USGS
science for a changing world

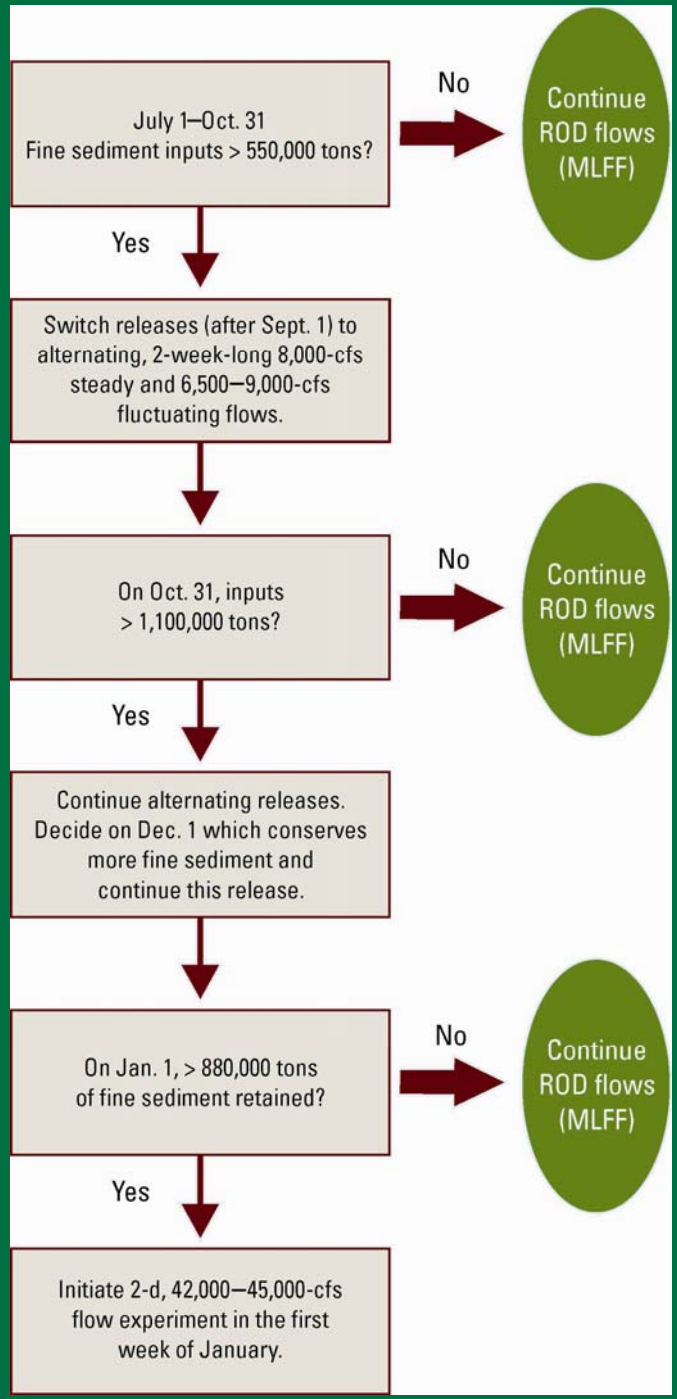
Sediment Transport and Budget during the November 2004 Controlled-Flood Experiment, with Comparisons to the 1996 Controlled Flood Experiment

David J. Topping, David M. Rubin, John C. Schmidt, Joseph E. Hazel, Jr., Theodore S. Melis, Scott A. Wright, Matt Kaplinski, Amy E. Draut, and Michael J. Breedlove

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

2002 Experimental Plan

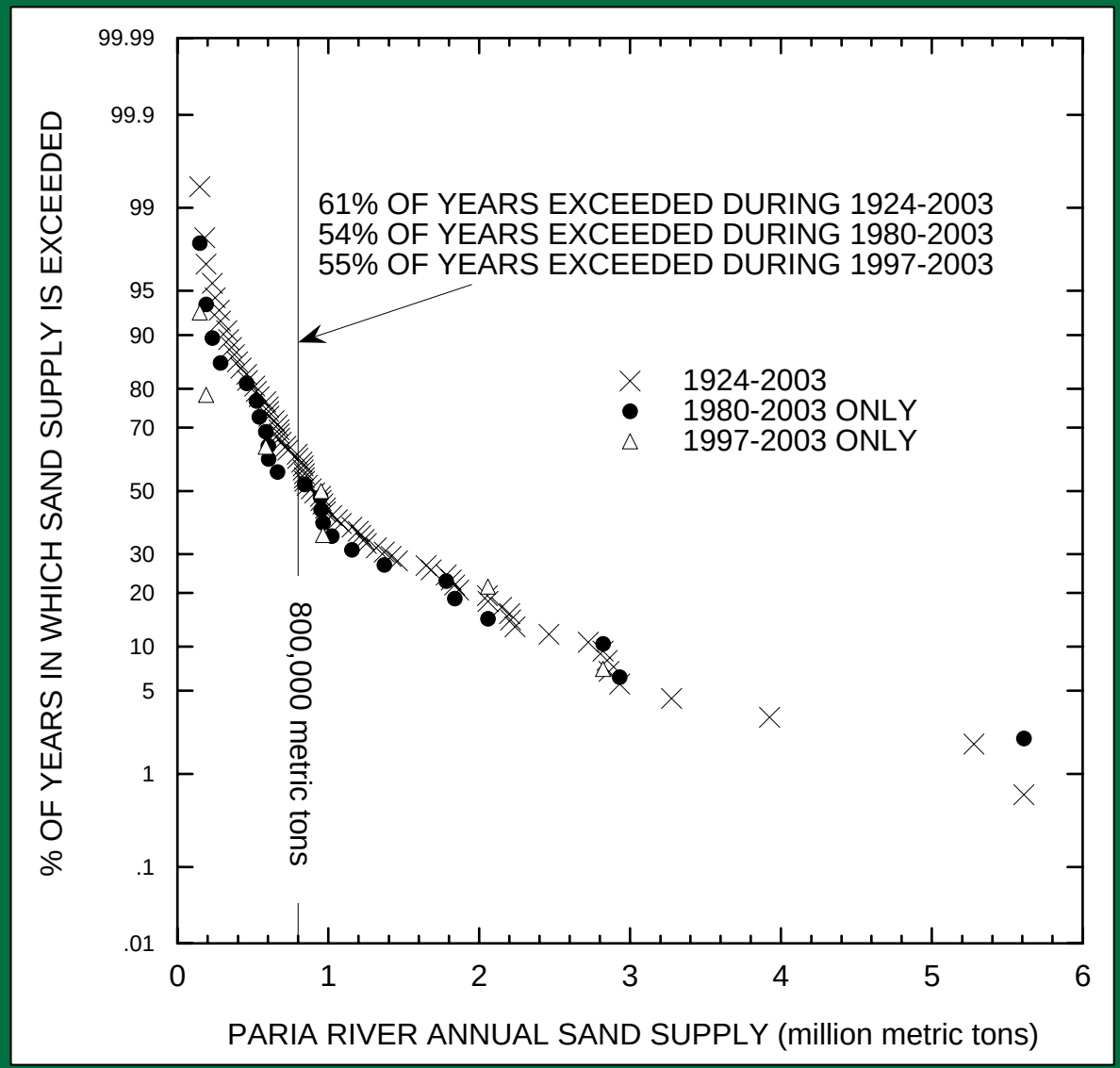
Based on findings since 1996 flood, triggering criteria for a high-flow experiment were established based on tributary inputs and retention.



USGS

High-Flow Experiment Trigger

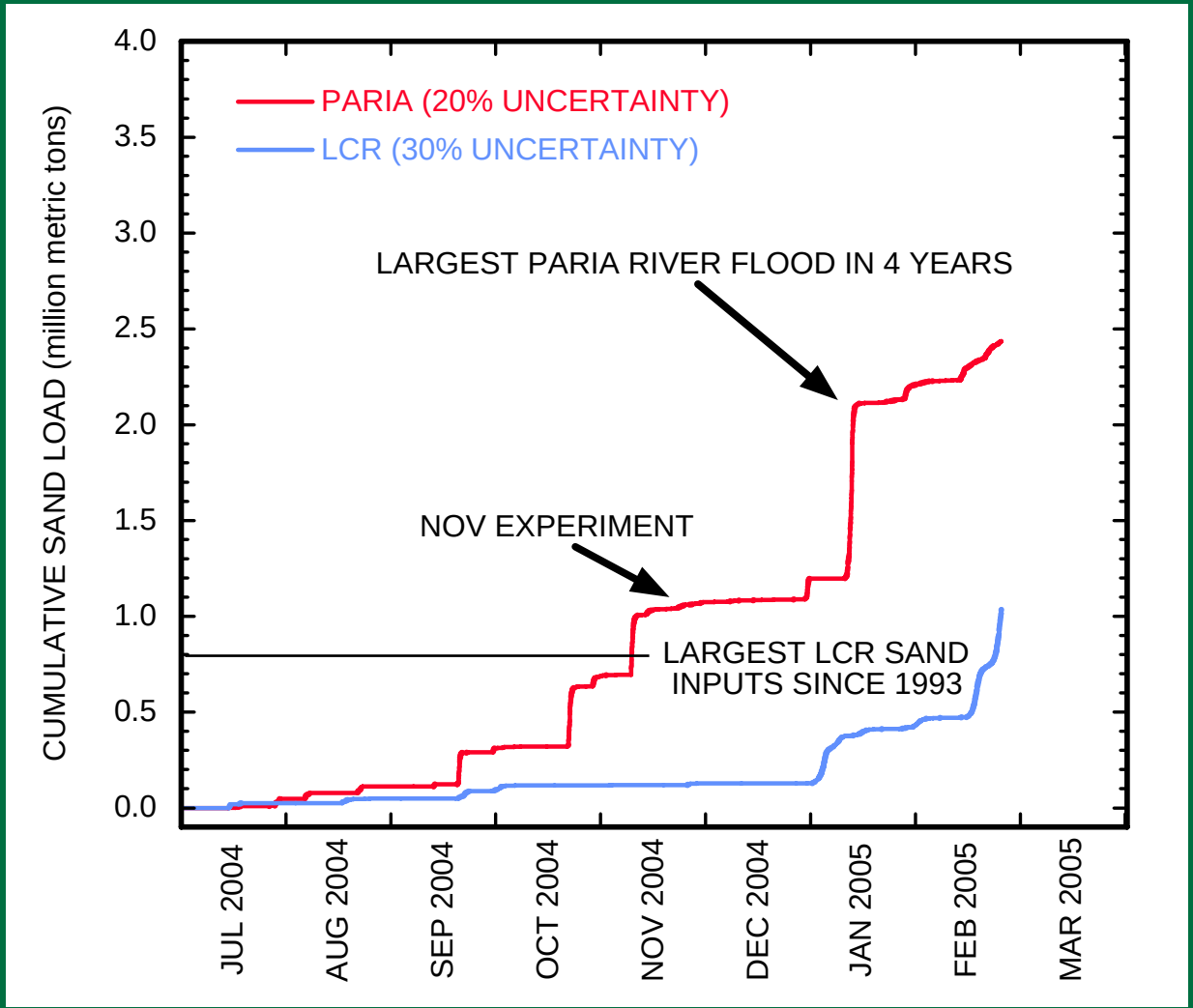
Based on Paria River sand supply that's exceeded every other year – 800,000 metric tons.



USGS

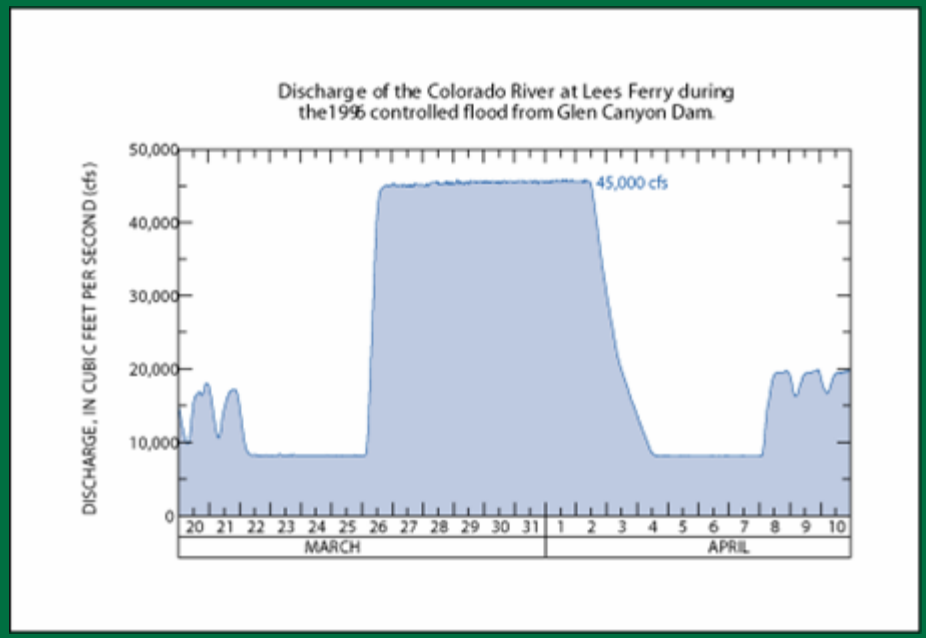
Fall 2004 Tributary Inputs

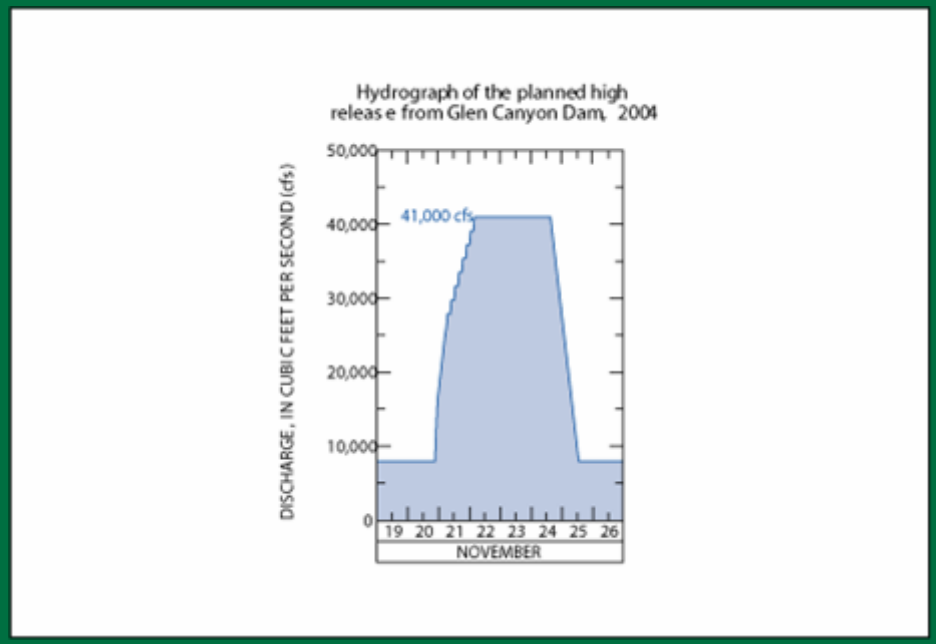
980,000 ± 22% metric tons of sand retained in Marble Canyon by early November



USGS

1996 and 2004 Hydrographs





USGS

Sediment Transport Data Collection During 2004 Flood

- Hourly sampling at 4 sites:
  - 30-mile
  - 61-mile (above Little Colorado River)
  - 87-mile (Phantom Ranch)
  - 225-mile

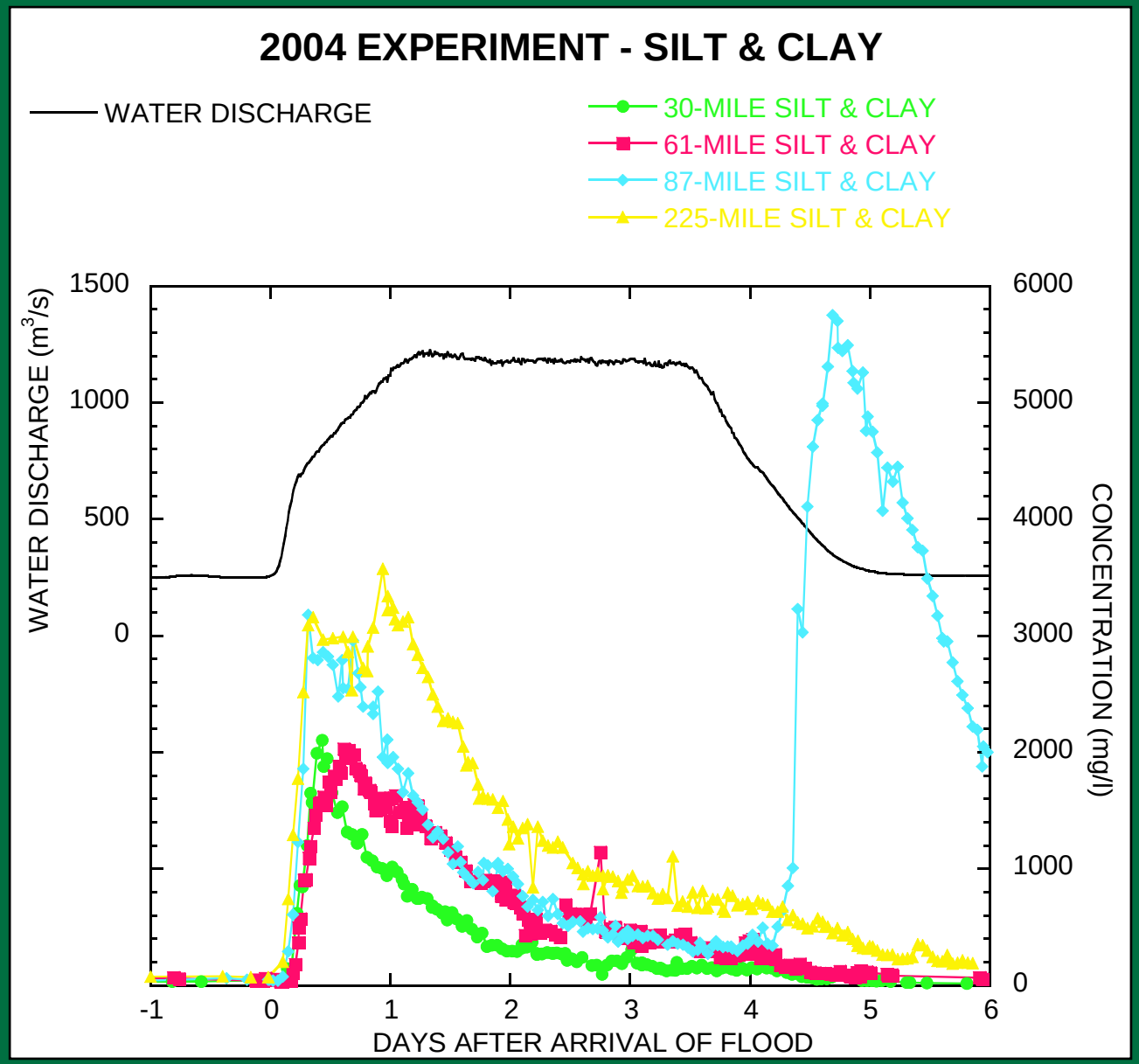
- “Float Trip” designed to sample a single parcel of water on the peak as it moved through the system

USGS

2004 Silt and Clay Concentrations

Concentrations increased rapidly on the rise, then dropped off.

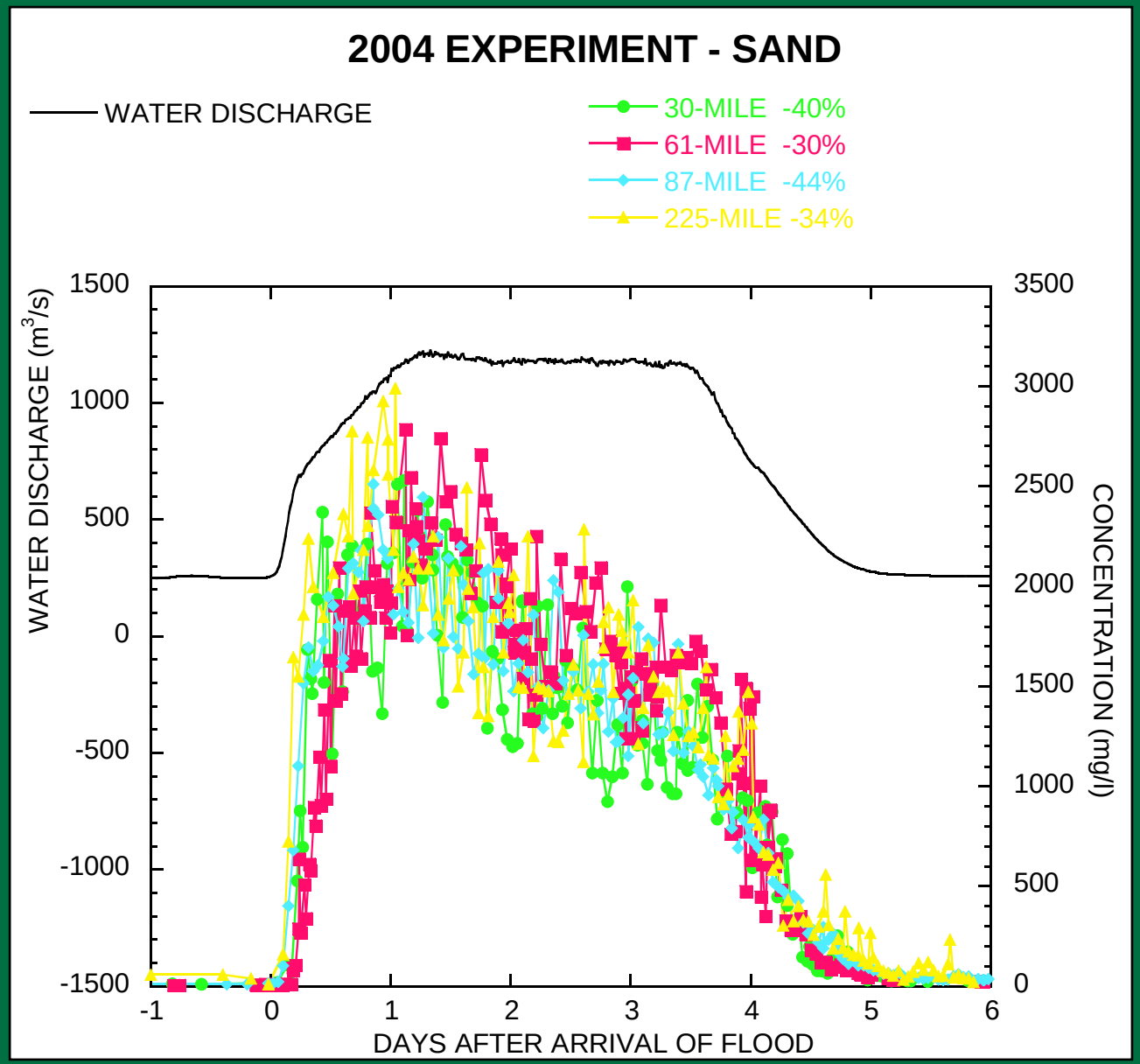
Concentrations increased downstream.



USGS

2004 Sand Concentrations

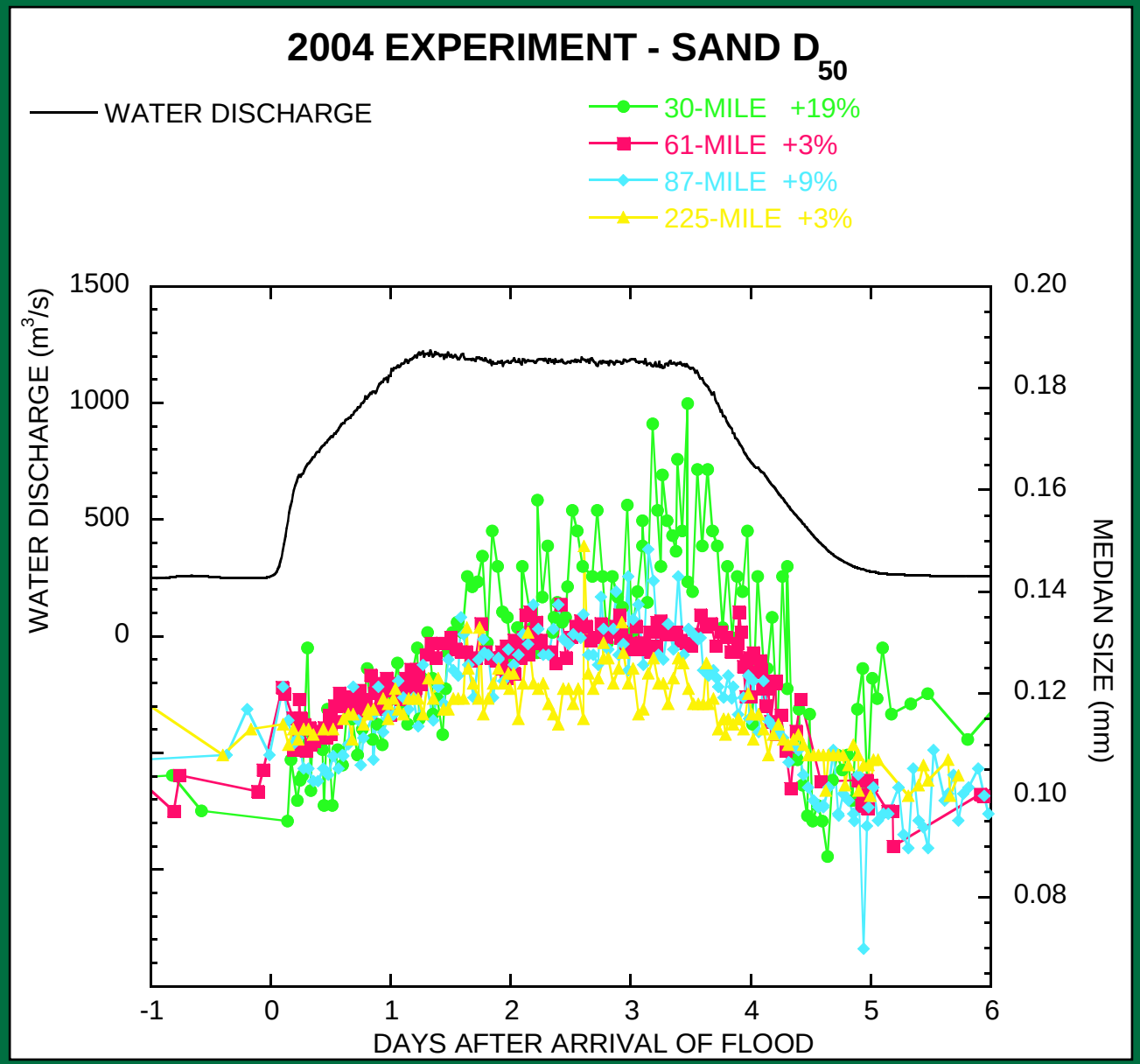
Concentrations peaked with the discharge, then gradually decreased as supply was depleted.



USGS

2004 Sand Median Size

Sand size increased gradually as concentration dropped – depletion of fine sand supply

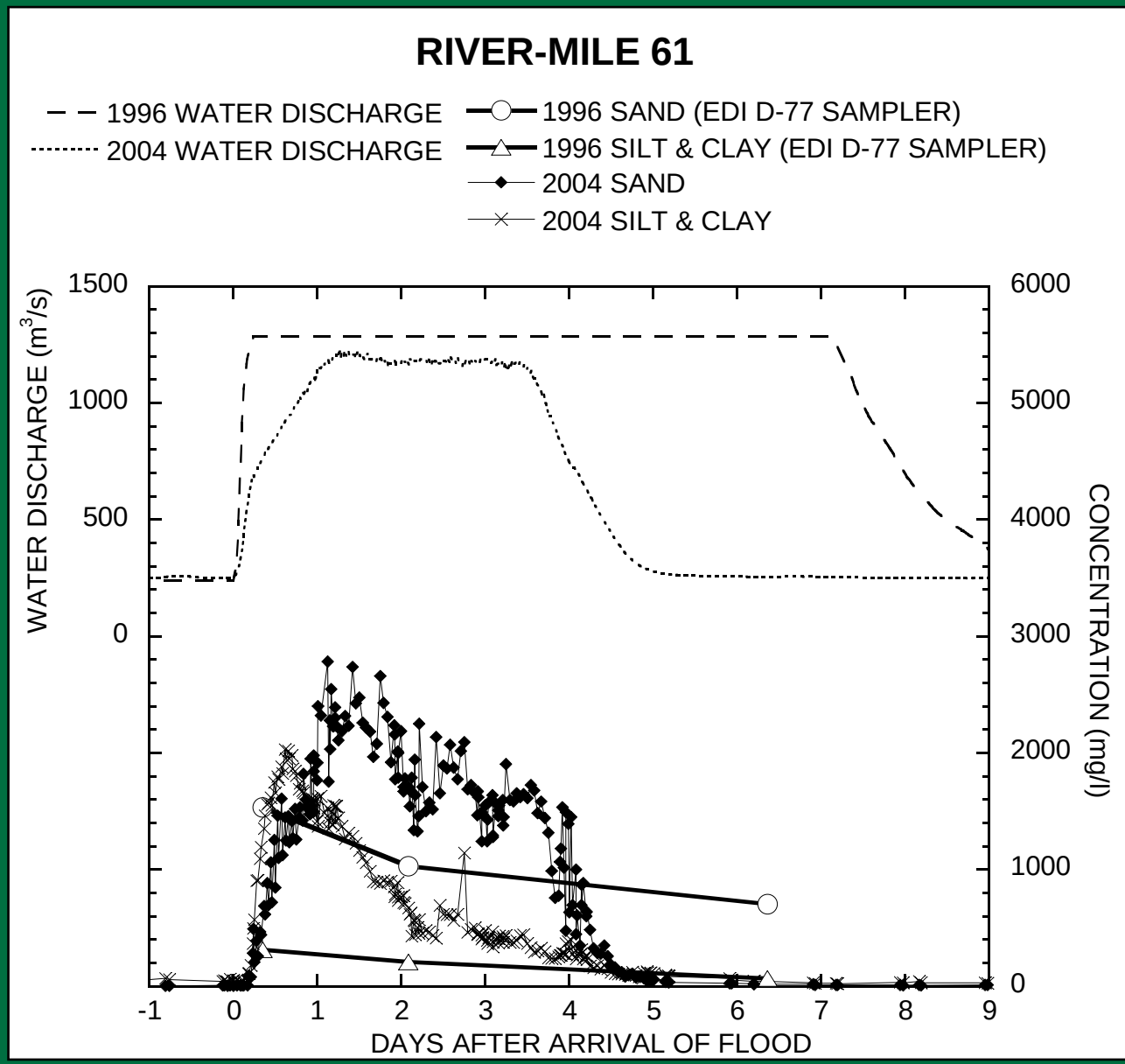


USGS

Comparison with 1996 at 61-mile

Much higher silt and clay concentrations in 2004

Sand concentrations 60-90% higher in 2004

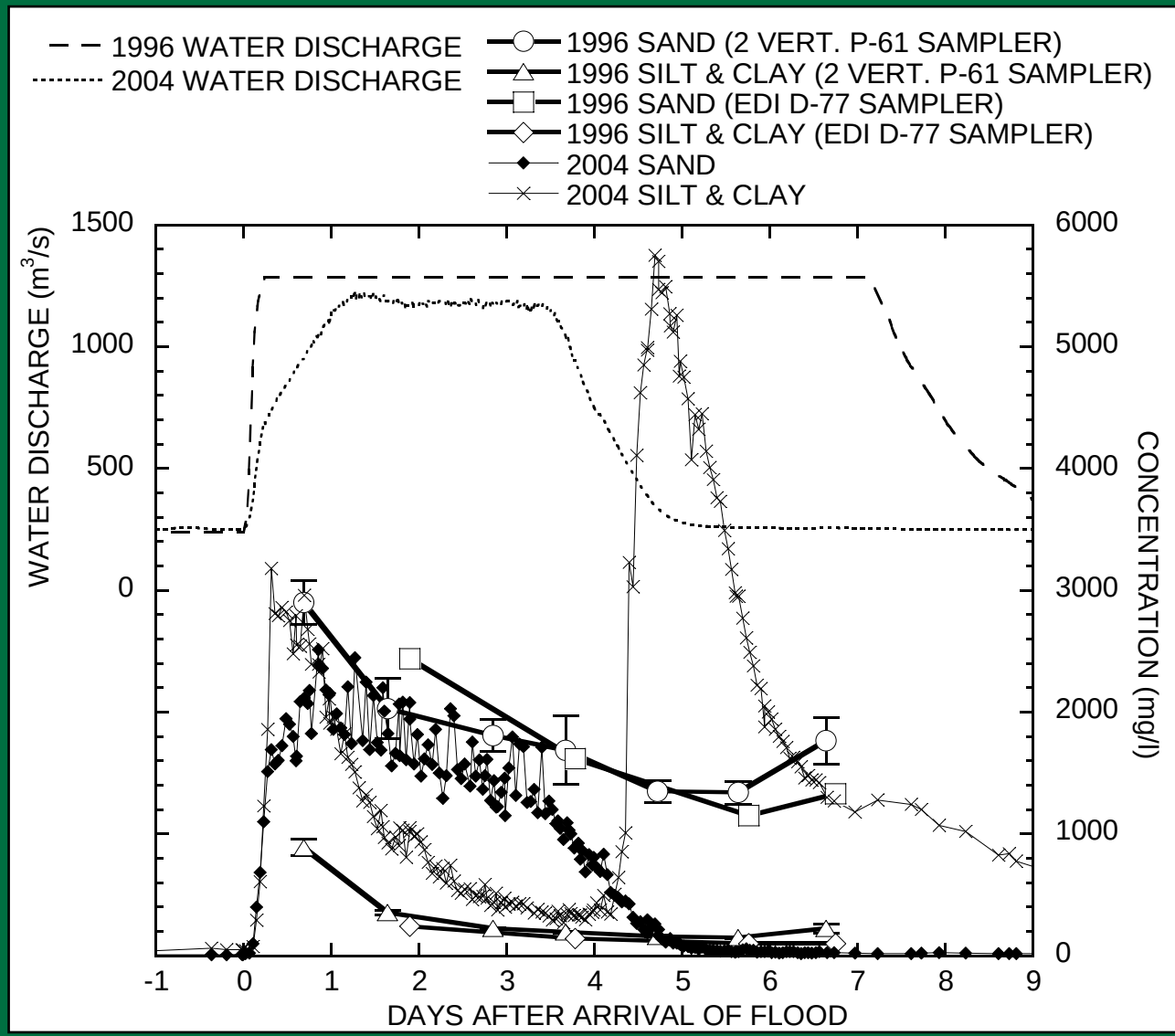


USGS

Comparison with 1996 at 87-mile

Much higher silt and clay concentrations in 2004

Sand concentrations 20-25% less in 2004

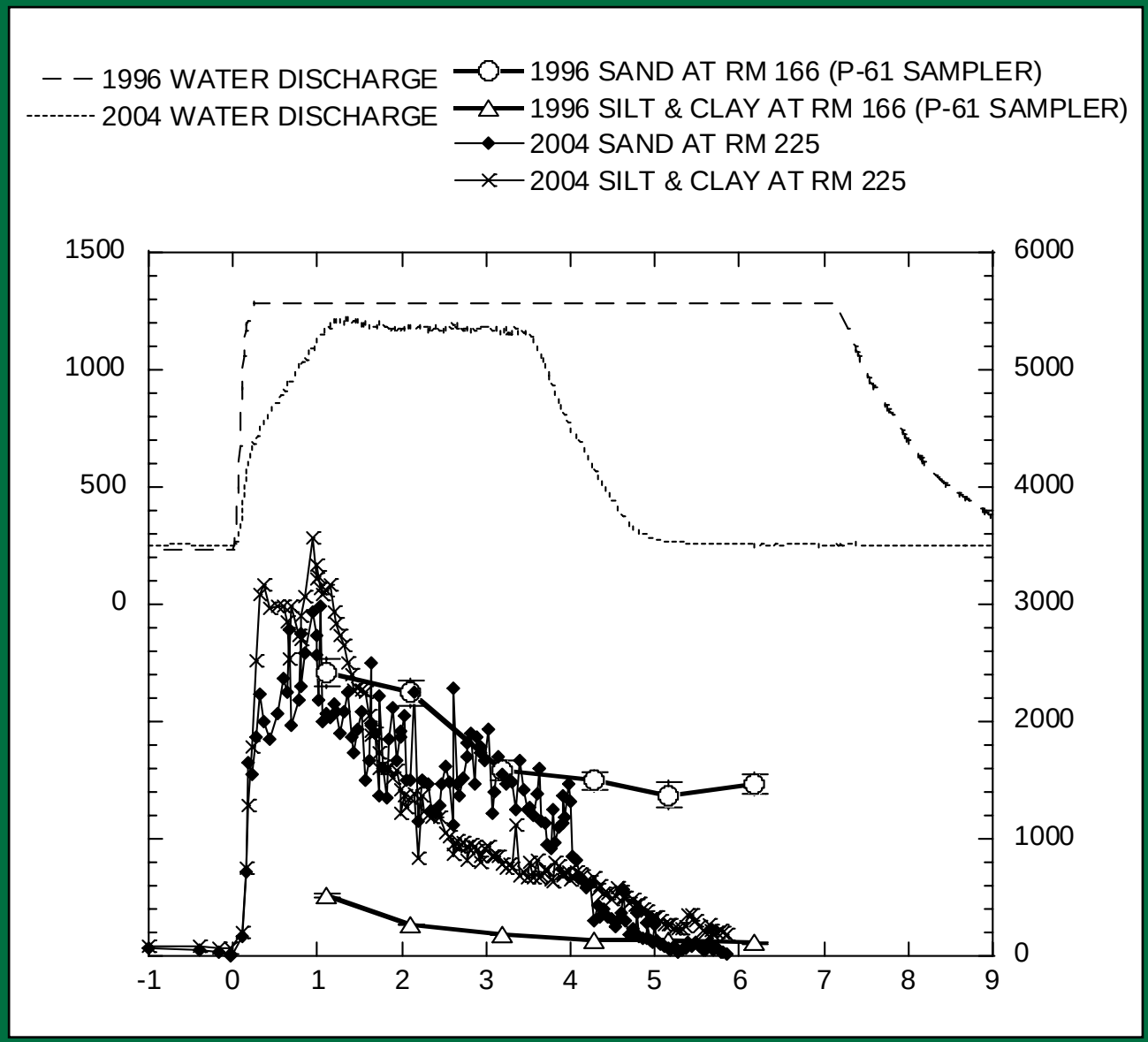


USGS

Comparison with 1996 at 226-mile

Much higher silt and clay concentrations in 2004

Sand concentrations 20-25% less in 2004



USGS

Summary Comparison of 2004 with 1996

- Silt and clay concentrations substantially higher at all sites in 2004
- Sand concentrations 160-240% higher at 30-mile
- Sand concentrations 60-90% higher at 61-mile
- Reflects retention of Paria River sand and some silt and clay in Marble Canyon under low dam releases
- Sand concentrations 20-25% lower at 87-mile and 226-mile
- Reflects minor LCR inputs during Fall 2004 and negative mass balance between 1996 – 2004

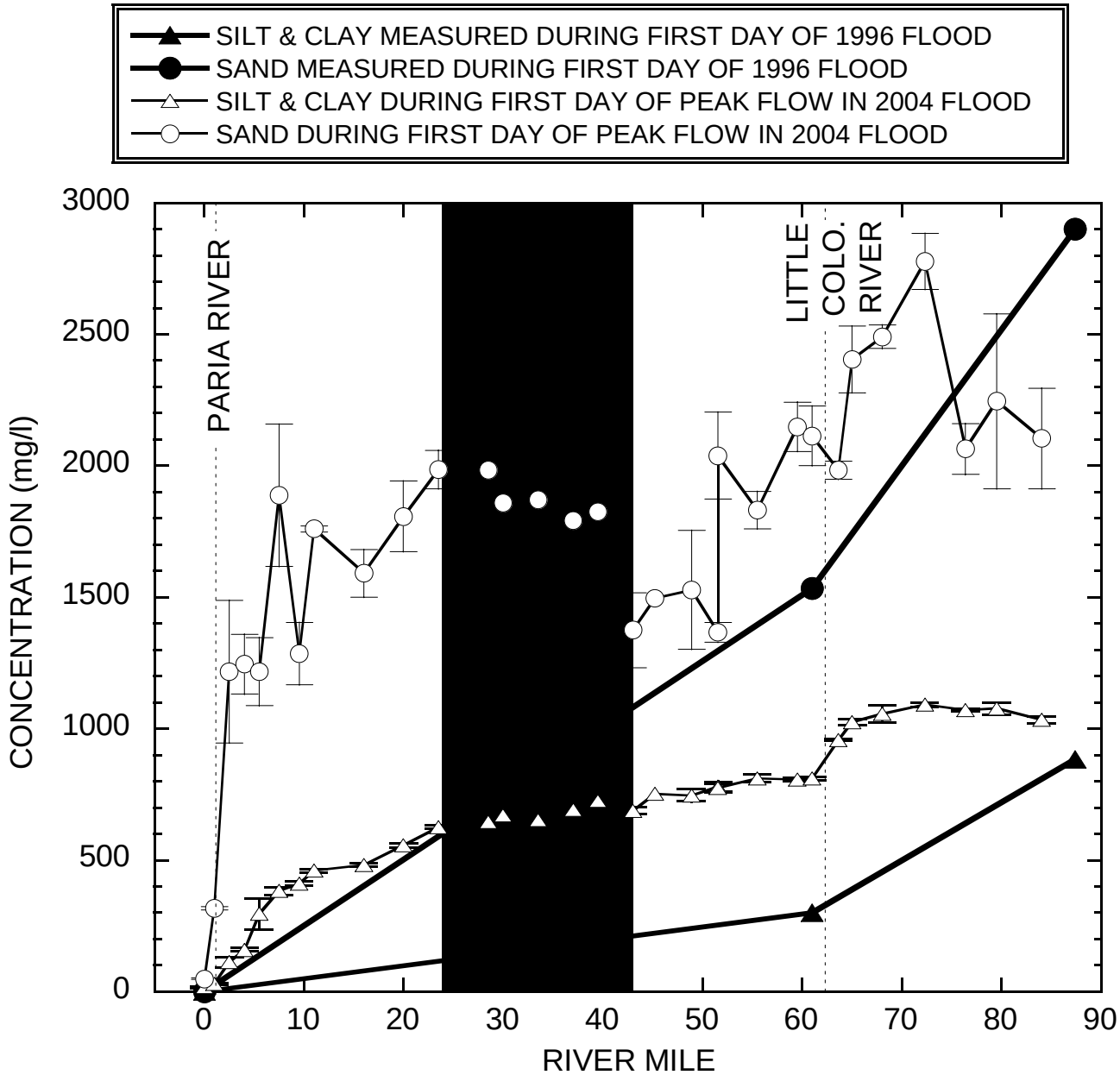
USGS

2004 Flood Mass Balance Results

- About 130,000 metric tons of Paria sand remained above 30-mile after the flood.
- This sand presumably was transferred to eddies, resulting in net increases in eddy volume (and area).
- Downstream from 30-mile, the mass balance was either zero or slightly negative.
- This resulted in 1996-like response: increase in high-elevation volume and area but net loss of sand from eddies.

USGS

2004 Flood “Float Trip” Results



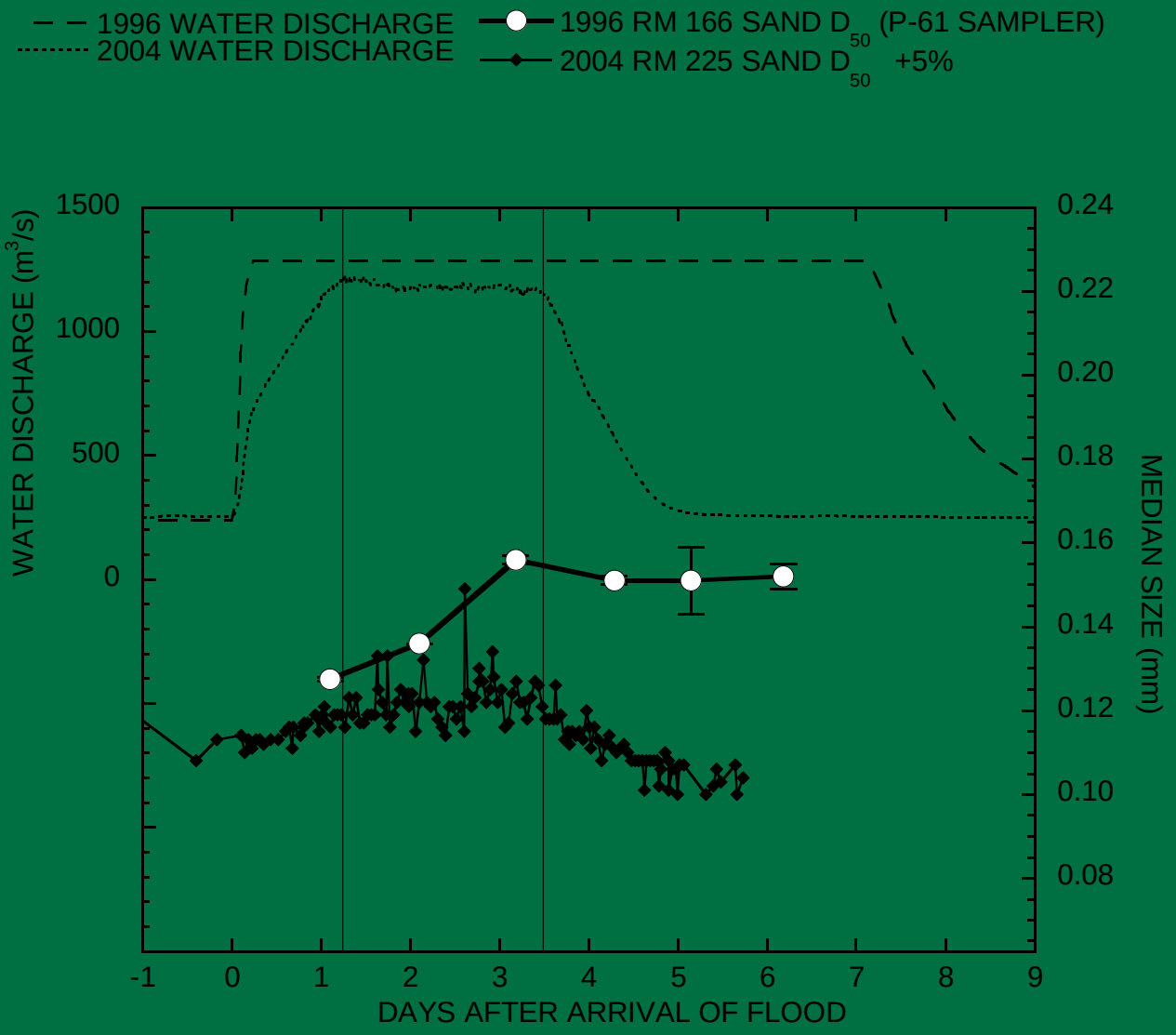
Conclusions

- High-flows under sediment-enriched conditions can result in a positive mass balance and net transfer of sediment from the channel to eddies (contrary to 1996)
- Level of inputs/retention in Fall 2004 resulted in a positive mass balance and sandbar response in only first 40 miles or so of Marble Canyon
- Larger inputs/retention and/or more frequent high-flows are required to promote a positive response throughout Marble and Grand Canyons

USGS

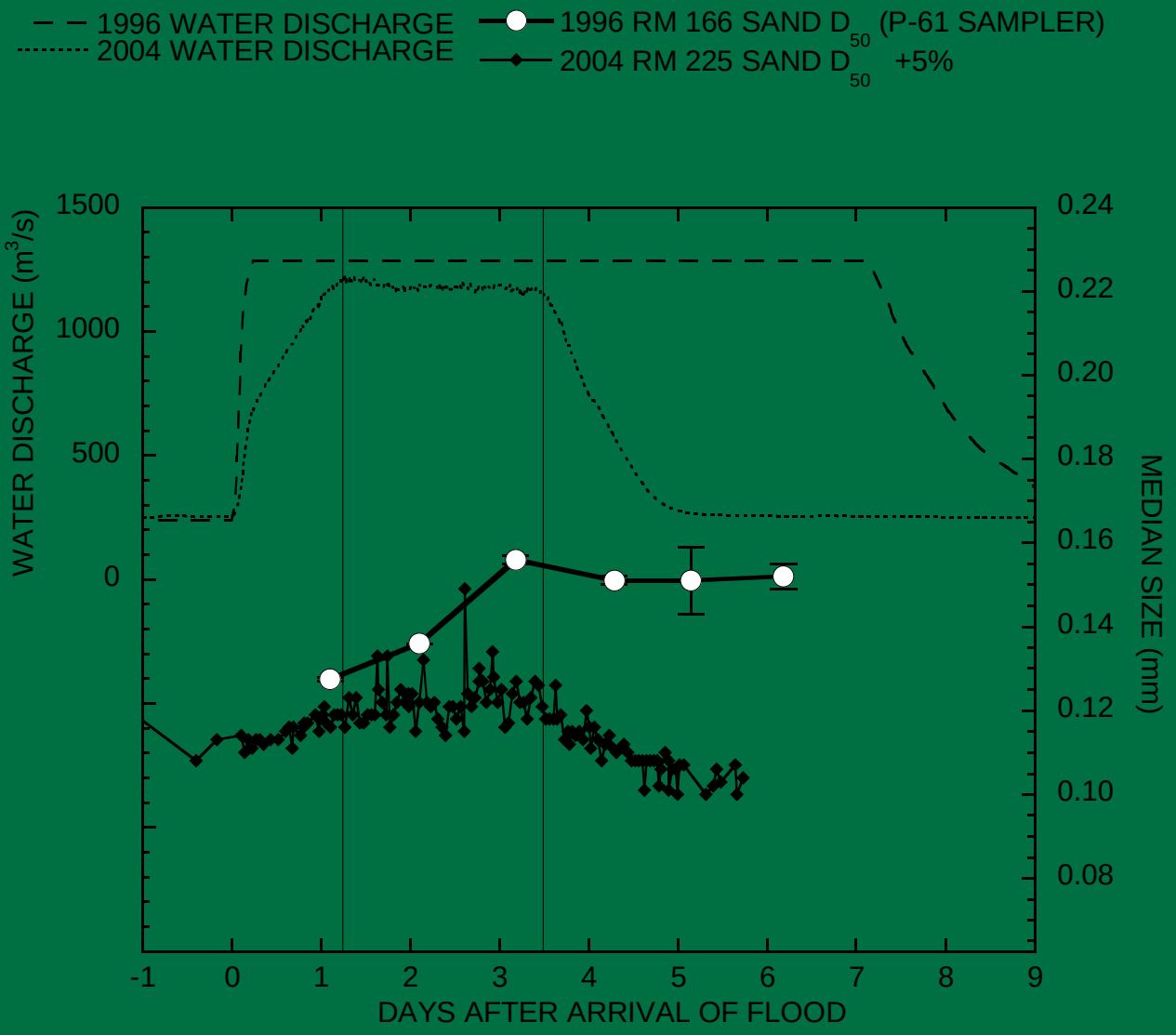
Thank You!

RIVER-MILES 166-225



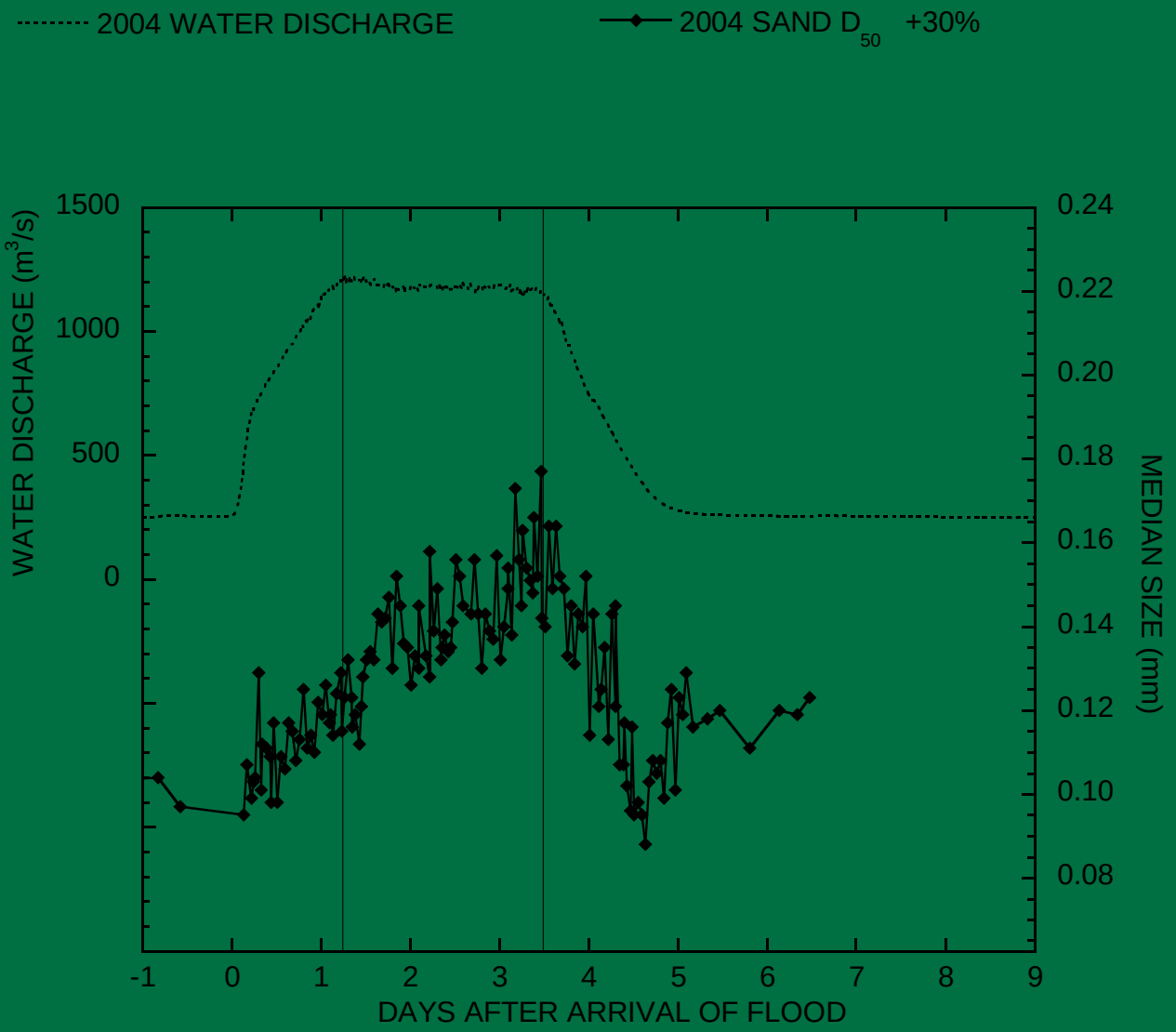
USGS

RIVER-MILES 166-225



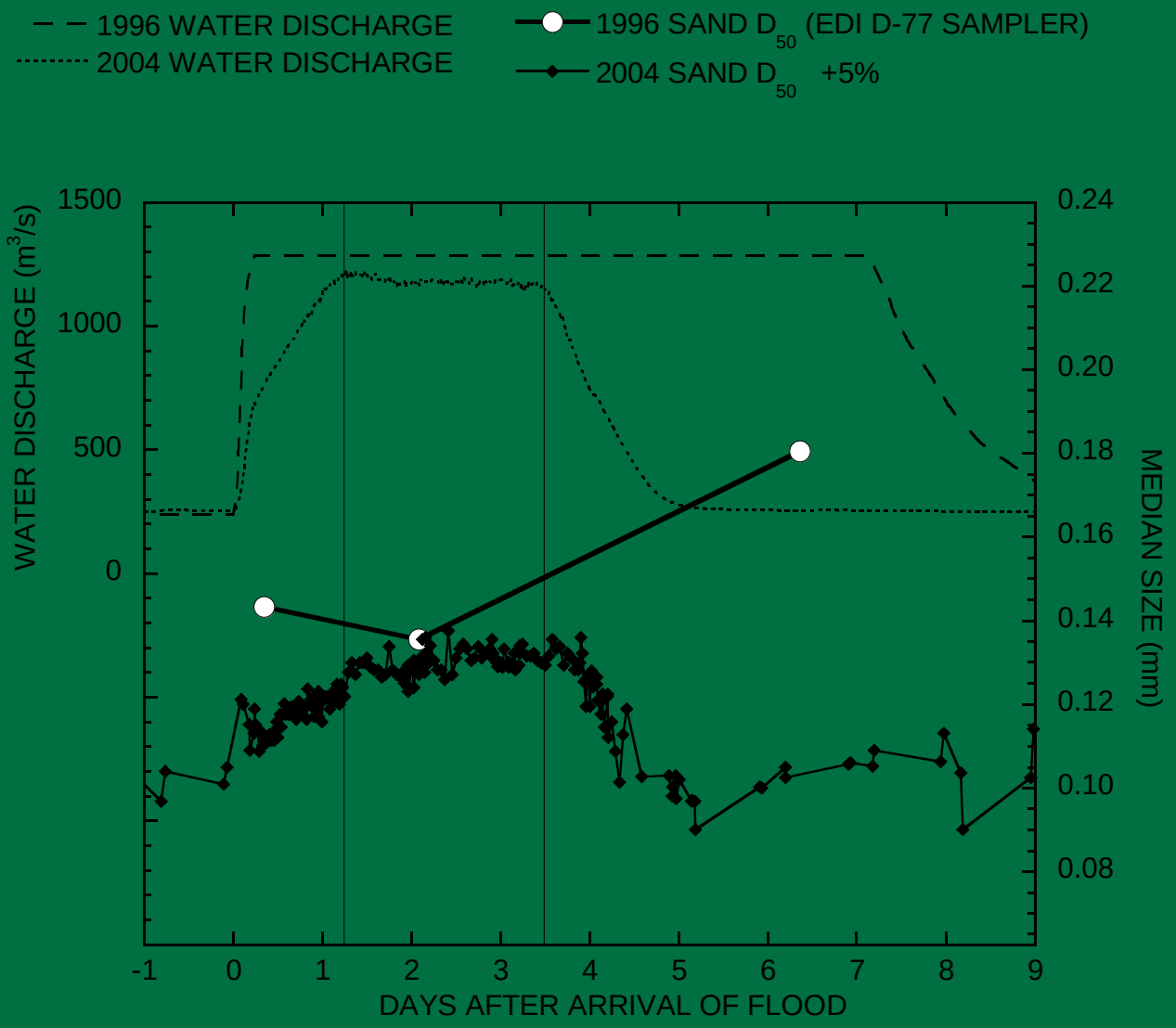
USGS

RIVER-MILE 30



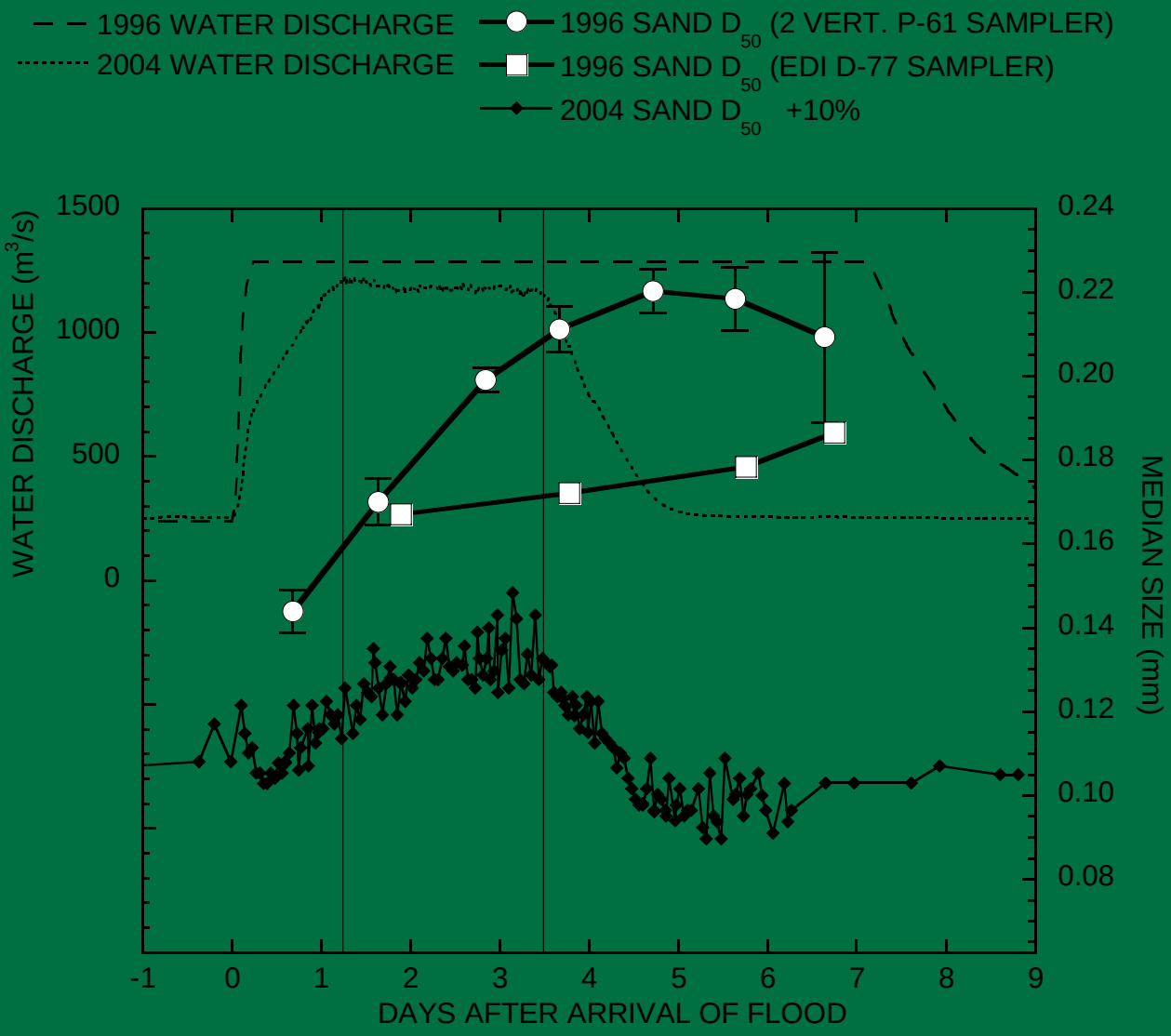
USGS

RIVER-MILE 61



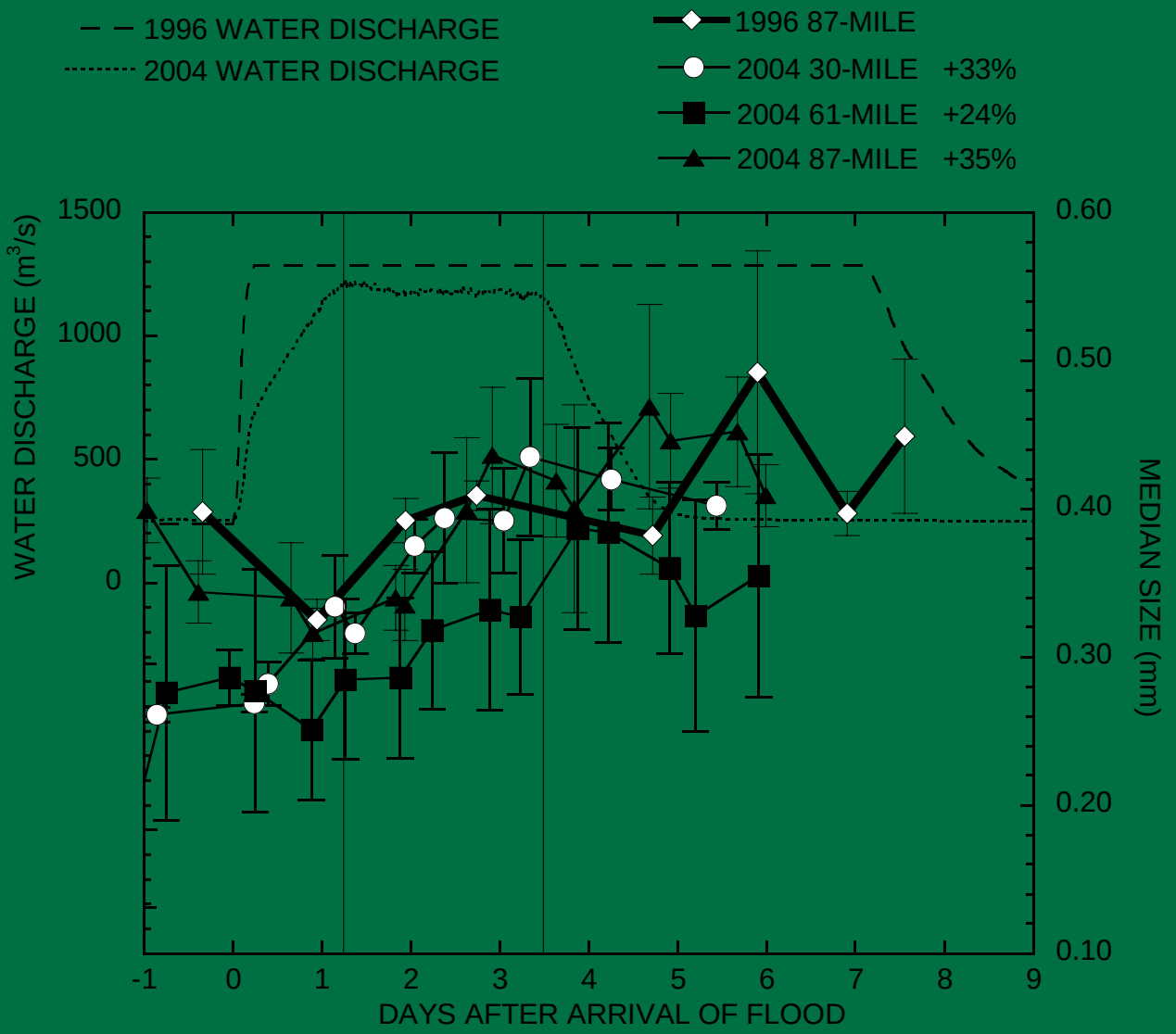
USGS

RIVER-MILE 87



USGS

MEDIAN SIZE OF BED SAND



USGS