High-Resolution Site Characterization and the Development of a Better Conceptual Site Model: A NAPL Release Site Case Study

SCG
REMEDIATION SERVICES
A Subsidiary of NELSON Environmental Group

Remediation Technologies Symposium

RemTech

Banff, AB
October 16-18, 2024

The STORY

In the early 1990s, the remediation industry in Canada took off mostly with US-imported technologies.

As a result, SCG Remediation was founded in 1993 seeing an opportunity to provide Canadian remediation services, led by Canadian-made technologies and local expertise, and has remained competitive, bringing the most innovative solutions to the industry through the years.

Today, SCG has consolidated as a preferred in-situ soil and groundwater remediation player, and water treatment equipment and systems manufacturer through its strength in design and ability to leverage practical and technical understanding of technology applications. This experience enabled SCG to help its clients by customizing systems designed to meet the most demanding project requirements.

In 2018, SCG became part of the NELSON Environmental Group.

30 Years of Technology Manufacturing and Design

By acting as both the manufacturer and the operator, SCG Remediation has a unique perspective on site characterization, remedial action planning, system design, operation, and application. The technologies used and manufactured by SCG are user-friendly and remediation programs are tailored to the site-specific goals of our clients.

Remedial Options Assessment and Evaluation Services

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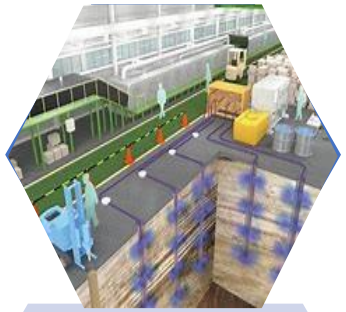
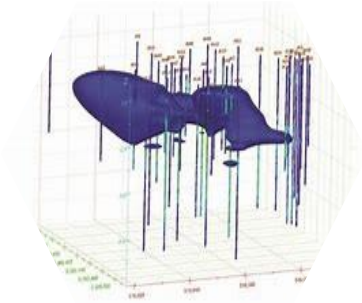
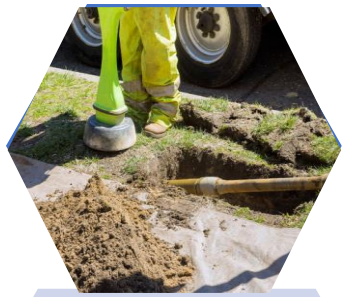


In-Situ Injection Services



High-Resolution Site Characterization Services

In-Situ Water Treatment Systems Design and Manufacturing Services

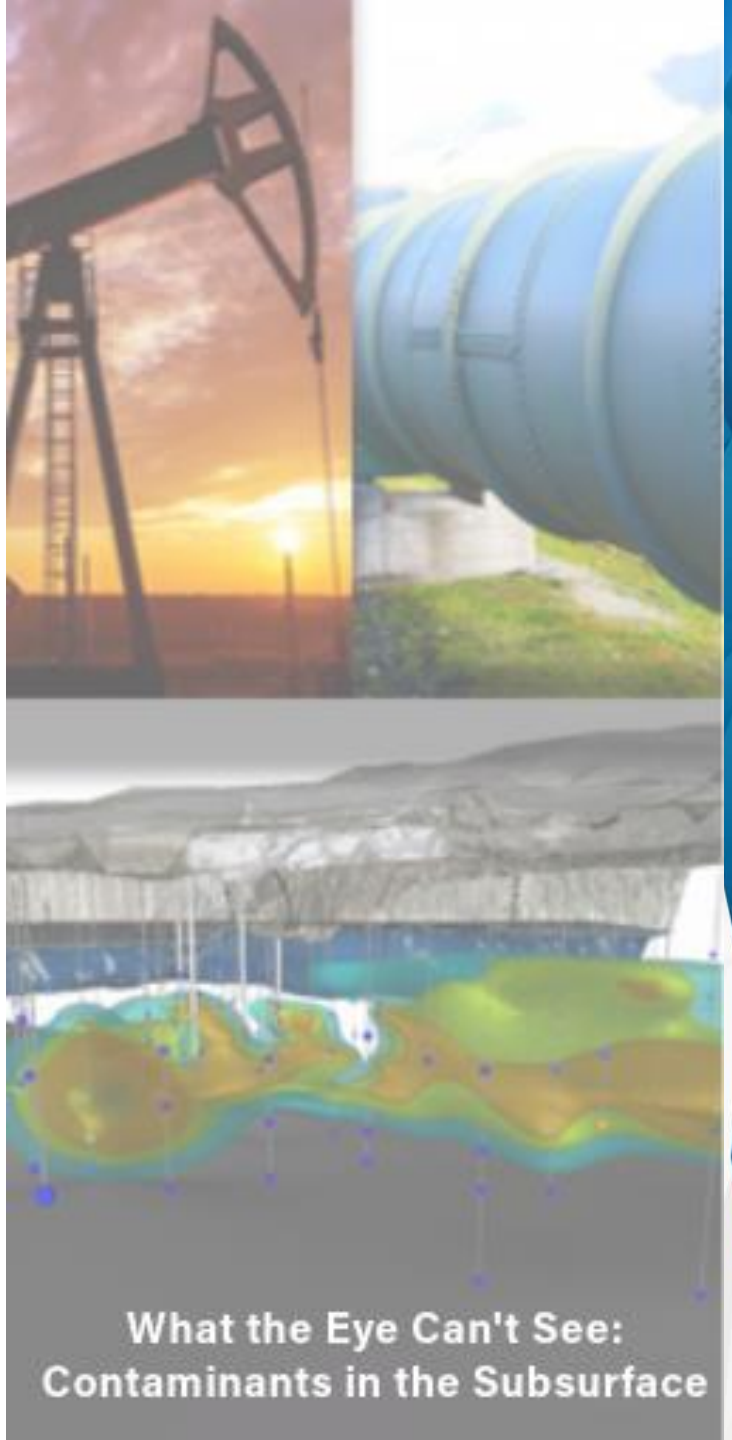


In-Situ Soil Remediation Services

Discussion POINTS

Discussion Points

1. What are Conceptual Site Models (CSM)
2. What is High-Resolution Site Characterization (HRSC)
3. HRSC Technologies (UVOST)
4. HRSC and CSM Integration
5. Case Studies (2 sites)



Conceptual Site MODELS (CSM)

Conceptual Site Models (CSMs)

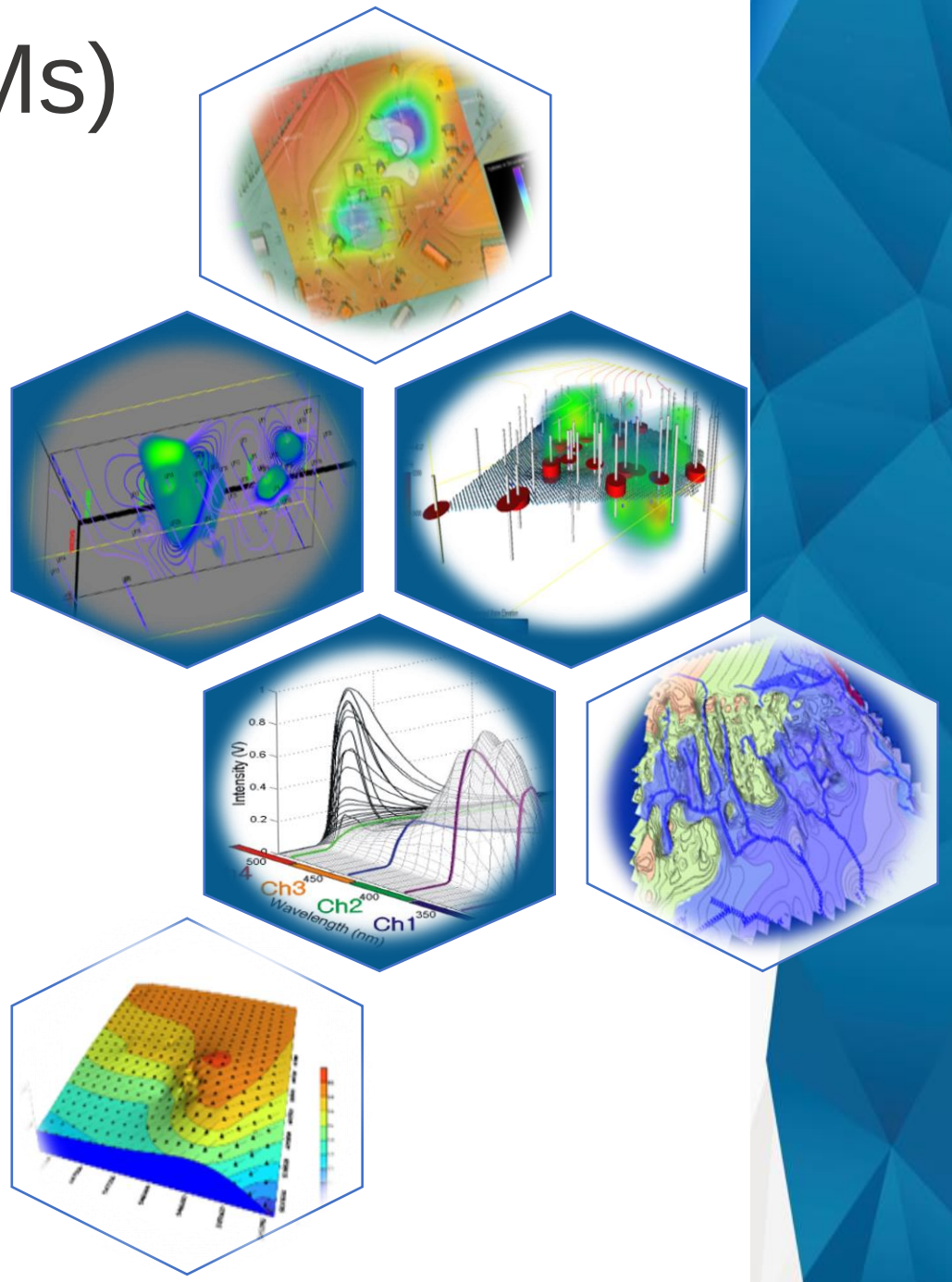
Conceptual Site Models (CSMs) are simplified representations of a contaminated site's geology, hydrogeology, and contaminant distribution.

Why Are CSMs Important?

- CSMs provide a structured framework for understanding and addressing contamination issues.
- They serve as a foundation for effective site assessment, risk assessment/risk management, and remediation.

Key Components of a CSM:

- Site Geology:
  - Description of subsurface geology and lithology.
  - Identification of potential migration pathways.
- Hydrogeology:
  - Aquifer characteristics, including hydraulic conductivity and flow direction.
  - Assessment of water table fluctuations and groundwater gradients.
- Contaminant Distribution:
  - Mapping and modelling of contaminant plumes.
  - Identification of source zones.

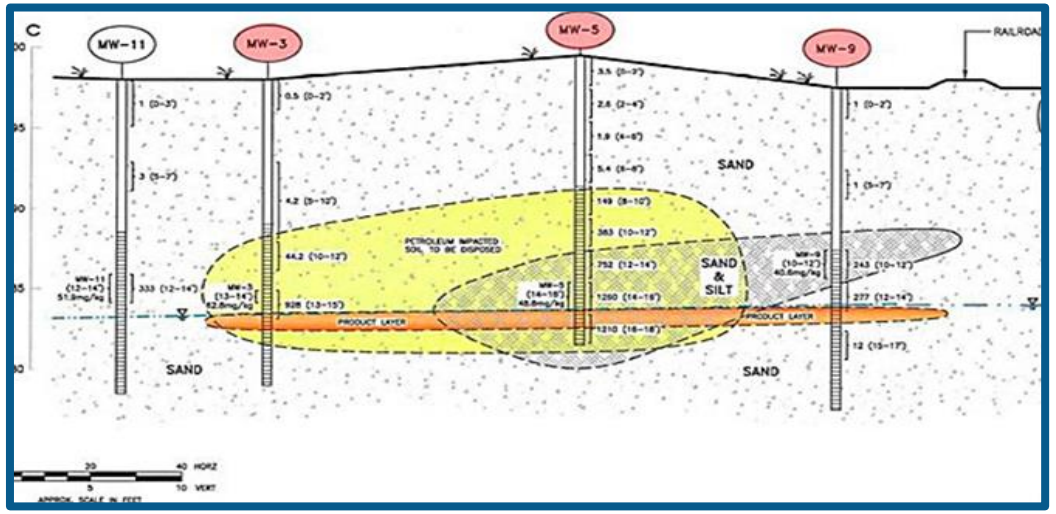


LNAPL Sites - Misconceptual Site Models

CSMs derived for NAPL-contaminated sites are often oversimplified and inaccurate.

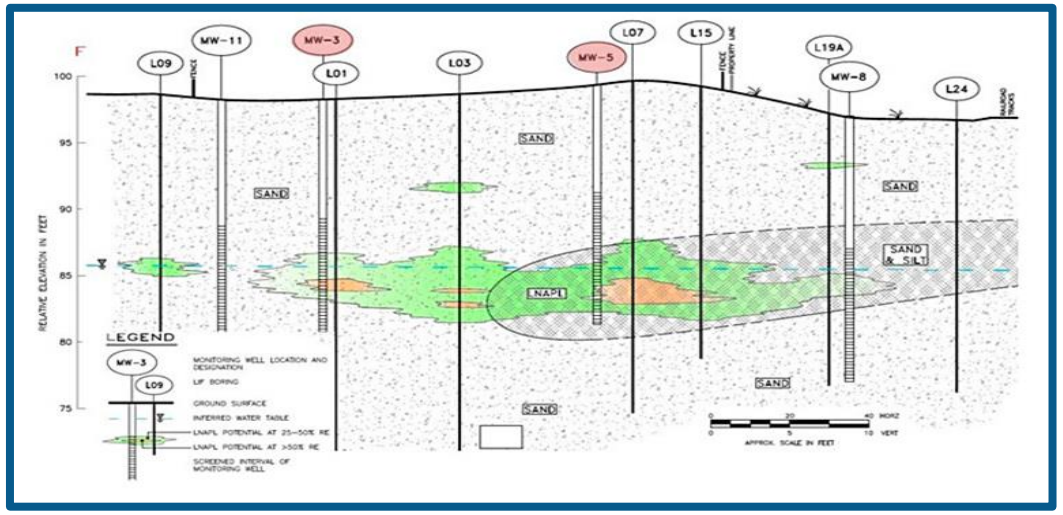
Possible sources of error from borehole data:

- Inaccurate borehole logs (perhaps not as detailed as they could be)
- Sediment samples collected, but are they representative of site conditions?
- Innate heterogeneity of sediment can lead to abnormal NAPL distributions (not always easy to predict with limited data)



Possible sources of error from wells:

- Is the well screened in the correct zone?
- Do fluctuations in the water table affect your contaminants distribution (i.e dry vs wet season)?

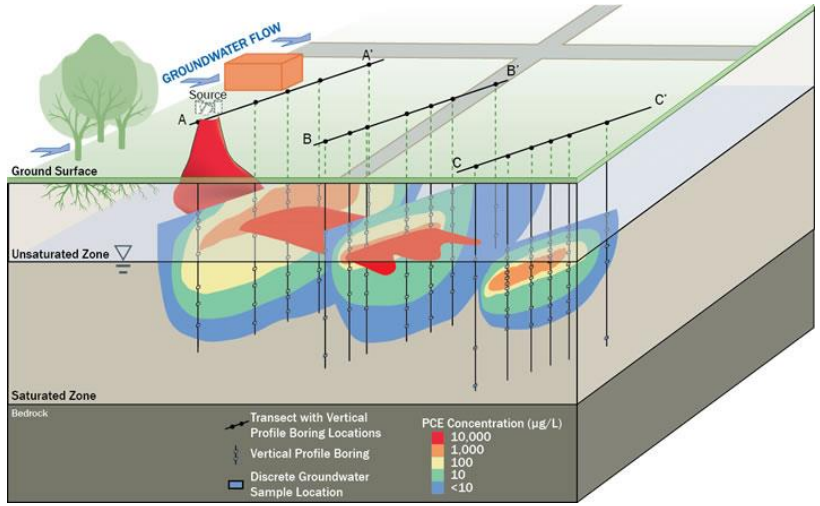


ITRC LNAPL-3, 2018

How do we develop a well defined CSM?

Combine, Render, Visualize, and evaluate in a lifecycle.

CSMs are living visualizations and should be refined and scrutinized as we obtain more data.



USEPA 2020

Geology

- EC logs
- BH locations, depths of samples
- Lithology

Hydrogeology

MW locations, depths and screen intervals
Water level measurements

- Seasonal data for water table fluctuation
- Hydro stratigraphy
- Hydraulic Conductivities/Transmissivities

Contaminant Distributions

- UVOST logs and 3D visualizations
- Soil contaminant concentrations
- Groundwater contaminant concentrations
- LNAPL measurements

GIS

- LiDAR
- DEMs
- Sat Imagery
- Utilities
- Land Use

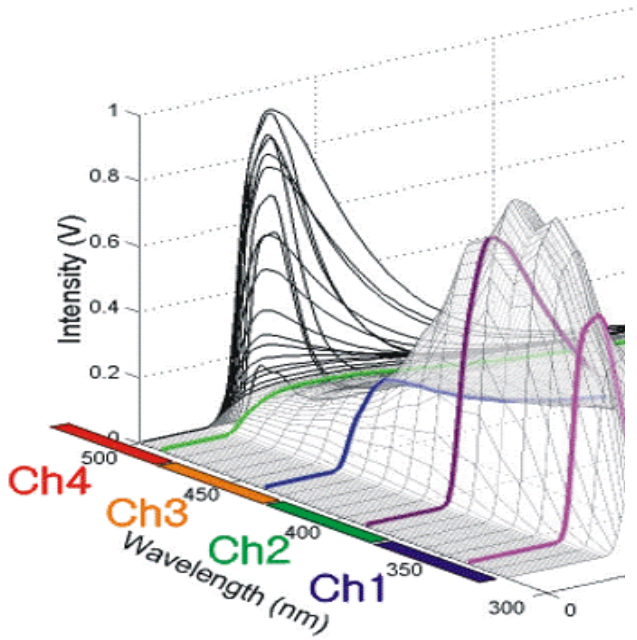
Data **Management**

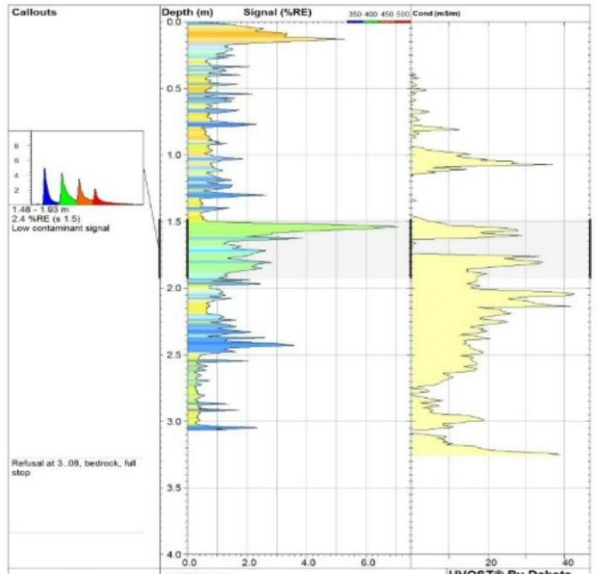
- Geospatial data standard
- QA/QC
- XYZ Data filtering, noise reduction
  - Removal of high-intensity mineral fluorescence,
  - intensity cut-off values, channel-specific filtering
  - Averaging fluorescence over a range
  - Removal of surface noise from organics or asphalt etc.
  - Colour filtering

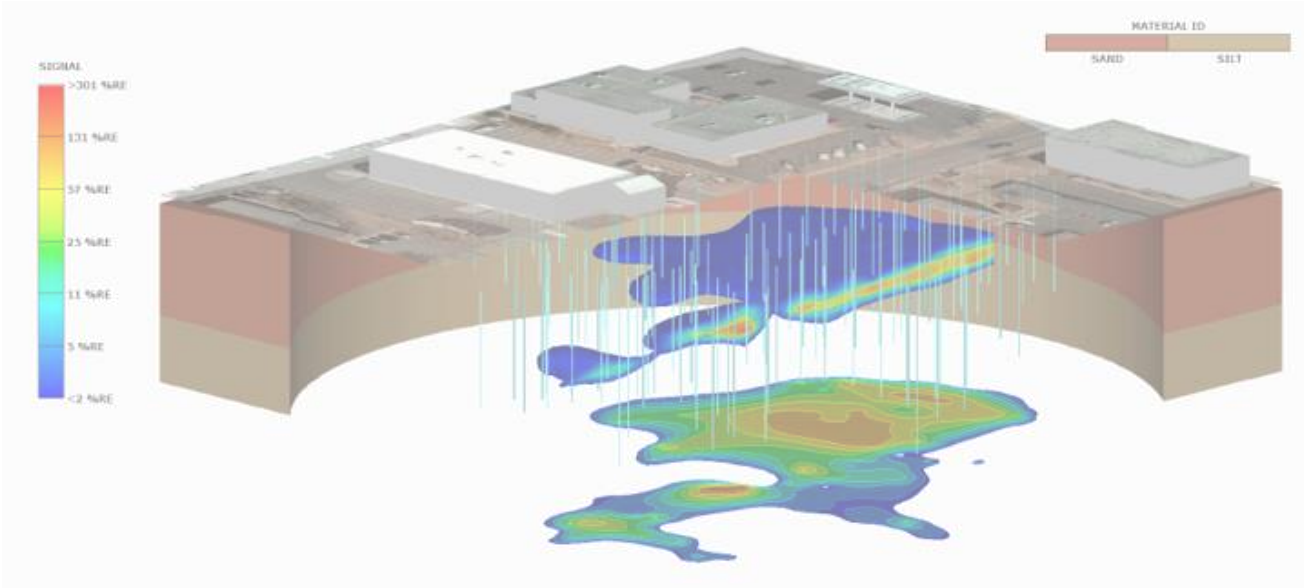
What is High Resolution SITE CHARACTERIZATION (HRSC)

High-Resolution Site Characterization (HRSC) Definition:

“Strategies and techniques that use scale-appropriate measurements and sample density to define contaminants distributions, and the physical context in which those reside, with greater certainty, supporting a faster and more effective site cleanup”.







HRSC Technologies

SCG Remediation Services HRSC Technologies

In-situ Direct-Push Technologies are versatile, relatively low-cost, and mobile.

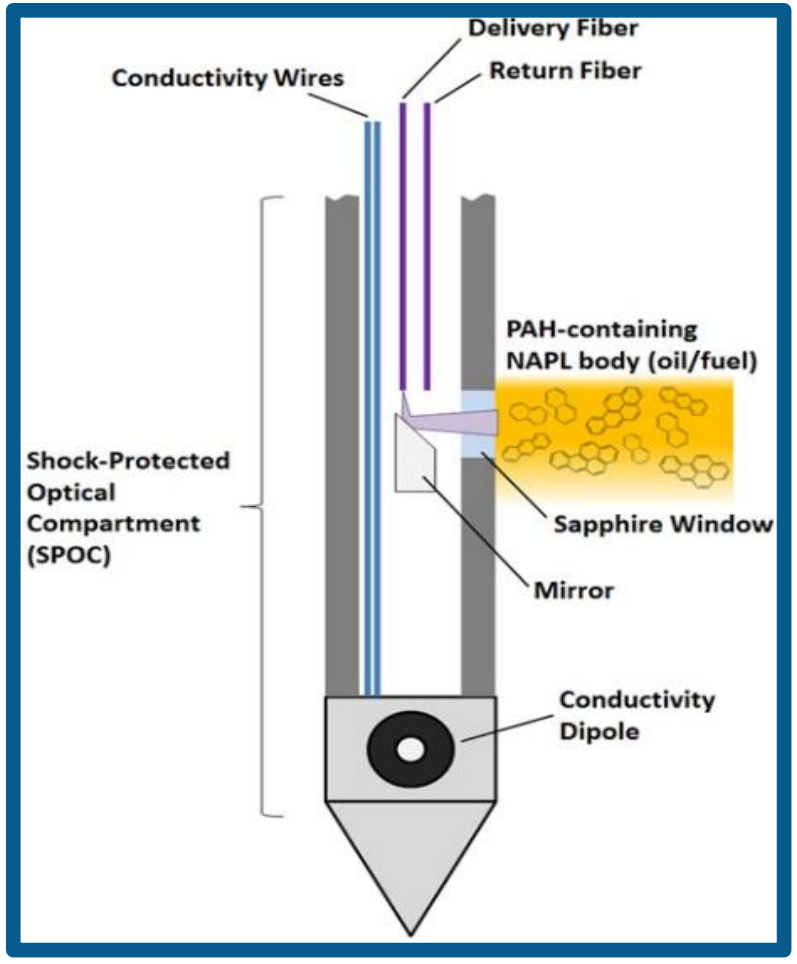
SCG's available technologies use a combination of:

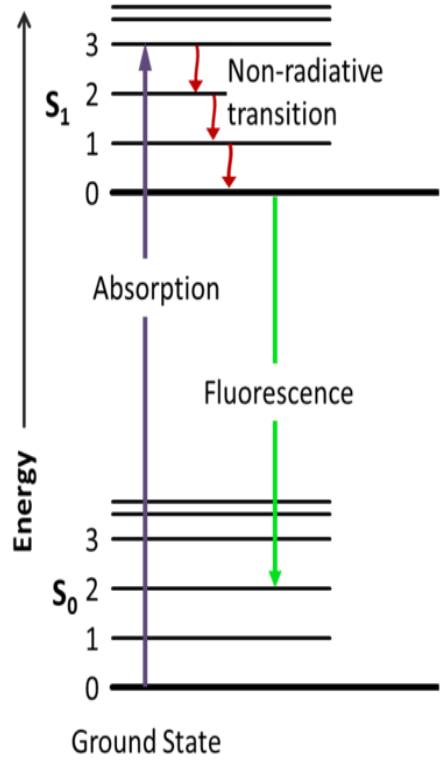
- **UVOST:** Ultraviolet Optical Screening Tool: Imaging tool used to delineate residual free phase petroleum contamination in soil through laser-induced fluorescence (LIF).
- **EC:** Electric Conductivity: Measures Soil Electrical Conductivity.
- **MIP:** Membrane Interface Probe: Delineates soils and groundwater contamination, especially organic compounds (VOCs) in both free and dissolved phases.
- **HPT:** Hydraulic Profiling Tool: A logging tool which measures the pressure required to inject a set flow of water into soil as a probe is advanced through soil. The measurement of both injection pressure and flow is an indicator of a formations permeability and can be used to determine contaminant migration pathways, inform monitoring well screen placement, and guide remedial planning.

Ultraviolet Optical Screening Tool (UVOST)

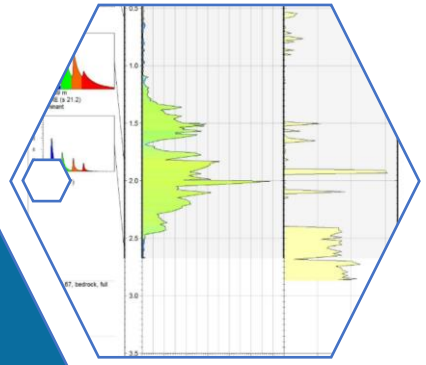
In-situ Direct-Push Technology: Versatile, Relatively Low-cost, and Mobile.

UVOST: Imaging tool used to delineate residual free phase petroleum contamination in soil through laser-induced fluorescence (LIF)

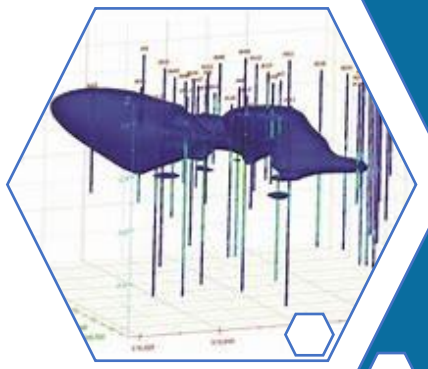




UVOST
Ultra-Violet Optical Screening



Real Time Information



Above and Below Saturated Zone

3D Modelling

Delineates petroleum, oil, and lubricant (POL) contaminants in the subsurface via the fluorescence response of their polycyclic aromatic hydrocarbon (PAH) constituents: gasoline, diesel fuel, jet fuel, and hydraulic fluids. The fluorescence signal scales proportionally with NAPL concentration.

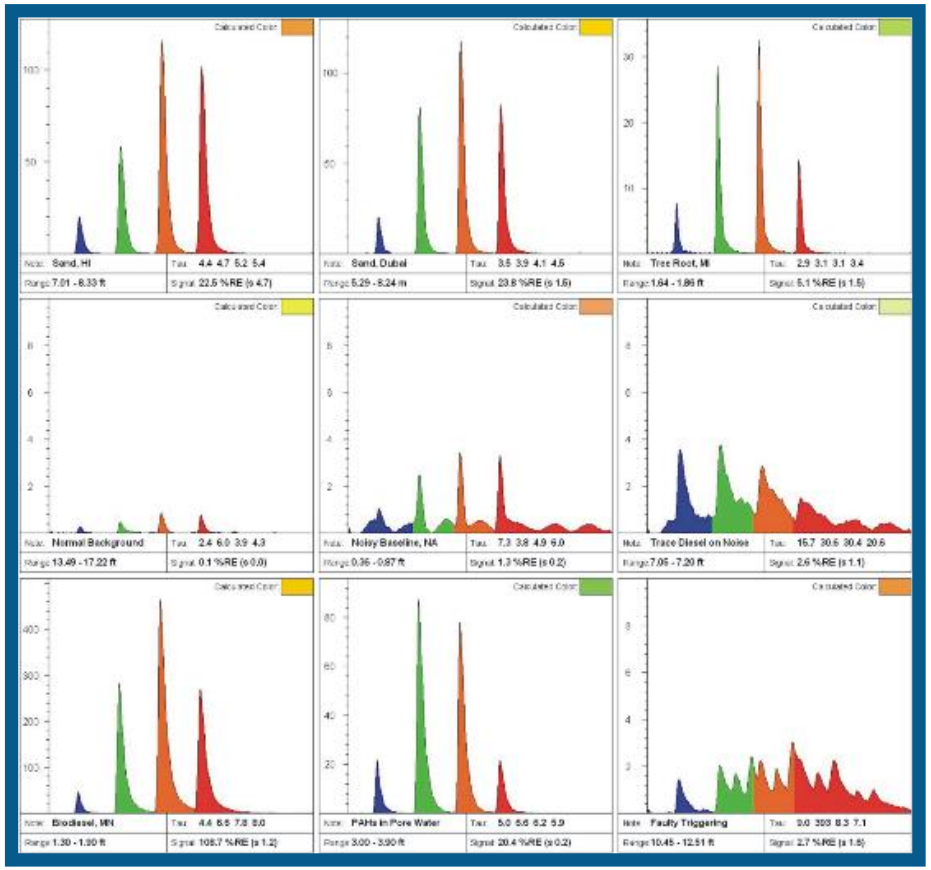
UVOST's LIF technique, in conjunction with direct push deployment and survey data, can provide a detailed three-dimensional model of NAPL distribution.

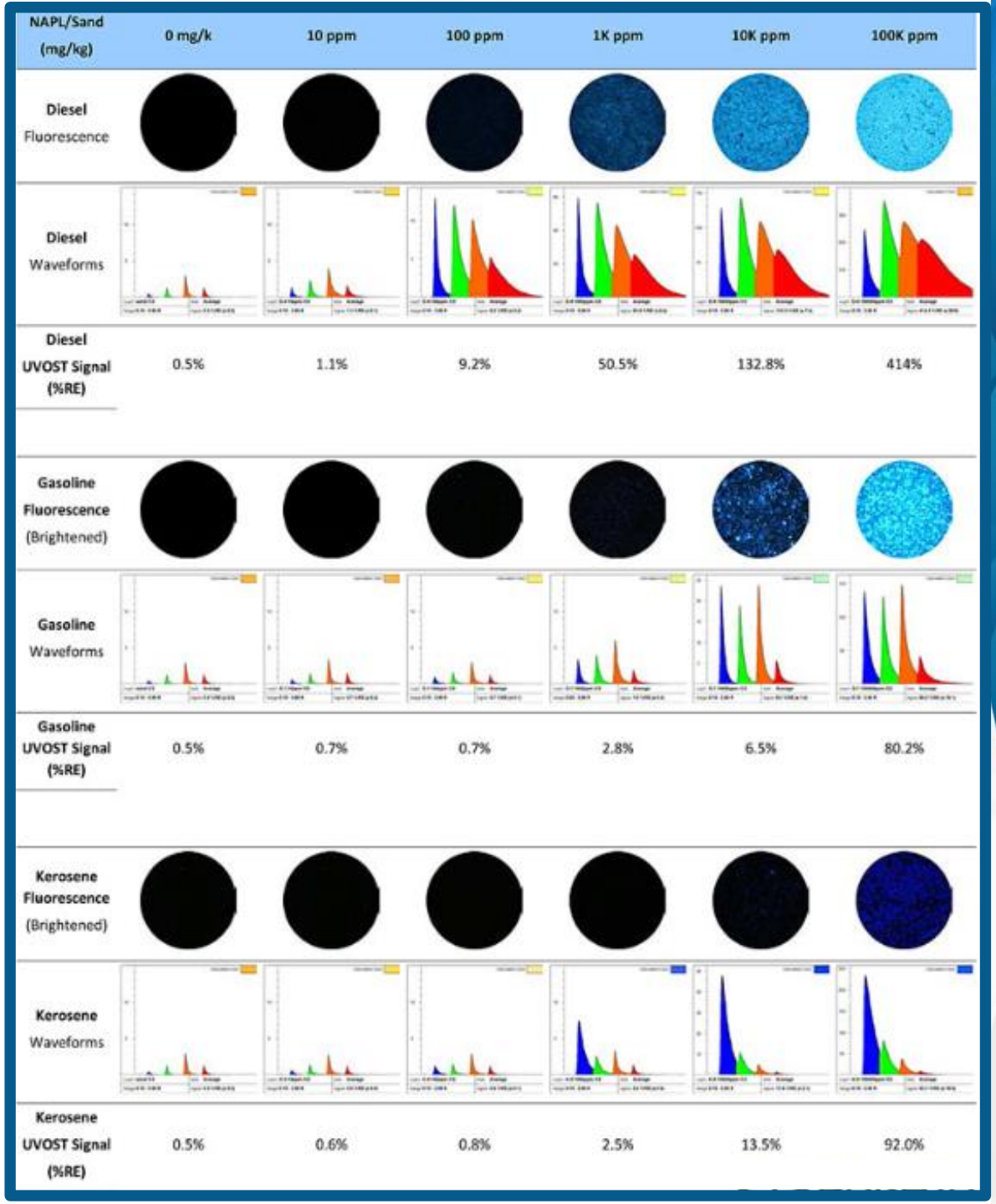
NOTE: UVOST cannot be used to detect NAPLs such as tars, bunkers, etc.

UVOST Benefits

- Typical detection limit of >10-500 ppm (NAPL type and soil dependent).
- Operates effectively above and below the saturated zone.
- Probe advancement at roughly 0.8 in/sec (2 cm/sec) without pause.
- One-inch data density coupled with nearly instantaneous response provides a continuous detailed log of product distribution and heterogeneity.
- Color-coded logs for the **qualitative** assessment of contaminant plumes.
- Waveforms offer product identification/verification and rejection of non-contaminant fluorescence such as mineral, peat, and other false positive results.
- Electrical conductivity dipole is integrated into the UVOST probe to provide additional information on ionic plumes and can be used to interpret sediment distributions of unconsolidated deposits.

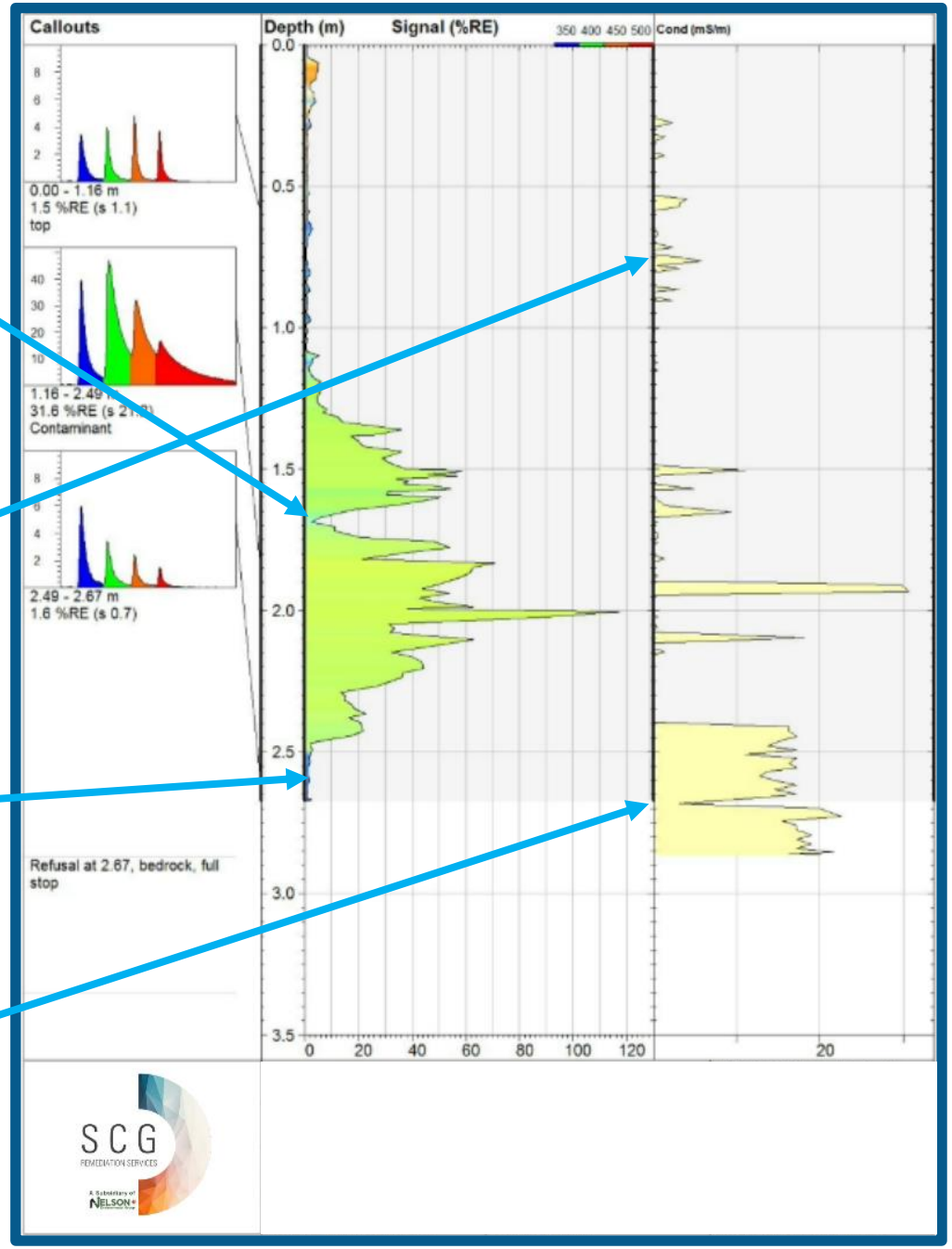
UVOST Limitations





UVOST Log Sample

- Contaminant detected between 1-2.5 mbgs.
- EC was noted to be low in this zone, possibly indicating coarser-grained material with interbedded clay layers.
- At the site, refusal was hit at 2.67 mbgs at bedrock.
- Contaminants likely present within fractured bedrock.

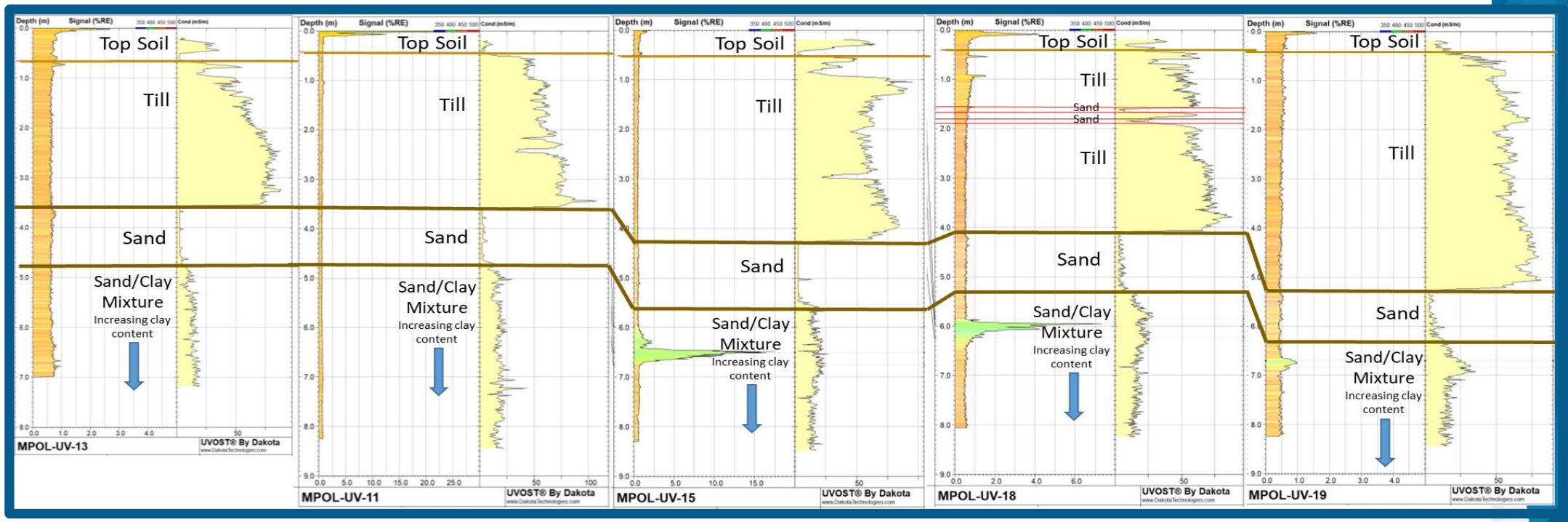


HRSC to CSM Integration

Data **Interpretation and Visualization**

XYZ structure of UVOST and EC log data lends itself to 3D visualization and spatial rendering.

- Many visualization software that will take you from 2D to 3D.
  - C Tech - Earth Volumetric Studio
  - Surfer/Voxler
  - ArcGIS / ArcScene



Case STUDY 1

Heating Oil Spill at Former School

Setting: 45,000L underground heating oil tanks were removed in the early 1990s and replaced with natural gas.

Leak identified during removal, suspected contamination.

Previous Studies:

- **1999** Phase II ESA:
  - 5 BHs (max 6m depth)
  - Delineation not achieved

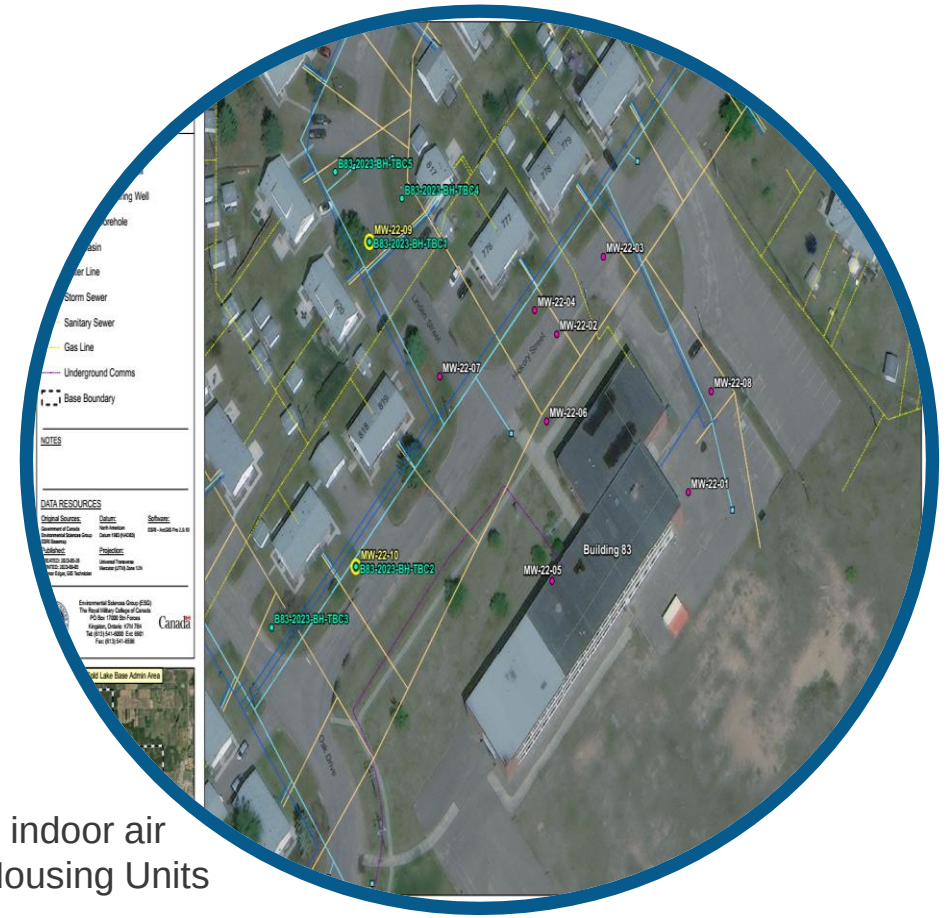
- **2017** Updated Phase II ESA :
  - 6 BHs
  - 1 GW well installed and sampled (Gen chem, PAH, PHC, VOC, IE)

    - ➢ Delineation not achieved
    - ➢ Impacted soil between 3-5 mbgs
    - ➢ **TPH – 17100 mg/kg**

OBJECTIVE

Phase III ESA (FCSAP Step 7) - 2020-2023

- Delineate NAPL body UVOST
- Update/supplement Soil (BHs) and Groundwater (MWs) data
- Assess transport in Utility Corridors
- Update NCSCS



FY 20/21

- 15 UVOST-EC borings
- 4 BH/MWs

FY 21/22

- 10 UVOST-EC borings
- 5 BHs
- 4 MWs
- Soil vapour sampling and indoor air sampling of Residential Housing Units (3rd Party)

FY 22/23

- 2 MW installed
- GW monitoring of well network
- Indoor Air and sub-slab sampling at B-83 Gymnasium
- Additional data collected included a self-logging pressure transducer for time series WLs and snapshot annual WLs from the well network.

Data Interpretation

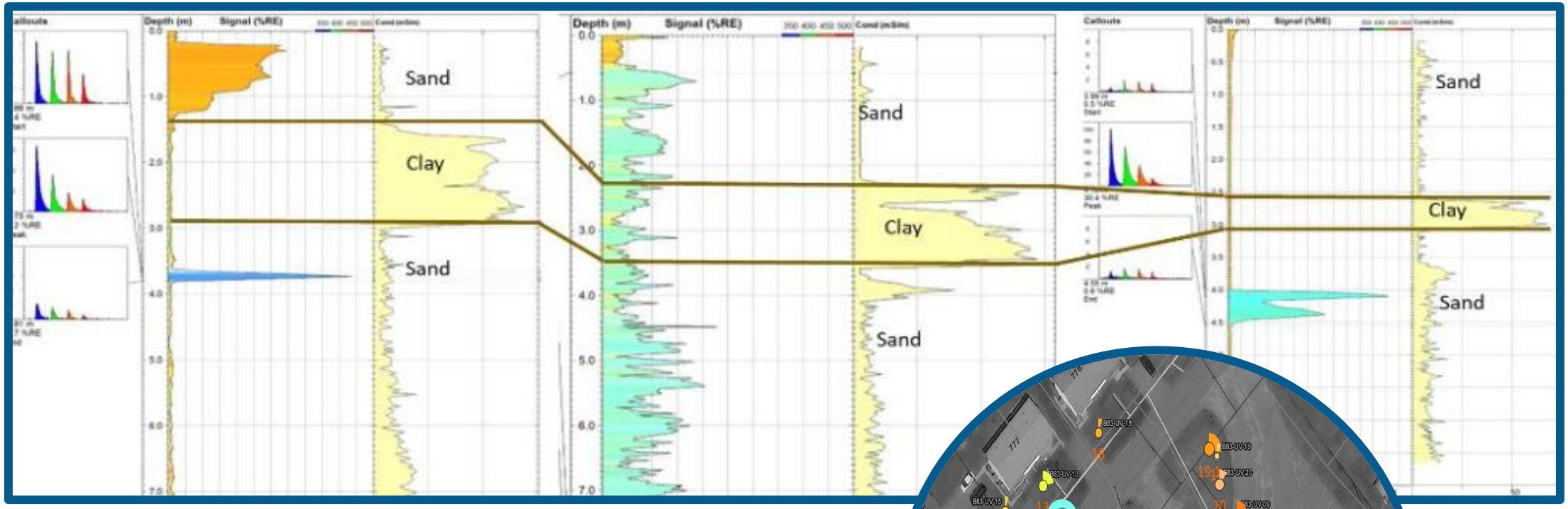
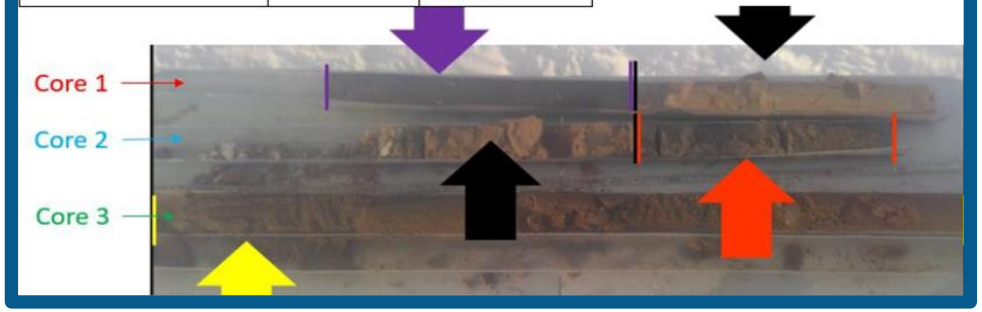
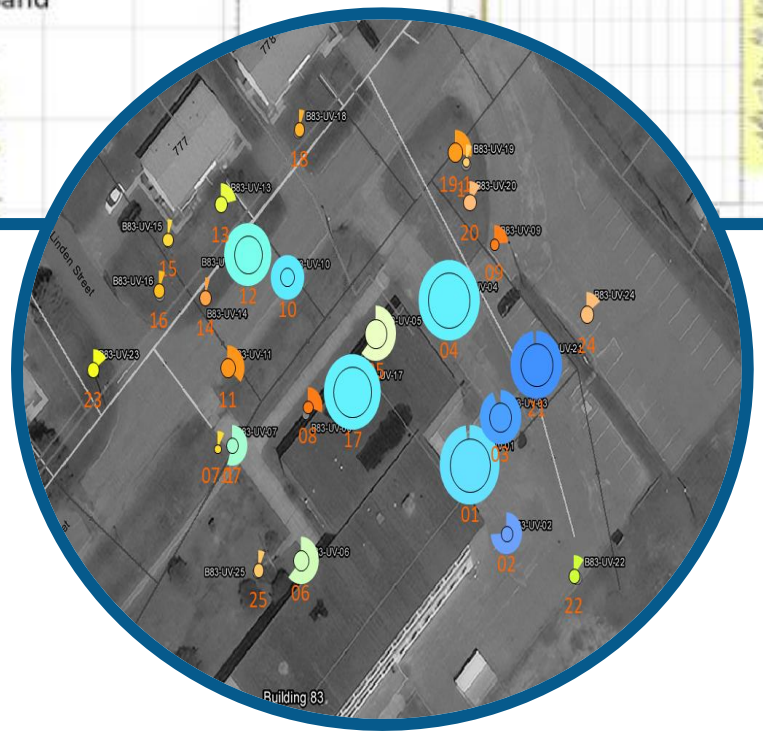


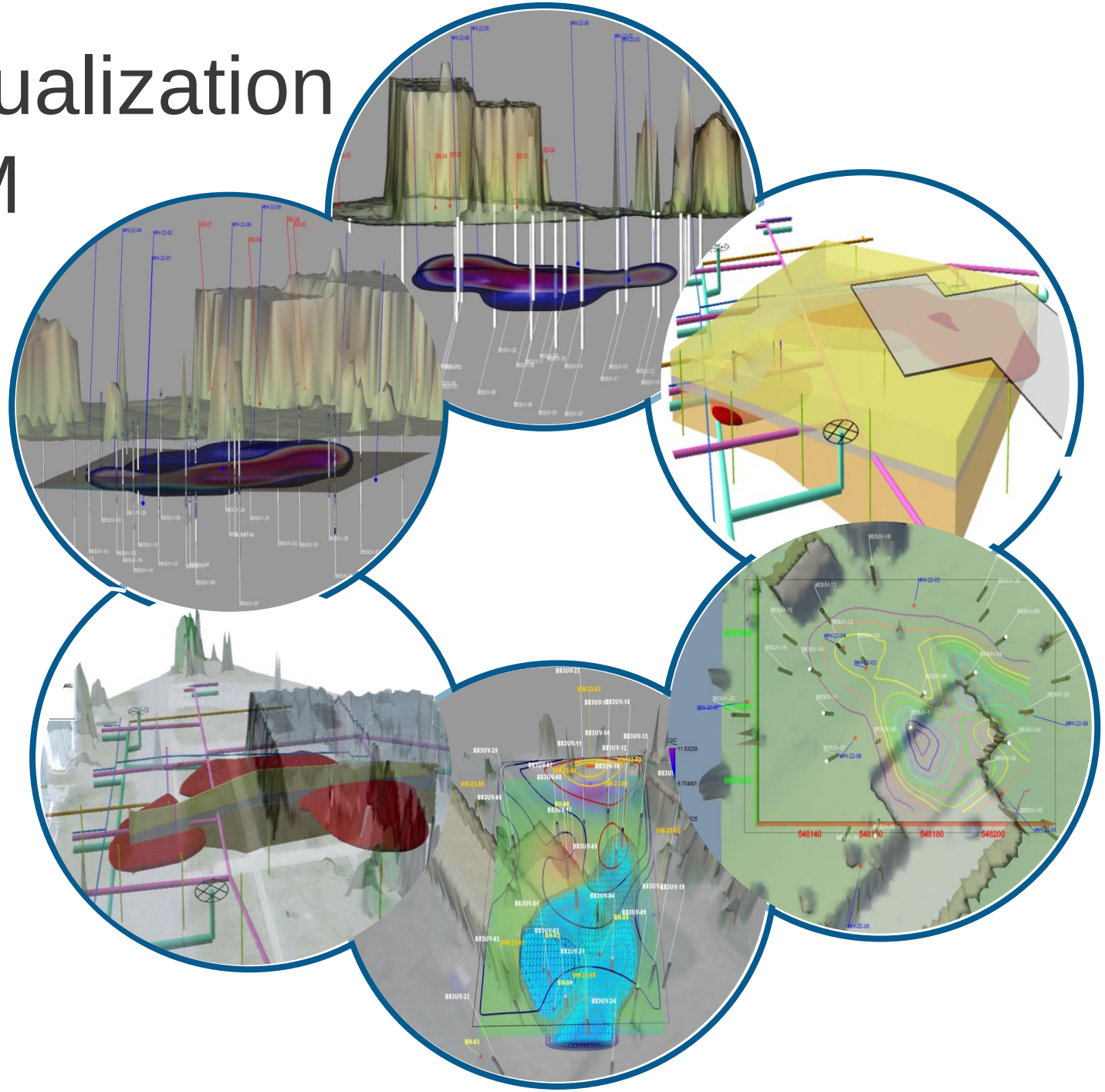
Table 8: Soil stratigraphy summary for Building 83 based upon boreholes advanced in fall 2022

Soil Description	Depth below ground surface (mbgs)	
	Top of Layer	Bottom of Layer
Organic loam	0	0.3
Sandy clay, yellow orange	0.3	0.5 - 1.5
Sand, poorly graded	0.5 – 1.5	2.2 – 3.1
Clay or sandy clay	2.2 – 3.1	3.0 – 3.5
Sand, fine to medium coarse grained	3.0 – 3.5	6.0 – 7.0 (borehole completion)





Data Visualization and CSM



Case STUDY 2

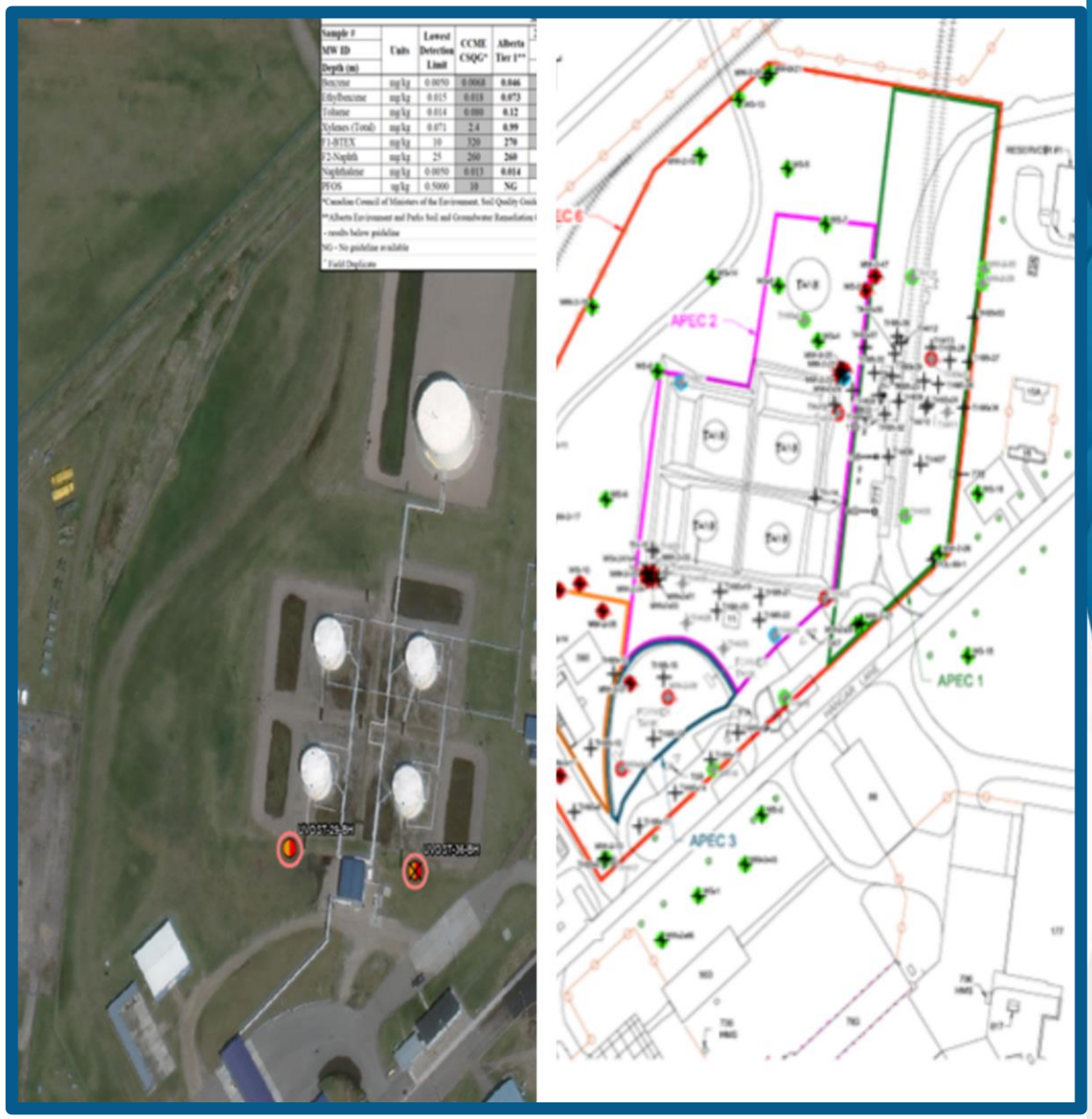
Bulk Storage POL Facility

Previous Studies:

- 18 reports from 1993 to 2011.
- Data Gap Analysis in 2011.
- In total: 81 BH and 46 monitoring wells have been installed.
- Last monitoring event 2010.
- **Need to delineate NAPL bodies identified.**
- **Recommendation of 31 BH to achieve delineation from Gap Analysis.**

POL and fuel distribution compound: 33,400 L of JP-4 fuel was reportedly released between 1989 and 1995; approximately 9,330 L was not recovered.

Additional legacy sources at the site.



Site is in Long Term Monitoring Stage of FCSAP (Step 10) Objectives:

- Delineate NAPL and site lithology using UVOST-EC.
- Update/supplement soil (BHs) and Groundwater (MWs) data.
- Trend analysis and refinement of LTM based on new information and long-term data.

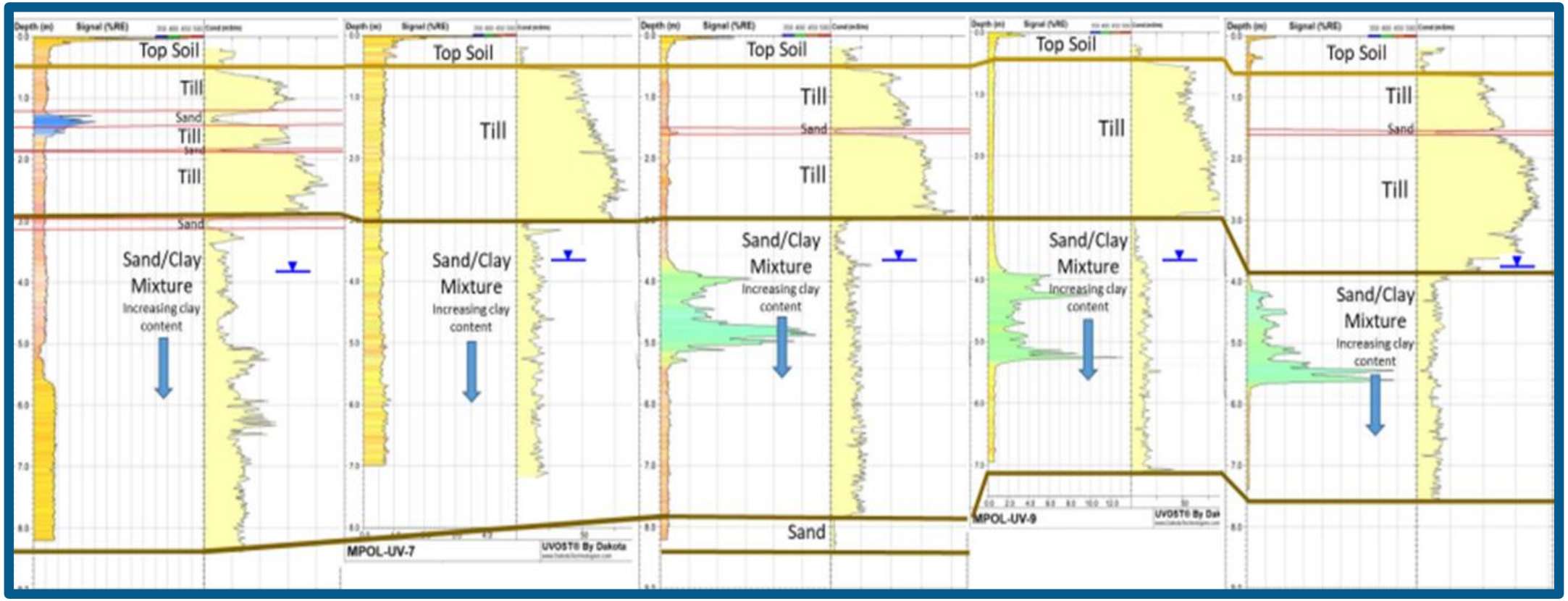
FY 21/22

- 21 UVOST-EC borings with advanced waveform analysis.
- 8 BH - 4 associated with sentinel wells and 4 UVOST verification.
- 4 MWs – Sentinel wells.
- GW monitoring of well network for VOCs, PHCs, PAHs, PFAS.
- Water level measurements and long-term pressure.

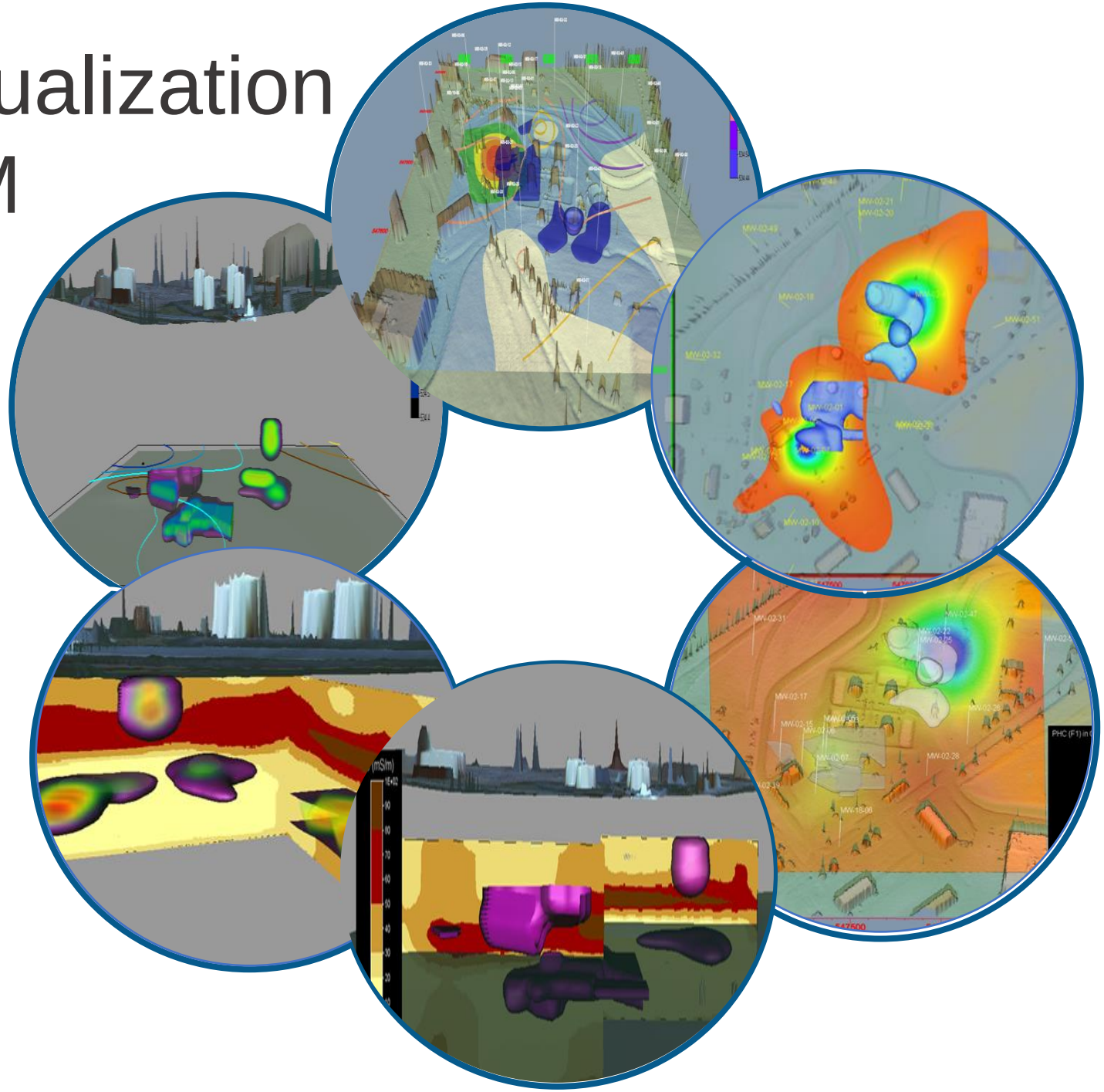
FY 20/21

- 28 UVOST-EC borings with advanced waveform analysis.
- GW monitoring of well network for VOCs, PHCs, PAHs.
- Water level measurements – snapshot and long-term (pressure transducers).

Data Interpretation and Visualization



Data Visualization and CSM



Key TAKEAWAYS

Key Takeaways

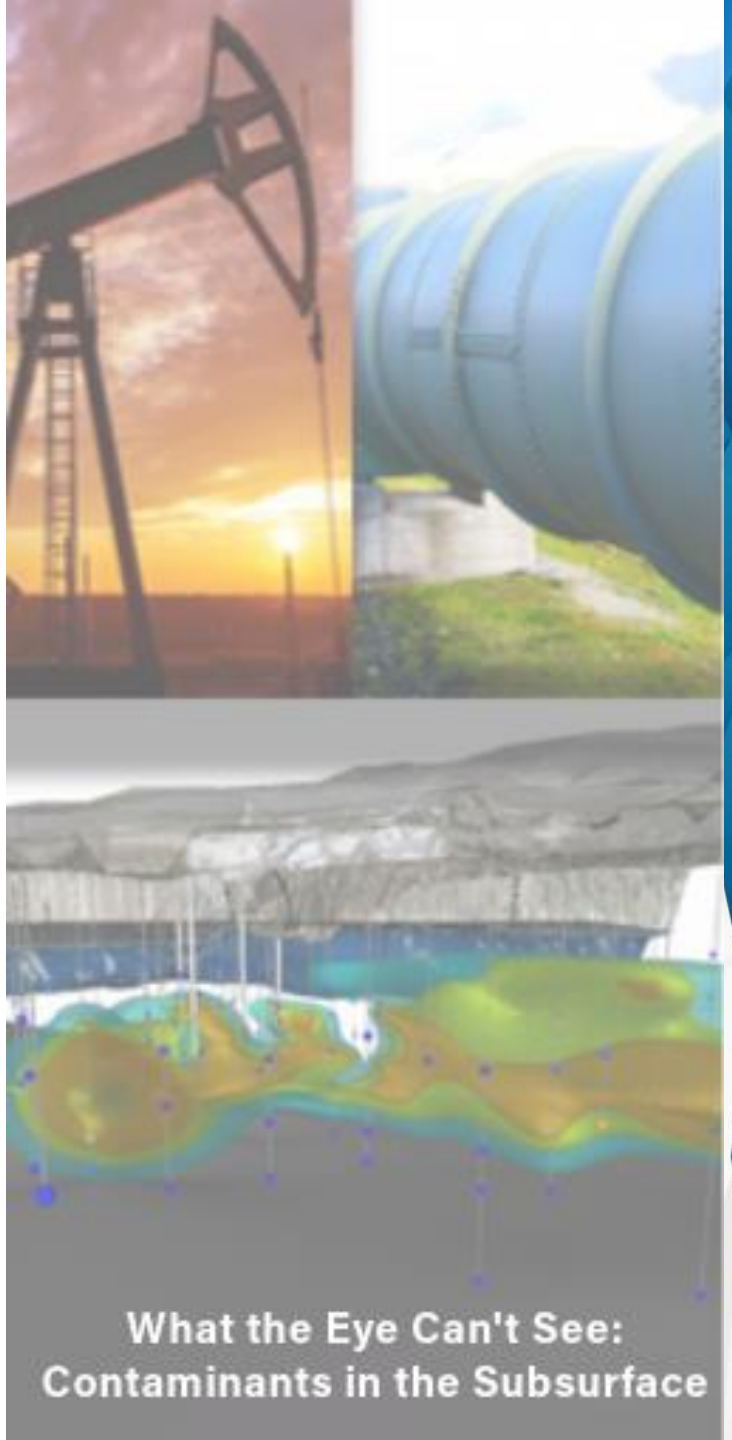
1. What are Conceptual Site Models (CSM)
   - **Know the difference between a good and bad CSM**
   - **Data volume and quality are key**
   - **Utilize multiple data sources**

2. What is High-Resolution Site Characterization (HRSC)
   - **HRSC is designed to provide robust data sets, which form the basis of a sound remediation.**

3. HRSC Technologies (UVOST)
   - **Free product (PAH) delineation: UVOST**
   - **Dissolved phase product (PAH, BTEX, and more): MIP**

4. HRSC and CSM Integration
   - **HRSC technologies can be easily integrated into CSMs**

5. Case Studies (2 sites)
   - **HRSC Technologies can be readily applied at a variety of sites, and should be applied first, to inform proceeding site investigations.**



ACKNOWLEDGEMENTS

Acknowledgements

In collaboration with:

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Any QUESTIONS?

THANK YOU

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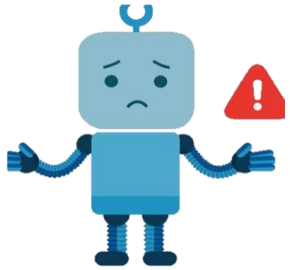
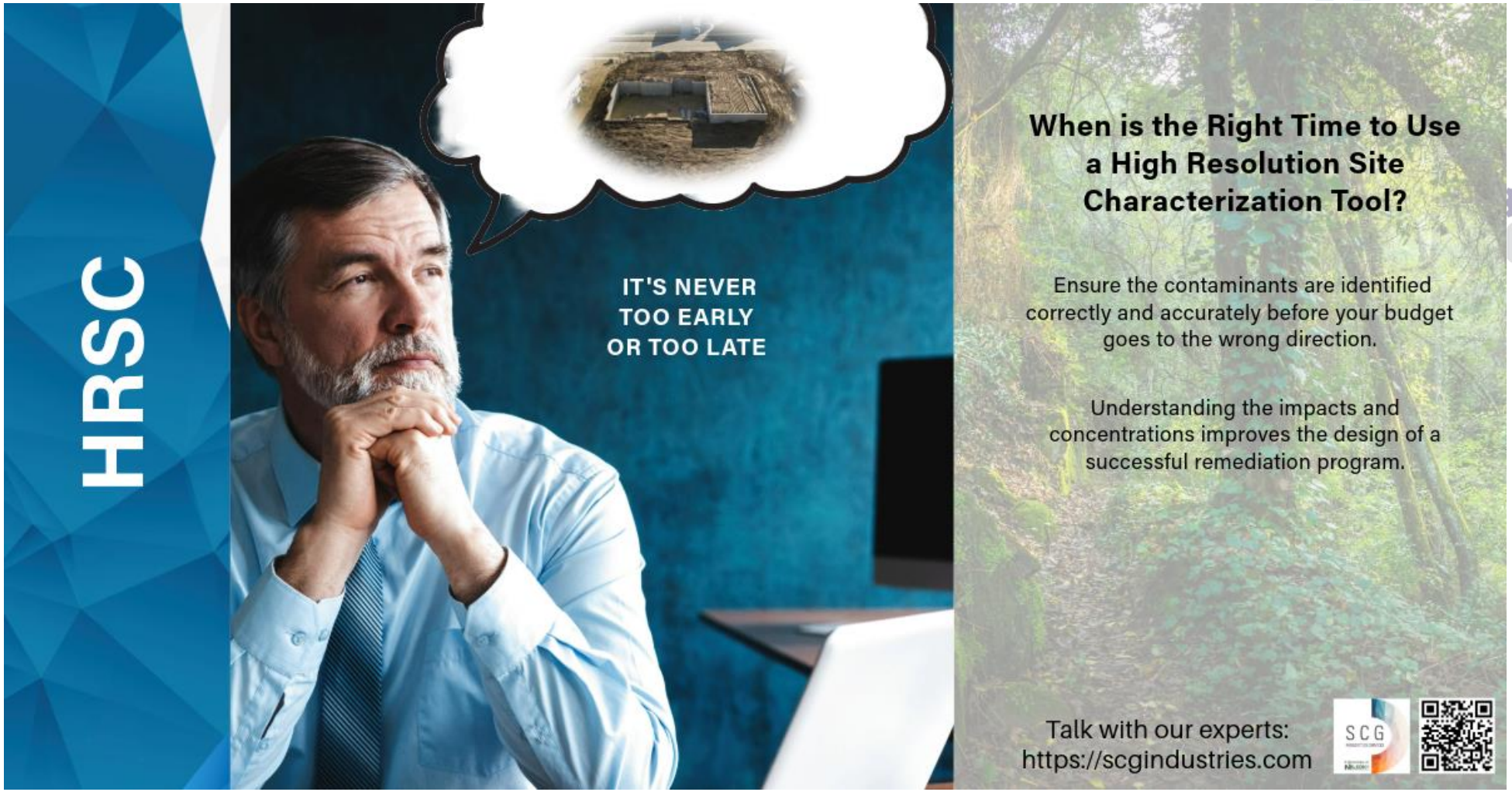
FAQ Icebreaker





FAQ Icebreaker

UVOST specializes in detecting free phase PAH‘s (lighter end)

TarGOST specialises in detecting heavier PAH’s such as coal tar and creosote

EC specializes in determining the electrical conductivity of your sediment

Which HRSC tool should be used where?

OIP specializes in detecting free phase PAH‘s (lighter end

HPT specializes in determining preferential pathways and the overall hydraulic conductivity of your sediment

MIHPT specializes in detecting dissolved phase BTEX, PAH’s, and chlorinated solvents