Characterizing NAPL Sites

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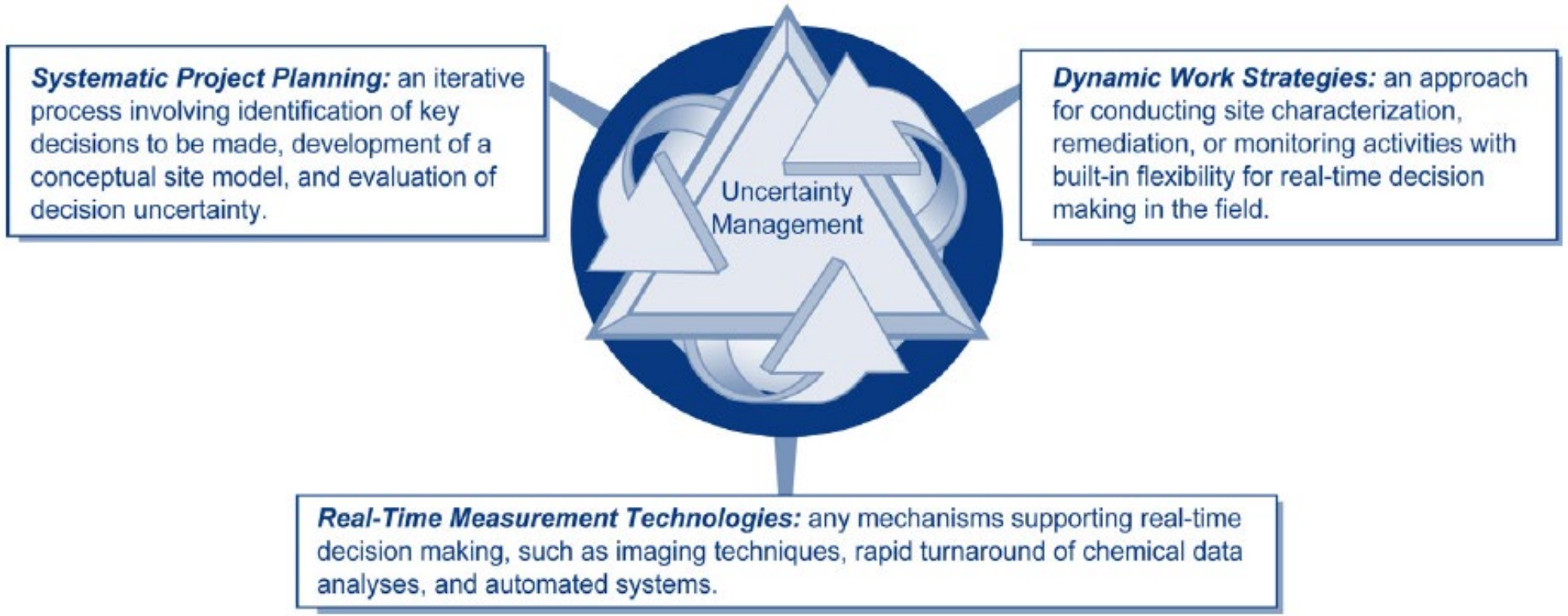
Characterization is Vital for Effective & Efficient Remediation

- Purpose of the characterization
  - Pre-ROD or pre-design investigation?
- Where the contamination is
  - Mass of contaminant in NAPL & dissolved phase
- Geologic setting
  - Soil types – geology, stratigraphy
- Hydrogeology
  - Present & historical water table
  - Groundwater flow direction & velocity
- Characterization approach & tools that works at one site may not be optimal for another site

Triad Approach for Site Characterization

- Respond in the field to the data being collected to guide future data collection
  - Real time data needed



Triad Approach: Systematic Planning How to Start?

- What you already know about the site
  - What had been done there & where it was done
    - Main processing area, waste ponds, above & below ground storage tanks
  - What chemicals/fuels were used &/or stored on site
  - Historical data – don't throw it all out! But consider quality of data & what may have changed since the data was collected
  - Site usage many have changed over time
    - Aerial photos may be useful
- Planning consists of specifying how to respond to new data that is obtained

Triad Approach: Dynamic Work Strategy

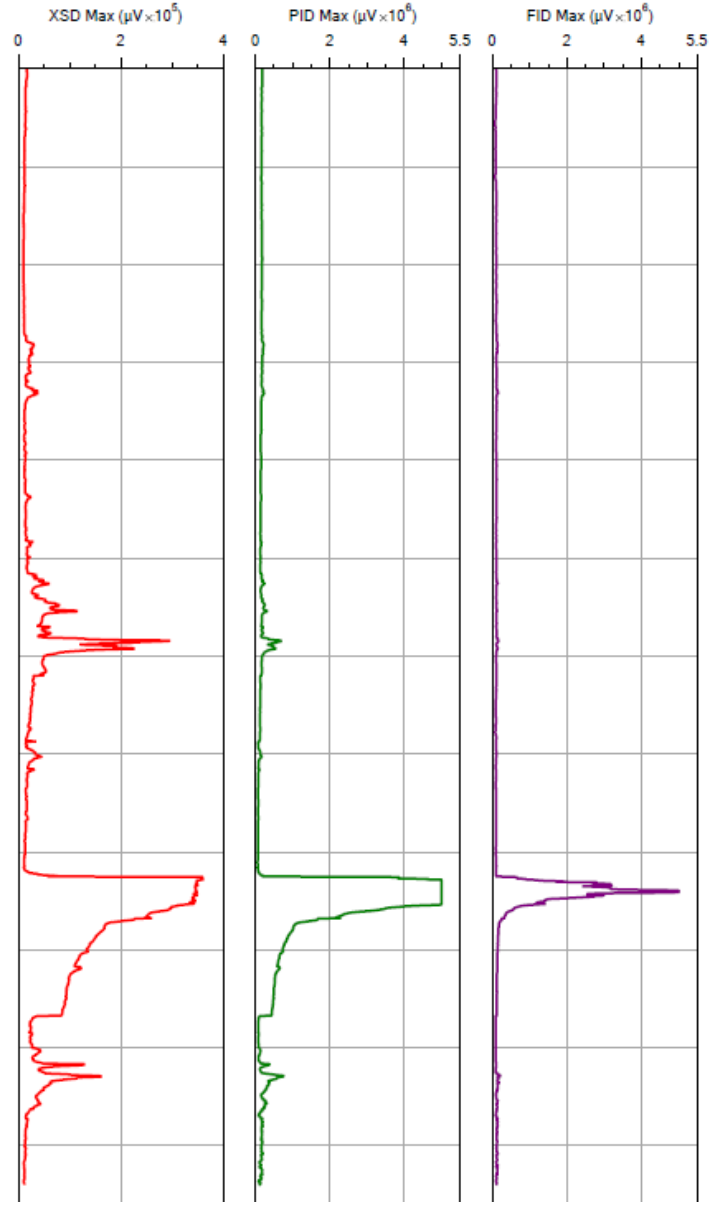
- Start with screening tool that provides real time date such as Membrane Interface Probe (MIP) or Laser Induced Fluorescence (LIF) in area of known NAPL contamination to confirm that it can detect the NAPL
- Confirm screening results with soil samples
  - Soil borings should confirm a percentage of the screening results
- Step out in all directions until lateral extent of NAPL has been determined
  - Distance between boring generally 20 to 50 feet depending on the overall size of the site & objectives
- Generally want to have ‘clean’ borings surrounding the NAPL area

When looking for NAPL, use ‘lines of evidence’ approach

- Screening tool results
  - MIP
  - LIF
- Soil core inspection:
  - PID/FID screening
  - Visual observation
  - Odor
  - Oil red dyes
  - Analytical samples
- Ancillary indications of contamination
  - Groundwater Data
  - Oil sheen on water or in soils
  - Soil Vapor Data

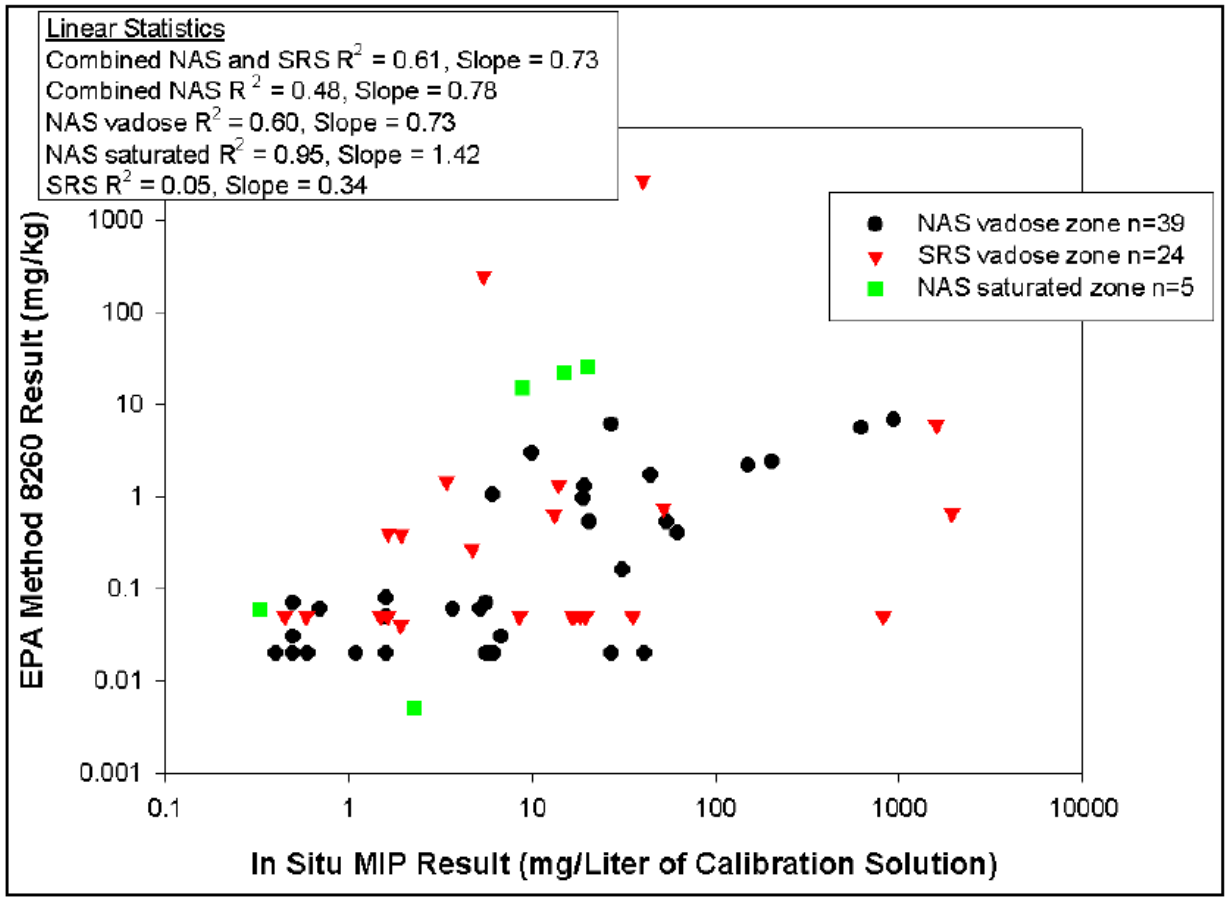
Triad Approach: Real Time & Continuous Vertical Data

- Screening for indication of VOCs
- Membrane Interface Probe (MIP) for chlorinated volatile organic compounds (VOCs)
- 3 detectors have differing sensitivity to VOCs
  - PID – CVOCs
  - FID – hydrocarbons
  - XSD – halogens



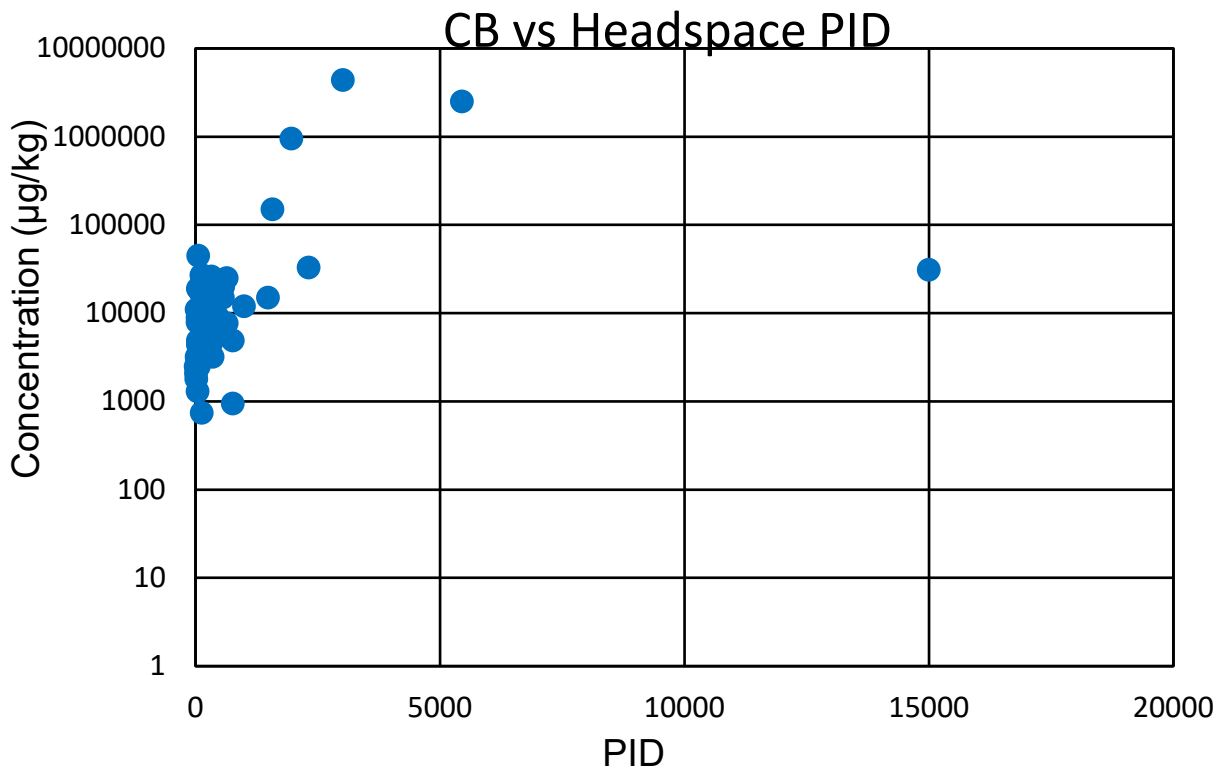
Screening data does not correlate to analytical data

- MIP data indicates the presence of VOCs, but not the concentration of VOCs
- MIP data should not be used for estimating mass in the subsurface
- Soil concentration data is best for estimating NAPL mass, but still only an estimate



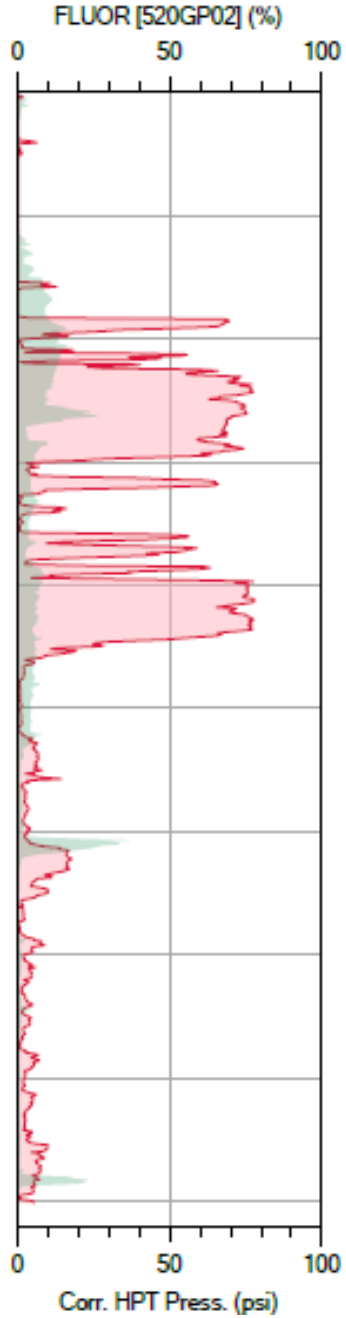
Screening of soil core with PID does not correlate directly with contaminant mass

- Analytical results for chlorobenzene vs PID scan of soil core are shown
- PID & analytical results are not linearly related
- Soil analytical results are needed for estimating contaminant mass



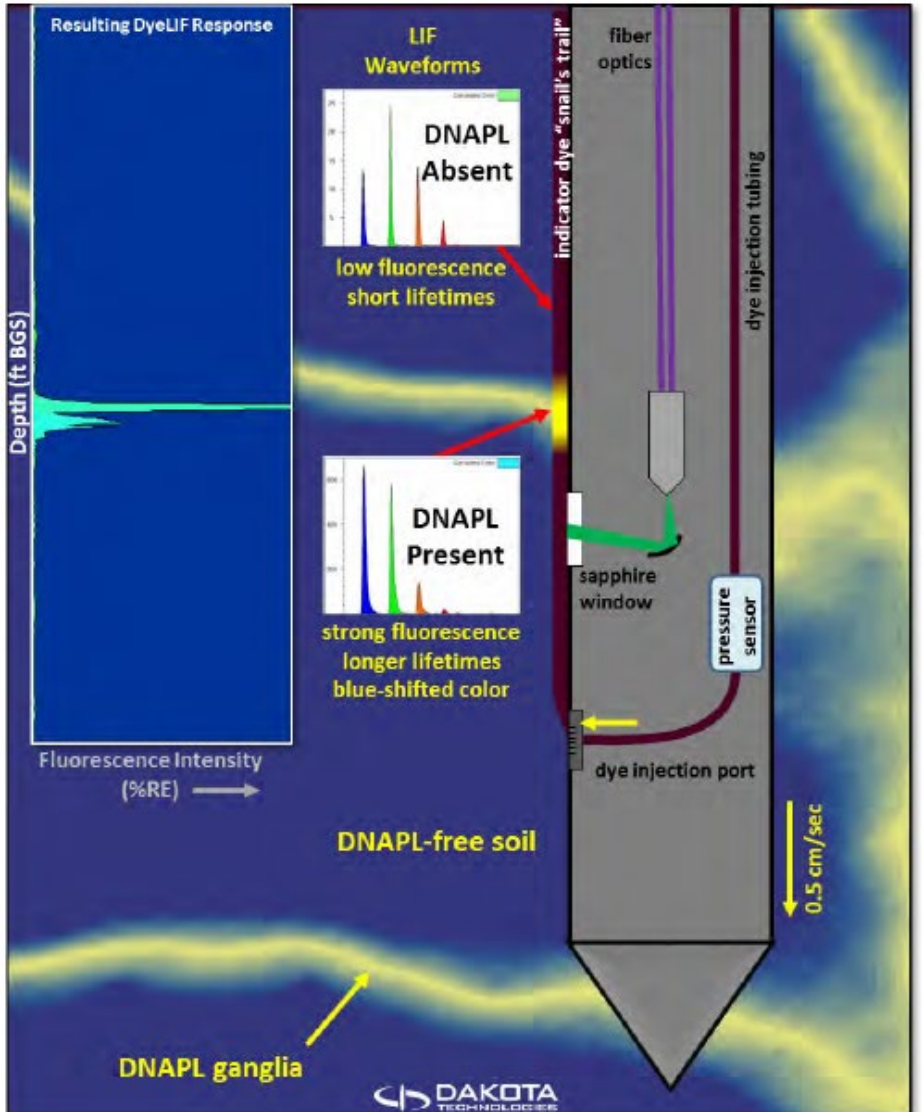
Screening for Creosote or other PAHs, fuels

- Laser Induced Fluorescence (LIF)
- Different lasers available for different petroleum hydrocarbons
- CPT based
- % response does not correlate to PAH concentration or TPH
- ‘False positives’- naturally occurring materials such as shells can cause fluorescence response
- Validate response with soil core observation & analytical samples



DyeLIF

- For VOCs, chlorinated solvents
- Another line of evidence of NAPL
- Response must be validated against soil cores
- Lab testing of soil core for fluorescence response recommended before deployment of the tool in the field



DyeLIF is not straightforward to interpret

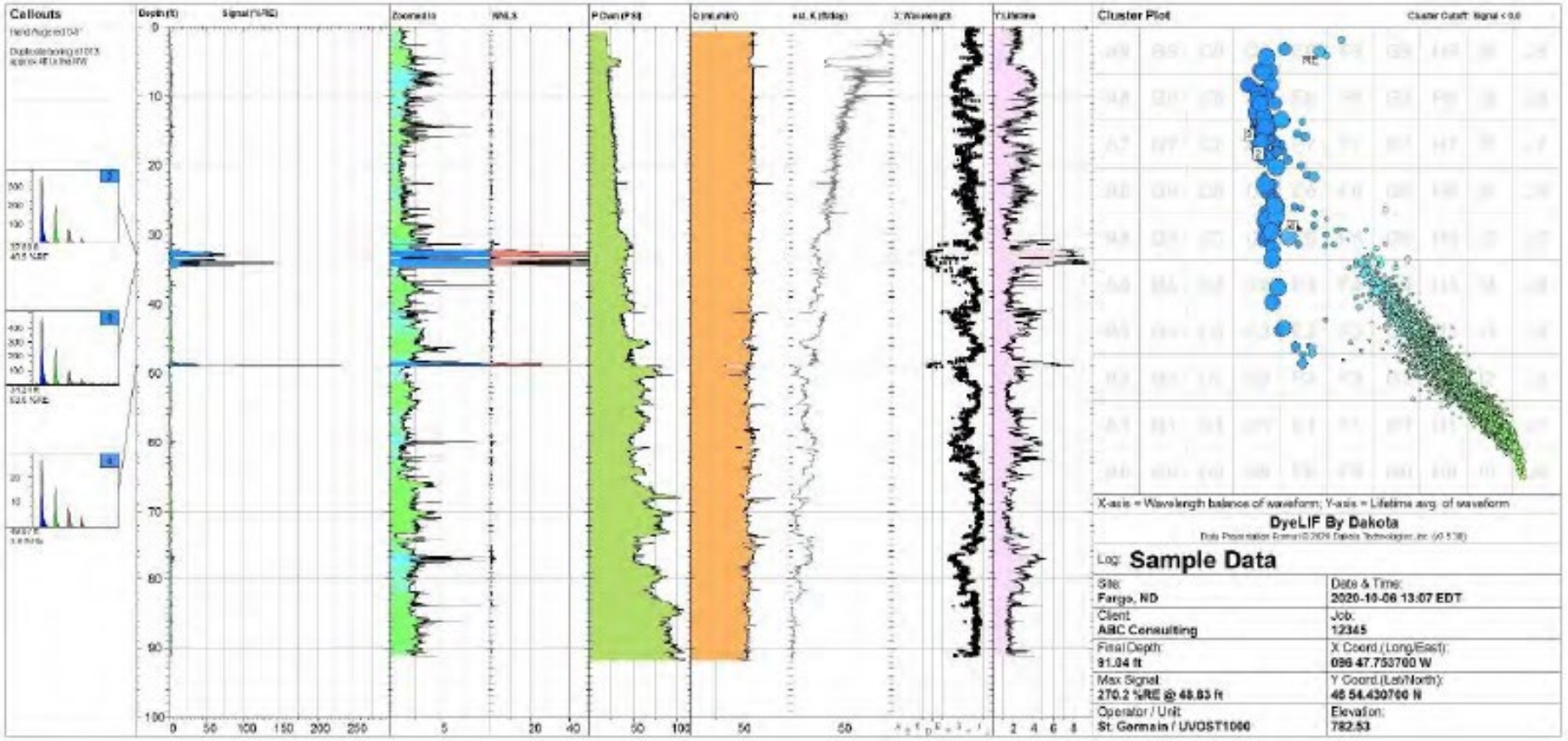
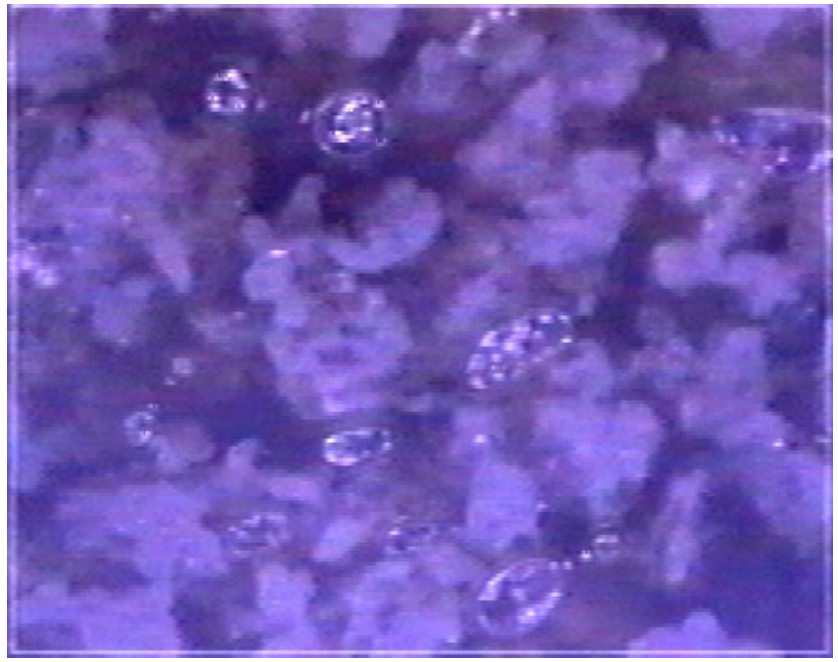


Figure 2. Typical DyeLIF log

Downhole camera can help to visualize subsurface soils & NAPLs

- GeoVis picture of NAPL & air in pore spaces
- Waste solvent site – oil & vapor/air bubbles
- Valuable for detecting creosote, coal tar



Direct Push Technologies Screening Technologies

- Cone penetrometer (CPT) based
- Fast, less costly
- Real time data
- Continuous vertical readings
- Must be validated by comparison to soil core
- Do not correlate to soil concentration
- Smaller rigs may improve accessibility
- Depth limited by the soil stratigraphy
- Refusal caused by tight soils, weathered bedrock, subsurface obstructions
- Thick sand beds can also limit penetration depth

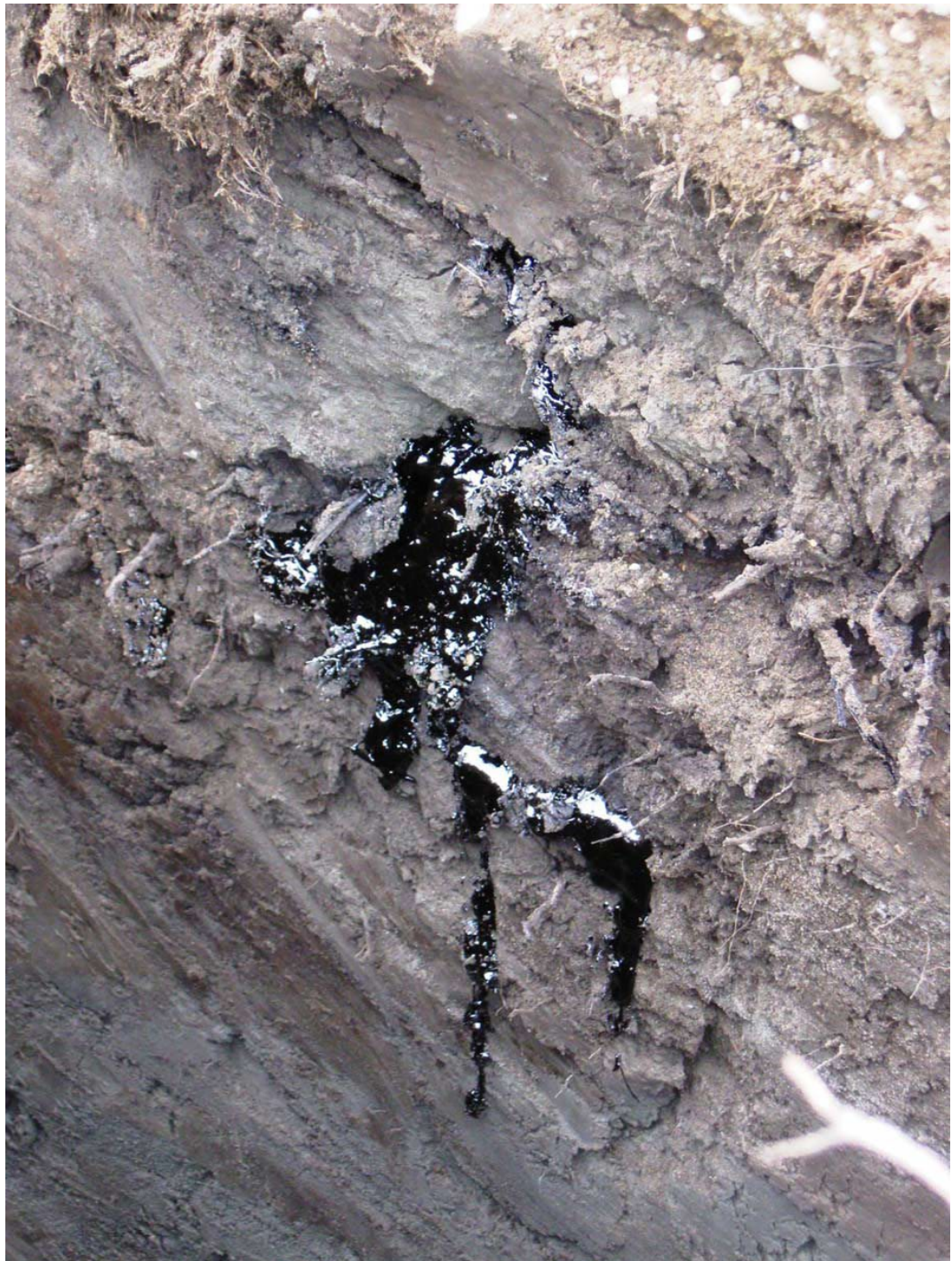
Cone penetrometer (CPT) can be used to obtain soil cores

- Direct push basis limits depth
- Soil cores are small in diameter, 1 – 2 inches, which can make it more difficult to detect NAPL presence
- Short runs – slower process
- Refusal at tight soils, weathered bedrock, gravel, boulders

Rotosonic (Sonic) Drilling Technique

- Larger diameter, continuous cores obtained
- In unconsolidated soils, heat generation is not generally an issue
- 10 foot runs – faster drilling technique
- Generally use outer casing around core barrel which does not allow DNAPL to flow down the borehole
- Bentonite plugs at bottom of low permeability zone can protect lower high permeability zone from downward migration of DNAPL in borehole

Coal tar & creosote-type NAPL often visual in soil & groundwater



Fuels, chlorinated solvents not as easily visible

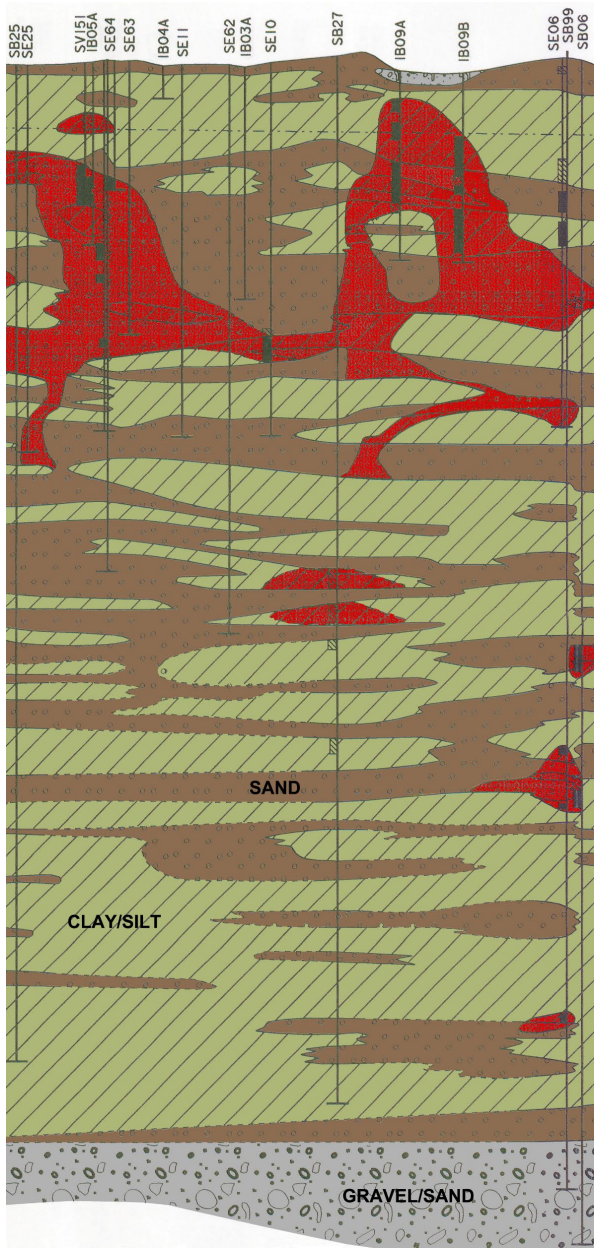
- Jet fuel – not visible in soil
- Oil Red O test – very faintly positive
- PID screening of core indicates NAPL
- Analytical samples more reliable
- Don’t limit the number of analytical samples!

Use of FLUTe Ribbon to screen sonic soil core

How deep should you go when looking for NAPL?

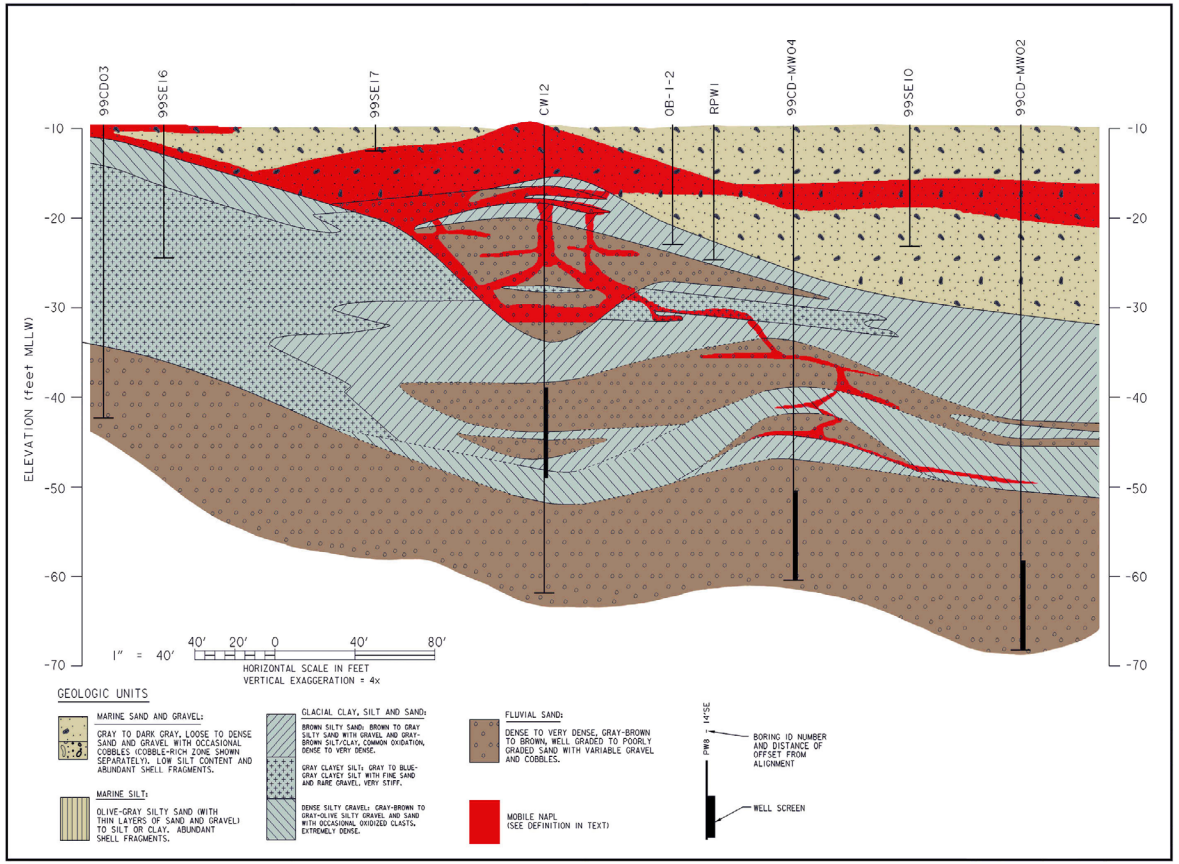
- LNAPL – to historic low groundwater table at time of spills
- DNAPL – site specific, based on geology
  - At site represented, to gravel sand unit 250 feet bgs
  - Top of competent bedrock

  To depth of deepest groundwater contamination



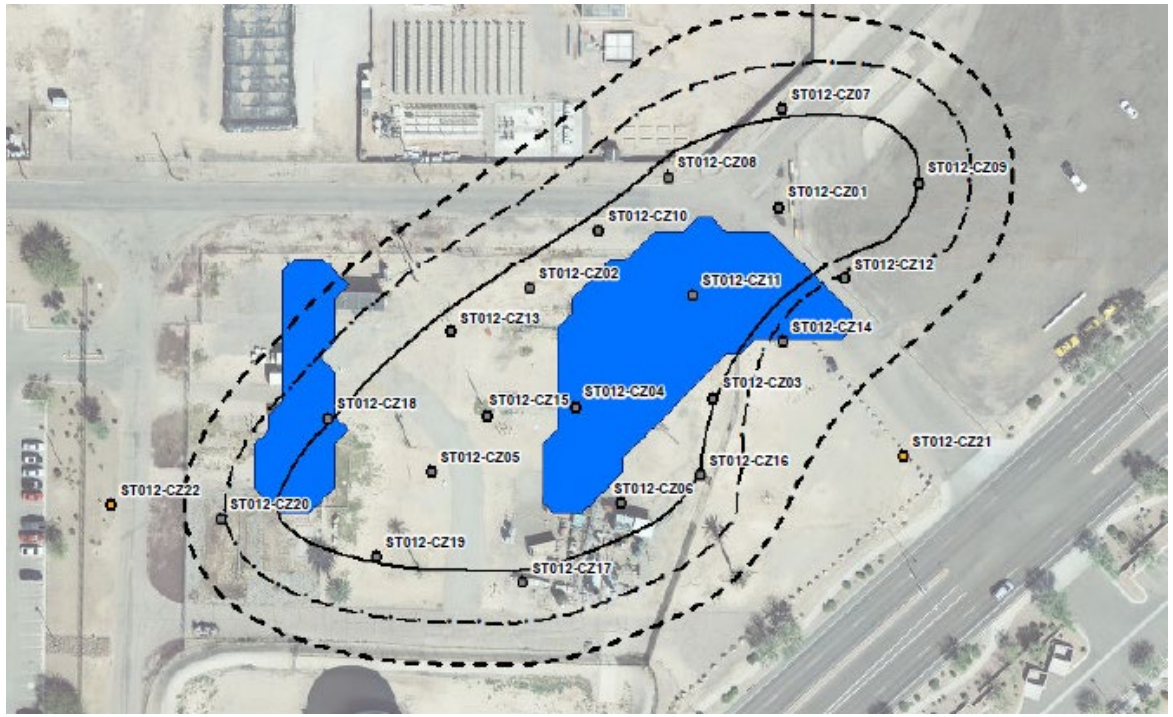
As I said, DNAPL can migrate through low permeability soils . . .

- Red in cross section depicts creosote
- ‘Aquitard’ at the site has large areas of interbedded sands
- DNAPL penetrated ‘aquitard’ to lower sands
- DNAPL at this site also migrated on top of ‘aquitard’ following dip

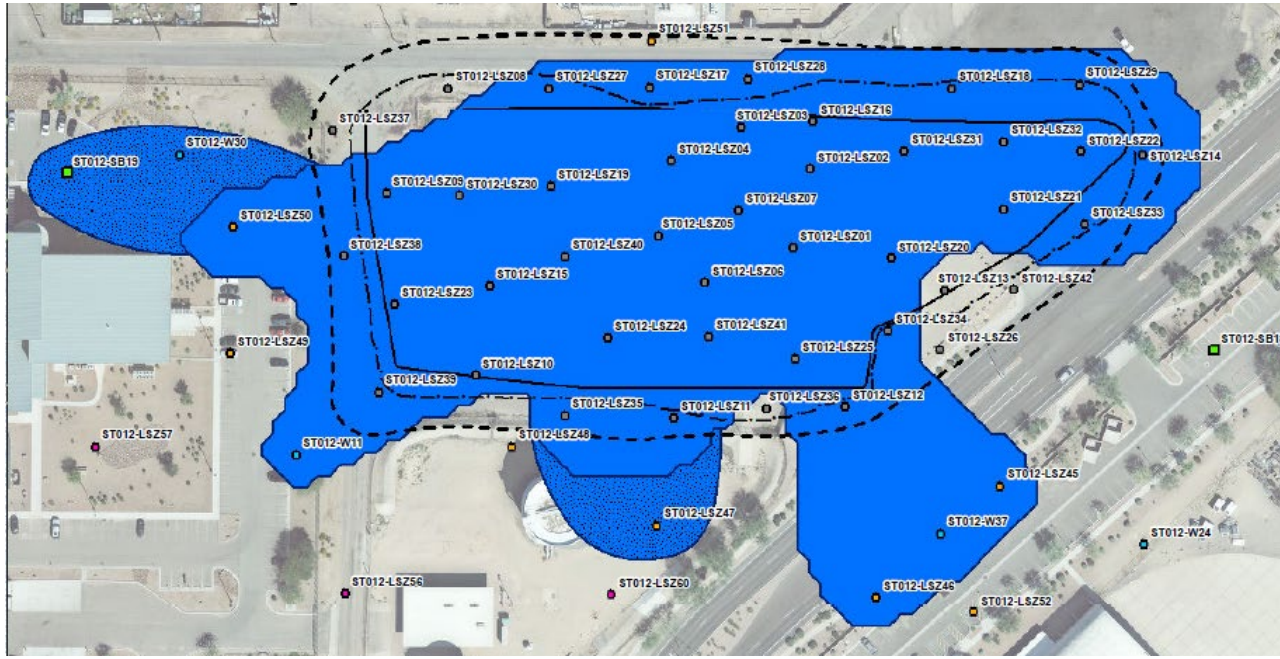


Spread of LNAPL at depth to where the water table had been

155 ft bgs

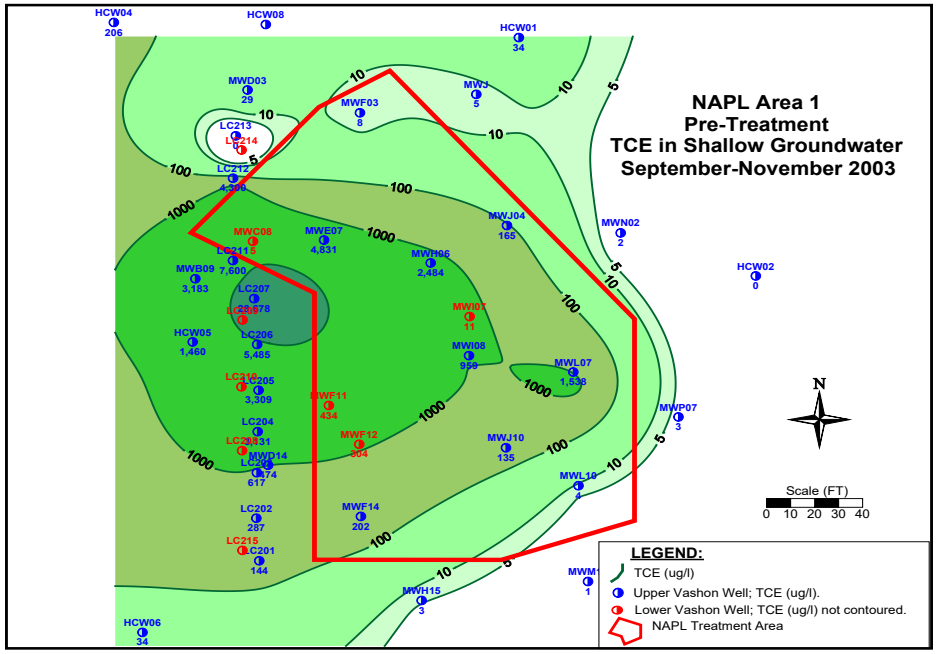


215 ft bgs

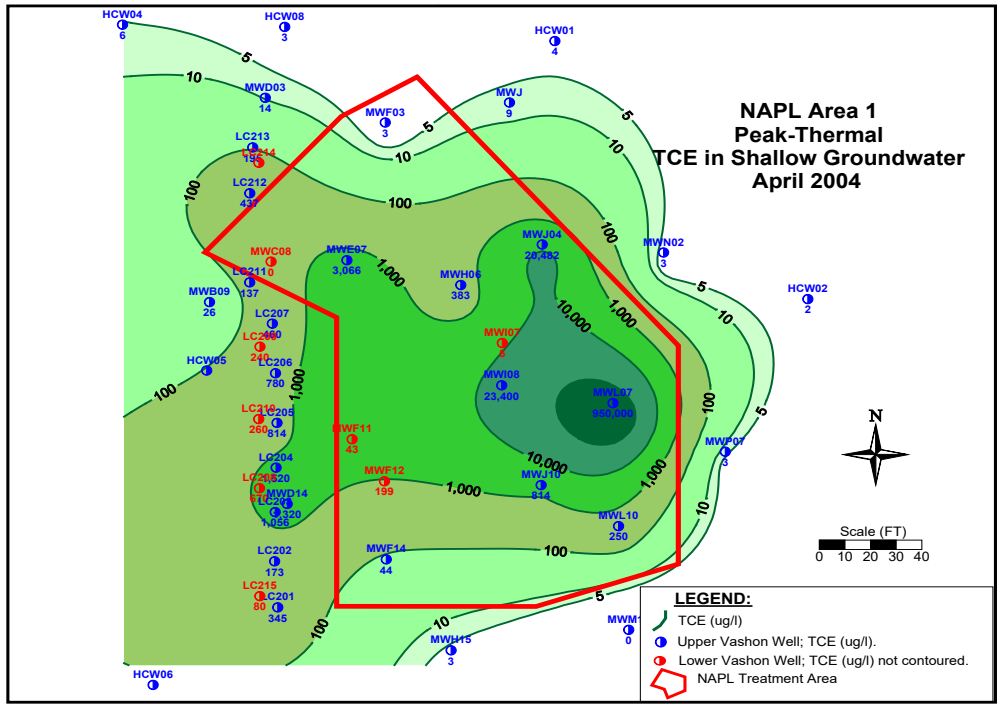


What does groundwater data tell you?

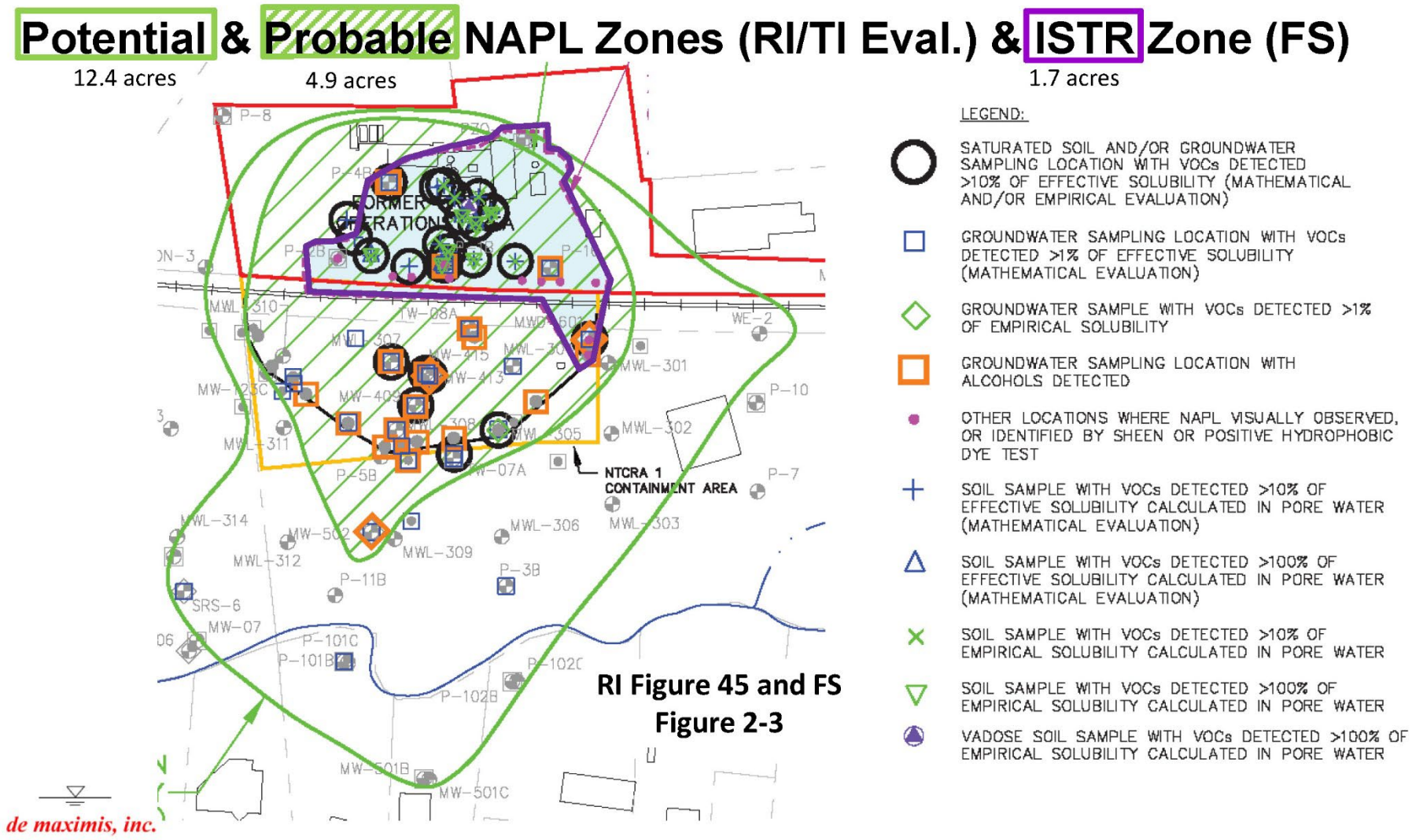
Baseline groundwater concentrations



Groundwater concentrations during heating



What type of data should be used to define NAPL area?



Waste Oil NAPL Delineation

LIF deployed by CPT on barge

Quality of characterization data

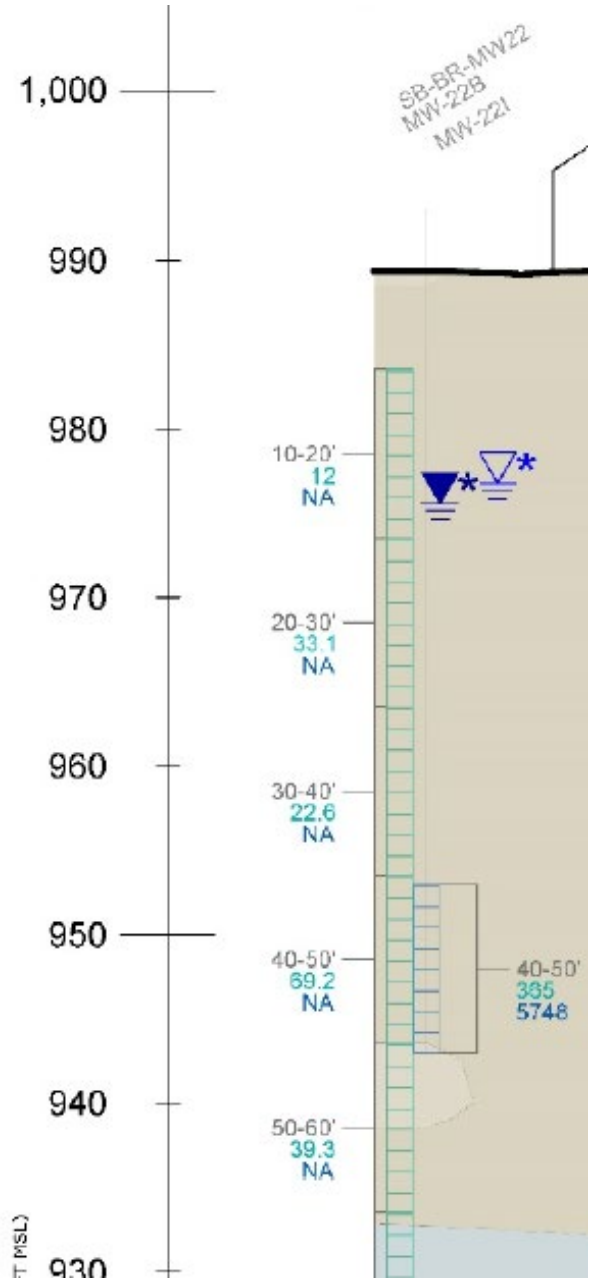
- VOCs in Soil – limit vaporization before analytical sample locations chosen & samples containerized
- Spilt soil core in half, cover half with foil to reduce evaporation of VOCs
- Scan other half of soil core with PID quickly
- Obtain soil samples for analysis where PID reading are highest from covered half of core
- Obtain samples every 5 – 10 feet of core

VOCs in Groundwater

- Soil cores are like ‘soda straws’ – very small portion of the subsurface is being examined
- Groundwater samples from monitoring wells queries a larger area – may indicate NAPL presence that would be missed with soil cores
- Low flow sampling techniques remove stagnant water from the wellbore to get more representative groundwater sample from the formation
- Collect sample directly into VOA vial, ensure there are not bubbles
- Pouring sample between containers, for example from bailer into VOA can vent VOCs

Contaminants may Migrate in Thin Vertical or Horizontal Zone

- Temporary well groundwater samples taken with short screen every 10 feet missed a zone with much higher contaminant concentrations



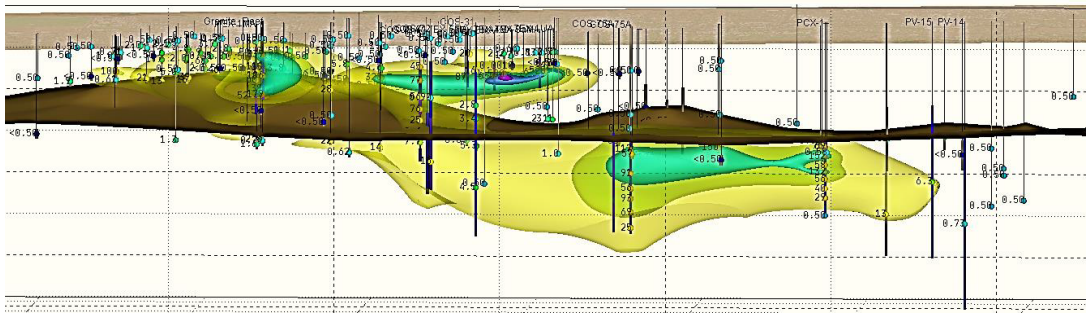
QA of Analytical Samples

- VOCs
- Ensure that you have the proper container & preservative for the analysis to be done
- Ensure proper storage & shipment of samples
- Ensure holding times are met
- Water samples must not have bubbles in the sample container

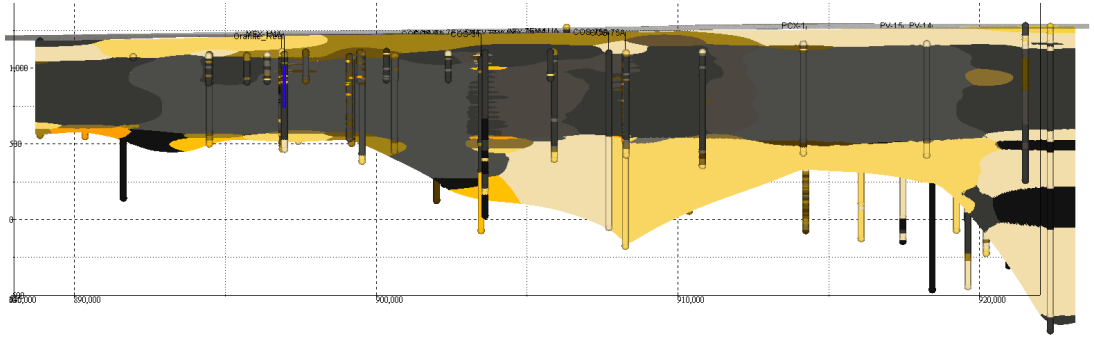
- SVOCs (creosote, coal tar)
- EPA Method 8270 only identifies & quantifies a relatively small number of the PAH compounds contained in these NAPLs
- Analyze for Total Petroleum Hydrocarbons (TPH) (gasoline range, diesel range, oil & grease) for total mass estimates

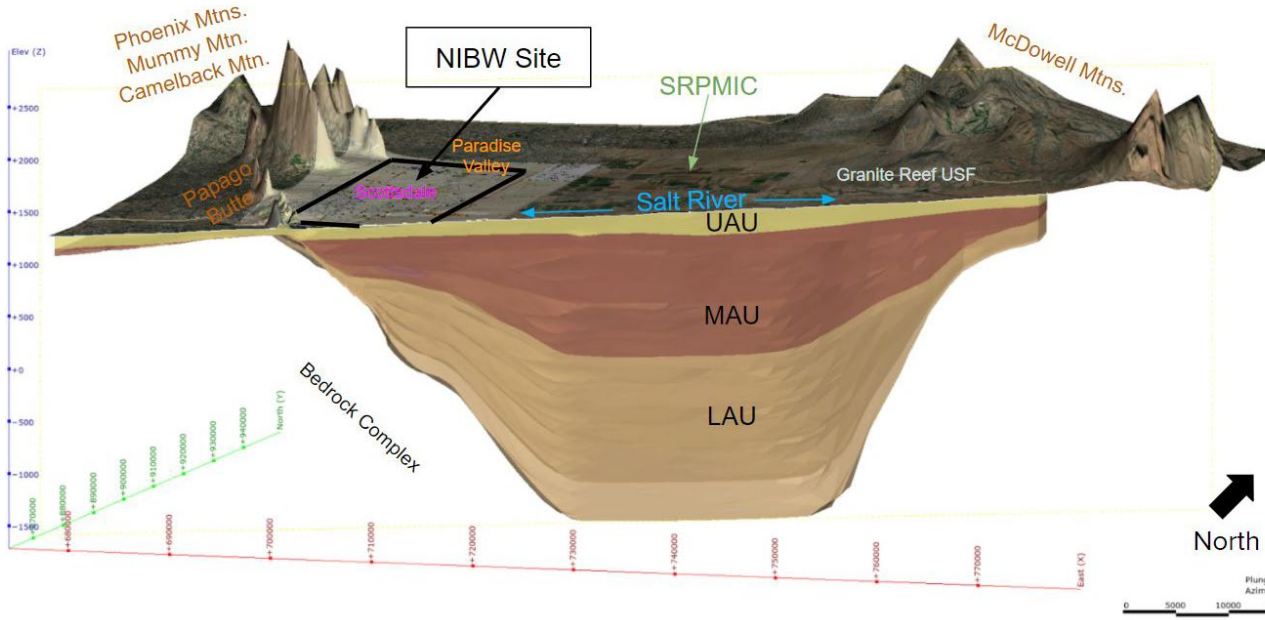
Data presentation: 3D vs cross sections

Groundwater concentrations



Lithology





Contours – pros & cons

- Help to visual data, whether it's potentiometric surface to indicate groundwater flow direction or groundwater concentrations

- Can be very misleading if not all wells are sampled
- For example, wells containing NAPL are often not sampled, so areas of highest groundwater concentrations would not have data to be included in the contouring
- Changes in wells/ground surface can affect calculated water table elevation

Take to the field message

- Triad approach reduces number of mobilizations needed to characterize the site
- Thus reduces the time & cost to complete the characterization
- Can be more complex contracting when the number of borings are not specified
- Takes more coordination of the project team with the field personnel

Characterization Conclusions

- Experience finally allowing more ‘science’ to it - not necessarily being carried over to the field yet
- Field work generally done be least experienced personnel – they need proper training/instruction to perform the work correctly
- NAPL delineation requires ‘multiple lines of evidence’ especially for NAPLs that are difficult to see in soils (CVOCs, refined fuels)
- Delineation of creosote, coal tar may be based more on visual observation as well a LIF screening
- Soil concentrations are the best data to estimate mass