A New, Sustainable Remedial Technology to Facilitate Risk Management and Closure of Mobile NAPL Sites

Virtual RemTech

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Presenter

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Vertex Environmental Inc.

- Founded in 2003
- Bruce Tunnicliffe, M.A.Sc., P.Eng.
- Specialized Environmental Remediation Contracting (in-situ, ex-situ, systems)
- High Resolution Site Characterization (HRSC)

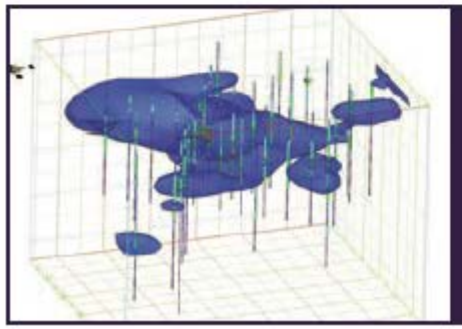
Vertex Environmental Inc.

In-Situ Remediation

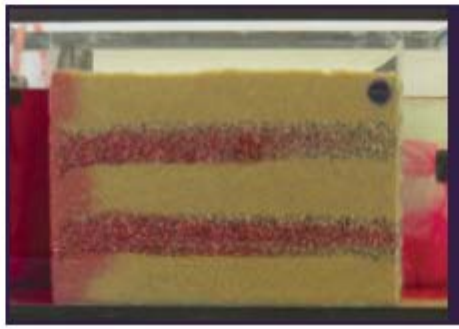
Ex-Situ Remediation

High Resolution Characterization

Treatment Systems



Remedial Design



Bench-Scale Testing

Presentation Overview

- Applicability
- Remedial Approaches
- Risk Assessment Challenges
- Block & Adsorb Technology
- Bench-Scale Testing
- Pilot-Scale Testing
- Next Steps
- Conclusions
- Acknowledgements
- Questions

Applicability

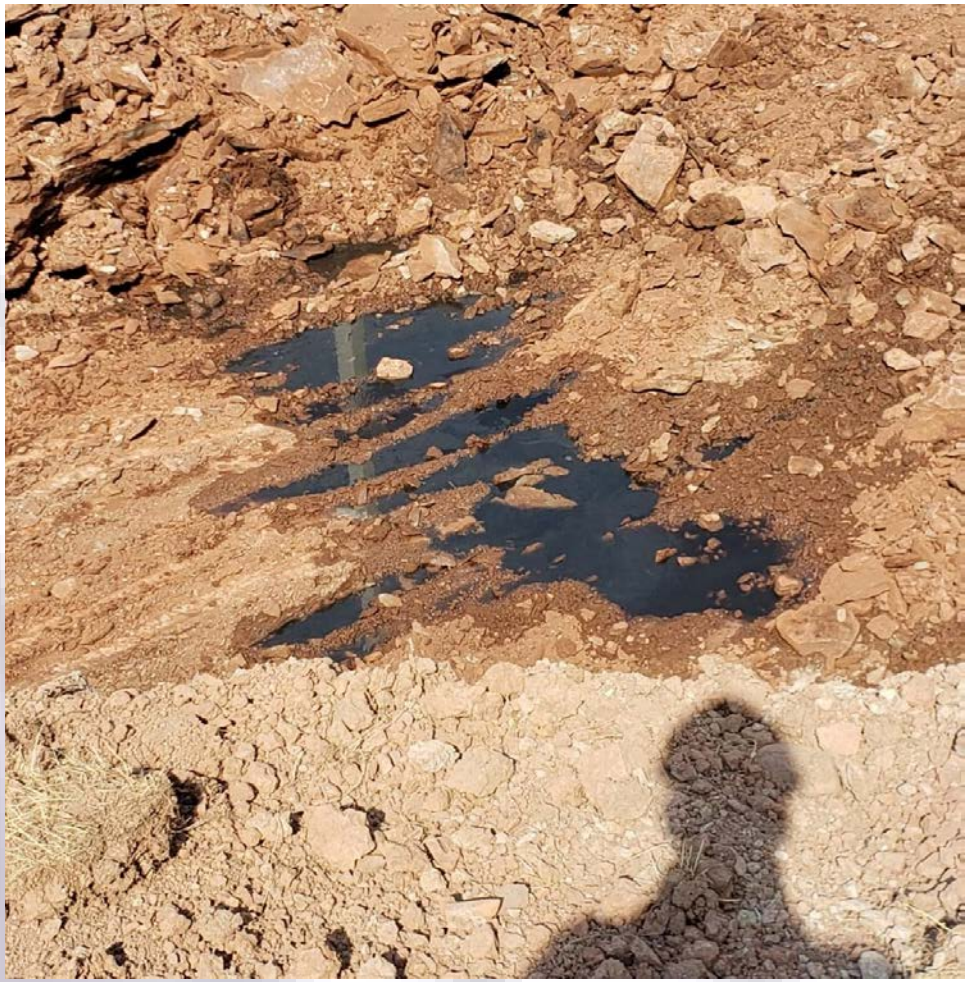
Applicability

Types of LNAPL impacts applicable to the technology:

- Phase-separated PHCs (measurable, films & sheens)
- Mobile or migrating; not residual
- Removal / destruction not needed from risk perspective
- Removal not possible / desired:
  - Coincident excavation not planned
  - Too deep; beneath structures; in B/R, etc.

Remedial Approaches

Remediation Approaches



Removal / Destruction:

- Excavation
- Fluid Recovery
- AS / SVE
- Thermal
- ChemOx
- Bio remediation / sparging / venting

Control / Management:

- MNA / NSZD
- Adsorption
- Permeability Reduction / Stabilization
- Isolation / Containment
- Risk Assessment / Risk Management

Combinations of the above

Risk Assessment Challenges

Risk Assessment Challenges

Several Canadian jurisdictions allow RAs on PHCs:

- BC:
  - Must assess **whether LNAPL is mobile** or stable (1 yr monitoring needed)
  - LNAPL (>2 mm) in MWs and mobile LNAPL can trigger **“high-risk site”** classification
  - Must assess VI considerations
- AB:
  - Control (non-mobile) or **actively remediate** (remove) to the **“extent practicable”** (mobile)
  - LNAPL source control: “stable” and “decreasing”
  - Exposure controls and risk management may be needed

Risk Assessment Challenges

- ON:
  - Permitted (B/R) but not preferred (O/B)
  - Remove LNAPL to the **“extent practicable” (incl. films, sheen and >50% solubility)**
  - Must assess VI considerations

What if there were a way to effectively immobilize LNAPL in-situ to allow easier approval of an RA?

Assist with reducing off-site risks & need for barrier walls; address GW to SW migration pathway; reduce vapour concerns; shorten length of monitoring programs, etc.

Block & Adsorb Technology

Block & Adsorb Technology

Concept:

- Bind mobile LNAPL & high concentrations of PHCs in soil and groundwater
- Lower formation permeability
- Enhance biodegradation potential

Block = Portland Cement (PC)

& Adsorb = Activated Carbon (GAC / PAC)

Block & Adsorb Technology

Possible Scenario:

- Risk Assessment
  - Soil and groundwater concentrations pass RA
  - No mobile LNAPL allowed under RA guidance
  - Possible concern over LNAPL migration
- Block & Adsorb Solution
  - Immobilize LNAPL in-situ
  - Not limited by depth or water table
  - No wastes generated
  - No other treatment necessary

Bench-Scale Testing

Bench-Scale Testing

Two stages Bench-Scale testing completed:

1. Separate:
    - Blocking capacity of PC alone
    - Adsorption capacity of GAC alone
2. Combined:
    - Assessment of synergies by using PC and GAC together

Soil samples obtained from site:

- Baseline testing for PHCs and LNAPL / sheen presence
- Spiked as needed to increase PHC contamination level:

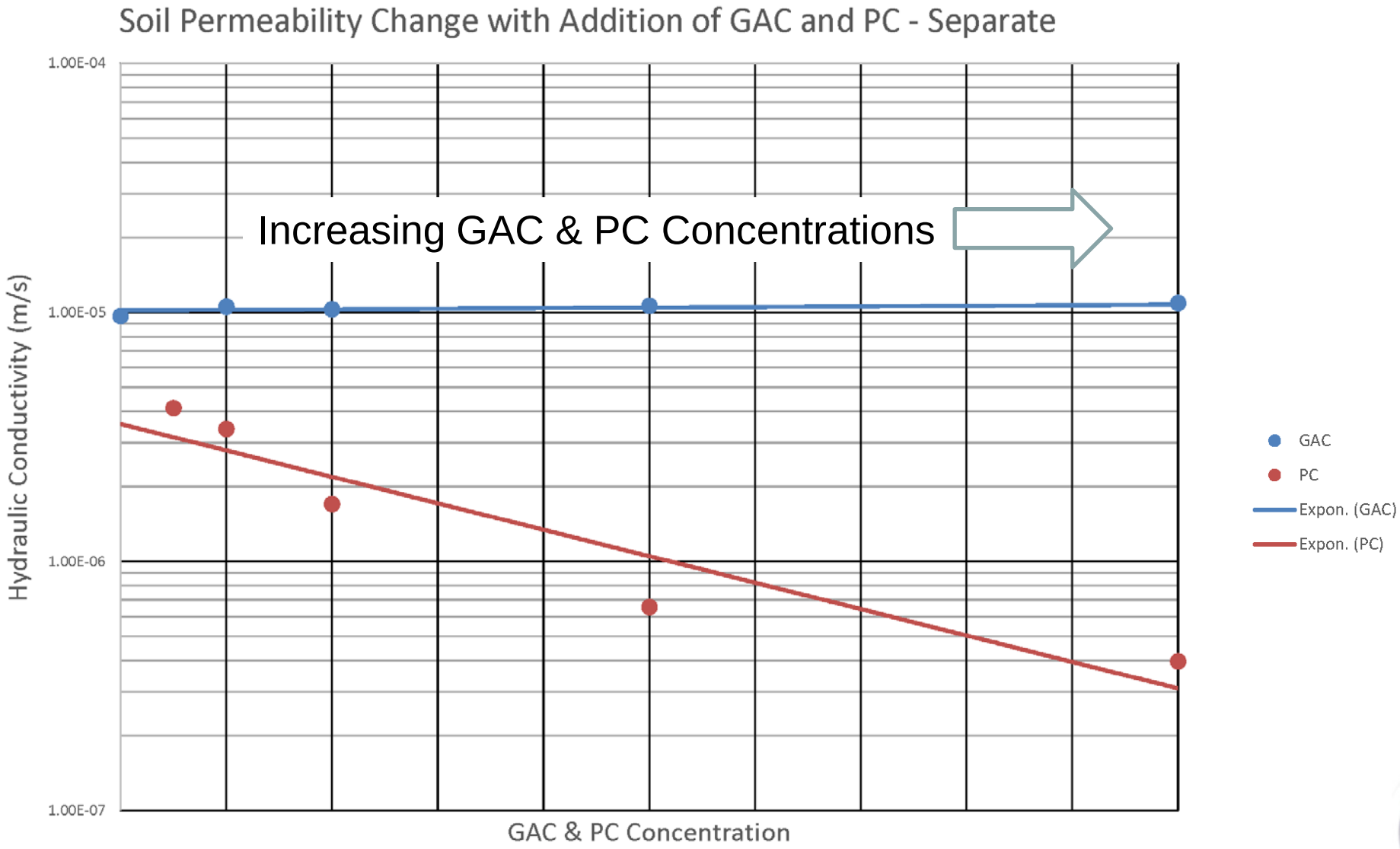
~30,000 ppm of F2 and F3 range PHCs

Bench-Scale Testing

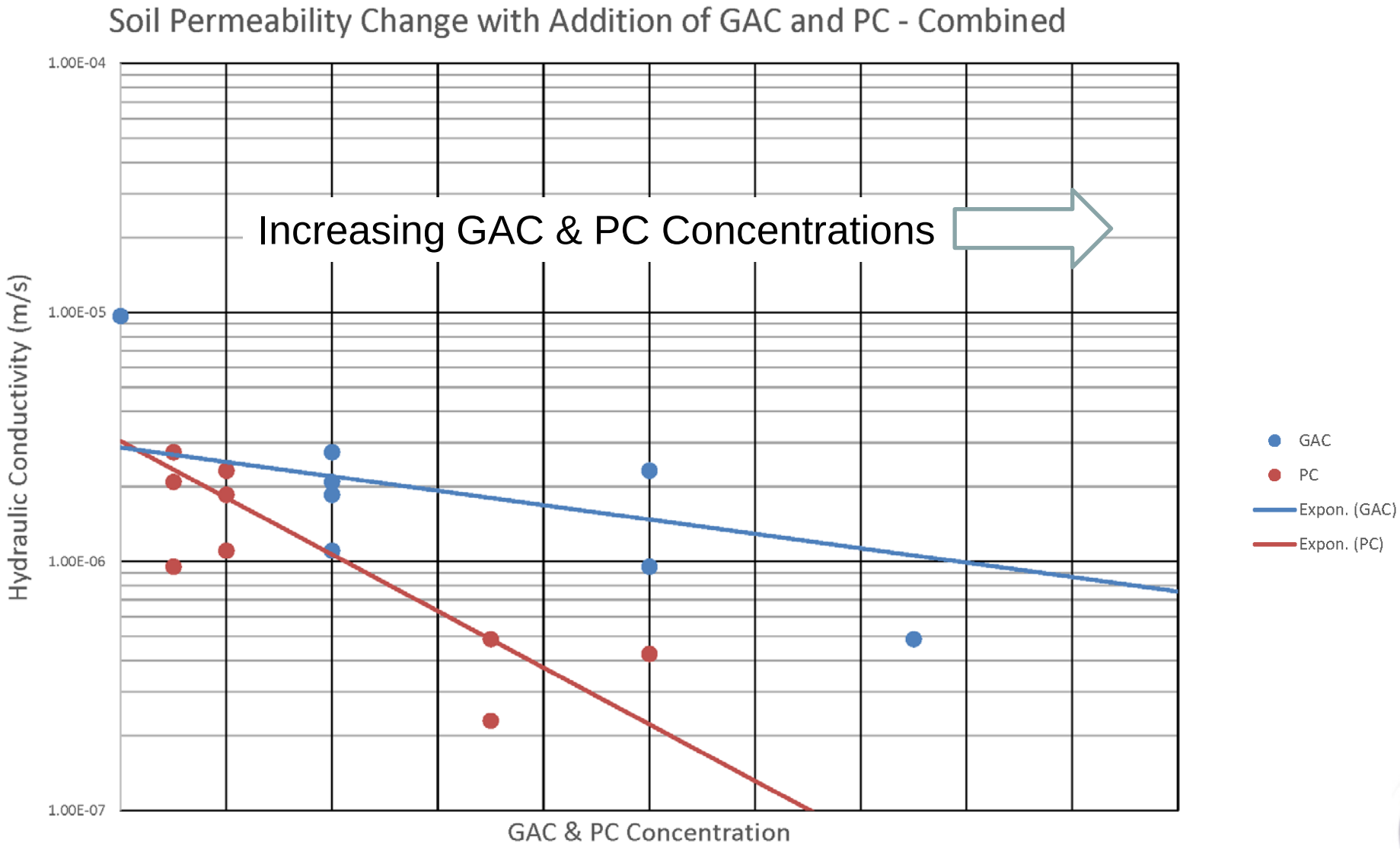
Soil samples were assessed pre- and post-treatment for:

- Hydraulic conductivity
- LNAPL or sheen mobility:
  - Liberation from soil via agitation
  - Leachate via flow-through column
- “Workability” (soil-like)
- PHC concentrations in soils and leachate

Bench-Scale Testing



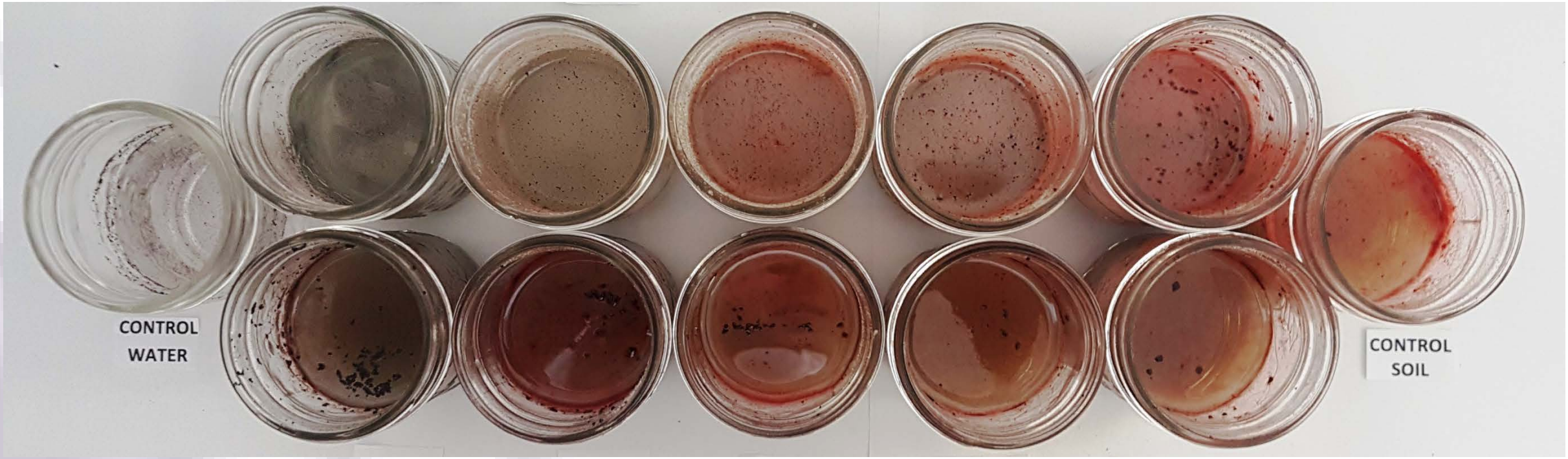
Bench-Scale Testing



Bench-Scale Testing

Visual LNAPL (dyed) in Individual PC & GAC Test Samples

Increasing PC Concentration



Increasing GAC Concentration

Bench-Scale Testing

Increasing GAC Concentration

GAC Alone

Reactor	Average
Control	Heavy
G1	Slight
G2	Slight
G3	Trace
N/A	-
G4	Trace
N/A	-
G5	No

GAC & PC Combined

Reactor	Average
Control	Heavy
PG1	No
PG2	No
PG3	No
PG4	No
PG5	No
PG6	No
PG7	No
PG8	No
PG9	No

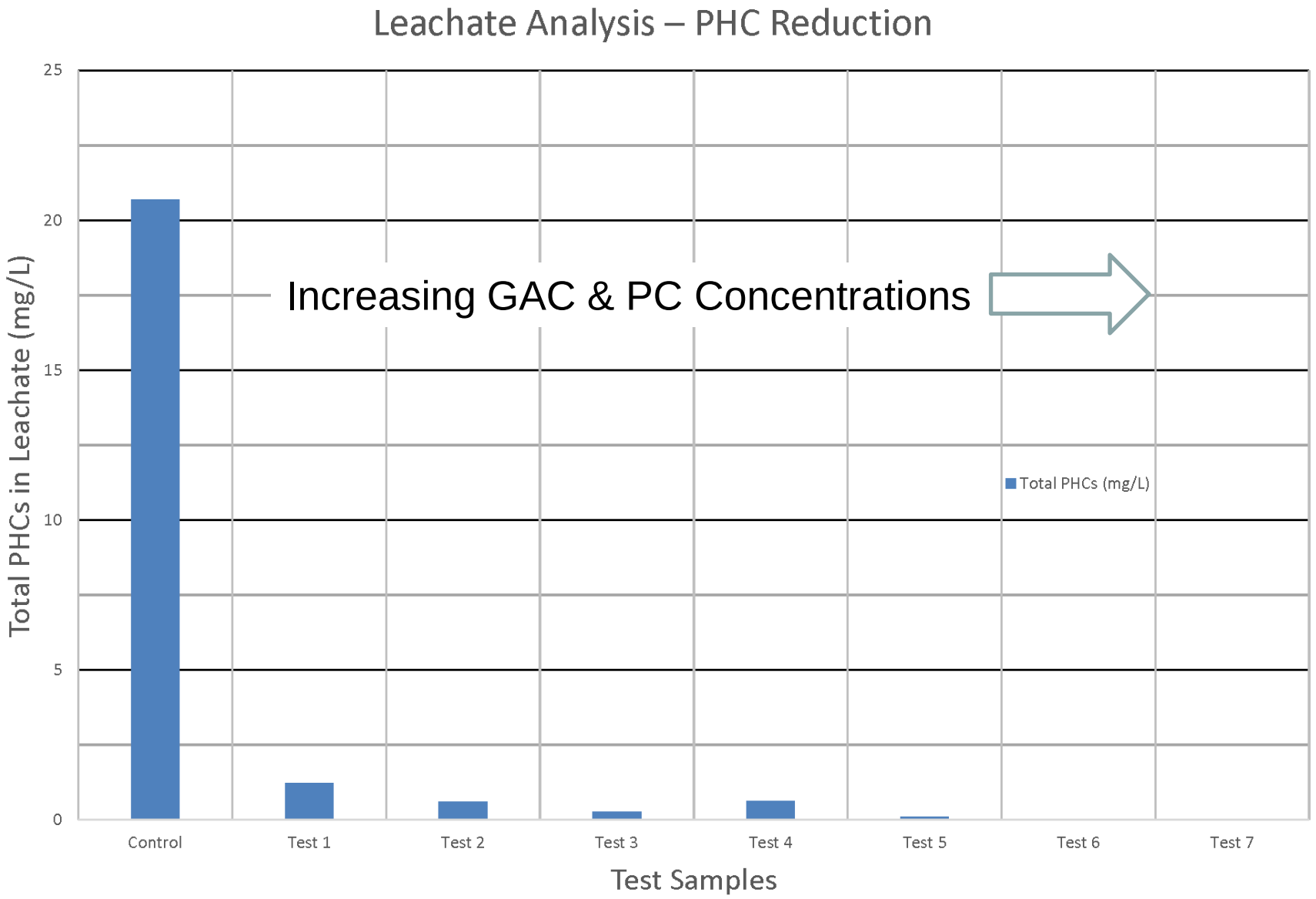
PC Alone

Reactor	Average
Control	Heavy
P1	Moderate
P2	Slight
P3	Trace
N/A	-
P4	No
P5	No

Increasing PC Concentration

Finding: relatively low concentrations of PC and GAC in combination are **more effective** at immobilizing PHC LNAPL that using higher concentrations of just PC or GAC

Bench-Scale Testing



Finding: for soil mixtures containing PC and GAC above certain concentrations, the treated soils would not only have immobile PHC LNAPL, but **essentially unleachable** levels of PHC parameters as well.

Bench-Scale Testing

Main findings:

- Combined PC and GAC more effective than individually
- Effective **immobilization of PHC LNAPL and sheens** in soils at up to 30,000 mg/kg
- Still **“soil-like”** with up to moderate concentrations of PC
- Low to moderate concentrations of PC **decreases permeability** by 80% to 95%
- Reduced levels of dissolved-phase PHCs
  - **Significant reduction** in leachability with low PC & GAC
  - **Essentially unleachable** at higher concentrations
- The technology should be applicable to **treat soils in-situ**

Pilot-Scale Testing

Pilot-Scale Testing

Pilot-scale trials to further validate Block & Adsorb technology included the following activities:

- **Site characterization** of soil and groundwater conditions to establish baseline (PHCs in soil of ~45,000 ppm)
- Construction of **three test plots** to investigate **control** conditions, **soil mixing** approach, and **injection** approach
- **Groundwater sampling** following application of technology
- **Analysis of analytical data** collected over 8 weeks throughout the testing

Pilot-Scale Testing

Three test plots with similar degrees of PHC LNAPL contamination were selected:

1. **Control Plot**: Left undisturbed. No amendments or other changes introduced
2. **Test Plot 1 (Soil Mixing)**: Amendments introduced into subsurface via direct placement followed by soil mixing using excavator
3. **Test Plot 2 (Injection)**: Amendments introduced into subsurface via mixing into suspensions / slurries & injection using direct push drill rig & pumps

Pilot-Scale Testing

Pilot-Scale Testing

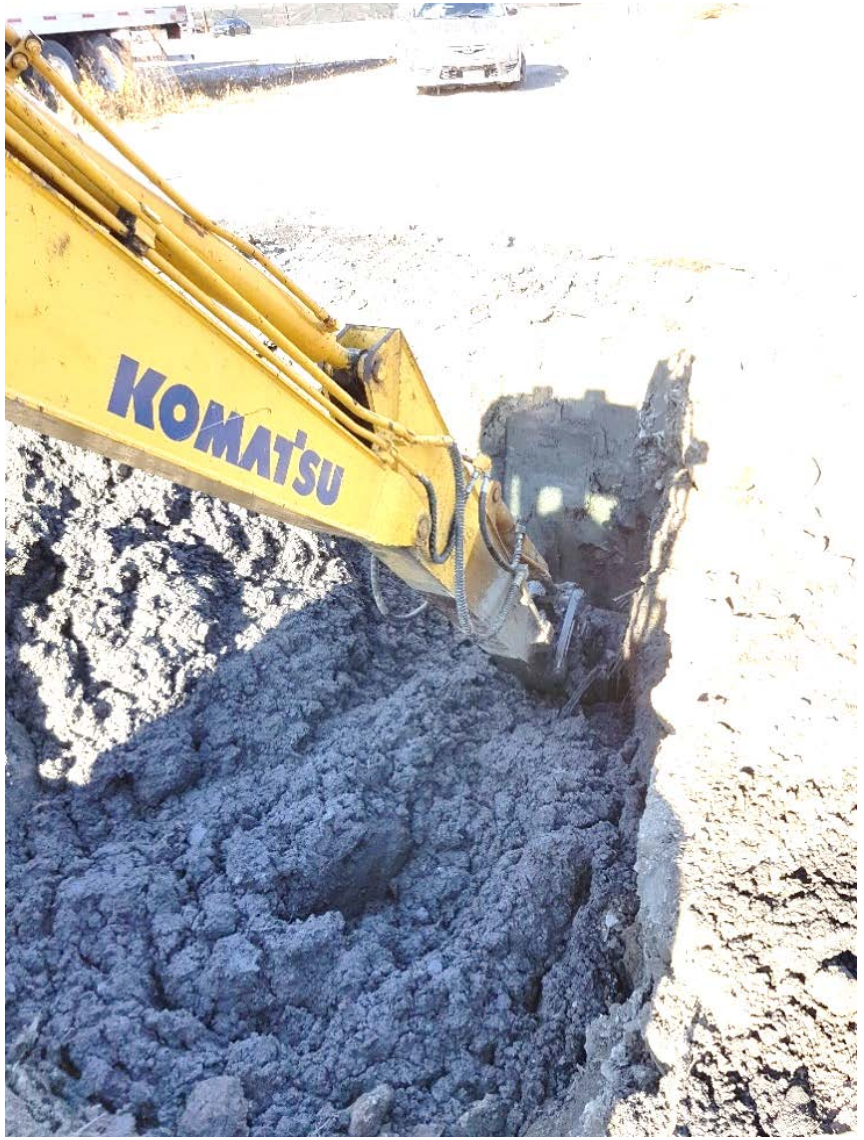
GAC addition and soil mixing

Pilot-Scale Testing

PC addition and soil mixing

Pilot-Scale Testing

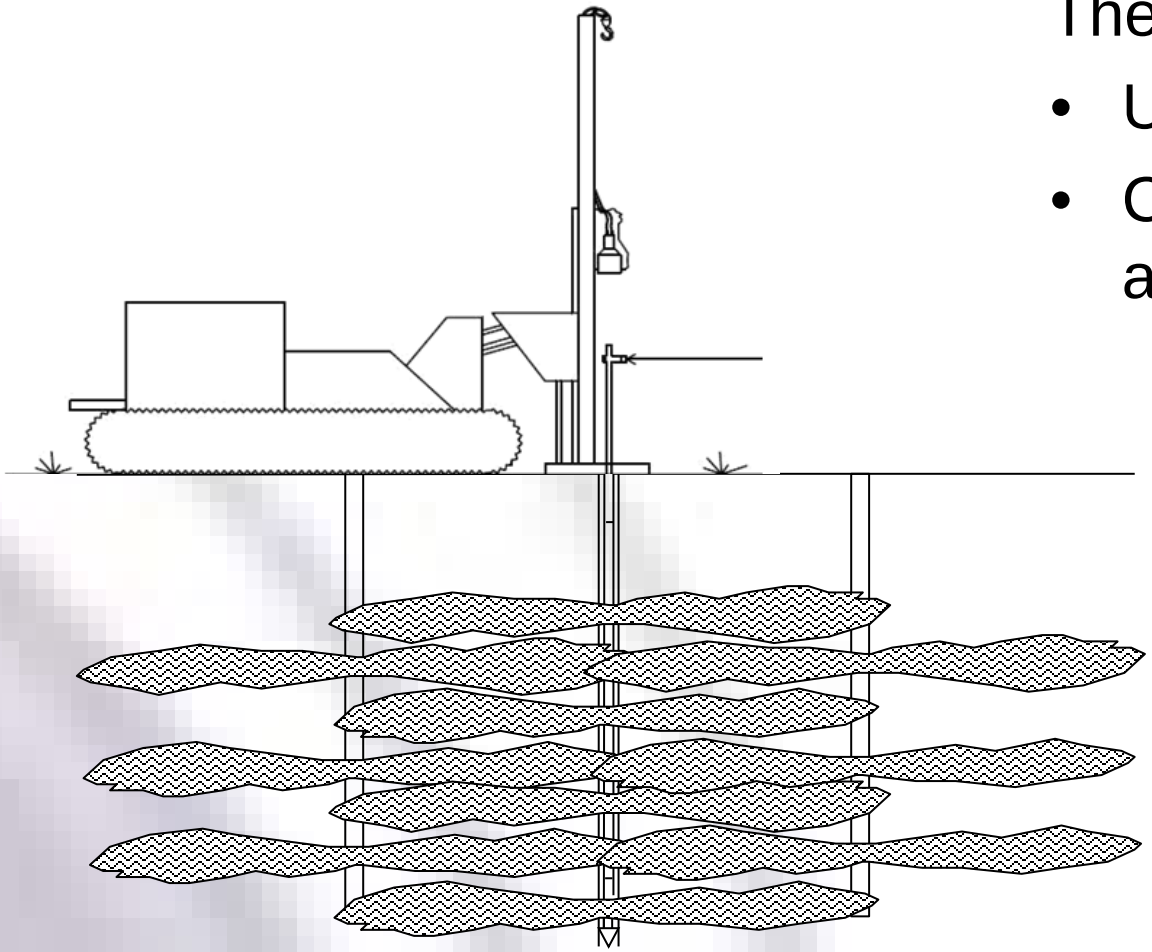
Soil consistency before
and after in Soil Mixing Plot



Pilot-Scale Testing

PAC injection
and PC injection

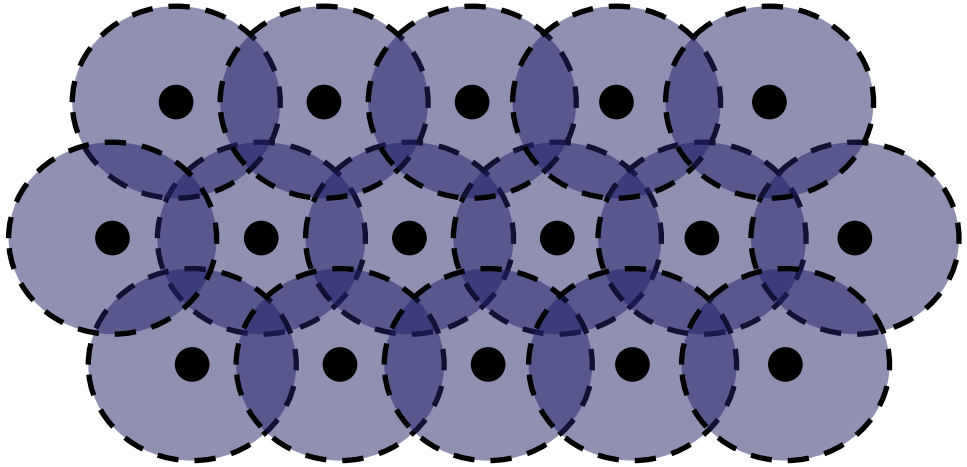
Pilot-Scale Testing



Profile View

The Goal:

- Uniform Distribution
- Contact between remedial amendment and contaminants



Plan View

Pilot-Scale Testing

Groundwater Samples Collected from (L to R): Control Plot (No Treatment), Test Plot 1 (Soil Mixing) and Test Plot 2 (Injection)

=

Pilot-Scale Testing

Test Pit Excavated into Test Plot 1 (Soil Mixing) – Within (left) and Beyond (right) Treated Soil Mass

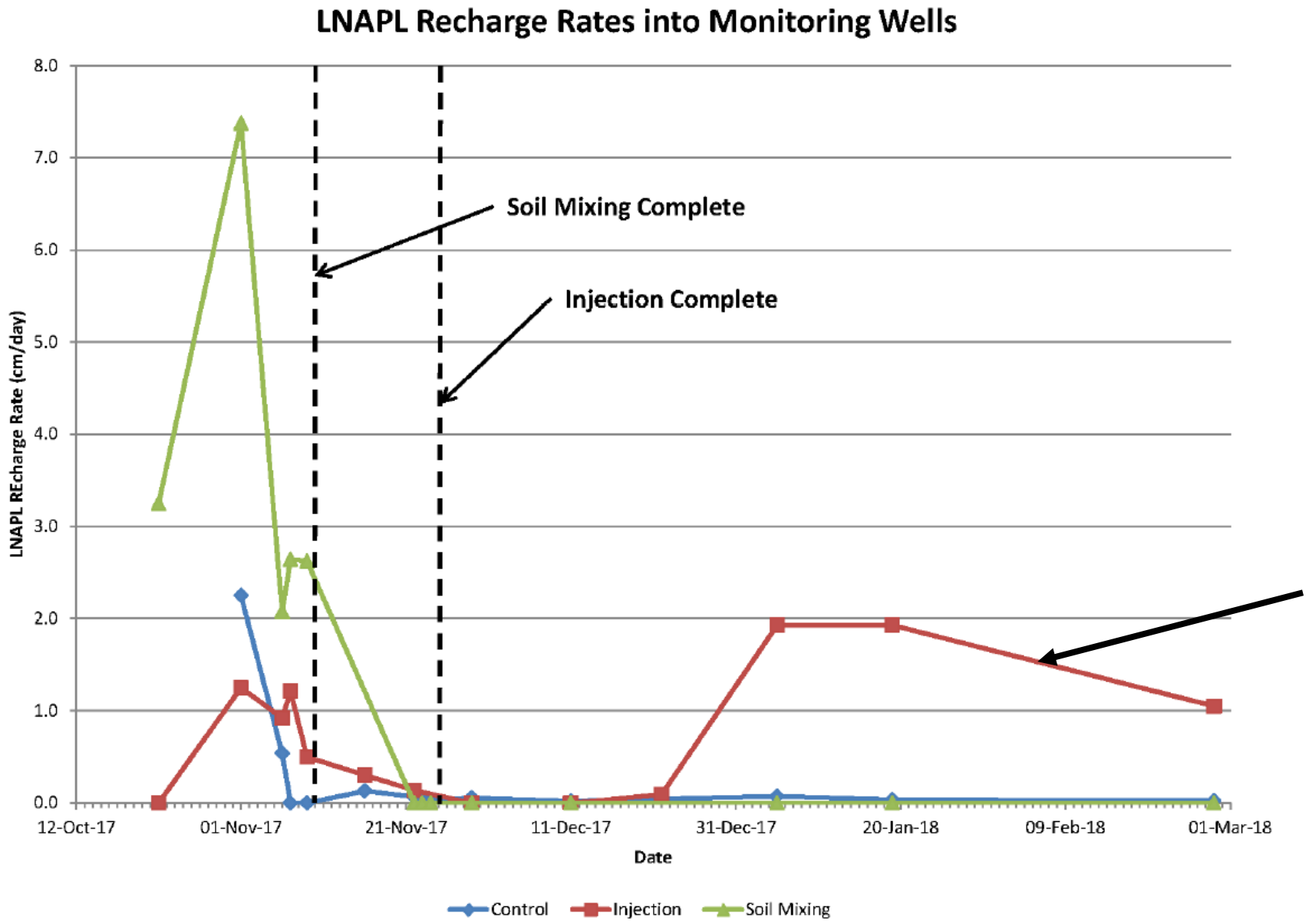
Pilot-Scale Testing

Test Pit Excavated into Test Plot 2 (Injection) – Less uniform than Plot 1; Note entry of LNAPL and water from outside area of injection influence (R)

Pilot-Scale Testing

Treated Soils from Test Plot 1 (Soil Mixing) (L) and
Test Plot 2 (Injection) (R)

Pilot-Scale Testing



Baseline PHCs in soil of ~45,000 ppm in both pilot-scale test plots

Recharge of LNAPL in Plot 2 likely due to mass limitations when injecting amendments (insufficient PAC)

Pilot-Scale Testing

Main findings:

- Block & Adsorb proven **effective at immobilizing LNAPL in-situ**
- Delivery methods tested are each **suitable for the delivery / distribution** of remedial amendments in subsurface:
  - **Soil Mixing** suitable for **near surface soils** and areas amenable to physical disturbance
  - **Injection** suitable for **deeper soils** and areas not amenable to physical disturbance (e.g. under buildings)
- Both application methods are designed to **overcome heterogeneities** in stratigraphy
- Block & Adsorb technology **reduced dissolved phase groundwater concentrations** of PHCs by upwards of >90%

Conclusions

Conclusions

What if there were a way to effectively immobilize LNAPL in-situ to allow easier approval of an RA?

Block & Adsorb Technology:

- **No excavation** / extraction / mass removal / destruction required
- Proven to **immobilize up to at least 45,000 mg/kg of PHCs** in soil (mixing) and ~15,000 to 20,000 mg/kg (one injection event)
- Drastically **reduces dissolved-phase PHCs** in groundwater also
- Can be directly **soil mixed or injected** depending on site conditions
- **No wastes** generated
- Relatively low cost and **sustainable** solution

Next Steps

Next Steps

- Additional assessment of NAPL mobility on treated soils:
  - Frozen core residual saturation testing
- Longer term assessments needed:
  - Durability of treatment (sustained LNAPL immobilization)
- Applicability of technology:
  - Other COCs (BTEX, emulsified oils, DNAPLs, etc.)
  - Other stratigraphies (silts/clays, bedrock)
- Effect of technology on vapour suppression
- Further field trials / full-scale implementation at other sites
- Assessment of regulatory body acceptance

Acknowledgements

Acknowledgements

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Client

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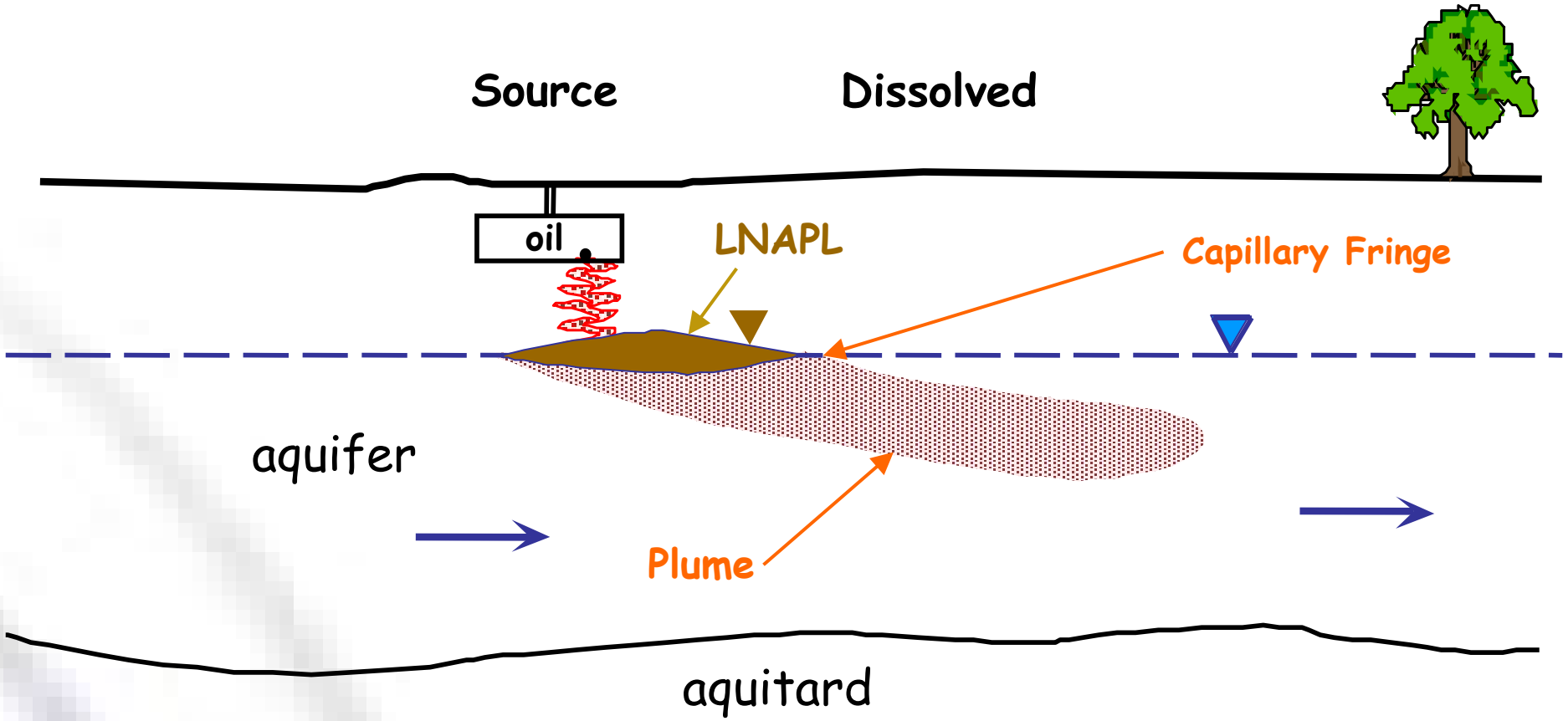
Project Funding

FCM FEDERATION OF CANADIAN MUNICIPALITIES FÉDÉRATION CANADIENNE DES MUNICIPALITÉS

VERTEX



Questions?

Thank You for Your Time!

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