Synthesis of Results and Application to River Management

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(for the team)

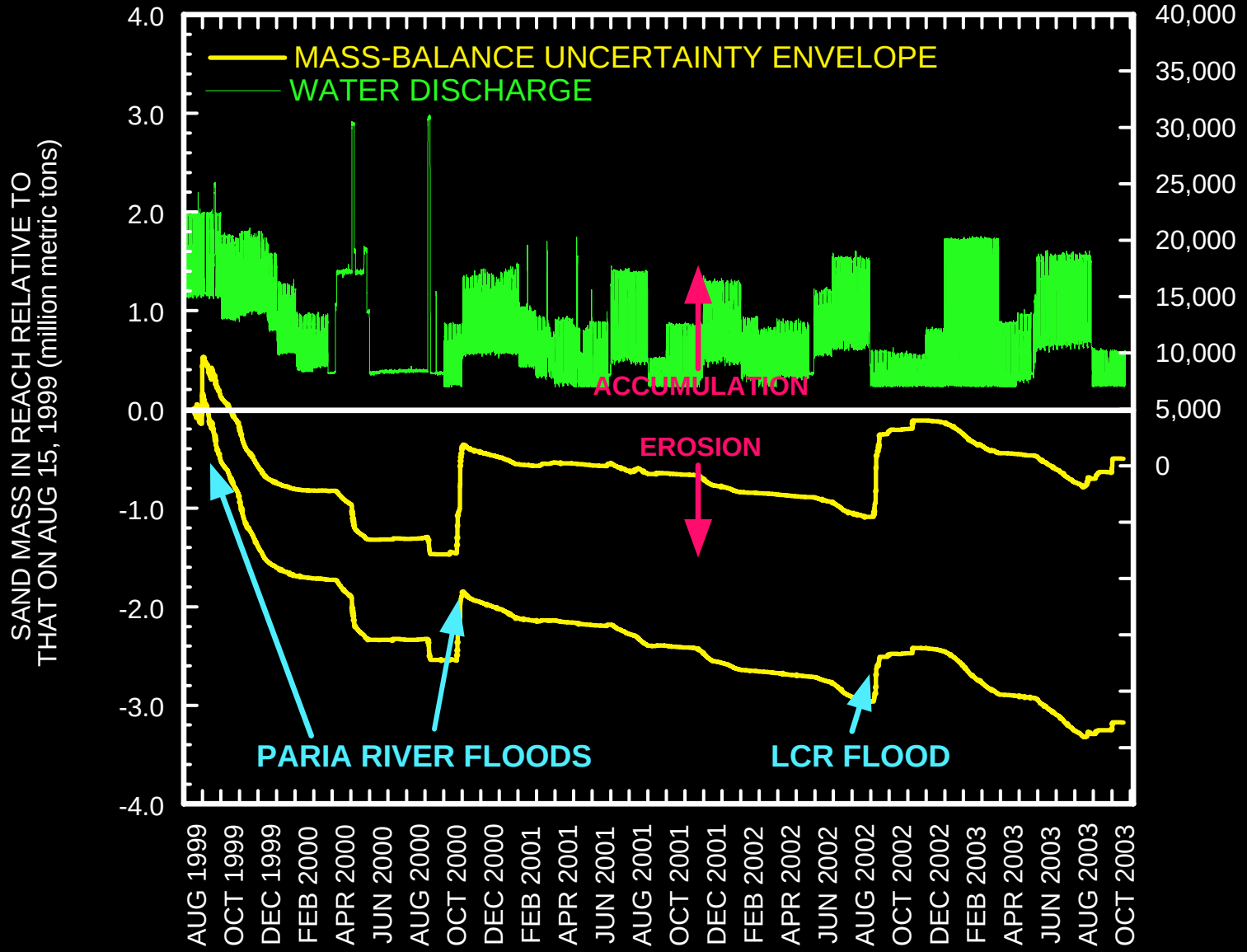
Outline

- Present understanding of the system
- Implications for monitoring the status of resources
- Implications for planning future experiments
- Implications for long-term policies that affect environmental management of the river and the establishment of management objectives

Present Understanding -- large scale mass balance

- Gravel and boulders are accumulating over decadal time scales
- Fine sediment (sand, silt, and clay) is being lost over annual to decadal time scales and only accumulates over day to week time scales
- Thus, gravel is accumulating and fine sediment is being lost.

MASS-BALANCE SAND BUDGET BETWEEN LEES FERRY AND THE GRAND CANYON GAGE

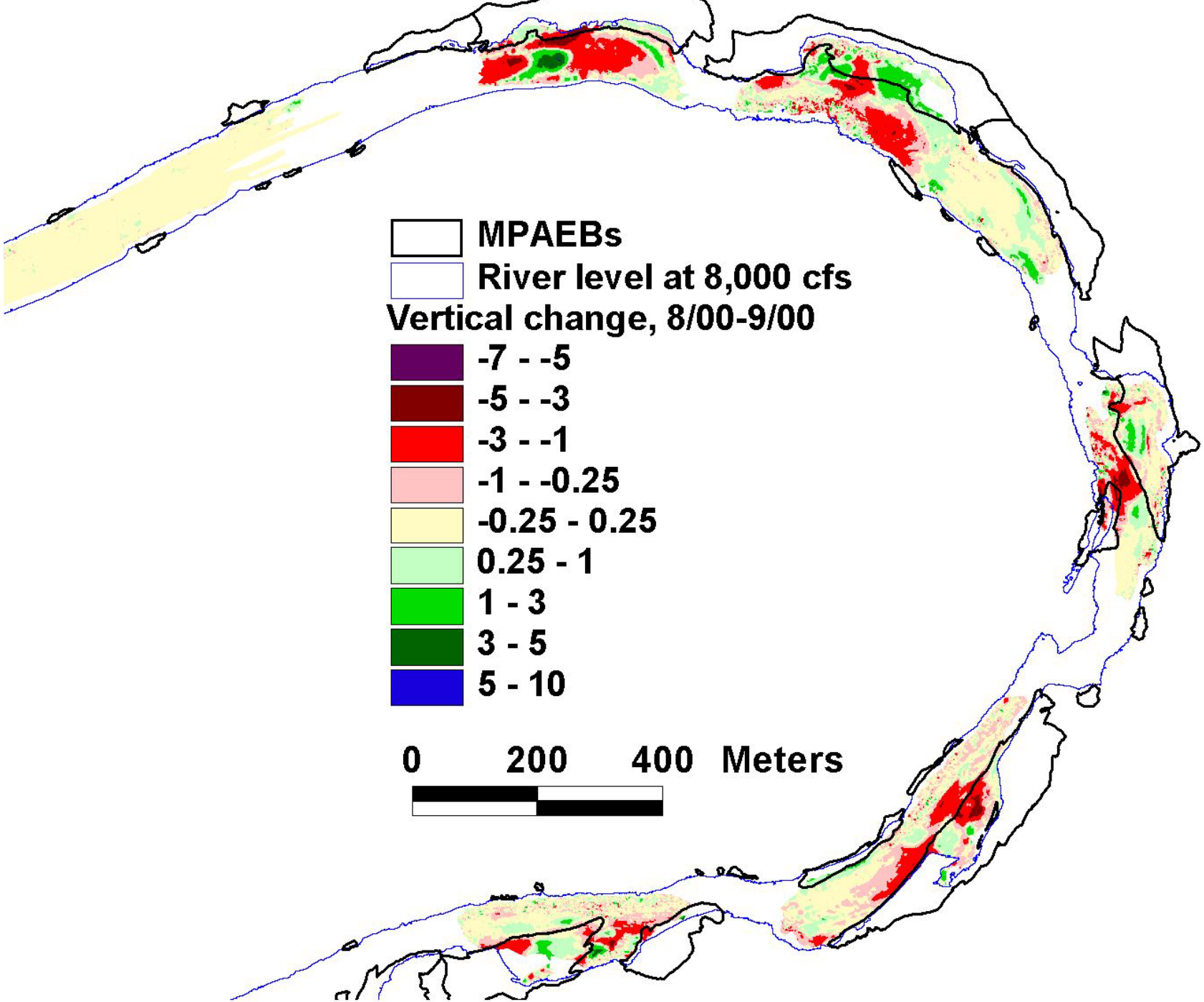


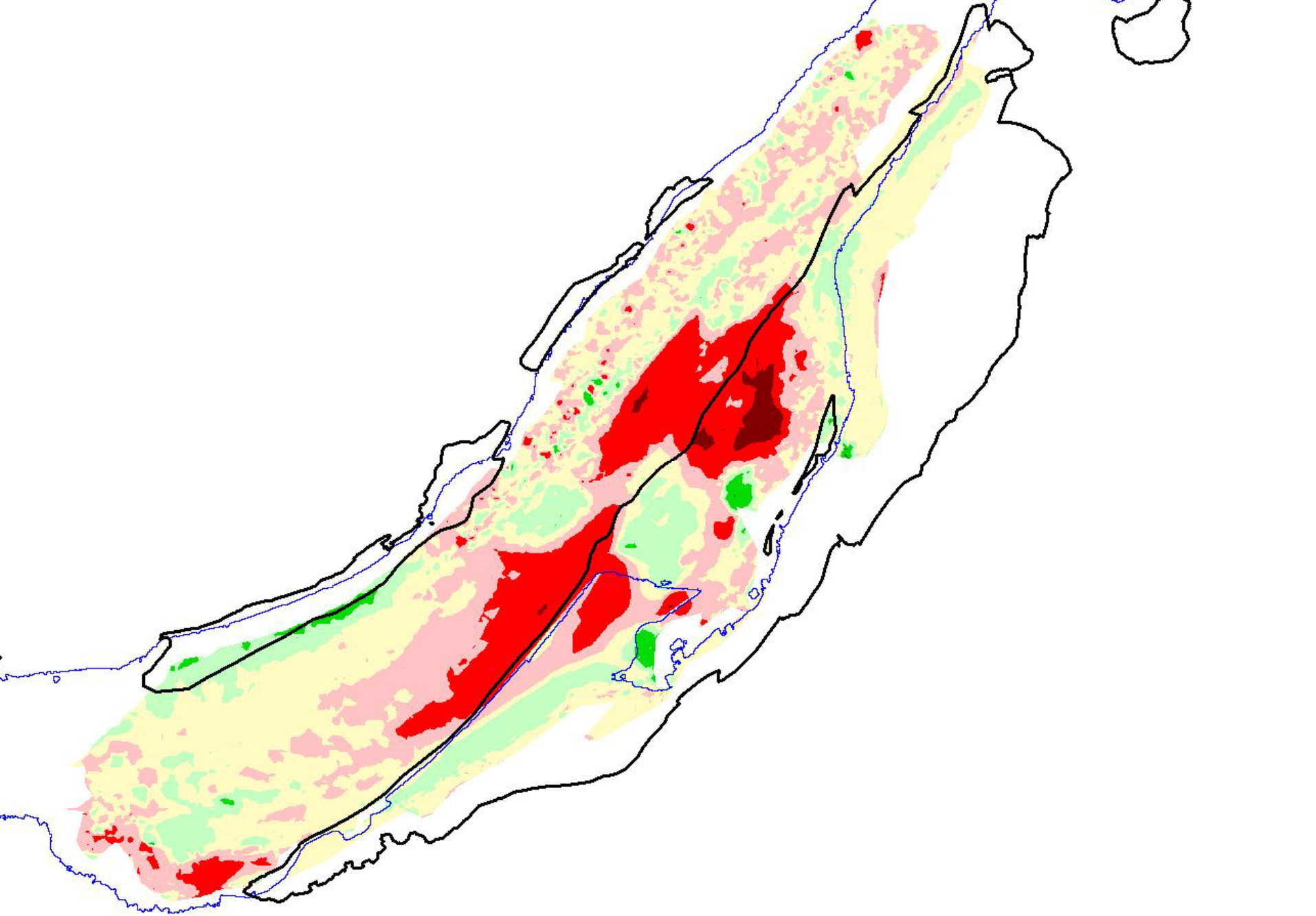
Present Understanding -- Distribution of Sand in Storage

- More than half of the sand in active storage in Marble Canyon is in eddies. This sand is stored in less than 20% of the channel area.
- Total sand in eddy storage is of the same order of magnitude as the amount of sand that can be transported by a prescriptive flood.
- Most of the sand transported beyond Marble Canyon in floods is eroded from eddies.

Present Understanding -- Channel Dynamics

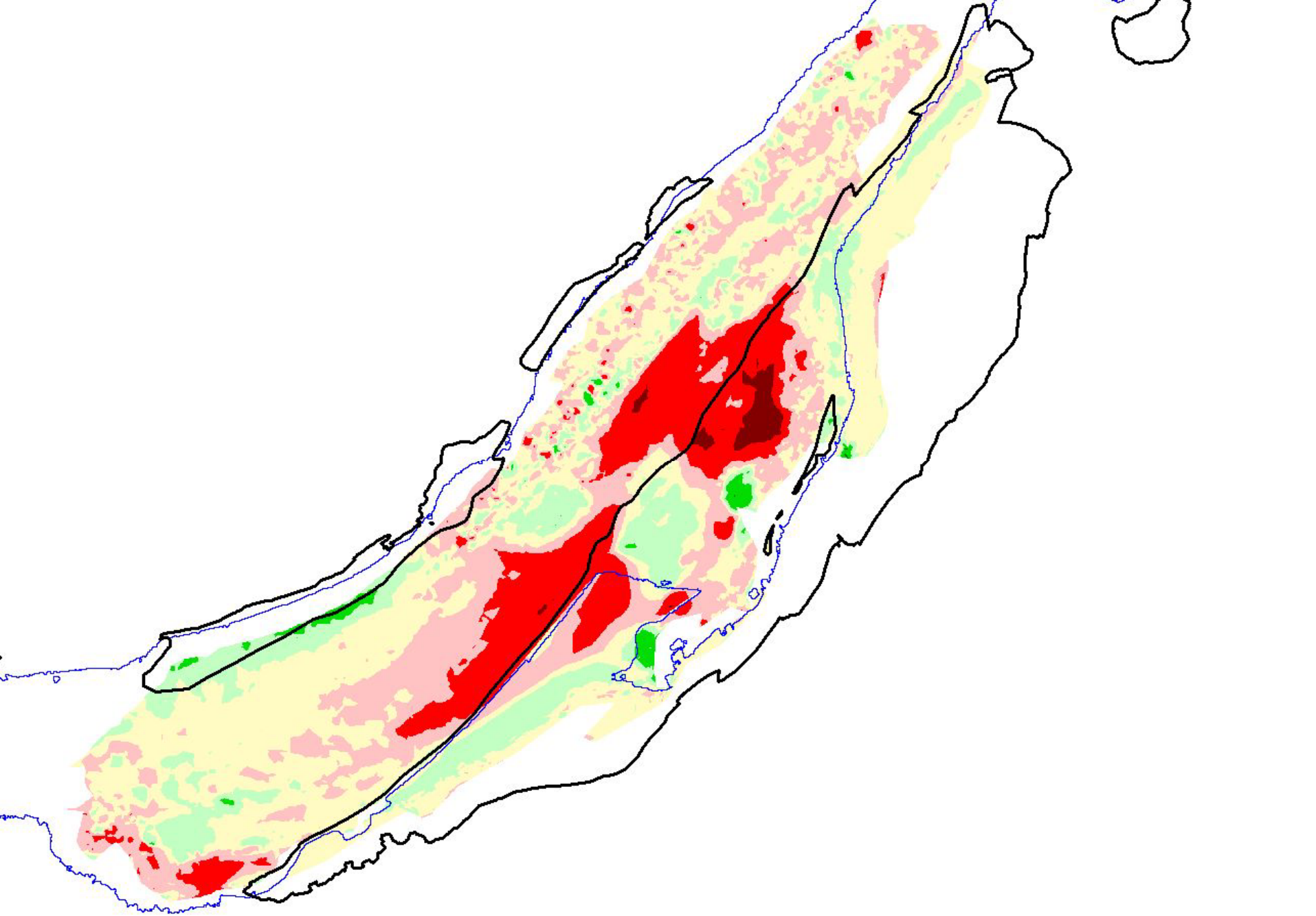
- During a short duration flood, bed scour occurs in discrete pools and along the slope of eddy bars that extends from the pool to the eddy bar crest.
- Scour may also occur in low elevation parts of the eddy bar crest while deposition occurs in high elevation parts of the same eddy bar.

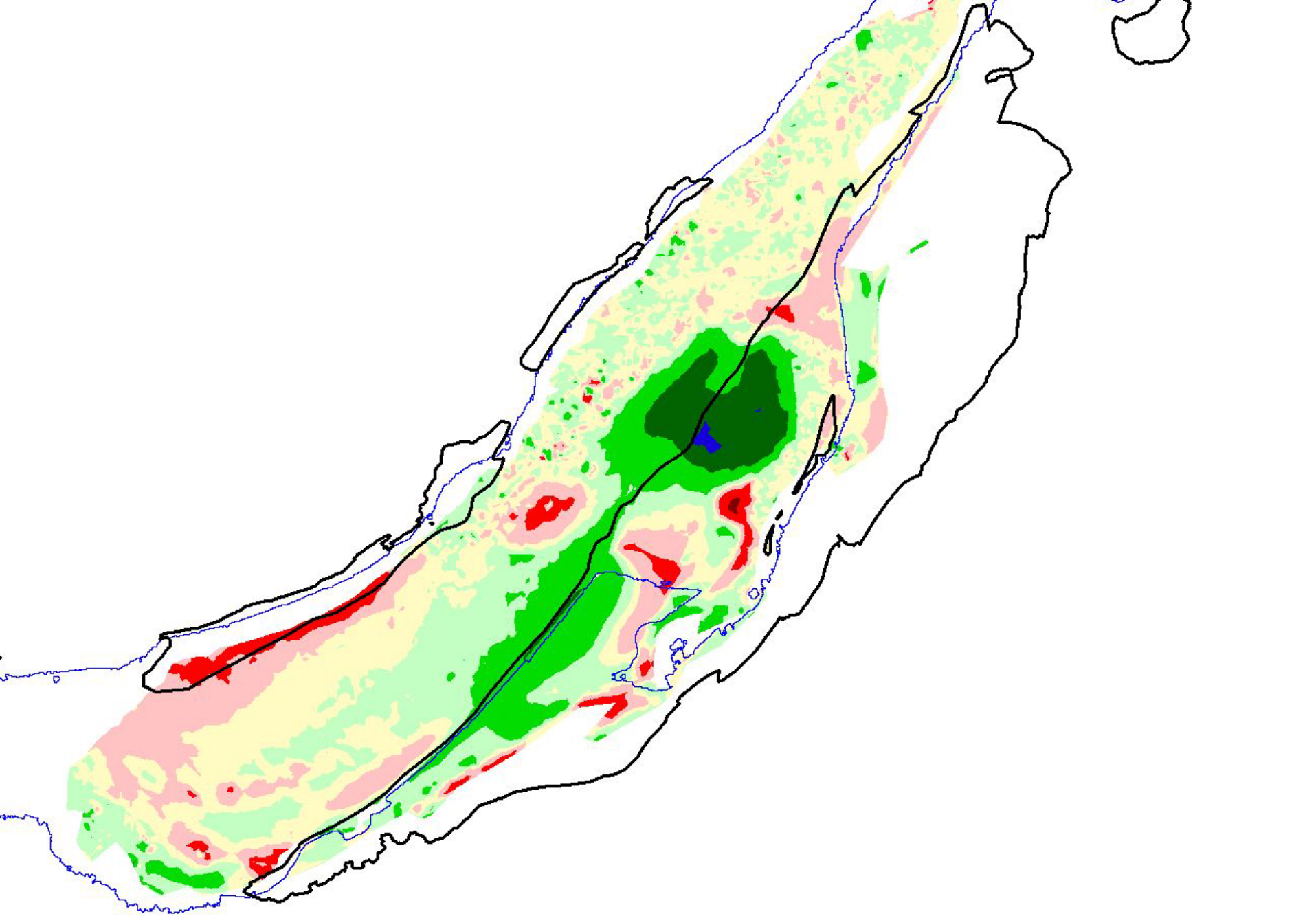

MPAEBs
River level at 8,000 cfs
Vertical change, 8/00-9/00
-7 - -5
-5 - -3
-3 - -1
-1 - -0.25
-0.25 - 0.25
0.25 - 1
1 - 3
3 - 5
5 - 10
0
200
400
Meters

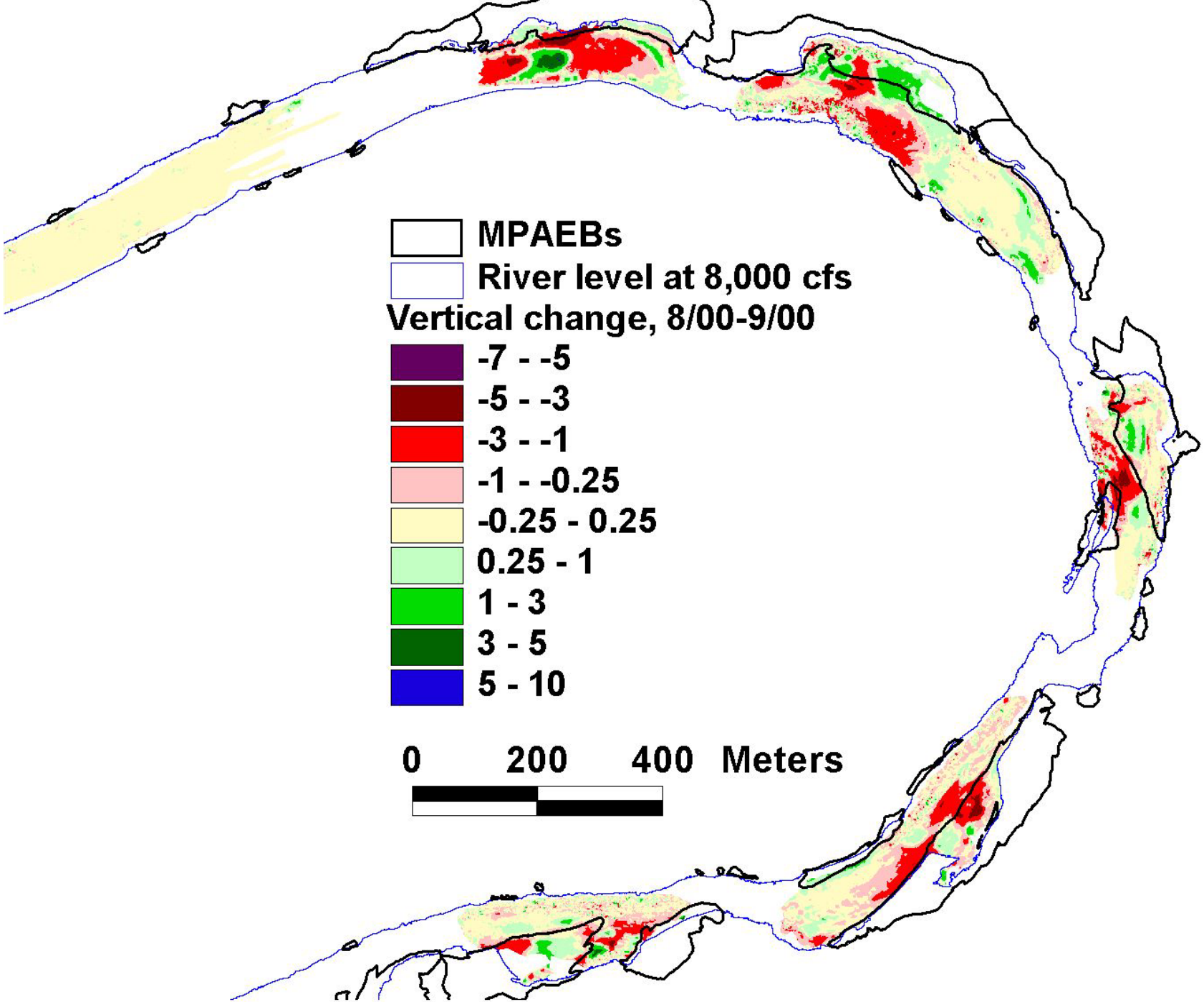


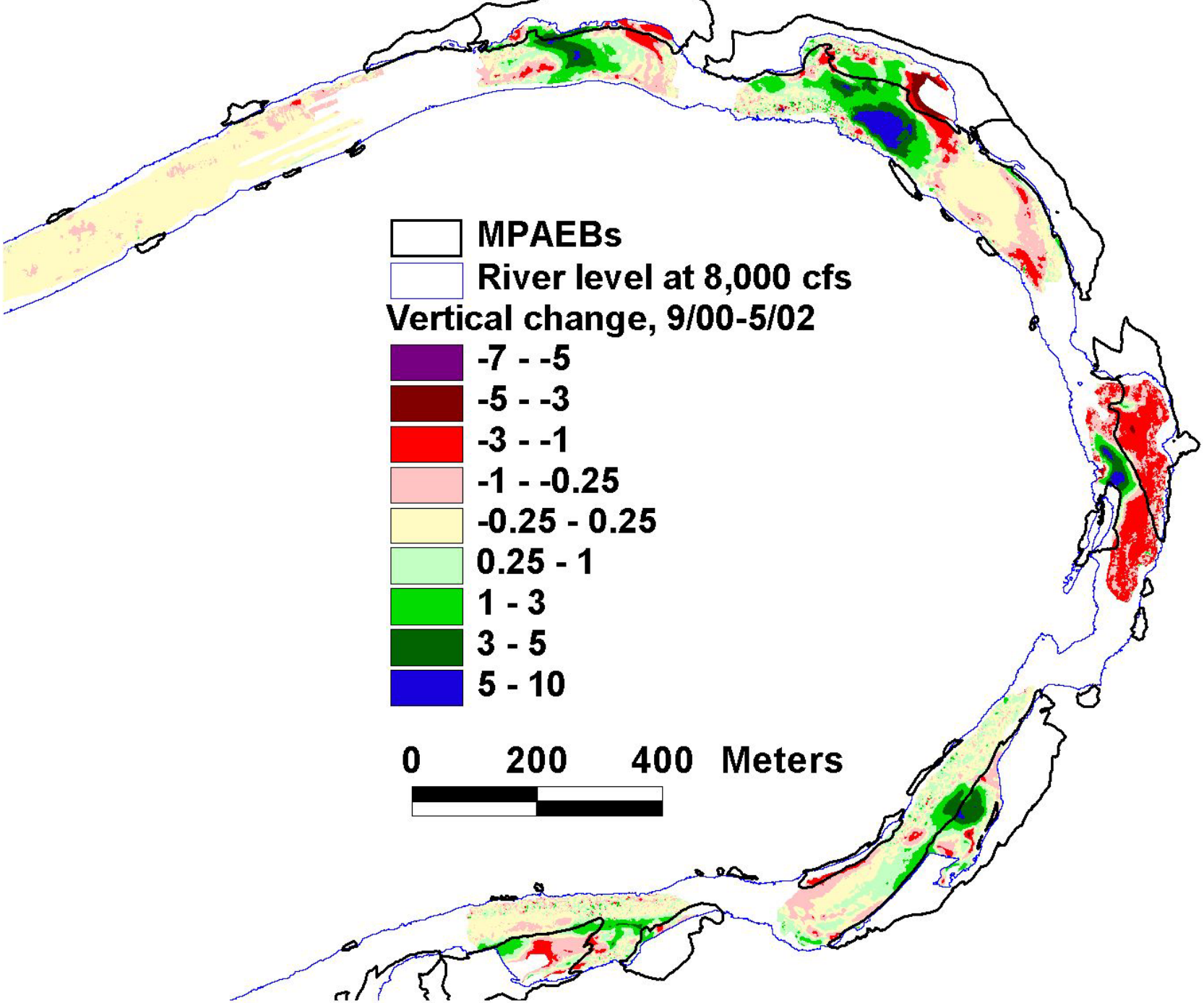
Channel Dynamics -- periods of low flow

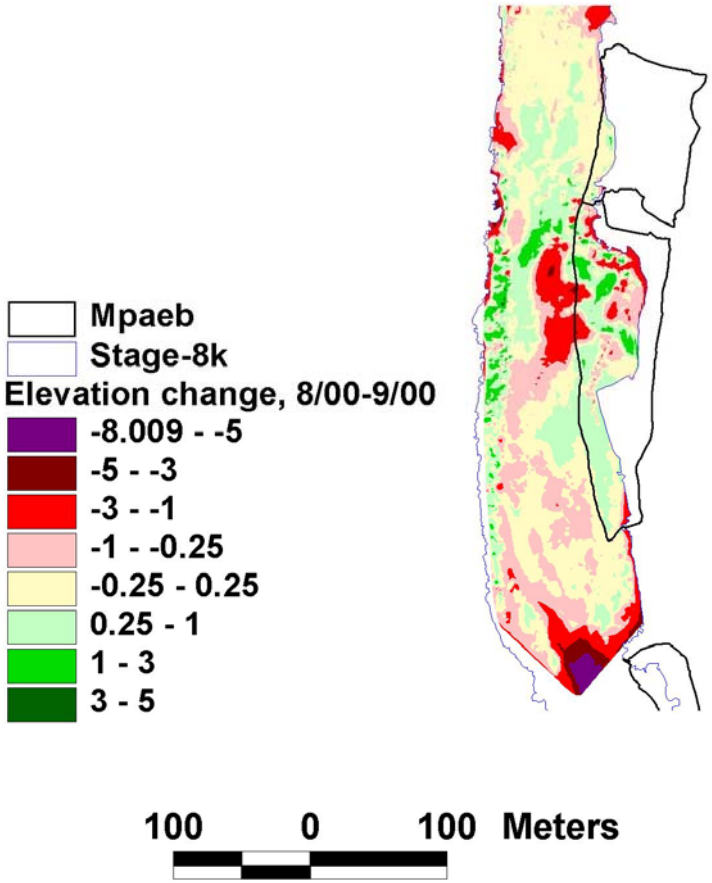
- The channel and low parts of eddies accumulate fine sediment when flows are less than about 9000 ft^3/s.
- Areas that had scoured during high flows tend to be the same places where accumulation occurs during low flows. Thus, parts of the river system are dynamic storage sites and the rest of the system experiences little change.

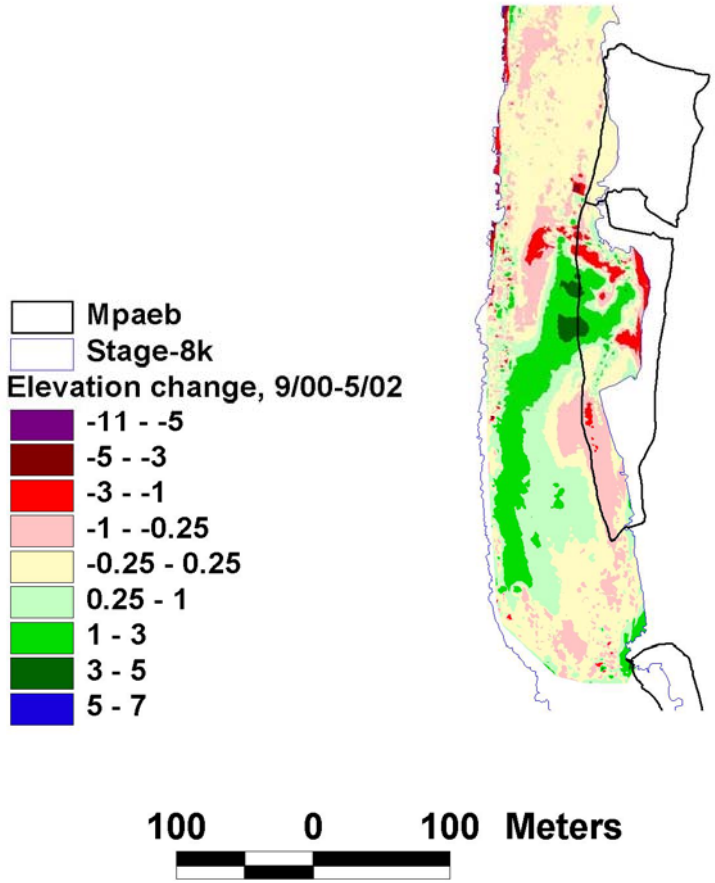


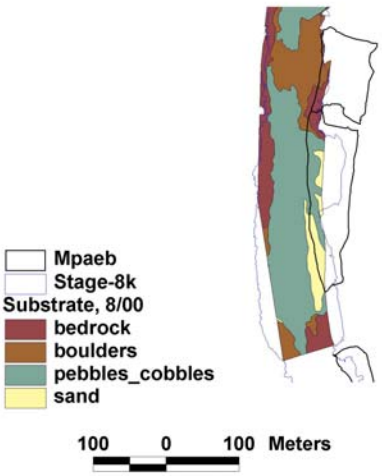



MPAEBs
River level at 8,000 cfs
Vertical change, 8/00-9/00
-7 - -5
-5 - -3
-3 - -1
-1 - -0.25
-0.25 - 0.25
0.25 - 1
1 - 3
3 - 5
5 - 10
0
200
400
Meters


MPAEBs
River level at 8,000 cfs
Vertical change, 9/00-5/02
-7 - -5
-5 - -3
-3 - -1
-1 - -0.25
-0.25 - 0.25
0.25 - 1
1 - 3
3 - 5
5 - 10
0
200
400 Meters

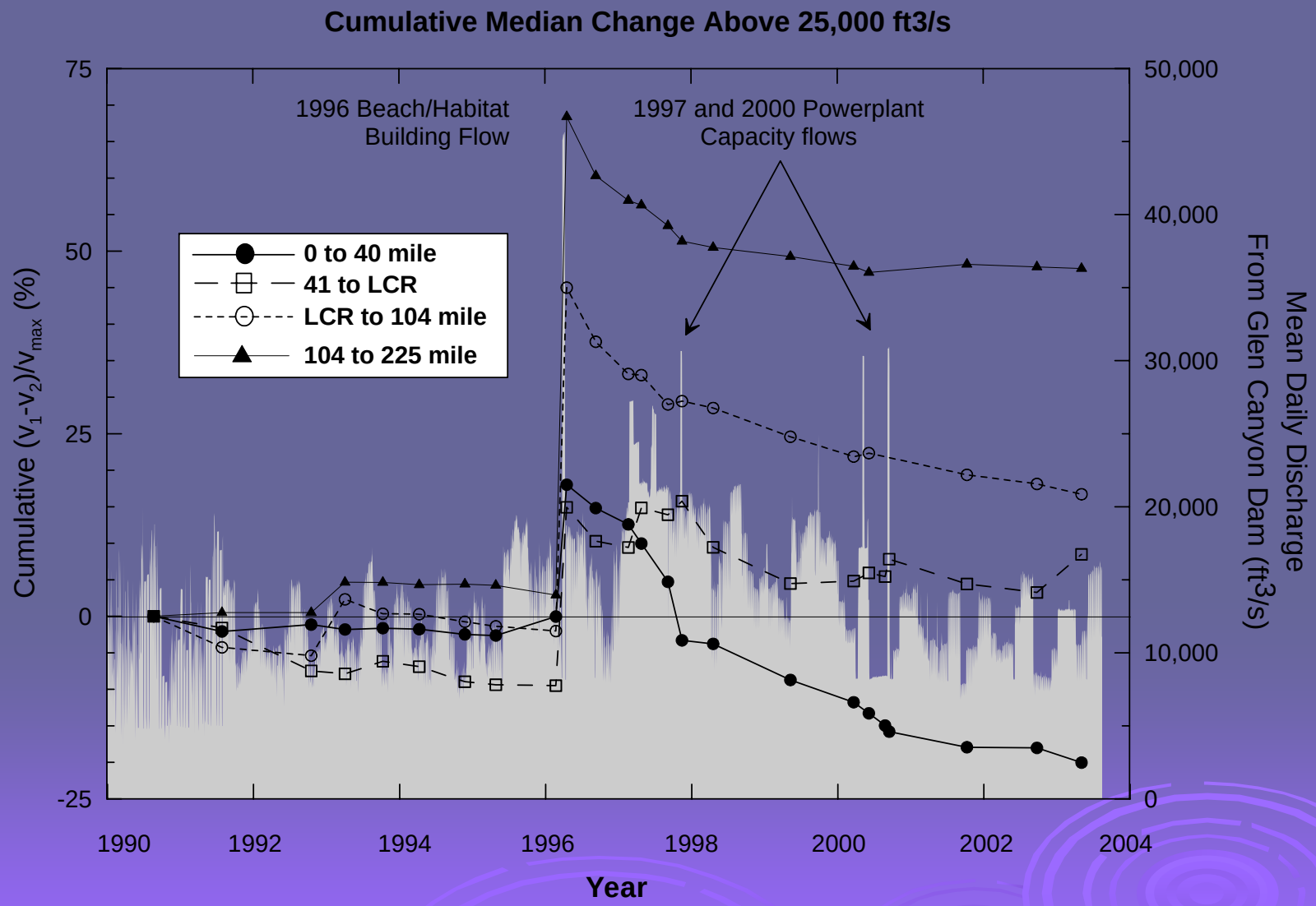

Mpaeb
Stage-8k
Elevation change, 8/00-9/00
-8.009 - -5
-5 - -3
-3 - -1
-1 - -0.25
-0.25 - 0.25
0.25 - 1
1 - 3
3 - 5
100 0 100 Meters

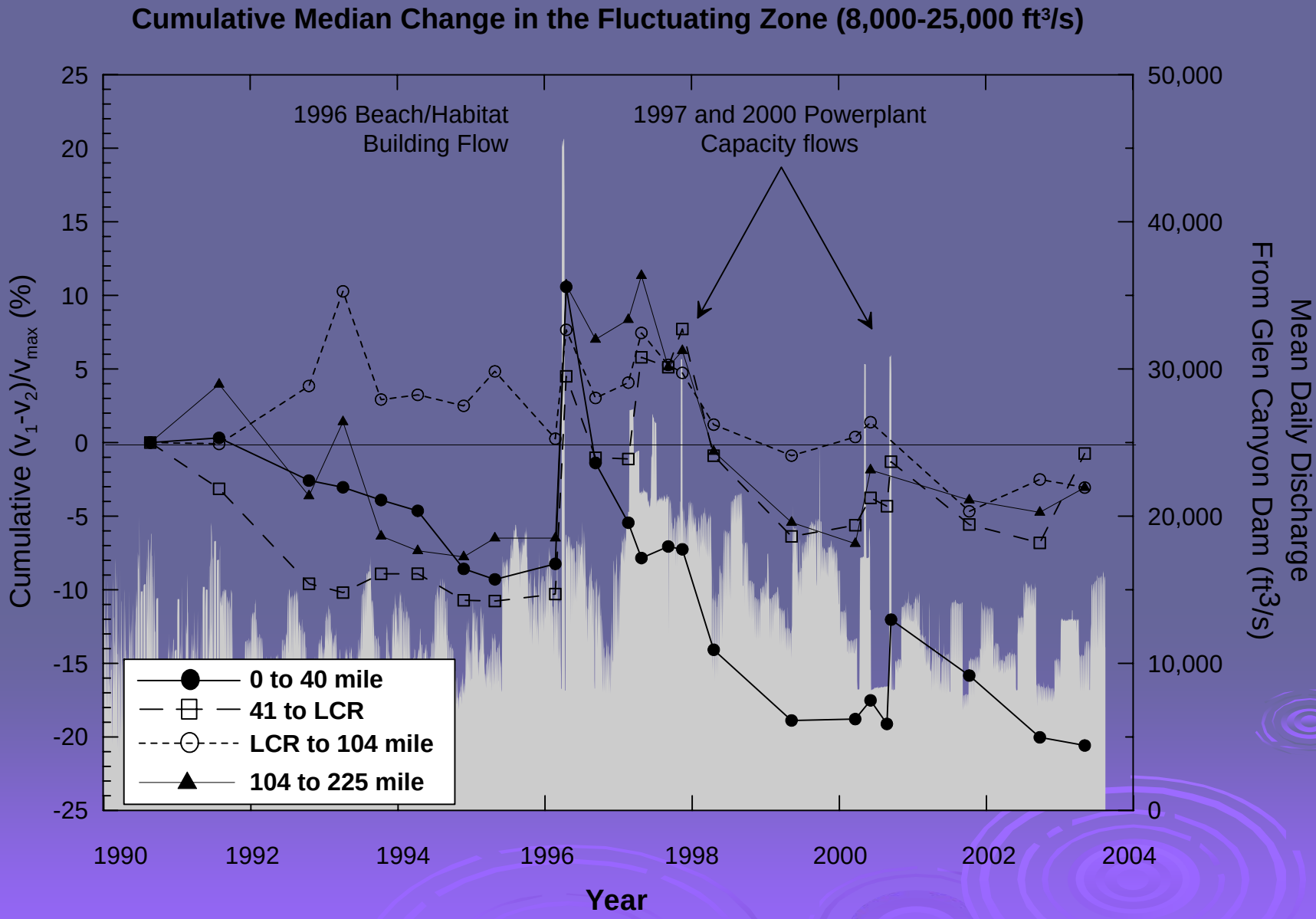

Mpaeb
Stage-8k
Elevation change, 9/00-5/02
-11 - -5
-5 - -3
-3 - -1
-1 - -0.25
-0.25 - 0.25
0.25 - 1
1 - 3
3 - 5
5 - 7
100 0 100 Meters


Mpaeb
Stage-8k
Substrate, 8/00
bedrock
boulders
pebbles_cobbles
sand
100 0 100 Meters

Current Understanding -- Status of the Resource

- The volume of eddy sand, above 25K stage, is less today than it was in 1990 in upper Marble Canyon.
- Elsewhere, the “positive” benefits of the 1996 are declining but have not yet completely disappeared.


Cumulative Median Change Above 25,000 ft3/s
1996 Beach/Habitat Building Flow
1997 and 2000 Powerplant Capacity flows
0 to 40 mile
41 to LCR
LCR to 104 mile
104 to 225 mile
Cumulative (v1-v2)/vmax (%)
Mean Daily Discharge From Glen Canyon Dam (ft3/s)
Year
75
50
25
0
-25
50,000
40,000
30,000
20,000
10,000
0
1990
1992
1994
1996
1998
2000
2002
2004


Cumulative Median Change in the Fluctuating Zone (8,000-25,000 ft³/s)
1996 Beach/Habitat Building Flow
1997 and 2000 Powerplant Capacity flows
Cumulative (v1-v2)/vmax (%)
Mean Daily Discharge From Glen Canyon Dam (ft3/s)
Year
0 to 40 mile
41 to LCR
LCR to 104 mile
104 to 225 mile
25
20
15
10
5
0
-5
-10
-15
-20
-25
50,000
40,000
30,000
20,000
10,000
0
1990
1992
1994
1996
1998
2000
2002
2004

Implications to Monitoring:
Sediment Budgeting Remains the Essential Organizational Framework for Data Collection and Interpretation

- Maintenance of sediment-transport measurement at gages at the upstream and downstream ends of key management-defined reaches is imperative.
- Only continuous operation of these gages allows calculation of a long-term sediment mass balance.

Implications to Monitoring

- The inherent errors in sediment budgets necessitate direct measurement of the change in storage of fine sediment. It is insufficient to define the status of fine-sediment resources in a reach merely as the difference between two imprecise transport numbers.

- The effort to measure sand resources throughout long river segments, i.e. Marble Canyon, using remote sensing and LiDAR will reduce the need for geomorphically-based extrapolations. These efforts will result in more accurate measurements in change in storage.

Implications to Monitoring

- Bed topography remains a labor intensive data collection effort.
- Analysis of bed material change from side scan sonar is labor intensive and alternative means should be examined for making these evaluations.

Implications to Planning Future Experiments -- Key Unanswered Questions

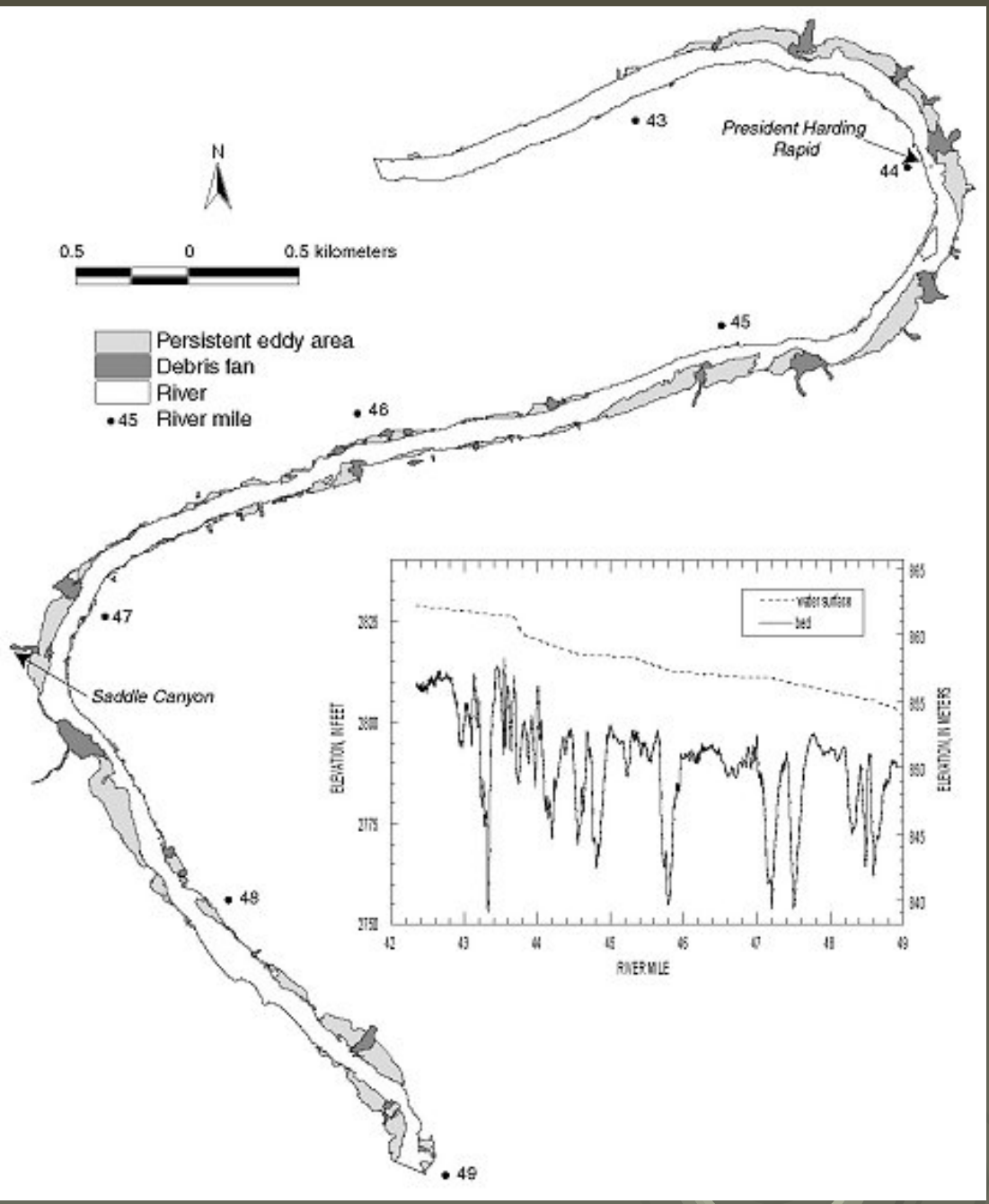
- Is it possible to reverse the long-term loss of sand from eddies by effectively managing a large input of Paria River sand?
  - If successful, is it possible to reverse these trends with less sand?
  - If not successful, how much more sand than that naturally supplied by the Paria is required?

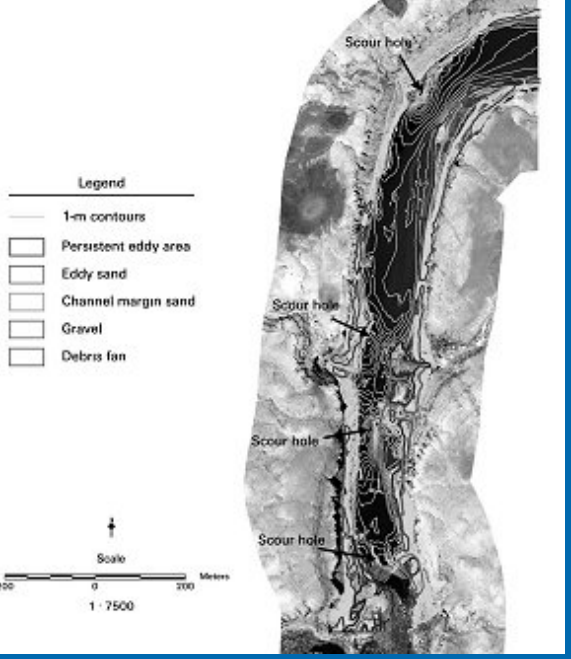
Other experimental questions

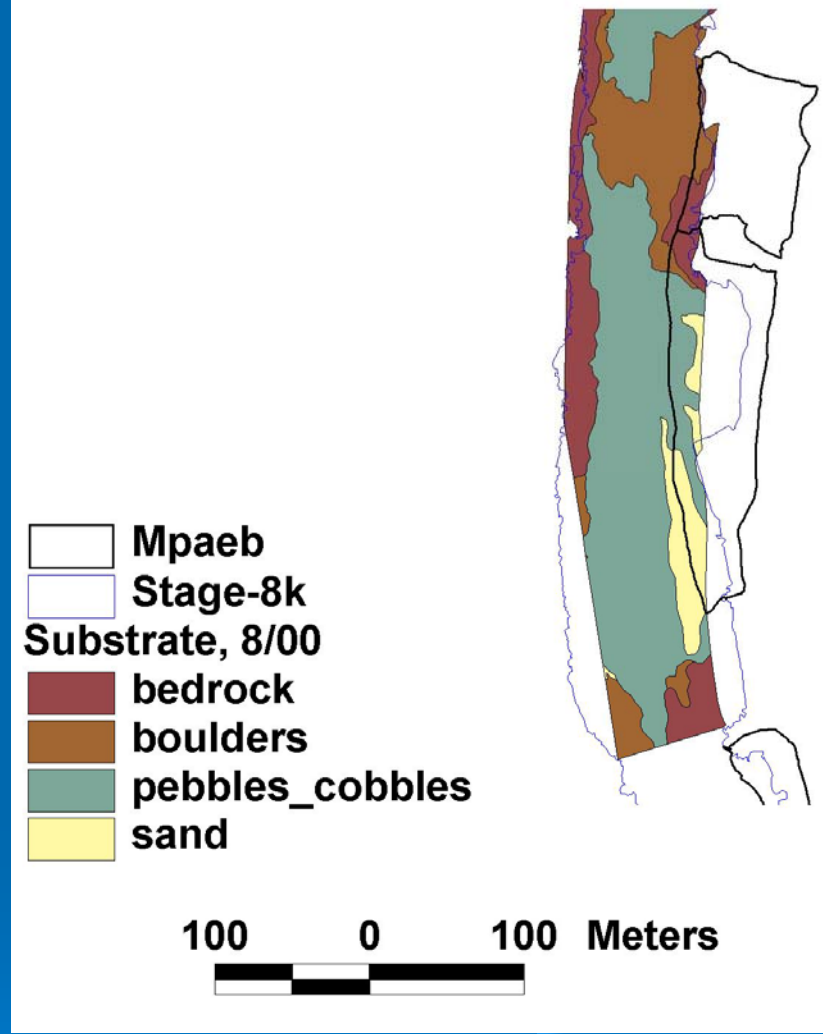
- Are the sources and sinks of fine sediment different during conditions of enriched fine sediment supply?
- What is the largest sustained dam release that still stalls fine sediment in upper Marble Canyon? (a model may be necessary to answer some of this)
- What is the most efficient flood design that delivers the greatest amount of fines into eddies in relation to what passes downstream?

Why Study Fine Sediment?

- Fine sediment deposits have been identified as having inherent value as an attribute of the pre-dam river and as campsites.
- Fine sediment deposits are an important attribute of the existing aquatic and terrestrial ecosystems.
- Integration?


N
0.5
0
0.5 kilometers
Persistent eddy area
Debris fan
River
45 River mile
43
44
45
46
47
48
49
President Harding Rapid
Saddle Canyon
water surface
bed
ELEVATION, IN FEET
ELEVATION, IN METERS
RIVER MILE


Scour hole
Legend
1-m contours
Persistent eddy area
Eddy sand
Channel margin sand
Gravel
Debris fan
Scour hole
Scour hole
Scour hole
Scale
Meters
1 : 7500


Mpaeb
Stage-8k
Substrate, 8/00
bedrock
boulders
pebbles_cobbles
sand
100 0 100 Meters