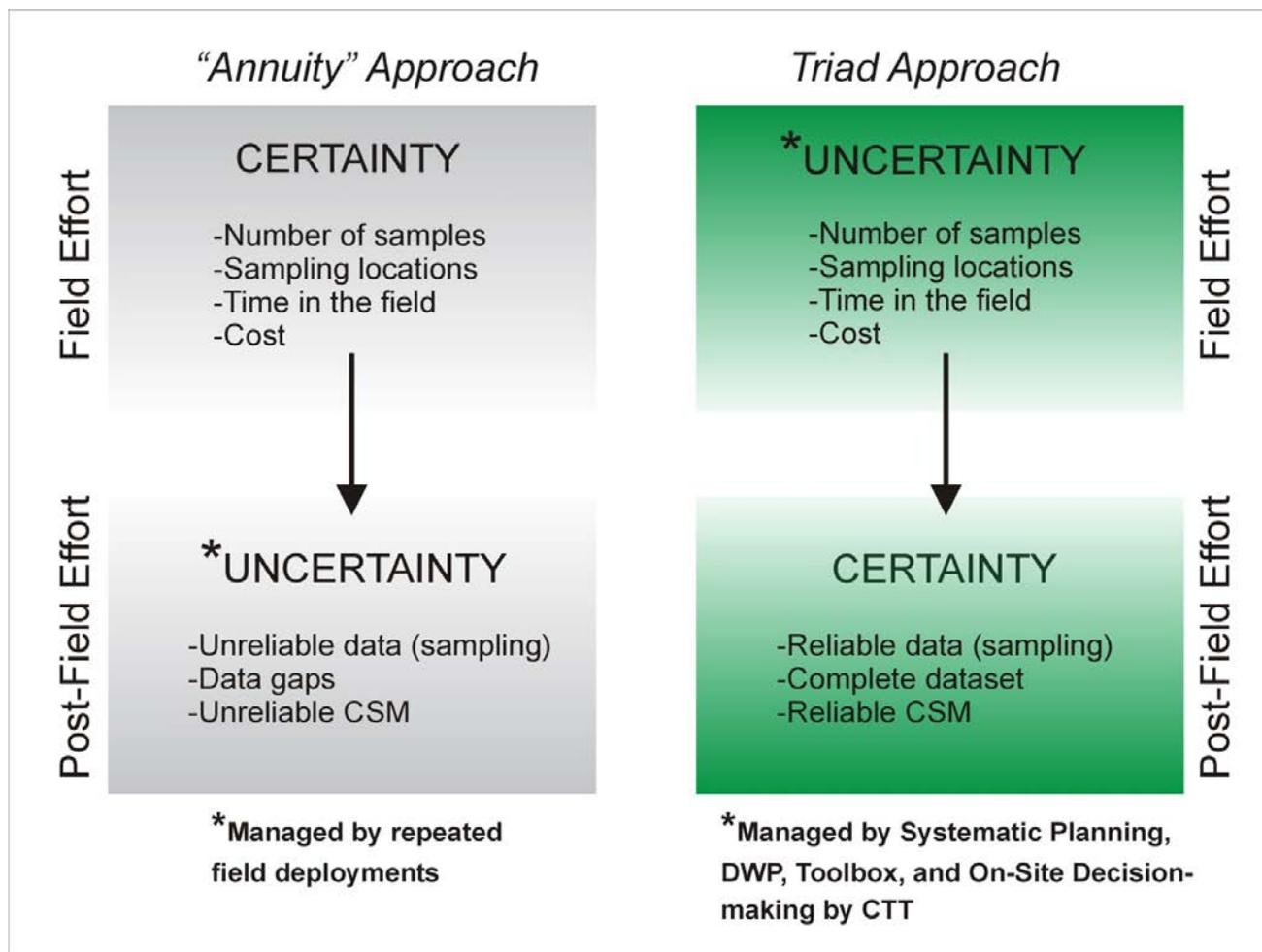


Solutions for Complex Sites

Brad Carlson
Cascade Technical Services



The Main Idea

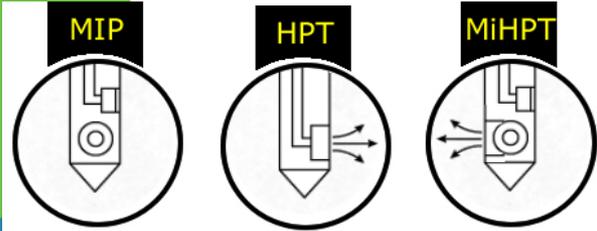


Moving On From Monitoring Wells

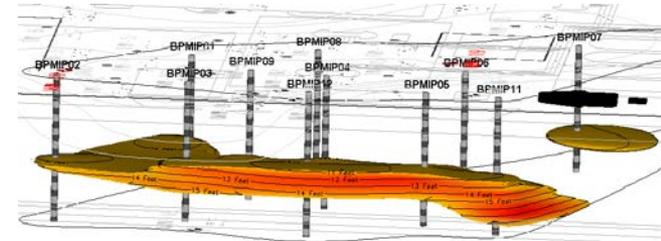
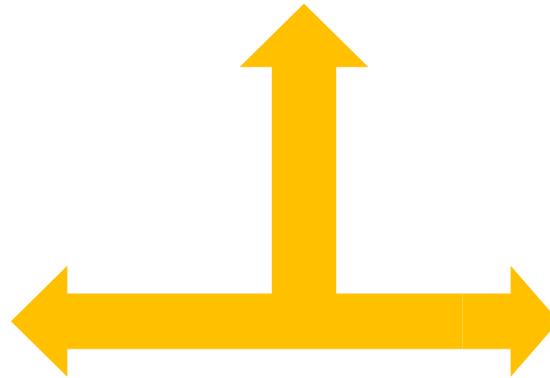
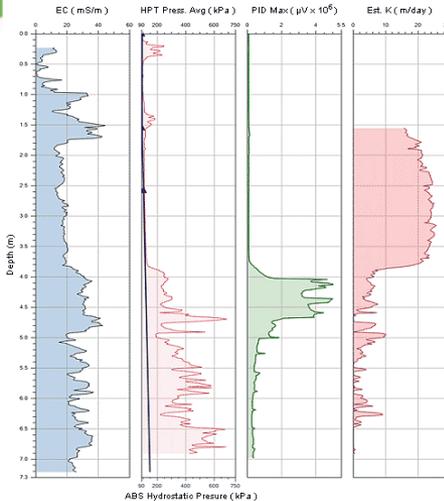
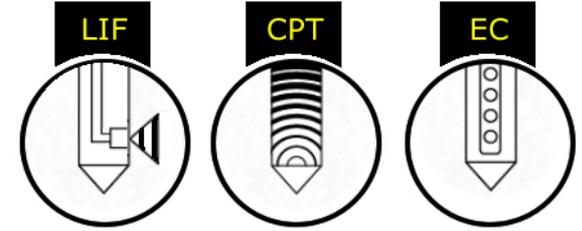


- Monitoring Wells (MWs) yield depth-integrated, flow-weighted averaged data, with no vertical distribution of contaminants in the screened interval.
- Monitoring wells are holes in the ground that can lie.
- MWs and 5 foot soil cores do not define the small scale heterogeneities controlling contaminant transport.

Real-Time Measurement Systems



Real-Time Decision Making and Information Sharing



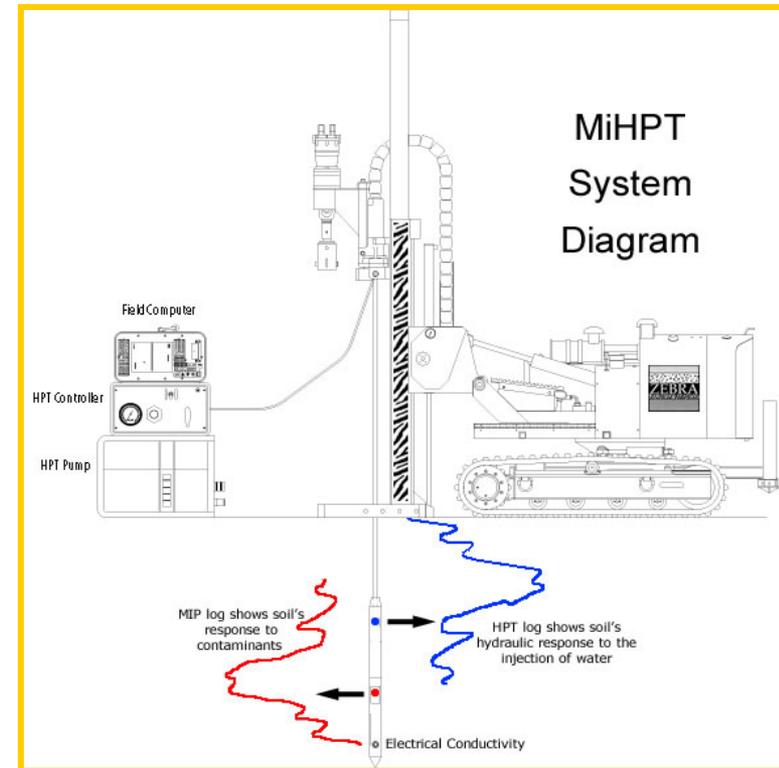
The High Resolution Tools for Site Characterization

HRSC System Setup

Setup is similar to all real time measurement systems...

Three components:

- DPT/Probe rig
- Tool String
- Data collection equipment

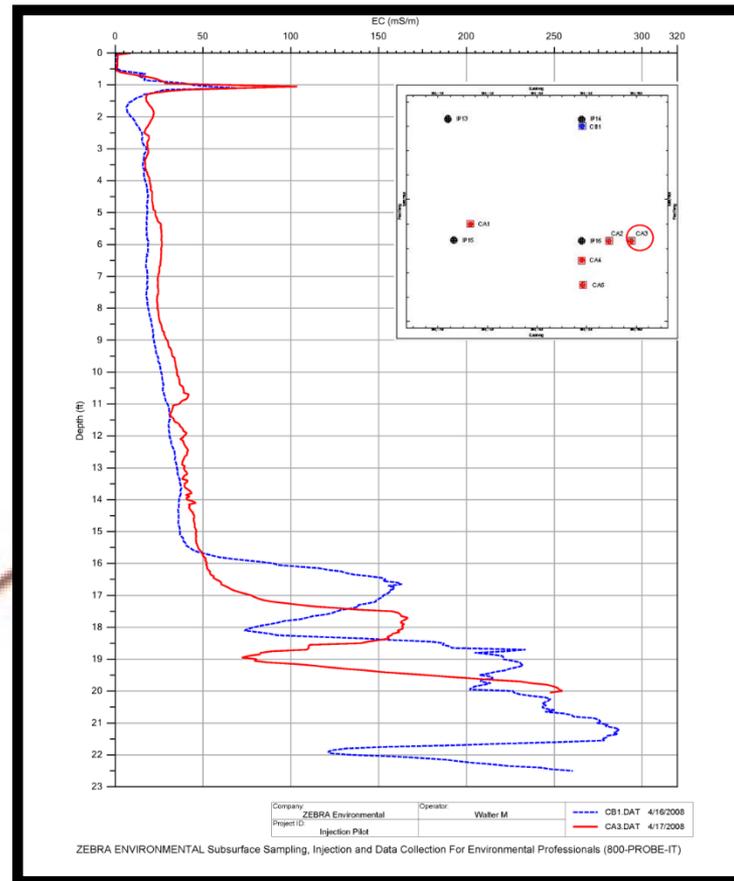
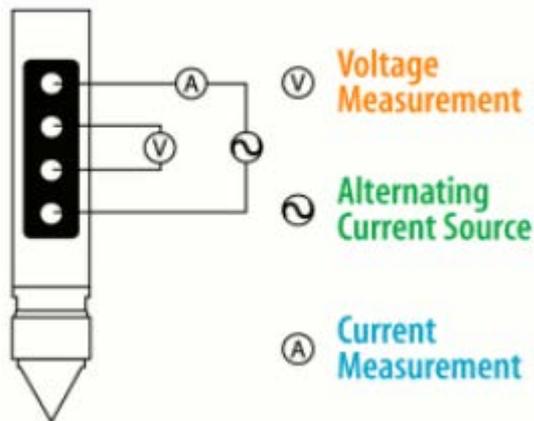




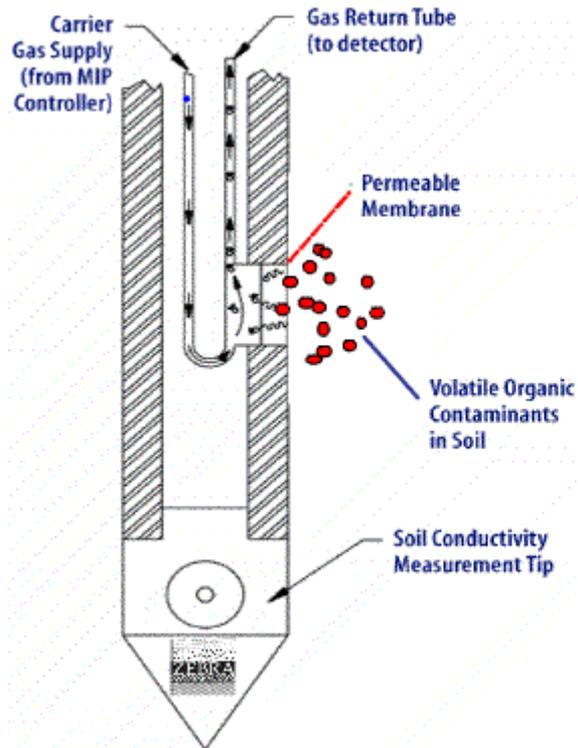
EXCELLENCE ON EVERY LEVEL™



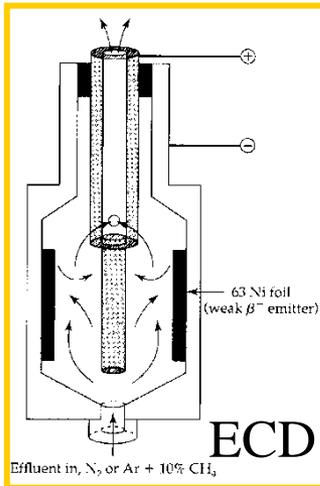
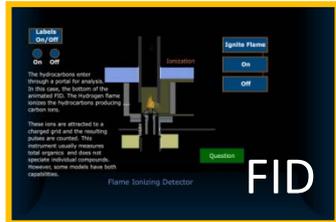
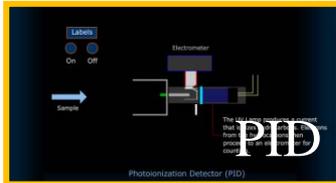
Electrical Conductivity EC Probe



The (MIP) Membrane Interface Probe System



The (MIP) Membrane Interface Probe System



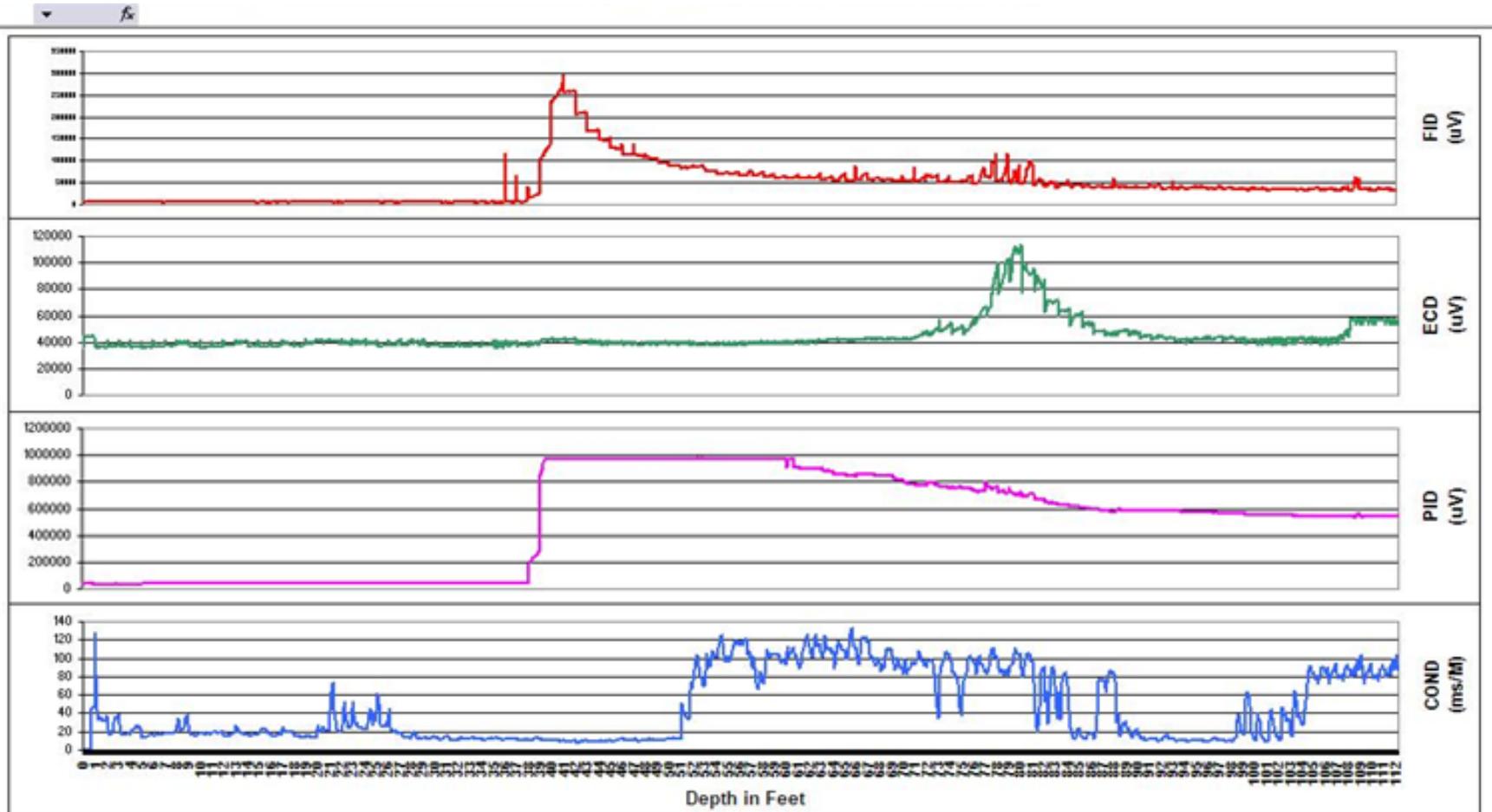
- Screening Tool with semi-quantitative capabilities

- Lab grade Detectors

- PID (BTEX)
- ECD (CVOC's)
- XSD (CVOC's)
- FID

- Standard Practice ASTM Method D7352-07

Example MIP Log



Permeability ?

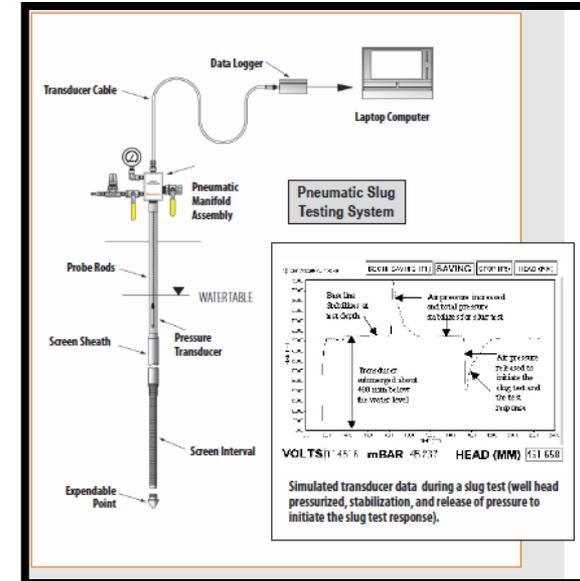
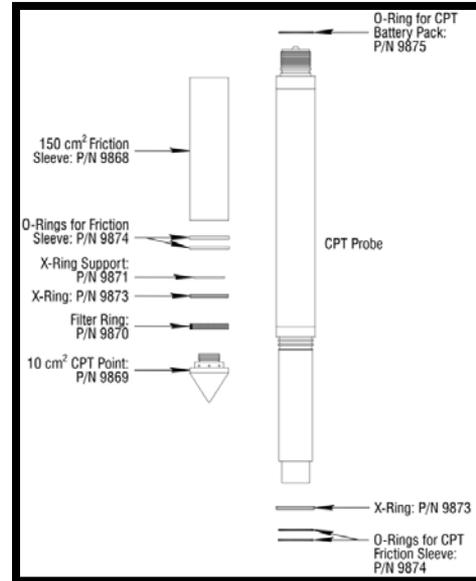
Leogane, Haiti



HPT Permeability Testing

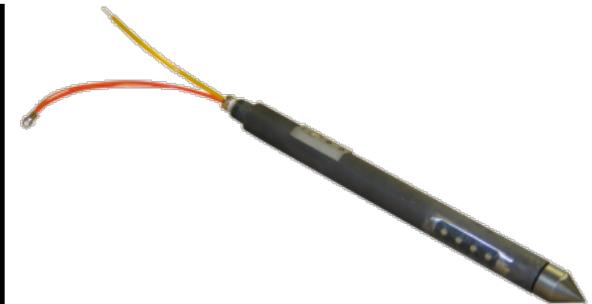
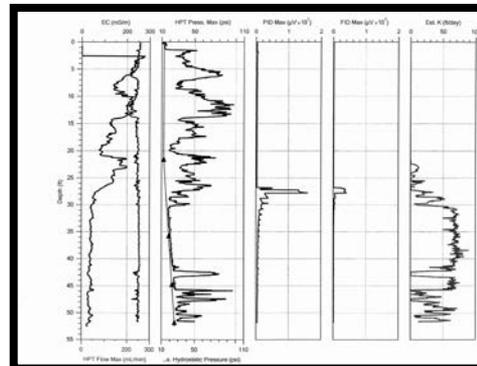
•Point Methods

Average Data
CPT
SLUG



•Profile Methods

Specific Data
HPT
Waterloo APS

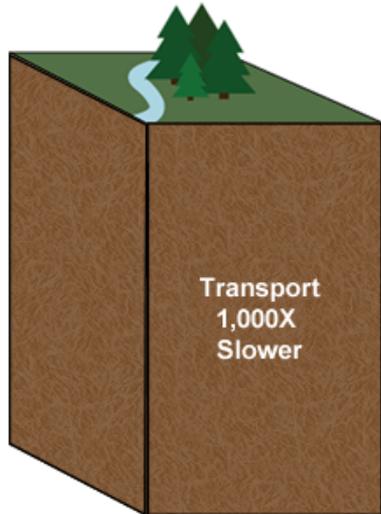


HPT Permeability Testing

Tools must provide specific permeabilities estimates, not large scale averages.

Point Methods

- CPT Dissipation Test
- Slug Test

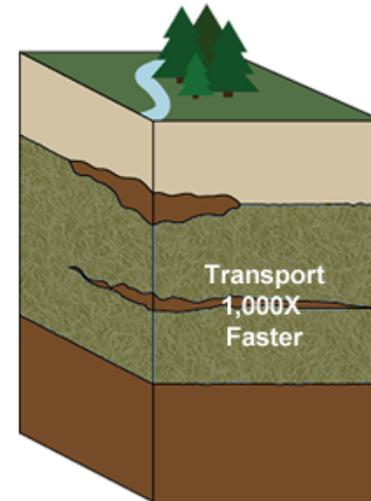


$$K_{avg} = 3 \times 10^{-3} \text{ cm/sec}$$

$$K = 3 \times 10^{-3} \text{ cm/sec}$$

Profiling Methods

- MiHPT & HPT
- Waterloo



$$K = 1 \times 10^{-5} \text{ cm/sec}$$

$$K = 1 \times 10^{-2} \text{ cm/sec}$$

$$K = 1 \times 10^{-5} \text{ cm/sec}$$

$$K_{avg} = 3 \times 10^{-3} \text{ cm/sec}$$

Average K is the same in both examples

HPT - Average Path versus Actual Path

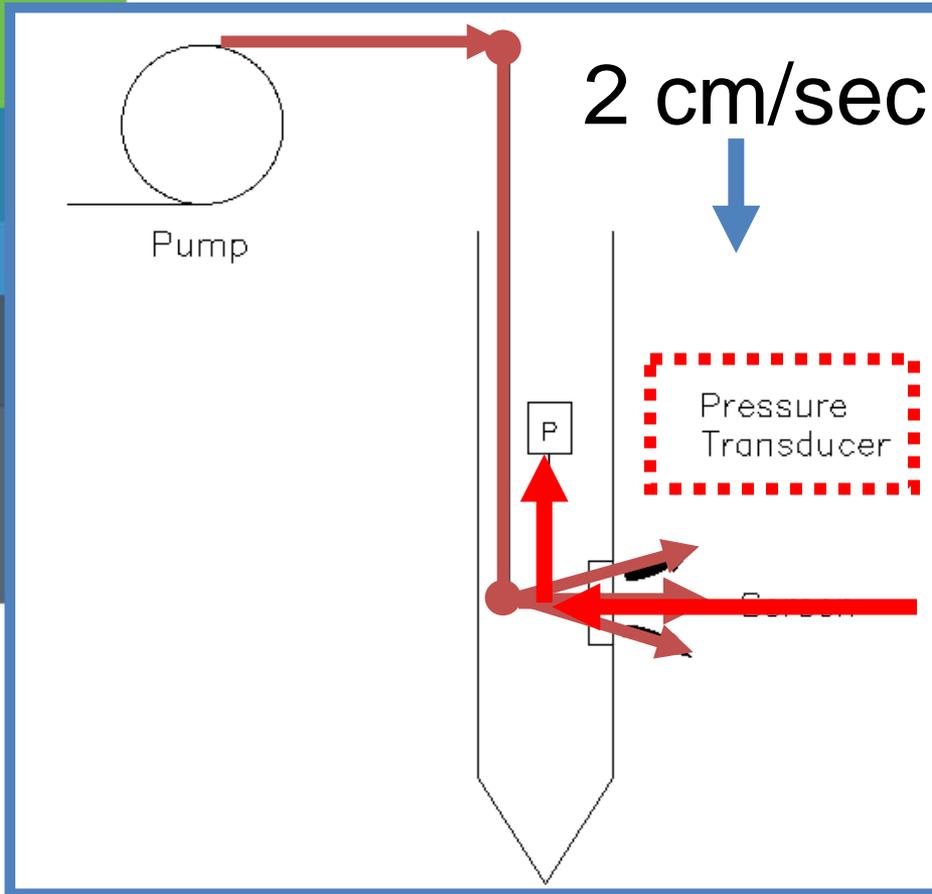


Permeability
Average
Point Method

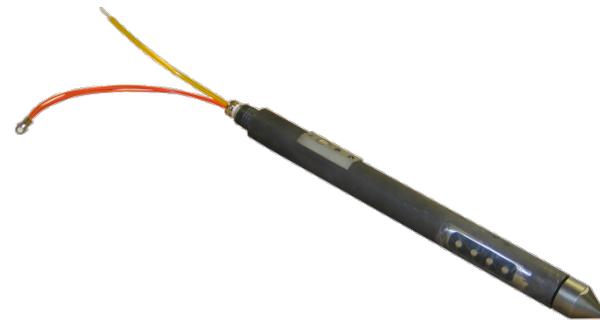
Permeability
Actual
Profile Methods



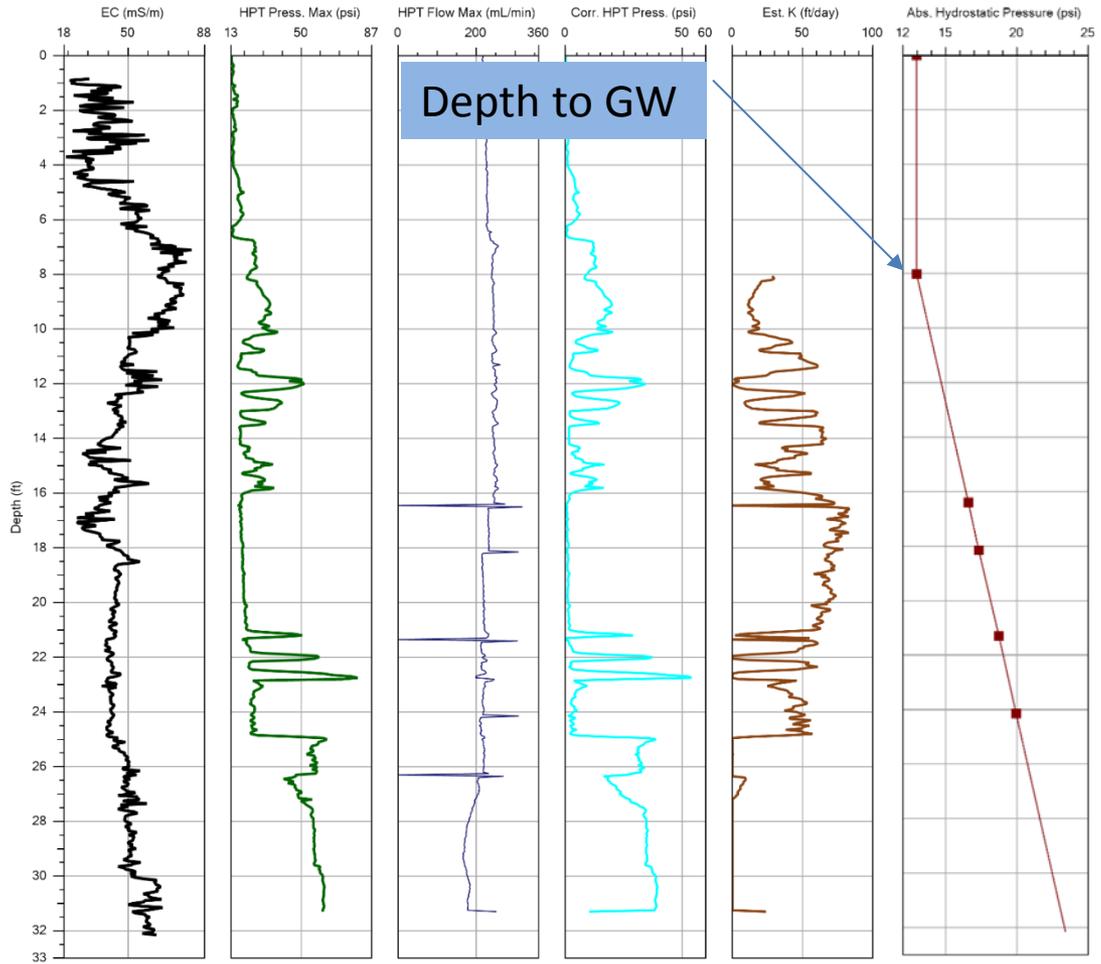
The Hydraulic Profiling Tool (HPT) System



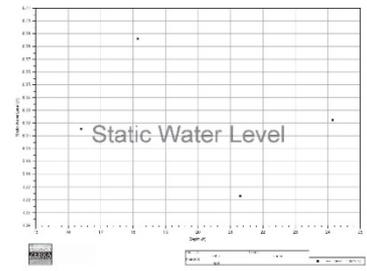
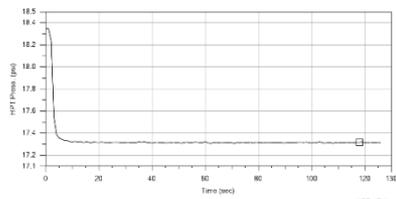
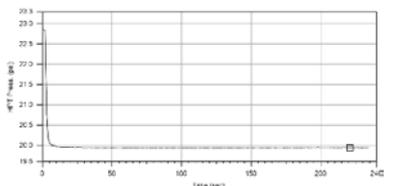
- Advance probe at constant rate
- Inject water at low flow rate
- Measure formation pressure response



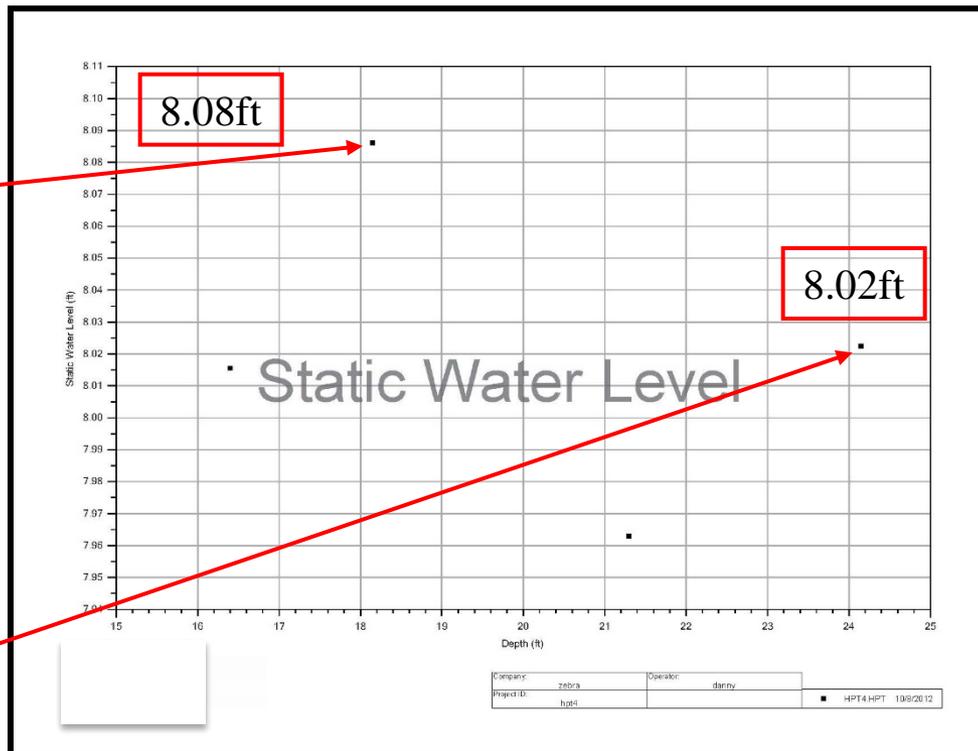
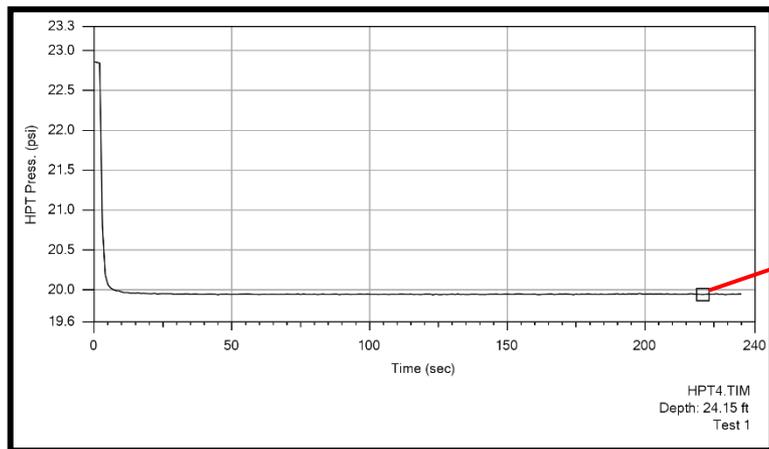
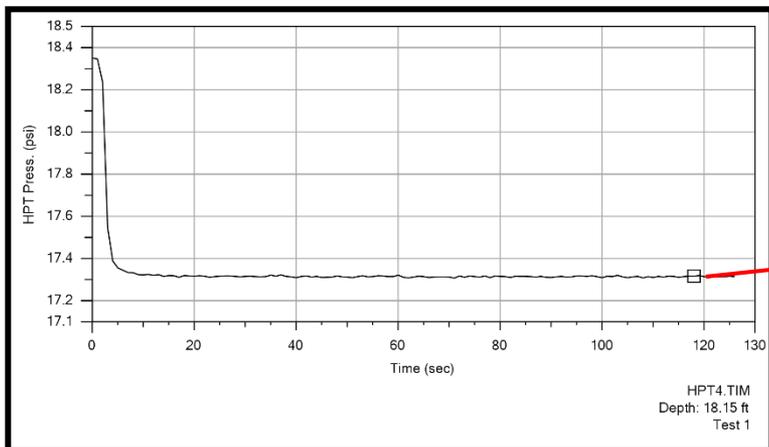
HPT Log



EC HPT Press Flow Corr HPT Est K Abs Hydro Pressure



Dissipation – Static Water Level

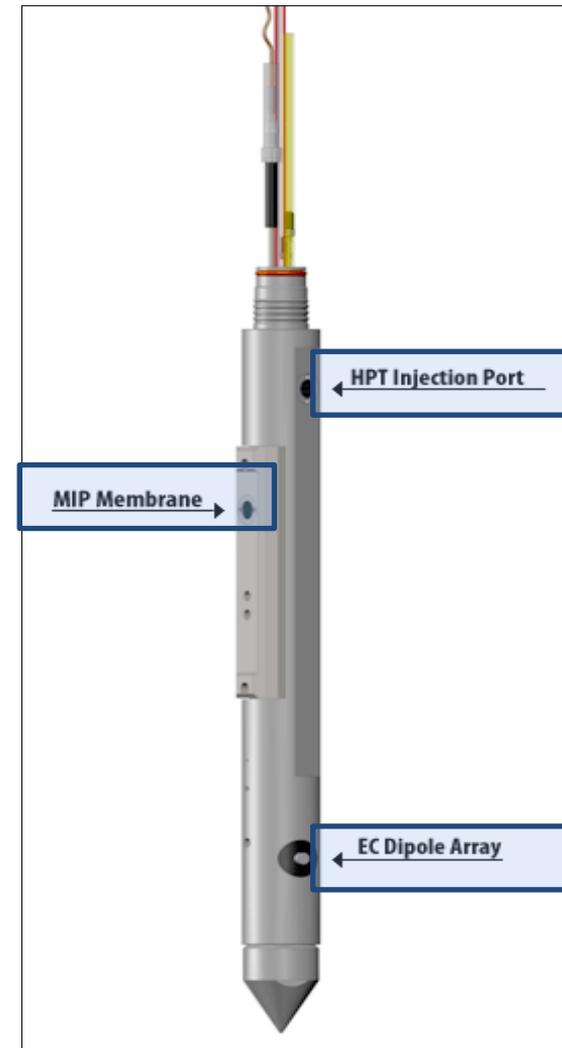


MiHPT – “Your Can Run But You Can’t Hide”

- Providing the Whole Picture
 - **Lithology**: Electrical Conductivity (EC)
 - **VOC Mass**: Membrane Interface Probe (MIP)
 - **Hydraulic Conductivity**: Hydraulic Profiling Tool (HPT)
- 3 Tools – One Boring

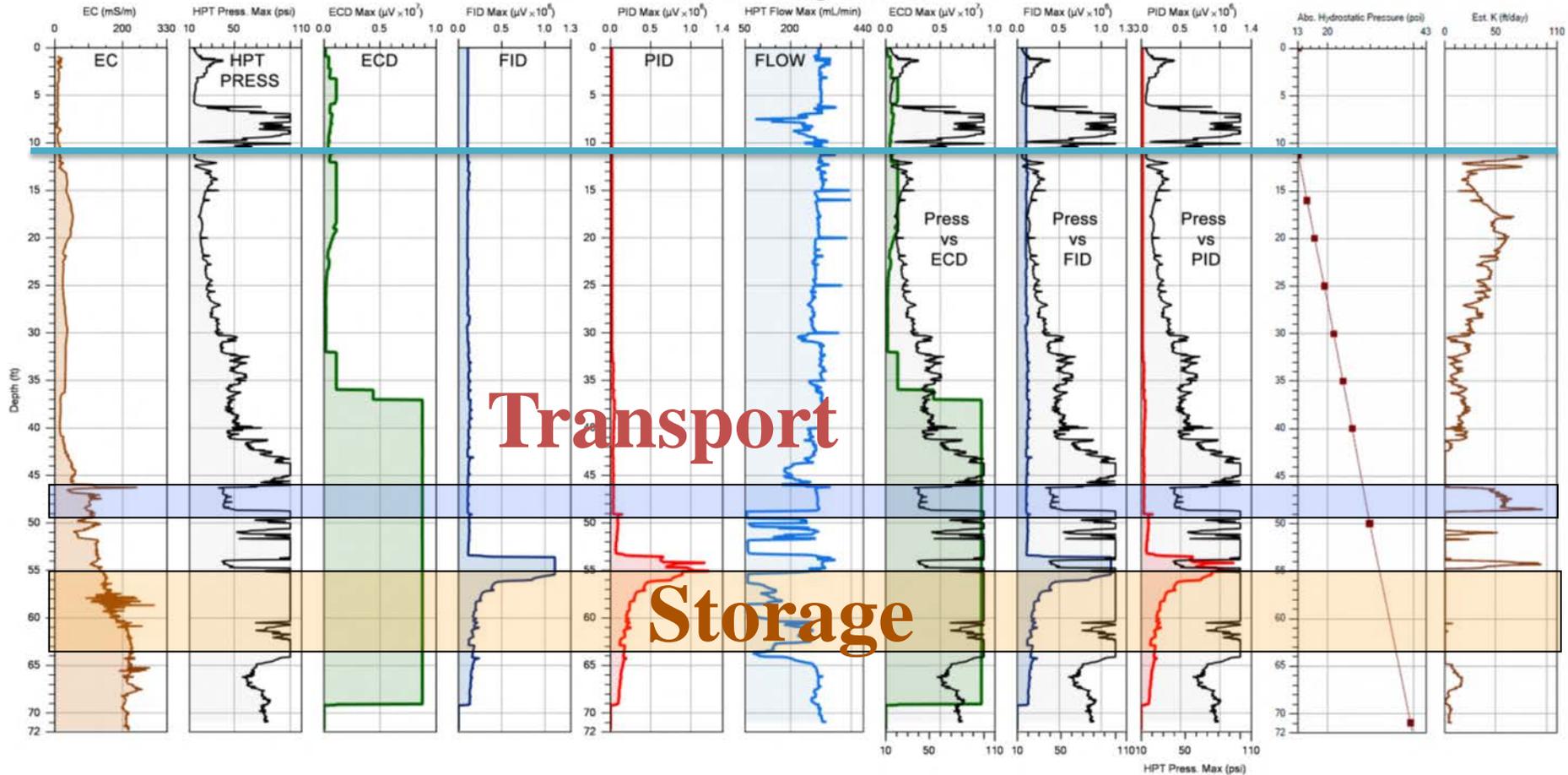


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MiHPT LOG

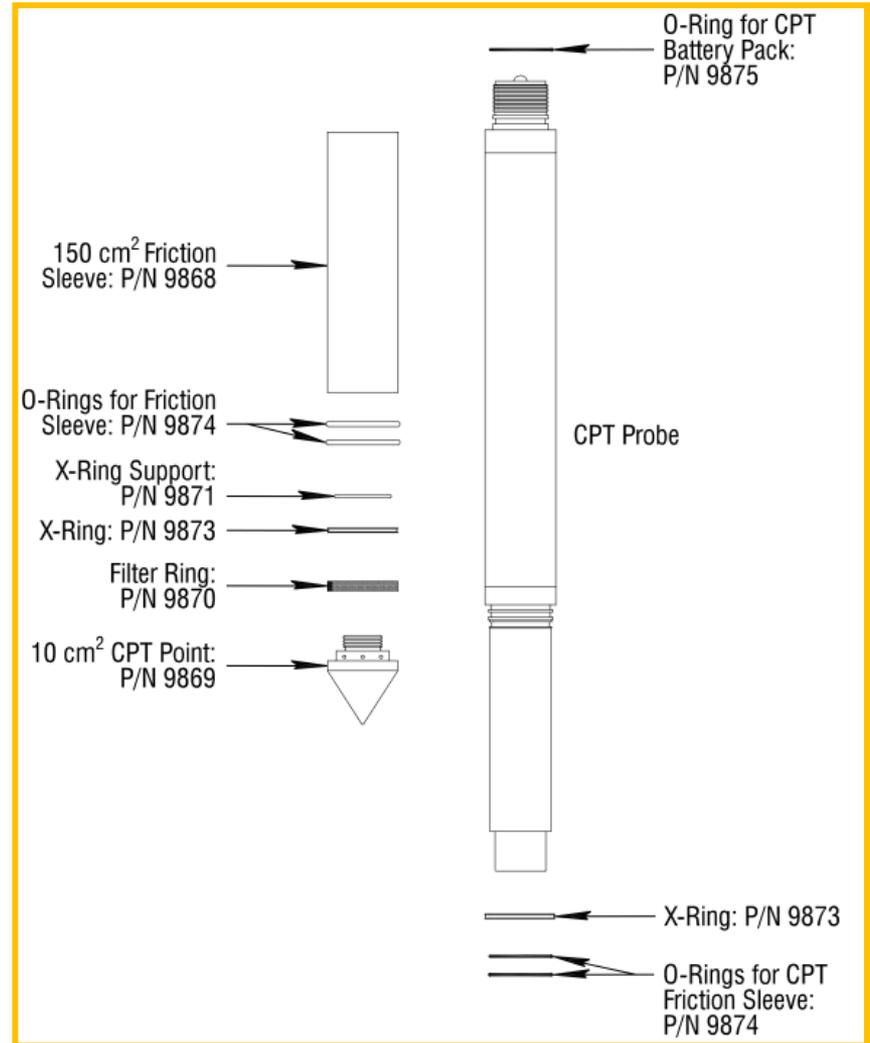
MiHPT Log SDI-201-A



Transport

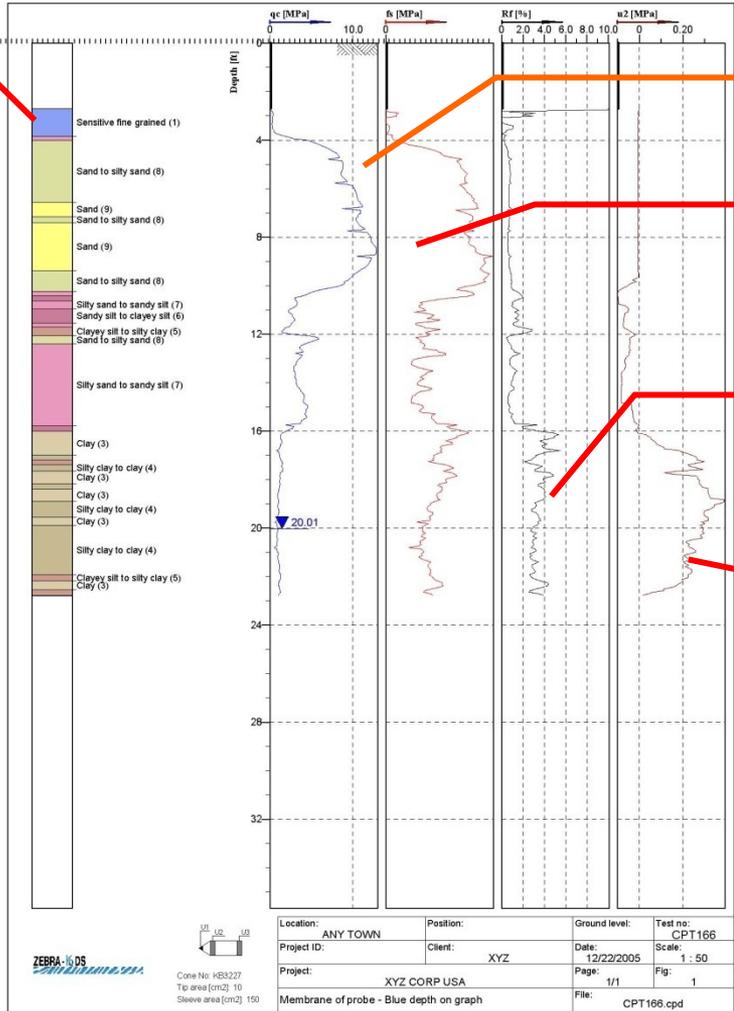
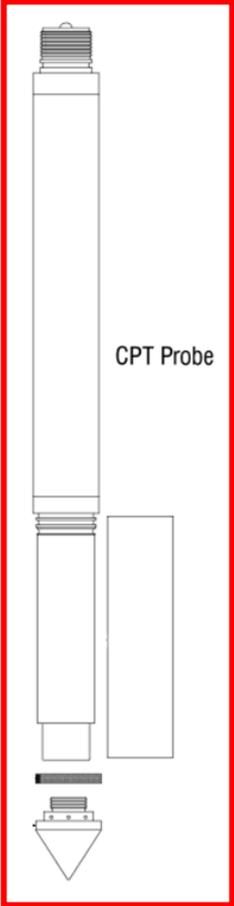
Storage

Cone Penetrometer Testing - CPT



CPT log

Lithology Description



Tip Pressure

Sleeve Friction

Friction Ratio

Pore Pressure

The UVOST System

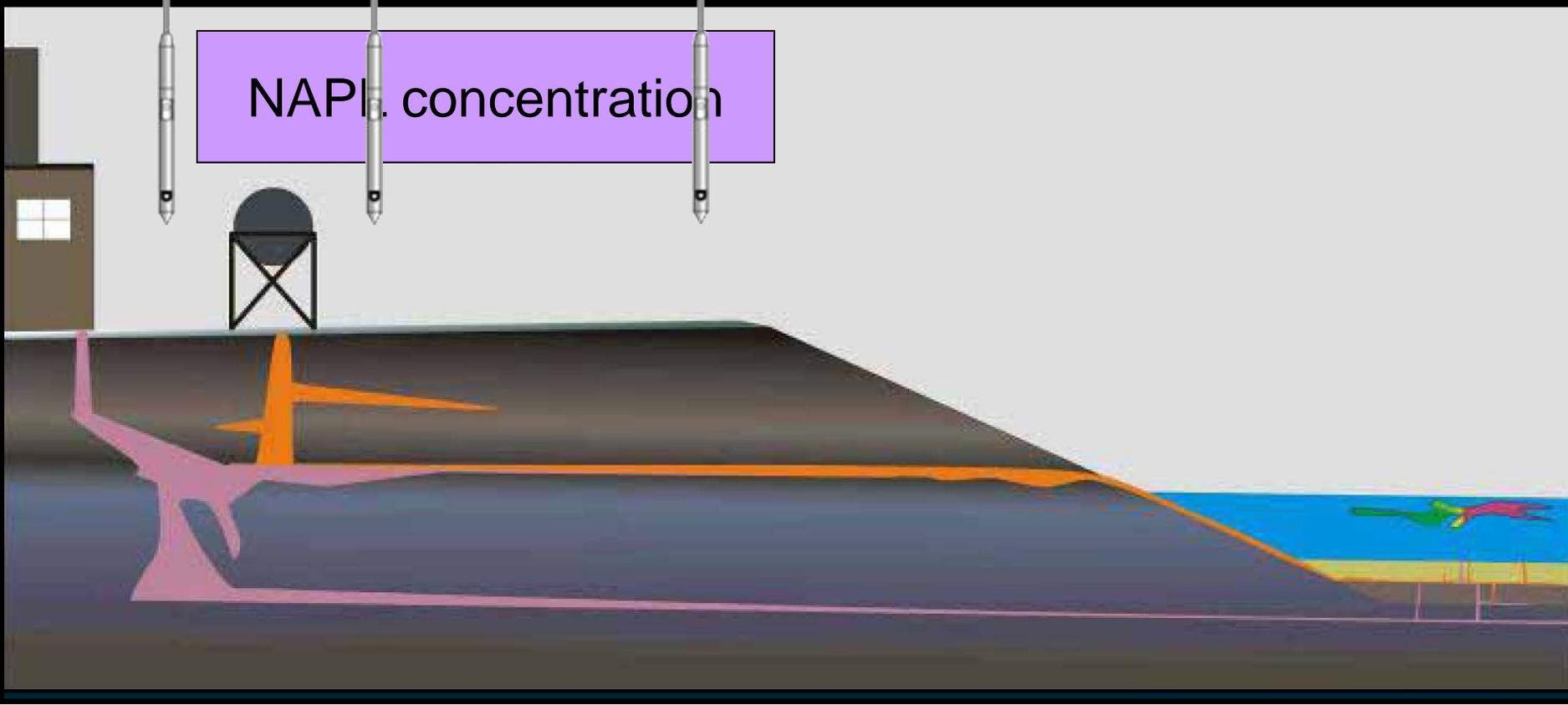
Ultraviolet Optical Screening Tool



Potential LIF Characterization Sites

- Leaking Underground Storage Tanks
- Pipelines
- Refineries
- Fueling Areas
- Automobile Service Locations
- Lagoons and Waste Ponds

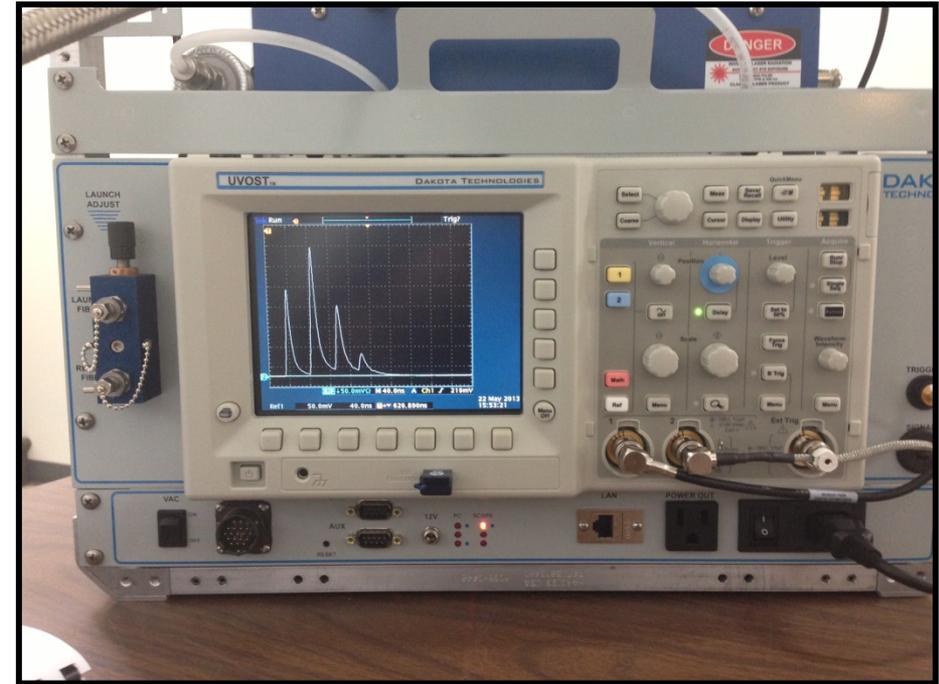
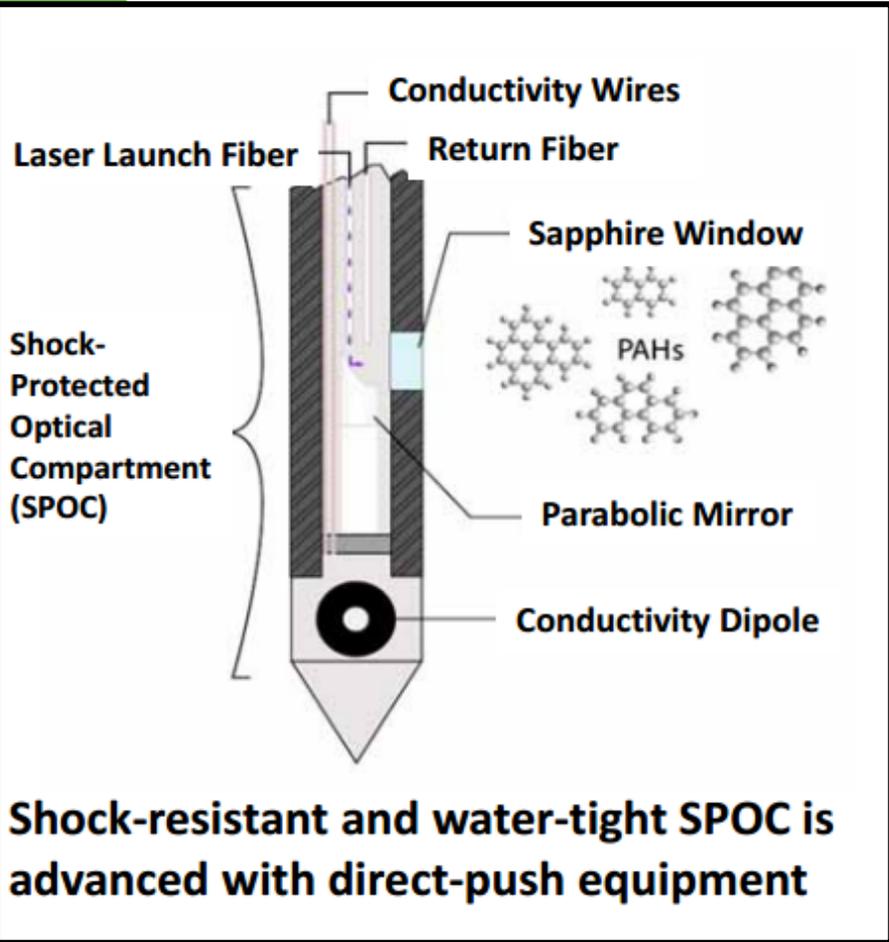




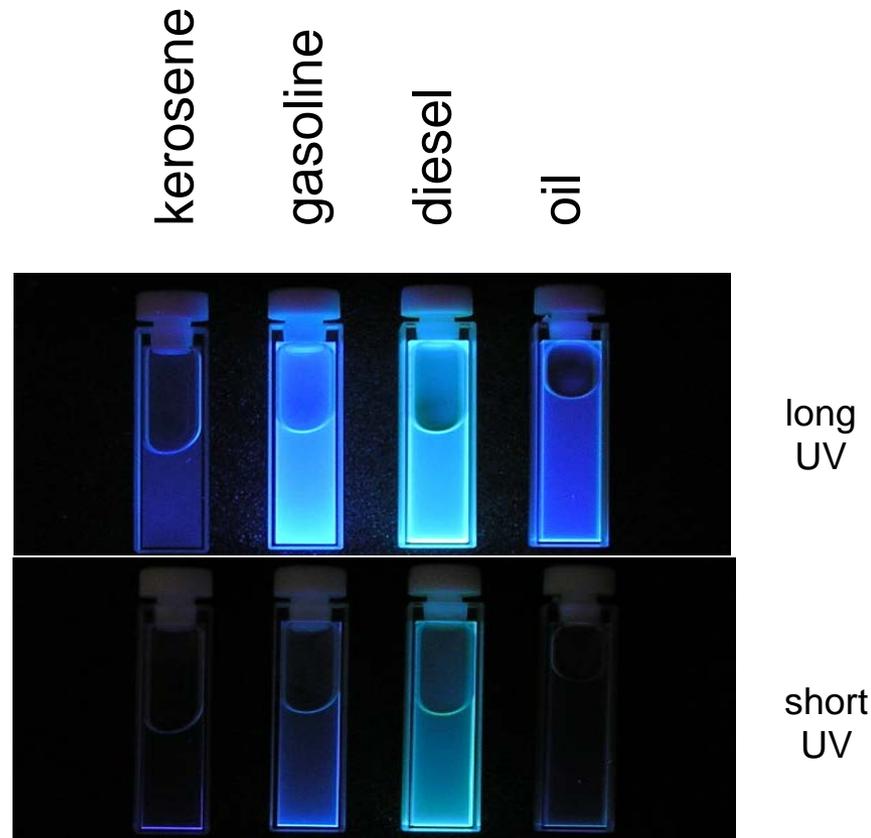
The diagram illustrates a cross-section of the ground surface and subsurface. On the left, a brown building and a black satellite dish are visible. Three vertical probes are suspended from the top, with their sensors positioned in the subsurface. A purple rectangular box with the text 'NAPL concentration' is centered above the probes. Below the ground surface, a dark grey layer represents the soil. An orange plume, representing NAPL, originates from a source on the left and spreads horizontally. A pink plume is also visible on the left side. In the background, a blue sky and a colorful bird are visible.

NAPL concentration

The UVOST/LIF System

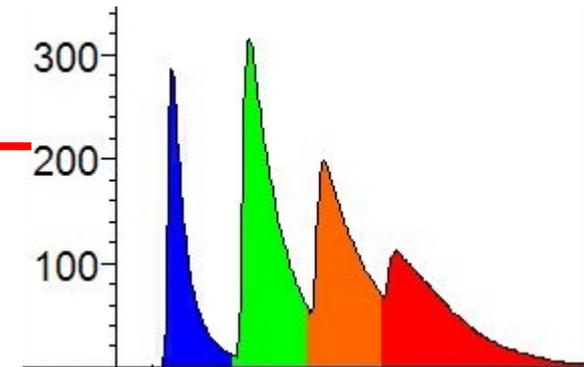
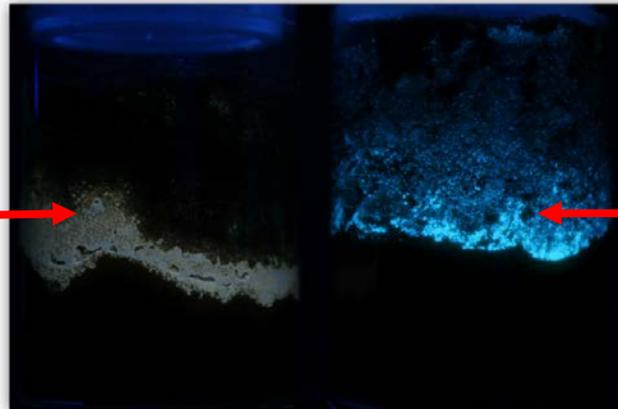
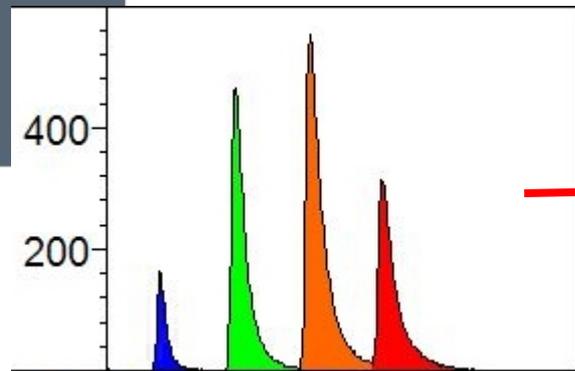


Fortunately all PAH non-aqueous phase liquids or NAPLs Fluoresce



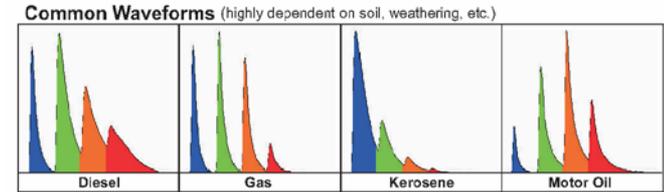
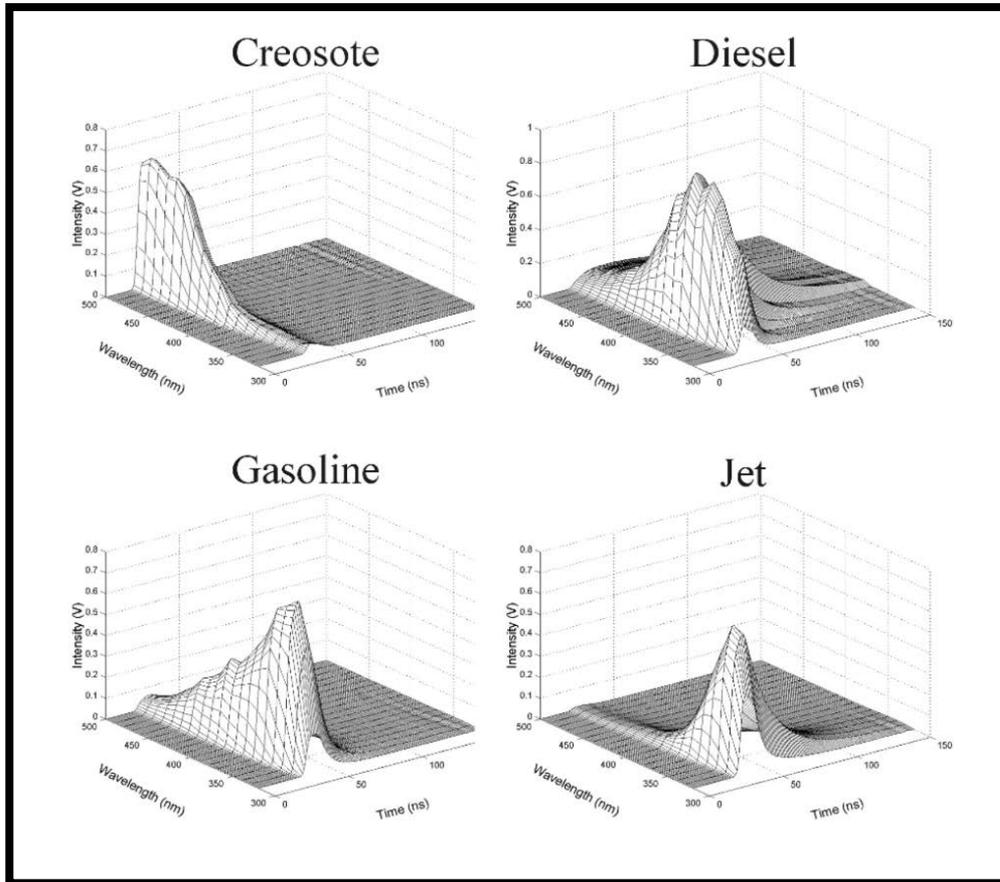
PAH fluorescence is a way to detect them by their “glow”

Example of Fluorescence



Laser Induced Fluorescence (LIF) Concepts

Each Aliphatic Solvent yield a fairly unique wavelength/time matrix (WTM)



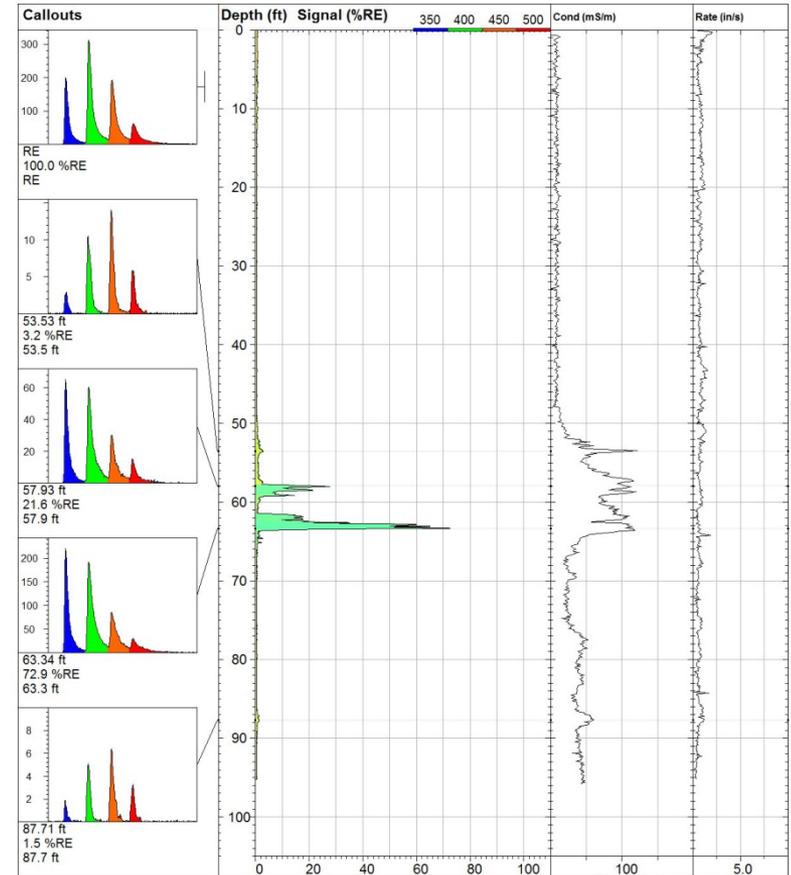
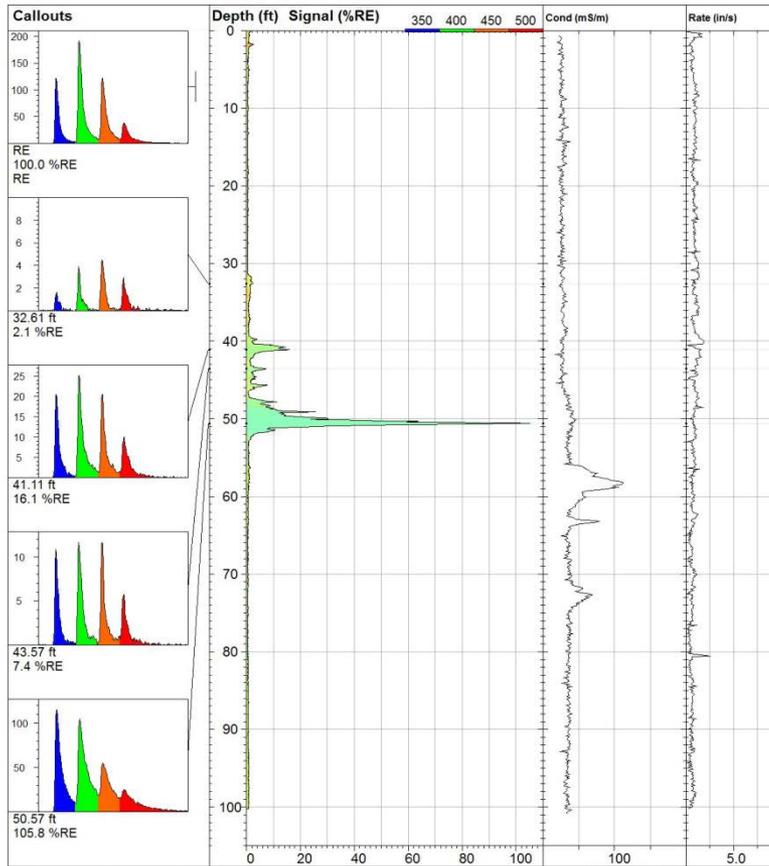
Diesel

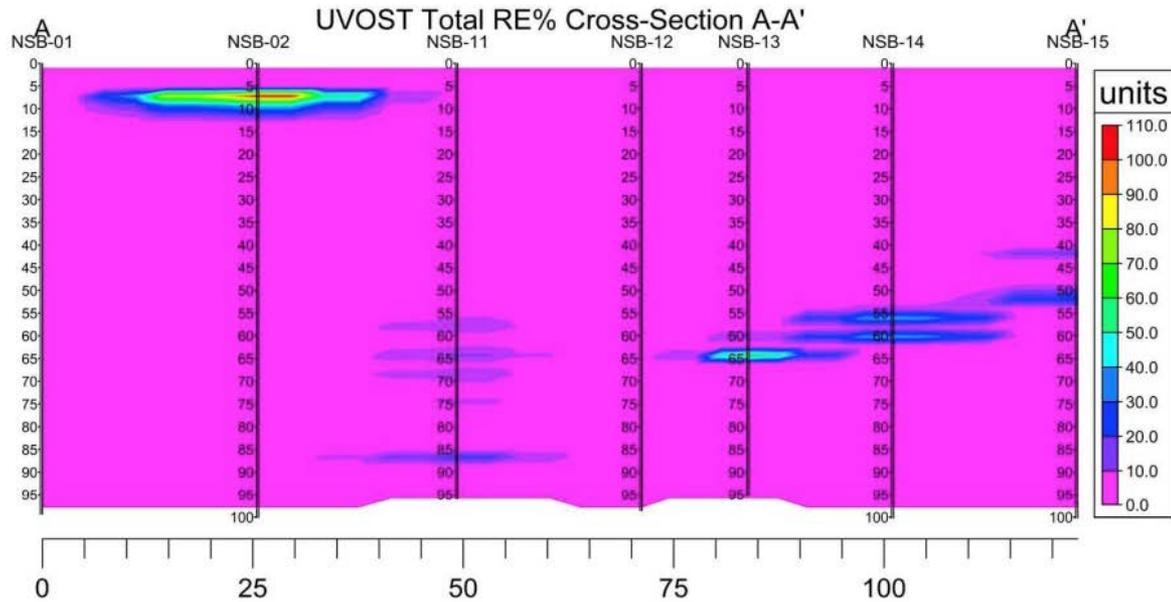
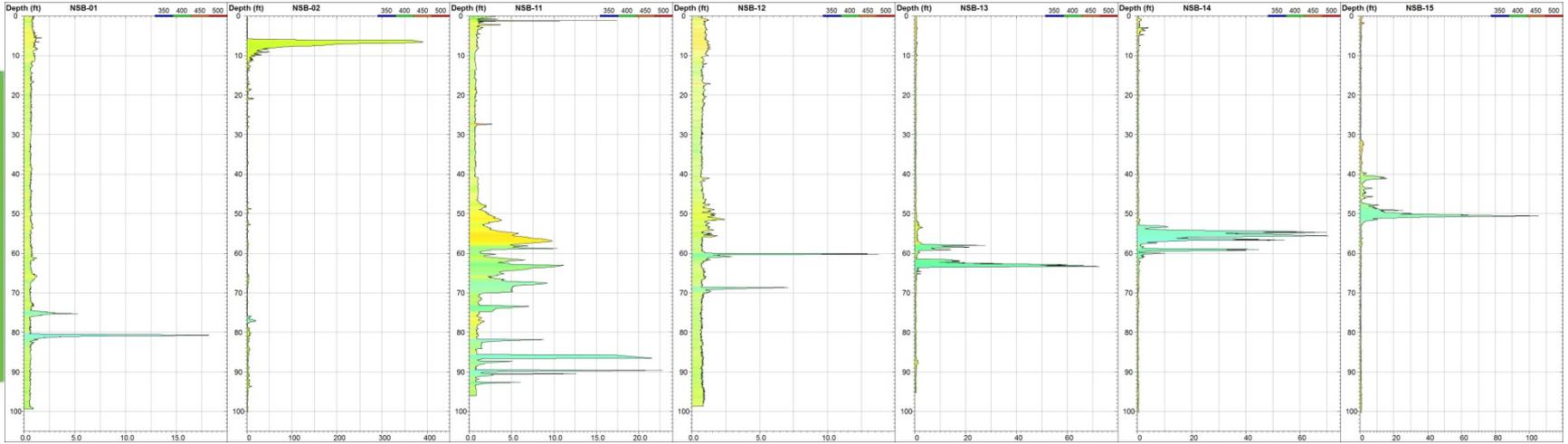
Gas

Jet

Motor Oil

UVOST/LIF Logs





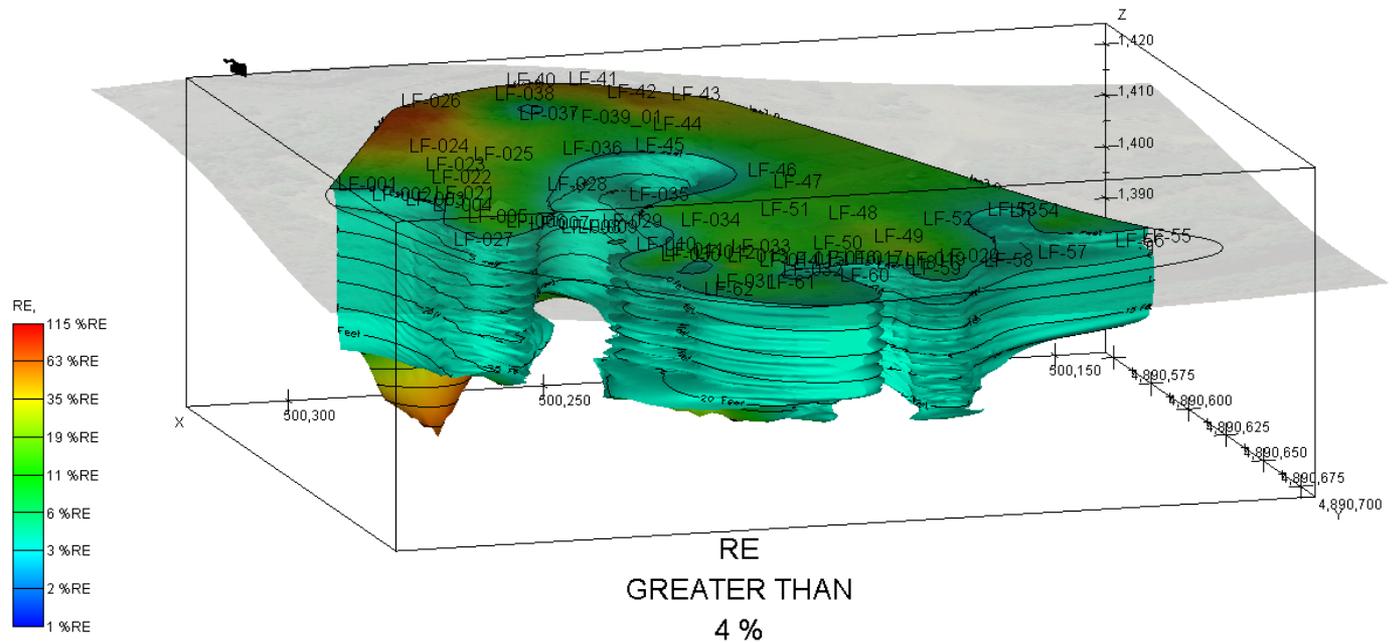
ZEBRA Environmental - Subsurface Sampling, Injections and Data Collection for Environmental Professionals Since 1992.

HRSC

High Resolution Site Characterization

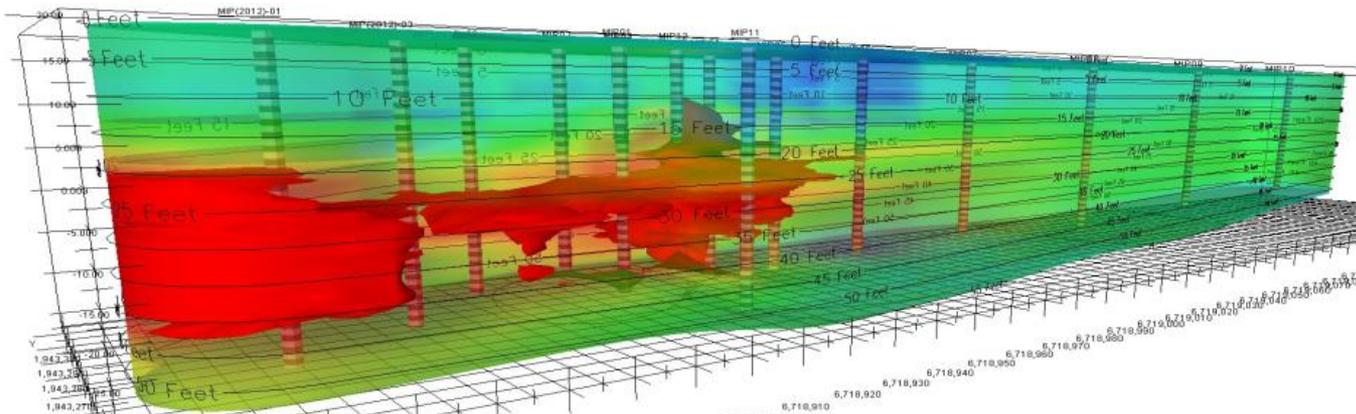
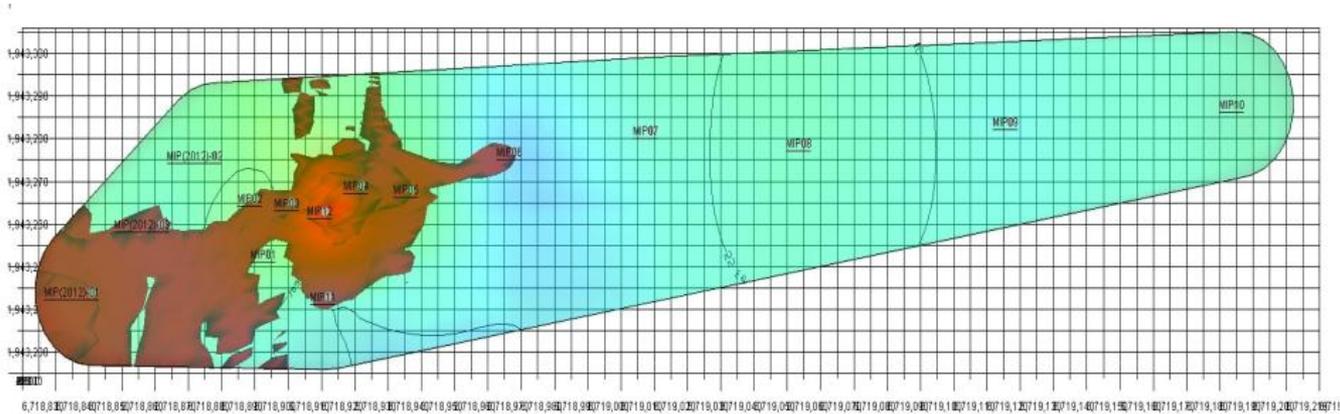


State-of-the art analysis and visualization.
Targeted Injection Plans



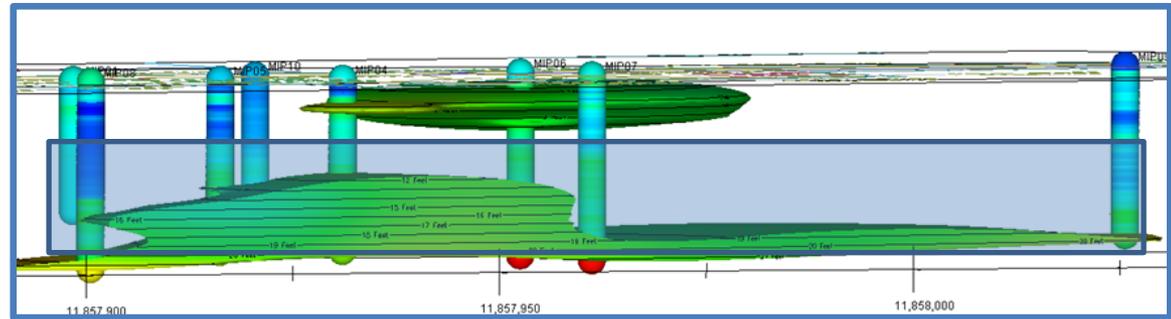
Evolution of HRSC

3D Imaged Source Area – PID > 1 x 10⁶ microvolts

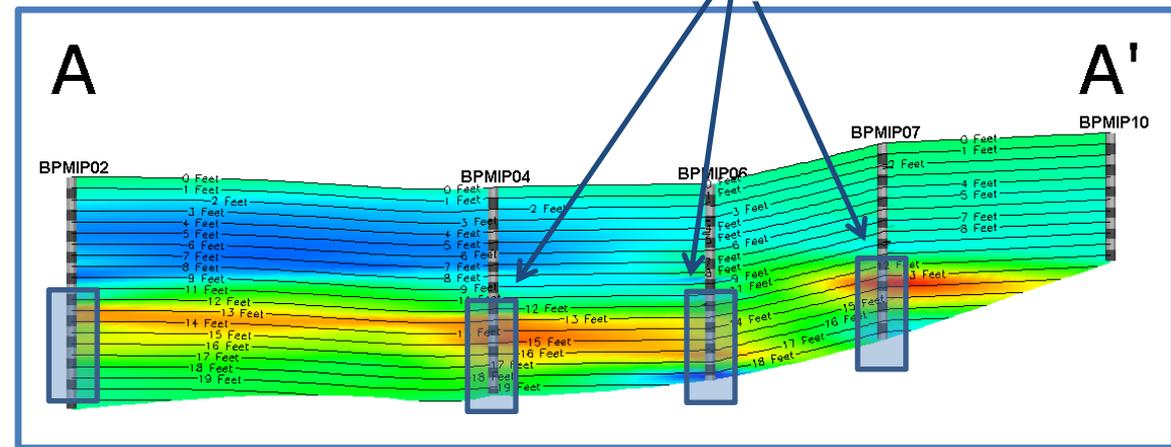


MVS – HRSC Integration

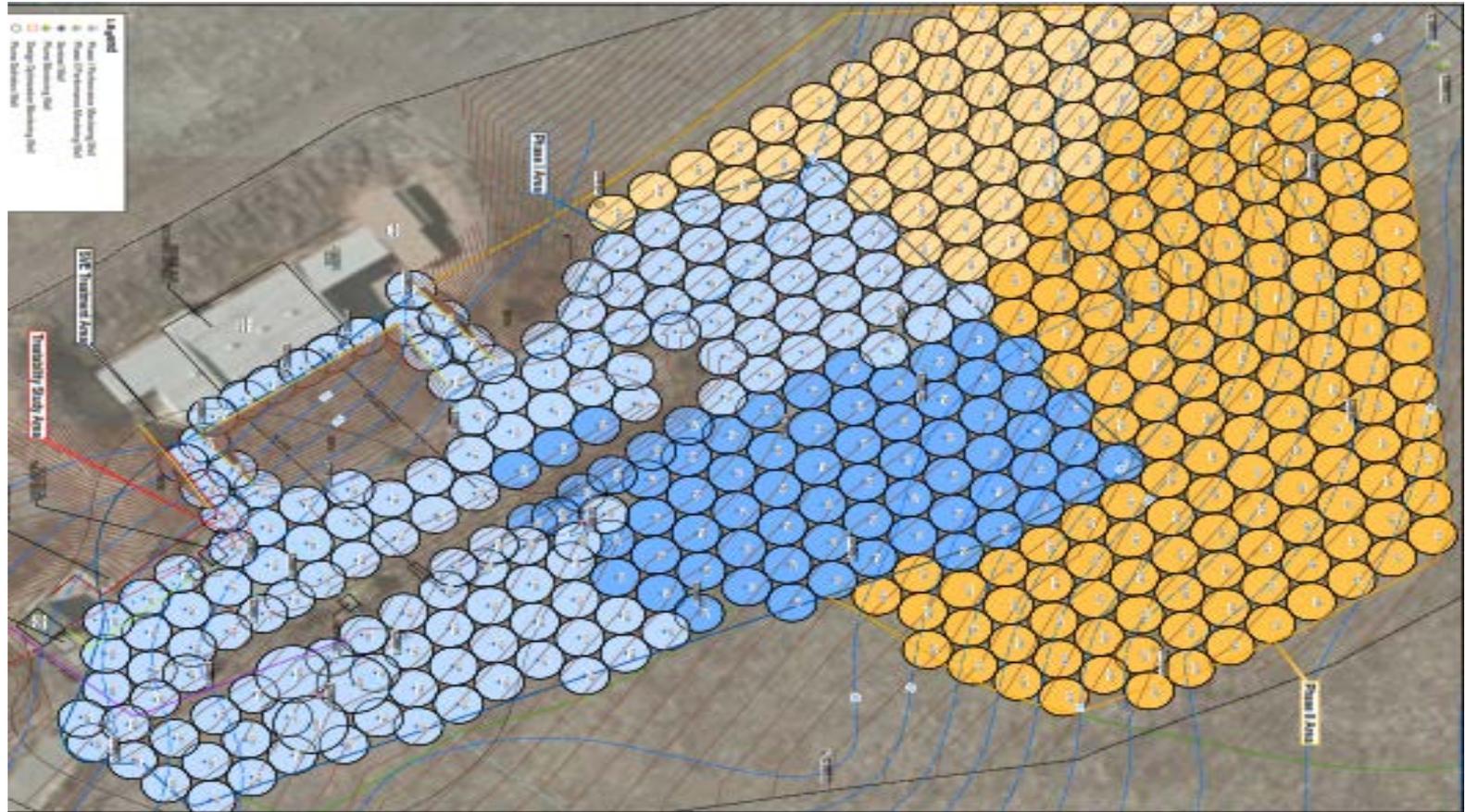
- Conceptual Site Model (CSM) development



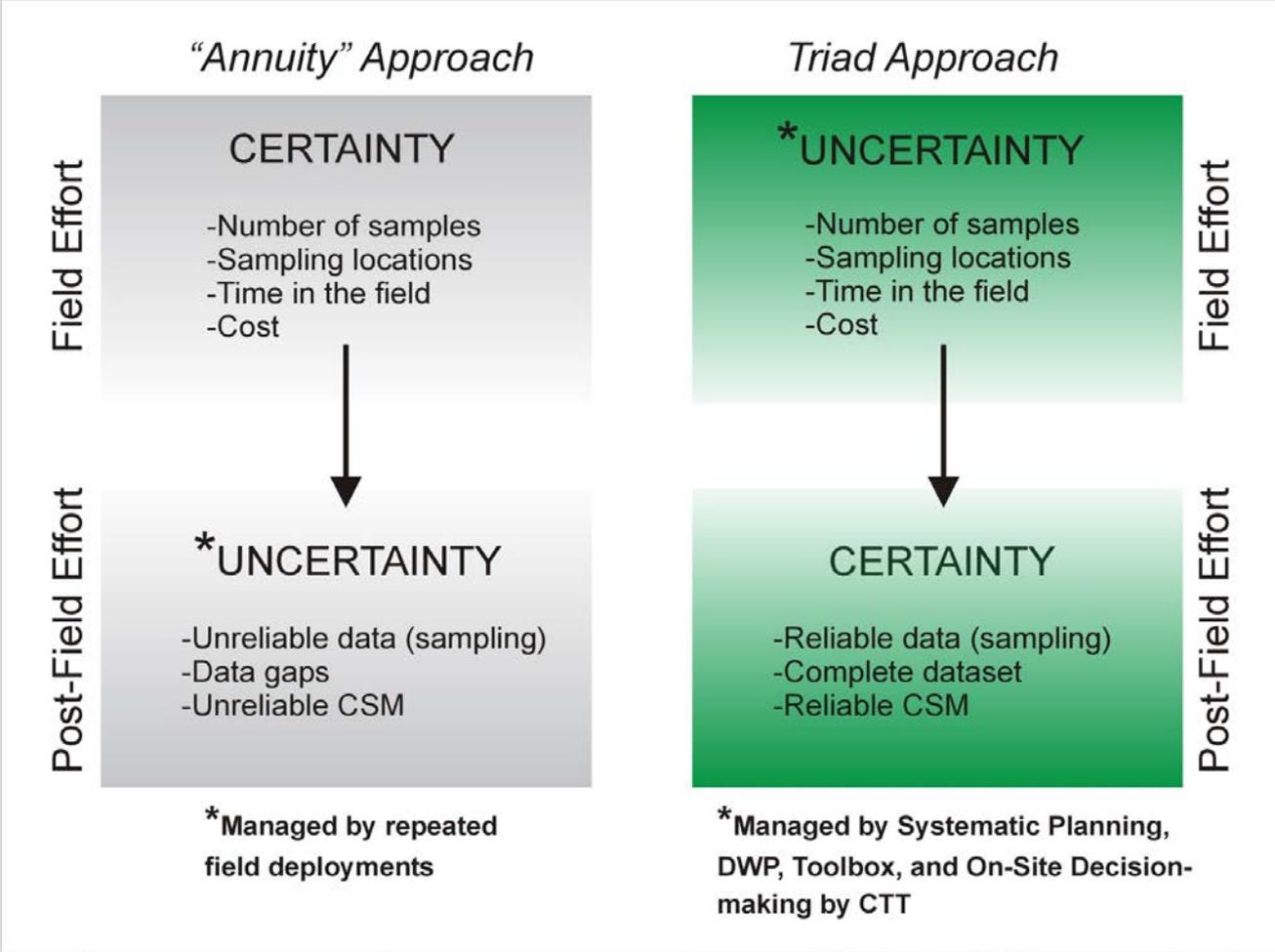
Well Screen Zones



HRSC Injection Planning



The Main Idea





Questions