A Seep Origin Story: Using Electrical Hydrogeology to Find Mysterious Deep LNAPL Source

Todd Halihan, PhD, PGp
Professor (Oklahoma State University)
Chief Technical Officer (Aestus, LLC)

Stuart W. McDonald, PE (Aestus, LLC)
Kyle Spears (Aestus, LLC)

Is this a seep (abiotic) or an abscess (biotic)?

What Tools/Processes to Apply?

Managing A Hydrocarbon Seep

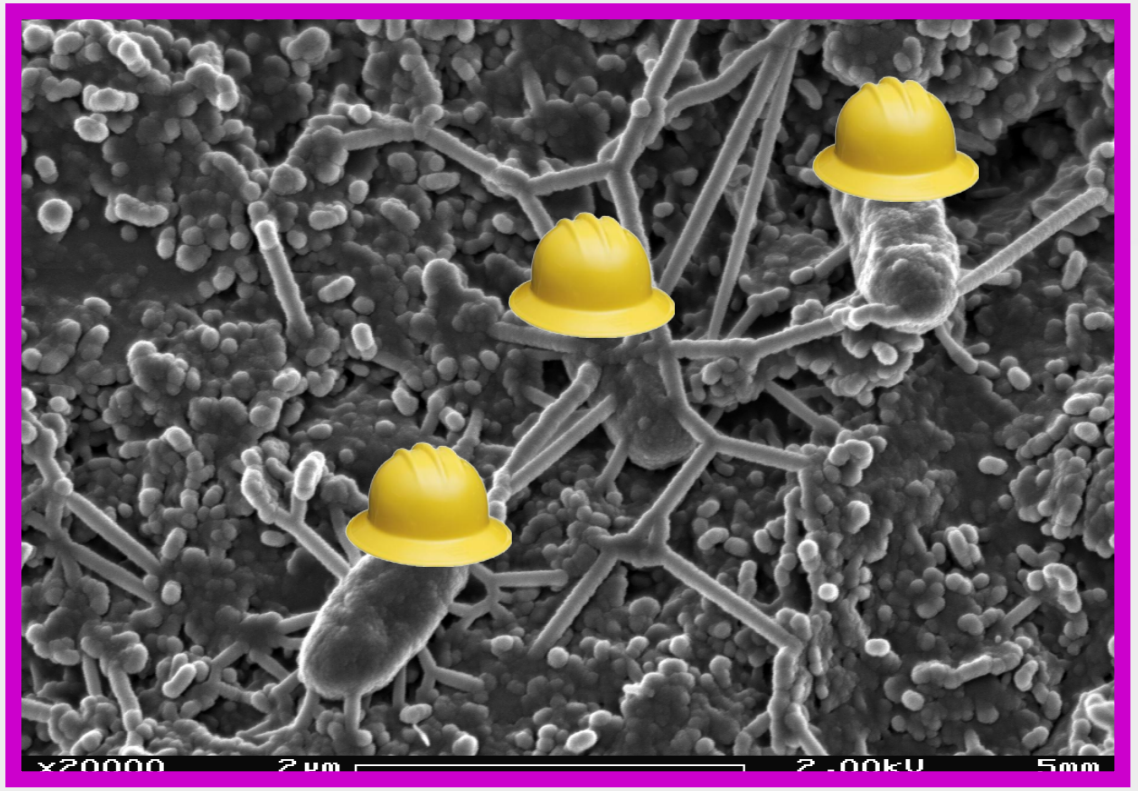
Small volume seeps into tidal flat at base of cliff made of fill material

- What is the origin?
- What is the flowpath?
- What is the mechanism for migration?
- How to best remediate?

Electrical Hydrogeology of Abiotic/Biotic LNAPL

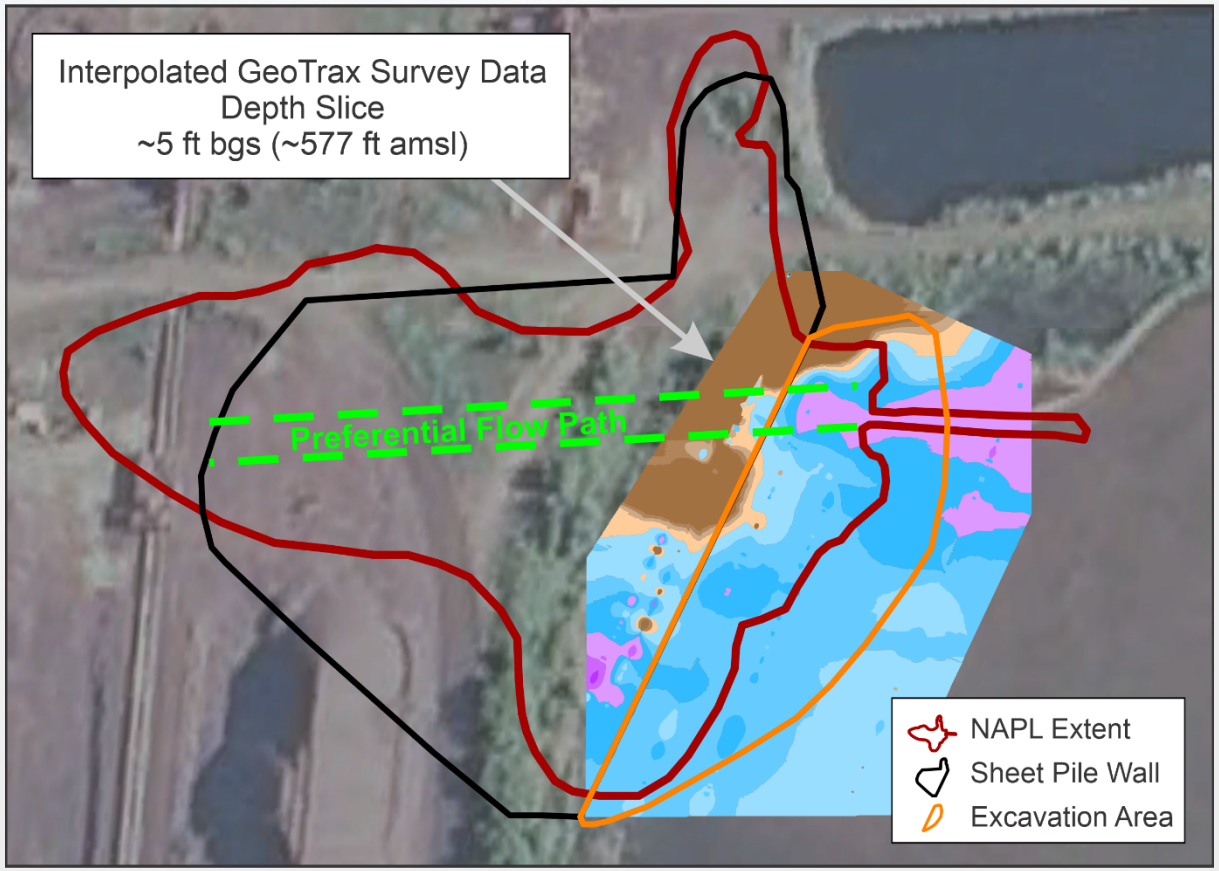
- Abiotic: More Resistive

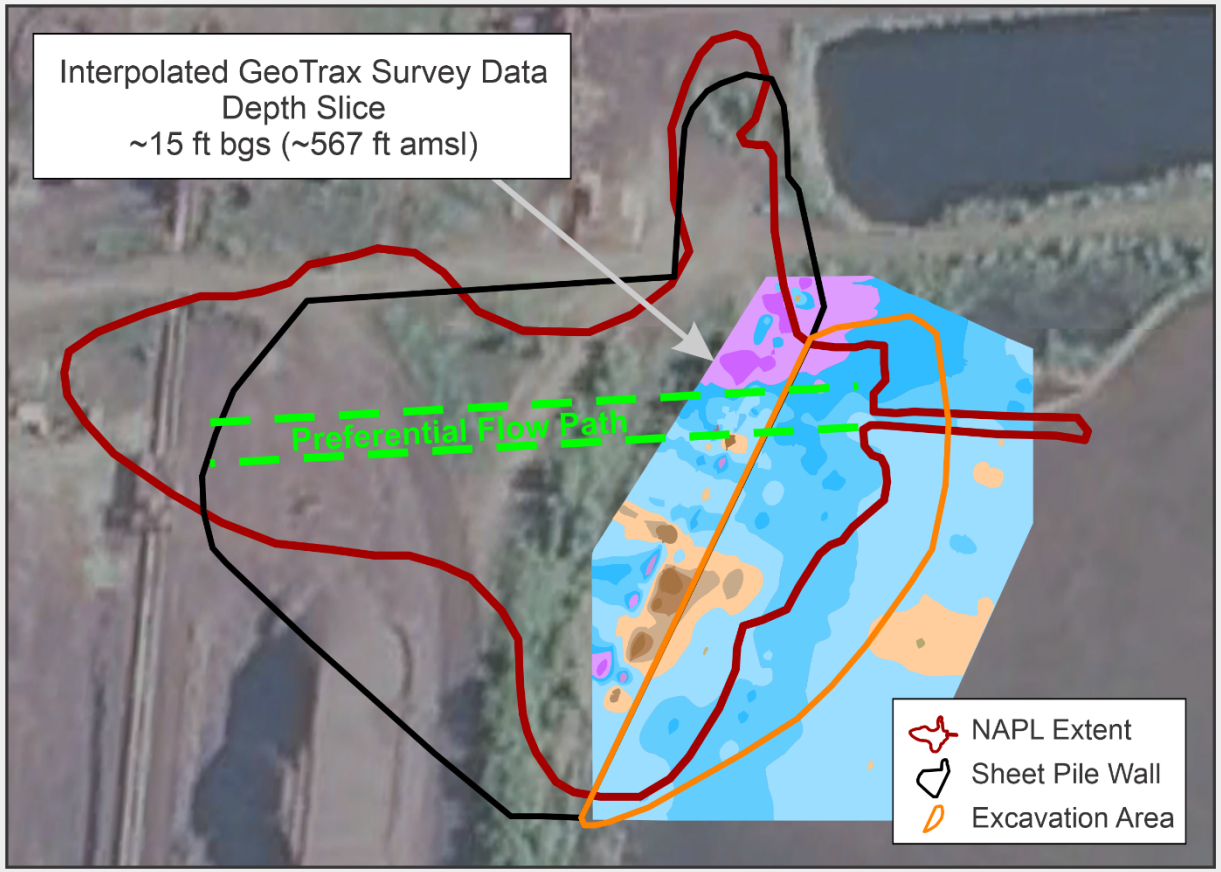
- Biotic: More Conductive



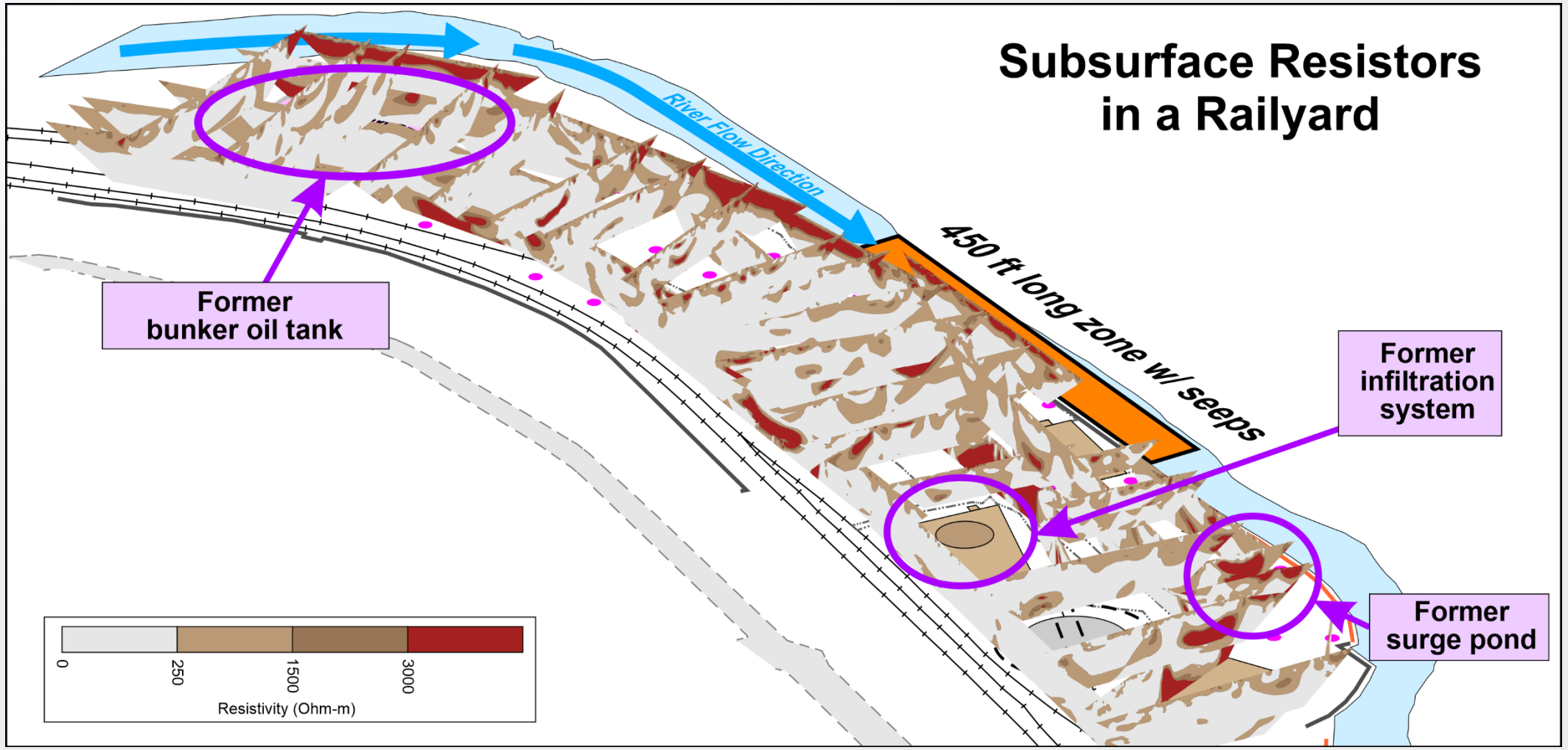
Aestus, LLC

Beach Site: Biological Control of Transport

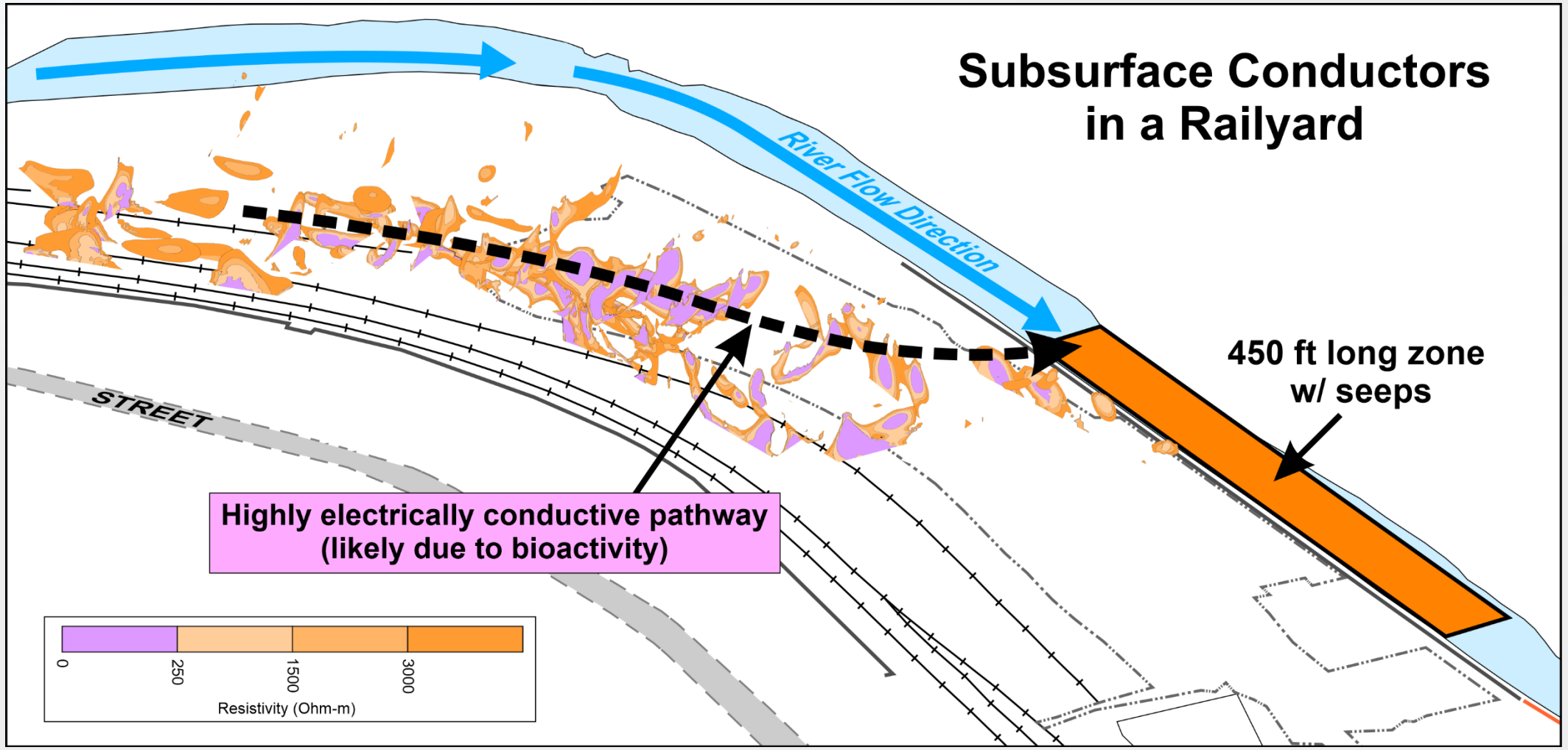




Stream Site: Resistors are in Area

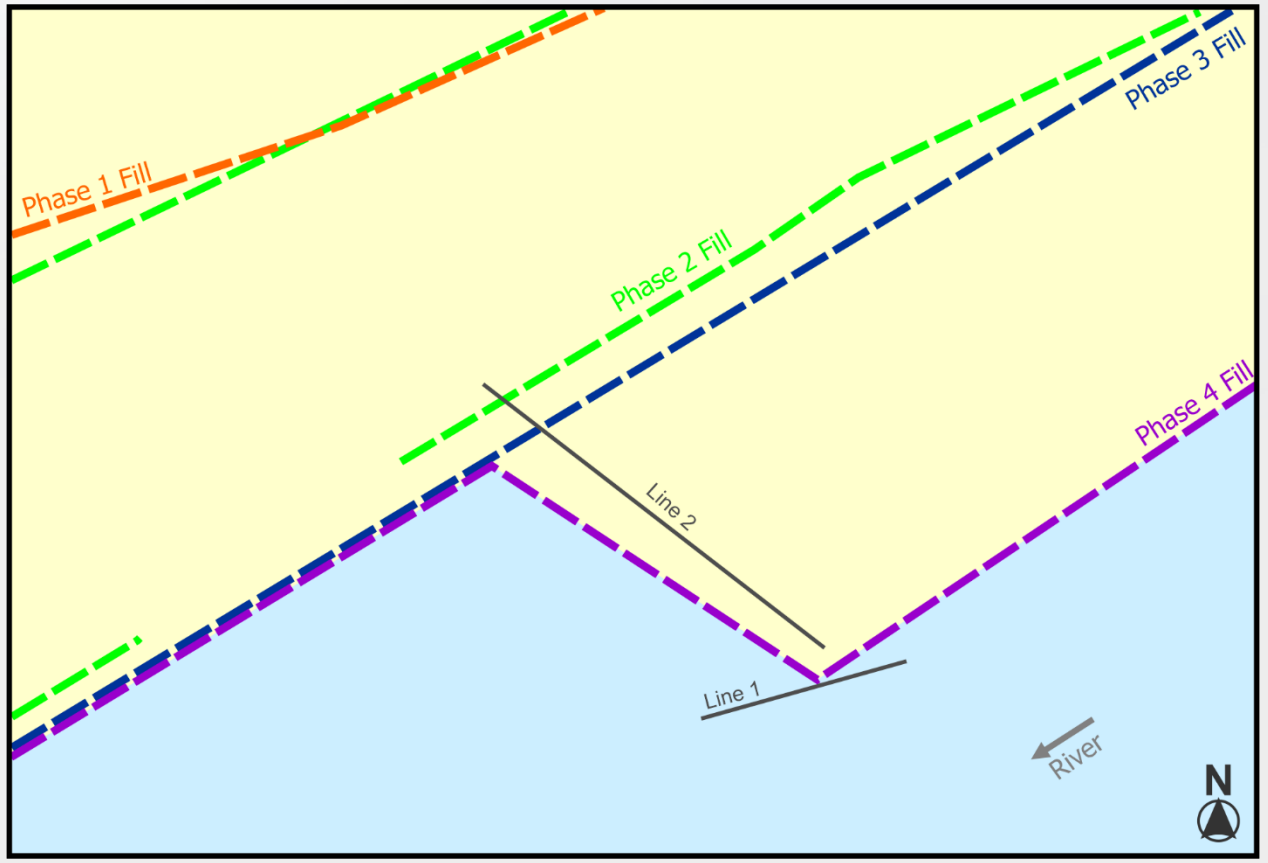


Stream Site: Conductors are Mobile



Mystery Seep Origin Story

- Progressive land addition (fill) to shallow waterfront
- Facility wastes, debris, and other fill
- Seeps developed at slope edge

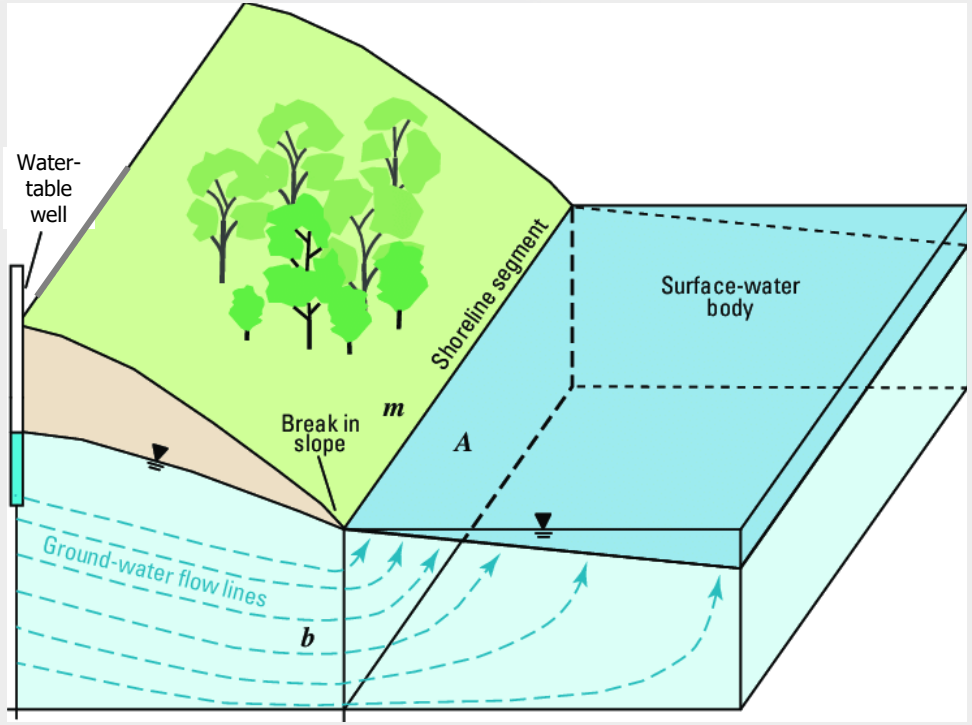


Technologies Applied Previously

- Fluid Sampling
- Sediment Sampling
- Chemical Sampling
- Geologic Modeling
- Groundwater Modeling

Seep pathway and origin remain unclear…

New Paradigm: LNAPL Migration from depth?



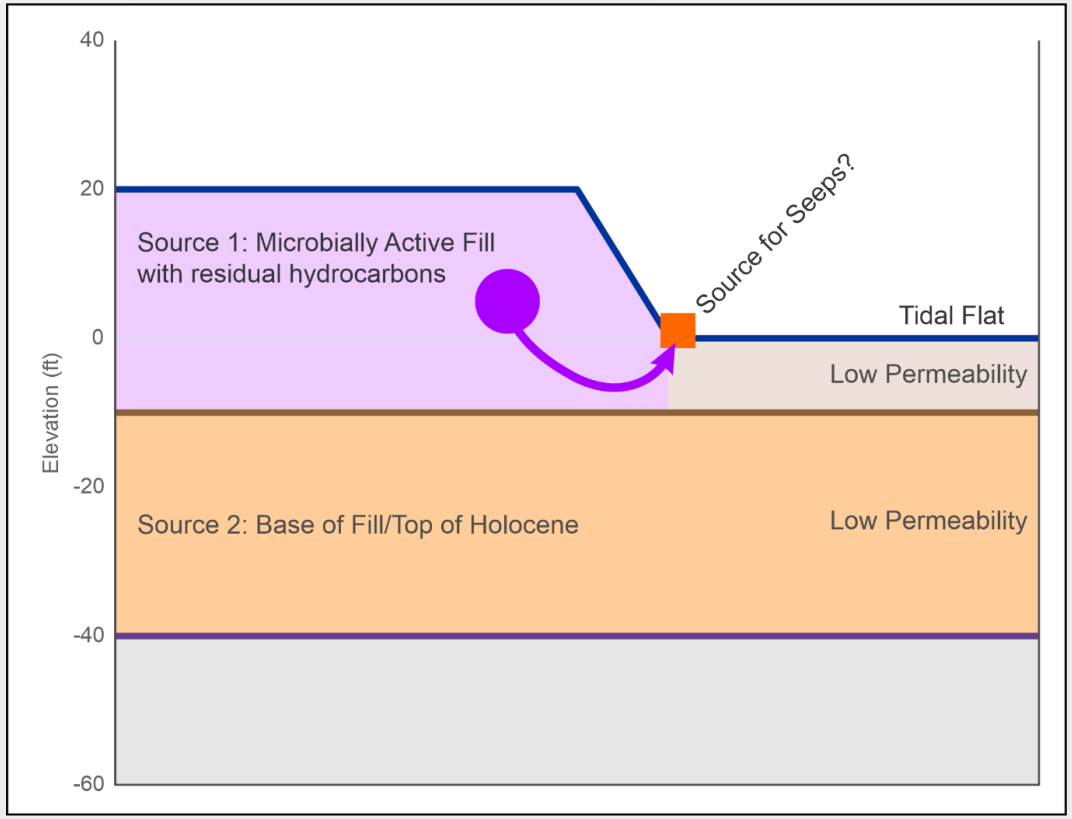
Typical hydraulic conditions in the vicinity of the shoreline of a surface-water body. (Artwork by Donald O. Rosenberry.)

Where is Conceptual Site Model Incorrect?

Need new paradigms/tools/process:

1) Electrical hydrogeology screening tool (scan first)
2) Targeted confirmation drilling
3) 3D data/CSM visualization
4) Experienced team; collaborative

Pre-Existing CSM: Shallow Migration to Seeps?



Ultra-HRSC/Remedial Design Characterization 5-Step Process Employed

1 Visualize Existing Site Data in 3D

- Client sends existing site data
- Must occur prior to field work (Step 2)

2 Ultra-High Resolution Electrical Scan

- Field Acquisition: specialty 2D Imagery
- Use Dynamic work strategy with QA/QC

3 Interim Report (w/Hypotheses)

- Integrate/QC data sets in 2D & 3D
- Propose confirmation drilling (biopsy) locations

4 Confirmation Drilling (by Client)

- Targeted drilling and sampling' test CSM hypotheses
- Client send final confirmation drilling data

5 Final CSM+ Report

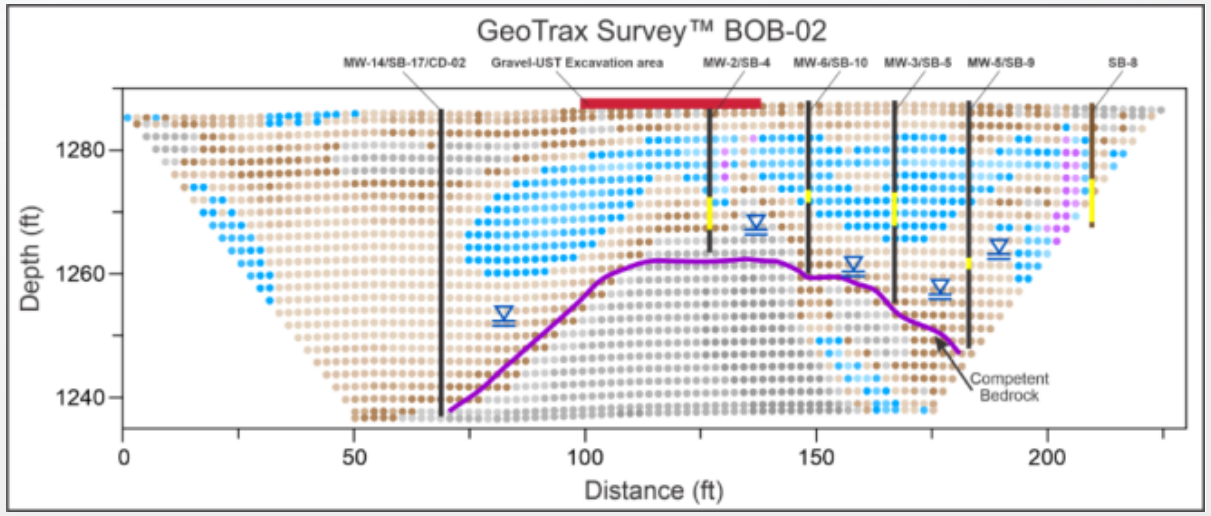
- Integrate confirmation data
- Finalize Updated CSM+ as input to remedial design or next steps

Electrical Hydrogeology Scans

Use electricity to scan/view the subsurface

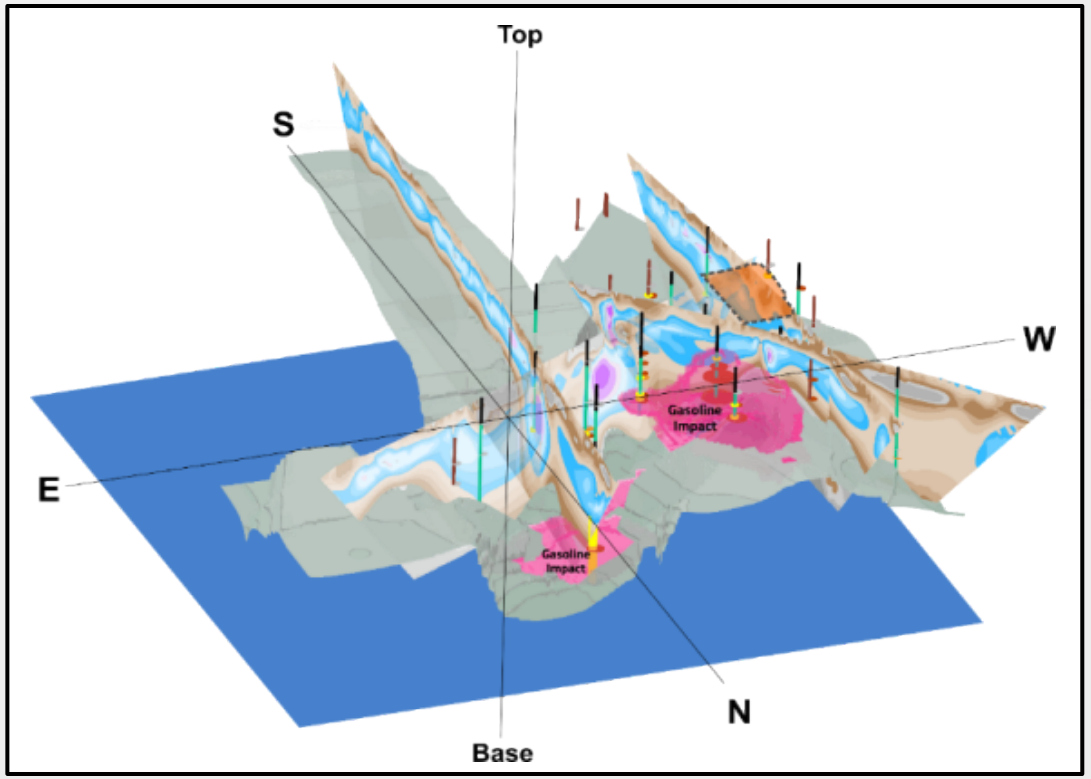
Electrical Hydrogeology w/ 3D Viz

Missouri Karst LNAPL Site



ERI Scan, then confirm

- 2,750 electrical data points
- 6 borings
- BTEX data
- PID data



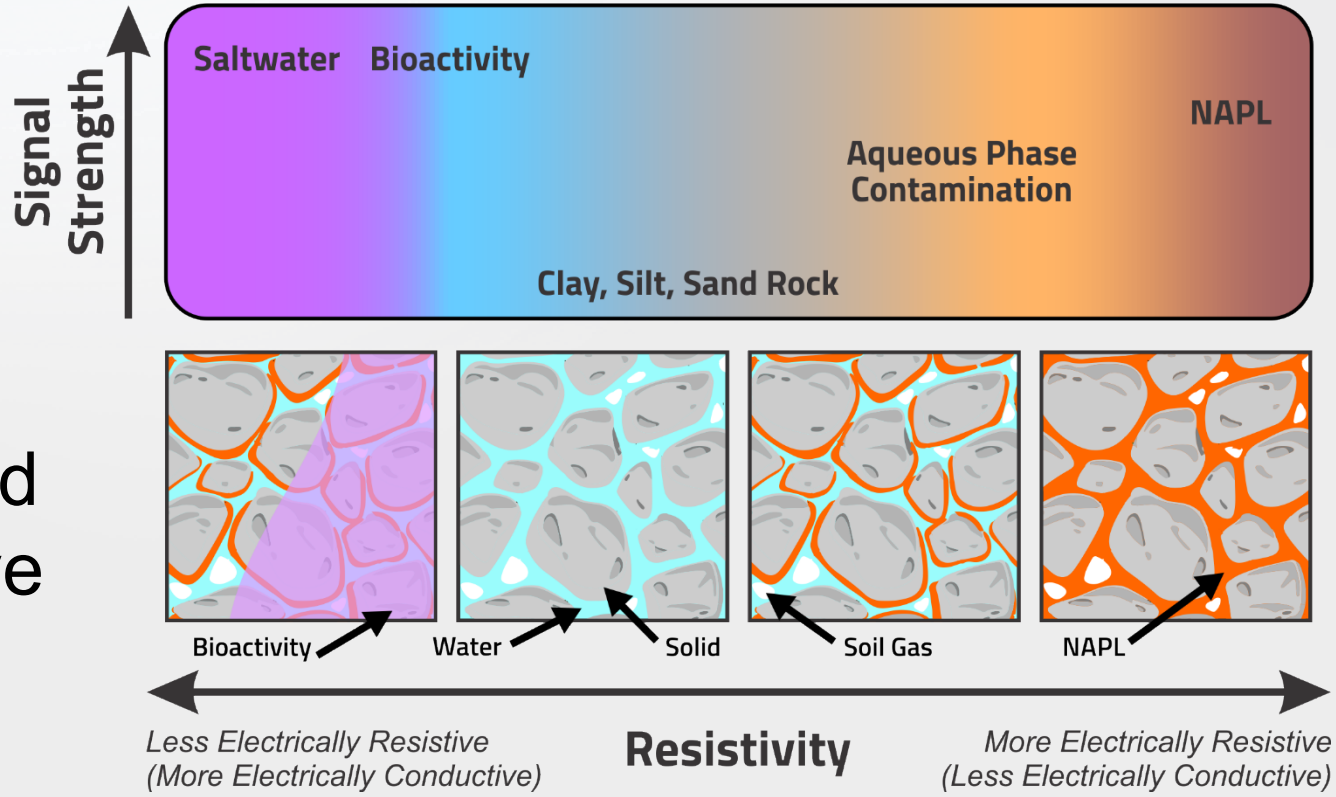
3D Conceptual Site Model

- 22,000 electrical data points
- Pathways delineated

Aestus, LLC

Hydrocarbons Provide Electrical Contrast

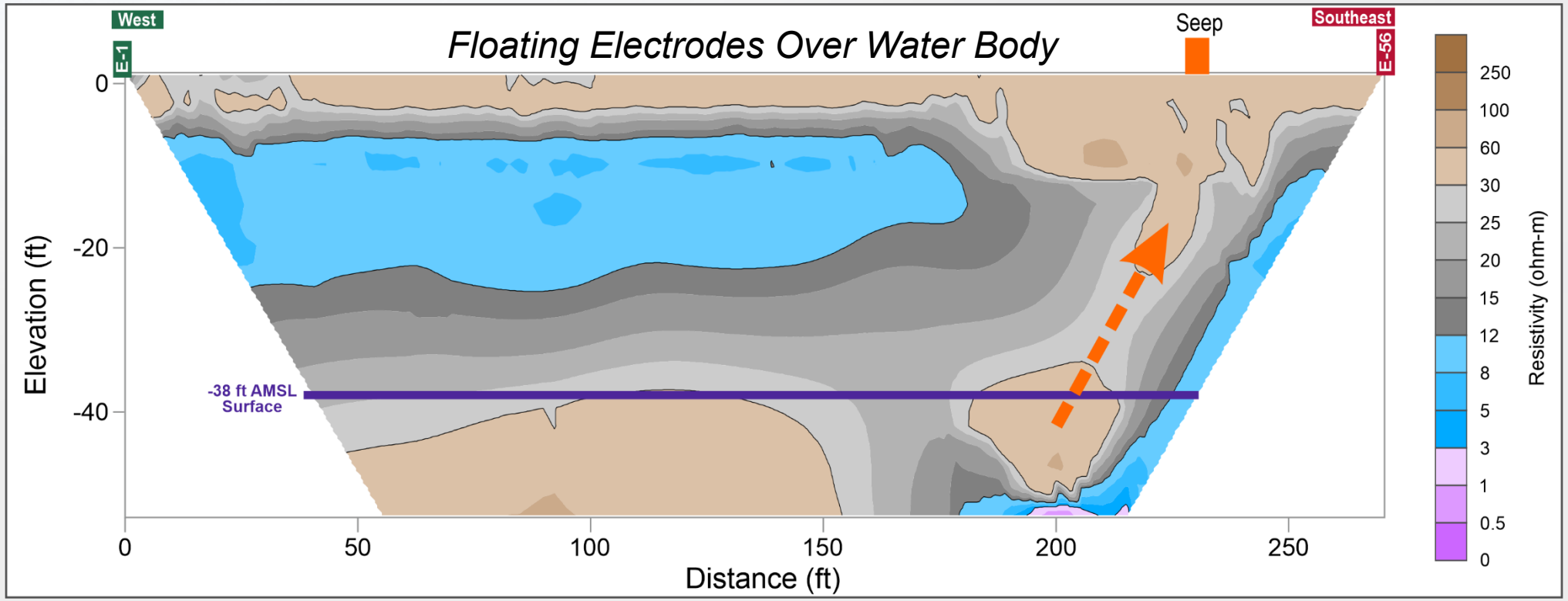
Weathered
Conductive



Free Product
Resistive

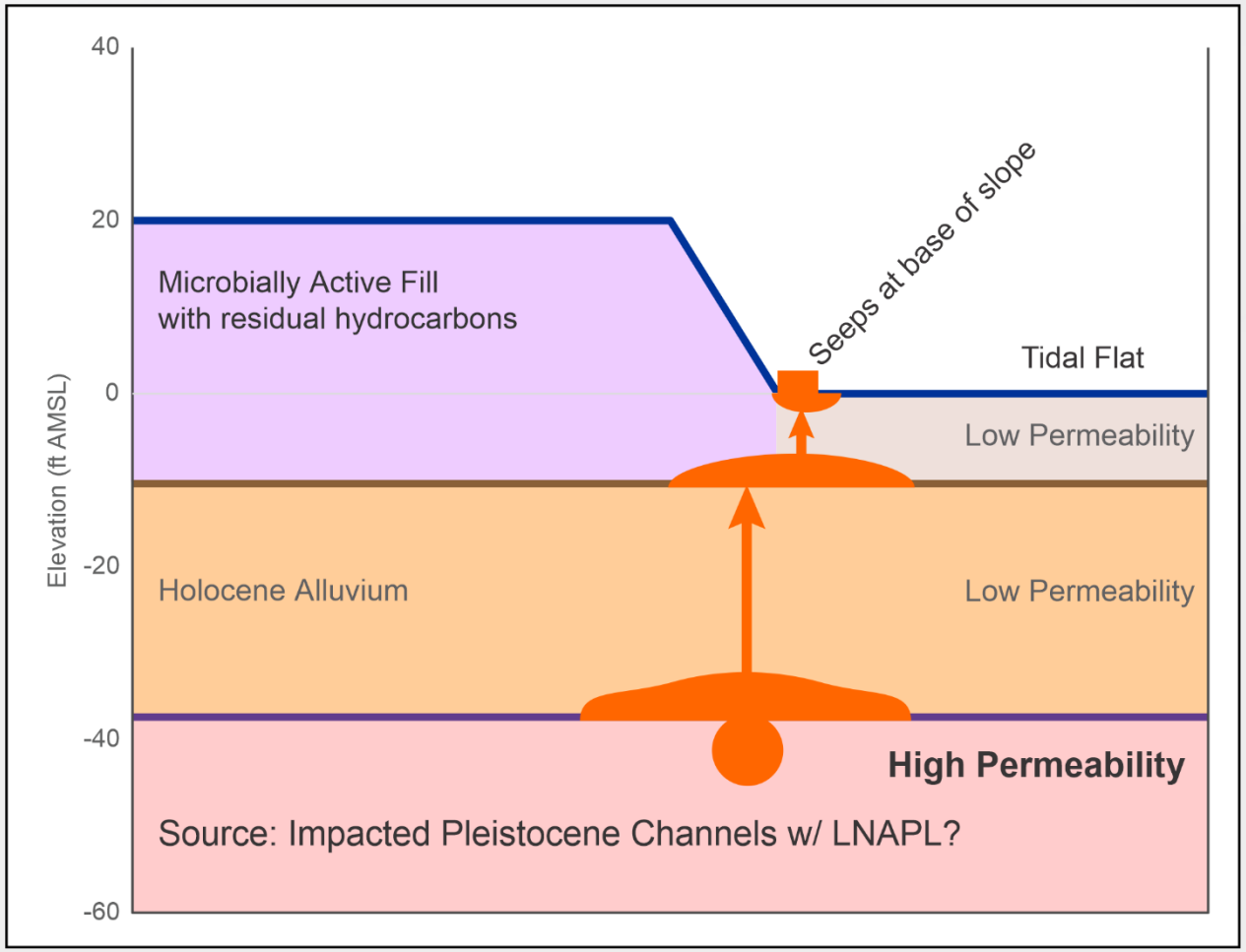
Mowder et al., 2018

Image Collected Over Seep Through Water

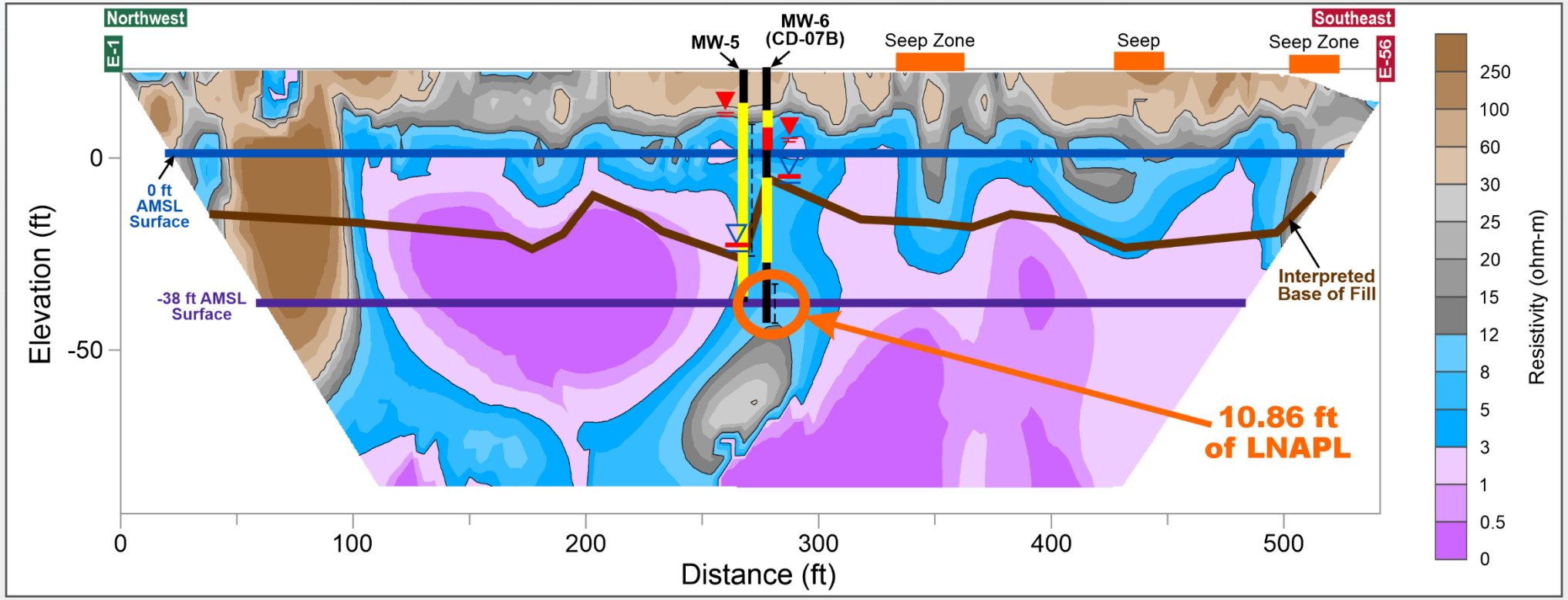


Question:
What Could Be Down There Geologically?

Does unweathered LNAPL discharging from ~40’ below the water table make sense?

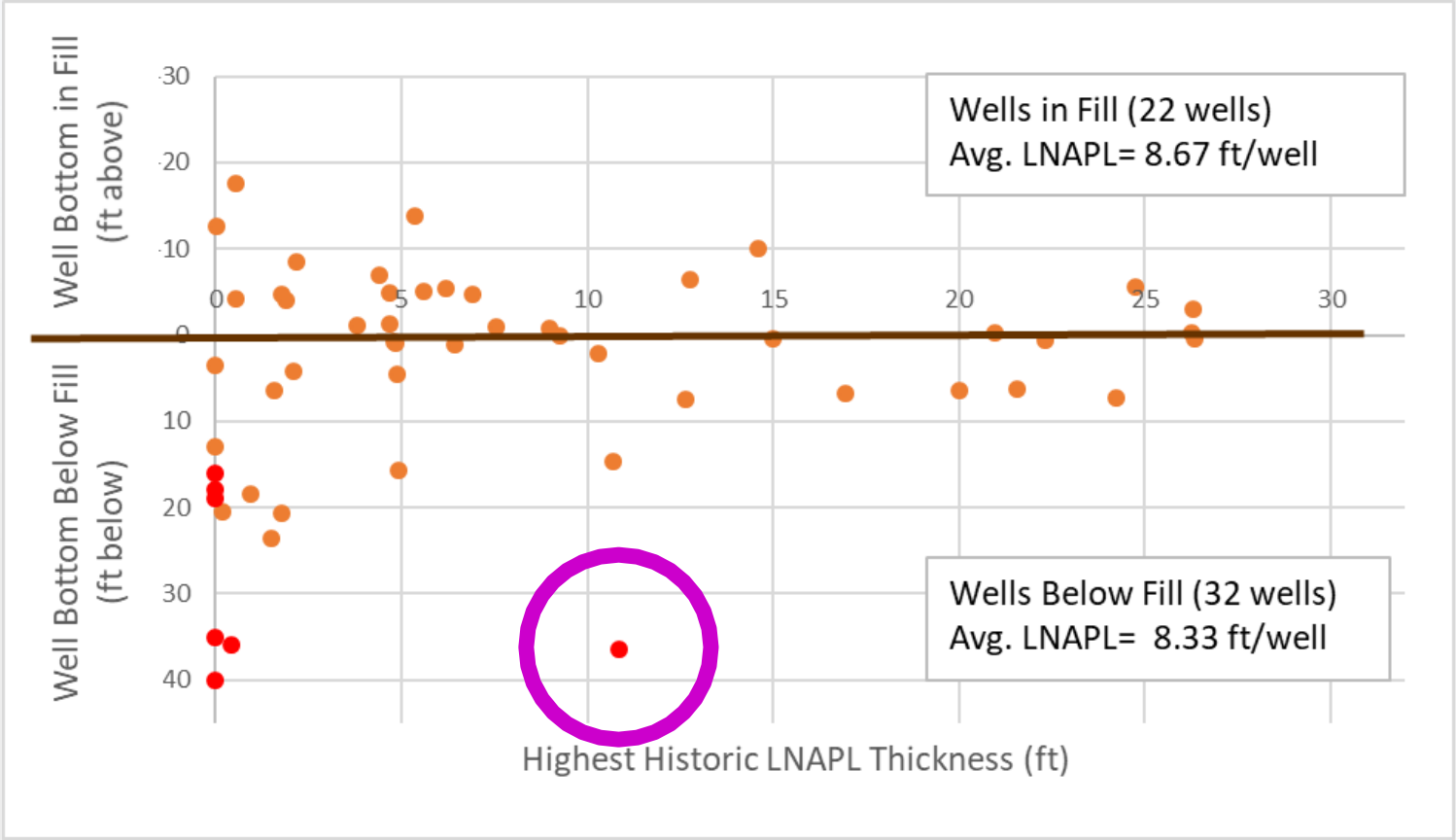


Test the Hypothesis (via Targeted Drilling)



Geology and Contaminant Data

Base of Fill



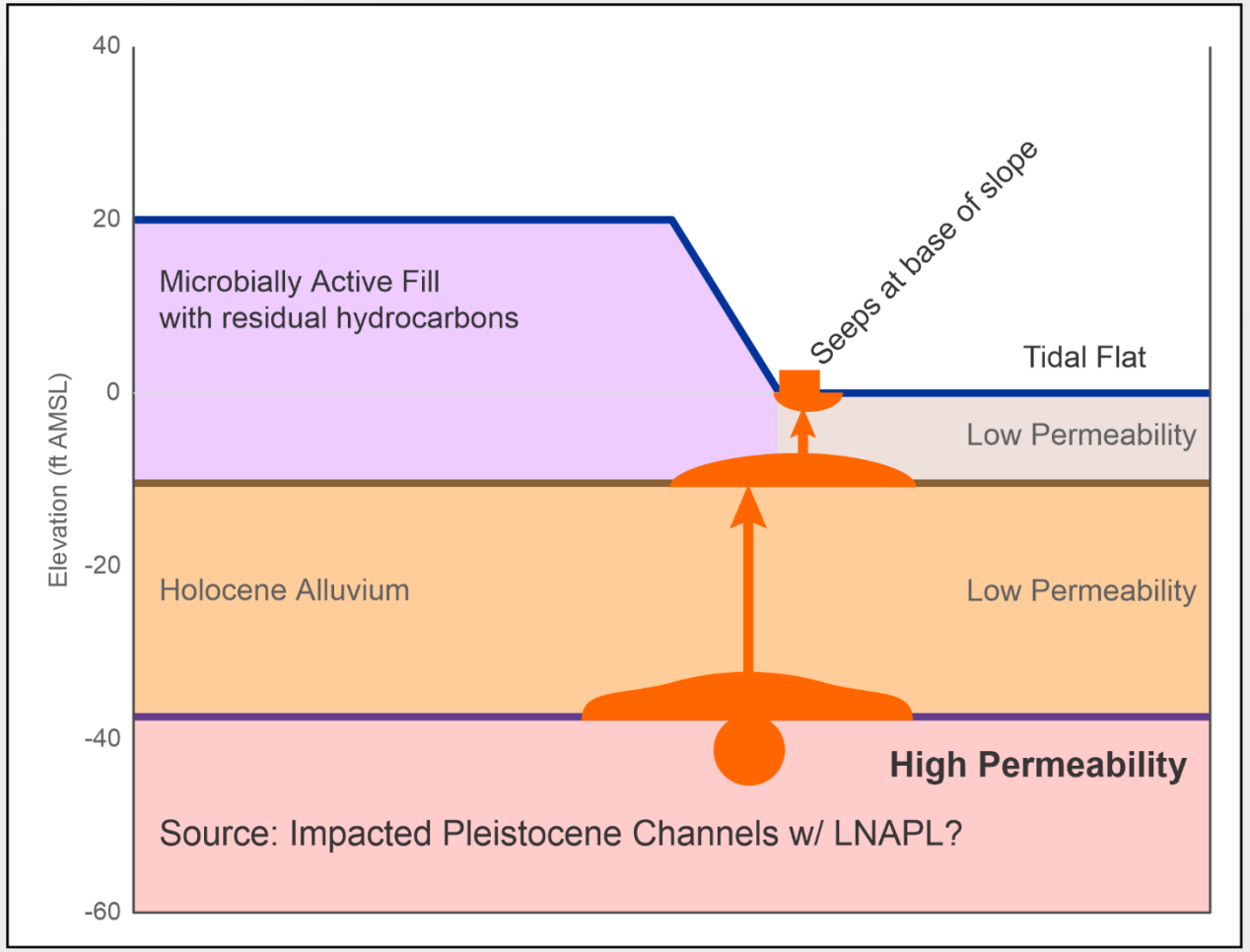
Legend

- CD Wells
- Pre-Existing Wells

Answer:
What Is Down There Geologically?

- Deep hydraulically conductive channels providing pathway for impacts at seeps

- Confirmed via targeted drilling/sampling



Lessons Learned

1. Many sites have complicated histories and flowpaths with multiple sources for impacts

2. Drilling holes with intent, but no supporting data rarely improves a CSM (key features are too small)

3. Scanning sites electrically provides guidance on location and state of hydrocarbon impacts

4. Visualization and communication are key factors in successful remediation

Thank you! Questions?

Todd Halihan, PhD, PGp
todd.halihan@okstate.edu
halihan@aestusllc.com
www.aestusllc.com

Stuart W. McDonald, PE
Kyle Spears
info@aestusllc.com
1.888.GEO.TRAX
www.aestusllc.com