Laser-Induced Fluorescence (LIF) and Integrated Site Visualizations™ (ISV)

High Resolution Site Characterization Technology for Identification and Delineation of Light Non-Aqueous Phase Liquids (LNAPL) at Hydrocarbon Release Sites

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What we will discuss:

- Basic use and principles of technology
- Deployment methods
- Output
- LNAPL delineation
- Interferences & limitations
- Data analysis
- LNAPL Conceptual Site Model (LCSM)
- Case study & ISV examples

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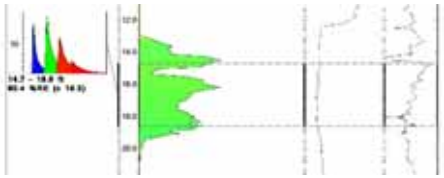
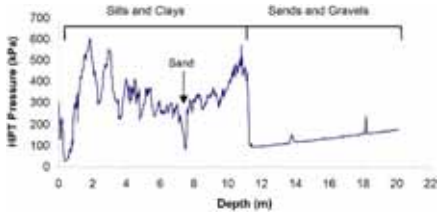
High Resolution Site Characterization - HRSC

LIF (UVOST™)
LNAPL Petroleum

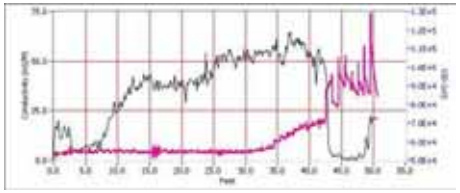


HPT
Lithologic / Hydraulic Properties

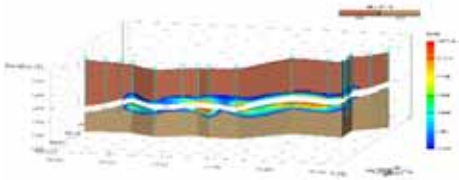


HRSC Toolbox

MIP
Vapor, Dissolved & Sorbed Phase VOCs



ISV
Real-Time Interactive 2D & 3D Visualizations



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Laser-Induced Fluorescence (LIF)

Developed by Dakota Technologies, Inc., Fargo, ND

UVOST®

Ultra-Violet Optical Screening Tool

Detects fuels/oils containing low to moderate PAH concentrations.

TarGOST®

Tar-specific Green Optical Screening Tool

Detects coal tars/creosotes containing moderate to heavy PAH concentrations.

Both technologies employ lasers for excitation of polycyclic aromatic hydrocarbons (PAHs) present in NAPL.

This presentation focuses primarily on the UVOST® technology.

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UVOST® Features

- LIF excitation of PAHs present in LNAPL
- Direct-sensing of mobile and residual LNAPL
- Real-time data, logs response vs. depth
- Direct-push delivery (CPT or push probe)
- Rapid assessment (250 to 500 ft./day)
- Greater cost-effectiveness than traditional LNAPL assessment strategies (ROI: *return on investigation*)

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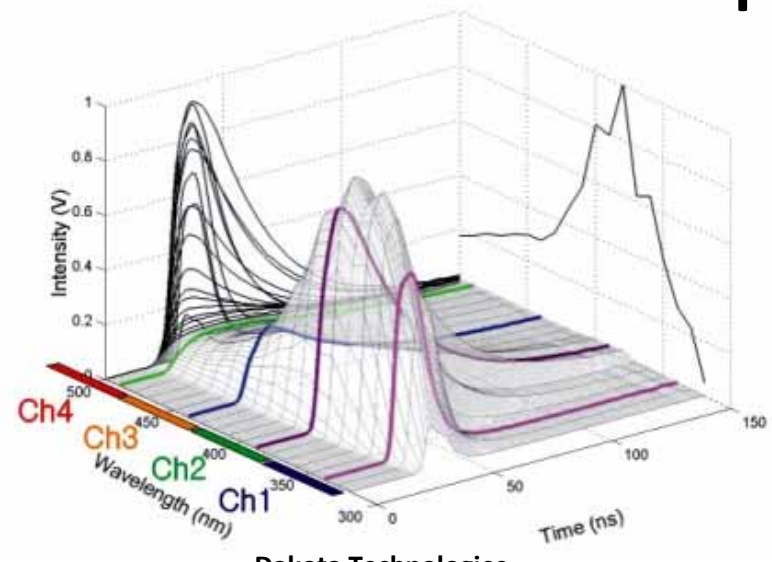
UVOST® Technology Description

- **Fluorescing properties of PAHs**

  Predictable and unique wavelengths

  Predictable and unique decay times



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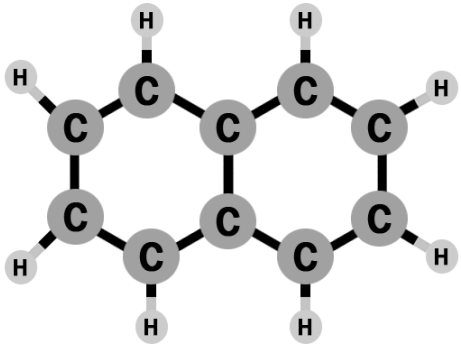

Naphthalene
$C_{10}H_8$

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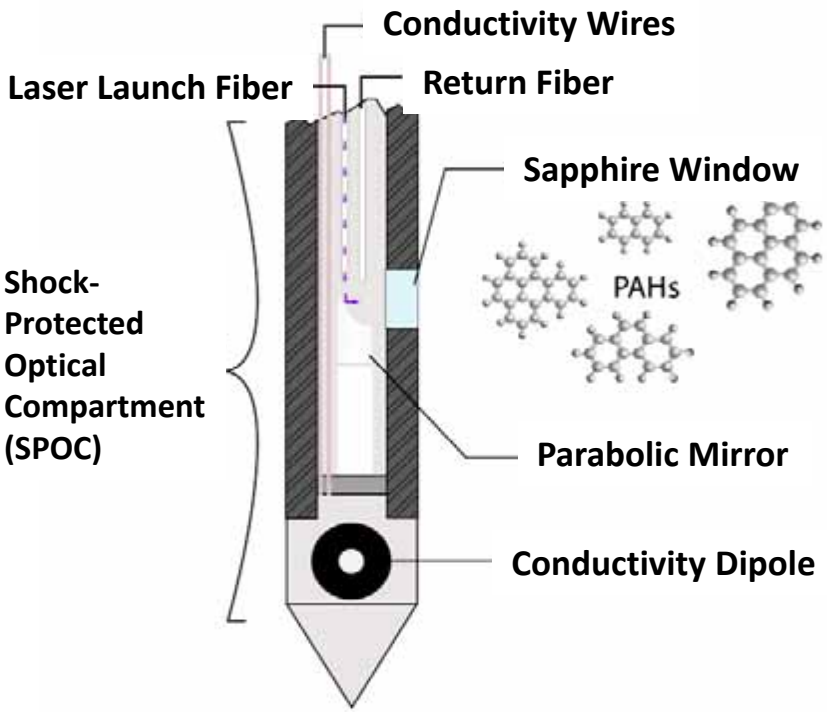
UVOST® Technology Description



Shock-resistant and water-tight SPOC is advanced with direct-push equipment.

UVOST® and computer provide real-time data logging during assessment.

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UVOST® Deployment

Matrix advances the UVOST® tooling using direct-push technology from a variety of delivery platforms.

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UVOST® Deployment

Truck-mounted and tracked probing units are commonly used to deploy the UVOST®.

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UVOST® Deployment

Matrix is often required to deploy UVOST® under complex site access scenarios.

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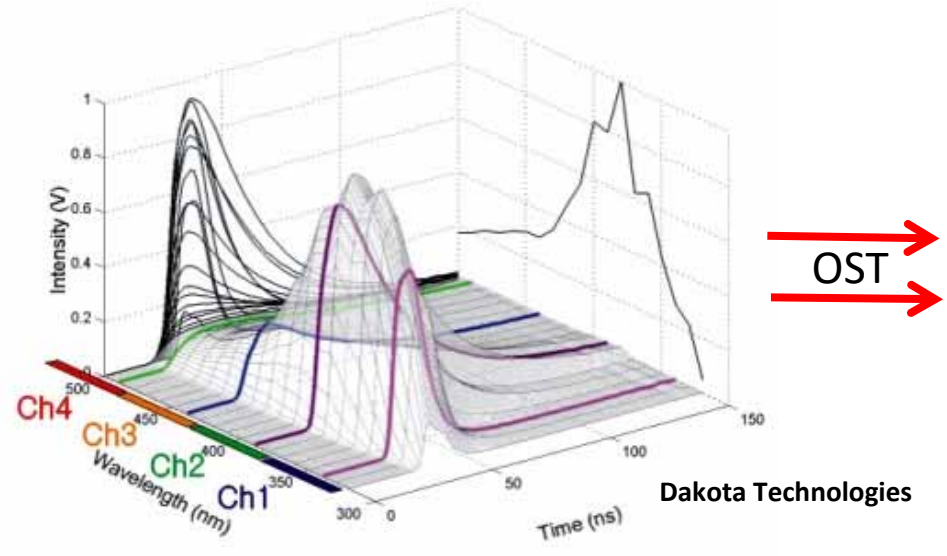
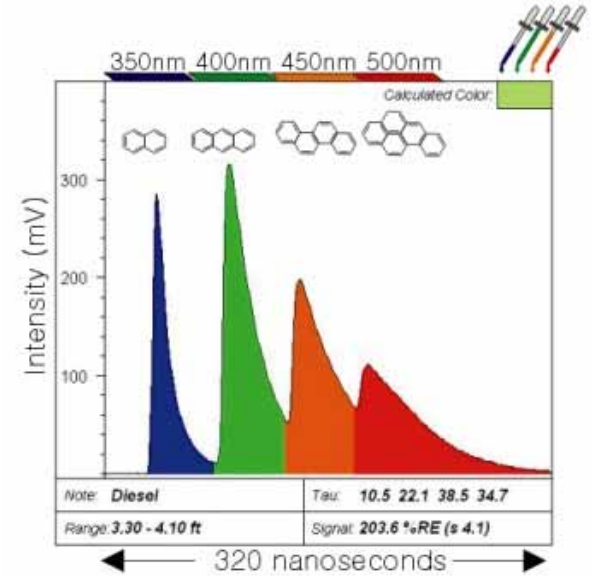
UVOST® Output

The OST translates the fluorescence emission into a multi-wavelength waveform.





3D illustration of diesel's fluorescence emission – wavelength/time matrix (WTM)

Diesel's multi-wavelength waveform

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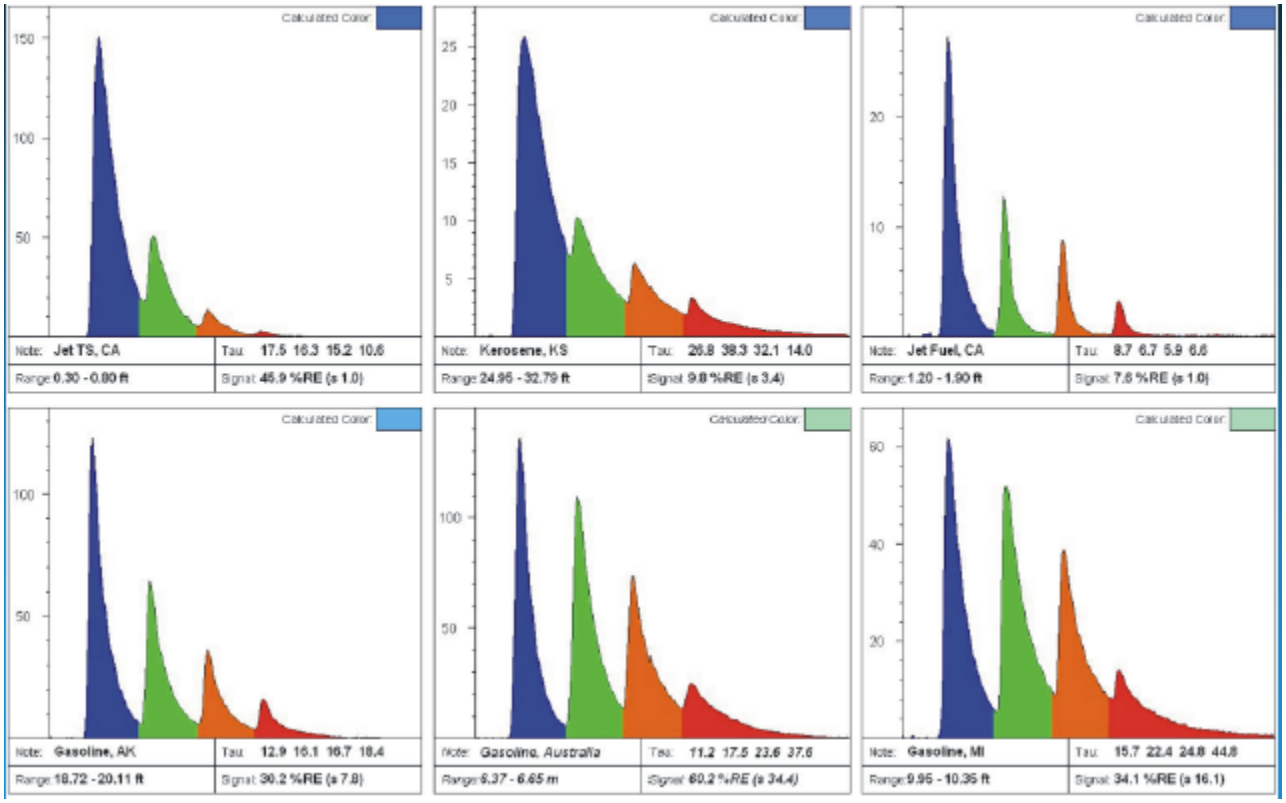
UVOST® Output

Jet fuel / kerosene

Gasoline



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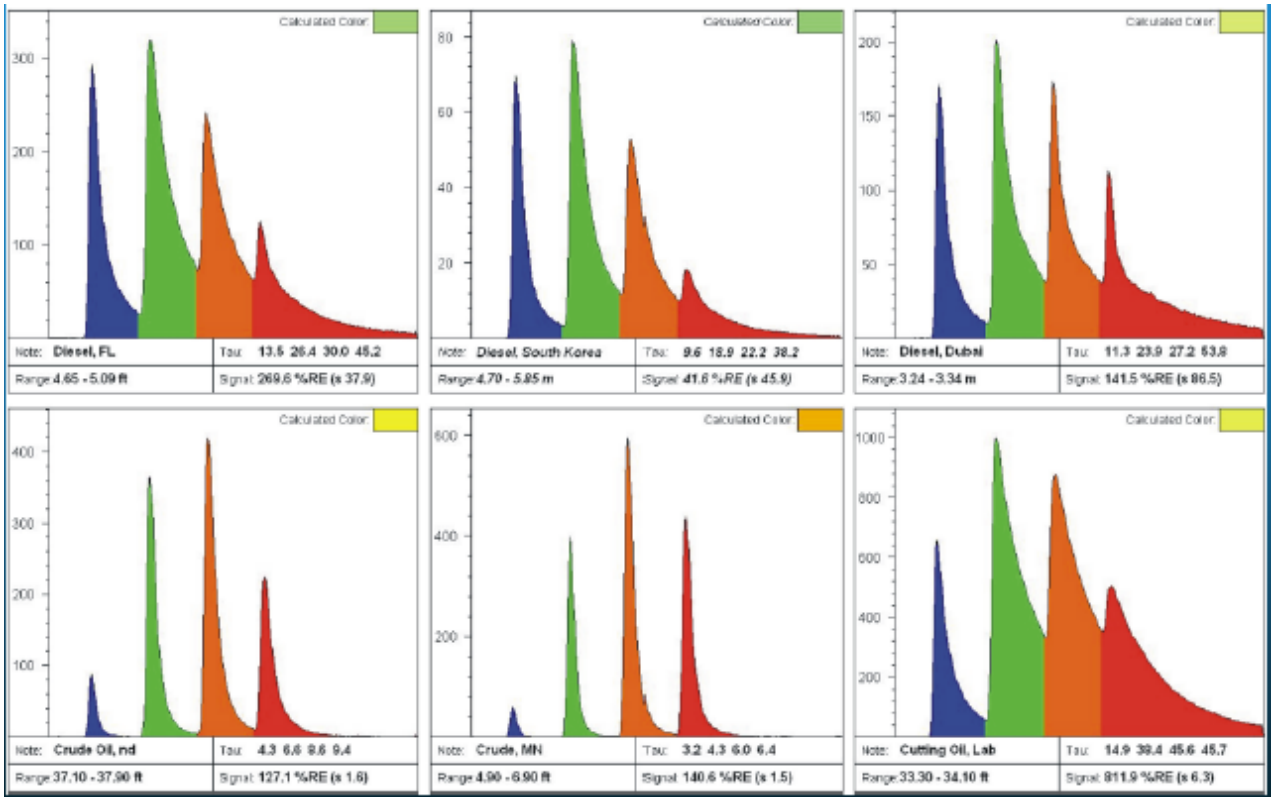
UVOST® Output

Diesels

Oils



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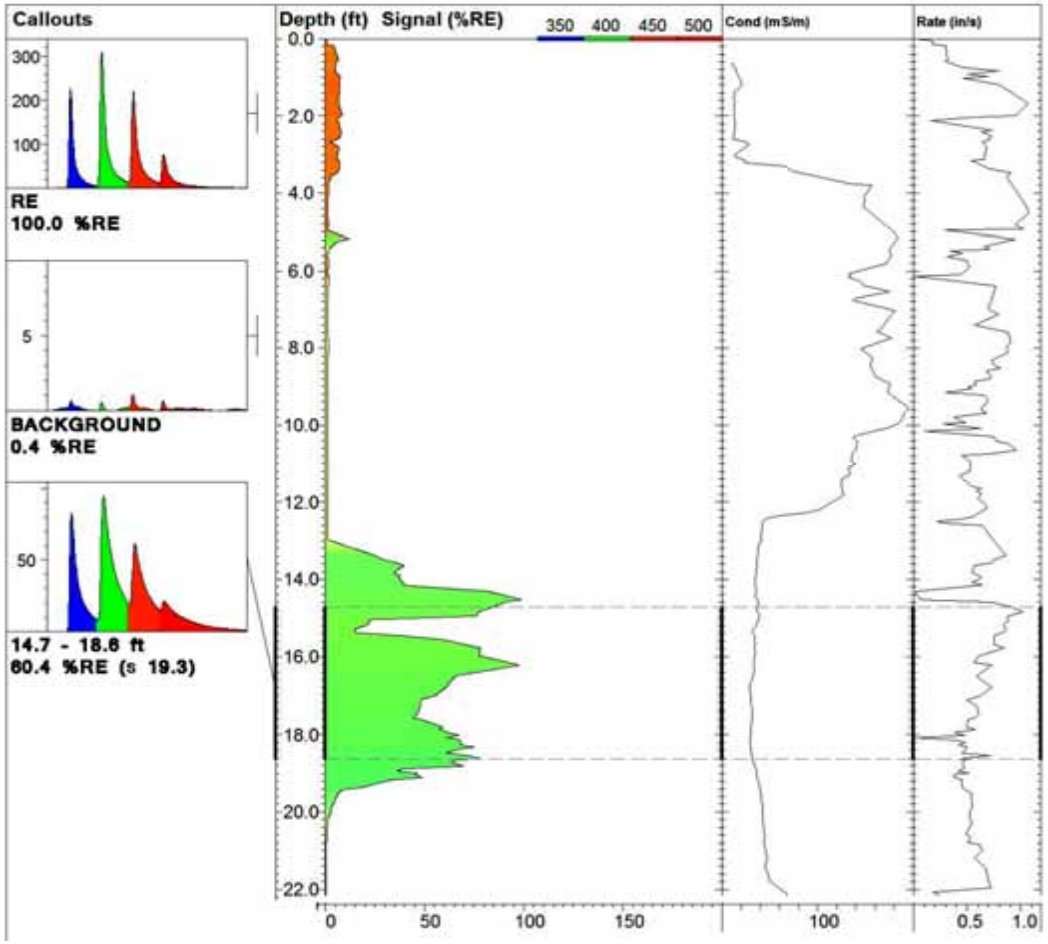
UVOST® Output

Real-time logs display response vs. depth

Waveform callouts on demand

Electrical conductivity simultaneously logged with each UVOST® probe for lithology assessment



Representative UVOST Log

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Contaminant Phases

Hydrocarbon contamination exists in four phases in the subsurface:

1) **Vapor Phase (soil gas)**
2) **Adsorbed Phase (molecular)**
3) **Dissolved Phase (aqueous phase liquid)**
4) **Non-aqueous Phase Liquid (NAPL)**
   a) **Mobile**
   b) **Residual**

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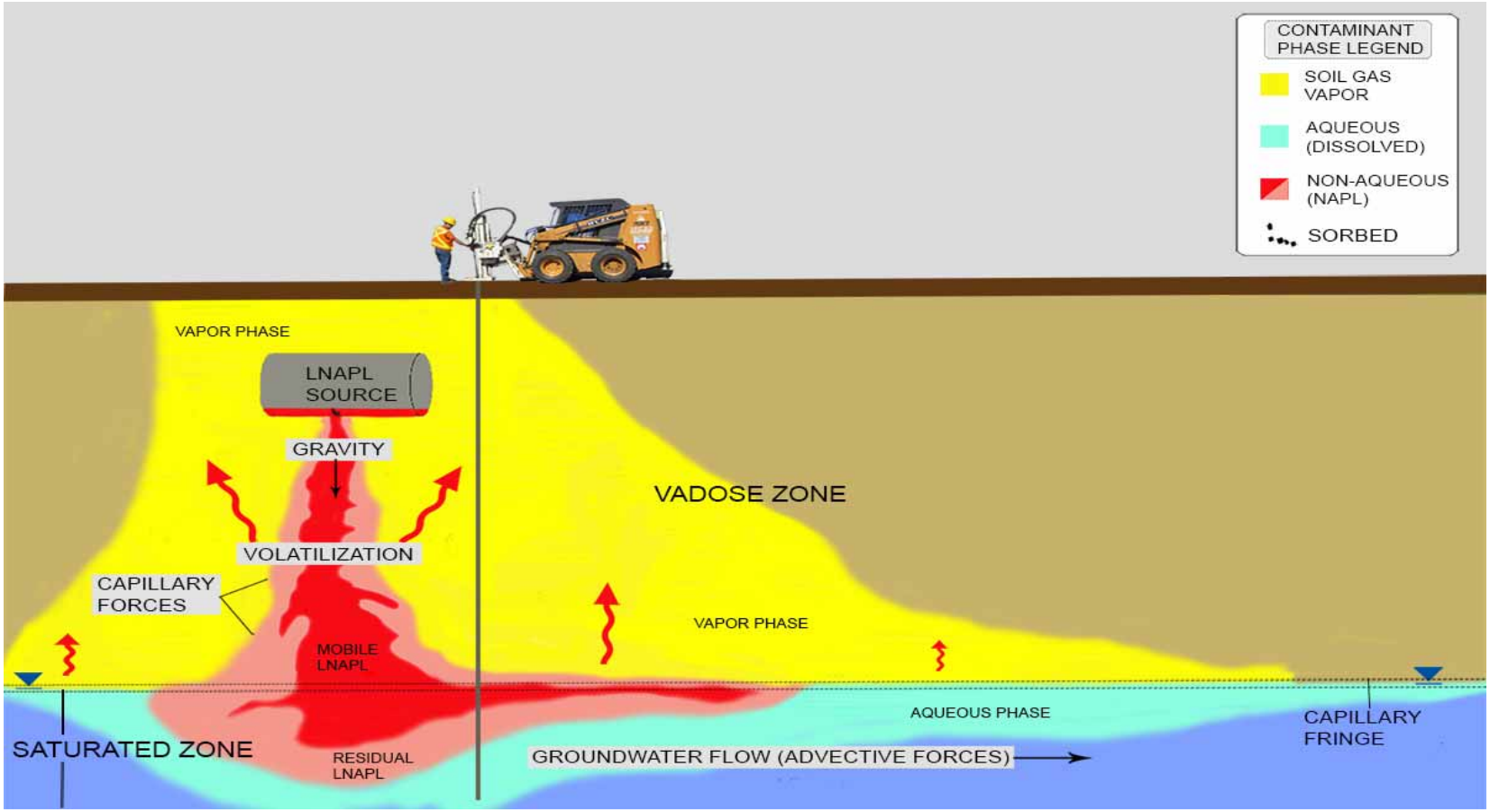
Contaminant Phases



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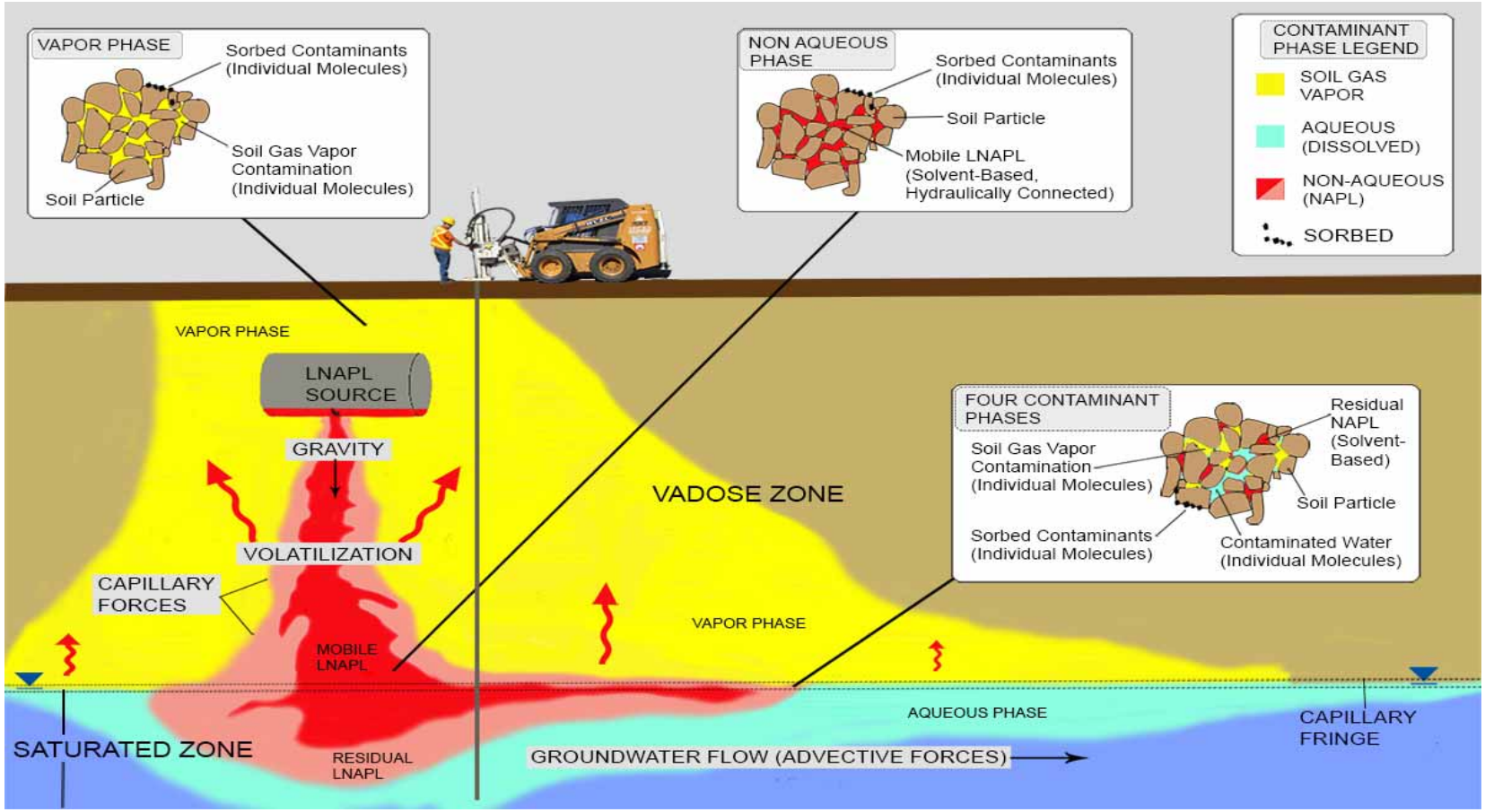
Contaminant Phases



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NAPL Assessment Tools – Why Add LIF?

Standard LNAPL Assessment Methods:

1) **Soil Boring Investigation**
2) **Monitoring Well Network**
3) **Vapor Survey**
4) **Membrane Interface Probe (MIP)**

Responsive to <u>all four</u> phases of contamination

Poor NAPL delineation

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High Resolution Data with UVOST®

Subsurface heterogeneities can occur at scales that are often too small for conventional investigation strategies and technologies to adequately characterize.

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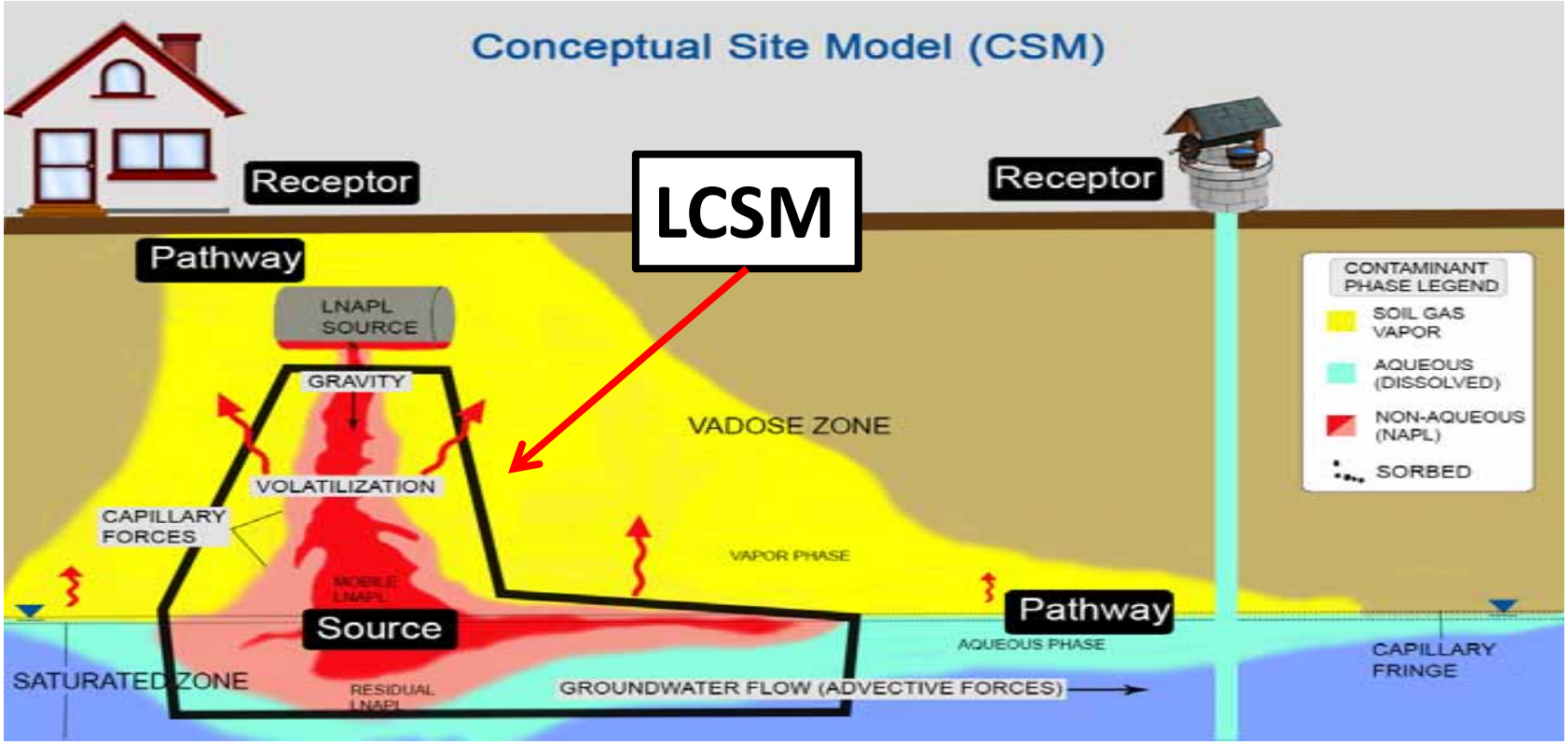
UVOST® Application

The UVOST® responds *only* to LNAPL



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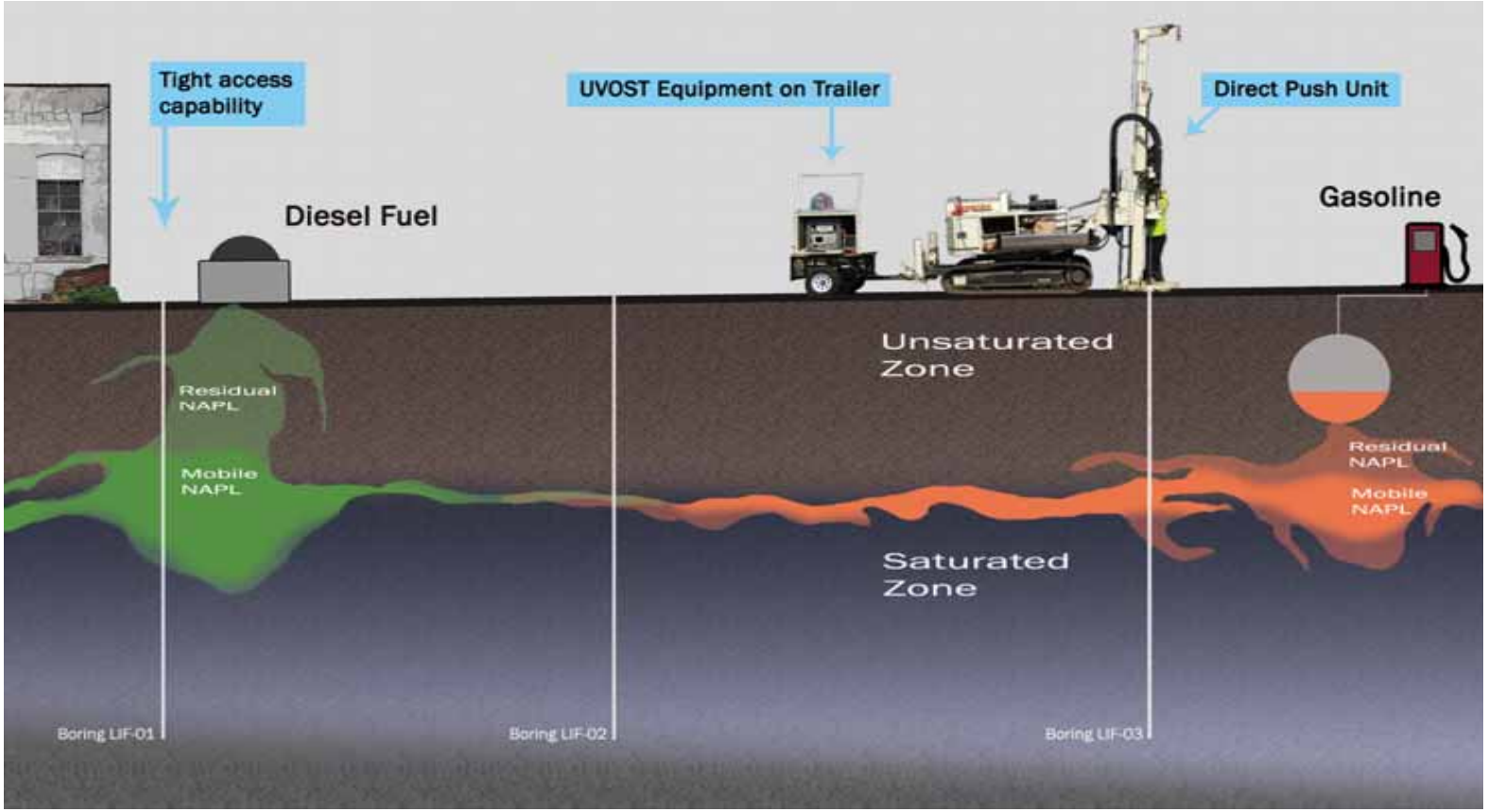
LNAPL Source Identification with UVOST®

Diagram of conceptual field application of UVOST® technology



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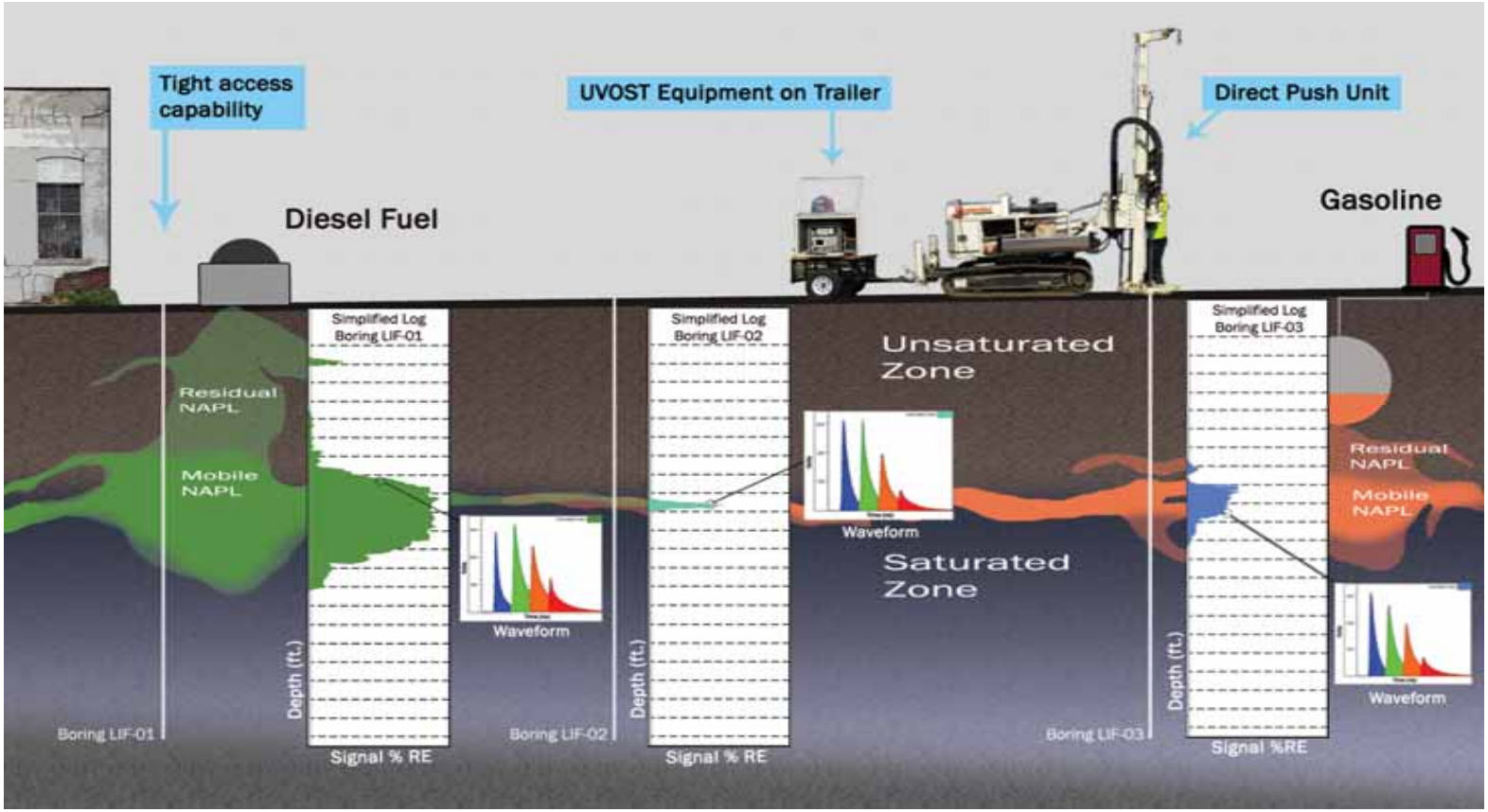

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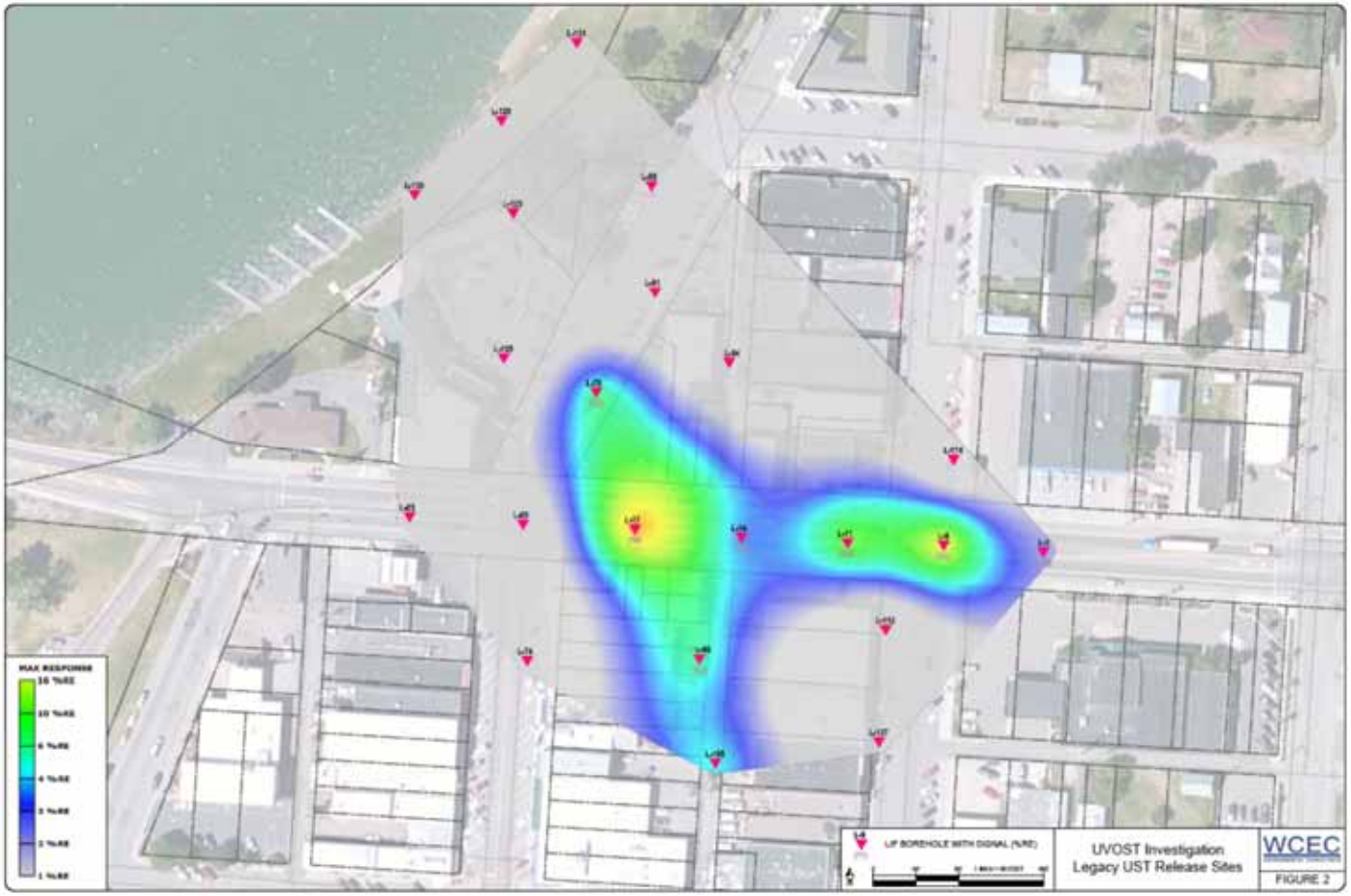
UVOST® Data Density



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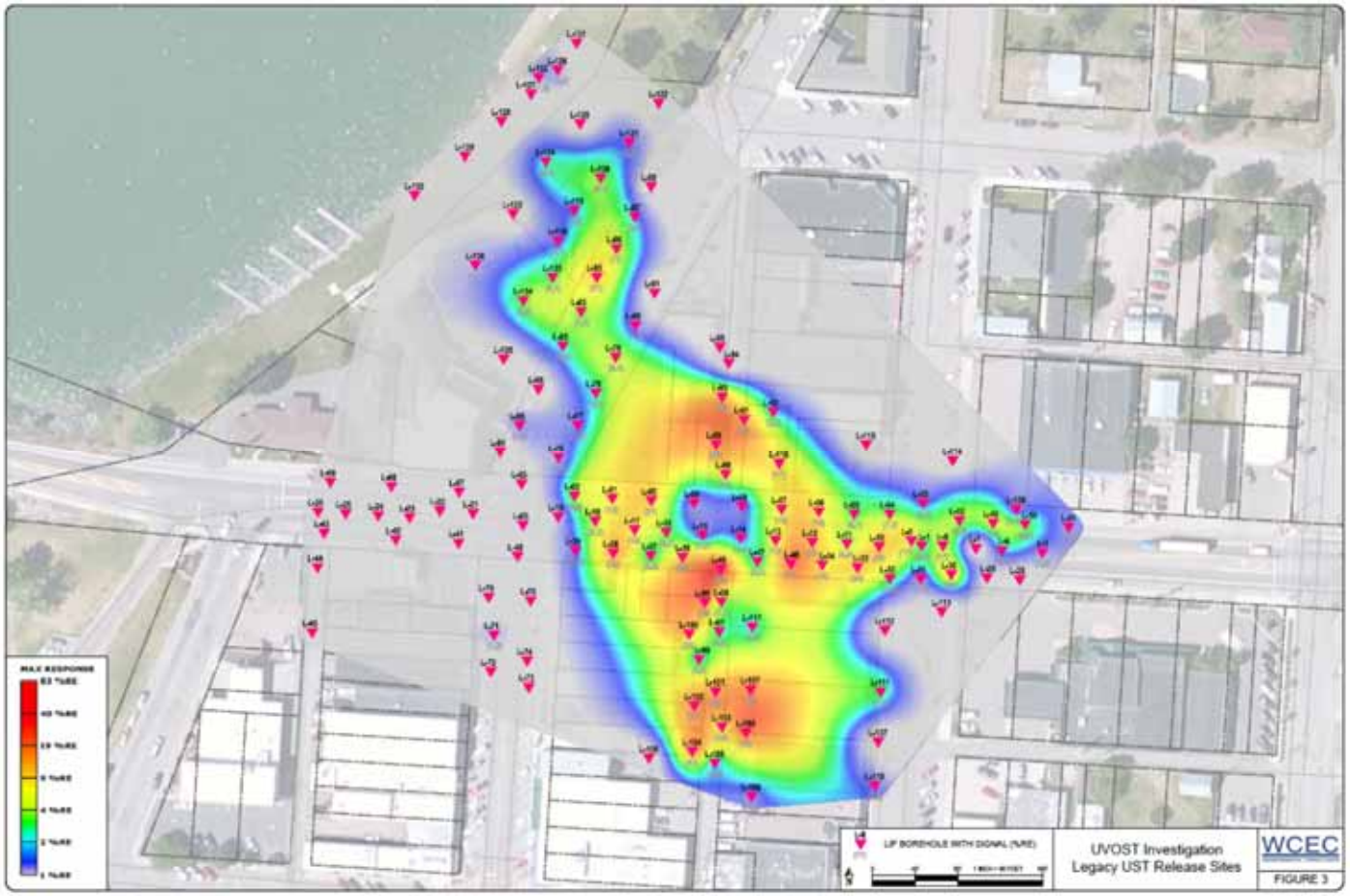

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UVOST® Applications & Limitations

UVOST® Detects:

- Gasoline
- Diesel
- Jet fuel (kerosene)
- Motor oil
- Hydraulic fluids
- Cutting fluids

Note: Tar-specific Green Optical Screening Tool (TarGOST®) is used for the detection of coal tars, creosotes, heavy crudes, tank bottoms, etc.

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UVOST® Does Not Detect:

- PCBs
- Dissolved phase PAHs
- Chlorinated Hydrocarbons [1]

[1] See www.dakotatechnologies.com for information regarding Dye LIF

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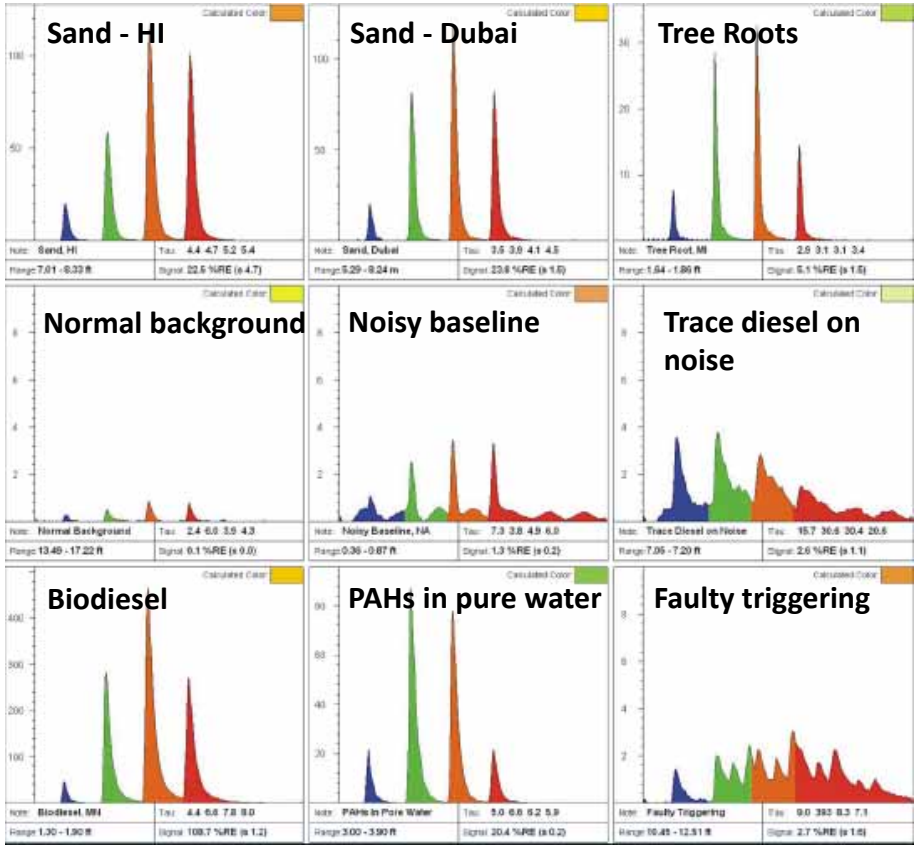
UVOST® Applications & Limitations

UVOST® False Positives:

- Organic matter
- Sea shells
- Calcite
- Calcareous sands
- Peat
- Shorter lifetimes
- "Odd" appearance



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Key Take-Aways

- **LIF responds *only* to NAPL –**
  - ✓ **Differentiates NAPL from other contaminant phases**

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Key Take-Aways

- **LIF responds *only* to NAPL –**
  - ✓ **Differentiates NAPL from other contaminant phases**
- **High data density –**
  - ✓ **Accurate delineation of NAPL body**
  - ✓ **Development of robust LCSM with multiple lines of evidence**

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Key Take-Aways

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  - ✓ **Differentiates NAPL from other contaminant phases**
- **High data density –**
  - ✓ **Accurate delineation of NAPL body**
  - ✓ **Development of robust LCSM with multiple lines of evidence**
- **Cost-effective, real-time data**

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UVOST® Data Analysis & LCSM Development

Integrated Site Visualization (ISV™)

- Delivers a 3D representation of the site conceptual model
- Allows complex information to be easily evaluated and understood by technical and non-technical stakeholders

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UVOST® Data Analysis & LCSM Development

- High resolution GIS imagery
- Traditional basemap features (CAD drawings)
- Topographic maps
- Aerial photographs
- Lidar data

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UVOST® Data Analysis & LCSM Development

Deliverables include:

- **Static images**
- **Digital animations**
- **Dynamic 3D files with interactive viewer (4-DIMs)**

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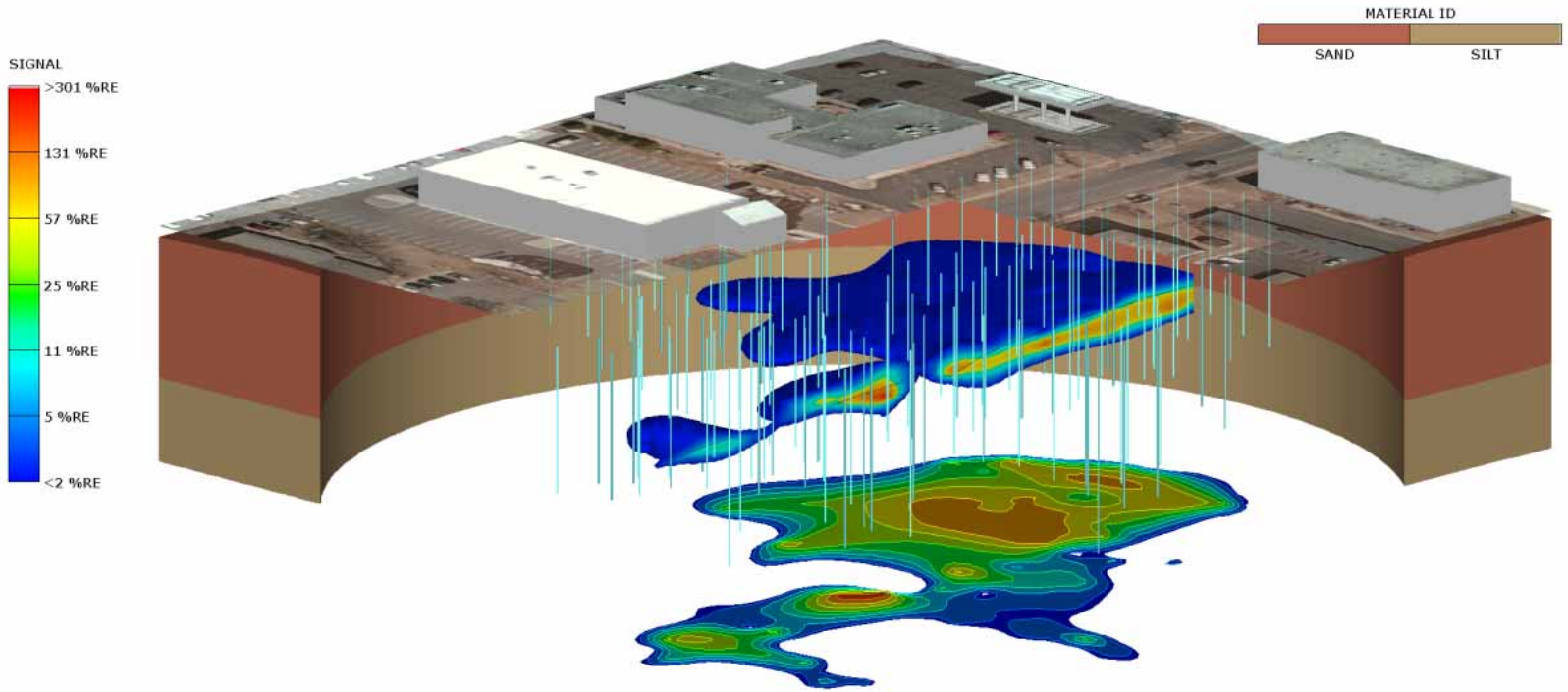
UVOST® Data Analysis & LCSM Development

Typical ISV deliverable, consisting of LIF and electrical conductivity (EC) data



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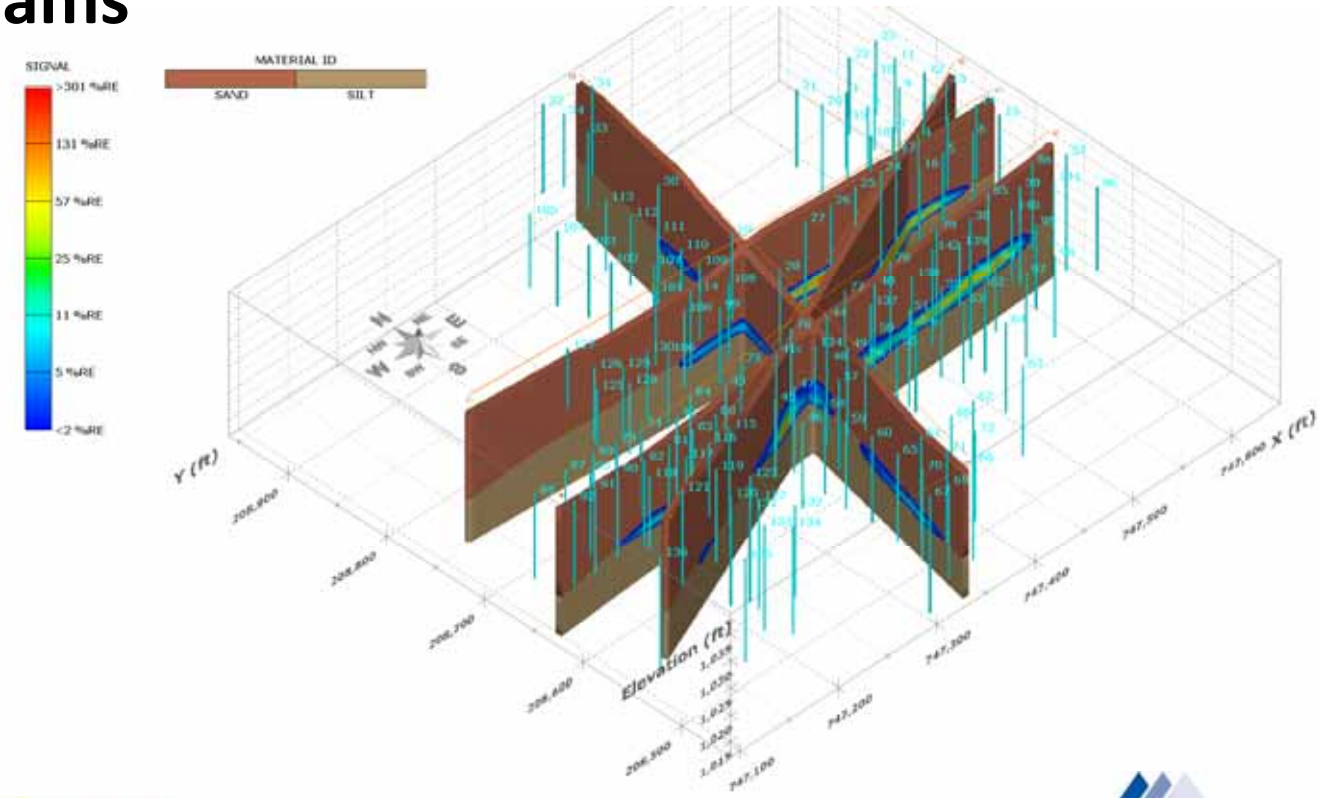
UVOST® Data Analysis & LCSM Development

Contaminant chemistry, lithology and stratigraphy data can also be presented in cross-sectional diagrams



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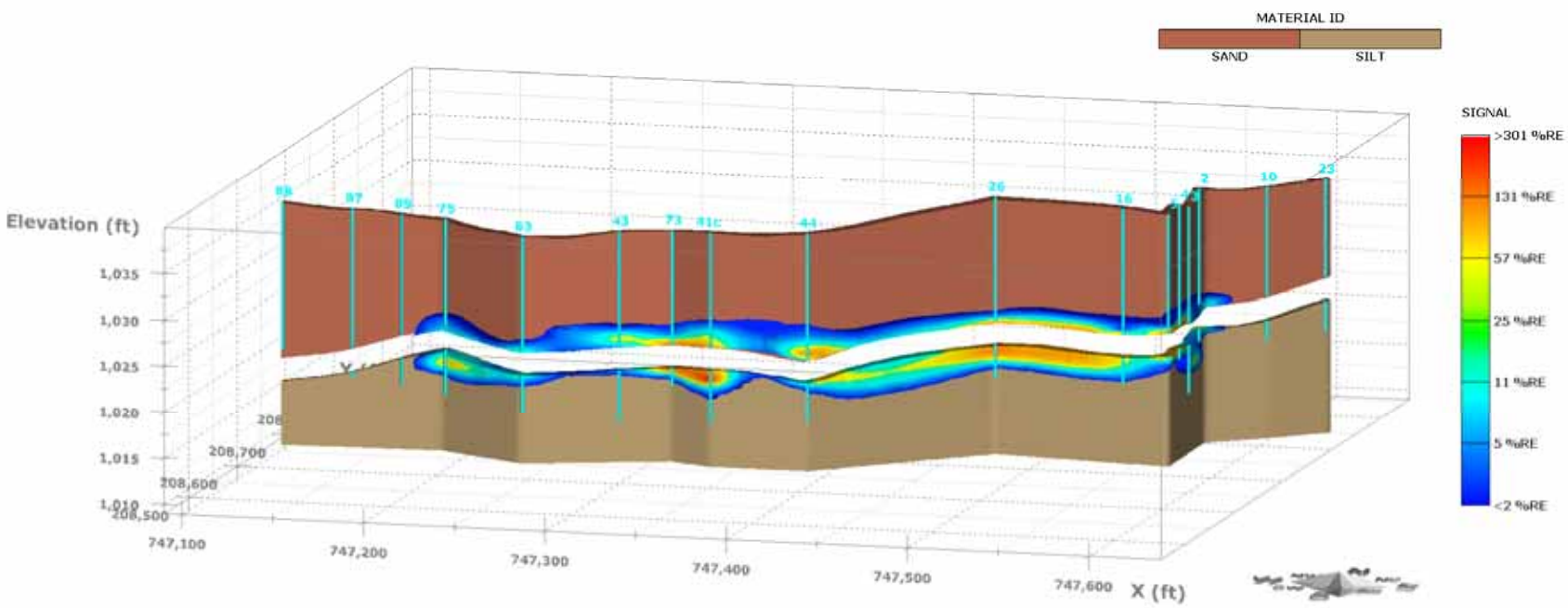
UVOST® Data Analysis & LCSM Development

3D fence diagrams are also used to depict the extent and magnitude of the contaminant plume



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UVOST® Investigation Case Study

- Legacy petroleum release site in downtown Polson, Montana, initial investigation in early 1990s
- 13 facilities with releases and individual PRP ownership
- Large undefined LNAPL plume, LNAPL present in various monitoring wells across the site
- Complex lithology consisting of fine-grained, varved lakebed sediments
- Sensitive surface water receptor (Flathead Lake)
- Various regulatory agencies including MTDEQ, City of Polson, Lake County, CSKT Tribe & USEPA

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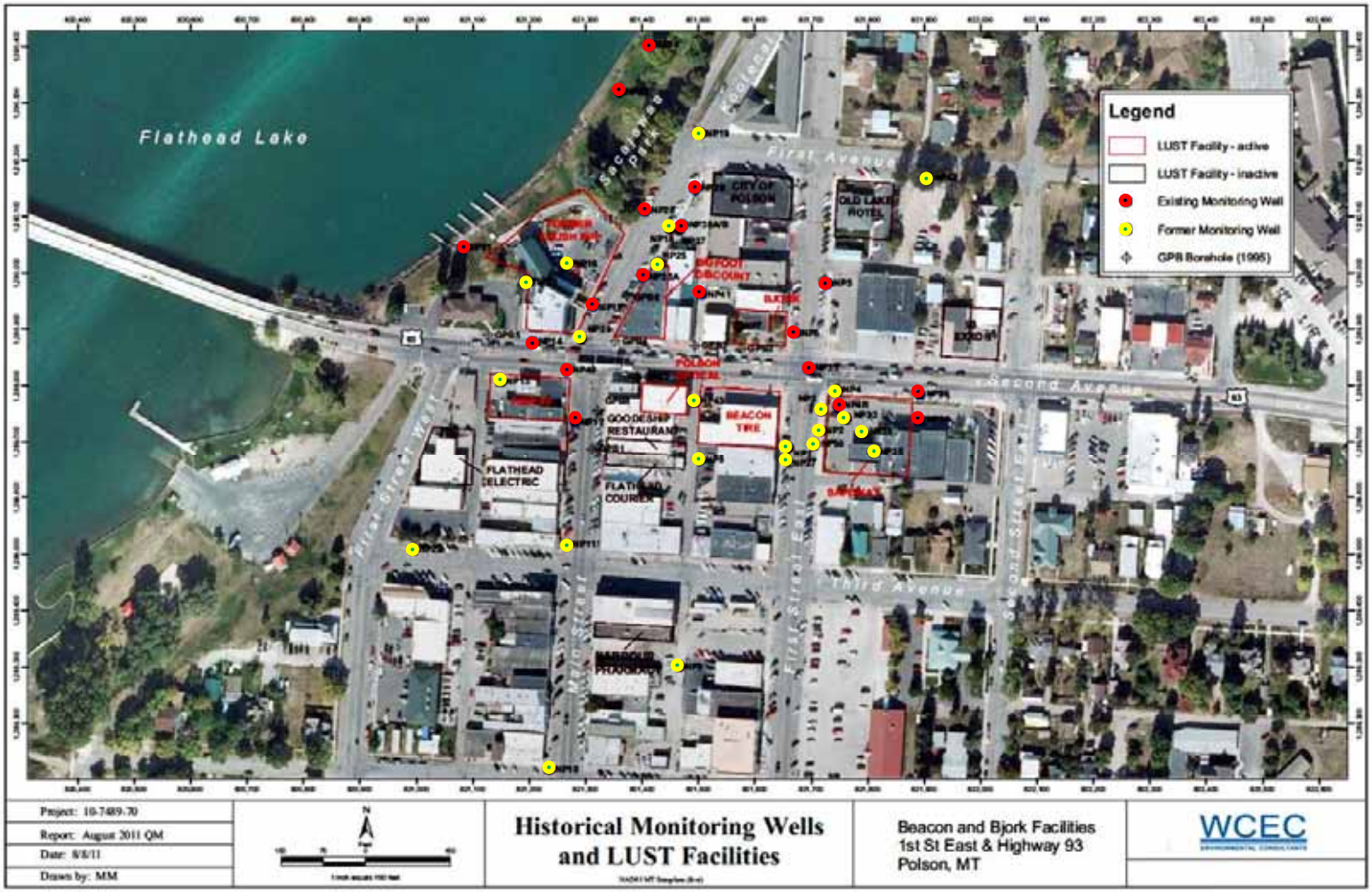
UVOST ® Investigation Case Study



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UVOST® Investigation Case Study

- Investigation included 138 UVOST® borings completed over 10 day period
- Geospatial data points recorded for each boring using sub-decimeter GPS equipment
- Daily uploads of UVOST® response and GPS data conducted using WCEC's Real Time Data Transmission (RTDT) service
- WCEC UVOST® analyst provided daily 2D LNAPL isoconcentration maps as a tool to guide the investigation
- Depth of borings was correlated to high and low pool lake elevations

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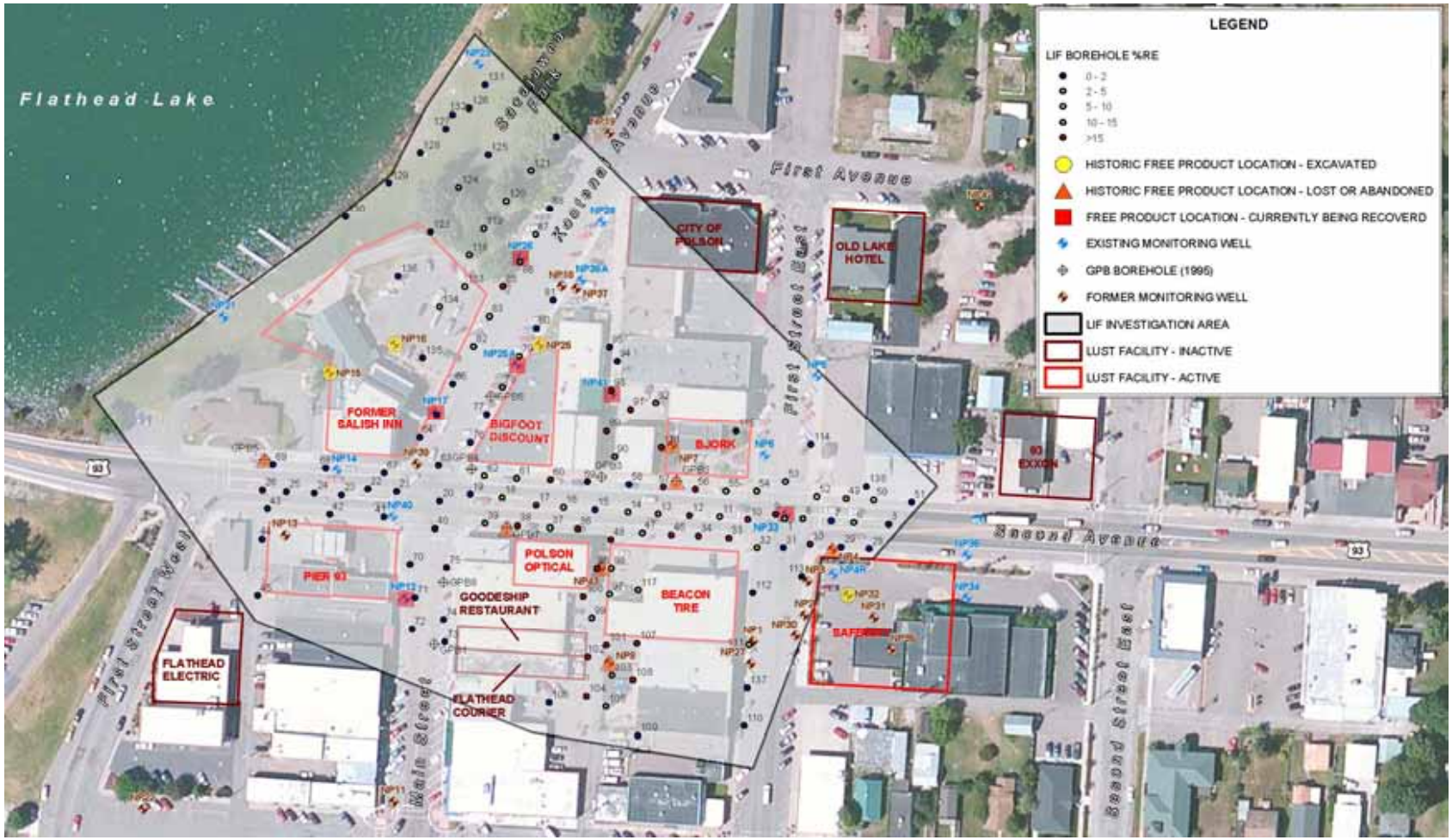
UVOST ® Investigation Case Study



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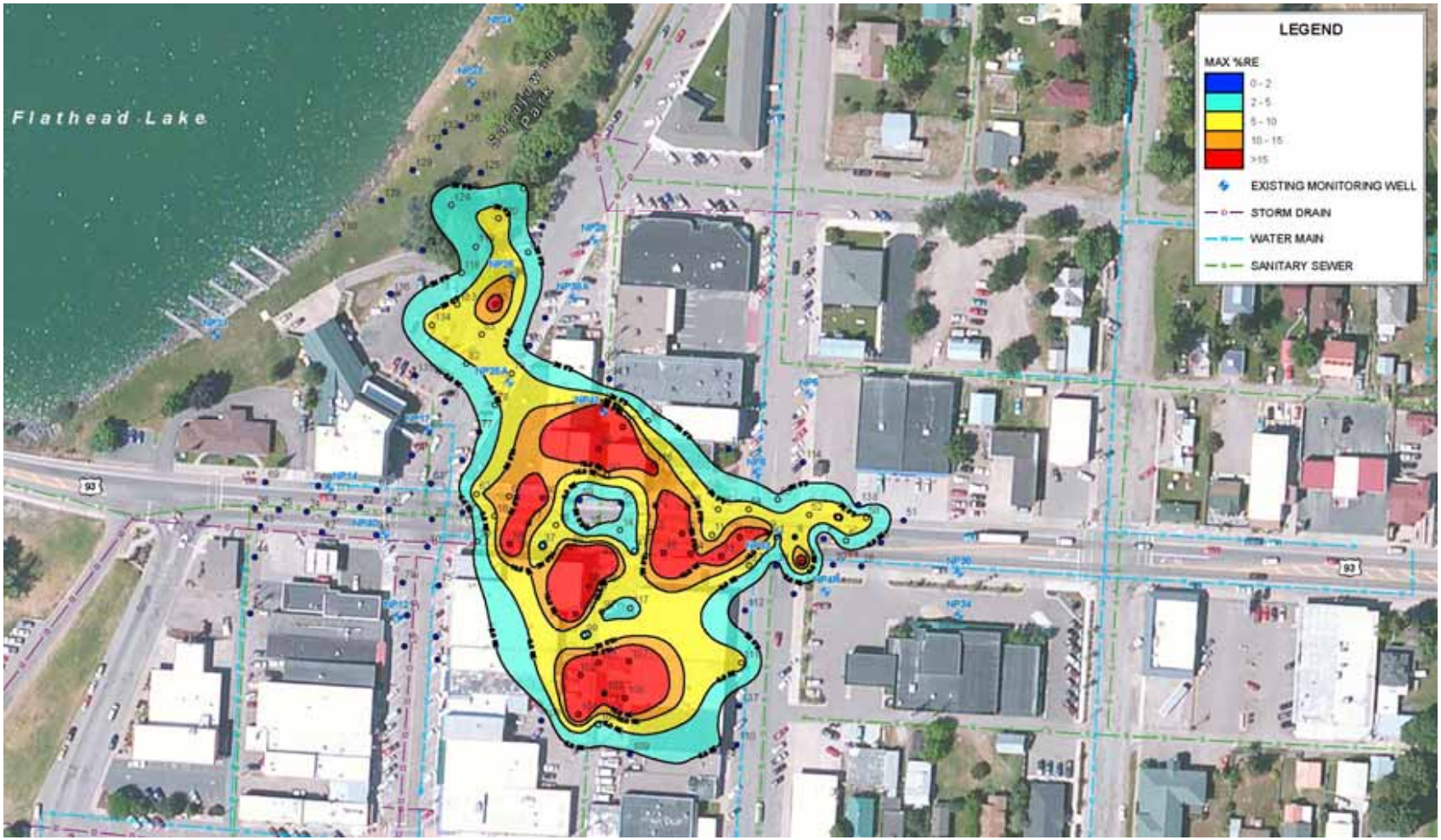

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UVOST ® Investigation Case Study

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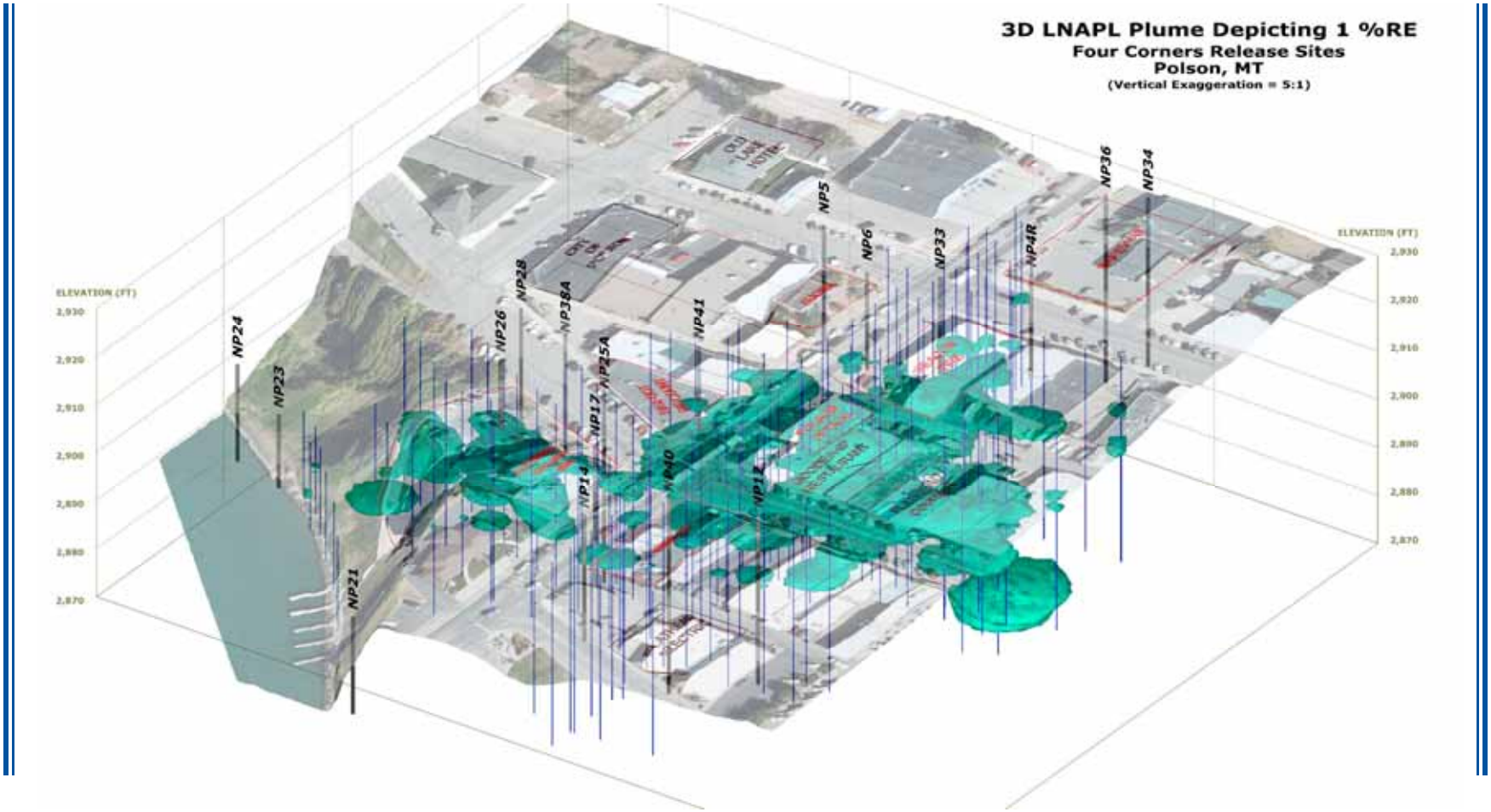

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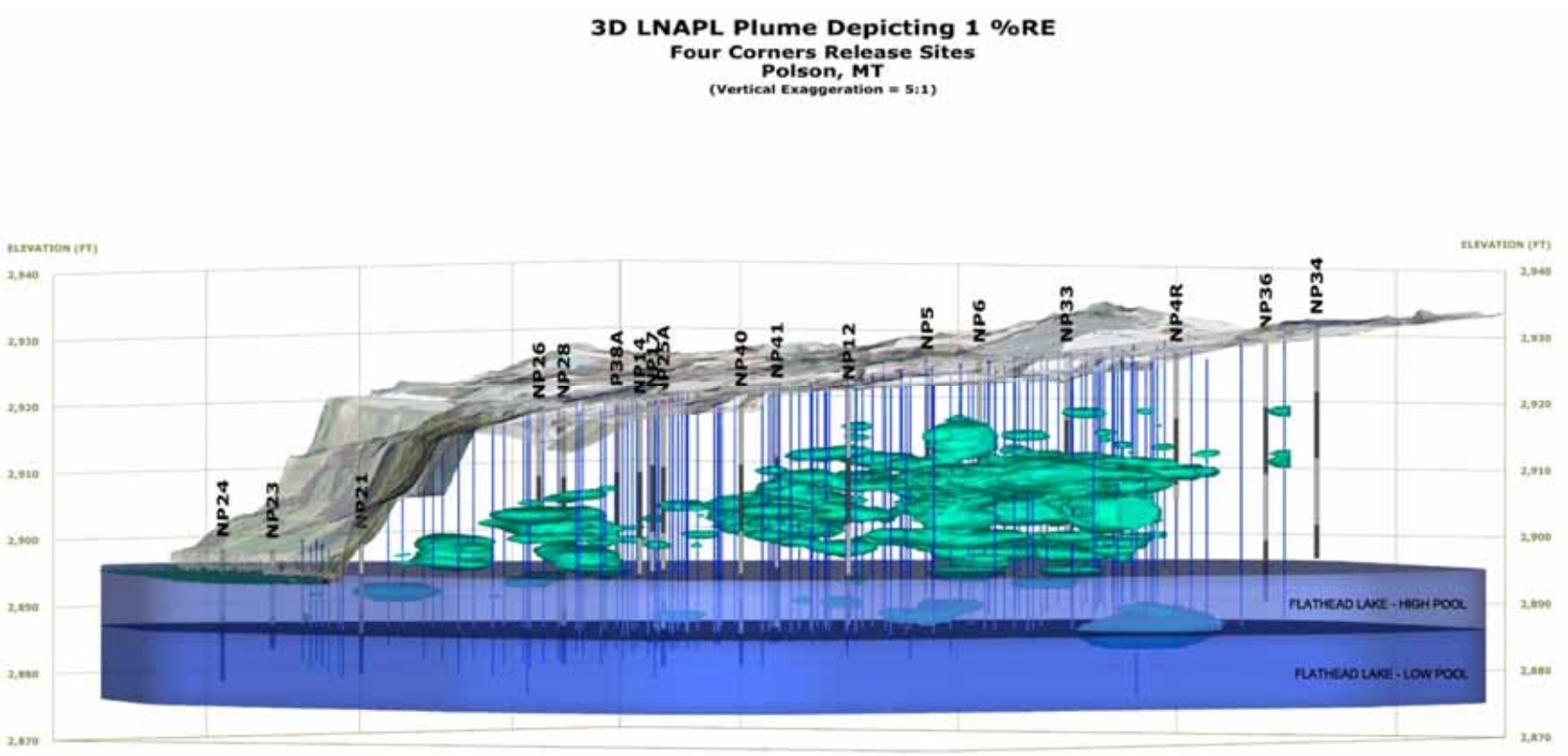

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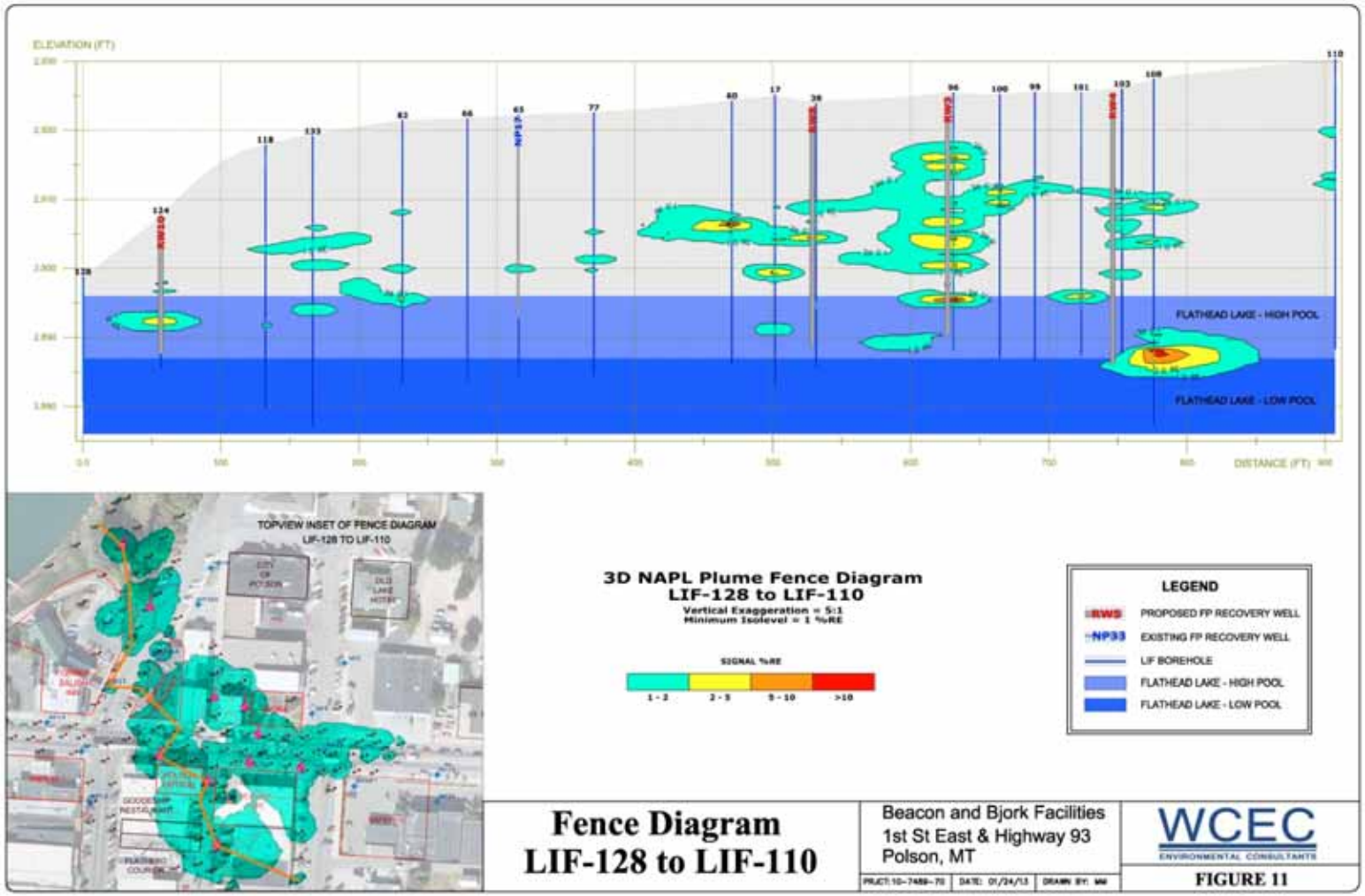

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UVOST® Investigation Case Study

- Investigation successfully delineated horizontal and vertical extent of LNAPL plume allowing for targeted LNAPL recovery
- Completed in 10 field days with total cost of under $100,000
- Previous investigations totaled over $1M and were not successful in delineating plume
- Greatly advanced the CSM through collection of detailed LNAPL distribution and geophysical data (EC)

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Thank you!

Ed Creaden

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A recording of this presentation given as a webinar is available on our website

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