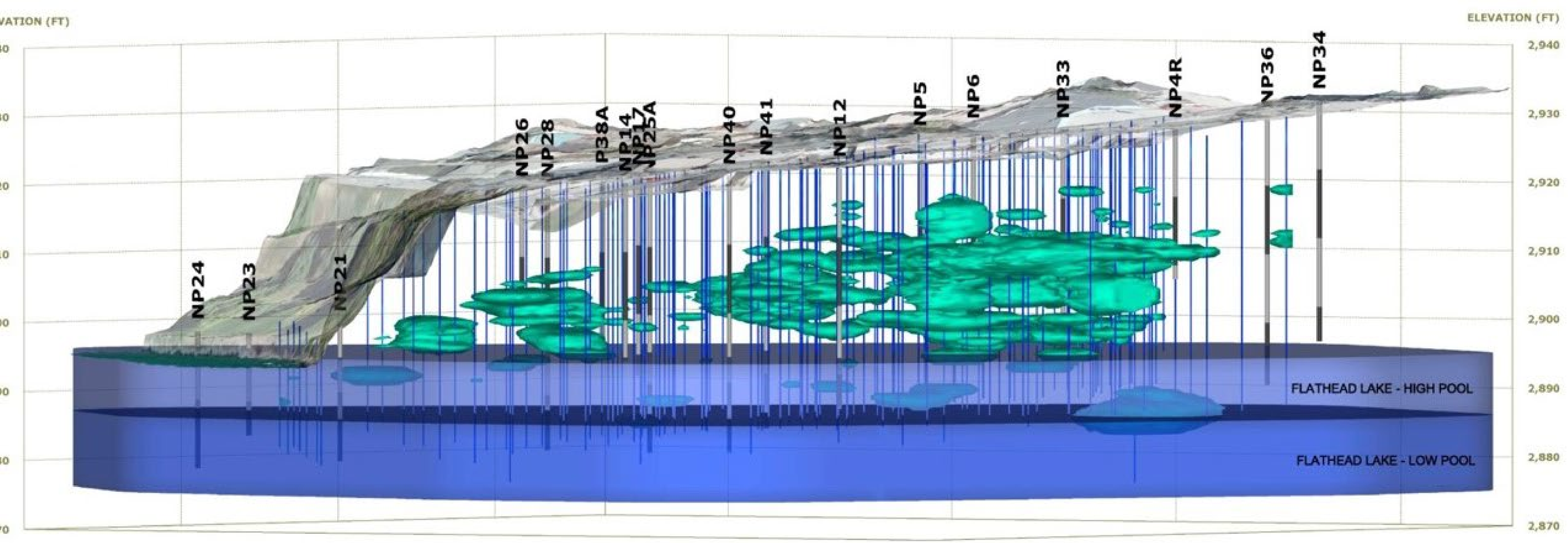

Implementing Advanced Site Characterization Tools

High-Resolution Site Characterization at Petroleum Release Sites

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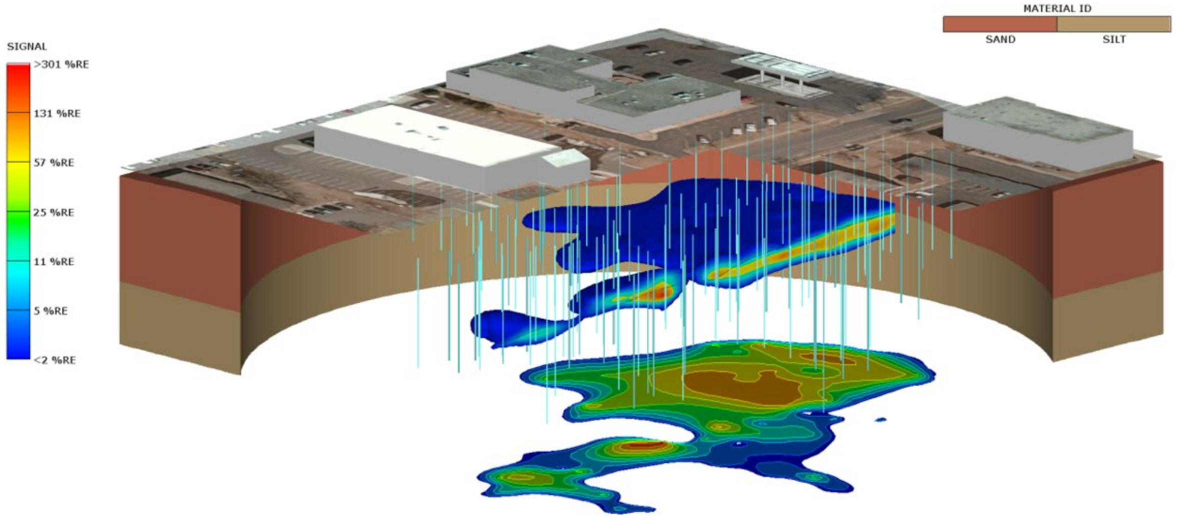
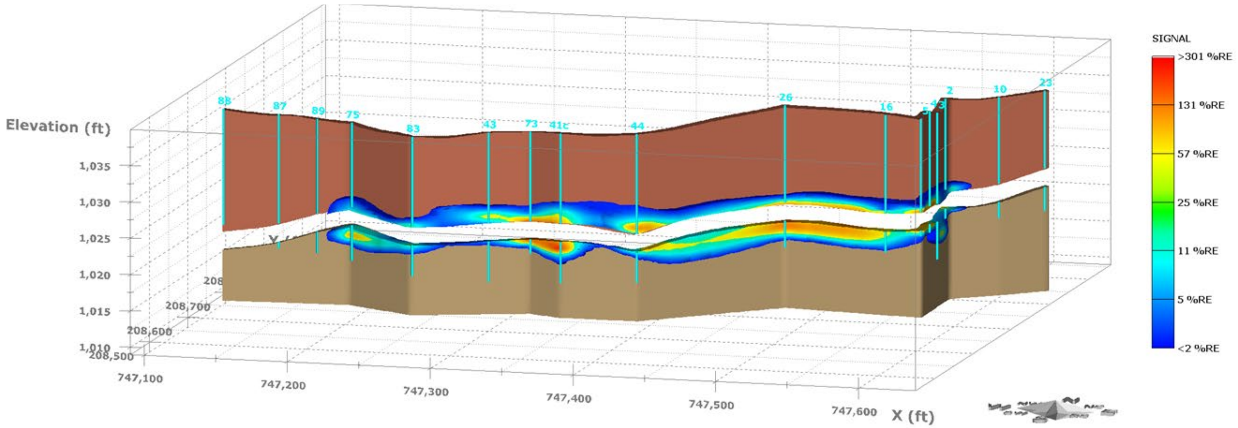
Introduction

- What are ASCTs & HRSC?
- Introduction to ASCTs for HRSC of Petroleum Releases
- HRSC – When & Where?
- Structuring a Successful HRSC Investigation
- Case Studies & Lessons Learned



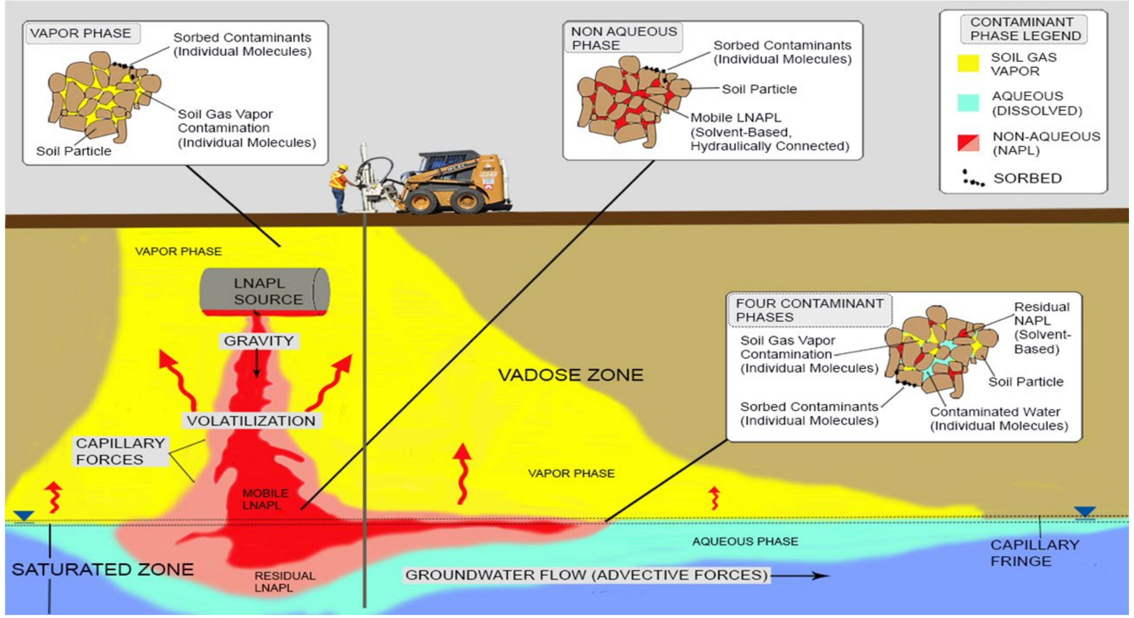


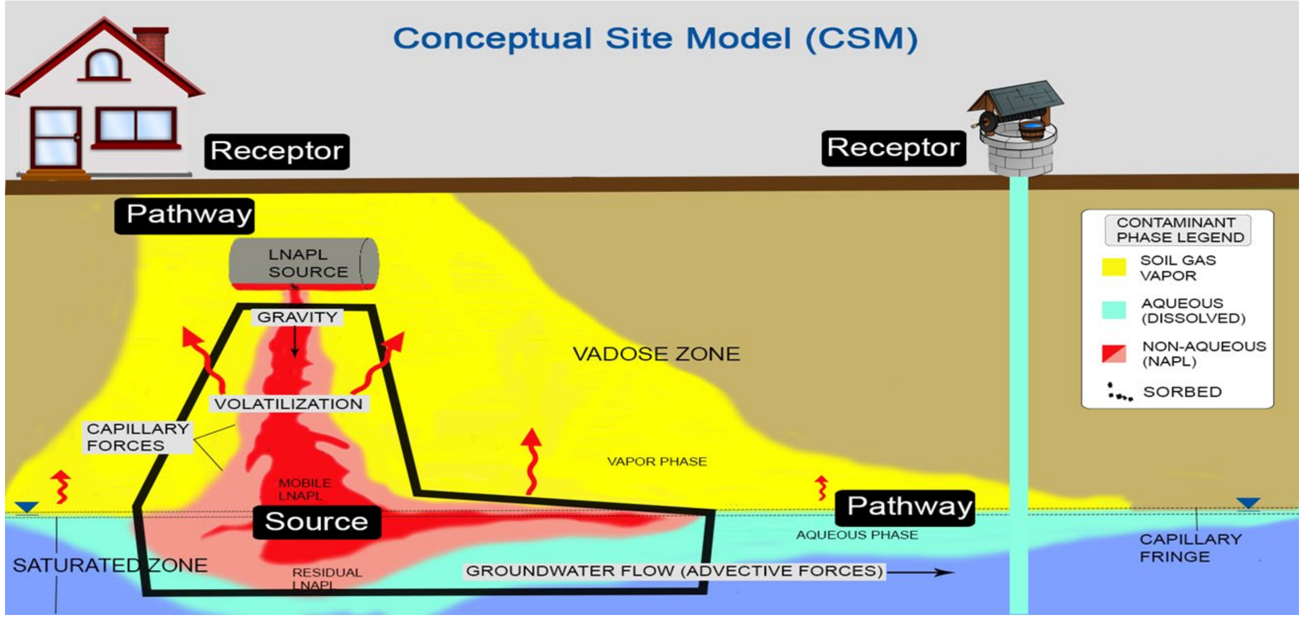
Advanced Site Characterization Tools (ASCTs)

- **What are ASCTs?**
  - Incorporate direct sensing of the parameter of interest through direct contact or precise discrete sampling [ITRC, 2019]
  - Provide scale-appropriate measurement and sample density to define contaminant distributions and the physical context in which they reside
  - Allow for greater data density and enhance the practitioner's understanding of site-specific contaminant mass discharge and mass flux.
  - This greater degree of certainty supports development of robust and reliable CSMs and faster and more effective site cleanup

High-Resolution Site Characterization (HRSC)

- **What is HRSC?**
  - Application of ASCTs for site investigation
  - Real-time data used to intuitively progress the investigation
  - HRSC typically includes 2D and 3D Data Visualizations of the CSM





High-Resolution Site Characterization (HRSC)

HRSC vs Traditional Site Characterization

High Resolution Site Characterization

- Produces a more detailed characterization of mass flux
- Reduce uncertainty through scale appropriate measurements
- Adaptive approach for single mobilization delineation
- Robust and reliable conceptual site models
- Develop right-sized, targeted remedies that focus on the mass that matters

Traditional Site Characterization

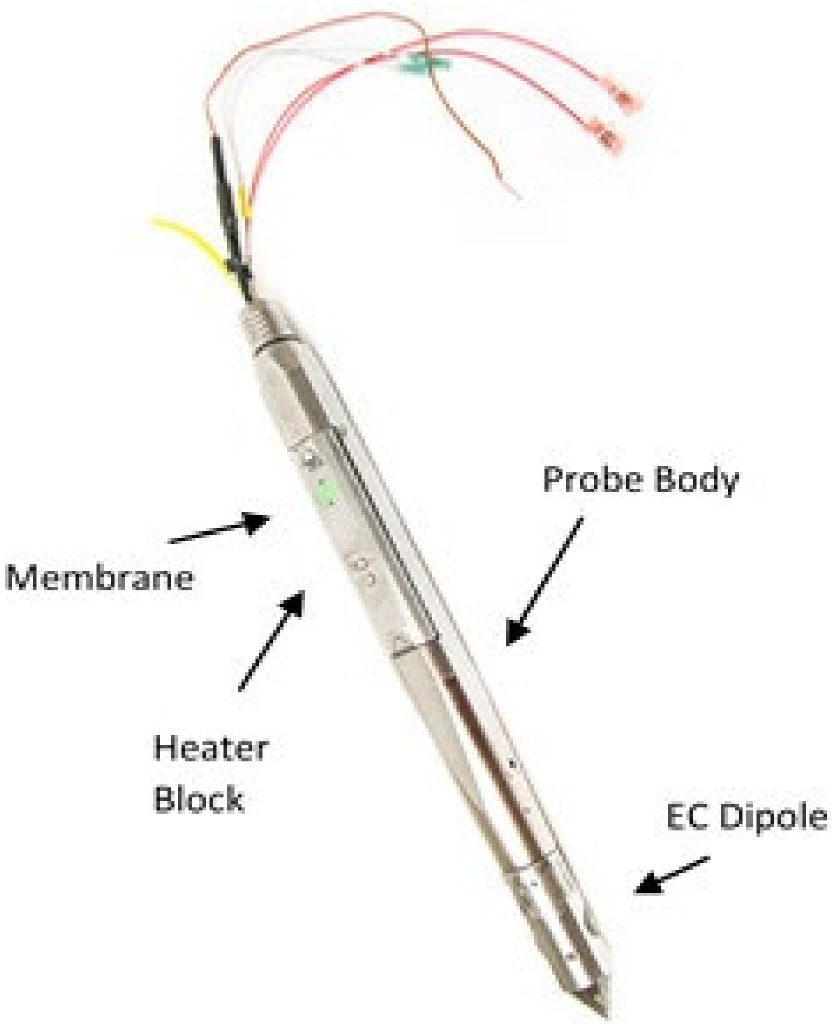
- Iterative work plans
- Soil and groundwater sampling
- Geologic and hydrogeologic testing
- Time consuming analysis of data
- Reporting followed by additional field sampling to complete delineation
- Poor differentiation between contaminant phases
- Poor characterization of subsurface heterogeneities

HRSC Tools for Petroleum Release Investigation

- **Direct Sensing Tools**
  - **Membrane Interface Probe (MIP)**
  - **Optical Imaging Profiler (OIP-UV & OIP-G)**
  - **LIF Ultra-Violet & Tar-Specific Green Optical Screening Tools (UVOST & TarGOST)**
  - **Electrical Conductivity (EC)**
  - **Hydraulic Profiling Tool (HPT)**

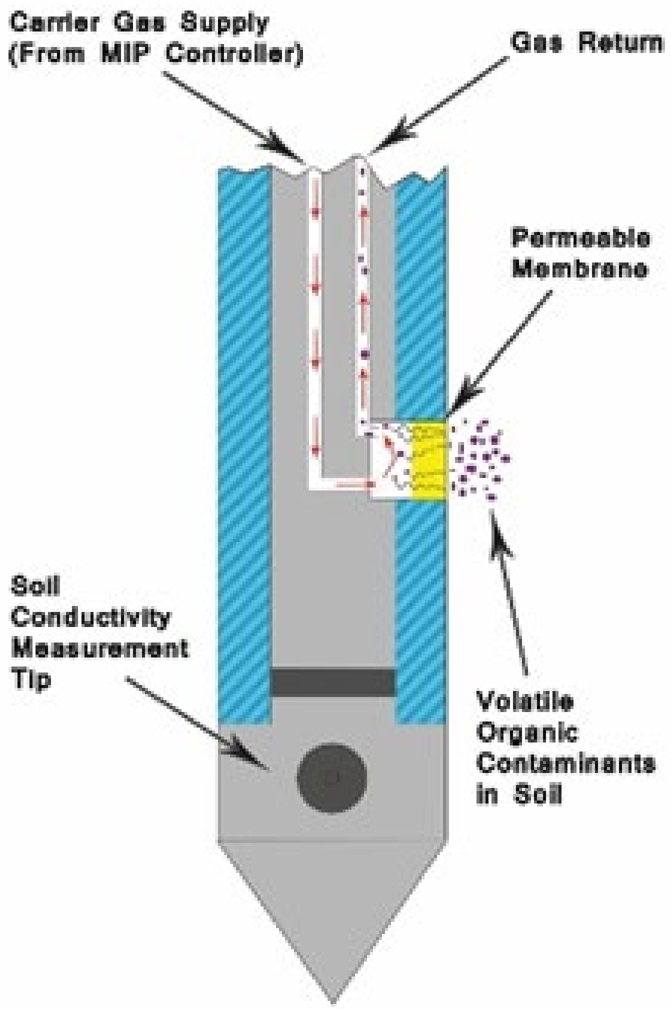
HRSC Tools for Petroleum Release Investigation

- **Membrane Interface Probe (MIP)**
  - Screening tool used to log relative concentration of VOCs with depth
  - Steel probe equipped with a semi-permeable membrane
  - Trunk line pre-strung through the drill rods that connects the probe to carrier gas and uphole sensors
  - Deployed with either percussion driven direct push machines or push-only (CPT)



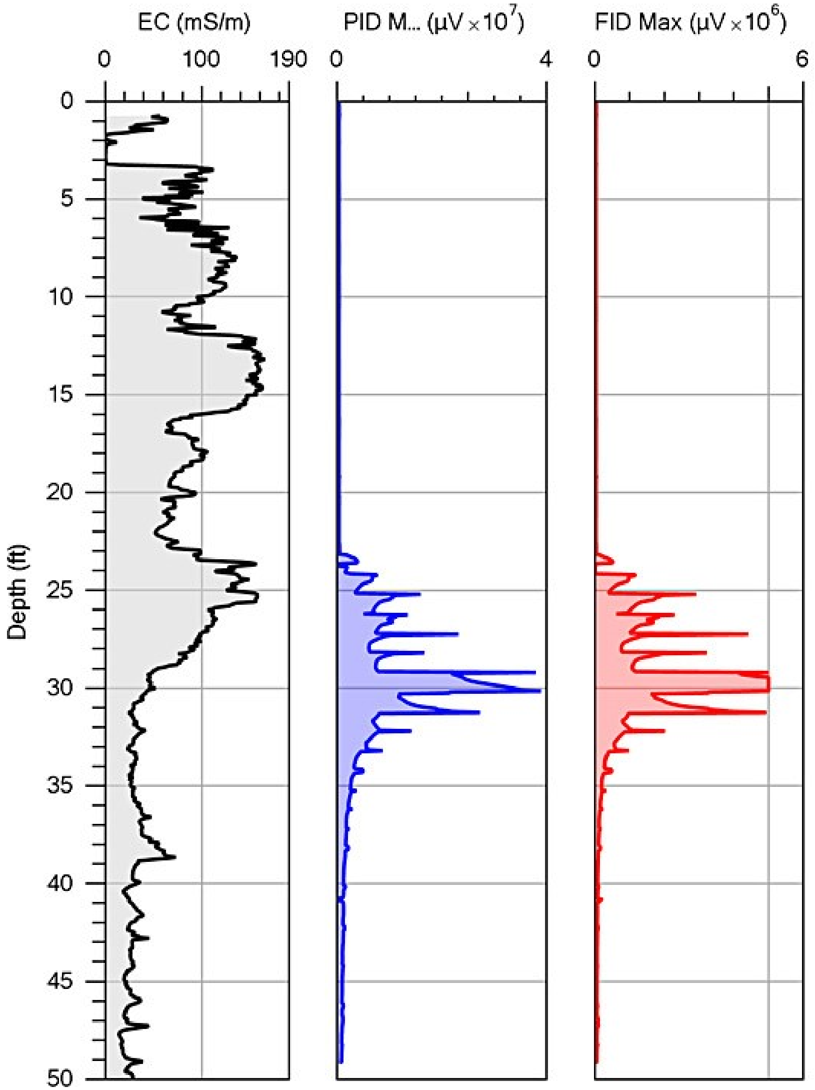
HRSC Tools for Petroleum Release Investigation

- **Membrane Interface Probe (MIP)**
  - Probe is advanced at 1-foot intervals
  - Volatilization of contaminants enhanced by heating the media adjacent to the heating block
  - VOCs released from the formation cross the membrane and enter the carrier gas flow where they are carried uphole to the detectors (PID, FID, XSD).
  - Typically coupled with EC or HPT



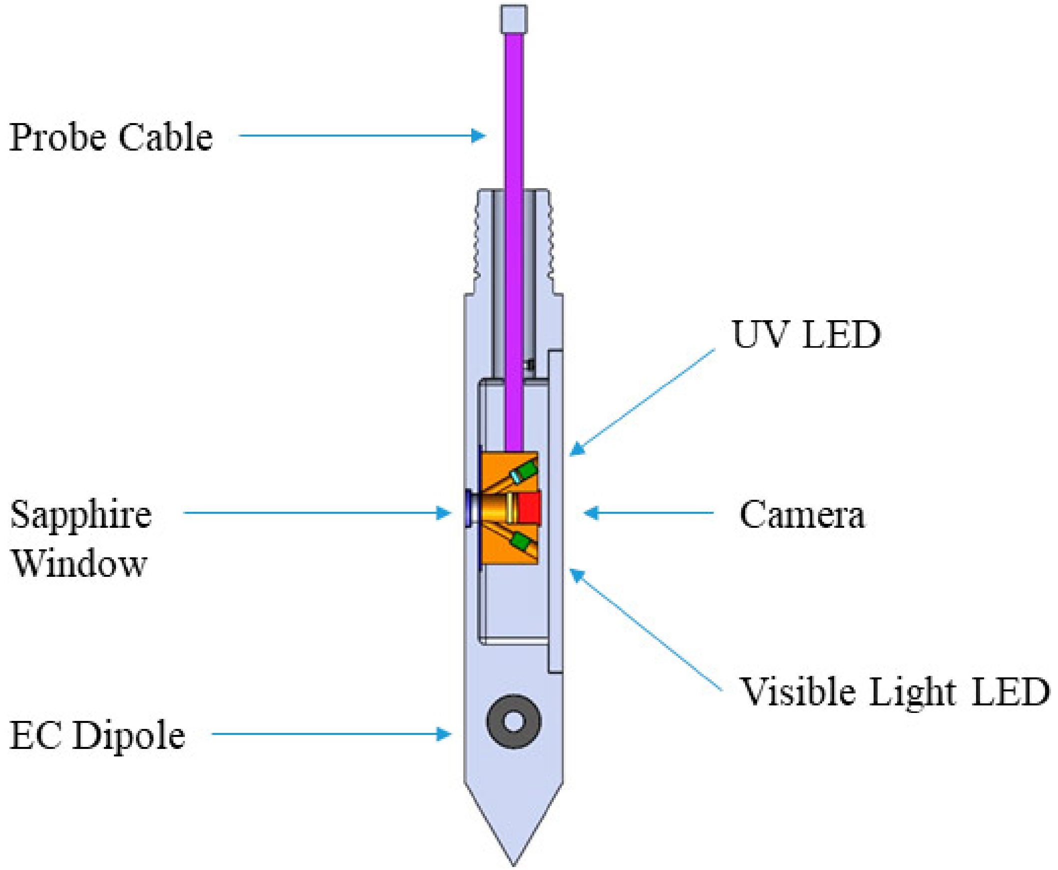
HRSC Tools for Petroleum Release Investigation

- **Membrane Interface Probe (MIP)**
  - Typical production rate of 100 to 300 feet per day
  - Grid layout with 30 foot initial spacing
  - Progress investigation “clean-to-dirty” to minimize system clean-up wait times
  - Confirmation soil and groundwater sampling recommended
  - Comparison of EC or HPT data to soil boring logs



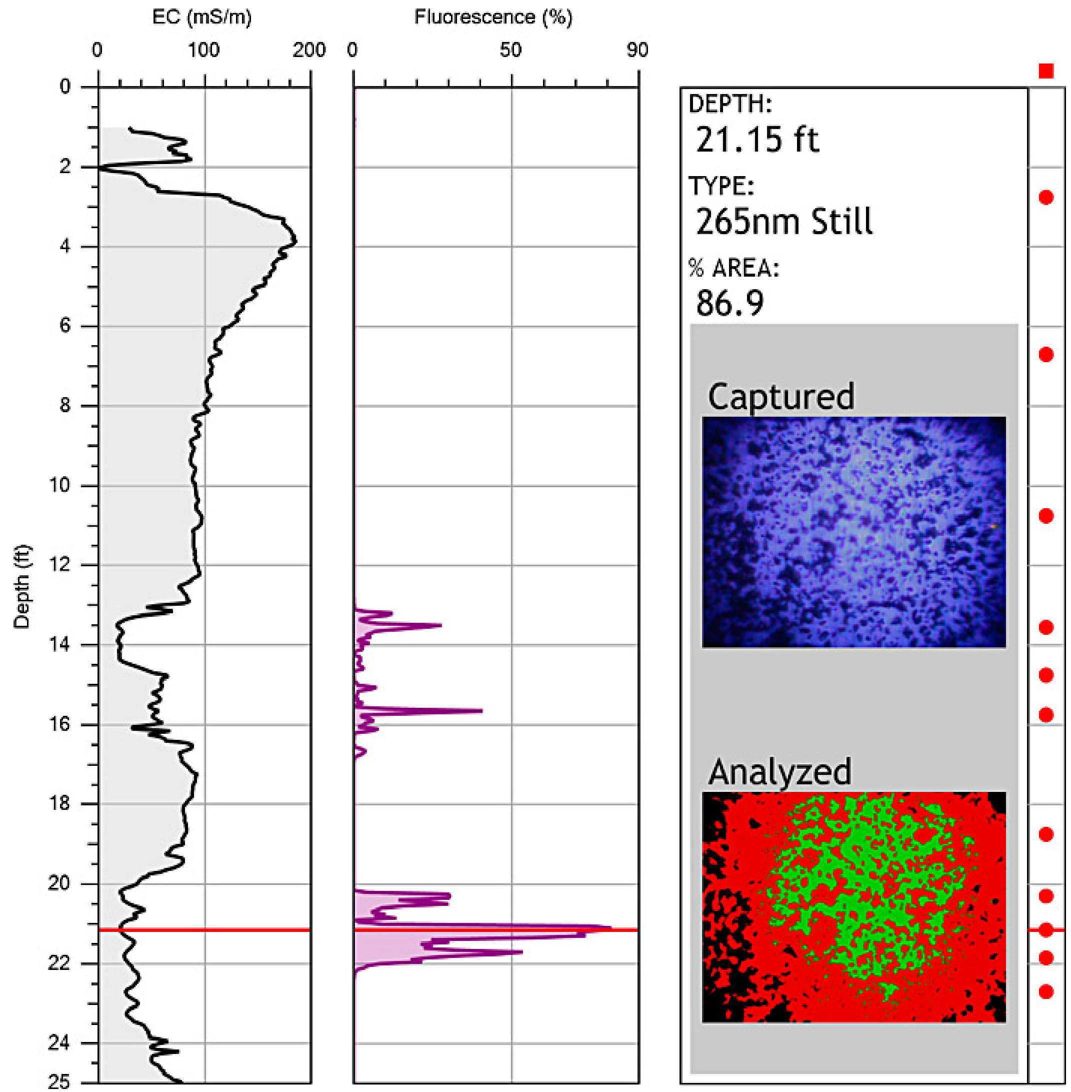
HRSC Tools for Petroleum Release Investigation

- ## Optical Imaging Profiler (OIP-UV)
  - Uses a combination of 275 nm UV LED, visible spectrum white light LED, and an integrated downhole camera
  - Advanced via direct push percussion probing or push only (CPT) methods
  - The camera captures images of fluorescence response at 30 frames/sec with one image saved for every 0.05 ft of probe advancement



HRSC Tools for Petroleum Release Investigation

- **Optical Imaging Profiler (OIP-UV)**
  - Can identify the presence and distribution of NAPL containing PAHs
  - Logs display percent area of fluorescence of the captured image
  - The average area illuminated (% fluorescence) per frame is calculated using multiple filtered frames from the 0.05 ft interval
  - Response in the visible light spectrum only, blind to UV range fluorescence response

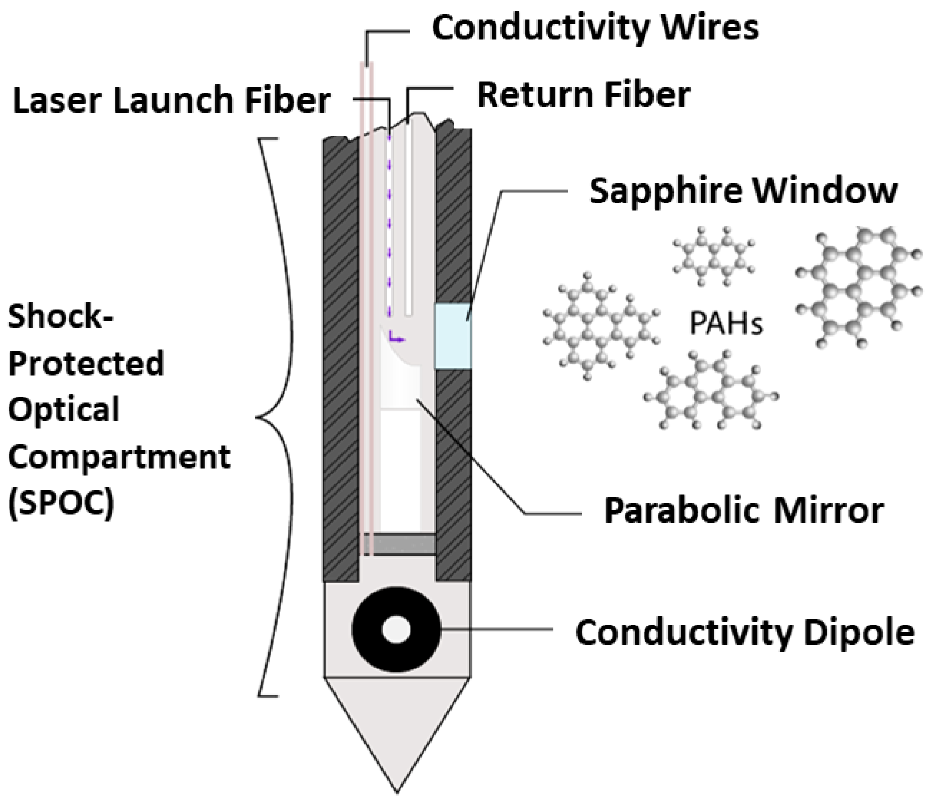


HRSC Tools for Petroleum Release Investigation

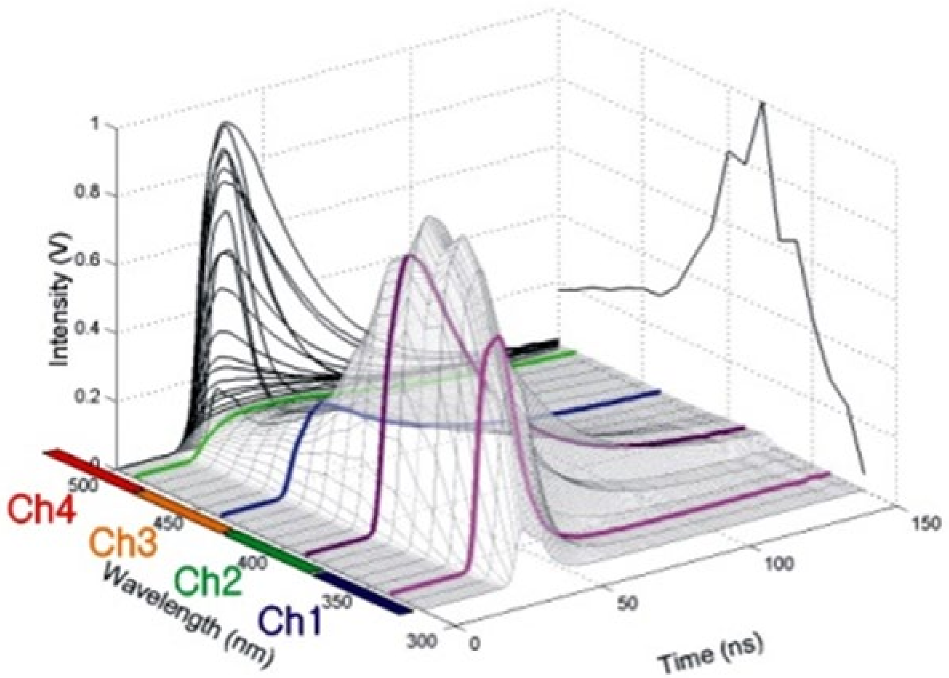
- **Optical Imaging Profiler (OIP-UV)**
  - Typical production rate of 150 to 300 feet per day
  - Grid layout with 30 foot initial spacing
  - Progress investigation “dirty-to-clean”
  - Confirmation soil and groundwater sampling recommended
  - Comparison of EC or HPT data to soil boring logs
  - Also available with a 520 nm green light LED (OIP-G) for detection of heavier NAPLs (creosote, coal-tars)
  - Does not differentiate product types

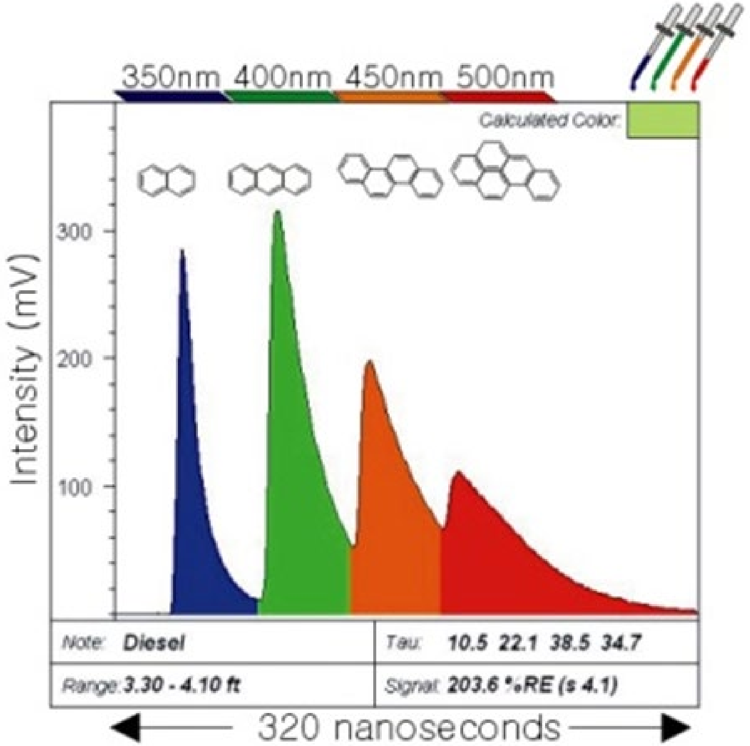
HRSC Tools for Petroleum Release Investigation

- **Ultra-Violet Optical Screening Tool (UVOST)**
  - Developed by Dakota Technologies in 1990's, widely known in the environmental industry as "LIF"
  - LIF excitation of PAHs
  - Direct sensing of mobile and residual LNAPL
  - Provides real-time data of fluorescence response vs. depth



- **Ultra-Violet Optical Screening Tool (UVOST)**
  - **OST translates fluorescence emission into a multi-wavelength waveform**



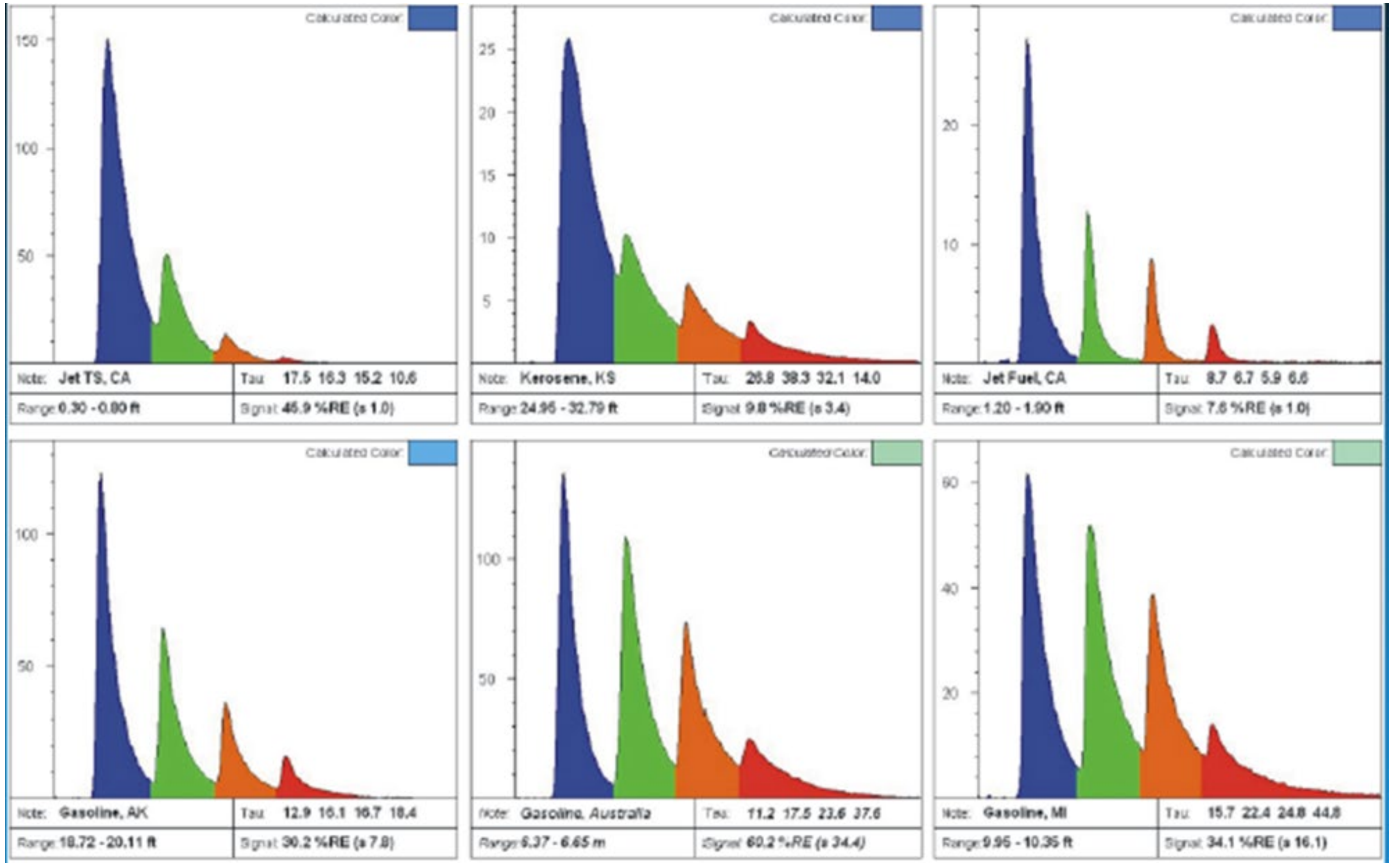


HRSC Tools for Petroleum Release Investigation

- **Ultra-Violet Optical Screening Tool (UVOST)**
  - **UOVST Output allows for differentiation of LNAPL types**

Jet fuel / kerosene

Gasoline

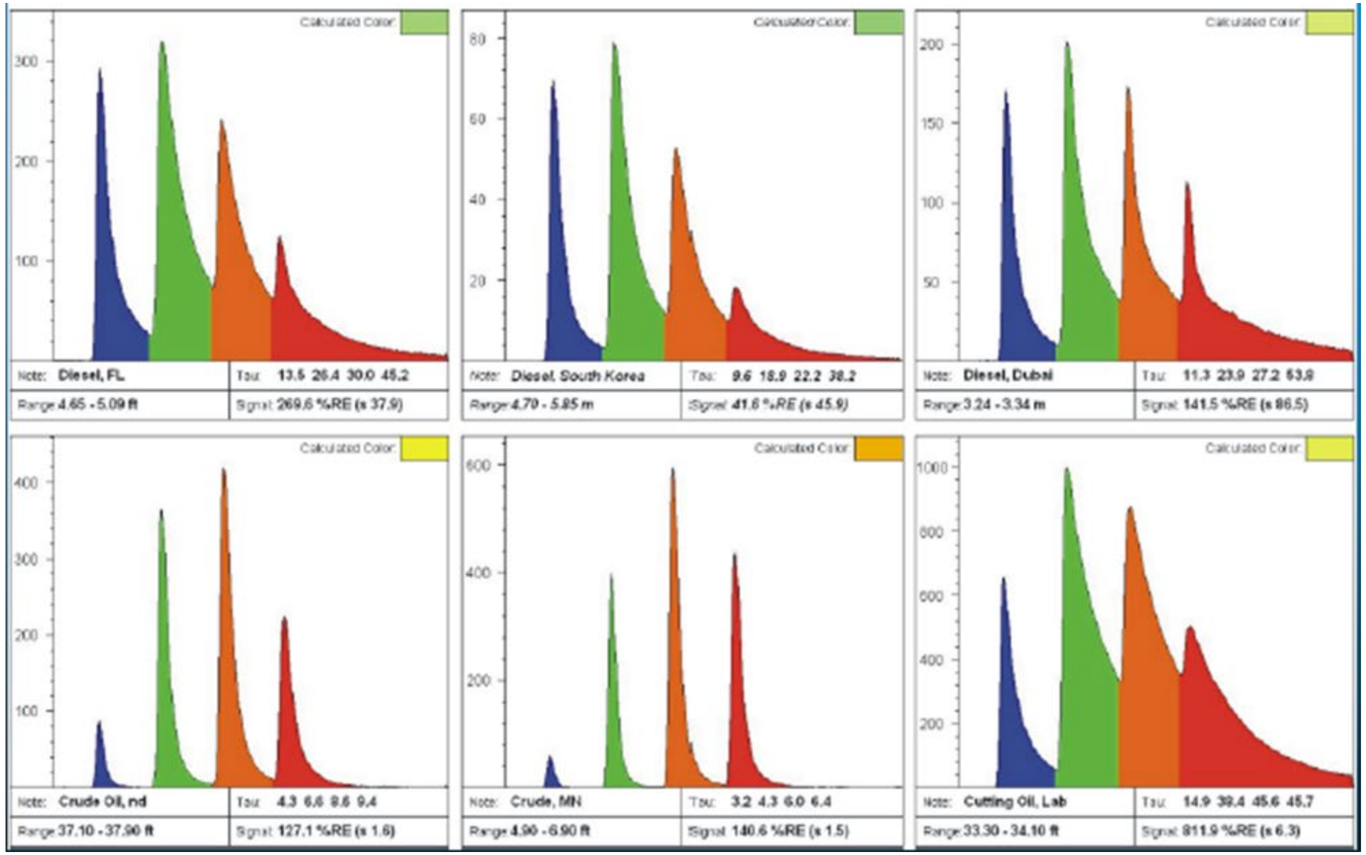


HRSC Tools for Petroleum Release Investigation

- **Ultra-Violet Optical Screening Tool (UVOST)**
  - **UOVST Output allows for differentiation of LNAPL types**

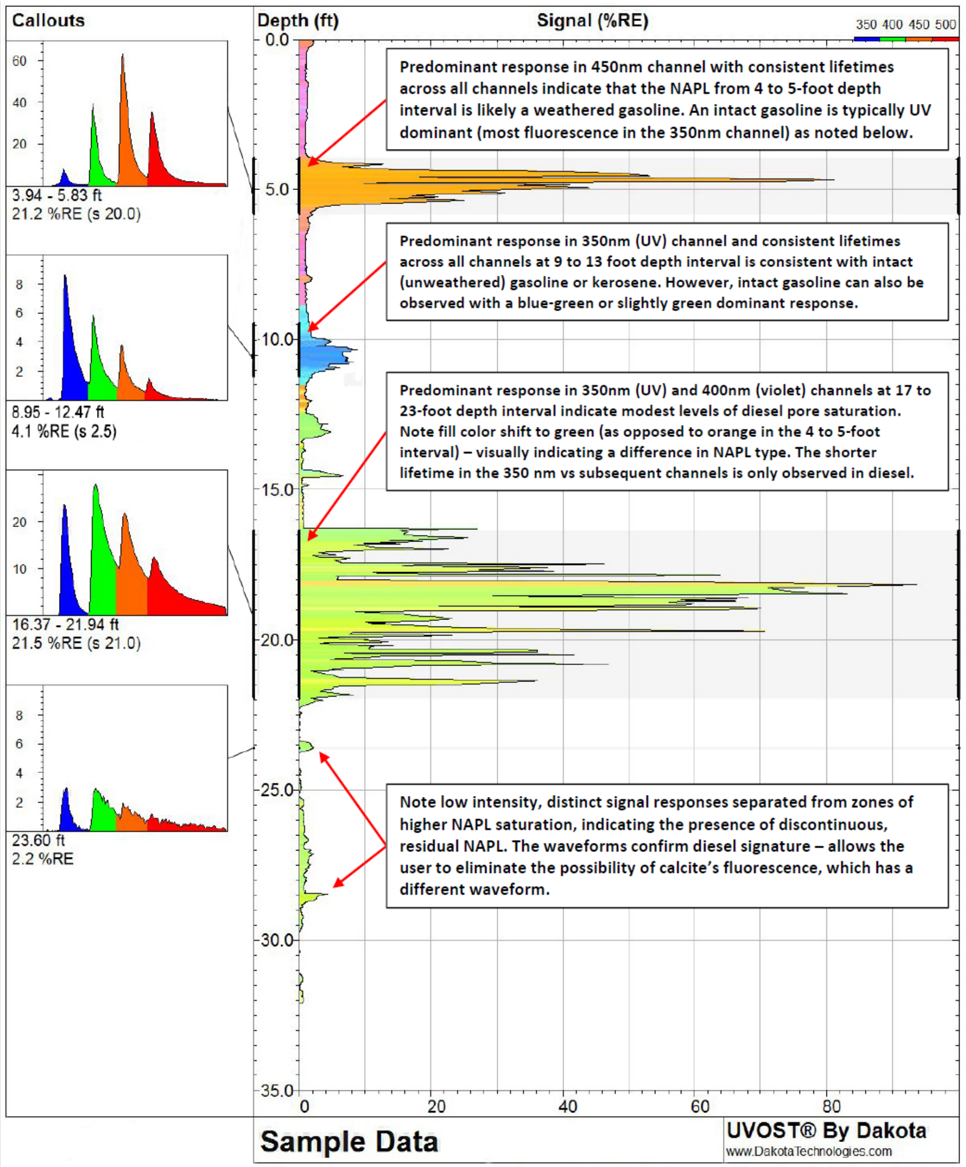
Diesels

Oils



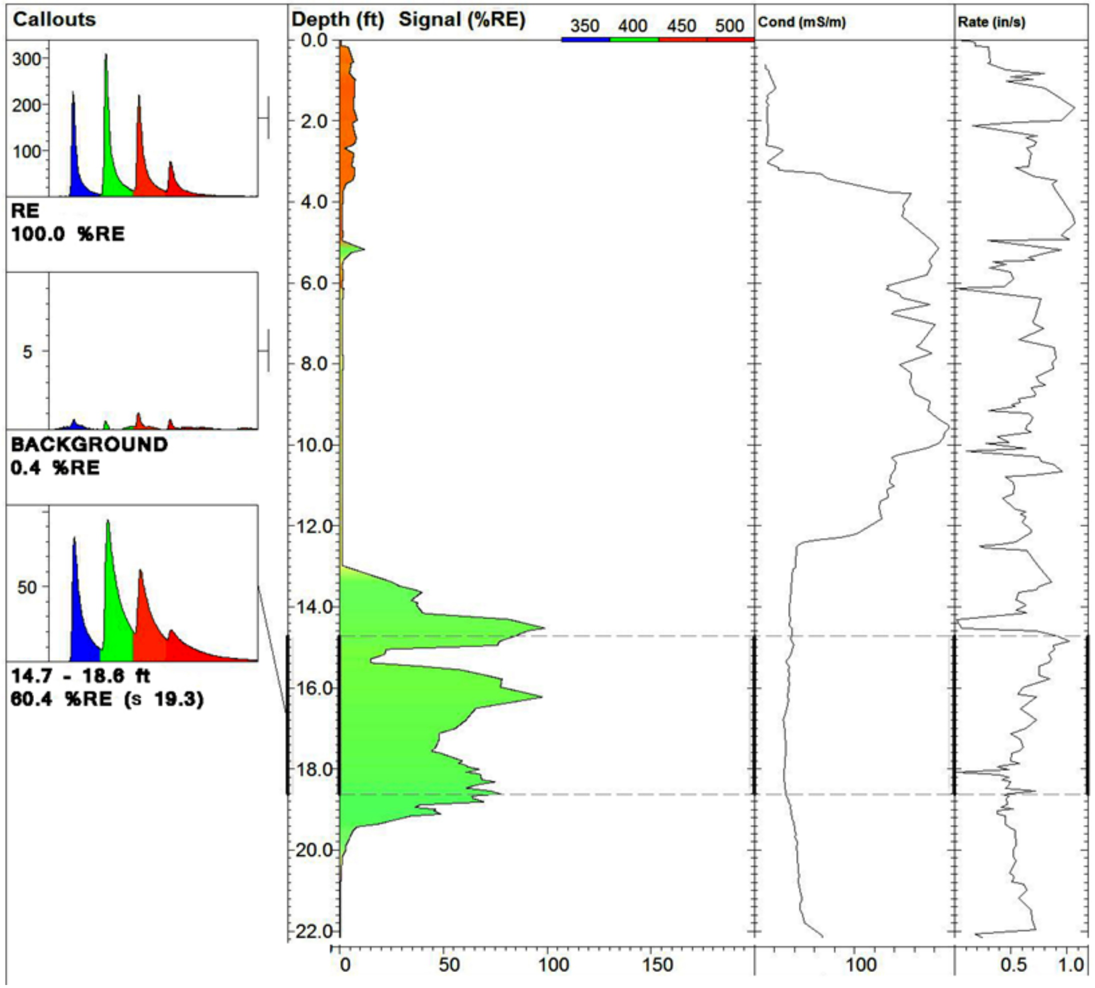
HRSC Tools for Petroleum Release Investigation

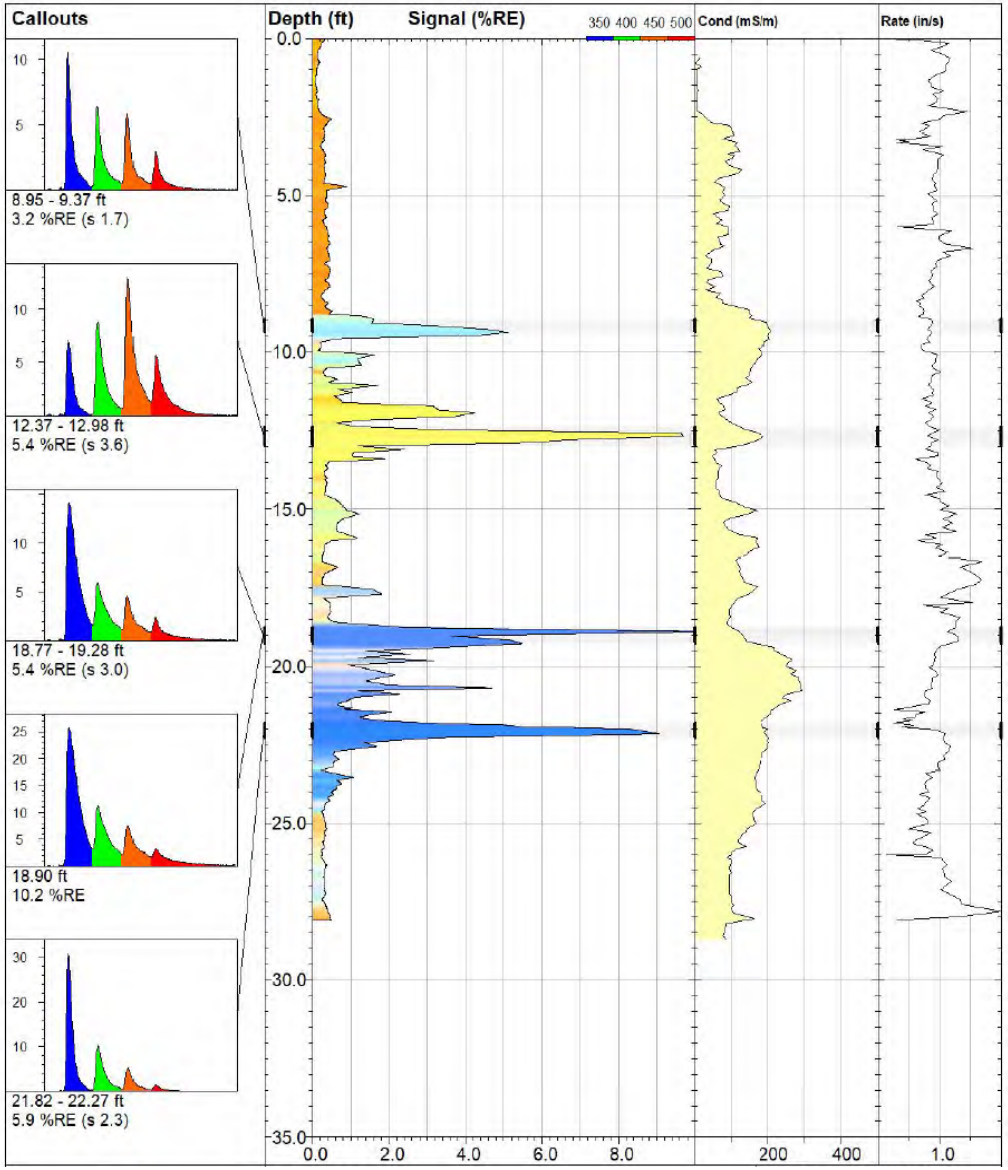
- **Ultra-Violet Optical Screening Tool (UVOST)**
    - Differentiates product types in real-time
    - Fluorescence displayed in %RE
    - Coupled with EC dipole or HPT



HRSC Tools for Petroleum Release Investigation

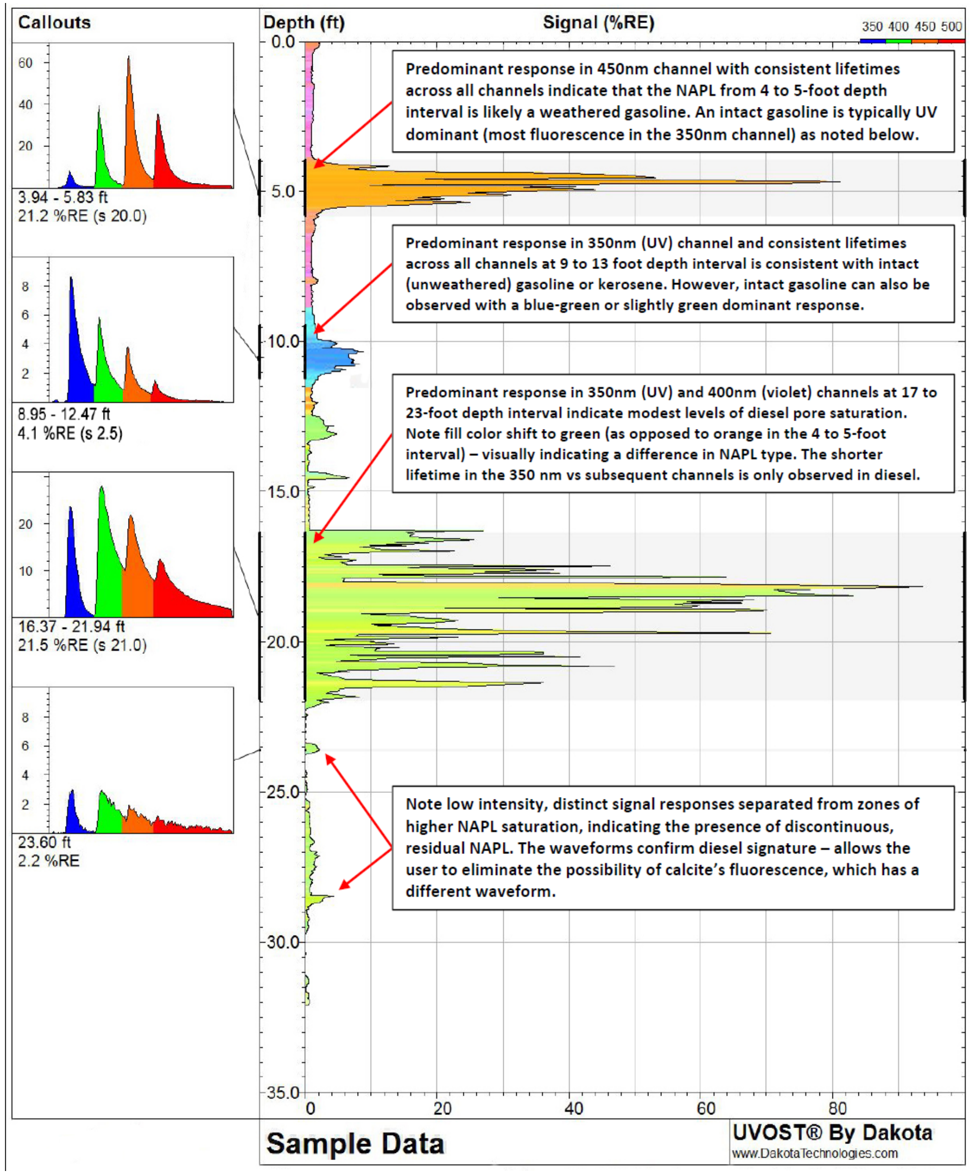
- **Ultra-Violet Optical Screening Tool (UVOST)**





HRSC Tools for Petroleum Release Investigation

- **Ultra-Violet Optical Screening Tool (UVOST)**
  - Typical production – 200 to 400 ft per day
  - Progress investigation “dirty-to-clean”
  - Grid layout with 30 foot initial spacing
  - Confirmation soil and groundwater sampling recommended

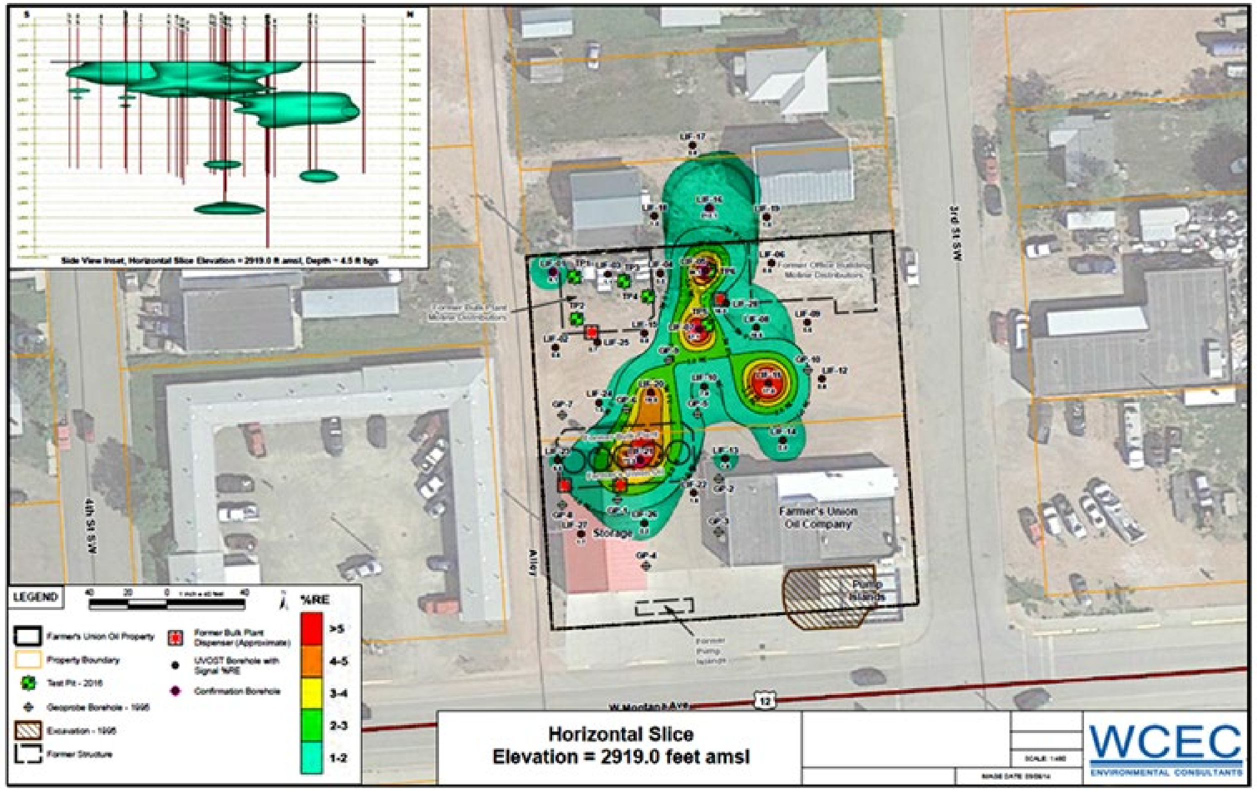


ASCT Summary

ASCT	Product Types	Lithology	Productivity (Ft / Day)	Limitations
MIP	VOCs	Direct push / hammerable only	100 - 200	High concentrations / LNAPL problematic. Limited distinction of product types.
OIP-UV	Light PAHs / LNAPLs	Direct push / hammerable only	150 - 300	Cannot differentiate product types. False positives from naturally occurring materials.
OIP-G	Heavy PAH / LNAPLS (creosote/coal tars	Direct push / hammerable only	150 - 300	Cannot differentiate product types. False positives from naturally occurring materials.
UVOST	Light PAHs / LNAPLs	Direct push / hammerable only	200 - 400	False positives from naturally occurring materials.
TarGOST	Heavy PAH / LNAPLS (creosote/coal tars	Direct push / hammerable only	200 - 400	False positives from naturally occurring materials.

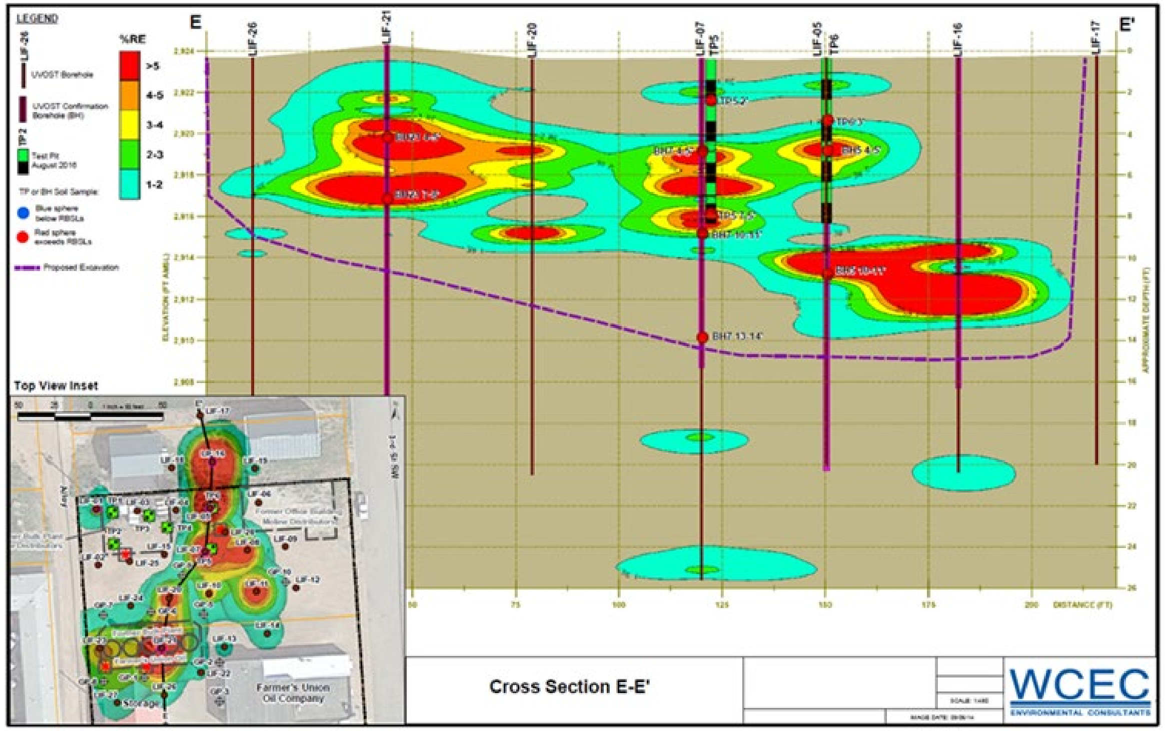
HRSC – When & Where?

- **Initial RI at high-risk sites for rapid advancement of the CSM**
- **To alleviate CSM data gaps when receptors are threatened or impacted**
- **Informed Remedial Design**
- **ITRC *ASCT Selection Tool & ASCT Direct Sensing Checklist***



Structuring a Successful HRSC Investigation

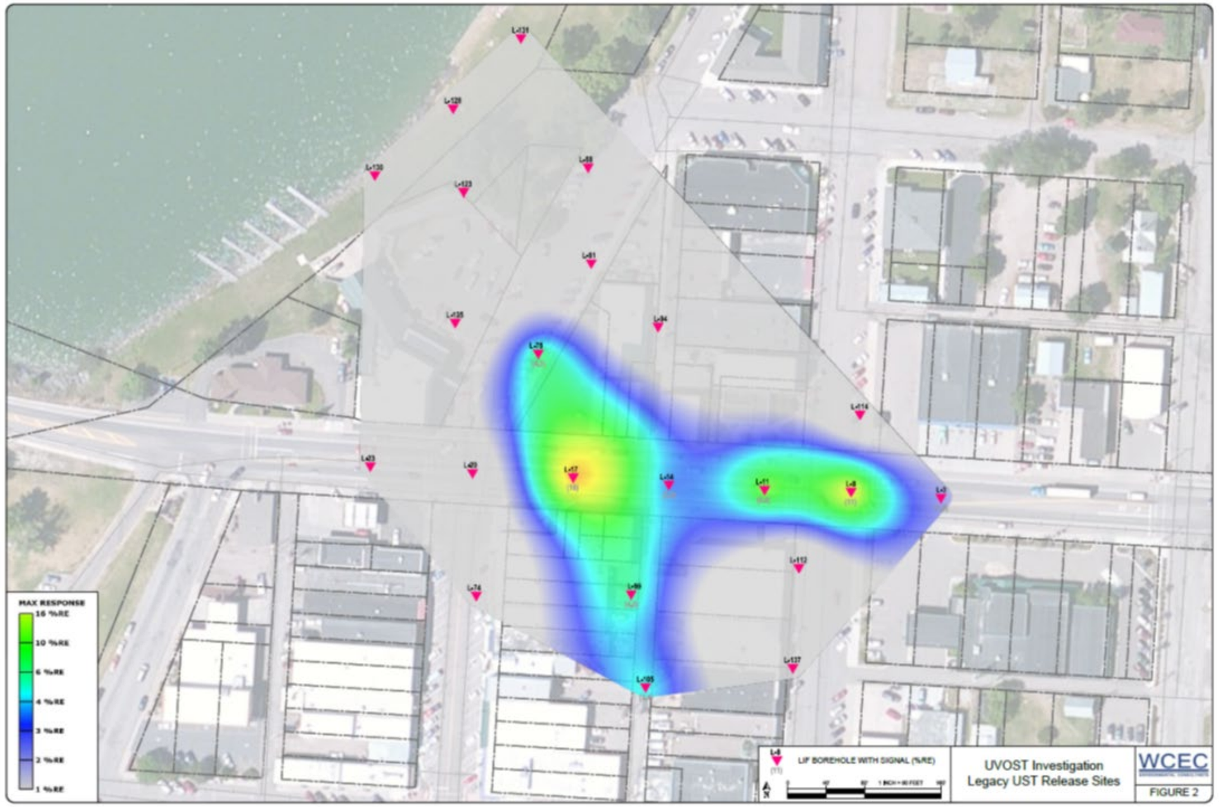
- **Goal of HRSC Investigation**
  - **To define the extent and magnitude of horizontal and vertical contaminant distribution, particularly LNAPL distribution**
- **HRSC Investigation Planning**
  - **Discuss your project with the HRSC provider to assist with tool selection and investigation design**
  - **Learn the technology before going into the field**
  - **Be prepared to expand the investigation**
  - **Understand the data necessary for CSM visualization**



Structuring a Successful HRSC Investigation

HRSC Investigation Basics:

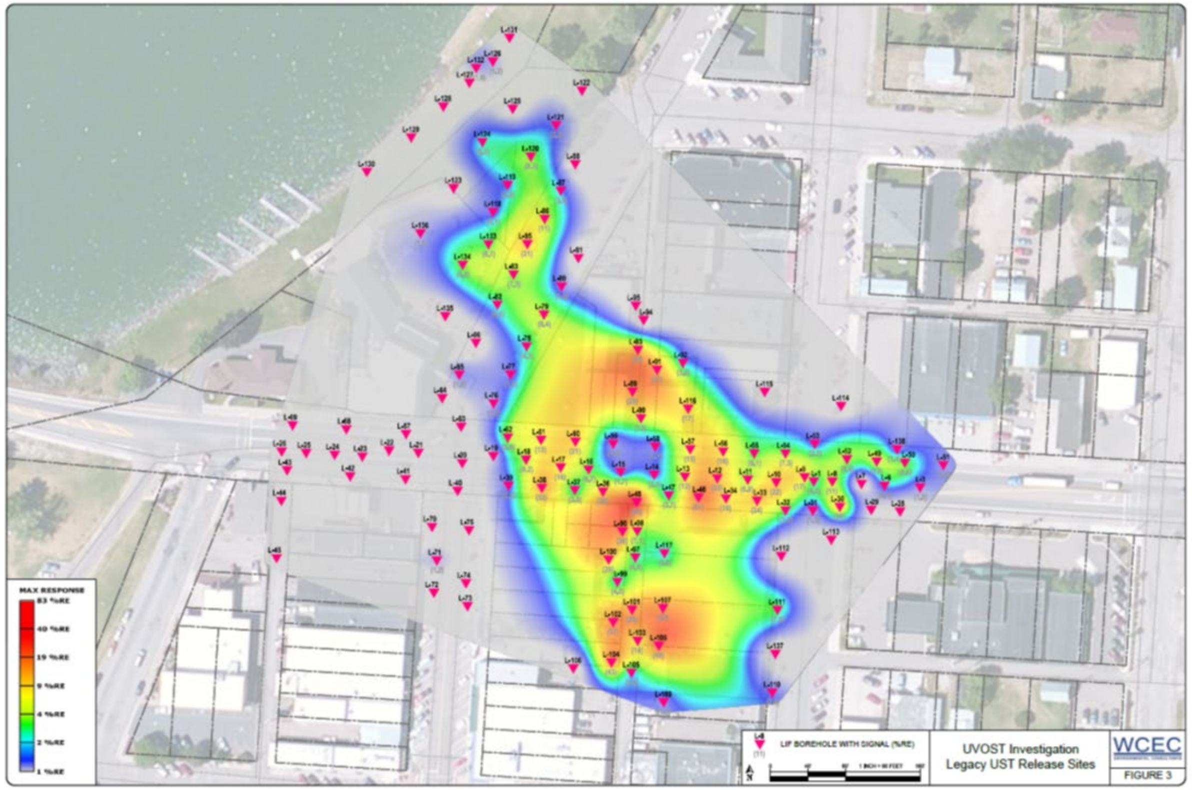
- Start with 30-foot grid spacing with borings extending to at least 10’ below the groundwater surface
- Advance initial borings in areas known to have the highest impacts
- Use source area response and / or waveforms to help guide the investigation
- Maintain consistent terminal boring depths
- Use real time data to inform decision process and progress the investigation
- Define the horizontal and vertical boundaries. In-fill with additional borings for higher resolution data within the source area or LNAPL body.



Structuring a Successful HRSC Investigation

HRSC Investigation Basics:

- <u>Non-Detects Are Your Friend!</u>
  - Non-detect borings or depth intervals allow for “bounding” of the plume and are critical in truly defining extent and magnitude.
- Correlate EC or HPT logs with continuous soil cores for lithology
- Accurately map the vertical and horizontal locations of each boring relative to site features (buildings, utilities, etc.)
- Collect a variety of correlative samples from each identified product type and from a range of response intensity
- Implement multiple HRSC tools “HRSC Toolkit” method

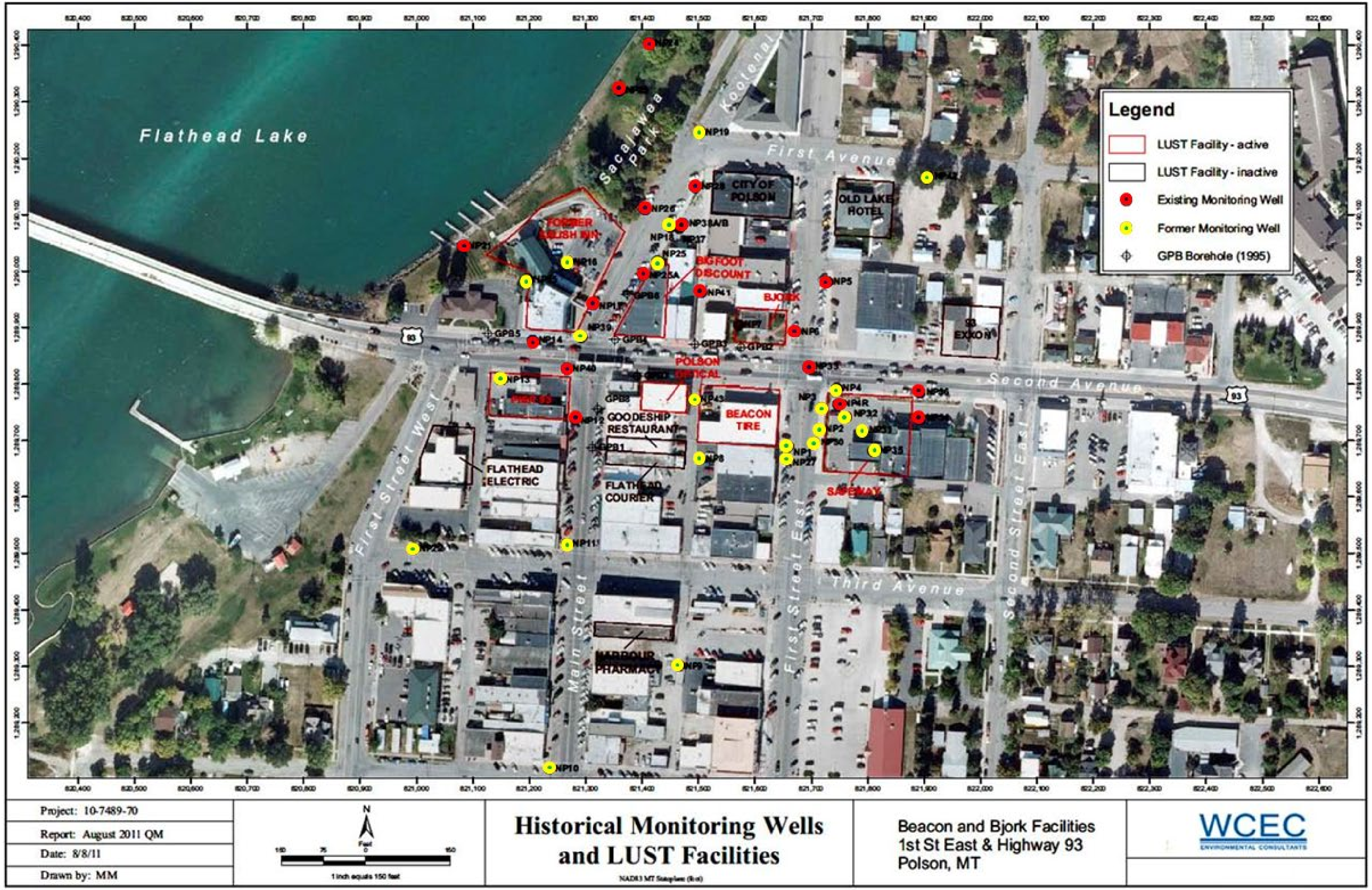


HRSC Investigation Case Study

Project Background Information

- Legacy petroleum release site in downtown Polson, 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

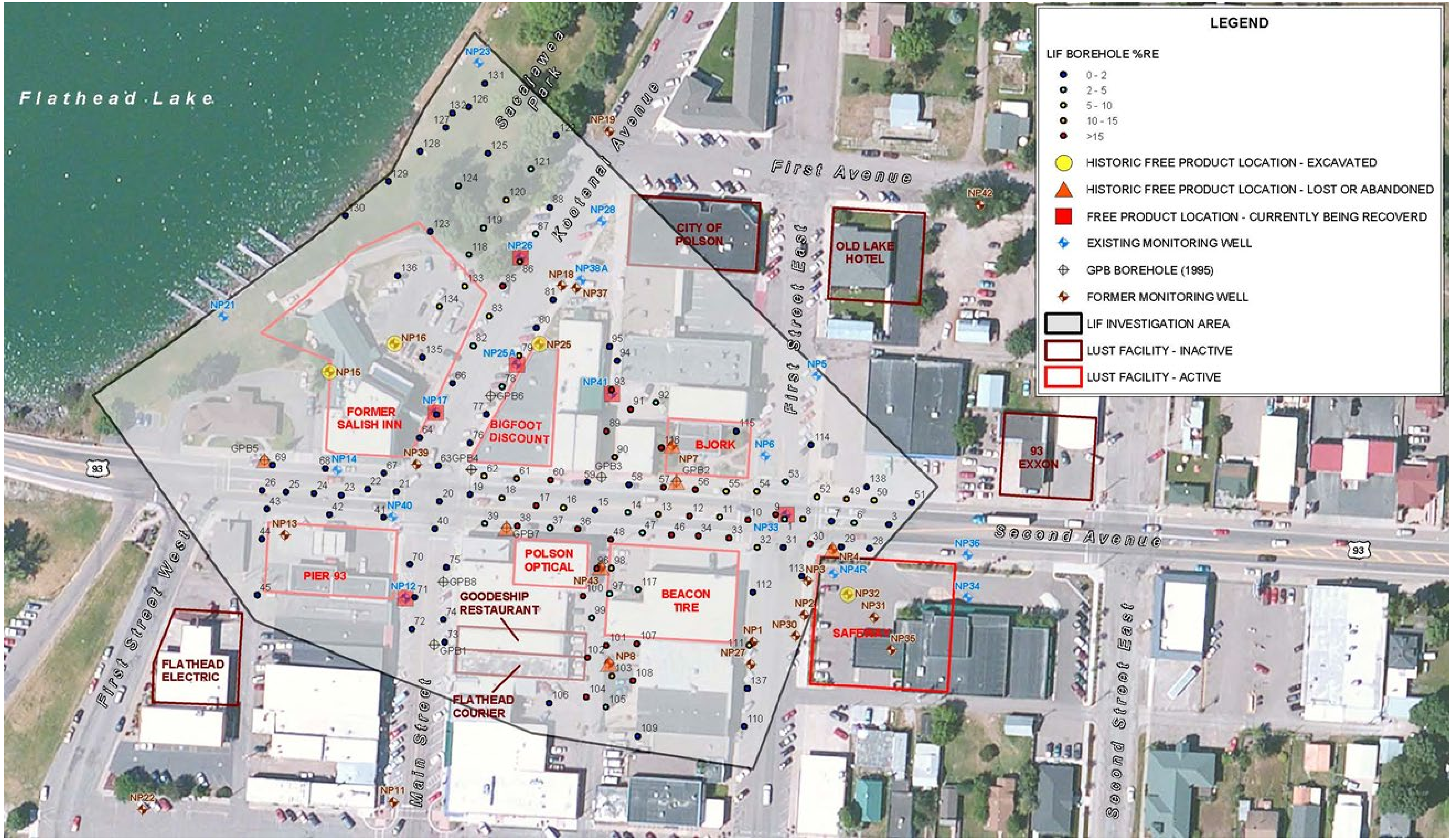
HRSC Investigation Case Study



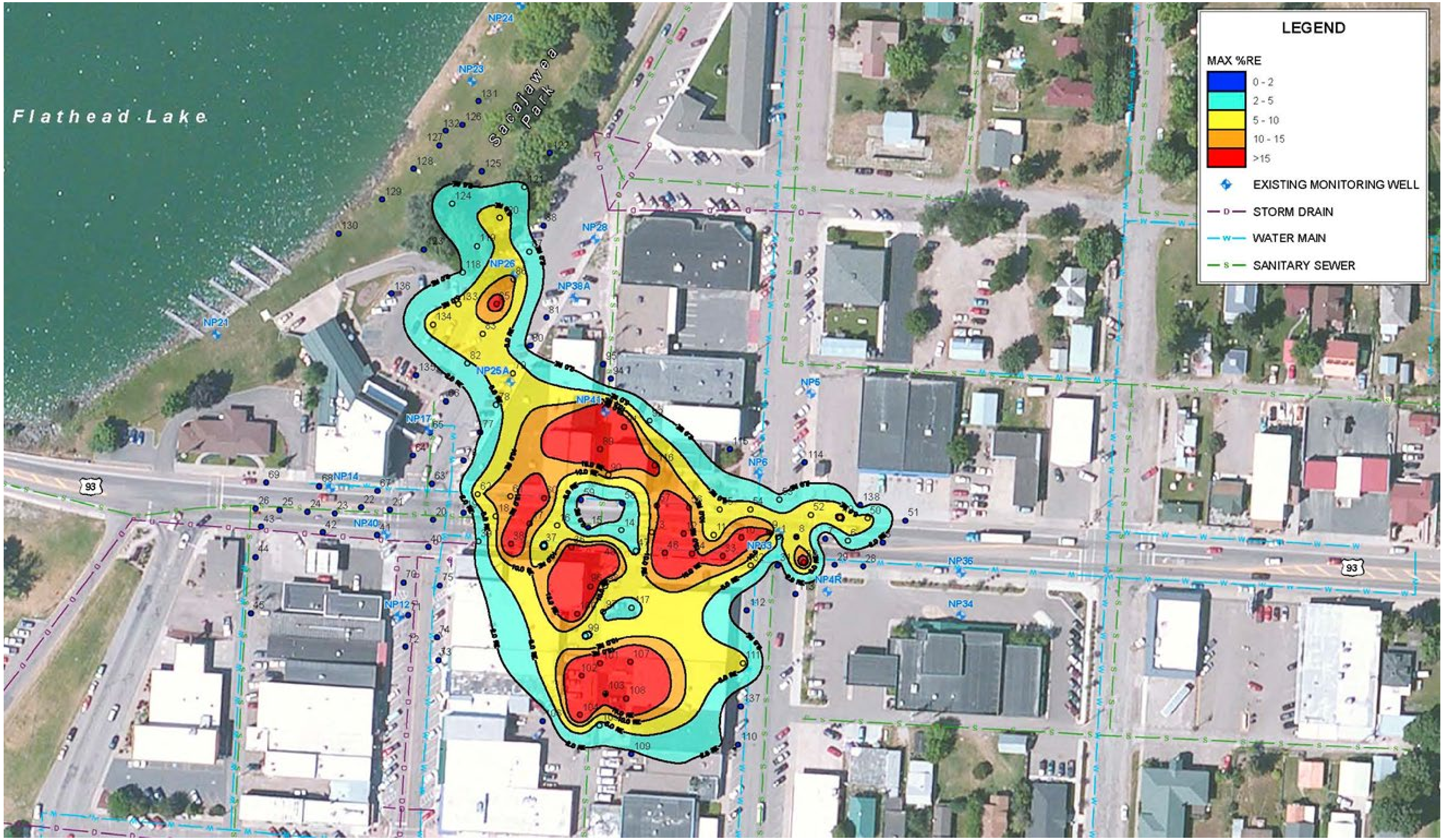
HRSC Investigation Details

- 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
- 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

HRSC Investigation Case Study



HRSC Investigation Case Study



HRSC Investigation Case Study

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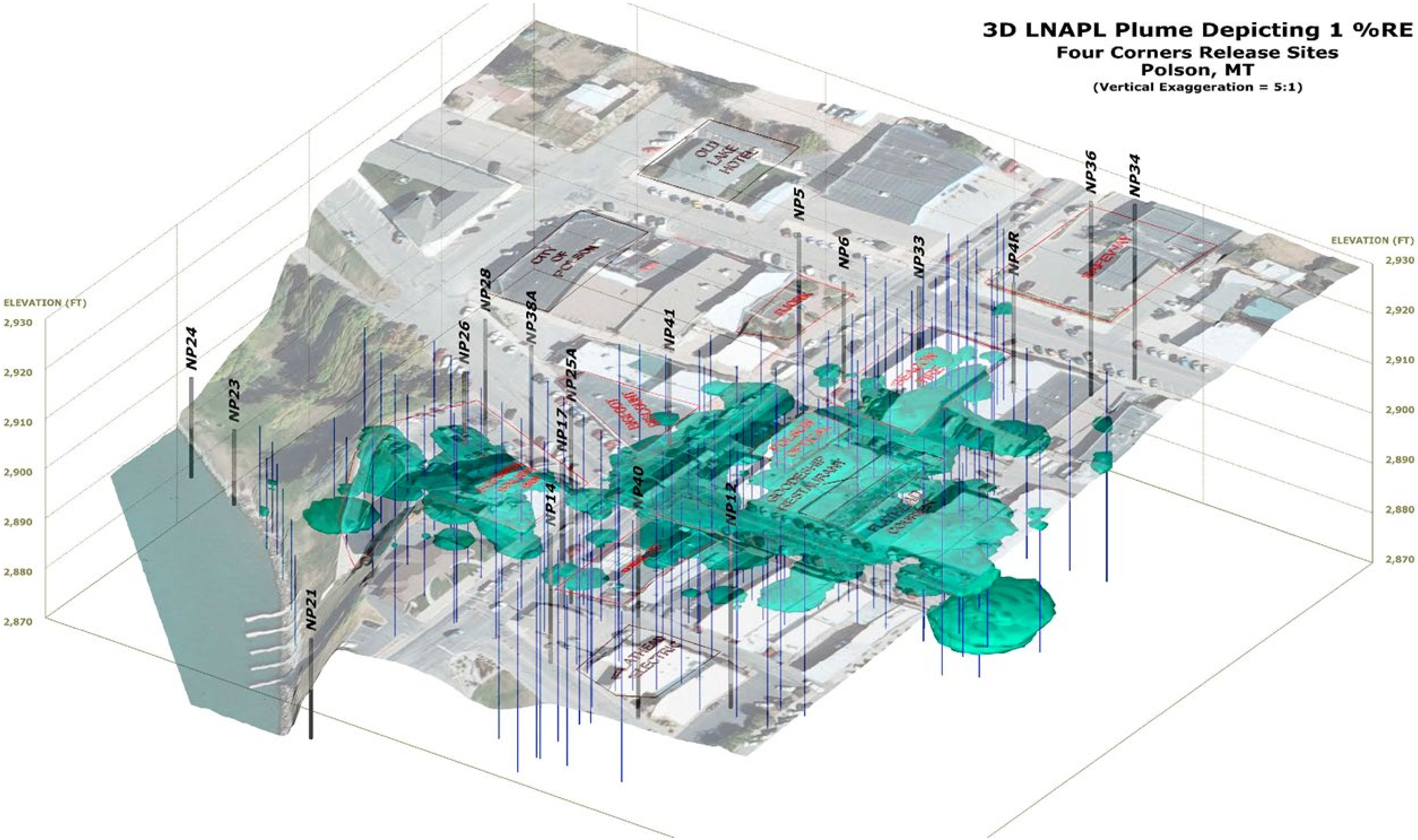

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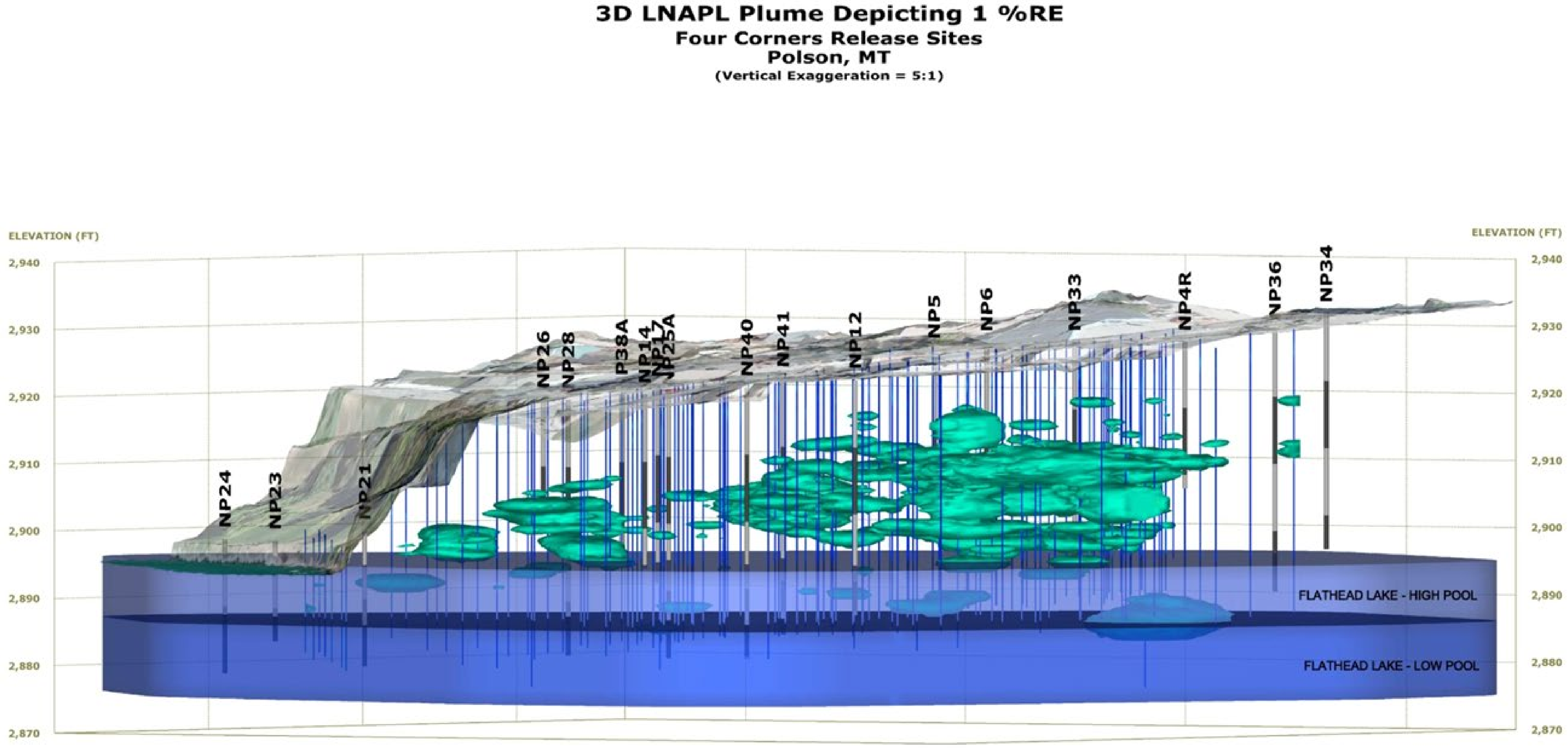
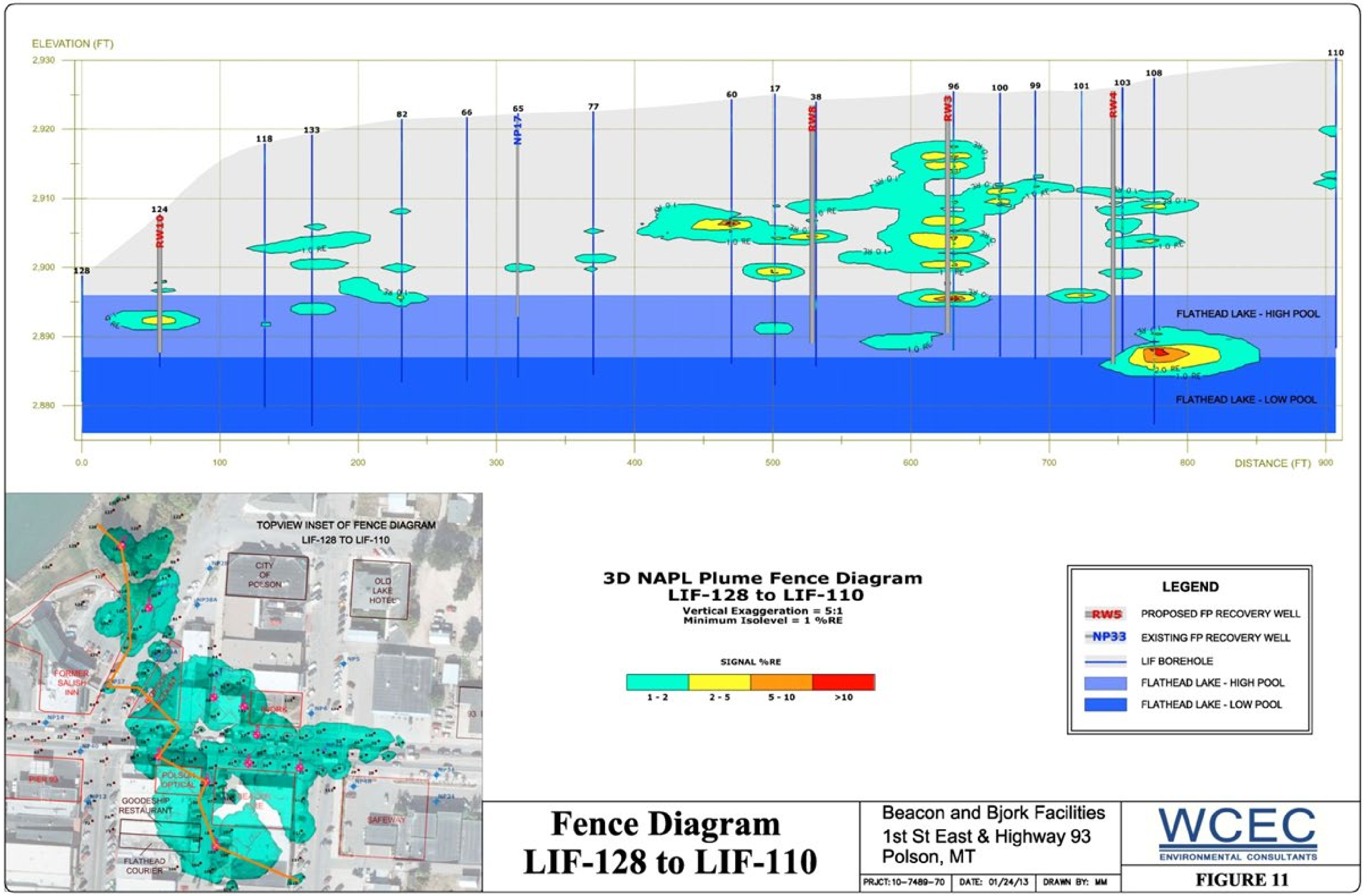
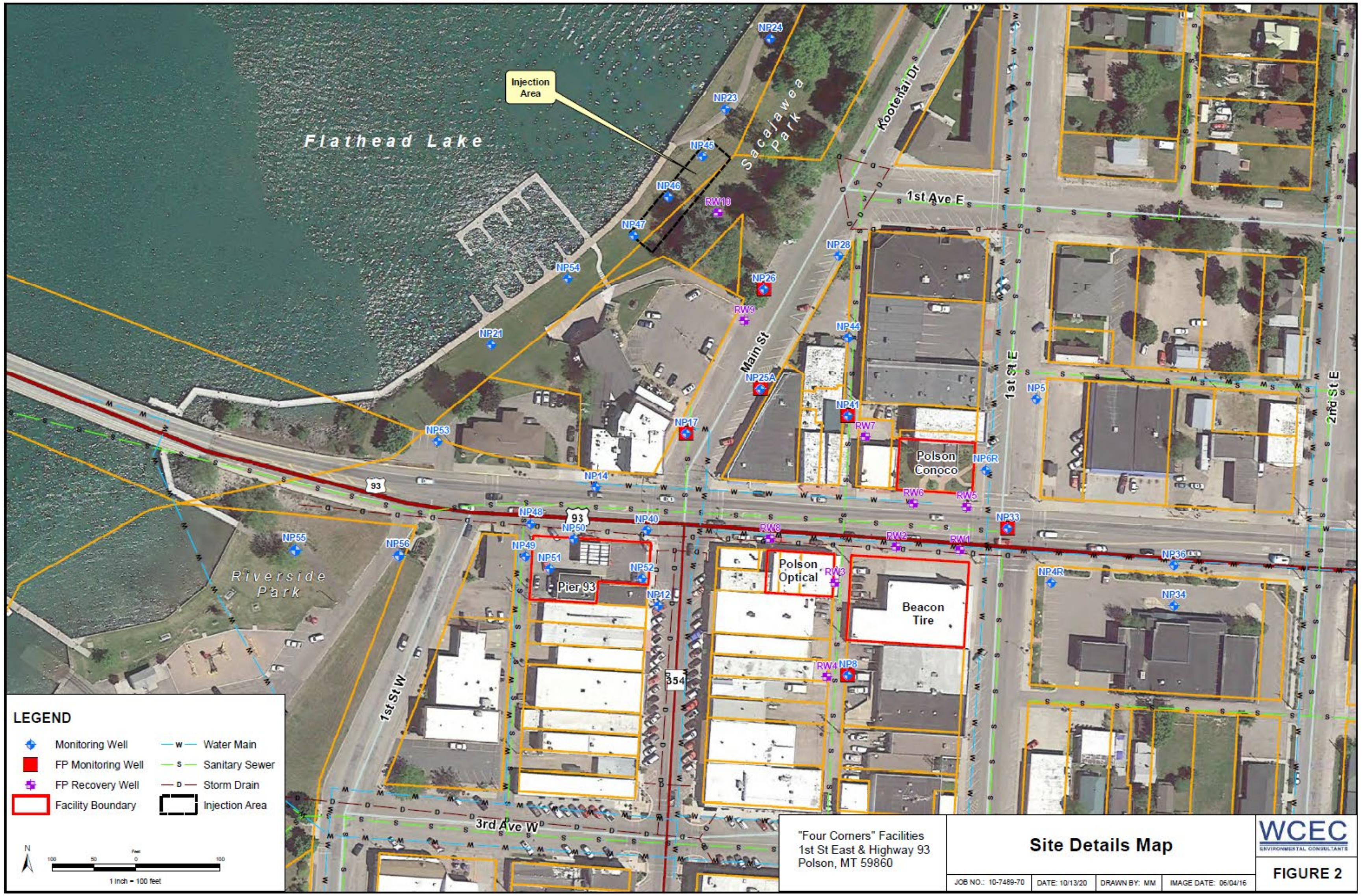


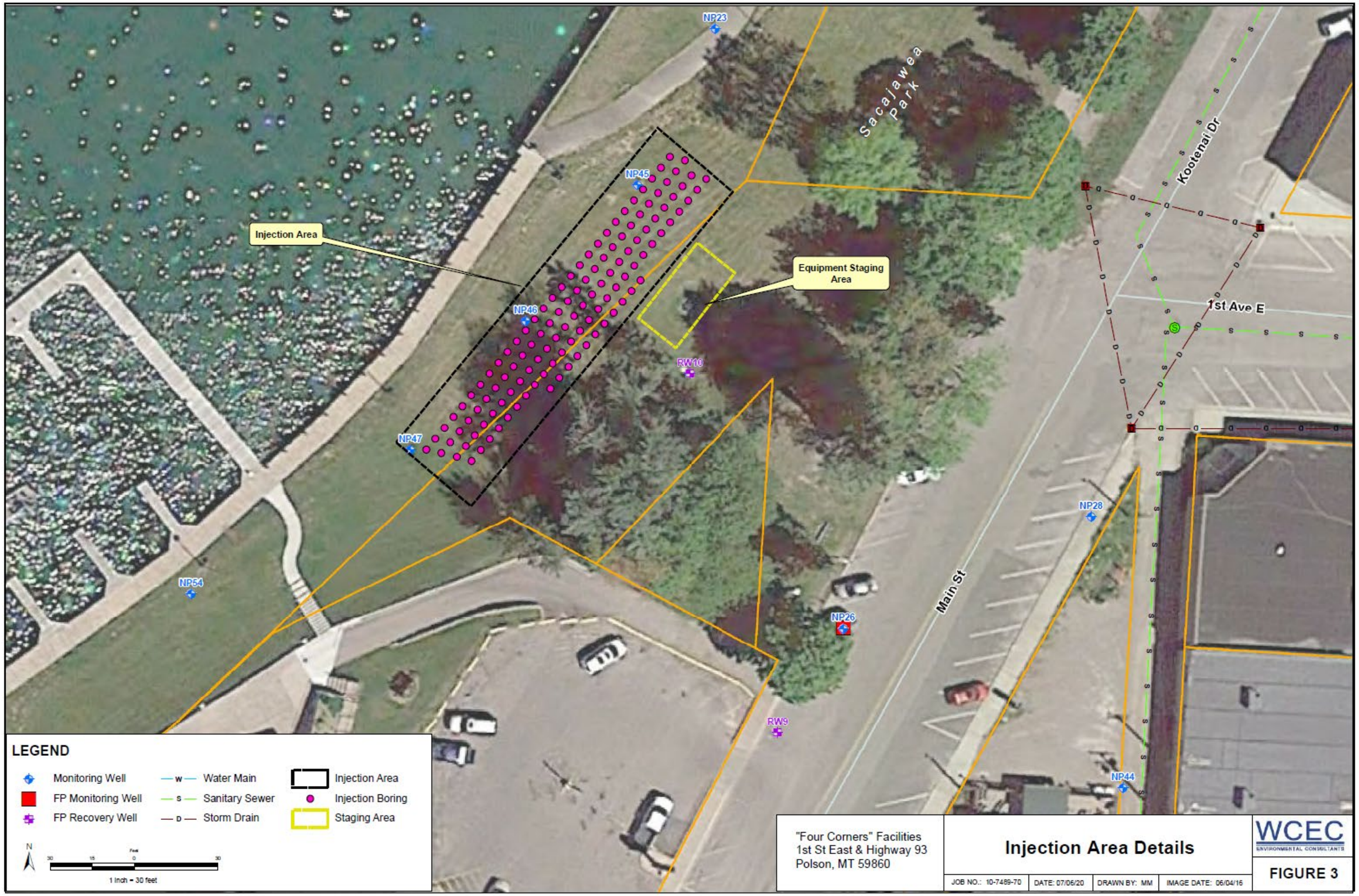
HRSC Investigation Case Study



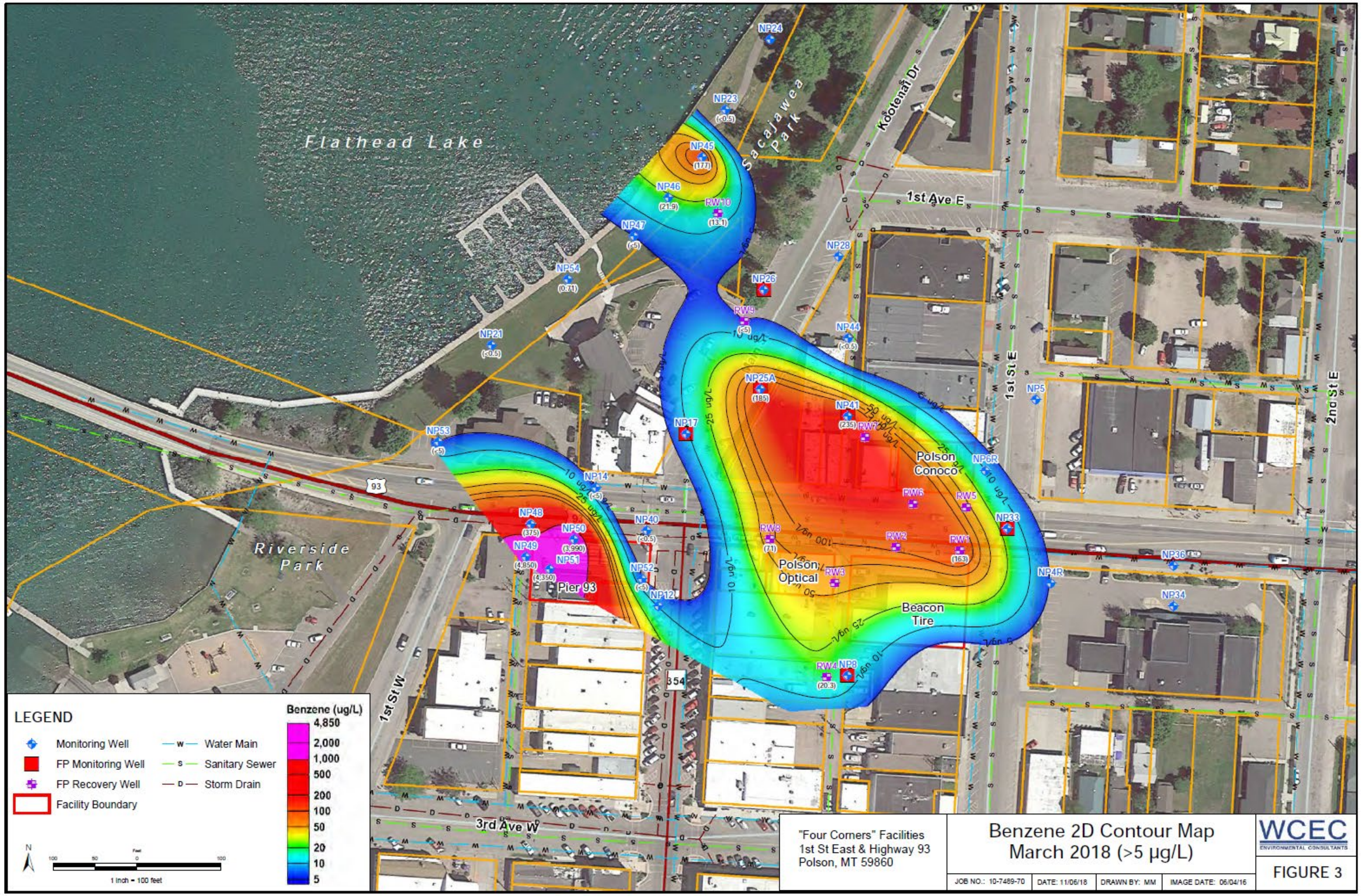
HRSC Investigation Case Study



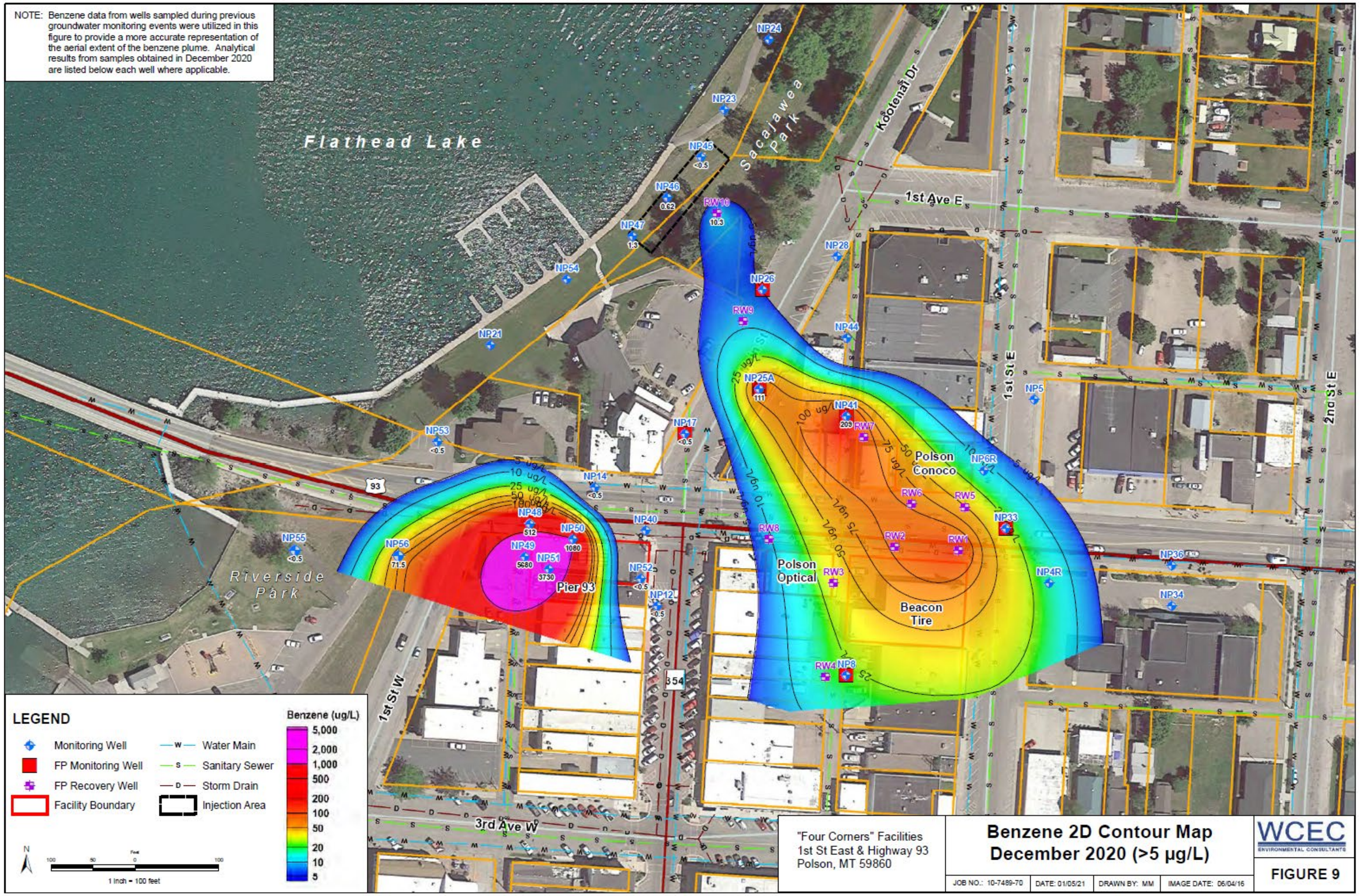
HRSC Investigation Case Study



HRSC Investigation Case Study



HRSC Investigation Case Study



HRSC 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 $1MM and were not successful in delineating plume
- Greatly advanced the CSM through collection of detailed LNAPL distribution, geophysical (EC) and geospatial data
- Background information and thorough planning was key in understanding the HRSC data needed for CSM development
- Provided HRSC data for targeted remedial design

References & Questions

- **Questions?**

- **References:**
  - **ITRC:** Implementing ASCTs
  - **Dakota Technologies – UVOST:** Dakota Intro to UVOST & LIF
  - **GeoProbe Systems – OIP:** OIP | Geoprobe Systems® Fluorescence Detector
  - **Dakota Technologies – MIP:** Membrane Interface Probe (MIP) & MiHpt