Site Characterization
HRSC Design Optimization

One Partner. Many Solutions.

CASCADE   TERRATHERM a Cascade Company   www.cascade-env.com

SITE CHARACTERIZATION SERVICES

No matter the data you need or the budget you're on, we have the experts and technology to support your project.

Cascade Environmental has the in-house capabilities and expertise to support your project from concept to completion. We offer services ranging from traditional site characterization to proprietary and multi-sensor high resolution technology options. We work closely with you to identify cost-effective solutions utilizing individual or combined technologies to help you build your conceptual site model.

THE CASCADE ADVANTAGE

- **National Footprint** - With offices, experts and equipment nationwide, we're never far from your site.
- **Resources** - Cascade is the only nationwide provider of integrated services, and we have more traditional and high resolution resources than anyone else in the industy.
- **Experience** - Our team of seasoned site characterization experts have the know-how to deploy the right tools at the right time to achieve the data you need.
- **Integration** - Our range of services mean you can integrate characterization and remediation for optimized results—all under a single contract.

SITE CHARACTERIZATION SERVICES

- Optical Image Profiler (OIP)
- Membrane Interface Probe (MIP)
- Membrane Interface & Hydraulic Profiling Tool (MIHPT)
- Ultraviolet Optical Screening Tool (UVOST)
- Waterloo^{APS} Advanced Profiling Tool
- High Resolution Piezocone
- Soil Vapor Monitoring Probes
- 3D Data Visualization Software
- Temporary Wells
- Continuous Core
- Piezometer & Slope Inclinometer
- Split Spoon Sampling
- Push Ahead Sampler
- Multi-Level Monitoring Systems
- Design & Data Interpretation Support

COMBINED TECHNOLOGIES AVAILABLE

Ready to get started on your next project?
Request a quote now: www.cascade-env.com/request-a-quote

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OPTICAL IMAGE PROFILER OVERVIEW

OPTICAL IMAGE PROFILER (OIP)

The Optical Image Profiler (OIP) is a high resolution site characterization (HRSC) tool that efficiently delineates non-aqueous phase liquid (NAPL, or free product) hydrocarbon fuels in the subsurface. The OIP is advanced via direct push drill rig, generating multiple data sets simultaneously. This system provides real-time information which allows the investigation team to make changes to the program while mobilized to target the locations and depths that will provide the most value. Combining the vertical profiles from multiple locations enables the development of more complex visual representations of NAPL distribution, such as transects, three-dimensional models, and interactive maps. Ultimately, these data enable better decision making. Whether the next step is a risk assessment, additional characterization, or remediation, this tool will reduce uncertainty – saving time and money.

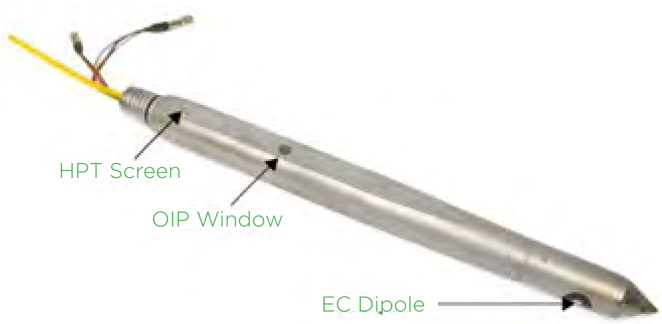
OIP SYSTEM OVERVIEW

The OIP system was developed by Geoprobe for the detection of NAPL hydrocarbon fuels, oils, and tars present in the soil. NAPL may be detected as layers, ganglia, blebs or droplets of product in the formation matrix. Compounds in the NAPL will fluoresce when exposed to certain types of light. The tool operates by focusing a light source through a sapphire window and then capturing the resulting fluorescence with a camera 30 times per second as the tool is pushed downward. Back at the technician's station above ground, a software filter is applied to measure the amount of fluorescence in each image and a vertical log is generated in real time.

In addition to the NAPL fluorescence measurement, the tool includes an integrated electrical conductivity (EC) array and a Hydraulic Profiling Tool (HPT). The EC array measures bulk formation conductivity which can be used to make inferences about the soil type encountered. The HPT measures back pressure and flow rate of an injected water to generate an estimated soil transmissivity value. Together, these tools provide a powerful collaborative data set for understanding hydrostratigraphy. Cascade deploys both of the light sources available from Geoprobe: the OIP-UV and OIP-G.

OIP-UV Probe - The OIP-UV probe uses an UV LED and visible light camera and is suitable for delineation of fuels such as gasoline, diesel, etc. In addition to the software-filtered images showing percent areal fluorescence, the OIP-UV also provides the client with full color images of the soils outside the probe window.

OIP-G Probe - The OIP-G probe uses a green laser diode and an infrared camera, ideal for delineating coal tars, creosote and heavy fuels or oils. Since this system uses an infrared camera to filter out the green light, the visible light images returned by this probe are in black and white.



DATA COLLECTION

Data is collected and viewed in real time on a computer, visible to the entire field team. In addition to the boring logs, an electronic data deliverable (spreadsheet based) is created that is suitable for incorporation into common database tools (e.g., EQuIS) and for use in three-dimensional modeling software, such as EVS. Cascade also offers near-real time data transfer via online mapping tools such as ArcGIS, and can assist you in interpreting HRSC data.

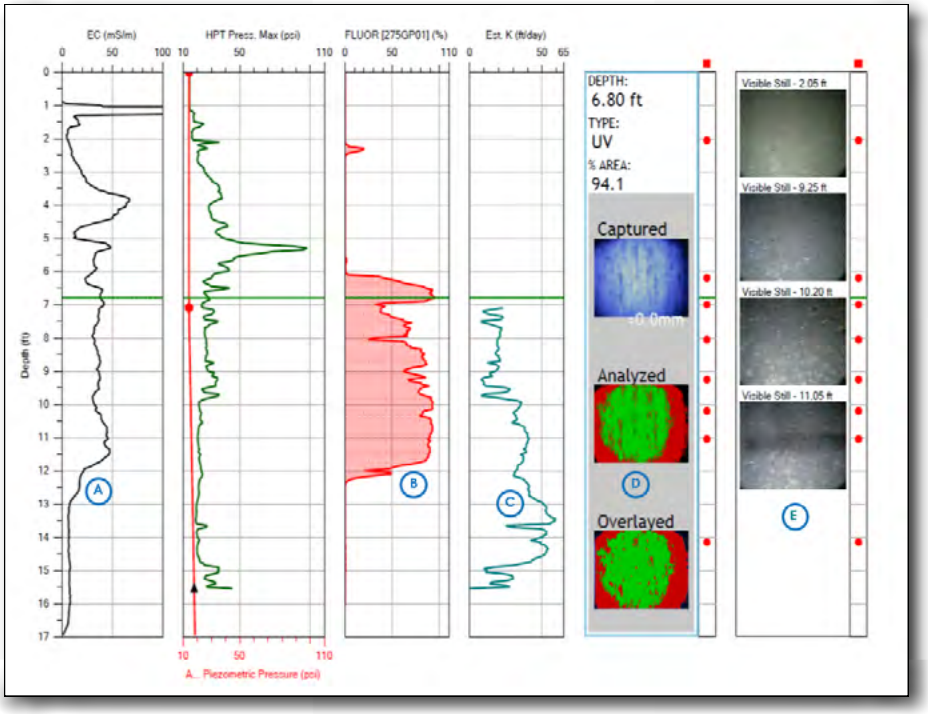
BENEFITS OF OIP

- **Real-time data acquisition** - allows for "on-the-fly" decision making and selection of the next borehole location, leading to more efficient and successful investigation programs
- **Visible images of in situ soils** - provide an additional line of evidence for soil characterization. Qualitative assessments of grain size and soil color can be made to improve the site conceptual model
- **Adaptability** - Cascade's OIP team arrives on site with Membrane Interface Probe (MIP) tool capability and can easily switch to that system to delineate dissolved phase impacts. Our full suite of HRSC tools can be mobilized to help you solve complex site investigation problems
- **Simplicity** - Cascade can seamlessly switch over to more conventional investigation tools such as soil borings and groundwater screen point samplers as desired to collect confirmatory data.
- **No IDW** - true in situ information without investigation derived waste, carryover, or handling and storage of samples
- **Fast** - production rates of 200 to 400 feet per day (typical direct push conditions)

OIP Log Generated by Cascade HRSC Team

This log shows the multiple data sets created during advancement of the OIP tool in the subsurface, including:

- Electrical conductivity **(A)**;
- Percent areal fluorescence (NAPL detection) **(B)**;
- Estimated hydraulic conductivity **(C)**;
- UV light and software filtered images from a selected depth, in this case 6.8 feet below ground surface **(D)**; and,
- Visible light images from selected depths **(E)**.



MORE DATA PER BOREHOLE

MIHPT

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WHAT IS THE MIHPT?

The MIHPT is the combination of the Membrane Interface Probe, Hydraulic Profiling Tool, and an electrical conductivity probe. The simultaneous collection of data from these systems during tooling advancement generates significant value by providing the relative concentrations of volatile organic compounds (VOCs), the relative permeability of the subsurface, and an approximation of the soil grain size, all versus depth in real-time. It is the most common high resolution site characterization (HRSC) tool used for the delineation of VOCs, whether they are in the form of petroleum hydrocarbons or chlorinated solvents.

CAPABILITIES

Real-time logs of depth v. VOCs concentrations and hydrogeology

Multiple VOCs detectors enable differentiation of compound families

Identifies components of VOCs mass in high-and low-K zones for more effective remedial alternative design

Identifies VOCs mass in soil and groundwater simultaneously, unrestricted by sampling flow rates

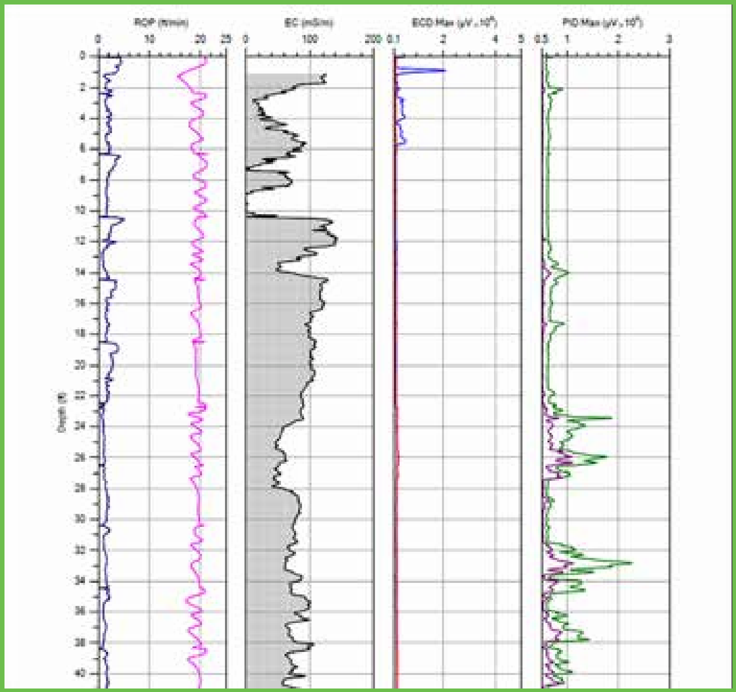
Multiple configurations to meet characterization needs

MEMBRANE INTERFACE PROBE

The Membrane Interface Probe (MIP) is commonly used for quickly determining the locations of VOC source zones and plumes. The MIP is most valuable in terms of its ability to provide “spatial correspondence”, meaning that where the MIP detector responses show peaks, there is likely to be elevated soil and groundwater concentrations. The MIP can also be used to provide extremely valuable data to streamline subsequent investigative tasks and improve the overall efficiency and accuracy of the site investigation. Vertical profiles, cross-sectional views and three-dimensional images of contaminant distribution can all be produced from the electronic data generated by the MIP logs. The capability of providing reliable, real-time information allows for informed and timely decision making in the field.

HYDRAULIC PROFILE TOOL

The hydraulic profiling tool (HPT) creates a log of the relative formation permeability versus depth in real time as the probe is advanced into the subsurface. It operates by injecting clean water at a constant flow rate from an aboveground reservoir through the direct push rods and out into the surrounding soil via an injection port on the side of the probe. Simultaneously, sensors record the flow rate, the back pressure required by the pump to maintain that flow rate, and the current depth of the probe. These measurements are collected by the onboard software and an estimated hydraulic conductivity (estimated K) value is calculated and plotted alongside the other measurements in real time.



HOW DOES IT WORK?

The MIP works by heating the soils and groundwater adjacent to the probe to 120 degrees Celsius. This volatilizes the VOCs and allows them to transfer through a Teflon membrane via a combination of concentration and pressure gradients. These VOC are then swept into a nitrogen gas loop that carries them to a series of detectors housed at ground surface. Continuous response profiles are generated from each hole. The electrical conductivity of the soil is also measured, and these logs can be compared to the chemical logs to better understand the relationship between the lithology and the contaminant distribution.

Ready to get results with the MIHPT?
We're ready to help.
Call or email us to get started.

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DEFENSIBLE CHARACTERIZATION

WATERLOO$^{APS™}$

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WHAT IS THE WATERLOO^{APS}?

The Waterloo Advanced Profiling System™ (Waterloo^{APS}) is the premier high resolution site characterization (HRSC) tool for measuring hydrostratigraphic data, while collecting multiple groundwater samples on a single direct push rig advancement. This system has been deployed in a broad array of environments and, while built on a direct push platform, has achieved depths of 600 feet below ground surface using hybrid drive methods. Since the groundwater samples are collected via low-flow sampling procedures and analyzed by a laboratory, the Waterloo^{APS} allows for representative, defensible characterization of most groundwater contaminants.

CAPABILITIES

600' depths

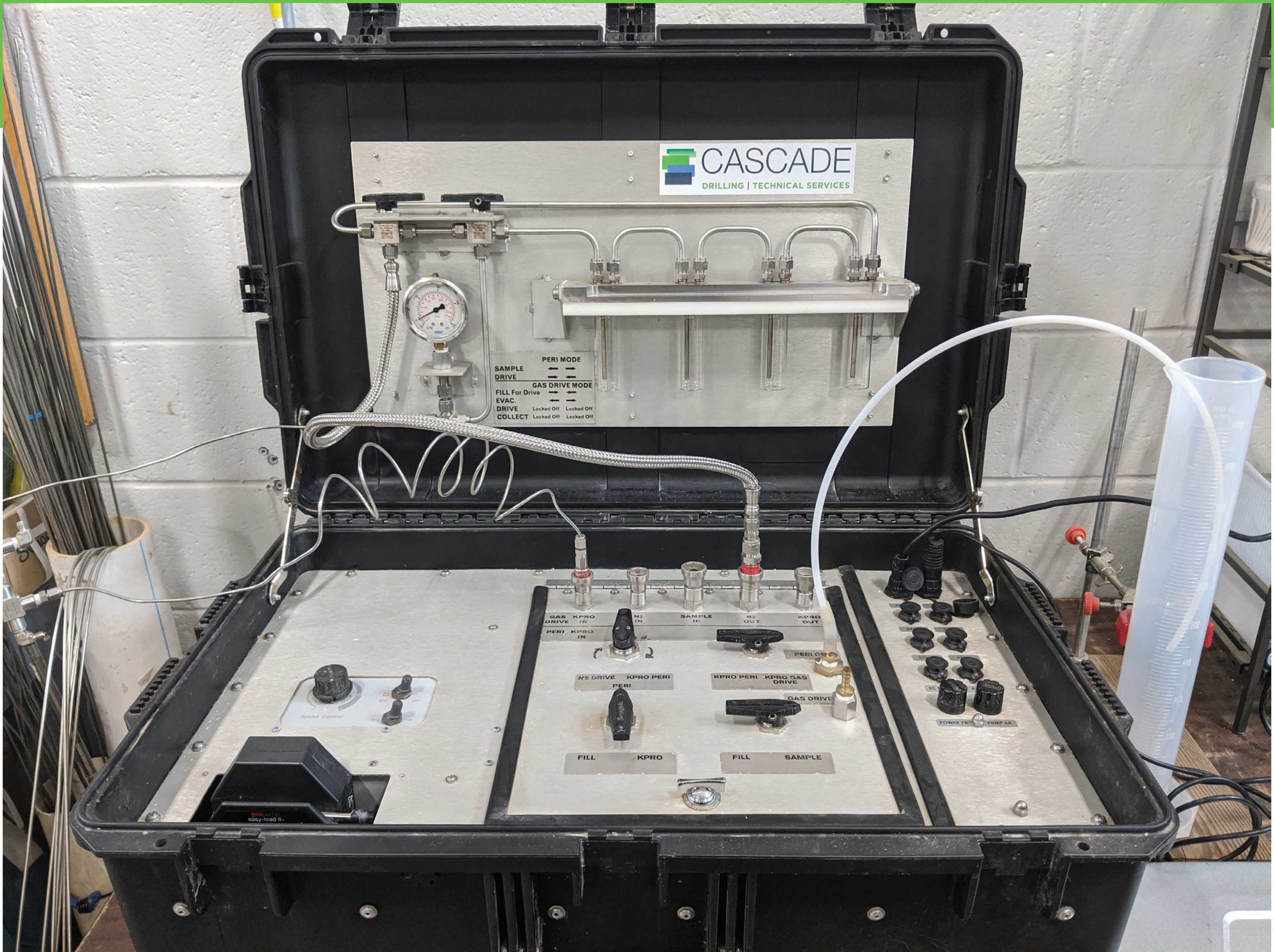
Multiple models for various hydrogeologic conditions

High resolution, discrete sampling

Can be set up in remote, restricted access, & extreme temperature areas

Not restricted by contaminant type; Analyzed for compounds at whatever detection limits are possible

Premier HRSC tool for PFAS and 1,4-dioxane investigations



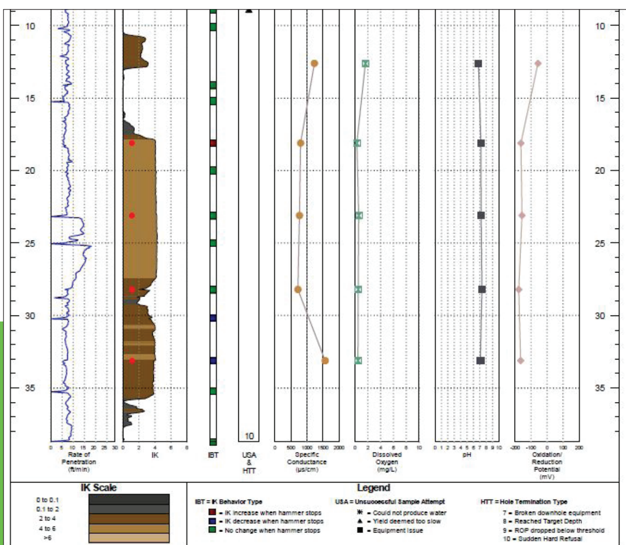
HOW IT WORKS

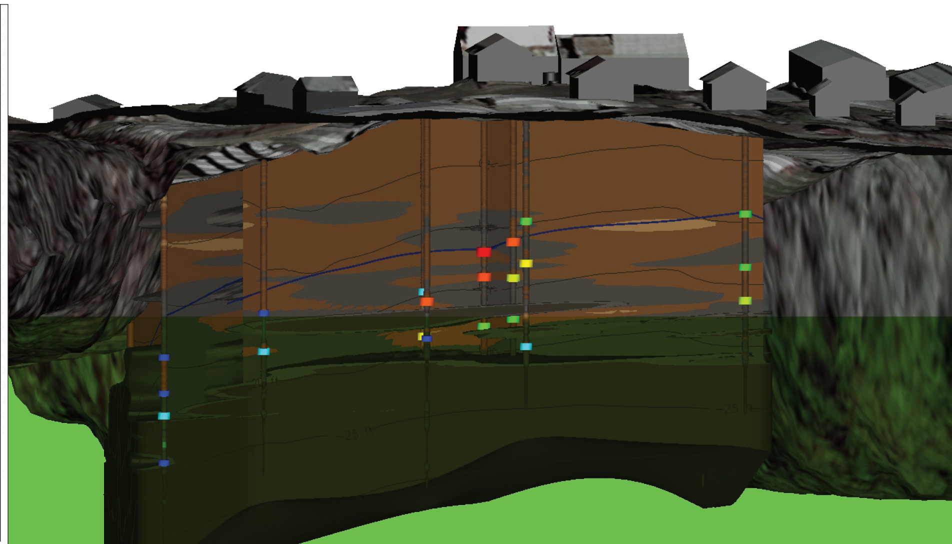
As the tool is advanced, clean water is injected into the formation through the stainless-steel tubing and tip, while depth, pressure, and flow rate are monitored.

From these data, a real-time continuous log of the relative permeability, called the Index of Hydraulic Conductivity (I_K), is calculated and used to determine the best depths for groundwater sample collection. While the I_K log is comparable to the “estimated K” log generated by the HPT tool, the Waterloo^{APS} utilizes a constant pressure with a fluctuating rate of flow. Conversely, the HPT performs this injection logging technique by holding the flow constant and allowing the pressure to increase. In low permeability soils, the Waterloo^{APS} method reduces the amount of water injected into the subsurface and virtually eliminates the potential for the HPT to fracture the formation.

The real-time I_K log is used to identify the exact point at which groundwater should be sampled. At an interval selected for groundwater sampling, the advancement of the Waterloo^{APS} probe is stopped, and flow through the tip is reversed by use of either a peristaltic or gas-drive pump. Water is purged through a flow-through cell and a water quality instrument is used to monitor stabilization criteria following whichever Standard Operating Procedure for low-flow or low-stress sampling is applicable.

These groundwater samples are collected directly from an in-line sampling jig located before the pump and flow-through cell, thus providing an extra measure of quality for VOCs samples, which are never exposed to ambient air. Other types of laboratory sample bottles and glassware can be filled using an adaptor.





Real-time hydrostratigraphic profiling with discrete depth sampling, without withdrawing the tool between samples, allows for efficient high-resolution groundwater investigation. In the example report log on the left, the IK allowed the field technician to identify and sample a sand unit between two clay units that served as a major contaminant transport pathway. On the right is an example of a cross section modeling a Waterloo^{APS} data set.

Ready to get results with the Waterloo^{APS}? We're ready to help.
Call or email us to get started.

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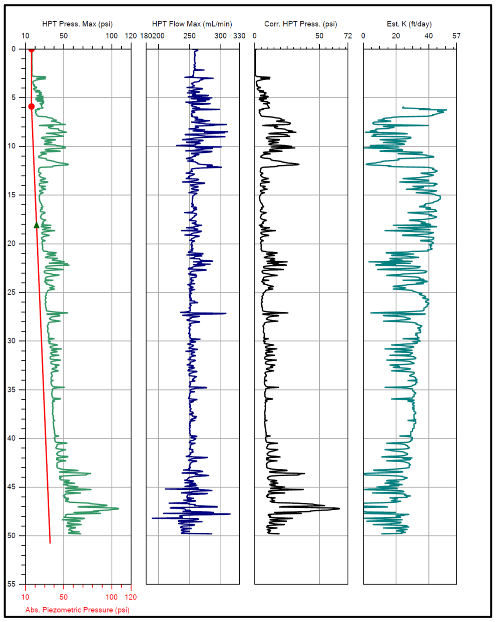
PROJECT HIGHLIGHT

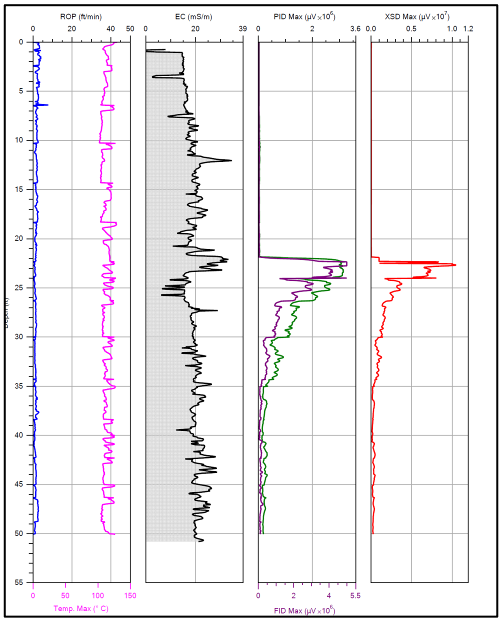
PRE AND POST HRSC OPTIMIZED REMEDIATION

MiHPT Investigation Pre-Remediation

Cascade performed the membrane interface-hydraulic profiling tool (MiHPT) in April 2017 at a chlorinated solvent site in the Northwest.

Example MiHPT Log on the right, showing CVOC mass at 22 feet bgs and associated low EC. HPT pressure and high flow indicating a transmissive target interval.





Injection – Anaerobic Bioremediation: May 2017

Injections were performed by direct push at 15 locations where approximately 13,500 gallons of bio substrate diluted with anaerobic water. Bioaugmentation also occurred with KB1 at each location. Each locations target interval was defined by the MiHPT detector responses.

					% Solution				
Day	Date	On-site Time	Off-site Time	Wells Completed	EVO (Gallons)	Anoxic Water (Gallons)	KB1 (Liters)	Flush Water Injected (Gallons)	Total Injected (Gallons)
Monday	5/15/2017	7:30 AM	5:45 PM	0.0	138.0	1,862.0	0.8	0.0	2,000.0
Tuesday	5/16/2017	7:15 AM	7:00 PM	4.0	339.0	3,516.0	2.1	0.0	3,855.0
Wednesday	5/17/2017	7:00 AM	6:15 PM	5.0	525.0	2,975.0	2.5	0.0	3,500.0
Thursday	5/18/2017	7:00 AM	6:00 PM	3.0	465.0	2,635.0	2.0	0.0	3,100.0
Friday	5/19/2017	7:00 AM	3:30 PM	3.0	135.0	865.0	0.5	75.0	1,075.0

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HRSC Optimization Post Remediation: June 2017

Based on remediation results, CVOC reductions in monitoring wells, it was decided to get a better understanding of the MiHPT Data, injection performance in terms of total volumes injected and associated pressures and flow rates, monitoring well screens and monitoring well results. With this additional analysis, optimization of future remediation events could be accomplished. Below are a few of the 3D models created to troubleshoot overall remediation design and performance to optimize follow up injection events. Based on this data review and modelling it was determined that:

1. Injection target intervals identified by MiHPT were consistent with monitoring well screened intervals.
2. Injection flows and pressures designed by MiHPT results generally demonstrated that distribution occurred below fracture pressures to provide optimal contact. For future injection events the digital logging of pressures and flows will make it easier to model the actual injection data and not rely on manually prepared injection logs.
3. Future remediation events will focus more on design volumes to achieve ROI and impact compliance monitoring wells based on soil type and groundwater seepage velocity
4. Alternative injection approaches to provide contact underneath and adjacent to the building source zone will be developed.

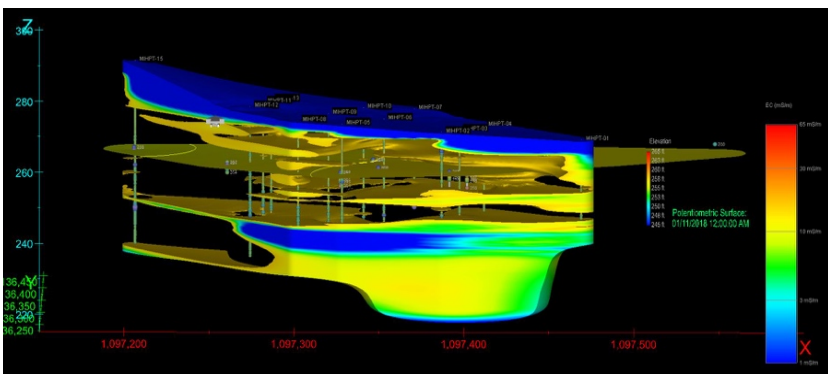

Figure 1 – EC versus Groundwater Surface

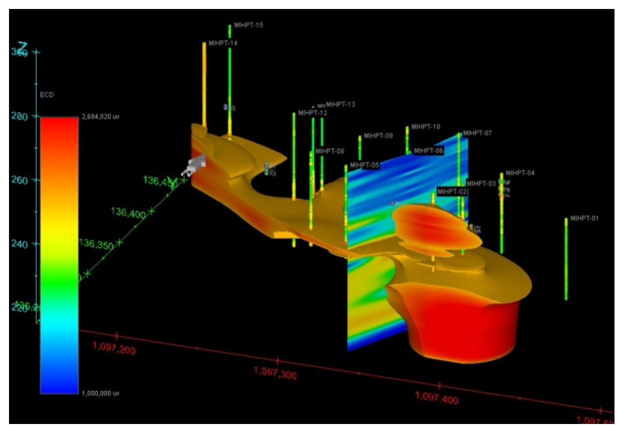

Figure 2 – EDC Responses Above 1 x 10+^ uvolts

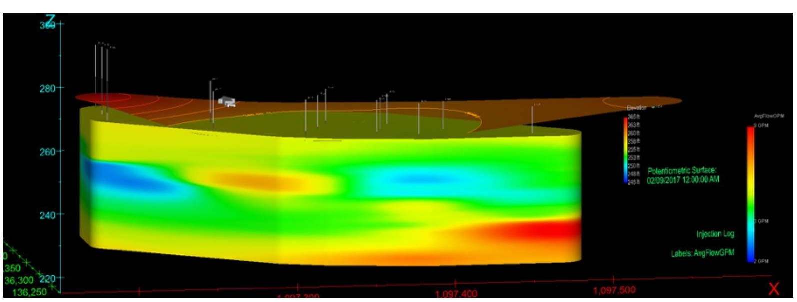

Figure 3 – Injection Flow Rates

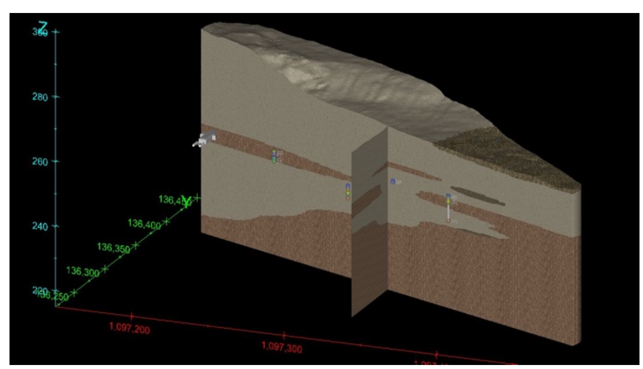

Figure 4 – Simple Geology