Real-Time NAPL Delineation Tools:
A Comparison of Laser-Induced Fluorescence and Optical Profilers

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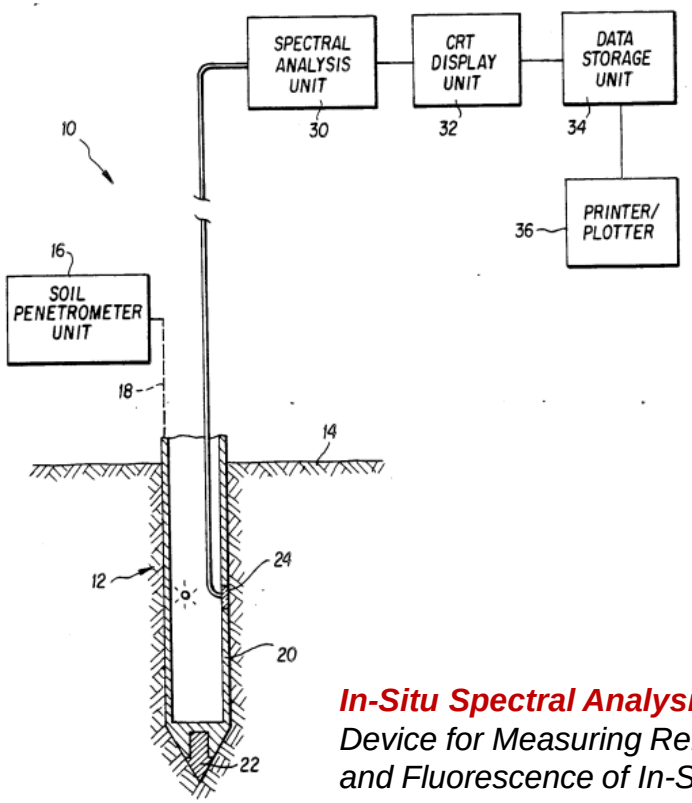
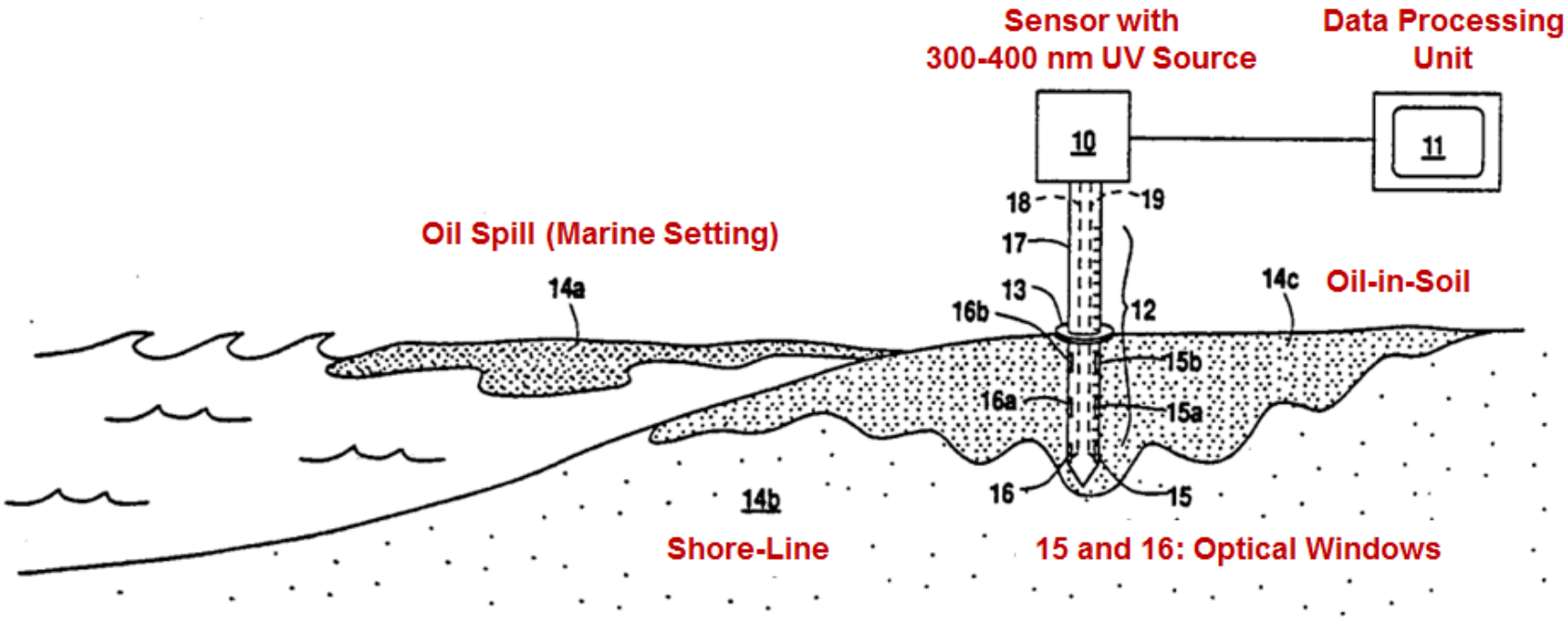
Overview of Technologies

- Real-time vertical profiling tools.
- Probe attached to a direct-push platform.
- Nonaqueous phase liquid (NAPL) detection predicated upon ultraviolet fluorescence of polynuclear aromatic hydrocarbons present in NAPL.
- The basic components were described in 1992 patent.
- Two primary platforms now.



In-Situ Spectral Analysis
Device for Measuring Reflectance and Fluorescence of In-Situ Soil
US Patent No. 5,128,882
Cooper, et al., 1992

An Early UV Fluorescence Probe



Method for Determining Petroleum Saturation in a Subsurface
US Patent No. 5,065,019
Darilek, et al., 1991

Related Prior Art

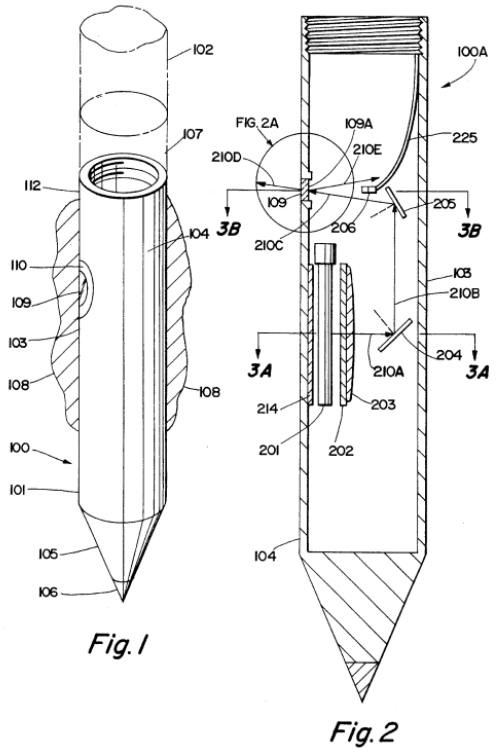


Fig. 1

Fig. 2

Sapphire Window
Probe Device for Detecting Contaminants in Subsurface Media
US Patent No. 5,246,862
Ballard, et al., 1996

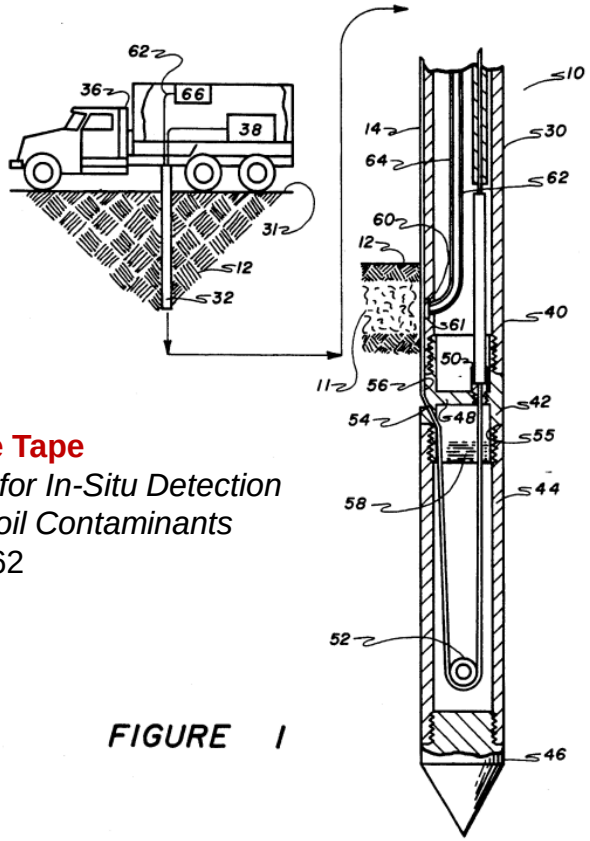


FIGURE 1

Weird Use of Reactive Tape
Method and Apparatus for In-Situ Detection and Determination of Soil Contaminants
US Patent No. 5,246,862
Grey, et al., 1993

Platform Comparisons

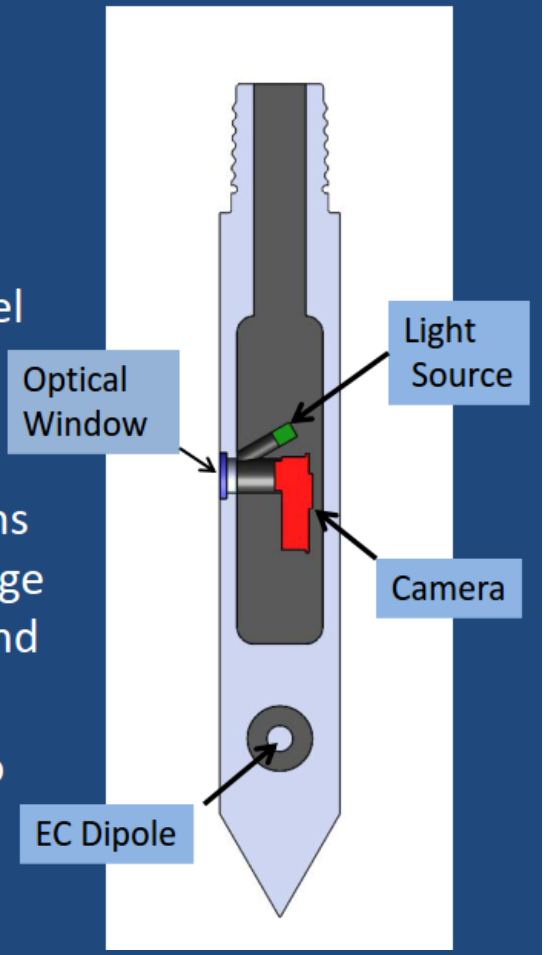
Ultra-violet Screening Tool and Optical Image Profiler

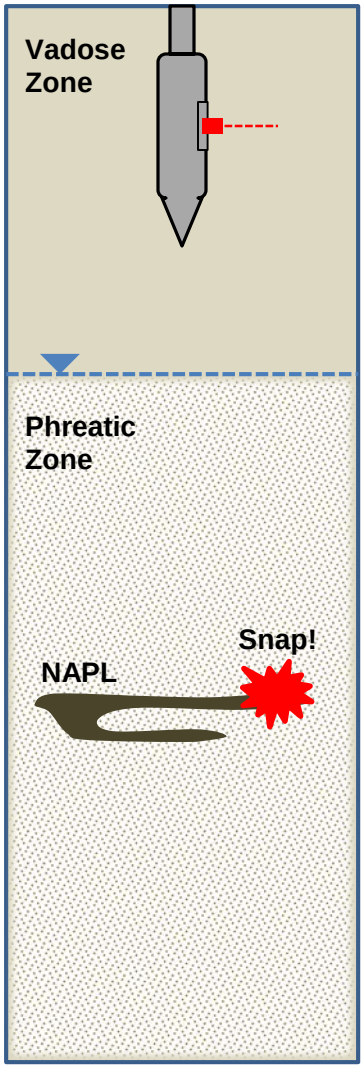
System Components	Laser-Induced Fluorescence	Optical Image Profiler
Platform	UVOST®	Geoprobe Systems® OIP
Heritage	LIF-ROST®	No Direct Ancestor
Deployment	Usually Direct-Push	Usually Direct-Push 1.75 SL
UV Source	308nm Laser via Fibre Optic	265nm ±10nm LED
Fluoresence Capture	Oscilloscope via Fibre Optic	CMOS Imaging Camera
Log Generation	Spectrally-Separated Data (4-channels) Converted to Voltages	Measurement of Pixel Area Exhibiting Fluorescence
Waveform Differentiation	Yes	No
Data Outputs	lif.data	640 x 480 px.jpg, .zip
File Size 30' Deep Profile	<20KB	Approximately 300MB
Options	TarGOST®, EC, HPT	Green LED, EC, HPT
Calibration	Use of Reference Emitter	Color Standards
Software Platform	OST Viewer	MIP Viewer
Costs (Michigan)	$3700 / 10 Hour Day	$3700 / 10 Hour Day

Optical Imaging Probe

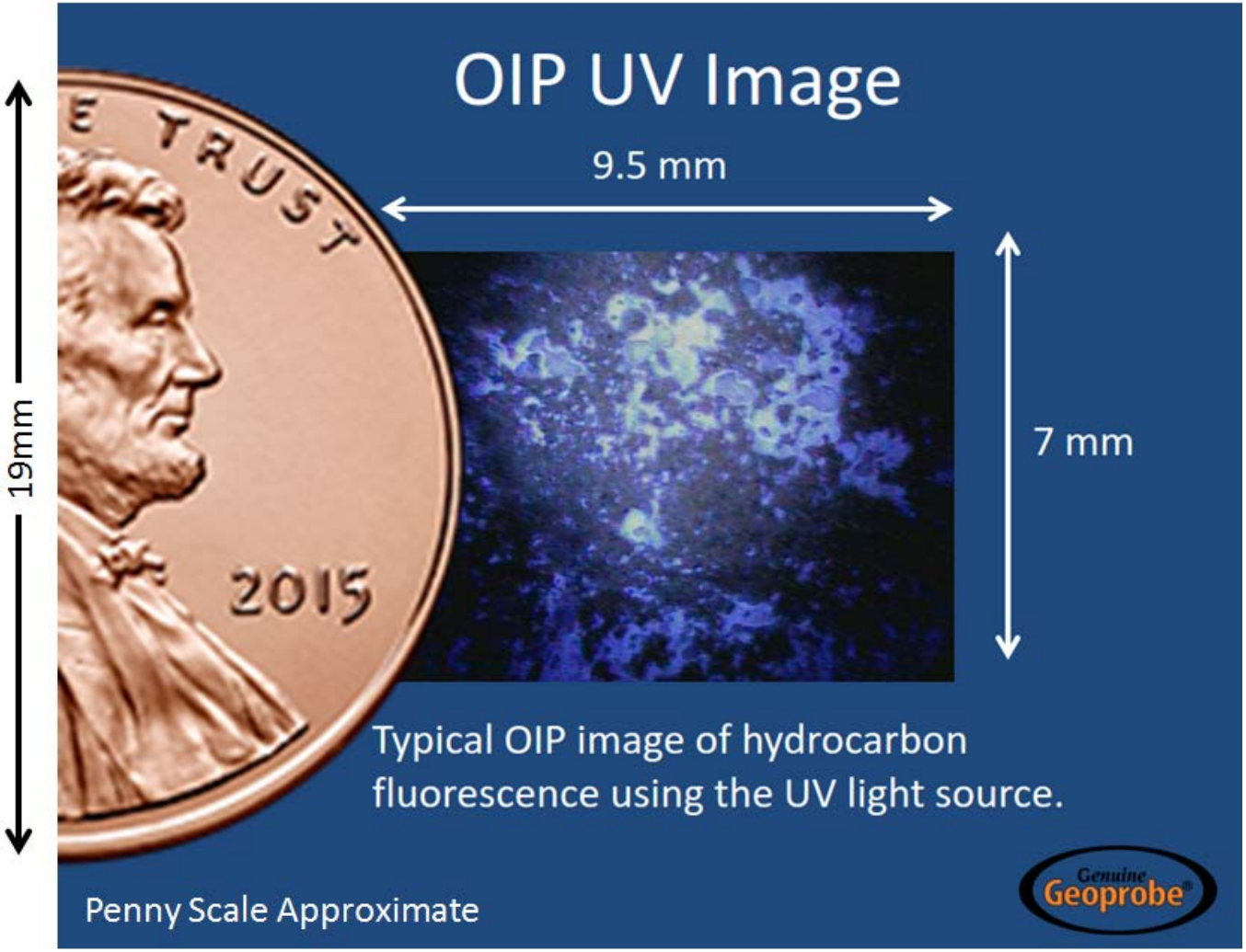
OIP Description

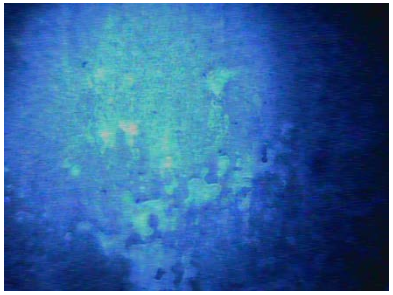
- **Purpose:** Detecting UV induced fluorescence of non aqueous phase fuel hydrocarbons in soil.
- **Method:** High intensity UV light directed at the soil causes hydrocarbons present in the soil to fluoresce. An Image of the soil is captured by the camera and analyzed for fluorescence.
- Visible light images of the soil may also be obtained.

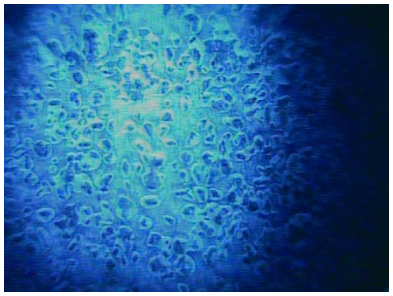




Millimeter-Scale Imaging







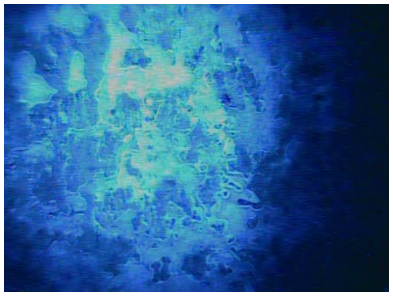
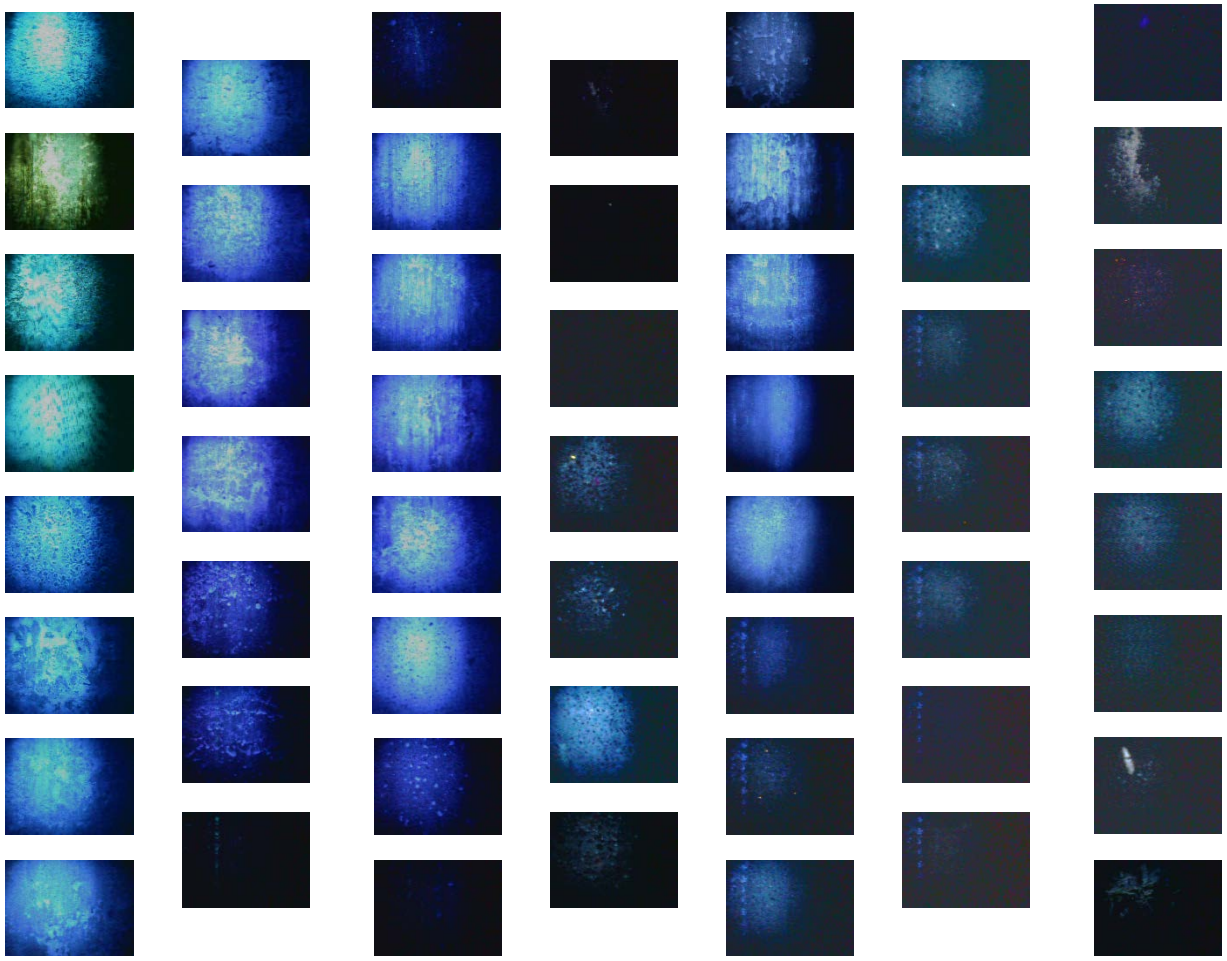
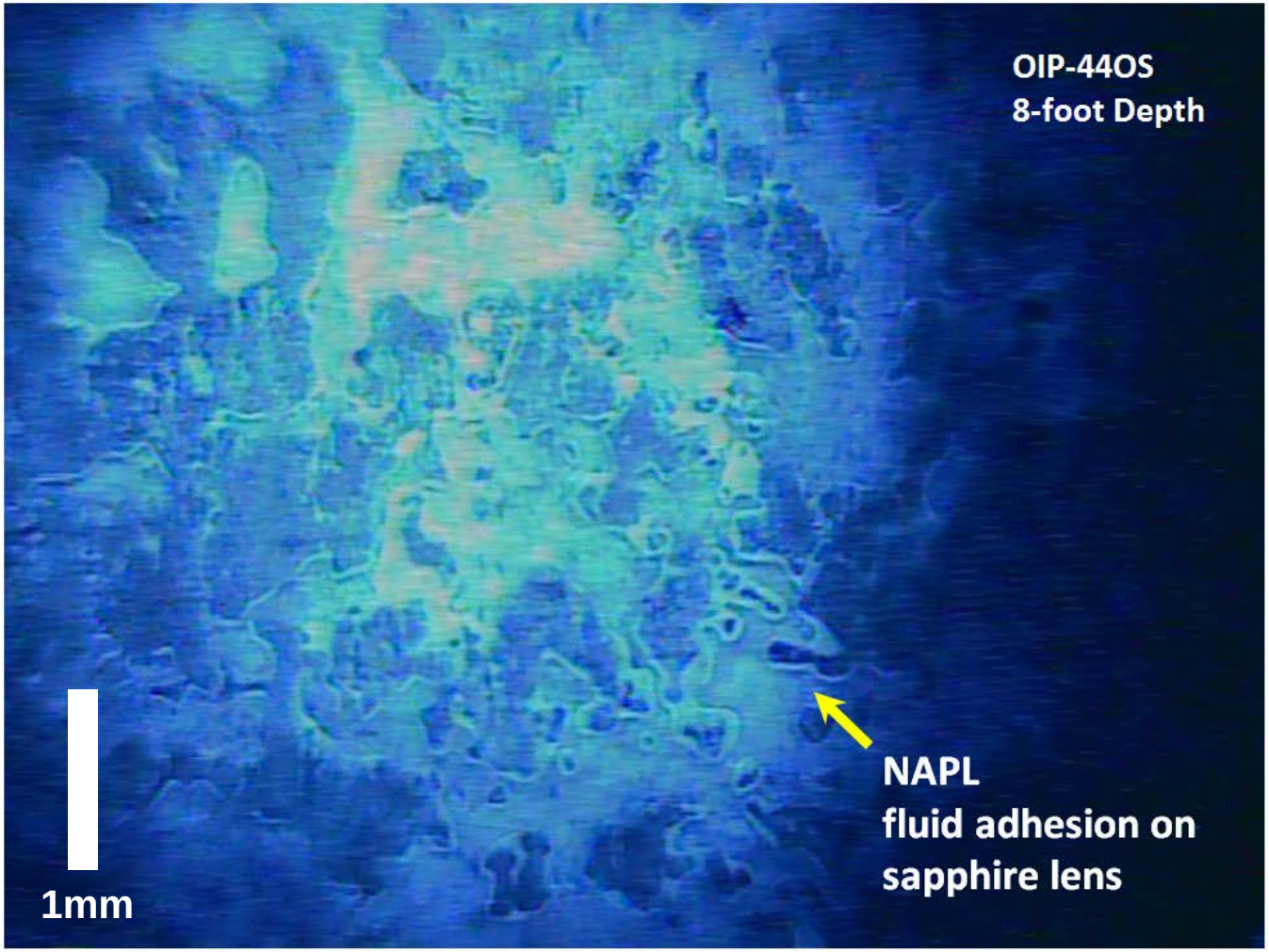


Image Profile Scale



= 37 cm

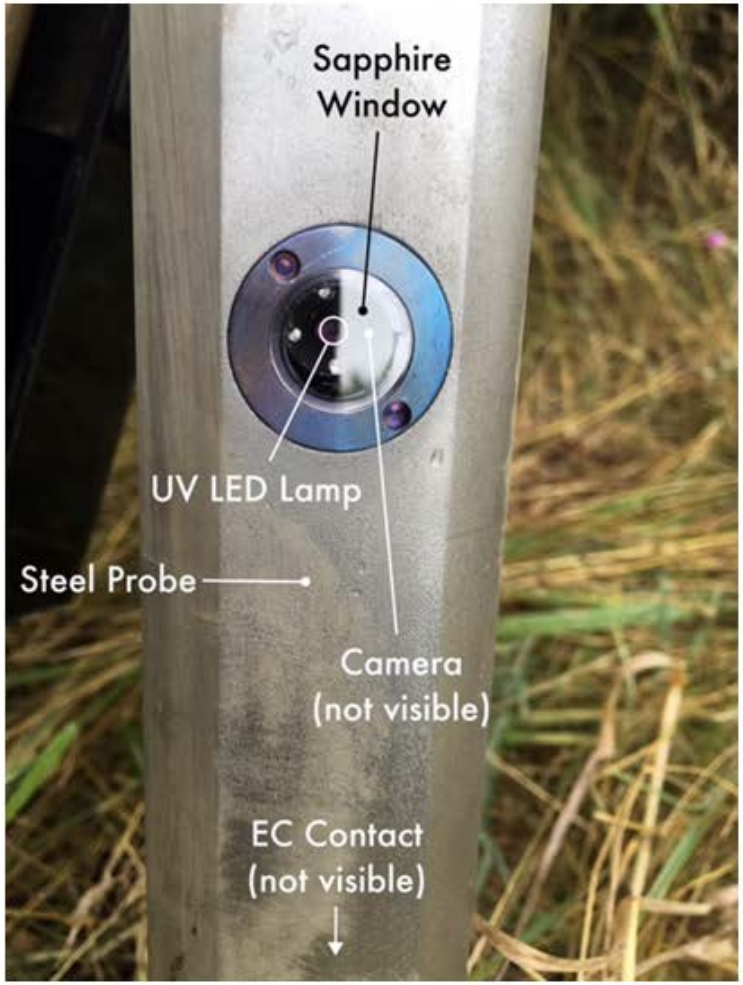
OIP Imaging: NAPL “Ganglia” Artifacts



NS Locomotive Fuel Test Site
Kalamazoo, MI

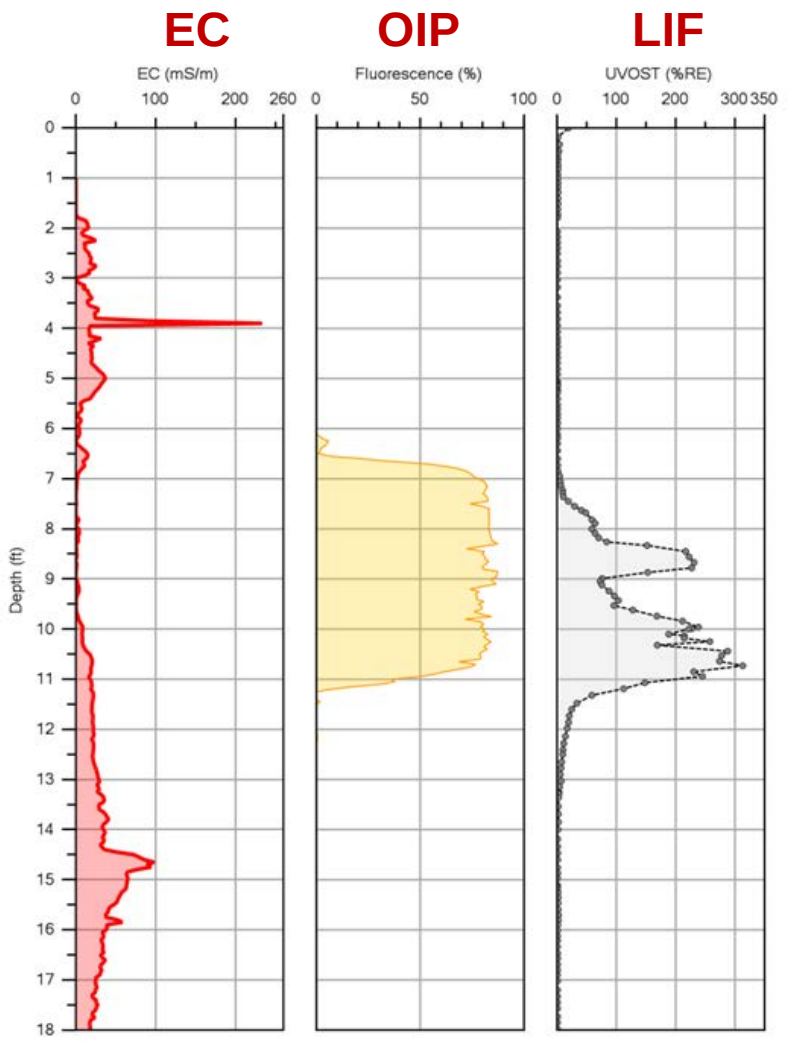
LIF-UVOST and OIP Platforms side by side

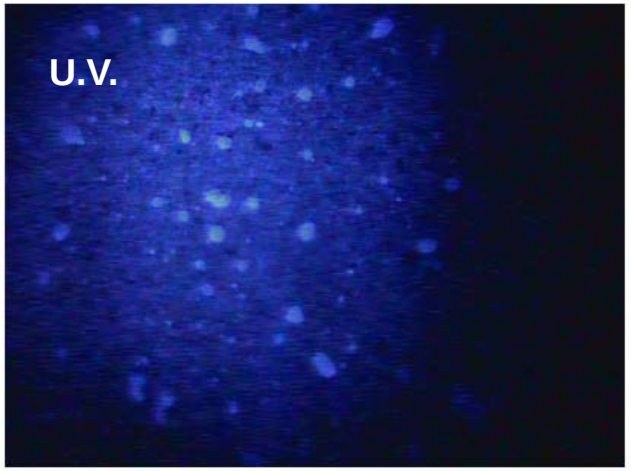
Venders:
Stock Drilling
GeoProbe Services



OIP Probe

OIP Log Compared to LIF-UVOST® Log

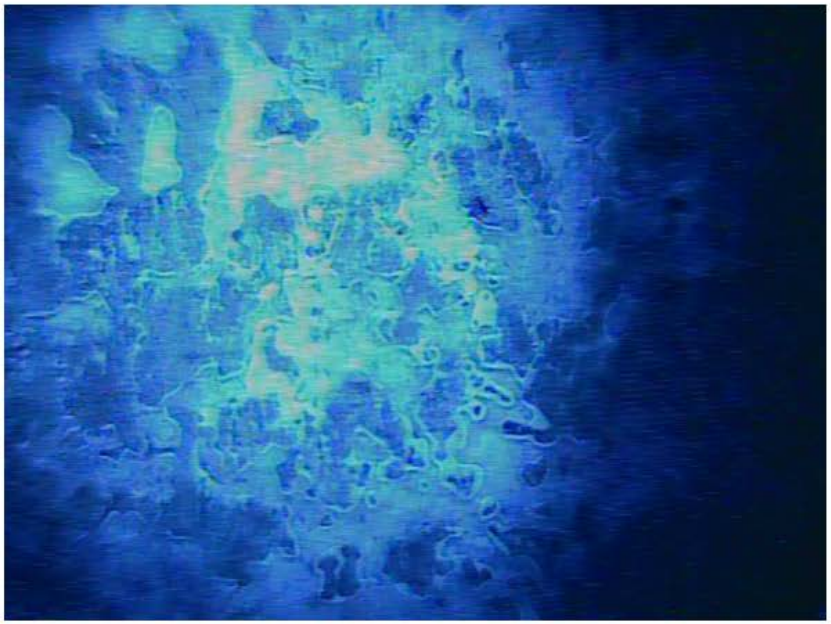




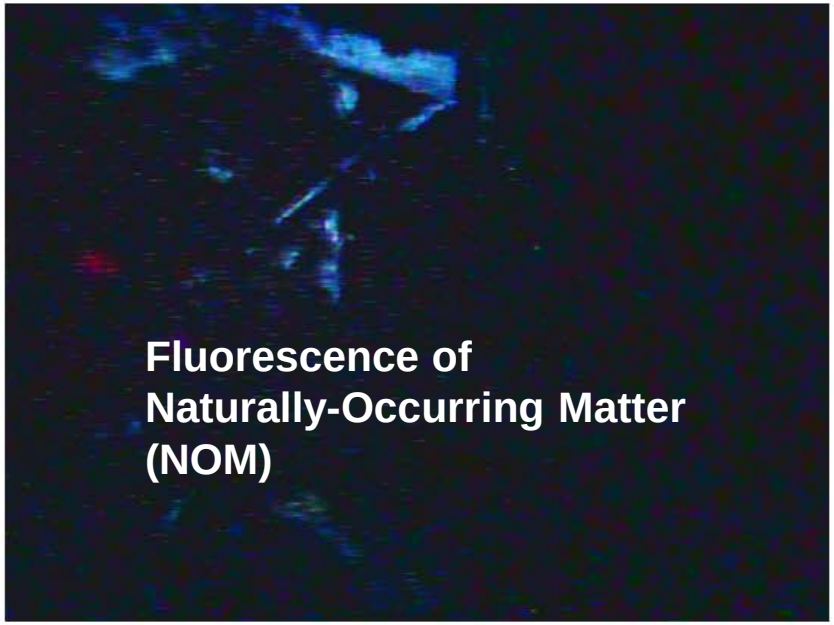
OIP: Visible and UV Imaging

Visible Light

UV Light



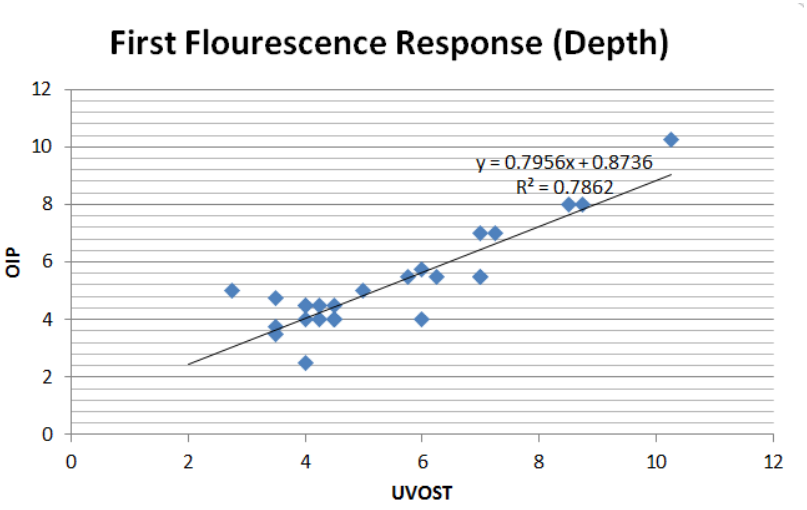
OIP: False Positives

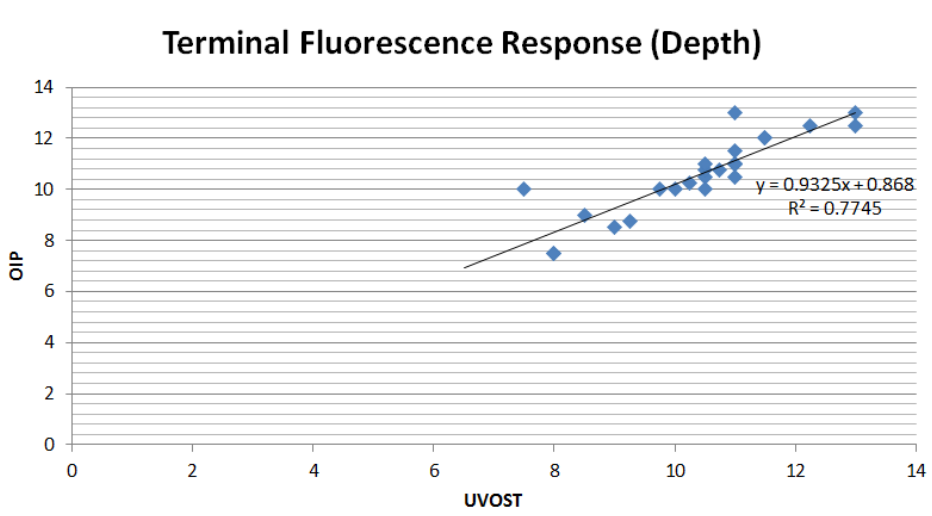


OIP Image Captures at 18-foot depth adjacent to a Fluvial Channel
Kalamazoo, Michigan

Comparison of OIP and LIF Accuracy
Fluorescence Response at Depth

- Gasoline UST Site, Brooklyn, Michigan, courtesy MDEQ and GeoProbe.
- 37 co-located OIP and LIF profiles.
- Data filtered at 95% confidence level.
- R^2 = 0.77-0.79.
- Signals do not always correlate (next slide).

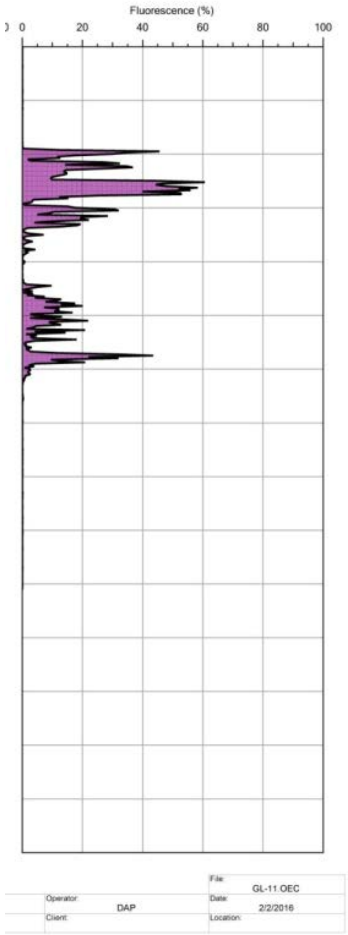




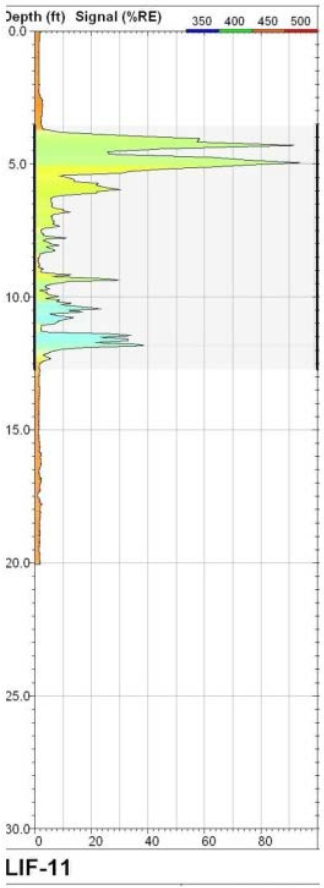
Comparison of Select Logs

Brooklyn, MI

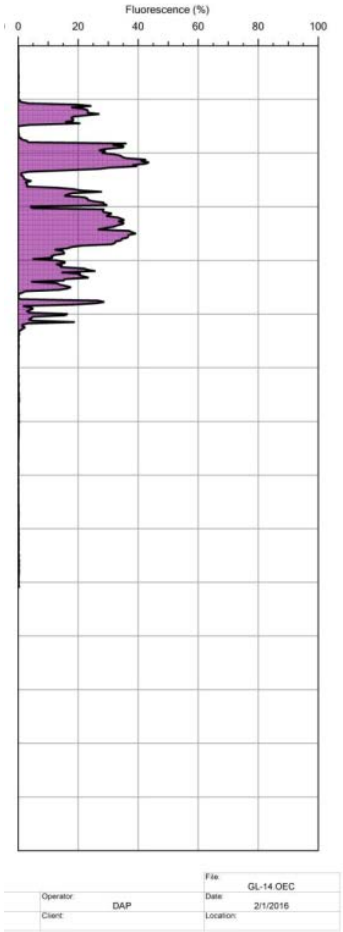
OIP



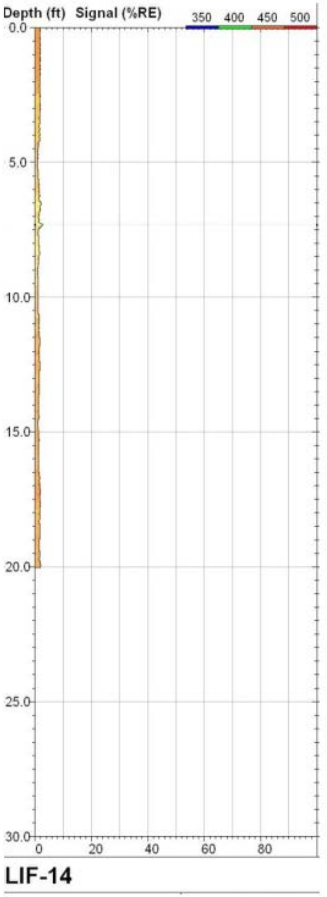
LIF



OIP



LIF



Which Platform to Choose?

LIF-UVOST®

- Co-mingled or mixed NAPL footprints
- When waveform diagnostics are needed
  - Weathering
  - Forensic Type Investigations
- Some field durability issues due to fiber optics and laser components
- Established system

OIP

- Obvious NAPL footprints (e.g. Diesel spills)
- Screening and targeting where NAPL is present
- Straight platform has less to go wrong
- Big data files due to images
- New platform being improved
- Gaining regulatory acceptance

Final Thoughts

- Both LIF and OIP are reliable field-screening tools for NAPL.
- Comparative costs.
- LIF offers more bang-for-the-buck due to waveform diagnostic and is a long-standing proven technology.
- OIP works as described for Diesel fuel, kerosene and gasoline, and probably other refined fuels.
- Be cautious of false positives for both platforms but more so with OIP. LIF waveform analysis allows ID of false-positives.
- Off-set and collect litho-stratigraphic data for either platform.
- OIP: Understand scale. Images depict grains and laminae not beds. Think Lincoln's nose on a penny. Millimeter-Scale.

Thanks!
Questions or Comments?