Sediment Management for Dam Removals

As Presented To:

"Sediment Management for Dam Removals", A Hands on Workshop on the Latest Techniques for Dam Modification and Removal, Purdue University Calumet, IN, April 18, 2002.

"Sediment Management for Dam Removals", Marquette University Environmental Engineering Seminar, Milwaukee, WI November 20, 2003.

Marty E. Rye, P.E.

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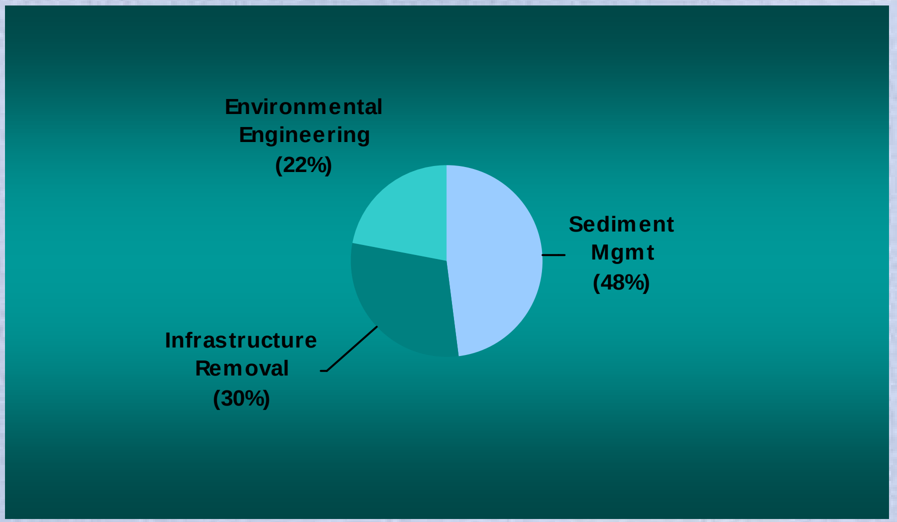
Why Do We Care?

- Project Cost
- Permitting
- Environmental Concerns
- Liability
- Project Performance
  - Aesthetics
  - Recreational Use
  - Economic



Relative Magnitude of Costs for Dam Removal Elwha River, WA (Morris & Fan, 1997)

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Purpose Of Presentation

- *Briefly* Describe Physical Process of Sedimentation
- *Briefly* Describe Options for Sediment Management for Dam Removal
- Some Data on Short-Term Impacts of Dam Removal on Downstream TSS
- Summary of Tools Needed to Ensure Responsible Dam Removal Sediment Management

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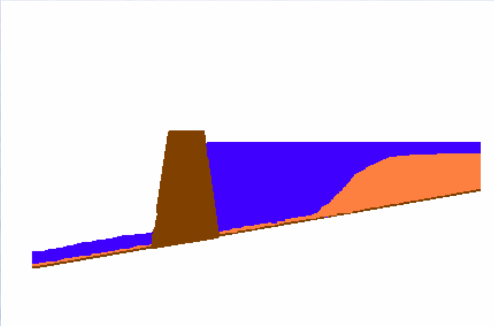
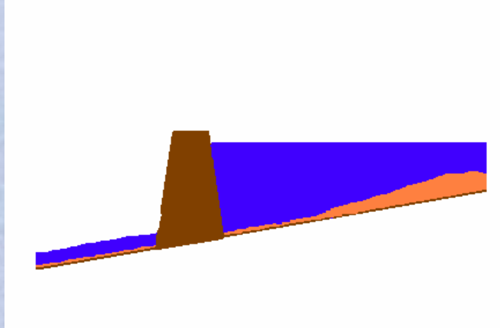
Sedimentation Patterns Related to Several Conditions

- *Hydrologic Conditions*
- *Stream Inlet Locations*
- *Sediment Characteristics*
- *Reservoir Geometry*
- *Outlet Design*
- *Operating Rule*

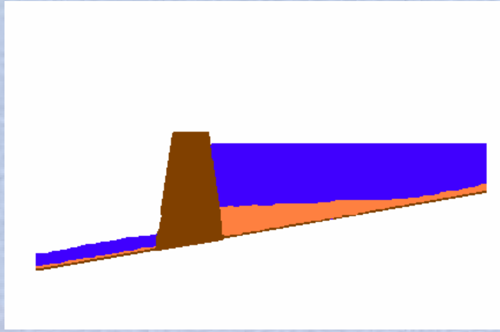
Longitudinal Deposit Geometry



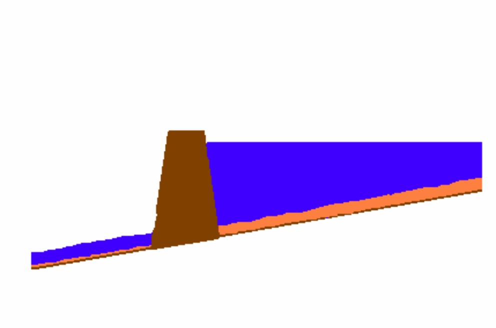
Delta



Tapering



Wedge

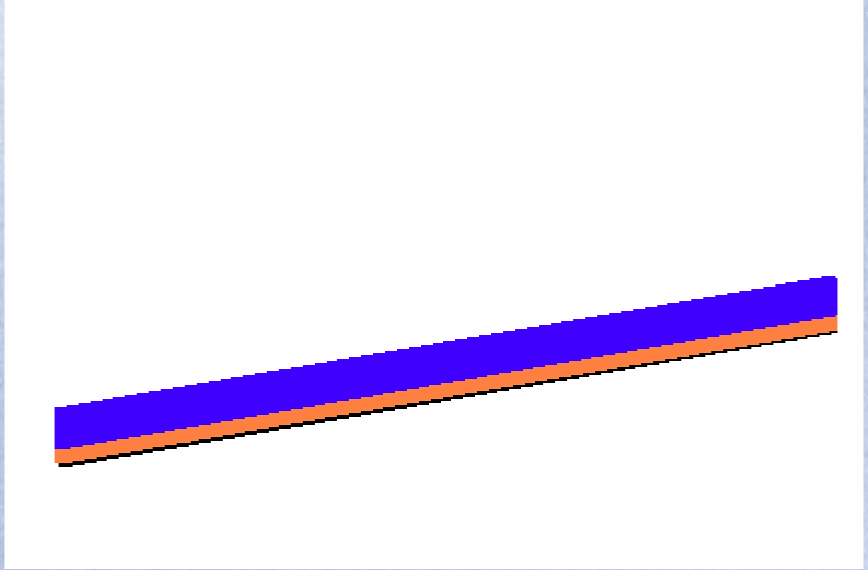


Uniform

Morris & Fan, 1997

Physical Process of Sedimentation

Pre-Dam Conditions



Sediment Transport
Continuity

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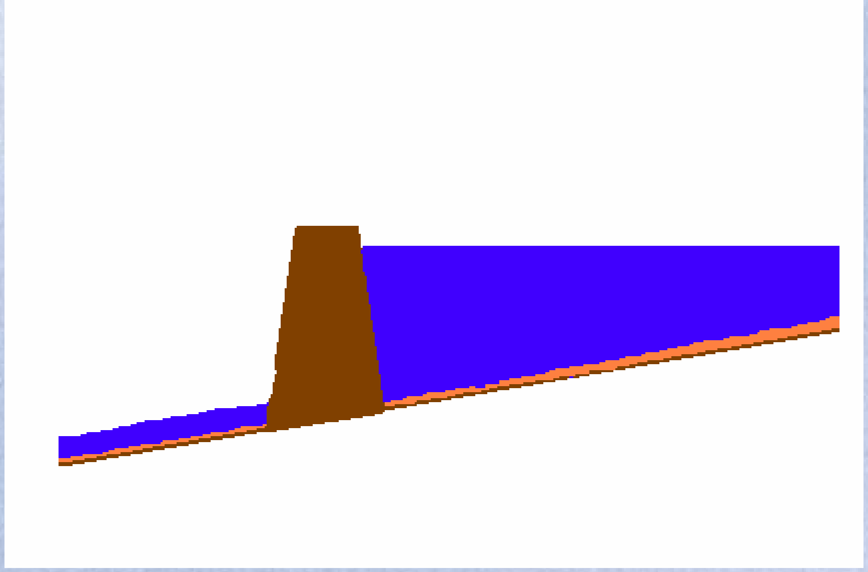
Physical Process of Sedimentation

New-Reservoir Conditions



Interruption of Sediment Transport

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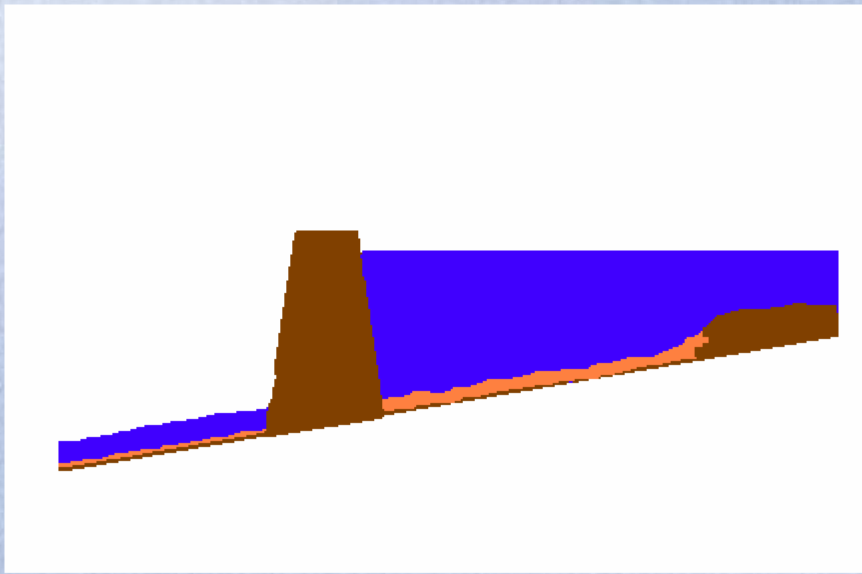
Physical Process of Sedimentation

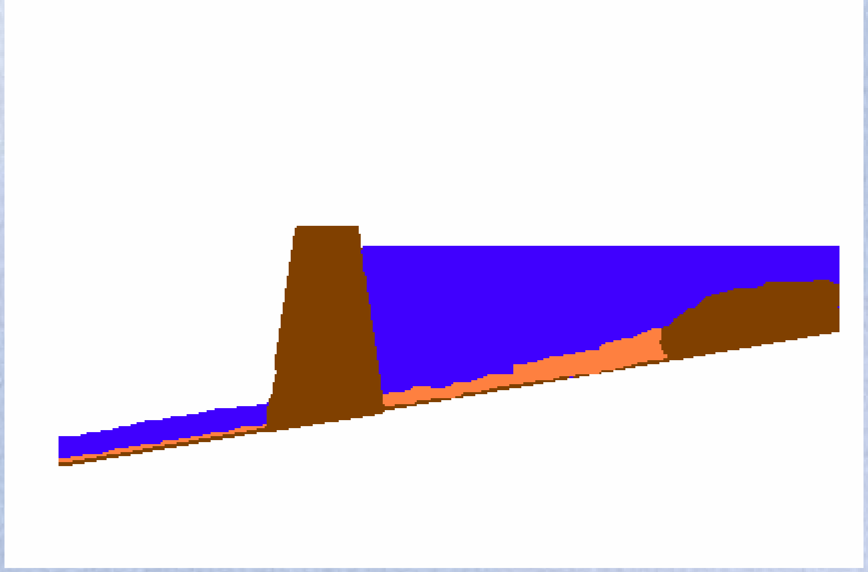
Young Reservoir Conditions



Coarser Sediment Drops Out at Upstream Limits

Physical Process of Sedimentation

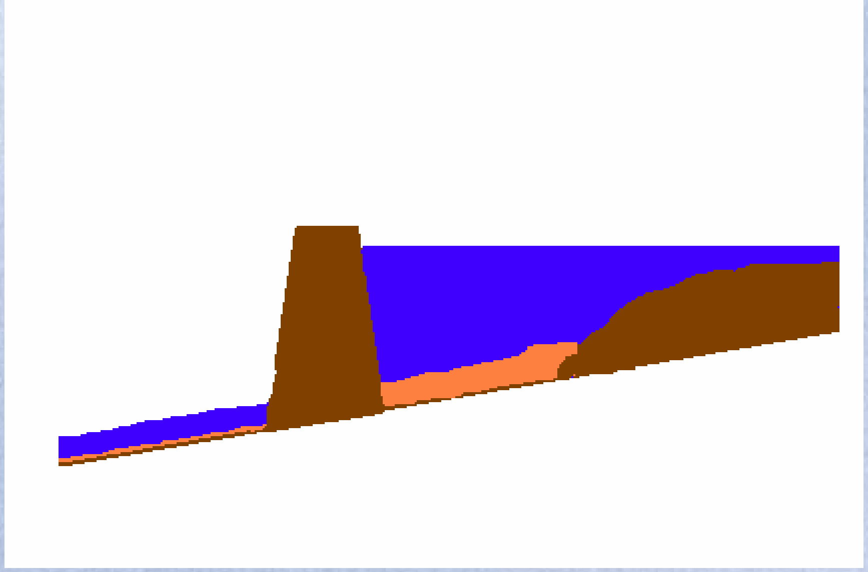
As the Reservoir Ages



- Sediment Delta Progresses Downstream
- Finer Sediment Deposited Near the Dam Face

Physical Process of Sedimentation

As the Reservoir Ages



- Sediment Delta Progresses Downstream
- Finer Sediment Deposited Near the Dam Face

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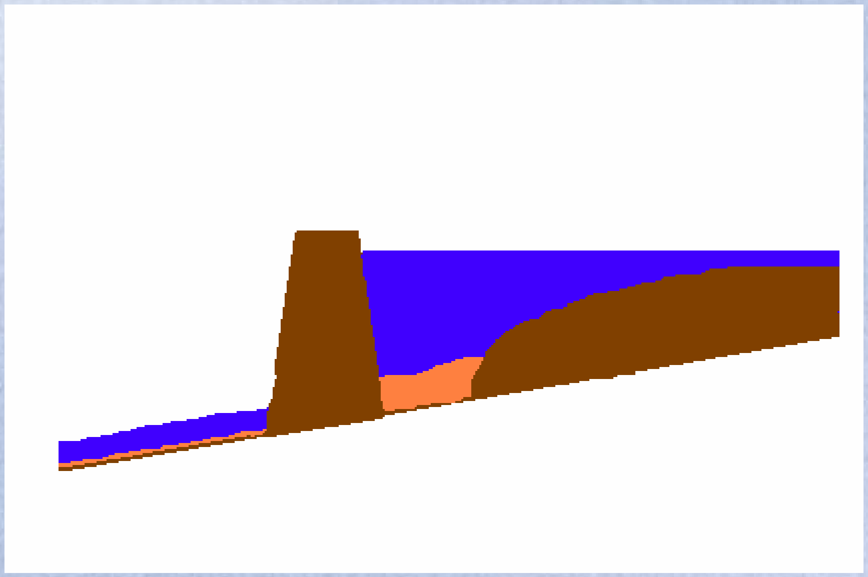
Physical Process of Sedimentation

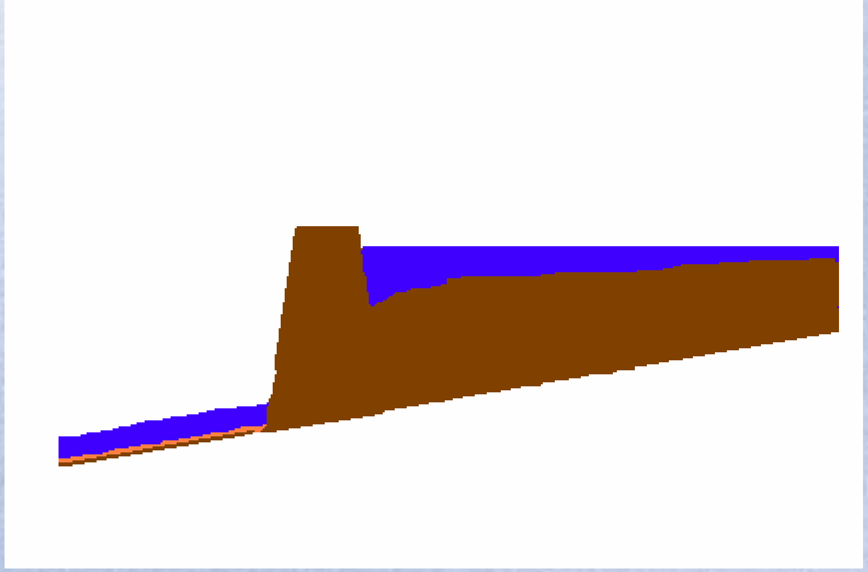
As the Reservoir Ages



- Sediment Delta Progresses Downstream
- Finer Sediment Deposited Near the Dam Face

Physical Process of Sedimentation

Aged Reservoir



- Equilibrium is Reached
- Sediment Layers

  Finer Material Covered by Coarser Material

  Consolidation of Material

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Impacts of Sediment Release

- Fisheries
- Benthic Organisms
- Municipal Water Supply
- Industrial / Agricultural Uses
- Water Treatment
- Morphology
- Conveyance Capacity

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Deterministic Tools Are Limited

- Stochastic Phenomenon
- Dam Removal Similar to Flushing Operations Used for Reservoir Sediment Management
  - *Widely Used in France for Inspection*
  - *Used in China as Part of Rule of Operation*
  - *Published Data is Limited and Project Specific*

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Sediment Management Approaches for Dam Removal

- Minimal Management
- In-Place Stabilization
- Time Stepped Approach
- Excavation and Stabilization of Reservoir Sediments

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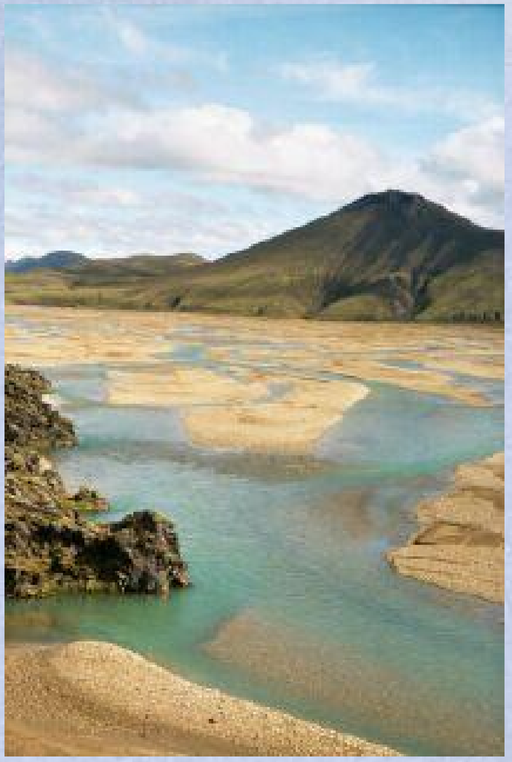
Two Extremes in Timescale Yield Two Extremes in Sediment Management

Geologic Time Scale



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This Leads to the “Rip ‘n Run”

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Minimal Management

Advantages	**Concerns**
Cheaper than Active Management of Sediment	Degraded Stream Reach
Easier to Design	Downstream Impacts
No Long-Term Construction and Monitoring	Aesthetics
Allows More Dams to be Removed	Social Impacts

Engineering Time Scale
Leads to a "Full-Restoration"

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Full Restoration

Advantages	**Concerns**
Restores Ecological Function Quickly	Resource Competition Delays Other Dam Removals
Aesthetic	$$'s
Social Benefits	
Restores Capability of Stream to Adapt	
Engineering Objectives Can Be Met	

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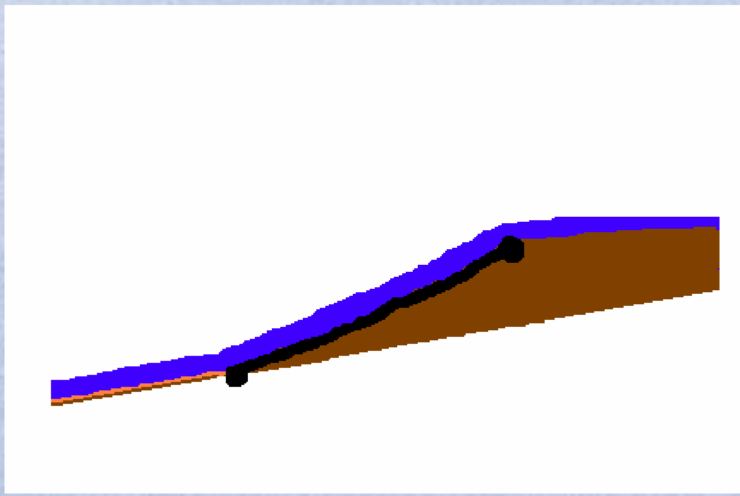
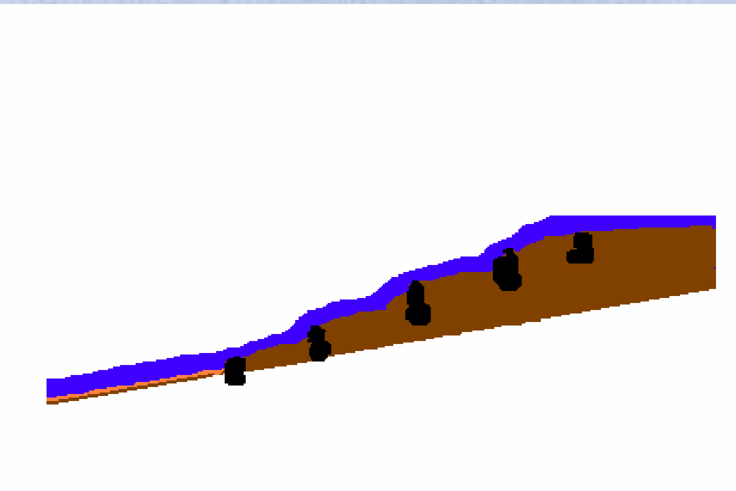
Choices within the Extremes

In-Place Stabilization by Constructing an Over-Steepened Transition Channel or a Series of Transitions



Ramp – Steep Channel



Step-Pool Series of Drops

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Partial Restoration

Advantages	**Concerns**
Initially Cheaper than 'Full-Restoration'	Is this River Restoration? Responsiveness
Provides Some Short-Term Function	Design Components / Design Standards
Aesthetic Benefits	Life-Cycle Costs / Maintenance
Minimizes Floodplain Sediment Migration *(Contaminated Sediment)*	

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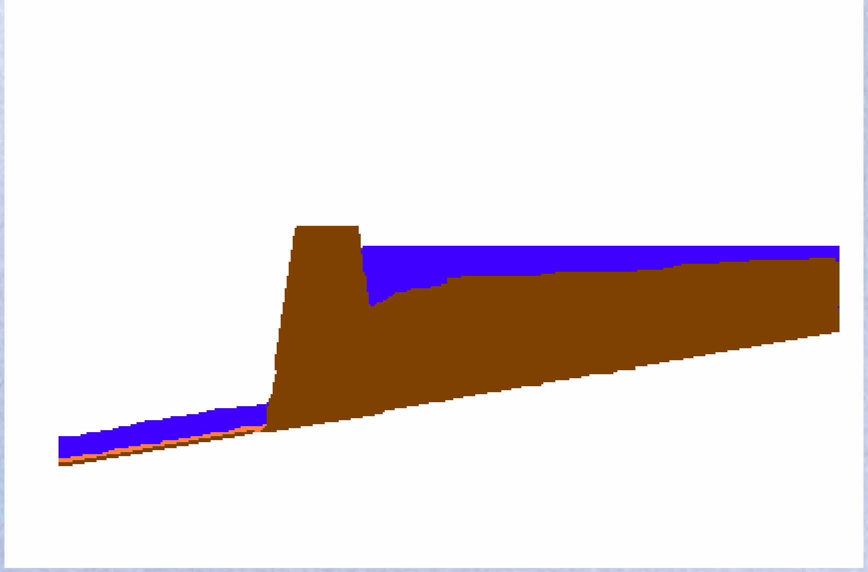
Time-Stepped Approach Dam Removal



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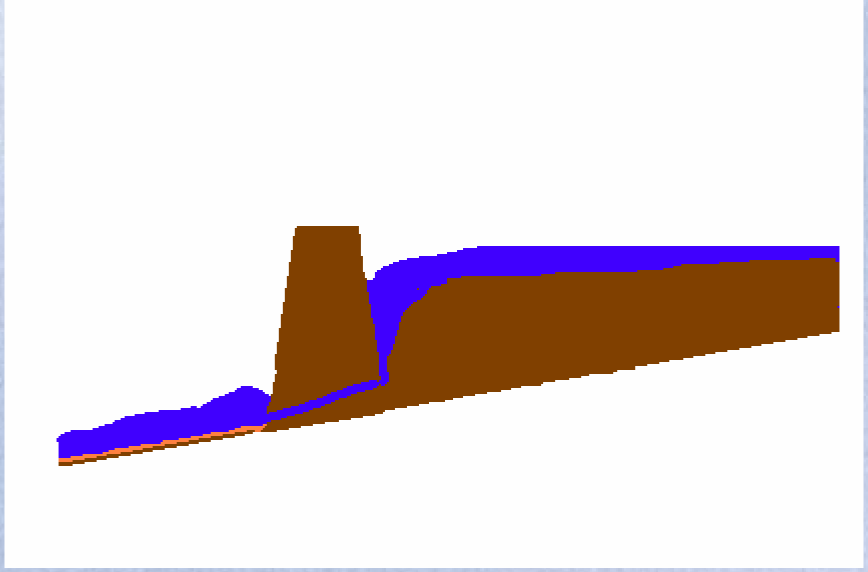
Time-Stepped Approach Dam Removal



Open Lower Gate

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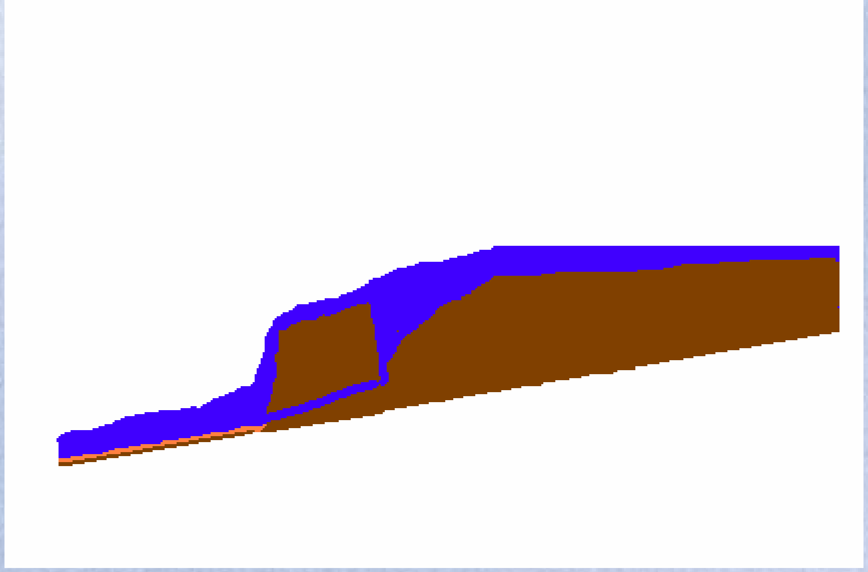
Time-Stepped Approach Dam Removal



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Time-Stepped Approach Dam Removal

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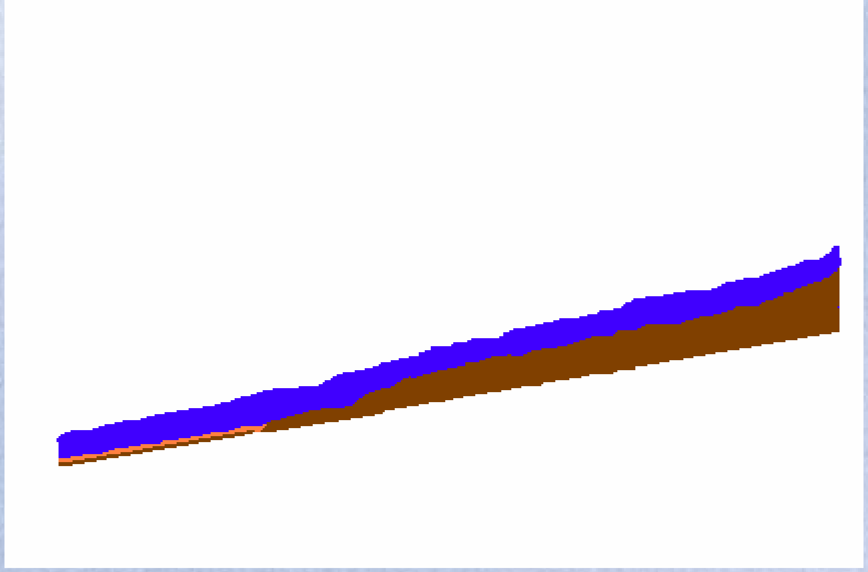
Time-Stepped Approach Dam Removal



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Time-Stepped Removal

Advantages	**Concerns**
Spreads the Impact Over Time – Allows Downstream Natural Communities to Adapt	Does Not Explicitly Address Floodplain Sediment Removal
Allows Floodplain Sediments to Dewater, Aerate, Consolidate, Vegetate	Still Have An Incised System – Can Get Stabilized by Vegetation Establishment Delaying Eventual “Natural Rehabilitation”
Can Monitor Downstream Impacts During Process	

Impact of Storm Event on Channel Substrate Following Dam Removal

Baraboo, WI

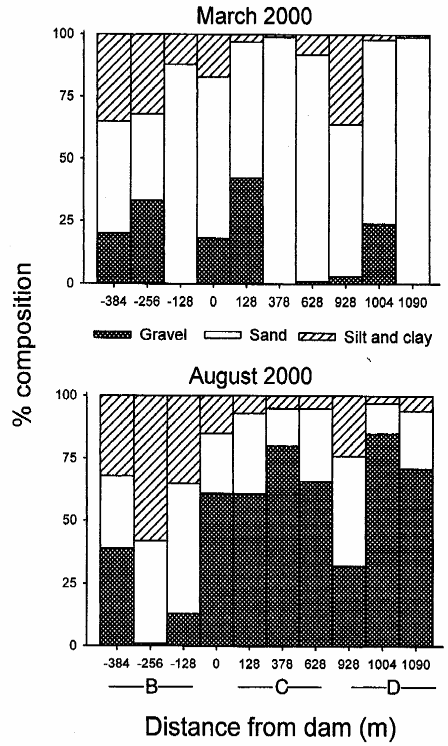

FIG. 5. Relative composition (as % of total sample mass) of sediment size fractions along a longitudinal transect from 384 m above to 1090 m below the Dam #1 removal site (0 m), March and August 2000. Reaches for individual sampling points are indicated on the x-axis. Fine sediments <0.05 mm; sand = 0.05–2.0 mm; gravel >2.0 mm.

(Stanley, Luebke, Doyle, Marshall, 2002)

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Short-Term Impacts of Dam Removal on TSS

Two Case Studies

- Mill Pond Dam on the Pomme de Terre River

- Frazee Dam on the Otter Tail River

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Appleton Mill Pond
Dam Removal Case History

Pomme de Terre River in Western Minnesota

Provided Power for Local Mill Site

Concrete Rubble Dam

Dam Ht = 17 ft

Dam Length = 157 ft

Size of Reservoir = 57 ac

D.A. = 907 sq. miles

Removed in Winter 1998

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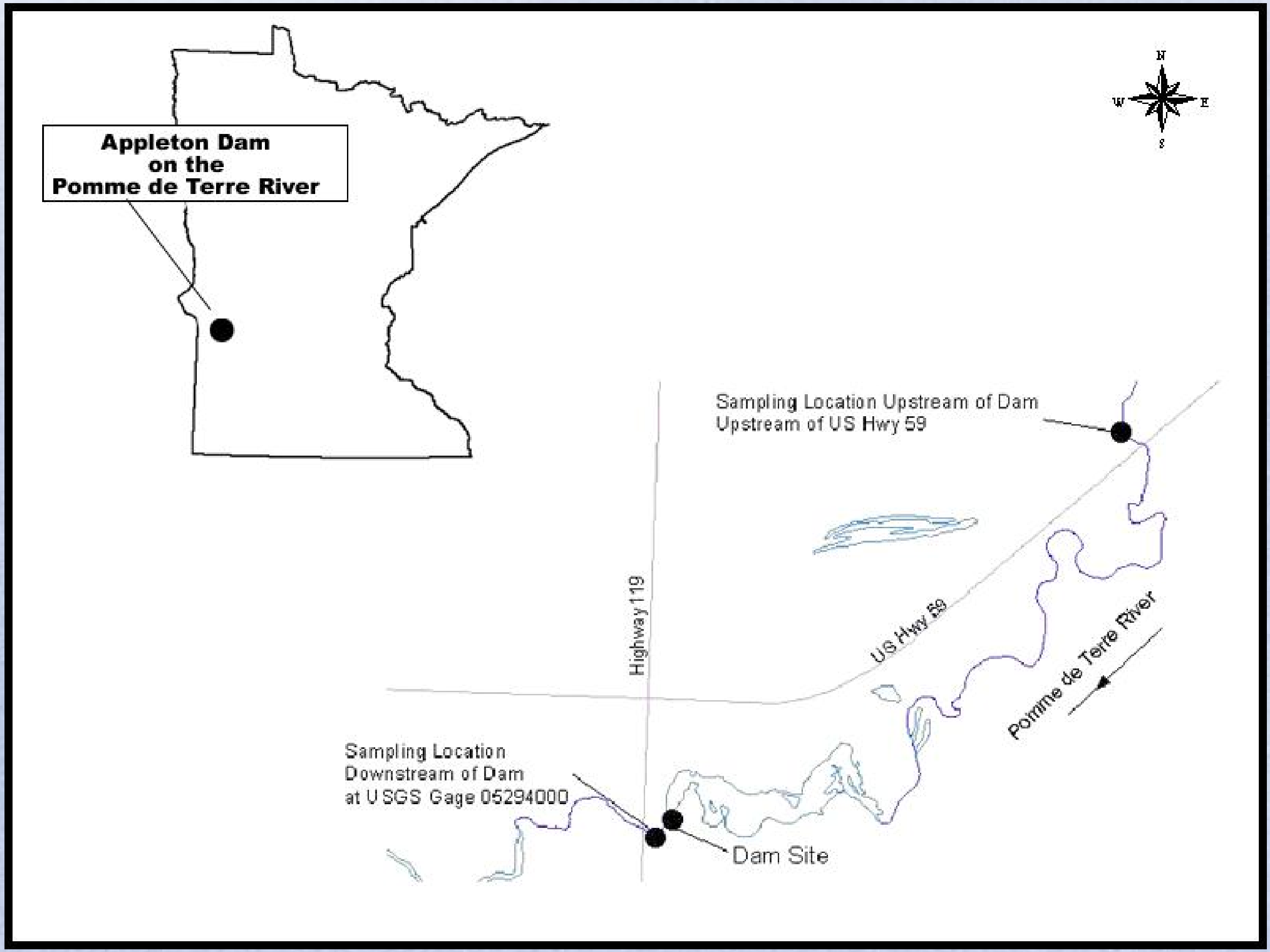
Appleton Dam Location



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Appleton Dam Before Removal

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Aerial Photo of Appleton Dam’s Pool

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Appleton Dam After Removal

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Frazee Dam Removal Case History

Otter Tail River in Northwest

Minnesota

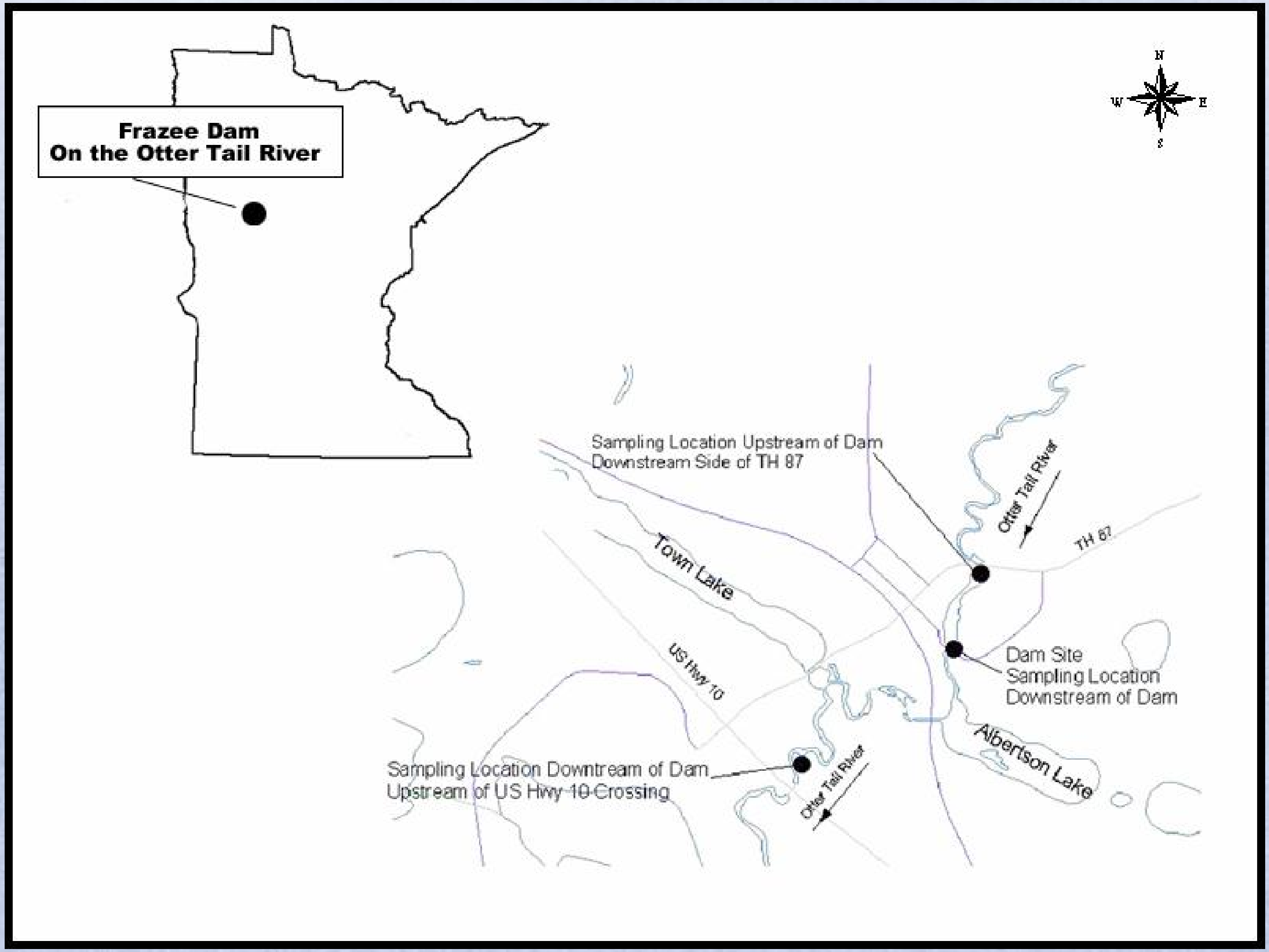
Dam Ht = 19 ft

Dam Length = 60 ft

D.A. = 237.7 sq. miles

Removed in Winter 1998

Frazee Dam Location



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Frazee Dam Before Removal

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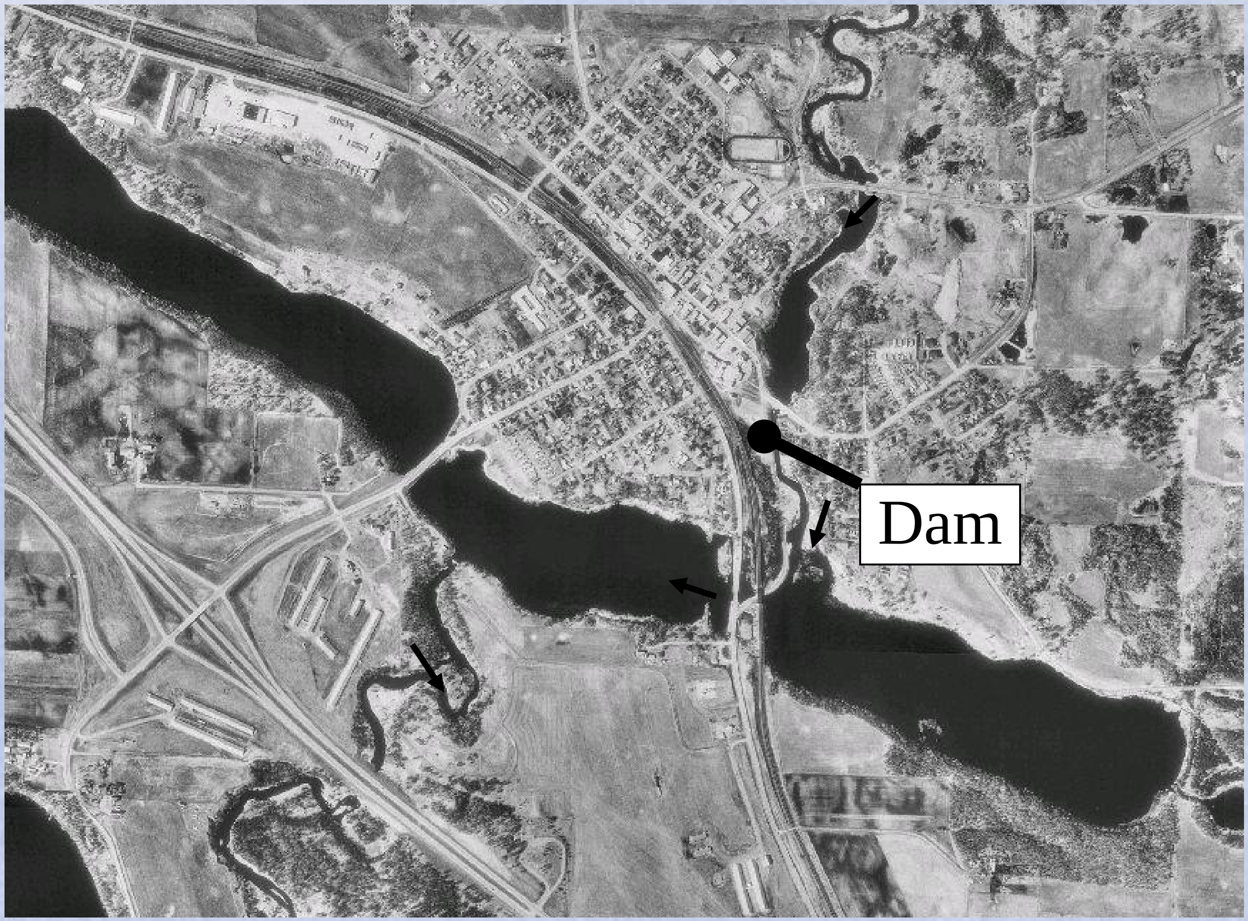
Aerial Photo of Frazee Dam Pool Before Removal



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Frazee Dam Site After Removal

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T.H. 87 Crossing Upstream of Dam Site

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Progression of Frazee Pool
Spring Before Removal

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Progression of Frazee Pool

Fall Before Removal

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Progression of Frazee Pool

Winter During Removal

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Progression of Frazee Pool
Spring After Removal

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Progression of Frazee Pool
Summer After Removal

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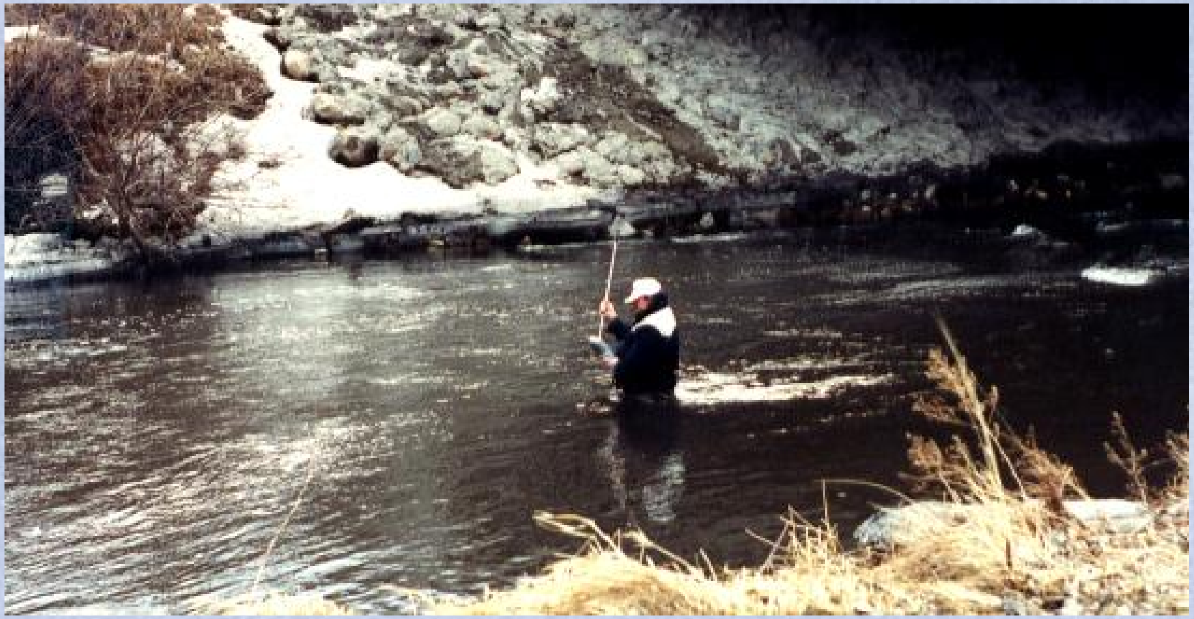
Impact of Dam Removal on Water Quality Was Measured

Total Suspended Solids (TSS) Concentrations were Measured Using a Depth Integrated Sampler



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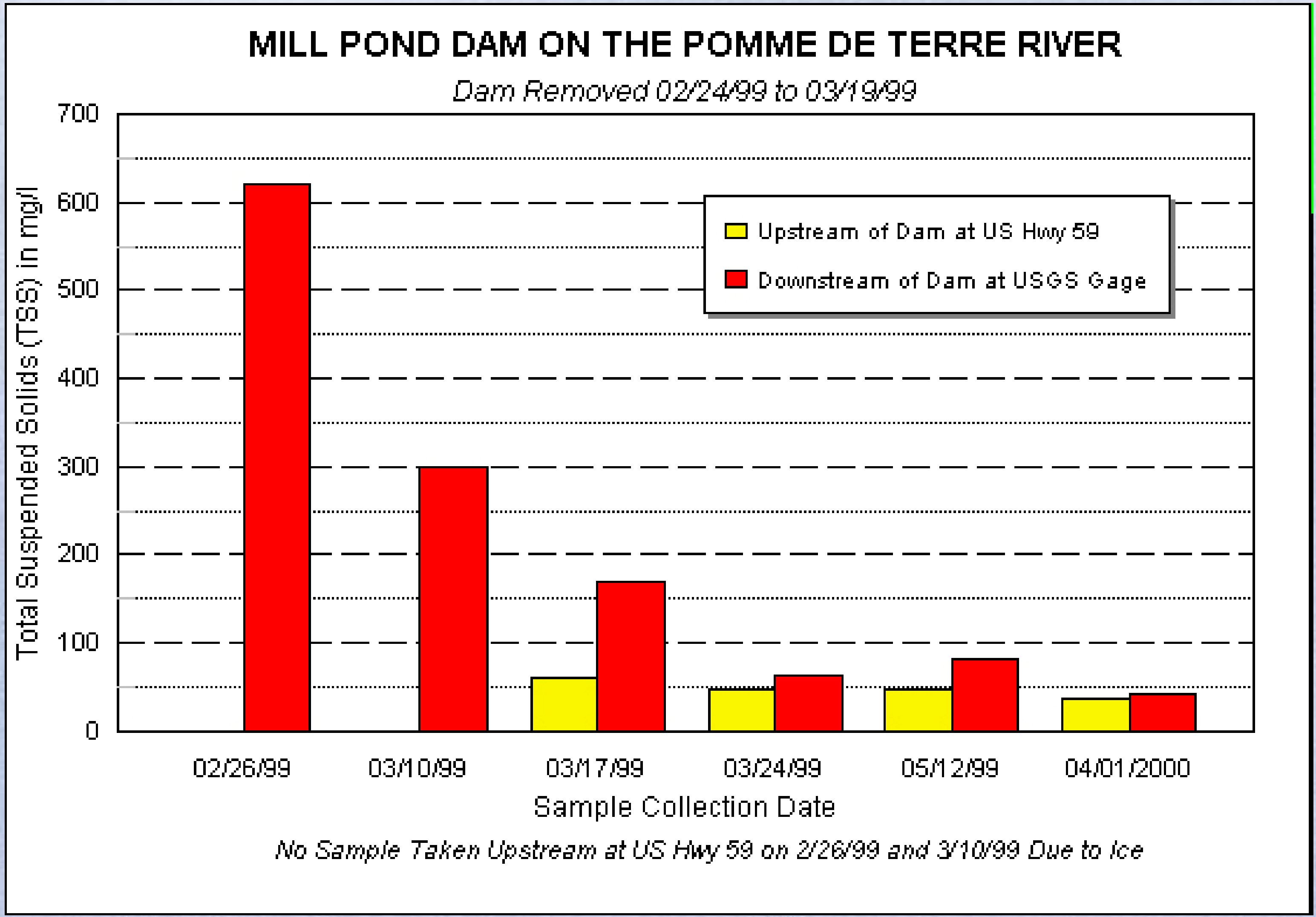
Results of Water Quality Sampling



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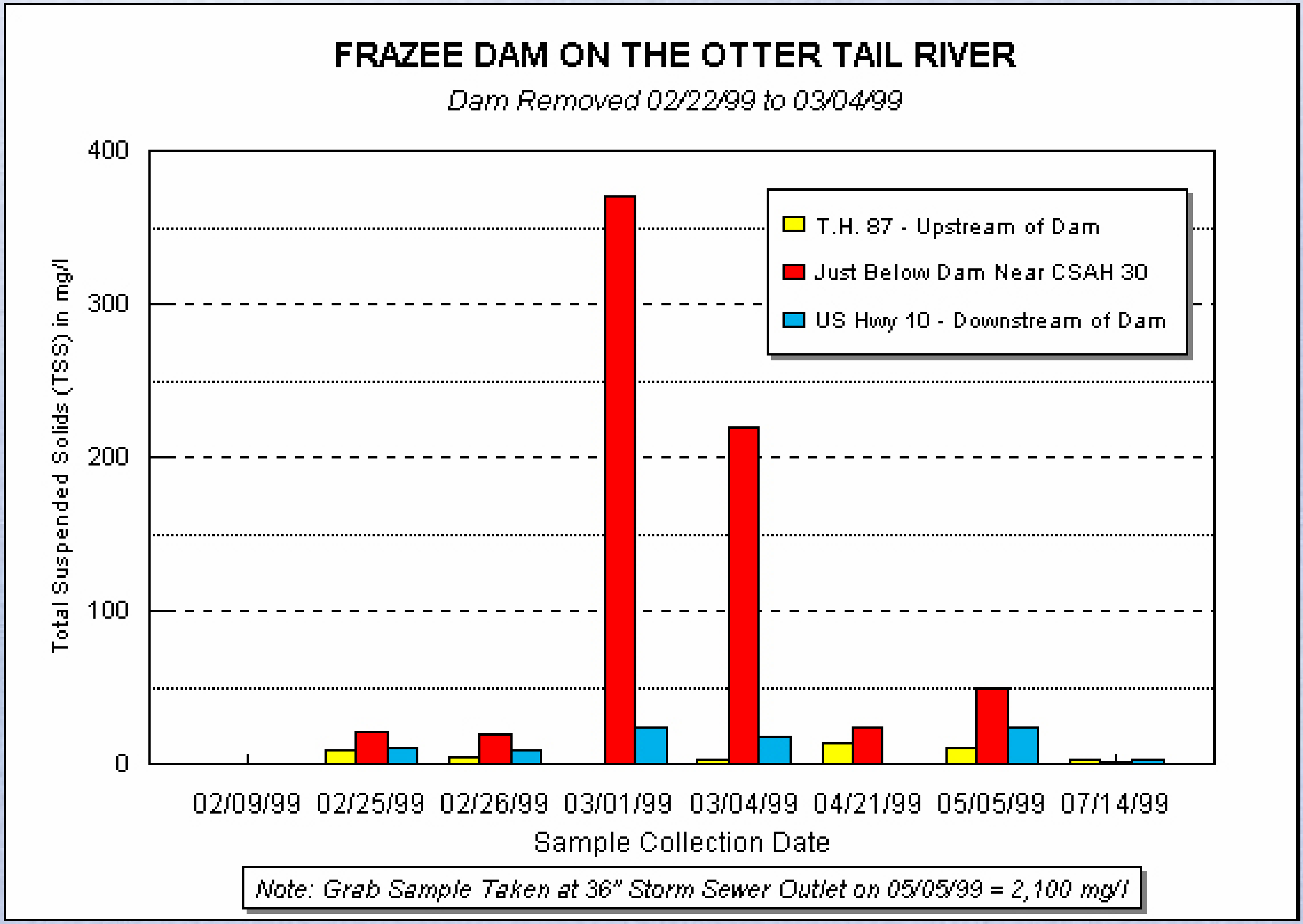
Results of Water Quality Sampling



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Comparison of Measured TSS Values

A Grab Sample Taken At Frazee (2,100 mg/l)

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Conclusions – Tools Needed

- Ensure Sufficient **Flexibility in Permitting Rules** to Treat Dam Removal as *a Component* of River Restoration /Management
  - Risk-Based
  - Site / Project Specific with an Understanding of Overall Goals

- Ensure **Flexibility in Funding** Allows Different Approaches

- Ensure Dam Removal **Design Incorporates a Specific Strategy** to Meet Specific Project Goals

- **Include a Monitoring Component of Dam Removal** - Collect and Publish More Data Regarding Dam Removal (Morphology, Short/Long Term Sediment Concentration, Fisheries, Macroinvertebrate, Water Quality, etc)

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