Reservoir Sediment Management & Analysis for Engineers

Reservoir Sedimentation Problems

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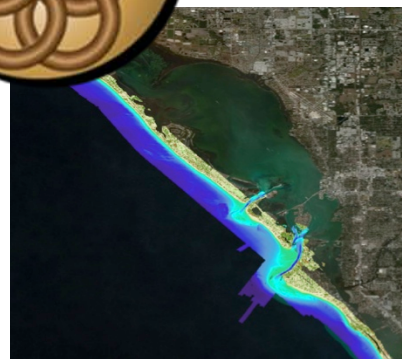
University of Kansas
LEEP2 Building – Room G415
June 11-15, 2018



ERDC
Engineer Research and Development Center

Introduction

https://www.youtube.com/watch?v=HQ-Y8ClEpgw&feature=youtu.be

Outline

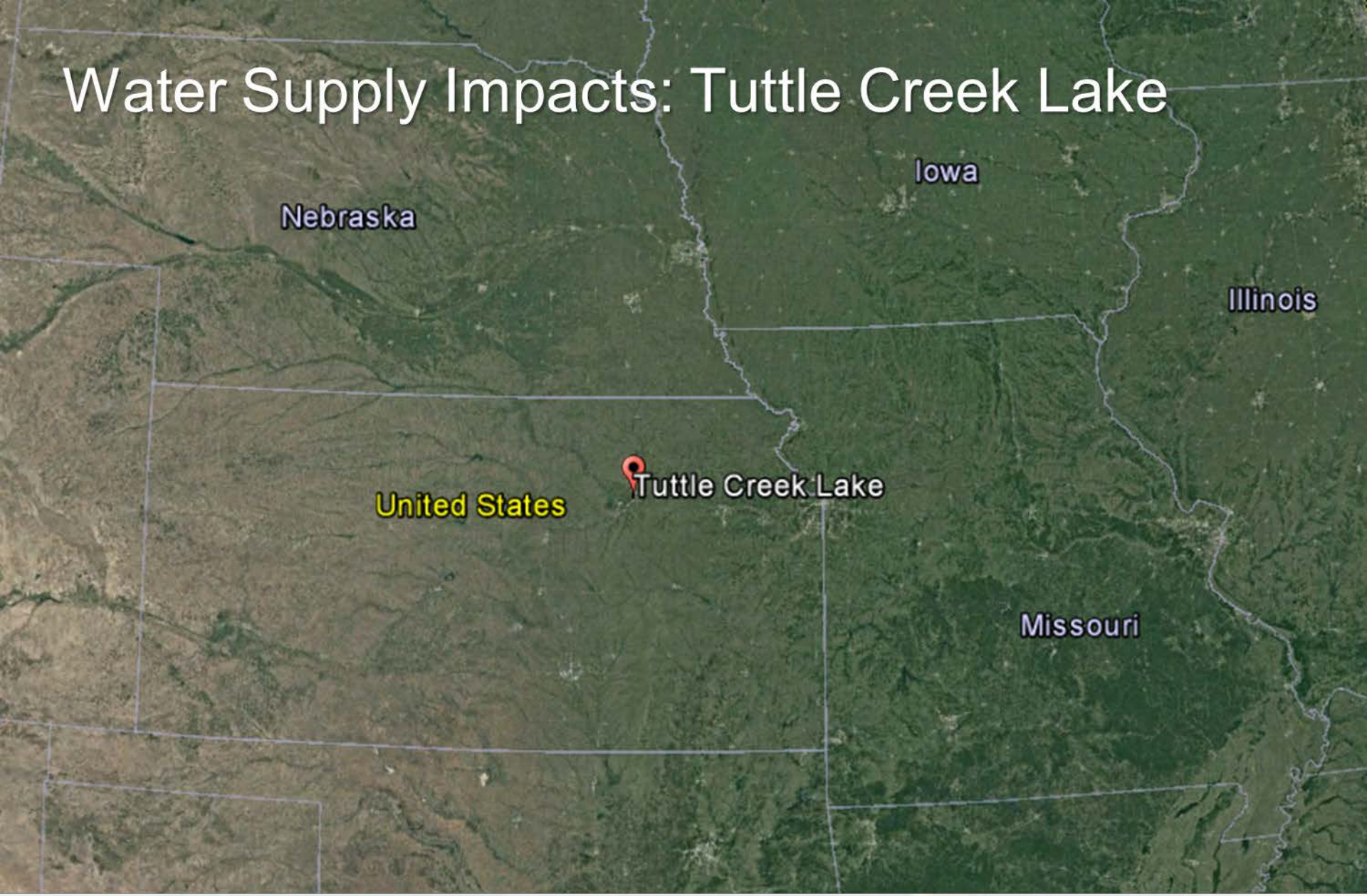
- Effect on authorized purposes
- Urgency

Water Supply

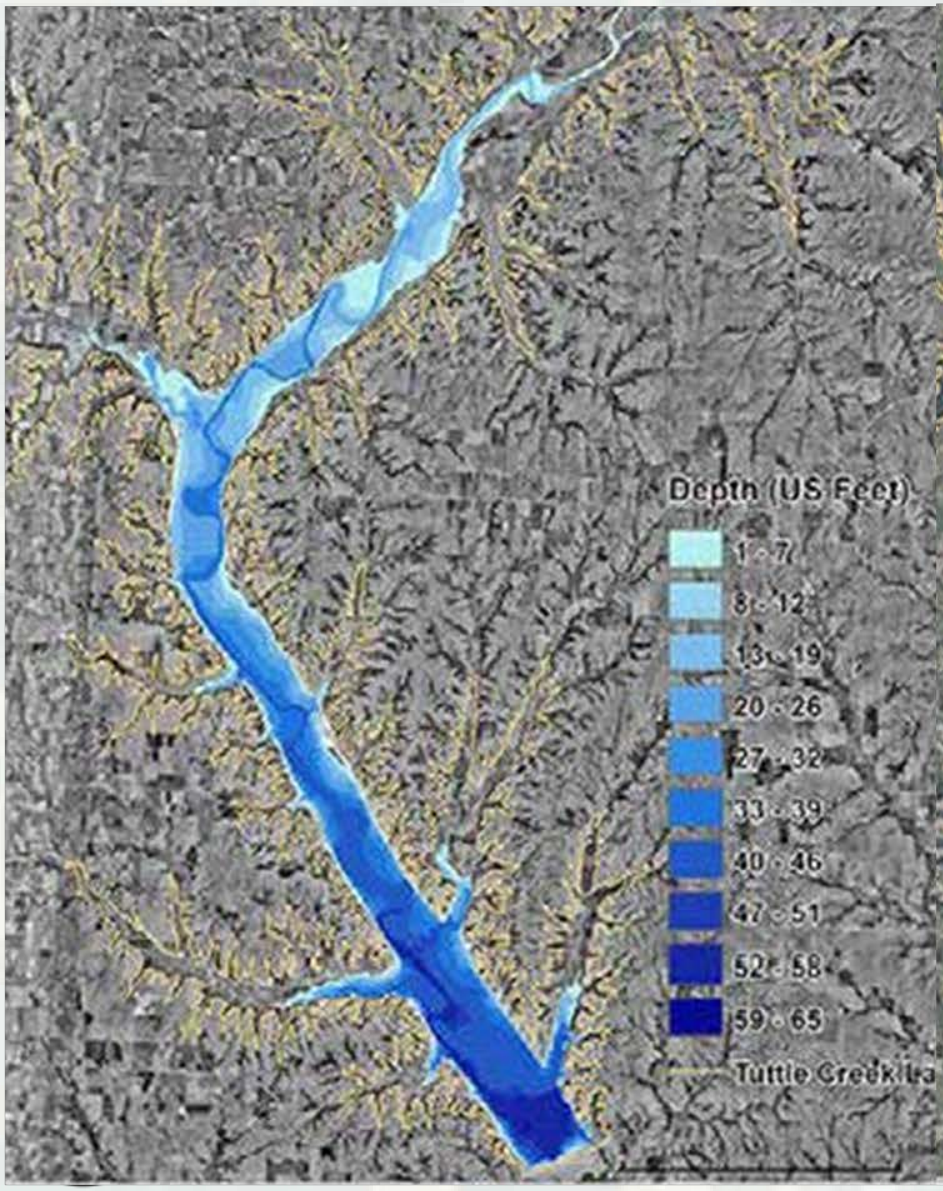
If you fill your cup with mud, there's less room for the water.

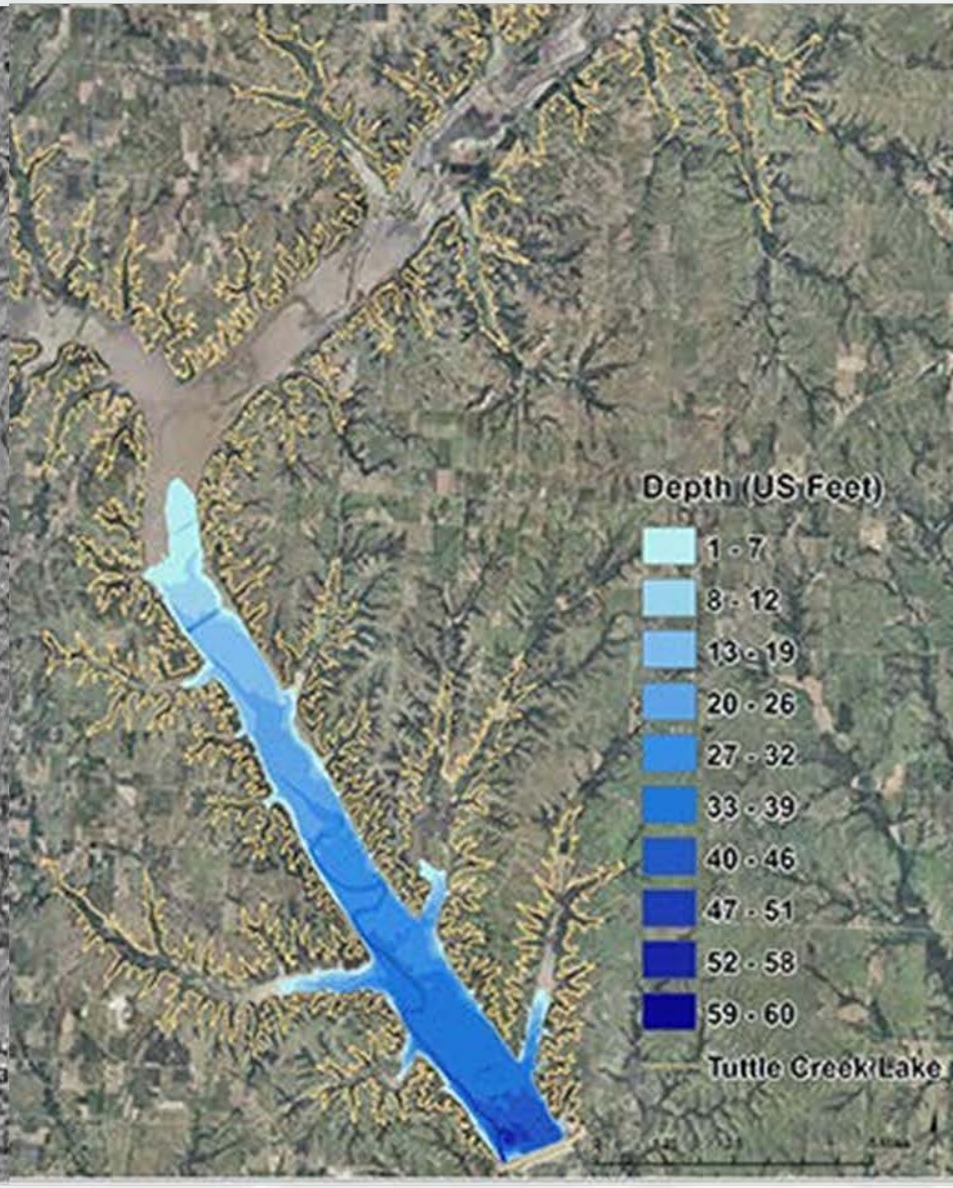
You can't drink mud.

Water Supply Impacts: Tuttle Creek Lake

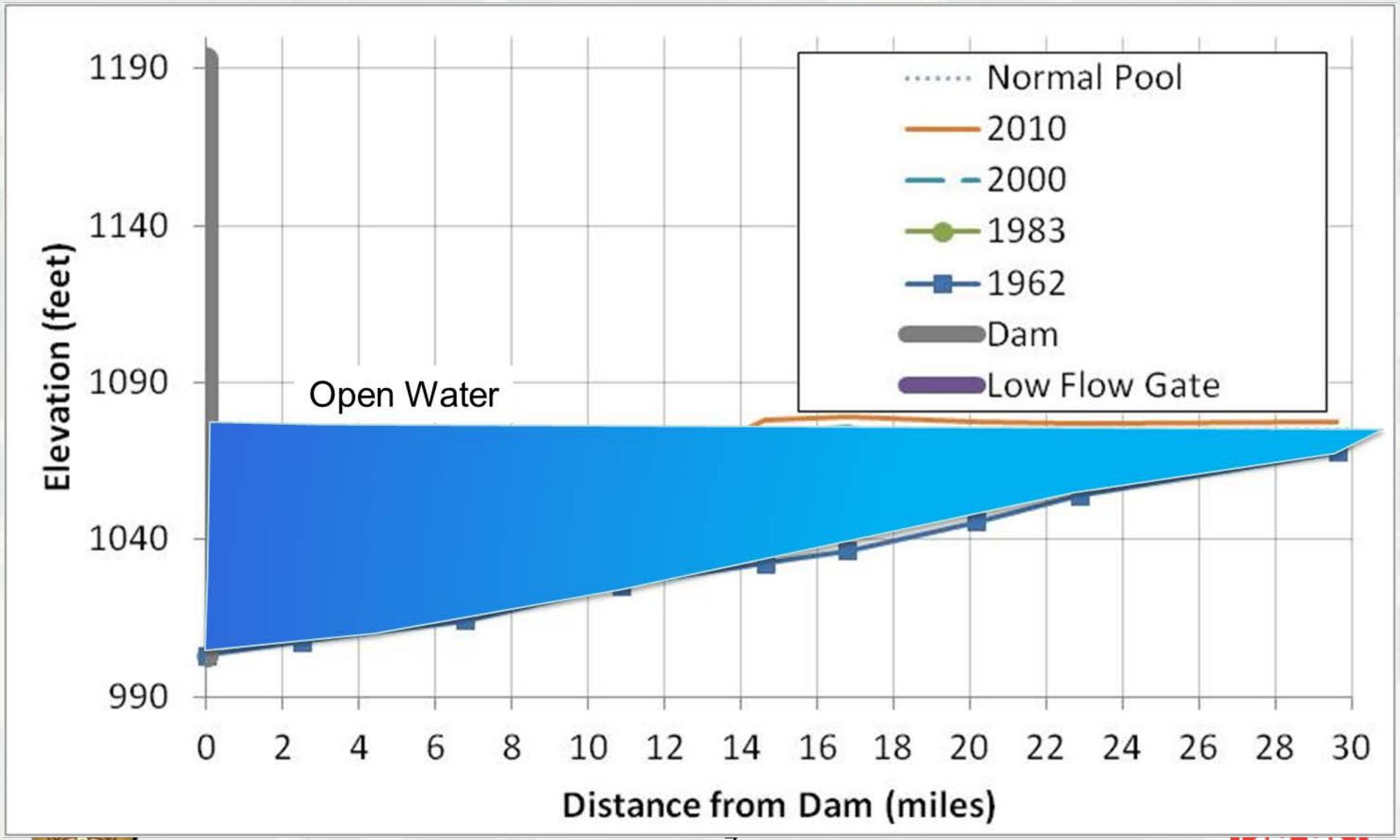


Tuttle Creek Lake: 1957 to 2010

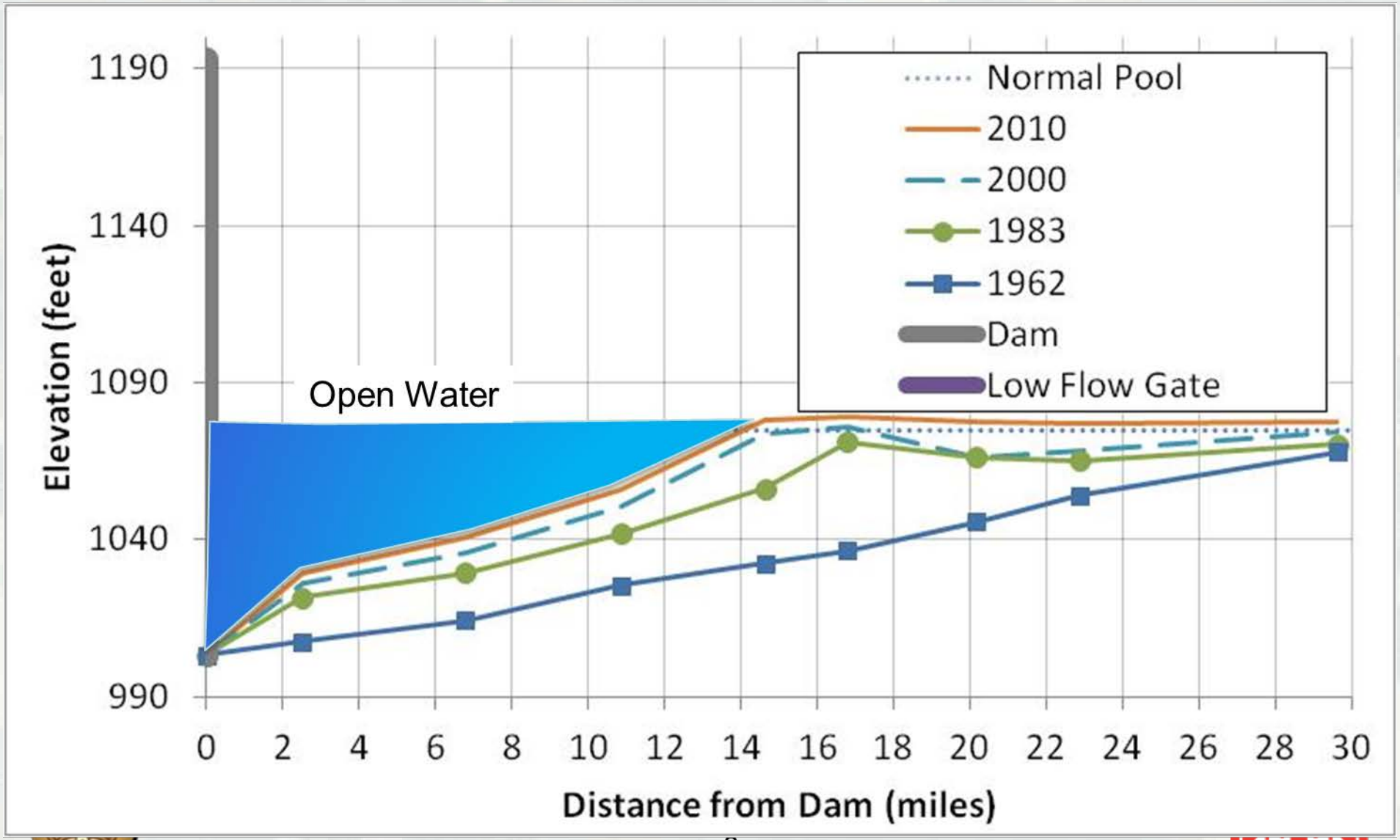




Tuttle Creek Lake



Tuttle Creek Lake



Annual Storage Volume Lost

Sedimentation rate in multi-purpose pool (1962 to 2009):

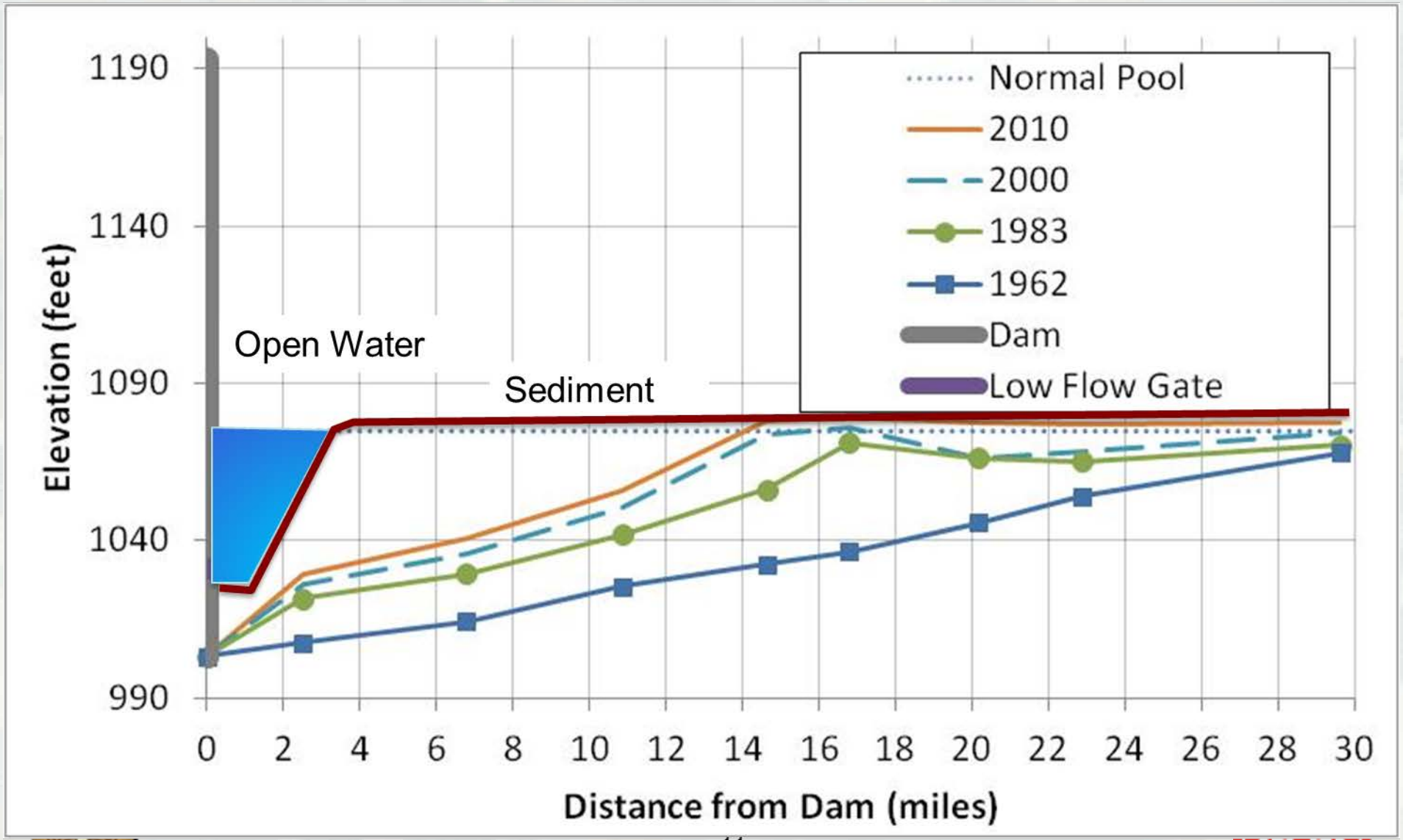
3,500 ac-ft/yr

5.6 million yd^3 / year

Tuttle Creek Lake: At the same annual rate of sedimentation

- Multi-purpose pool will be 88% full in 50 years
- Total storage (multi-purpose + flood control) will be 21% full

Tuttle Creek Lake: 50 years

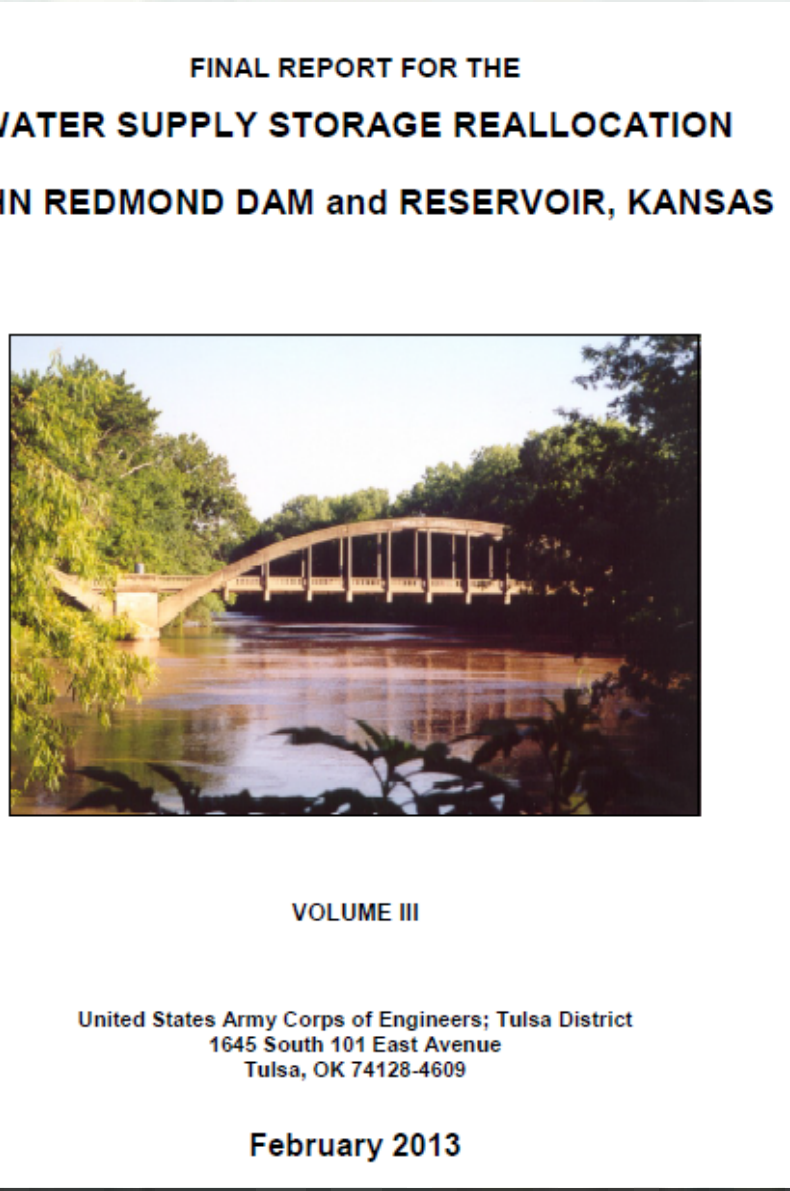


Flood Control

- Downstream impacts
  - Sediment displaces storage in the flood control pool
  - Sediment accumulation in the multi-purpose pool can lead to the need for pool reallocations
- Upstream impacts
  - Backwater → Delta → Water surface rise upstream of flood control pool

Flood Control Impact: John Redmond Reservoir Pool Raise

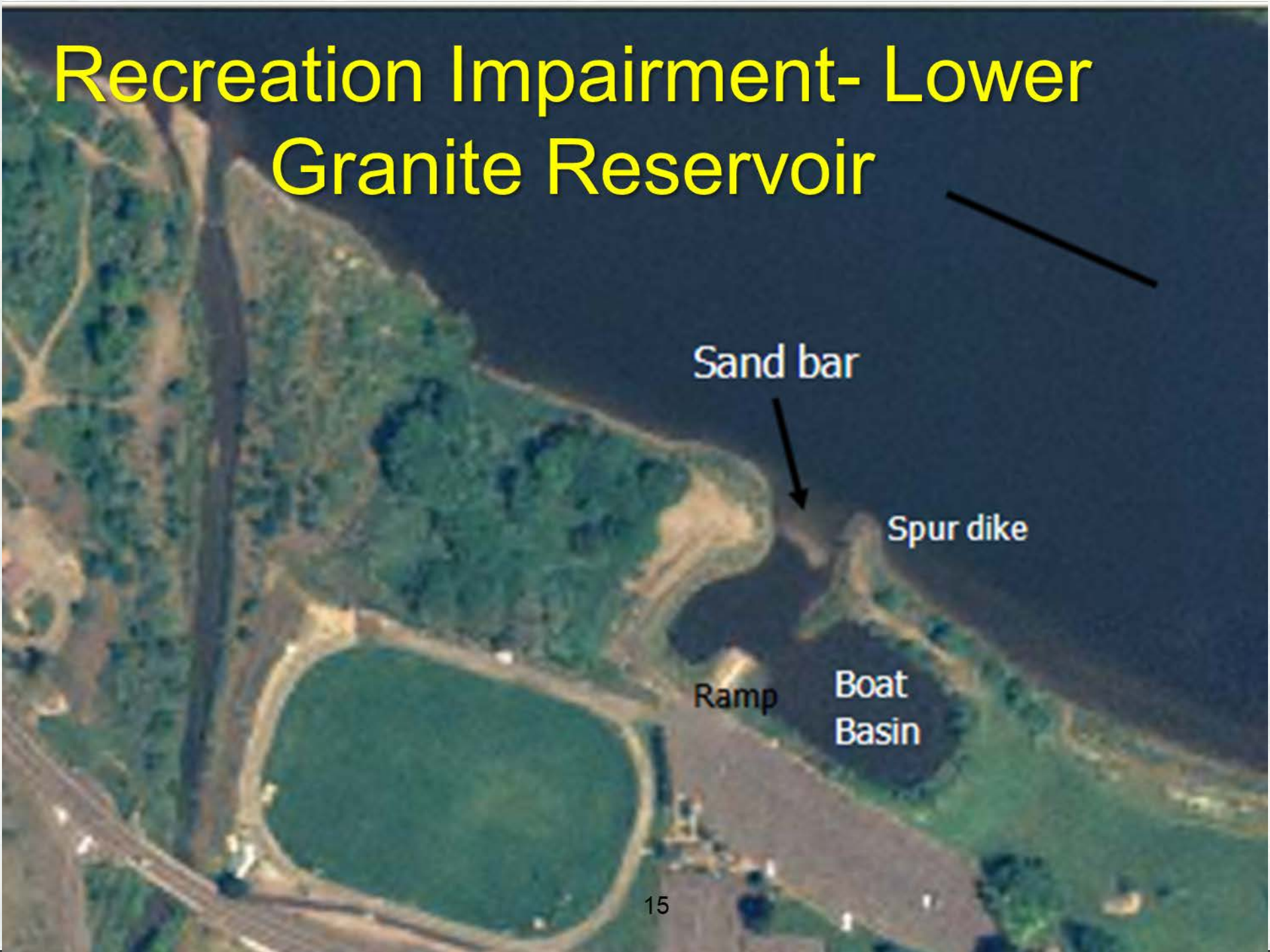
- 2 ft pool raise in 2013
- Reallocation **from flood control** to water supply
- Deemed in the public's best interest



Upstream Aggradation Impacts

Increased surface and groundwater stage
Reduction in channel capacity & increased flooding

Recreation Impairment- Lower Granite Reservoir

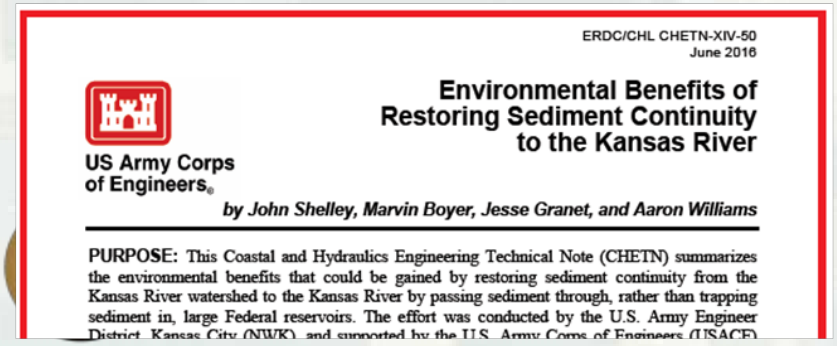


Environmental Impacts: Kansas River

Pre-dam Sediment Load: 44 million tons per year

Post-dam Sediment Load:13 million tons per year

A 70% reduction in sediment transport



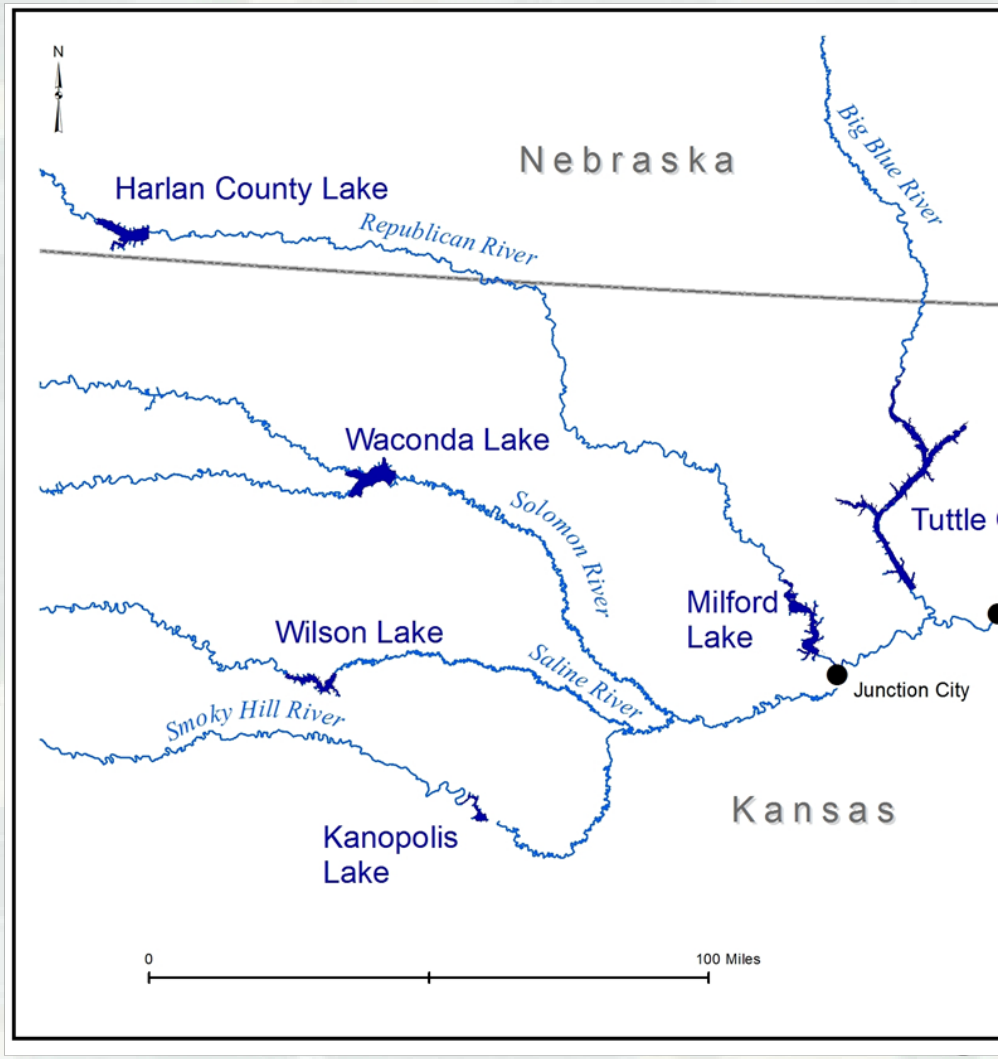
ERDC/CHL CHETN-XIV-50
June 2016

US Army Corps of Engineers

Environmental Benefits of Restoring Sediment Continuity to the Kansas River

by John Shelley, Marvin Boyer, Jesse Granet, and Aaron Williams

PURPOSE: This Coastal and Hydraulics Engineering Technical Note (CHETN) summarizes the environmental benefits that could be gained by restoring sediment continuity from the Kansas River watershed to the Kansas River by passing sediment through, rather than trapping sediment in, large Federal reservoirs. The effort was conducted by the U.S. Army Engineer District, Kansas City (NWK), and supported by the U.S. Army Corps of Engineers (USACE)

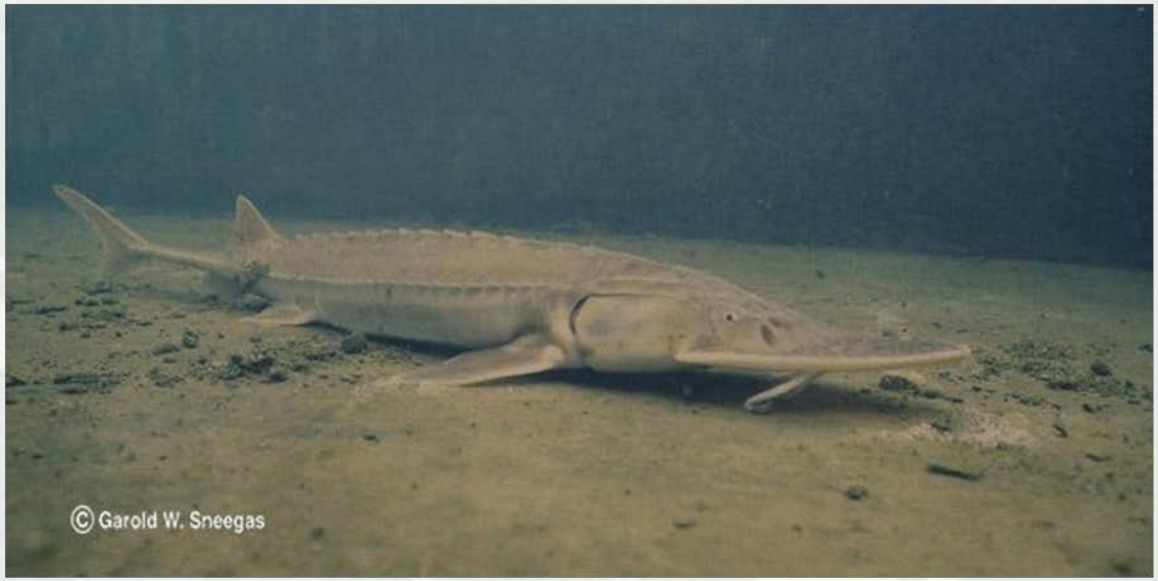


- Turbid-water Fish
  - Smaller eyes
  - Smaller optic lobes of brain
  - Electro-sensory and chemo-sensory organs
  - Non-sight feeding
  - Thrive in naturally high-turbidity environments

- Clear-water Fish
  - Larger eyes
  - Larger optic lobes of brain
  - Site-feed
  - Out-compete native Kansas River fish in the current, unnaturally clear Kansas River environment

Shovelnose Sturgeon

- Once abundant in the Kansas River, no longer present in much of Kansas



Identified in *Current status of native fish species in Kansas*, Transactions of the Kansas Academy of Science, Vol 108, 2005.

Imperiled Due to Increased Water Clarity and Predation and Competition from Sight-Feeding Fish

- Formerly found in the lower Kansas River. Not found for 20 years. Considered “extirpated, or nearly so, in Kansas.”

- Significantly reduced in abundance

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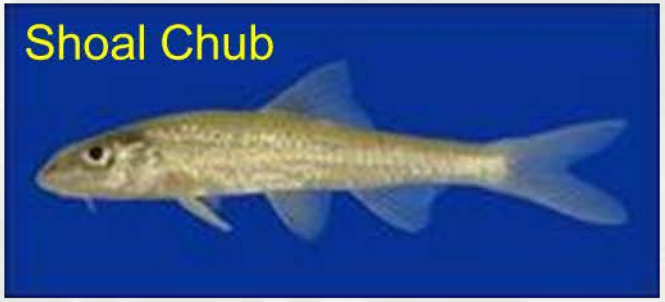
Imperiled Due to Increased Water Clarity and Predation and Competition from Sight-Feeding Fish



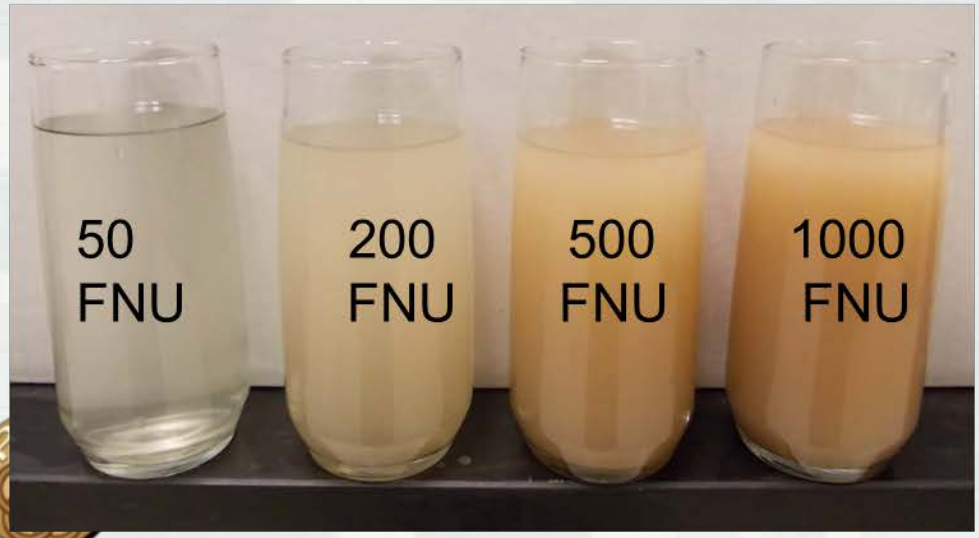
Significantly reduced
in range or abundance

Other impacted species showing significant decline or complete extirpation: Silver Chub, Flathead Chub, River Shiner, Carmine Shiner, Sturgeon Chub

Impacts from Lack of Turbidity: Colorado River

David Ward and Rylan Morton Starner, USGS, Grand Canyon Monitoring and Research Station

- Humpback Chub numbers have decreased substantially and they are now federally protected
- One primary reason is that the Colorado River used to be usually over 1000 FNU, but after construction of Glen Canyon Dam now is usually below 50 FNU. The small chub become easy prey for trout species in clear water.



Brown trout
mean TL = 261 mm

Humpback chub
mean TL = 56 mm

Impact on Hydropower

At a 1000 MW power station, Pelton needle valves under 800 meters of head. (A) 10,000 hours normal operations. (B) less than 24 hours passing sand. (Source: Morris, 2016)

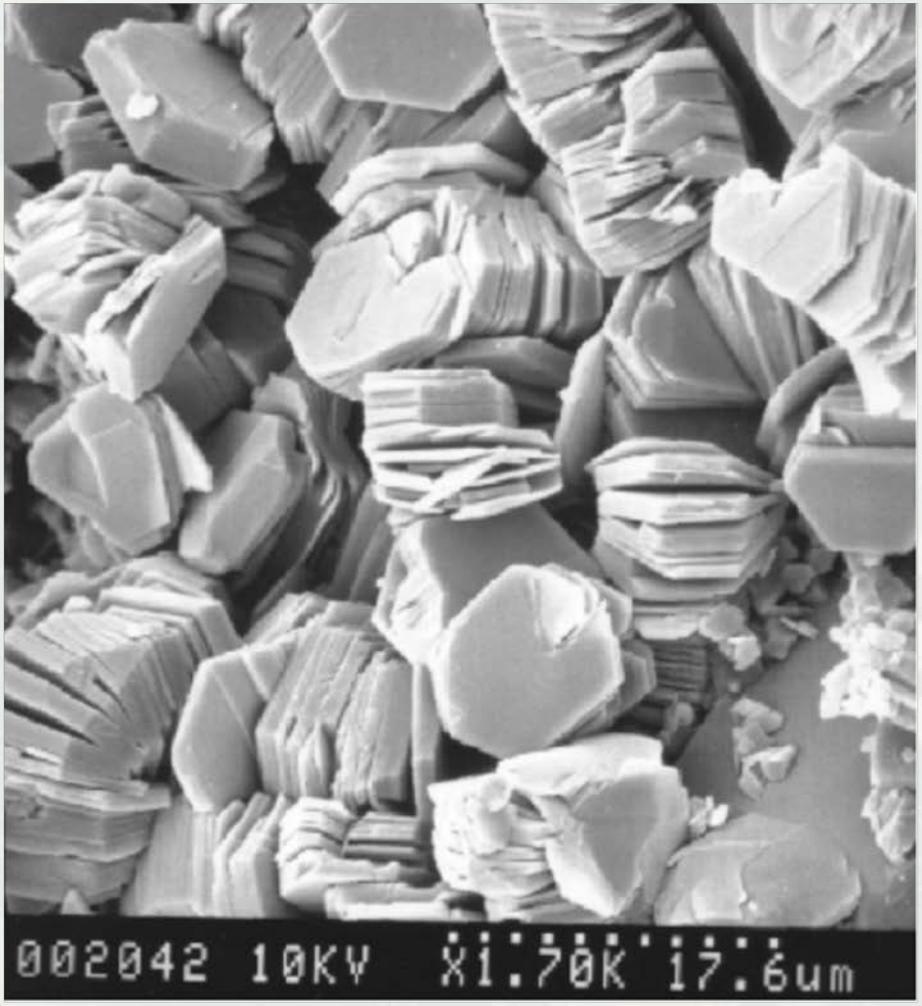
Sedimentation and Dam Safety

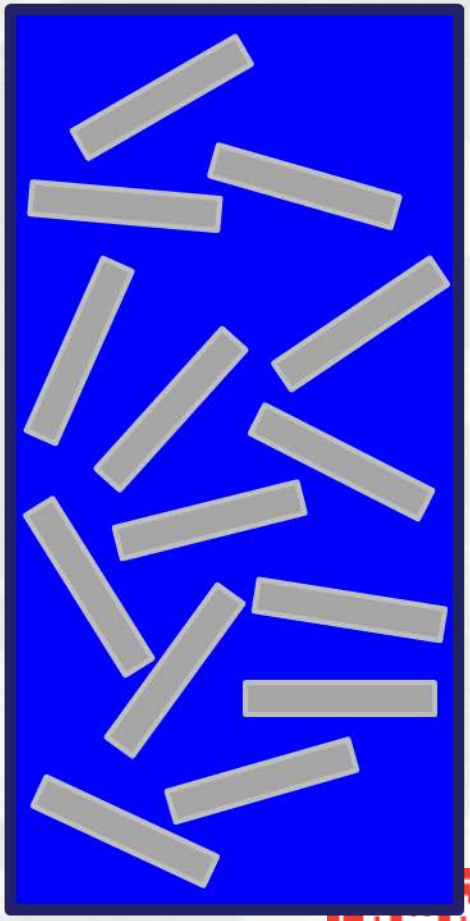
- Increased sediment within or immediately upstream of an intake tower may
  - Change flow patterns, vibrations within the tower, and potential areas of cavitation.
  - Cause blockages and inability to operate gates resulting in reduced or zero releases.
  - Prevent emergency bulkheads from lowering the pool during a dam emergency
  - Inability to pass inflows through intake tower could result in higher record pools (untested embankment) or spillway releases resulting in additional risk to populations downstream of dam.

Operations

Reservoir sediment management is important…
…but is it urgent?

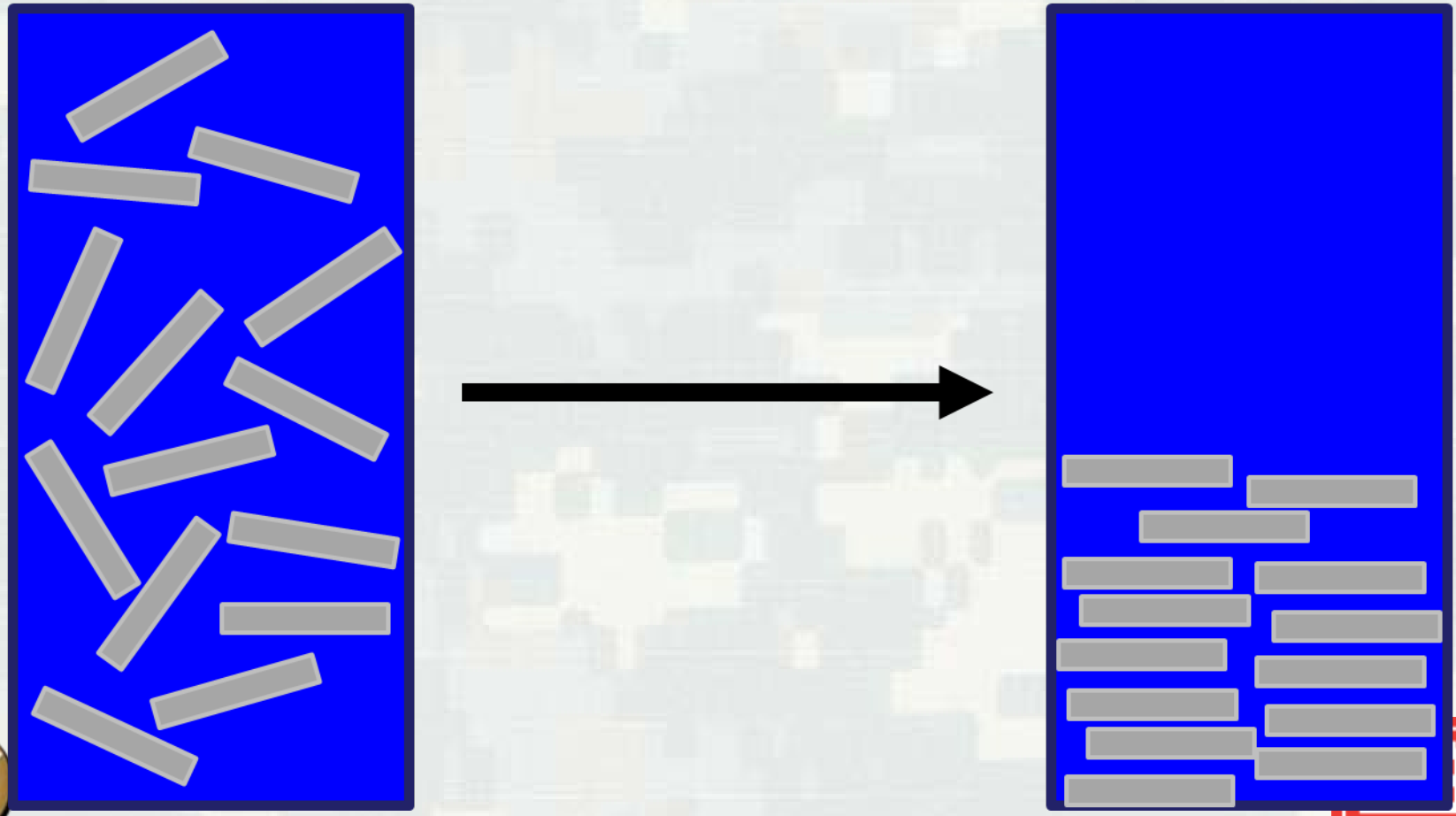
Clay Consolidation





From https://www.azonano.com/article.aspx?ArticleID=3080

Clay Consolidation



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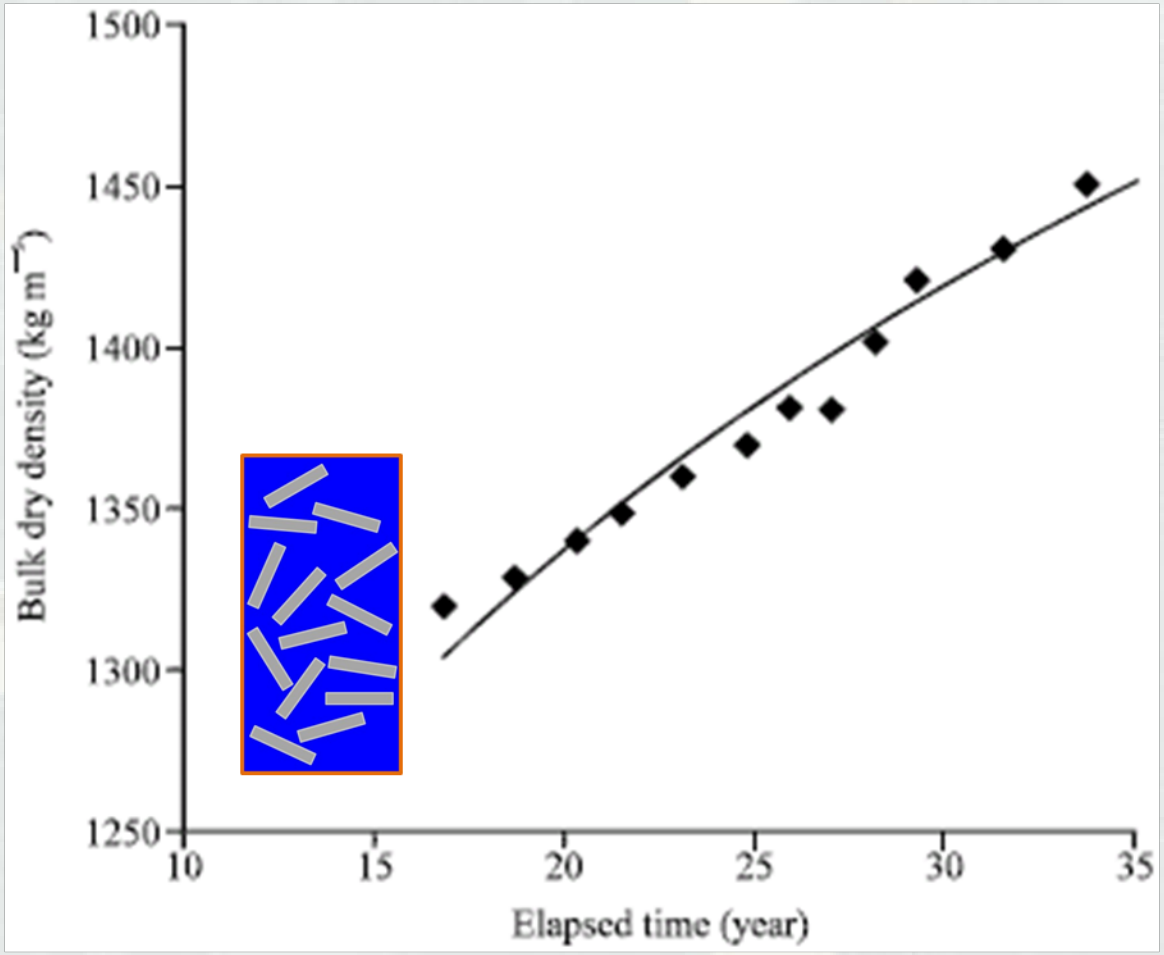
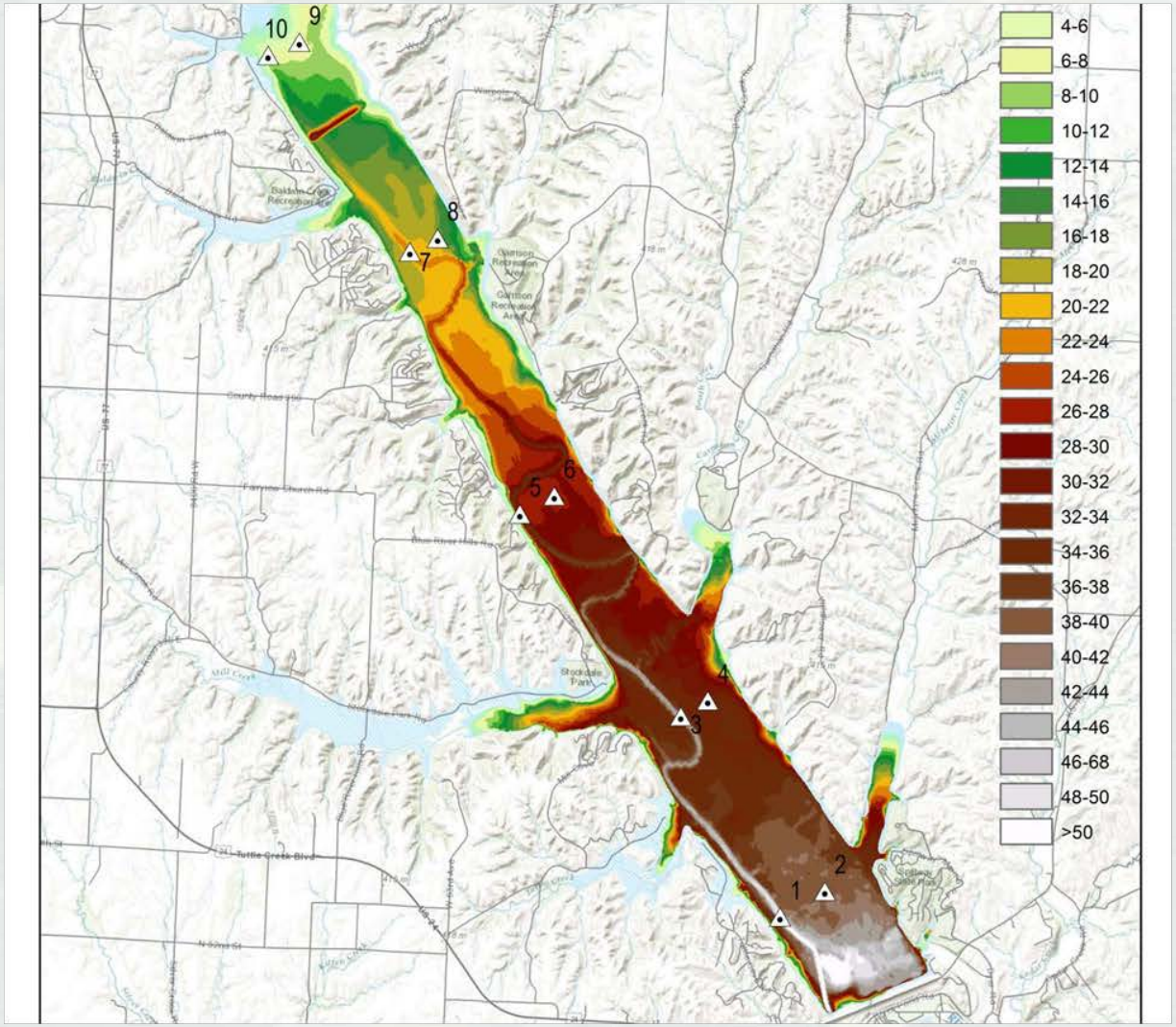
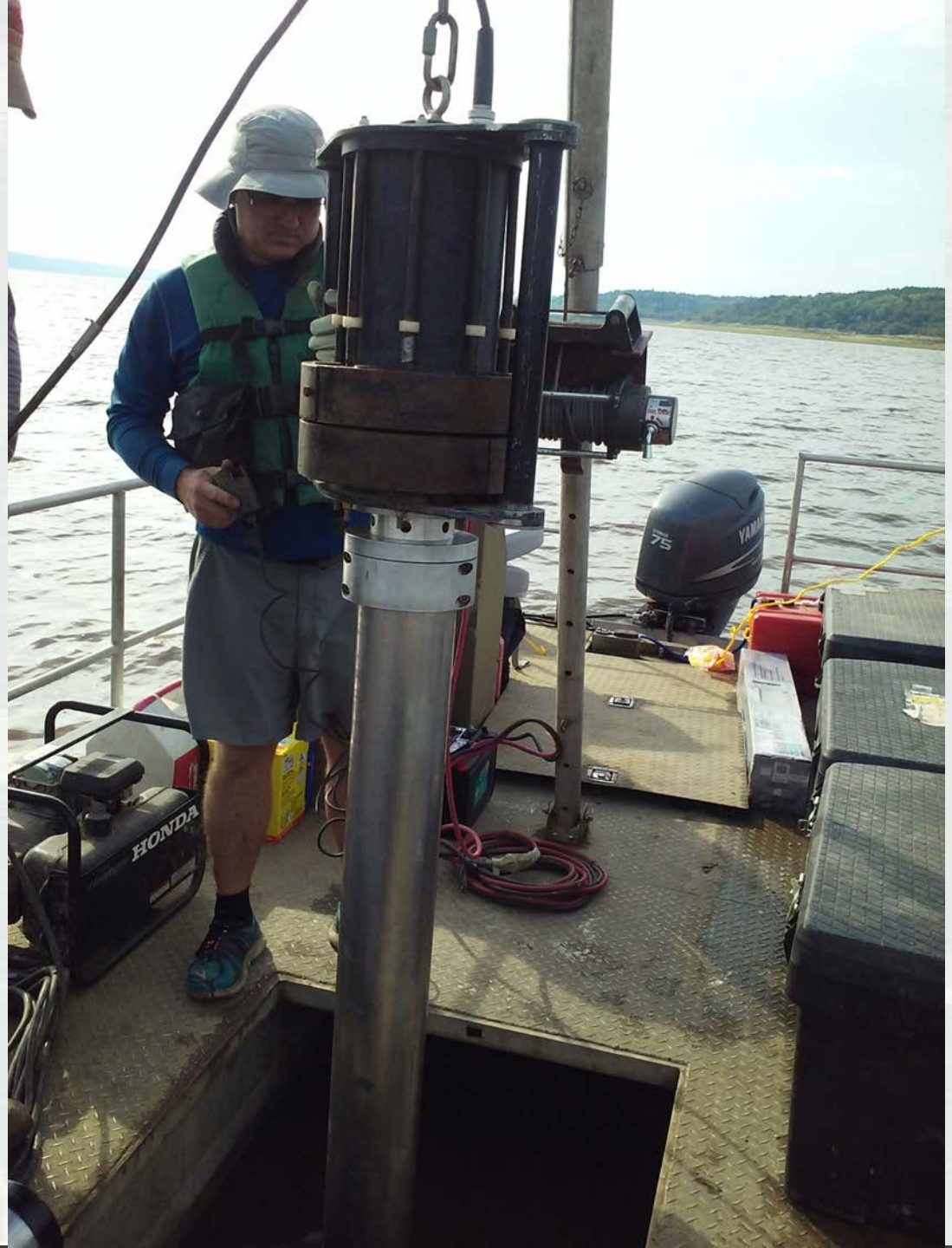


H. Samadi Boroujeni, M. Fathi-Moghadam and M. Shafaei-Bejestan, 2009. Investigation on Bulk Density of Deposited Sediments in Dez Reservoir. *Trends in Applied Sciences Research, 4: 148-157.*

Effect of time on sediment erodibility of silts/clays



Erodibility testing in Tuttle Creek Lake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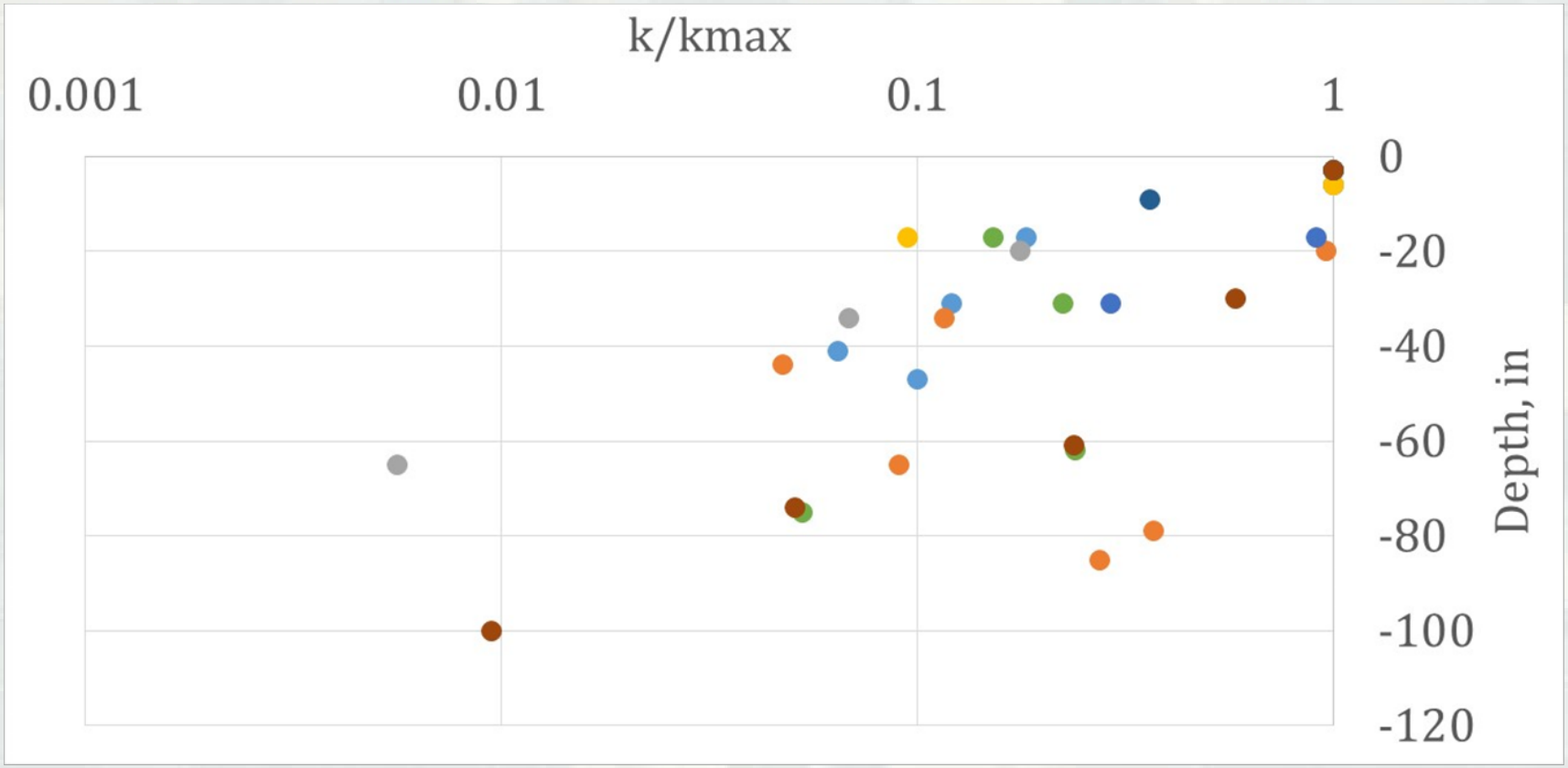
Laboratory Jet Erosion Tester at USDA-ARS

Variation in Erodibility vs. Depth



Deeper (older) deposits are up to 200 times less erodible
The longer we wait, the harder the sediment is to erode
Orders of magnitude easier (less expensive) to prevent or remove fresh deposits than to recover storage later.

Conclusion

- Effect on authorized purposes
- Urgency