Best Management Practices for Site Characterization

The End of Poke and Hope?

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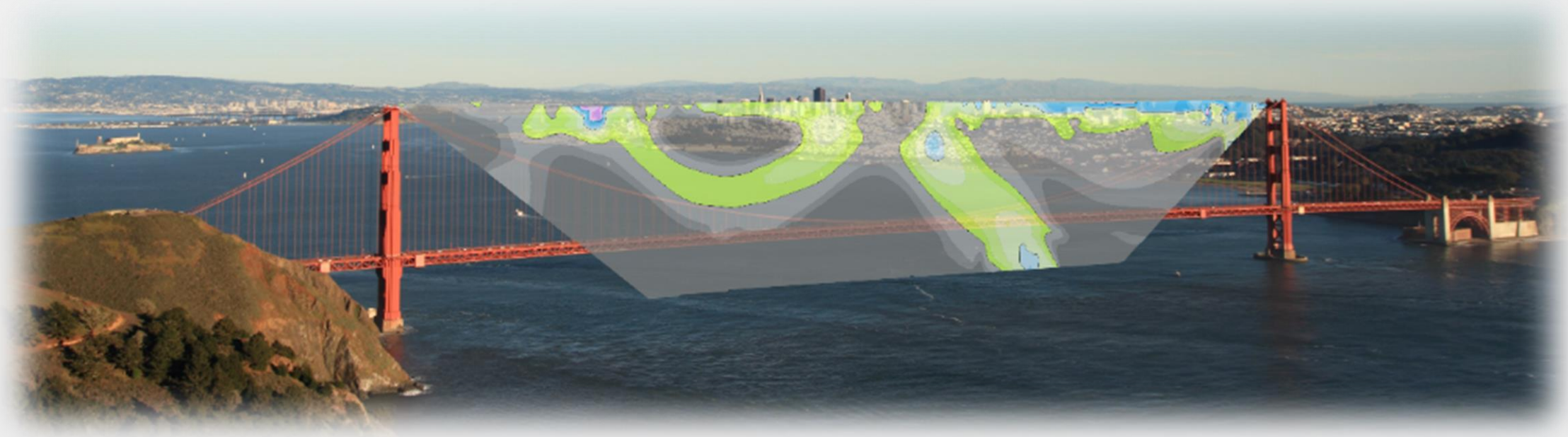
Aestus

The End of Poke and Hope?

I. The Problem with Poke and Hope

II. Best Management Practices (Electrical Hydrogeology Process)

III. A New Hope: Benefits of Scanning First



Monitoring Well Misconceptions

- "Monitoring Wells" = "Characterization Wells"
- Early Site Assumptions:
  - Single source, single pathways
  - Homogeneous geology/hydrogeology
- Monitoring Well Assumptions:
  - Install without QA/QC or development
  - No routine maintenance needed
  - Samples representative of subsurface

Original HRSC!

3D contaminant migration

Cape Cod (LeBlanc et al. 1991)

Borden (Sudicky et al. 1983)

Scan then Target Approach: Aligning with Other Industries

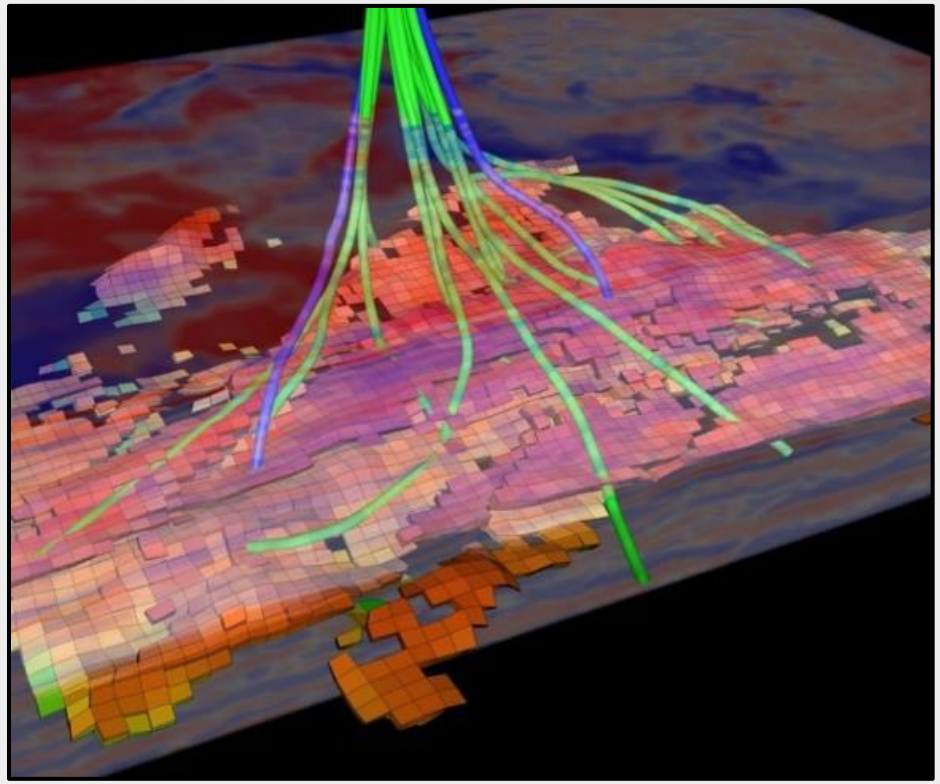
"(seismic) reflections were not even considered on a par with the divining rod, for at least that device had a background of tradition"

E. E. Rosaire

Other industries requiring data "below the surface" evolve to scan first then go invasive

X-ray of Skull

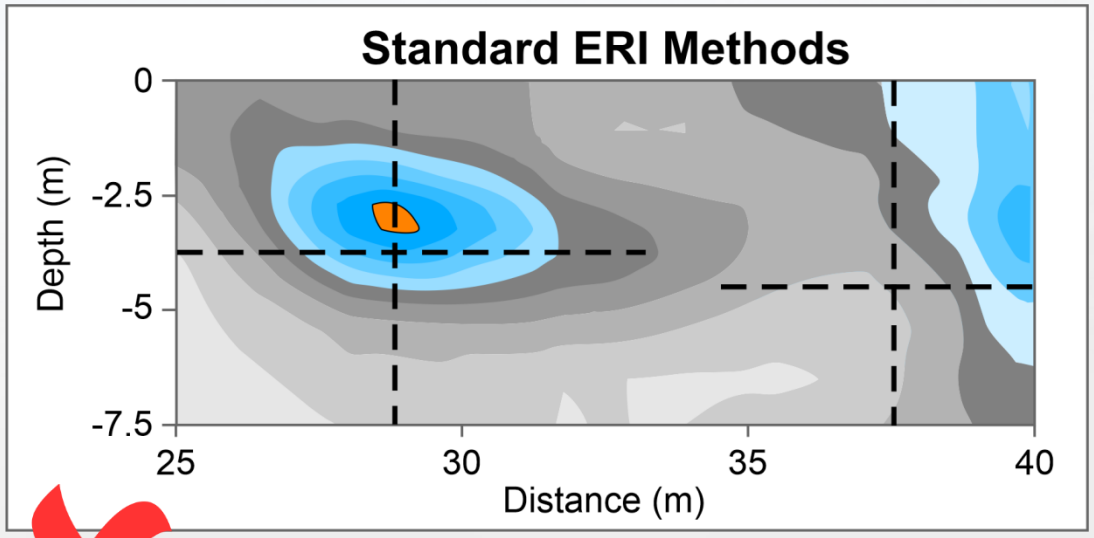
nydailynews.com

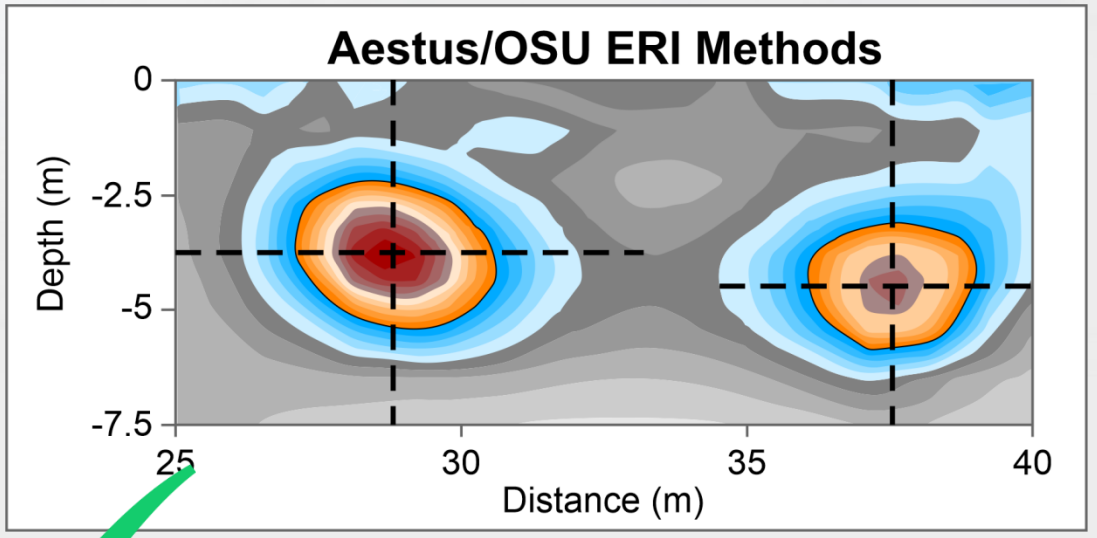


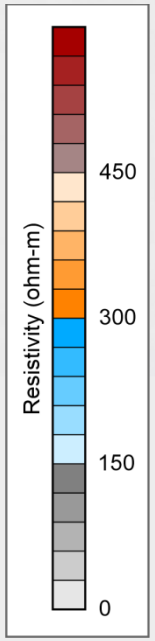
3-D Seismic North Sea

dgi.com

Traditional ERI vs GeoTrax Survey™







Standard ERI

Aestus GeoTrax Survey™

Confirmed by EPA Ada Lab
Drillable Image
Halihan et al, 2005

NAPL is Distributed as Blobs

- Sufficient data density to see NAPL distribution
- "Drillable" datasets
  (discrete targets for drilling)

Post-remediation evaluation of a LNAPL site using electrical resistivity imaging

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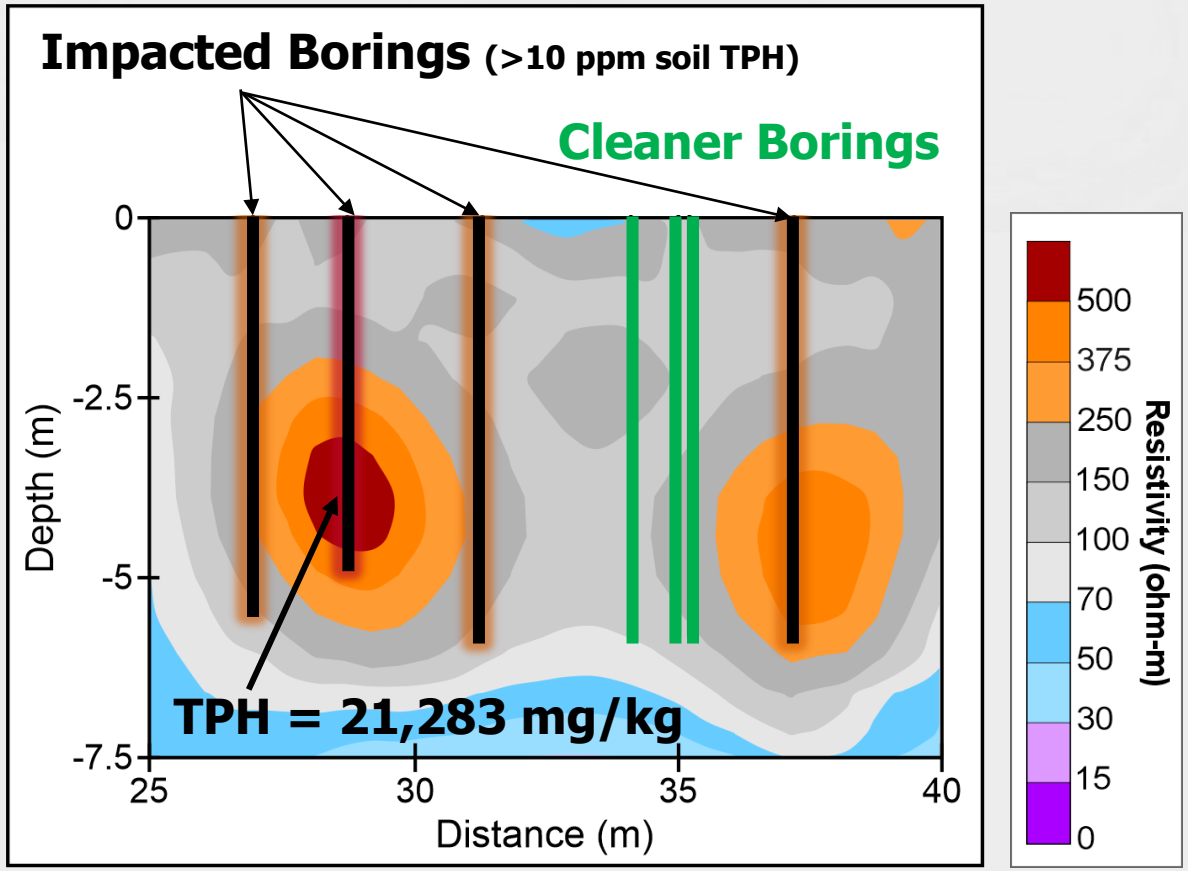
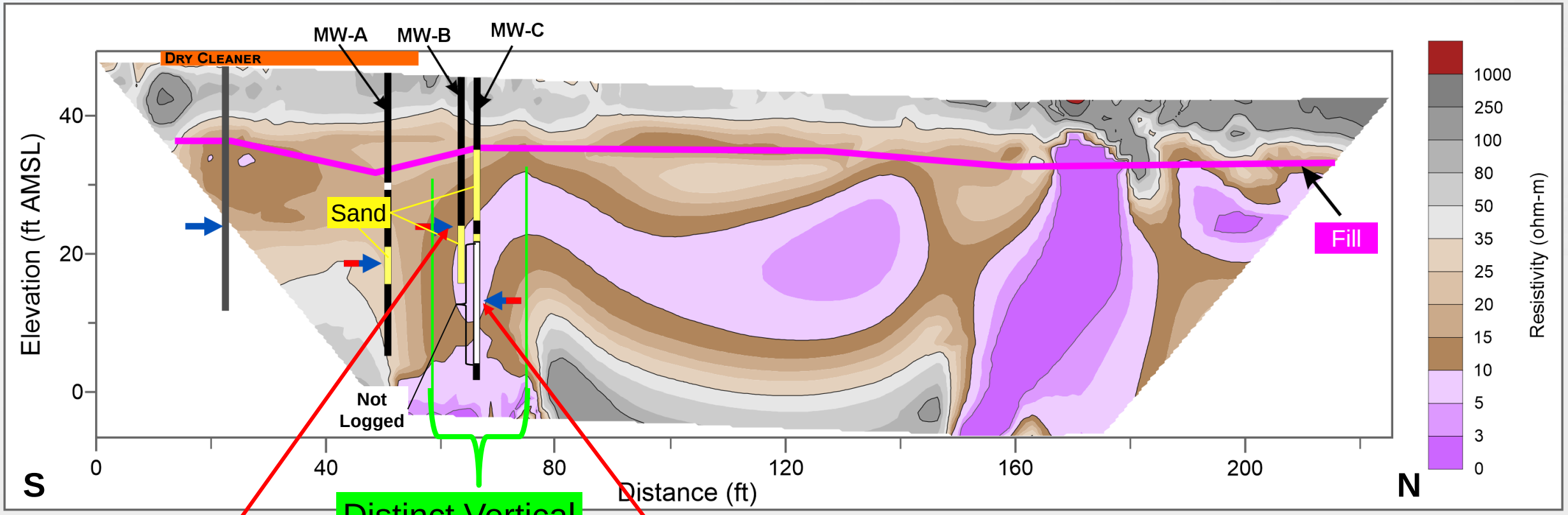


Flow Paths Are Discrete



PCE – 120,000 µg/L TCE – 22,000 µg/L DCE – 15,000 µg/L VC – 1,300 µg/L

Distinct Vertical Flow Feature

PCE – 25,000 µg/L TCE – 3,200 µg/L DCE – 15,000 µg/L VC – ND

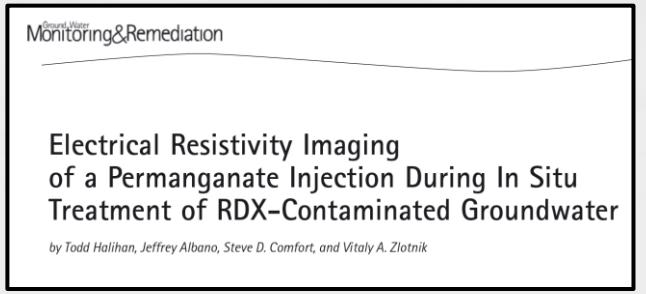
DNAPL in glacial till
(Dry Cleaner Brownfield Site)

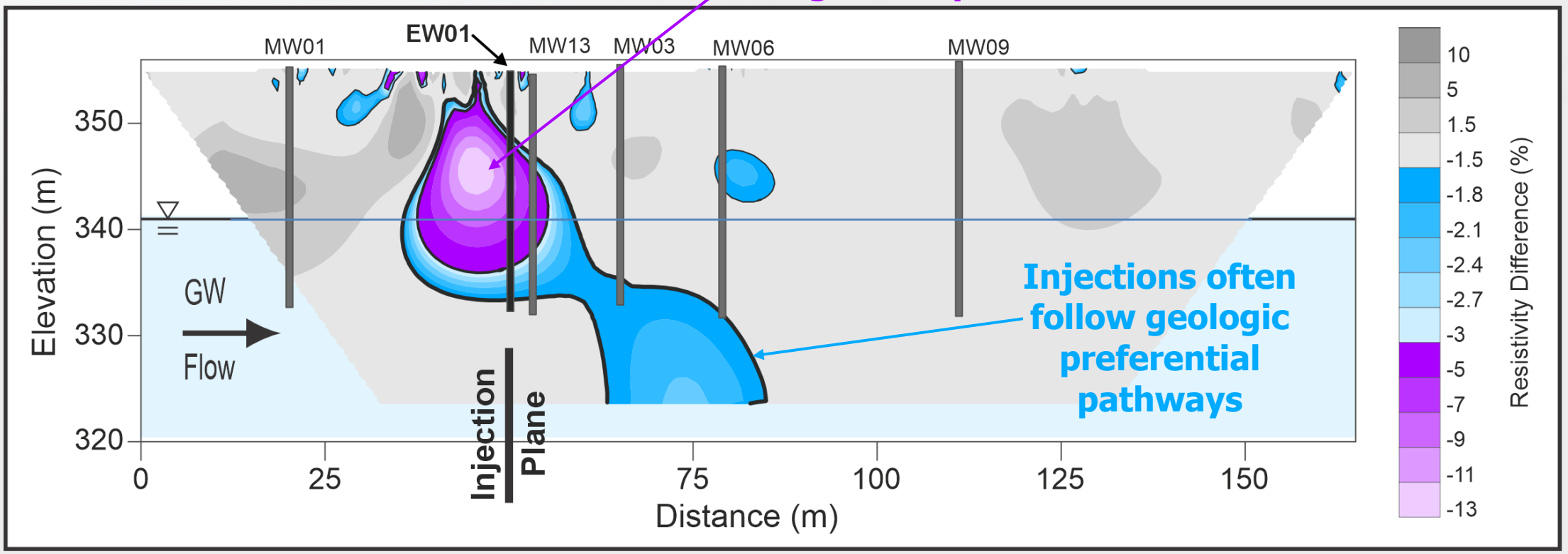
Targeted drilling

Radius of Influence Is Not Uniform

Injection ROI hard to predict, but can be imaged

Permanganate concentrated to side of injection plane and migrated upwards





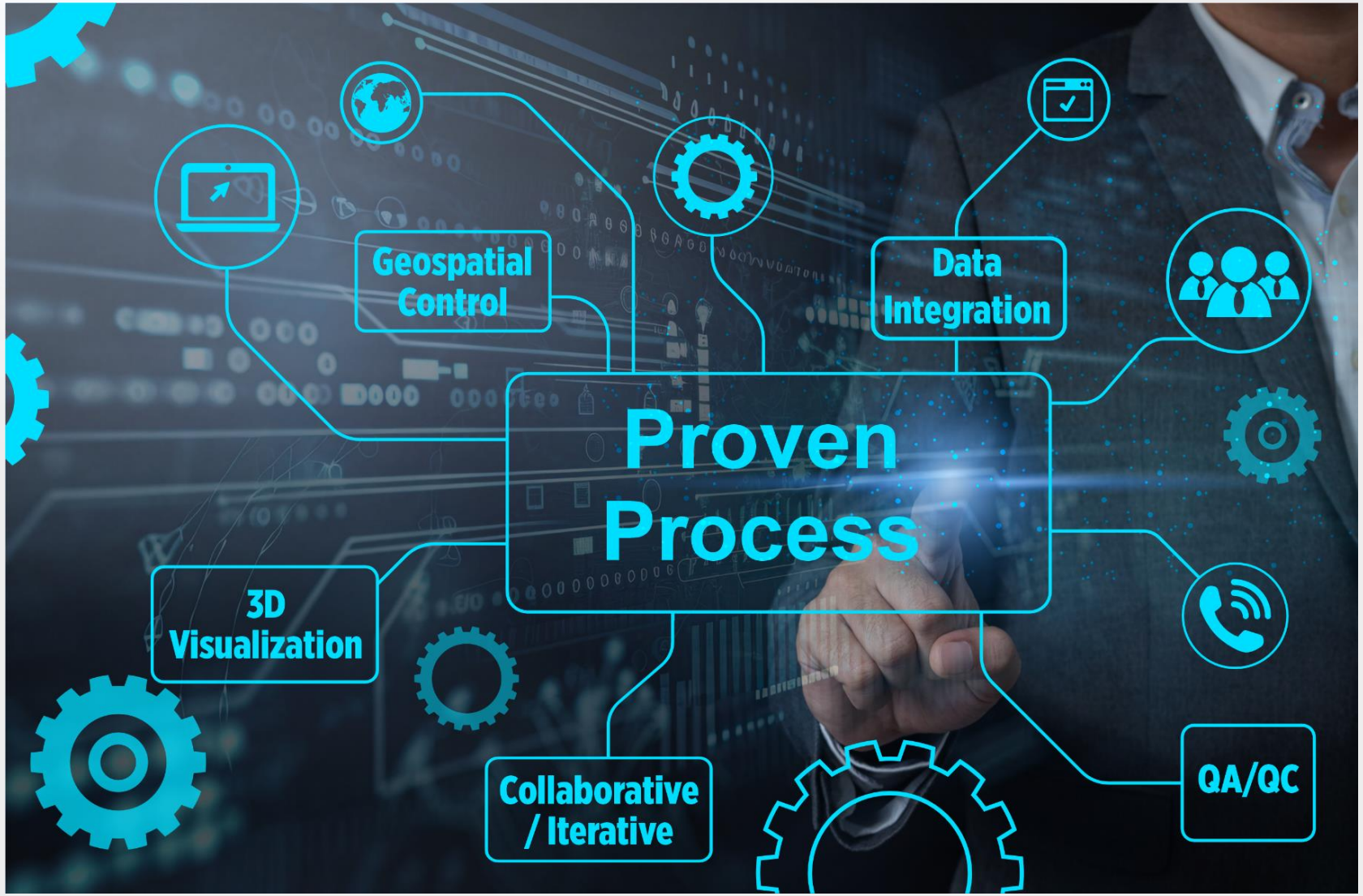
Temporal ERI (TERI) image showing changes in subsurface over time

Monitoring Wells ≠ Characterization Wells

What an image can see that a monitoring well cannot:

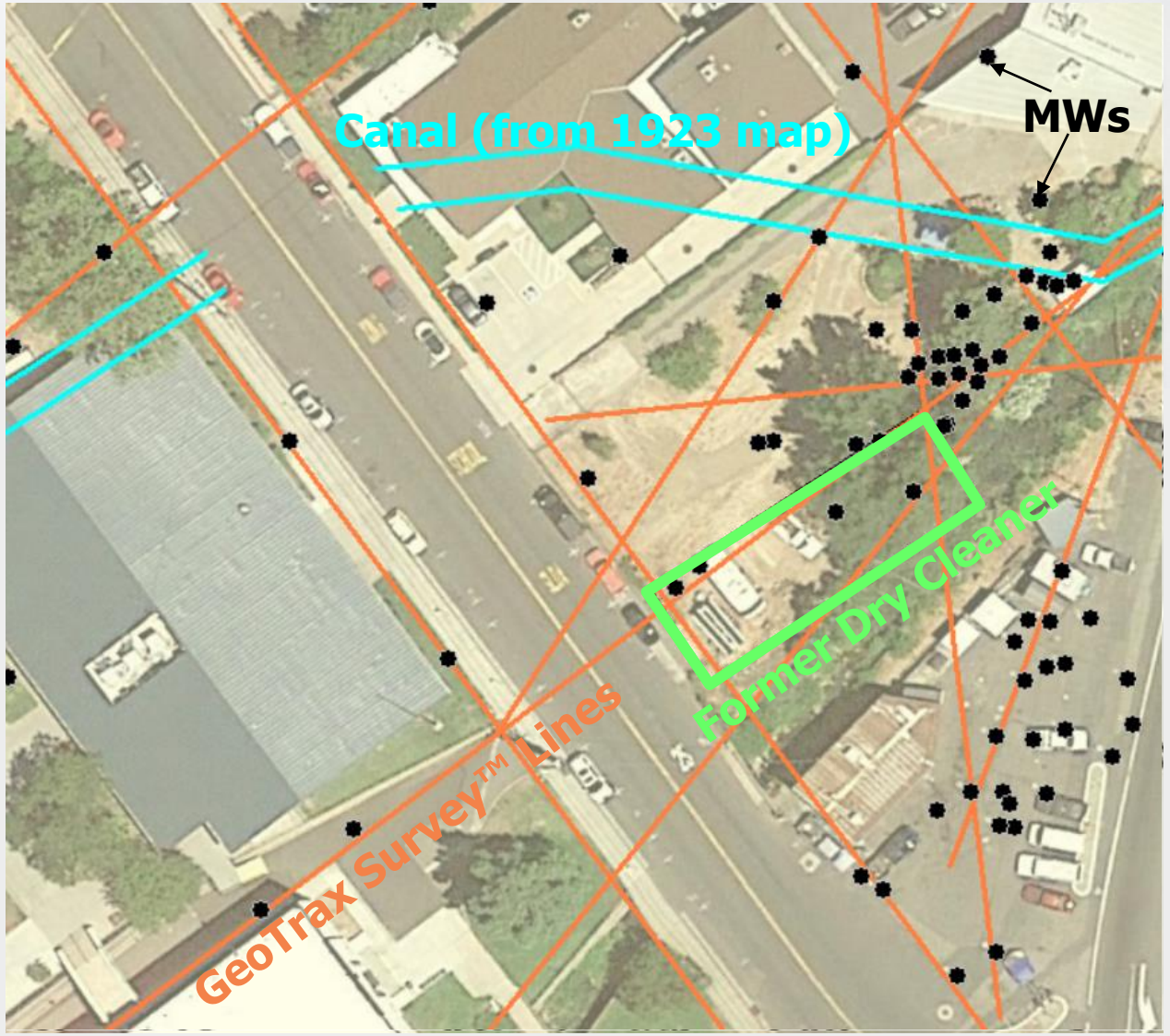
- ✓ NAPL is distributed in blobs
- ✓ High concentrations/source zones on old or previously remediated sites
- ✓ Discrete contaminant flow paths
- ✓ Injections are not uniformly distributed
- ✓ Microbial growth structures

Best Management Practices



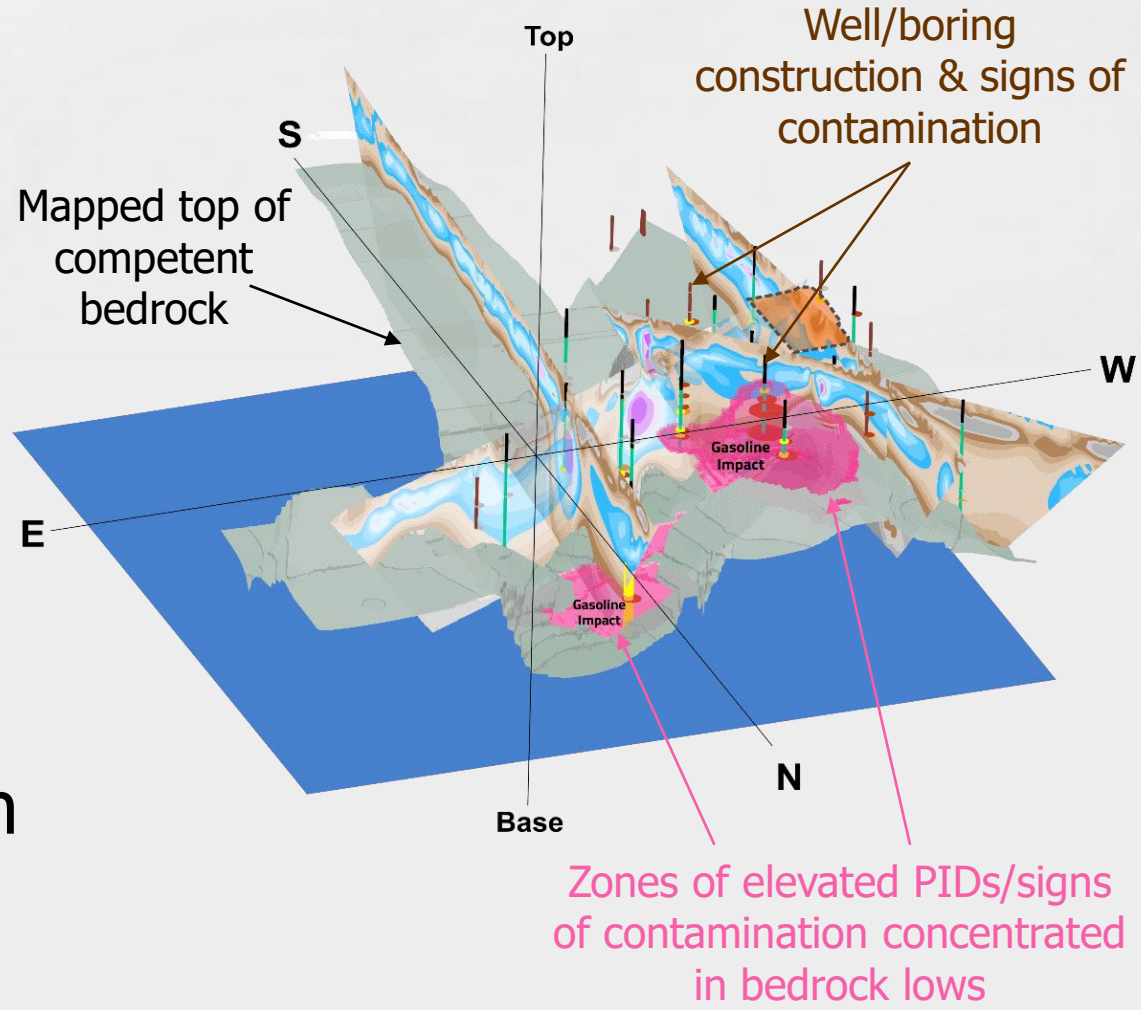
Data Integration & Geospatial Control

- Integrate all available data
  - Historical Records/Aerial, DEM, Regional Geology
  - Chemical Info and Previous Site Work/Remediation
- Multiple lines of evidence
- Robust data base
- Geospatial control is critical



3D Visualization

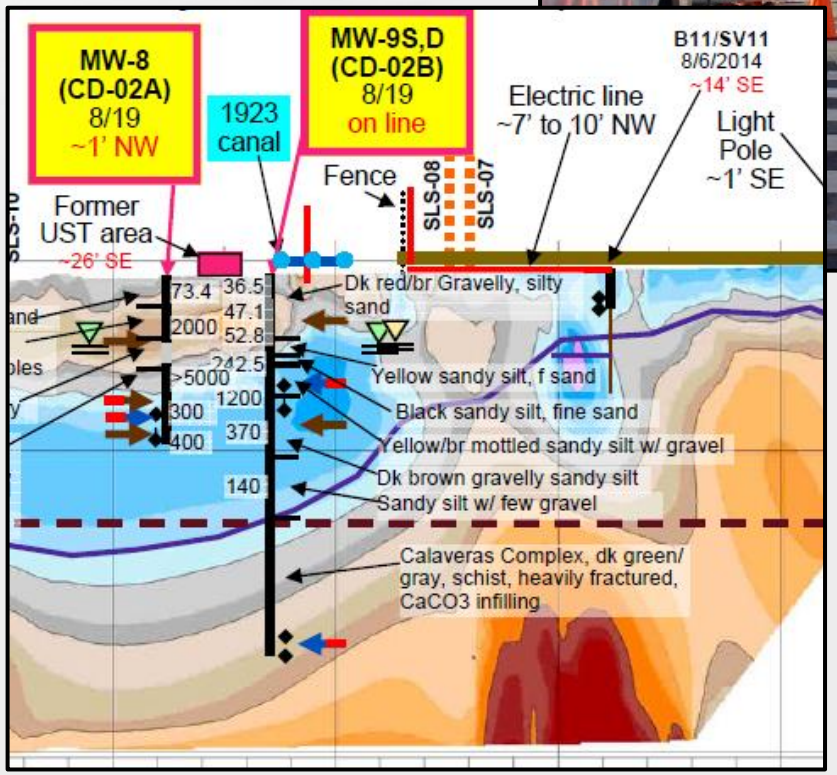
- Robust modeling capabilities
  - Geologic contacts
  - Contaminant extents
- Understand how multiple lines of evidence relate
- See data gaps to inform next steps
- Regulator, RP, & stakeholder buy-in



QA/QC

Critical at every step!

- QAPPs
- Data collection/ sampling
- Data base compilation
- Data integration
- 3D Modeling



Collaboration/Focused Next Steps

Collaborative Team Seeking Data-Driven Solutions

Expect Surprises/ Iterative Ops

Agree on Next Steps

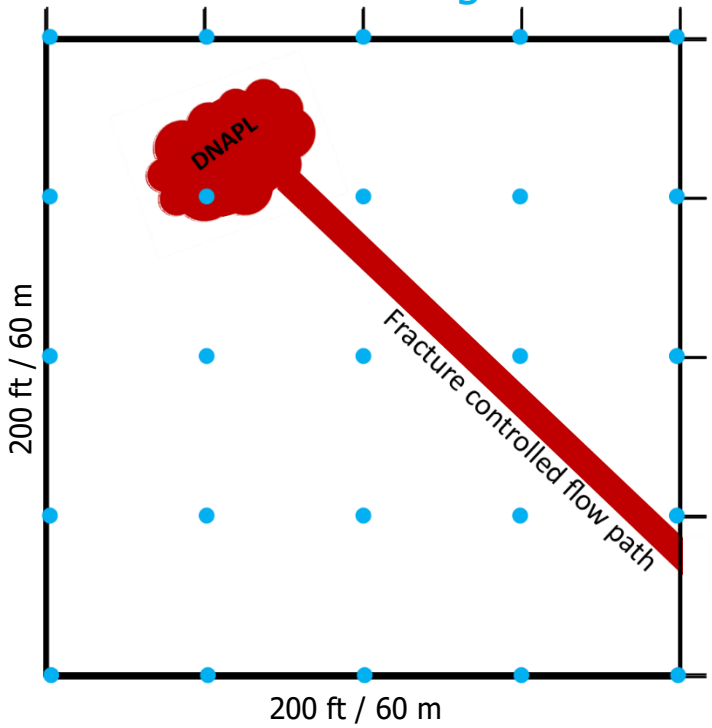
Use Proven Process

Electrical Hydrogeology (Scan First) Workflow

1	2	3	4	5
Visualize Existing Site Data in 3D - Client sends existing site data to Aestus - Must occur prior to field work (Step 2)	**Ultra-High Resolution Electrical Scan** - Field Acquisition: *GeoTrax Survey*™ 2D Imagery - Use dynamic work strategy with QA/QC	**Interim Report (w/Hypotheses)** - Integrate/QC data sets in 2D&3D (*GeoTrax Viz*™) - Select confirmation drilling (biopsy) locations with client	**Confirmation Drilling (by Client)** - Targeted drilling & sampling; test CSM hypotheses - Client sends final confirmation drilling data to Aestus	**Final CSM+ Report** - Integrate confirmation data (*GeoTrax Viz*™) - Finalize GeoTrax CSM+™

Scanning Increases Characterization Certainty

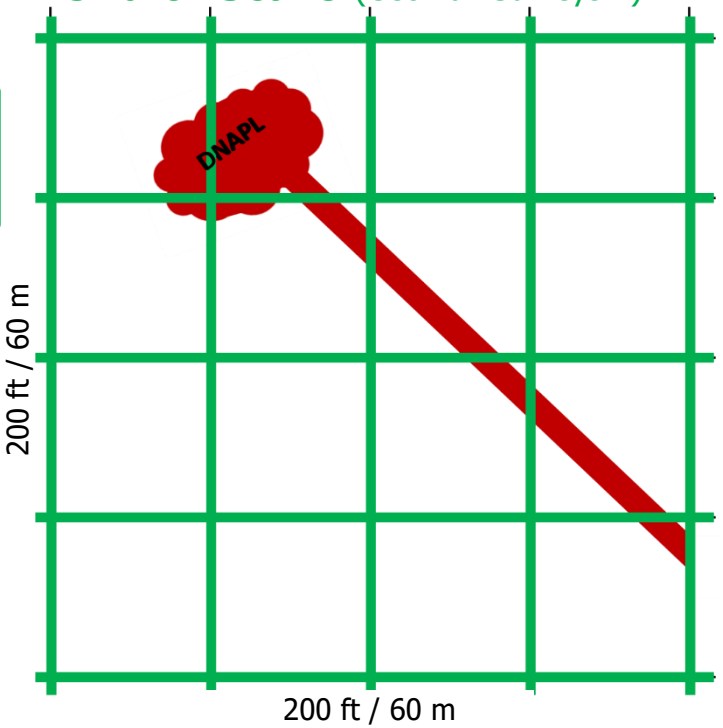
Grid of Monitoring Wells



	MWs	Scans
Number of Wells/Surveys	25	10
Impacted Zones Detected	1	8
Impact Extents Understood?	No	Yes
3D Model Included?	No	Yes
Targeted Areas for Additional Investigation?	No	Yes
Total Approx. Cost	$114k	$200k
Approx. Cost / ft²	**$230**	**$20**

Sampling interval of 50 ft/15 m for both MWs & ERI Scans
Values calculated assuming 30 ft drilling depth, 2" PVC
Costs in USD

Grid of Scans (GeoTrax Surveys™)

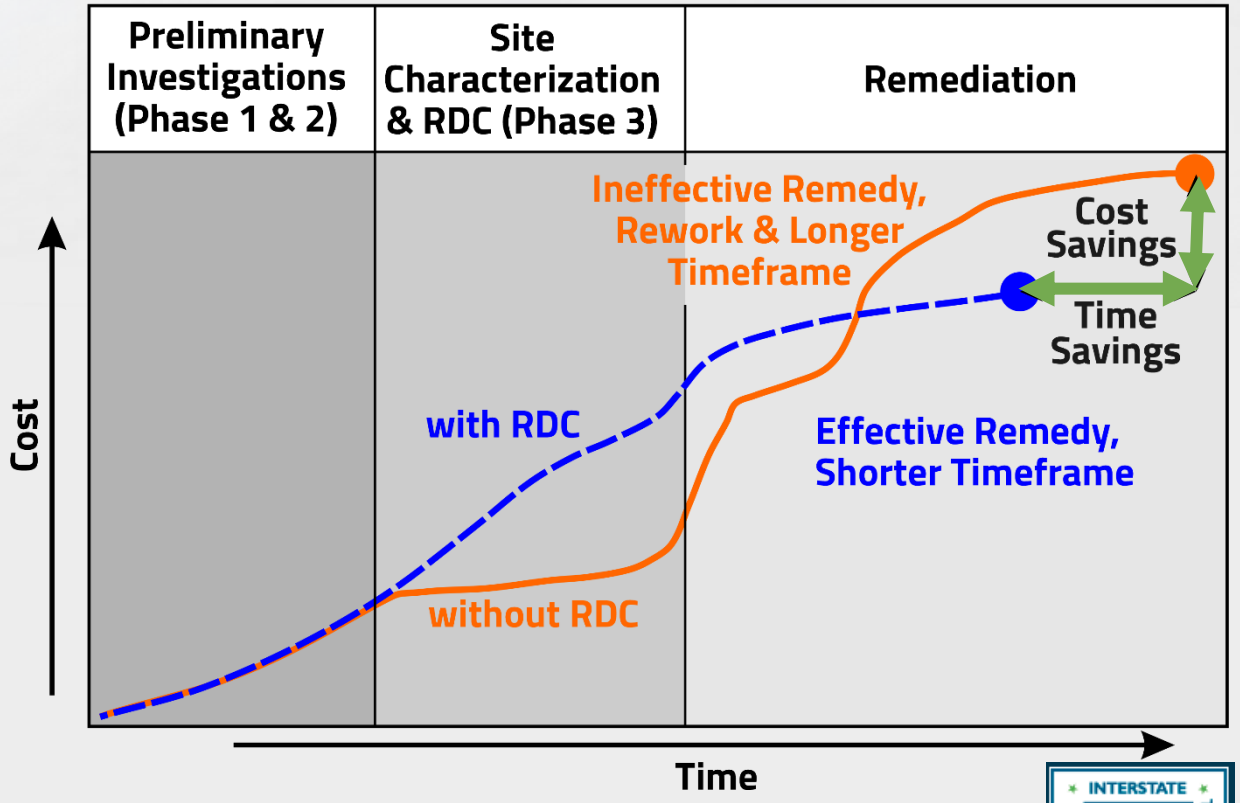


Most sites aren't this simple!

Scanning first is more cost effective and provides clear next steps

Characterization & RDC Saves Time and Costs

- Investing in remedial design characterization (RDC) will save significant ***time and money*** on an overall project basis
- Electrical hydrogeology (scan first) process → more certainty in next steps

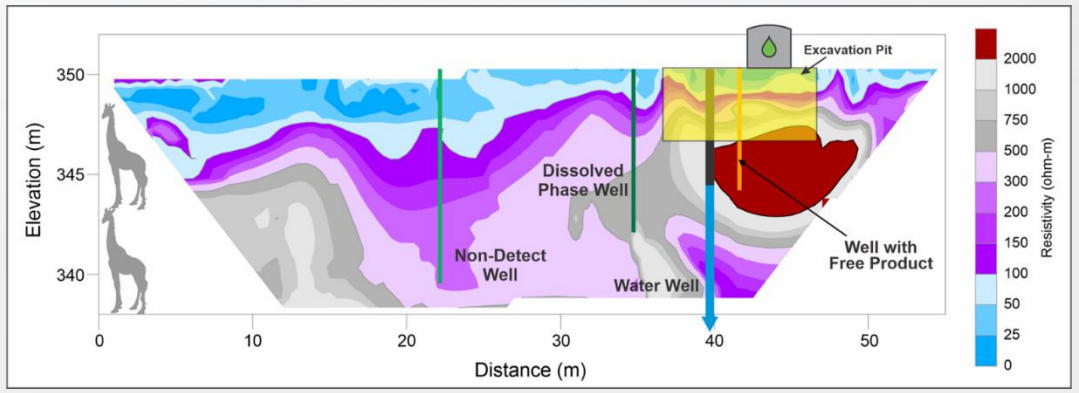


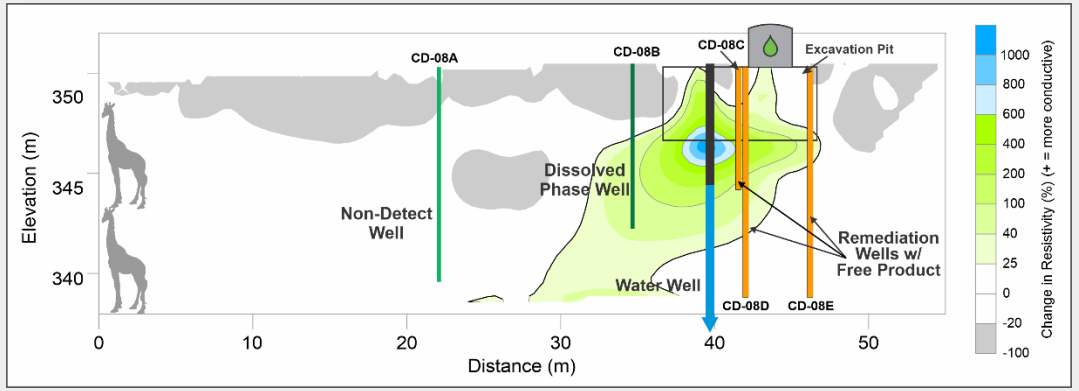
After Interstate Technology & Regulatory Council. 2020.

Every $ spent on characterization can save $$$ on remediation

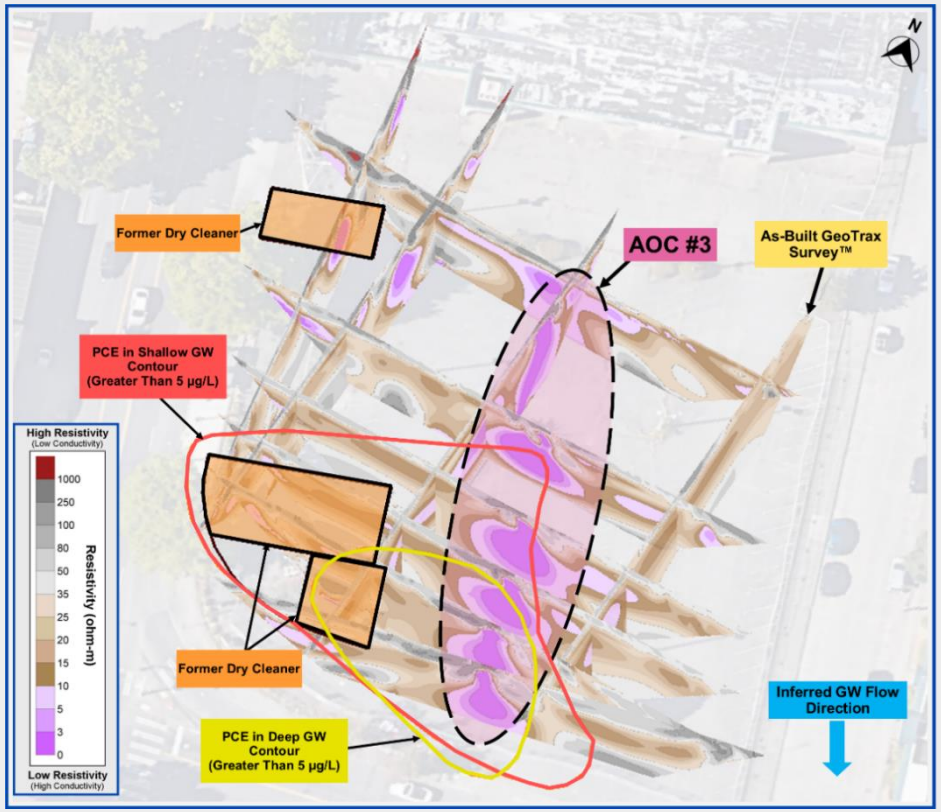
Following the Process: Time and Cost Savings Realized

TIME: LNAPL in Karst (OK)
Site Closure in Less Than 2 Years





COST: CVOCs in Glacial Till (WA)
~$3.7M Saved on Remediation



Cost vs Benefit?

Can we afford to scan prior to remediation?

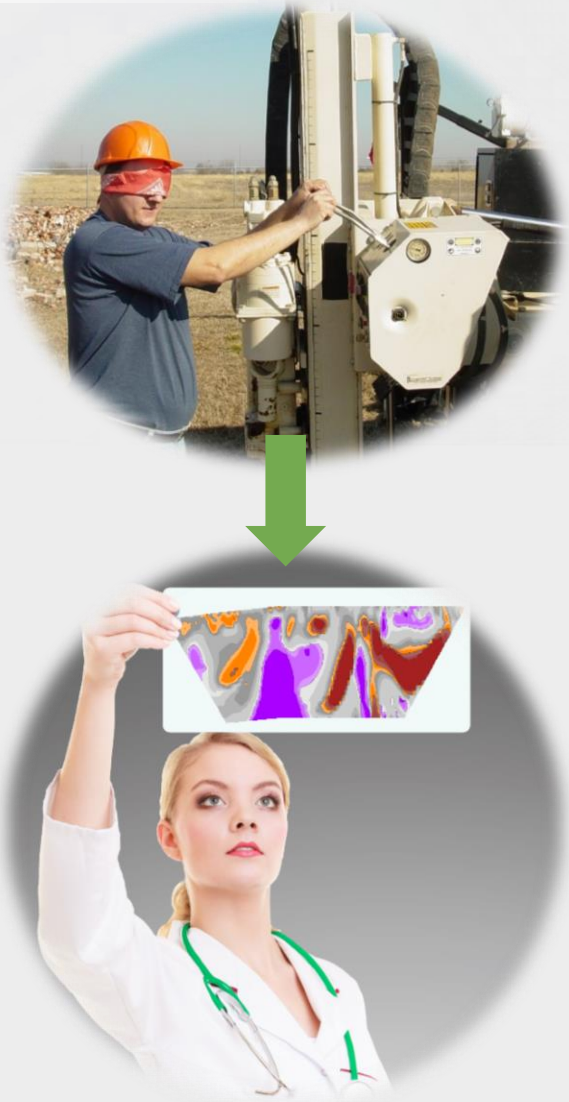
Cost vs Benefit?

~~Can we afford to scan prior to remediation?~~

Can we afford NOT to scan prior to remediation?

Best Practices for Modern Characterization

- **Monitoring Wells ≠ Characterization Wells**
- Successful site characterization requires integrated process:
  - QA/QC & safety protocols
  - Integrated geospatial database
  - Scan (or other HRSC) prior to remediation
  - 3D visualization
  - Iterative & collaborative evaluation
- Electrical hydrogeology yields time and cost savings for remediation with minimized trailing liabilities



Acknowledgements & References

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United States Environmental Protection Agency

Geocon

California Waterboard

City of Ada, Oklahoma

Greystone Environmental

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QUESTIONS?

Thank you for your time!

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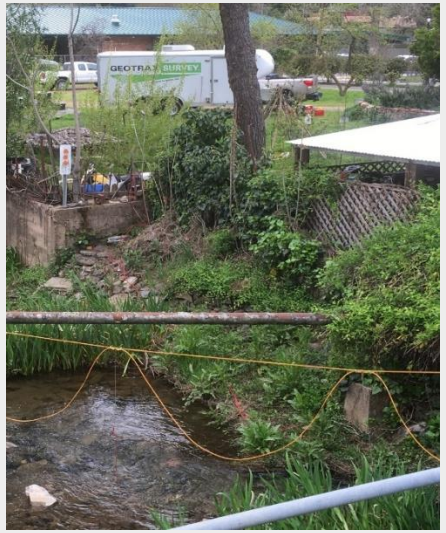
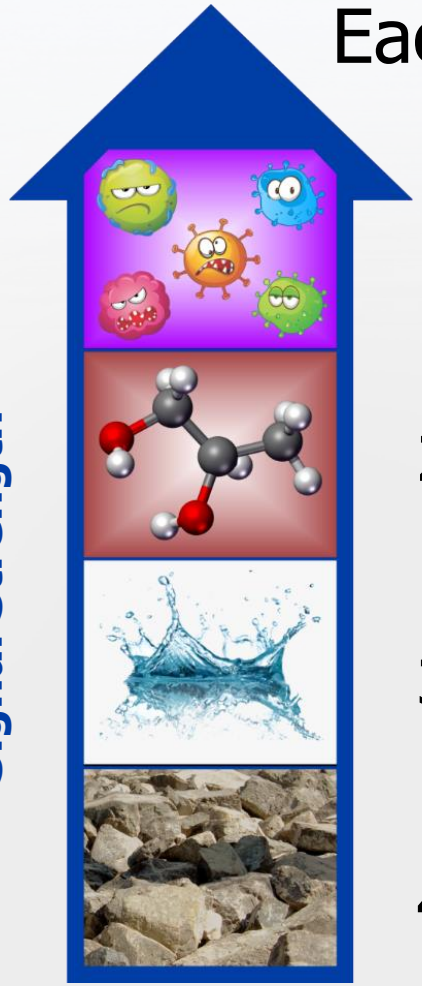
APPENDIX SLIDES FOLLOW

GeoTrax Survey™ Field Deployment

- 56 evenly spaced electrodes
- Must be in a straight line
- Line length = 5 x imaging depth

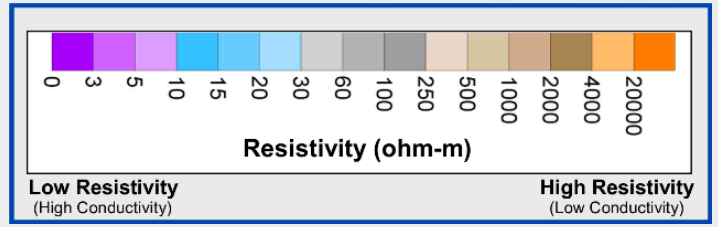


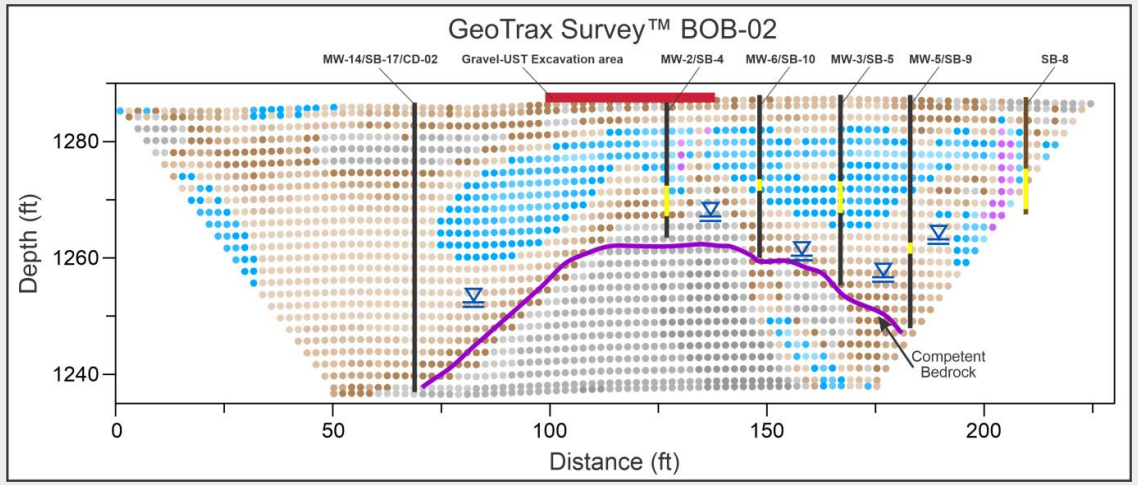
What Does Aestus See?



Each data point (pixel) equals the sum of:

1. Biological activity
2. Contamination/ Injectates/etc.
3. Groundwater/Fluids
4. Soil and rocks





Typical Electrical Properties