Drilling Not Able (to find) Precise Location of Solvents

Presented By

Dr. Todd Halihan (Oklahoma State University & Aestus, LLC)
Stuart W. McDonald, P.E. (Aestus, LLC)

NEWMOA Workshop
Characterizing Chlorinated Solvent (DNAPL) Sites

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Today’s Discussion Points Regarding DNAPL Site Characterization

- Conventional site characterization methods are not providing complete & cost effective site characterization; a new tool is available to help (i.e., high resolution ERI)
- Review reasons why wells/borings alone are not sufficient to characterize DNAPL sites
- Discuss new paradigm of NAPL source behavior in subsurface developed by use of high resolution ERI (GeoTrax Survey™)
- Review Case Studies - EPA, States, consultants, have demonstrated that high resolution ERI (GeoTrax Survey™) works to locate NAPLs in subsurface
- Better site characterization → Better Project Results
Doc said he could give you a CAT scan but he wants to try it this way first!
Most common characterization approach is to scan first

- Medical
  - X-ray
  - MRI
  - Sonogram

- Petroleum
  - Seismic
  - Gravity
  - Magnetics

- Environmental
  - Drill
  - Probe
  - Excavate

Sampling array at the Cape Cod Site; over 10,000 subsurface sampling ports. –USGS-
Typical Site Characterization Problems

- Costly Investigations
  - Few useful data points (low data density)
  - Too much “interpretation” between data points
- No continuous “picture” of the subsurface
- Site impacts with no known source
- Over/under design and inefficient O&M
- Is the site really clean following remedial action?
Why don’t we “scan” first?

1. **Cost**
2. **Social limitations** (3rd Party scanning?)
3. **Previously difficult to effectively scan**
   - Lots of “noise”
     - Pipes
     - Disturbed ground
   - Most contaminants geophysically “invisible”
     - Non-magnetic
     - Low density contrast
     - Non-conductive to highly non-conductive
Characterize my DNAPL problem…

1. I put an organic cocktail into the ground with many possible constituents
2. I don’t know when or exactly where
3. My subsurface property distribution is unknown
4. Biodegradation is occurring at some rate
5. I may have added a few things….
What is Electrical Resistivity Imaging (ERI)?

- Based on
  - DC resistivity techniques (>100 yrs old)
  - computing/electronics power (<10 yrs old)
- Instead of 10’s of data, collect thousands (high data density)
- Geological digital photography
- Provides high resolution map of electrical properties of the subsurface
How ERI Works – “Setting Up The Camera”

- 56 Electrode Stakes (3/8-inch diameter) Hammered Into Ground
- Geophysical Cables Attached to Electrode Stakes
- Data Collection Starts (~1-2 Hours; Site Dependent)

Take Only Pictures…Leave Only “Footprints”!
How ERI Works – “Taking the Picture”

Four Electrodes Yield One Measurement Data Point (“pixel”)

One Data Point or “Pixel”
How ERI Works – “Developing the Film”

Iterative Measurements Yield Matrix of Data Points or “Pixels”

Proprietary Software Generates Subsurface 2-D Image from Data Set

A Kilopixel Digital Camera Taking Electrical Picture of Subsurface
How ERI Works – Viewing the “Pictures”

ERI Output – 2-D Data “Fences” in 3-D Space
How ERI Works – Viewing the “Pictures”

3-D ERI Model Output – Enid, OK
What would you like the Enid Site conceptual model to be?

*(all cores within 60 feet of each other)*
Why didn’t we do this before?

Technological Progression

• Data acquisition now 100x faster than 1990
• Data processing now 350x faster than 1990
• Images were not “drillable”
  – OSU/Aestus created dramatically improved images
  – Images can “see” resistive subsurface targets others can’t
Proprietary OSU/Aestus Data Acquisition Algorithms

Standard Electrical Resistivity Techniques

Proprietary OSU/Aestus Data Reduction/Processing

Aestus Proprietary Supplemental Field Equipment

High Resolution Subsurface Image

That is “Drillable”
Technological Comparison

- Standard ERI methods barely able to detect “blob” with the highest concentration of LNAPL detected on this site
- Second LNAPL “blob” does not show up using standard ERI

- OSU’s/Aestus’ ERI Methods detect both LNAPL “blobs” present
- Image shows concentrations in a semi-quantitative manner
- Images are “Drillable”

* Confirmation Drilling Data Collected by EPA; images from Golden, OK Site Case Study
Why has it been so hard to understand your site?

- Wells do not provide a good estimate of subsurface conditions at DNAPL sites
- No site imaged with this ERI technique has shown a uniform layer with a “thickness” of DNAPL – occurs as discontinuous “blobs”
- Well data should be viewed differently depending on well function, well construction, and whether pre- or post-remediation
DNAPLs at Landfill Waste Pit

GeoTrax Survey™ Results

At the time the image was taken, wells were “clean”
DNAPLs at Landfill Waste Pit - Zoomed

Approximate zone of recovery well influence

Potential DNAPL Excursion
Dept. of Health/Human Services Building - Hobart, OK

(Aestus, August 2004)
Dept. of Health/Human Services Building - Hobart, OK

Core Data - detects high total petroleum hydrocarbon concentrations

Well Data - all were non-detect, No apparent problem

(Secor, August 2004)
Some references that demonstrate problems with monitoring LNAPL using only wells


Now, in general…

- Wells provide a limited picture of the subsurface.
- ERI provides a great tool to allow sites to be better characterized; ERI is not a magic bullet as confirmation data is required to calibrate images.
- Because DNAPL distribution is discontinuous, the total volume estimated using ERI is typically much less than estimates using only well data.
- Visual tools provide increased ability to understand sites and communicate to project stakeholders.
Why do you need confirmation borings?

- Every site is different—there are infinitesimal combinations of lithology, pore fluids, pore structure, contamination, and previous remediation attempts.

- We don’t have a “magic” resistivity scale that categorizes every site.

- Images MUST be calibrated in order to provide the best interpretation.
Case Studies
Locating DNAPLs in Hard Rock Geology
Using GeoTrax Survey™ Subsurface Imaging

Dry Cleaners Site – PCE and TCE
Case Study - Dry Cleaner Site with TCE & PCE in Sands/Clays Overlying Bedrock

- TCE-72.8 ug/L, PCE-2,740 ug/L
- TCE-6.2 ug/L, PCE-472 ug/L
- TCE-7.9 ug/L, PCE-17,600 ug/L
- TCE-14.4 ug/L, PCE-2,350 ug/L
- PCE-14.2 ug/L
- PCE-5.0 ug/L
Case Study - Dry Cleaner Site with TCE & PCE in Sands/Clays Overlying Bedrock - Zoomed

Groundwater Sampling Results

- MIP-5: 9,400,000 uV @36 feet BGS
- MIP-9: 12,800,000 uV @36 feet BGS

Analytical Results:
- TCE: 72.8 ug/L
  - PCE: 2,740 ug/L
- TCE: 6.2 ug/L
  - PCE: 472 ug/L
- TCE: 7.9 ug/L
  - PCE: 17,600 ug/L
- TCE: 14.4 ug/L
  - PCE: 2,350 ug/L
The Road We Want

Characterization | Cleanup | Closure
The Road We Want

Characterization  Cleanup  Closure

Possible Direction

Common Earth Model  Targeted Cleanup  Solid Confirmation

High Res. ERI w/ confirmation drilling  Direct heating Surfactant Flush Dig and Haul Others  High Res. ERI w/ confirmation drilling
Moral of This Story:

Stop Drilling Blind!
THANK YOU!

Questions?

Dr. Todd Halihan
Oklahoma State University
School of Geology
105 Noble Research Center
Stillwater, OK 74078
todd.halihan@okstate.edu

Reed T. Terry
Aestus, LLC
4177 Route 2
(518) 326-1279
Troy, NY 12180
rtt@aestusllc.com

Stuart W. McDonald, P.E.
Aestus, LLC
2605 Dotsero Court
Loveland, CO 80538
(970) 278-4090
swm@aestusllc.com