



In-Situ Permeable Reactive Barrier Remediation Optimization using High Resolution Site Characterization Tools – A Case Study

RemTech East

June 1, 2022

Patrick O'Neill, M.A.Sc., P.Eng.

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**In-Situ
Remediation**



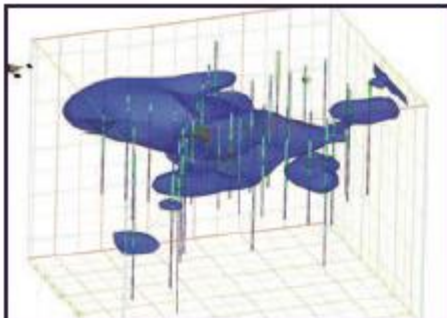
**Ex-Situ
Remediation**



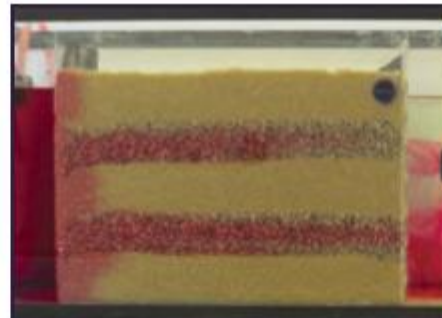
**High Resolution
Characterization**



**Treatment
Systems**



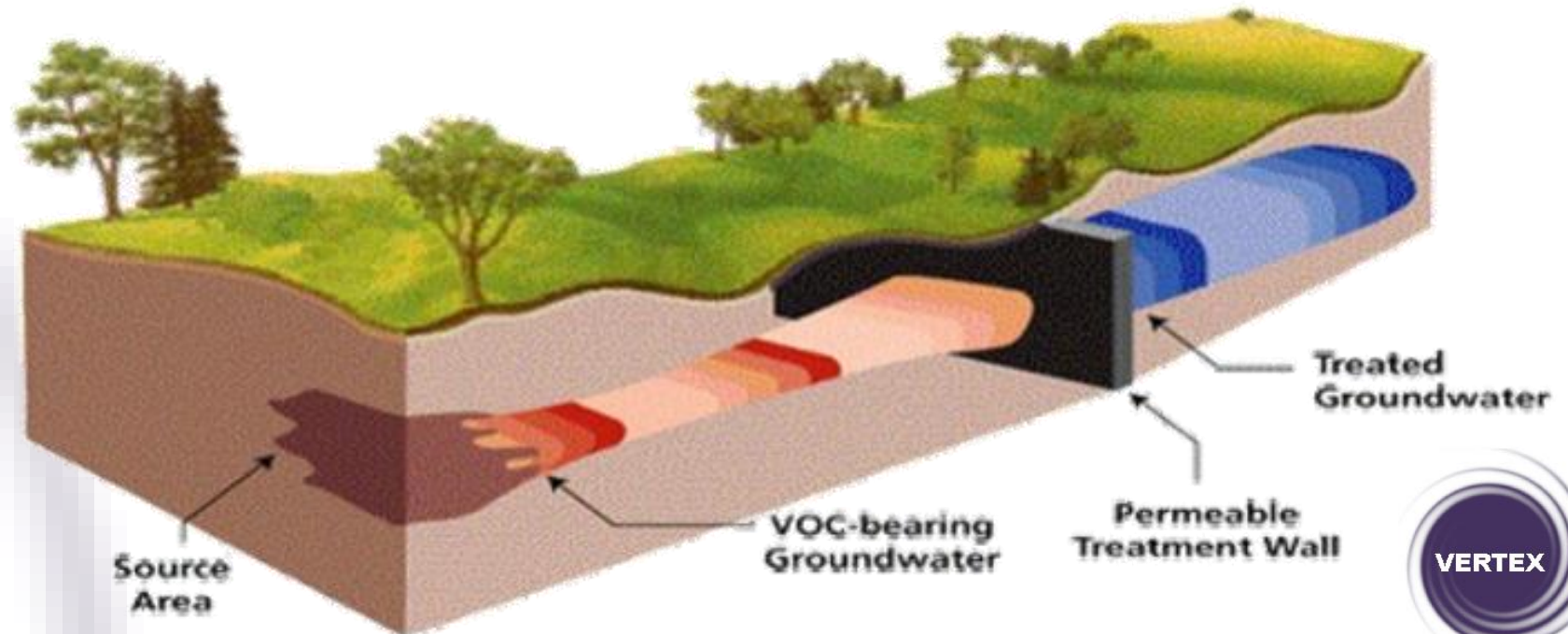
**Remedial
Design**



**Bench-Scale
Testing**

Presentation Overview

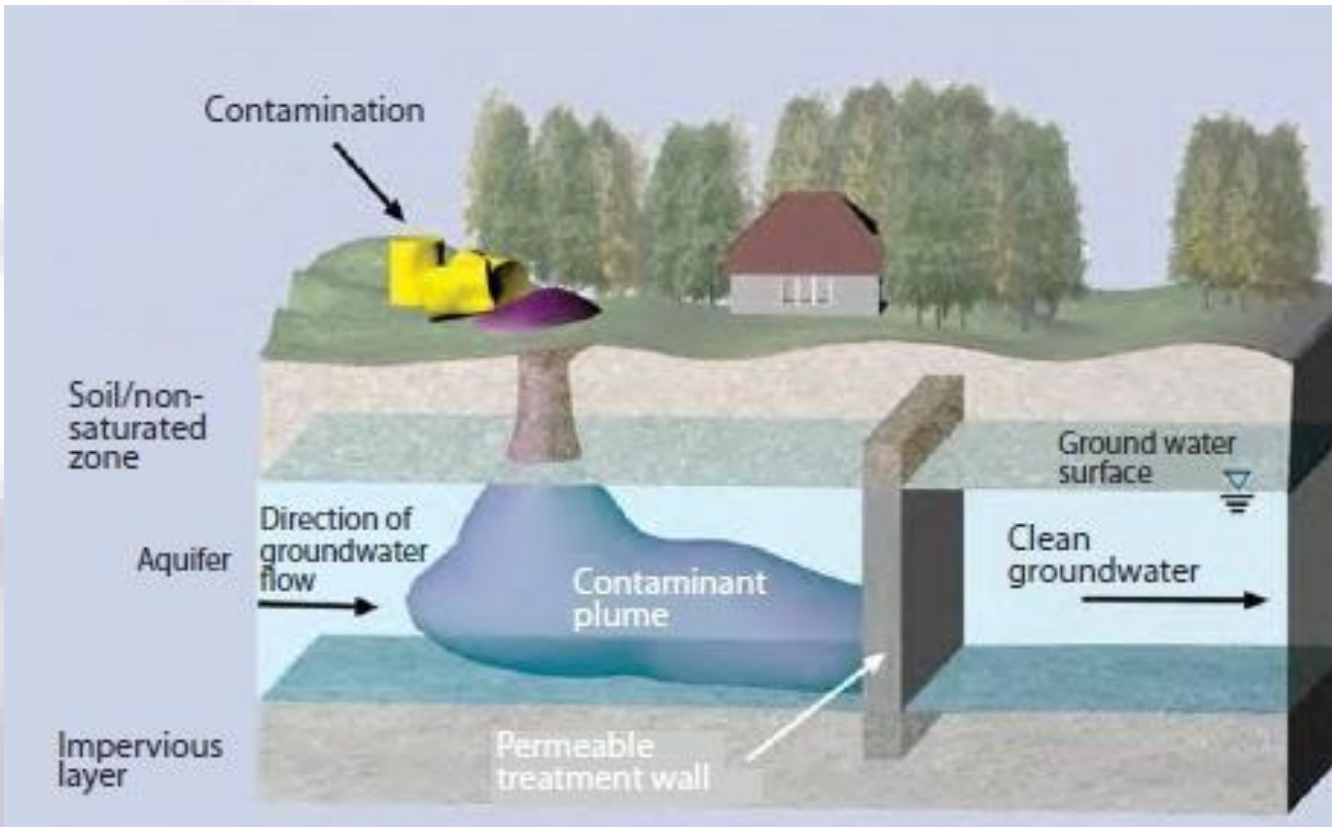
- Permeable Reactive Barriers (PRB)
- How to Design & Install a PRB
 - Old School (Traditional Approach)
 - New School (High Resolution Site Characterization Approach)
- Case Study: PRB Optimization using HRSC
 - Initial Design
 - HRSC Work
 - HRSC Results
 - Optimized Design & Cost Savings
- Questions



Permeable Reactive Barriers



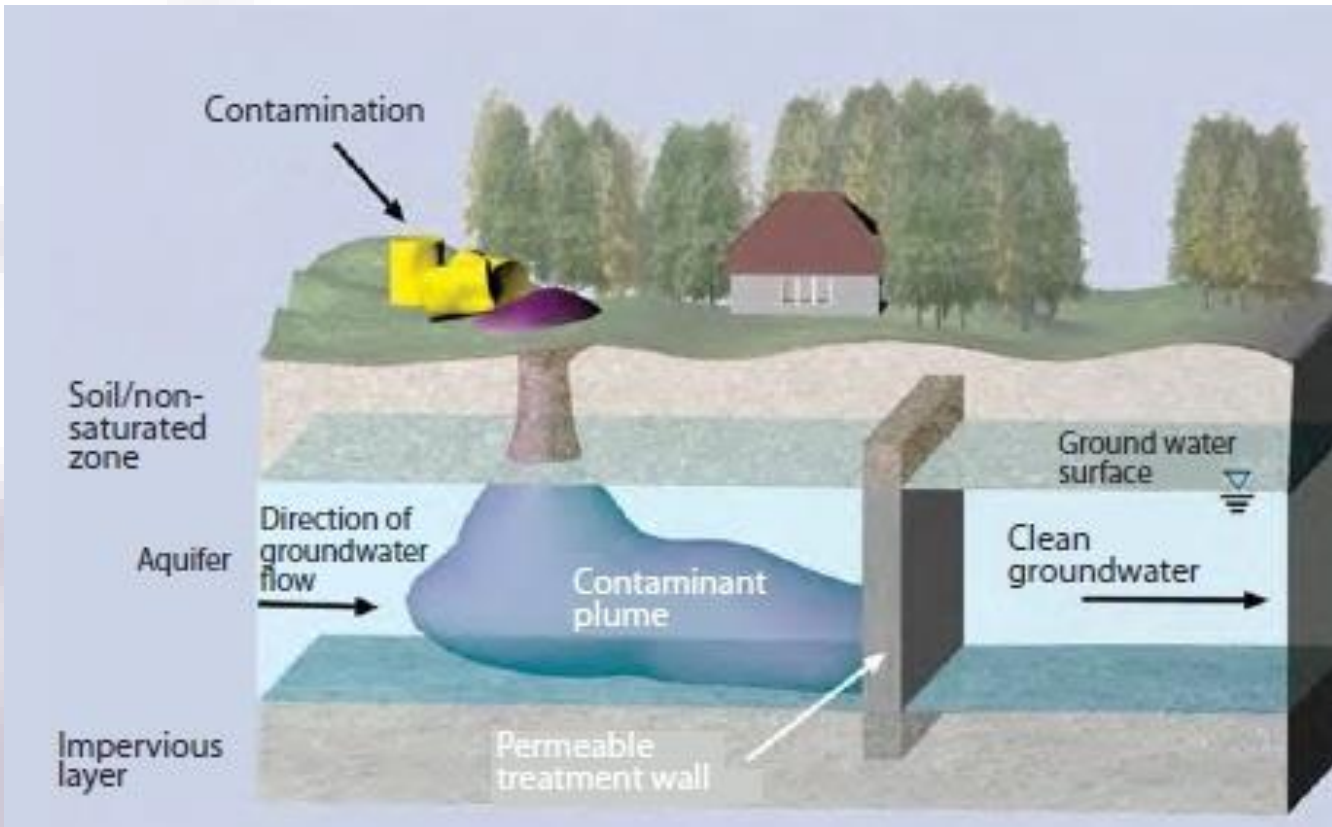
PRB Background – Applications



What is a Permeable Reactive Barrier (PRB)?

- PRBs intercept and treat contaminated groundwater plumes (passive)
- Allow groundwater to flow through unimpeded
- Can be excavated or injected
- Sustainable (no energy use to operate)

PRB Background – Applications

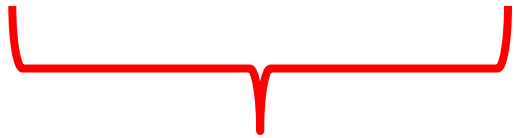
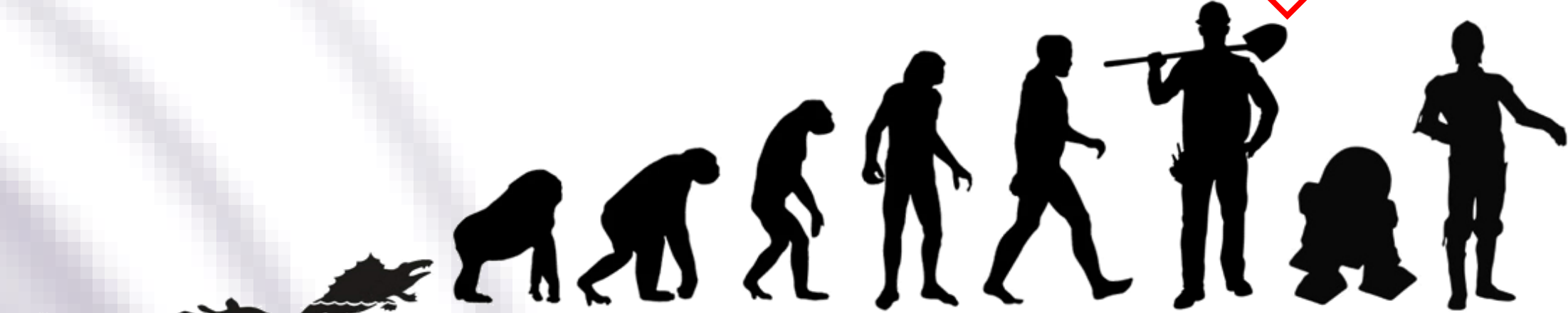


Why Would You Need a PRB?

- Property boundary control (prevent off-site migration or protect from off-site source)
- Risk to sensitive receptors: human health or ecological (e.g. residential or creek)
- Pressure to Act: lawsuit
- Cannot access or clean-up an off-site source of contamination (i.e. upgradient)

A Brief History of PRBs

Where we are today



Old School way



PRB Design & Installation - Old vs New



How to Design and Install a PRB – Old School

- Traditional Techniques;
 - Borehole drilling & environmental sampling,
 - Monitoring well installation,
 - Groundwater well development & sampling,
 - Analysis of soil and groundwater samples,
 - Low Flow sampling
 - Wide range of parameters to be scanned
- Usually requires multiple iterations/mobilizations for proper delineation and proper Site assessment
 - Costs can and will add up over time over time, delineation and characterization can be very costly in time and money!
 - Not a very sustainable model!



How to Design and Install a PRB – Old School



- Use generic assumptions / rules of thumb
- Dig a trench
- Mix up some ZVI and sand
- Maybe do some mag. separation testing
- Backfill the trench
- Hope for the best...
 - Under design = Failure
 - Over design = Wasted \$\$
- But what if there is something unusual about your site?
- Is there a better way? **YES!**

High Resolution Site Characterization (HRSC)



How to Design and Install a PRB – New School

- High Resolution Site Characterization (HRSC) Techniques;
 - Borehole drilling & environmental "sampling" in real time on-Site,
 - Geotechnical & Environmental parameters collected
- Optimized monitoring well installation & sampling,
 - Analysis of targeted soil and groundwater samples,
 - Specific set key parameters to be analyzed
- HRSC can be completed in one mobilization for extensive screening/delineation both vertically and horizontally
 - Costs for HRSC surveys can pay for themselves multiple times over when considering multiple traditional mobilizations to collect same data AND when considering potential remediation costs of the Site
 - Less mobilizations = a more sustainable and efficient program



How to Design and Install a PRB – New School

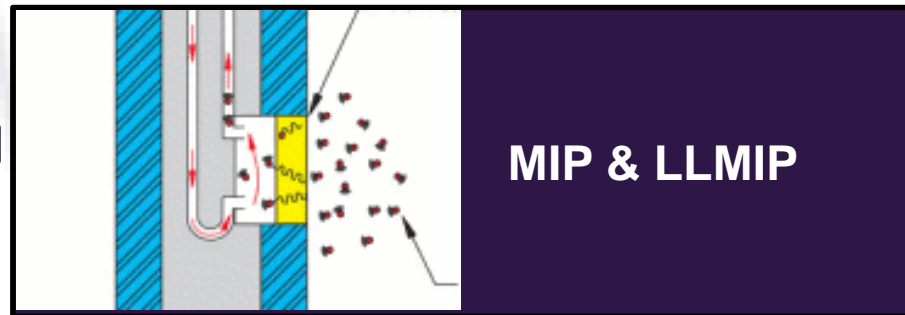


- Use HRSC and analytical data to create a highly detailed understanding of the Site/PRB alignment
- Incorporate hydrogeological information to estimate contaminant flux
- Optimize PRB design for Site specific parameters
- Select specific amendment for contaminants and begin installation (cut & fill and/or in-situ injection)
- Complete amendment specific QA/QC during installation
- Mitigate uncertainty!
- Monitor PRB for performance

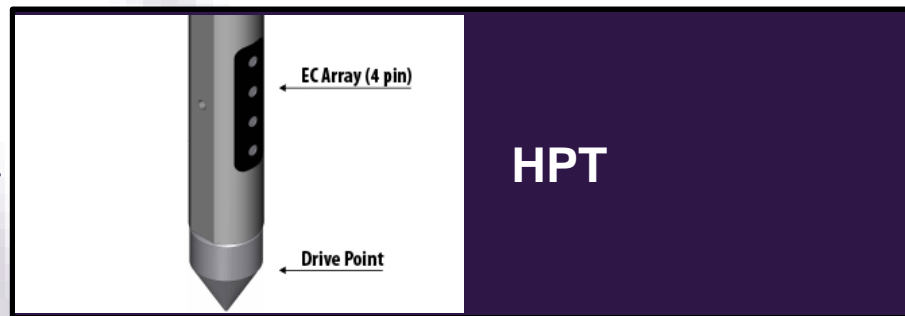
High Resolution Site Characterization Tools



Free Phase (PHCs)



Dissolved Phase



Subsurface Permeability

Combined! MiHpt
& LLMiHpt



Case Study – PRB Design Optimization Using HRSC

Case Study

Site details / background:

- Southwestern Ontario Site
- Chlorinated Volatile Organic Compounds (cVOCs) migrating from off-Site source onto property
- Objective: Install PRB to protect on-Site tenants and for bank refinancing
- A few rounds of limited traditional delineation work and sampling completed by consultants
- Vertex asked to develop PRB to based on sparse data
- LLMiHpt brought in to fill in data gaps of cVOC plume definition was limited at best
- No hydrogeological information was estimated for on-Site in previous works



Case Study

Original PRB Design:

- Based on limited information from 4 groundwater monitoring wells with significant gaps between
- Monitoring wells had some soil samples submitted during installation
- Water table measured at approximately 1 mbgs
- Initial PRB installation depths from 1 to 4 mbgs (3 m of saturated wall thickness)
- No information on Site hydraulic conductivity only assumptions based on geology, literature and experience
- Conservative estimate included entire length of property boundary ~\$180,000 to install



Case Study

HRSC Work Completed on-Site:

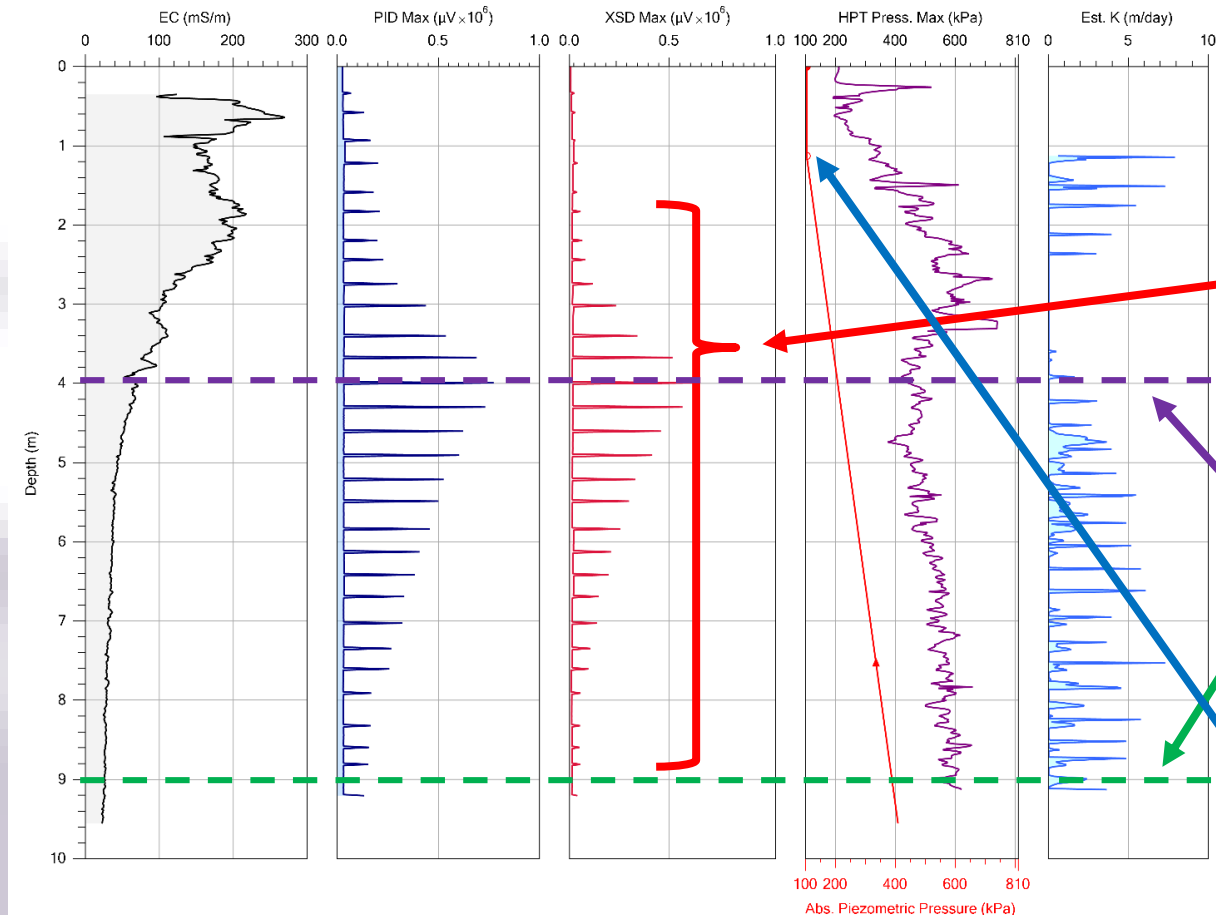
- Completed fifteen (15) LLMiHpt locations in 4 days along property boundary and interior of active facility
 - 9 LLMiHpt locations along PRB alignment
 - 6 LLMiHpt locations inside active facility (downgradient of proposed PRB)
- Depth of Probing = up to 9.7 mbgs (*up to 4 mbgs maximum on previous design*)
- Tighter locations along property boundary and on-Site building AND working around active facility storage racks, equipment, and employees
- Many considerations must be made with working inside active facilities → on-Site disruptions and time management!



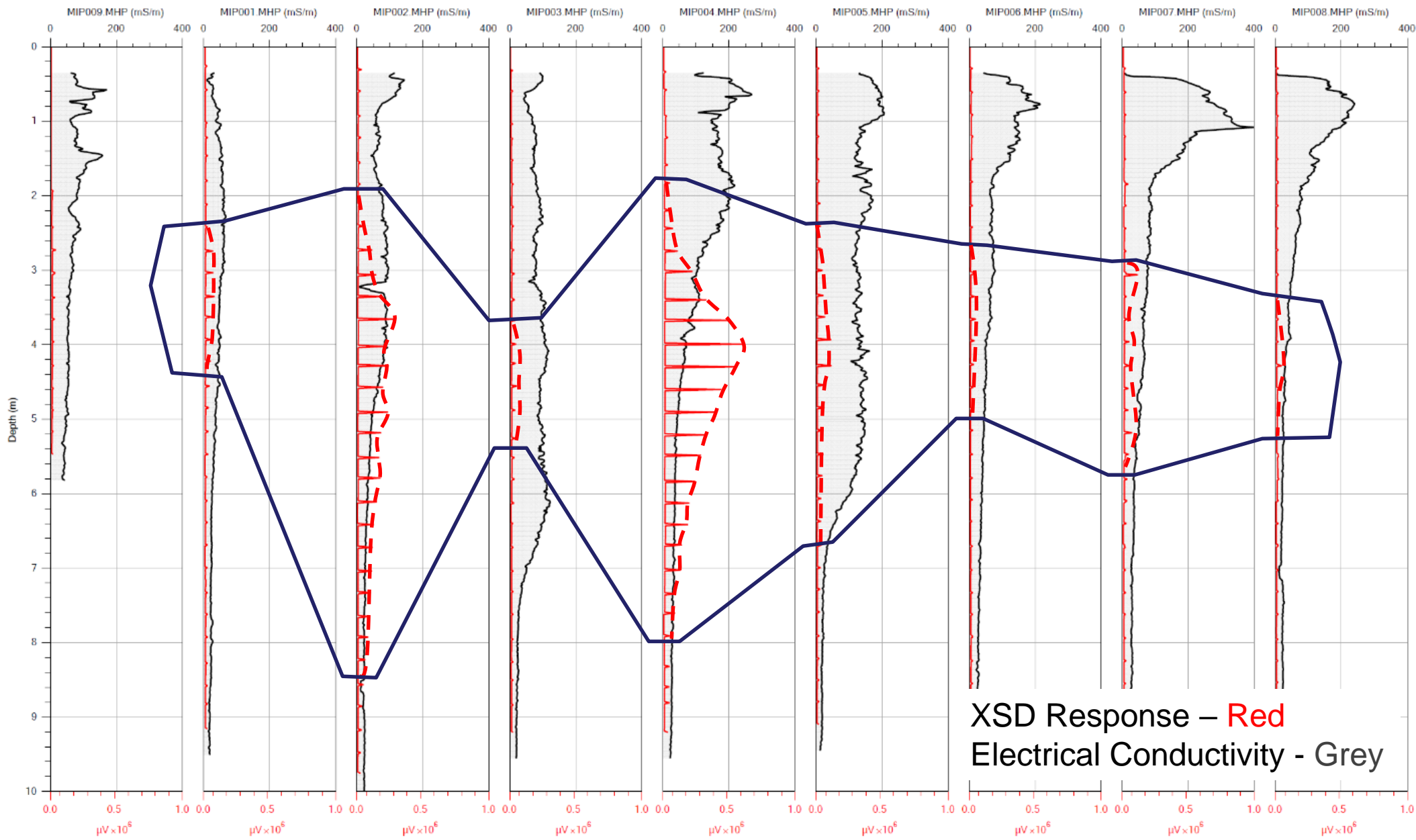
Case Study

HRSC Results:

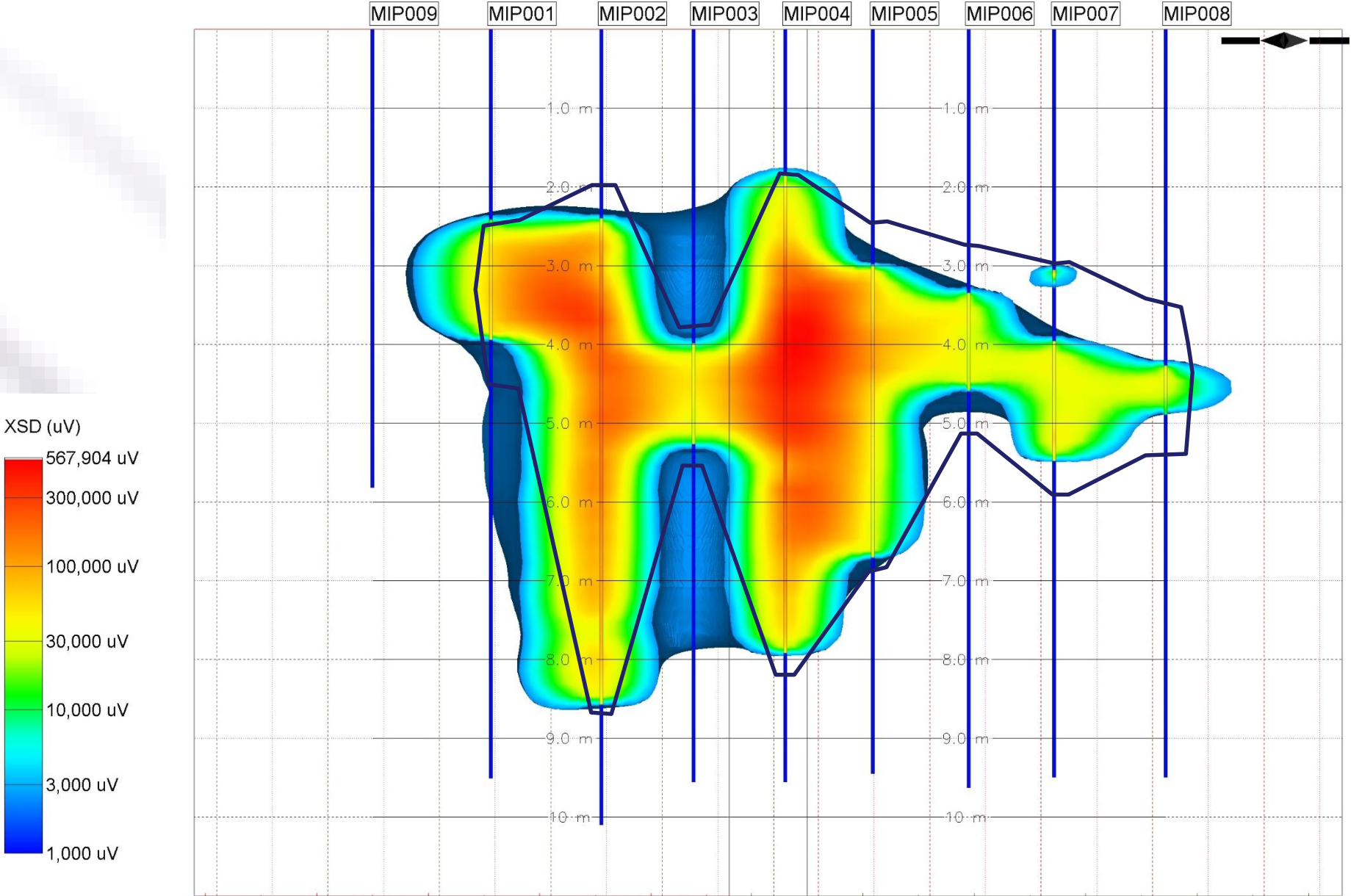
- Utilized for vertical and horizontal data gap analysis and PRB design optimization
- Good agreement with PID and XSD data confirming CVOC impacts along property boundary
- CVOC impacts found to be much deeper than what previous information collected/provided
 - Previous reports indicated ~4 mbgs max depth of impacts, LLMiHpt had significant responses up to ~9 mbgs,
- Hydraulic Profiling Tool highlighted transport and storage zones within the subsurface
- Shallow water table confirmed by HPT
- Similar geology across the Site with varying permeabilities and estimated hydraulic conductivities (horizontally and vertically)



Case Study



Case Study

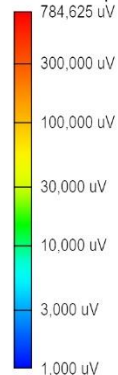


Case Study

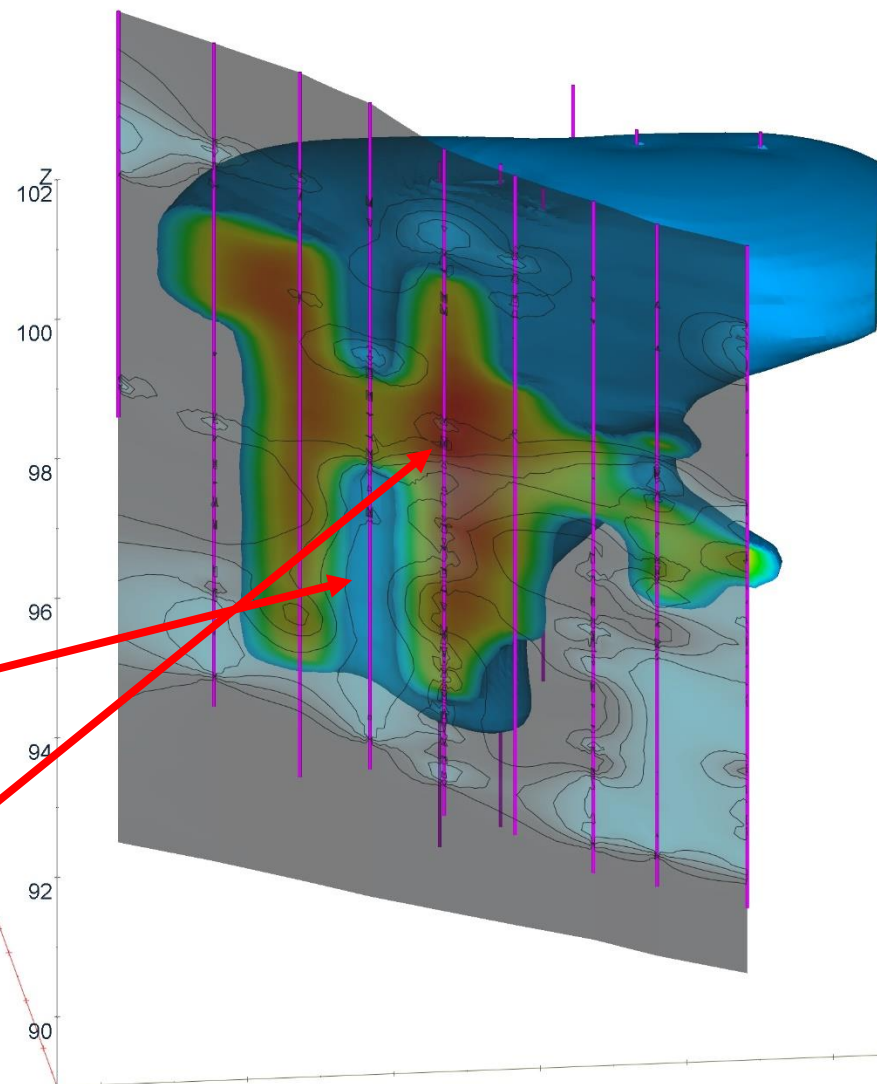
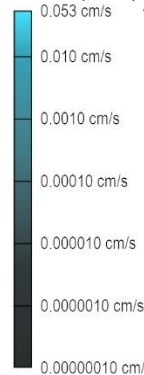
Highlights from LLMiHpt Survey

- CVOC impacts profiled along property boundary indicated horizontal and vertical delineation
- Transport and storage zones within PRB alignment mapped out
- Generally highest LLMiHpt detector responses in lower conductivity zones (i.e. lower contaminant mass discharge across property boundary)

XSD Response from Baseline (uV)



Est. K (cm/s)



Transport

Storage

XSD Response from Baseline (uV) with Est. K (cm/s) fence

Case Study

Comparison – Original vs Optimized

	Original	Optimized
Length	Up to 80 m	55 m
Installation Interval	1 to 4 mbgs	1 to 9 mbgs
Total Cross-Sectional Area	240 m ²	~388 m ² **
Total Remedial Cost	~\$180,000	~\$105,000

** - final PRB design had variable installation depth intervals along the length of PRB

- Optimized PRB design had \$75,000 derived from HRSC program
- Remedial savings = 2.5x times the total cost of the HRSC program
- Original design would have missed a significant portion of the GW plume = **FAILURE**



Closing Thoughts



Closing Thoughts

Permeable Reactive Barriers;

- “Old” technology that still works (when designed and installed properly)
- “New” technologies have improved PRB’s
 - Many different amendments (slow-release oxidants, ZVI, Trap & Treat, etc...)
 - Better Characterization techniques and technologies
- Still a sustainable and cost-efficient remediation technology

On-Site Characterization:

- Started with test pitting and auguring boreholes/monitoring wells
- Direct push technologies use real-time HRSC data to understand a Site better
 - Optimized sampling and monitoring well installation program “take the guess work out of the process”

Case Study Recap:

- Original PRB design was setup for failure to achieve remedial goal AND \$180,000 → Limited information
- HRSC program completed on-Site to gather more information
- Optimized PRB design increased remedial certainty AND \$105,000 → More information





Questions?

**Thank You for
Your Time**

Patrick O'Neill, M.A.Sc., P.Eng.
Vertex Environmental Inc.
patricko@vertexenvironmental.ca

www.vertexenvironmental.ca

