

Sandbar Monitoring for November 2012 Controlled Flood



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USGS Grand Canyon Monitoring and Research Center with
cooperation from Northern Arizona University, Grand Canyon
National Park, and Grand Canyon River Guides



HFE Protocol Science Question

- Can sandbar building during HFEs exceed sandbar erosion during periods between HFEs, such that sandbar size can be increased and maintained over several years?
- Building sandbars
 - High flows to build the bars (relatively low uncertainty)
 - Sand supply (relatively high uncertainty)
- Key Monitoring Activities:
 - Monitoring sediment flux
 - Annual (fall) sandbar monitoring at long-term sites
 - Analysis of remote sensing images every 4 years (2002, 2005, 2009, 2013...)
 - In-channel sand storage monitoring

Monitoring and Research for Individual High Flows: What do we need to learn?

- We know that the high flows build sandbars and that there is variability in sandbar response → **Further quantification yields little new insight at great expense.**
- Some Additional monitoring required to:
 - **Confirm that each high flow is having a positive sandbar-building response.**
 - **Evaluate the effect of changing the high flow hydrograph.**

Use of remote digital cameras to monitor sandbar response

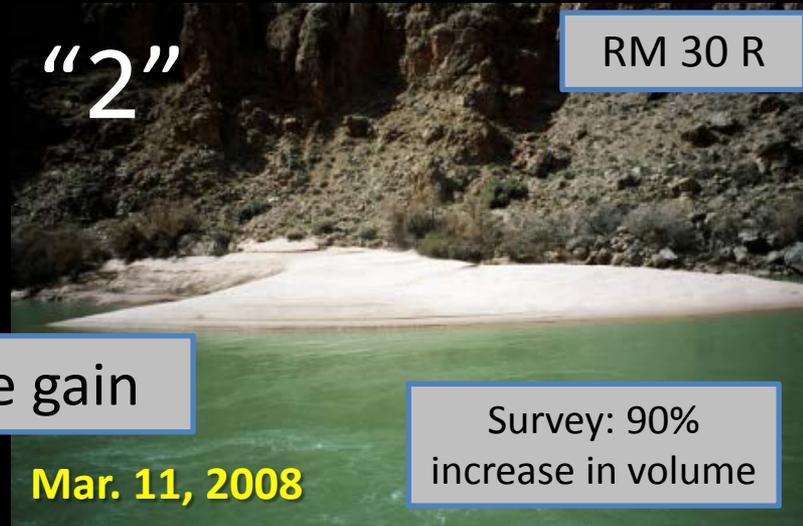
- Digital cameras now installed at 33 (out of 44) of the long-term sandbar monitoring sites
 - Each camera takes 5 photos daily to capture range of water levels and lighting conditions
 - Cameras powered by solar panels and can store photos for up to 1 year
- Test analysis using images collected before and after 2008 HFE
 - 26 sites with remote cameras (mostly film cameras) and pre- and post-HFE surveys

Categorization of Sandbar Changes

Sandbar size (area and volume) evaluated relative to pre-flood reference condition (March 2008) on each photo:

Rating	Apparent change in photos	Measured Change by survey
• 2	Large Increase	> 10 % increase
• 1	Small Increase	3 – 10% increase
• 0	Negligible Change	-3 – +3% change
• -1	Small Decrease	3 – 10% decrease
• -2	Large Decrease	> 10% decrease

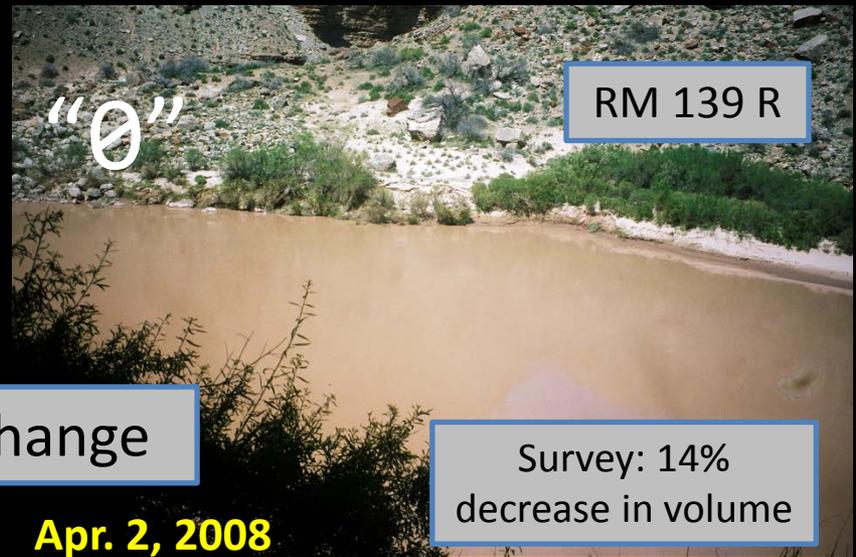
Classified Change in Sandbar Size



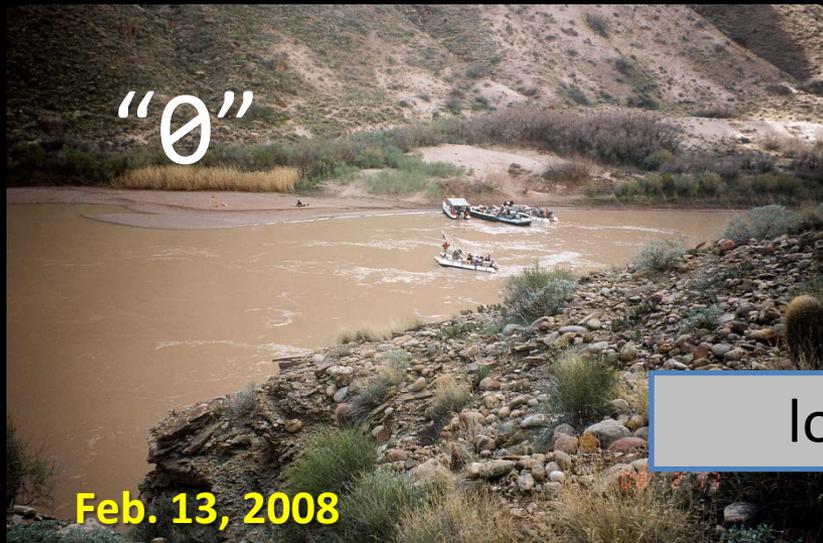
Classified Change in Sandbar Size



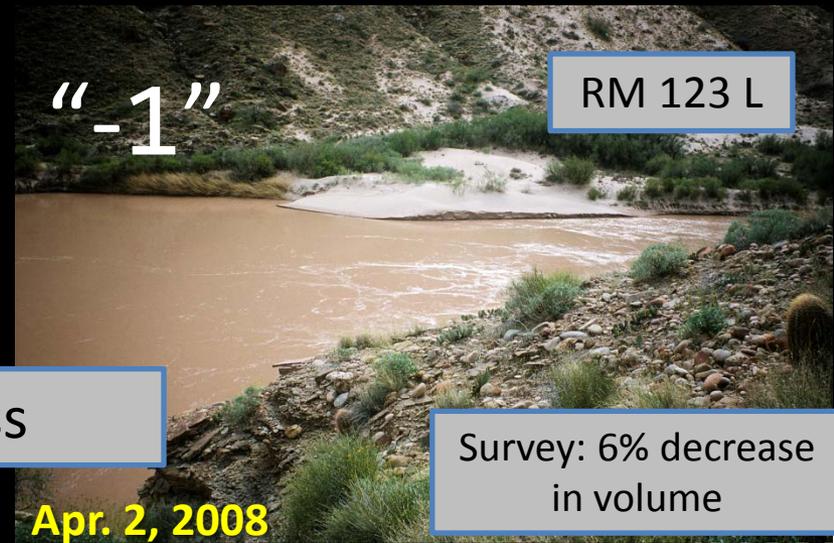
No change



Survey: 14% decrease in volume



loss



Survey: 6% decrease in volume

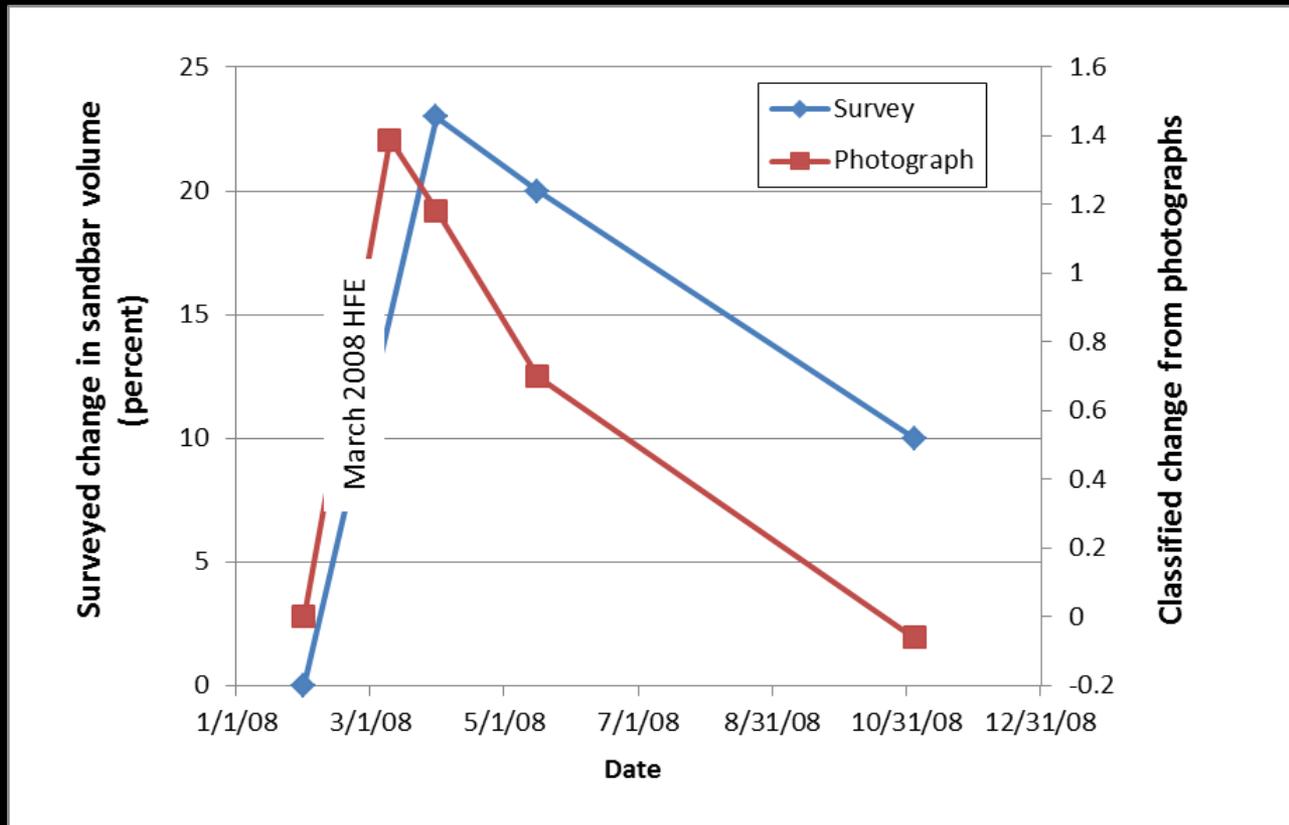
Comparison of Sandbar Response to 2008 HFE based on Topographic Surveys and Analysis of Images

Change	Number of sites with surveyed volume change	Change identified from photos
Deposition	17 sites	Deposition at all sites
No change	1 site	Erosion
Erosion	4 sites	Deposition at 2 sites; no change at 1 site; erosion at 1 site

- Photo analysis picks up deposition,
- May confuse erosion and “no change”

Preliminary data subject to revision – do not cite.

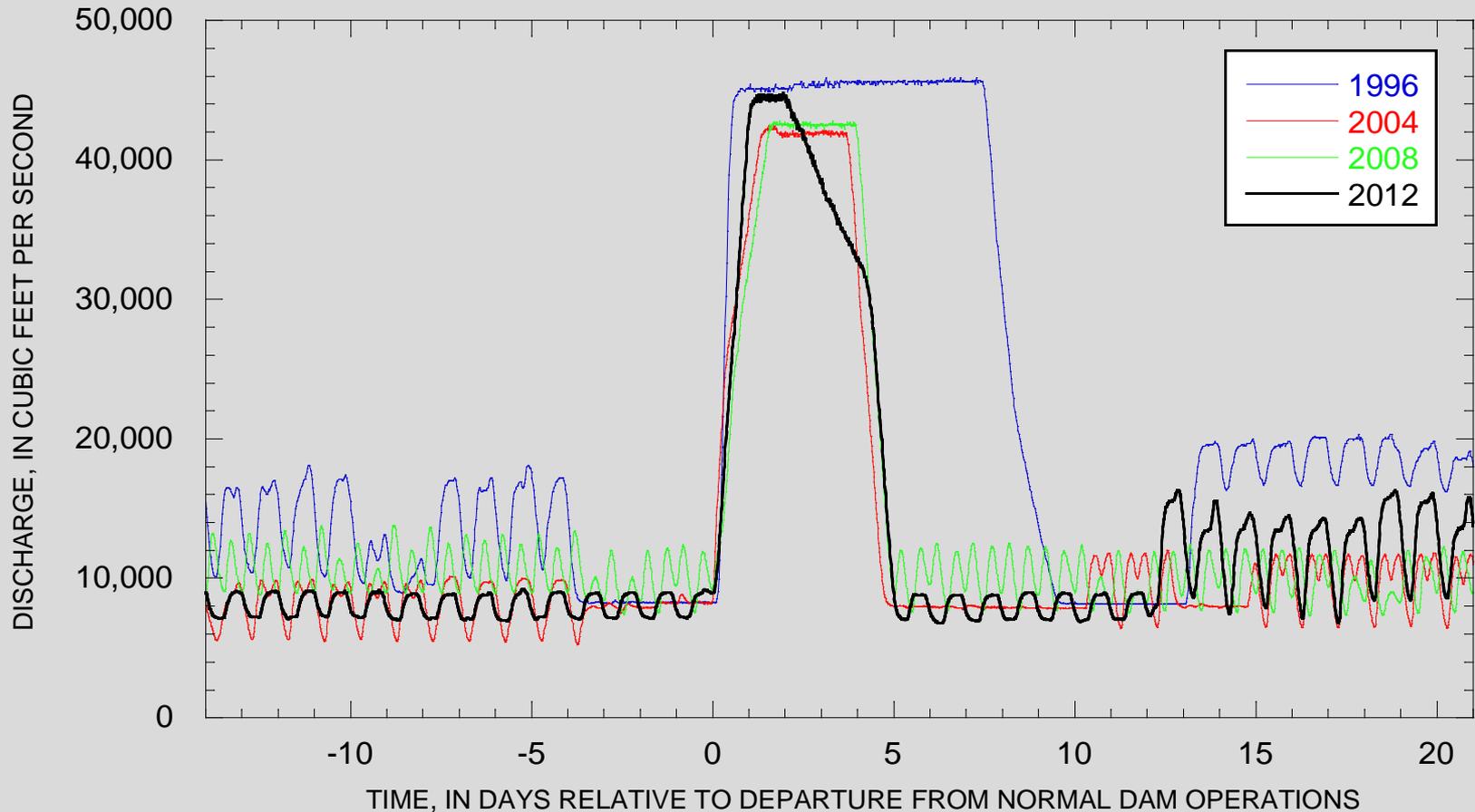
Comparison of Sandbar Response based on Topographic Surveys and Analysis of Images



Average response estimated from photographs is consistent with average response based on topographic surveys

Preliminary data subject to revision – do not cite.

2012 Controlled Flood



- 24 hr. upramp from 7,000 to 43,400 ft³/s
- 24 hr. peak at 43,400 ft³/s

- 53 hr. downramp from 43,400 to 31,200 ft³/s
- 24 hr. downramp from 31,200 to 7,000 ft³/s

Sandbar Response to 2012 HFE based on Analysis of Images from Remote Cameras

- **Summary of evaluations at 33 sites for 2012 HFE response**
 - Substantial Gain (deposition): 18 sandbars (55% of sites)
 - No substantial change: 12 sandbars (36% of sites)
 - Substantial Loss (erosion): 3 sandbars (9% of sites)
- **Downstream trends**
 - All sites between RM 0 and RM 32 increased
 - Downstream from RM 32, split between sites of noticeable gain and no change, with a few showing noticeable loss

Substantial Gain (18 sites)



RM 9 L

11/18/2012

0

11/24/2012

1

RM 16 L

11/18/2012

0

11/24/2012

1

RM 22 R

11/17/2012

0

11/26/2012

2

RM 30 R

11/18/2012

0

11/27/2012

1

RM 32 R

11/17/2012

0

11/28/2012

1

RM 45 L

11/18/2012

0

11/28/2012

2

RM 65.1 R

11/17/2012

0



11/28/2012

2

RM 66.1 L

11/17/2012

0



11/29/2012

1

RM 68.8 R

10/09/2012

0



12/01/2012

1

RM 81 L

11/17/2012

0



11/25/2012

1

RM 94 L

11/18/2012

0

11/25/2012

1

RM 104 R

11/18/2012

0

11/26/2012

1

RM 119.4 R

11/18/2012

0

11/26/2012

2

RM 145 L

11/18/2012

0

11/27/2012

1



No Substantial Change(12 sites)



RM 44 L

11/18/2012

0

11/28/2012

0

RM 47 R

11/18/2012

0

11/28/2012

0

RM 50 R

11/18/2012

0



11/28/2012

0

RM 55 R

11/17/2012

0



11/28/2012

0

RM 65.8 L

11/18/2012

0



11/28/2012

0

RM 87 L

11/17/2012

0



11/25/2012

0



RM 194 L

11/17/2012

0



11/27/2012

0

RM 225 R

11/18/2012

0



11/27/2012

0

Substantial Loss (3 sites)



RM 91 L



RM 173 L



Comparison of Response Among 4 Controlled Floods: 1996, 2004, 2008, 2012

- **15 sites with cameras present during all 4 events**
 - In each year, a few sites did better, a few not as well, nothing stands out, too few sites to make any general conclusions
- **26 sites with cameras present in 2008 and 2012**
 - Sandbar larger in 2012: 4 sites, 3 above RM 32
 - Sandbar smaller in 2012: 7 sites
 - Sandbar about the same in 2012: 15 sites

Observations at Sites Not Monitored by Remote Cameras

RM 35L, Nautiloid Camp



Grand Canyon River Guides Adopt-a-Beach Site



Shinumo
Wash Camp
RM 29.4 L



Grand Canyon River Guides Adopt-a-Beach Site



May 2008

Clear Creek
Camp
RM 84.6 R



Nov 2011



Dec 2012

Grand Canyon River Guides Adopt-a-Beach Site



Zoroaster
Camp
RM 84.9 L



Grand Canyon River Guides Adopt-a-Beach Site



Stone Creek
Camp
RM 132.4 R



Sandbar Surveys

- October 2012 – surveyed all 44 long-term sandbar monitoring sites between Lees Ferry and Diamond Creek on annual monitoring trip
- November-December 2012 – surveyed 6 of those sites on post-flood NPS trip



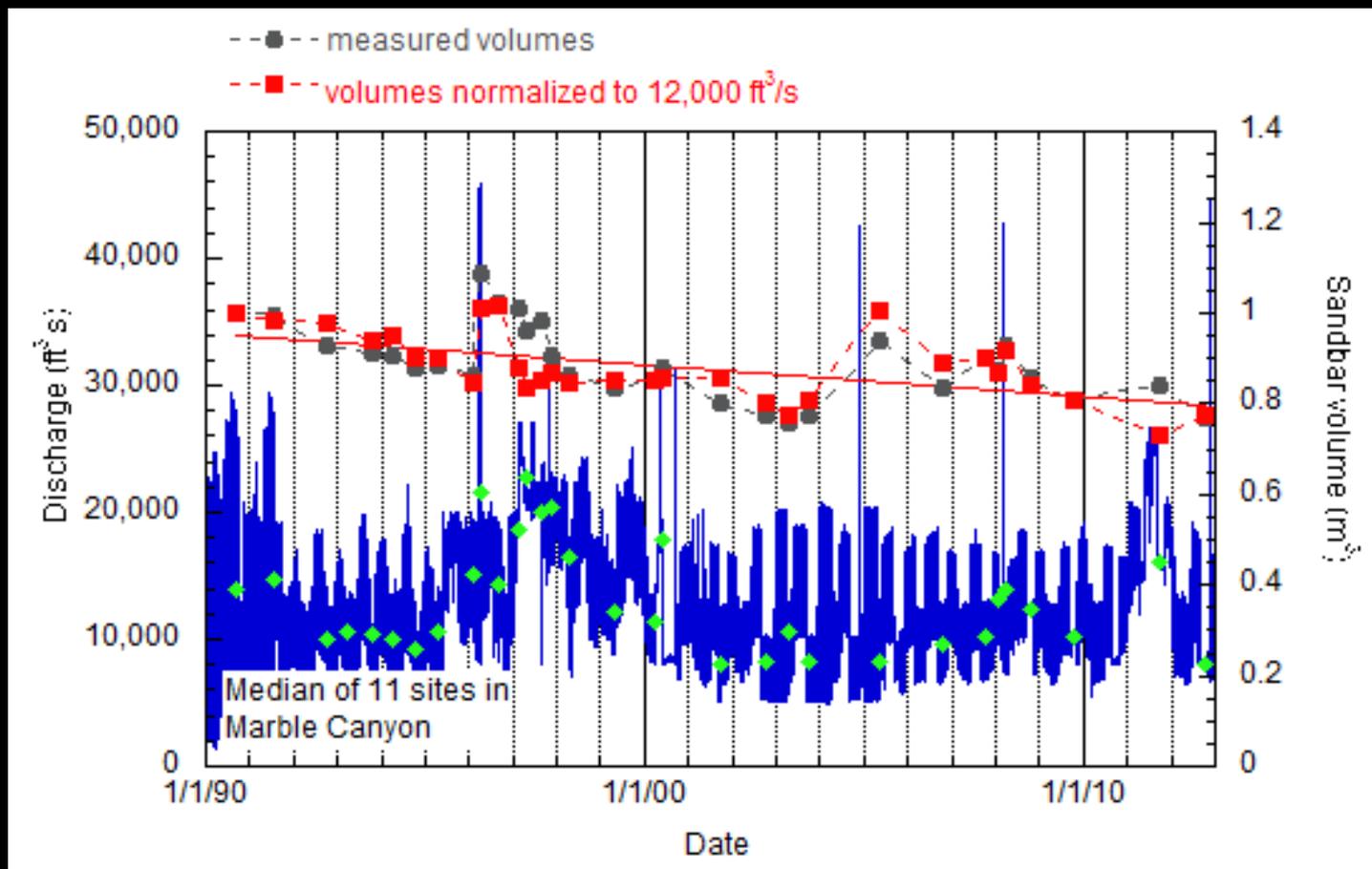
October 2012 (pre-HFE) Sandbar Volume in Marble Canyon

	Number of Sites Compared	Number Larger	Number Smaller
Bar volume compared to 1990	16	6	10
Bar volume compared to 2008 pre-flood	31	12	19
Bar volume compared to 2008 post-flood	31	2	29

Preliminary data subject to revision – do not cite.



Sandbars in Marble Canyon before 2012 Controlled Flood



- Some increase between October 2011 and October 2012
 - Both 2011 and 2012 are low relative to early 1990's and post-flood surveys
- Preliminary data subject to revision – do not cite.*

Sandbar Surveys Following Nov. 2012 Controlled Flood

	RM 9	RM 30	RM 44	RM 47	RM 65	RM 68
Classification from photo analysis	Gain	Gain	no noticeable change	no noticeable change	Large gain	gain
Surveyed change in average bar elevation	68 cm	93 cm	- 3 cm	6 cm	114 cm	32 cm

- *Analysis from remote cameras consistent with surveyed changes in sandbars*

Sandbar Surveys Following 2012 controlled flood compared to other controlled floods

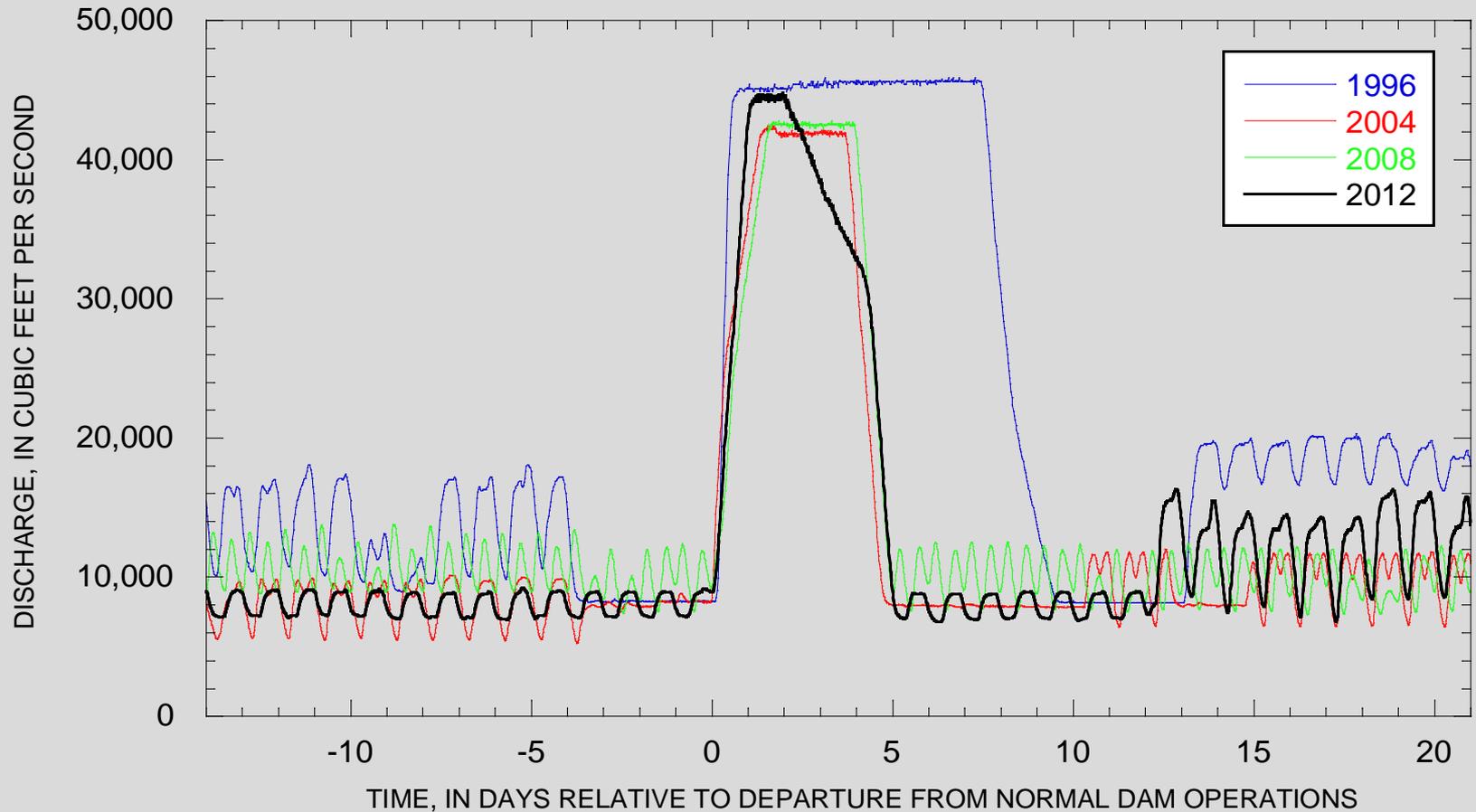
Bar Elevation Relative to 2012 post-HFE*	RM 9	RM 30	RM 44	RM 47	RM 65	RM 68
2012	0 (1)	0 (2)	0 (4)	0 (3)	0 (2)	0 (2)
2008	-0.03 (2)	-0.64 (4)	0.55 (1)	0.37 (2)	0.22 (1)	0.22 (1)
2004	na	-0.13 (3)	0.39 (2)	na	-0.28 (3)	na
1996	na	0.08 (1)	0.02 (3)	0.49 (1)	-0.83 (4)	-0.30 (3)

* Ranking for the 4 floods in parentheses

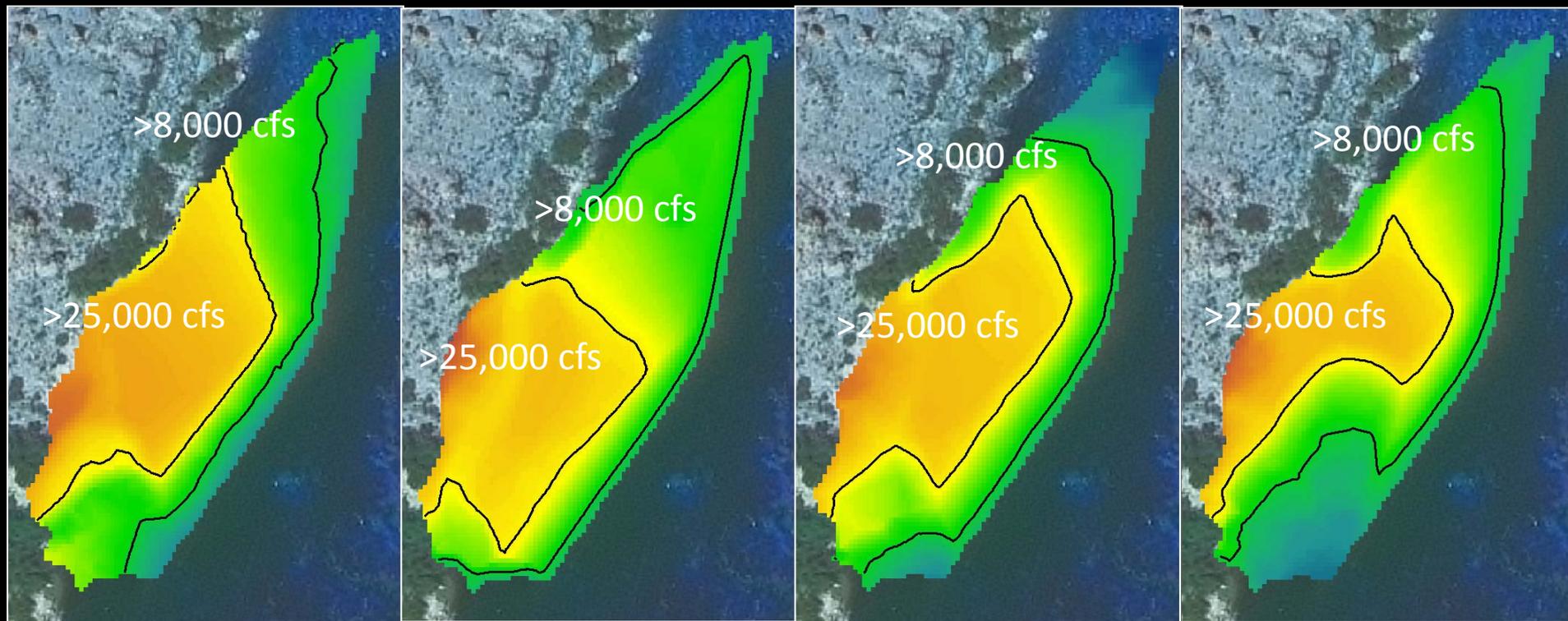
- *Magnitude of bar building during 2012 flood is comparable to previous floods*
- *Very few sites to compare, but nothing stands out as dramatically different*

Preliminary data subject to revision – do not cite.

What is the effect of changing the hydrograph of the high flow?



Sandbar Shape – RM 30



1996 post-HFE

2012 post-HFE

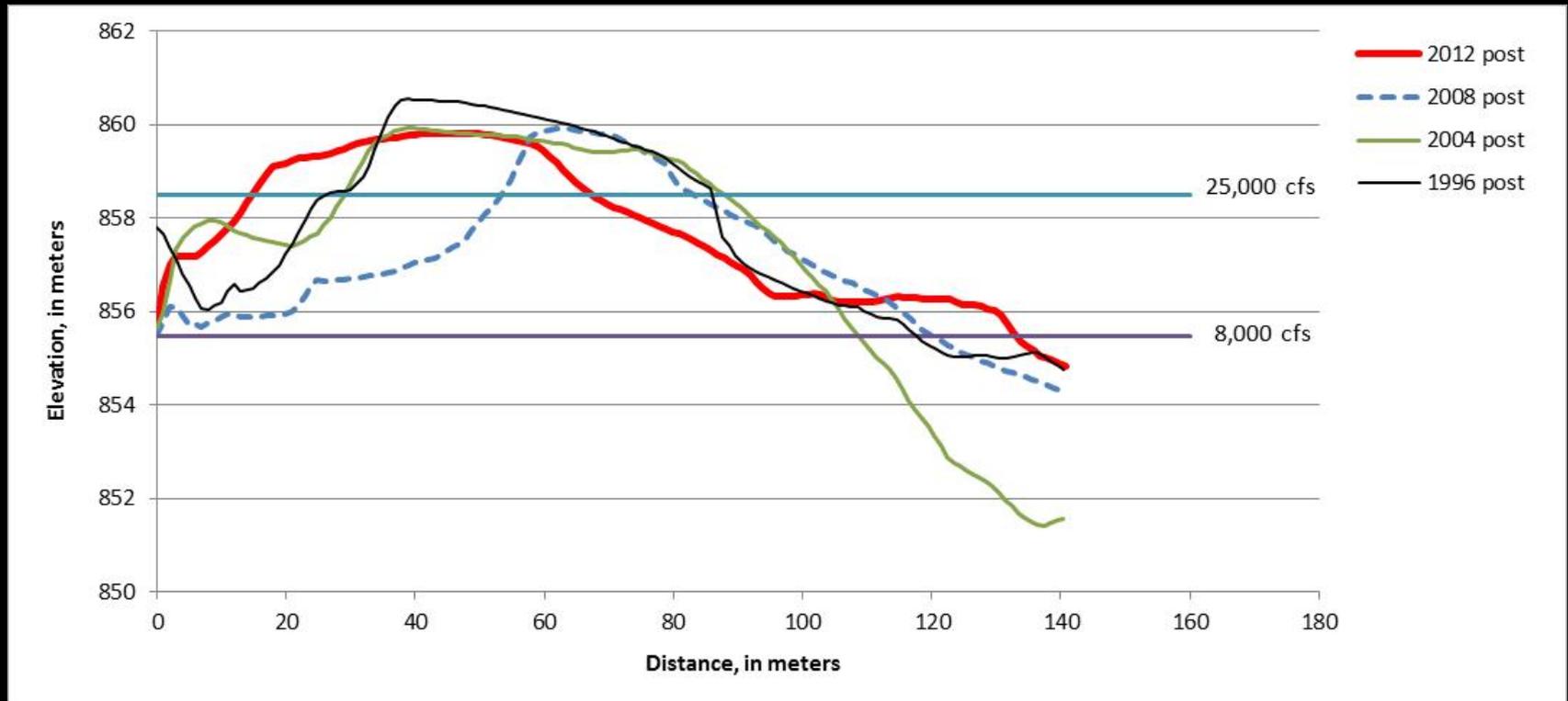
2004 post-HFE

2008 post-HFE

- *Bar volume largest in 1996, area above 8,000 cfs stage largest in 2012*

Preliminary data subject to revision – do not cite.

Sandbar Shape – RM 30



- Slope from bar crest to 8,000 cfs level less steep than other floods
- For 3 sites with post-flood surveys and large reattachment bars, the area of newly deposited bar above the 8,000 cfs stage with slope less than 8 deg. was larger in 2012 than previous floods

Preliminary data subject to revision – do not cite.

Conclusions

- 2012 flood resulted in sandbar building, as observed in previous controlled floods
- Bar building not as widespread as 2008
 - But likely stronger than 2008 in upper Marble Canyon
- Effect of slower rate of flood recession
 - Not a dramatically different response
 - May have resulted in bars that are less steep in a few locations
 - Need more observations, numerical modeling, and probably controlled laboratory experiments to better understand the effect of hydrograph shape

Work in FY13 and FY14

- In work plan
 - Monitoring in-channel sand storage
 - Mapping of bed texture with application for fish and aquatic habitat
 - Annual sandbar surveys (44 sites)
 - Analysis of overflights to monitor sandbars throughout Grand Canyon
 - Geomorphic attributes of campsites
 - Continue work on modeling eddy sandbars
 - Interactions between sediment on bed and in suspension
- Pilot monitoring
 - Measurements of sandbar topography from remote cameras