

# Thorough Site Investigation is Critical for Developing Effective Cleanup Strategies

## *Case Study of a Major Petroleum Release at a Western Kentucky UST Site*

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# Introduction

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- Background
- Site Investigation Toolbox
- What is HRSC?
- Why HRSC?
- HRSC Tools/Methods
  - Hydraulic Profiling Tool
  - LIF-UVOST
  - Electronic Conductivity
  - High Resolution Sampling & Analysis
- HRSC: Tool/Method-Application through Remediation
- Lessons Learned & Considerations



# THE “SITE INVESTIGATION TOOLBOX”

HRSC technologies provide important, data-specific tools bolstering our site-characterization **toolbox**.



HRSC tools should be teamed with “traditional” site-characterization tools to **target** the source-area, monitoring locations, sampling locations, receptors, etc.



# WHAT IS HRSC?

## High-Resolution Site Characterization

HRSC refers to intrusive environmental site-characterization tools and procedures

HRSC tools are designed to efficiently collect real-time, scale-appropriate, site-specific, physical & chemical environmental data.

HRSC tools/procedures **are not** a replacement for “*traditional*” site-characterization tools, methods & strategies.



# WHY HRSC?

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## Reinforce/Update Conceptual Site Model (CSM)

- Qualitative & Quantitative data collection & evaluation
- Dense-array of real-time data points
- Minimize data-gaps
- Confirm contaminant nature & extent
- Characterize site-specific soil-lithology & hydrogeologic characteristics
- Discrete HRSC sampling/analyses

# WHY HRSC?

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- Quantify contaminant-mass
- Evaluate geology/lithology influence on mass-transport & plume geometry
- Targeted Site Cleanup
  - Evaluate remedial-strategies (Treatment Train?)
  - Targeted remedial-design
- Site Closure

# THREE HRSC TECHNOLOGIES

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## **Laser-Induced Fluorescence/Ultra-Violet Optical Screening Tool<sup>®</sup> (LIF/UVOST)**

- Overburden high resolution NAPL screening tool

## **Hydraulic Profiling Tool (HPT)**

- Overburden relative-permeability screening-tool

## **Electronic Conductivity (EC)**

- Grain-size & lithology/stratigraphy screening tool



# LIF/UVOST

- UVOST<sup>®</sup> measures the laser-induced fluorescence (LIF) of PAHs in petroleum LNAPL as it is advanced via direct-push technology (DPT)
- UVOST<sup>®</sup> responses are plotted in real-time on a graph of UVOST<sup>®</sup> signal vs. depth
- UVOST<sup>®</sup> signal units are a percentage of a Reference Emitter (%RE)
- Target-Data: Detects petroleum LNAPL in overburden material

# HYDRAULIC PROFILING TOOL (HPT)

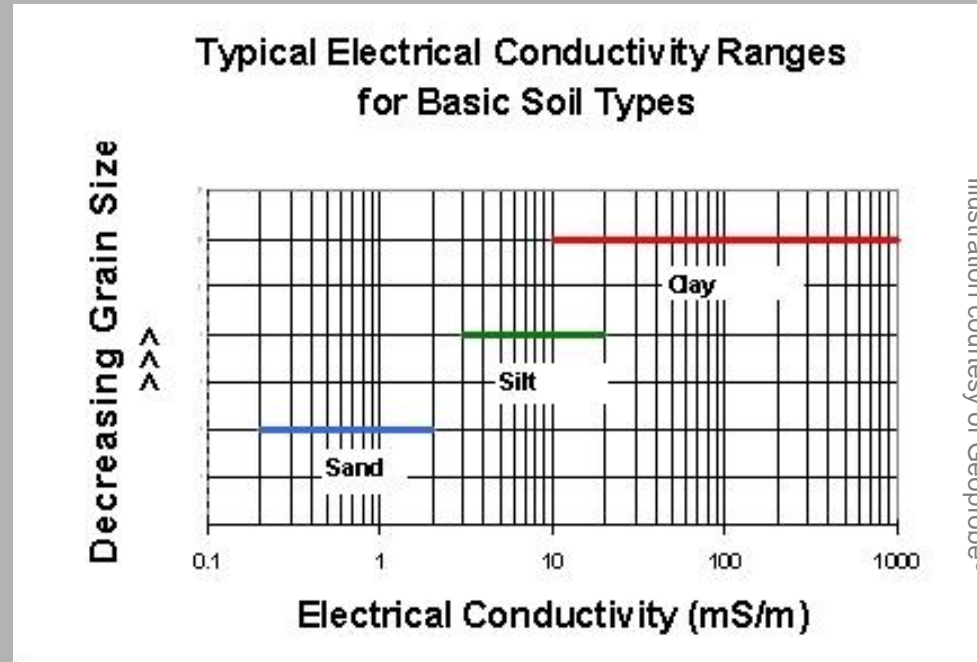
- Evaluates hydraulic behavior of unconsolidated materials
  - Inject clean water into the subsurface at discrete intervals
  - Measure pressure differences (relative permeability) in overburden stratigraphy.
- **Target-Data:**
  - Pore-pressure profile (relative permeability)
  - Hydraulic conductivity (“Effective K”) estimation via dissipation test
  - Conceptualization of contaminant-flow based on hydrogeology

*\*Often teamed with an electrical conductivity (EC) probe to interpret and map the subsurface lithology.*

# ELECTRONIC CONDUCTIVITY (EC)

## Electronic Conductivity (EC)

- Soil conductivity typically varies with grain size.
- Finer grained soils (silts & clays) tend to produce higher EC signals than coarser sands & gravels.



**Target Data:** Correlate EC response with grain-size, lithology, stratigraphy, hydrogeologic properties & plume-geometry

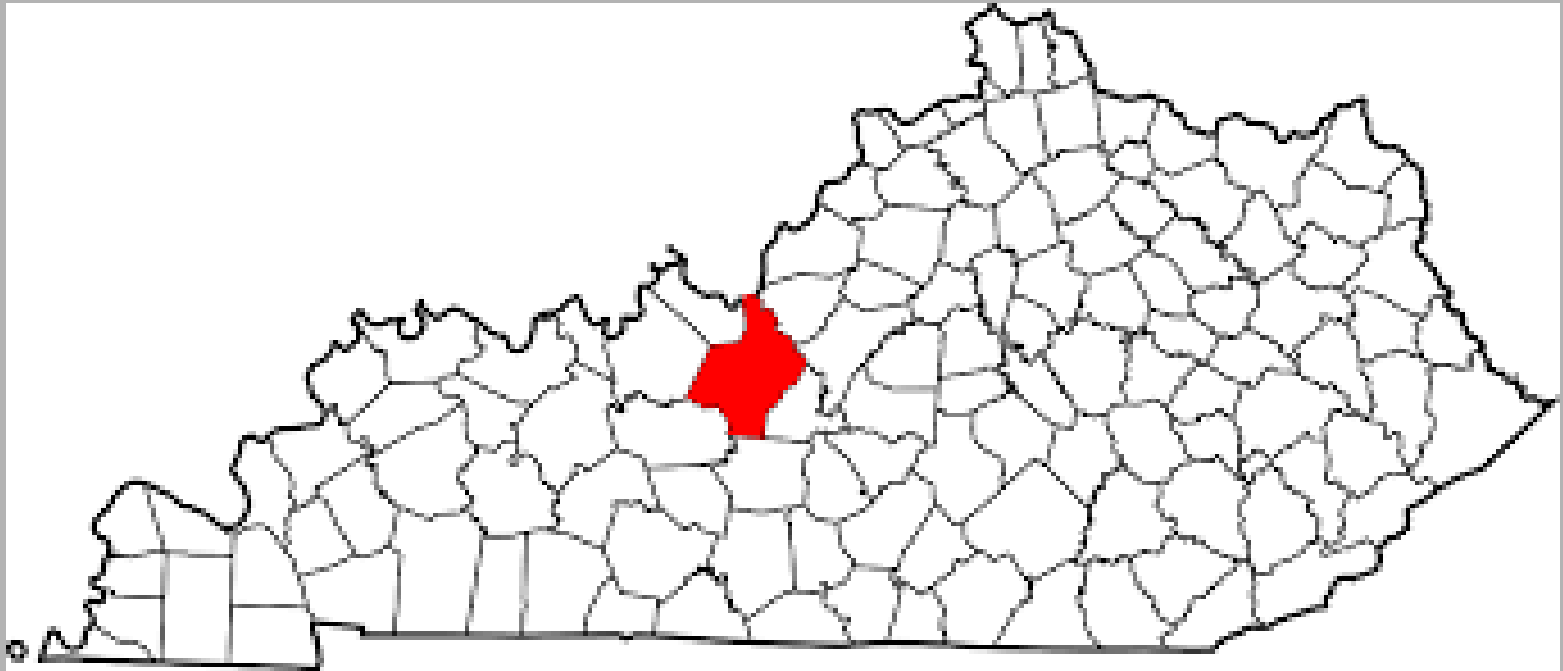


# SAMMY'S GROCERY

## SONORA, HARDIN COUNTY, KENTUCKY

### GEOLOGY

- Karstic bedrock (Saint Genevieve & St. Louis limestone)

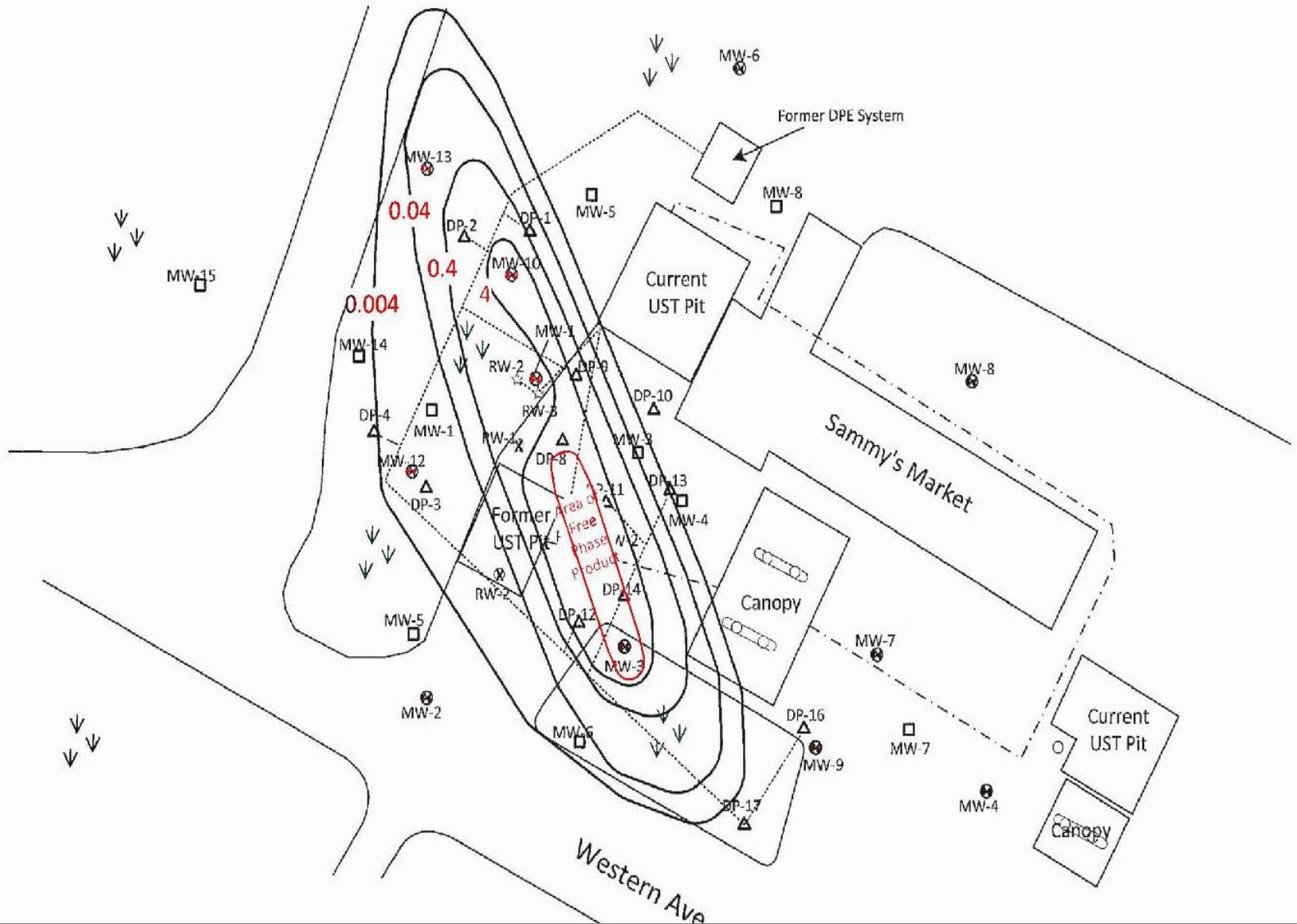


# SAMMY'S GROCERY SITE DETAILS

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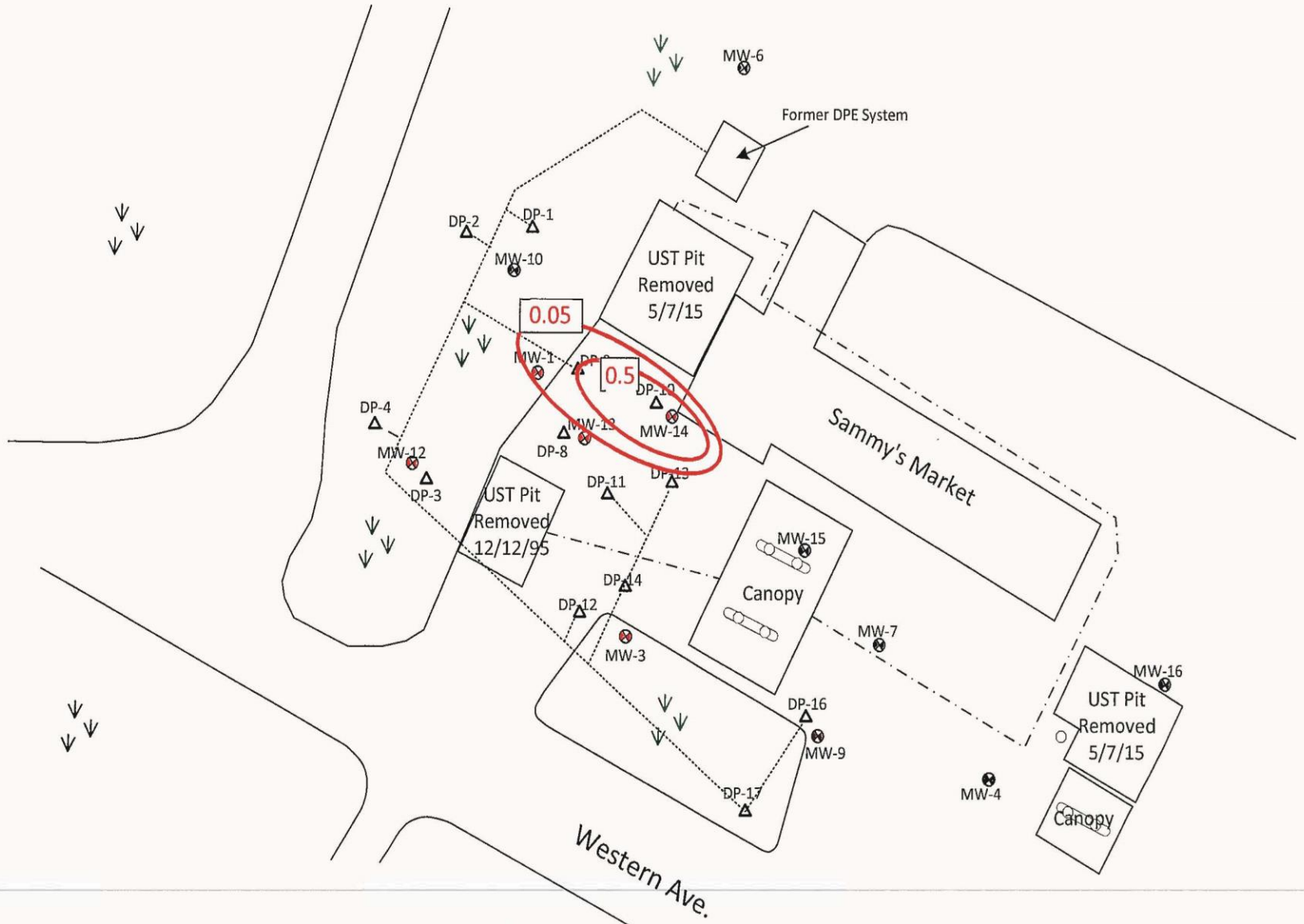
- Bedrock > 60 ft bgs
- Silty-Clay & Terra Rossa (to ~10 ft bgs)
- Hard/compact sand zones
- Heaving-sands and silt with clay-stringers
- Highly-variable water-table ranging from 8 to 18 ft bgs
- Comingled plumes from multiple tank-pits

# BENZENE IN GW (PPM) & MEASURABLE LNAPL (2016)





# MEASURABLE LNAPL (2018)



# 2018 - BENZENE IN SOIL (PPM)



# 2018 - NAPHTHALENE SOIL (PPM)

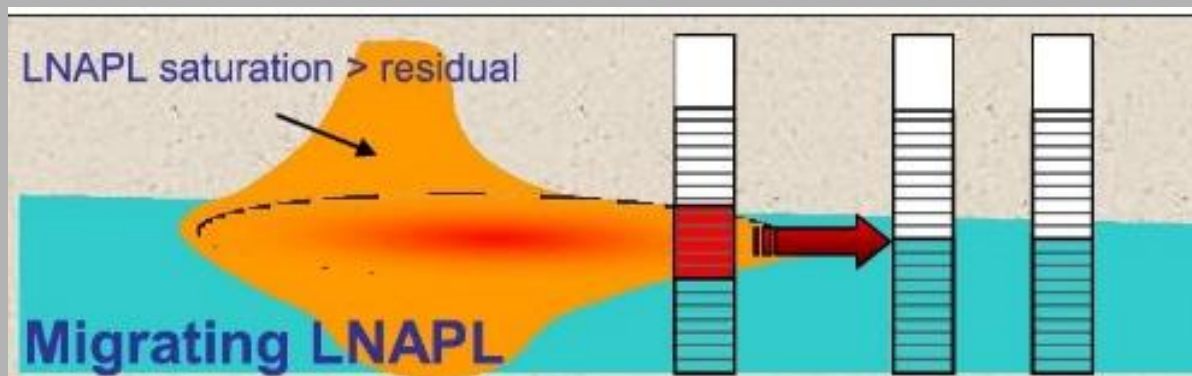




# CONCEPTUALIZING LNAPL

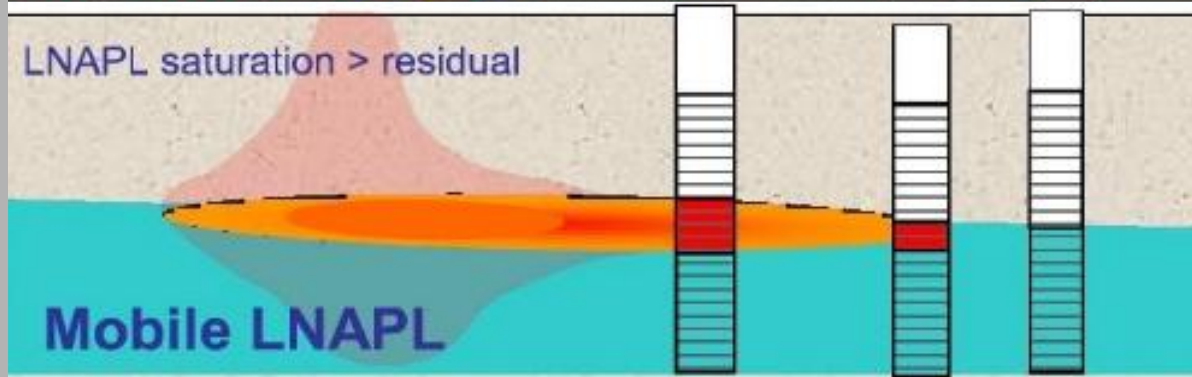
## LNAPL in Wells Mobile **AND** Migrating

(LNAPL head exceeds  
formation conditions)

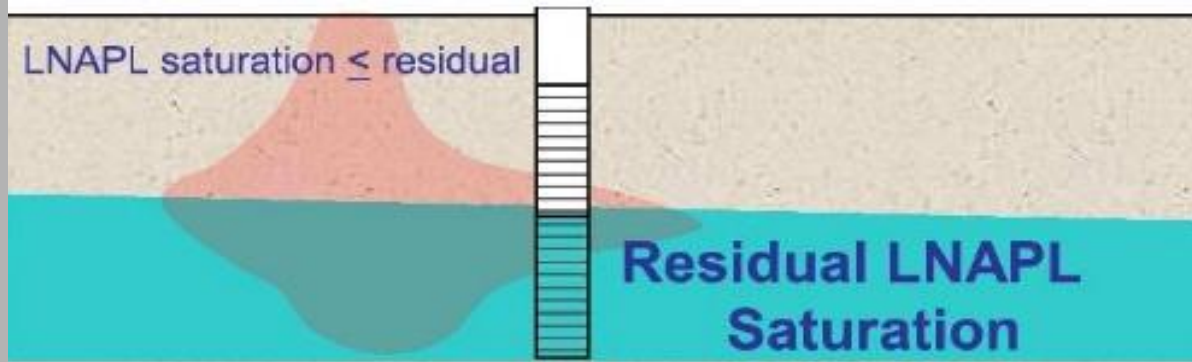


## LNAPL in Wells Mobile **NOT** Migrating

(LNAPL equilibrates with  
formation conditions)



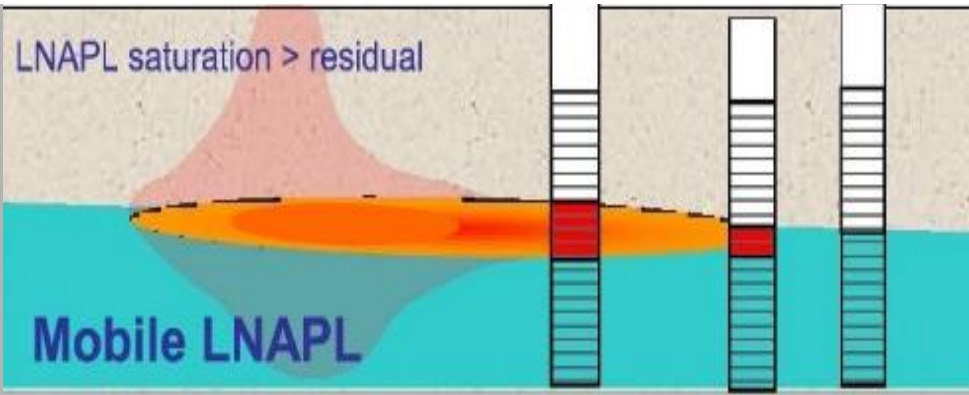
## LNAPL **NOT** measurable in Wells ("ganglia", smear-zones, etc.)



# CONCEPTUALIZING LNAPL

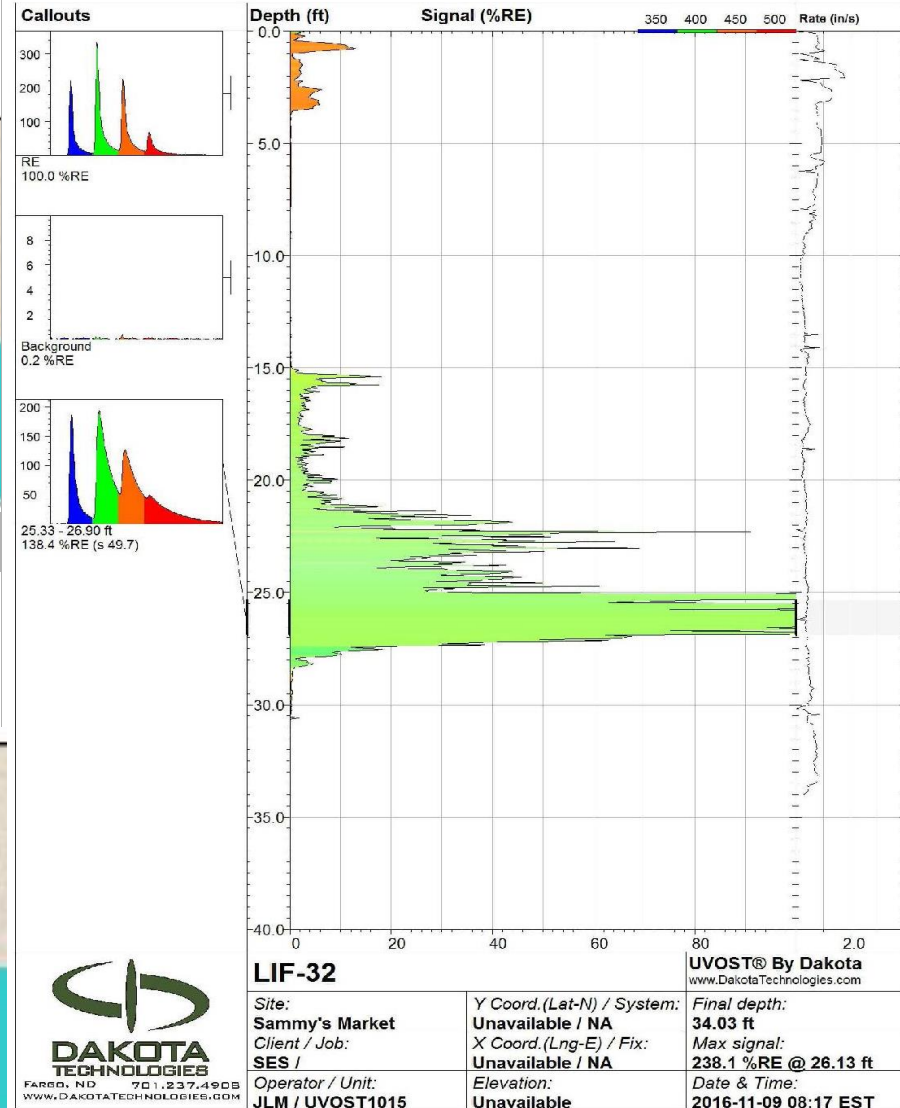
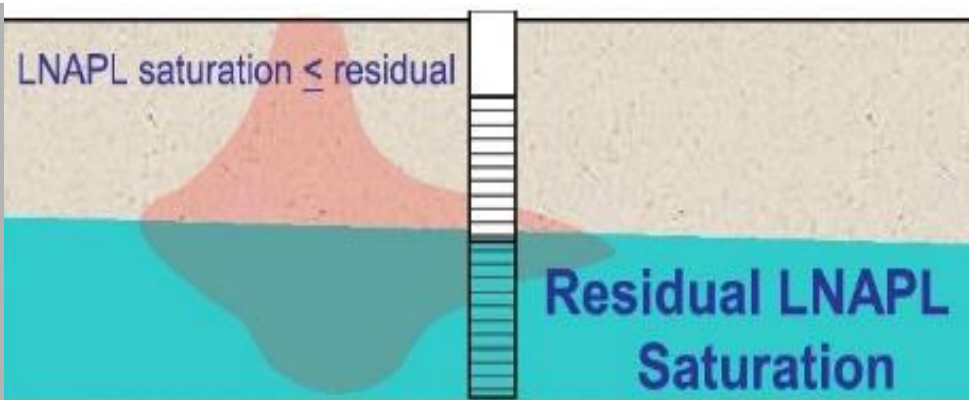
## LNAPL measurable in MWs

(LNAPL equilibrates with formation conditions)



## LNAPL NOT measurable in MWs

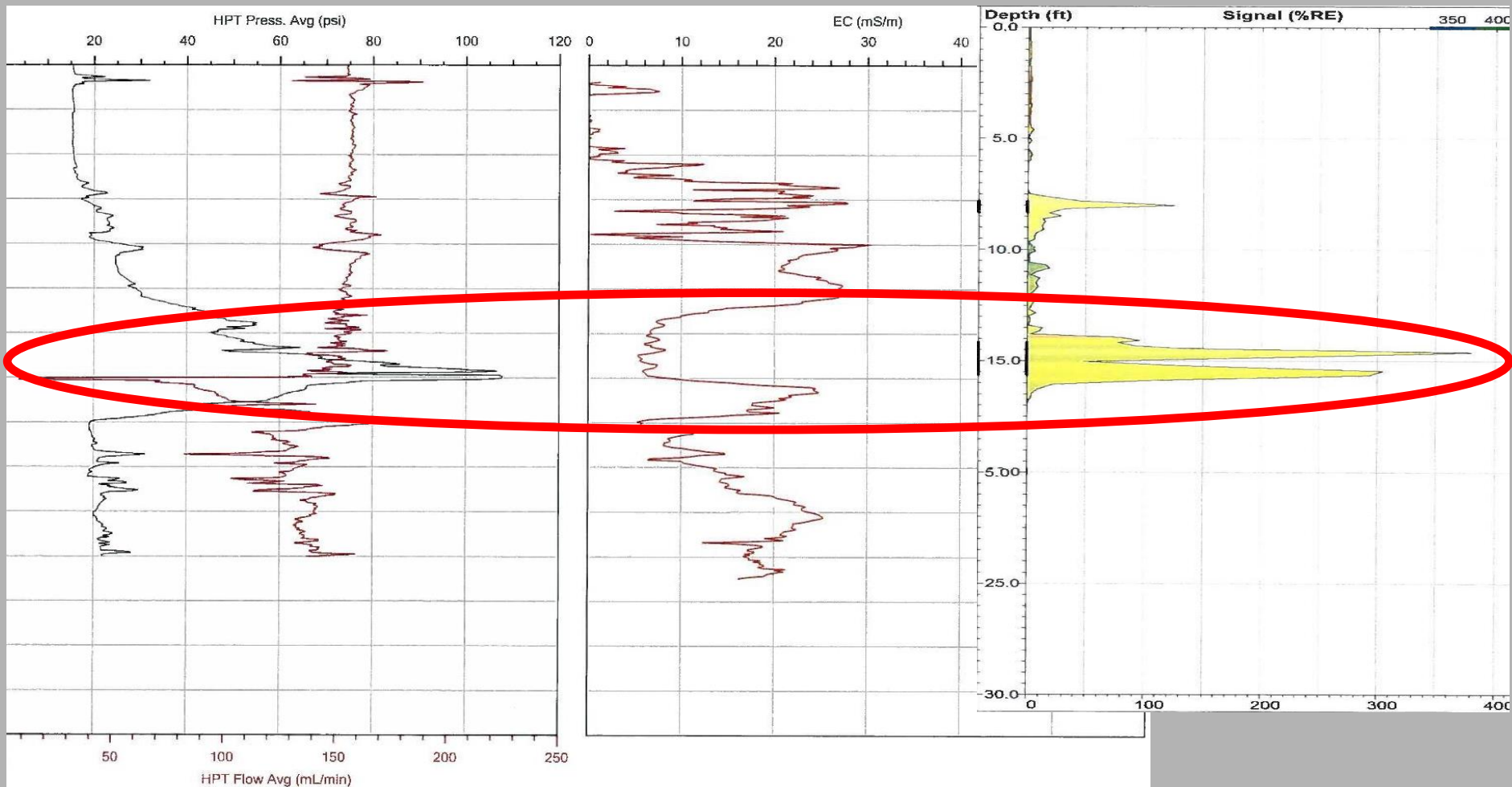
("ganglia", smear-zones, etc.)



Waveform interpretation by Dakota Technologies

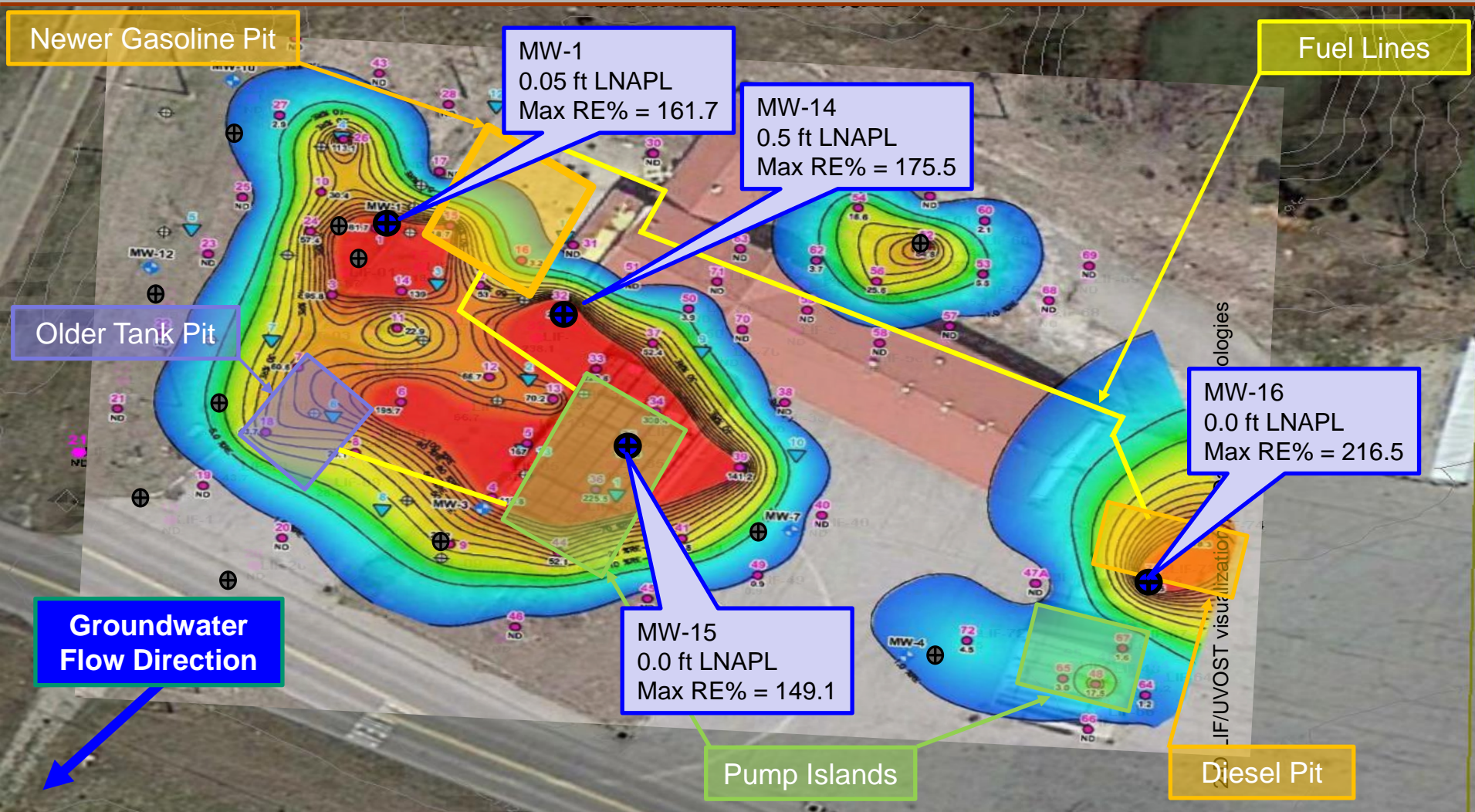
Drawings courtesy of ITRC (Interstate Technology & Regulatory Council)

# COMBINING UVOST, HPT & EC





# SAMMY'S GROCERY





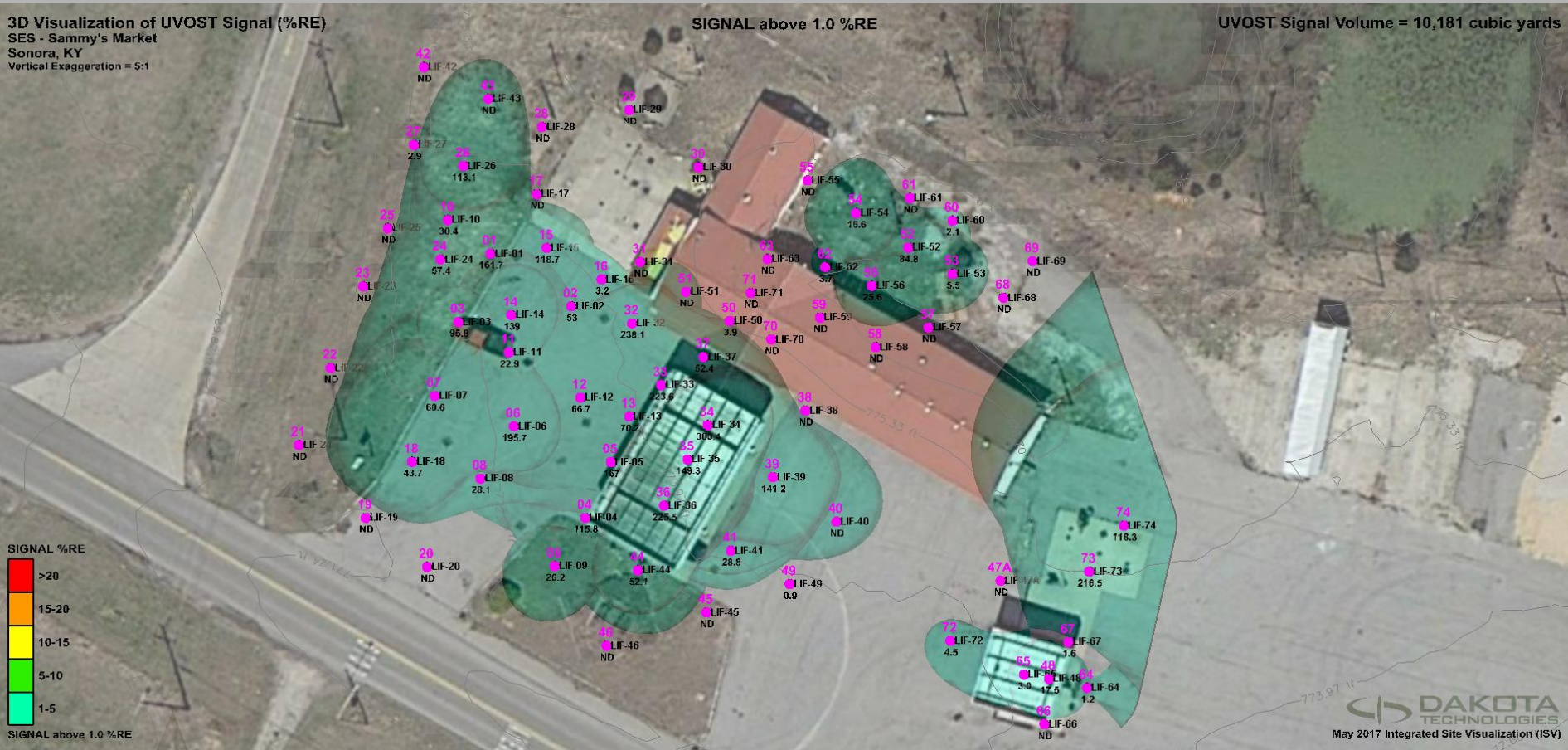
# CONTAMINANT MASS

## 3D Visualization of UVOST Signal (%RE)

SES - Sammy's Market  
Sonora, KY  
Vertical Exaggeration = 5:1

SIGNAL above 1.0 %RE

UVOST Signal Volume = 10,181 cubic yards

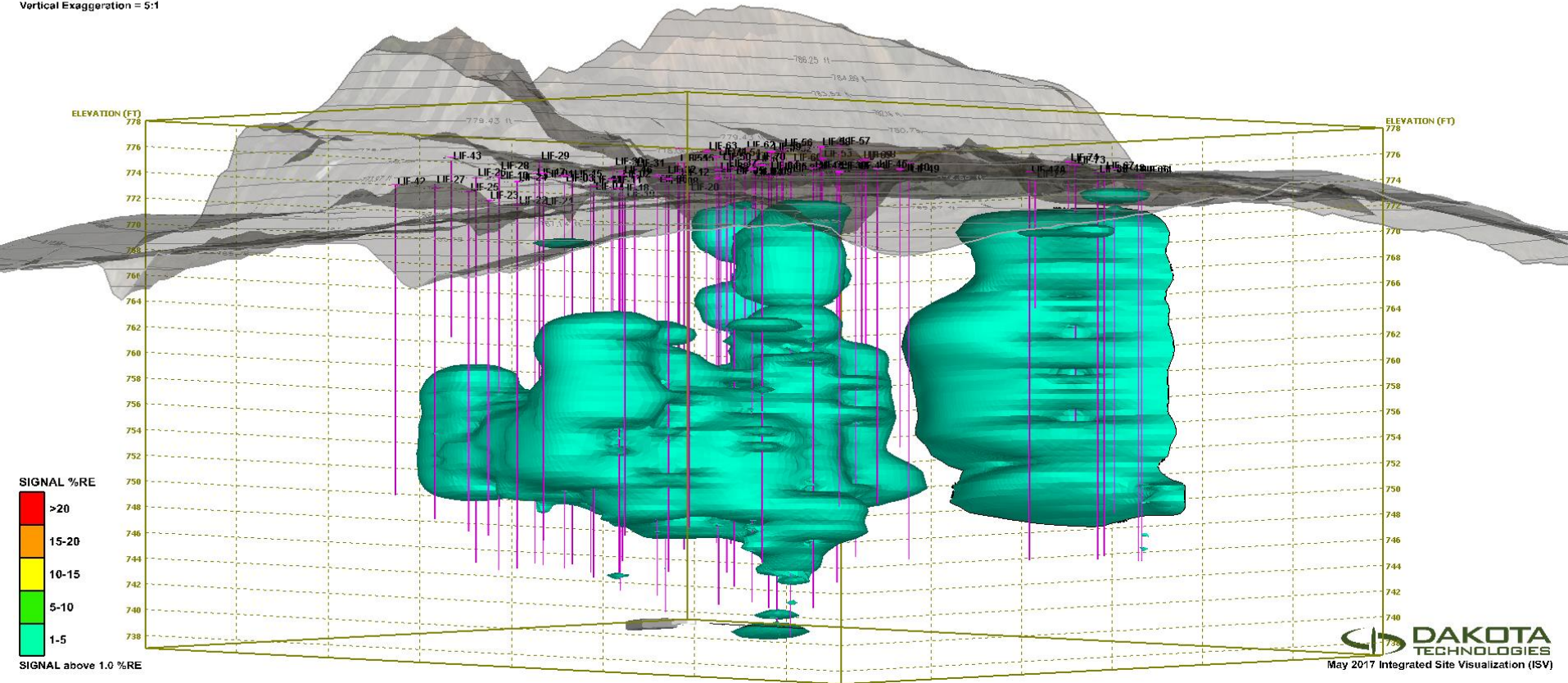




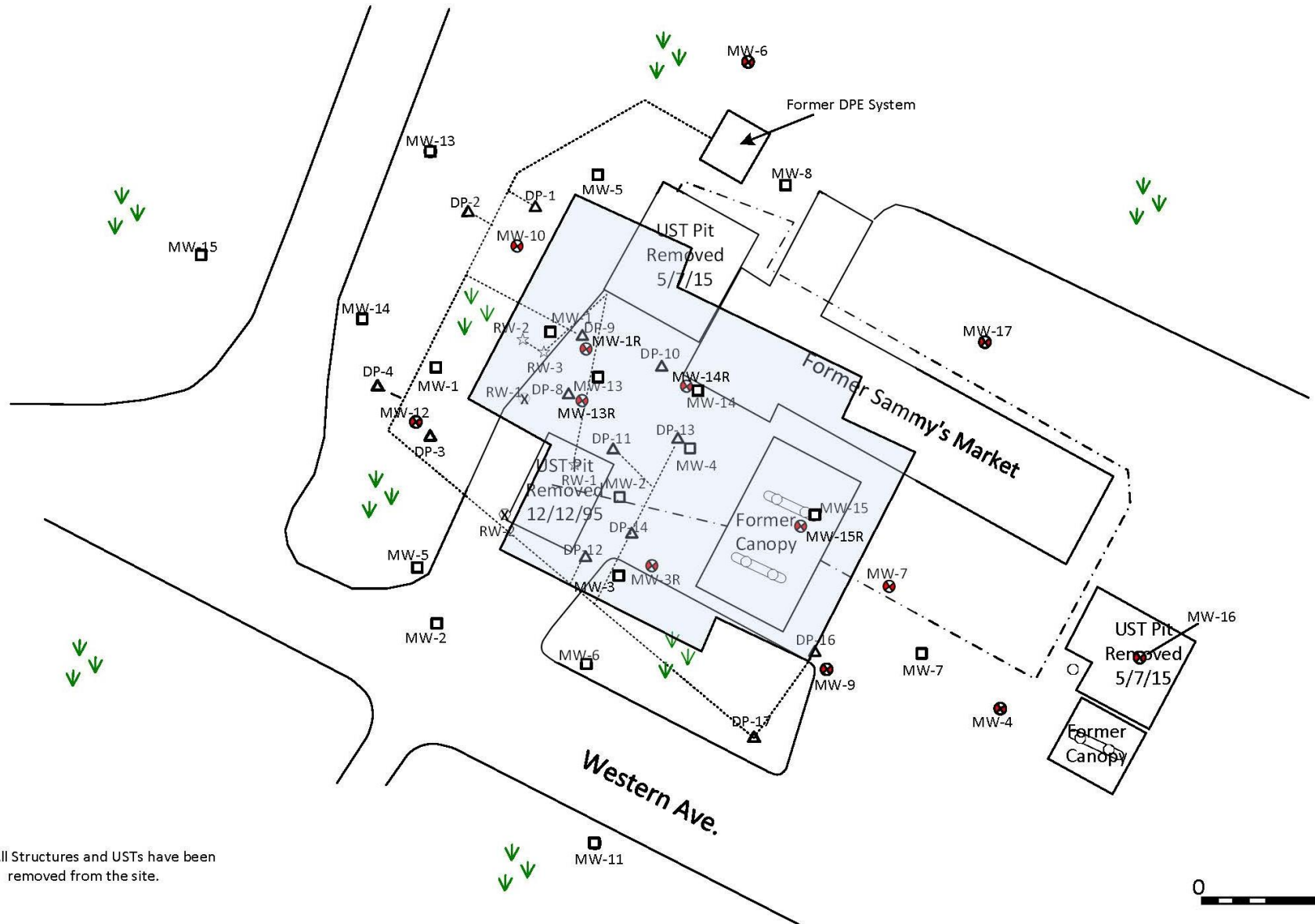
# CONTAMINANT MASS

3D Visualization of UVOST Signal (%RE)  
SES - Sammy's Market  
Sonora, KY  
Vertical Exaggeration = 5:1

SIGNAL above 1.0 %RE



# Remedial Action (11/2019 to 2/2020)



Note: All Structures and USTs have been removed from the site.



# Remedial Action (11/2019 to 2/2020)



**Soil Remediation of 3,700  
Cubic Yards of Gasoline  
Contaminated Soil**

# Post-Remediation GW



Note: All Structures and USTs have been removed from the site.



# LESSONS LEARNED

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## HPT & EC

- Lithologic characterization (overburden)
- Migration pathway characterization
- Development of potential injection strategy
- Facilitate location & design of new monitoring-wells

## LIF/UVOST

- LIF/UVOST worked well for characterizing LNAPL plumes.
- Does not necessarily reflect measureable-thickness of LNAPL at monitoring-well.
- Be hesitant to “cherry-pick” peaks

# SITE CLOSURE CONSIDERATIONS

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- Sensitive Receptors (or other)?
- Vapor?
- Future land Use?
- Migrating, Stable, Shrinking Plume?
- Sustainability



# ACKNOWLEDGEMENTS

## Kentucky DWM - USTB

300 Sower Boulevard  
Frankfort, Kentucky 40601



## Southern Environmental Services

4369 Louisville Road  
Bowling Green, KY 42101



## Geoprobe

1835 Wall St.  
Salina, Kansas 67401



## Dakota Technologies

2201-A 12<sup>th</sup> Street North  
Fargo, North Dakota 58102



# QUESTIONS?

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Thank You!

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