Remediation, Restoration, and Ecological Engineering

Penobscot River (Maine)

Site History – Orrington, ME – Penobscot estuary

- A mercury cell chlor-alkali facility operated within the estuary from 1967 – 2000
- Operations released ~ 10 tons of mercury into the estuary
- The most significant release period (70%? 80%? 90%?) occurred pre-1972 (CWA).

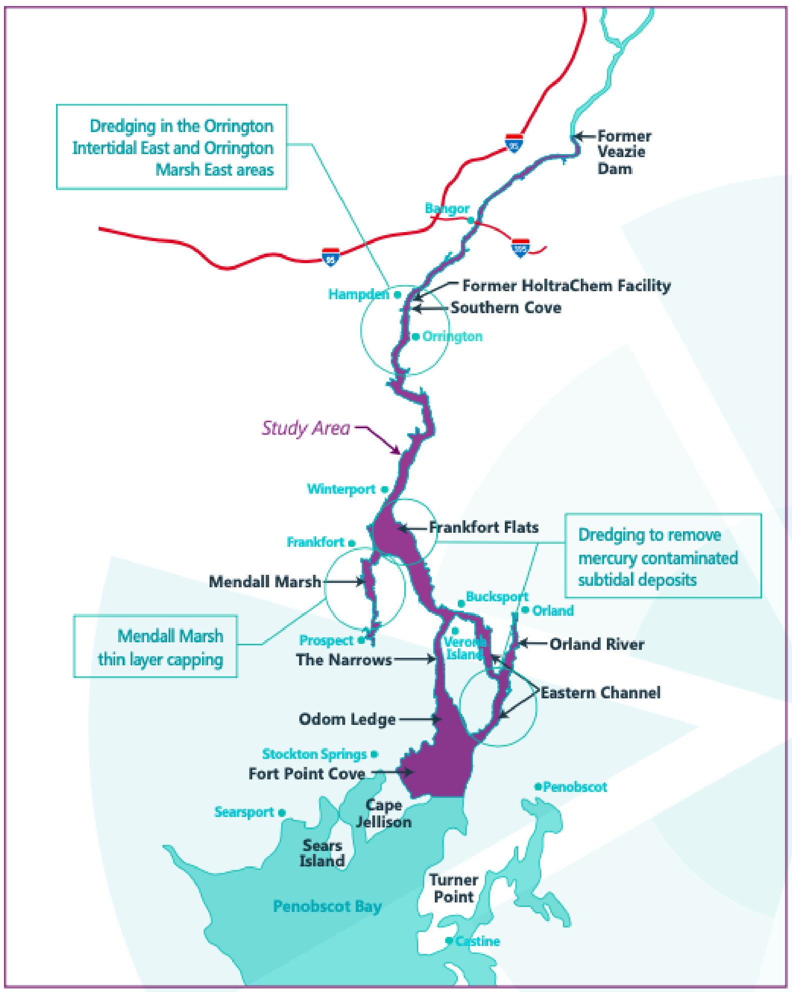
What Does Remedy Look Like?

Primary remedies - $187 million

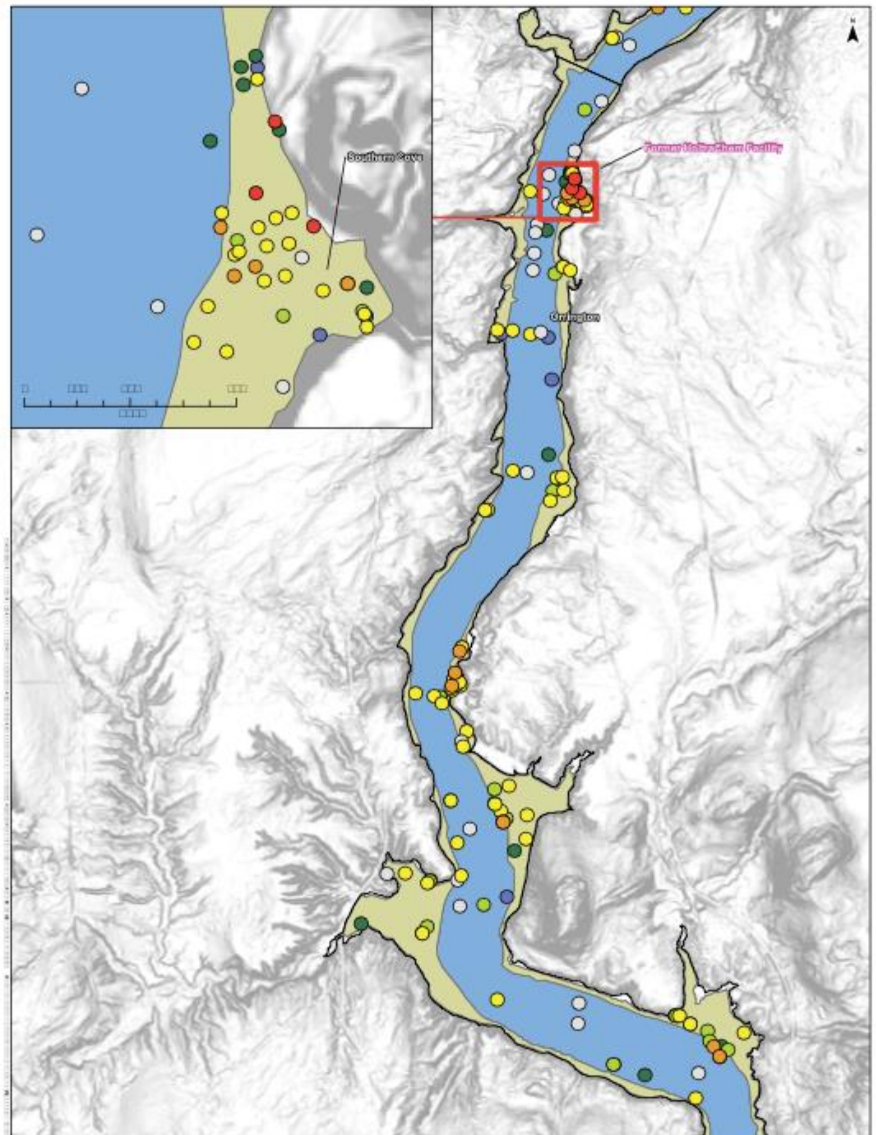
- Orrington Reach: $50 million
- Beneficial Environmental Projects: $20 million
- Targeted Mobile Sediment Removal: $70 million
- Orland River: $30 million
- Project Management: $7 million
- Long-Term Monitoring: $10 million

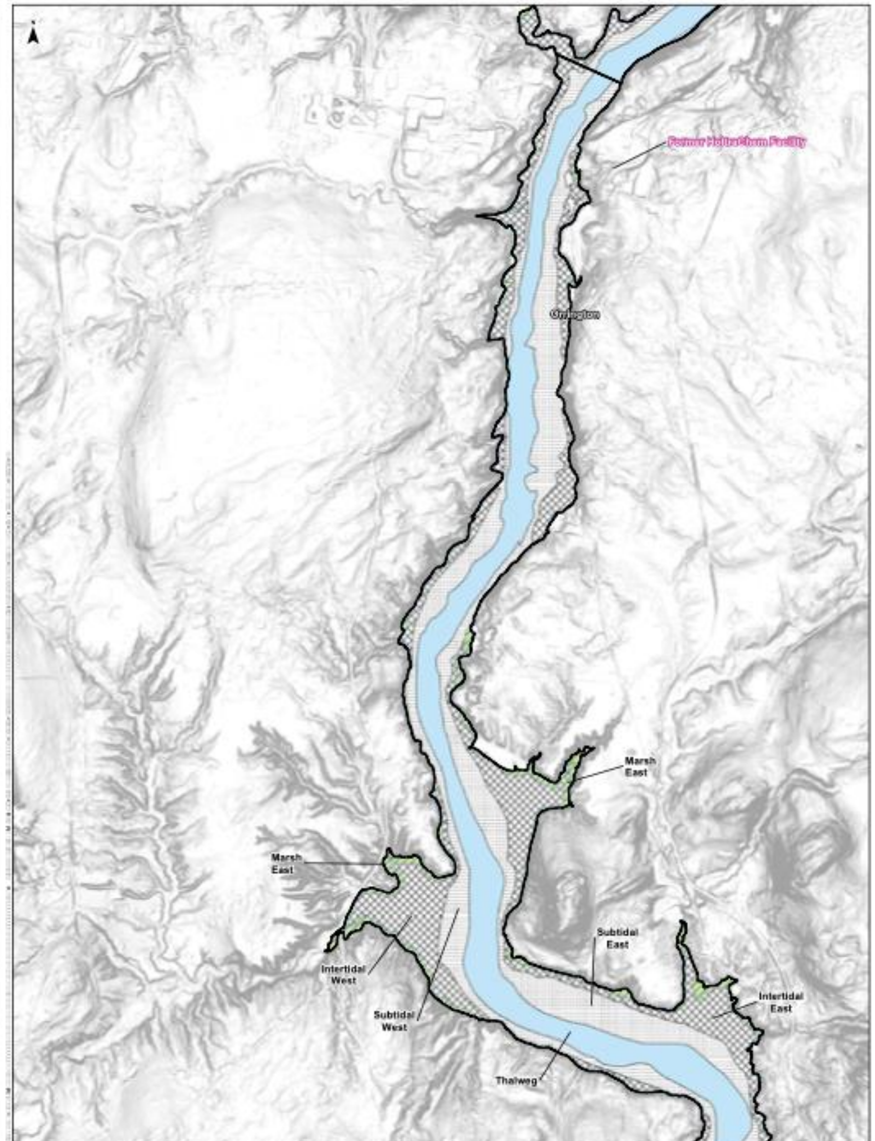
Contingent remedies up to $80 million, as follows:

- Orrington Reach: $10 million
- Targeted Mobile Sediment Removal: $50 million
- Project Management: $10 million
- Long-Term Monitoring: $10 million

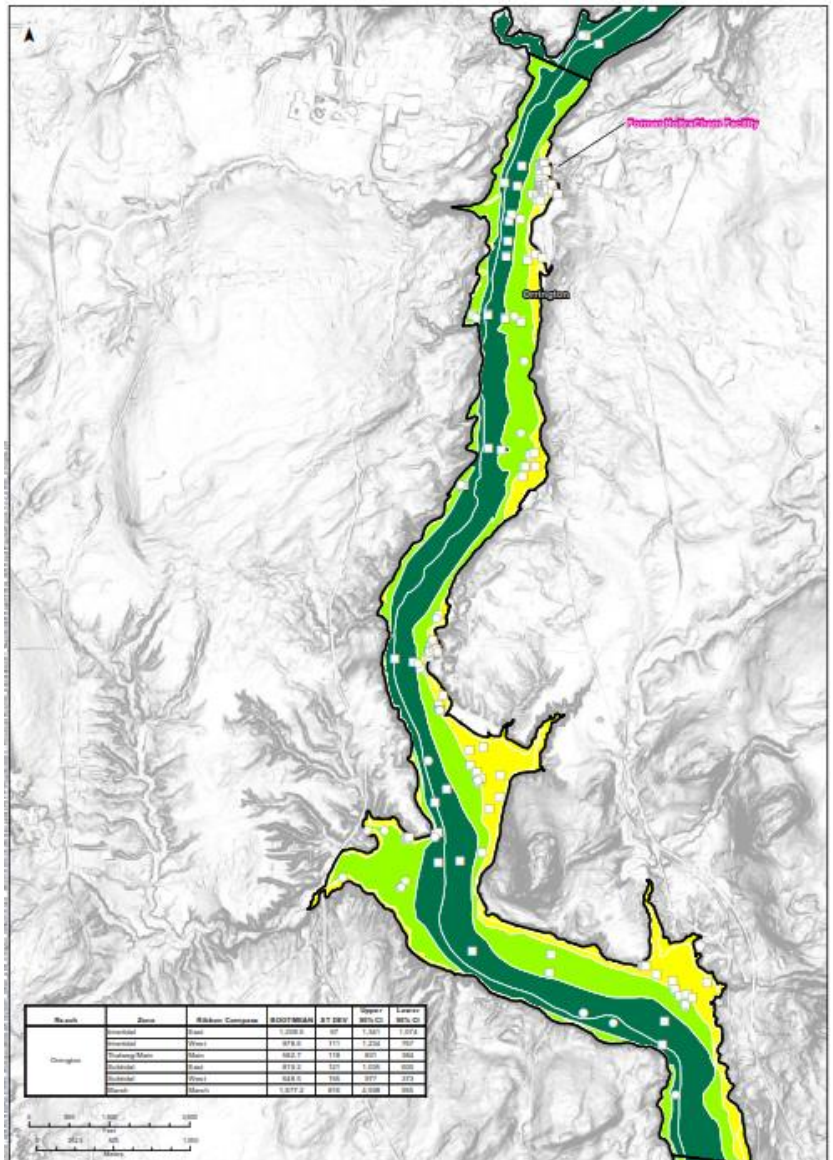


Example: Site Mapping - Orrington Reach





Orrington Reach – Area × Concentration Estimates

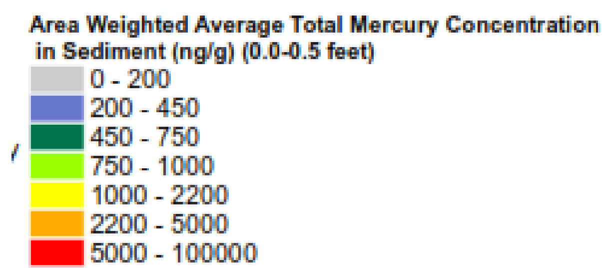


How large an area is contaminated at what concentration?

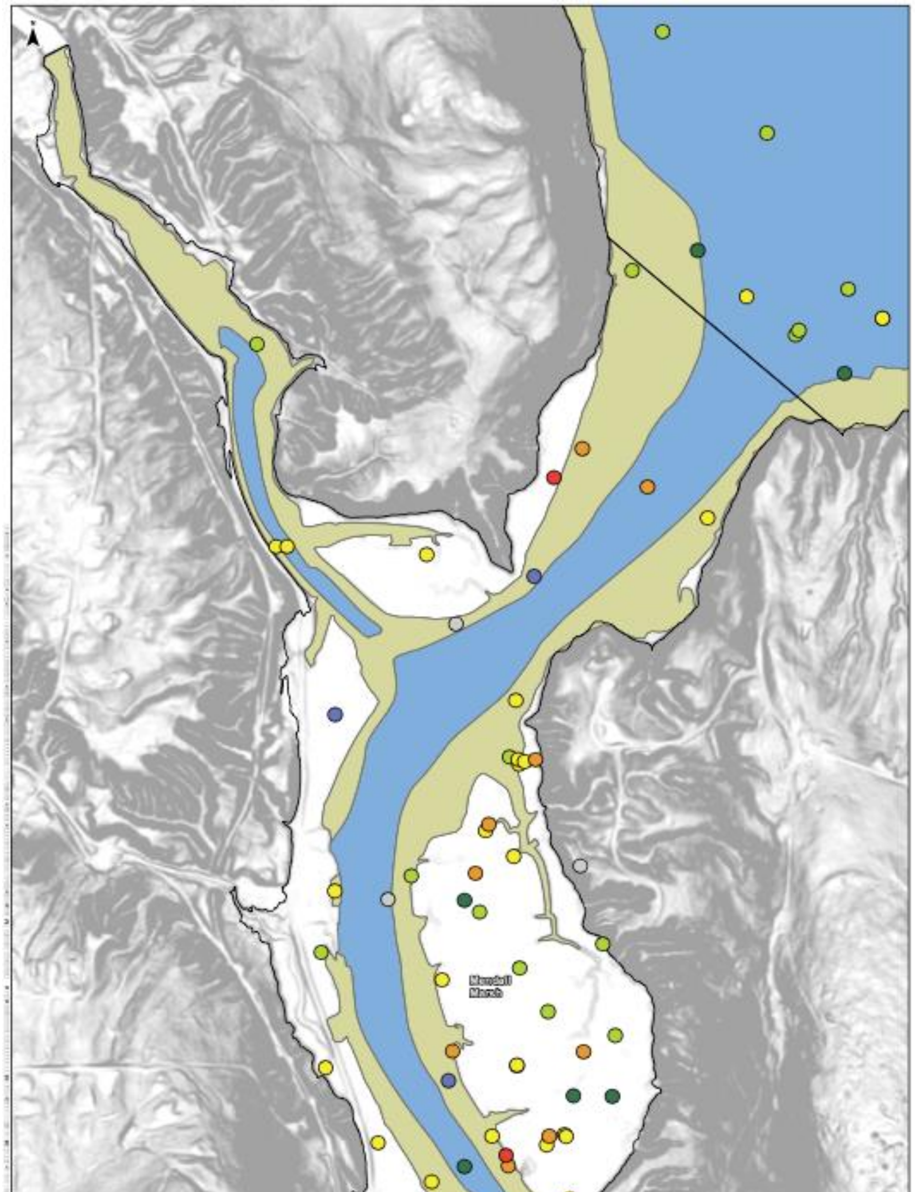
How deep does the contamination go?

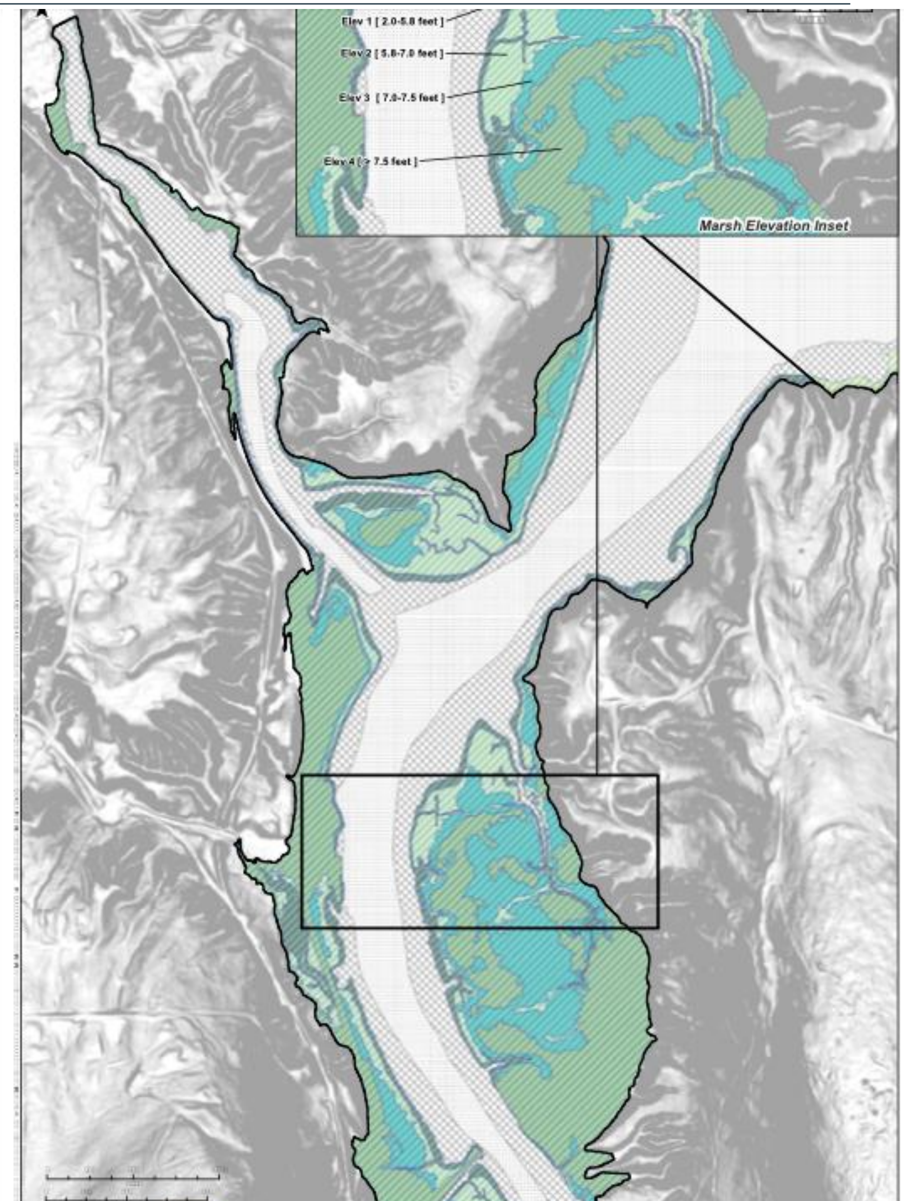
How deep does biology interact with the contamination?

How stably buried is the contamination?



Example: Mendall Marsh – Sensitive Habitat Mapping





Scope for Evaluating Remediation

- Evaluation of risks and potential risk reduction following remedy
- Development of site understanding including fate and transport dynamics for Contaminants of Concern (CoC)
- Assessment of baseline system-wide recovery rates without active intervention
  - Do we know enough to know whether we can improve upon the background recovery rate?
  - What would improvement upon that rate look like?
- Evaluation of feasibility, potential effectiveness and costs associated w/ active remediation, if warranted
- Humility, patience and context to understand what affected communities want to see as a remedy

Remediation Processes Take Decades

Field Sampling

Preliminary Site Characterization

Preliminary Evaluation of Ecological and Human Health Risks

Agency and Public Comment and Review

Additional Sampling and Re-Evaluation of Risks

Preliminary Recommendations for Remedy

Preliminary Technology Screening

Full Alternatives Evaluation

Final Recommendations for Remedy

Implementation of Remedy

Long Term Monitoring of Remedy

Sediment Excavation (v1) – Open Water Dredging

Excavators can work from a barge and load to another barge or can work or load directly to the shore; hydraulic clamshell dredges seal to minimize sediment loss during dredging

Now you have to dewater what you dredged…

About 2.1 million cubic yards (1.6 million cubic metres) of sediment, which had been heavily contaminated from a century of industrial activity, was dredged from Onondaga Lake and dewatered in a 50-acre (20-hectare) cell where six layers of Geotube® containers are held permanently. The Geotube® containers were then covered and capped with a barrier system to provide public health protection from the contaminants in the sediment, as well as to allow a natural habitat to re-establish on site.

Sediment Excavation (v2) – Excavation in the Dry

A sheetpile wall is installed to separate the river from the area to be excavated.

Area to be excavated is pumped out and mud is excavated in the dry.

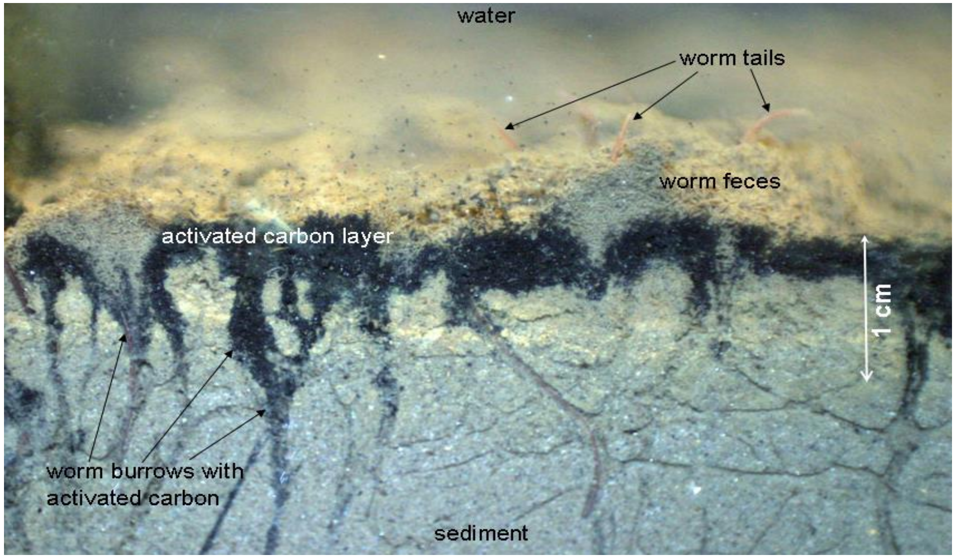
Requires less area for material dewatering after dredging… but requires continuous pumping during excavation …

Riverbank Remediation, Stabilization & Restoration


- Excavating riverbanks that contain high levels of CoCs
- Placing root wads, geosynthetics and rocks to reduce erosion & stabilize shorelines
- Replanting vegetation and restoring fringing marshes


Capping with Clay (+ Amendments)

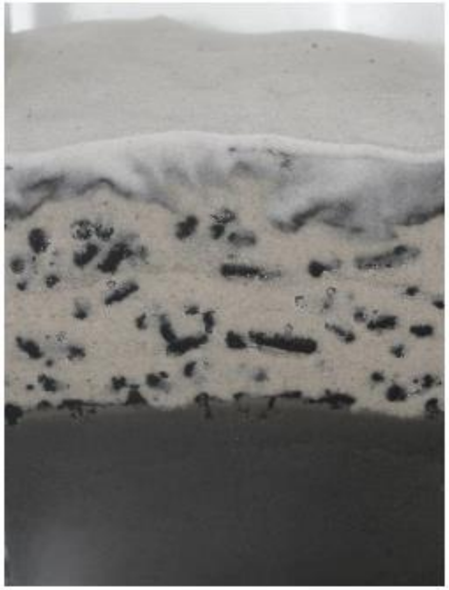
Amendment integration into sediment



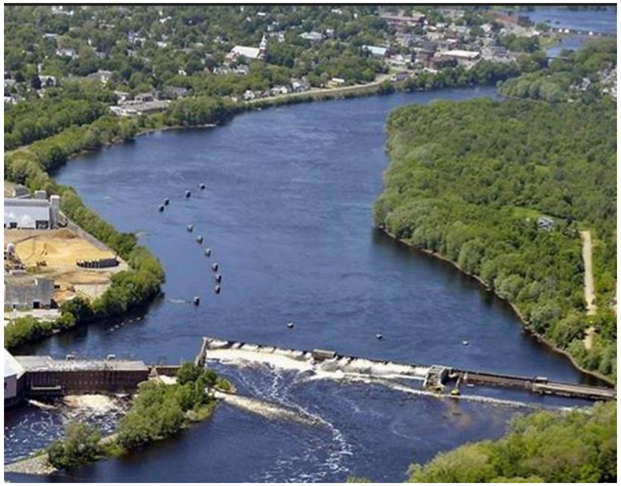
SediMite™

- activated carbon
- clay material
- sand

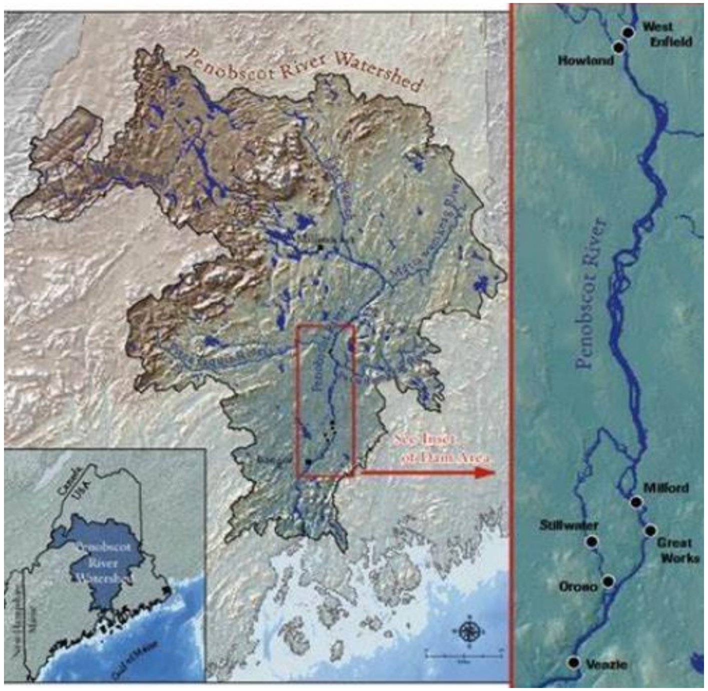
Slow release in sediment to facilitate CoC sorption and decrease bioavailability



Dam Removals – Penobscot River (2004 – 2016)



Access Restoration – Penobscot River (2004 – 2016)



Wetlands and Marsh Restoration

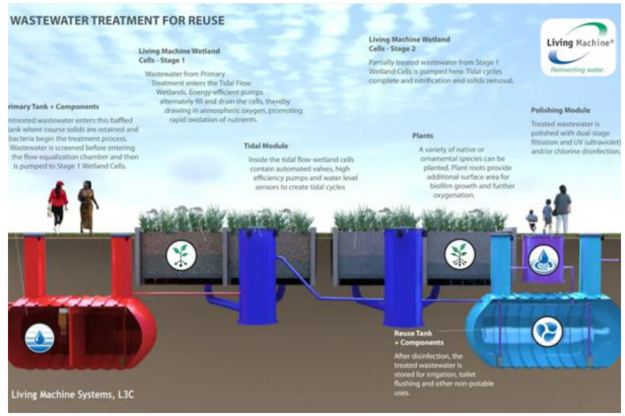


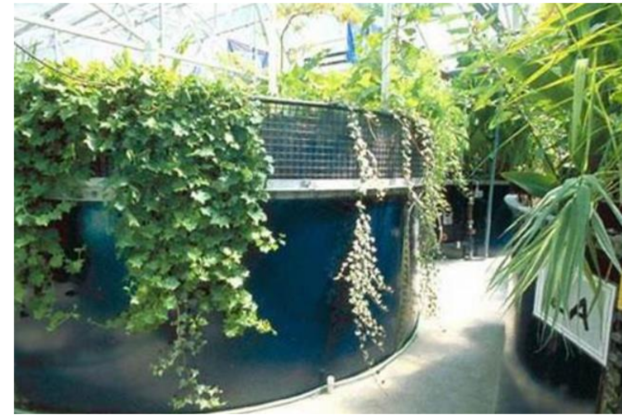


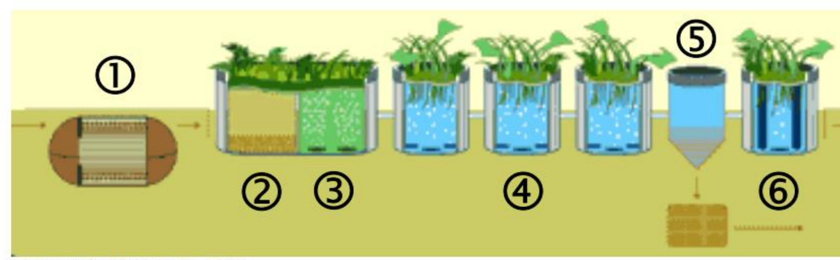




Wastewater Treatment (Engineered Ecology)







Source: Living Machines Inc., 2001.

FIGURE 1 THE COMPONENTS OF THE LIVING MACHINE®: (1) ANAEROBIC REACTOR, (2) ANOXIC REACTOR, (3) CLOSED AEROBIC REACTOR, (4) OPEN AEROBIC REACTORS, (5) CLARIFIER, AND (6) "ECOLOGICAL FLUID BED"

Manufactured Wetlands (Ecological Engineering)

Sweetwater Wetlands Park (Gainesville, FL)

125+ acres of wetlands and ponds created to improve water quality of wetlands in Paynes Prairie and the Florida Aquifer.