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Contaminated Sediments: New Tools and Approaches for In Situ Remediation Using Amendments

Joel G Burken, Professor

Missouri University of Science and Technology

Coauthors and support

- Drs. A. Curt Elmore, Gregorz Galecki, David Summers, Danny Reible (UT Austin)
- Gavin Risley, Aaron Archer, Grace Harper, Ryan Stringer, Chris Redell
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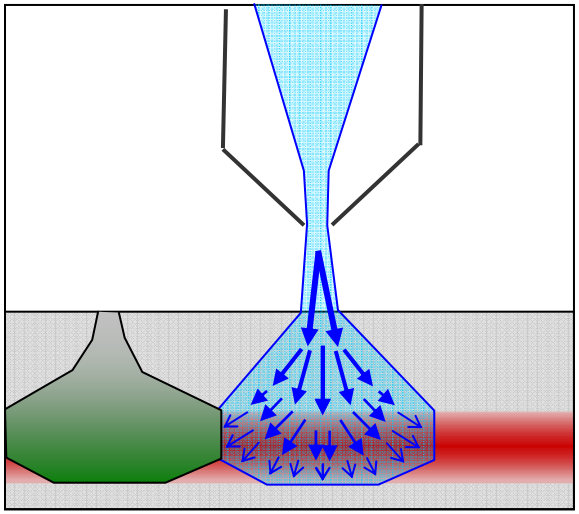
  Program officer: Heather Henry

Background – Waterjet Amendment Injection

- Controlled placement of remediation amendments into sediments :
  - Liquid
  - Fe^0 - ZVI
  - Activated Carbon
- Reductions in contaminant resuspension vs. other methods
- Reductions in benthic mortality vs. other methods



Pulsed Injection: Liquid amendment

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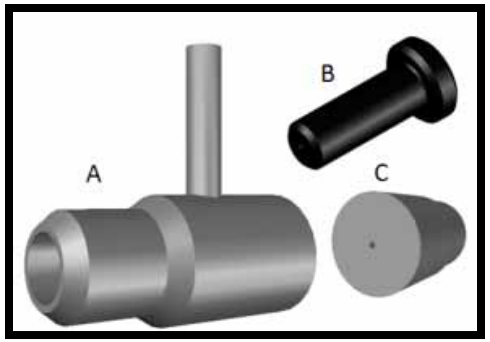
Preliminary work summary

- Liquid/aqueous amendments can be injected to desired depth with Pulsed injections.
- Minimal surface disturbance.
- Minimal resuspension was observed.

- Solid amendments were not viable
  - Plugging, the stop-start stalls and packs the amendment
  - Concentration limitations
  - Damage to equipment

Granular Amendment Delivery Method 1

- Pneumatic amendment delivery
- Amendment and water meet at the nozzle.
- New nozzle designed for both ZVI and PAC



- Also tried direct pumping of:
  - Mixed aqueous
  - Suspension in Guar

Performance – Concentration Tests

Pump (psi)	% Fe in Discharge
700	33.0
1,000	54.7
1,500	46.8
1,500	46.5
Using Atomet28 from QMP while maintaining pressure vessel and nozzle conditions.	

Performance – Concentration Tests

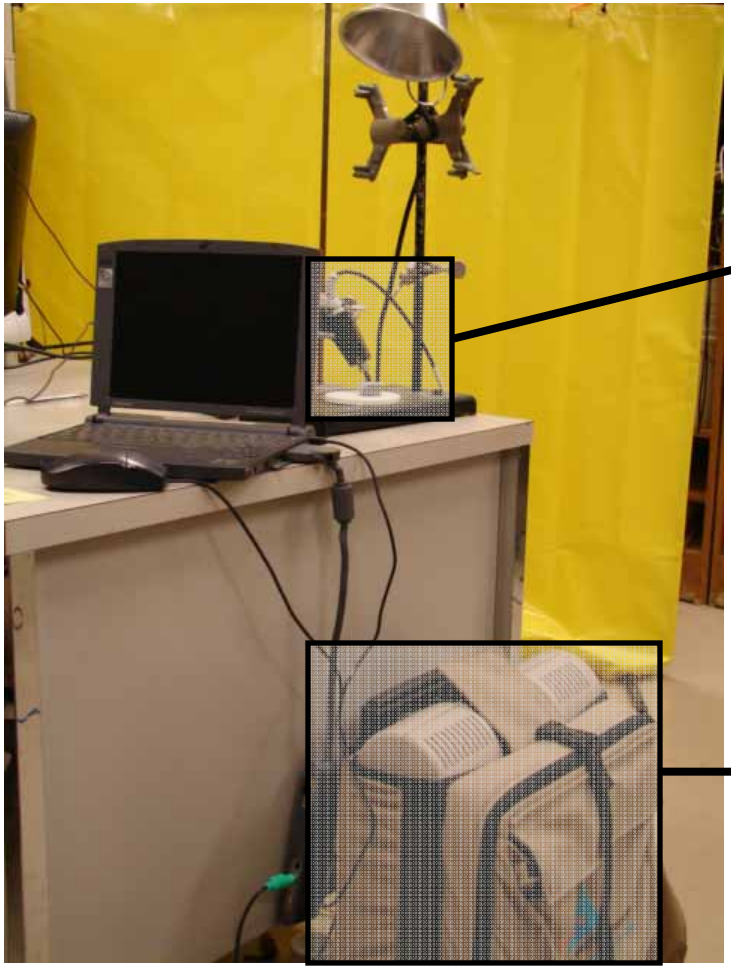
Pump (psi)	% PAC in Discharge
200	47
300	16
700	16
1,000	10
Using WPH powdered activated carbon from Calgon Carbon Corporation while maintaining pressure vessel and nozzle conditions.	

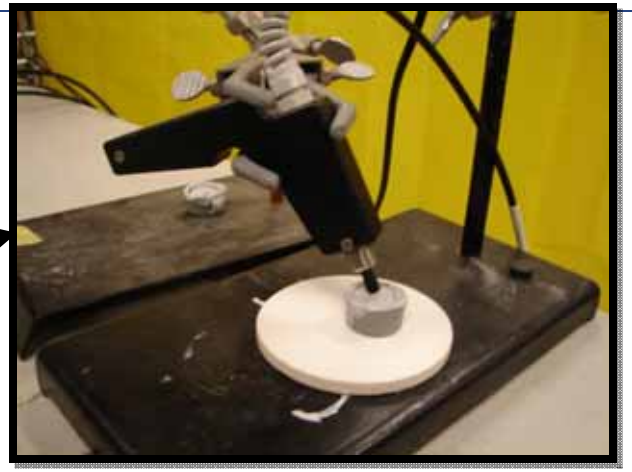
Performance Testing – Surrogate Injections

PAC Quantification Methods – Spectroradiometer

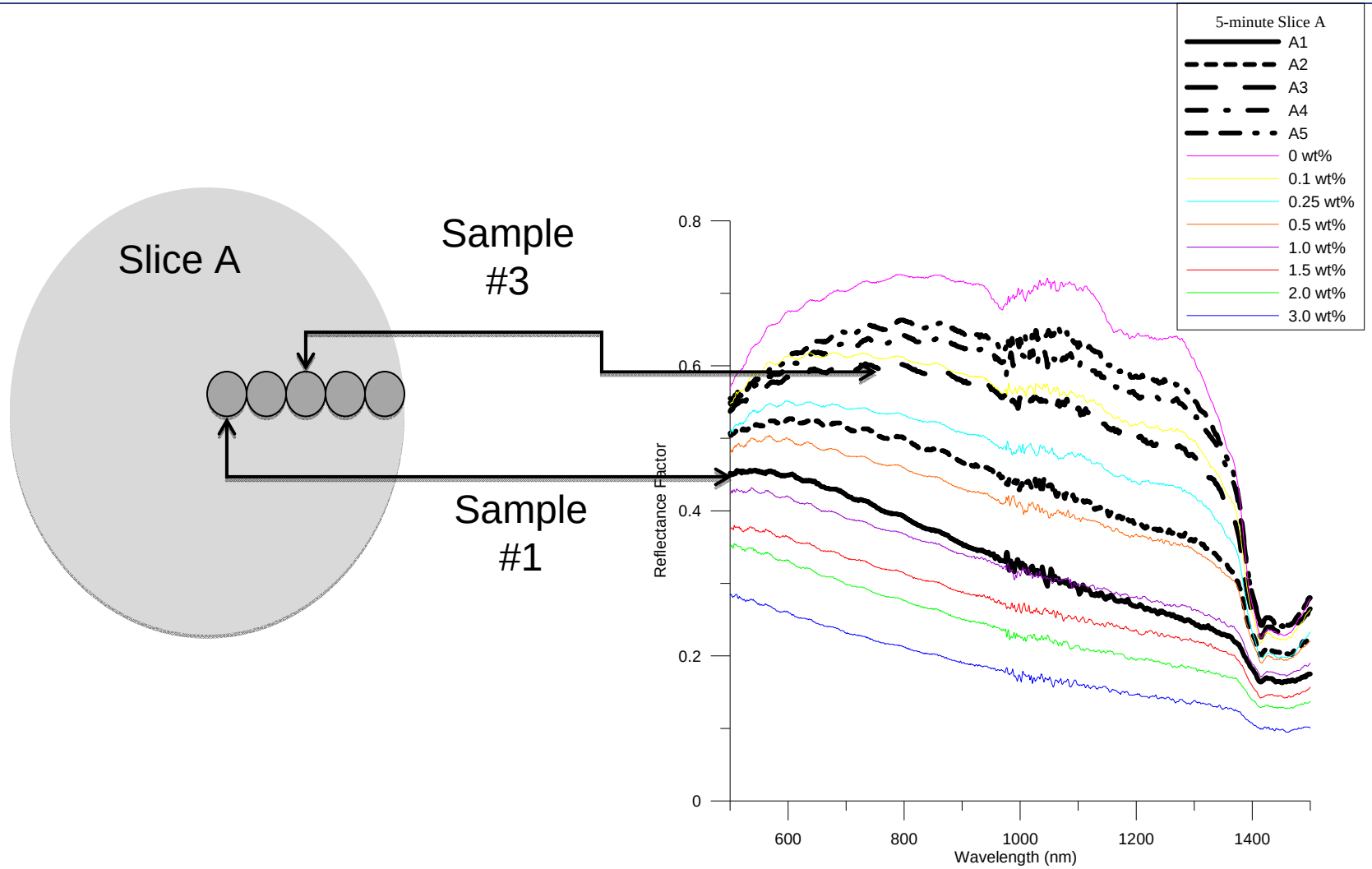
- Spectroradiometer – measures reflectance of light off of a sample vs. the wavelength emitted from the light source
- Differentiates between different concentrations of carbon within kaolinite clay due to highly contrasting color

Quantification Methods – Spectroradiometer





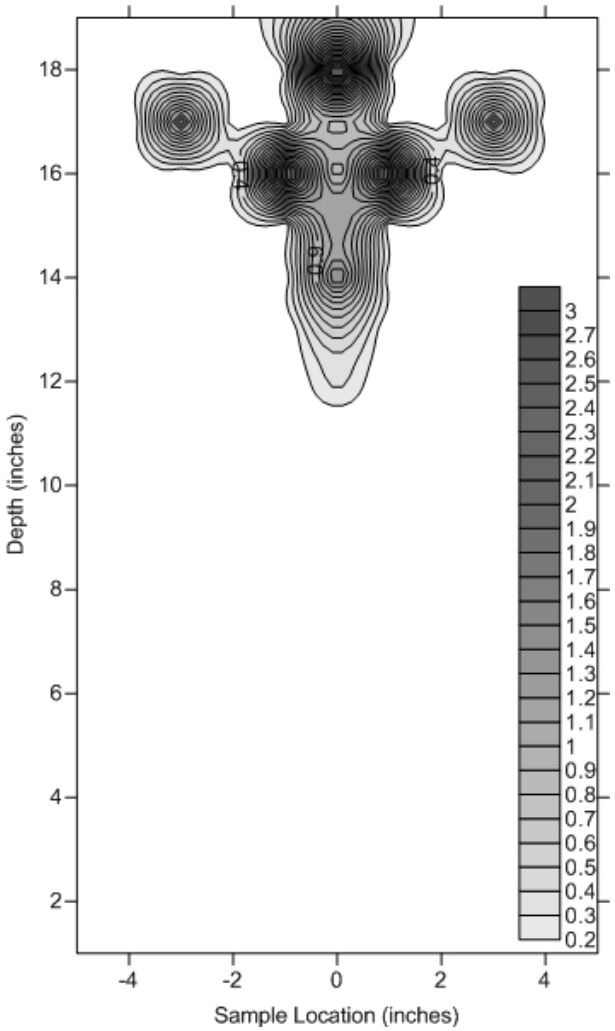
PAC Quantification Methods – Spectroradiometer



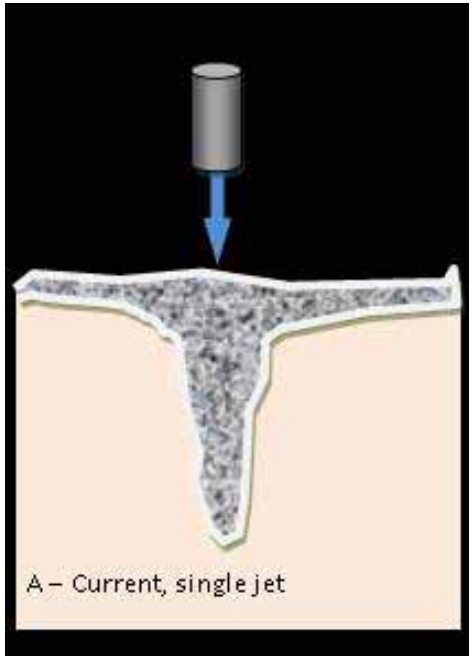
PAC Concentration Distribution

Spectroradiometer data

- 5-minute injection duration at
  500 PSI
- Depth ~ 8 inches
- Pocket formation



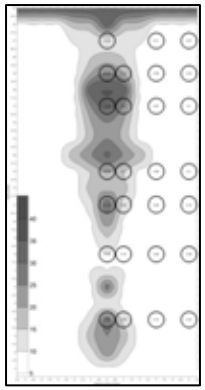
Injection Profiles



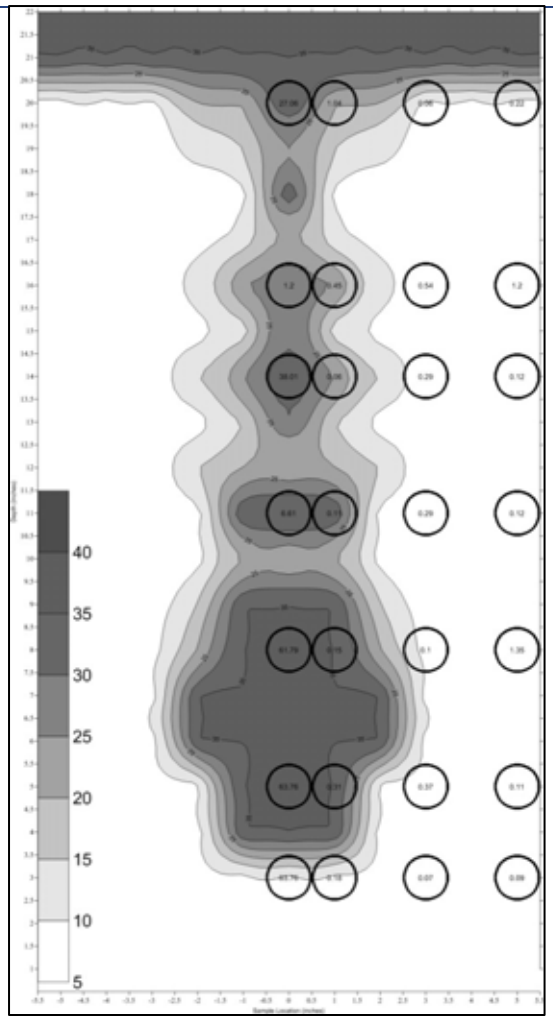
152mm

Iron Concentration Distributions

- Visual Comparison Analysis
  - Pattern confirmed using ACME Labs data
- Depth ~ 20 inches
  - 2.5 times PAC injection depth
- Pocket/Vein distribution: Likely due to the air escape from the pneumatic addition of the amendment



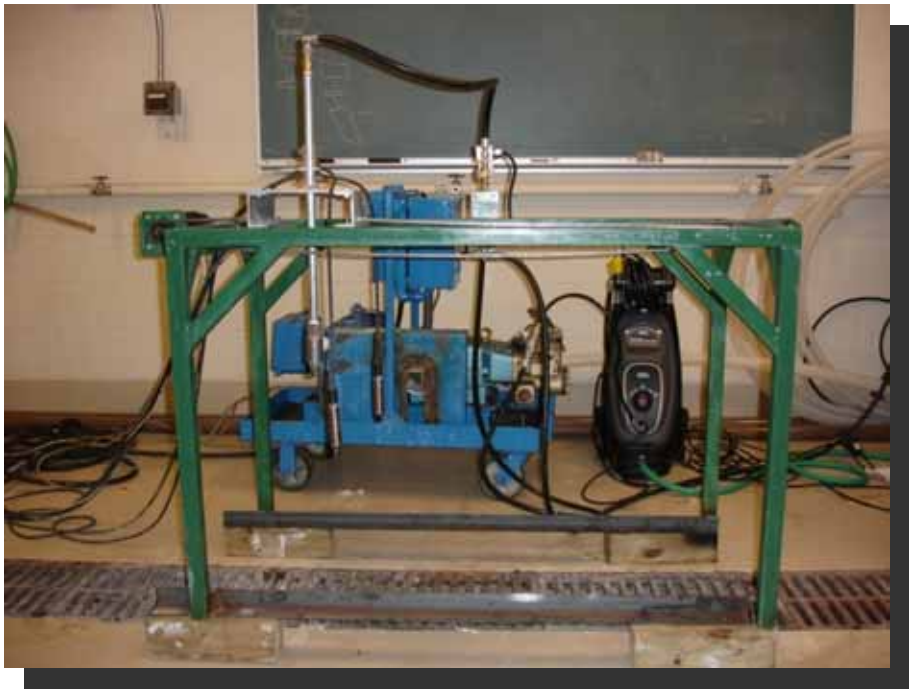
30 second injection

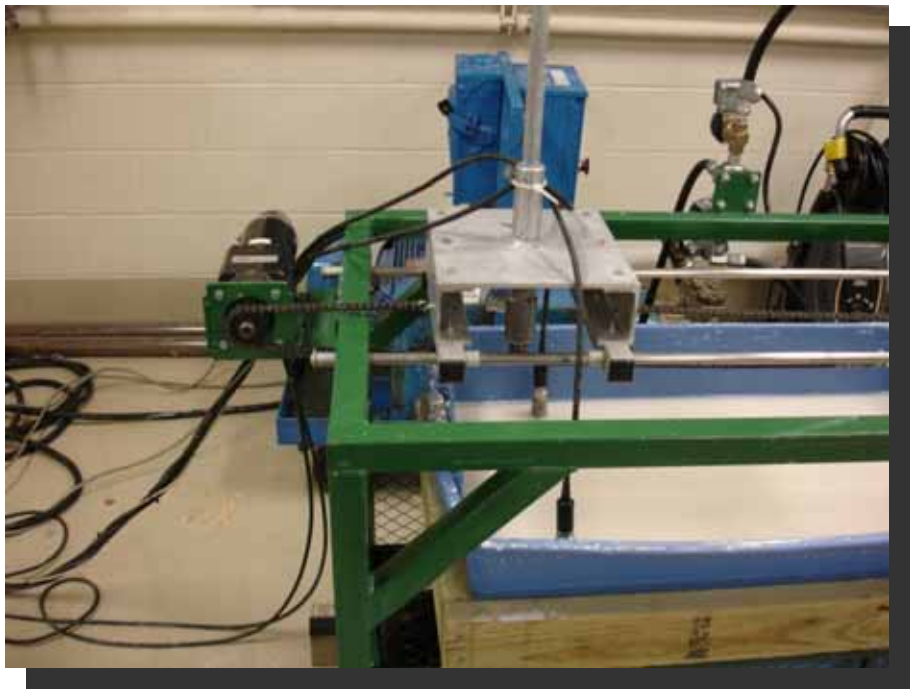


1 minute injection

Sediment injections

- Testing platform developed to repeat testing
- Control flow, traverse speed, lance location
- Capture video, turbidity, P, Q





Group participation: Everybody Hope & Pray

- Video…..

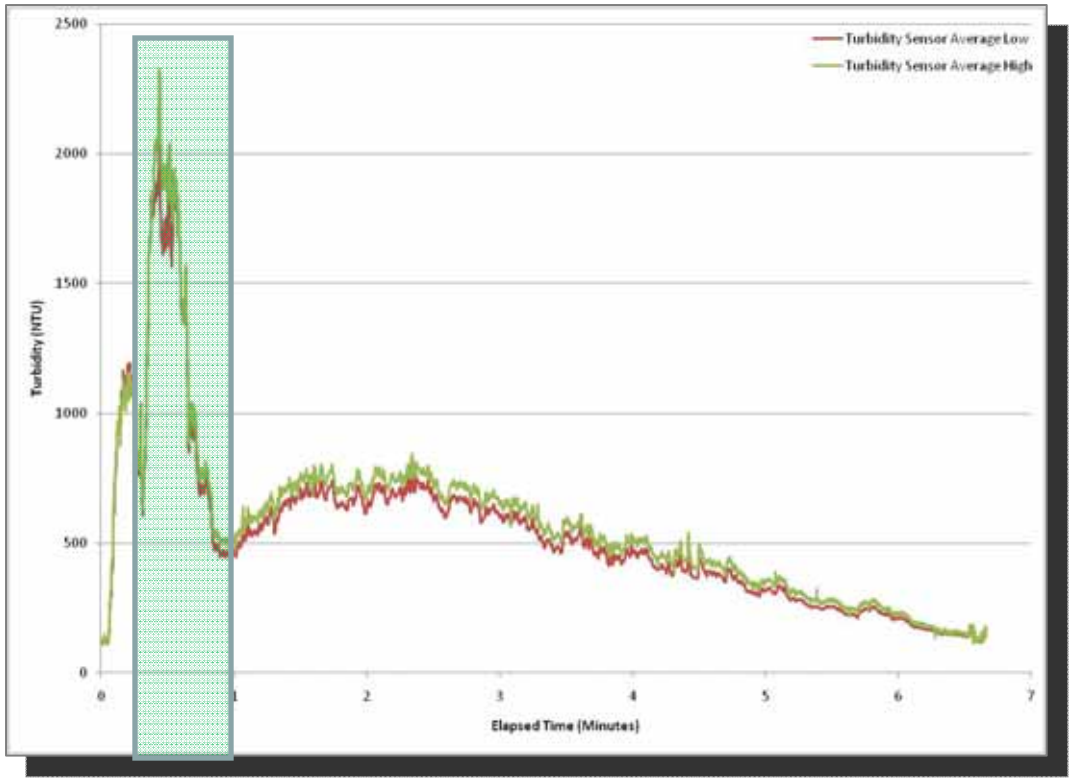
PAC injected into Kaolin

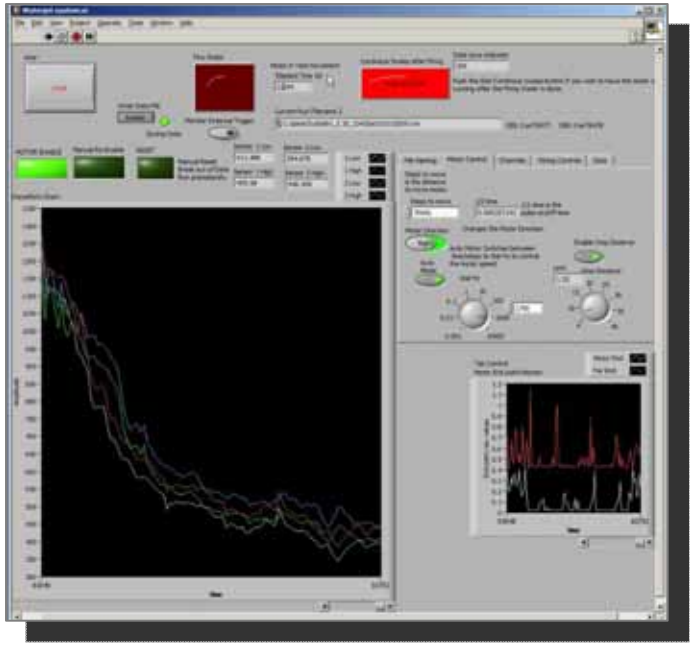
PAC injected to a depth of 12 inches consolidated sediment

Sediment and cap, before and after

- Cap was disturbed, but still observed. Amendment was not evenly distributed in consolidated sediment

Turbidity spike





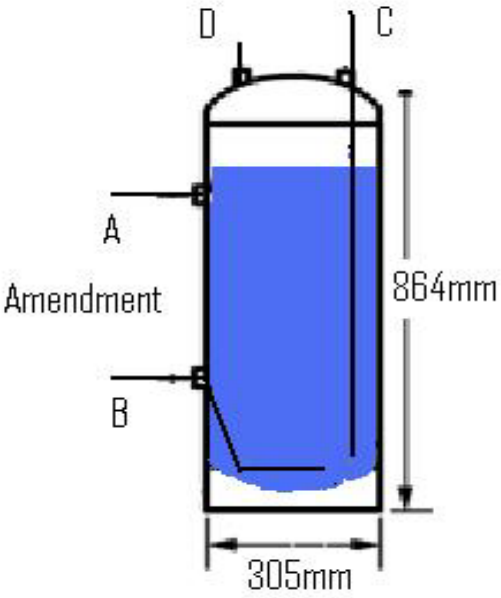
- Turbidity spike was higher than hoped due to the pneumatic feed.

Sediment Redeposition on Cap

- Injection to capped surrogate sediment (Clay)
- Some sediment was suspended to the water column, but cap was still continuous.
- Sediment deposition was on order of 1mm to 7 mm

Pneumatic Pressure system

- Pressure chamber mixed pneumatically
- Up to 35% PAC in solution.
- 120 PSI, did not reach targeted depth of delivery, more pressure needed.. Pneumatic Danger.
- Can be ‘boosted’ with pumping, at the expense of a reciprocating pump…
- Progressive cavity pump waiting.

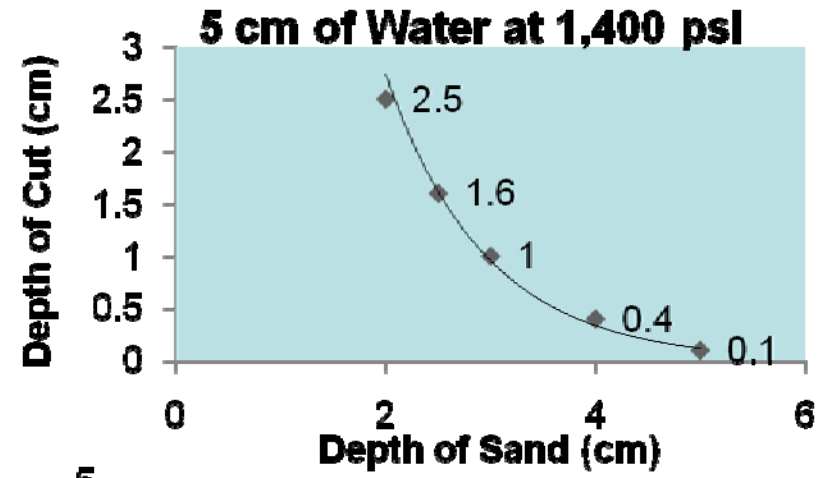


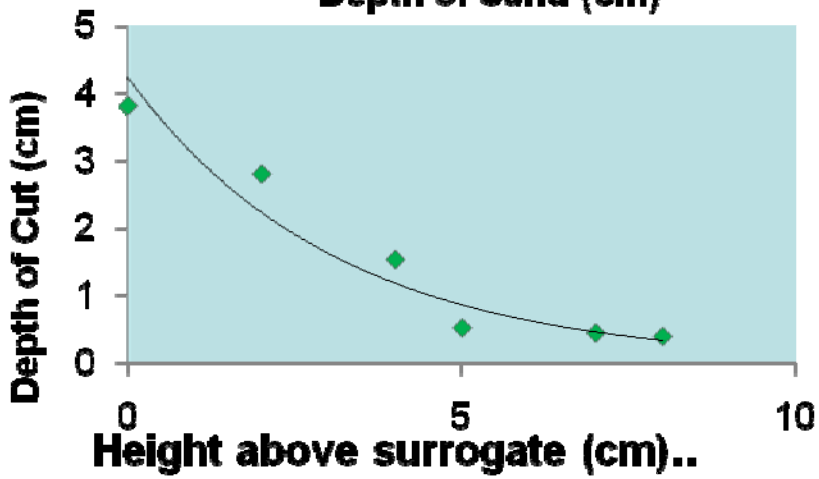
Benthic Damage testing

- <u>Experiments on Benthic Impacts</u>
- Tested acute damage to Mussel shells
- Tests were developed to use polystyrene surrogates and not live test subjects
- Penetration depth into dense polystyrene recorded
- Tests were performed at different pressures and depths below water or sand

Benthic Impacts Findings

- Little to no direct damage to mussels at up to 1400 PSI
- Damage directly injecting to only 5 cm depth (energy dispersed)
- Surface disturbance of <15% expected, But sediment will be redeposited to the surface…..
  WITH the amendment





Summary

- Amendment can be delivered via a variety of methods, each with challenges and benefits.
- Slurries to 35% carbon can be delivered with the
- Resuspension was substantial and penetration was limited with pneumatic amendment feed.
- Impacts to benthic organisms were minimal
  - No impact to mussels to 1400 PSI
  - Disturbance of <15% of surface
  - Amendment deposition with resuspended sediments likely limits bioavailability