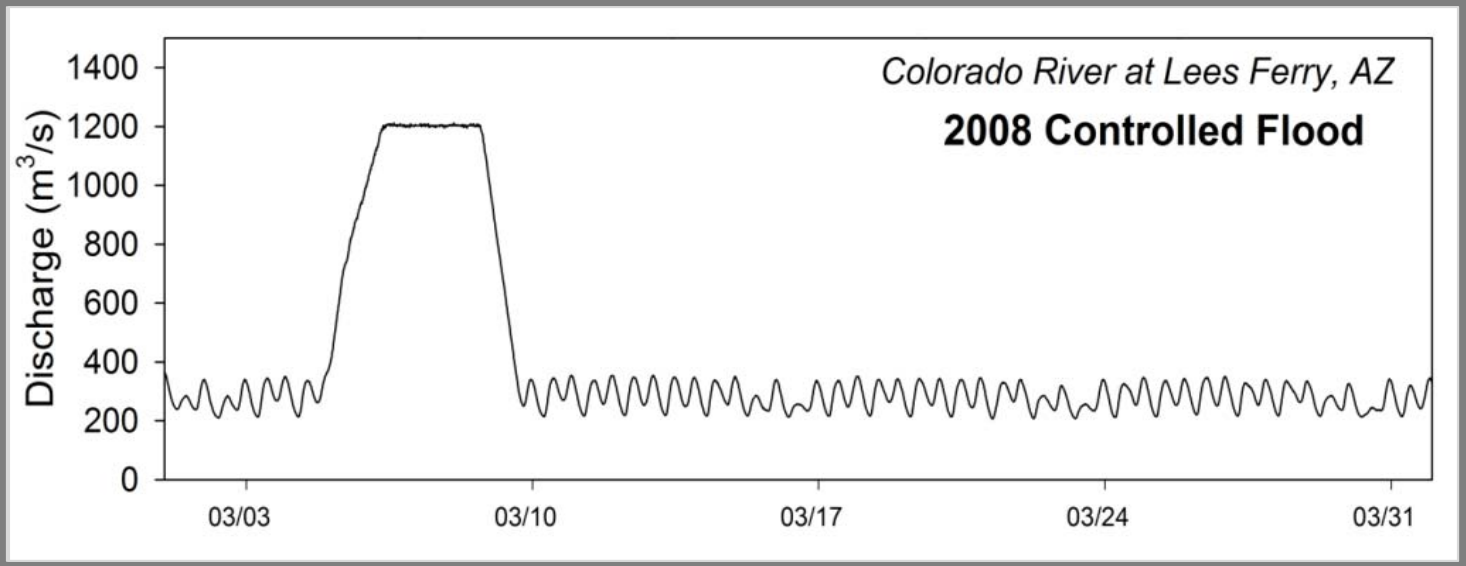
  I. Distance from dam
  II. Narrow/wide
  III. Eddy characteristics
  IV. Vegetation?





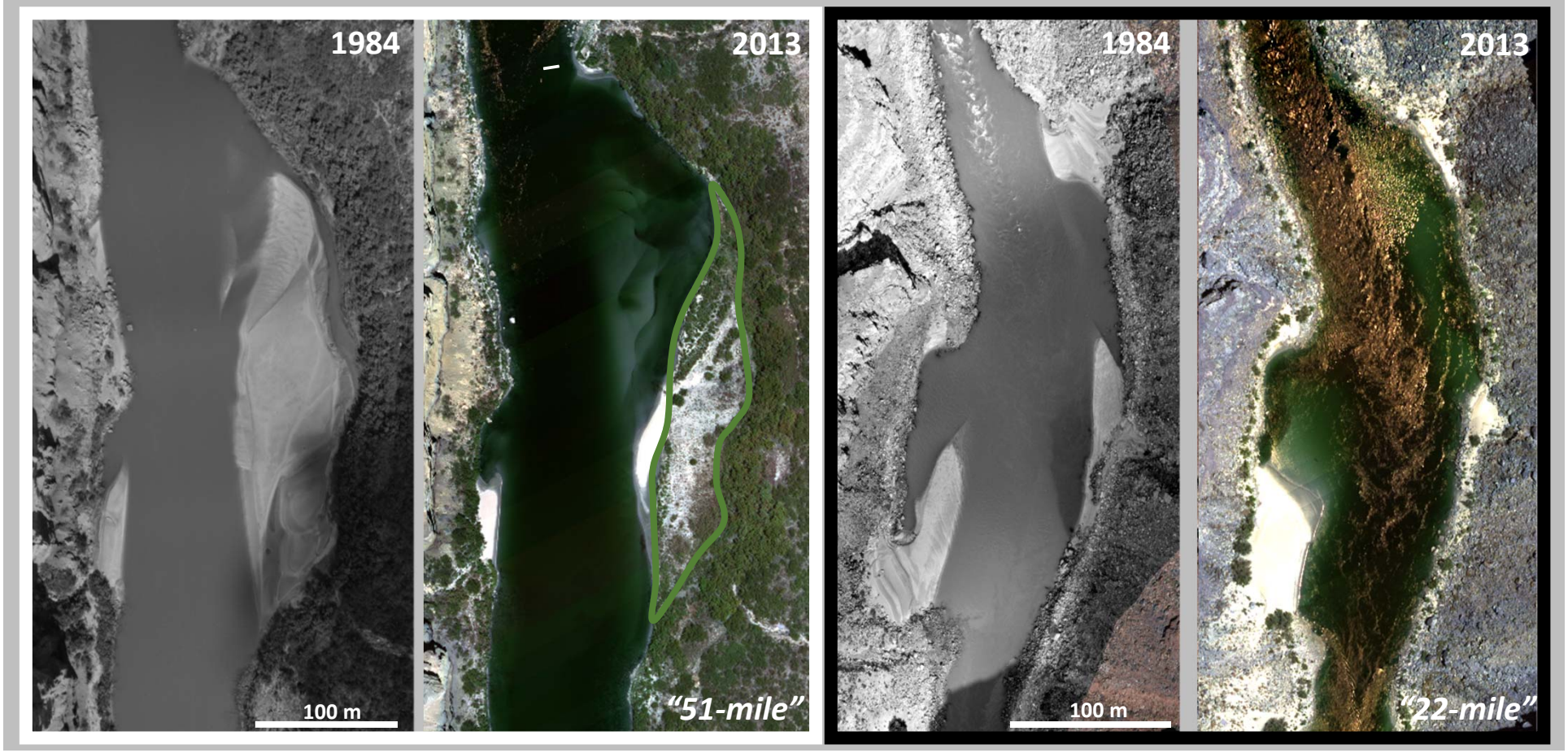
- Focus on ~24 sites with reattachment bars typical of a fan-eddy complex (13 MC/11 GC)
- Annual to sub-annual bar surveys; less frequent full bathymetric surveys
- Most recent pre- and post-flood bathymetric surveys from 2008

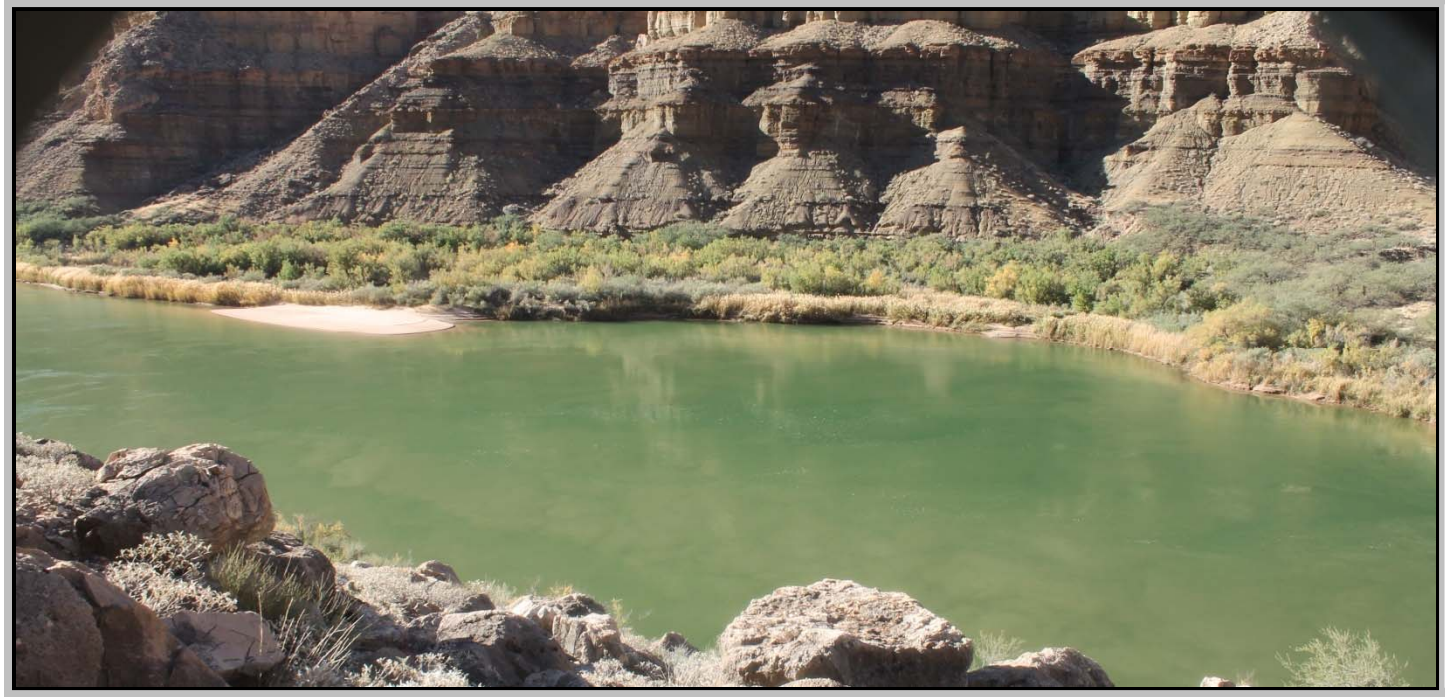


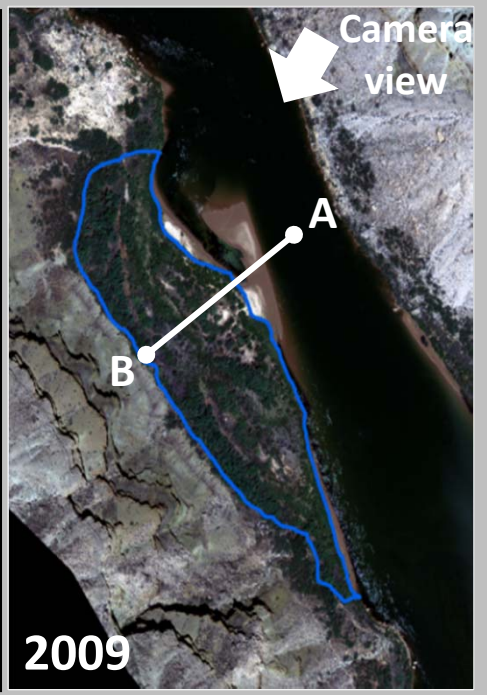


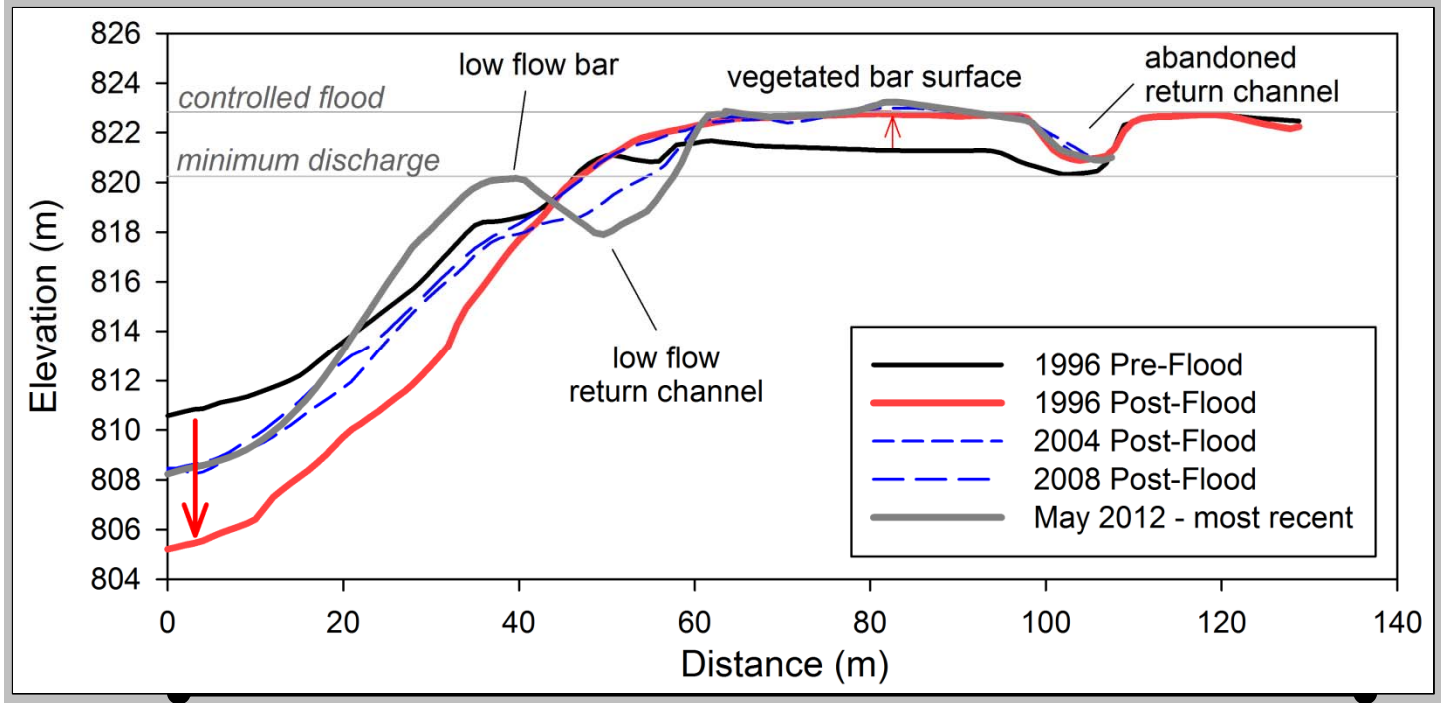
Background

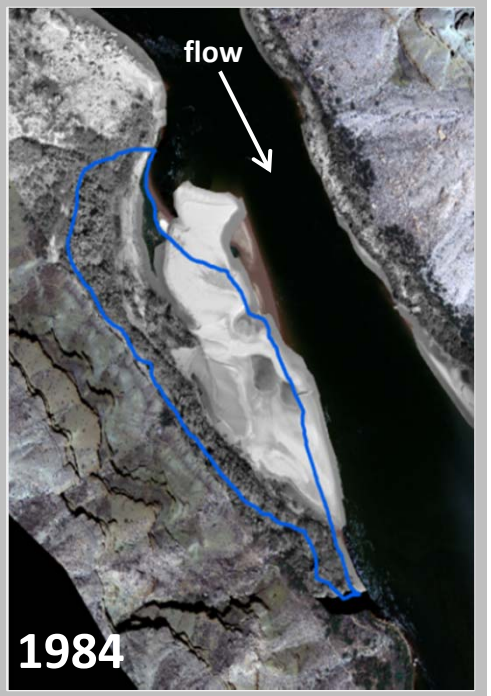
- The 1980s floods were the largest post-dam floods, approximately double recent controlled floods
- Many long-term monitoring sites were still relatively free of vegetation in the early 1990s
- Vegetation establishment on bars has varied between sites, influencing controlled flood response

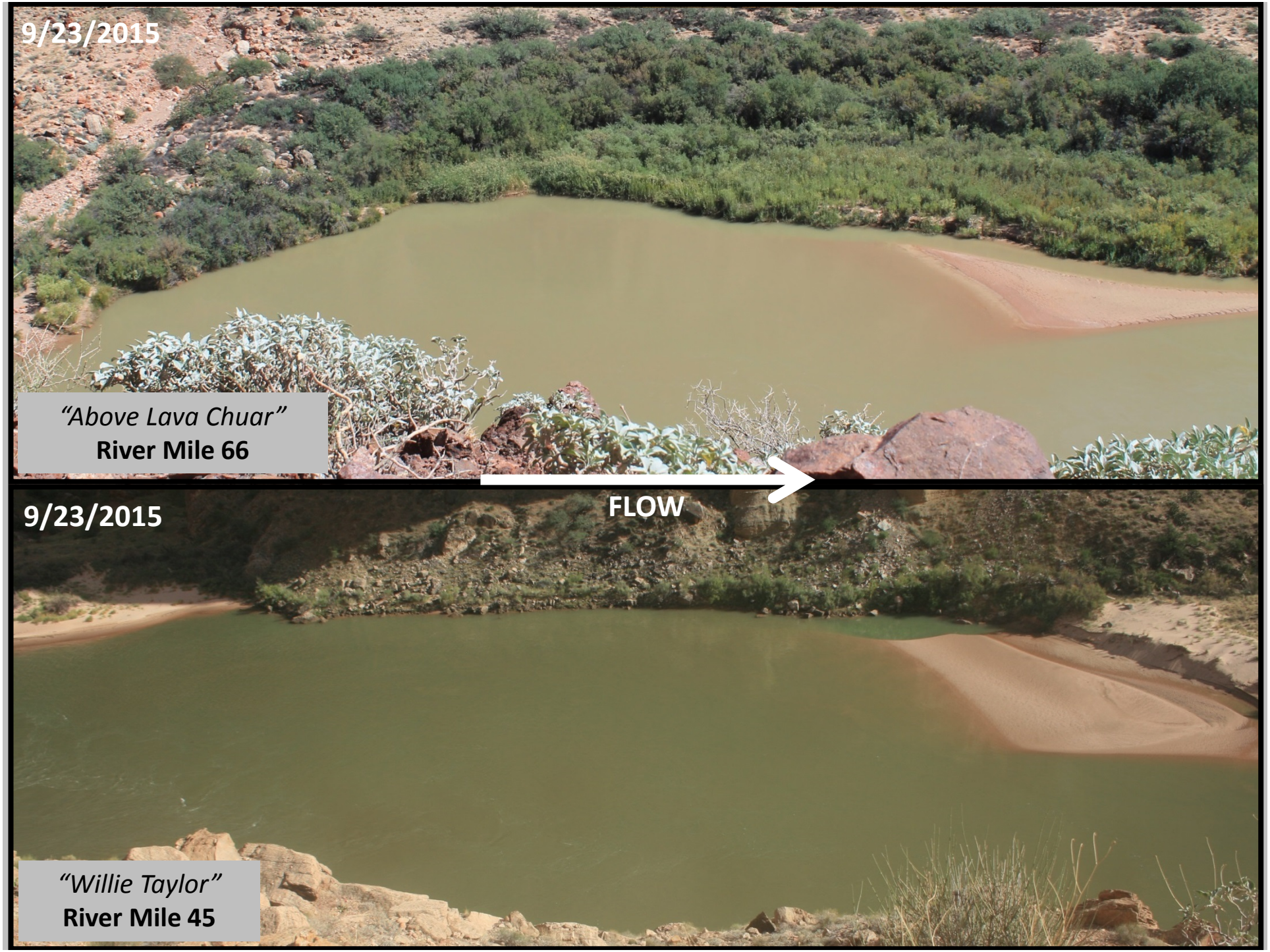




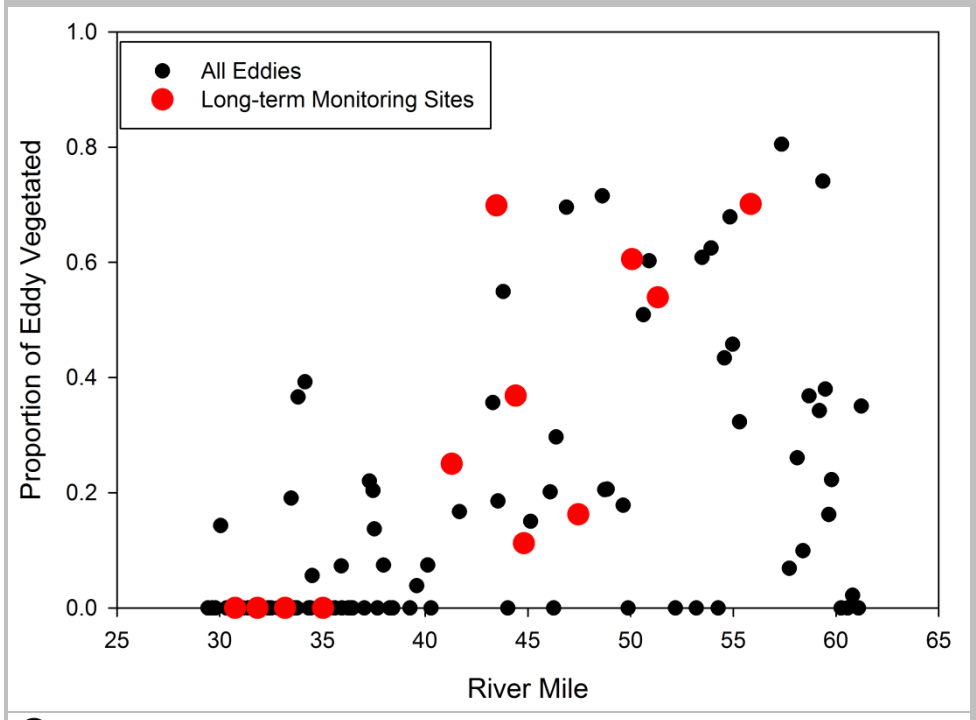

Camera
view
A
B
2009

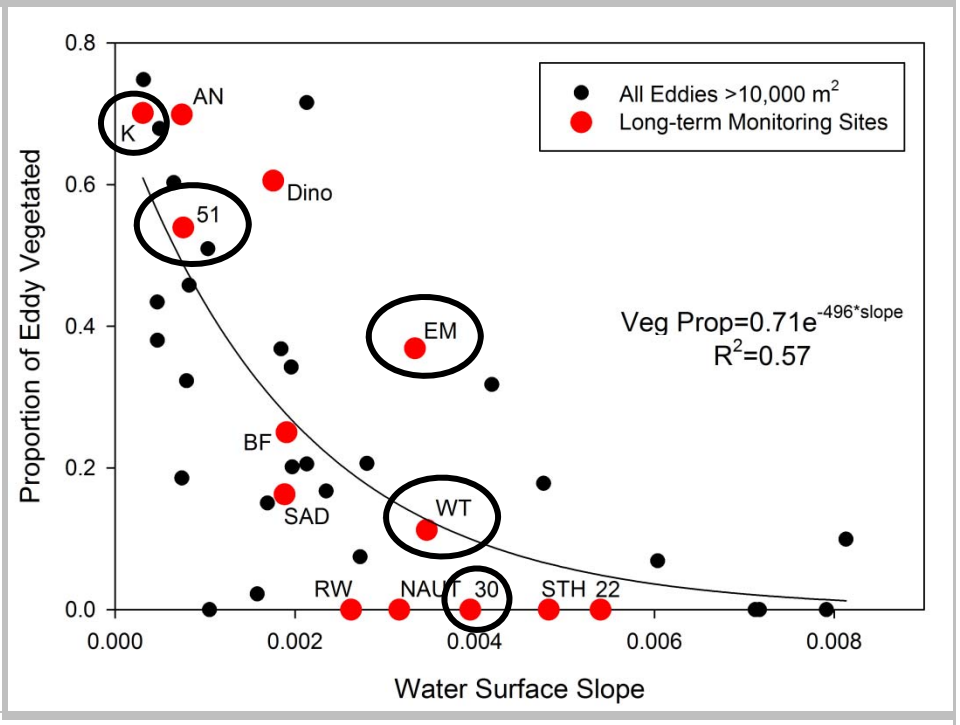

826
824
822
820
818
816
814
812
810
808
806
804
Elevation (m)
0
20
40
60
80
100
120
140
Distance (m)
controlled flood
minimum discharge
low flow bar
vegetated bar surface
abandoned
return channel
low flow
return channel
1996 Pre-Flood
1996 Post-Flood
2004 Post-Flood
2008 Post-Flood
May 2012 - most recent

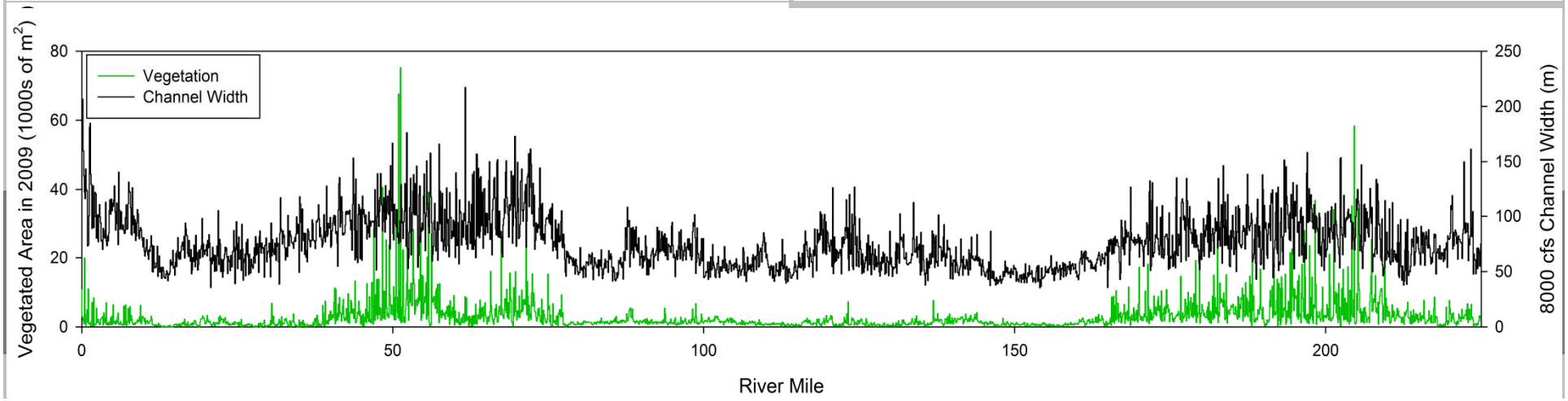

flow
1984


9/23/2015
"Above Lava Chuar"
River Mile 66
FLOW
9/23/2015
"Willie Taylor"
River Mile 45

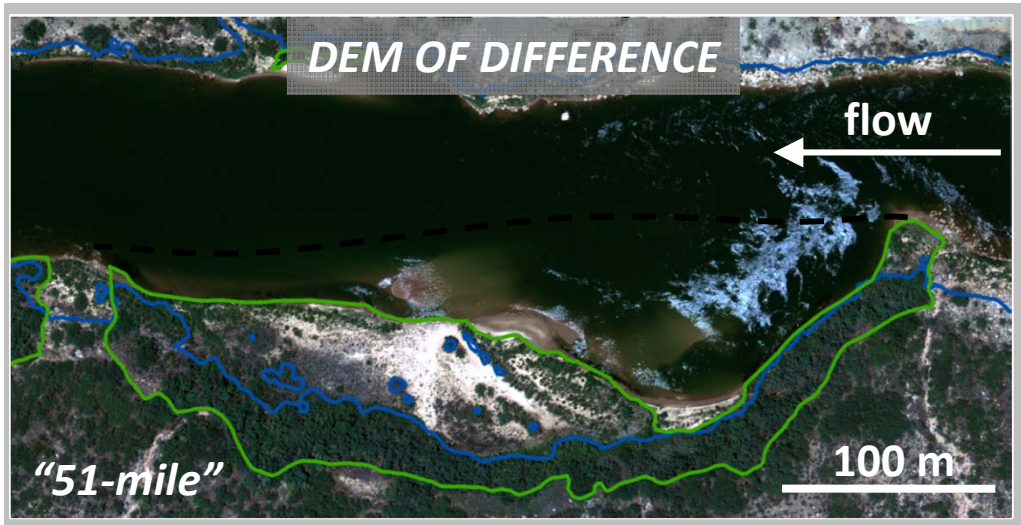
Can the degree of riparian vegetation encroachment serve as a metric to better predict sediment dynamics in individual eddies?

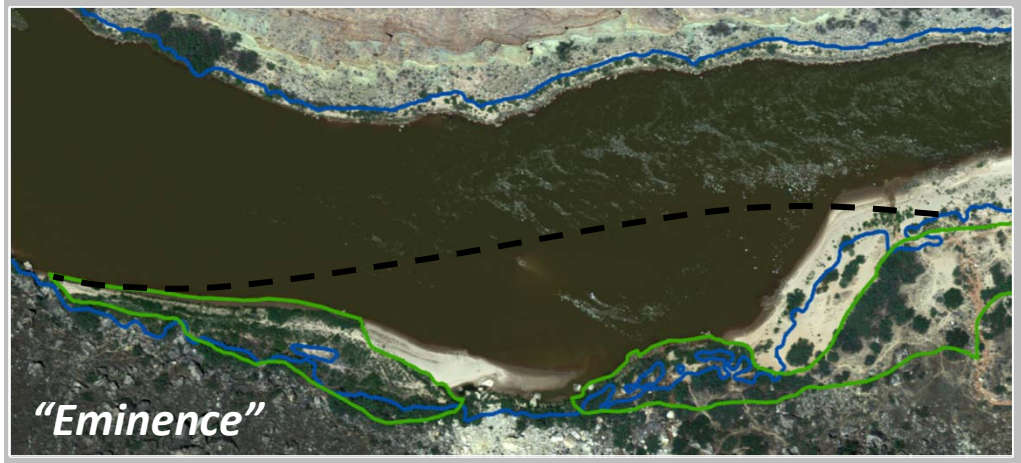


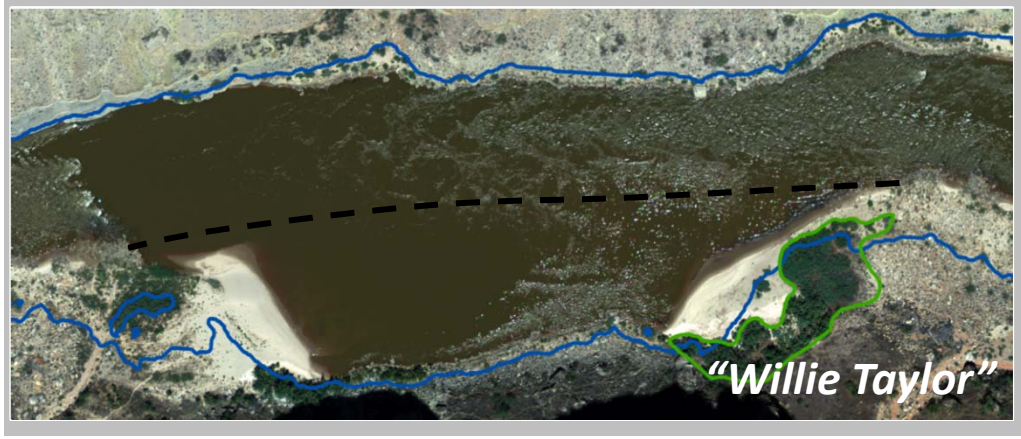




2008 Flood Response



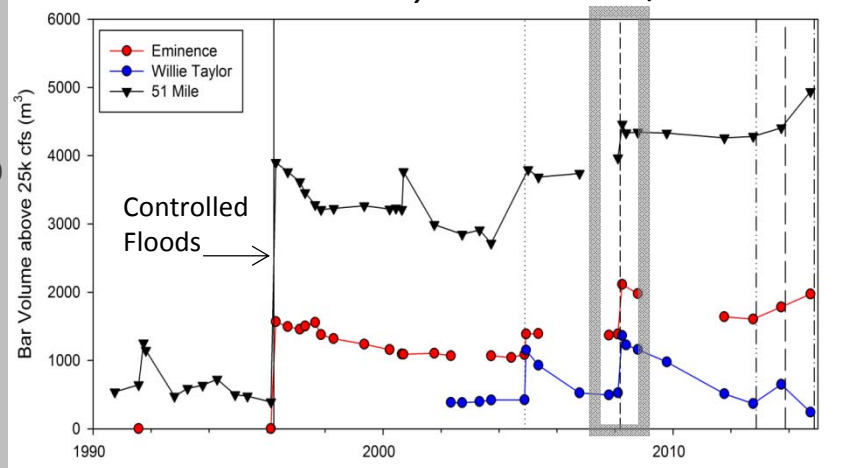




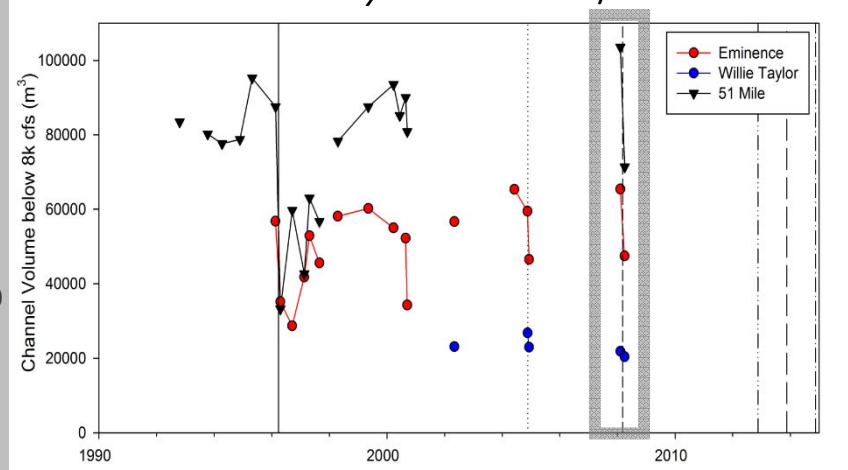
more veg

less veg

reattachment bar only above 708 m^3/s elevation



Channel and Eddy below 227 m^3/s elevation



Green: Marshed vegetation

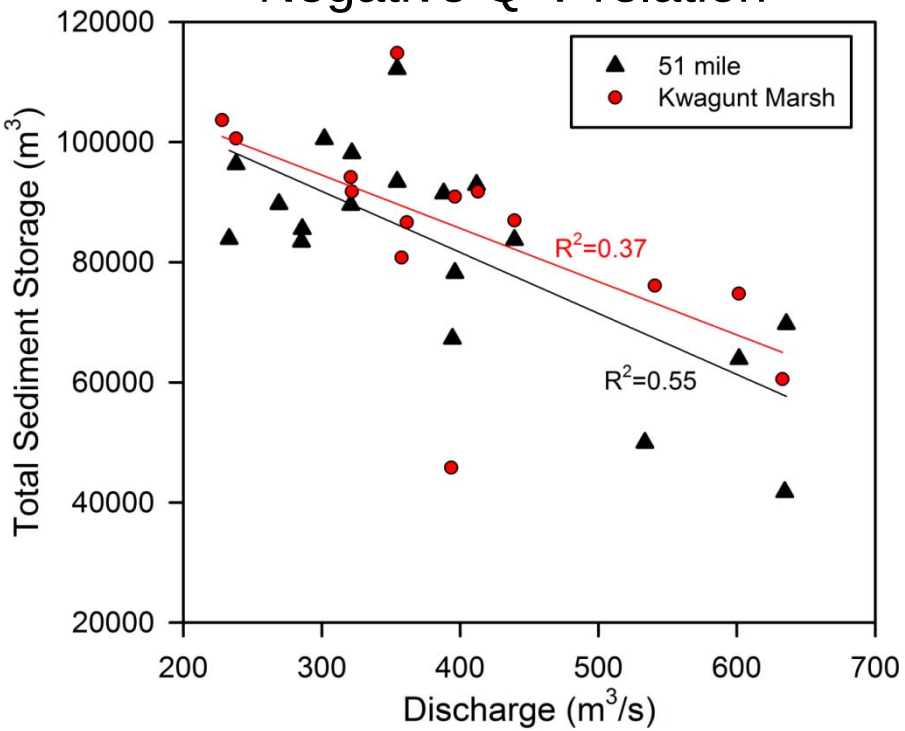
meters of change

-7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7

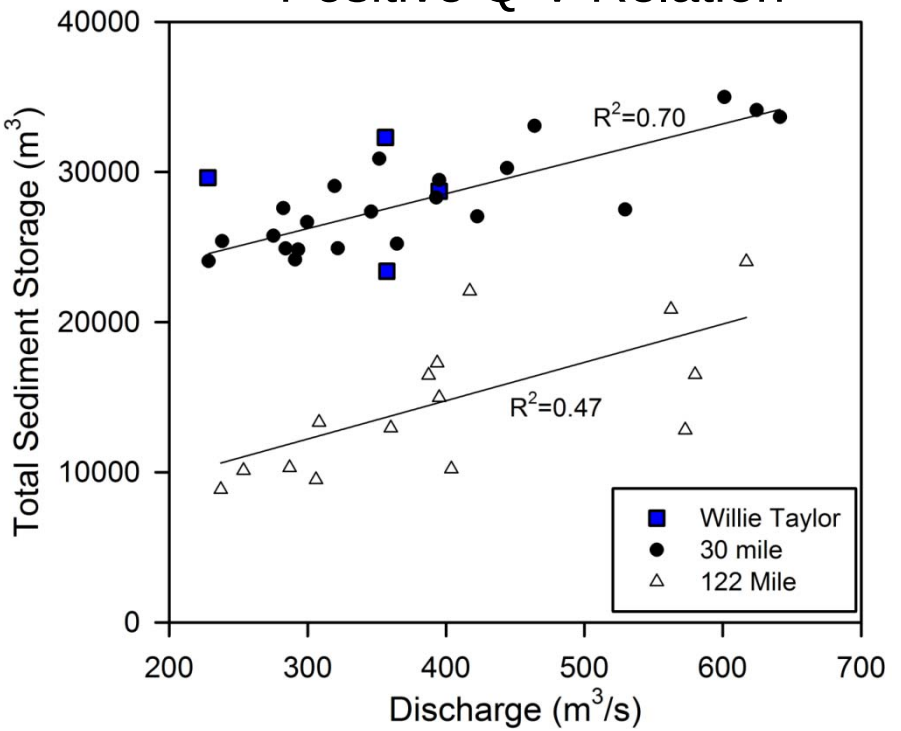
More Narrowing/Veg

Less Narrowing/Veg

Negative Q-V relation

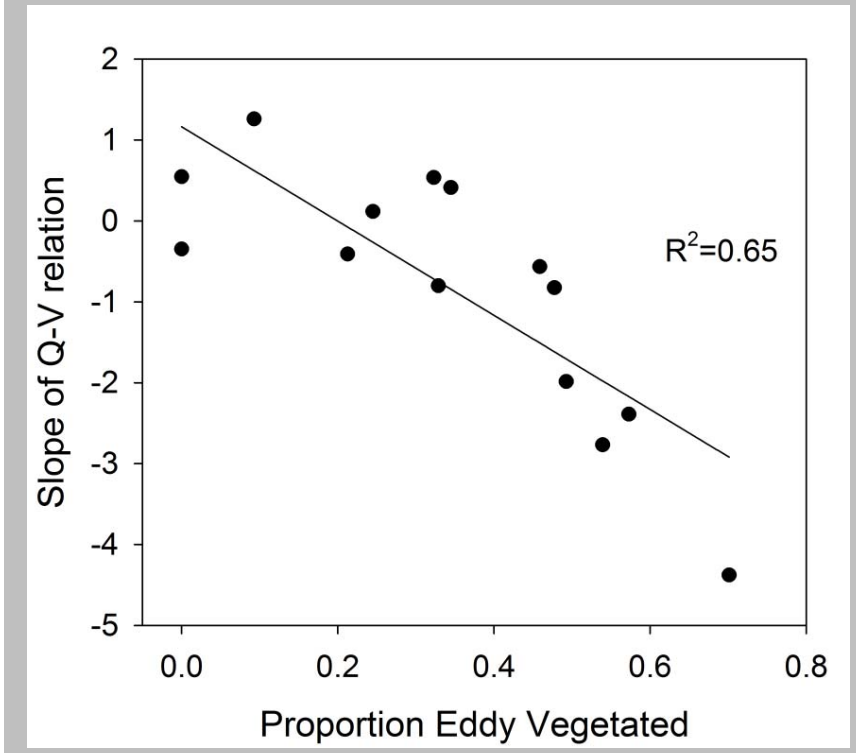


Positive Q-V Relation

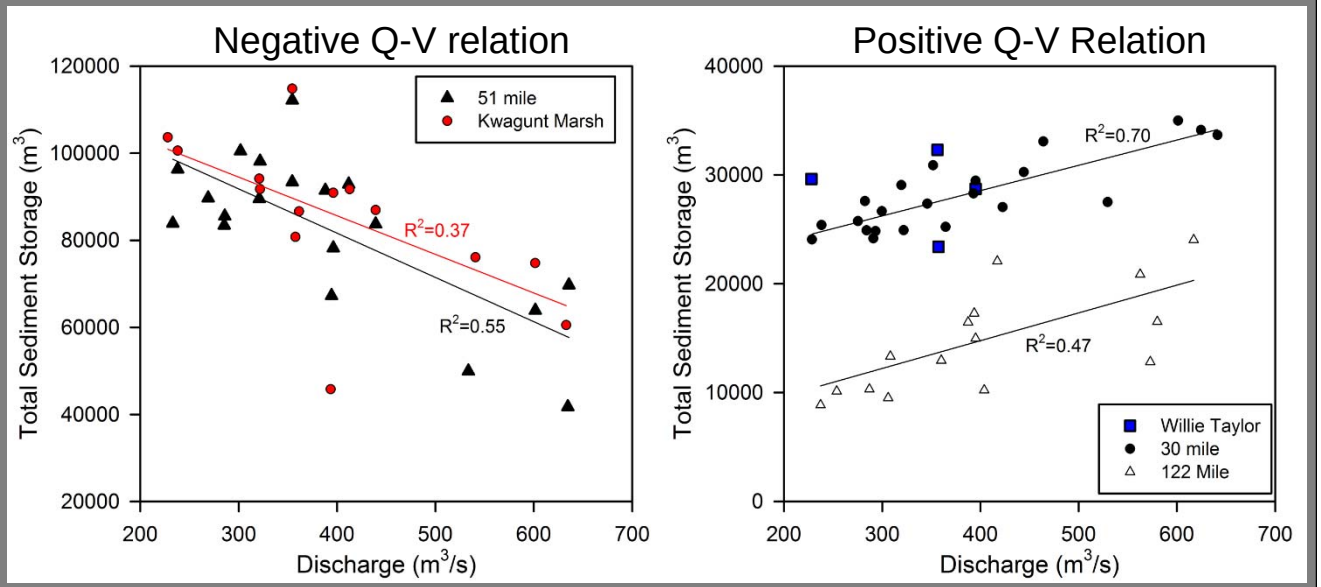


"Kwagunt Marsh"

"30-mile"

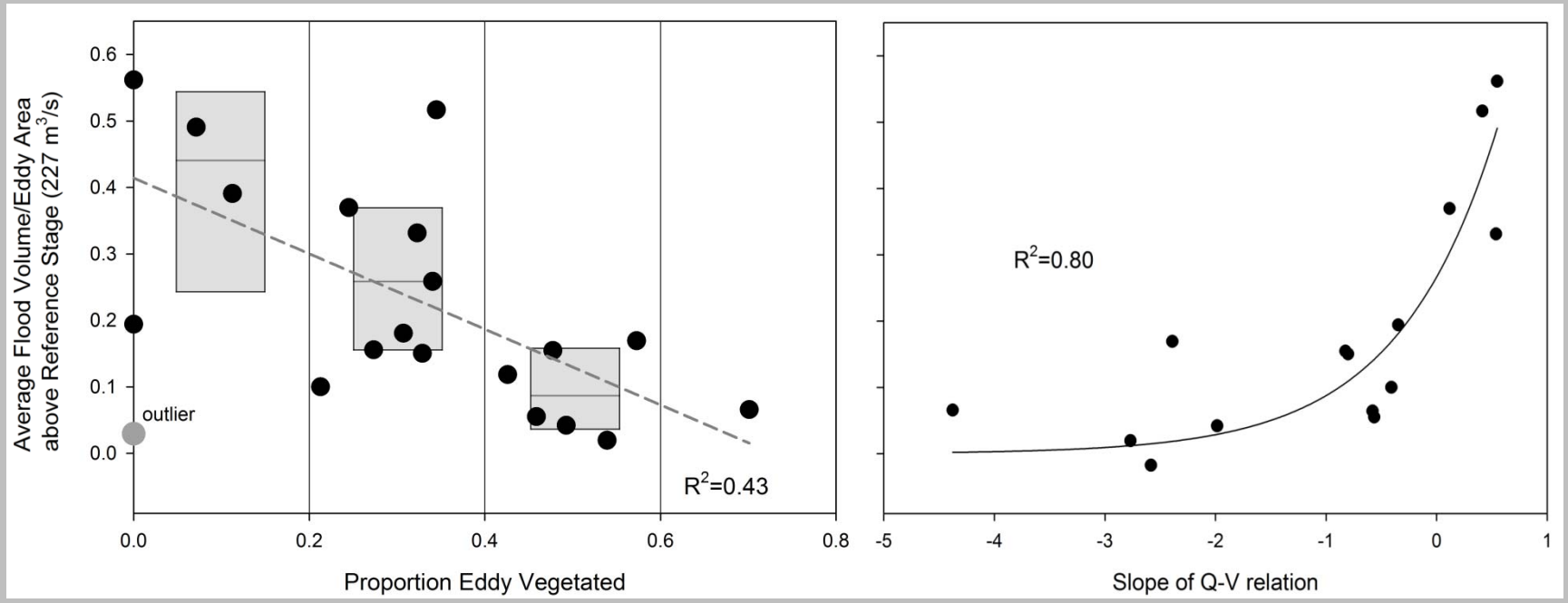


Total site sediment storage change with discharge (slope of the "Q-V relation") shows a clear correlation with the degree of vegetation encroachment



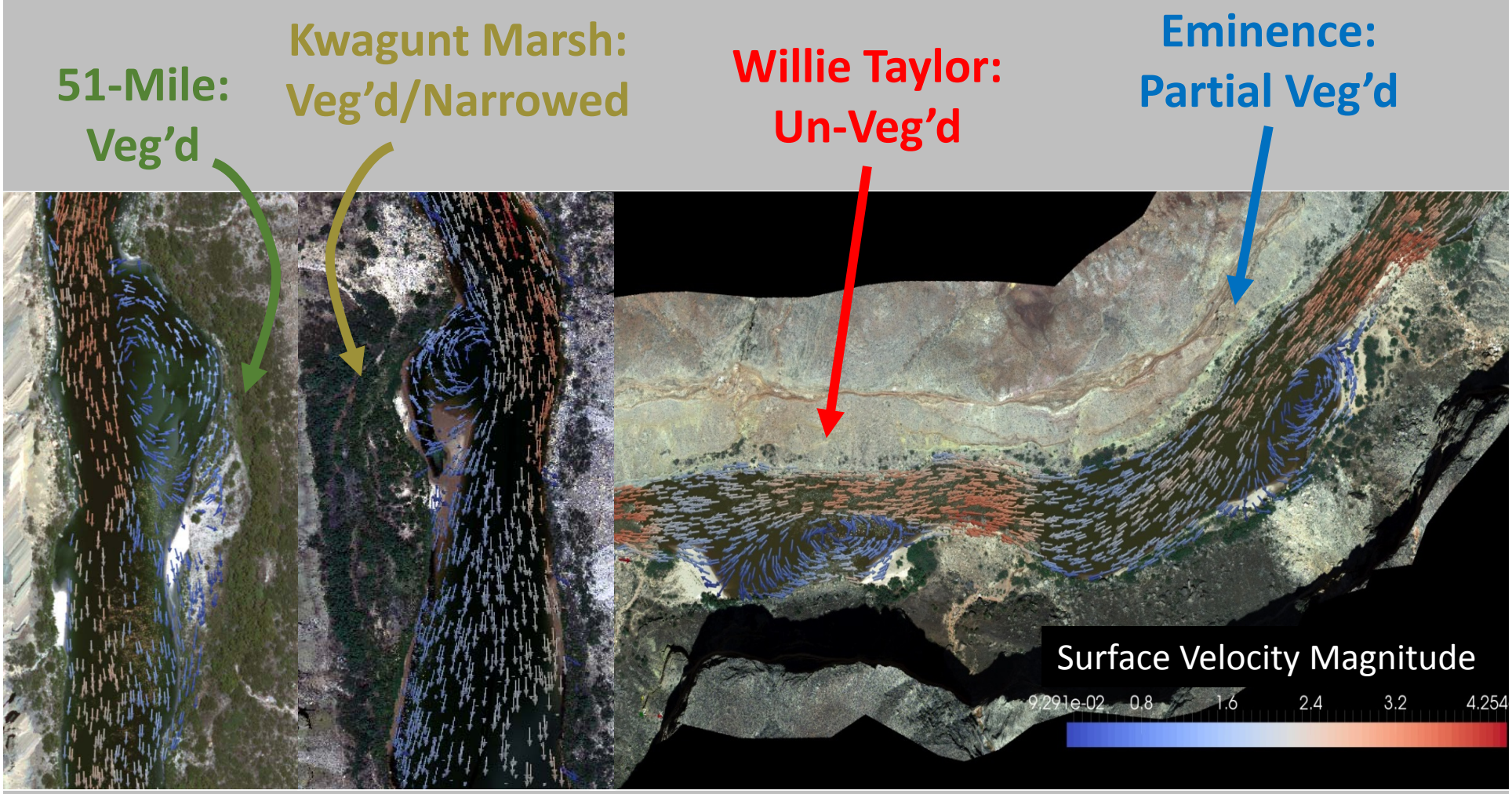
Contribution of flood area only linked with 1996, 2004, and 2008 and slope of Q-V relation…

Larger post-flood sandbars



Post-2014 Flood

Linkage to hydraulics: Large Eddy Simulation (LES) Modeling



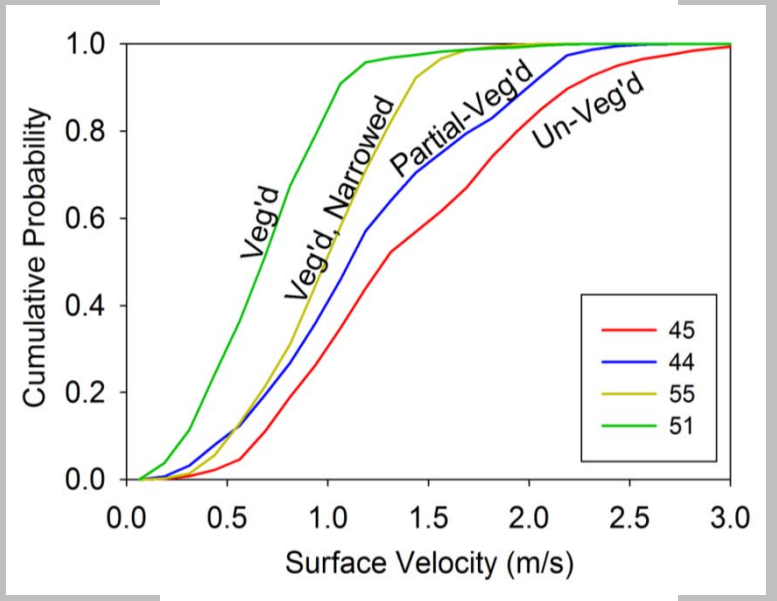
Hypothesis 1: Vegetation mirrors hydraulic field → low energy = more vegetation

Hypothesis 2: Vegetation is changing hydraulic field → more vegetation = shrunken eddy

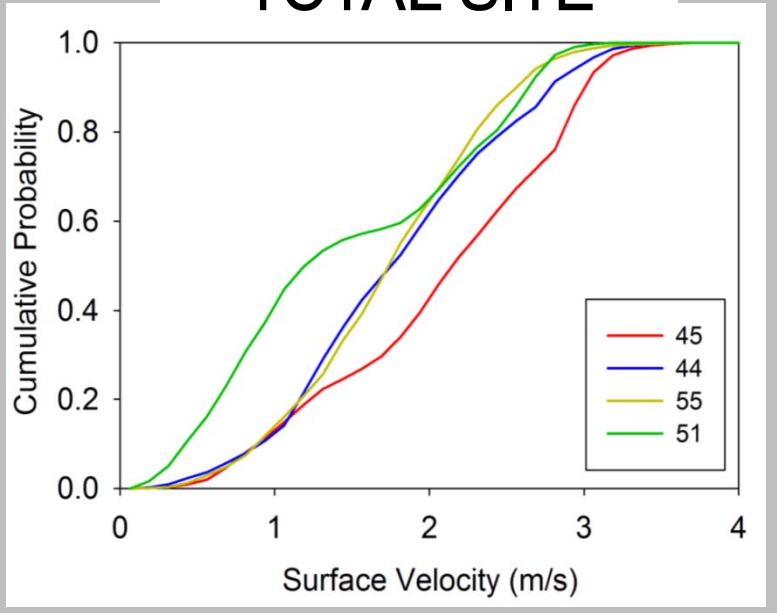
Rapid Post-Flood Erosion

"Willie Taylor" RM 45

EDDY



TOTAL SITE



Conclusions

- The degree of bar stabilization/channel narrowing by vegetation is indicative of eddy-channel sediment storage dynamics and flow hydraulics
- Bars with limited vegetation establishment tend to be in higher energy settings and often erode more rapidly following HFEs
- Observations of vegetation change may thus allow for a better understanding of spatial variability in bar response
- Ultimately, sandbar variability coupled to sediment supply and hydraulics shaped by the channel boundary

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, Jack Schmidt, Rob Ross, Bob Tusso, Dan Buscombe, Tom Gushue, Barbara Ralston, Emily Palmquist, and many more.