New Geocomposite Mats – Adaptable Remediation Tools

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Outline of Talk

- Introduction to Reactive Mats
- Current Work to Enhance/Adapt
- Research Highlights and Results
- Future Work

Background

Conventional Subaqueous Sediment Treatment

Environmental Dredging

- significant re-suspension potential
  - leakage
  - sediment disturbance
- large disposal volume

Geomaterial capping

- erosion
- navigation hazard

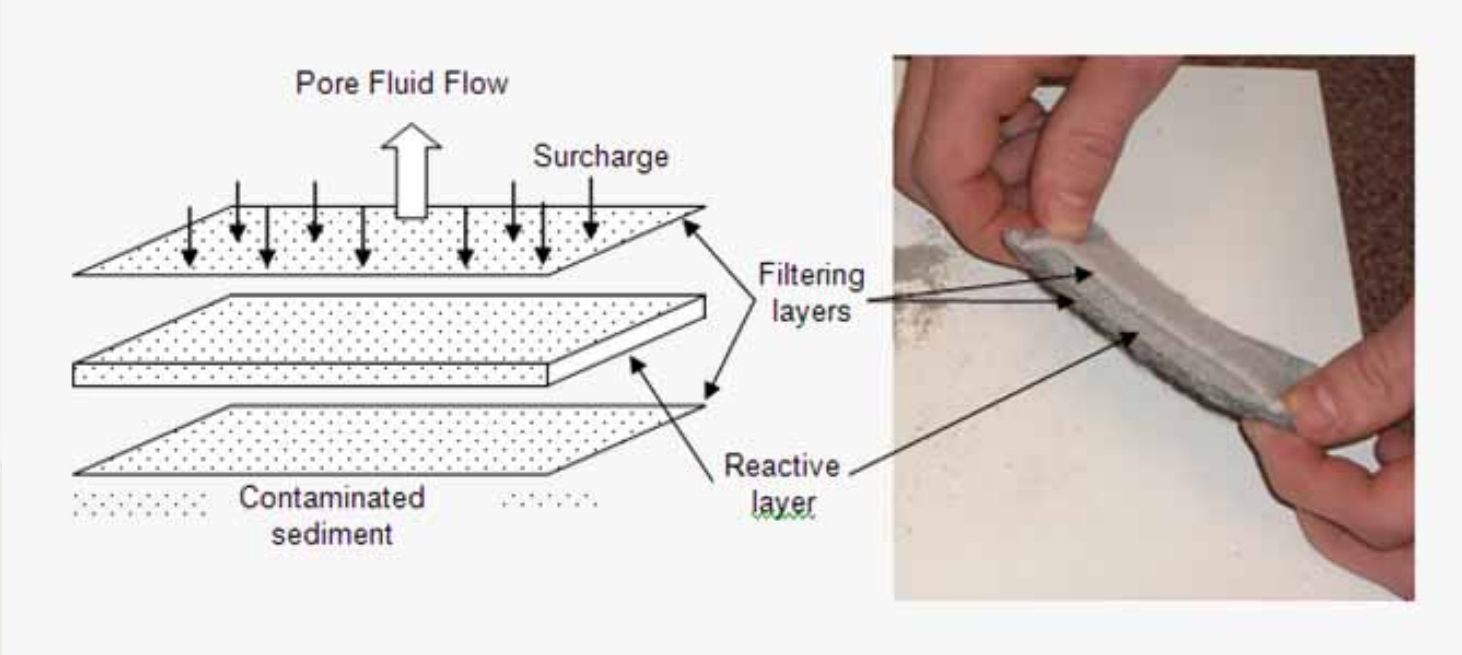
Natural Attenuation

- no action taken
- long duration
- requires favorable environmental conditions

www.yosemite.epa.gov

Introduction to Reactive Core Mats

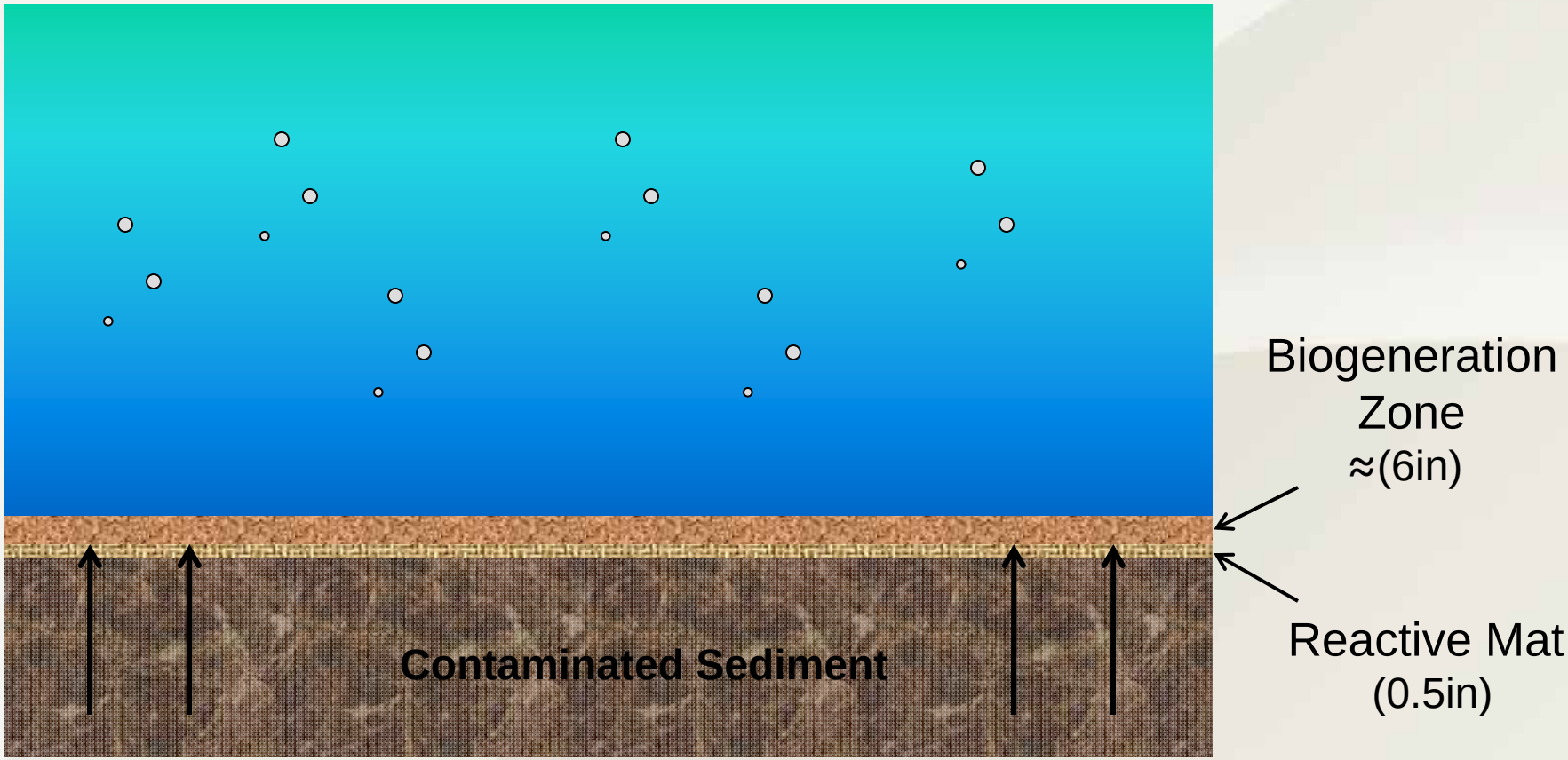
- Reactive/adsorptive matl. with filtering geotextiles
- Placed on top of contaminated sediment
- Advection/diffusion draws pore fluid through RCM



Reactive Core Mat – Field Placement

Placement on Subaqueous Sediment (courtesy of CETCO®)

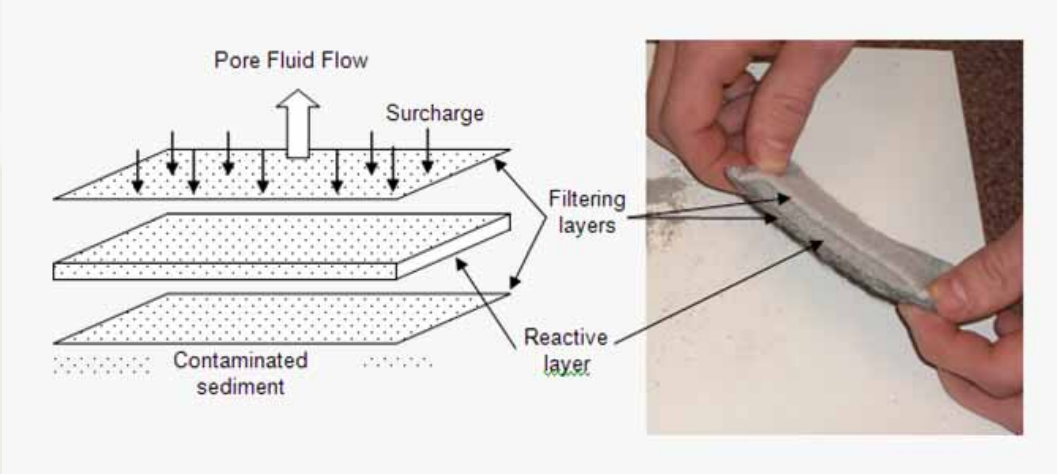
Reactive Core Mat – Application Schematics



Advantages of Reactive Core Mats

RCM Advantages over traditional caps:

- can neutralize/adsorb/isolate contaminants
- prevent migration of fines
- foundation for new, overlying sediment
- “designer” reactive core for diff. contaminants



State of RCM Knowledge & Use

- Use is becoming more common

However…

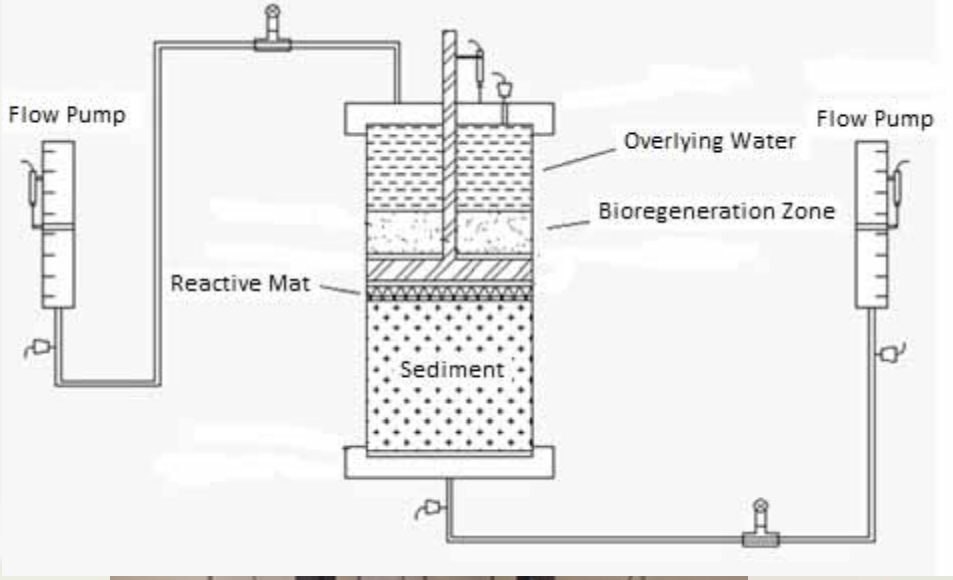
- Remediation/isolation efficacy …
- Long-term capacity…
- Contaminants for which RCMs appropriate …
- Modeling of processes and scalability…

…are not well understood

Research Approach

- Develop Benchtop Device, Testing Protocols
- Test efficiency of reactive mat
  - Isolation of contaminants
  - Remediation of contaminated sediment
  - Bioavailability in overlying sediment regeneration zone
- Measure RCM reactive capacity
- Analytically model process for field scalability

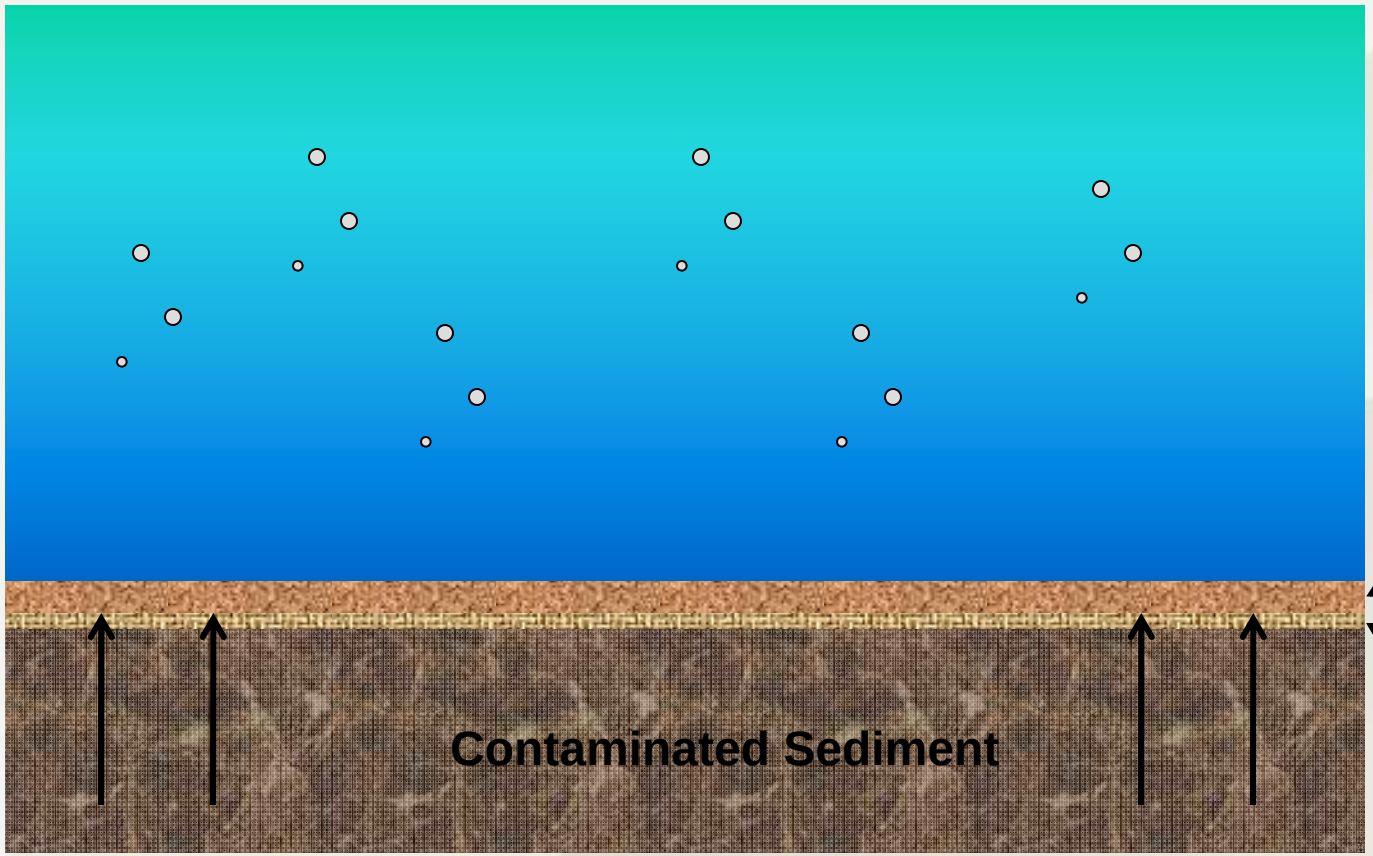
New Testing Device - ICSTAC



New Testing Device - ICSTAC

- Design constraints
  - constant/incremental load appl.
  - matls. chemical-resistant
  - suitable to large strain consolidation
- Other requirements
  - simple mechanism

Physical Model of Field Condition



Biogeneration Zone
≈(6in)

Reactive Mat
(0.5in)

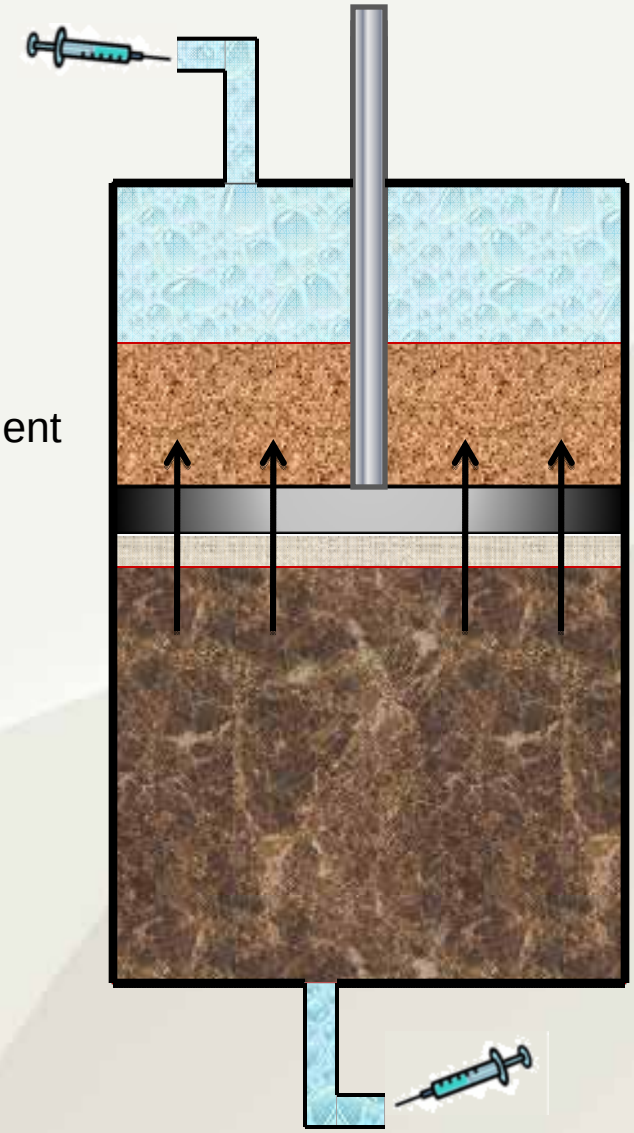
ICSTAC Physical Model

Water

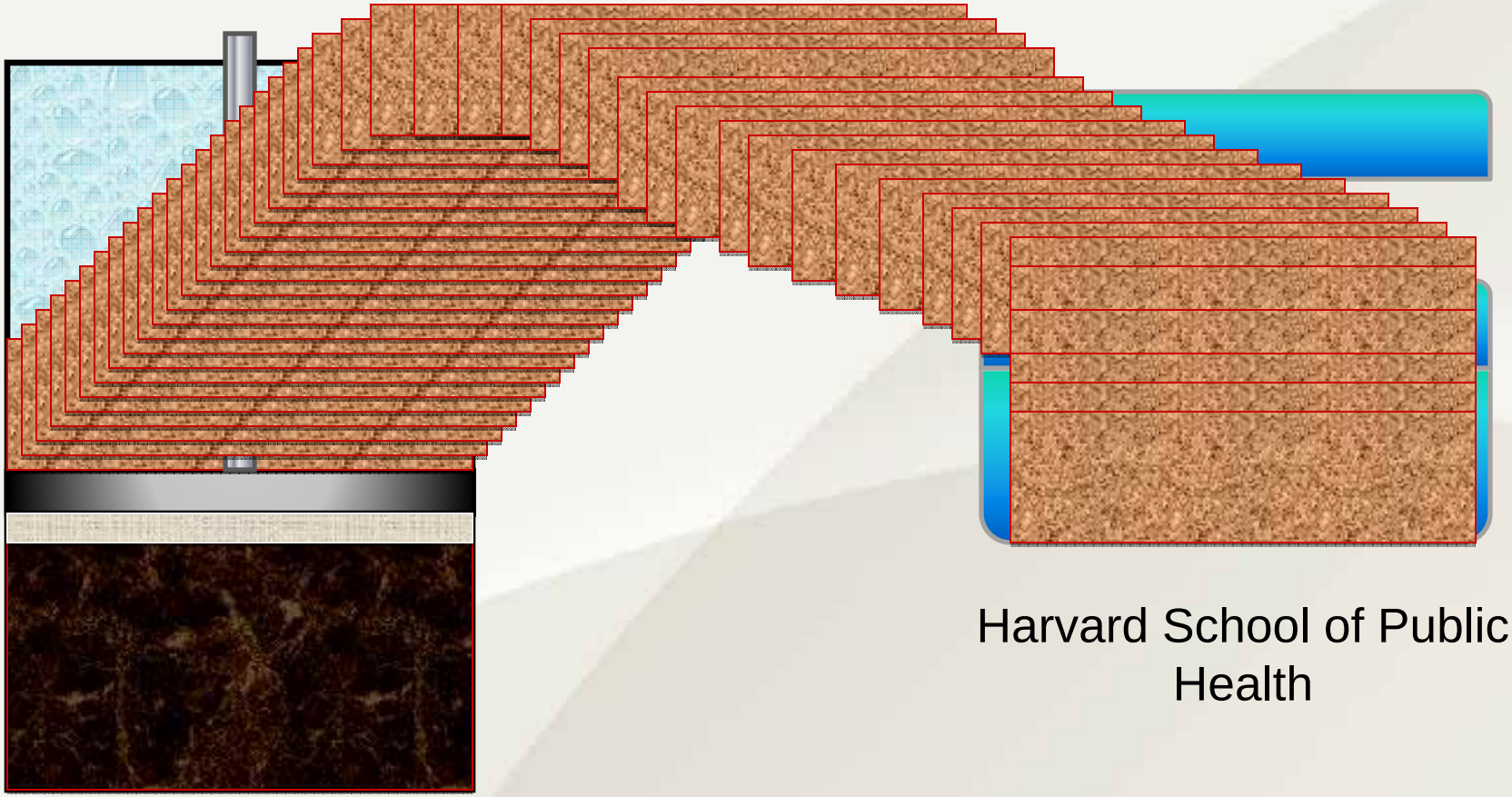
Biogeneration Zone

Contaminated Sediment

Reactive Mat



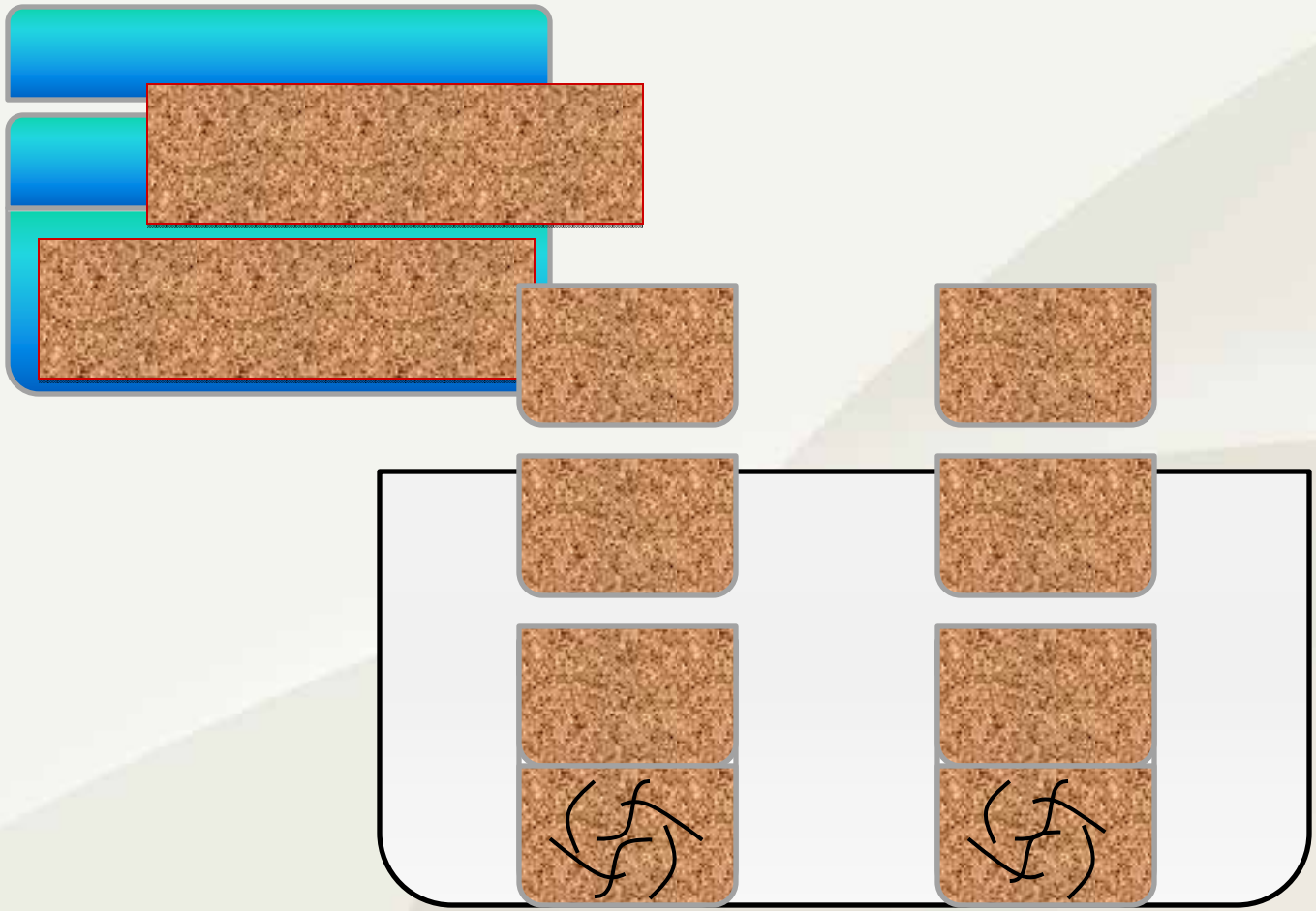
Integrated Research with HSPH



Harvard School of Public Health

Northeastern University

Bioavailability Tests



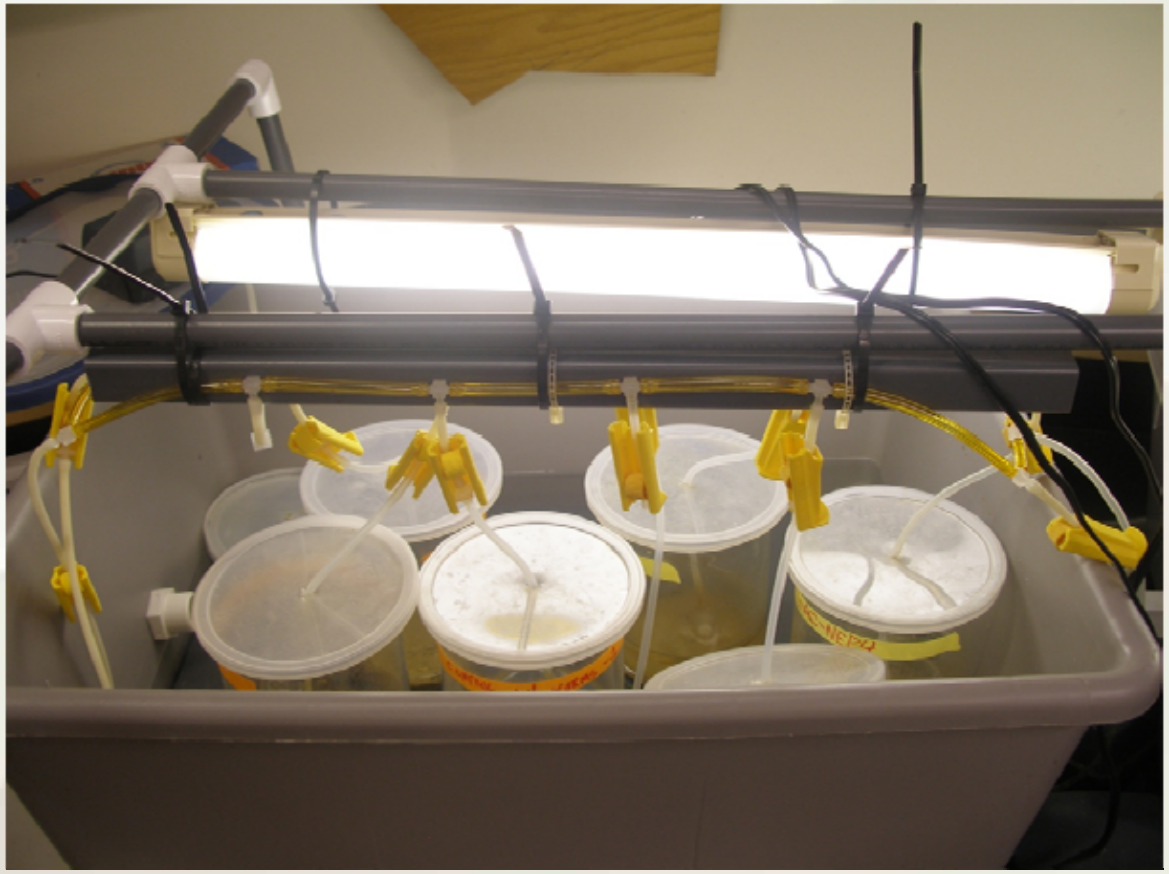
Worm exposure tests: 28 days in biogeneration zone

Bioaccumulation Testing

- Process
- Day 1 - Start 14-day incubation period
- Day 15 - Worms added
- Day 43 - Worms frozen and acid digested

Worm Species

- Nireus Virens (fresh-water tests)



Courtesy Harvard School of Public Health

Sediment Sampling and Preparation

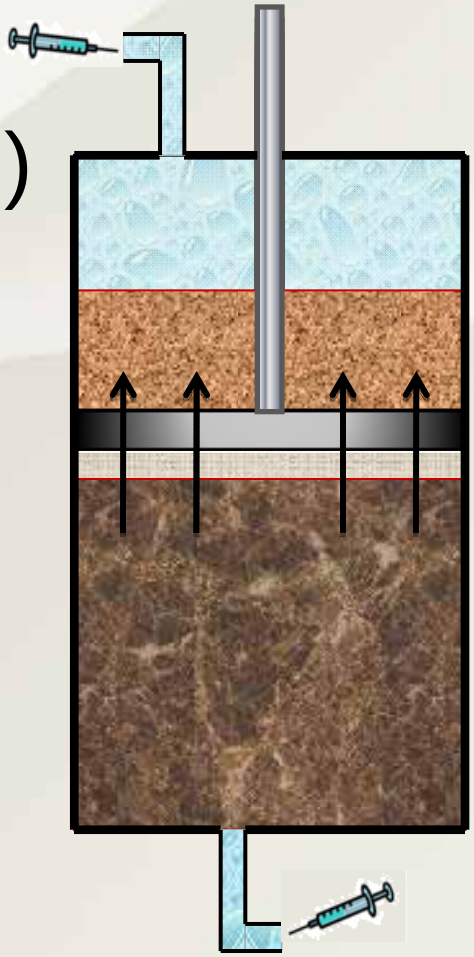
Tilestone & Hollingsworth Dam, Neponset River MA DEP Site (PCB)
(5 sets of sampling performed)

Sediment Sampling and Preparation

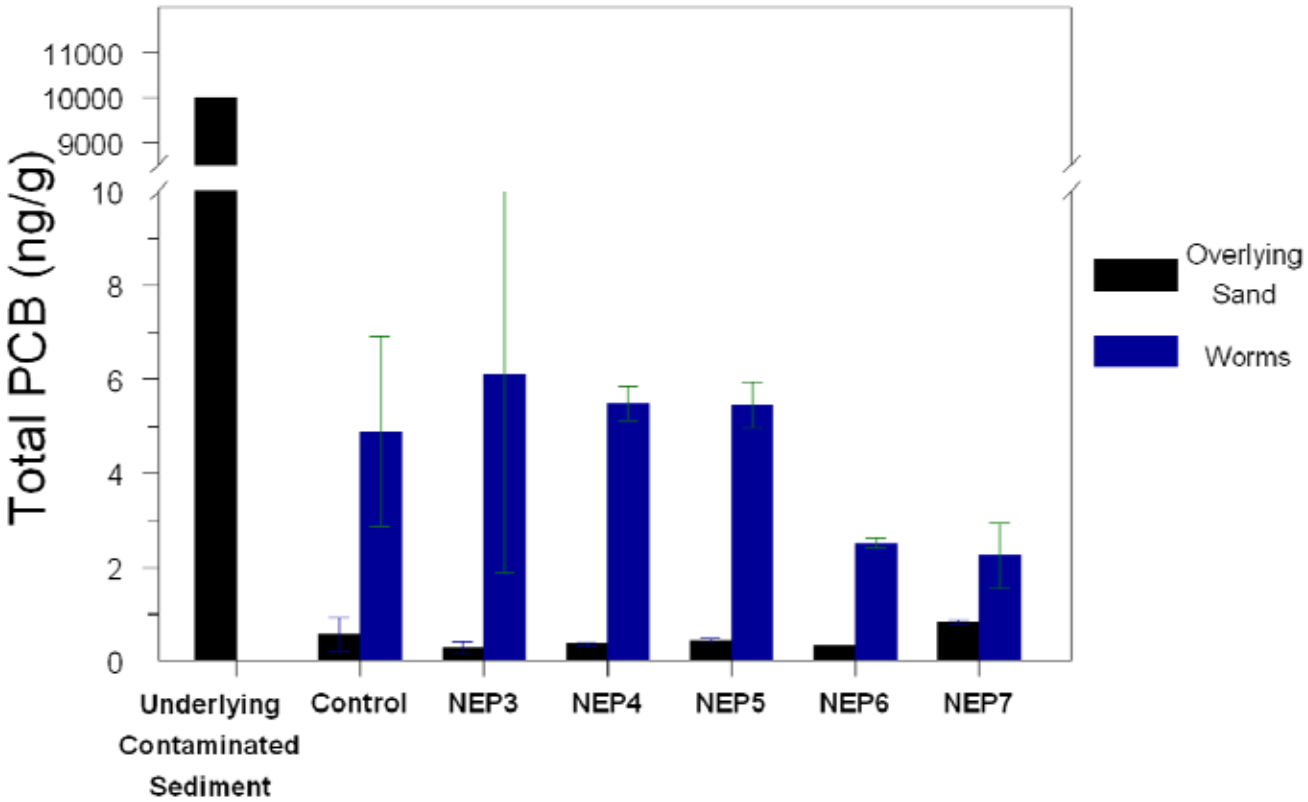
- Early tests used natural sediment
  ≈ 10 ppm PCB
- Then moved to naphthalene spiking
  - higher solubility – better test of RCM
  - (much) lower chemical costs
  - safer to work with in high concentrations
- 14 day rotational mixing

Research Results - PCB

- Bioavailability based on worm exposure tests
- Natural sediment (no spiking)
- Results from
  - original sediment
  - overlying sand, worms
    pre-/post-treatment

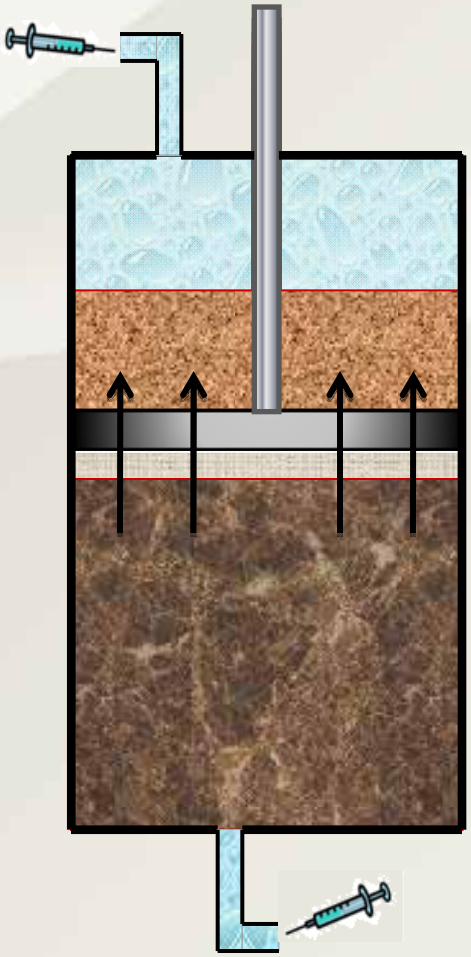


Research Results - PCB

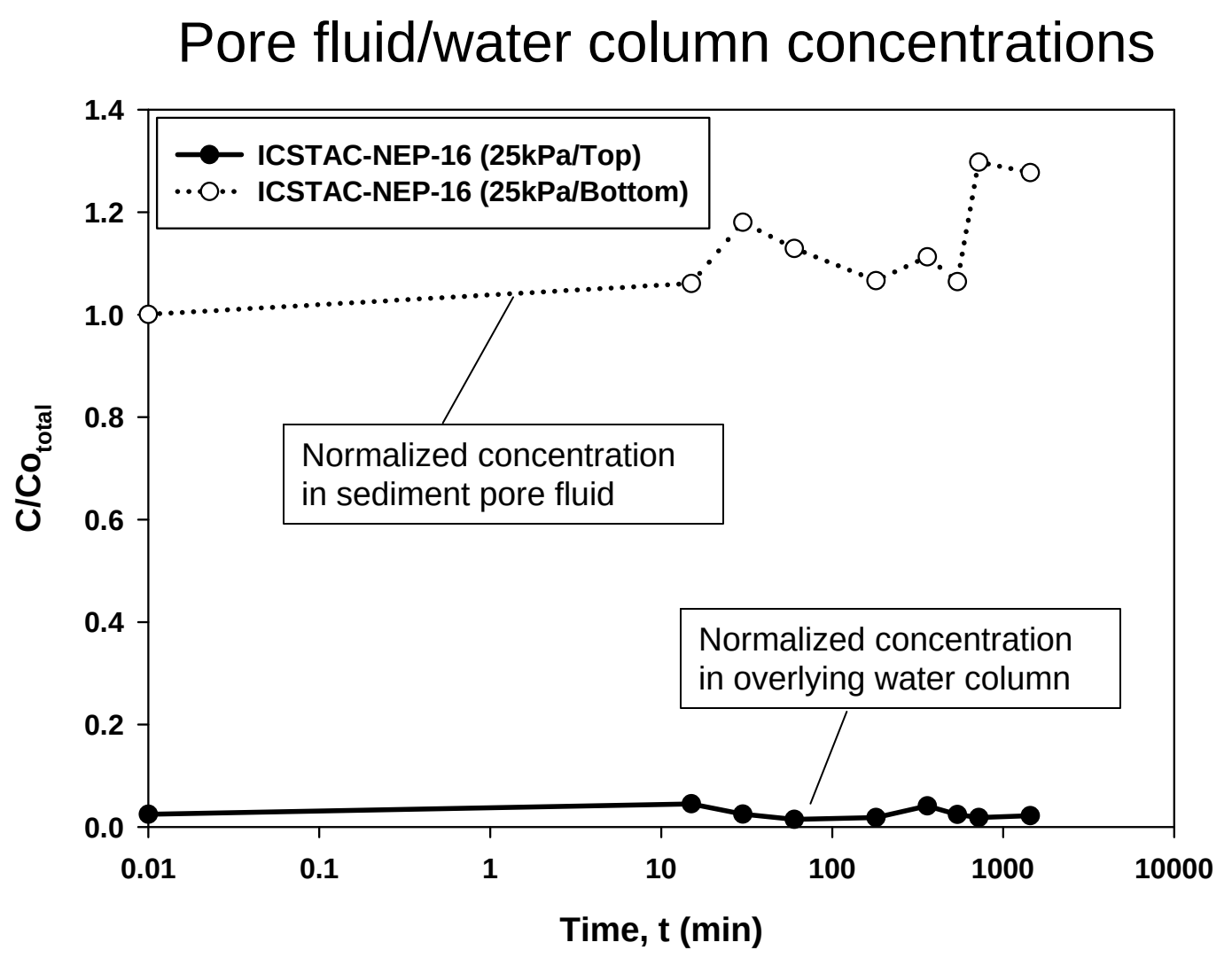


Research Results - PAH

- Spiked natural sediment
- 250 mg naphthalene/kg dry sediment
- Sampled from ICSTAC during consolidation testing
- Analyzed using GC-MS
- Plotted normalized C's



Research Results - PAH



Research Results – Modeling of Process

- CS2 Model – modified (Fox,1997)
  - Piecewise-linear model for large strain consolidation
  - Accounts for: finite strain, self-weight, variable Cv & kv
  - Facilitates application of different initial/boundary conditions

Future Plans

- Still running further controls
- Awaiting PAH worm exposure test results
- Return for full test set on PCB-spiked sediment
- Saltwater tests – New Bedford Harbor
- Modeling - coupled mechanical/chemical
- Field tests
- Long-term capacity/sequestration ability
- Biodegradation of RCM?

Summary

- New ICSTAC device & protocols developed
- Good data on PCB/PAH remediation/isolation
  - Minimal PCB bioaccumulation
  - Dramatic PAH containment
- Mechanics model adapted and validated
- Much work remains, but promising benchtop performance so far
- RCMs can be the sediment remediation tool of the future

Participants and Sponsorship

Participants

Northeastern University: Akram Alshawabkeh, Dogus Meric, Mansoureh Norouzirad, Sara Barbuto
Harvard School of Public Health: Jim Shine
EPA Region 1: Steve Mangion

Disclaimer

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