

# Improving NAPL Site Investigations using UVF and LIF Technologies Together

Image courtesy of Dakota Technologies, Inc.

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**Sitelab Corporation**



**Steve Boynton, Co-Author**



**Technical Session: Life Cycle Risk Management  
in the Evaluation of NAPL Plumes**

**Tuesday, October 14<sup>th</sup> 1:15 PM – 1:40 PM**

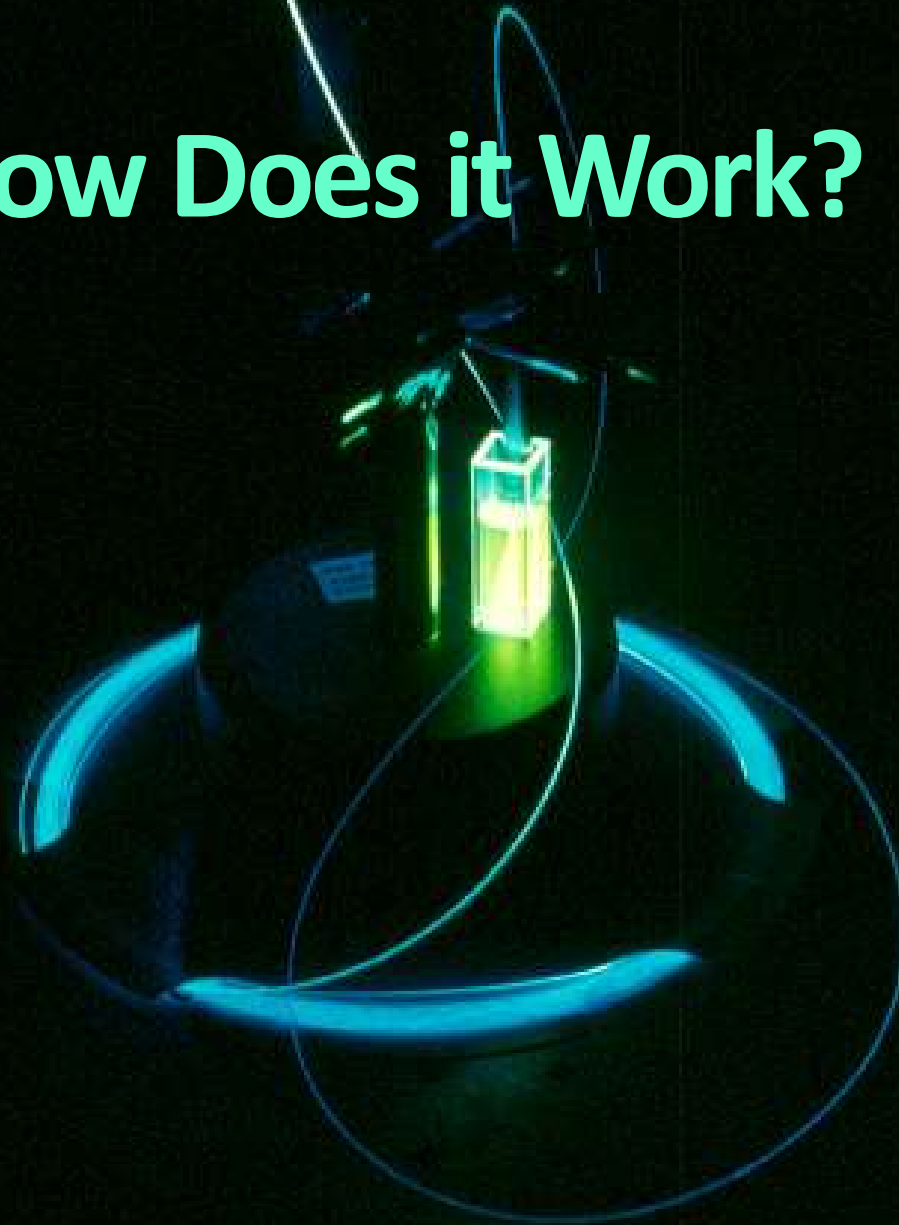


Environmental Issues and Solutions in Exploration,  
Production, Refining & Distribution of Petroleum

**October 14-16, 2014**  
**Houston, Texas**  
**Marriott Westchase Hotel**

# What is Ultraviolet Fluorescence?

## How Does it Work?



# What Fluoresces

- ✓ Gasoline
- ✓ Jet Fuel
- ✓ Kerosene
- ✓ Diesel Fuel
- ✓ Home Heating Oil, No 2. Fuel Oil
- ✓ Heavy Fuel Oil, No. 6 Fuel Oil
- ✓ Motor Oils
- ✓ Waste Oils
- ✓ Lubricating Oils
- ✓ Cutting Oils
- ✓ Transformer Oil
- ✓ Hydraulic Fluid
- ✓ Gas Condensates
- ✓ Drilling Muds & Drilling Fluids
- ✓ Crude Oils
- ✓ Bitumen, Tar Sands
- ✓ Creosote,
- ✓ Coal Tars, Coal Ash

# And What Doesn't

Fluorescence does not detect straight chain aliphatic hydrocarbons:

- ✓ PCE, TCE, dry cleaning solvents
- ✓ Other SVOC chlorinated solvents
- ✓ Methanol or Hexane used with test kits

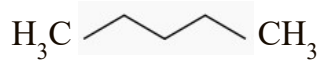


## Popular UVF and LIF Applications

- Soil excavation and cleanup
- Site Assessments
- Remediation & Treatment
- UST Fuel Sites
- Oil Refineries, Pipeline Spills
- Power Plants, MGP Sites
- Military Sites, Airports
- Natural Disasters, Oil Spills
- Oil & Gas Production

# Aliphatic Hydrocarbons

Saturated , Straight Chain Compounds (Alkenes)



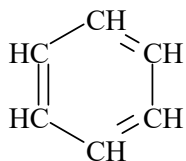
Pentane **C5**



Octadecane **C18**

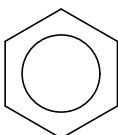
# Aromatic Hydrocarbons

Unsaturated , Ring Shaped Compounds (Arenes)



Benzene

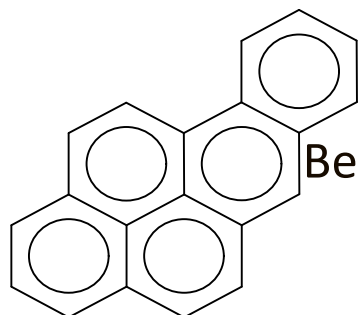
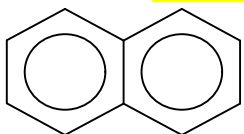
1-ring **C6**



BTEX: Benzene, Toluene, Ethylbenzene and Xylenes

Naphthalene

2-rings **C10**



Benzo [a] Pyrene

5 rings **C20**

PAHs: Polynuclear or Polycyclic Aromatic Hydrocarbons

# TPH by GC-FID

Petroleum contaminants  
are split into different

**Carbon Ranges or Fractions:**

Volatile Compounds

GRO, VPH, BTEX, VOCs:

C6-C10, C5-C12 or C6-C12

Semi to Non-Volatile Compounds

TPH, EPH, EDRO, ETPH, TRPH:

DRO:

C10-C28

C12-C28

ORO or RRO:

C20-C35


C25-C36

C28-C36



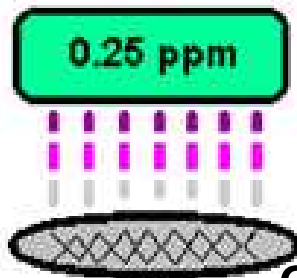
**UV Fluorescence detects Aromatic hydrocarbons over a wide range of petroleum contaminants**

# Fixed Wavelength Fluorometer (UWF)



**Samples are extracted in solvent using methanol or hexane.**  
**Soil, sediment, water, NAPL or wipe samples can be analyzed.**

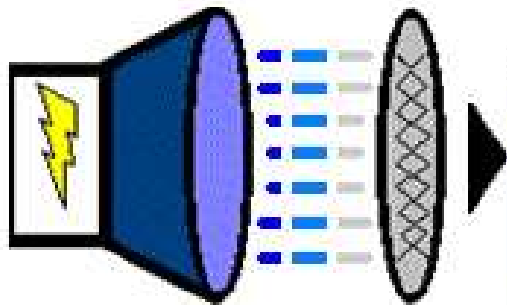
**Photomultiplier Detector**  
**Converts Voltage to Concentration**



**Emission**  
**Optical Filter**



**UV Lamp energizes aromatic molecules at 254 nm**



**Excitation**  
**Optical Filter**



**Glass cuvette contains sample extract or calibration standard**



# Portable Analyzers using Fluorescence

## siteLAB<sup>®</sup> Petroleum Hydrocarbon Solutions



### INSTRUMENT SPECIFICATIONS

Weight & Dimensions:	13 lbs (5.9 Kg); 11" x 9" x 8" (28 cm x 23 cm x 21 cm).
Power Requirements:	External power supply, 100-120 VAC, Max. 30 watts.
Operating Temperature:	45°F to 95°F; 7°C to 36°C.
Principle of Operation:	Ultraviolet fluorescence spectrophotometer.
Detector:	Factory-installed photomultiplier tube (PMT).
Lamp:	Mercury vapor lamp included with analyzer (approx. 10,000 Hr life expectancy). Replacement/spare lamps are available.
Min. Detection Limits:	Varies depending on Sitalab Calibration Kit used; GRO 0.5 ppm, EDRO 0.1 ppm, PAHs 0.05 ppm and TPH-Oil 0.5 ppm.
Display:	16 x 2 character LCD (3.9" x 0.9"; 9.8 cm x 2.2 cm).
Data Output:	100% ASCII format through a 9-pin RS-232 serial cable at 9600 baud. USB adapter available, Part No. 3100-USB, sold separately.
Software:	Menu driven microprocessor-controlled. CD-ROM with software included for computer connection, Microsoft compatible.
Filter Cylinder:	Accommodates up to eight, 25 mm (1-inch) round optical filters (up to 4 excitation and 4 emission filters).
Cuvettes:	Includes cuvette adapter and two glass cuvettes. Replacement/spare cuvettes are available.
Readout:	Direct concentration (in ppm or ppb) or raw fluorescence.
Calibration:	Multi-point calibration for direct concentration measurement.
Blank:	Reads and subtracts blank using methanol or hexane solvents.
Warranty:	One-year warranty, parts and labor.
Approvals:	CE, UL and C-UL. ISO 9001 manufacturing. Made in USA.

## UVF 3100

### CONTAMINANTS

Ideal for gasoline, jet fuel, diesel fuel, heating oils, lubricating oils, crude oils, gas condensates, creosote, coal tars, coal ash and many other types of petroleum hydrocarbons.

### QUICK RESULTS

Test soil, sediment or water samples in just 5 minutes using Sitalab test kits with solvent extraction.

### ACCURACY

Correlates well to regulatory lab GC methods performed by certified laboratories. Ranked highest in U.S. EPA's "TPH in Soil" evaluation study. Publication No. EPA/600/R-01/080

### FINGERPRINTING

Test BTEX and PAHs for forensic applications to determine the type or age of petroleum on your site.



Sitalab's UVF-3100A and UVF-3100D models include a field case with all the tools needed to perform tests.

The analyzer is fitted with optical filters sensitive to the gasoline range, diesel and oil range and Target PAH ranges. Sitalab's GRO, EDRO and PAH Calibration Kits provide fast, accurate measurement with quality control.

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UVF-3100 Analyzer Brochure

Visit: [site-lab.com](http://site-lab.com) Call Toll Free 877-SITELAB or Dial (USA) 978-363-2299  
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## siteLAB<sup>®</sup> Petroleum Hydrocarbon Solutions



### INSTRUMENT SPECIFICATIONS

Weight & Dimensions:	13.9 oz (0.4 Kg); 1.75" x 3.5" x 7.25" (4.5 cm x 8.9 cm x 18.4 cm).
Power Requirements:	Four AAA batteries. Batteries good for approx. 1,000+ readings.
Operating Temperature:	45°F to 95°F; 7°C to 36°C.
Principle of Operation:	Hand-held ultraviolet fluorescence spectrophotometer.
Detector:	Factory-installed photomultiplier sensor.
Lamp:	Light Emitting Diode (LED).
Min. Detection Limits:	Varies depending on Sitalab Calibration Kit used; TPH-Oil 5 ppm, Heavy PAHs 25 ppb.
Display:	16 x 2 character LCD (2.5" x 0.6"; 6 cm x 1.5 cm); ppm or ppb units.
Data Output:	Not available. Record results manually.
Automatic Power Down:	After 3 minutes of inactivity.
Optical Filters:	Includes two sets of factory-installed excitation and emission filters; use Channel A optics for Sitalab applications.
Cuvettes:	Uses disposable 8 mm round glass cuvettes. Cuvettes are included with Sitalab sample extraction kits and calibration kits.
Calibration:	Single-point and blank.
Blank:	Reads and subtracts blank using methanol or hexane solvents.
Response Time:	5 Seconds.
Diagnostics:	Displays percent fluorescence sensitivity of calibration and blank.
Alarms:	Low battery, circuit failure, high blank.
Warranty:	One-year warranty, parts and labor.
Approvals:	CE, UL and C-UL. ISO 9001 manufacturing. Made in USA.

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TD-500D Analyzer Brochure

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## TD 500D

### CONTAMINANTS

Test samples for TPH with heavy fuel oils, waste oils or crude oils. Test for PAHs in old, weathered fuel oils, creosotes, coal tars and coal ash.

### QUICK RESULTS

Test soil, sediment or water samples in just 5 minutes using Sitalab test kits with solvent extraction.



### ACCURACY

When used with Sitalab Calibration Kits, TPH-Oil results correlate well to EPA's 1644 gravimetric method. PAH results correlate well to EPA's 8270 method as sum of PAH compounds.



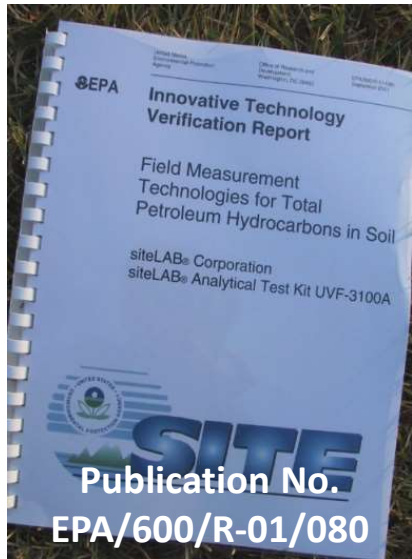
### EASY TO USE

The equipment is simple to operate. Sitalab's TD-500D model includes a field case with all the tools needed to perform tests.



Manufactured for Sitalab Corporation by Turner Designs Hydrocarbon Instruments, Inc.

# Accuracy is Everything!



**Evaluated by U.S. EPA in 2001**

Ranked highest compared to other screening devices for TPH in soil.

Over 200 samples were tested. EPA spent \$800,000 on project.

Results were compared to split samples sent to certified lab for TPH analysis using 8015 by GC-FID.



**GRO, EDRO & PAH Calibration Kits**

Certified calibration standards are specially formulated to correlate well to laboratory GC methods.



**Sample Test Kits**

Used to prepare and analyze soil, sediment or water using solvent extraction. Results take 5 minutes.

**Sitelab's popular UVF-3100D instrument is fitted with 3 sets of optical filters which are sensitive to different hydrocarbon ranges.**



**Can perform TPH Fingerprinting!**

# Laser Induced Fluorescence (LIF)



Laser-induced fluorescence (LIF) uses laser light to excite fluorescent molecules and is highly sensitive to non-aqueous phase liquids (NAPLs) in soil containing petroleum fuel oils, coal tars, creosotes, crude oils, etc.

A probe with sapphire window delivers short pulses of laser light by fiber optic cable into the soil below the ground. A detector simultaneously measures a time-resolved pulse of fluorescence at different wavelengths.



**LIF probes are compatible with all direct push systems, like Geoprobe or CPT**

## UVOST

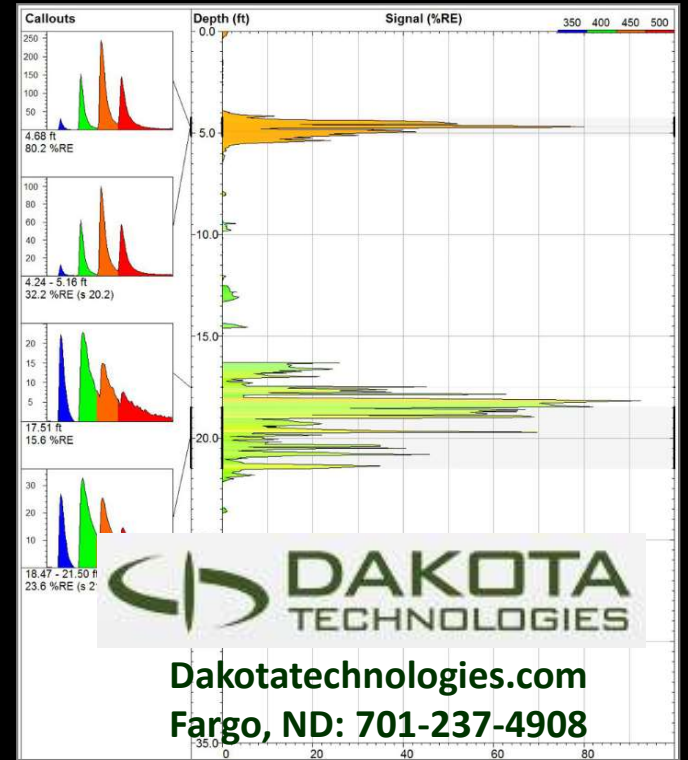
For most petroleum applications.

## TARGOST

For coal tars, creosote, heavy crude oil.

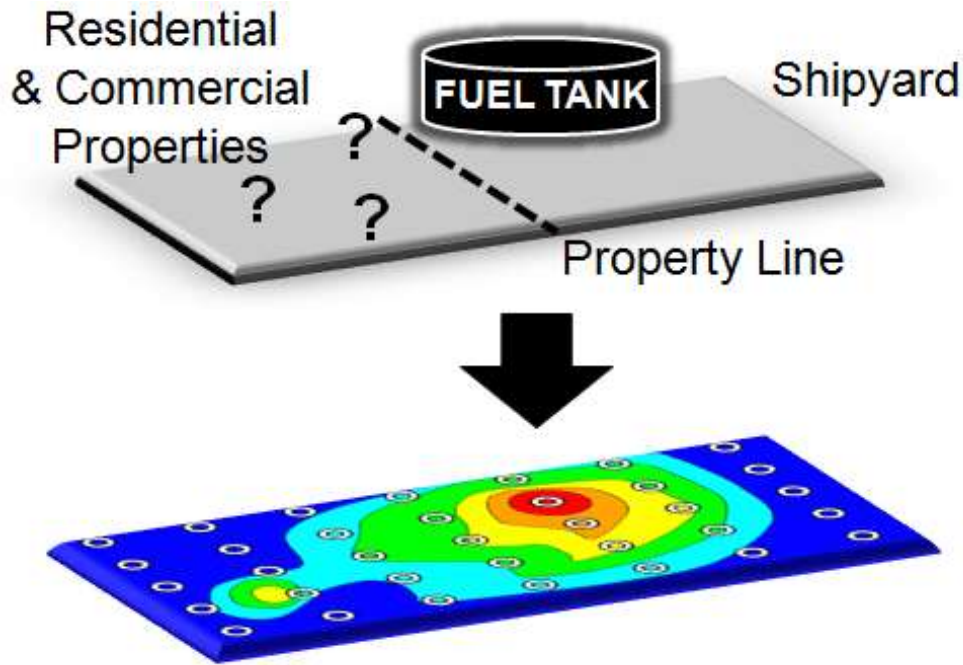
## DyeLIF

For DNAPL chlorinated solvent applications.





# Example using UVF for Vertical Profiling



Site assessment is performed to investigate or remediate a property. Lab testing is required.

Field screening data is used to delineate the vertical and horizontal spread of contamination.

Off-site certified laboratories can be expensive with turnaround time taking 1 to 2 weeks.

Soil Boring Depth (Ft)	TPH (ppm)
6'-8'	100
8'-10'	4
10'-12'	50
13'-14'	16,400
14'-16'	8,320
16'-17'	7,250
17'-18'	3,700
18'-19'	230
19'-20'	120



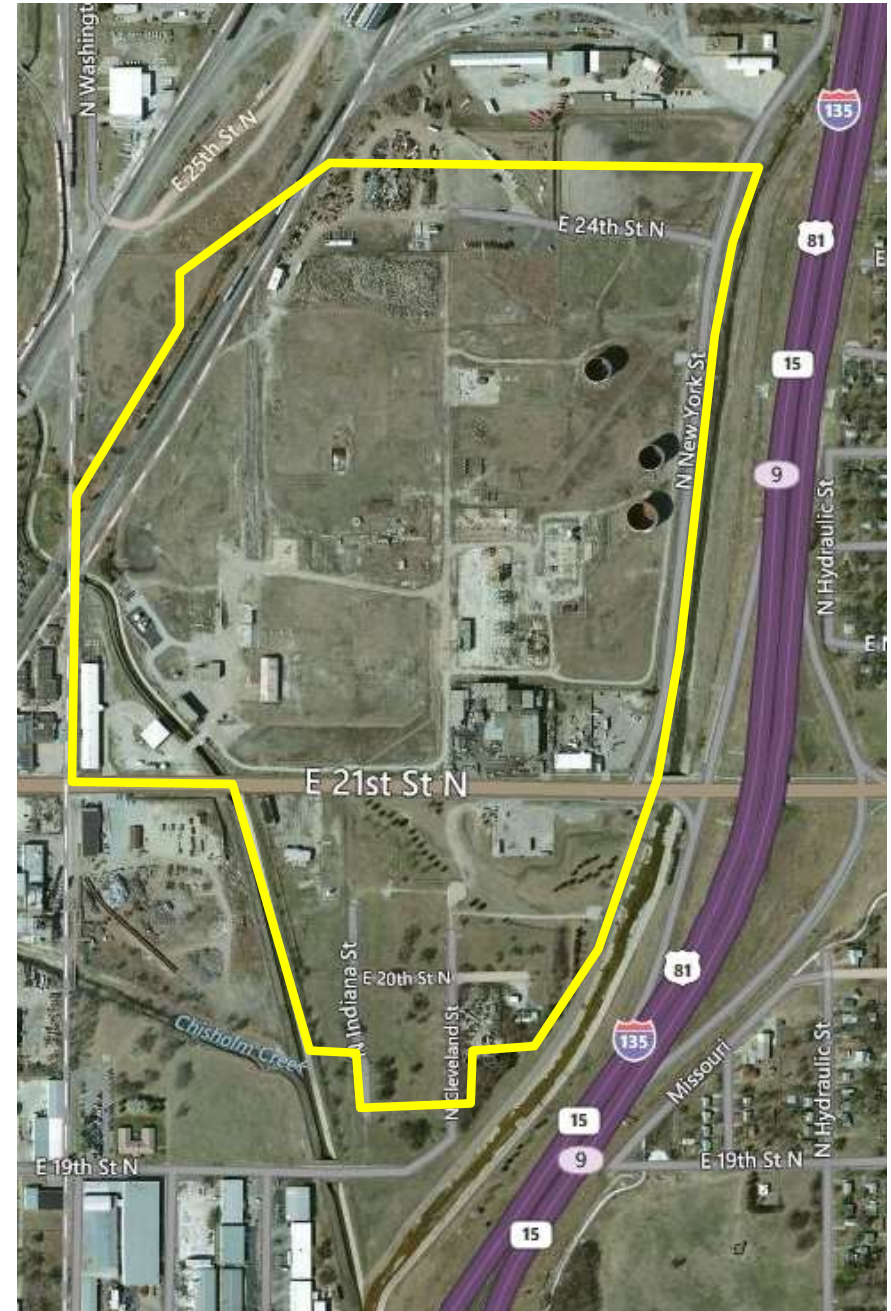
# NAPL Investigation using UVF and LIF



Site has a huge 100-acre size plume of LNAPL commingled with gasoline, diesel, fuel oils, crude oil and other petroleum products.

Consultant uses Sitelab UVF to field screen 255 soils over 5 days testing for GRO, EPH, PAHs and TPH fingerprinting. A total of 1,020 results were reported on-site.

Samples were collected from 30 borings next to LIF locations performed 3 years prior.

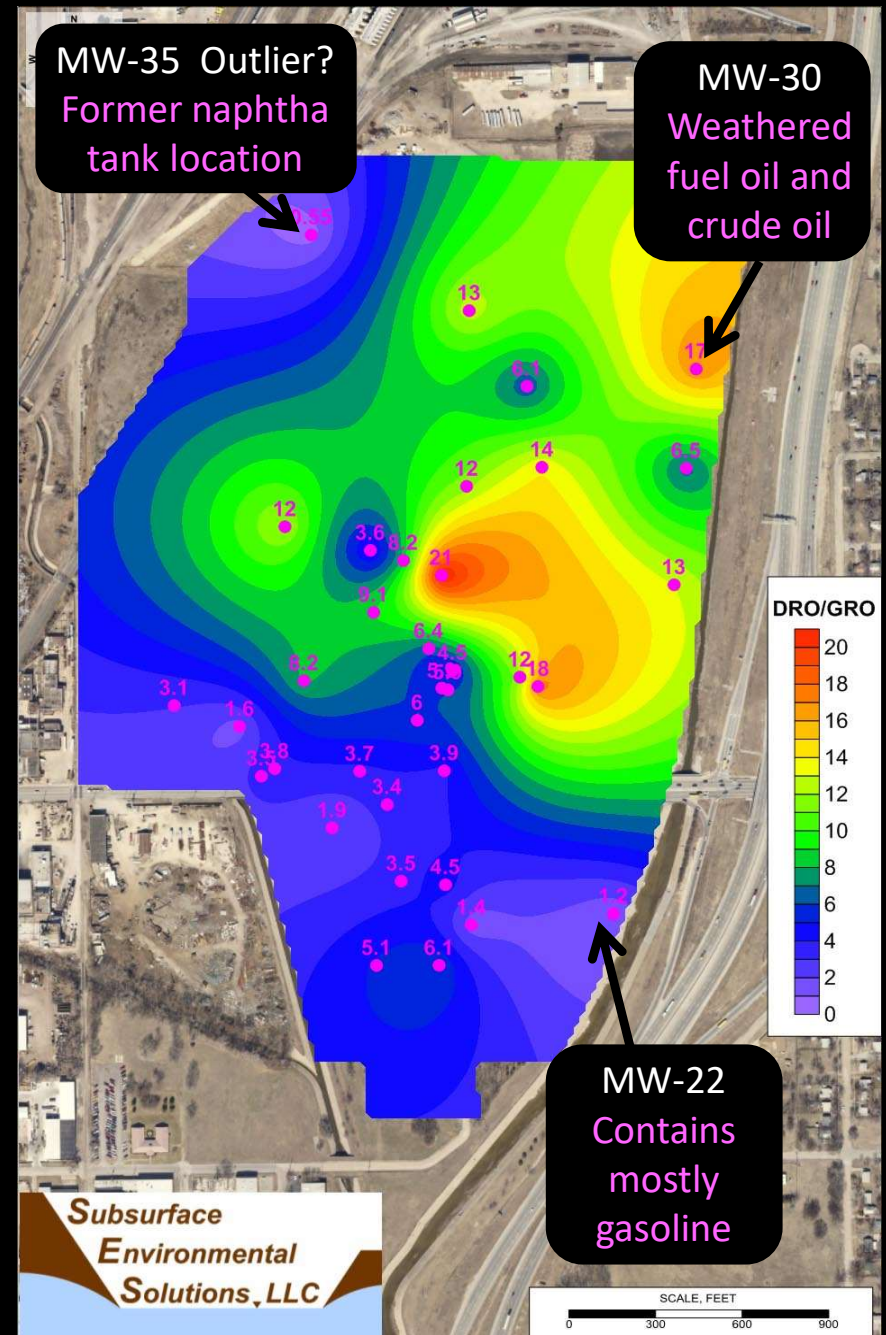


# Fingerprinting NAPL Plume using UVF

UVF-3100 analyzer response testing oil samples collected from 35 monitoring wells. NAPLs diluted in solvent and measured at 10 ppm concentrations for both gasoline and diesel range hydrocarbons:



Examples at 10 ppm	GRO Response	DRO Response	DRO/GRO Ratios
MW-22	1.52 ppm	1.80 ppm	1.2
MW-30	0.73 ppm	12.5 ppm	17
MW-35	0.32 ppm	0.18 ppm	0.6

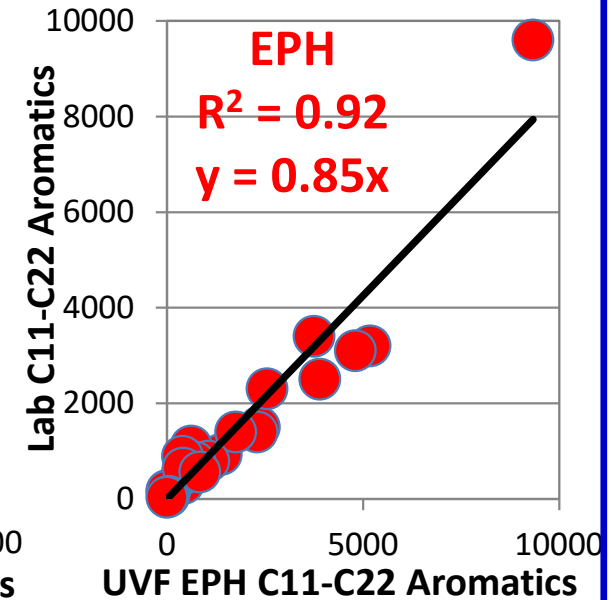
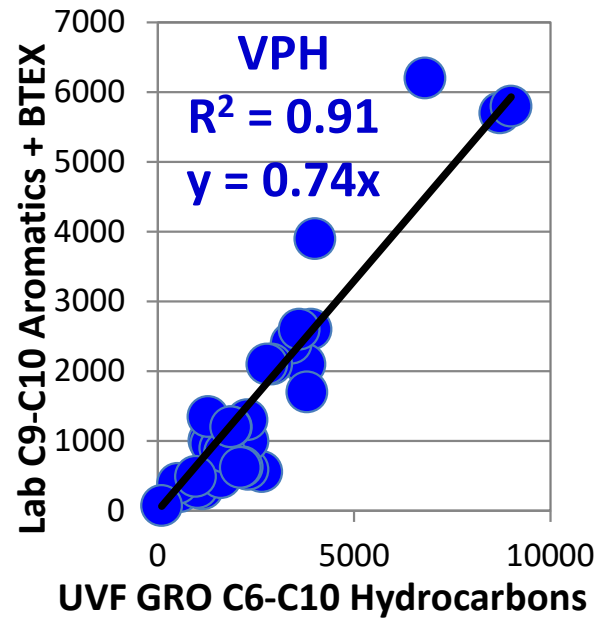


# UVF Accuracy vs. Lab GC Results

A large number of soils collected from 30 borings were sent to a certified laboratory for confirmation analysis using the Mass DEP's VPH/EPH method. This method detects the aliphatic and aromatic hydrocarbon ranges separately.

Results correlated well, allowing the consultant to rely heavily on using the UVF results to convert LIF data to TPH concentration.

## UVF-3100 vs. Laboratory GC-FID VPH/EPH Results Concentrations in ppm units (mg/Kg)



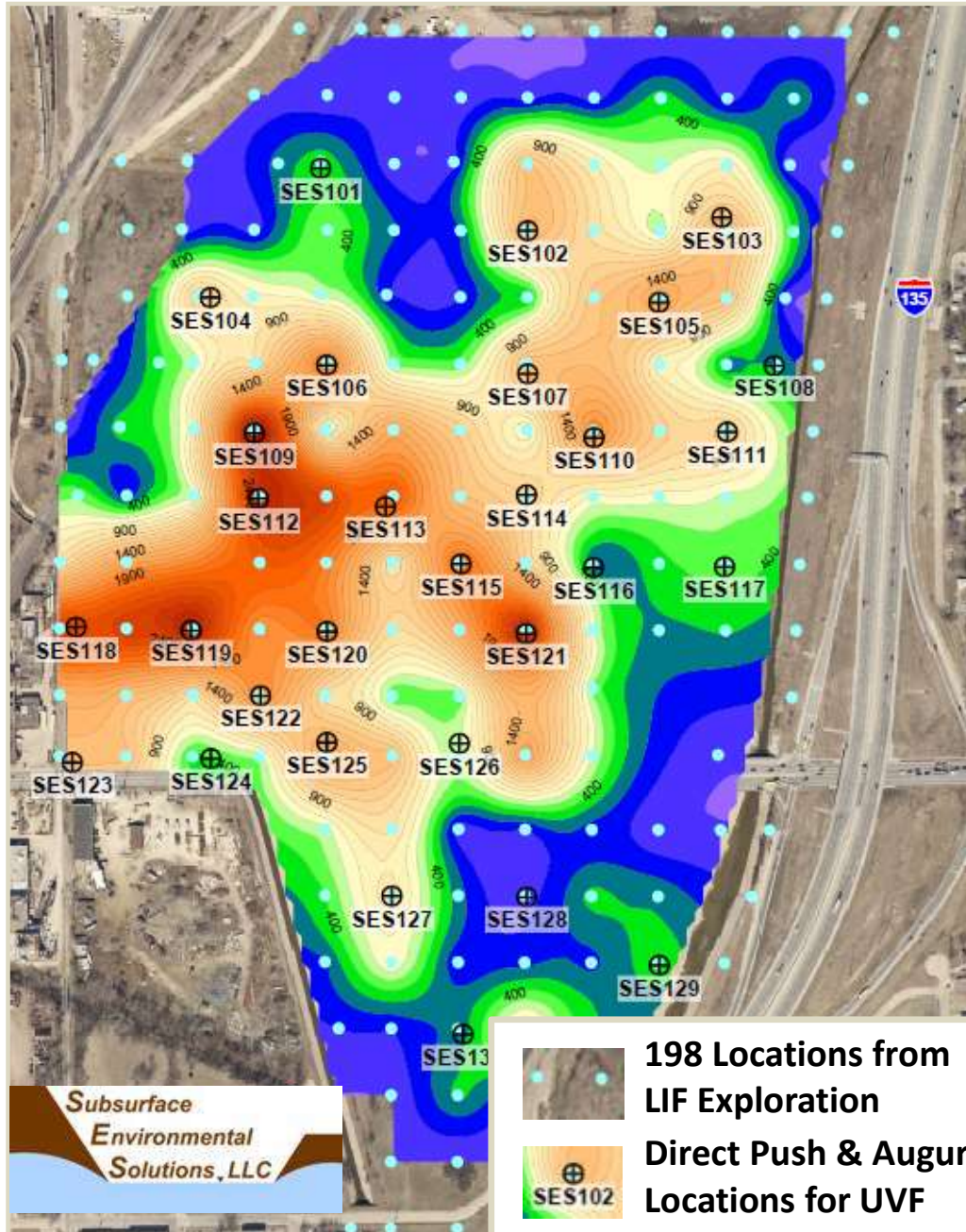
**CAL-025**      **CAL-060**

**Calibration and sample test results can be recorded using UVF software**

**Calibration standards are reusable and can be tested at any time to confirm calibration curve is linear**



# Site Plan with UVF and LIF Locations

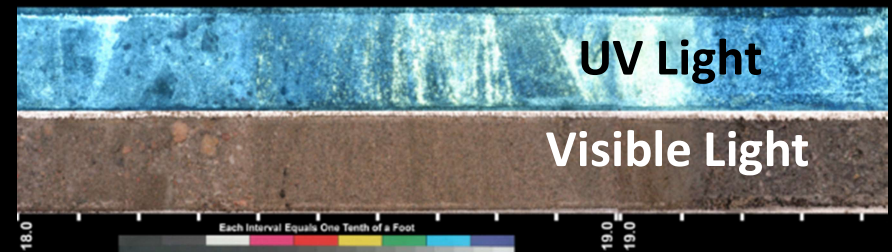


Consultant uses Surfer Software to create map showing extent of contamination.

Laboratory GC, UVF and LIF data is used to calculate the total mass of NAPL. This site has 6 million gallons of oil below the ground.

Previous estimates were 10 to 20 million gallons, based on invalid measurements such as product thickness.

Soil cores were also collected and frozen for physical testing: Centrifuge test measures residual oil saturation used to determine NAPL mobility and recovery.



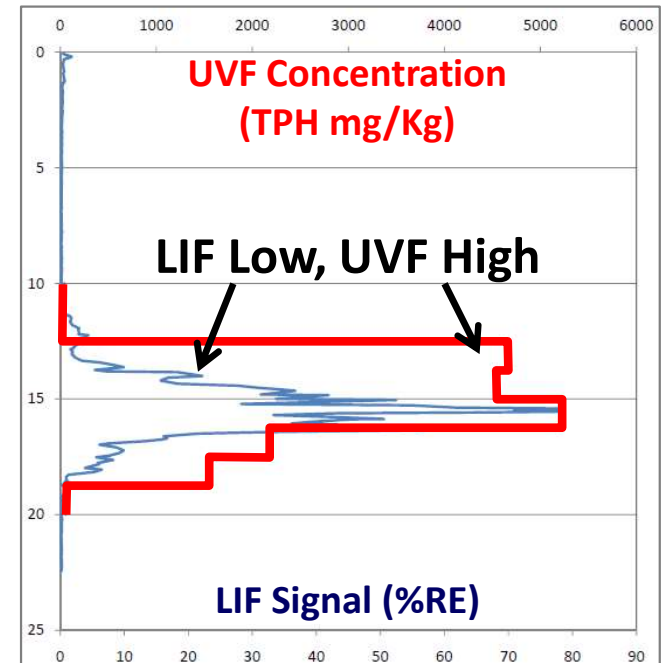
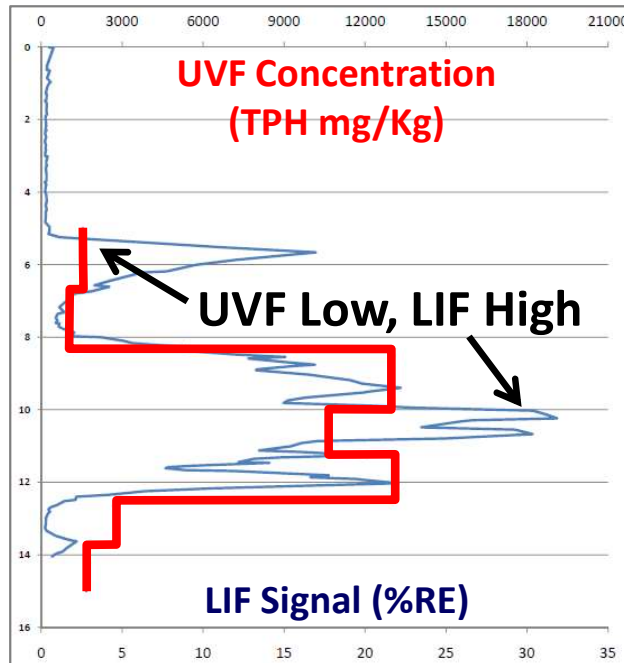
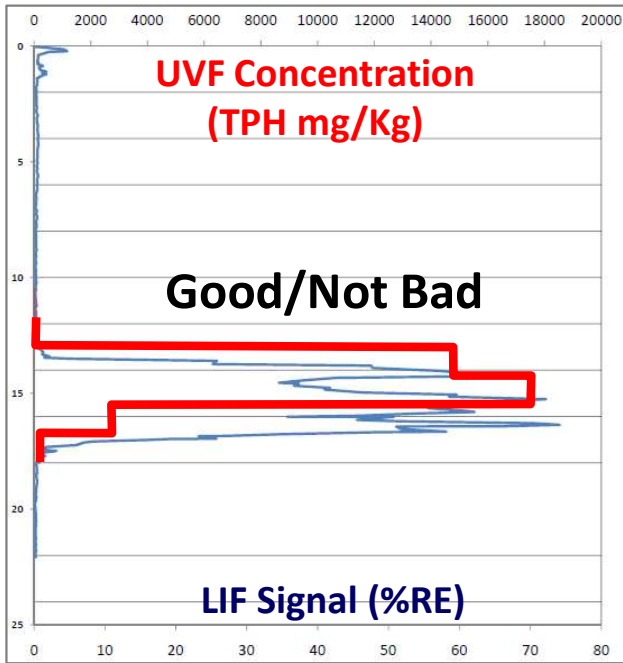
# Challenges and Limitations using UVF and LIF Technologies



# Jet Fuel Site



# Examples where LIF & UVF Profiles Don't Match Up



Poor recovery in soil borings can sometimes occur skewing depth of TPH

NAPL may not be distributed evenly in intervals used to composite soils for UVF





# End of Presentation

## Thank you



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