Introduction to Sediment Management

Dam Busters 101

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Mass Audubon

Sediment trapped behind a dam (dewatered conditions)

Thanks to my dam removal mentor → Mike Chelminski, PE

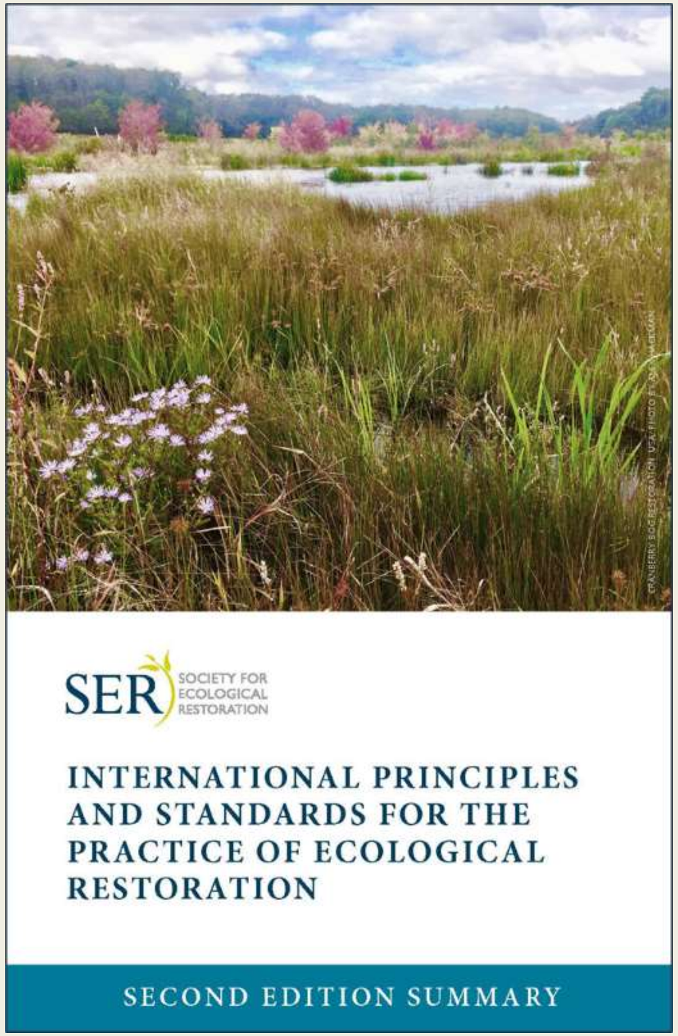
Photos by Alex Hackman unless otherwise noted (MA Division of Ecological Restoration 2007-2022).
Views and opinions herein by Alex Hackman as a dam removal practitioner and do not necessarily reflect the formal positions of Mass Audubon

Sediment trapped behind a dam (dewatered conditions)

Ecological Restoration

The process of assisting the recovery of an ecosystem that has been damaged, degraded, or destroyed

Massachusetts rivers are severely DEGRADED from thousands of human dams in place for 100+ years.



Assisting in recovery means…

- Repairing processes
- Restoring connectivity
- Involving people

1. **Take actions that allow nature to take care of itself**

   Identify stressors that limit recovery, carefully plan and take actions, monitor changes, and help ecosystems heal themselves.

2. **Remove barriers to re-connect ecosystems**

   Well-connected ecosystems allow organisms, energy, and material to flow freely across the landscape within and between different habitats.

3. **Engage people for wisdom and long-term care**

   We succeed by listening to and working with neighbors, farmers, Tribes, watershed groups, politicians, and many others.

Recent dam removal downstream. Restored channel and floodplain upstream here. Note the smile.

Takeaways from today:

1. Remove dams to restore rivers
2. Keep sediment in rivers to restore *even more*
3. Use costly dredging and off-site disposal only for significant risks
4. Evaluate local conditions to decide

Remove Dams to Restore Rivers

Bartlett Rod Shop Co. Dam Removal (2012)
Amethyst Brook, Pelham, MA

This river is **degraded**. The dam blocks fish passage and ruins critical natural processes for a healthy river (e.g., hydrology, sediment, and organic matter regimes)

Bartlett Rod Shop Co. Dam Removal (2012)
Amethyst Brook, Pelham, MA

For 150+ years…sediment and wood trapped upstream; fish unable to reach cold headwaters

“Degraded” = long term negative impact. **Note that existing laws and regulations let this happen**.

During removal (2012)
Engineered by Stantec Consulting Services. Constructed by SumCo Eco-Contracting

Removal complete December 2012

This bank looks a little odd because sediment was pushed here during dam removal for "timed release" over the coming years as the river evolves. This is one of many creative options teams can employ to manage sediment for lower cost and more benefit

Project Partners

Thank you!

2 years later: Critical river processes restored, healthier river, and no negative impacts

Benefits:

- Connectivity
- Water quality
- Resilience
- Dynamism
- Floodwater storage
- Public safety
- Owner liability reduced

We see these benefits over and over again. They are documented in local studies that mirror decades of findings from around country and world.

Removing dams restores river

October 26, 2012

Downstream…just before dam removal. Looks nice but this is poor quality fish habitat (too rocky!)

Photo credit: Robin MacEwan, Stantec Consulting Services

November 9, 2012

During dam removal. Storms mobilized several thousand CY of sediment downstream

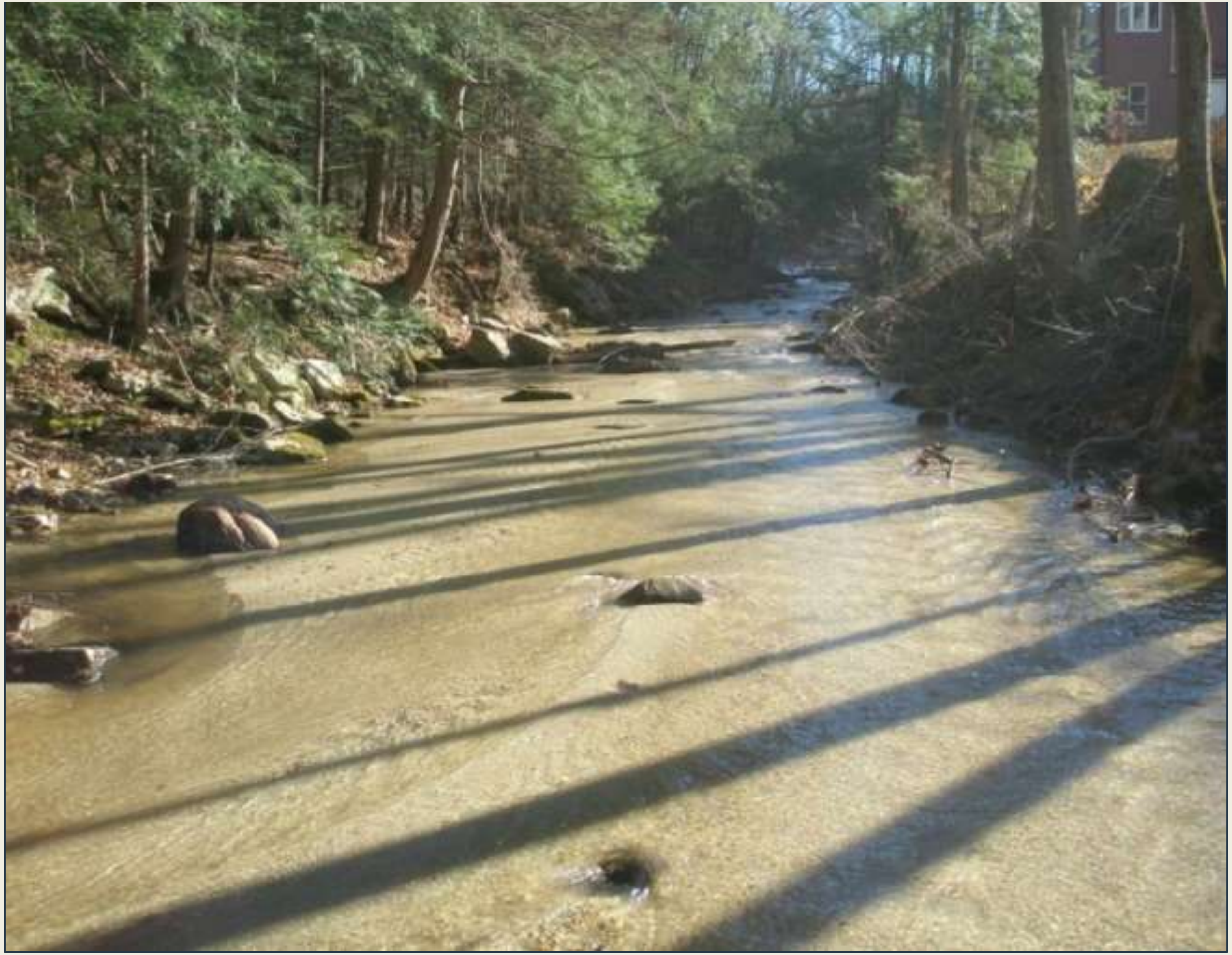


Photo credit: Robin MacEwan, Stantec Consulting Services

December 6, 2012

1 month later…the river already converting temporary impacts to benefits

Photo credit: Robin MacEwan, Stantec Consulting Services

June 6, 2013

6 months later: Dramatic improvements to in-stream habitat

Dam removals involve short term impacts, but yield permanent, and well-understood benefits that address decades of ecosystem degradation

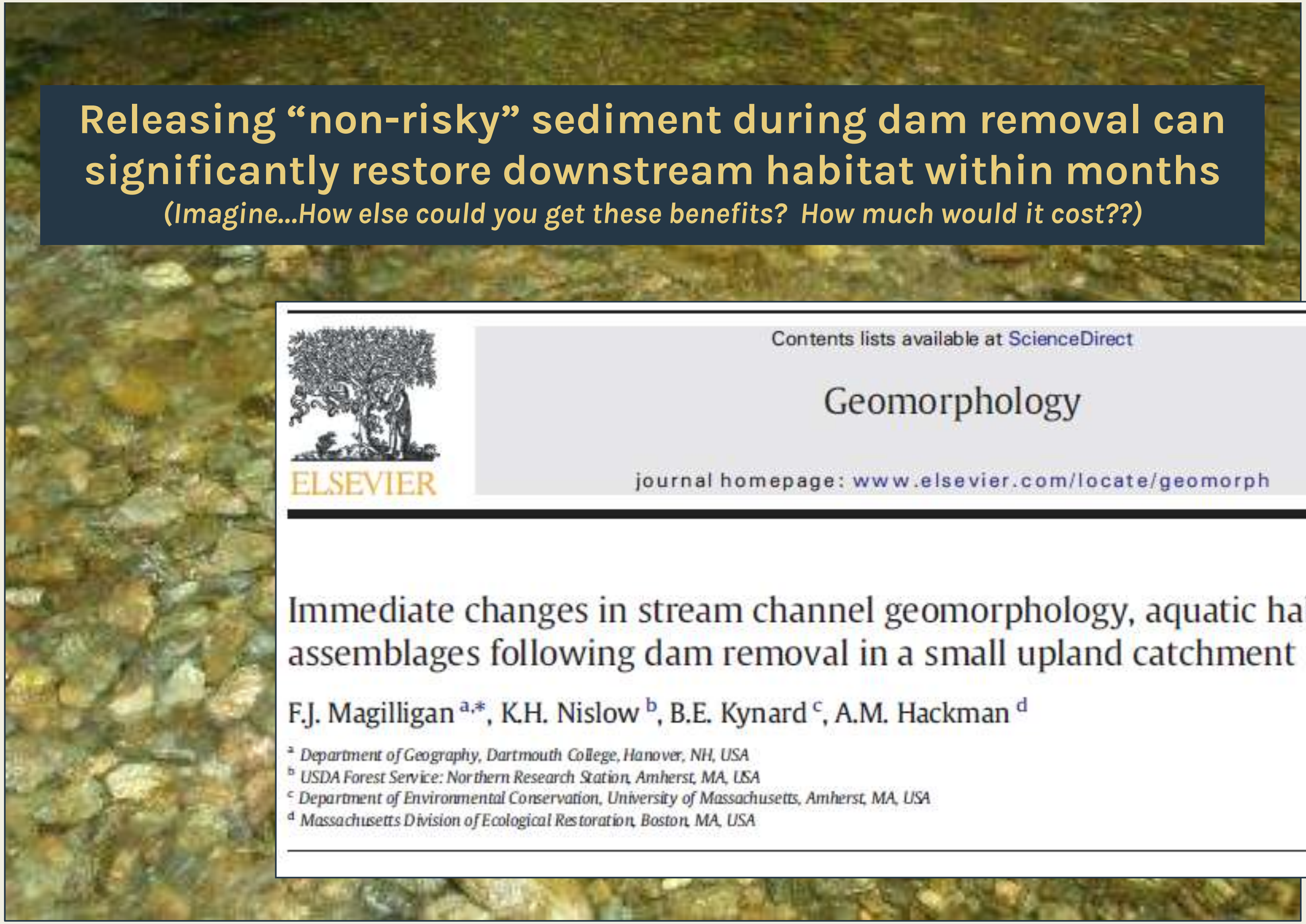
In-stream sediment management is allowable and permittable under existing regulations

Photo credit: Robin MacEwan, Stantec Consulting Services

June 6, 2013

Sea lamprey return for first time in decades

This is how **sediment release can drive downstream habitat restoration**!



Releasing "non-risky" sediment during dam removal can significantly restore downstream habitat within months

(Imagine...How else could you get these benefits? How much would it cost??)

Contents lists available at ScienceDirect

Geomorphology

journal homepage: www.elsevier.com/locate/geomorph

Immediate changes in stream channel geomorphology, aquatic habitat, and fish assemblages following dam removal in a small upland catchment

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Photo credit: Robin MacEwan, Stantec Consulting Services

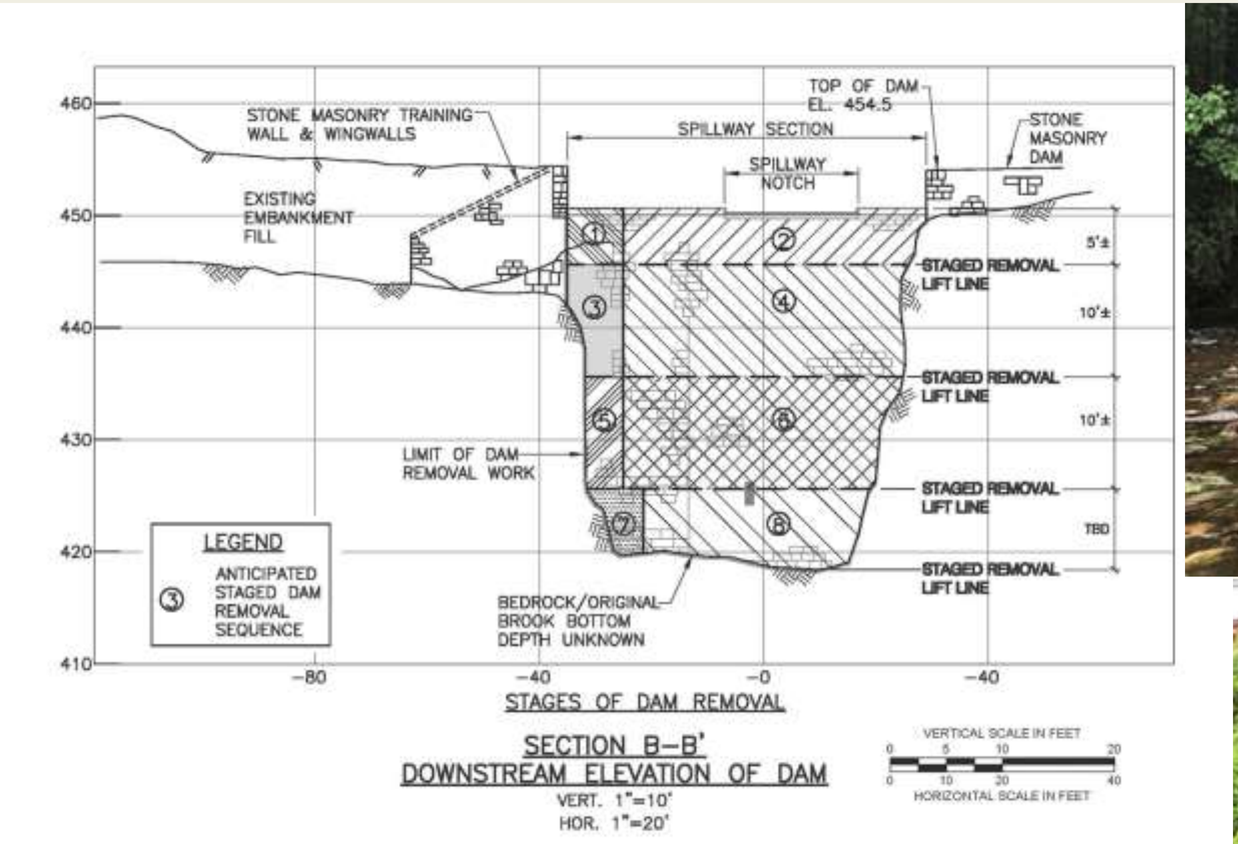
Keep sediment in rivers to restore *even more*

In-stream sediment management

Dewatering an impoundment in advance of dam removal can help firm up impounded sediment and make management easier

3 months later sediment is stabilized by native vegetation (without seeding)

Staged removal with downstream monitoring allowed this project to save $900,000, kept 10k CY of sediment in the river, and improved trout habitat



Make in-stream sediment management your default approach. Your sediment evaluation can try to prove it infeasible from a risk perspective. If not risky, keep the sediment in rivers for more restoration.

Upper Roberts Meadow Brook (Northampton)
Engineer: GZA
Images: Matt Taylor, PE
Contractor: SumCo

Give the ecosystem time to heal itself. The channel form, banks, and floodplain will find equilibrium over time. Only do costly channel construction and stabilization when you must (generally to protect infrastructure)

Thanks to Matt Taylor at GZA for these photos and his great work on this project

Use costly dredging and disposal only for significant risks

- Abundant solid waste, sheens and strong petroleum odors, and very fine-grained sediment suggest higher potential risks

- Sampling and laboratory analysis will help confirm

- Testing upstream and downstream will help estimate background conditions and thoughtfully consider risks

Mill River (Taunton). Photo credit: Beth Lambert

Dredging, disposal, channel construction

- Extremely expensive
- Can add $millions to projects
- Substantial impacts
- Use only for significant sediment risks

West Branch Housatonic River (Pittsfield)

Evaluate local conditions to decide

How? There is no formal standardized guidance

- Existing Massachusetts regulations do **<u>not</u>** offer sufficient guidance for sediment management for dam removals

- Other state and federal level guidance exists but is not well suited for our setting

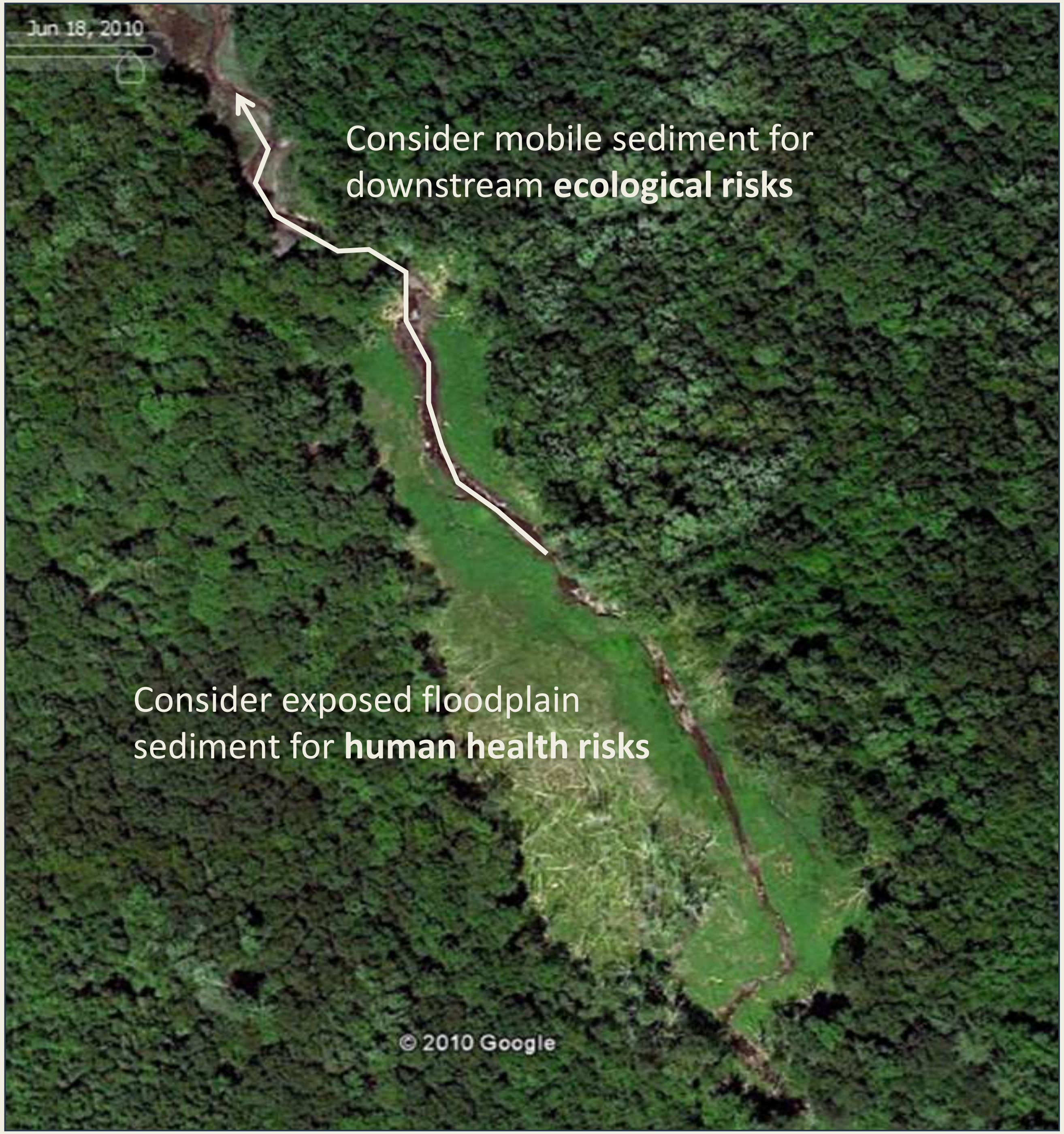
- Practitioners and DER have "**made it work**" over the past 15+ years and have developed tools to help

You must collect information*

- Stream, valley, and watershed characteristics, and land uses
- Potential for pollution (due diligence)
- Impounded sediment quantity, quality, and physical characteristics
- **Background sediment quality** (pollutants)
- Infrastructure

* See more detailed guidance at the end of this deck

Lower Dam, Ox Pasture Brook, Rowley



Mobile sediment = Material which erodes during natural channel reformation (or is dredged to construct a new channel)

Consider surrounding built environment for infrastructure risks

Infrastructure is assessed by the project engineer
This location = high infrastructure risks. Not all sediment related risks are about pollution!

Risks relative to what?

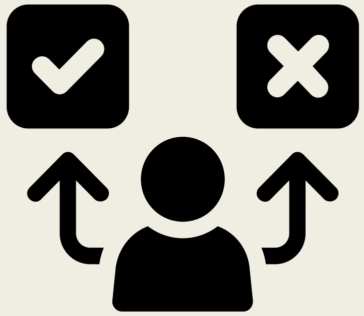
- How do the risks of a dam remaining in place compare to potential short-term risks from sediment mobilization?

- How does a potential release of sediment from a dam compare to what happens every storm event? Or over the course of a year?

Let's get real!

Roadway sand and salt pile underneath a storm drain and on a frozen stream

You must decide:



Would passive sediment management result in the following:

1. Degrade the downstream ecosystem?
2. Create new human health and exposure risks in the floodplain?
3. Put local infrastructure at increased risk?

- If no, use passive sediment management. Remember the benefits!
- If maybe, try to mitigate and develop hybrid approaches
- If yes, select the very costly and damaging dredging and disposal option

You will need tools, experts, and additional training

- Experts to call on
- Knowledgeable consultants
- Skilled contractors
- Sediment Quality Evaluation Tool (MA DER) →
- Much more in-depth training

Standard Analyses for Dam Removal Projects (adjust if due diligence suggests additional pollutant risks)		**Ecological Thresholds (aquatic)**				**Human Exposure Thresholds (upland/floodplain)**			Method 1 Soil Standards (MCP)
Parameters	Units	Freshwater		Marine		Direct Contact	Direct Contact	Direct Contact	*(for comparison)*
		TEC/TEL	PEC/PEL	TEL	PEL	Method 2 (S-1)	Method 2 (S-2)	Method 2 (S-3)	S-1 / GW-1
Metals, Total [mg/kg or ppm]									
Arsenic (ppm)	mg/kg (ppm)	9.79	33.00	7.24	41.60	20	20	50	20
Cadmium (ppm)	mg/kg (ppm)	0.99	4.98	0.68	4.20	70	100	100	70
Chromium (TOTAL)(ppm)	mg/kg (ppm)	43.40	111.00	52.30	160.00	100	200	200	100
Chromium III (ppm)	mg/kg (ppm)					1,000	3,000	5,000	1,000
Chromium VI (Hexavalent) (ppm)						100	200	200	100
Copper (ppm)	mg/kg (ppm)	31.60	149.00	18.70	108.00				
Lead (ppm)	mg/kg (ppm)	35.60	128.00	30.24	112.00	200	600	600	200
Mercury (ppm)	mg/kg (ppm)	0.18	1.06	0.13	0.70	20	30	30	20
Nickel (ppm)	mg/kg (ppm)	22.70	48.60	15.90	42.80	600	1,000	1,000	600
Zinc (ppm)	mg/kg (ppm)	121.00	459.00	124.00	271.00	1,000	3,000	5,000	1,000
PAHs (ug/kg or ppb)									
Acenaphthene	ug/kg (ppb)	7	89	7	89	1,000,000	3,000,000	5,000,000	4,000
Acenaphthylene	ug/kg (ppb)	6	128	6	128	1,000,000	3,000,000	5,000,000	1,000
Anthracene	ug/kg (ppb)	57	845	47	245	1,000,000	3,000,000	5,000,000	1,000,000
Benz[a]anthracene	ug/kg (ppb)	108	1,050	75	693	7,000	40,000	300,000	7,000
Benzo[a]pyrene	ug/kg (ppb)	150	1,450	89	763	2,000	7,000	30,000	2,000
Benzo[b]fluoranthene	ug/kg (ppb)					70,000	400,000	3,000,000	7,000
Benzo[g,h,i]perylene	ug/kg (ppb)					1,000,000	3,000,000	5,000,000	1,000,000
Benzo[k]fluoranthene	ug/kg (ppb)					70,000	400,000	3,000,000	70,000
Chrysene	ug/kg (ppb)	166	1,290	108	846	70,000	400,000	3,000,000	70,000
Dibenz[a,h]anthracene	ug/kg (ppb)	33	135	6	135	700	4,000	30,000	700
Fluoranthene	ug/kg (ppb)	423	2,230	113	1,494	1,000,000	3,000,000	5,000,000	1,000,000
Fluorene	ug/kg (ppb)	77	536	21	144	1,000,000	3,000,000	5,000,000	1,000,000
Indeno[1,2,3-cd]pyrene	ug/kg (ppb)					7,000	40,000	300,000	7,000
Naphthalene	ug/kg (ppb)	176	561	35	391	500,000	1,000,000	3,000,000	4,000
Phenanthrene	ug/kg (ppb)	204	1,170	87	544	500,000	1,000,000	3,000,000	10,000
Pyrene	ug/kg (ppb)	195	1,520	153	1,398	500,000	1,000,000	3,000,000	1,000,000
Total PAHs (ppb)	ug/kg (ppb)	1,610	22,800	1,684	16,770				
PCBs (mg/kg or ppm)									
Total PCBs (ppm)	mg/kg (ppm)	0.06	0.68	0.02	0.18	1	4	4	1

We all need systems change

1. Set higher **expectations** for what is possible (aim for 1 dam per week across the state)

2. Issue **state guidance document** now in draft form (work with DER to finalize)

3. Devise and adopt **new laws and regulations** to encourage restoration (3 steps in 3 months)

4. Create a “polluted rivers **cleanup fund**”

5. Dedicate to learning and sharing (all of us)

Takeaways from today:

1. Remove dams to restore rivers
2. Keep sediment in rivers to restore *even more*
3. Use costly dredging and off-site disposal only for significant risks
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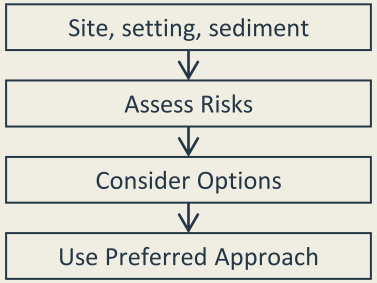
Extras

Recommendations for developing sediment management plans for dam removal projects



Recommended steps

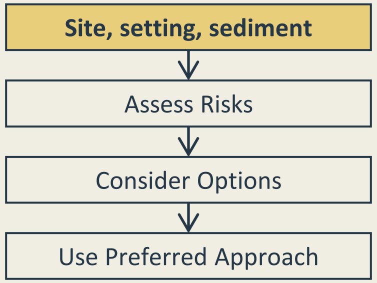
- Step 1 - Assess the **site, setting, and sediment** to develop baseline understanding and inform project risks and opportunities

- Step 2 - Assess **sediment-related risks** to ecology, human health, and infrastructure specific to the project setting

- Step 3 - **Review potential options** for sediment management and **consider best practices** to limit short term impacts

- Step 4 - **Select a preferred approach** for sediment management, describe it in a written Sediment Management Plan (SMP), and use for permitting, communication, project bidding, and implementation

Note – These topics are complicated and demand days of discussion to fully unpack. These slides only offer very high-level summary information.

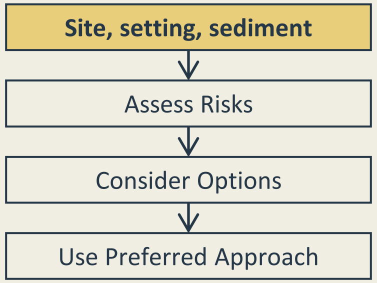


Step 1:
Get to know the site, setting, and sediment

1. **Desktop review and reconnaissance survey:** Inventory surrounding land uses, upstream and downstream habitat conditions, impoundment dewatering options, access to the impoundment, and sediment source and depositional areas

2. **Due diligence review:** Identify potential upstream pollutant sources and threats to sediment quality to help inform sampling design

3. **Sediment volume and physical characteristics:** Measure/estimate impounded sediment total volume and area, mobile sediment volume, and initial physical characteristics (e.g., grain size, cohesion) to inform sampling

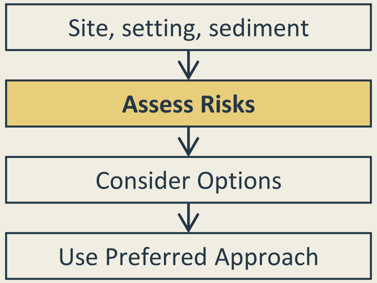


Step 1 (cont.):
Get to know the site, setting, and sediment

4. **Sampling frequency**: Estimate the number of samples needed to adequately characterize impoundment sediment quality

5. **Sediment sampling plan:** Write a plan to convey the logic and details of the assessment including number and location of samples (including upstream, downstream, and within the impoundment), and laboratory analyses; submit to DEP and review and approval

6. **Sample, analyze, compile data**: Perform field work and laboratory analysis. Manage data in a concise and useful spreadsheet to summarize sediment chemical and physical characteristics with comparison to risk thresholds



Step 2:
Assess sediment-related risks

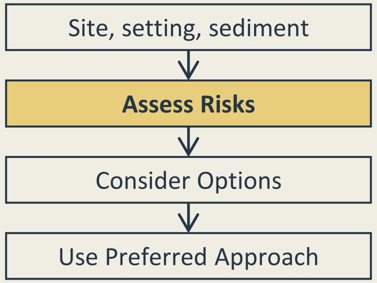
Three (3) dimensions of risk associated with impounded sediment should be considered for every dam removal project:

1. **Ecology** (stream channel focus)

2. **Human health and safety** (floodplain focus)

3. **Infrastructure and flooding** (river corridor focus)

For most dam removal projects, published pollutant thresholds will be used to screen for sediment risks to ecosystems and humans. Infrastructure risks are assessed by the project engineer.



Step 2:
Assess sediment-related risks

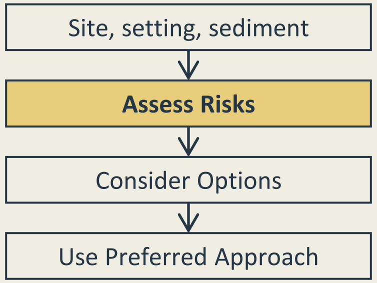
Ecology (stream channel focus)

- Goals: Identify potential for short term *significant* impacts from free petroleum product, and longer-term *significant* impacts from heavy metals, PAHs, and other persistent, bio-accumulative, and toxic (PBT) substances

- To screen: Compare the average concentration of pollutants in the impounded sediment to (1) ecological screening values* and (2) average background pollutant concentrations in the waterway (from Step 1)

- If significant risks are identified, then costly dredging and disposal of heavily polluted sediment is likely required

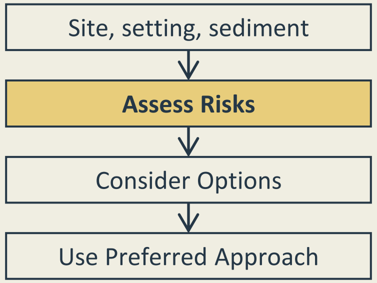
* Recommendations: For freshwater settings, use Probable Effects Concentrations (PECs; MacDonald et al, 2000). For marine settings, use Probable Effects Limit (PEL) from the NOAA Screening Quick Reference Tables (from MacDonald et al, 1996). These standards are found in the EXCEL tool available from MA DER. Note that empirical guidelines such as the PECs have many limitations including not addressing interaction effects, biomagnification, or site-specific uptake routes. More advanced methods are available for large complex projects.



Step 2:
Assess sediment-related risks

Human Health (floodplain focus)

- Goal: Identify significant pollutant concentrations where direct human contact with newly exposed and stabilized sediment in a restored floodplain may present health and safety risks*
- To screen: Use Method 2 Direct Contact Exposure-Based Soil Concentrations as thresholds from the Massachusetts Contingency Plan (MCP; 310 CMR 40.0000)
- Use S-1, S-2, or S-3 values based upon exposure scenarios: (1) Frequency of use, (2) intensity of use, and (3) accessibility to soil
- If pollutants are found > screening values, consider actions to mitigate risks (e.g., dense plantings, fencing, deed restrictions)



Step 2:
Assess sediment-related risks

Infrastructure and flooding (river corridor focus)

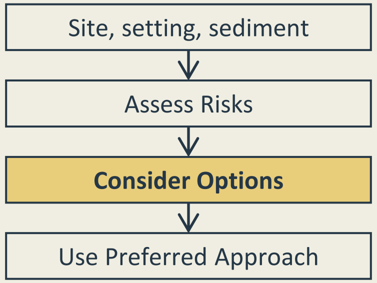
- Goal: Identify potential risks to upstream or downstream infrastructure (e.g., bridges, culverts, utility lines, water intakes) from stream bed erosion and sediment movement post dam removal
- To screen: Assessments should be done by the project engineer
- For many projects, there are no infrastructure risks because no infrastructure is present in the surrounding area.
- For others, some project adjustments may be necessary to counter identified risks.

Step 2 Output: Setting and Risk Summary Table

Setting:	Provide a description of the site, affected stream reach, and watershed (i.e., rural or urban). Focus on those issues describe the sensitivity of the setting as it affects potential sediment management options	
Risk Dimension	Risk Level	Discussion
Ecological	Low, Medium, or High	Describe basis for risk level assignment
Human health and safety	Low, Medium, or High	Describe basis for risk level assignment
Infrastructure and flooding	Low, Medium, or High	Describe basis for risk level assignment

Findings are the basis for (1) preferred sediment management approach, (2) best practices to limit short term impacts, and (3) monitoring

Step 3:
Consider Sediment Management Options

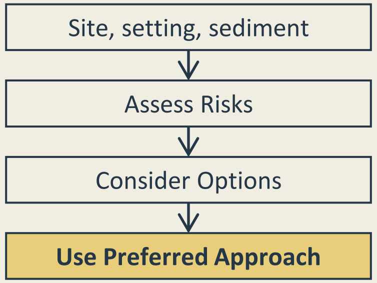


Common approaches

1. ‘In-stream’ sediment management
2. Partial dredging, partial in-stream management
3. Full dredging

Use of “Best Practices” to reduce short term impacts and/or risks

- E.g., Early impoundment drawdown, dam removal in stages



Step 4:
Select and implement a preferred sediment management approach

- Synthesize and articulate a preferred approach
- Develop a Sediment Management Plan (SMP)
- Considers multiple lines of evidence (risks, benefits, costs, tech feasibility) and best professional judgment
- Obtain permits and implement project – carry sediment related conditions (including monitoring) forward as needed