Monitored Natural Recovery and In-Situ treatment as remedies for contaminated sediments

Presentation through NEWOMA
April 29th and 30th 2010

Charles Menzie, Ph.D., Exponent
camenzie@exponent.com **571-214-3648**

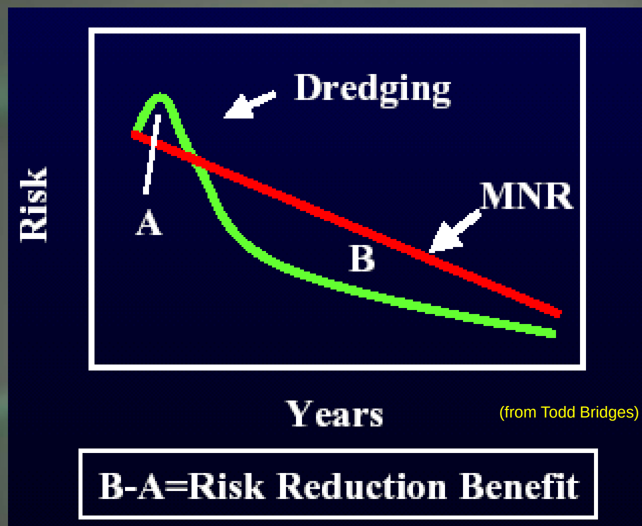
Exponent®

These remedies are useful when … Time is on your side (The Rolling Stones)

- **Monitored Natural Recovery (MNR) involves leaving contaminated sediments in place and allowing natural processes to reduce exposure. Reductions in exposure could occur as a result of degradation, burial with clean sediments, and reduction in bioavailability. Can be used in concert with other remedial measures.**

- **In-situ remediation involves adding chemical, physical, or biological "treatment" agents to the sediments to reduce the exposure to contaminants. Can be thought of as enhanced MNR. Can be used in concert with other remedial measures.**

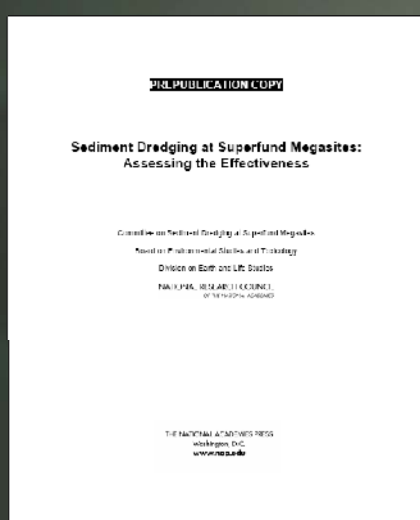
Remedial alternatives can be compared by considering risk reduction trajectories over time

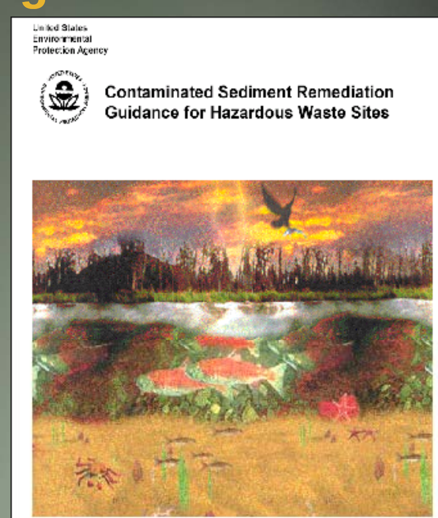


What is an acceptable timeframe?

37

Opportunities to use MNR and In-situ treatment arise, in part, from lessons learned and recent guidance





The USEPA guidance offers insights into how to compare alternative remedial measures

Monitored Natural Recovery	In-situ Capping	Dredging/Excavation
Expected human exposure is low and/or reasonably controlled by ICs Site includes sensitive, unique environments that could be irreversibly damaged by capping or dredging	Expected human exposure is substantial and not well-controlled by ICs Long-term risk reduction outweighs habitat disruption, and/or habitat improvements are provided by the cap	Expected human exposure is substantial and not well-controlled by ICs Long-term risk reduction of sediment removal outweighs sediment disturbance and habitat disruption

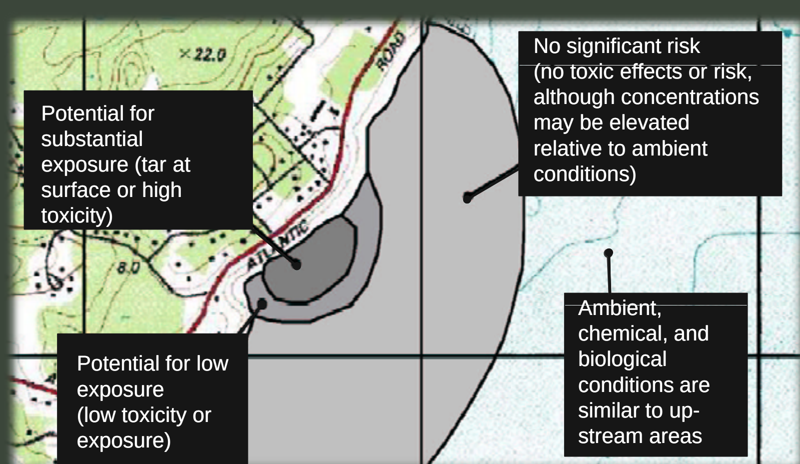
Comparative approaches …

Monitored Natural Recovery	In-situ Capping	Dredging/Excavation
Contaminant concentrations in biota and in the biologically active zone of sediment are moving towards risk-based goals Contaminants readily biodegrade or transform to lower toxicity forms Contaminant concentrations are low and cover diffuse areas Contaminants have low ability to bioaccumulate	Contaminants have low rates of flux through cap Contamination covers contiguous areas (e.g., to simplify capping)	Higher contaminant concentrations cover discrete areas Contaminants are highly correlated with sediment grain size (i.e., to facilitate separation and minimize disposal costs)

MNR and in-situ are attractive when natural resources may be impacted by more invasive methods (dredging and capping)

Note: these same areas are often the most productive regions of a lake or river and can make a proportionally greater contribution to chemicals in pelagic food webs

The exposure zone concept helps guide selection of remedial approaches including MNR and in-situ



An MNR site in New England where decreasing bioaccessibility is the key

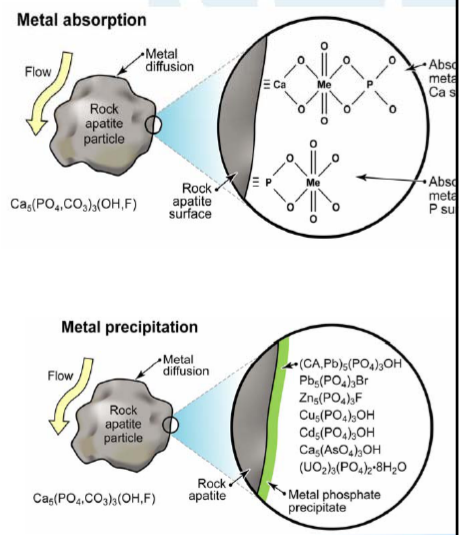
In-situ remedies

- Amendments
- Approaches
- Next steps

Sequestering Agents

Apatite

- Stable end-products
- Can be emplaced by existing technology
- Does not affect sediment physical properties
- Can be mixed with other additives
- Low cost, readily available, non toxic



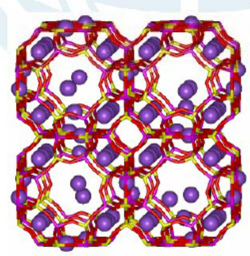
SRNL From Anna Knox

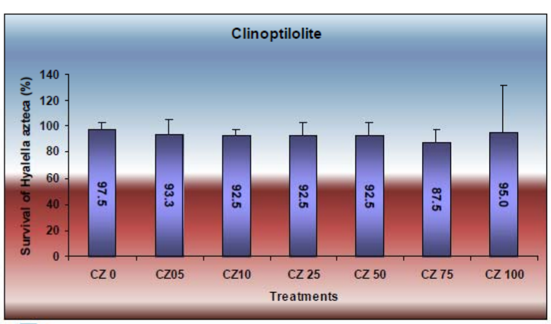
Sequestering Agents

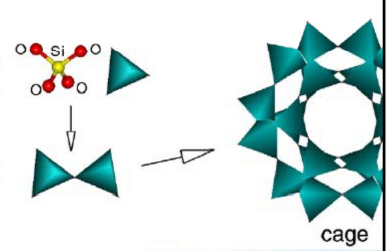
Zeolites "boiling stones"

- Naturally occurring aluminosilicate minerals
- Have three-dimensional framework with large vacant cages for cations and large molecules
- Clinoptilolite and phillipsite - common zeolites for metal removal
- Clinoptilolite is not toxic to aquatic organisms

Zeolite Structures





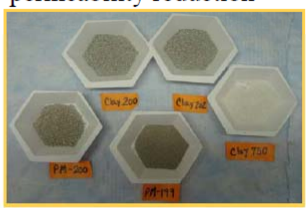


SRNL From Anna Knox

Sequestering Agents

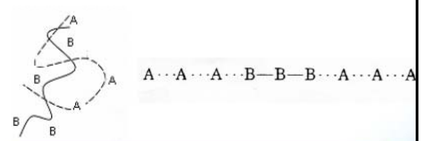
Organoclays

- ❑ Consist of modified bentonite
- ❑ Effective at removing organics (e.g. PCBs, and PAHs)
- ❑ Small positive charge permits removal of some anions
- ❑ Retained cation exchange capacity immobilizes metals
- ❑ Significant swelling and permeability reduction



Biopolymers

- ❑ Natural materials
- ❑ Can bind metals and organics
- ❑ Could resist biodegradation in cross-linked forms
- ❑ Plugging effect - increases shear strength of porous media to resist erosion
- ❑ Can be injected into sediments
- ❑ Economical

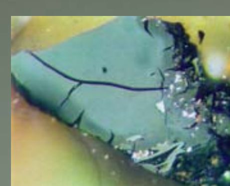


Interpenetrating polymer network

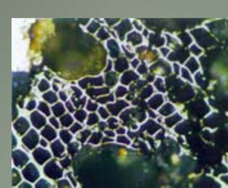
SRNL From Anna Knox

Carbon as an amendment for PCBs, PAHs, pesticides, MeHg

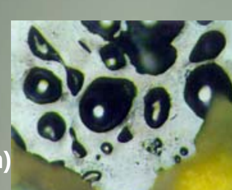
Hunters Point Sed (63-250 μm)



coal



charcoal

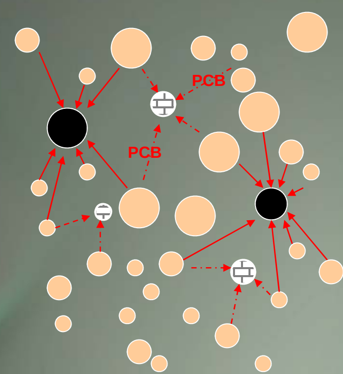


coke

From Upal Ghosh

14

How does the addition of activated carbon reduce exposure?



Sediment particles with PCBs

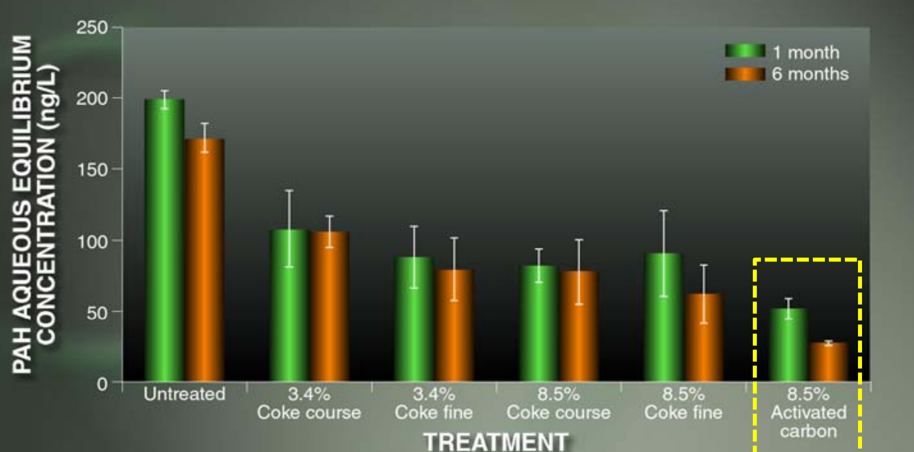
Natural carbonaceous particles

Introduced GAC particles

From Upal Ghosh

15

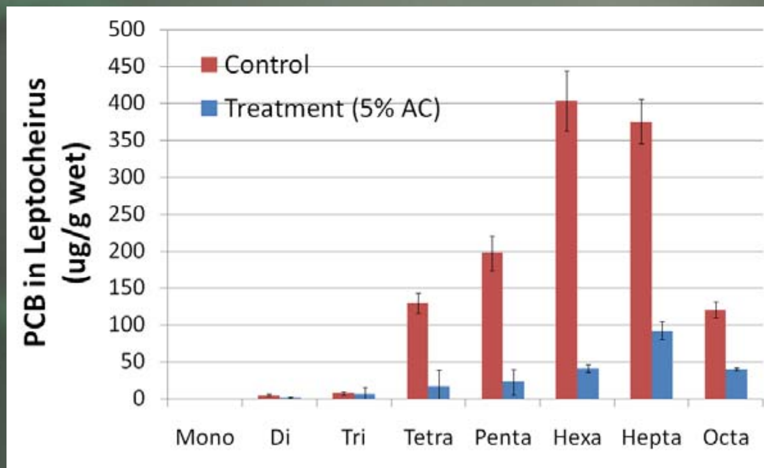
Reducing Bioavailable PAHs



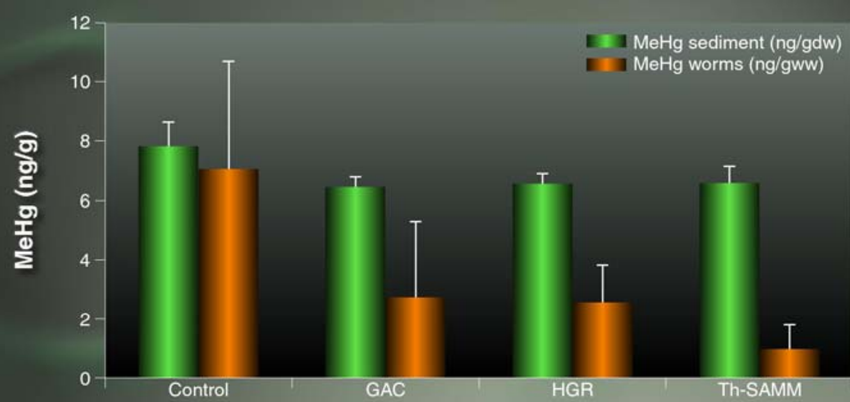
Notes: Total aqueous PAH concentration in untreated and treated sediment for contact times of 1 month and 6 months with 3.4 percent activated carbon and different doses and sizes of coke particles. Error bars represent one standard deviation from the mean of three replicates.

Source: Zimmerman et al. ES&T (2004)

Reducing bioavailable PCBs



Reducing Methylmercury Formation and Bioaccumulation



Notes: Methylmercury concentrations in sediments and in worm bodies, by treatment. Error bars represent the standard deviation of triplicate experiments.

PILOT DEMONSTRATION IN GRASSE RIVER

(Participants: Alcoa, EPA, UMBC, Stanford University, Anchor Env., Brennan, Tetra Tech, Arcadis-BB&L, QEA)

DELIVERY DEVICES USED AT GRASSE RIVER, NY

Tine injection system

Designed and built by Brennan with inputs from collaborators

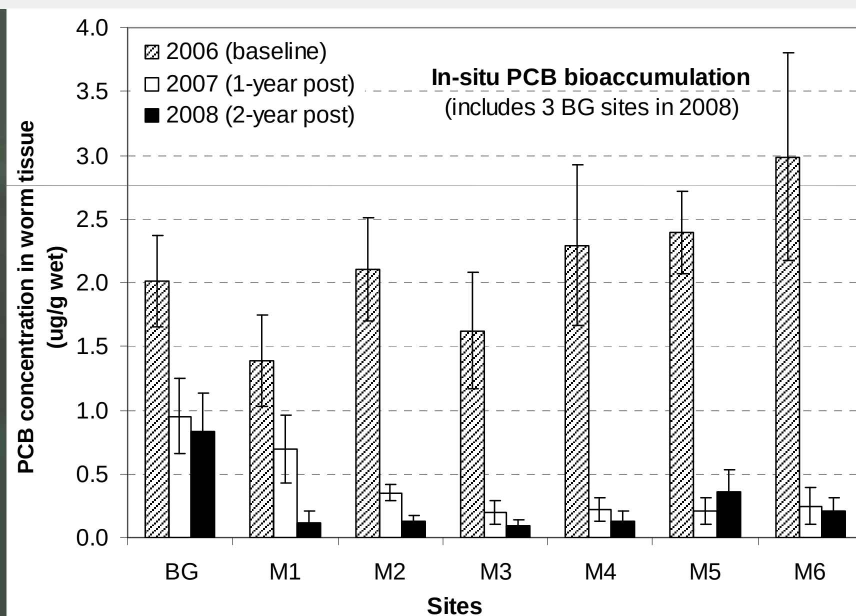
Injection and mixing in an enclosed rototiller

Designed and built by Brennan with inputs from collaborators

IN-SITU PCB MONITORING STUDIES

In-river deployment of field exposure cages with *L. variegatus* for baseline study using a modified ASTM draft method (Burton et al. 2005)

MIXED TILLER AREA WORM PCB IN-SITU



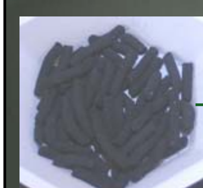
Most *In Situ* Approaches Rely on Mechanical Mixing

Slurry Injection System
(Williams Environmental Services, Stone Mountain, GA)

Limnofix *In Situ* Sediment Treatment Technology (LIST)
(Golder Associates)

Hunters Point, August 31, 2004

SediMite™ as a means of delivering in-situ treatment materials

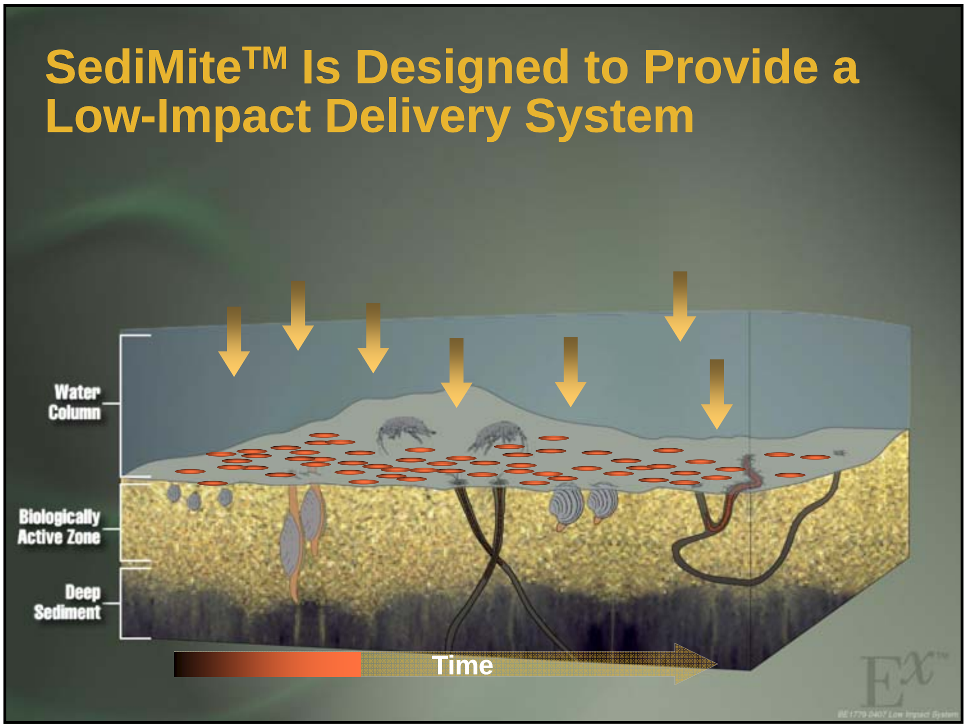


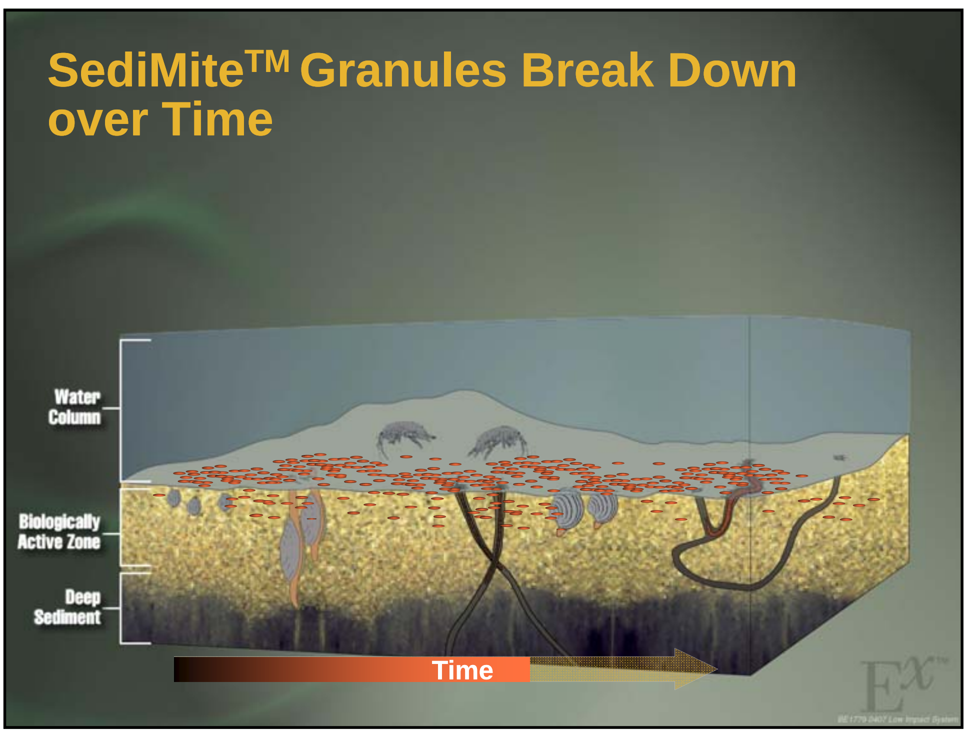
Tens of grams/day production in the laboratory

2-5 Million lb/year at a production facility

30 lb buckets

1800 lb bulk bags


SediMite™ Is Designed to Provide a Low-Impact Delivery System
Water Column
Biologically Active Zone
Deep Sediment
Time


SediMite™ Granules Break Down over Time
Water Column
Biologically Active Zone
Deep Sediment
Time

And Are Mixed by Bioturbation, Thus Targeting the Biologically Active Zone

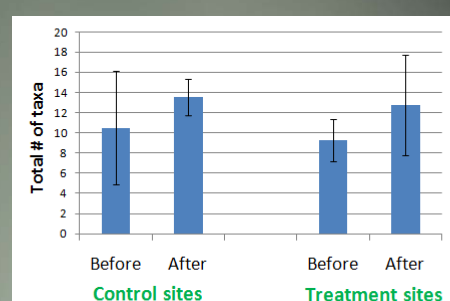
Biological Mixing of SediMite™ Treatment Materials into Sediments

The Workers

(burrowing depth increases left to right)

Effects on Benthic Community

Comparison of pre-treatment and 2-months post-treatment benthic community at a field demonstration site

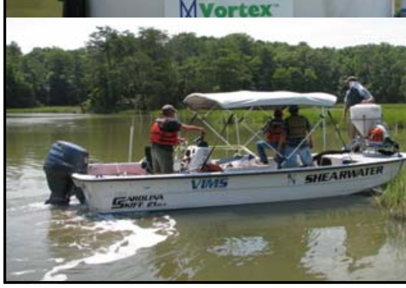


Error bars indicate ±95% CI

Data courtesy of Dr. Upal Ghosh, UMBC

Demonstration projects

SEDIMITE™ APPLICATION IN A CONTAMINATED WETLAND



August, 2009

Spreaders will be used at APG for methylmercury

Regulatory support at Federal level

- USEPA Regions 2, 3, 9
- Letters of support from EPA and NOAA
- EPA agreement to include as part of remedy in Region 3
- Expressions of interest by EPA headquarters, DoD and EPA Region 5
- Support expressed by U.S. Fish and Wildlife Service

Examining the compatibility of site conditions with sediment management alternatives

	MNR	Capping	Dredging	In-Situ	Reactive Caps
Site Characteristics					
Human and Ecological Environment					
Hydrodynamic Conditions					
Sediment Characteristics					
Contaminant Characteristics					
Compatible					
Moderate					
Low to Moderate					
Not Compatible					

Examining the compatibility of site conditions with sediment management alternatives at a site in Pennsylvania

	MNR	Capping	Dredging	In-Situ	Reactive Caps
Site Characteristics	Compatible	Uncertain	Low to Moderate	Compatible	Uncertain
Human and Ecological Environment	Compatible	Not Compatible	Not Compatible	Compatible	Not Compatible
Hydrodynamic Conditions	Moderate	Moderate	Moderate	Moderate	Moderate
Sediment Characteristics	Moderate	Compatible	Low to Moderate	Moderate	Compatible
Contaminant Characteristics	Moderate	Compatible	Low to Moderate	Moderate	Compatible
Compatible					
Moderate					
Low to Moderate					
Not Compatible					

Cost considerations

- Dollars
  - Short-term
  - Long term
  - Insurance
- Ecological and health considerations
  - Short term
  - Long term
- Public welfare

Logistical Considerations

- Permitting
  - U.S. Army Corps of Engineers
  - U.S. Fish and Wildlife Service
  - State environmental agencies
- These issues are no different than traditional remediation activities

Key challenges and possible steps

- Need to consider longer timeframes to let nature accomplish healing
- Need to address the "do little or nothing" reaction
  - Broaden the dimensions of the project to consider overall goals, consequences, and benefits
- May require courage and higher level support to think and act "out of the box"
  - Need political support and state-level regulatory guidance
  - Consider state-led or regional workgroups