Glen Canyon Dam Adaptive Management Work Group
Agenda Item Information
May 22-23, 2008

Agenda Item

Experimental Action: High Flow Experiment, Preliminary Observations

Action Requested

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

Presenters

John Hamill, Chief, Grand Canyon Monitoring and Research Center
Ted Melis, Deputy Chief, Grand Canyon Monitoring and Research Center
Steve Martin, Superintendent, Grand Canyon National Park
Bob Broscheid, Assistant Director, Arizona Game and Fish Department

Previous Action Taken

√ Other: The Bureau of Reclamation executed a high flow experiment of approximately 41,500 cfs for 60 hours beginning March 4, 2008.

Relevant Science

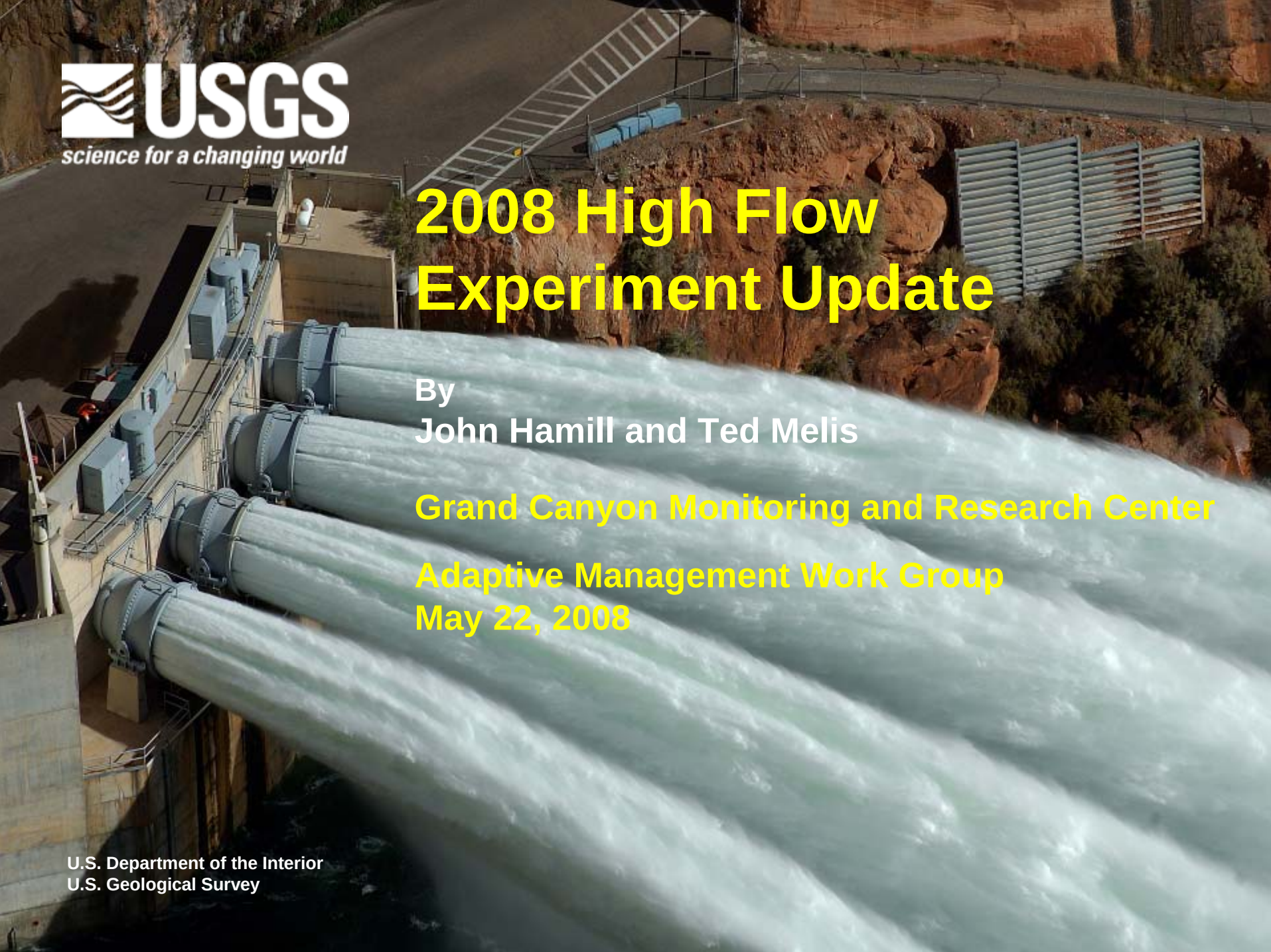
√ The following describes the relevant research or monitoring on this subject:
The "Science Plan for Potential 2008 Experimental High Flow at Glen Canyon Dam," can be found at http://www.gcmrc.gov/research/high_flow/2008/documents.aspx. Look for the last document under "Planning Documents" and click on "Proposed 2008 High-Flow Science Plan."

Background Information

The Department of the Interior initiated an experiment in early March 2008 to inform managers about the effectiveness of using high flows from Glen Canyon Dam to improve natural, recreational, and cultural resources in Grand Canyon National Park. Flows from the dam began increasing on the evening of March 4, with powerplant bypass flows beginning at approximately 10 am on the morning of March 5. Water was released through Glen Canyon Dam's powerplant and bypass tubes to a maximum of approximately 41,500 cubic feet per second for about 60 hours.

The Grand Canyon Monitoring and Research Center worked collaboratively with the Department of the Interior's Bureau of Reclamation, National Park Service, and U.S. Fish and Wildlife Service to prepare for and conduct the 2008 high-flow release. These agencies as well as the Arizona Game and Fish Department, Northern Arizona University, Utah State University, and other cooperators worked together to conduct and evaluate a range of research activities.

During this agenda item, representatives from the Grand Canyon Monitoring and Research Center, Grand Canyon National Park, and the Arizona Game and Fish Department will describe their preliminary observations of the high flow experiment. See the attached PowerPoint for information about GCMRC's preliminary findings, which will be updated before the AMWG meeting.



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2008 High Flow Experiment Update

By
John Hamill and Ted Melis

Grand Canyon Monitoring and Research Center

Adaptive Management Work Group
May 22, 2008

U.S. Department of the Interior
U.S. Geological Survey

Overview

- Review major objectives of the High Flow Experiment (HFE) Science Plan
- Review schedule for reporting results of the HFE
- Update on preliminary observations on the results of the HFE

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Peak Flow Magnitude and Duration

Peak Flow

- March 4-8 with peak of 41,500 cfs for 60 hours

Follow test with normal dam operations (MLFF)

- MLFF flows followed the test
- Higher equalization flows began in mid April
- Steady flows planned for Sept and October

Data collection continues through Fall 2008-Winter 2009

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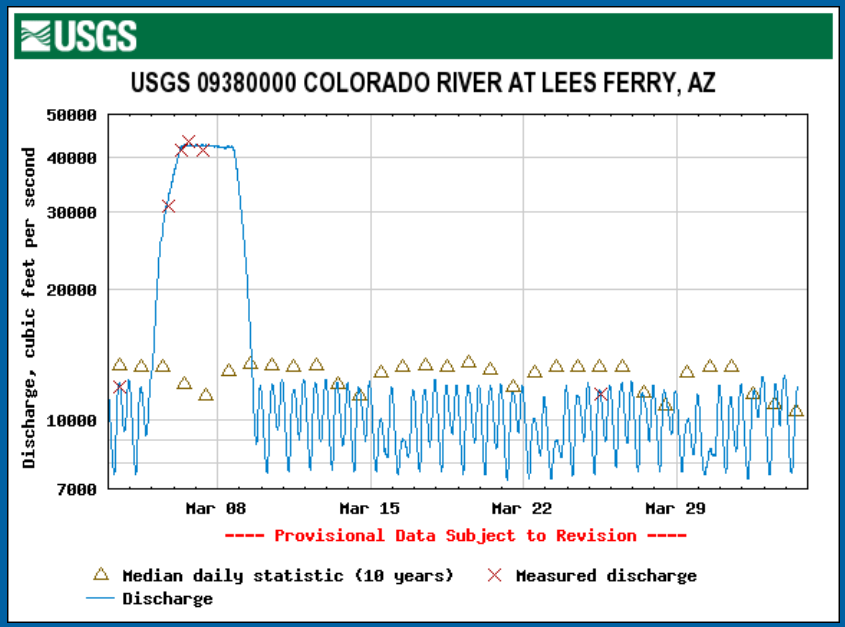
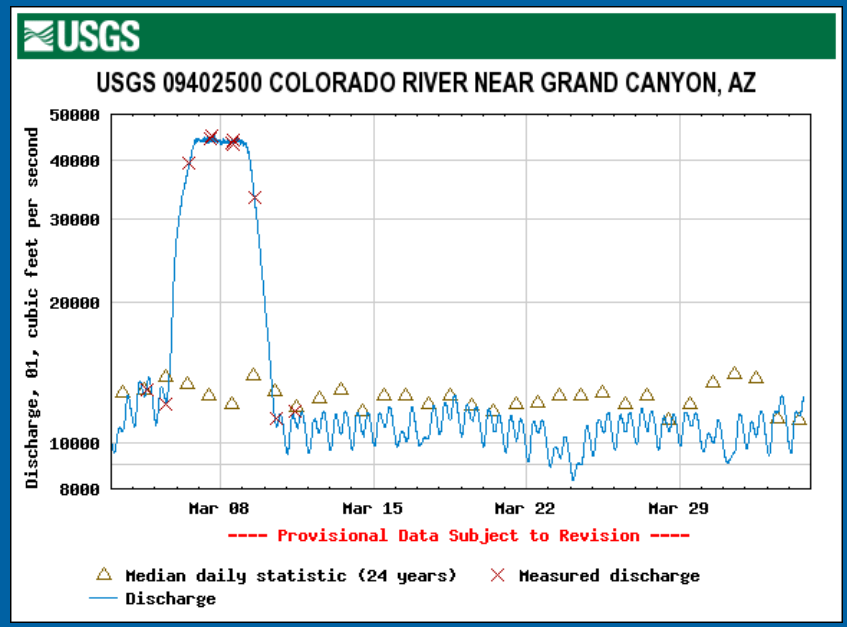
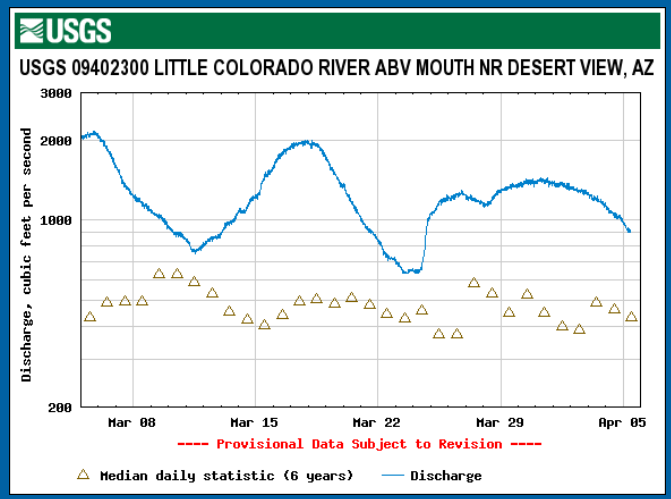
Peak Flow Magnitude ~ 45,000 cfs (A Helping Hand From Mother Nature)







~2,000 cfs Inflow from the LCR in Early March Will Make Sandbar Data More Comparable to Our 1996 Measurements From Mile 61 to 226

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Strategic Science Questions

- Based on AMWG concerns and AMP Goals

- Tier off strategic science questions in MRP
- Primary focus on sediment and humpback chub (backwaters habitats)

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Sediment Science Questions

Strategic Science Question: Is there a "flow-only" operation that will rebuild and maintain sandbar habitats over decadal timescales?

BHBF Science Questions

1. How does suspended sediment concentration and grain size vary through time and by reach under more enriched sand supplies; Is the net mass balance of sand following the BHBF test net positive, negative, or neutral?
2. What is the minimum duration for BHBF tests needed to build and maintain sandbars under sand enrichment?
3. Can the next BHBF test increase campable areas at sandbars on a sustainable basis?
4. How do post-BHBF flows affect the persistence of sandbars and related backwater habitats used by humpback chub and other fishes?

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Humpback Chub Questions

Strategic science question: How important are backwaters and vegetated shoreline habitats to the overall growth and survival of young-of-year and juvenile native fish?

BHBF science question

- Do BHBF tests result in creation of backwater habitats that may offer physical benefits to humpback chub and other native fishes?

- To what extent are backwater habitats created by a BHBF used by humpback chub and other native fishes?

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Cultural Resource Questions

- **Strategic science question: How effective are various treatments in slowing rates of erosion at archaeological sites over the long term?**

BHBF science questions

1. **Do sandbars deposited by BHBF tests contribute to preservation of archaeological sites in the river corridor?**

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Other Priority Questions

- **Strategic science question:** How is invertebrate flux affected by water quality and dam operations?
  - **BHBF science question:** How will a HFE affect food production and availability?
    - Impact rainbow trout in the Lees Ferry reach?
    - Impact native fishes?

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Other Priority Questions

BHBF science questions

- **Are open patches more susceptible to exotic species colonization and establishment than sites with existing vegetation following a disturbance?**
- **Lake Powell: Will a HFE result in higher nutrient releases and shrinking of the hypolimnion?**

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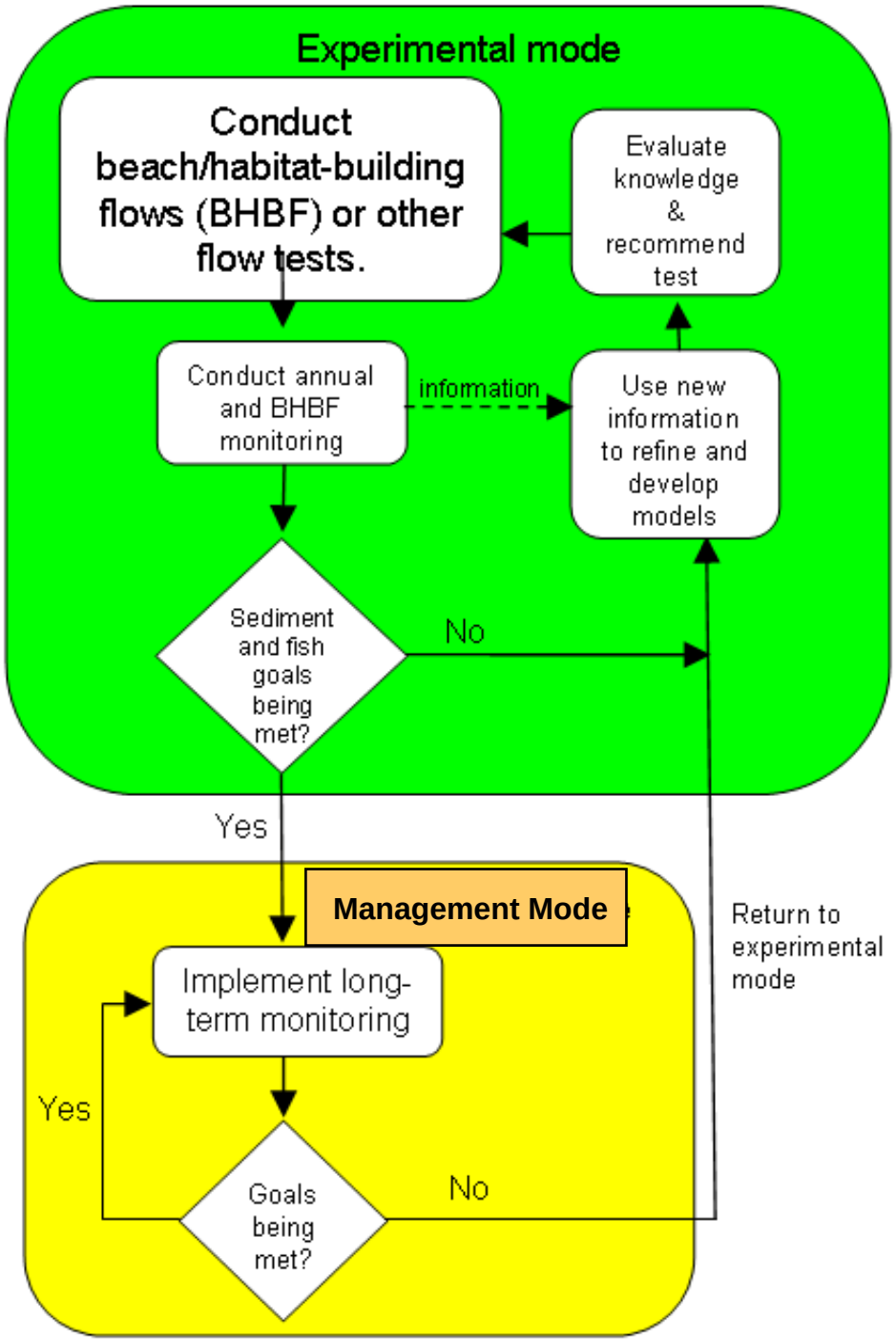

Long-Term HFE Strategy

Several HFEs may be required :

- **Sand supplies are limited**
- **High Flow events are inefficient**
- **Intervening flows export sand**
- **Effectiveness is based on cumulative effects of multiple events**
- **Effectiveness varies under different flow regimes and natural conditions**

Modeling may reduce the number of tests and costs

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Reporting Schedule: see handout

6-Month Update

May 2008 Grand Canyon Quality-of-Water (sand transport)

Glen Canyon Dam Adaptive Management Program Meeting, Phoenix, AZ

David Topping, Ron Griffiths, Tom Sabol, Nick Voichick, Bob Tusso, Ted Melis, Paul Grams, and many others at the USGS

May 22, 2008

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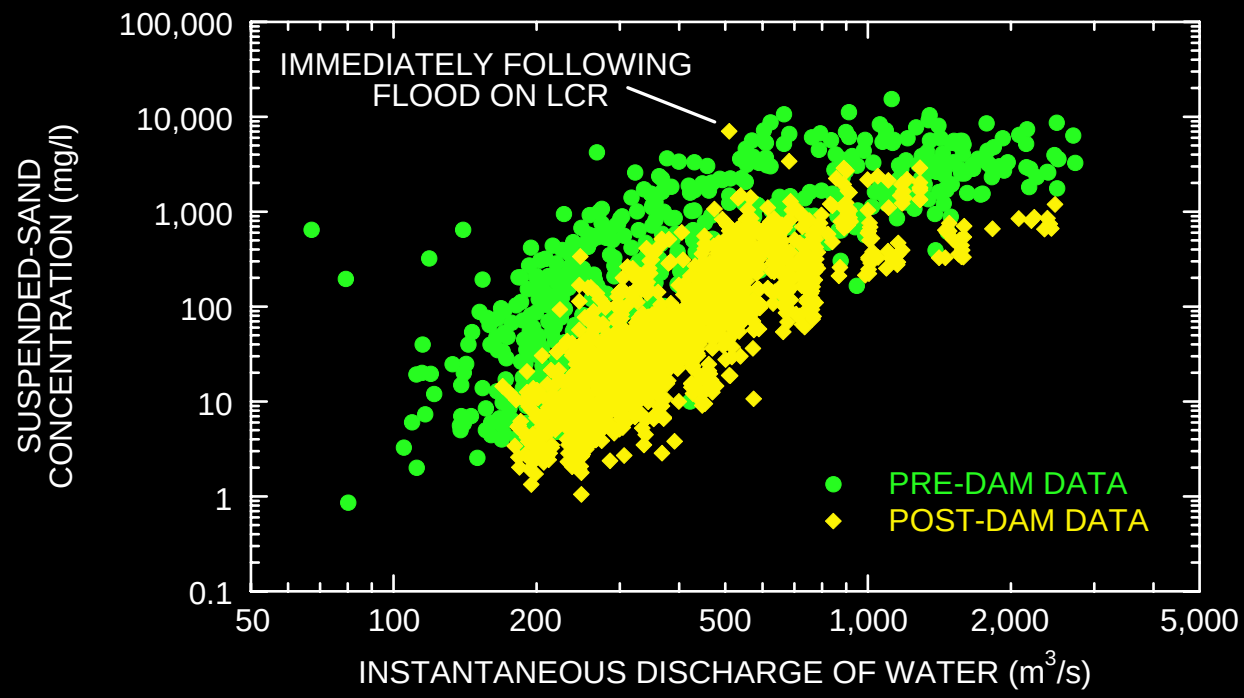
Large discharge-independent changes in suspended-sediment concentration and grain size over short (i.e., < hourly)timescales



Three orders of magnitude range in sand concentration at any given water discharge.

Implication...high resolution direct measurements of sand concentration are required (after Rubin and others, 2002)

Since 1999, We Have Been Studying Below-Average Water Years

- Knowing sand inputs is not enough to conduct future BHBF tests, levels of sand retention in key reaches must be known!
- Only a 20% increase in downstream water delivery will result in a minimum factor of 2 increase in sand export (details depend on monthly water distribution and grain size)
- The recent return to a more “normal” flow scenario will negate any of the sand retention we have observed during below-average 8.23 maf water years (2000-2007)
- Demonstrable retention of tributary sand in the Colorado River under “average” water years is < 2 months (Topping et al., *WRR*, 2000; Rubin et al., *EOS*, 2002; Wright et al., *USGS-Circ.*, 2005)
- Flows have increased above 8.23 maf this year for the first time since 1999!

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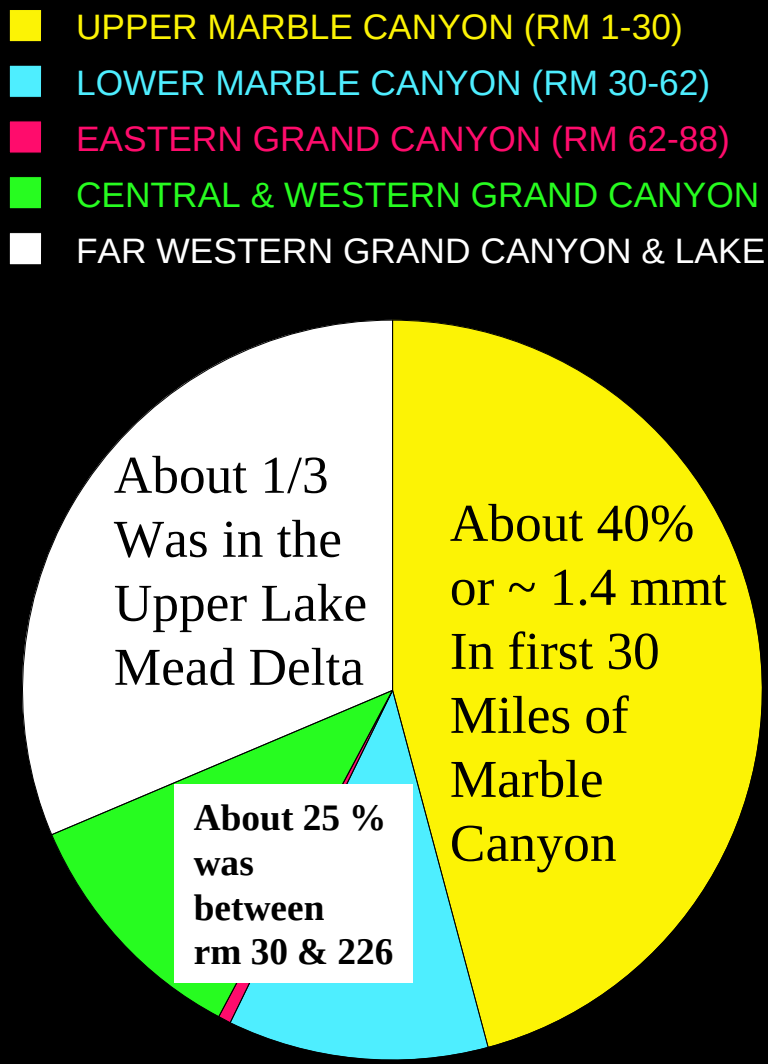
On January 20, 2008, where was the ~2.9 million metric tons of new tributary sand supplied since October 1, 2006?



Most of the New Sand Above Mile 226 was still in Upper Marble Canyon at the Time of the March 2008 High Flow Experiment

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Preliminary results – subject to review and revision

Initial Results from 2008 HFE

But First, a Brief Review of Past HFE Results . . .

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Preliminary results – subject to review and revision

Part I – Reviewing Previous High Flow Experimental Sediment Results

March 1996 (w/o sand enrichment)

November 2004 (w/ sand enrichment)

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1996 synopsis

- No recent tributary sand enrichment prior to flood
- Erosion of upstream sandbars led to high-elevation sand deposition downstream
- Upstream sandbars did not rebuild during subsequent years
- Non-sustainable approach (Rubin and others, 2002) – led to recommendations for future sand-enriched testing

Lees Ferry gage (0-mile)

30-mile

61-mile

166-mile

Grand Canyon gage (88-mile)

above Diamond Creek gage (226-mile)

(Schmidt, *AGU-Mono*., 1999; Hazel et al., *JGR*, 2006; Topping et al., *FISC*, 2006)

2004 synopsis (median Sand Supply)

- > 800,000 metric tons of sand retained above river-mile 30 prior to flood (mostly above river-mile 8)
- Sandbars built between river-miles 1 & 40
- Downstream from river-mile 40, erosion of upstream sandbars led to high-elevation sand deposition downstream
- Canyon-wide July-November 2004 sand mass balance remained positive
- Sustainable approach ????? (scientists recommend more high flow testing under sand enriched conditions)

Lees Ferry gage (0-mile)

30-mile

61-mile

166-mile

Grand Canyon gage (88-mile)

above Diamond Creek gage (226-mile)

(Topping et al., *FISC*, 2006)

Part II – Initial Project 1.A Data

"Sand Budgeting in Upper 1/3 of CRE"

Preliminary results – subject to review and revision

Mass Balance Remained Positive Through March 2008 HFE

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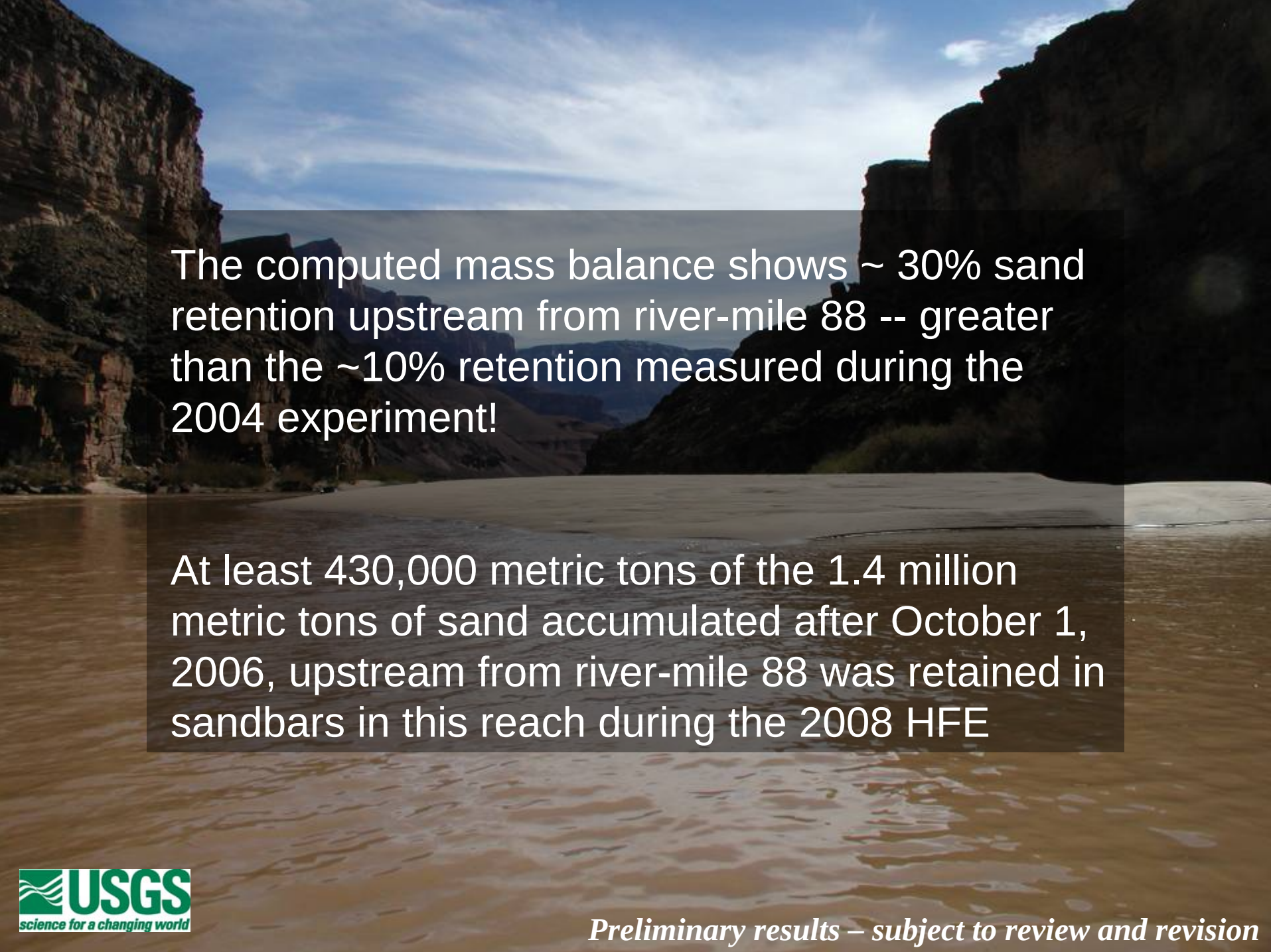

The computed mass balance shows ~ 30% sand retention upstream from river-mile 88 -- greater than the ~10% retention measured during the 2004 experiment!

At least 430,000 metric tons of the 1.4 million metric tons of sand accumulated after October 1, 2006, upstream from river-mile 88 was retained in sandbars in this reach during the 2008 HFE

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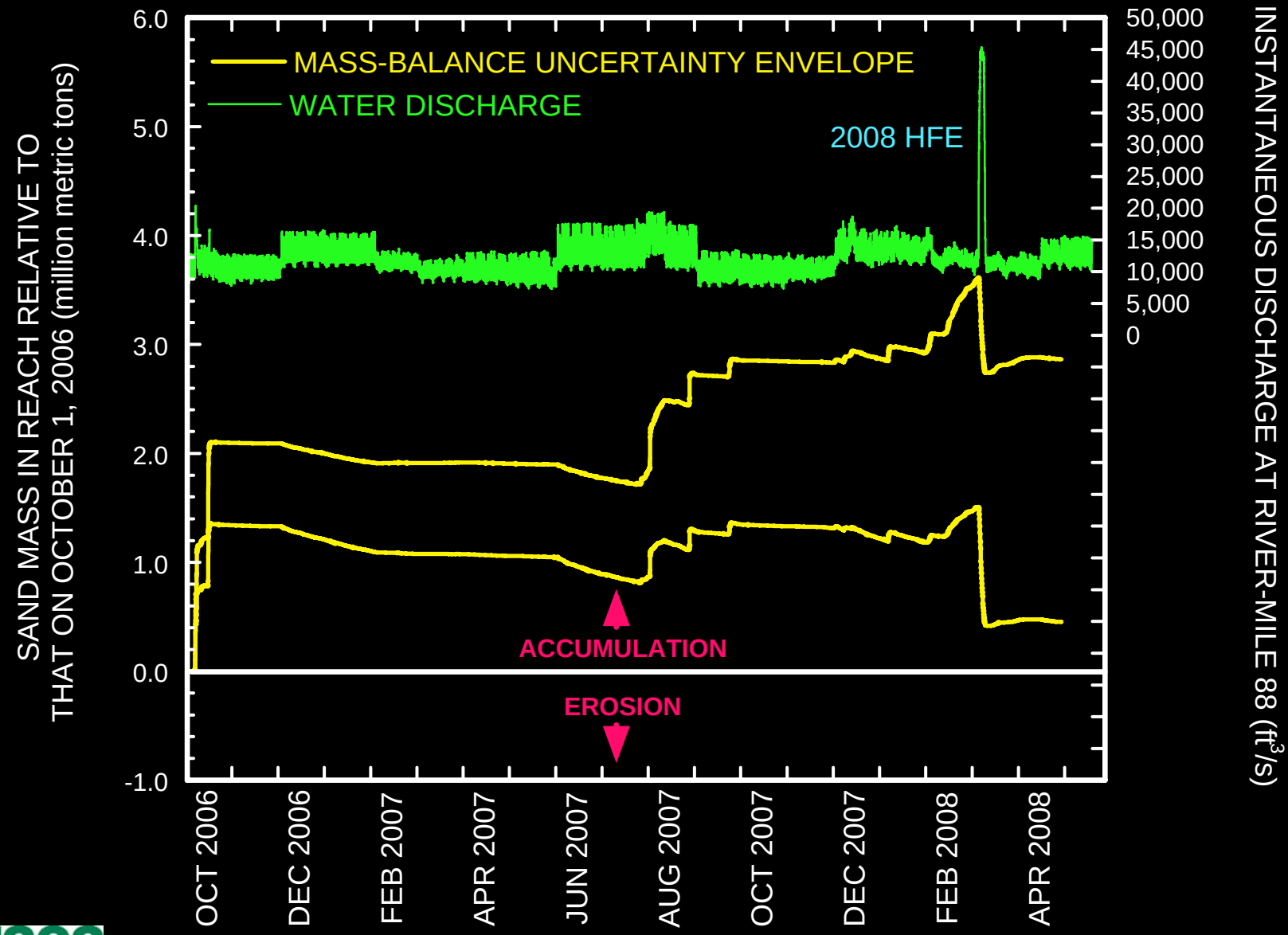
Preliminary results – subject to review and revision

OCT 2006 - MAY 2008 MASS-BALANCE SAND BUDGET FOR MARBLE CANYON AND EASTERN GRAND CANYON (river-miles 1-88)



Demonstrable > 430,000 metric tons sand retention!

Preliminary results – subject to review and revision

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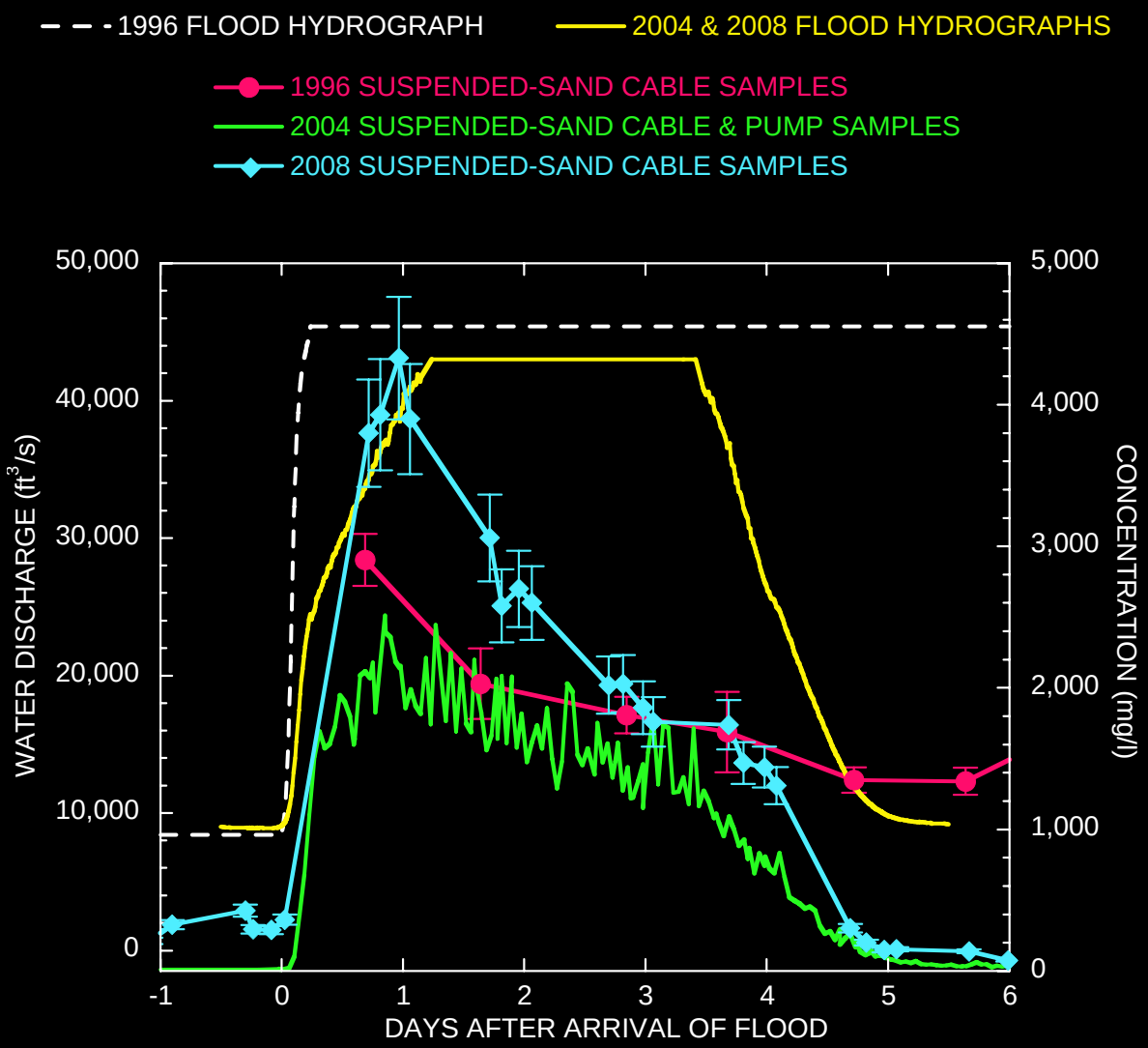
- At river-mile 88, sand concentrations were much higher during the 2008 HFE than during either the 1996 or 2004 controlled-flood experiments
- Thus, the river was most sand enriched at this site during the 2008 HFE, likely as a result of the downstream export of sand stored in lower Marble Canyon prior to the 2008 HFE.



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Preliminary results – subject to review and revision

When Will Project 1.A Results Be Finalized?

WELL, WE HAVE OVER 1,000 SUSPENDED-SEDIMENT SAMPLES TO PROCESS....STAYED TUNED FOR UPDATES in 2008-09’

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Part III – Initial Photographic Data

"Many Sandbars, But Not All Were Rebuilt During the March 2008 HFE"

Initial Results From Projects 1.C & 1.D

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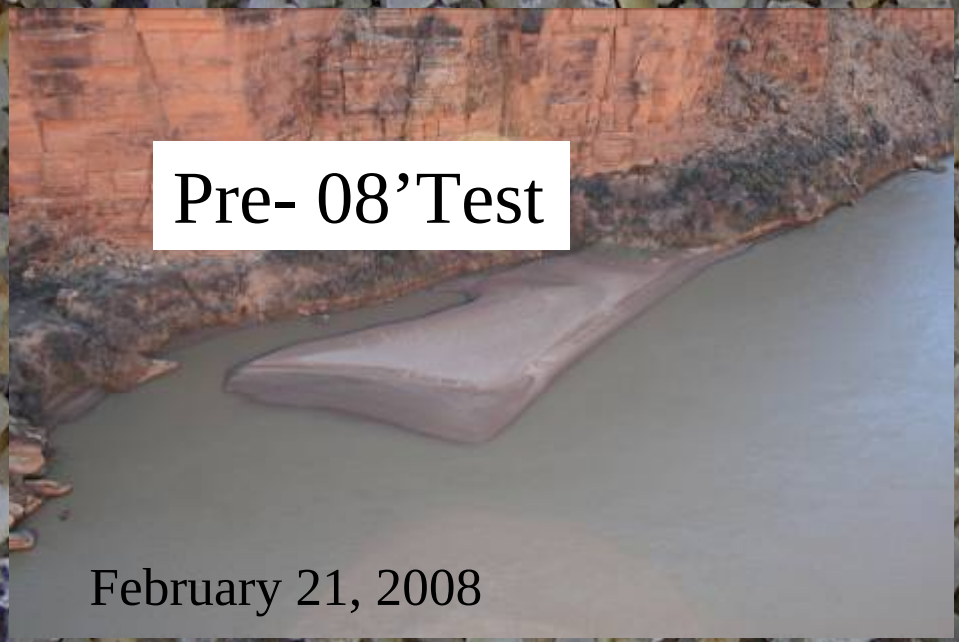
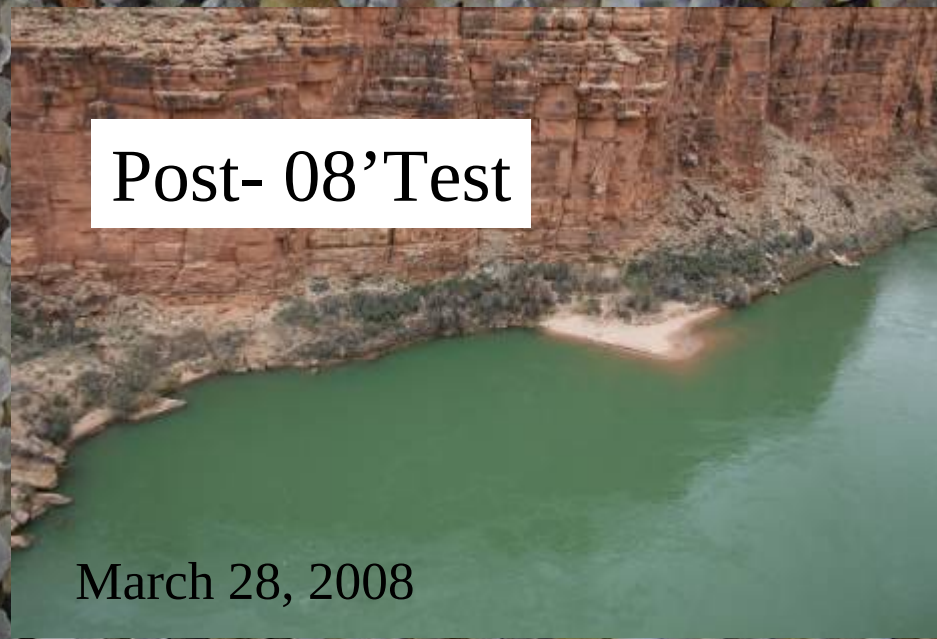
Photographic Data – RM 2

Sandbar and backwater loss

Above Cathedral Wash - River Left





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Photographic Data – RM 3

Matched Photos – Above Cathedral Wash - River Left

Net Erosion System-wide Was Predicted after Earliest Studies (Laursen and others, 1976)

October 1987

March 29, 2008

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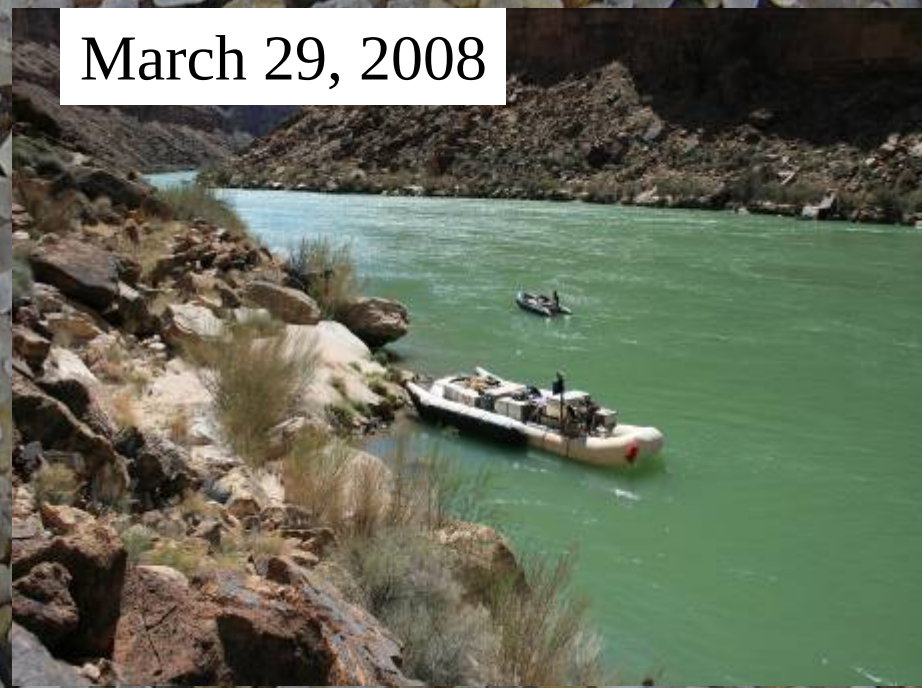
Photographic Data – RM 6

Matched Photos – Below Six Mile Wash on River Left

February 21, 2008

March 29, 2008



Low-Elevation Sandbars in Upper Marble Canyon Were Scoured; backwaters created by these bars were lost

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Photographic Data – RM 16

However, Ten Miles Downstream –
Hot Na Na Camp on River Left - Gained Sand!

Pre-HFE 2008

Post-HFE 2008

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R. Parnell, NAU Geology Dept

Photographic Data – RM 22

Matched Photos – 22-Mile on River Right
A Backwater Habitat Gain

Pre-HFE 2008

Post-HFE 2008

Project 1.D Question: How Long Will this Habitat Last?

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Photographic Data – RM 23

"Harry McDonald" Camp on River Left - Gained Sand

Pre-HFE 2008

Post-HFE 2008

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R. Parnell, NAU Geology Dept

Photographic Data – RM 30

Matched Photos – 30-Mile on River Right
Another Backwater Habitat & Campsite Gain

Pre-HFE 2008

Post-HFE 2008

Backwaters formed by new high-elevation bars are persistent across larger range of fluctuating flows than backwaters formed by low-elevation bars.

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Photographic Data – RM 30R

Matched Photos – "Fence Fault" Camp -River Right
A Gain Similar to the 2004 Response, but not Equal

Pre-HFE 2008

Post-HFE 2008

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R. Parnell, NAU Geology Dept

Photographic Data – RM 31R

Matched Photos – South Canyon Camp

Higher & Wider, But Perhaps Not as Large as 2004

Pre-HFE 2008

Post-HFE 2008

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R. Parnell, NAU Geology Dept.

Photographic Data – RM 34L

River Left "Nautaloid Camp" Also Gained Sand

Pre-HFE 2008

Post-HFE 2008

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R. Parnell, NAU Geology Dept

Photographic Data – RM 41L

River Right "Buck Farm Camp" Gained Sand

Pre-HFE 2008

Post-HFE 2008

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R. Parnell, NAU Geology Dept

Photographic Data - RM 45L

Matched Photos – Eminence Break Eddy – Long-Term Study Site

Backwater Habitat Gained

Pre- 08'Test

Post- 08'Test

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K. Schloff, Delft/Deltaris

Photographic Data – RM 45.3L

Matched Photos – 45-Mile on River Left

Pre-HFE 2008

Post-HFE 2008

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Photographic Data – RM 45L

Matched Photos – "Willie Taylor Site" on River Left

Pre-HFE 2008

Post-HFE 2008

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Photographic Data – RM 51L

Matched Photos – on River Left Above Nankoweap

Pre-HFE 2008

Post-HFE 2008

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Initial Report is that this long-term study site lost sand

Photographic Data – RM 55R

Matched Photos – Kwagunt Marsh

Pre-HFE 2008

Post-HFE 2008

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Photographic Data – RM 64L

Matched Photos – Salt Mine Eddy

Pre-HFE 2008

Post-HFE 2008

Small low-elevation bar buried by new bar resulting in large new backwater

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Photographic Data – RM 65L

Matched Photos – on River Left Above Lava-Chuar
Higher, Not Wider – Similar to 1996 Type Responses

Pre-HFE 2008

Post-HFE 2008

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Photographic Data – RM 81L

Grapevine Camp - Gained Sand in Critical Camping Area!
Higher & Wider!

Pre-HFE 2008

Post-HFE 2008

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R. Parnell, NAU Geology Dept

DRAFT 2008 synopsis (above average sand)

- Demonstrable sand enrichment prior to flood in all reaches ***except between river-miles 61 and 88***
- Some sandbars eroded in uppermost Marble Canyon
- Impressive sandbar deposition in parts of lower Marble Canyon and eastern Grand Canyon
- October 2006-March 2008 sand mass balance remained positive between river-miles 1 and 88
- Data are still being collected as you listen to this talk

> 1 million

Lees Ferry gage (0-mile)

30-mile

< 0.3 million

> 0.2 million

61-mile

166-mile

0

Grand Canyon gage (88-mile)

above Diamond Creek gage (226-mile)

Preliminary results – subject to review and revision

Sandbar-controlled backwater habitats

Large variation in form, size, and persistence across range of flows

Low-elevation sandbars: backwaters present at low range of fluctuating flows (< ~ 9,000 to 10,000 cfs).

HFE response: Low bars eroded or buried by new bars resulting in net loss of this type of backwater.

Large high-elevation sandbars: backwaters present over larger range of fluctuating flows (~7,000 to ~ 16,000 cfs).

HFE response: Deposition of new reattachment bars created this type of backwater.

Preliminary results – subject to review and revision

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More Sand Transport Monitoring Data

"Mid-April Changes in Dam Operations Increased Suspended Sand Transport"

Recall That the Test Being Evaluated Has Two Elements: 1) the Initial HFE Response and 2) The Fate of Sandbars Under Intevening Dam Operations

To Be Sustainable, Both Elements Need to Be Positive From One HFE to the Next…

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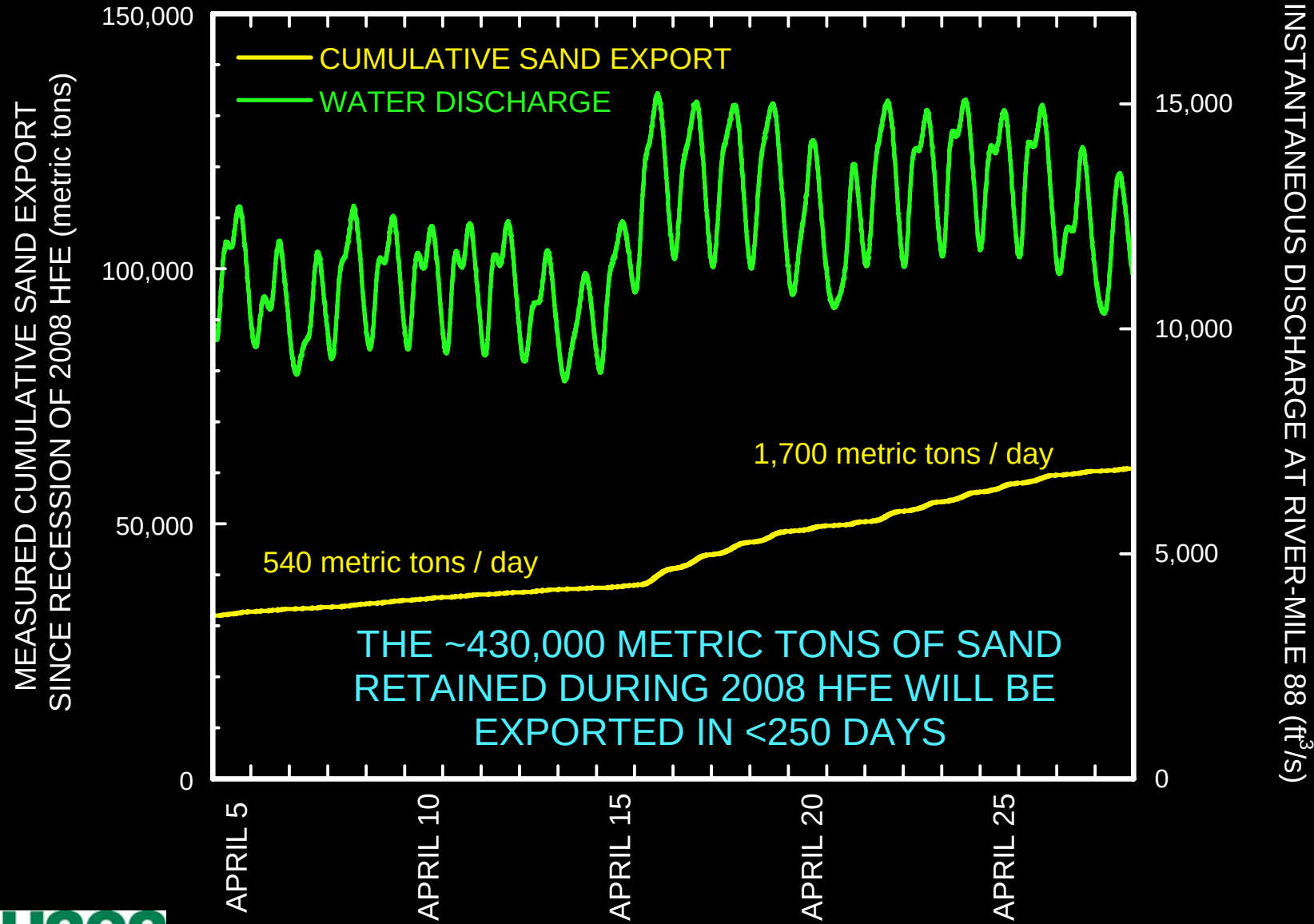
20% INCREASE IN DAM RELEASES RESULTS IN ~FACTOR OF 3 INCREASE IN RATE OF SAND EXPORT AT RM 88



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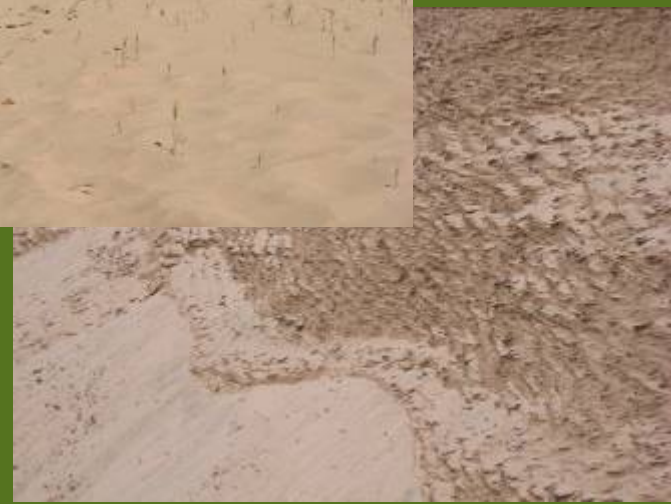
2008 HFE Update - Project 2 - Riparian vegetation – B. Ralston

- Cover and species presence/absence data collected September 07, April 08, Sept 08
- Primary burial of perennial vegetation
- Perennial shoots some seedlings – Seepwillow, camelthorn
- Exotic annuals occurring at top of HFE stage elevation
- Lots of organics in sediment
- Too early for Tamarisk seedlings—will see in Fall following Summer flows



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Preliminary results – subject to review and revision

2008 HFE Update - Project 3 – Food base – T. Kennedy

- **Sample processing is ongoing**

- **HFE Impacts—Preliminary Observations**
  - **New Zealand mudsnail abundance appears to have gone down system-wide**
  - **Does not appear that other invertebrates were strongly and negatively affected by HFE**
  - **Algae and macrophytes were scoured from Lees Ferry, but algae on hard substrates (i.e., talus, cobble) appears to have already recovered**

Preliminary results – subject to review and revision

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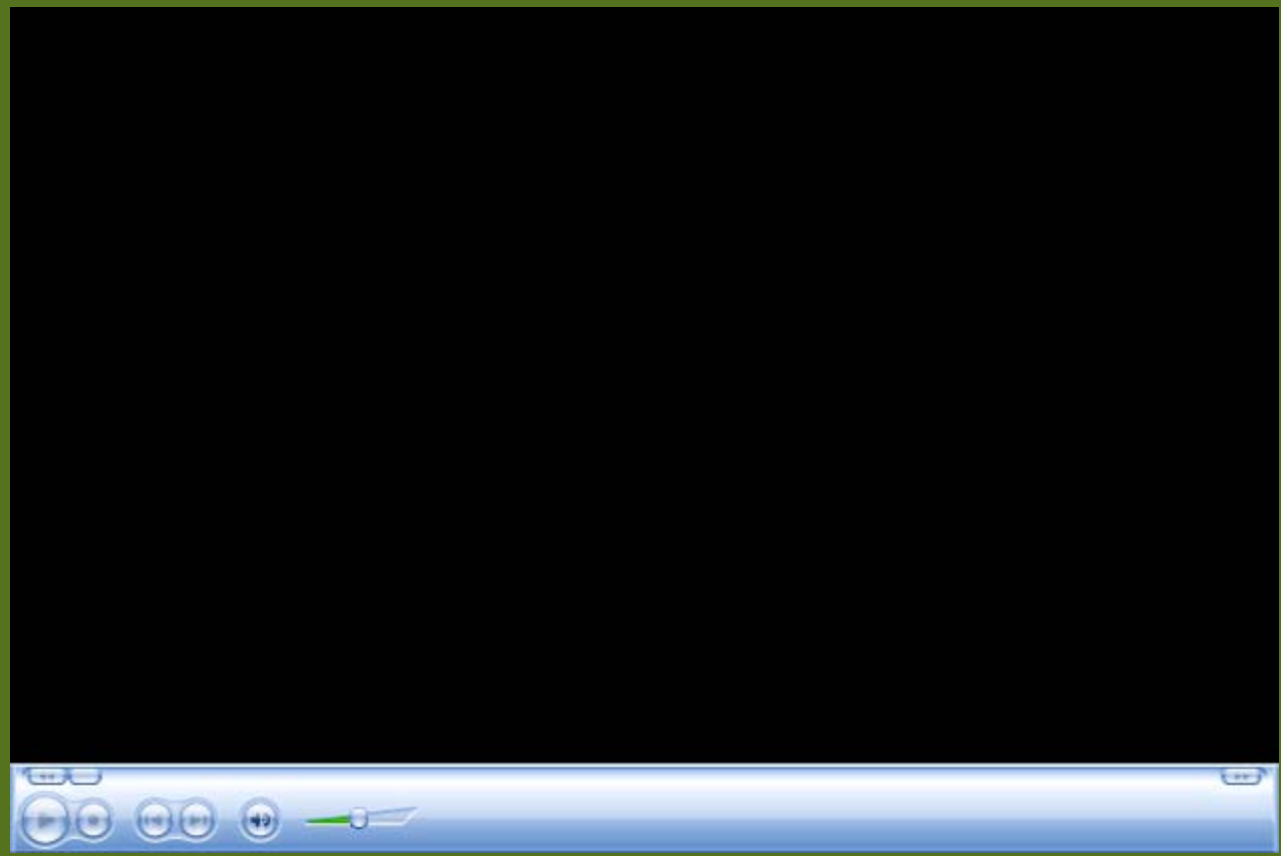
-8 Mile Cobble Bar
Feb. 25th (10 days Pre-HFE)



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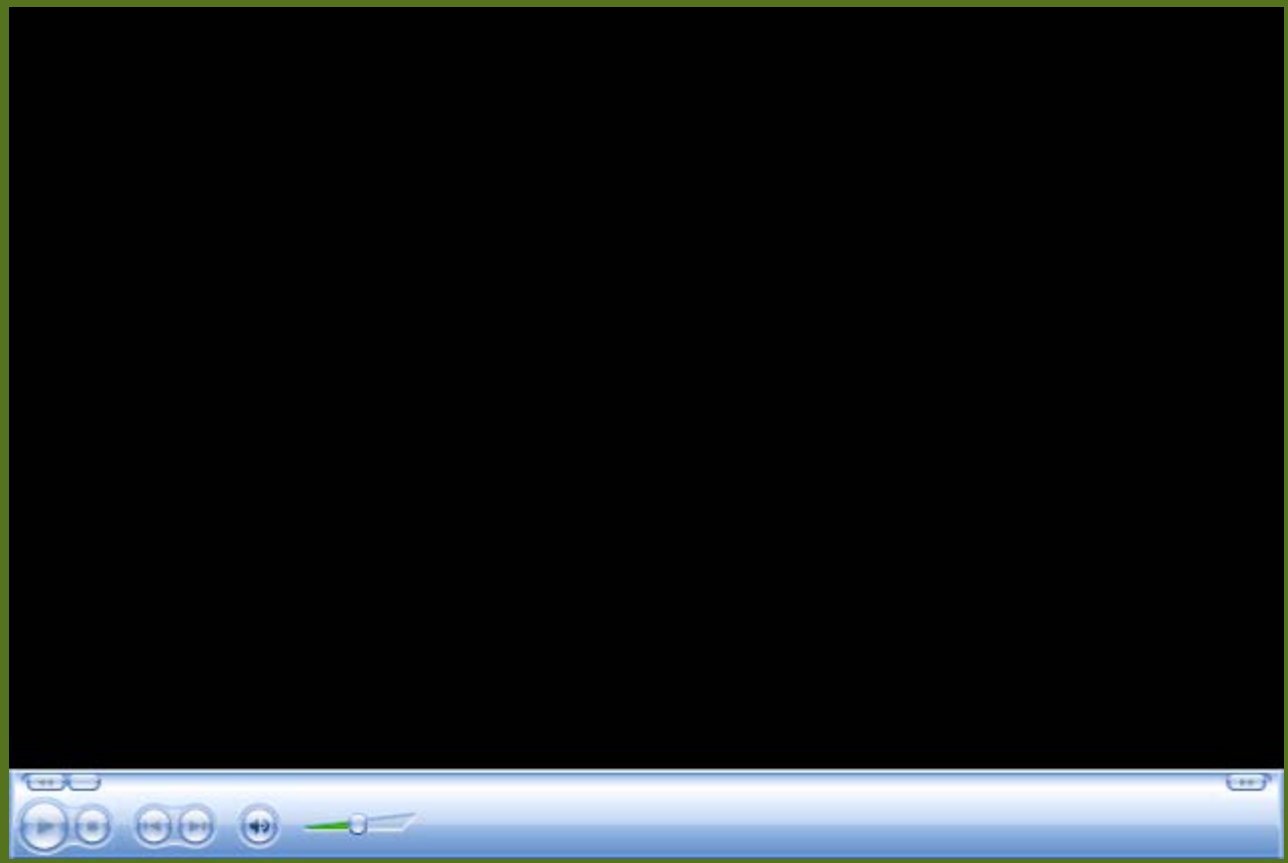
Preliminary movies – subject to review and editing!

-8 Mile Cobble Bar
March 12th (3 days Post-HFE)



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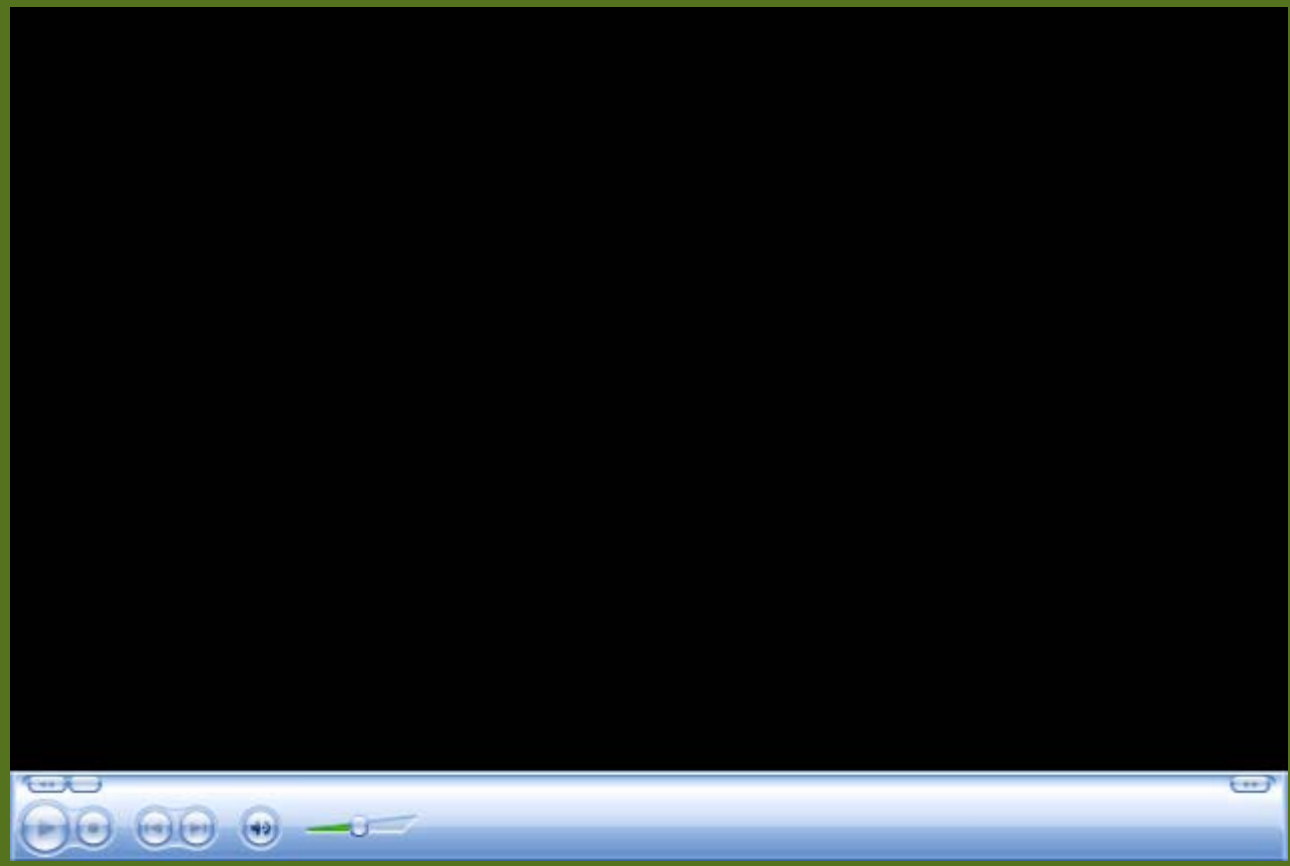
Preliminary movies – subject to review and editing!

-8 Mile Cobble Bar
May 12th (2 months Post-HFE)



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Preliminary movies – subject to review and editing!

2008 HFE Update - Project 4.A - Rainbow Trout—Movement Studies – K. Hilwig

HFE does not appear to have promoted downstream migration of rainbow trout from the Lees Ferry Reach

Preliminary Conclusions:

- 1) Tagged rainbow trout movement downstream was greater after release and before the HFE than was downstream movement during and after the HFE.
- 2) The majority of detected tagged trout remained in the Lees Ferry reach after the HFE.
- 3) Sonic tag remote receivers and manual receivers performed substantially better than previous attempts. Tag configurations will require more development.
- 4) Application of a wide scale sonic telemetry project in Grand Canyon is feasible, though it will require continued development of methods and technologies.

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Preliminary results – subject to review and revision

2008 HFE Update - Project 4.B - Rainbow Trout—early life stages – J. Korman

HFE does not appear to have adversely affected spawning, redds, or early life stages of rainbow trout in Lees Ferry

Preliminary Conclusions:

- **Large numbers of spawning fish and redds were observed immediately after HFE**
- **Spawning appears to still be ongoing**
- **Large numbers of small (20-35mm TL) rainbow trout were observed in early May 2008**
  - **These fish likely hatched from redds that were established prior to the HFE**

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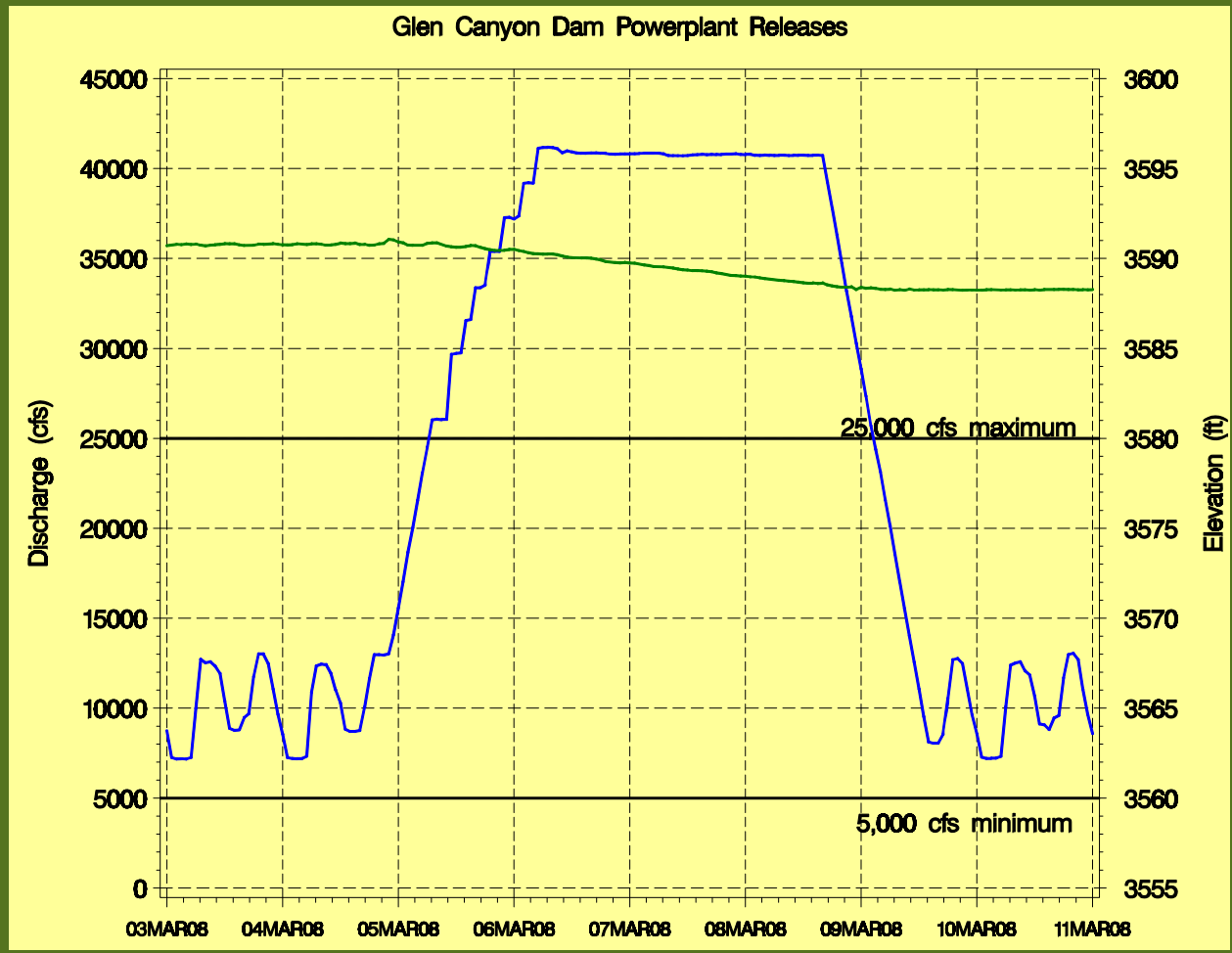
Preliminary results – subject to review and revision

2008 HFE Update - Project 5 – Quality of Water Monitoring March 2008 High-Flow Experiment - Vernieu

- 2.6 ft loss of Lake Powell elevation
- Drawdown could result in release of nutrients from sediment deposits in Lake Powell tributaries



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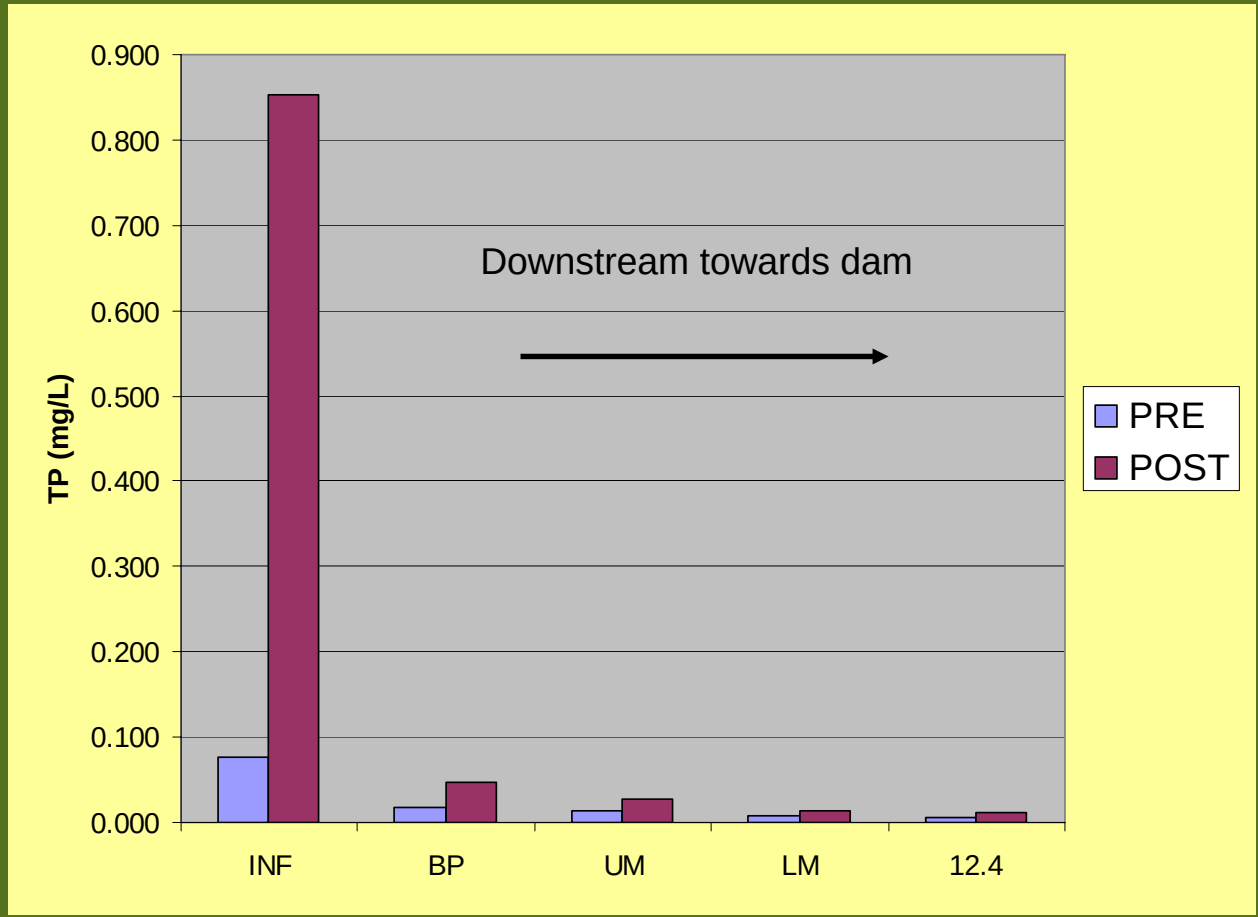
Preliminary results – subject to review and revision

2008 HFE Update - Project 5 – Quality of Water Monitoring Effect of HFE on Navajo Canyon Nutrients – W. Vernieu

- Longitudinal profile of nutrient concentrations in inflow area of Navajo Canyon, Lake Powell
- Results show increase of total phosphorus due to resuspension on delta deposits from reservoir drawdown during HFE



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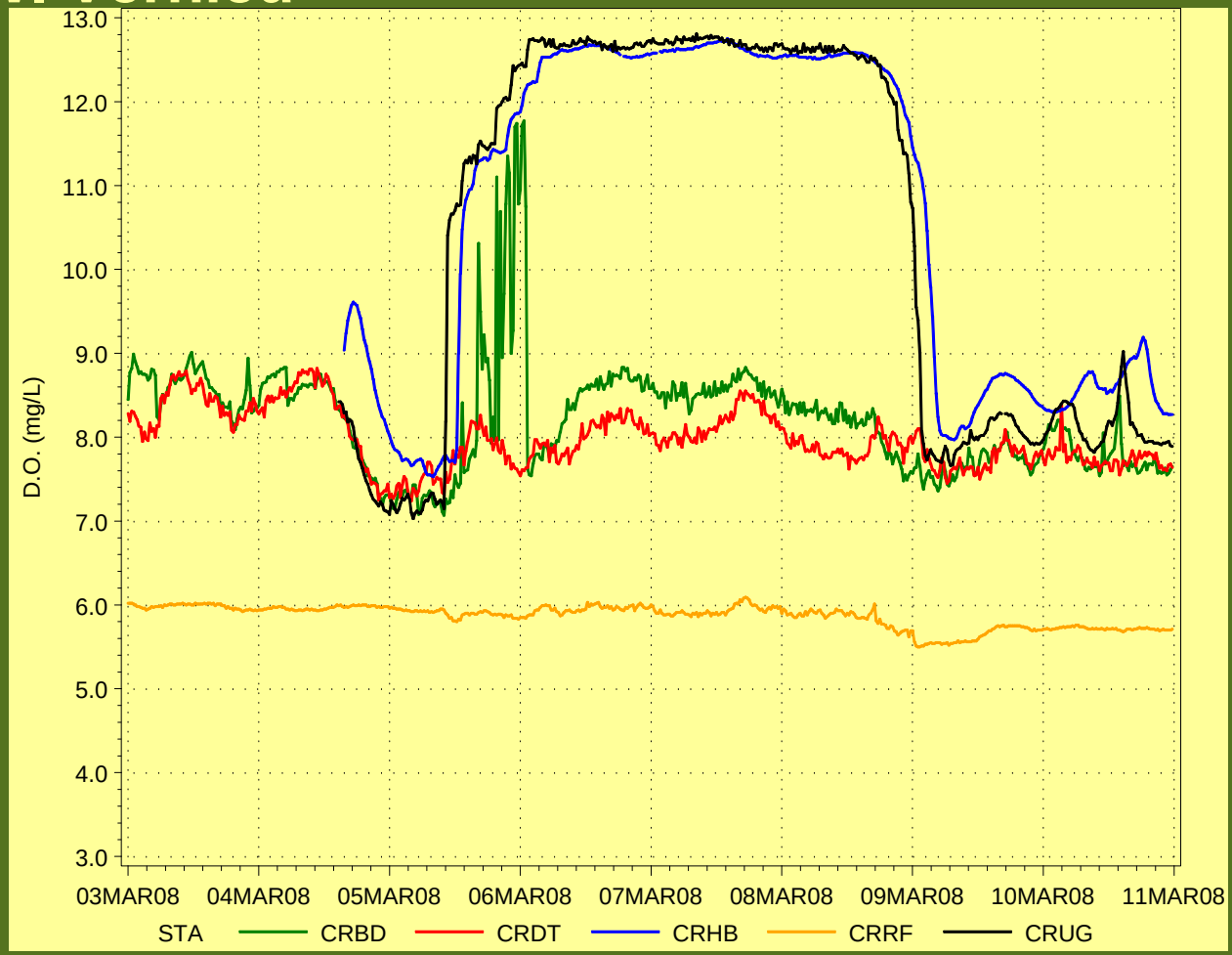
Preliminary results – subject to review and revision

2008 HFE Update - Project 5 – Quality of Water Monitoring Tailwater Aeration (Dissolved Oxygen) During HFE – W. Vernieu

- Orange – River Outlet Works
- Red – Draft Tubes
- Green – Below Dam
- Black – 1.0 mile below dam
- Blue – Horseshoe Bend



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Preliminary results – subject to review and revision

Thank You For Your Attention!

2008 HFE Update – Please contact John Hamill or Ted Melis with any additional questions at: (928) 556-7217

All Preliminary 2008 High Flow Experimental Results Presented at the May 2008 AMWG Meeting Are Subject to Peer Review and Revision under Provisions of the U.S. Geological Survey's Fundamental Science Practice Protocols

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