Reservoir Sediment Management:

Building a Legacy of Sustainable Water Storage Reservoirs

The nation's 90,000 dams and reservoirs constitute a critical component of the country's infrastructure ensuring the stability of water and energy supplies and flood risk management. However, the reservoir storage capacity, essential to meeting these purposes, has been filling with sediment (clay, silt, sand, gravel, and cobble).

NRSST - The Subcommittee on Sedimentation's National Reservoir Sedimentation and Sustainability Team presents on sustainable solutions to reservoir sediment management.

NRSST Sponsored by the Advisory Committee on Water Information (ACWI), Subcommittee on Sedimentation (SOS)

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ACWI, SUBCOMMITTEE ON SEDIMENTATION

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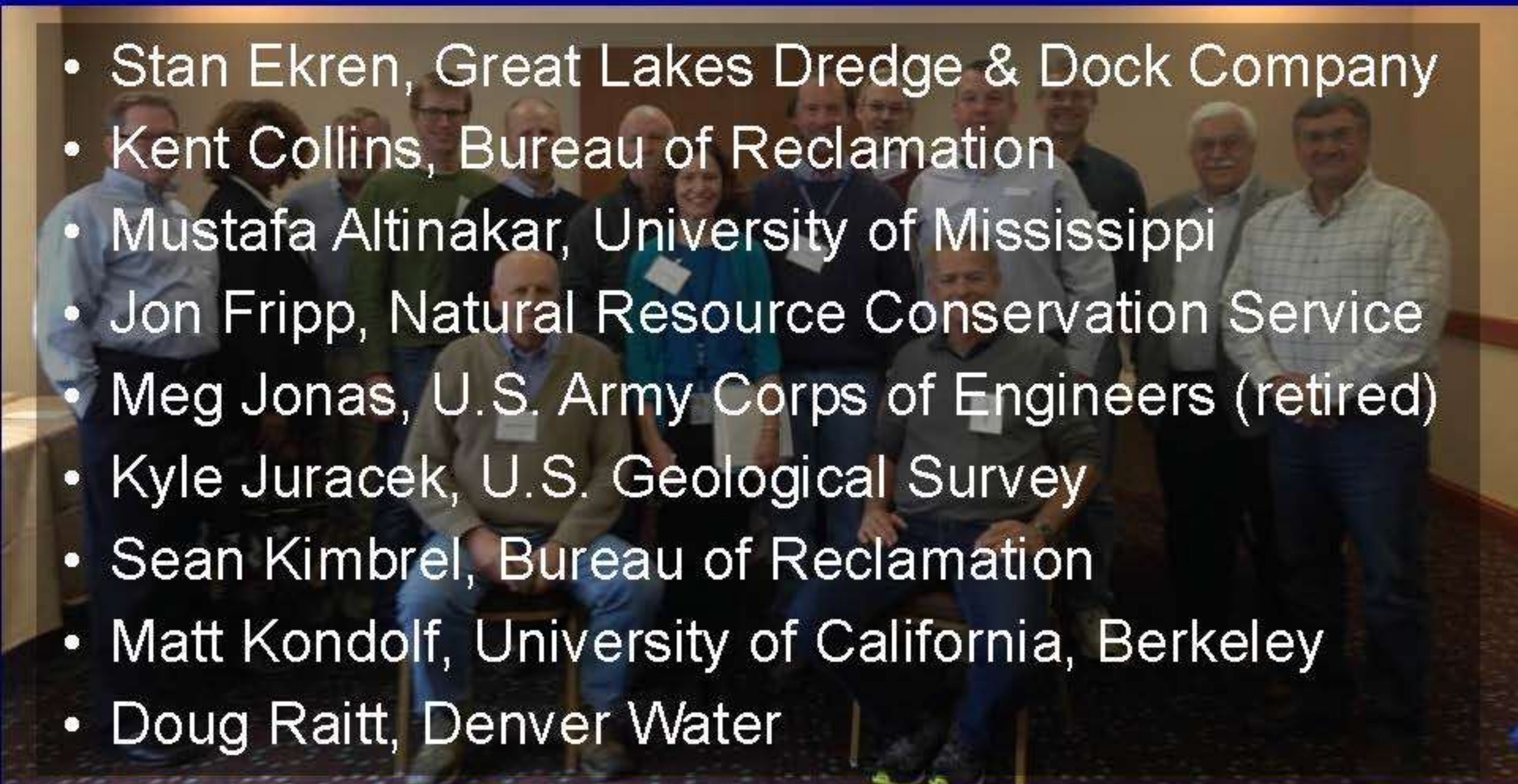

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Reservoir Sediment Design Life

- Typically 50 or 100 years
- Estimate the reservoir sedimentation volume and spatial distribution
- Design the dam’s outlet to be above the reservoir sedimentation level over the sediment design life
- Defer future sediment management to future generations

Old Best Management Practice

- NO ACTION, let the reservoir eventually fill with sediment (hopefully after you retire).
- INTERGENERATIONAL INEQUITY
  - 1st generation conceives, plans, designs, and constructs a dam and reservoir.

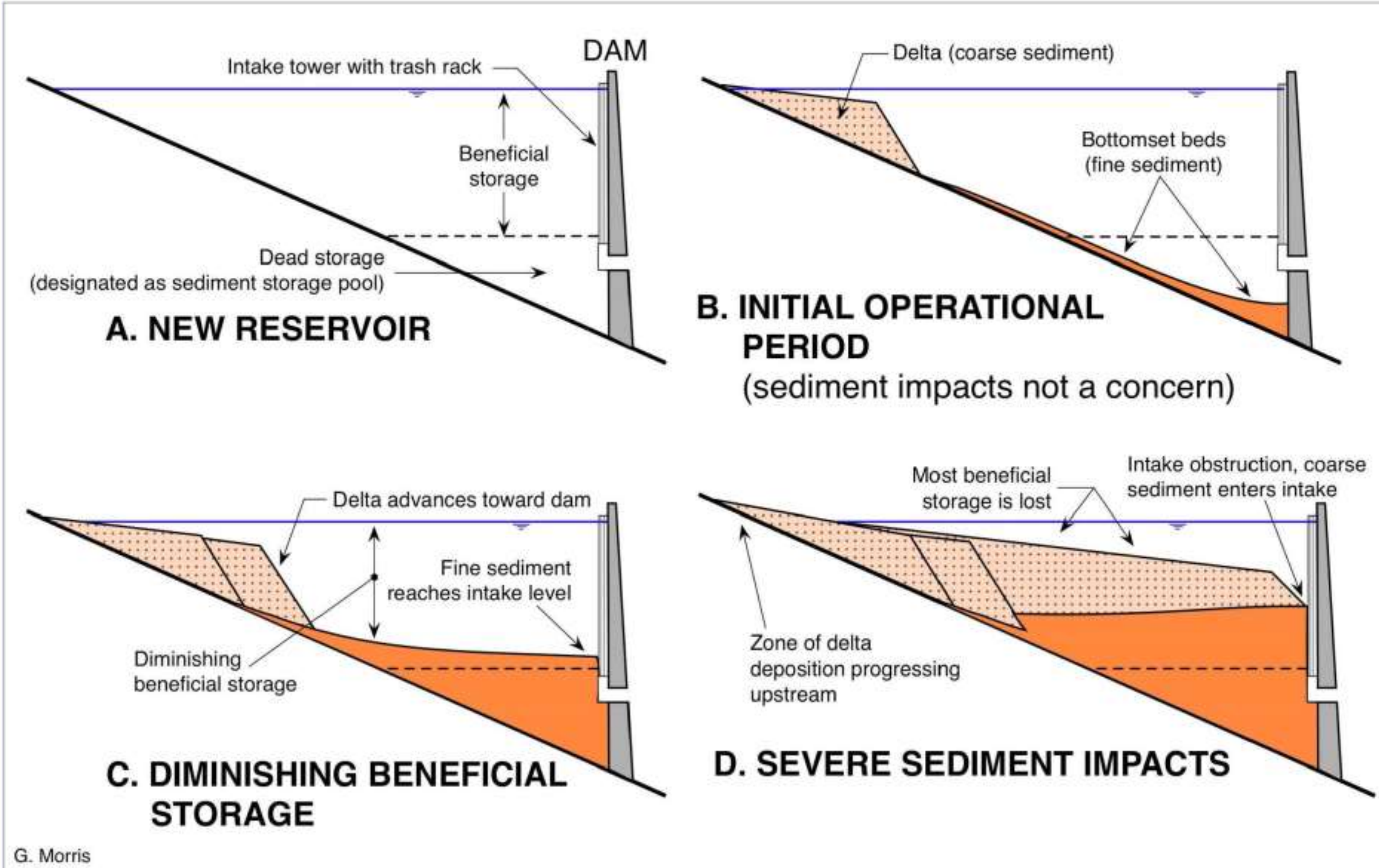
  - 2nd generation starts receiving benefits, repays capital costs, and pays O&M costs.

  - 3rd generation continues receiving benefits, repaying capital costs, and paying O&M costs.

  - 4th generation pays O&M costs, but not for sediment management.

  - Last generation is stuck with retirement bill and has to develop new water storage at a higher cost.

Reservoir Sedimentation



Without Reservoir Sediment Management

The eventual costs can be expensive

- Downstream channel degradation, infrastructure erosion, and habitat loss
- Dam decommissioning
- New dam construction needed to create replacement water storage
  - With 90,000 dams in the national inventory, the best dam sites have already been taken



Without Reservoir Sediment Management

The eventual costs can be expensive:

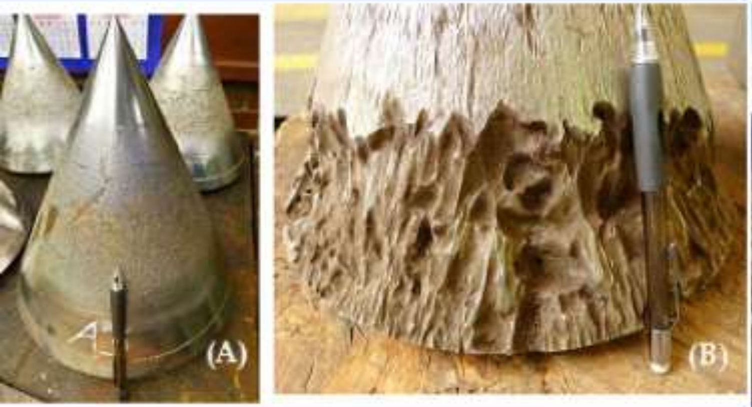
- Lost storage capacity over time (with increased water demands over time)
- Buried or impaired dam outlets, reservoir water intakes, boat ramps & marinas

37/03/26 Intake tower & upstream face of dam No. 187

Without Reservoir Sediment Management

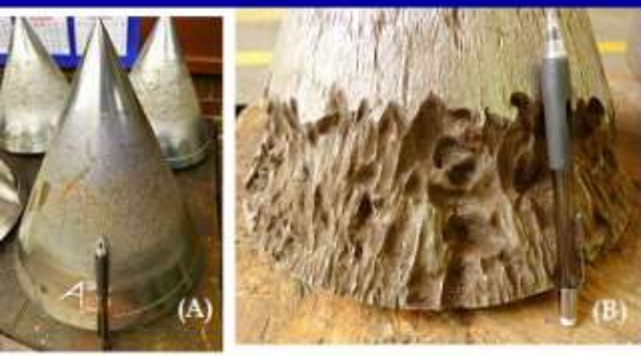
The eventual costs can be expensive:

- Abraded turbines, outlets, or spillways
- Reduced surface area for lake recreation
- Upstream channel aggradation and increases in flood stage and groundwater



Sedimentation Abrasion Impacts

- Sand or gravel is very abrasive to dam outlets, turbines, and spillways



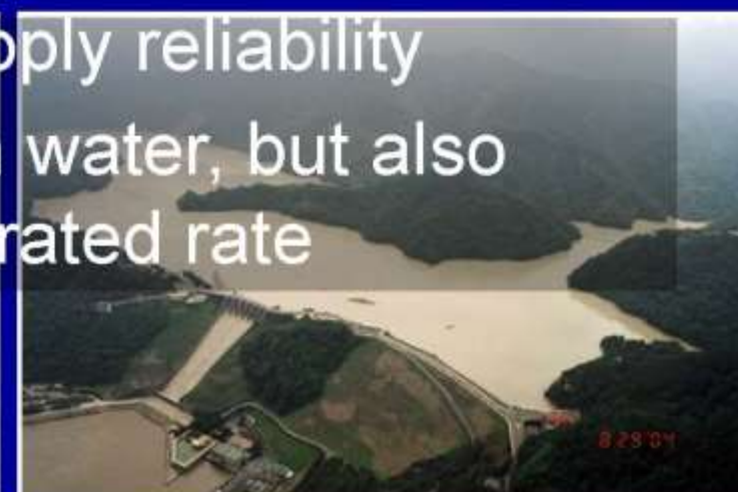


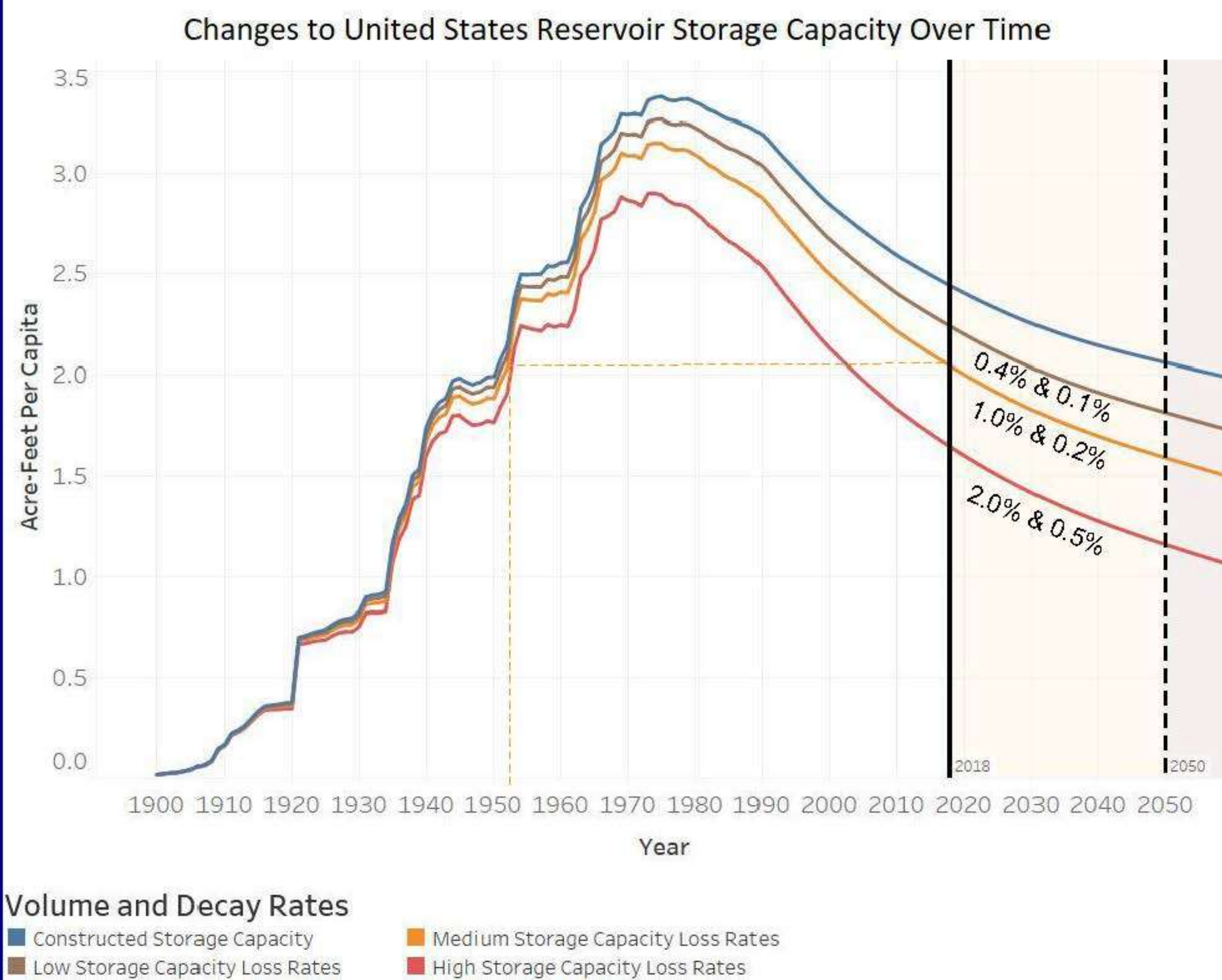



San Clemente Reservoir

Long Term Outlook

- Population and water demand will increase over time while reservoir storage capacity reduces due to sedimentation.
- In some regions, climate change may lead to increased hydrologic variability.
  - Droughts reduce water supply reliability
  - Floods refill reservoirs with water, but also sediment and at an accelerated rate




Changes to United States Reservoir Storage Capacity Over Time
Acre-Feet Per Capita
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
2030
2040
2050
Year
2018
2050
0.4% & 0.1%
1.0% & 0.2%
2.0% & 0.5%
Volume and Decay Rates
Constructed Storage Capacity
Low Storage Capacity Loss Rates
Medium Storage Capacity Loss Rates
High Storage Capacity Loss Rates

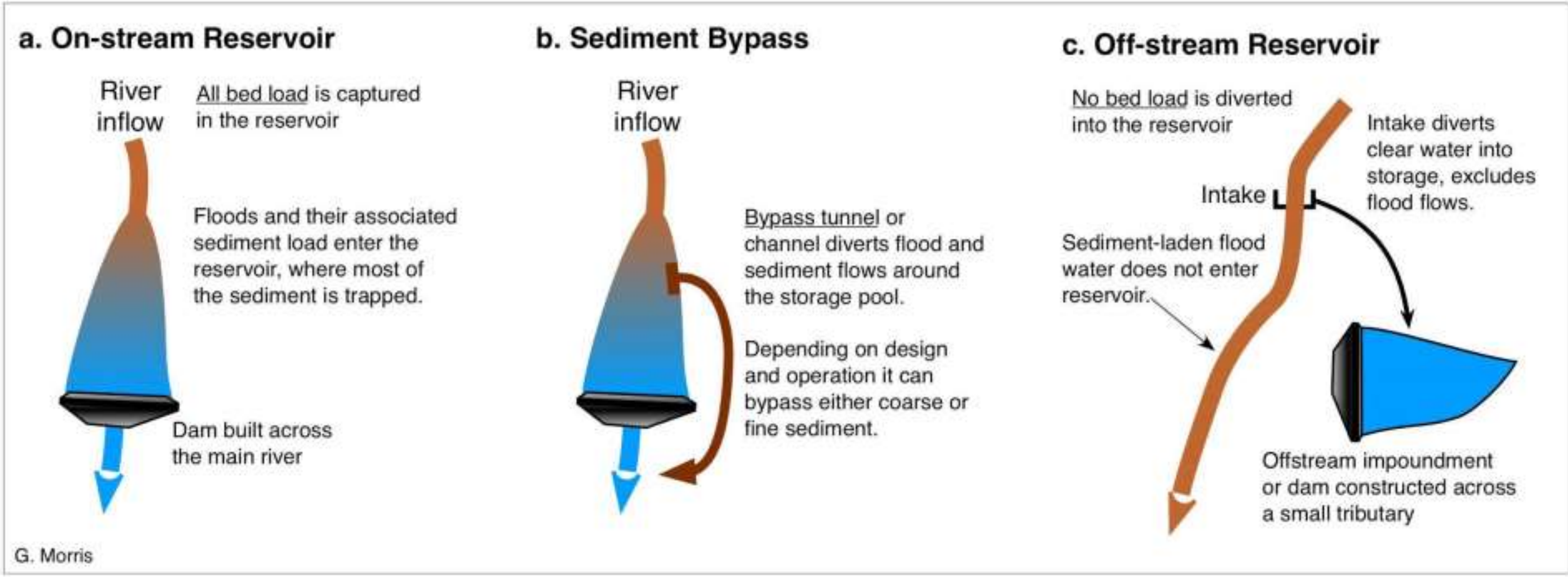
Reservoir Sediment Management Strategy

- Focus on managing recent or future sedimentation rather than past sedimentation
- Manage sedimentation each year
- Over the long term, sediment will have to pass downstream or supply other beneficial uses

Reduce Sediment Yield

- Reduce sediment production
  - Soil erosion control and revegetation
  - Landslide erosion control
  - Channel erosion control
- Sediment trapping above reservoir
  - Large dams
  - Small check dams and farm ponds
  - Gully stabilization
  - Stream channel stabilization and restoration

Route Sediment: Comparison of Strategies

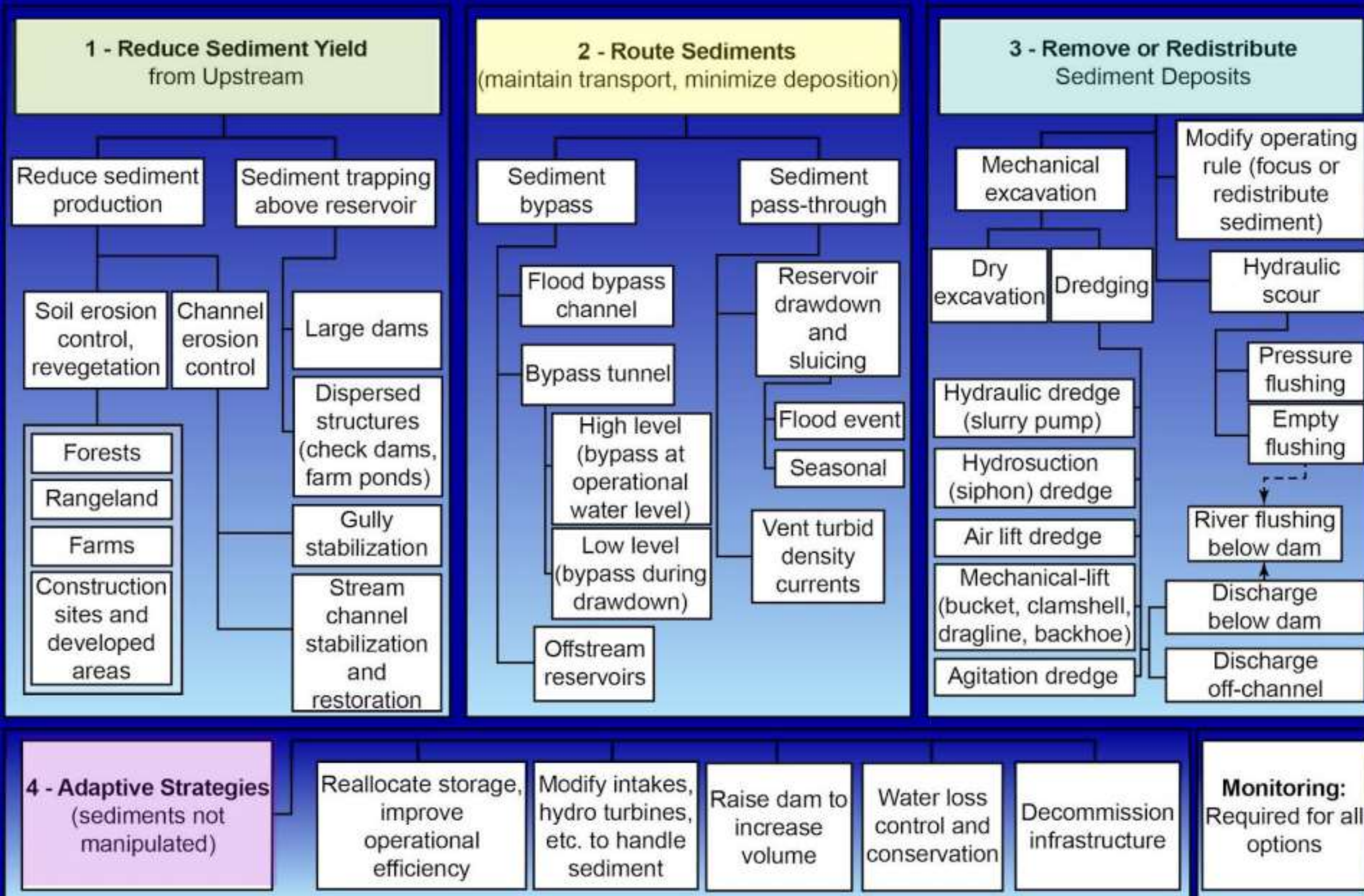


Morris, 2019

Reservoir Sediment Routing

- Tunnel bypass

Tunnel bypass at Miwa Dam, Japan



1 - Reduce Sediment Yield from Upstream
Reduce sediment production
Sediment trapping above reservoir
Soil erosion control, revegetation
Channel erosion control
Large dams
Dispersed structures (check dams, farm ponds)
Forests
Rangeland
Farms
Construction sites and developed areas
Gully stabilization
Stream channel stabilization and restoration
2 - Route Sediments (maintain transport, minimize deposition)
Sediment bypass
Sediment pass-through
Flood bypass channel
Bypass tunnel
High level (bypass at operational water level)
Low level (bypass during drawdown)
Offstream reservoirs
Reservoir drawdown and sluicing
Flood event
Seasonal
Vent turbid density currents
3 - Remove or Redistribute Sediment Deposits
Mechanical excavation
Modify operating rule (focus or redistribute sediment)
Dry excavation
Dredging
Hydraulic scour
Pressure flushing
Empty flushing
Hydraulic dredge (slurry pump)
Hydrosuction (siphon) dredge
Air lift dredge
Mechanical-lift (bucket, clamshell, dragline, backhoe)
Agitation dredge
River flushing below dam
Discharge below dam
Discharge off-channel
4 - Adaptive Strategies (sediments not manipulated)
Reallocate storage, improve operational efficiency
Modify intakes, hydro turbines, etc. to handle sediment
Raise dam to increase volume
Water loss control and conservation
Decommission infrastructure
Monitoring: Required for all options

Morris, 2015

Sediment Continuity

- Sediments passing through a reservoir may slow, stop, or reverse downstream channel erosion and degradation.
- Over the long term, sediment management cannot be allowed to overload the downstream transport capacity
- Some downstream sediment deposition may be acceptable so long as there is not unmitigated harm to people, property, or native species.

Remove or Redistribute Sediments

- Drawdown flushing for river erosion

Headcut Erosion in Spenser Reservoir

Sediment Flush below Spenser Dam

Remove or Redistribute Sediments

- Mechanical or hydraulic dredging or dry excavation
  - Transport by slurry pipeline, truck, or conveyor belt for discharge to the downstream river channel, disposal site, or beneficial use

Beneficial Uses

- Soil augmentation for agriculture
- Land development
- Construction fill
- Concrete aggregate
- Wetland and other shallow water habitat creation

Conclusions

- Monitoring is now more important because most reservoirs are in the 2nd half of their sediment-design life.
- A decade or more may be needed to plan and implement sustainable sediment management plans
- No action will lead to the eventual retirement of the dam and reservoir.

Conclusions

- Sustainable reservoir sediment management may harm introduced sport fisheries, but reservoirs cannot trap sediment forever.
- Releasing sediments at a point downstream of valuable fisheries may be a method to avoid impacts.

Conclusions

- Compare cost and impacts of reservoir sediment management with the costs of eventually retiring the reservoir and constructing additional water storage elsewhere.
- Future generations should be considered when choosing a reservoir sediment management plan.

Resolution on Reservoir Sedimentation and Sustainability

- The SOS encourages all Federal agencies to develop long-term reservoir sediment-management plans for the reservoirs that they own or manage by 2030. These management plans should include either the implementation of sustainable sediment-management practices or eventual retireme

ACWI, Subcommittee on Sedimentation

NRSST web page on SEDHYD

The first iteration of the NRSST web page on SEDHYD is now live where people can access THE white paper and get links to our recorded webinars, video, and answers to frequently asked questions.

https://www.sedhyd.org/reservoir-sedimentation/

SEDHYD - Reservoir Sedimentation and Sustainable Management

Sedimentation management is critically important to the future of the nation's reservoirs and all the benefits they provide. SEDHYD is providing useful information on this important topic from the National Reservoir Sedimentation and Sustainability Team, which is comprised of engineers and scientists from multiple Federal and local agencies, universities, consultants, and industry.

White Paper
Reservoir Sediment Management: Building a Legacy of Sustainable Water Storage Reservo

Watch the following Recorded Webinars:

Reservoir Sedimentation Management – Big Deal! Why should we even care about it?

Dr. George Annandale, P.E.

https://cires.colorado.edu/events/reservoir-sedimentation-management-big-deal-why-should-we-even-care-about-it

Sedimentation Management Alternatives at Reservoirs

Dr. Greg Morris, P.E.

https://cires.colorado.edu/events/reservoir-sedimentation-management-options-and-data-needs

Sedimentation Management for Multi-Purpose Reservoirs: A Federal Perspective

Dr. Tim Randle, P.E. and Dr. Paul Boyd, P.E.

https://cires.colorado.edu/events/sedimentation-management-multi-purpose-reservoirs-federal-perspective

Watch the following Recorded Webinars:

Permitting for reservoir sediment management

Dr. Rollin Hotchkiss, P.E. and David Olson

https://cires.colorado.edu/events/permitting-reservoir-sedimentation-management

Reservoir sedimentation monitoring

Dr. Greg Morris, P.E.

https://cires.colorado.edu/events/sedimentation-monitoring

Economics of Sustainable Reservoir Sediment Management

Dr. George Annandale, P.E. and
Dr. Rollin Hotchkiss, P.E.

https://cires.colorado.edu/events/economics-sustainable-reservoir-sediment-management

Answers to Frequently Asked Questions at
https://acwi.gov/sos/faqs_2017-05-30.pdf