HOW TO DEAL WITH SEDIMENT IN DAM REMOVAL

Fish Passage Workgroup:
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  – universities, consultants, & NGOs
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• Tom Augspurger, USFWS
• Subcommittee on Sedimentation
  – Sponsoring Organization
History of Dam Removal

Cumulative number of dams removed by year

Courtesy of Ryan Bellmore (USFS) and Jeff Duda, USGS
Guidelines needed for a wide range of dam removals

- Gold Hill Dam, Rogue River, OR
- Matilija Dam, Matilija Creek, CA
- Elwha Dam, Elwha River, WA
- Savage Rapids Dam, Rogue River, OR
- Chiloquin Dam, Sprague River, OR
- Glines Canyon Dam, Elwha River, WA
and a wide range of sediment issues

Former site of Chiloquin Dam

Reservoir sediment behind Matilija Dam

Reservoir sediment in Lake Mills behind Glines Canyon Dam
U.S. Subcommittee on Sedimentation: Dam Removal Analysis Guidelines for Sediment

Objective:

Provide a national guideline to link the risk of sediment impacts to the level of data collection, analysis, modeling, and sediment management alternatives.
GUIDELINE PROCEDURES

1. Identify Objectives
2. Collect Data
3. Determine Sediment Volume
4. Estimate Risk
5. Develop Dam Removal and Sediment Management Plans
6. Conduct Sediment Analysis
7. Assess Uncertainty
8. Sediment Impacts Tolerable?
9. Monitoring and Adaptive Management
Step 3 - Reservoir Sediment Probability Determination

- Estimate expected reservoir sediment erosion
  - <50%?
  - 50 to 75%?
  - > 75%?

- River Erosion
  - wide or narrow reservoir relative to river?
  - cohesive or non-cohesive?

- Mechanical Removal

- Reservoir Stabilization

[Images of river and reservoir with trees and water]
Step 3: Probability of Sediment Impact: Relative Reservoir Sediment Volume

The ratio of reservoir sediment volume ($V_s$) to mean annual sediment load ($Q_s$) is used to classify the impact:

- **Negligible** when $V_s / Q_s < 0.01$
- **Small** when $0.01 < V_s / Q_s < 0.1$
- **Medium** when $0.1 < V_s / Q_s < 1$
- **Large** when $V_s / Q_s > 1$

**For ratio convert volume to mass using bulk density**

**RECLAMATION**
Criteria for Negligible Reservoir Sediment Volume ($V_s$)

- $V_s < 0.1 \ Q_s$
- Alternate Reconnaissance Criteria
  - $W_{\text{reservoir}} / W_{\text{channel}} \leq 1.5$
  - Dam height $\leq$ bank-full height in alluvial reach
  - Little or no sediment found by visual observations or probing
  - Longitudinal profile does not reveal a sediment wedge
  - Sediment volume less than a sand or gravel bar
Step 4: Potential Impacts

Reservoir Area
- Headcut into infrastructure
- Non-native vegetation
- Non-native fish
- Well yield reduction

Downstream River
- Burial of habitat
- Elevated sediment loads
- Flood increase
- Erosion of property
- Burial of water intakes

*Tullo et al, 2016*
Categorize Sediment Consequences

<table>
<thead>
<tr>
<th>Low</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
</table>

- Fine vs coarse sediments
- Short-term vs long-term
- Localized or reach-scale
- Consider the benefits of restored sediment
Risk - Key Guideline Concept

**Risk = Probability × Consequence**

- **Probability**: reservoir sediment volume relative to mean annual sediment load (~ river’s ability to handle it)
- **Consequences**: potential sediment impacts should they occur (does impact matter?)
- **Guidance draws from**: EPA ecological risk framework, Reclamation Dam Safety, ACOE Levee Design

*Greater the risk, the greater the level of investigation*
Step 4: Risk Estimates

EPA defines risk: probability of harmful effects to receptors (human health, ecological systems, etc) resulting from exposure to an environmental stressor (sediment in this case).

<table>
<thead>
<tr>
<th>Probability of fine or coarse sediment impact (Sediment Exposure)</th>
<th>Consequence of Sediment Impact (Receptor Sensitivity)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
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<tr>
<td>Small</td>
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</table>
### Step 6: Sediment Analysis Tools

#### Sediment Risk Category

<table>
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<tr>
<th>Negligible</th>
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<th>Large</th>
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</thead>
<tbody>
<tr>
<td>Simple computations</td>
<td>Sediment wave model</td>
<td>Sediment transport capacity</td>
<td>1D or 2D sediment model, laboratory model, field test</td>
</tr>
</tbody>
</table>

- Develop conceptual model
- Total stream power calculations
- Mass balance calculations
- Geomorphic Analysis
Negligible Sediment Risk

• Divers found about 500 yds\(^3\) sediment, much less than an average annual sediment load and easily transported by river

• Cofferdam required more sediment than stored in reservoir
Low Sediment Risk

Chiloquin Dam, OR (2008)

- Sediment 20% - 30% of river’s mean annual transport capacity
- Sawed logs submerged in reservoir discovered after dam removal
- Main concern wood piling at bridge below dam
Moderate Sediment Risk: 1 to 2 yrs average annual supply sediment

Savage Rapids Dam, OR
Savage Rapids Outcome

• Few downstream pools filled with sediment - no flood increase
• Short-term turbidity increase - within range of flood flow
• Burial of water intake just downstream of dam required excavation - flushed by 2-year flood one year post removal
Guideline Completion

- Add more case examples to increase relevancy
- Share guidelines for interagency review
- Finalize and post online