

# ***Linking fluvial and aeolian sediment transport along the Colorado River in Grand Canyon***

*Alan Kasprak  
U.S. Geological Survey  
12 September 2017*

**USGS Grand Canyon  
Monitoring and Research Center  
Flagstaff, Arizona**

*With Dan Buscombe, Josh Caster,  
Amy East, Paul Grams, and Joel Sankey*



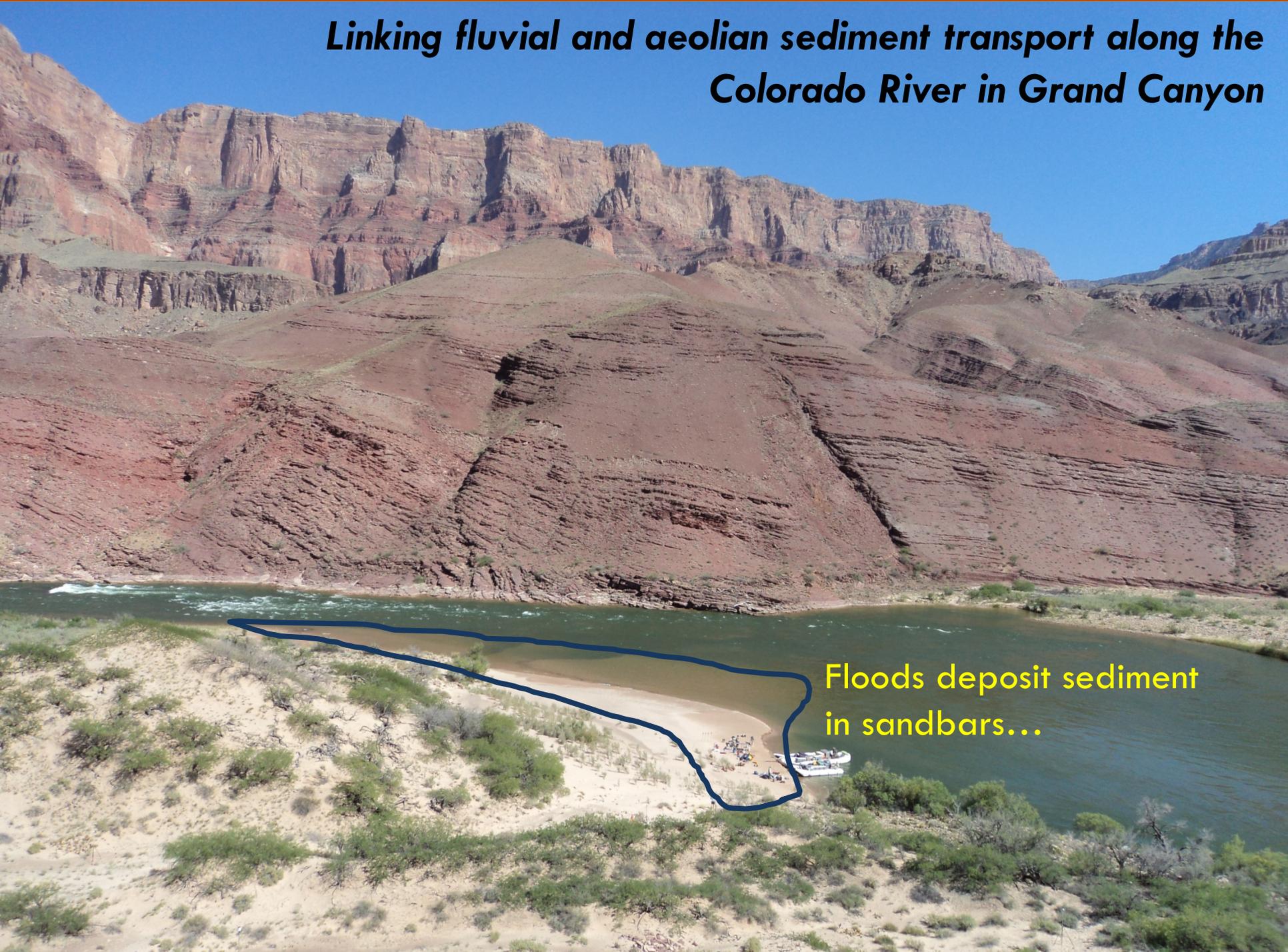
**Linking *River* and *Wind* sediment transport along the Colorado River in Grand Canyon**

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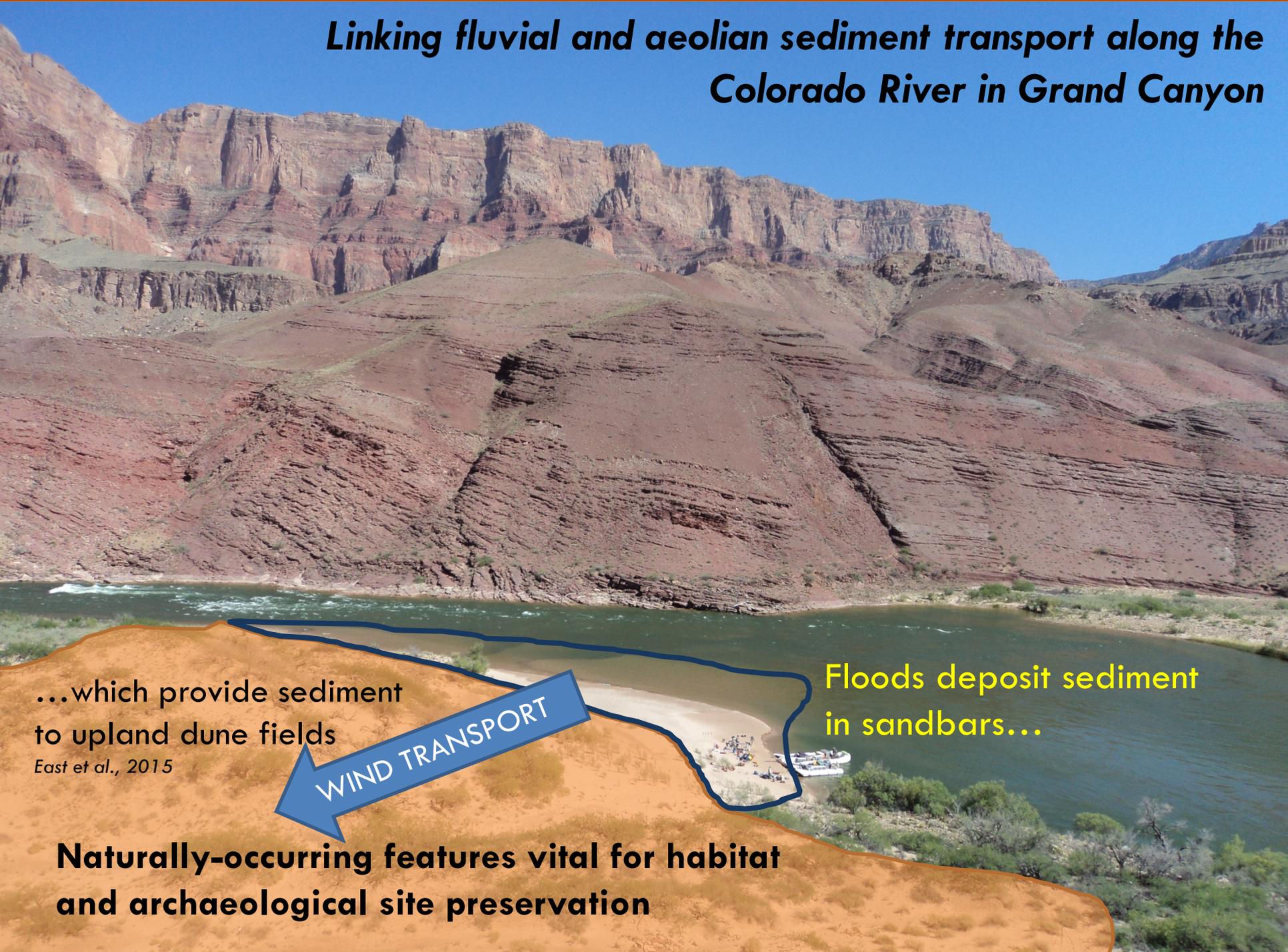
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# ***Linking fluvial and aeolian sediment transport along the Colorado River in Grand Canyon***



**Floods deposit sediment  
in sandbars...**

# Linking fluvial and aeolian sediment transport along the Colorado River in Grand Canyon



...which provide sediment to upland dune fields

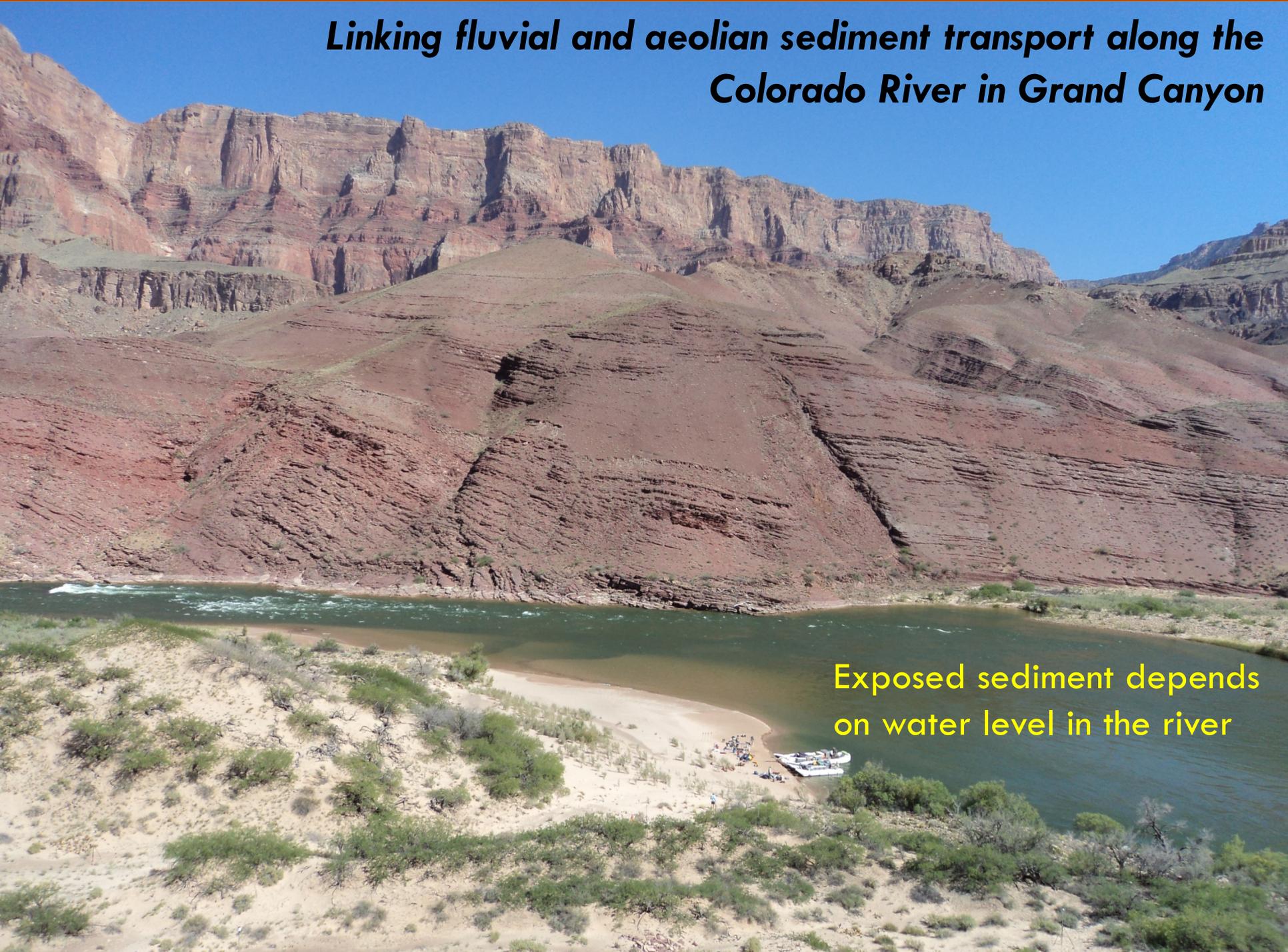
*East et al., 2015*

**WIND TRANSPORT**

Floods deposit sediment in sandbars...

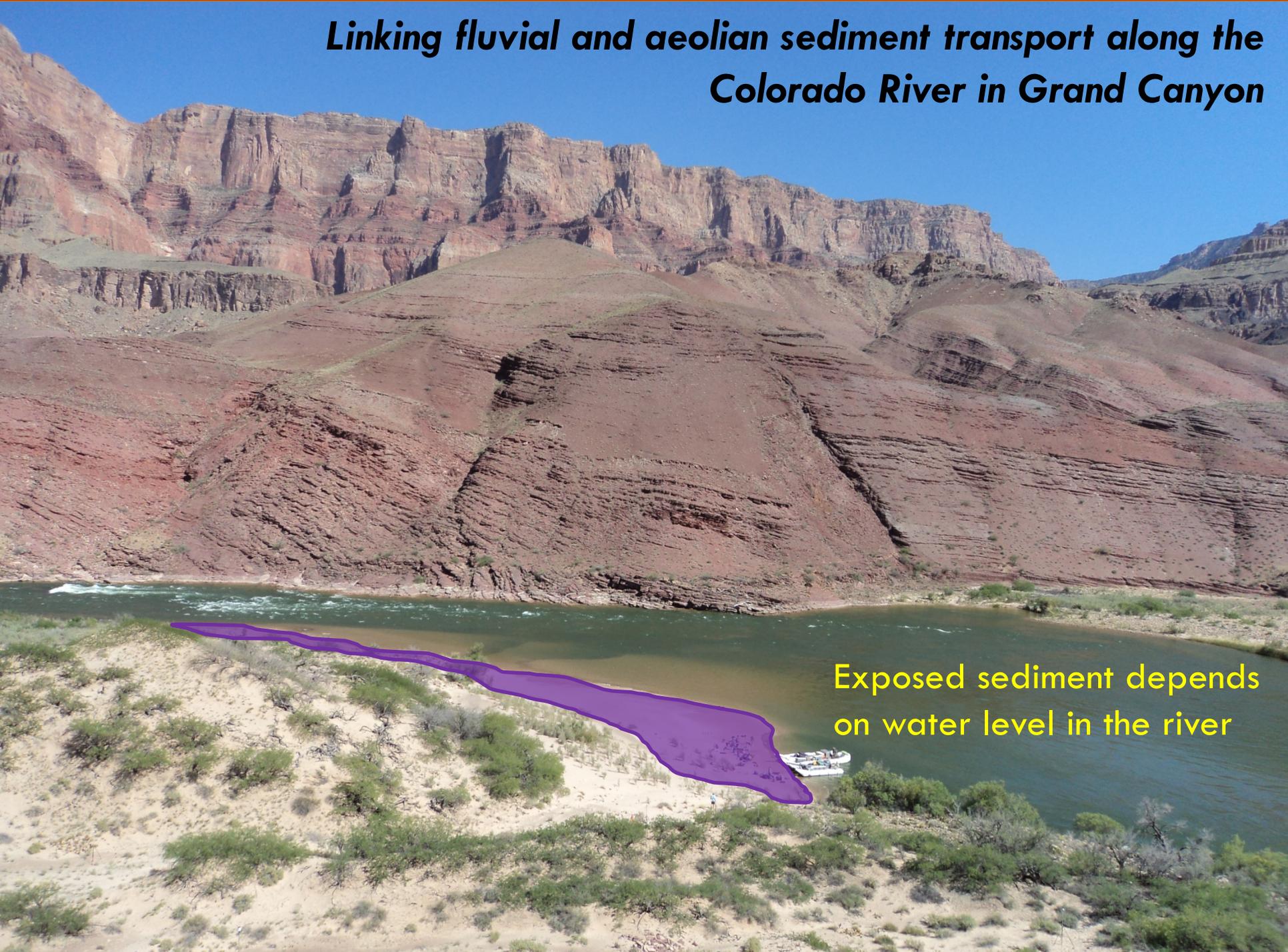
**Naturally-occurring features vital for habitat and archaeological site preservation**

***Linking fluvial and aeolian sediment transport along the  
Colorado River in Grand Canyon***



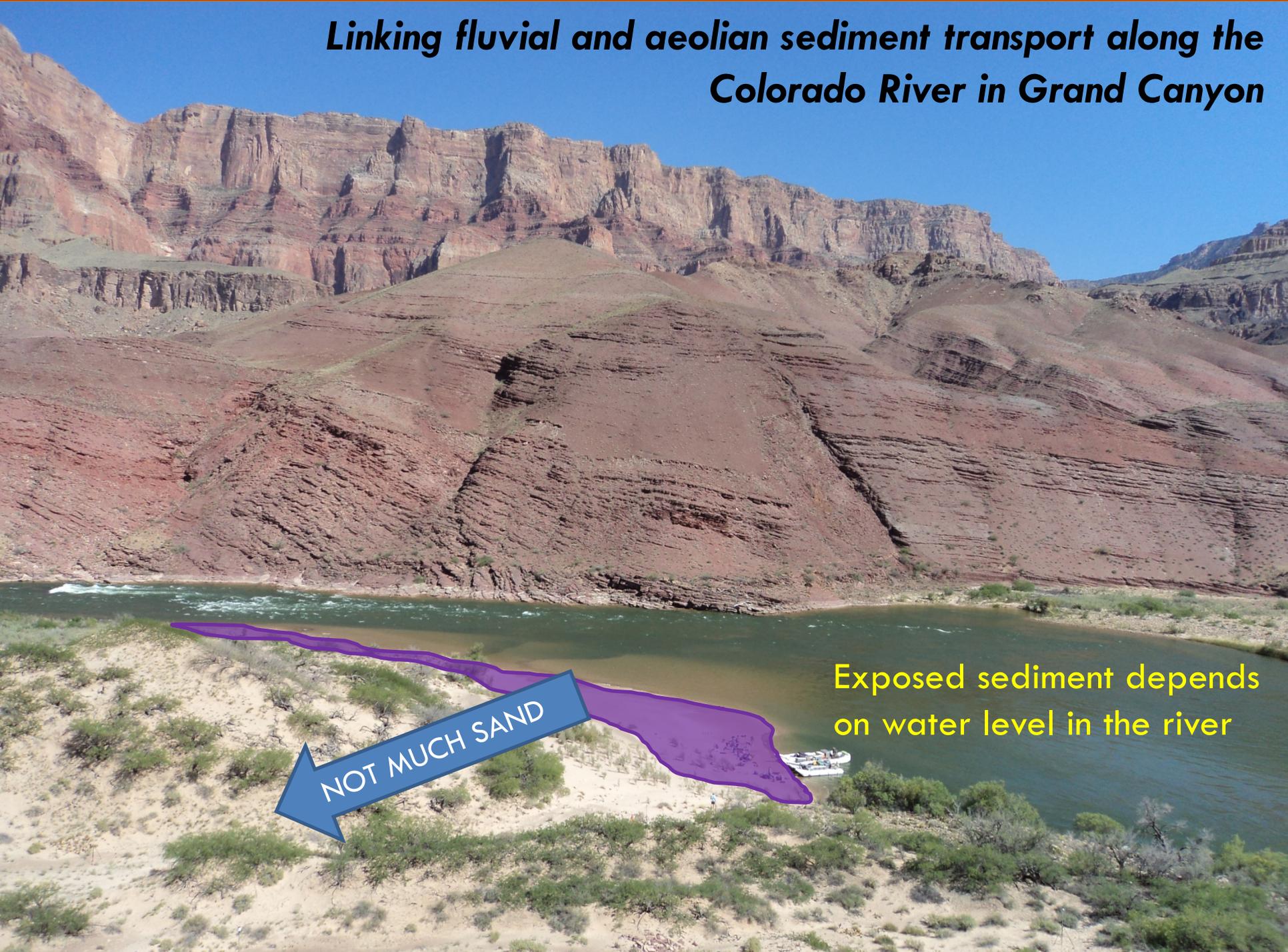
**Exposed sediment depends  
on water level in the river**

# ***Linking fluvial and aeolian sediment transport along the Colorado River in Grand Canyon***



**Exposed sediment depends on water level in the river**

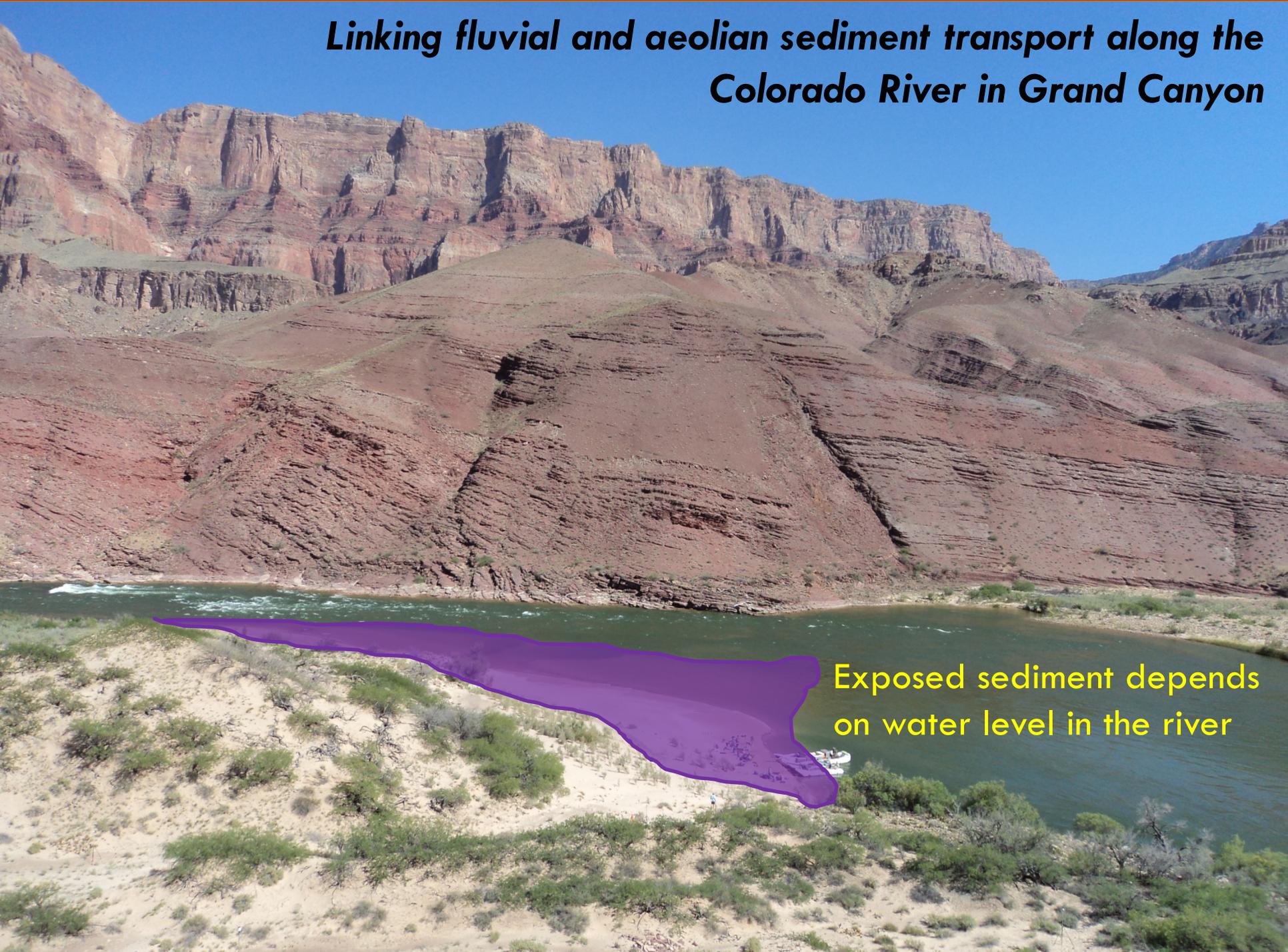
# ***Linking fluvial and aeolian sediment transport along the Colorado River in Grand Canyon***



**NOT MUCH SAND**

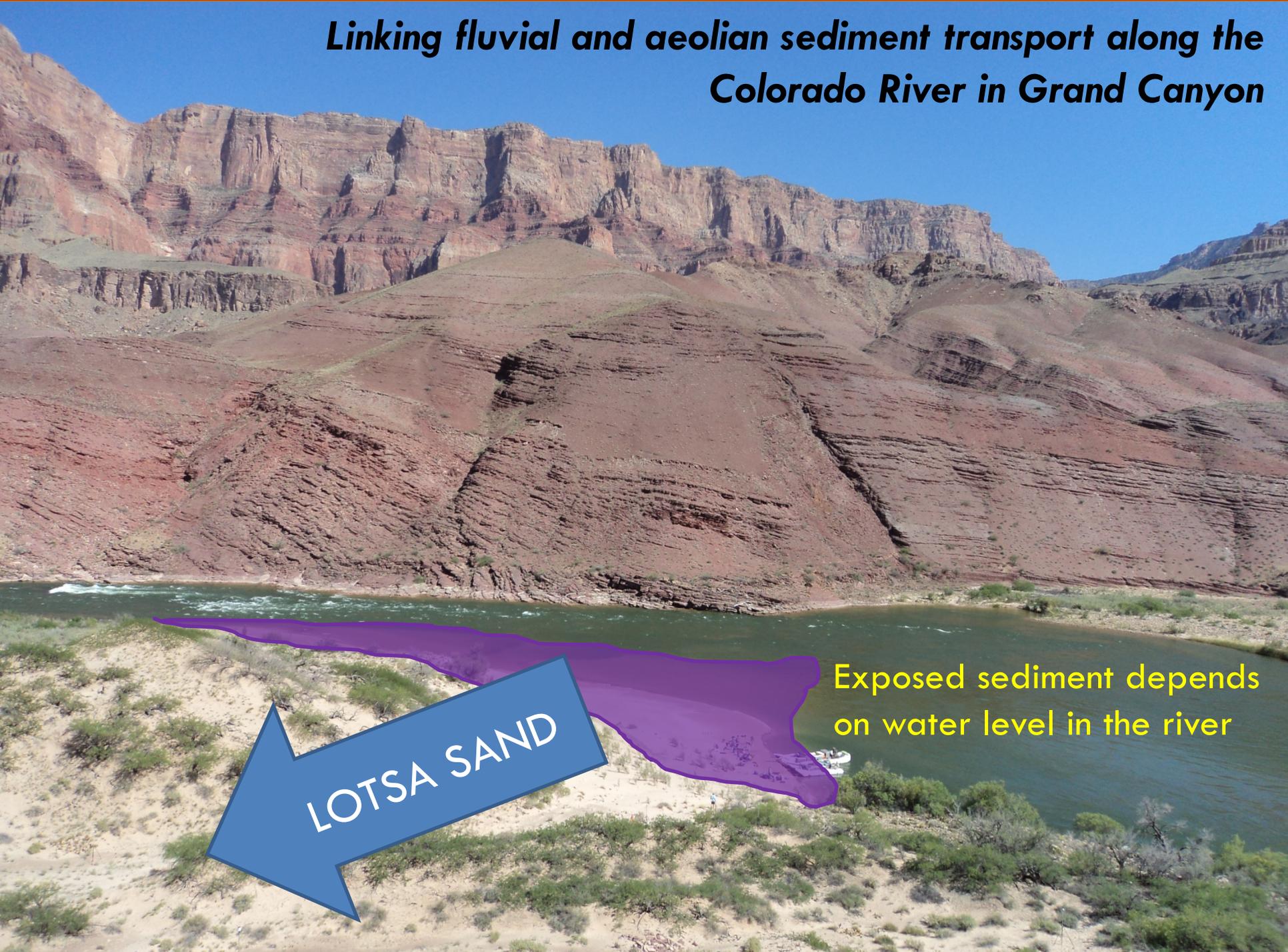
**Exposed sediment depends on water level in the river**

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**Exposed sediment depends on water level in the river**

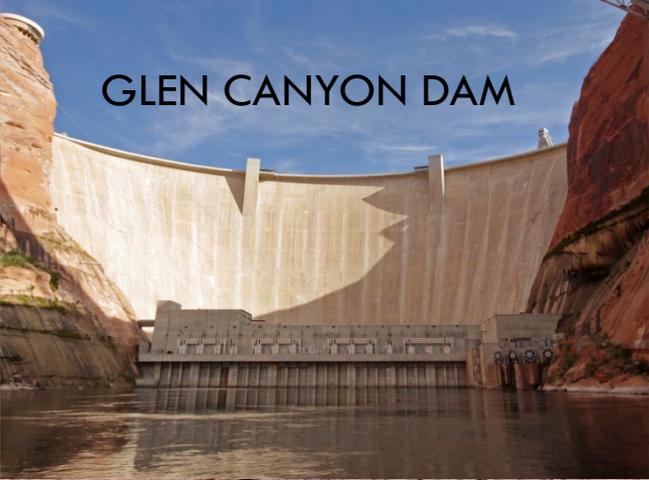
# ***Linking fluvial and aeolian sediment transport along the Colorado River in Grand Canyon***



**LOTSASAND**

Exposed sediment depends on water level in the river

# Linking fluvial and aeolian sediment transport along the Colorado River in Grand Canyon



GLEN CANYON DAM



85 Miles Upstream...

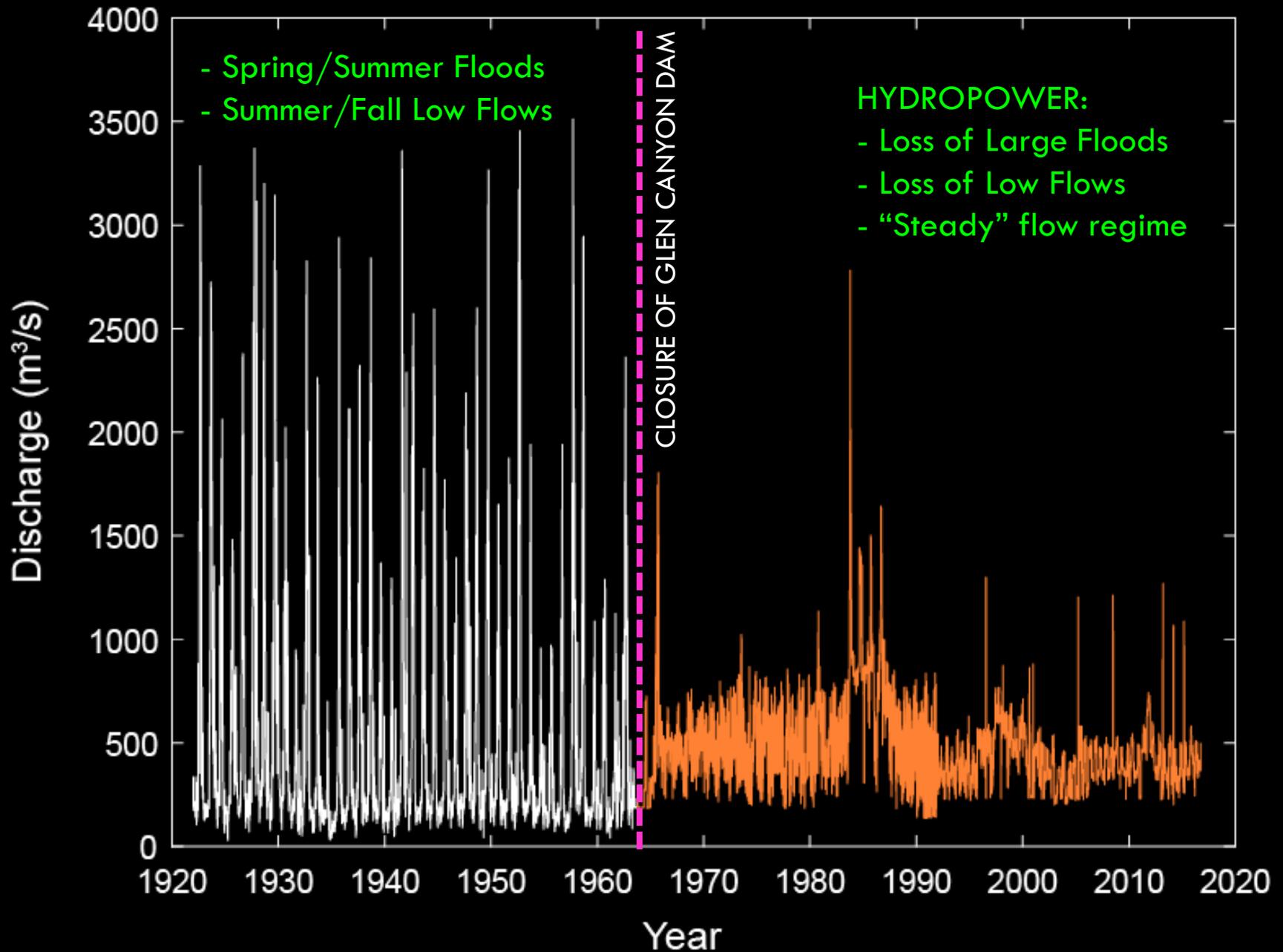


LOTS A SAND

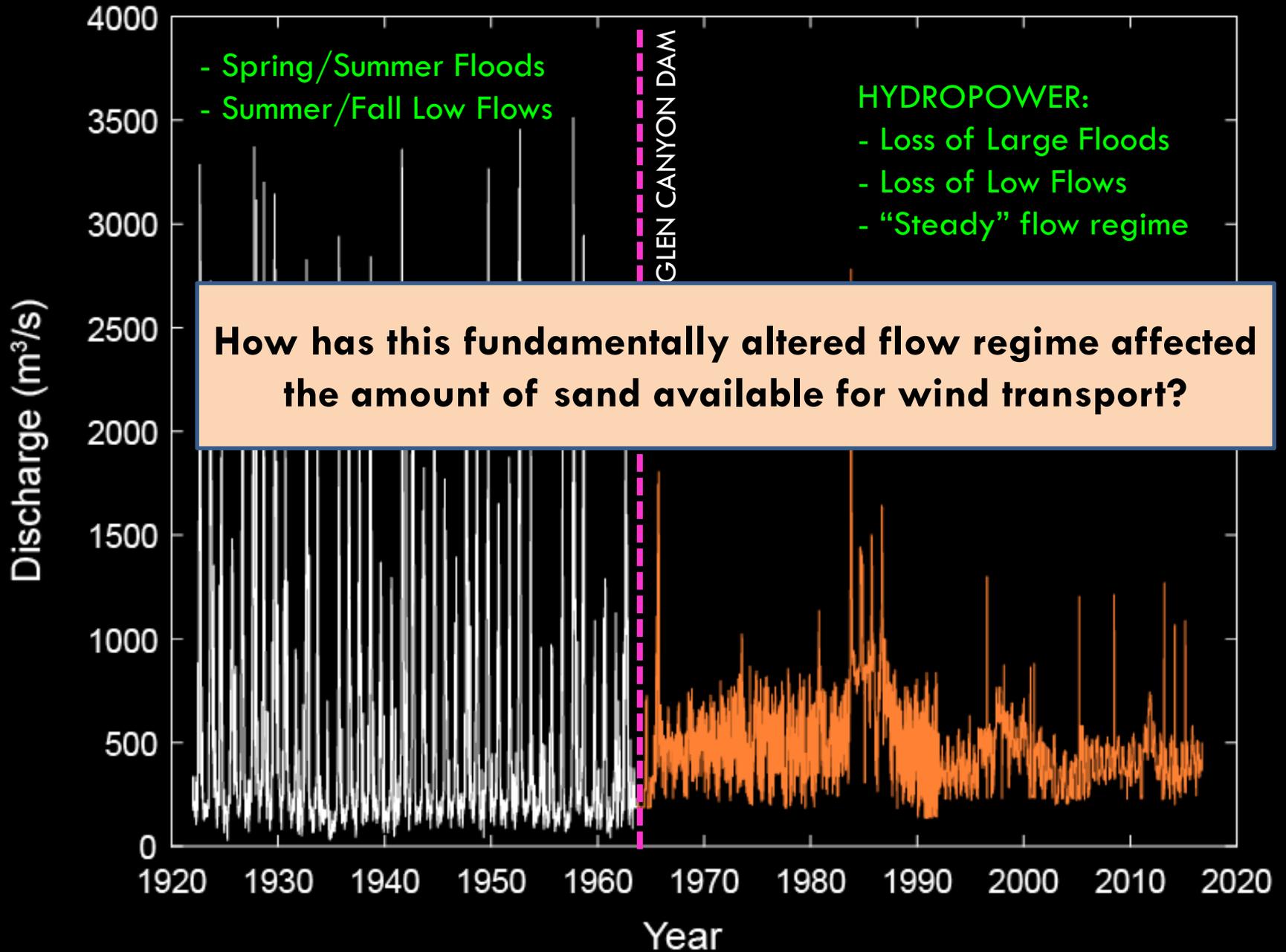


Exposed sediment depends on water level in the river

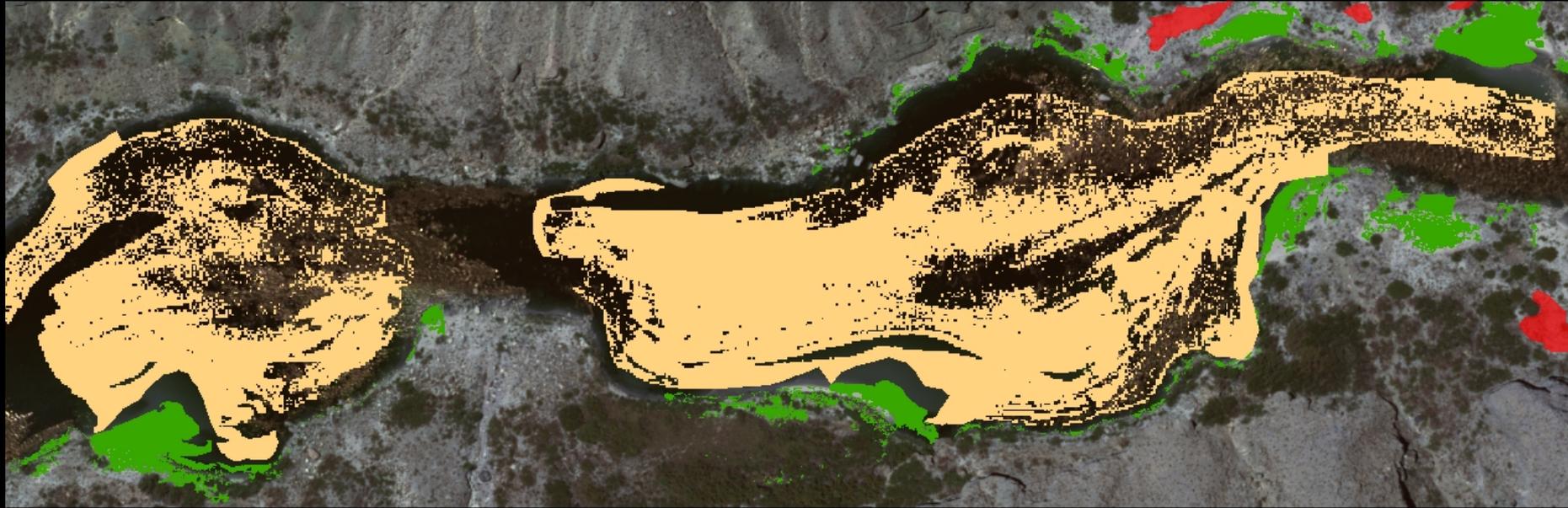
# Colorado River at Lee's Ferry (25 km downstream from Glen Canyon Dam)



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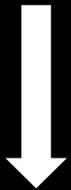
## Sand Mapping – for a 28 km reach of the Colorado River



Active Channel Sand

Remotely Mapped  
Upland Sand

Manually Mapped  
Upland Sand



From sonar surveys



From classification  
of aerial photos



From field mapping on  
river trips

**Mapped every square meter of sand from the channel bed  
to historic flood of record (5,947 m<sup>3</sup>/s) over 28 km reach**

# Hydraulic Modeling

Prepared in cooperation with the  
GRAND CANYON MONITORING AND RESEARCH CENTER

**Modeling Water-Surface Elevations and Virtual Shorelines  
for the Colorado River in Grand Canyon, Arizona**



Scientific Investigation Report 2008-5075

Magirl et al., 2008

226 m<sup>3</sup>/s

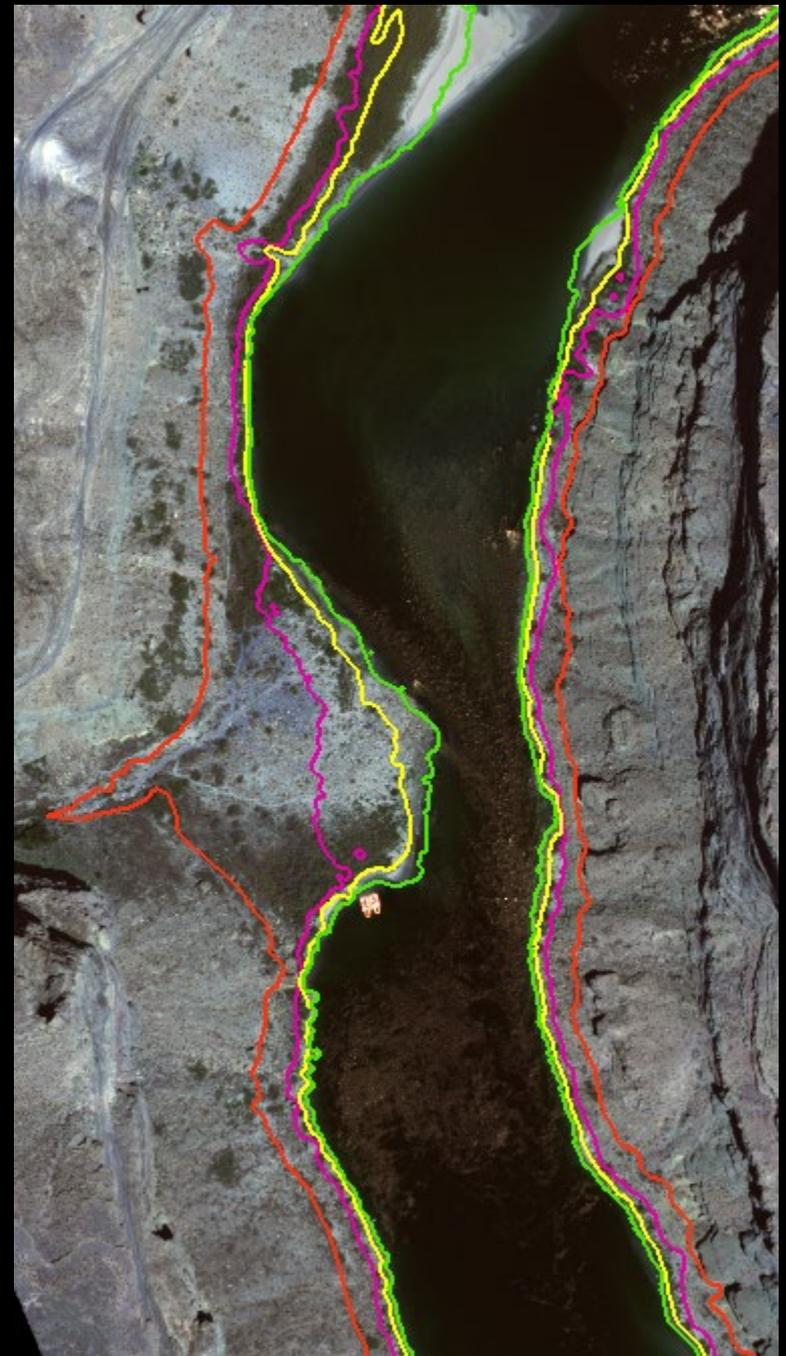
566 m<sup>3</sup>/s

1,274 m<sup>3</sup>/s

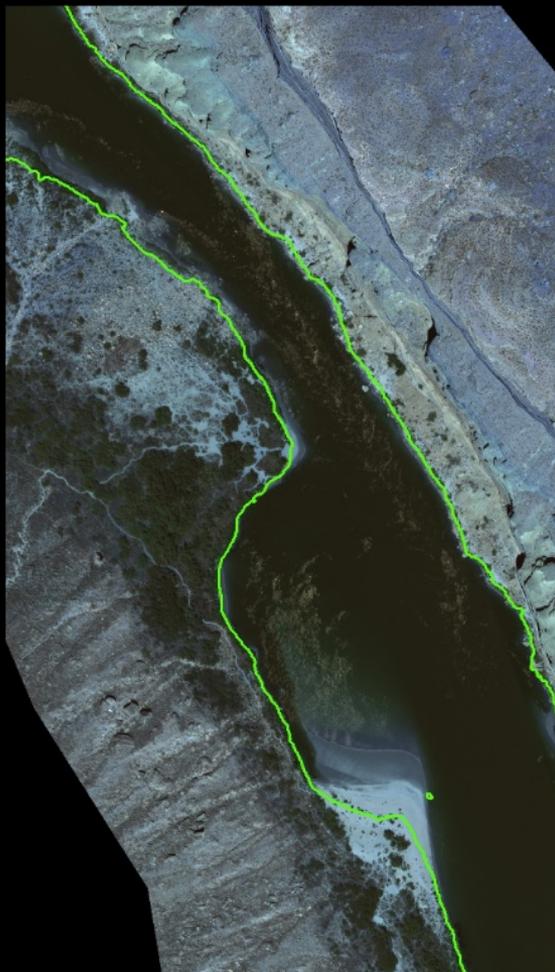
5,947 m<sup>3</sup>/s

*...and ten  
intermediate  
flows not  
shown here*

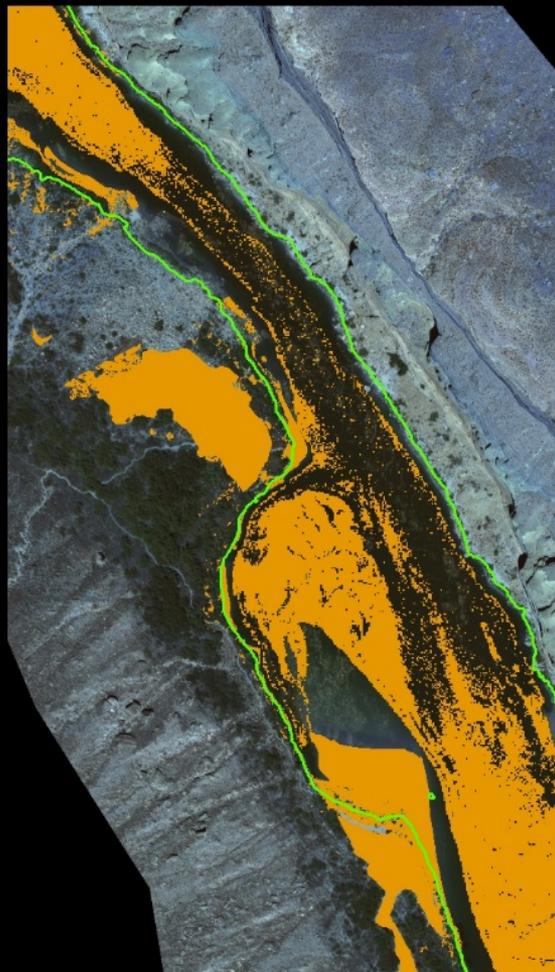
**What area of sand will be exposed for a  
given discharge from Glen Canyon Dam?**



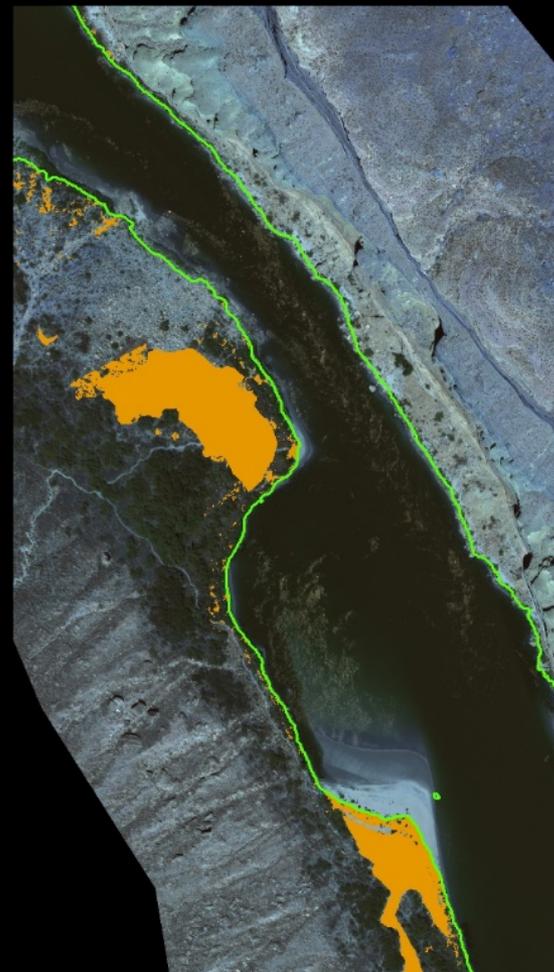
For every modeled  
inundation extent...



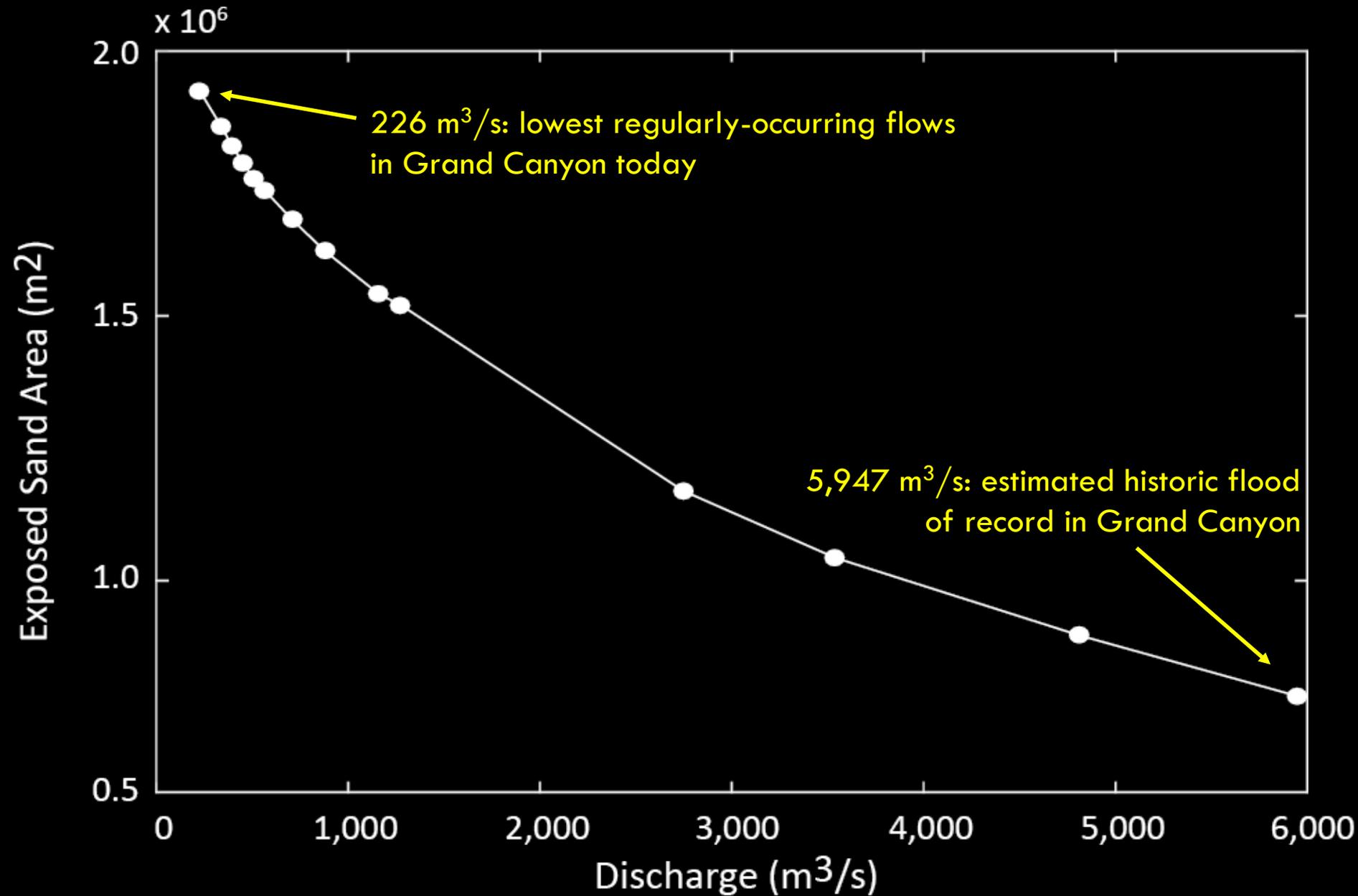
...take the map of  
total sand



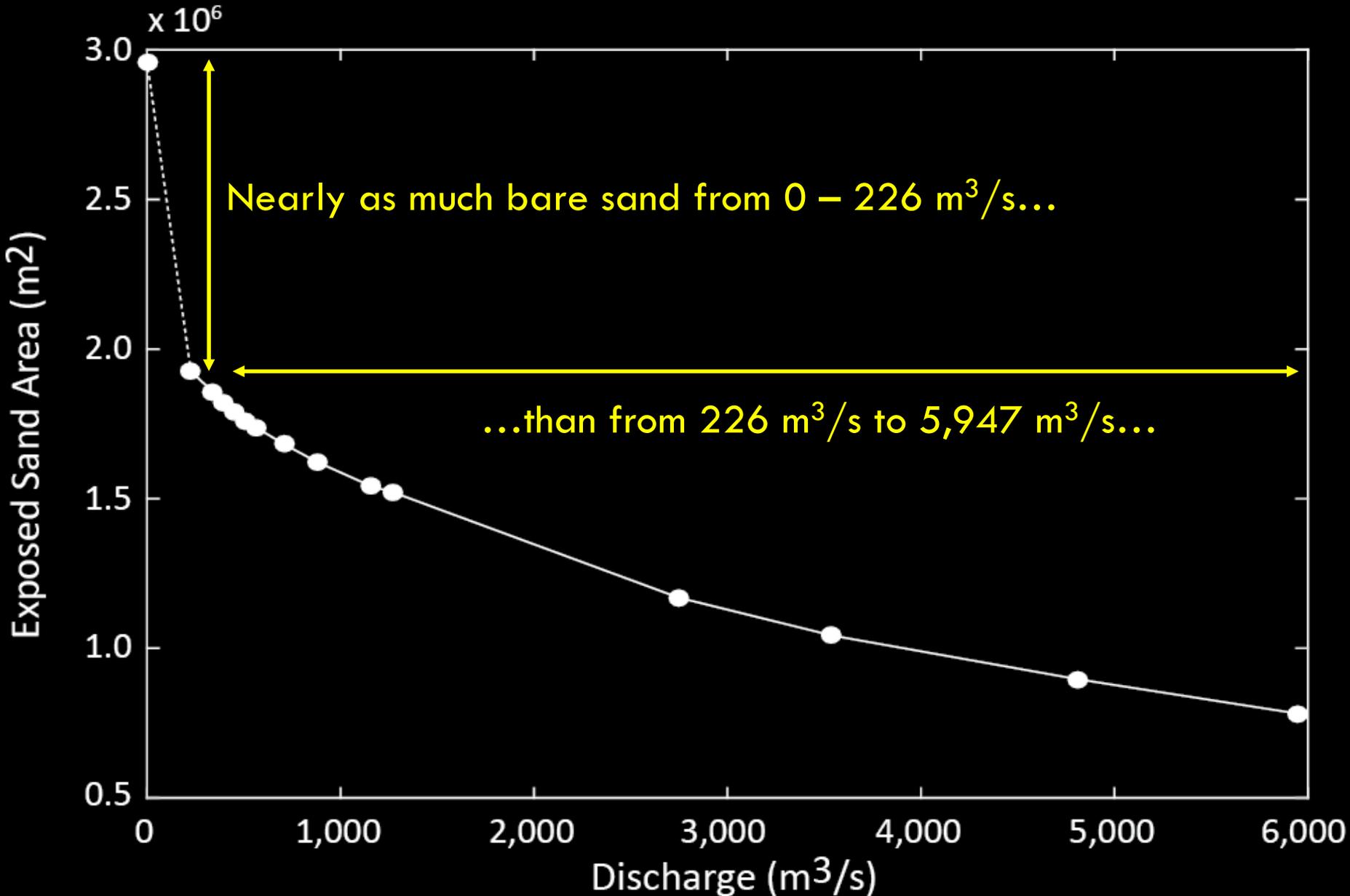
...and cut out anything  
that's underwater



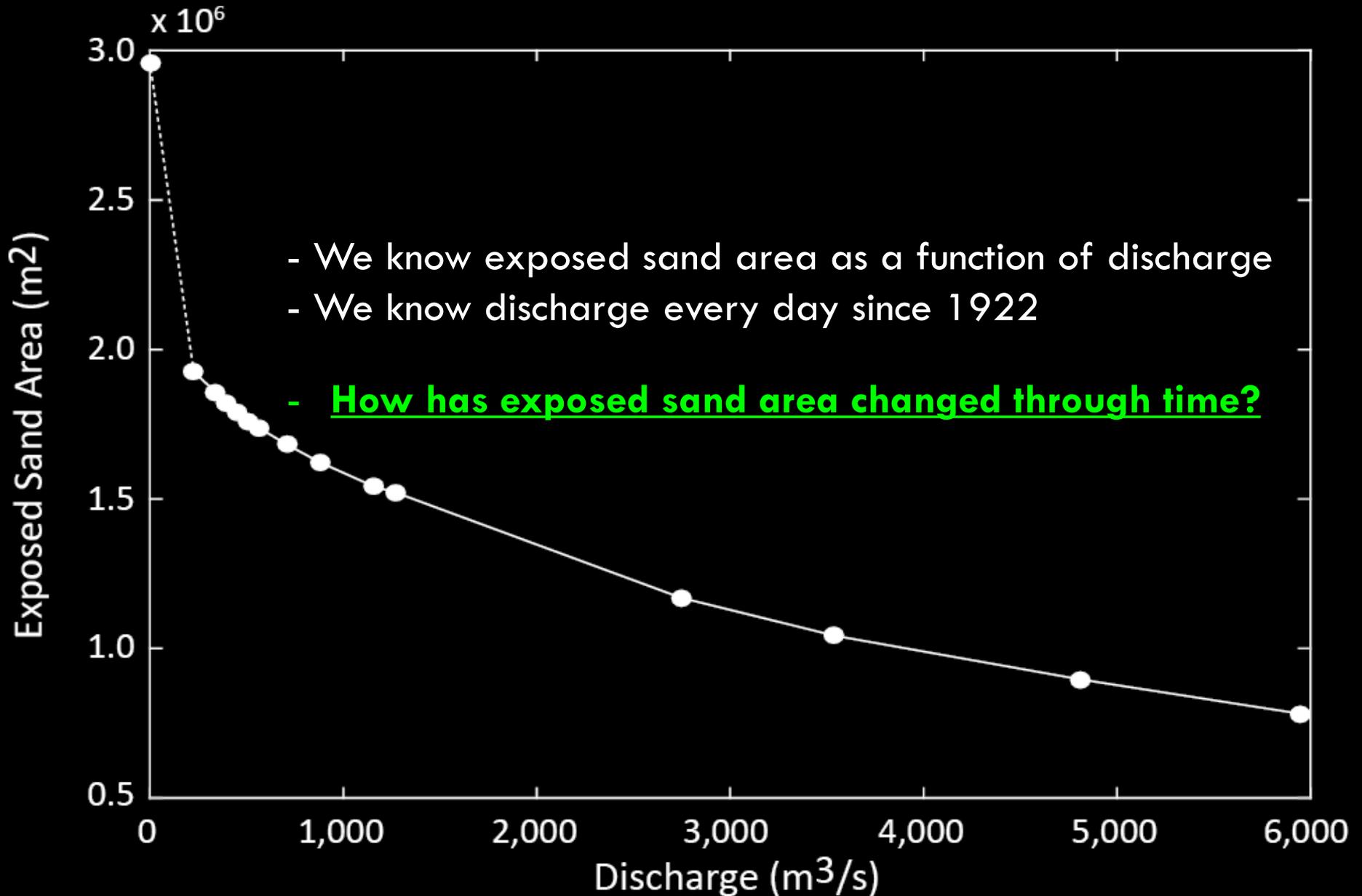
# Exposed Sand as a Function of Discharge

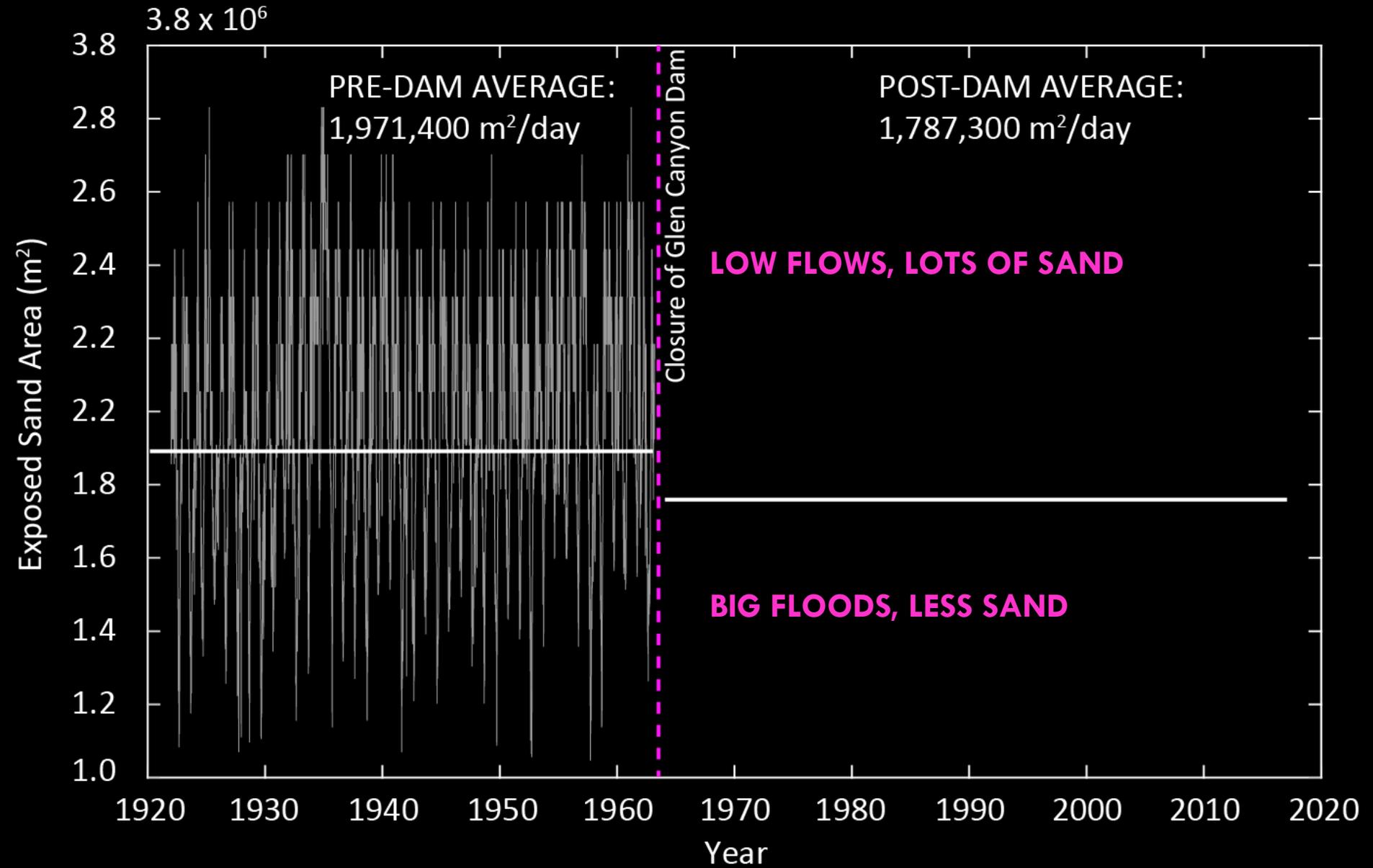


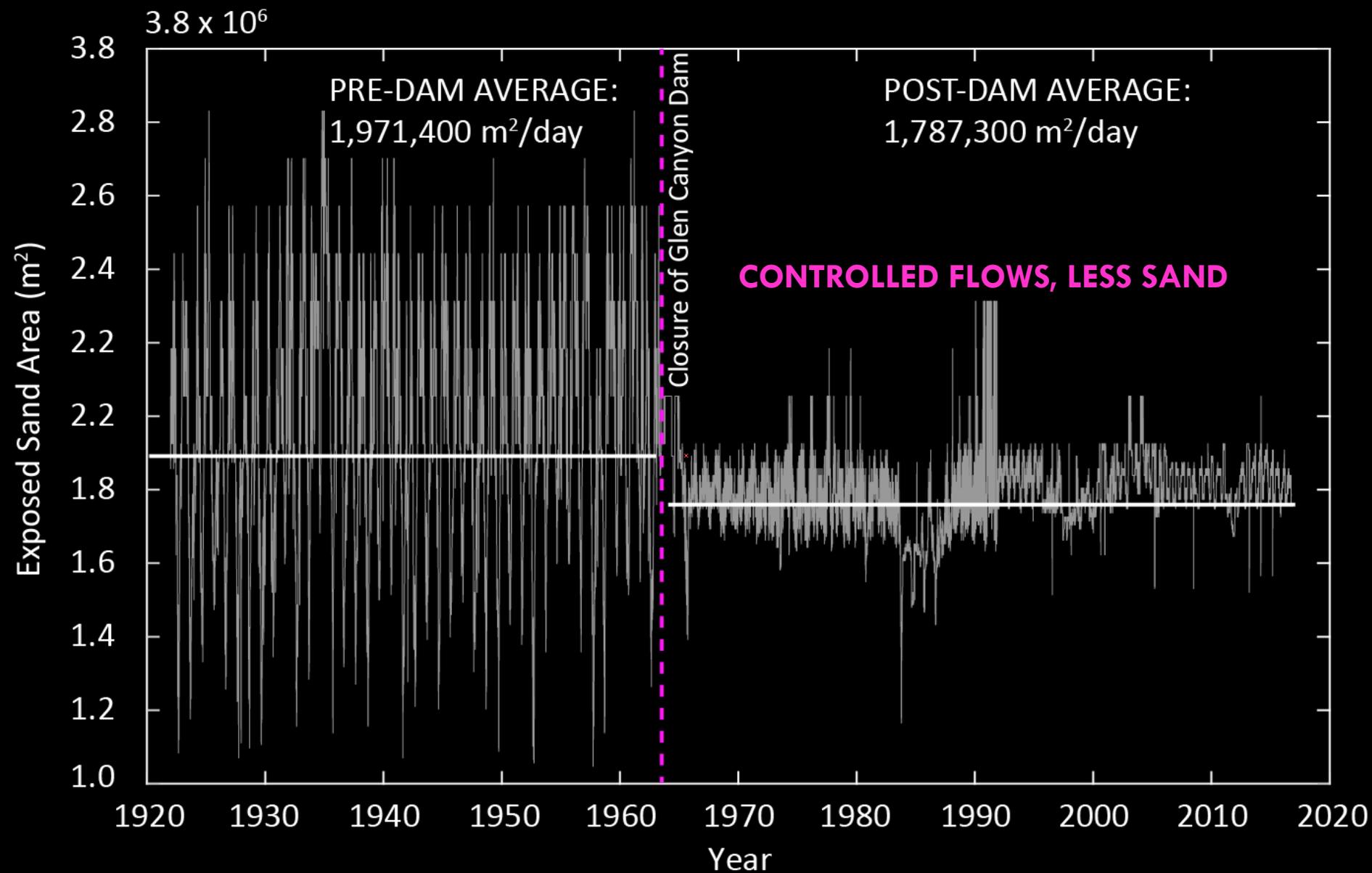
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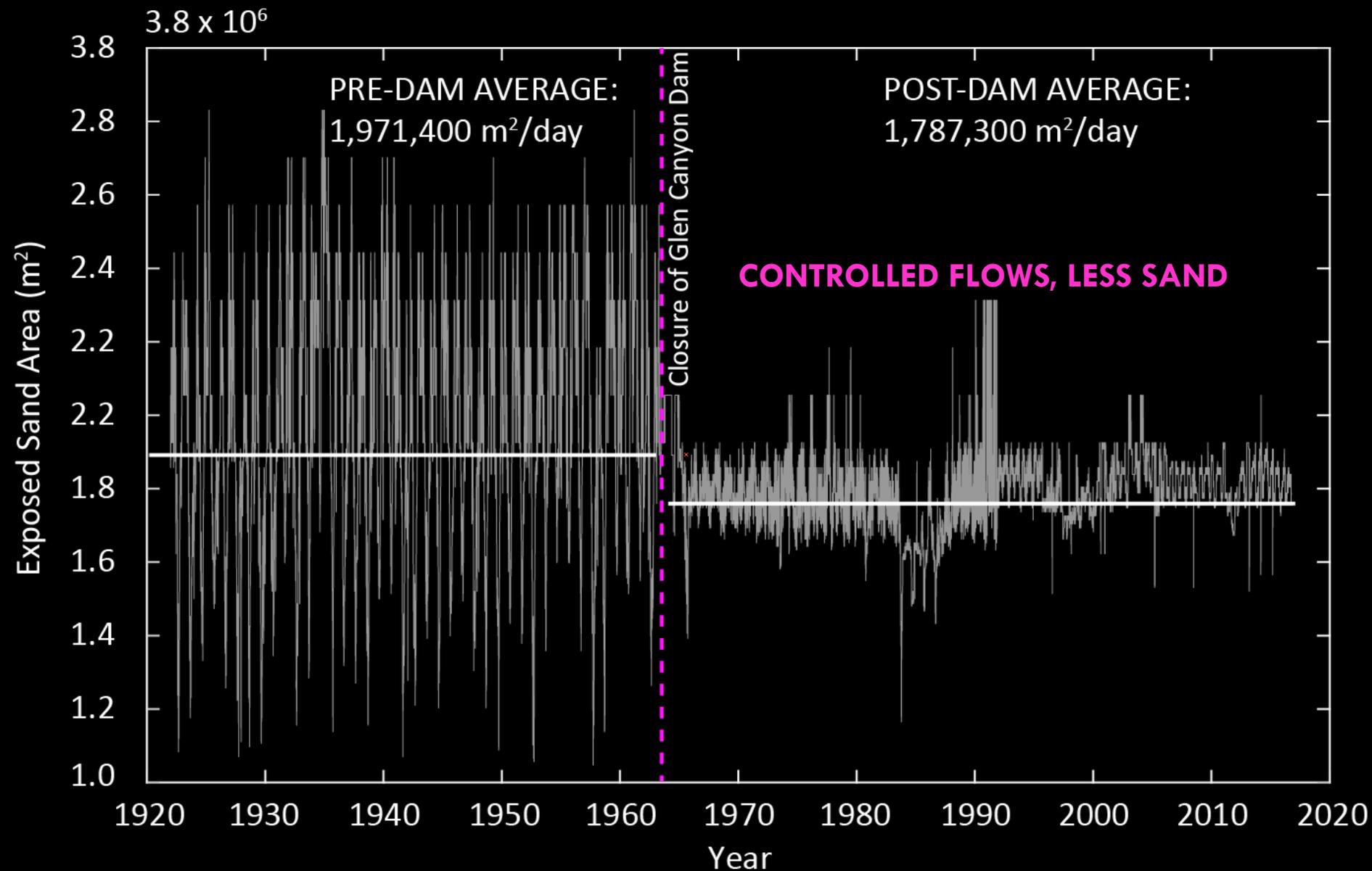


## Exposed Sand as a Function of Discharge







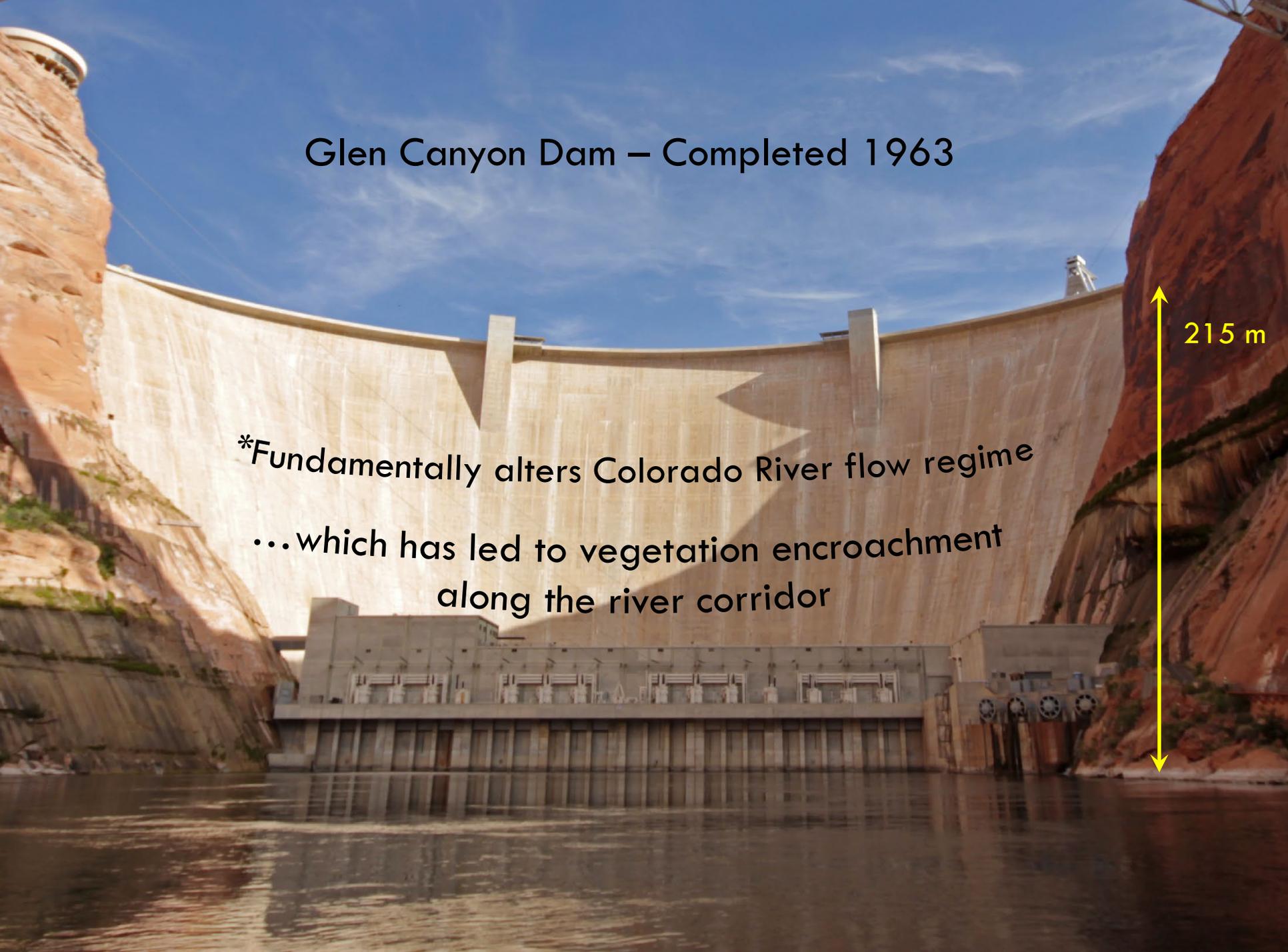


**Flow Alteration reduced exposed sand area by 9%**

# Glen Canyon Dam – Completed 1963

\*Fundamentally alters Colorado River flow regime  
...which has led to vegetation encroachment  
along the river corridor

215 m



# Observations of vegetation encroachment following dam construction



A trend toward:

- Increased vegetation area, particularly along the river
- Correspondingly reduced area of bare sand

1000 m

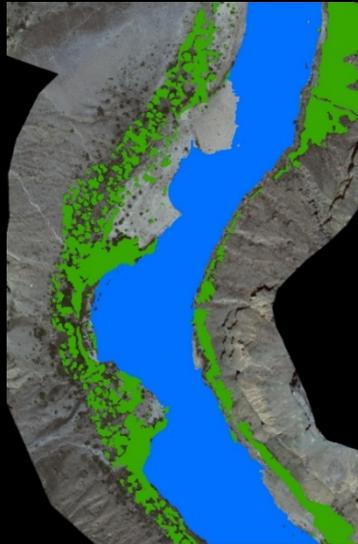


2009

1000 m



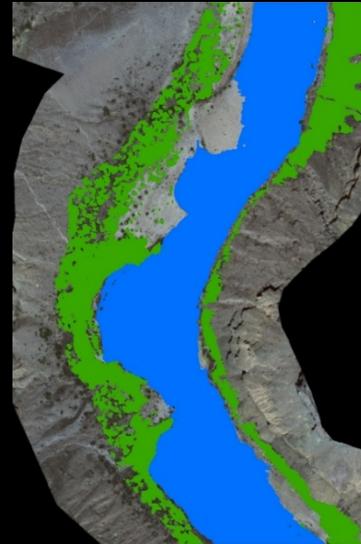
2009



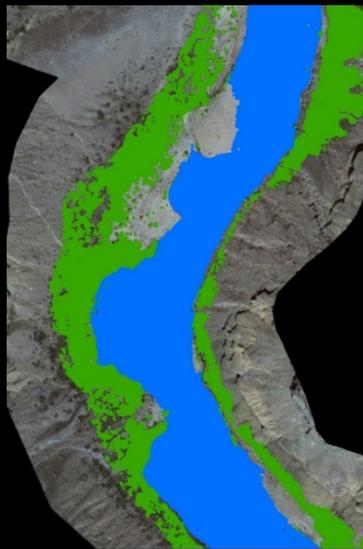
1965



+26% 1973



+18% 1984



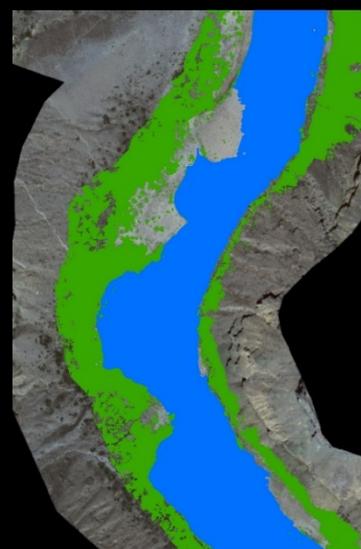
+12% 1992



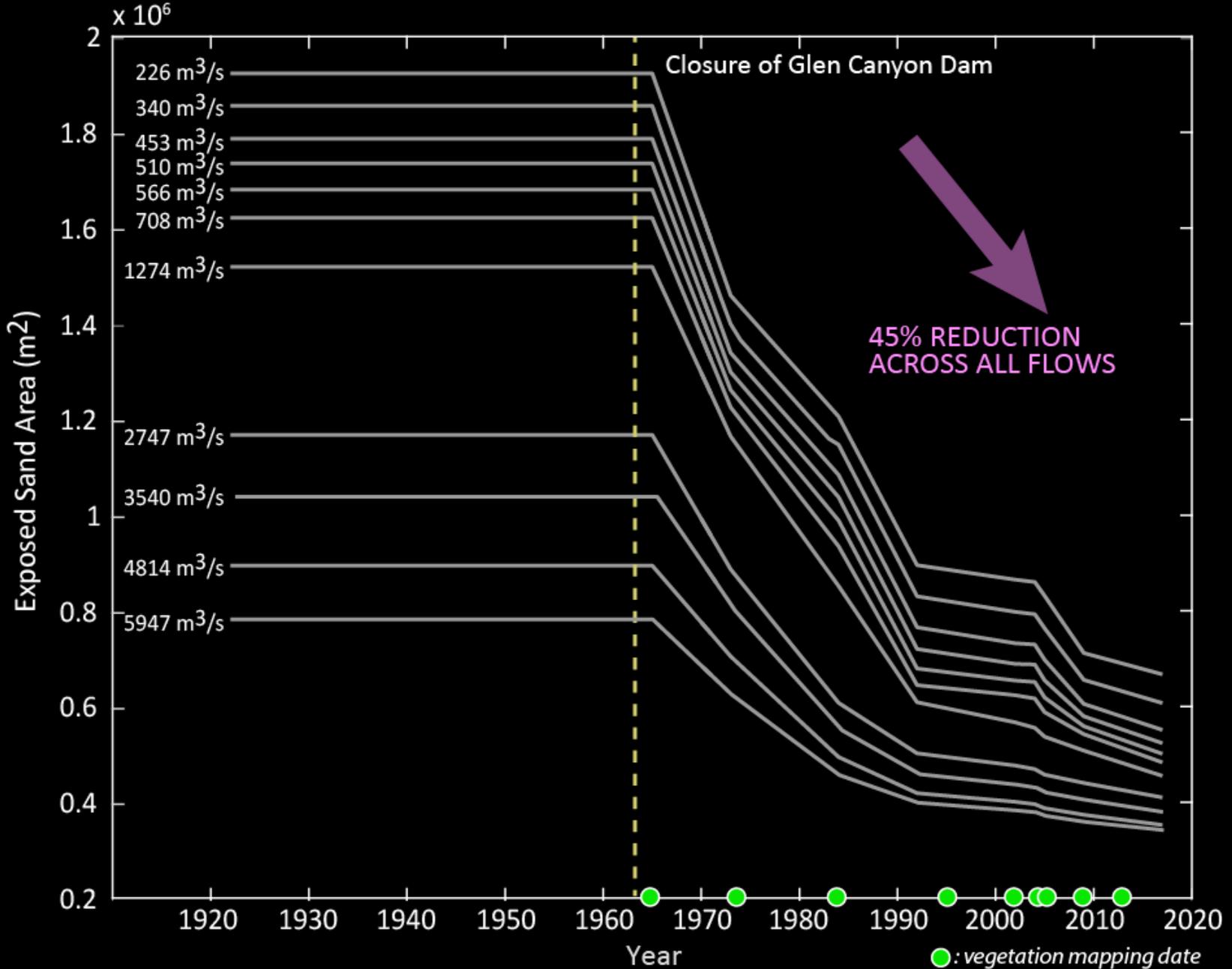
+2% 2002



+3% 2009

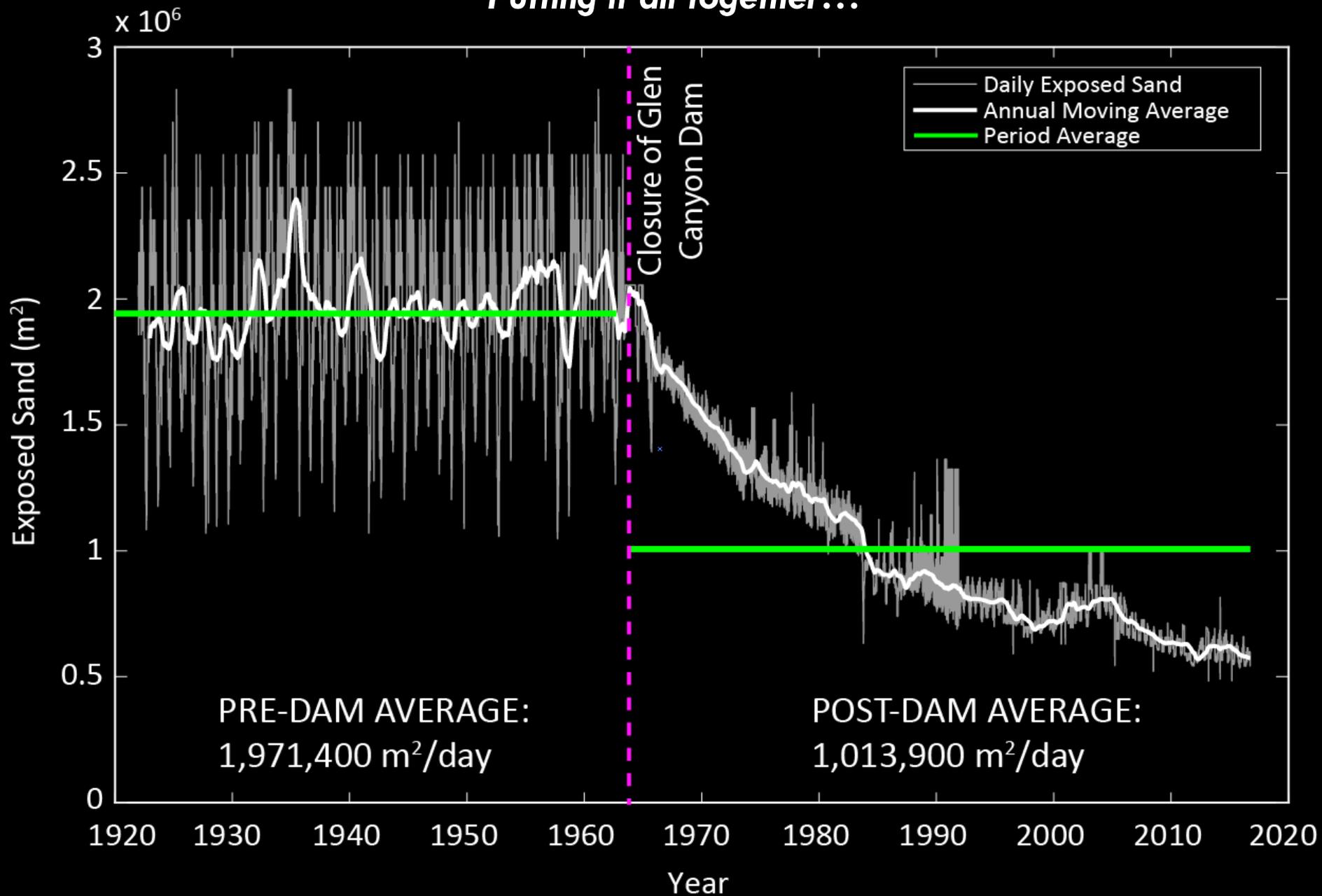


+1% 2013

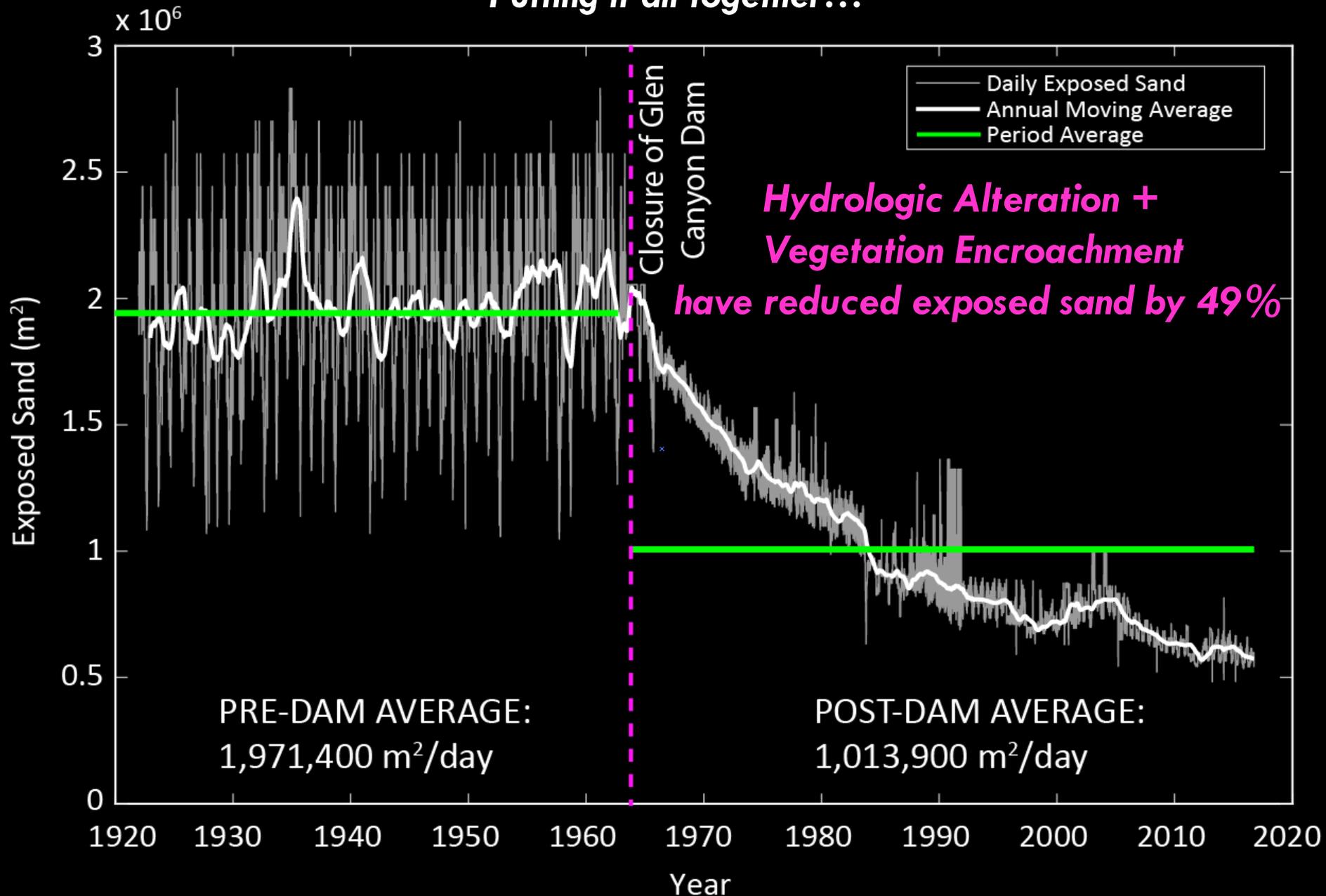


**Vegetation growth reduced exposed sand area by 45%**

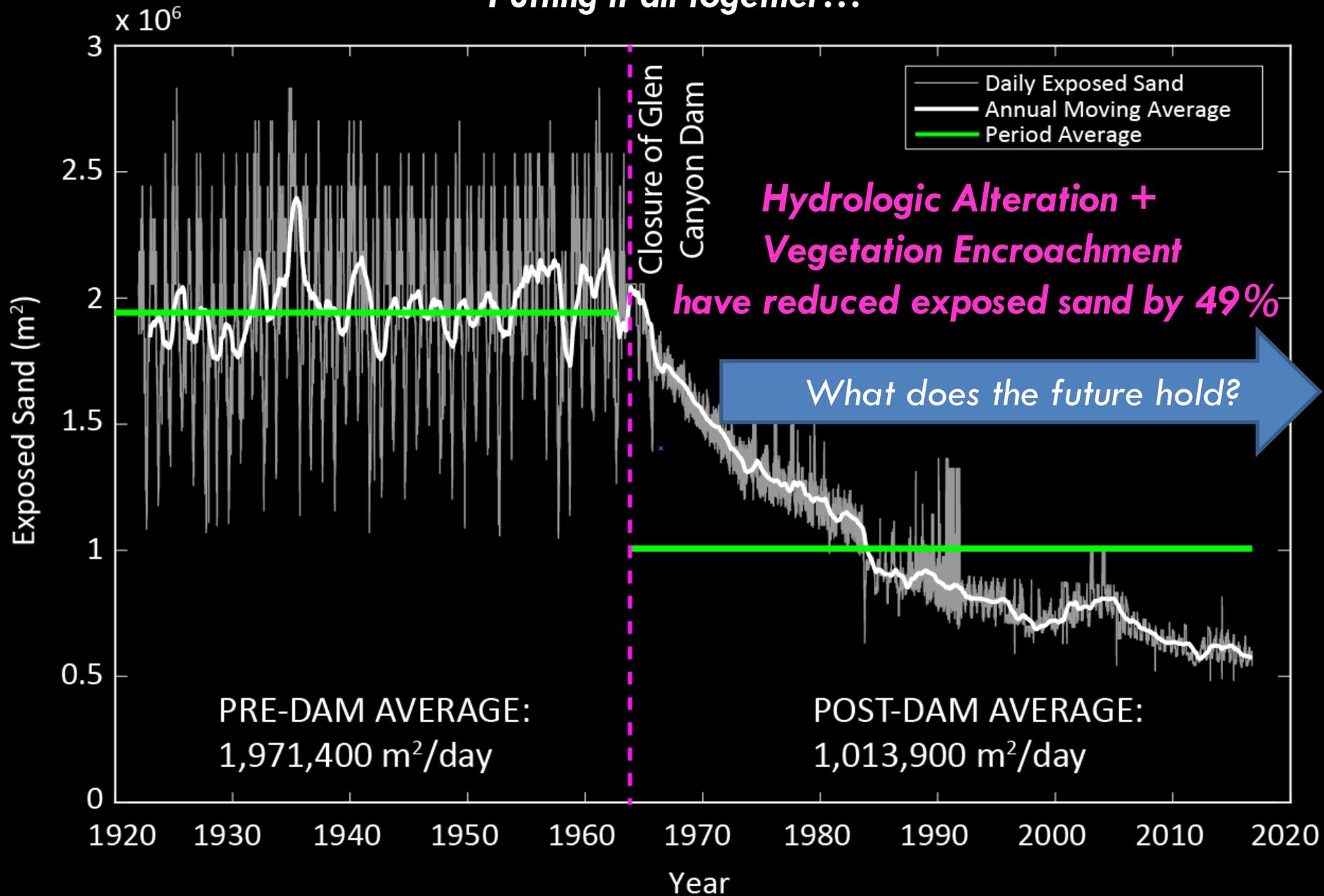
# Putting it all together...



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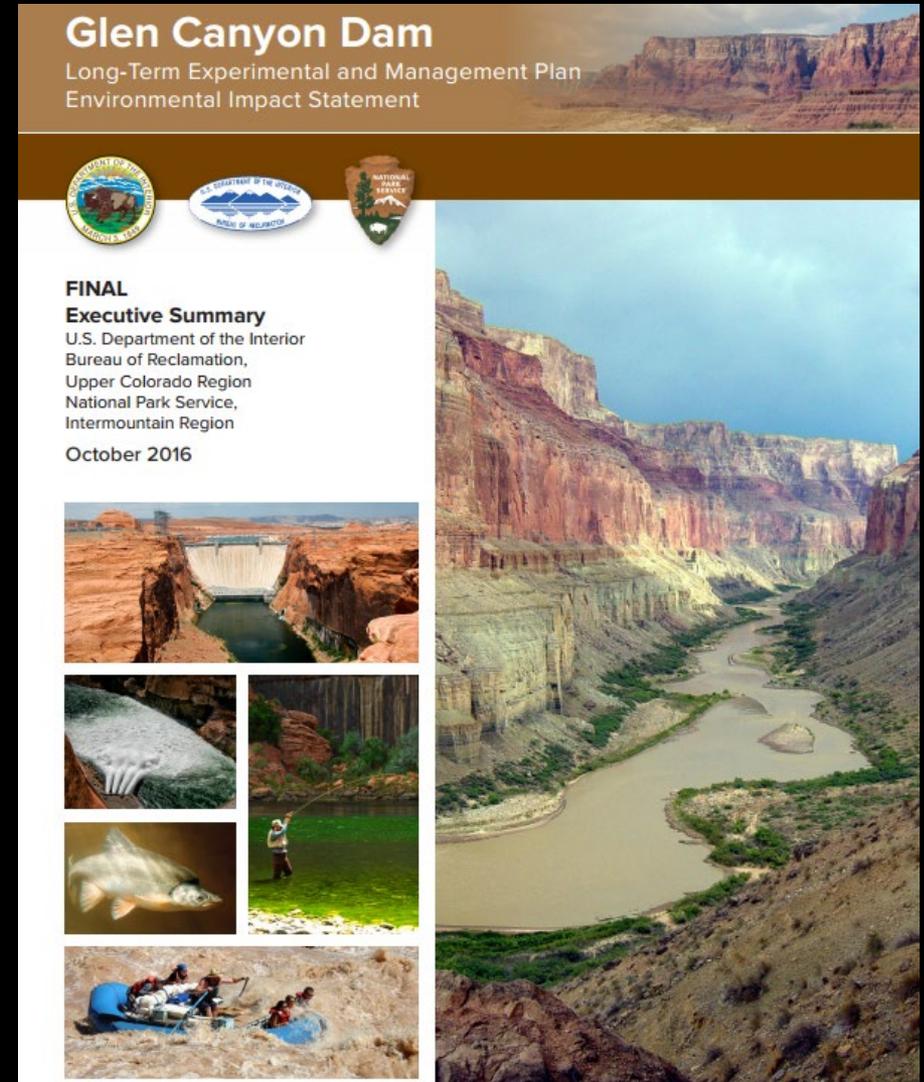
# New 20-year management plan for Glen Canyon Dam starting in 2017

## 7 alternative operation regimes analyzed for impacts on

- Fish/bug populations
- Recreation
- Sediment
- Cultural site preservation
- Hydropower generation

## “Alternative D” ultimately selected

- Allows for annual experimental floods
- Allows for low flows to conserve insect communities
- Relatively similar release pattern to current operating protocol

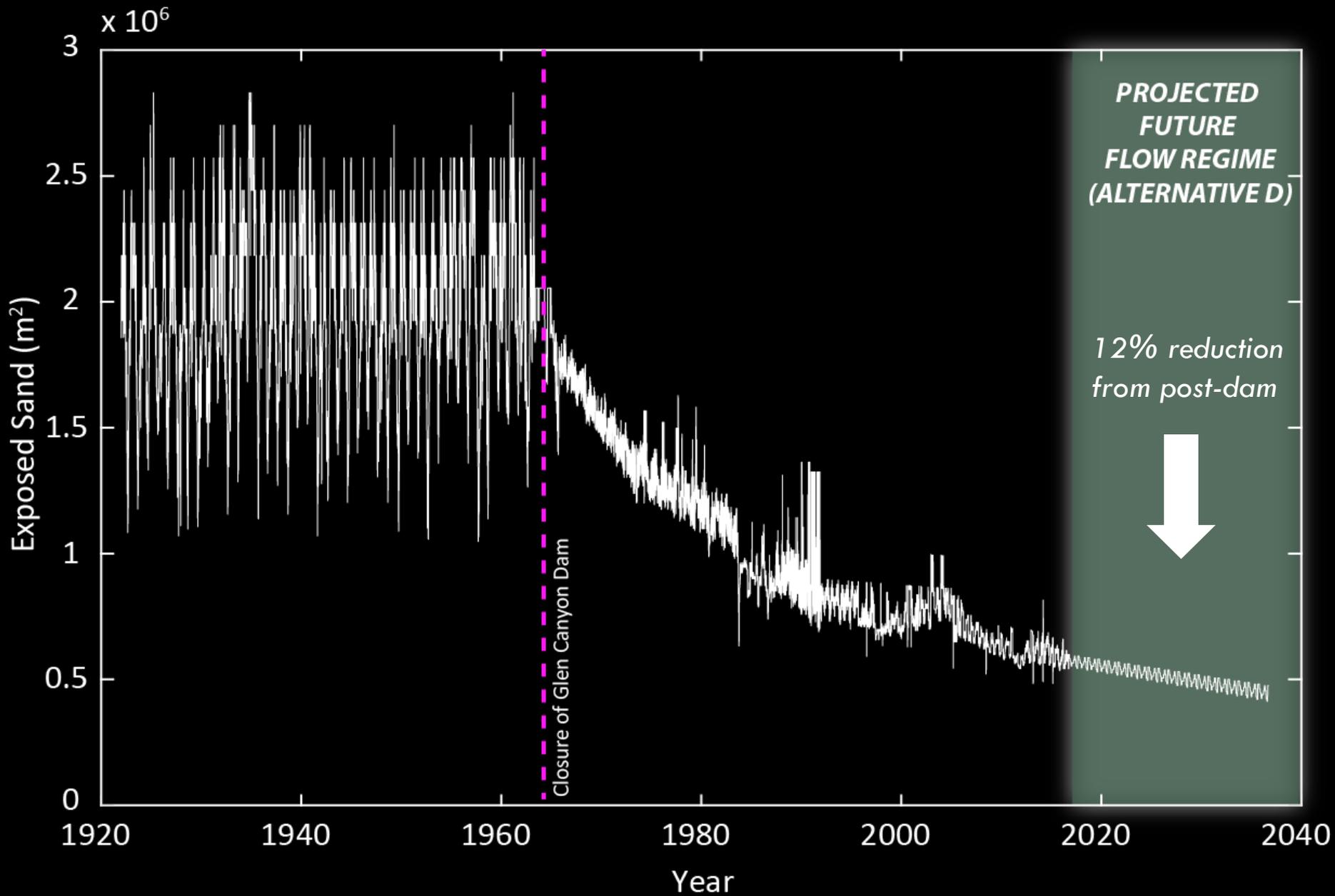


**Glen Canyon Dam**  
Long-Term Experimental and Management Plan  
Environmental Impact Statement

**FINAL**  
**Executive Summary**  
U.S. Department of the Interior  
Bureau of Reclamation,  
Upper Colorado Region  
National Park Service,  
Intermountain Region  
October 2016

The cover features a large photograph of the Colorado River winding through a deep canyon. A collage of smaller images is positioned on the left side, showing the dam structure, water flowing from a spillway, a close-up of a fish, a person fishing, and people rafting on the river.



## **Take-Home #1**

There's about half as much bare sand in this 28 km study reach now as there was before Glen Canyon Dam was built

- Flow alteration: 9% reduction
- Vegetation encroachment: 45% reduction



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## Take-Home #2

Low flows are disproportionately important in exposing sand

- About as much bare sand from 0 – 226 m<sup>3</sup>/s as there is from 226 m<sup>3</sup>/s – 5,947 m<sup>3</sup>/s



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## Take-Home #3

In the future, bare sand area will continue to shrink

- By 2037, a further 12% reduction in bare sand area compared to 2017



**Funding from** *Glen Canyon Dam Adaptive Management Program and National Center for Earth Surface Dynamics 2*

**Thanks to** *Kirk Burnett, Laura Durning, Geoff Chain, Helen Fairley, Dennis Harris, Joe Hazel, Matt Kaplinski, Rob Ross, Bob Tusso*

