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

RemTech

October 13, 2022

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

Vertex Environmental Inc.

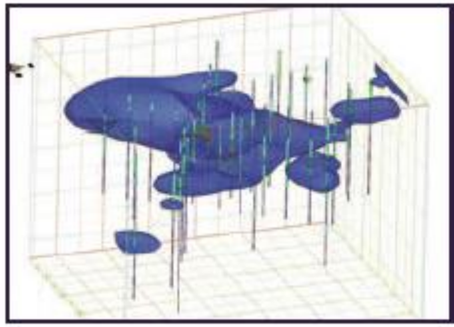
Vertex Environmental Inc.

In-Situ Remediation

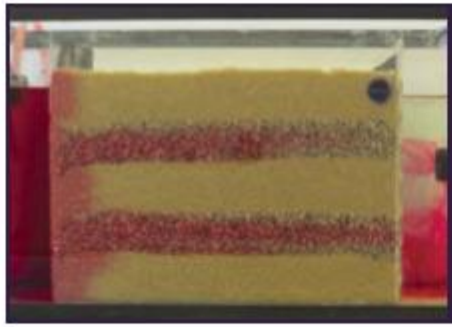
Ex-Situ Remediation

High Resolution Characterization

Treatment Systems



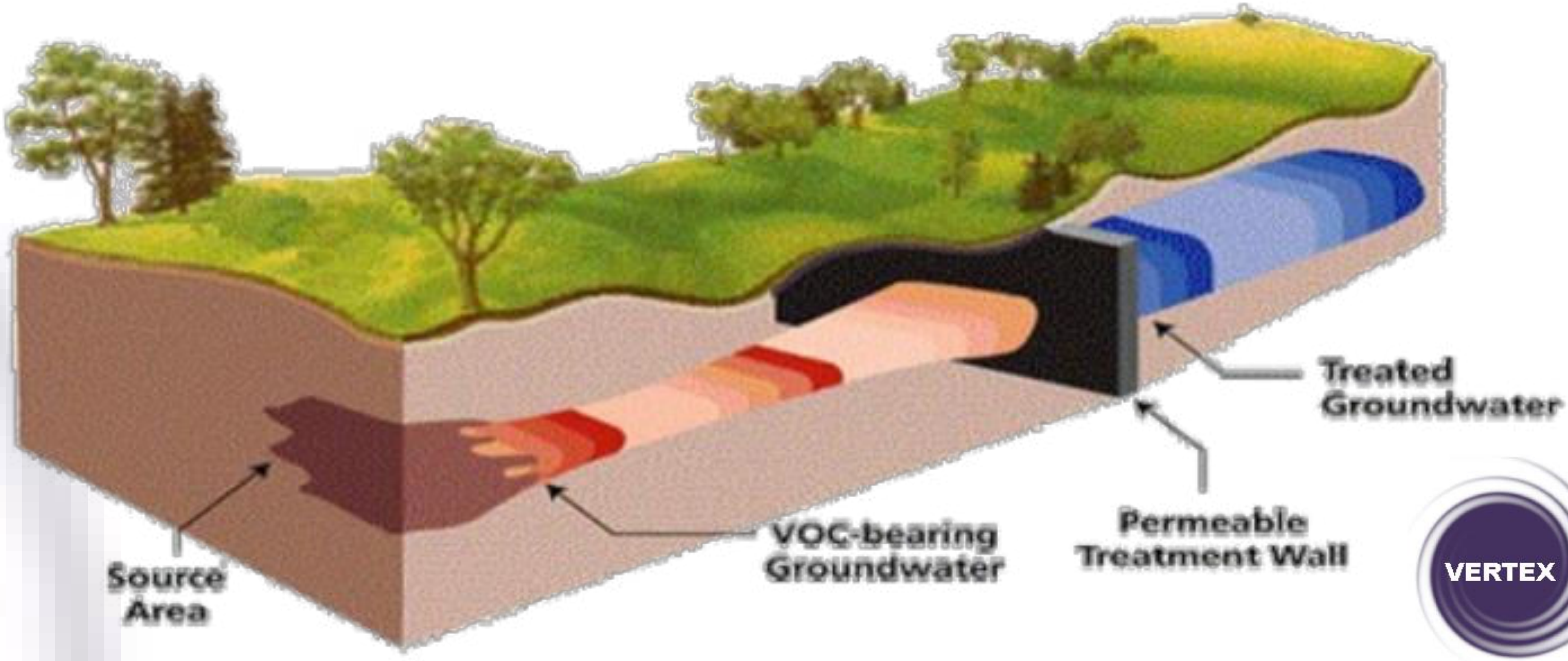
Remedial Design



Bench-Scale Testing

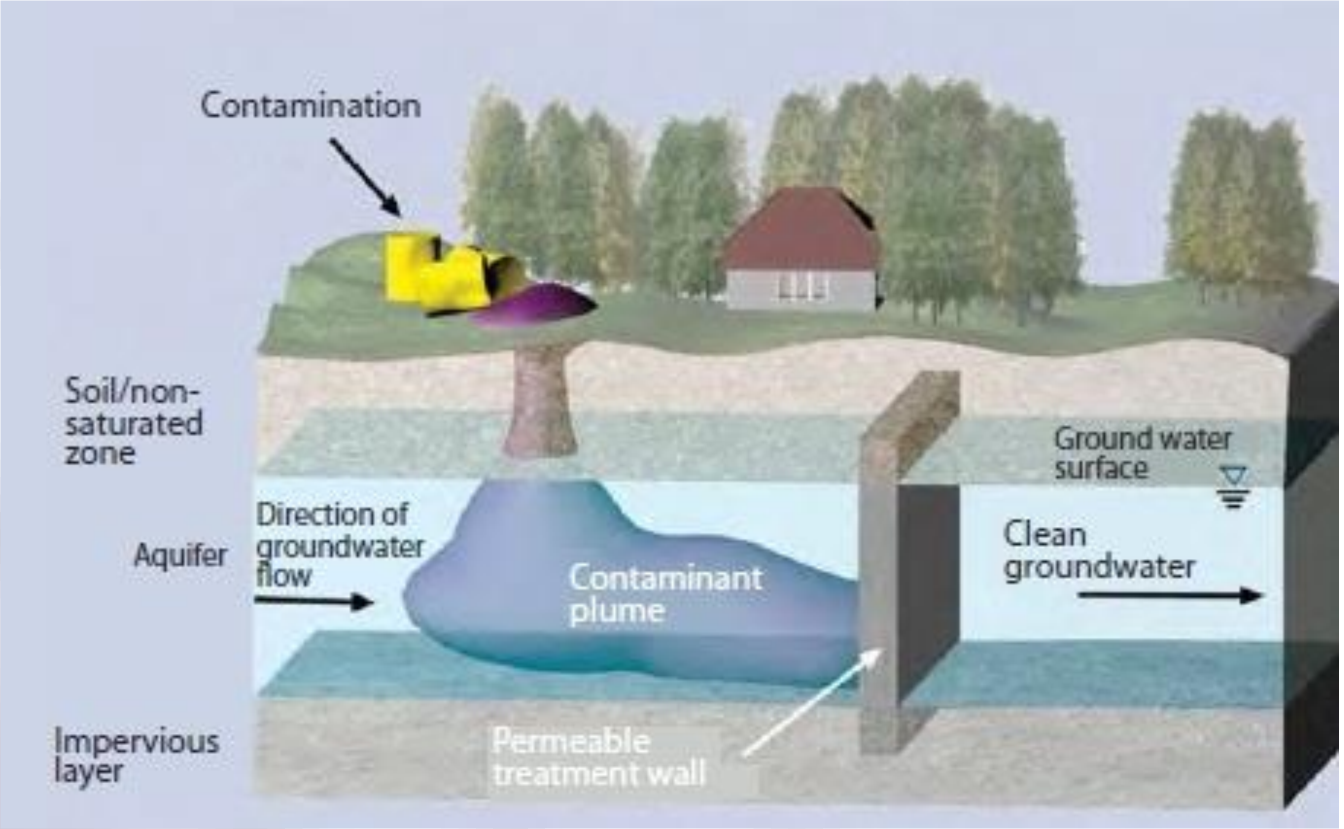
Presentation Overview

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



Permeable Reactive Barriers

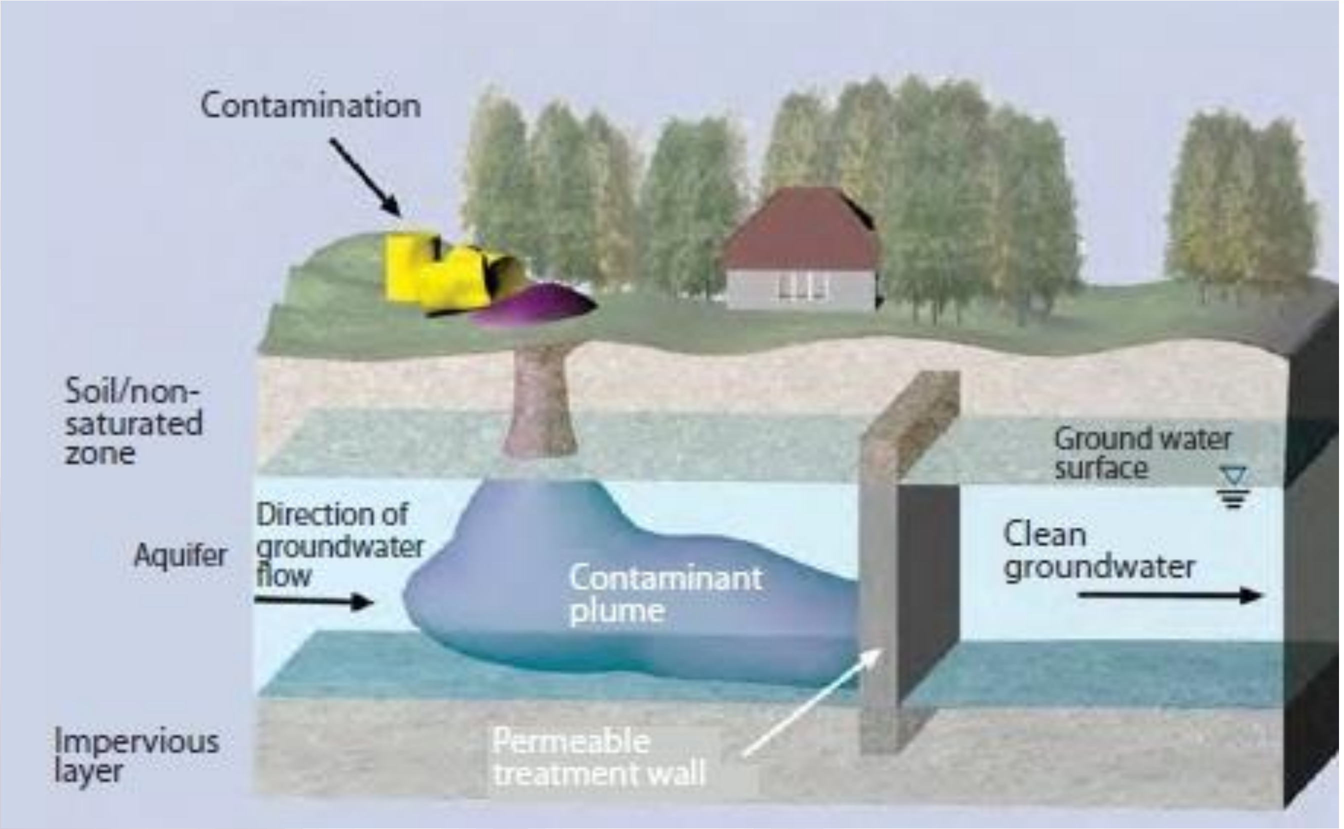
PRB Background – Applications



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

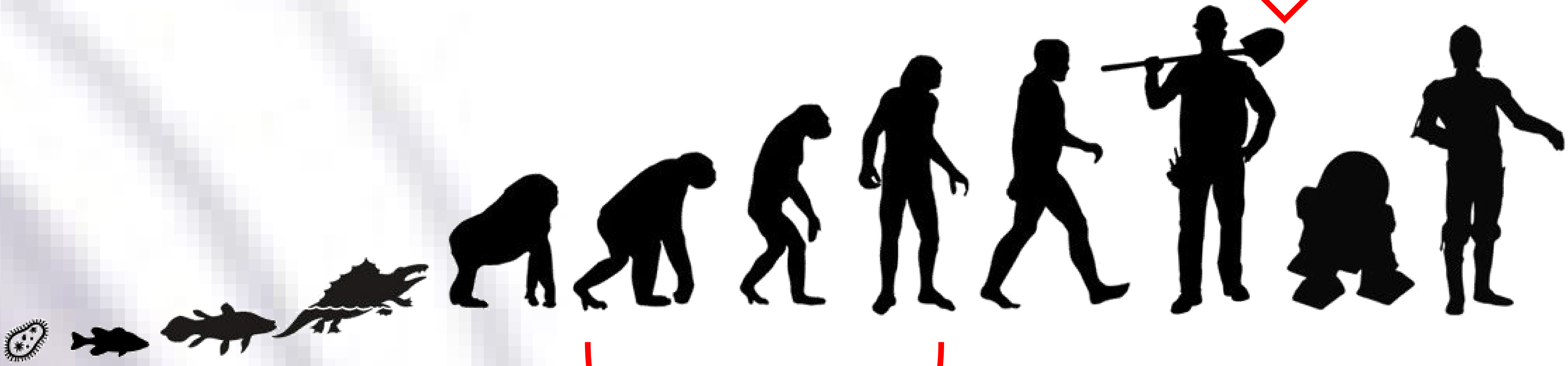


Why Would You Need a PRB?

- 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

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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!

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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!**

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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

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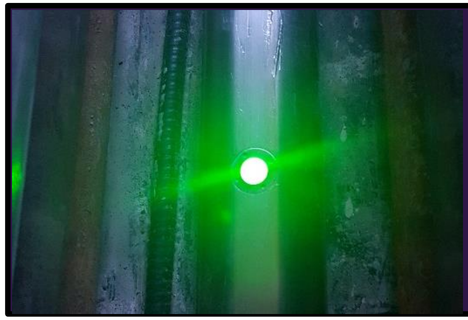
How to Design and Install a PRB – New School

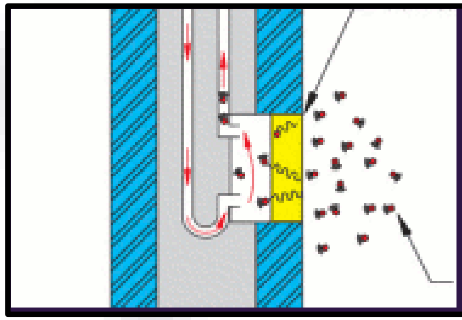
- Use HRSC and analytical data to create a highly detailed understanding of the Site/PRB alignment
- Incorporate hydrogeological information to estimate contaminant flux
- Optimize PRB design for Site specific parameters
- Select specific amendment for contaminants and begin installation (cut & fill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

High Resolution Site Characterization Tools



LIF

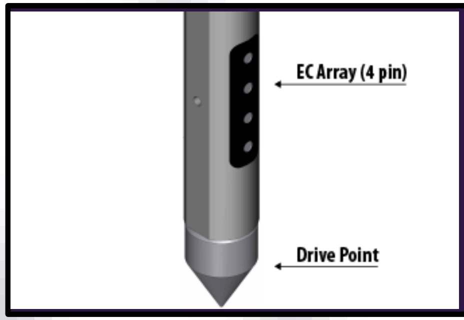
Free Phase (PHCs)



MIP & LLMIP

Dissolved Phase

Combined! MiHpt & LLMiHpt



HPT

Subsurface Permeability

Case Study – PRB Design Optimization Using HRSC

Case Study

Site details / background:

- 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:

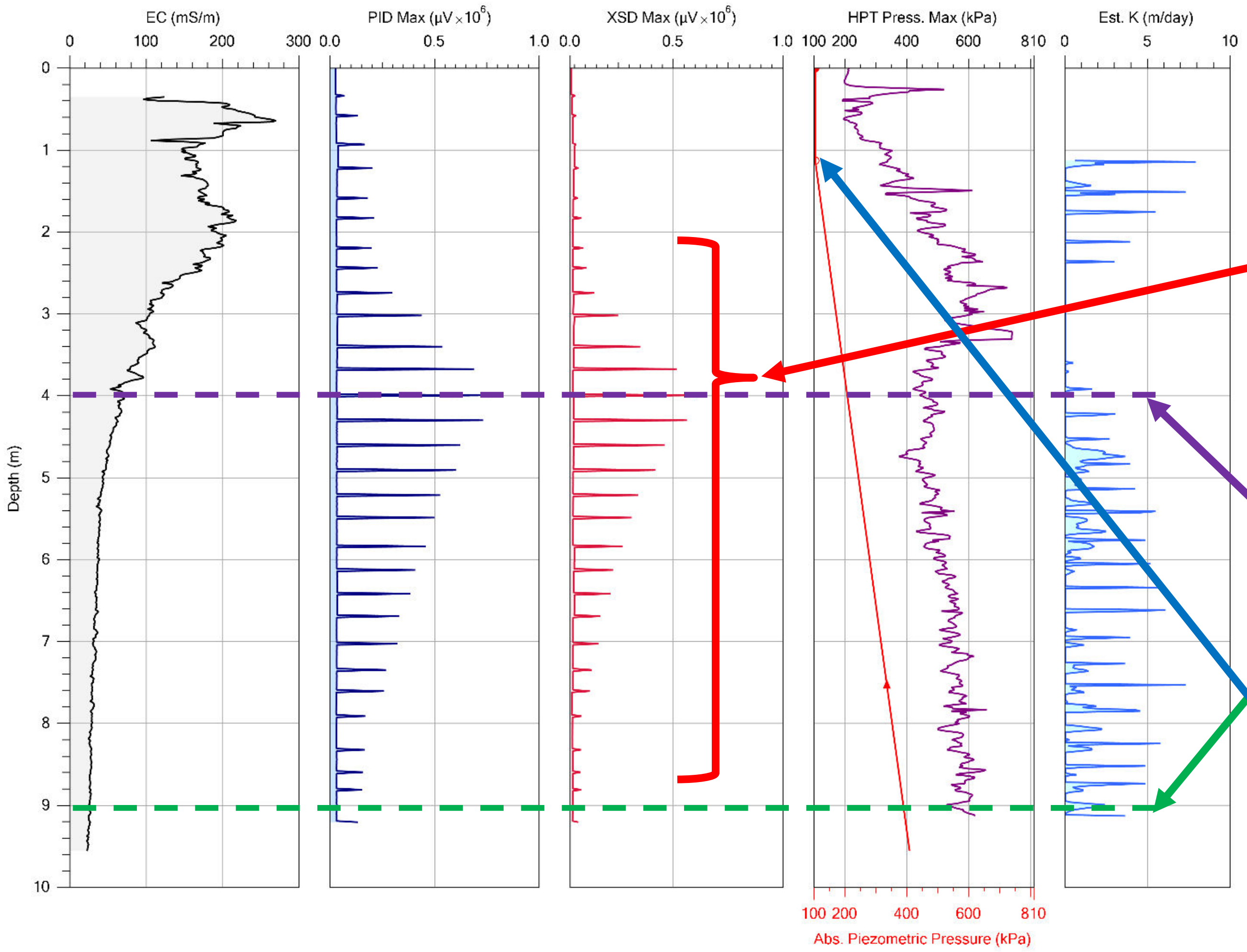
- Based on limited information from 4 groundwater monitoring wells with significant gaps between
- Monitoring wells had some soil samples submitted during installation
- Water table measured at approximately 1 mbgs
- Initial PRB installation depths from 1 to 4 mbgs (3 m of saturated wall thickness)
- 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 four (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)

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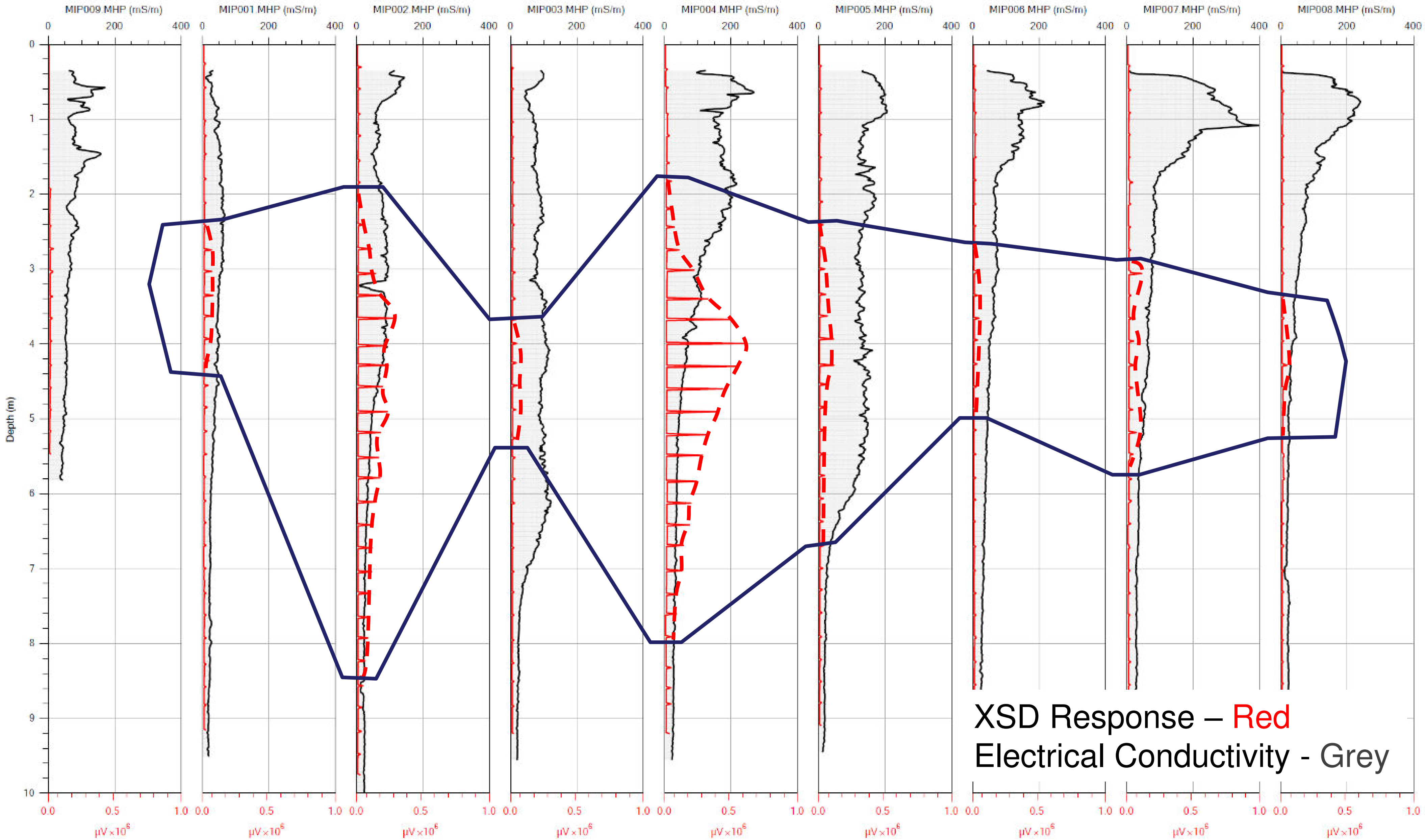
Case Study



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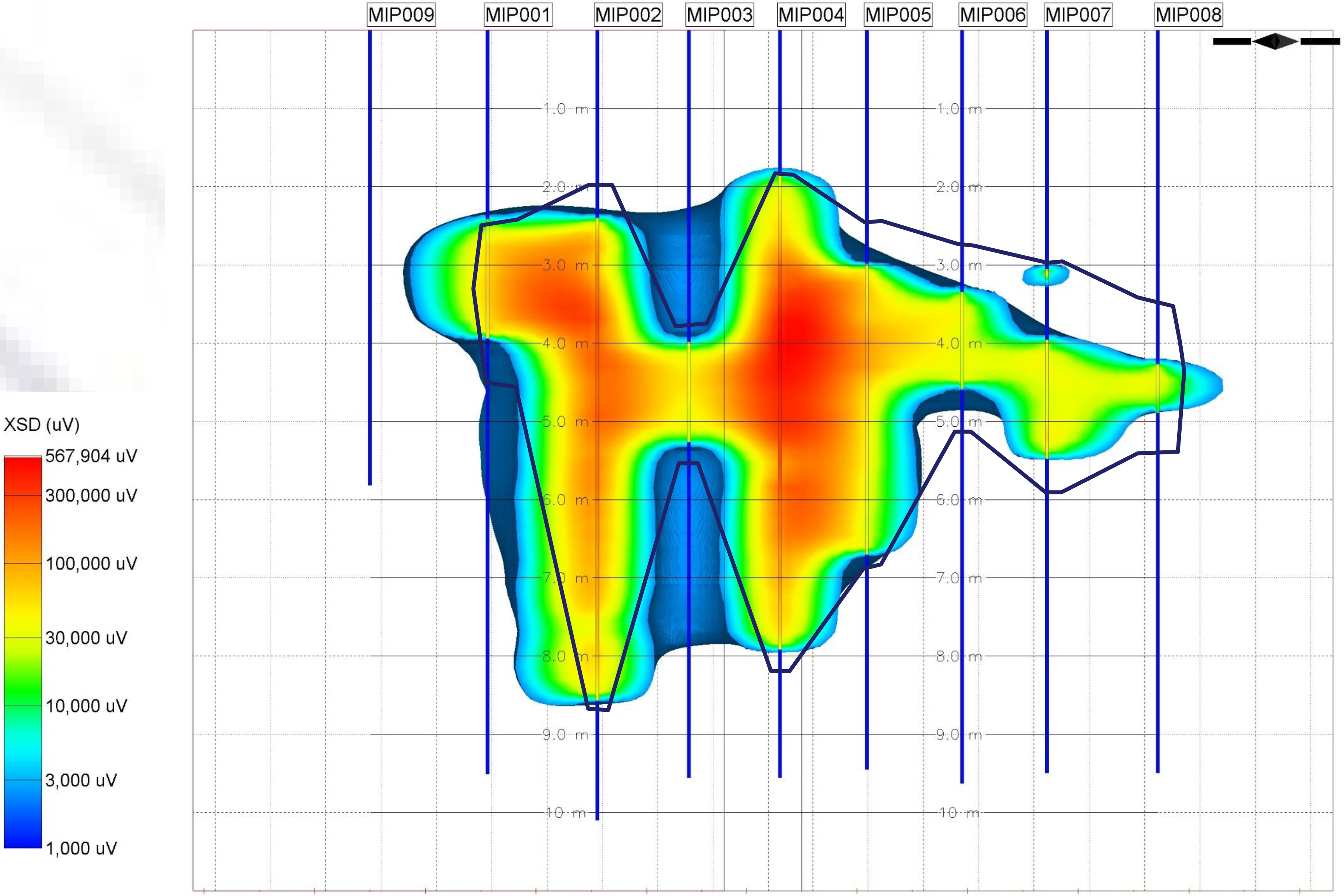
Case Study



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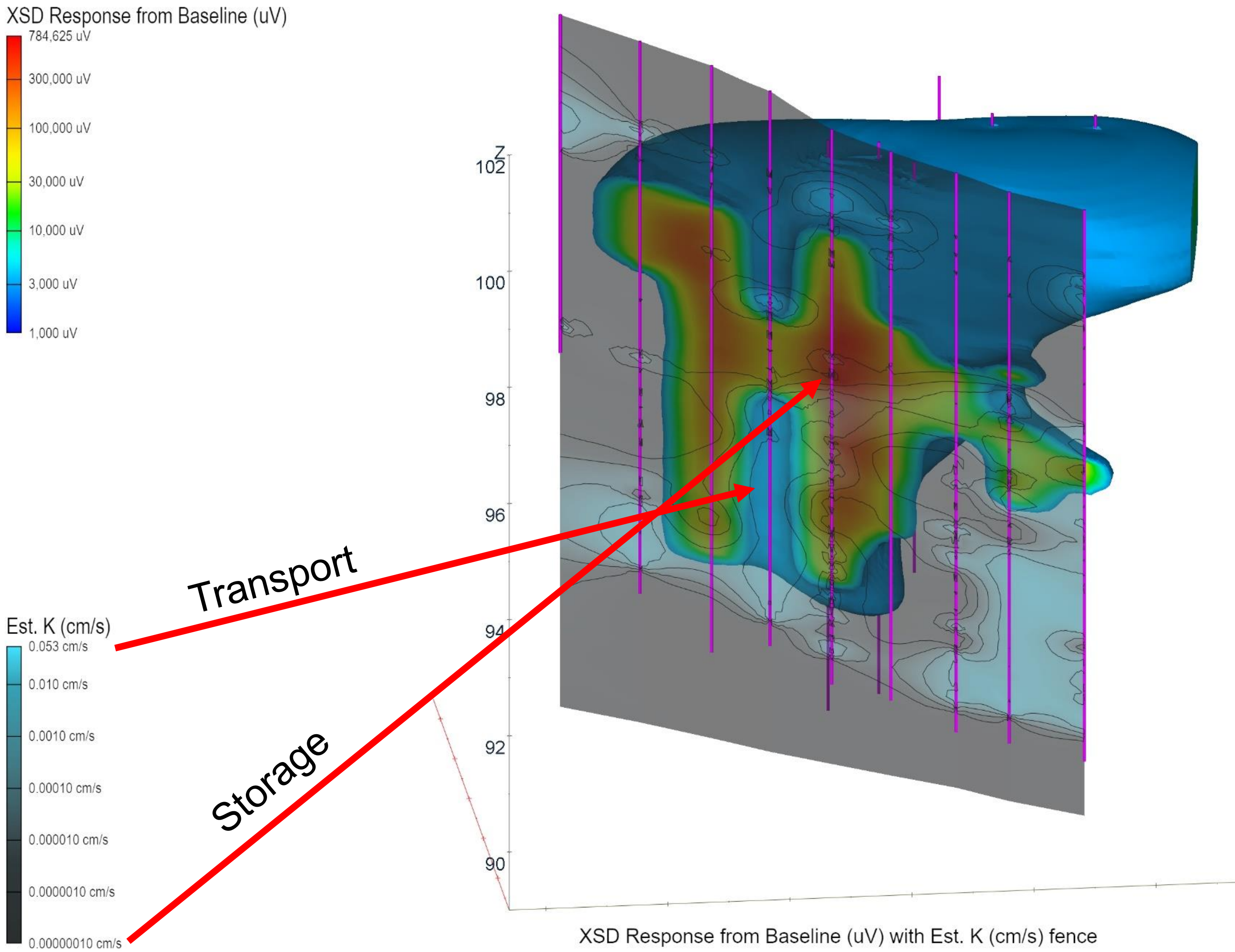
Case Study

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) 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

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Questions?

Thank You for
Your Time

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

www.vertexenvironmental.ca