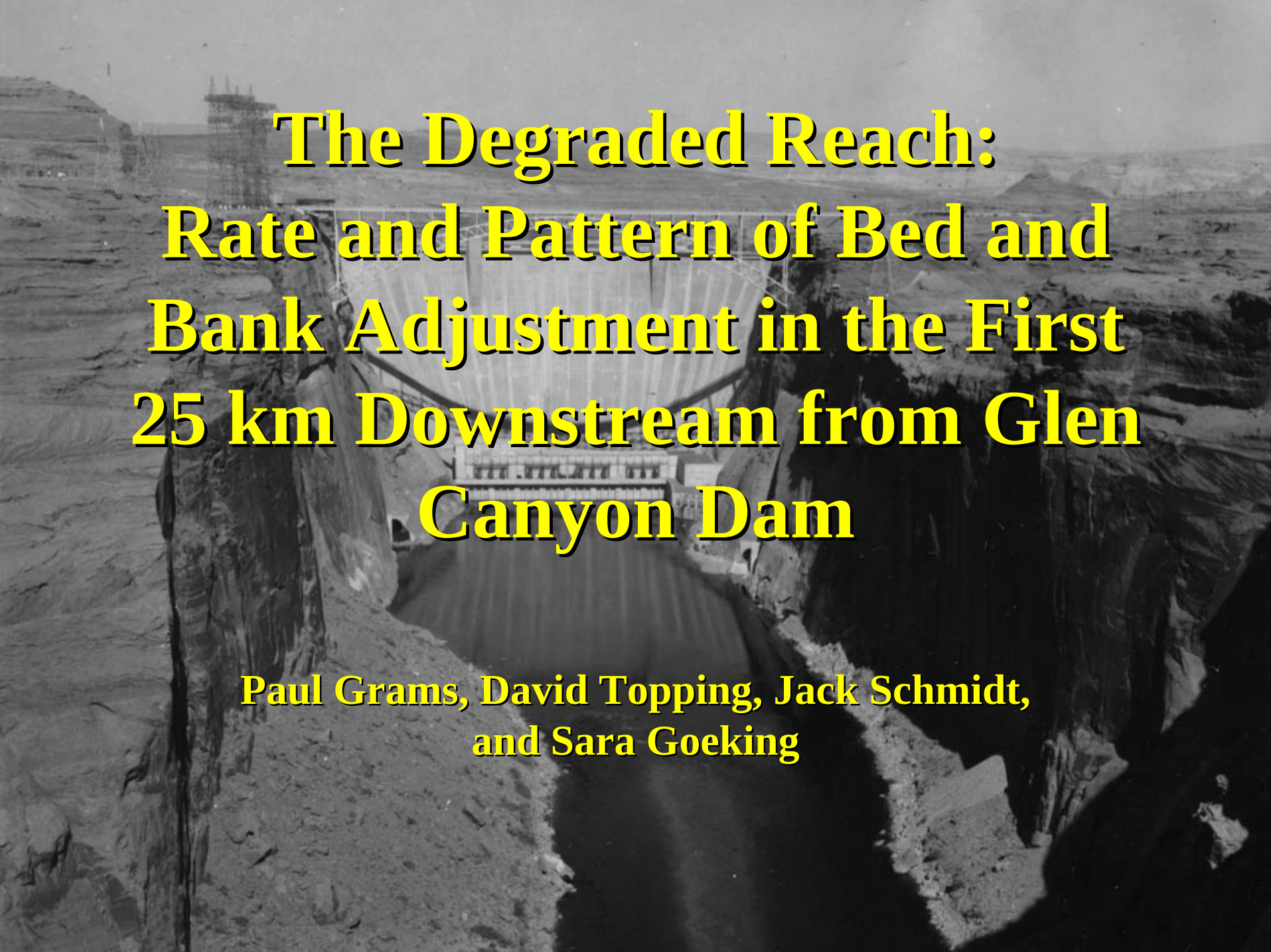


# The Degraded Reach: Rate and Pattern of Bed and Bank Adjustment in the First 25 km Downstream from Glen Canyon Dam

Paul Grams, David Topping, Jack Schmidt, and Sara Goeking

# Why Study Glen Canyon?

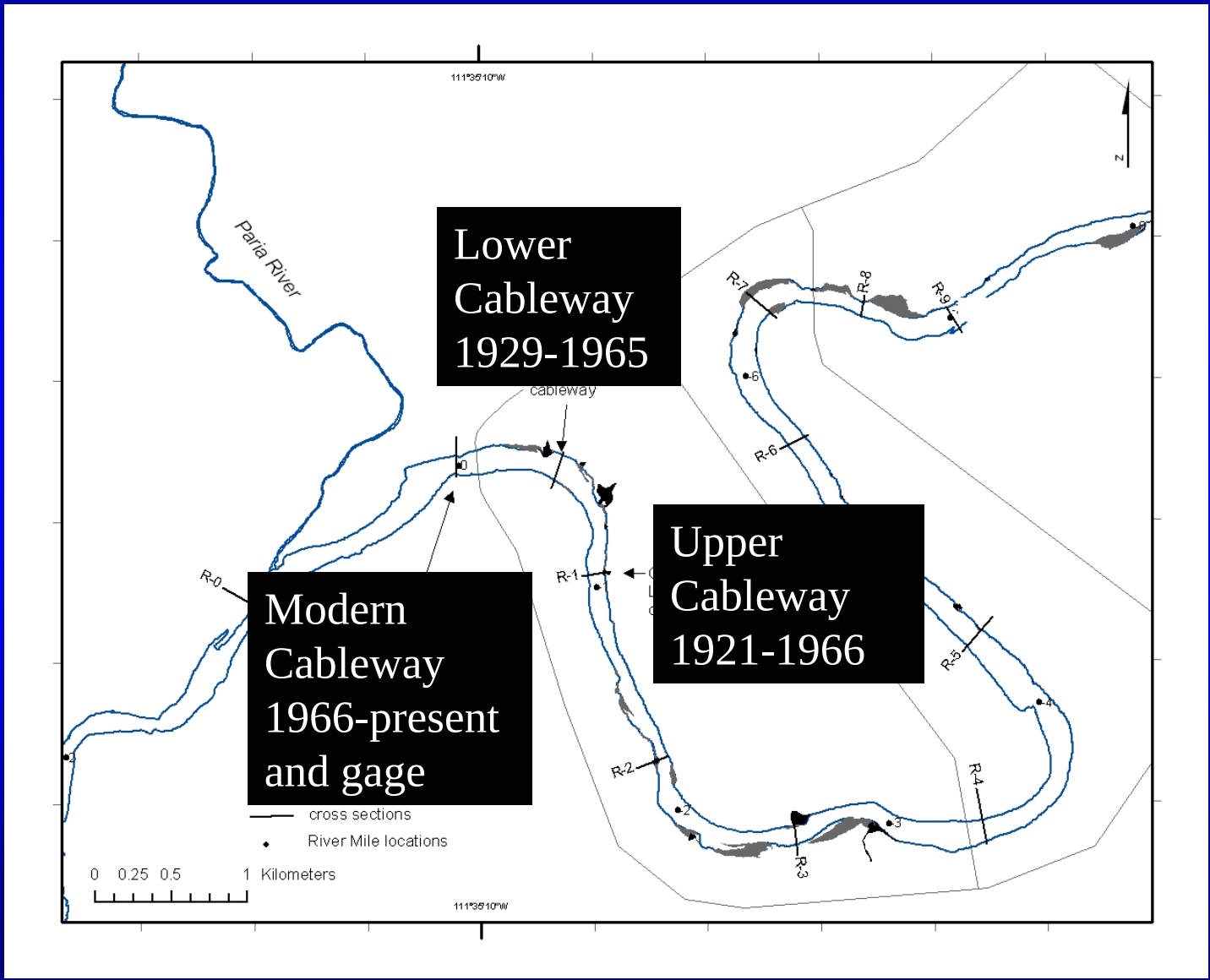
- Has bed degradation continued since 1975?
- What has been the spatial distribution of bed degradation within Glen Canyon?
- How have channel-side alluvial deposits changed since the pre-dam period?

# Components of Study

- Changes in bed elevation
  - Reclamation monitoring cross-sections
  - USGS gage station records of bed elevation
- Channel-side deposits
  - Mapping from historical aerial photographs
  - Historical oblique photographs
  - Comparison with cross-section data

# The Reclamation monitoring “Ranges”

# Lees Ferry Gaging Station



# Glen Canyon - 1956

# Glen Canyon 1889 - 1992

1889

1992

# Glen Canyon 1956 - 2000

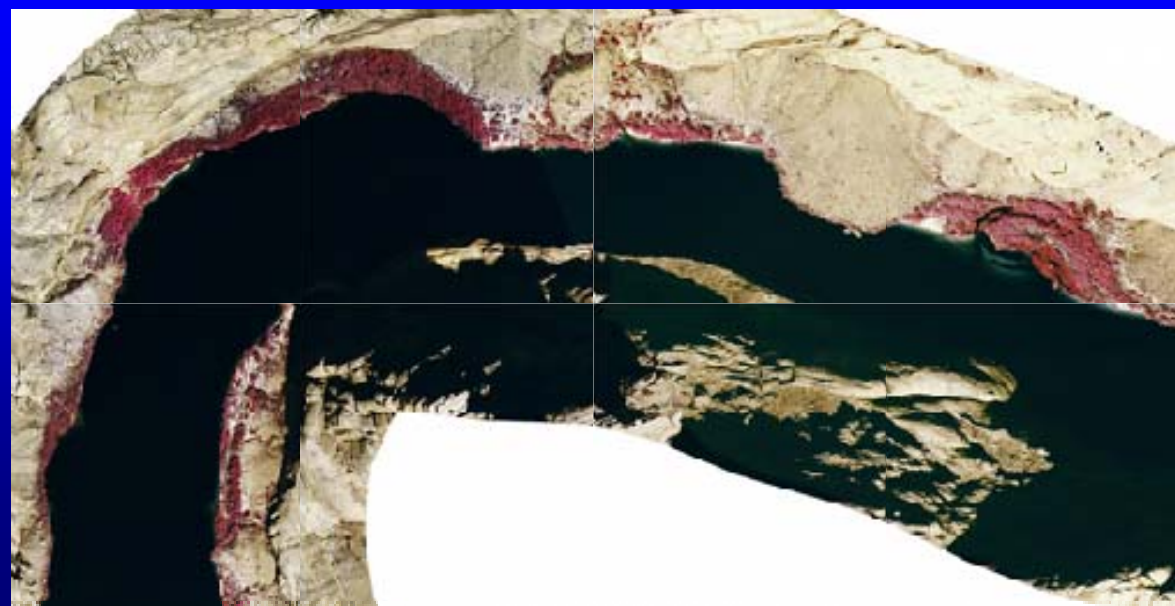

**July 1956**

**September 2000**

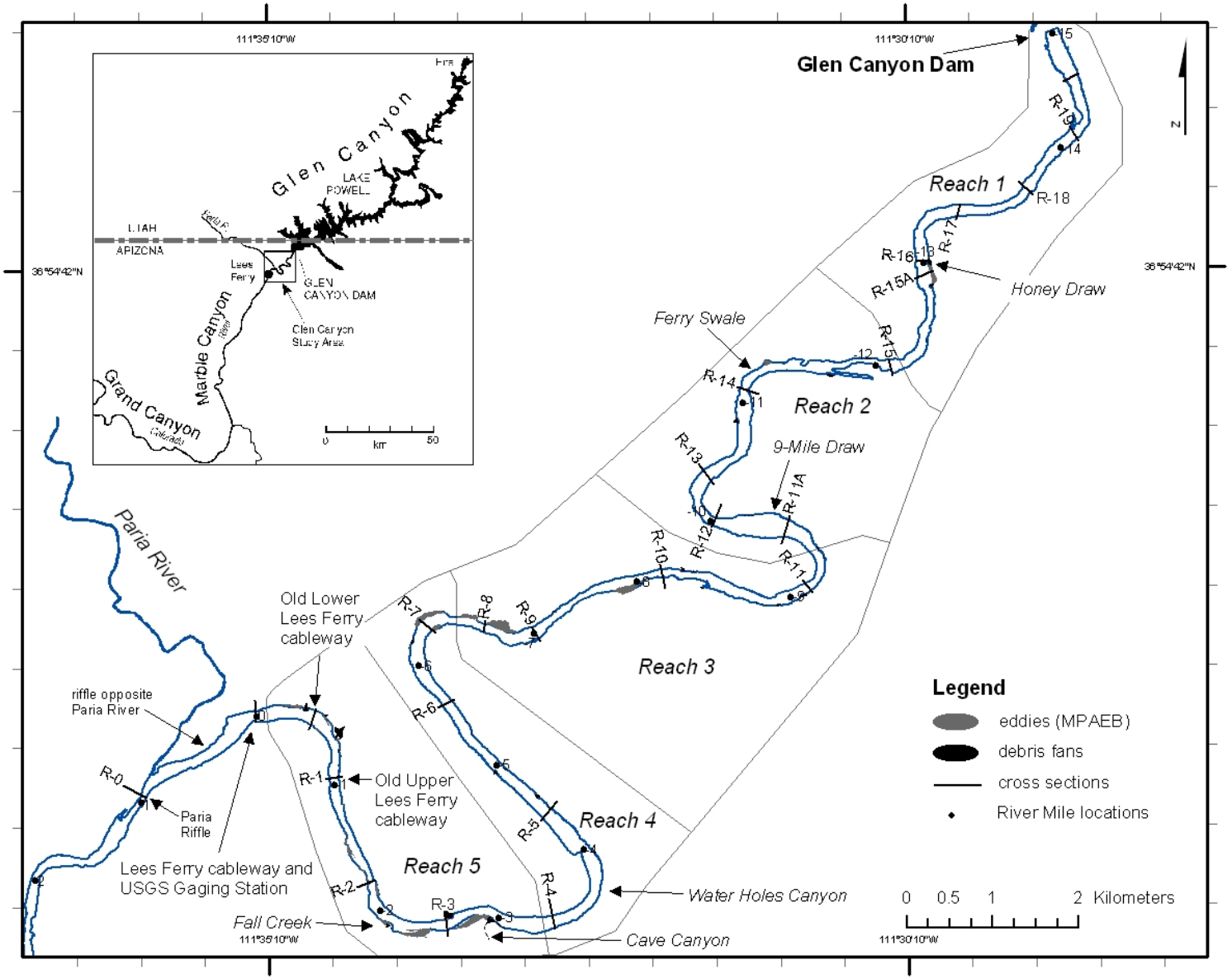
# Glen Canyon 1954 - 1999

1956

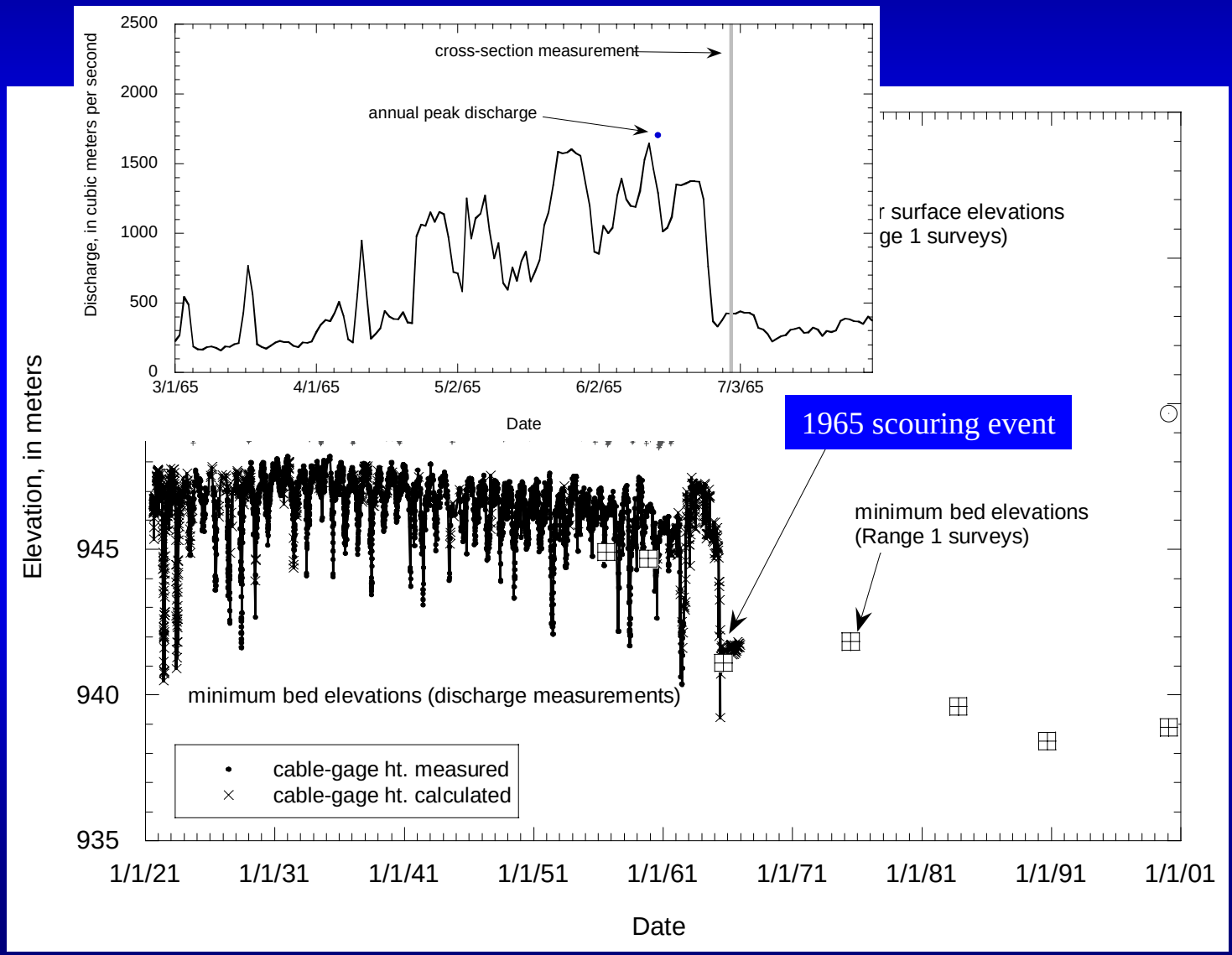
1998



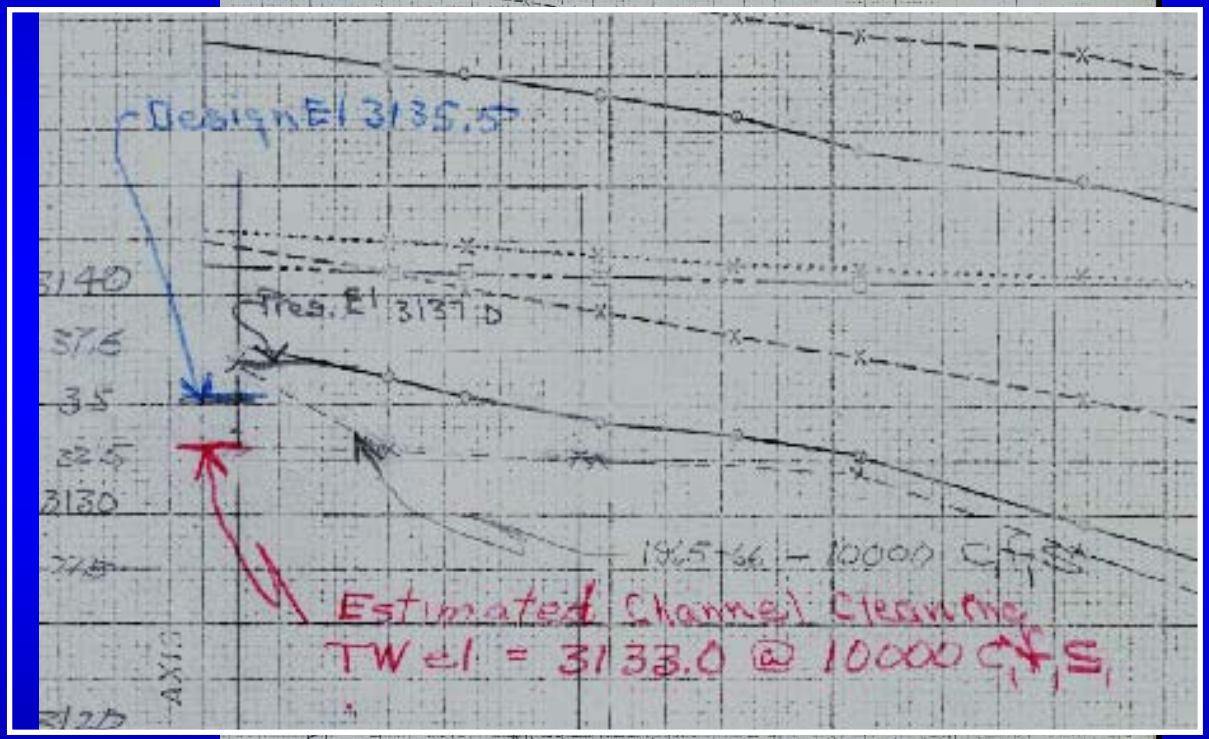
# Glen Canyon Location Map

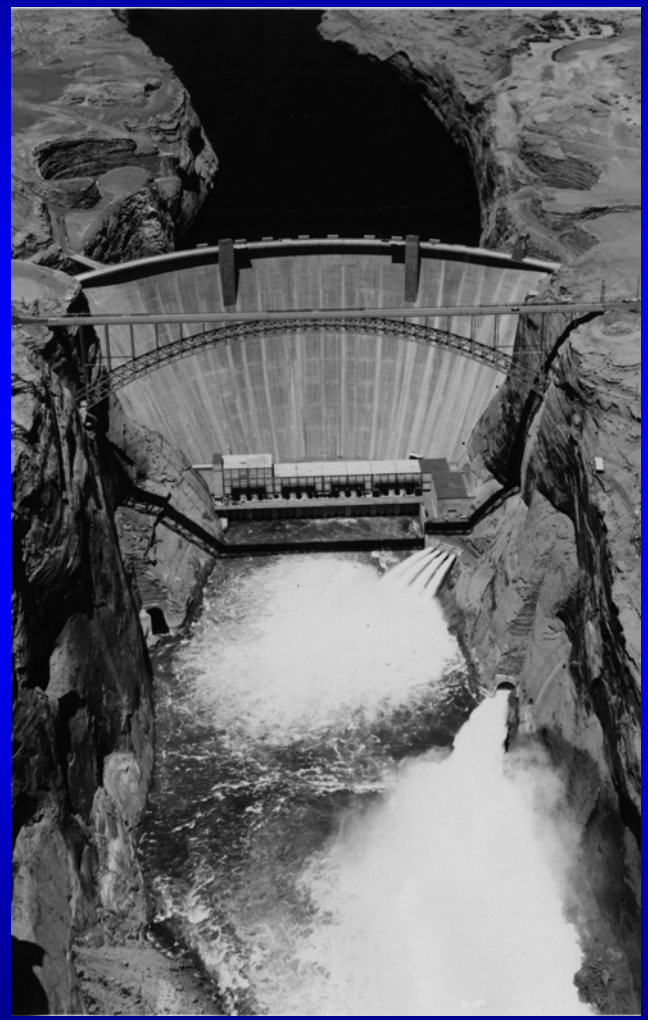


# Lees Ferry Upper Cableway Minimum Bed Elevation

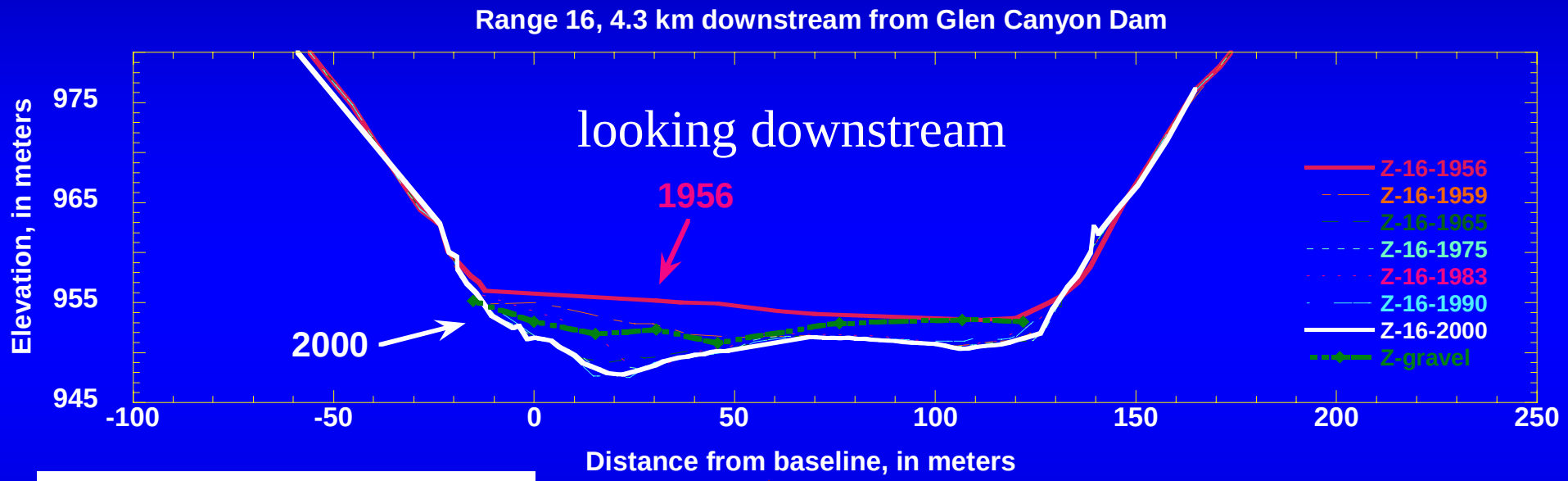


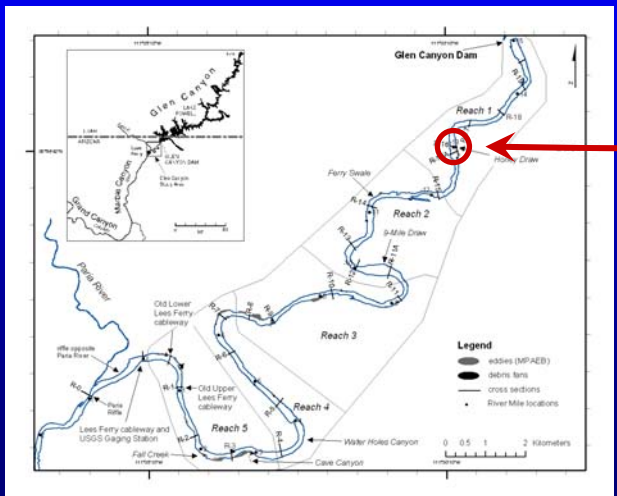
# “Channel Cleaning” Flows



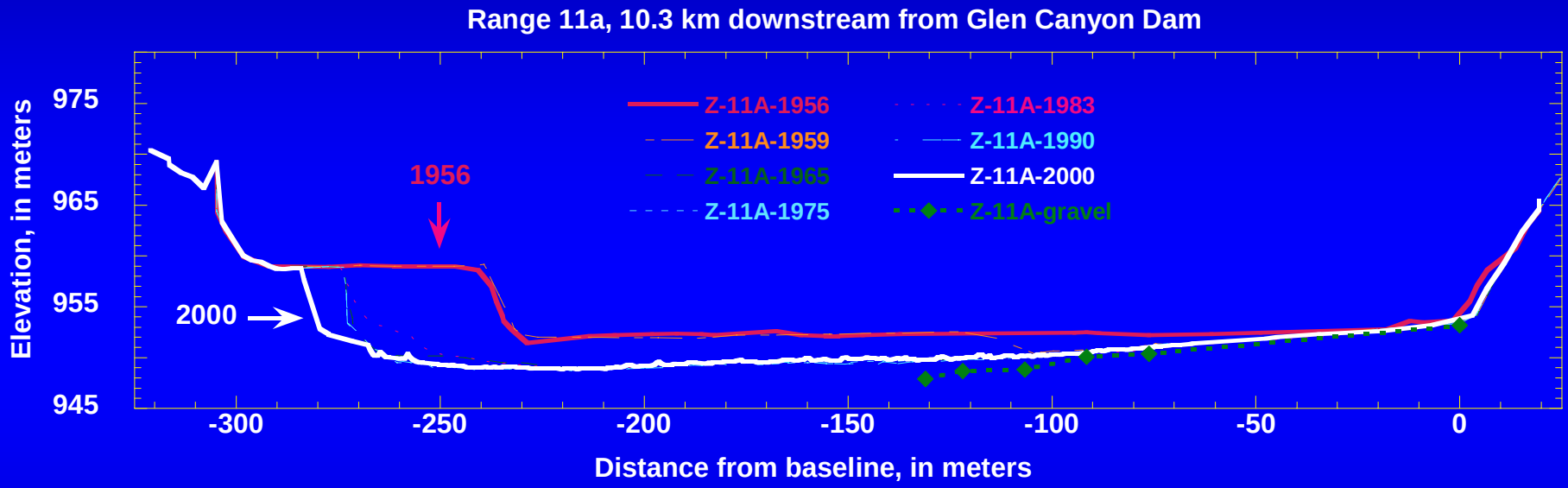



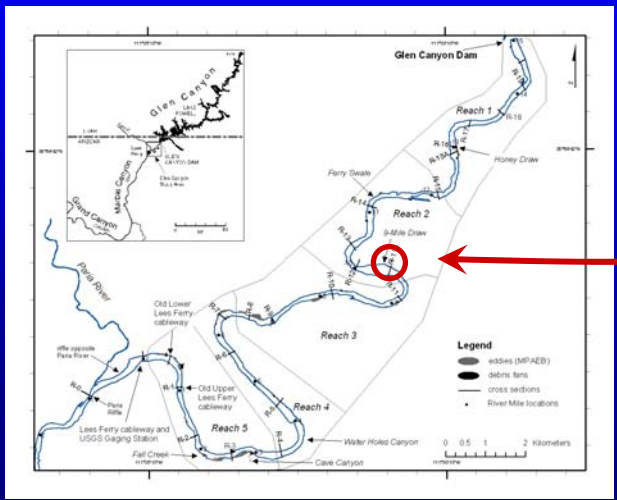
# Cross section showing bed degradation, 1956-2000



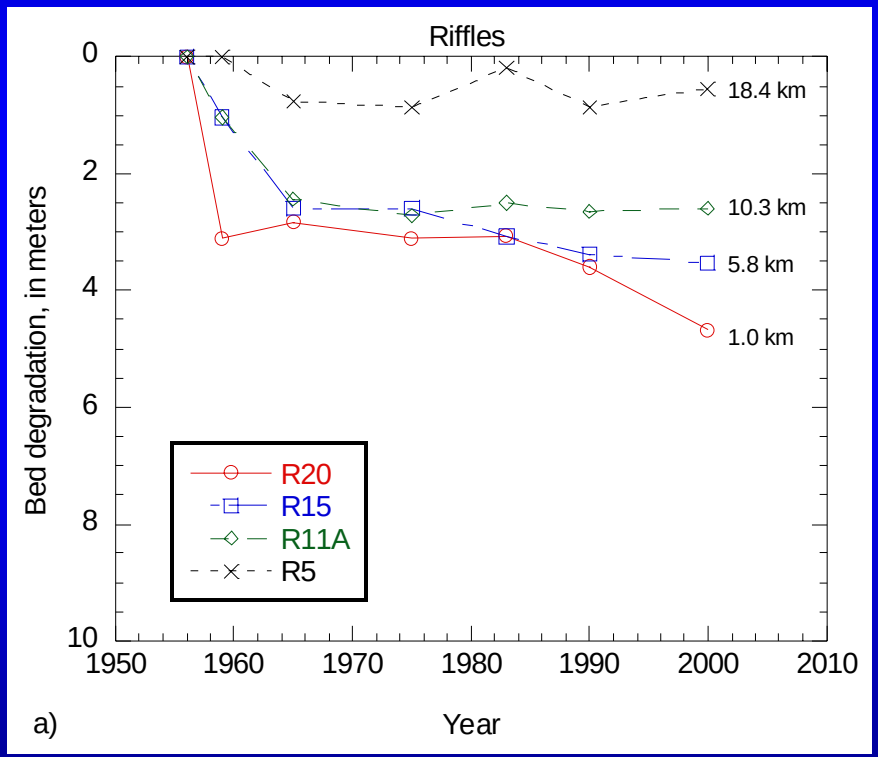
# Cross section showing bed degradation, 1956-2000

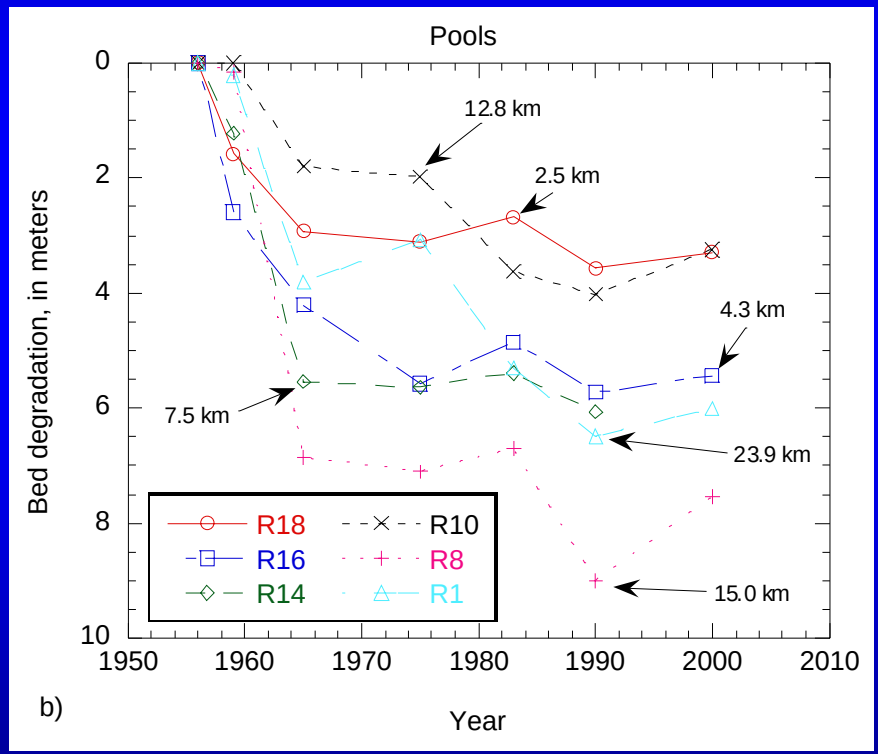


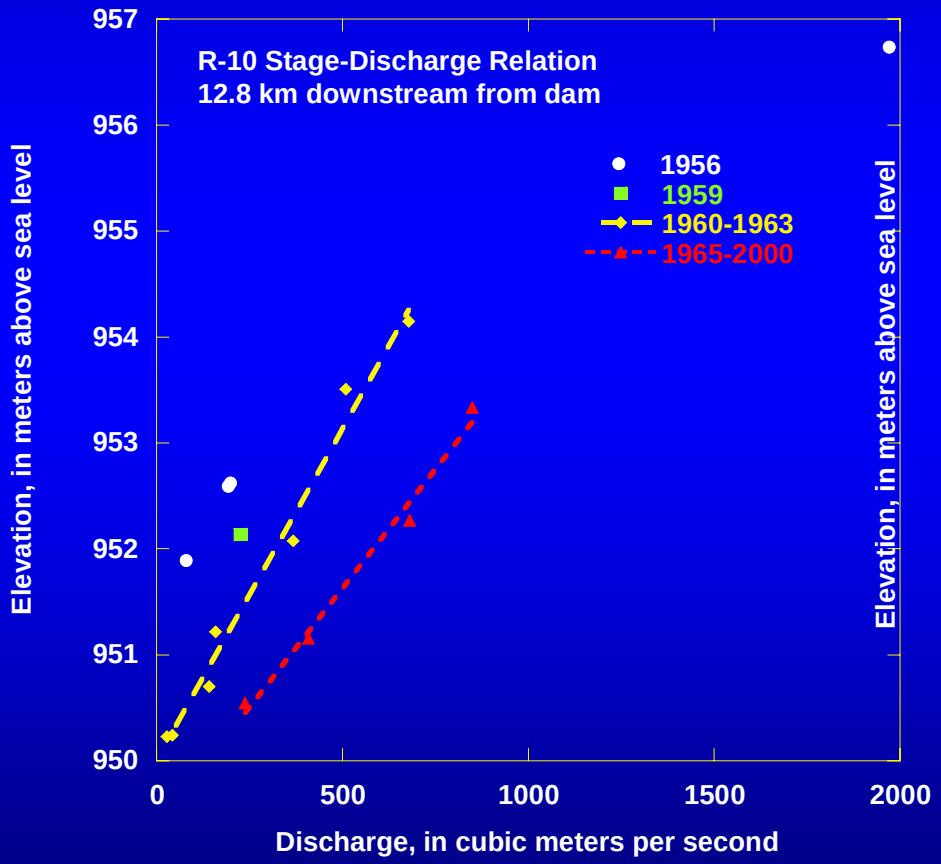

looking downstream

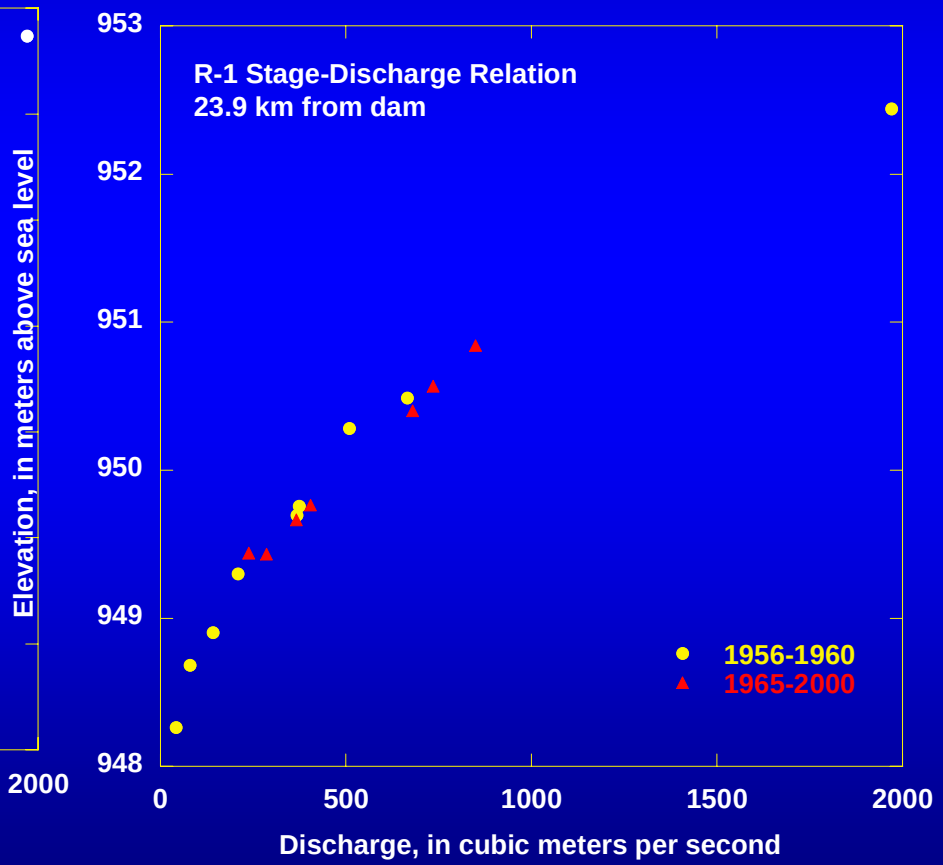
# Minimum bed elevation from 1956 to 2000 for cross-sections located in riffles and pools



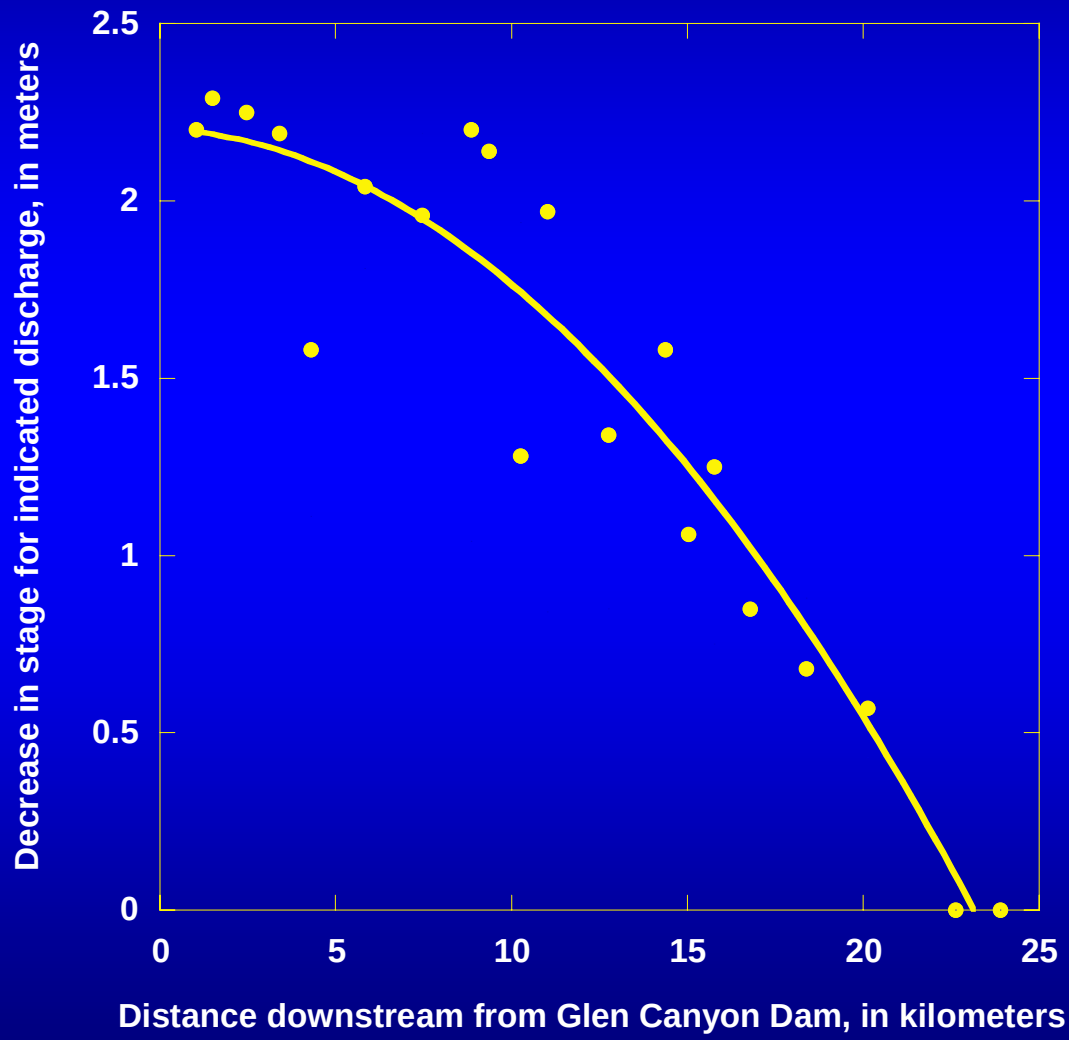



# Adjustment of Stage-Discharge Relations: Greatest at upstream end of Reach

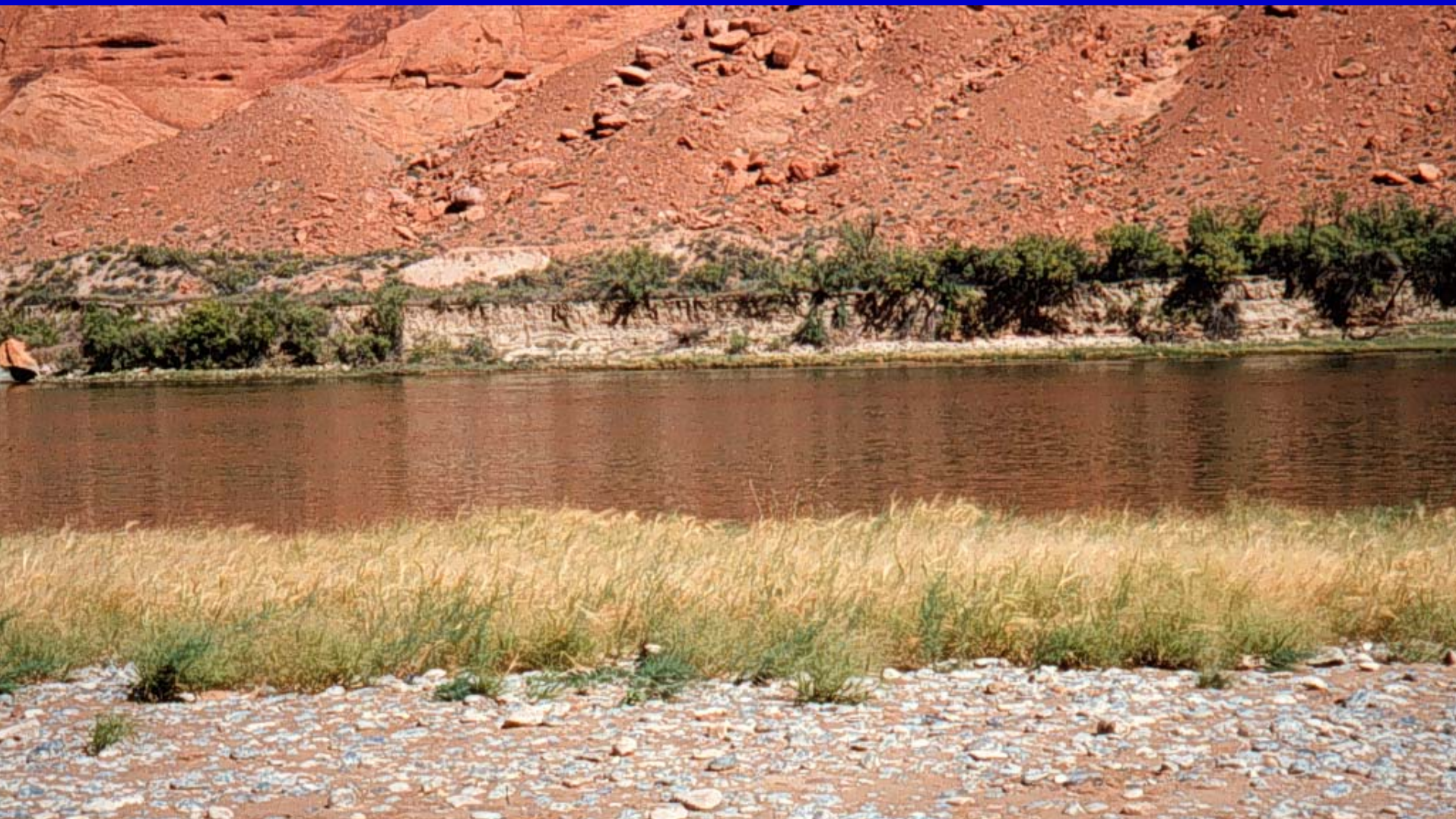


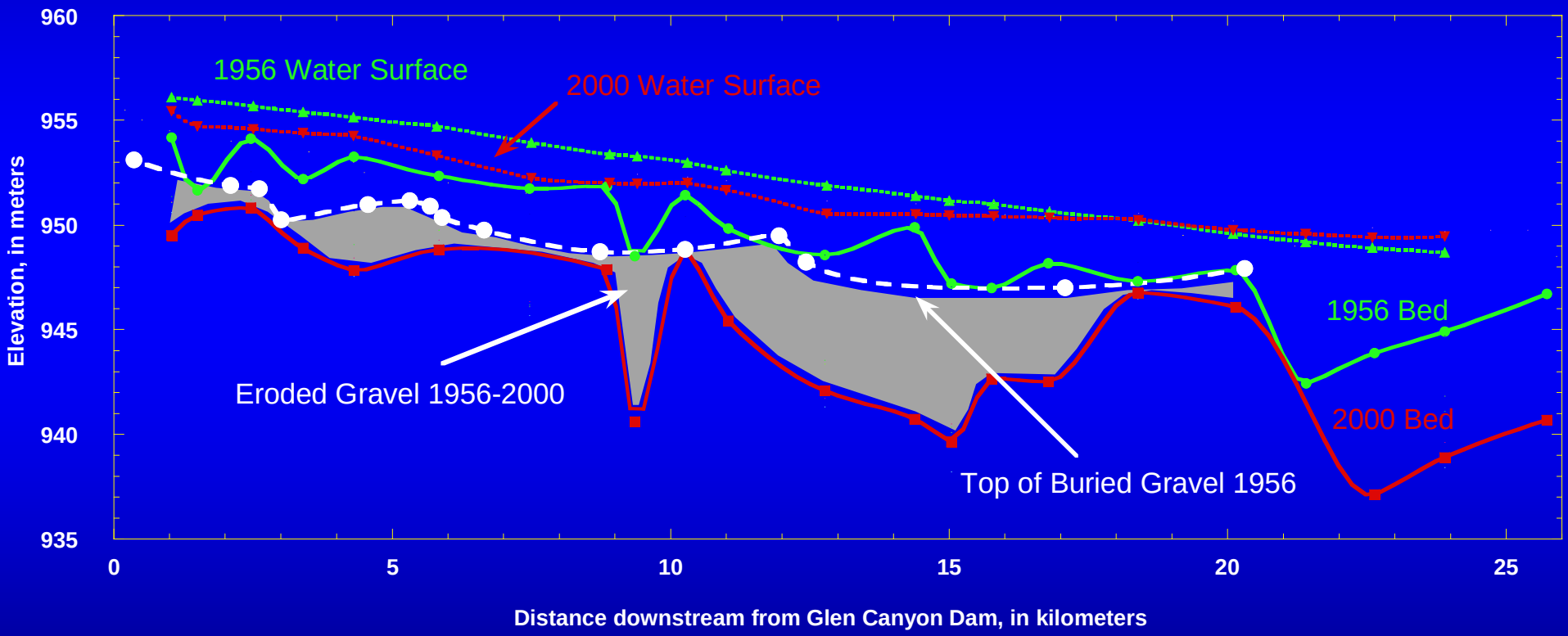
# Drop in Stage-Discharge Relation Decreases with Distance Downstream



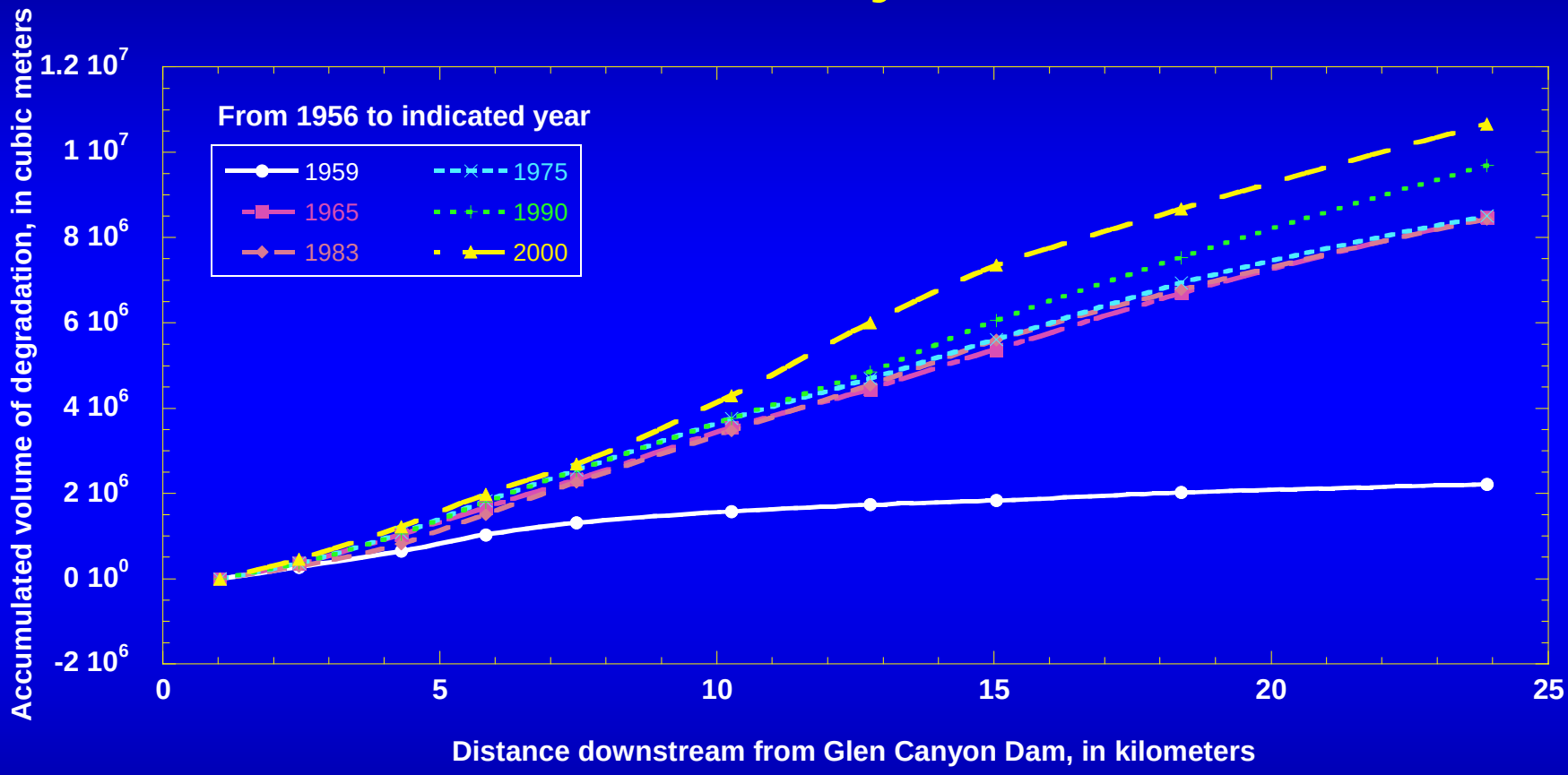
# Eroded bank and “Perched” terrace 10.3 km downstream from Glen Canyon Dam



# Longitudinal Profile of Bed Degradation: 1956 - 2000



# Accumulated sediment evacuation from Glen Canyon




8.3 million $m^3$ sediment evacuation predicted in 1957

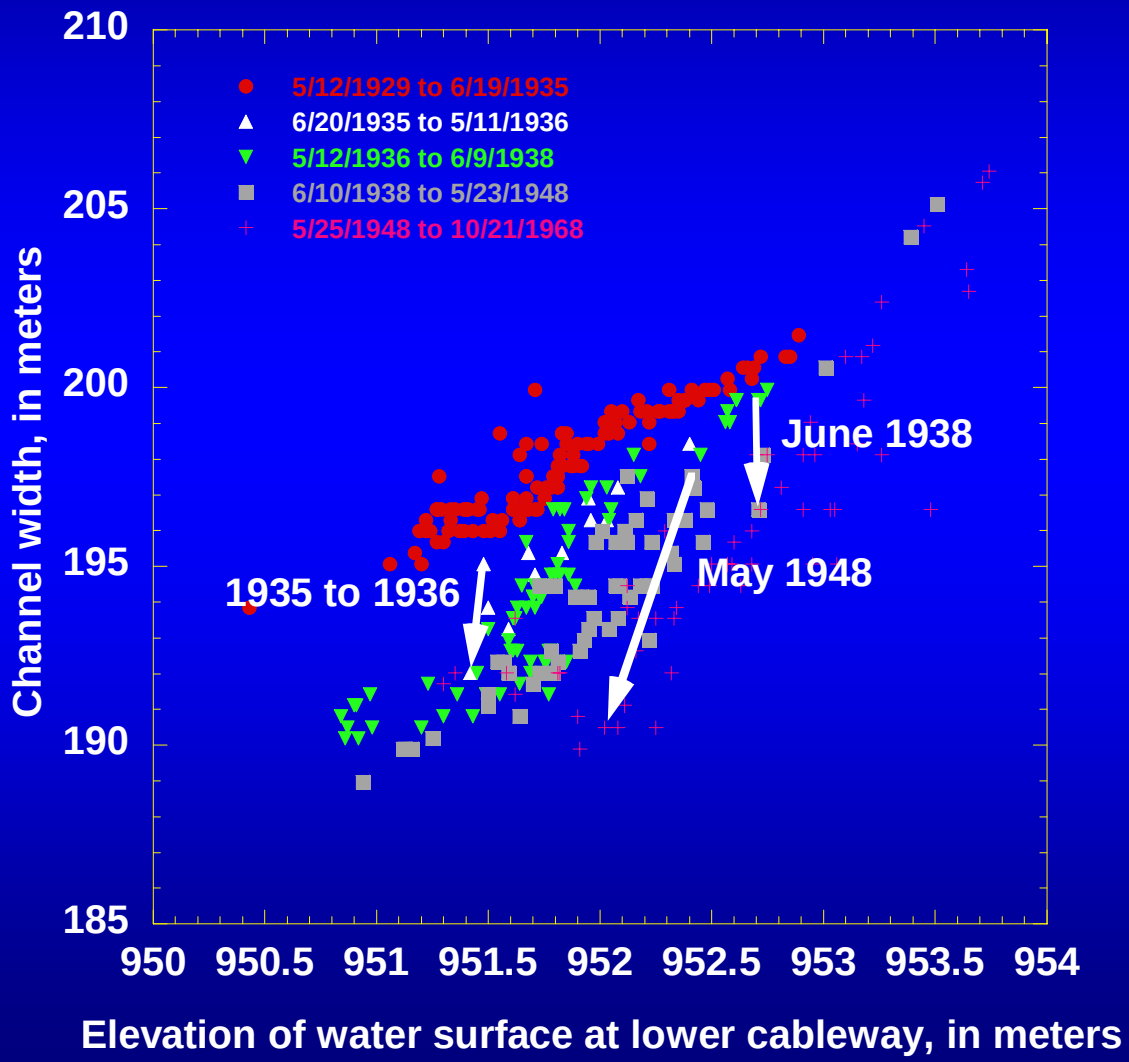
9.9 million $m^3$ measured in 1975

10.7 million $m^3$ measured in 2000 – exceeds predicted by ~ 30%

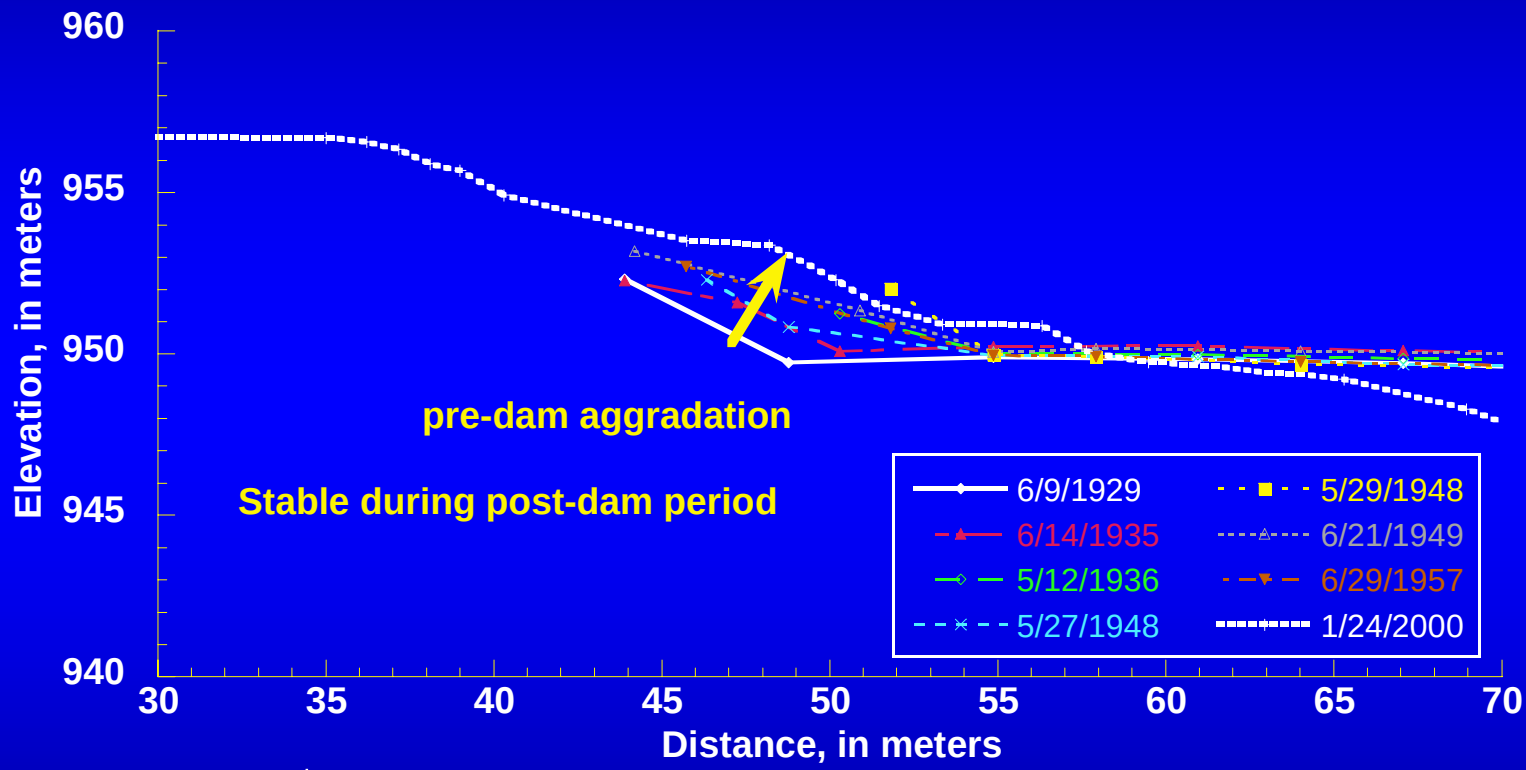
# Changes in Channel-Side Deposits

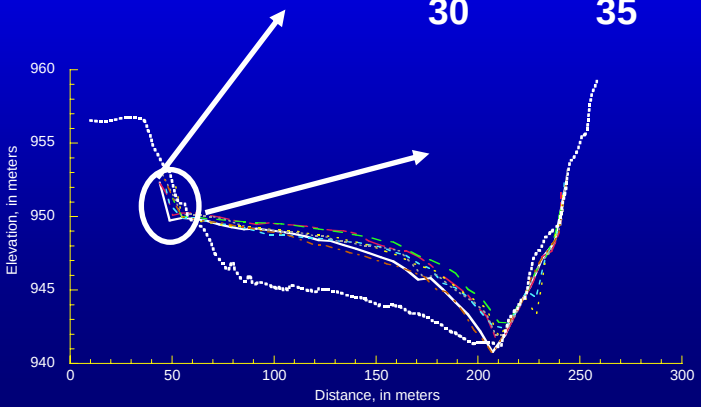
- Measurements at Lees Ferry Lower Cableway provide long pre- and post-dam time series for one location
- Mapping from aerial photographs provides comprehensive coverage from the dam to Lees Ferry

# Progressive decrease in channel width at Lower Cableway

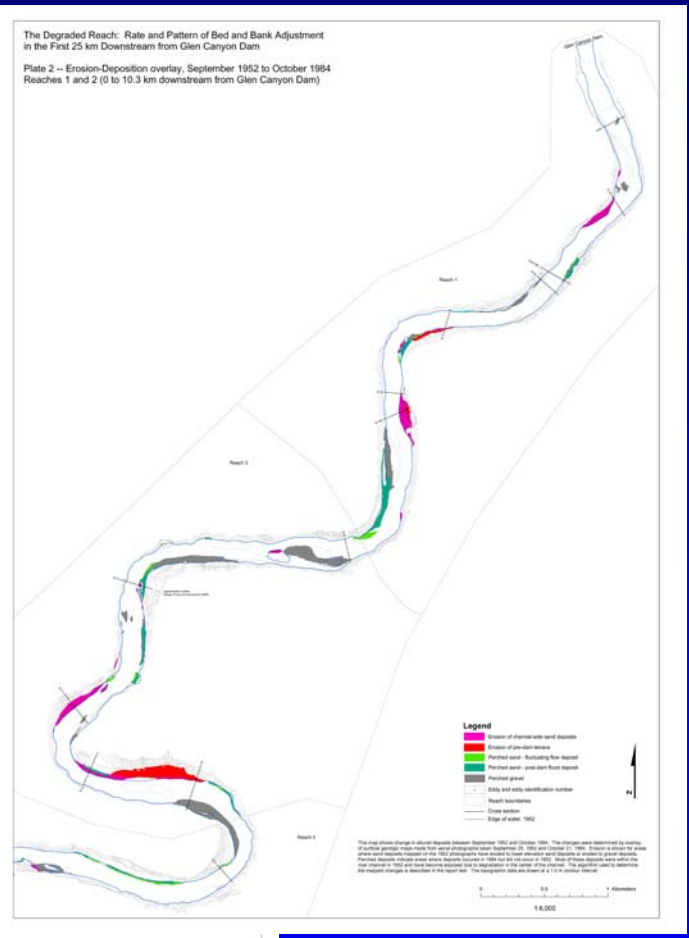


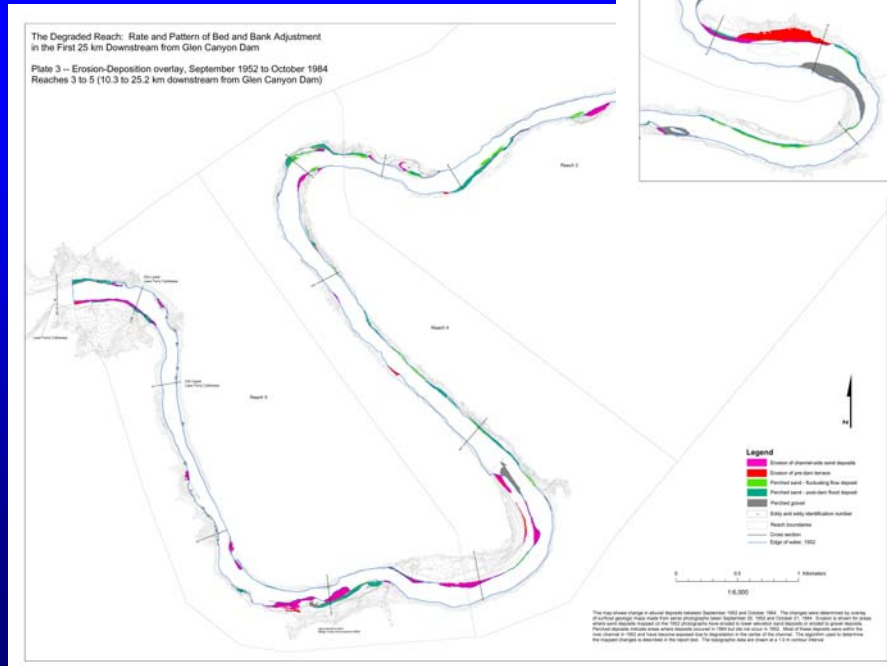
# Bed Scour and bank deposition at Lower Cableway



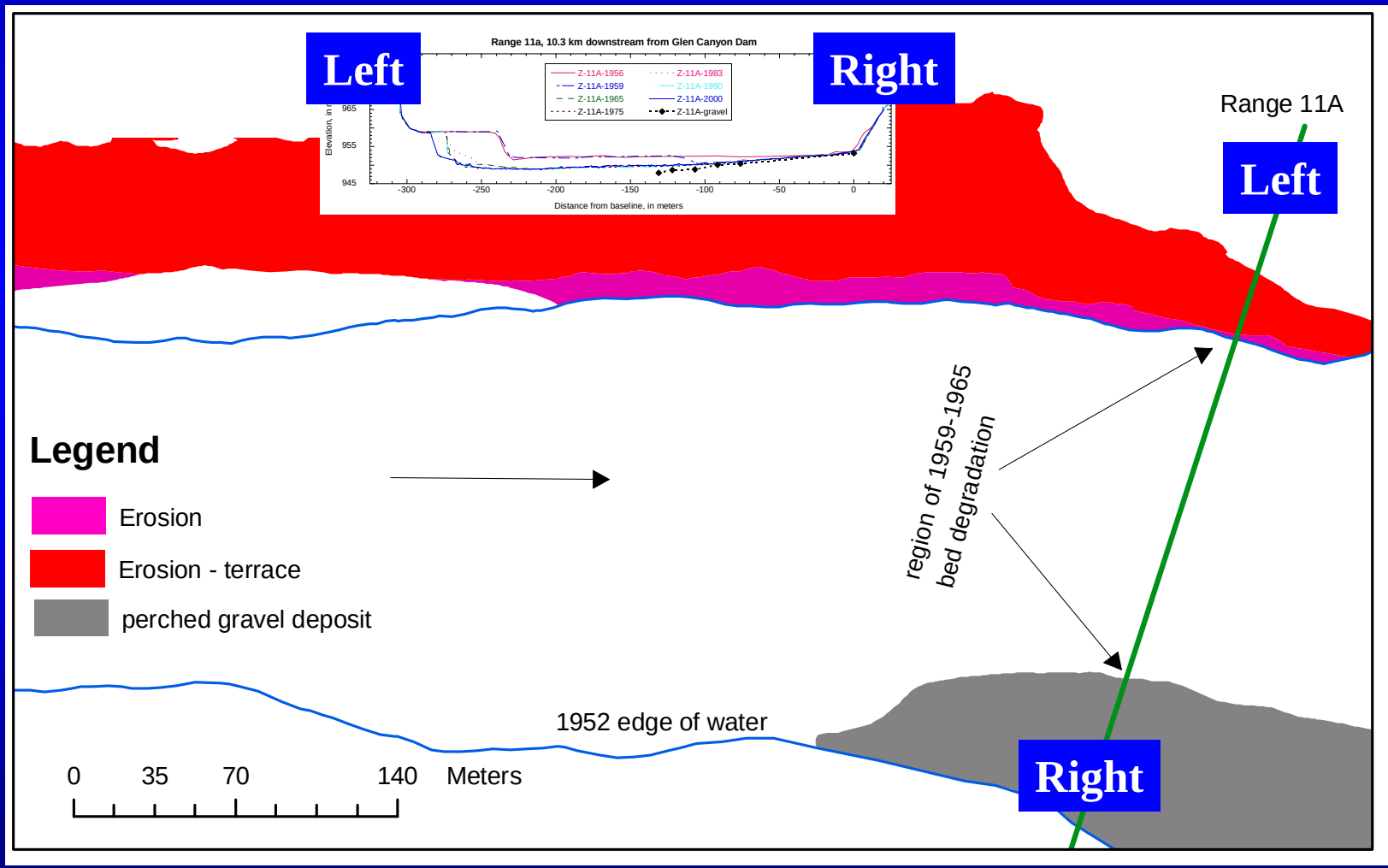



# Mapping from Air Photos

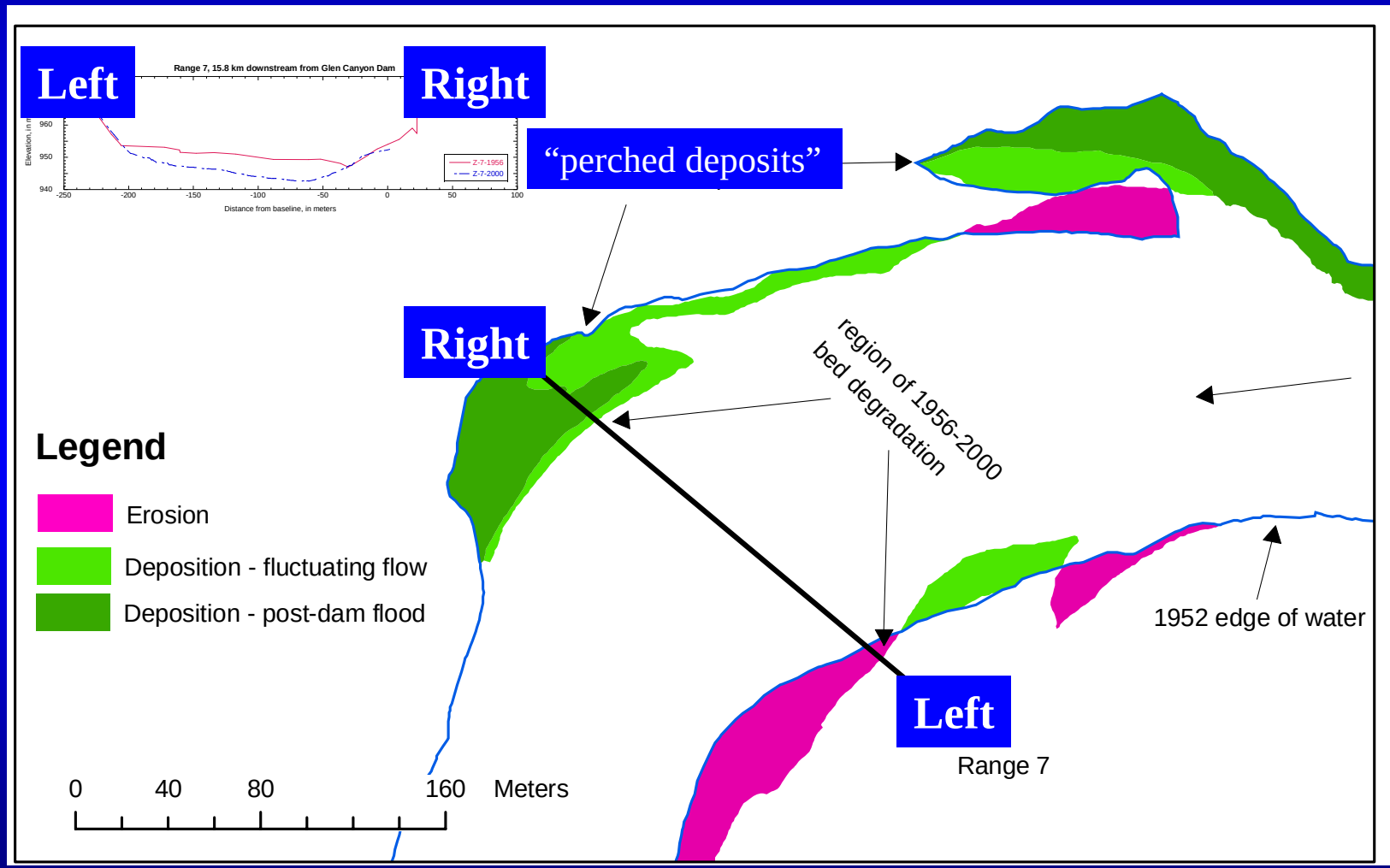


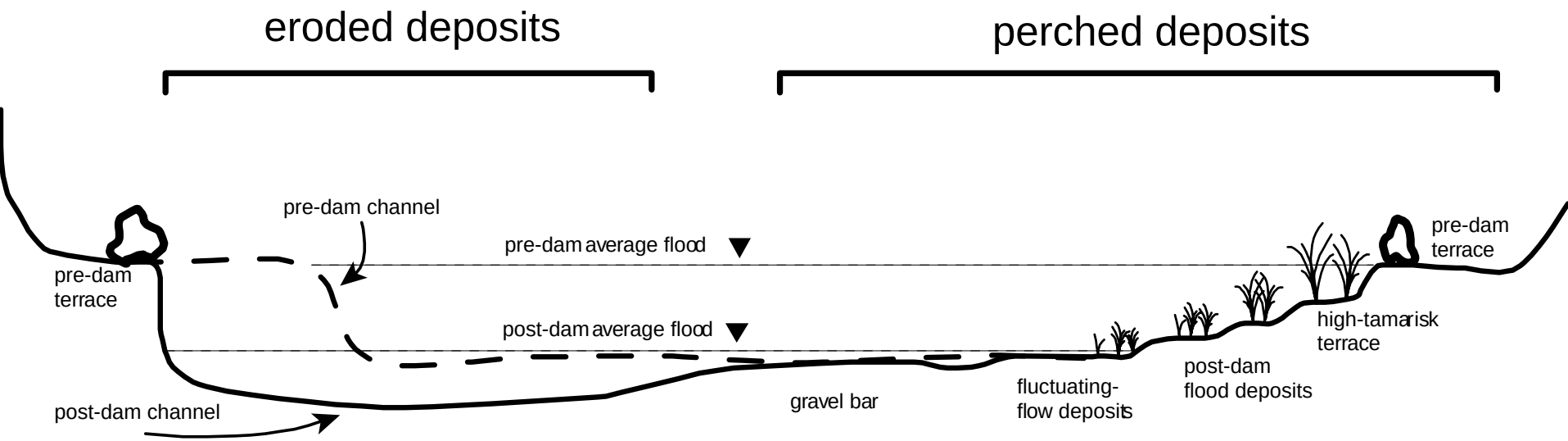
# Erosion of pre-dam terrace 1952 to 1984



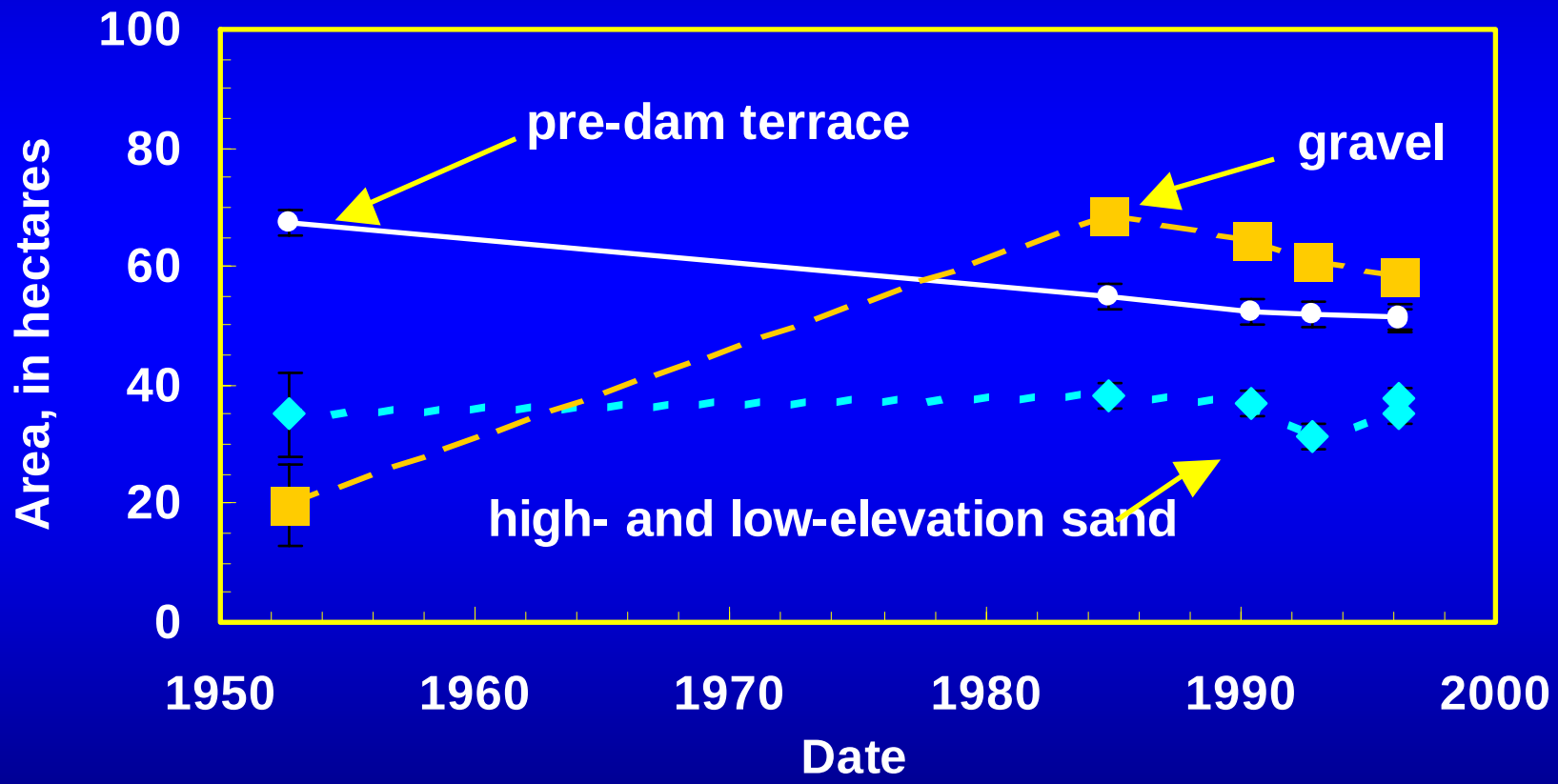
# Erosion and “perching” of channel-side deposits: 1952 to 1984



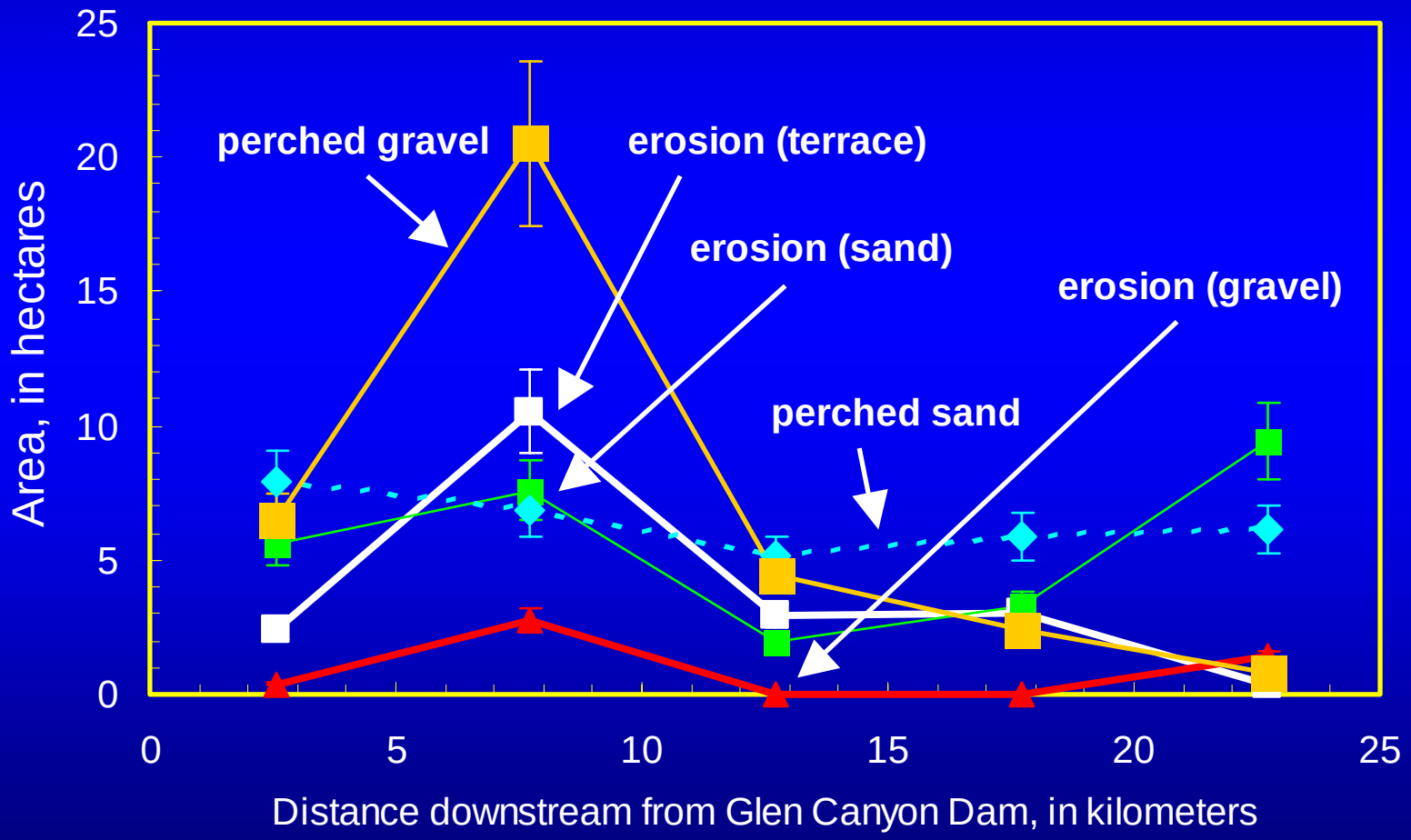
# Sketch of Pre- and Post-Dam Channel Cross-Section



# Changes in the area of alluvial deposits: 1952 to 1996



# Downstream distribution of changes in alluvial deposits: 1956 to 1984



# Conclusions I

- Sediment evacuation from Glen Canyon has continued since 1975, but at a much reduced rate
  - Has not significantly decreased mean bed elevations
  - Most degradation since 1975 occurred in pools
  - Magnitude of degradation in riffles decreases in downstream direction and extends downstream to 2 mi above Lees Ferry
  - Magnitude of degradation in pools does not correlate with distance downstream and extends below Lees Ferry
- The stage discharge relations have dropped by up to 1 m at the upstream end of the reach and have not changed at the downstream end of the reach

# Conclusions II

- Massive terrace erosion at localized sites during the channel cleaning flows, not widespread throughout reach and current rates of erosion are very low
- Channel-side sand deposits and gravel deposits “perched” above active channel and stabilized by vegetation

# Prognosis

- Continued evacuation of sediment from pools, primarily during floods
- No further degradation of channel controls (riffles), even during floods
- Possible aggradation of riffles over time and in the absence of scouring floods
- Subtle changes to channel-side deposits
  - Sporadic and localized terrace erosion
  - Small-scale erosion and deposition at sand bars