Dam Removal Webinar Series

Oct 27 Part 1: Overview of Dam Removal

Nov 3 Part 2: Sediment Management

Nov 10 Part 3: Assessment Methods

Nov 19 Part 4: Modeling Techniques

This webinar series is provided through the USACE - Ecosystem Management and Restoration Research Program.

Webinars will be posted at:
https://emrrp.el.erdc.dren.mil/webinars.html

Dam Removal Webinar Series

Part 4B:
Modeling Techniques:
2D & 3D Modeling Study:
Milltown Dam Removal
Case Study

November 19, 2020

Dr. Earl Hayter
ERDC Environmental Laboratory

Dam removal workshop
Aug 23-24, 2017

Me!

Predictive and Explorative Tools/Models

We can use predictive sediment transport models and tools to address some of those questions and concerns.

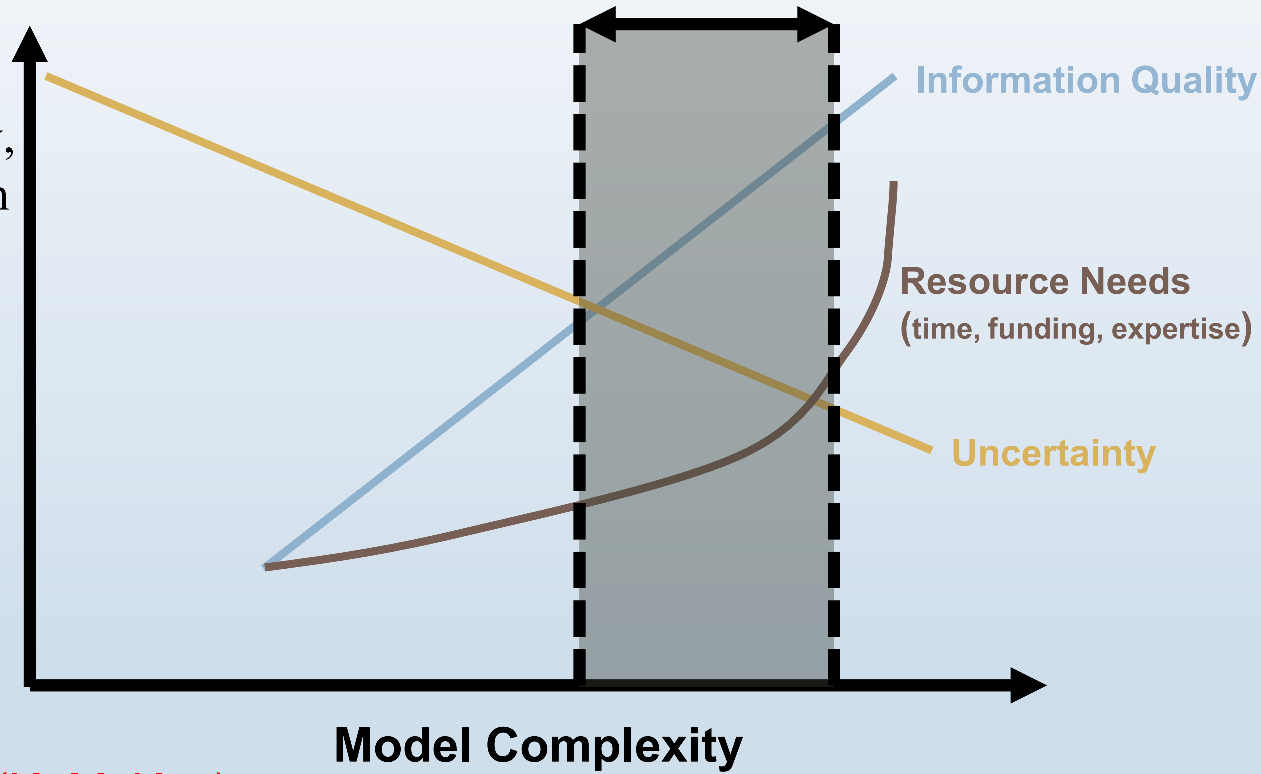
Important questions before we begin:

- Do we even need a model? (Dam Removal Analysis Guidelines)
- Which models are appropriate for which assessment?
  - How much data do I need? / How much data do I have?
  - What level of assessment is "good enough"?
  - How much time do I have?
  - How much money do I have?

Is it Worth it?

"Geomorphic tools should be selected in line with the project objectives, risks, data availability, and analysis time for a given dam removal; furthermore, multiple tools can be applied to a single site as an analysis proceeds from preliminary screening to permit application"

(Randle and Bountry 2017)



"Not everything is Milltown" (K. McKay)

Methods/tools used to quantify the geomorphic implications of dam removal

General increase in complexity

General List of Tools/Methods
Conceptual model
Generalized rule
Geomorphic analysis
Preliminary sediment analysis
1-D Sediment transport modeling
2-D Sediment transport modeling
Lagrangian transport modeling
3-D Sediment transport modeling

2-D & 3-D Sediment Transport Modeling

Benefits

- Allows users to better understand detailed and site specific issues:
  - Impact on water quality, e.g., increase in turbidity, downstream of the dam during removal operations.
  - Potential increase in the sedimentation downstream of the dam during and following removal operations.
  - bed morphology changes at specific locations of importance downstream of the dam.
  - Results are more spatially resolved.

Limitations

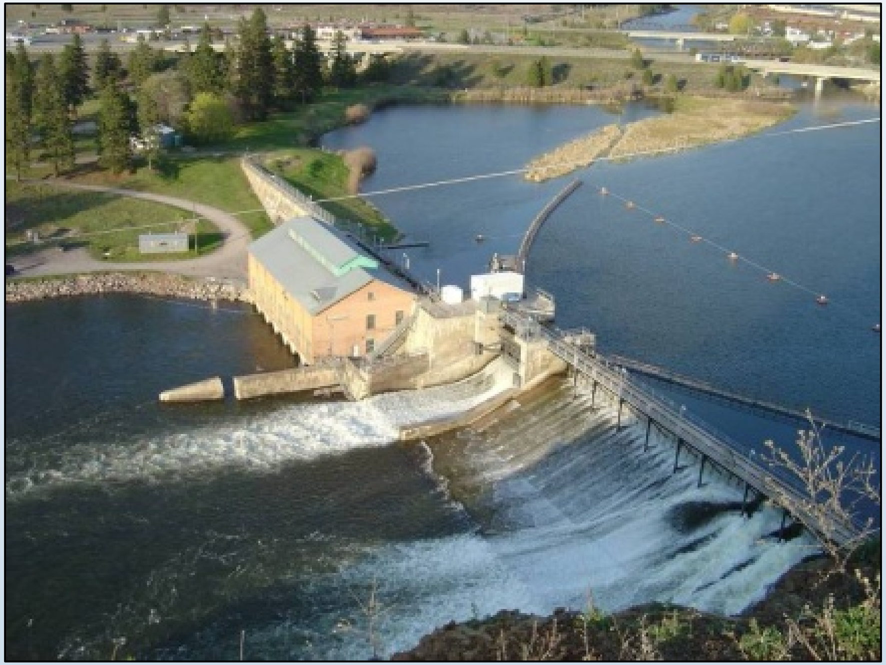
- Have not (to our knowledge) been applied in dam removal predictions (computationally intensive)
- Requires extensive site specific input data.

Case Study: 2-D and 3-D Sediment transport modeling at Milltown Dam, MT

2D & 3D hydrodynamic and sediment transport (both cohesive and non-cohesive) modeling are being performed.

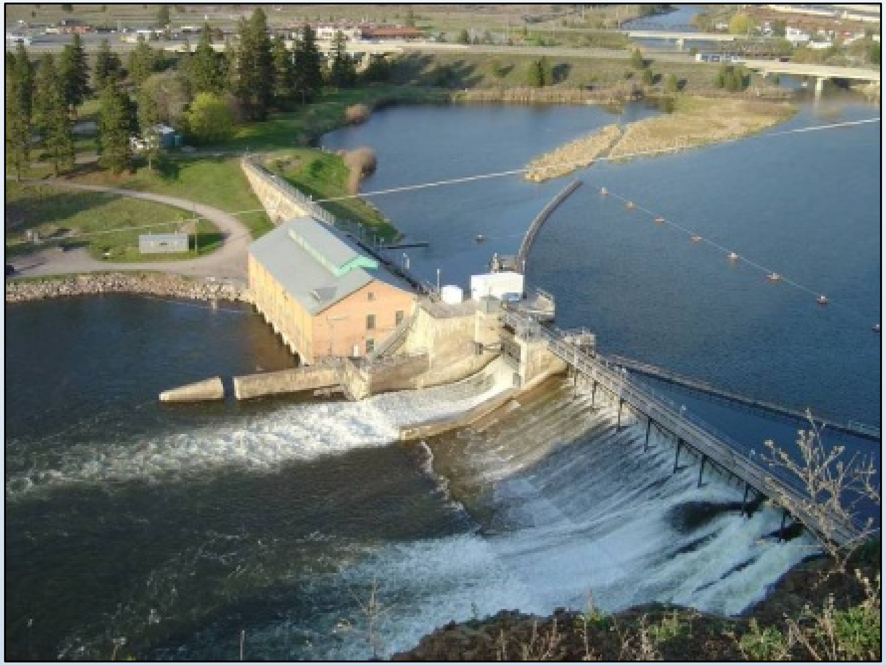
Some Questions Answered:

- TSS: what is the TSS at a specific location at a specific time (temporal range days - years)?
- Morphology:
  - what is the morphology change in the Clark Fork over time since dam removal
  - what is the fate of the impounded sediment that were not removed during dam removal operations?



Milltown Dam, MT at the confluence of the Clark Fork and Blackfoot Rivers.

Case Study: 2-D and 3-D Sediment transport modeling at Milltown Dam, MT



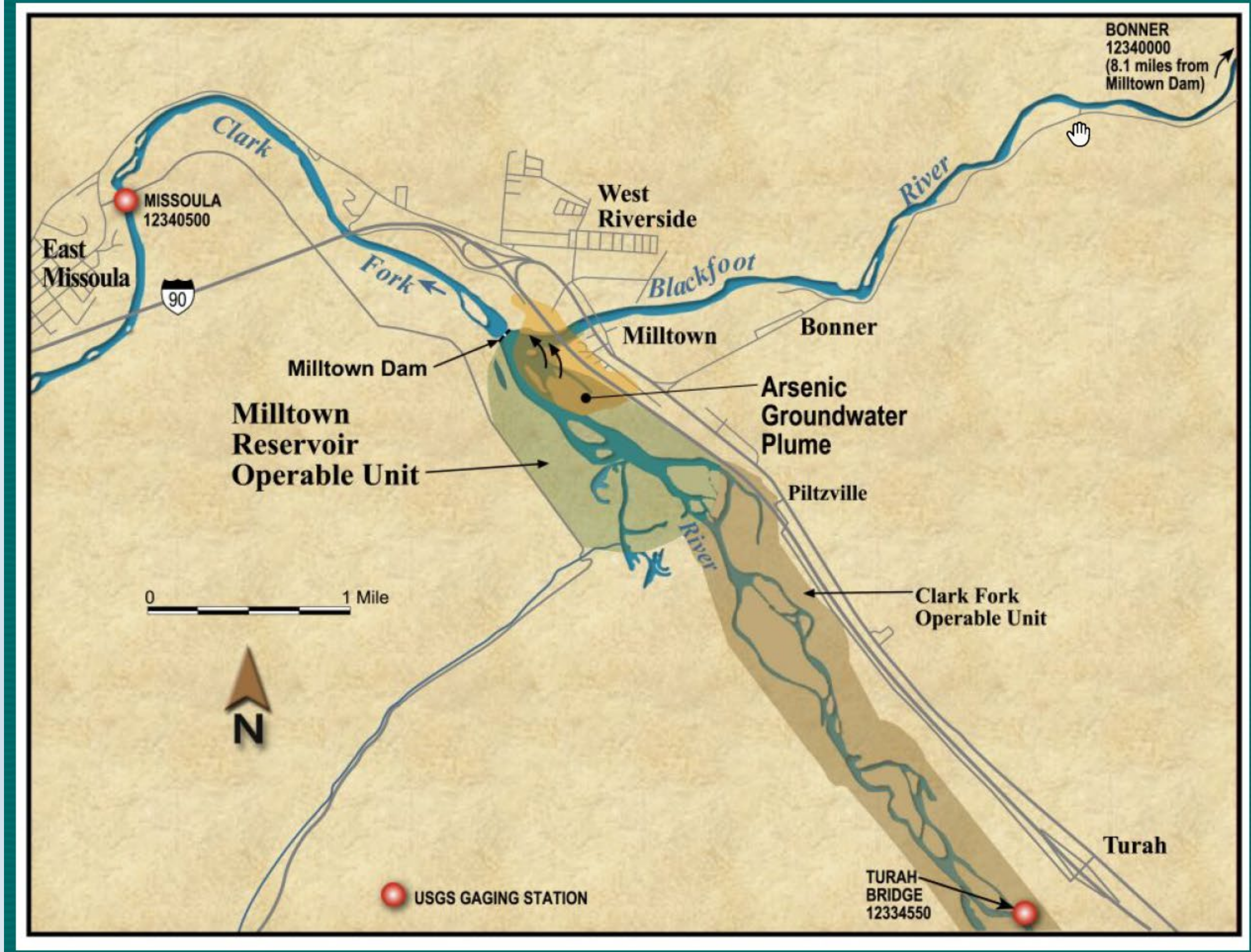
Milltown Dam, MT at the confluence of the Clark Fork and Blackfoot Rivers.

- From the 1860s until well into the 20th century, mineral- and arsenic-laden waste from mining activities in the region flowed into the headwaters of the Clark Fork.
- These mining activities and the downstream transport of mining-related wastes contaminated sediment, surface water and groundwater with heavy metals (Cu, As, Pb, Cd, and Zn).
- 28-ft dam constructed in 1907.
- Flood of record in 1908.
- 6.6 mcy of contaminated sediments accumulated behind the Milltown Dam over time.

1908 Flood – Transports Sediment from Upstream Mining and Smelting Areas

- Superfund site 1983: Milltown Reservoir Sediments/Clark Fork River site
- Includes ~ 120 miles of the Clark Fork upstream of the Milltown Dam.
- EPA decided to remove the dam in 2004.
- Dam removed in 2008.
- 2.2 mcy (of 6.6 mcy) of impounded fine-grained sediment removed.
- One reason for removal was concern that the aging dam may fail and release large amount of contaminated sediment downstream.
- Performed integrated NWS Dam break modeling and 1D sediment transport modeling in the early 1990s.

Milltown Dam Location and History



- Built 1907
- 7 million cu yds of sediment
- Geochemistry results in mobilization of arsenic from sediment, creating a groundwater plume

Milltown Dam Removal Case Study


April 2009 Post Dam Removal


2012 Restoration Construction


2016 Restored Floodplain


2016 Restored Floodplain from Upstream

Case Study: 2D and 3D Sediment transport modeling at Milltown Dam, MT

2-D & 3-D Sediment Transport Modeling

Public Information Repositories

- EPA provides space for the public to view records related to Superfund work at the site.

- EPA Superfund Records Center
  Montana Office
  10 West 15th Street, Suite 3200
  Helena, MT 59626

LTFATE Model Development

- Selection of model domain


LTFATE Model Domain for 2D & 3D Hydrodynamic and Sediment Transport Modeling
Clark Fork at Superior MT USGS 12353650
Blackfoot River near Bonner MT USGS 12340000
Clark Fork above Missoula MT USGS 12340500
Bitterroot River near Missoula MT USGS 12352500
Location of former Milltown Dam
Clark Fork near Drummond MT USGS 12331800
Rock Creek near Clinton MT USGS 12334510

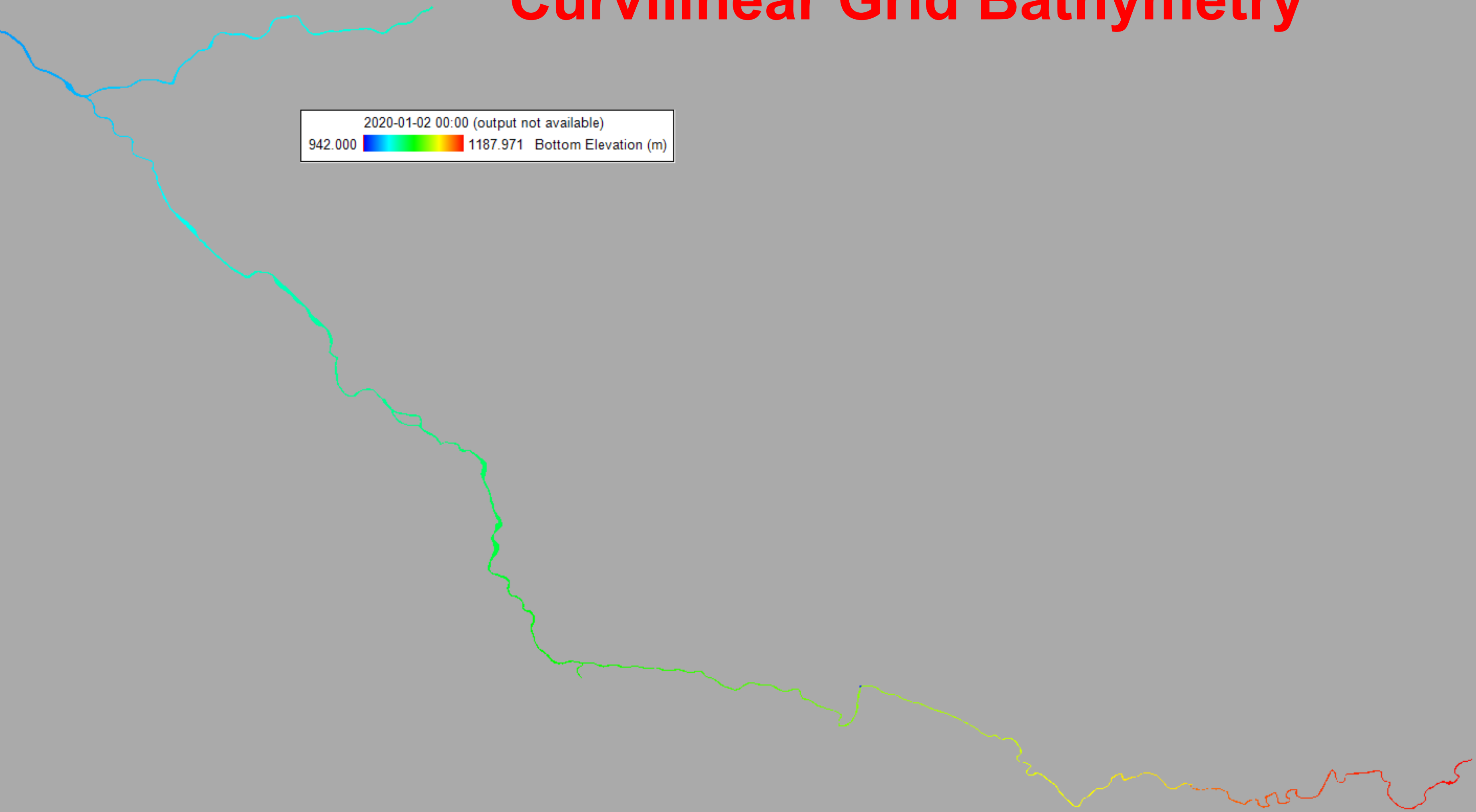
LTFATE Model Development

Development of 2D curvilinear grid

- 45,850 quadrilaterals cells
- Six lateral cells in every river
- Five vertical layers were used in the 3D model

Curvilinear Grid for LTFATE

Curvilinear Grid Bathymetry



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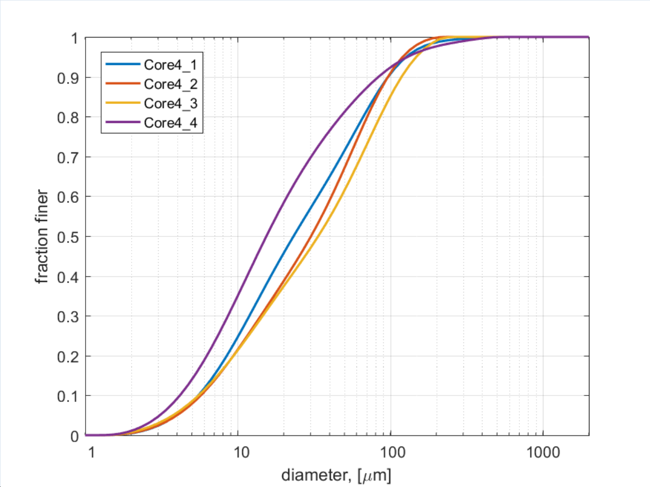
Multi-Dimensional Model Development

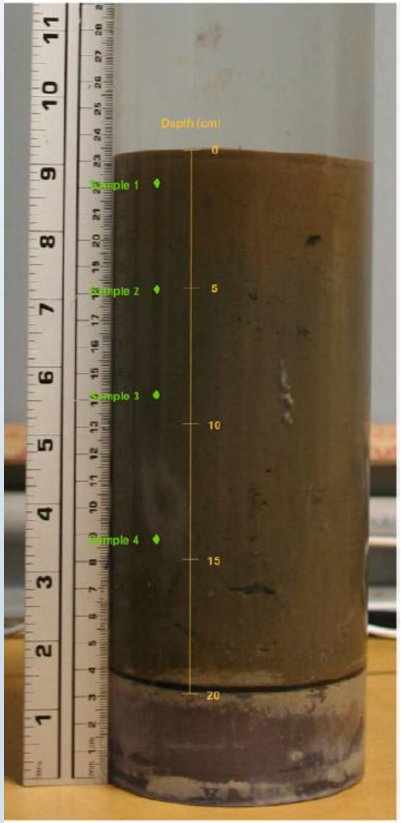
- Prepare boundary conditions for hydrodynamic model – stage time series at the downstream boundary, and discharge time series at the upstream boundaries of the Clark Fork, Blackfoot, and Bitterroot Rivers.
- Prepare boundary conditions for the sediment transport model – discharge-TSS rating curves at the upstream boundaries.
- Sediment grain size distributions are needed to represent the sediment properties in the rivers and floodplains.
- Erosion rates and other properties of cohesive sediment and mixed sediment need to be measured using special equipment (Sedflume).

Measurement of Erosion Rates for Cohesive and Mixed Sediments

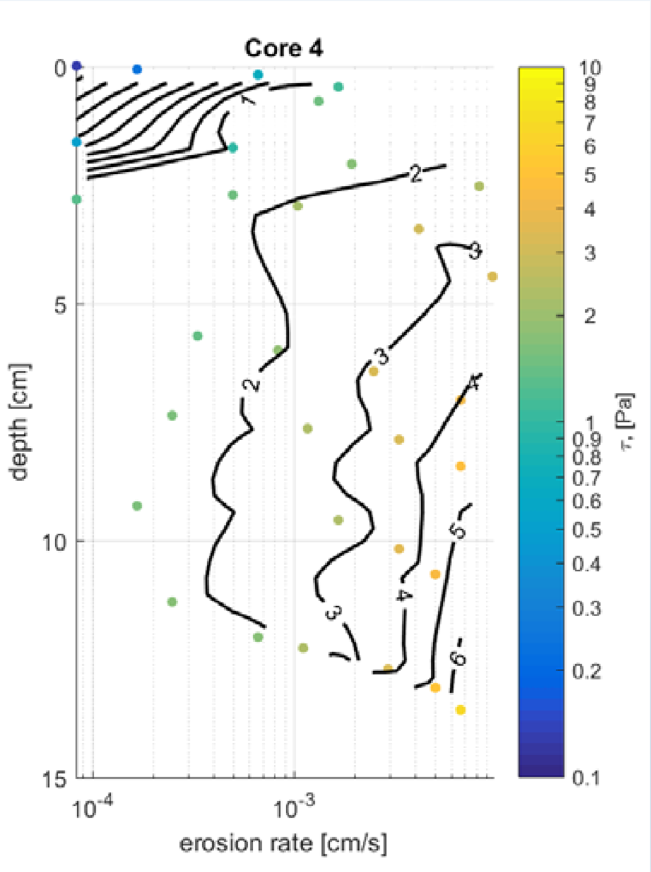
Model Input Requirements:

- Sediment characterization
  - cores (sediment grainsize, density, and critical shear stress described vertically within bed)
  - Sediment settling rates
- Sediment load data for boundaries
- Hydrodynamic boundary conditions (WSE, flowrate, velocities)





Example: Sediment Core

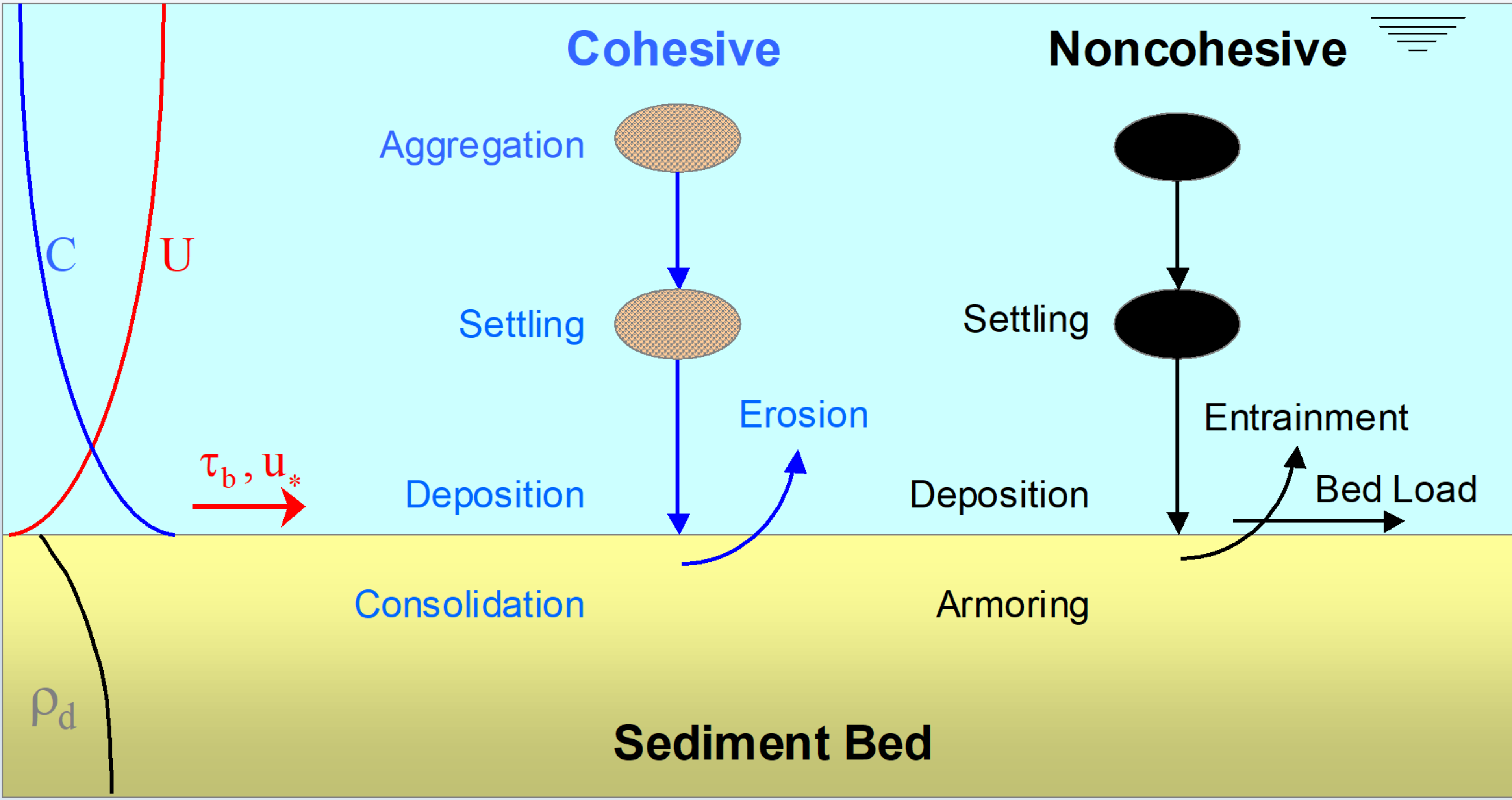


LTFATE Model Simulations

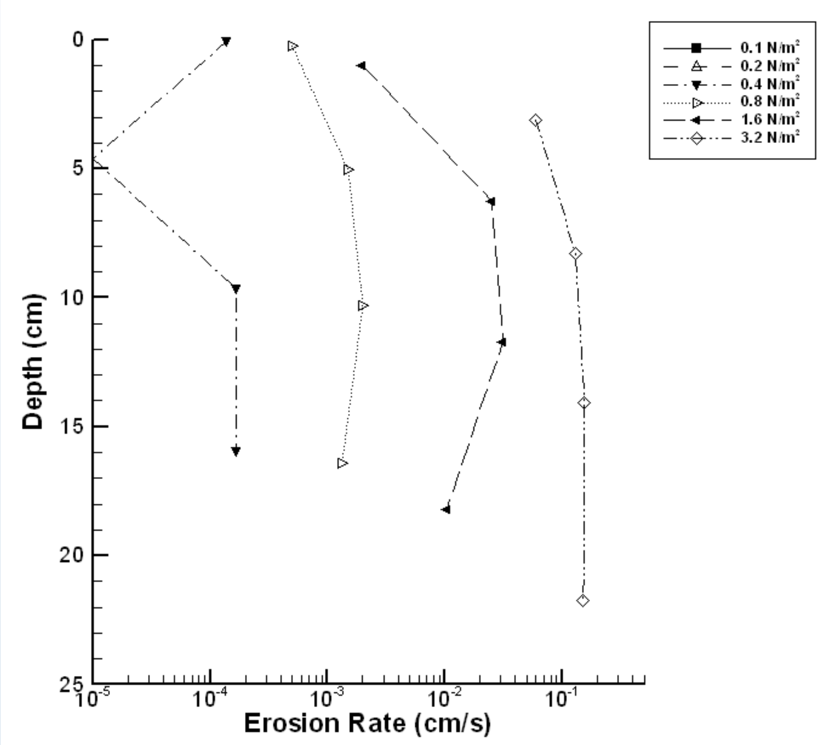
Sediment Transport Model

- Seven grain sizes are used – two cohesive and five noncohesive size classes
- Grain sizes: 10, 40, 180, 425, 750, 1500 and 3000 μm
- Effect of bed slope on bedload transport and erosion rate is represented
- Changes in bottom elevations due to erosion and deposition are accounted for in calculating the flow field during the next time step

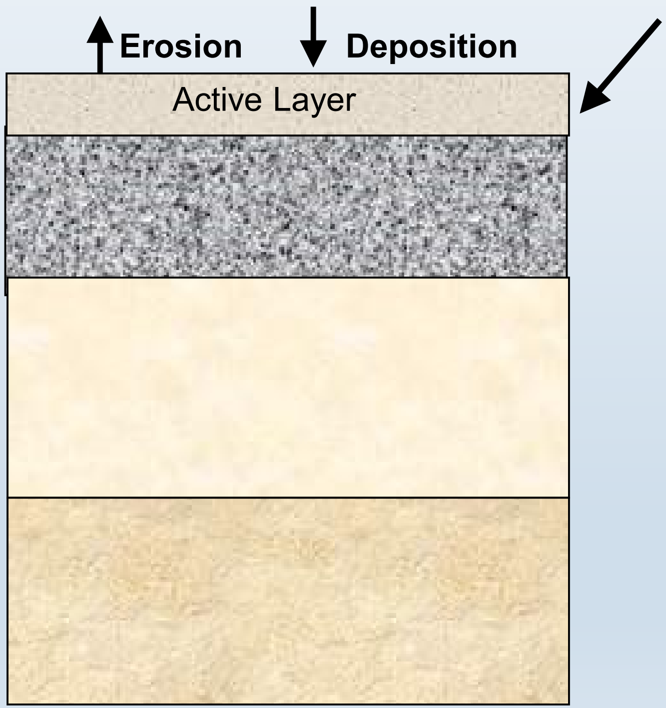
Sediment Transport Model in LTFATE



Sediment Bed Dynamics



Active Layer Dynamics



Active layer facilitates coarsening through the use of measured quartz erosion rates. The multiple bed layers in **SEDZLJ** accounts for the exchange of sediment through and change in composition of this layer. Active layer thickness = *F*(mean sediment diameter, critical shear stress for resuspension, bed shear stress)

LTFATE Model Simulations

Pre-Dam Removal

- 2D and 3D hydrodynamic model calibrated and validated
- Simulated sediment transport in the Blackfoot River and upstream Clark Fork, and sediment transport in the Clark Fork downstream of the dam to insure it could represent a) passage of fine-grain sediment through the dam, and b) sedimentation on the downstream flood plain following a flood event.

Post-Dam Removal

- 2D and 3D hydrodynamic model calibrated and validated
- Represented the changed morphology in the impoundment of the former reservoir in the sediment transport model
- Performing simulations to track the transport of eroded sediments from the former impoundments to the downstream reaches of the Clark Fork by using extra sediment size classes to represent the impounded sediments.

Summary

- We can use predictive sediment transport models and tools to address some of concerns regarding sediment transport due to dam removal:
  - Morphology
  - Increase in turbidity
  - Risk
- We looked at a wide range of methods and technologies to help categorize and understand appropriate model usage.
- Determining which tool to use is dependent on resources and the specifics of the question/concern. We need to understand:
  - Data requirements
  - Benefits
  - Limitations/Assumptions

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Dam Removal Webinar Series

Oct 27 **Part 1: Overview of Dam Removal**
- **1A** – Overview of dam removal
- **1B** – Synthesis of the science and case studies

Nov 3 **Part 2: Sediment Management**
- **2A** – Conceptual overview of sediment management
- **2B** – Sediment risk assessment, sediment quality, regulatory issues

Nov 10 **Part 3: Assessment Methods**
- **3A** – Overview of tools and techniques
- **3B** – Rapid sediment analyses to inform restoration planning in Moodna Creek, New York

Nov 19 **Part 4: Modeling Techniques**
- **4A** – Simkins case study…
- **4B** – Milltown case study…

Coming later this spring....

If you missed any webinars, they can be viewed at:
https://emrrp.el.erdc.dren.mil/webinars.html