

Characterization and Monitoring Using Electrical Hydrogeology

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Goal of Characterization and Monitoring

“Site characterization is the process of **developing an understanding** of the geologic, hydrologic and engineering properties at the site including the soil, rock, along with groundwater and in many cases, man-modified conditions in the subsurface (e.g. utilities, structures, mines and tunnels) **that can impact site conditions**. It also includes the **spatial and temporal assessment of contaminants when they are present**. Various terms such as site investigation, site assessment and **site characterization** have been used to describe this process and are often used interchangeably.”

Benson and Yuhr, 2016

Goal of Characterization and Monitoring

Noninvasive



SITE ELIGIBILITY

Site nomination and eligibility determination

PHASE 1 ESA

A research report that documents the history of a property and identifies potential environmental concerns

PHASE 1.5 ESA

High-resolution scan to assess presence/absence of contaminant signatures; identify Phase 2 drilling targets

Invasive



PHASE 2 ESA

Collect limited groundwater & soil samples; analyze for contaminants

PHASE 3 RDC

Delineates full nature & extent of contamination by filling Phase 2 data gaps; develop robust CSM for remedial design

SITE CLEANUP

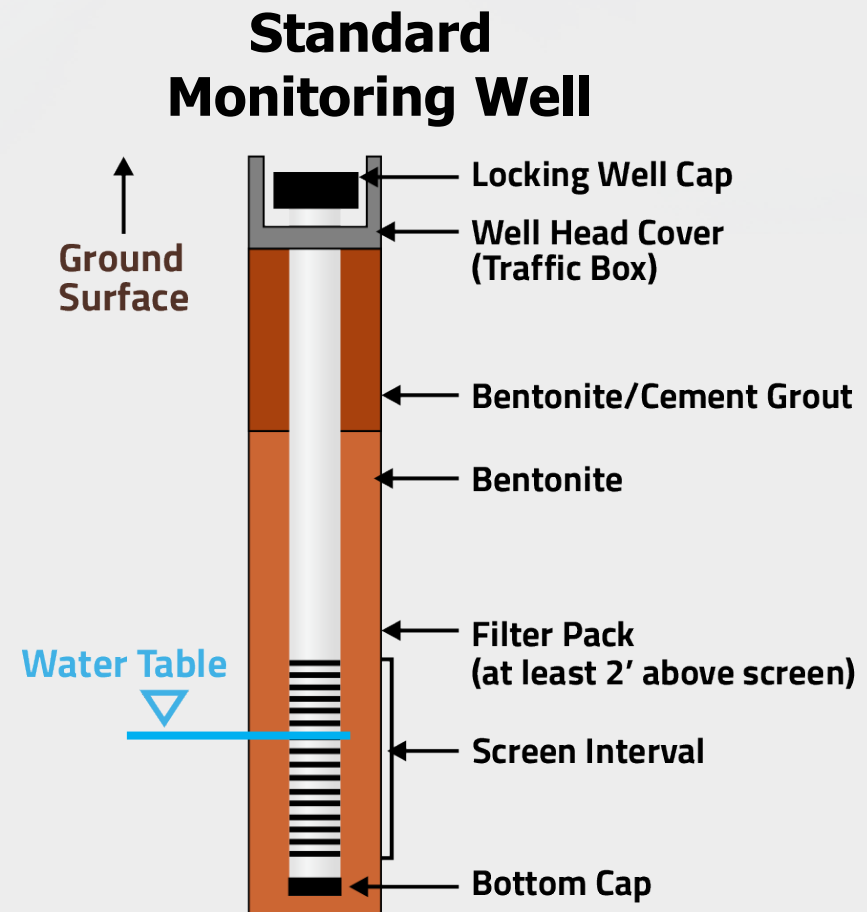
Remediate site to meet negotiated cleanup levels & perform ongoing monitoring, if required

SITE REUSE

Redevelop the site into a new use in accordance with prescribed institutional controls

Standard Invasive Tool: Wells

- **Costs:** ~\$125K/well lifetime
- **Benefit:** direct sample
- **Risks:** migration pathway changes with age
poor detection spatially

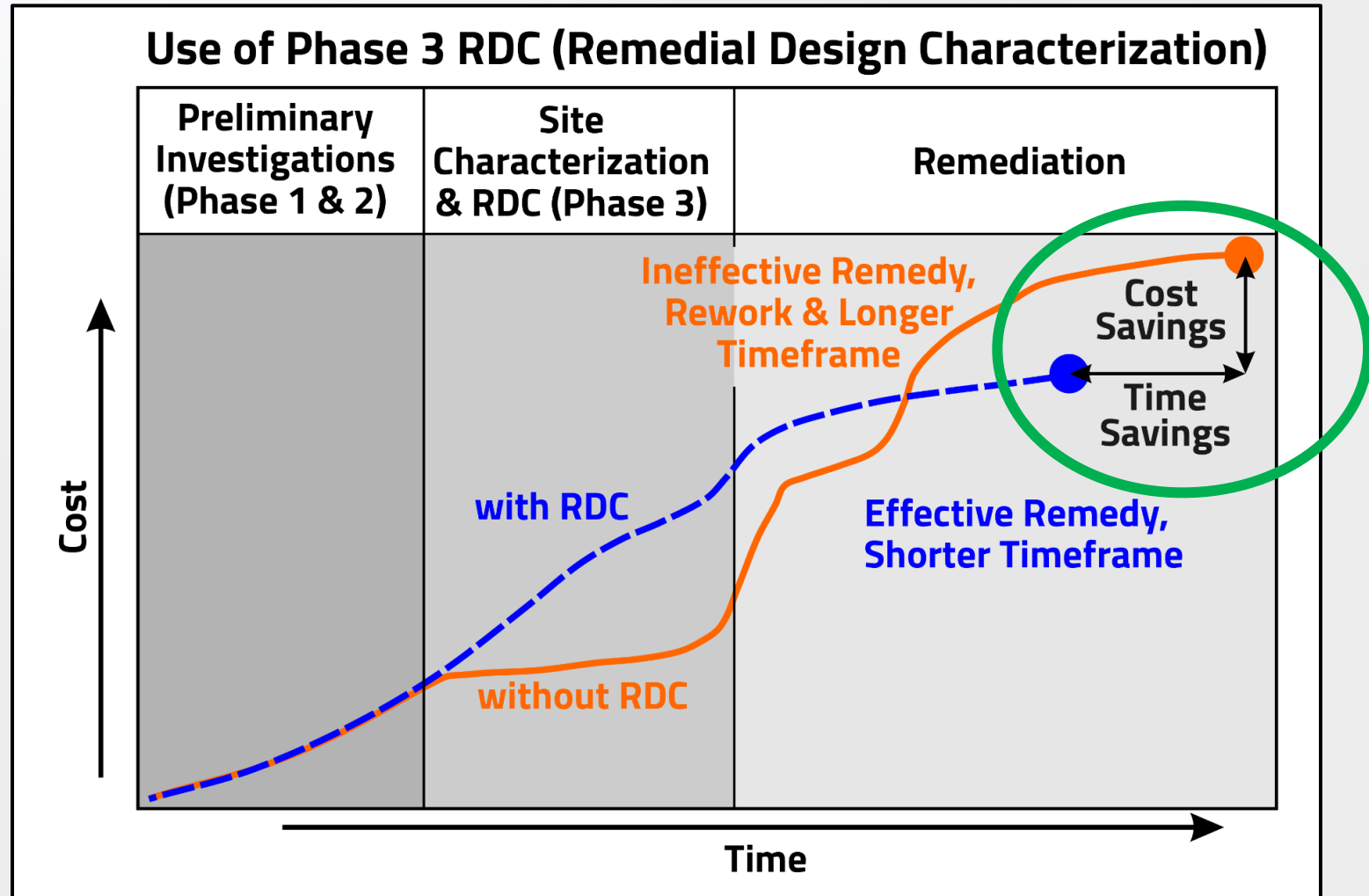


US ITRC Evaluation of Investments

RDC Remedial Design Characterization

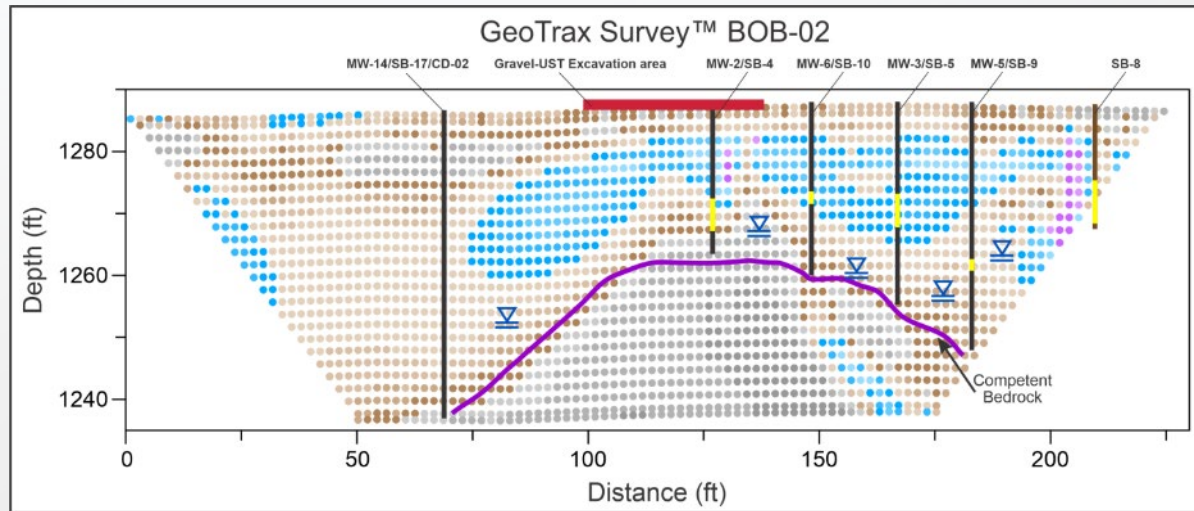
Investment in
Subsurface
Knowledge

10% RDC on
Remediation



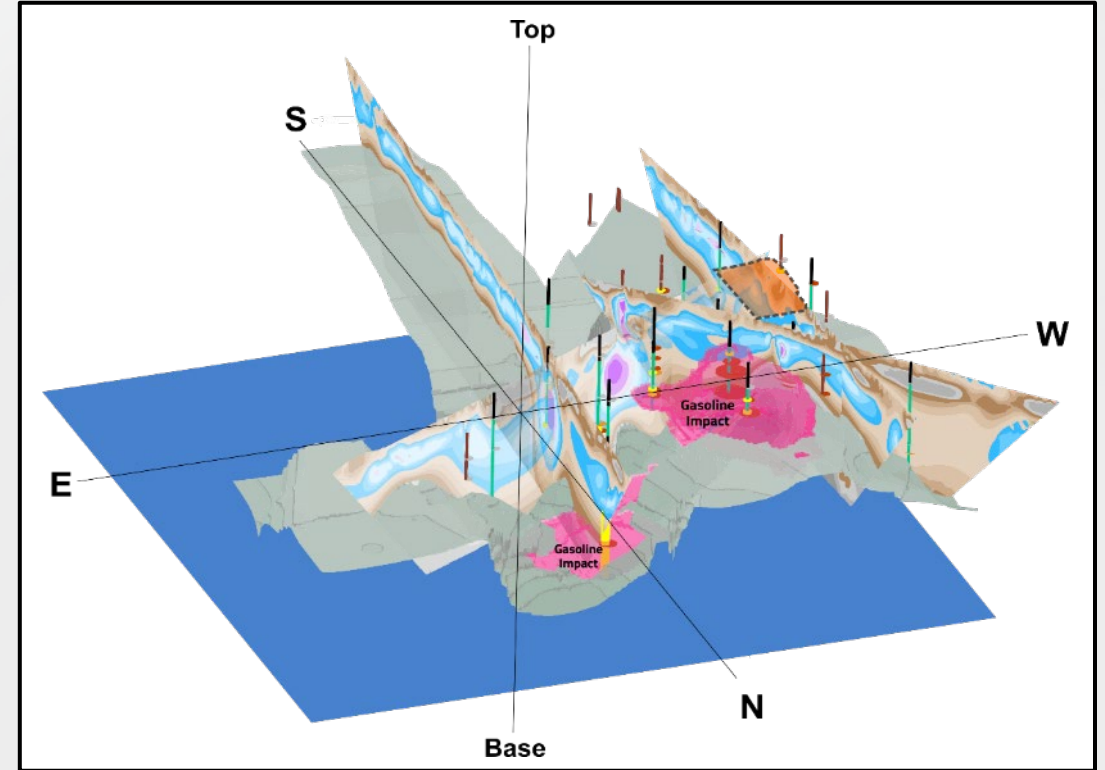
What is Ultra-HRSC Electrical Hydrogeology?

Missouri Karst LNAPL Site



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

ERI and TERI

ERI: Electrical Resistivity Imaging (1 image)

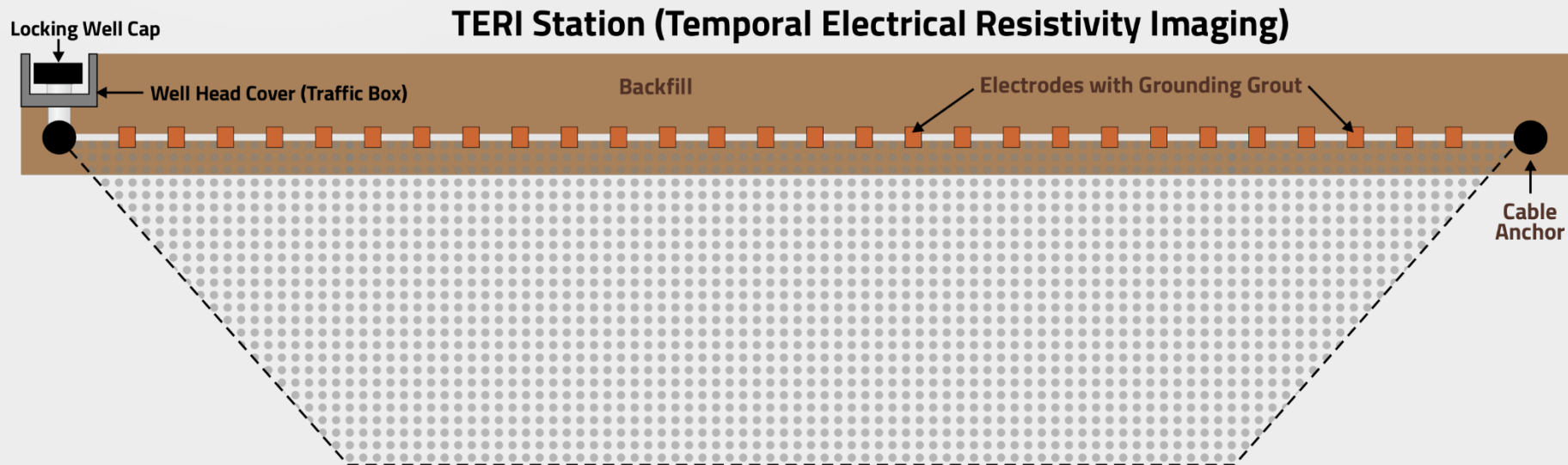
- ER data in ohm-meters
- Define structures and contaminants

TERI: Temporal Electrical Resistivity Imaging (2 or more)

- Changes in ER data in % change
- Quantify flow processes, biological growth, and remedial outcomes

“Standard” Electrical Tool: TERI

- **Costs:** ~\$10K/cable, 1K electrodes only, installation
- **Benefits:** Broad view of aquifer over 2D plane
Lack of trailing liabilities
- **Risks:** Not direct sample



TERI Field Deployment

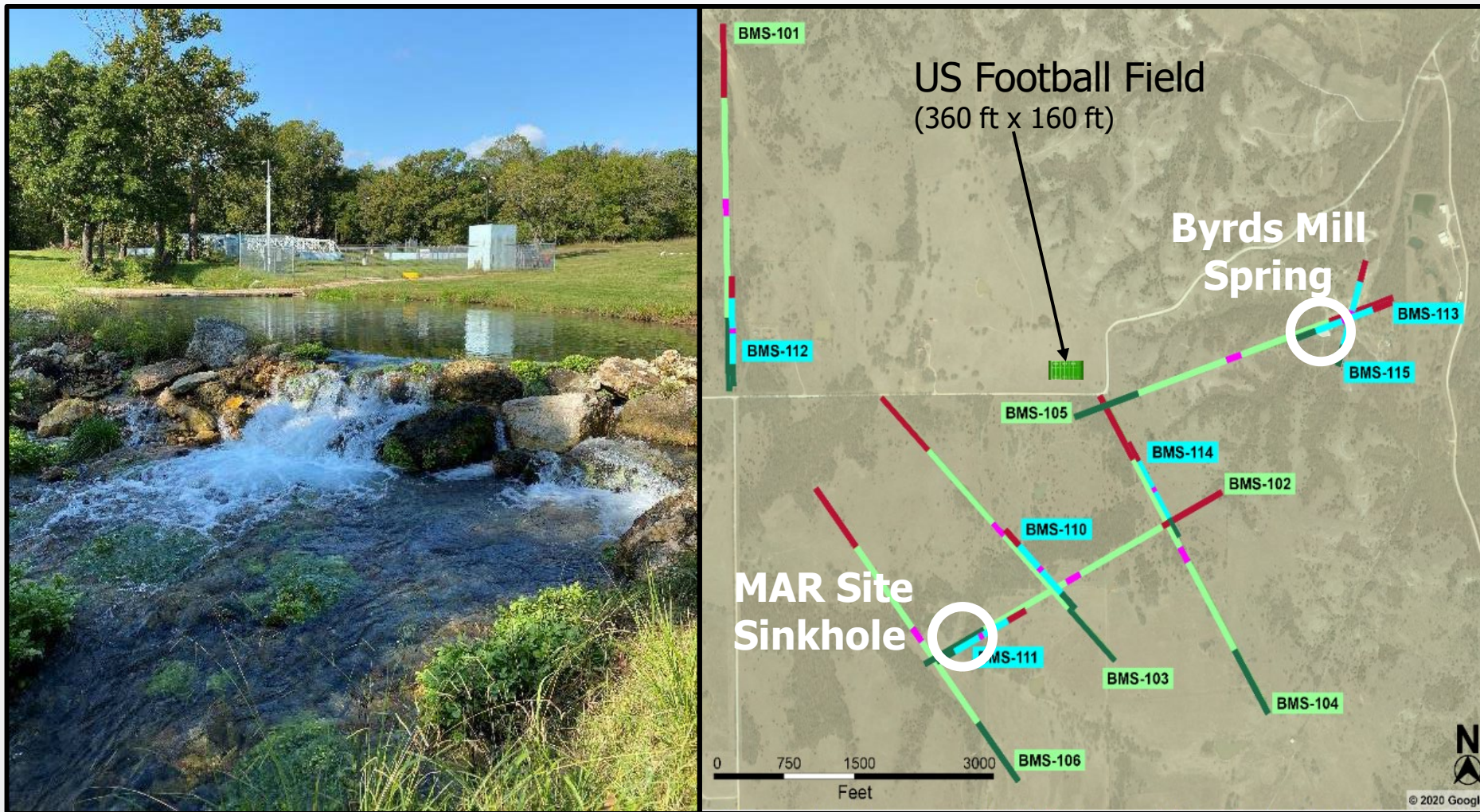


← TERI Cable installation good for long term monitoring (~\$10K + labor)

TERI Electrode only installation good for single event or uncertain monitoring (~\$100 + labor)

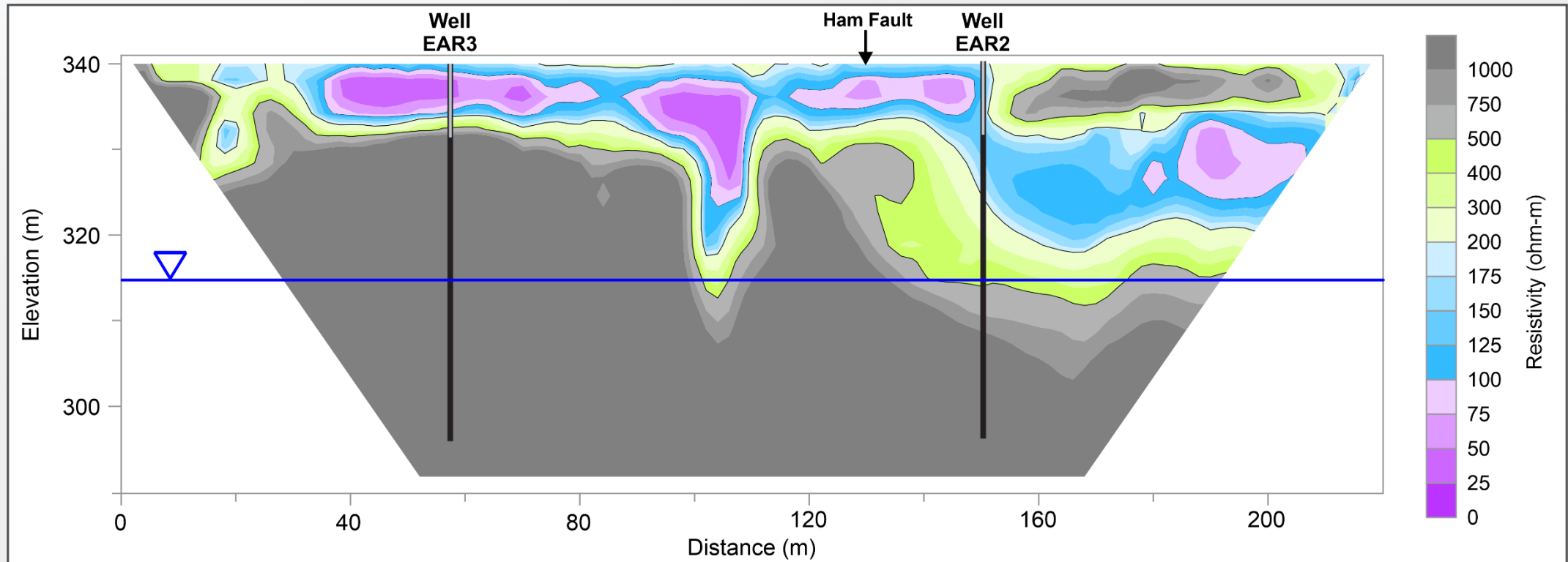


CASE I: Managed Aquifer Recharge Monitoring

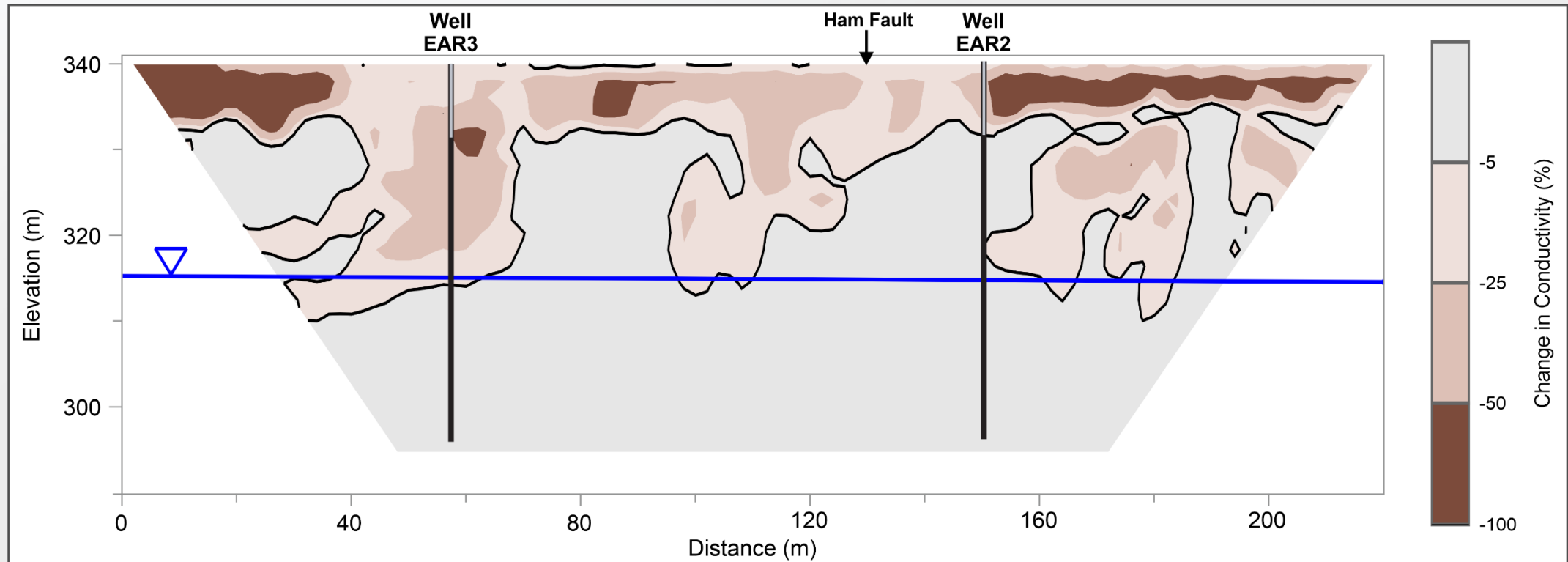


EPA/OSU Research Site

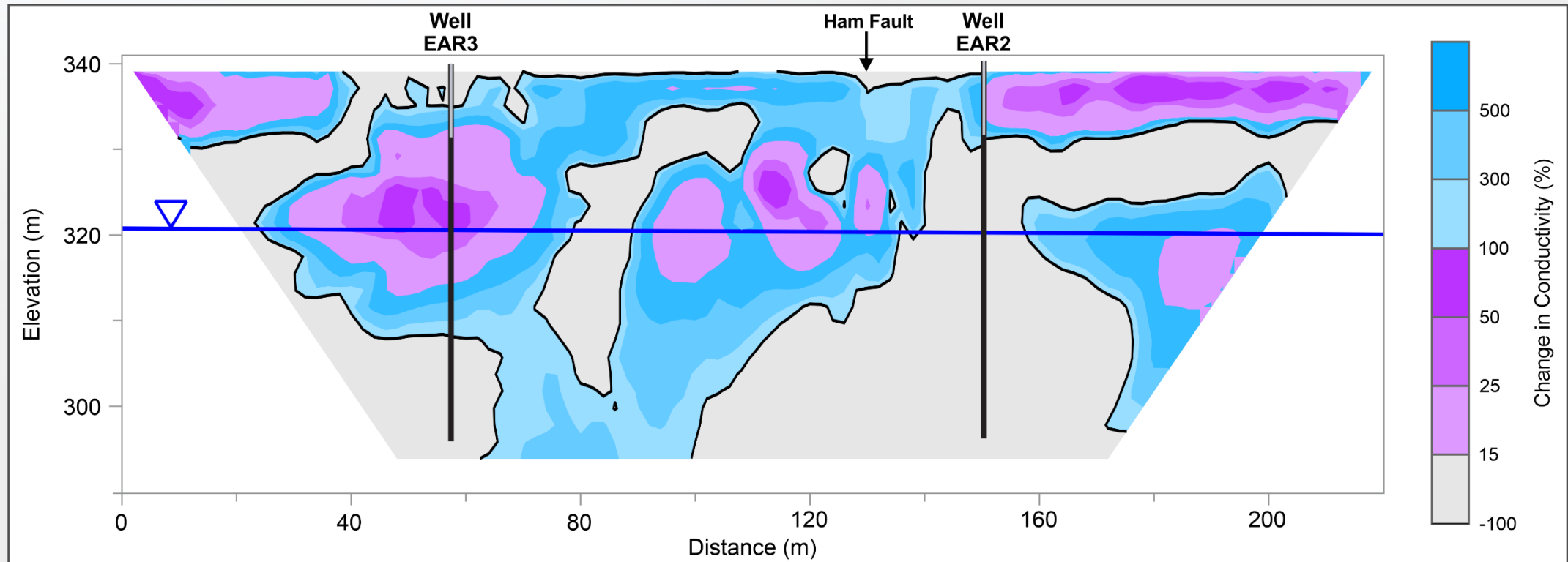
Background ERI Image



TERI Increase in Resistance ($-\Delta\text{Conductivity}$)



TERI Decrease in Resistance (+ Δ Conductivity)

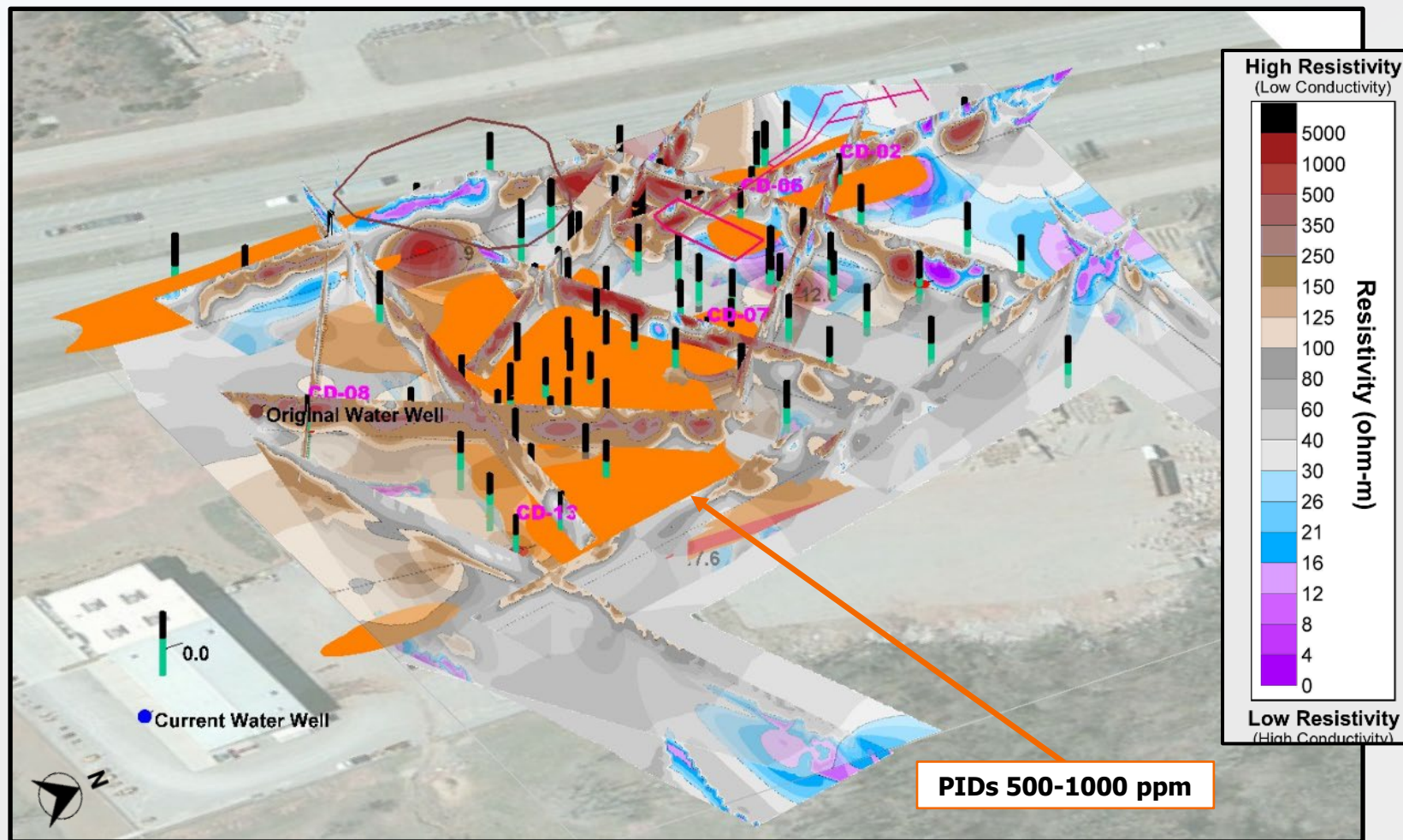


Case I:

TERI Benefits at MAR Site

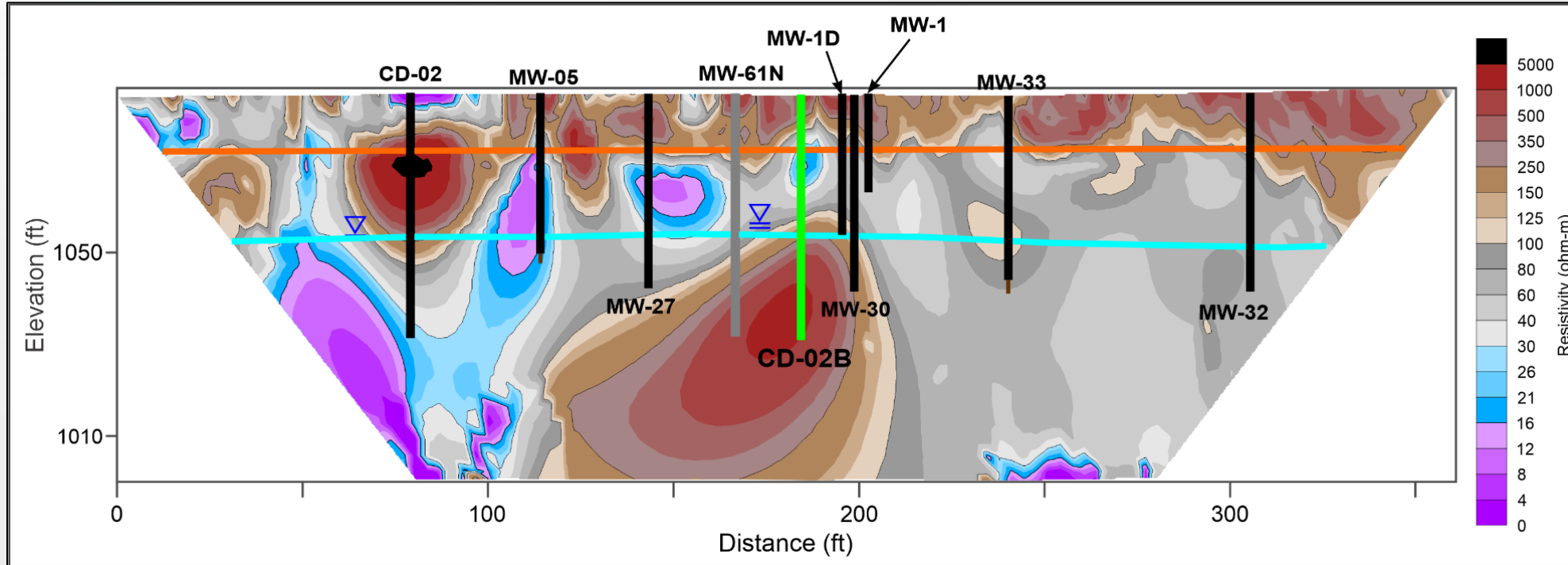
1. Clear understanding of recharge flowpaths in fault zone
2. Possible evidence of microbial blooms in water supply aquifer
3. Locations for targeted drilling of flowpaths
4. Will be utilized to monitor tracer tests

CASE II: Bedrock LUST Site at Truckstop

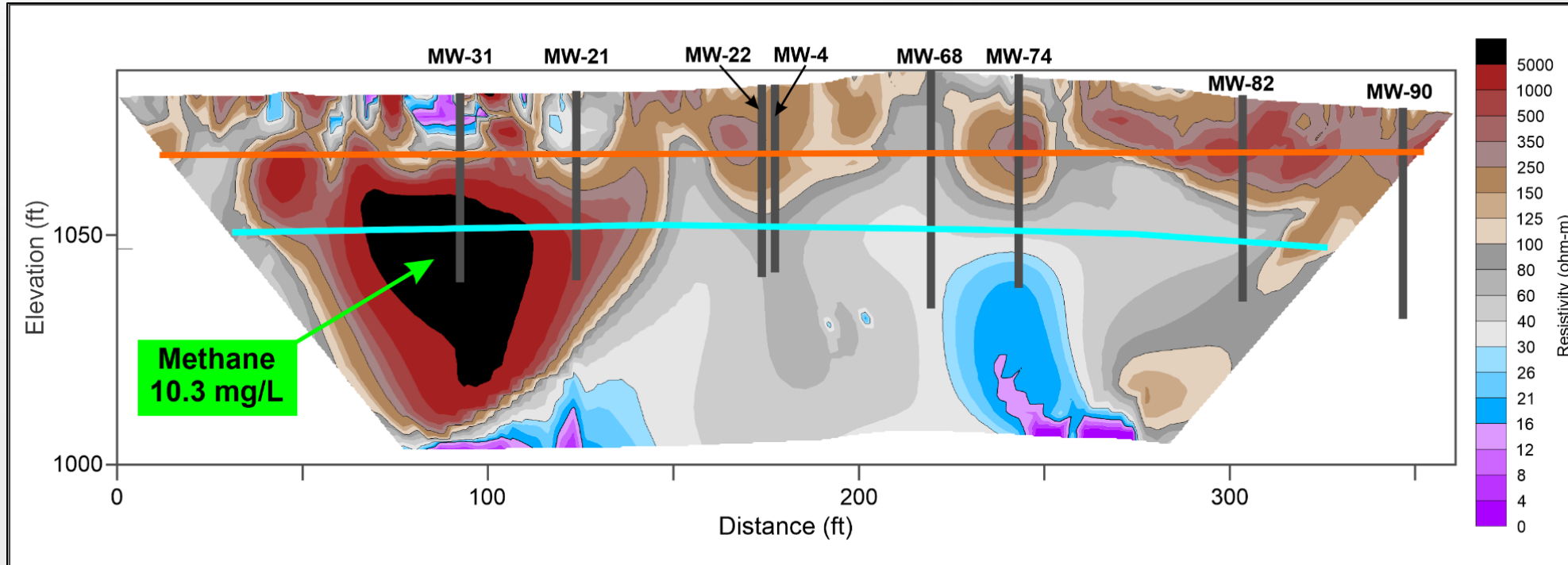


Greystone Consulting/OSU/Aestus Site

Potential Targets Above and Below Water Table

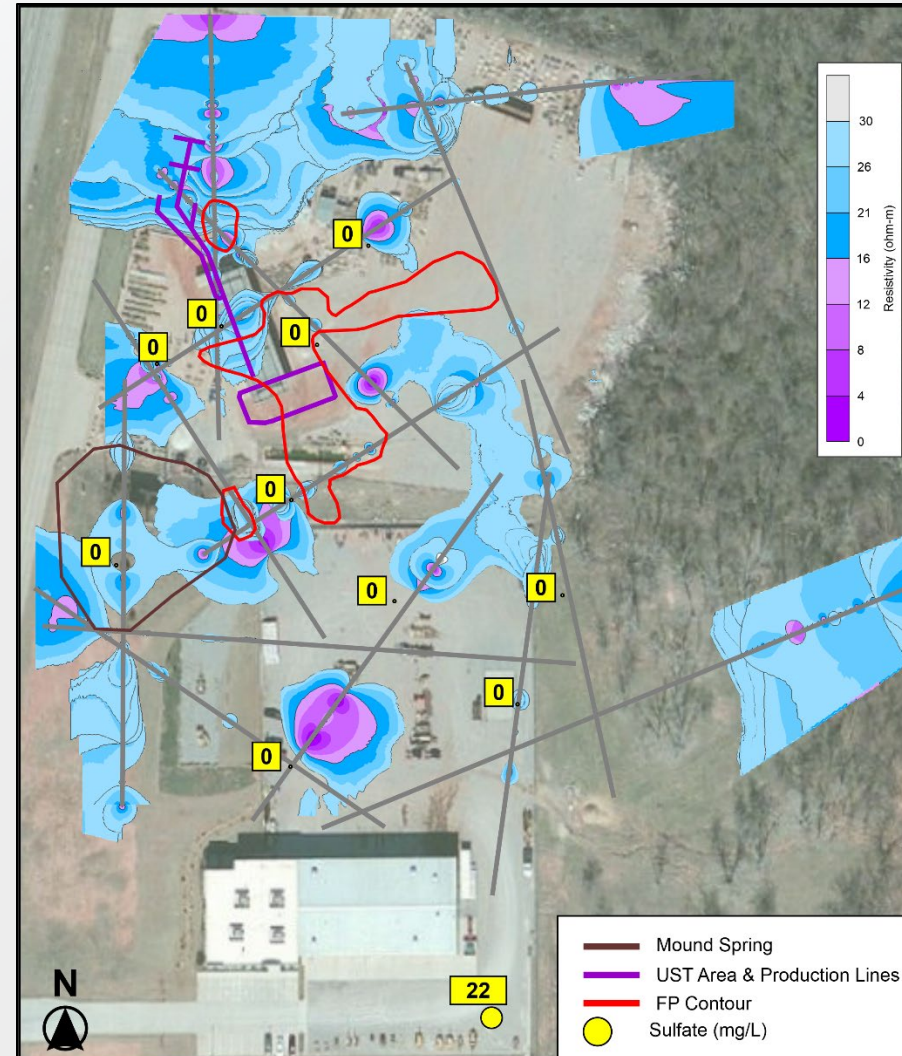


Varying Bioactivity



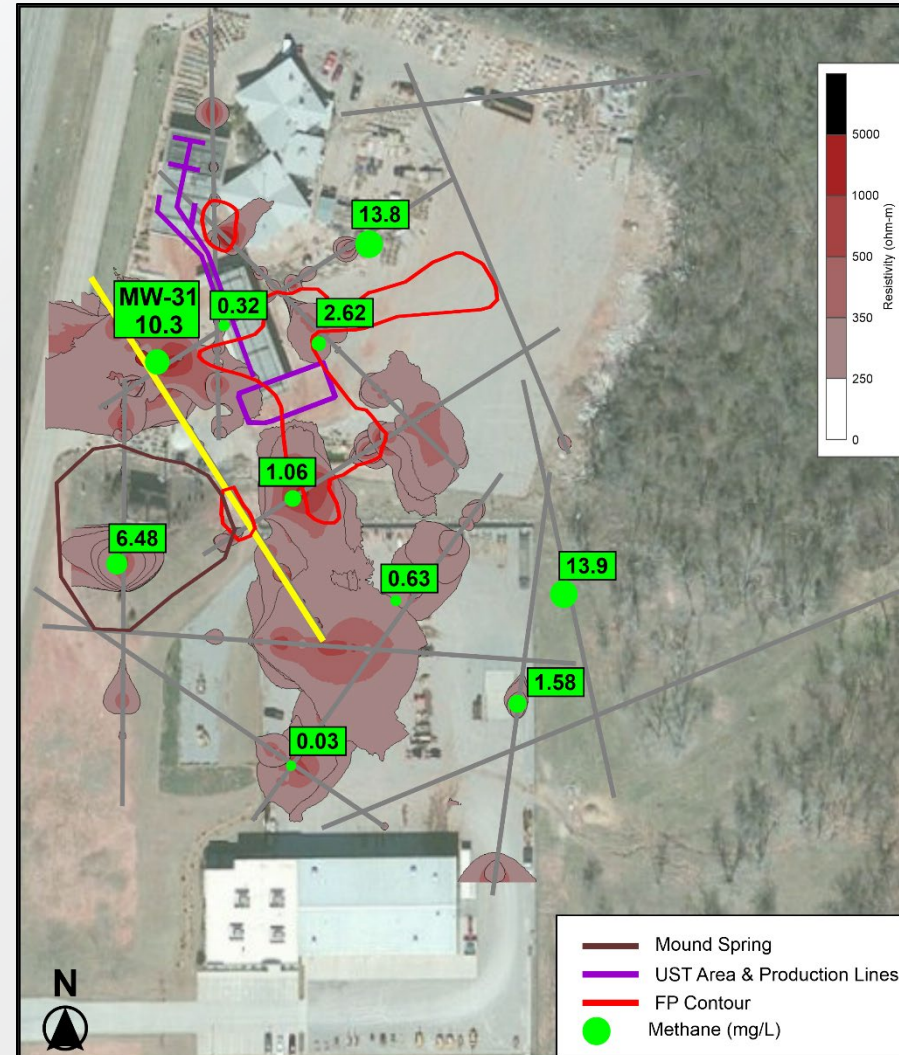
Lack of Electron Acceptors, Remnant LNAPL

- Electrically Conductive Bioactivity Signatures not in Free Product Areas
- No remaining sulfate
- No microbiological evidence of significant activity



Vadose Resistors Impacted as Source of Remnant LNAPL

- Confirmation Drilling demonstrated free product caught in vadose zone
- Vacuum extraction applied at targeted locations
- LNAPL extracted and bioremediation to be conducted including TERI monitoring



Case II: Benefits of Dynamic Team

1. Regulatory Authority Invested in RDC for “stuck” site
 - TERI
 - 3D Visualization
 - Confirmation Drilling
2. Remediation Consultant utilized Data in Dynamic Feedback Loop
 - CDs evaluating potential free product
 - Result informing bioremediation program
 - Heading toward closed site

Future of Electrical Hydrogeology

1. TERI Stations like car charging stations
2. Scales from 10 m to 10 km
3. Depths to bottom of aquifer systems
4. Technical requirement on a legal basis?



Thank you for your attention!

Contact for questions:

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