Three Case Studies: Using High Resolution Site Characterization

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Vertex Environmental

SMART Remediation
Toronto, ON | January 25, 2018
Ottawa, ON | February 15, 2018

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Three Case Studies: Using High Resolution Site Characterization for Better Remedial Design and Implementation

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Toronto – January 25, 2018
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Patrick O'Neill M.A.Sc.

Vertex Environmental Inc.

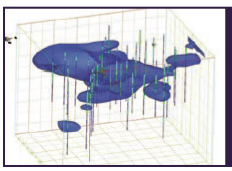
Company

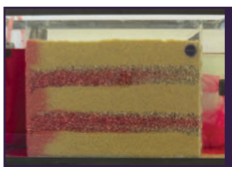

In-Situ Remediation


Ex-Situ Remediation


High Resolution Characterization


Treatment Systems


Remedial Design


Bench-Scale Testing

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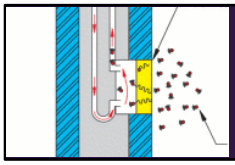
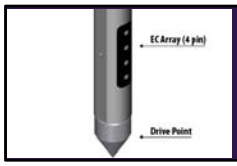
High Resolution Site Characterization

LIF

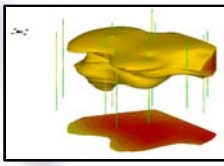


MIP

LL-MIP



HPT



Modelling

Presentation Overview

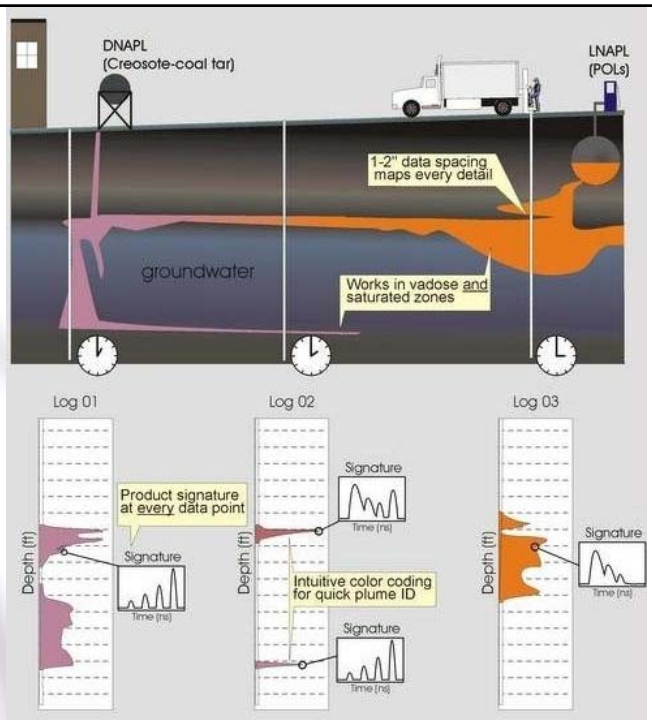
- High-Resolution Site Characterization (HRSC)
- Laser Induced Fluorescence (LIF)
  - LIF Case Study
- Membrane Interface Probe (MIP) & Low Level MIP
  - LLMIP Case Study
- Hydraulic Profiling Tool (HPT)
  - HPT Case Study
- Example HRSC Visualizations
- Closing Thoughts
- Questions

High Resolution Site Characterization (HRSC)

What is HRSC?

- *"High-resolution site characterization (HRSC) strategies and techniques use scale-appropriate measurement and sample density to define contaminant distributions, and the physical context in which they reside, with greater certainty, supporting faster and more effective site cleanup."* – US EPA

- Rapid, efficient, high quality data collection (Supplement/Compliment Phase II)
- Better Understand the Site/Problem(s)
- Make more informed/better decisions to lead to better remediation!



Source:
Dakota Web Site

High Resolution Site Characterization

- Laser Induced Fluorescence (LIF)
  - Free-Phase Product / LNAPL
- Membrane Interface Probe (MIP) and Low Level Membrane Interface Probe (LLMIP)
  - Dissolved Phase PHCs and CVOCs
- Hydraulic Profiling Tool (HPT)
  - Subsurface Permeability

High Resolution Site Characterization Deployment

- Direct Push
- Semi-Quantitative
- High Data Density
- Real Time

Laser Induced Fluorescence

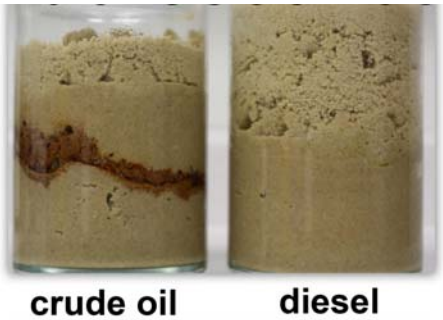
for Free-Phase Product / LNAPL

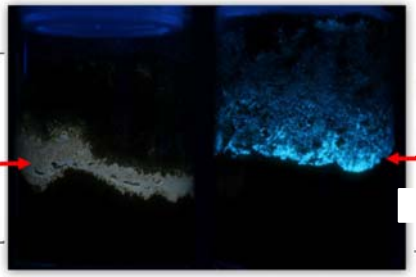
Laser Induced Fluorescence (LIF)

- Developed by US Army (‘90s)
- UVOST: Ultra-Violet Optical Screening Tool

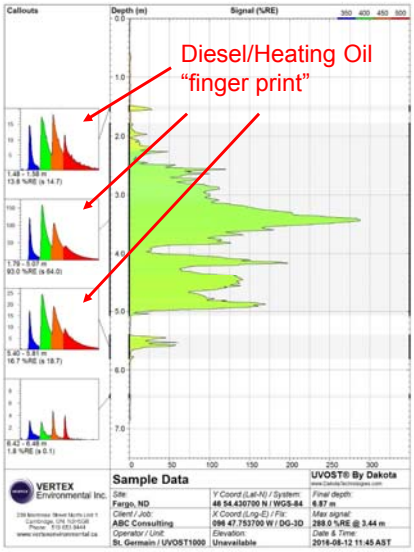
- Equipment
  - Direct push (GeoProbe)
  - Probe
  - Fibre optic cable

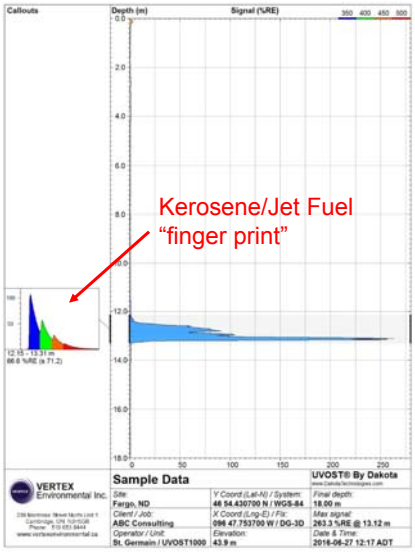
Where are the contaminants?





LIF Output





Case Study #1

Using LIF to Redefine Contamination

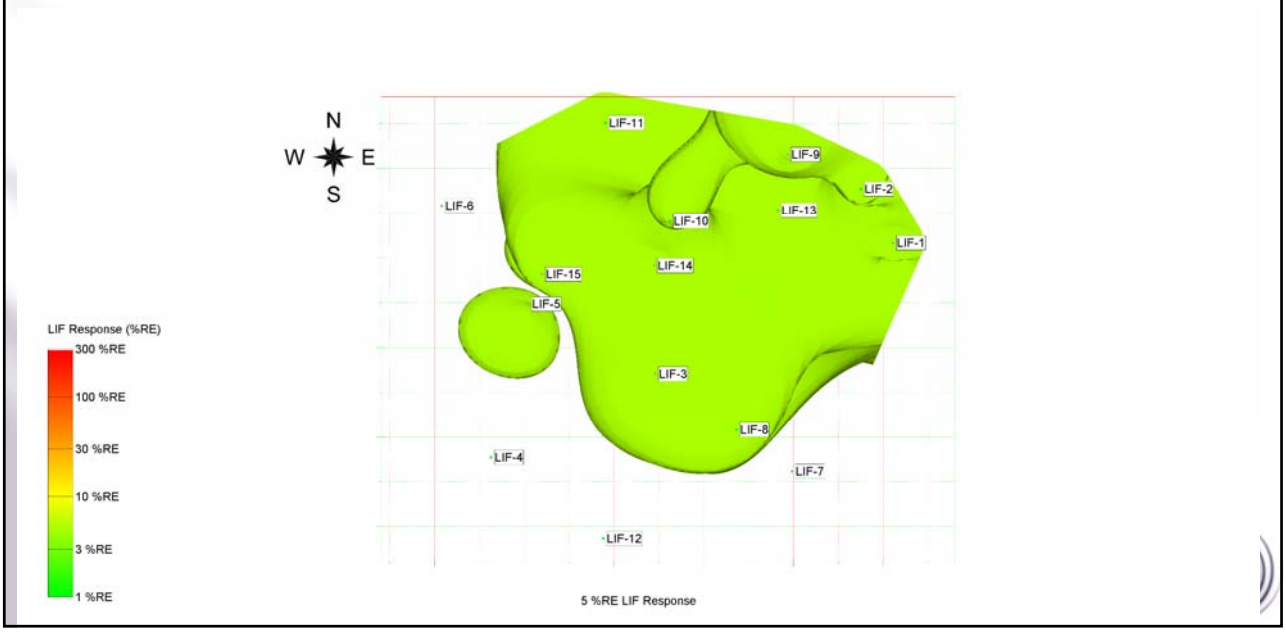
LIF Case Study - Background

Site details / background:

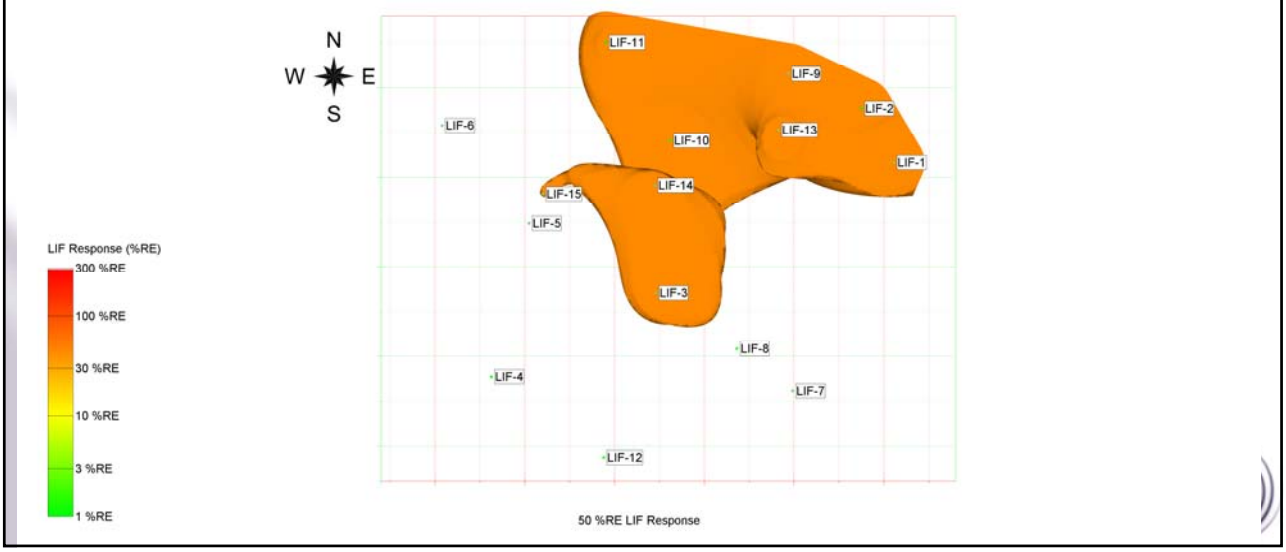
- Ontario site
- Active institutional building
- Fuel leak: Diesel range PHC & LNAPL impacts
- Small area and many utilities
- MPE system installed on-Site reached diminishing returns
- LIF used to assist with vertical and horizontal definition of remaining LNAPL PHCs on-Site
- LNAPL under multiple buildings

LIF Case Study – Site Photos

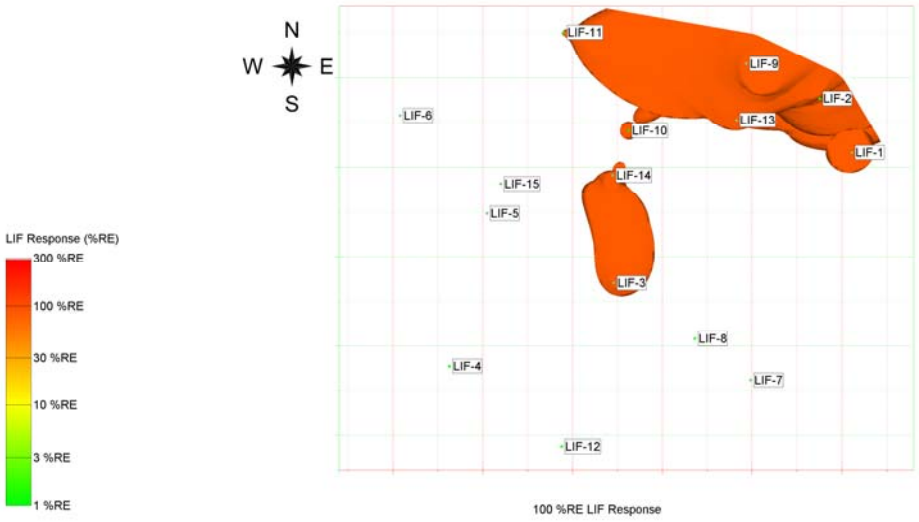
LIF Case Study – 3D Visualization



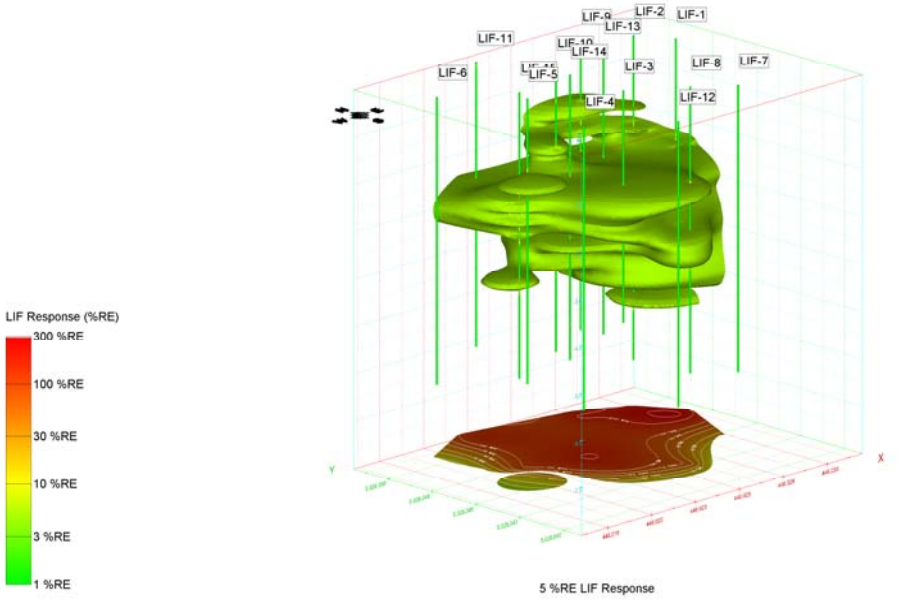
LIF Case Study – 3D Visualization



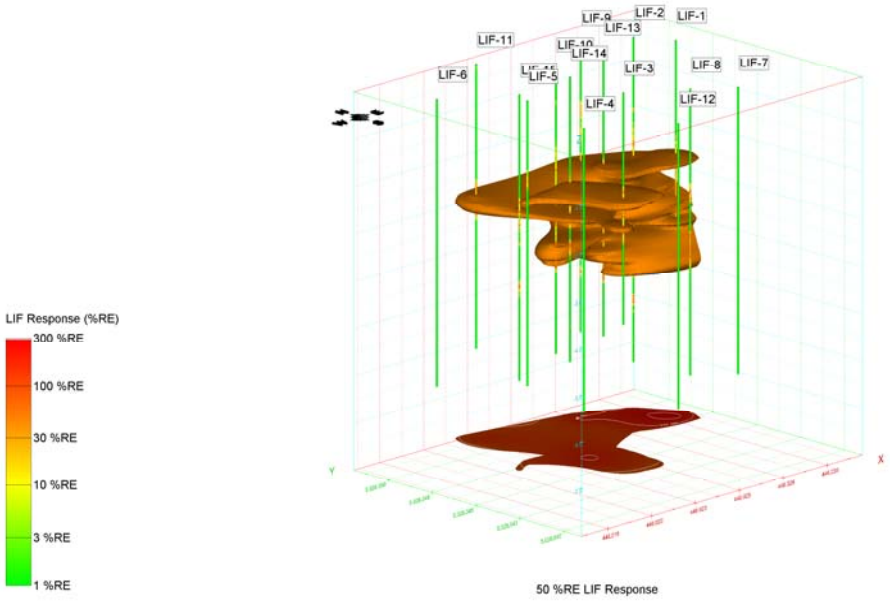
LIF Case Study – 3D Visualization



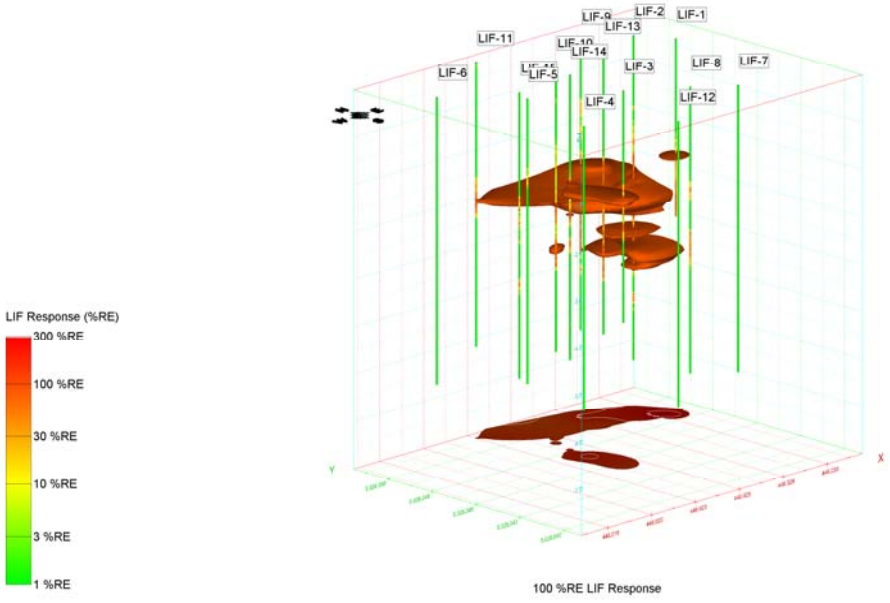
LIF Case Study – 3D Visualization



LIF Case Study – 3D Visualization



LIF Case Study – 3D Visualization



LIF Case Study - Remediation

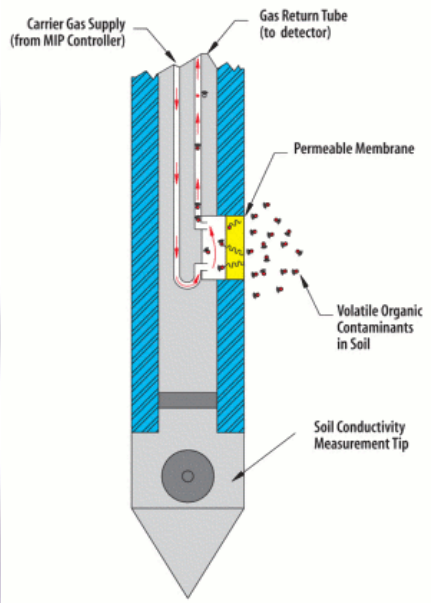
Site Remediation Continues:

- Bench-scale testing completed to determine surfactant enhanced extraction
  - Multiple surfactants tested with LNAPL extracted from Site
- Pilot scale testing completed on existing infrastructure and subsurface
  - Air flowrate up to 23 sCFM per extraction well
  - Liquid flowrate up to 1.53 LPM per extraction well
  - Vacuum radius of influence (ROI) up to 10 m and hydraulic ROI up to 6.2 m
- Full Scale system upgrades are currently proposed to intensify remediation on-Site

Membrane Interface Probe

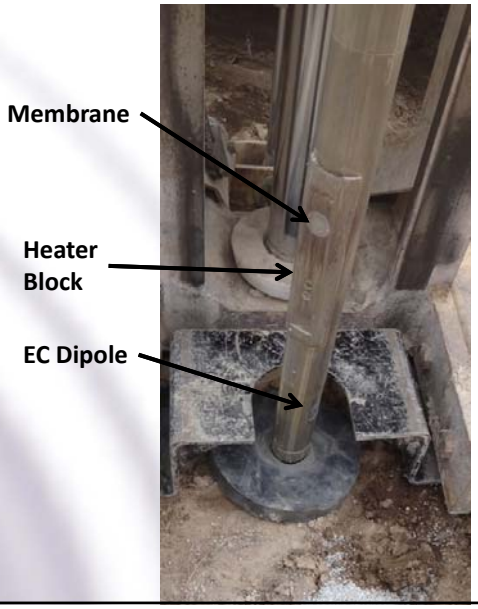
for Dissolved Phase PHC and CVOC Contamination

Membrane Interface Probe (MIP)



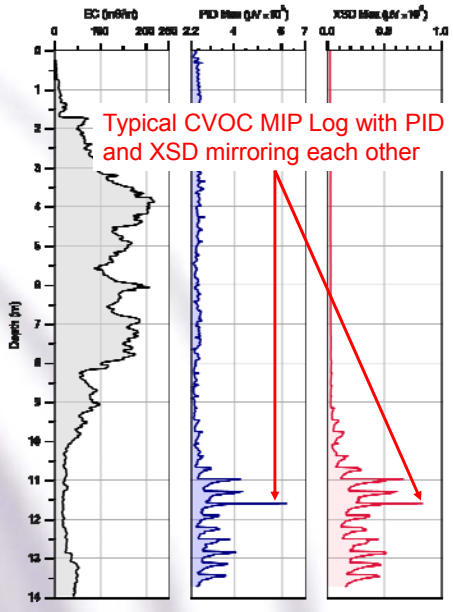
- Physical Transport of VOCs
- Equipment:
  - Geoprobe,
  - Probe with EC Dipole,
  - Semi-permeable membrane & heater block,
  - Above ground gas chromatograph / detectors

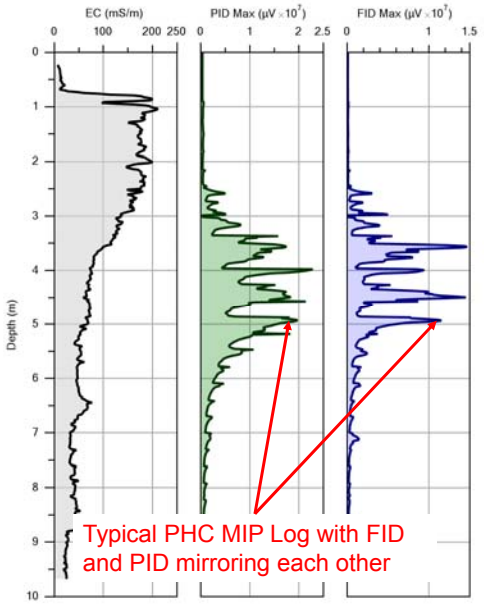
MIP Detection



- Three detectors:
  - Photoionization Detector (PID)
  - Flame Ionization Detector (FID)
  - Halogen Specific Detector (XSD)
- Detection of VOCs:
  - Petroleum Hydrocarbons (PHCs)
  - Chlorinated Solvents (TCE, PCE, TCA, etc.)
- Electrical Conductivity
  - Classify soil

MIP Output





Low Level Membrane Interface Probe

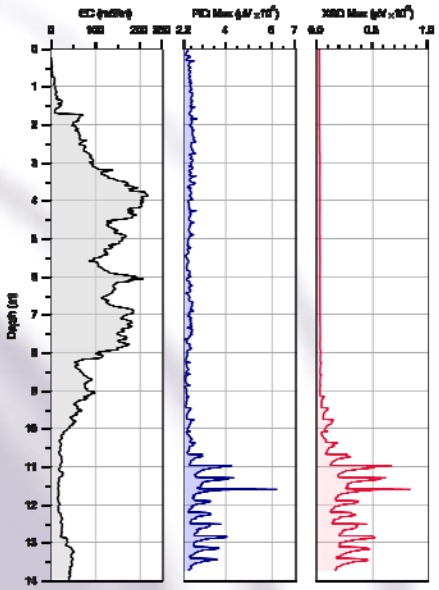
for Lower Dissolved Phase PHC and CVOC Contamination

Low Level MIP (LLMIP)

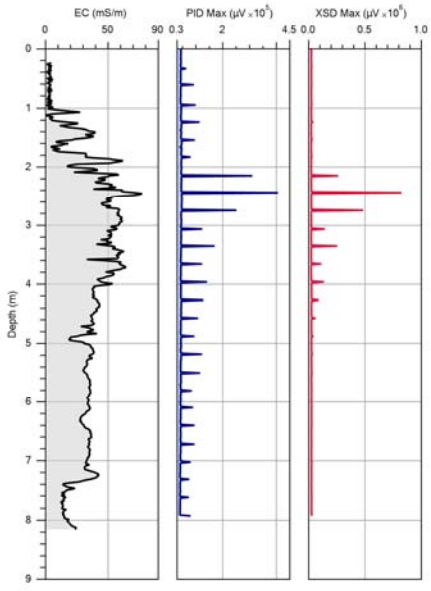
- Traditional MIP
  - Detection limits on PID and XSD approx. 200 ppb
- Low Level MIP
  - Same as traditional MIP with an added controller and software package
  - Detection limits on PID and XSD approx. 20 ppb
  - Drawback: approx. 25% slower advancement rate

MIP vs LLMIP Output

Traditional MIP Responses



LLMIP Responses



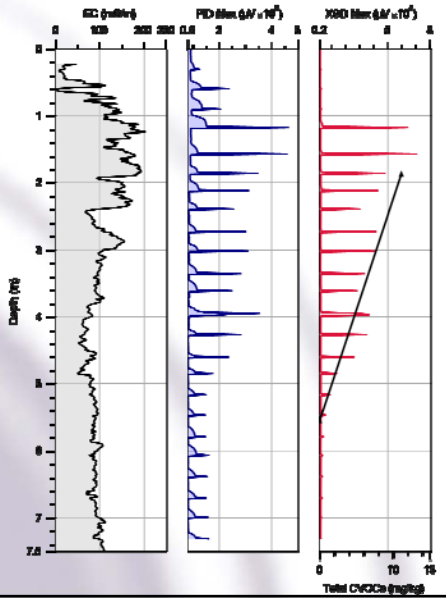
Case Study #2

Using LLMIP to Delineate a Diffuse CVOC Plume

LLMIP Case Study - Background

- Commercial site in Manitoba
- Chlorinated solvent plume from historic dry cleaner
- Active commercial property = after hours work
- Asked to delineate the edge of dissolved phase CVOC impacts with LLMIP
- Both interior and exterior work

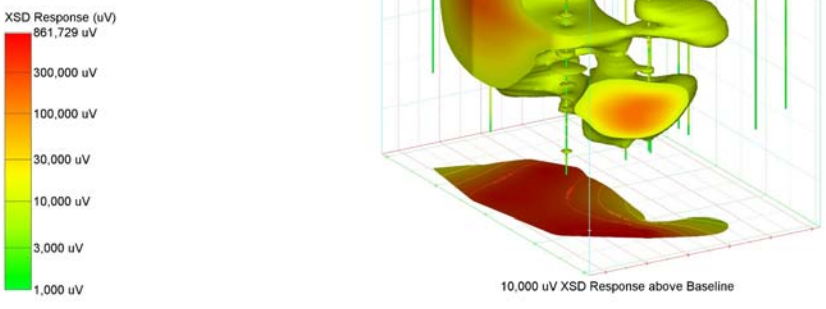
LLMIP Case Study - Background



- A combination of LLMIP and HPT points completed inside and outside the building
  - Understand the contaminant plume and potential transport pathways
- LLMIP response on XSD confirmed presence and extent of diffuse CVOC plume
- Results used to delineate the extent of the impacts in groundwater at the Site
  - Mainly under the building closer to surface

LLMIP Case Study - Visualization

Limits of Low Level CVOC Plume Delineated Down to ~20 ppb



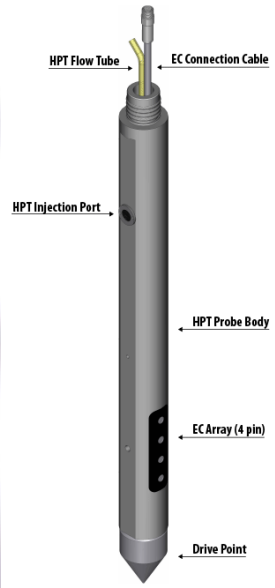
LLMIP Case Study - Remediation

- Pilot scale injections completed on-Site to determine effectiveness of in-situ program
  - Reductive approach to remediation
- Promising results from pilot scale injections completed on-Site
- Full scale in-situ program in proposal stages
  - Full scale design to incorporate information gathered from HPT and LLMIP data
  - Fringes of plume generally located under the building footprint
  - LLMIP data leads to better in-situ remediation contaminant targeting
  - HPT data leads to better understanding of potential contaminant pathways

Hydraulic Profiling Tool

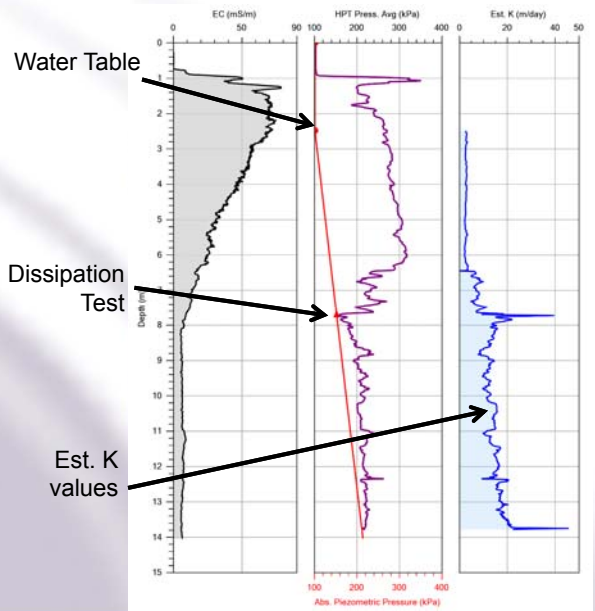
for Estimating Formation Permeability

Hydraulic Profiling Tool (HPT)



- Direct Push
- Assess Formation Permeability
- Water Injected into the Ground
  - Flow and Back-pressure measured
- EC: Estimate Soil Type
- Identifies location of Water Table
- Result: Empirical Estimate of Hydraulic Conductivity
  - on a cm scale

Hydraulic Profiling Tool (HPT)



Typical HPT Log:

- Continuous measurements during constant push
- HPT injection pressure indicates zones of relative formation permeability
- Dissipation tests completed below the water table required for hydraulic conductivity estimations and to estimate water table depth

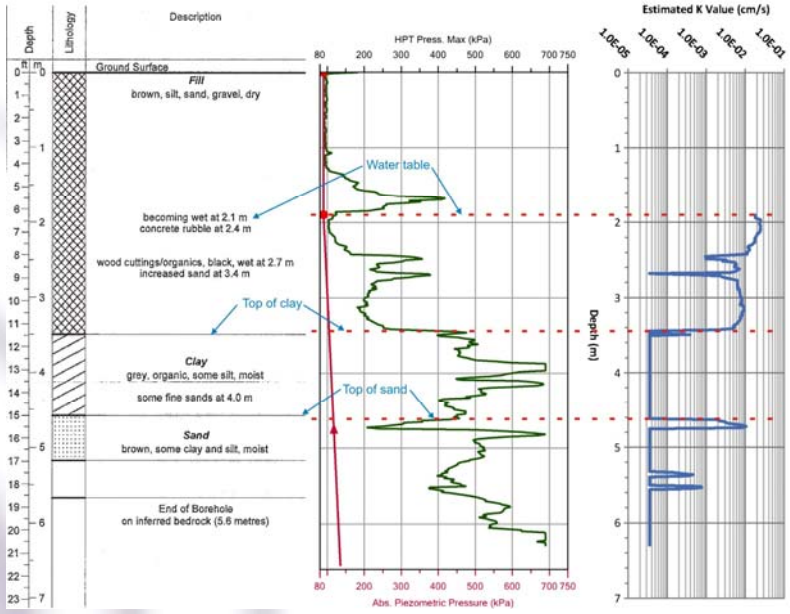
Case Study #3

Using HPT to Design a Permeable Reactive Barrier (PRB)

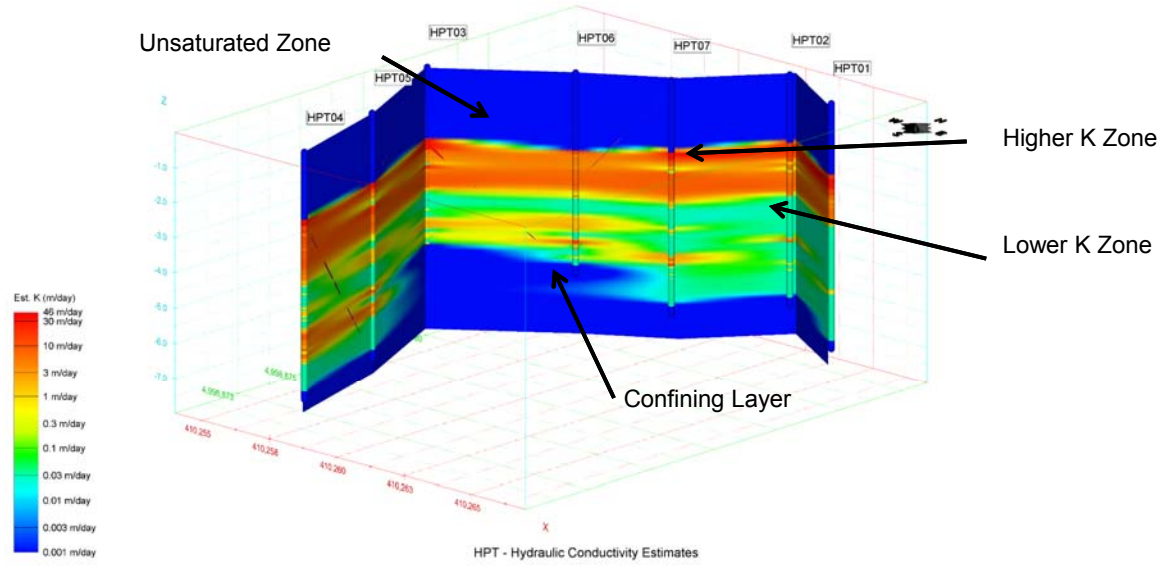
HPT Case Study - Background

- Commercial site near Ottawa, ON
- Site remediation called for traditional P&T System
- Alternative PRB approach proposed for CVOC groundwater plume coming on to the Site
- HPT Deployed to find preferential flow paths of saturated zone and to define lower “confining layer”

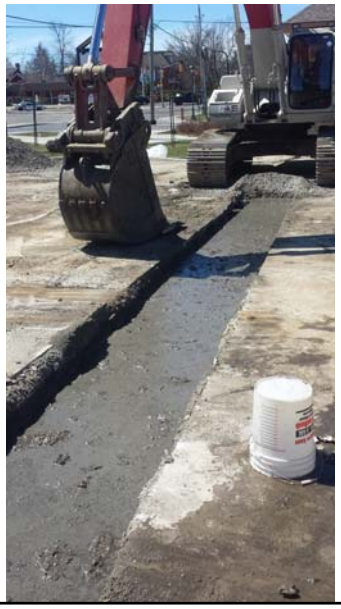
HPT Case Study – HPT vs BH



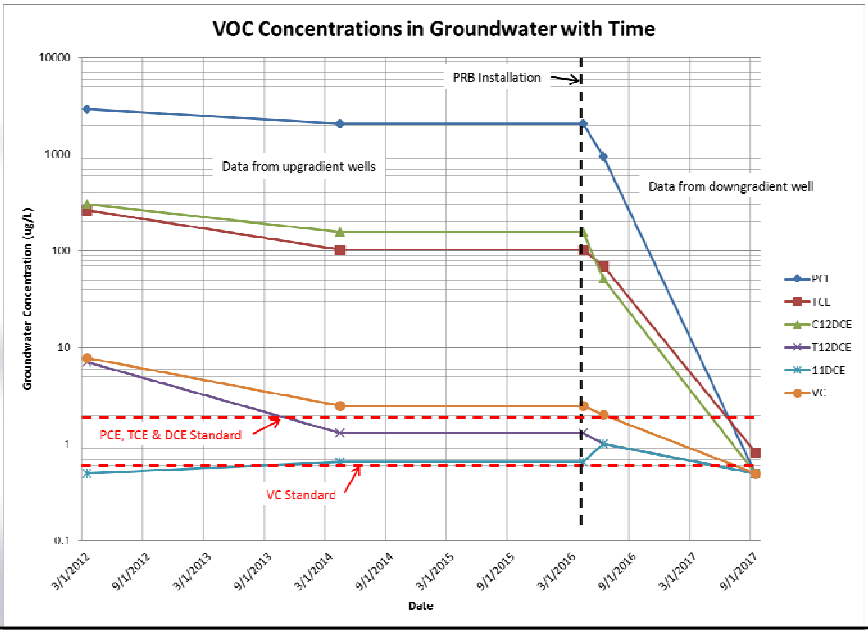
HPT Case Study – PRB Visualization



Case Study HPT PRB - Installation



HPT Case Study – PRB Performance

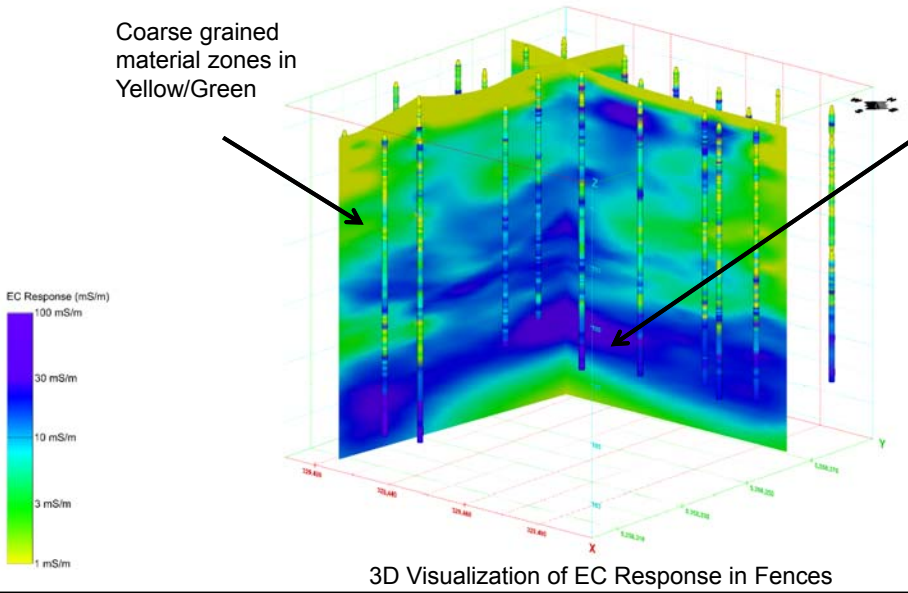


HRSC Data – 3D Visualization

HRSC Data - Visualization

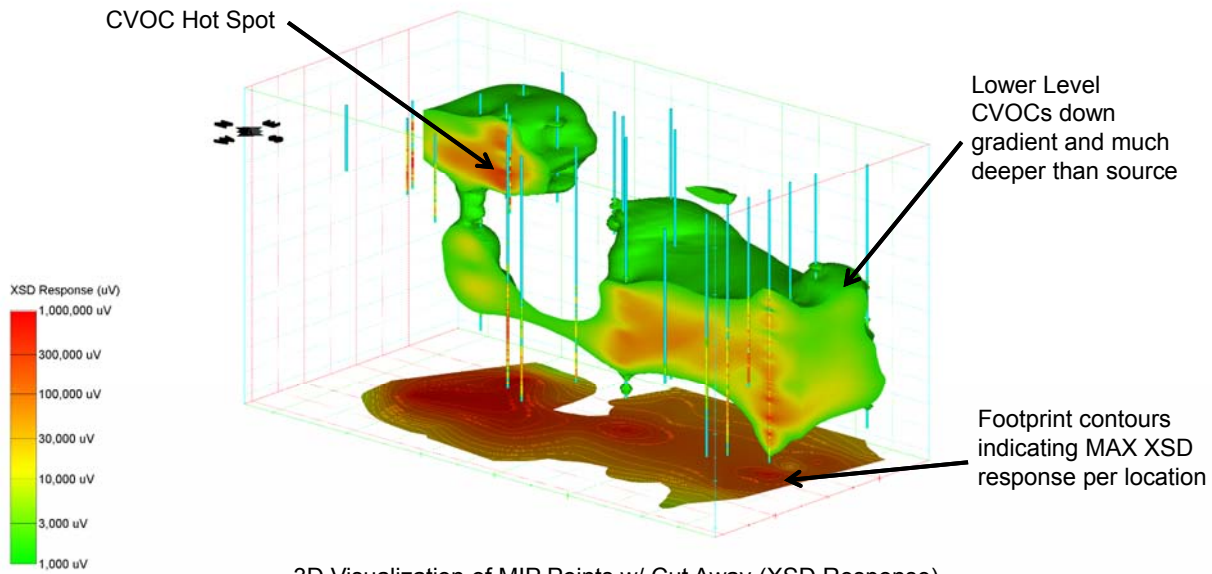
Coarse grained material zones in Yellow/Green

Finer grained material zones in Purple/Blue



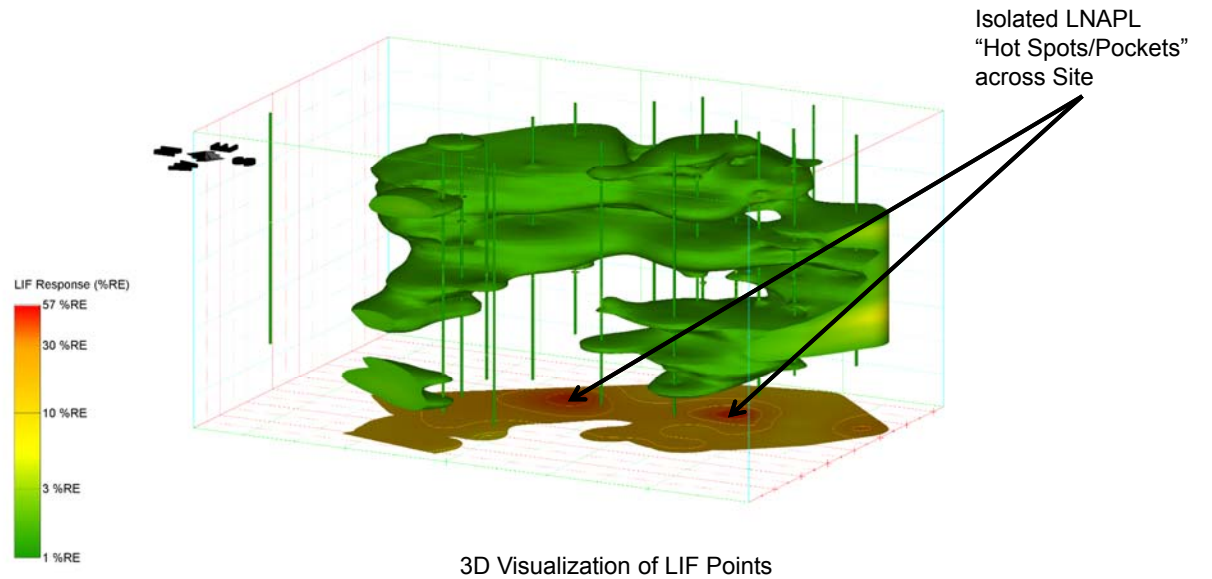
3D Visualization of EC Response in Fences

HRSC Data - Visualization



3D Visualization of MIP Points w/ Cut Away (XSD Response)

HRSC Data - Visualization



3D Visualization of LIF Points

Closing Thoughts

High-Resolution Site Characterization:

- Boreholes / Monitoring well (30 - 300 cm resolution)
- LIF – NAPL / free phase (~1 cm resolution)
- MIP and LLMIP – dissolved phase (30 cm resolution)
- HPT – hydrogeologic info (~1 cm resolution)

- Detailed data interpretation
  - Rapid and detailed contamination delineation
  - Produce 2D and 3D plots
  - Allows more precise design for successful remediation projects

Understand the Site better!

Questions?

Thank You for Your Time

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