

Complete Dechlorination via Bioaugmentation in Partially Weathered and Fractured Bedrock

Chris Shores, P.E. (CT, NC, PA, WV)
Principal Engineer

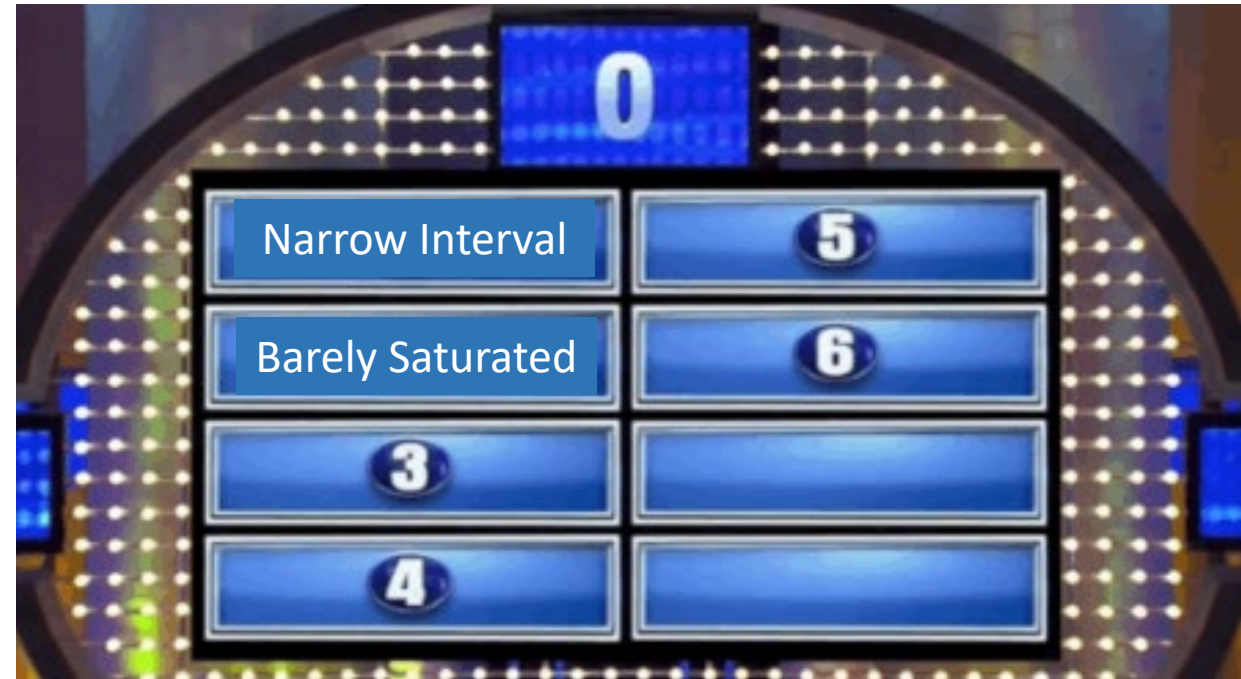
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Gut Reaction to this Injection Well Design?

Parameter	Value
Total Depth (ft)	30
Screen Interval (ft bgs)	29 – 30
Depth to Water (ft bgs)	28



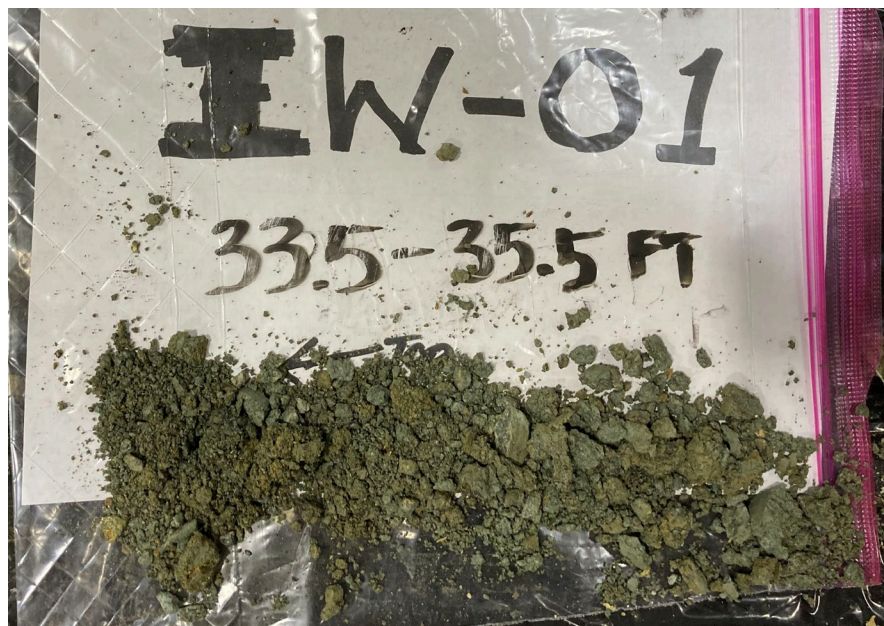
What is Partially Weathered Rock (PWR)?

Saprolite: Highly weathered parent rock



$K = 0.03 - 0.3$ ft/day
(Literature)

PWR: Transition Zone between Saprolite and Competent Rock



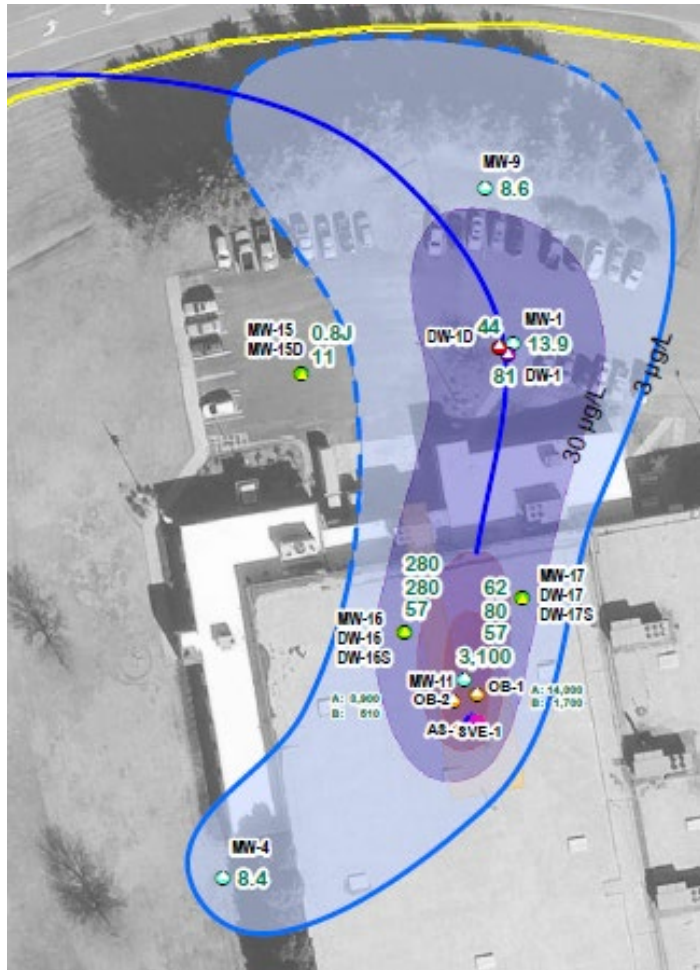
$K = 0.7 - 1.0$ ft/day
(Literature)

Competent Rock

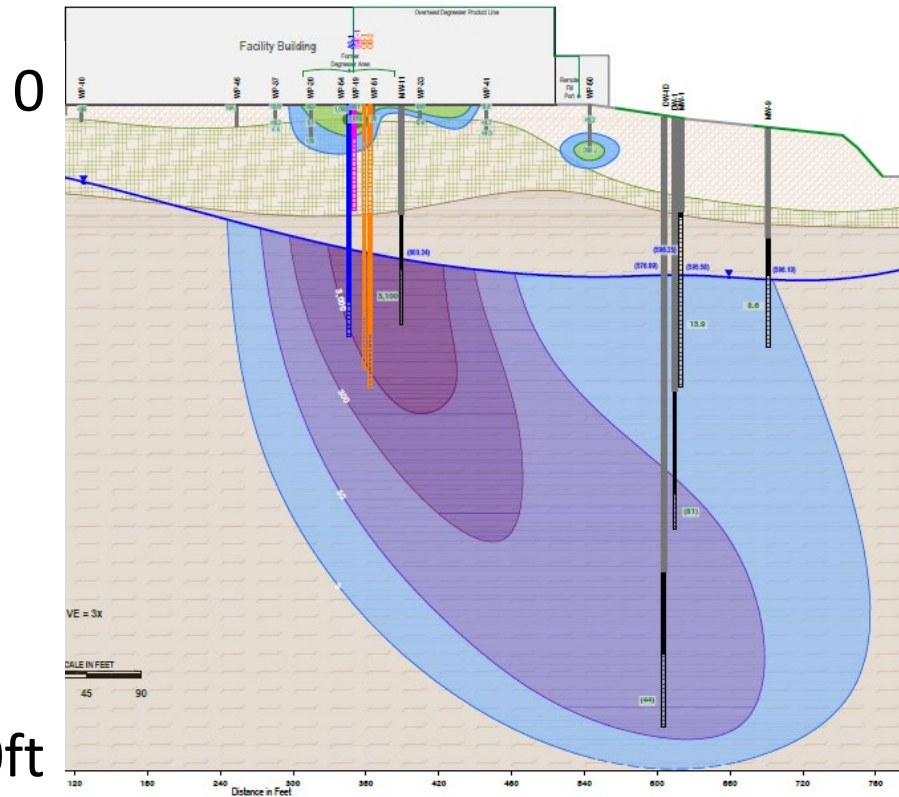


$K = 0.15$ ft/day
(Site)

Extent of Contamination – Proof of PWR's Importance

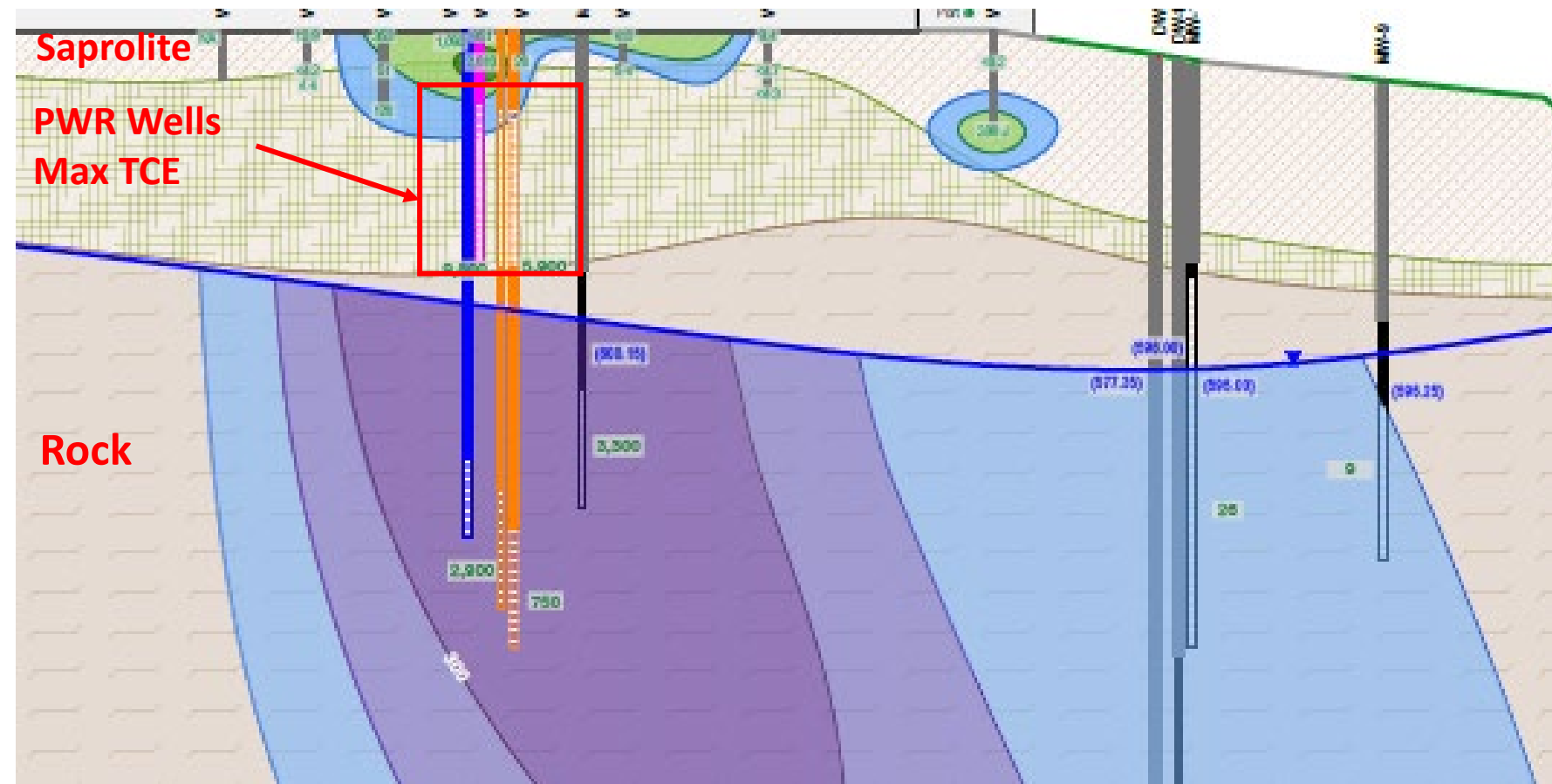


200ft



- Site used 2,000-gal TCE/Year 1989-1994
- 1.5 acre, >200 ft deep
- 500,000 CY+ saturated contamination

PWR is Easy to Mistake



- Initially thought to be thick and unsaturated
- Later wells screened to top of rock and found source
- MPE Remedy Installed across full Saprolite and PWR Zones

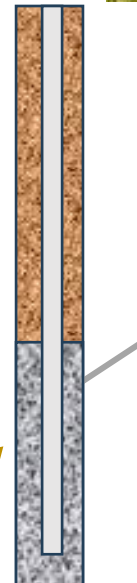
Focused FS Reset - Biotreatability

Parameter	Potential
pH	● pH around 7
Dissolved Oxygen	● Slightly High
Oxidation Reduction Potential (ORP)	● Near Zero
Temperature	● Over 20 deg. C
<i>Dehalococcoides</i>	● Non Detect
Daughter Product Formation	● Barely

Conventional Option for Direct Injection into Rock

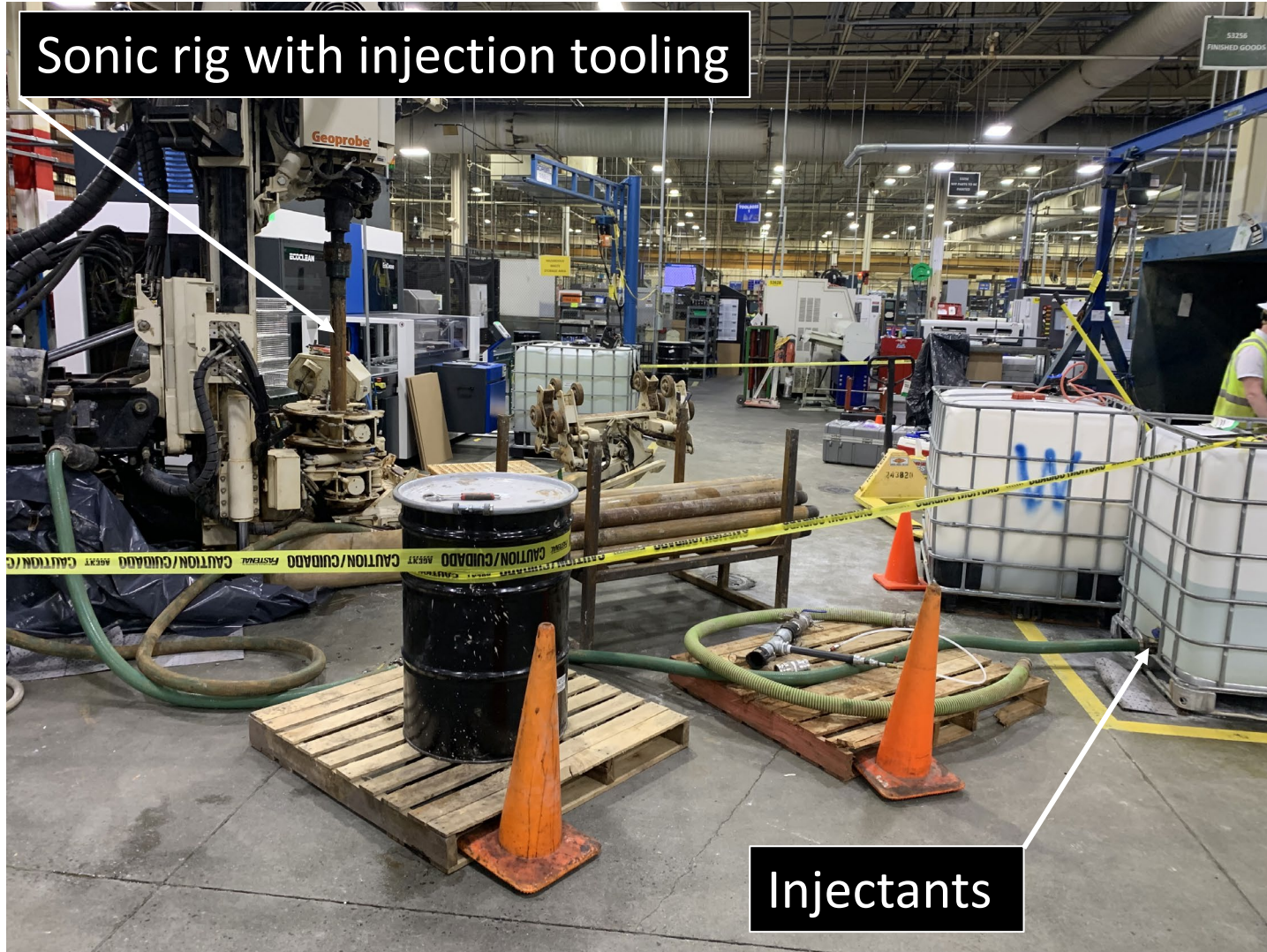


Step 1:
Sonic, Air Rotary,
or Other Rig
creates borehole
and backfills
with sand and
bentonite

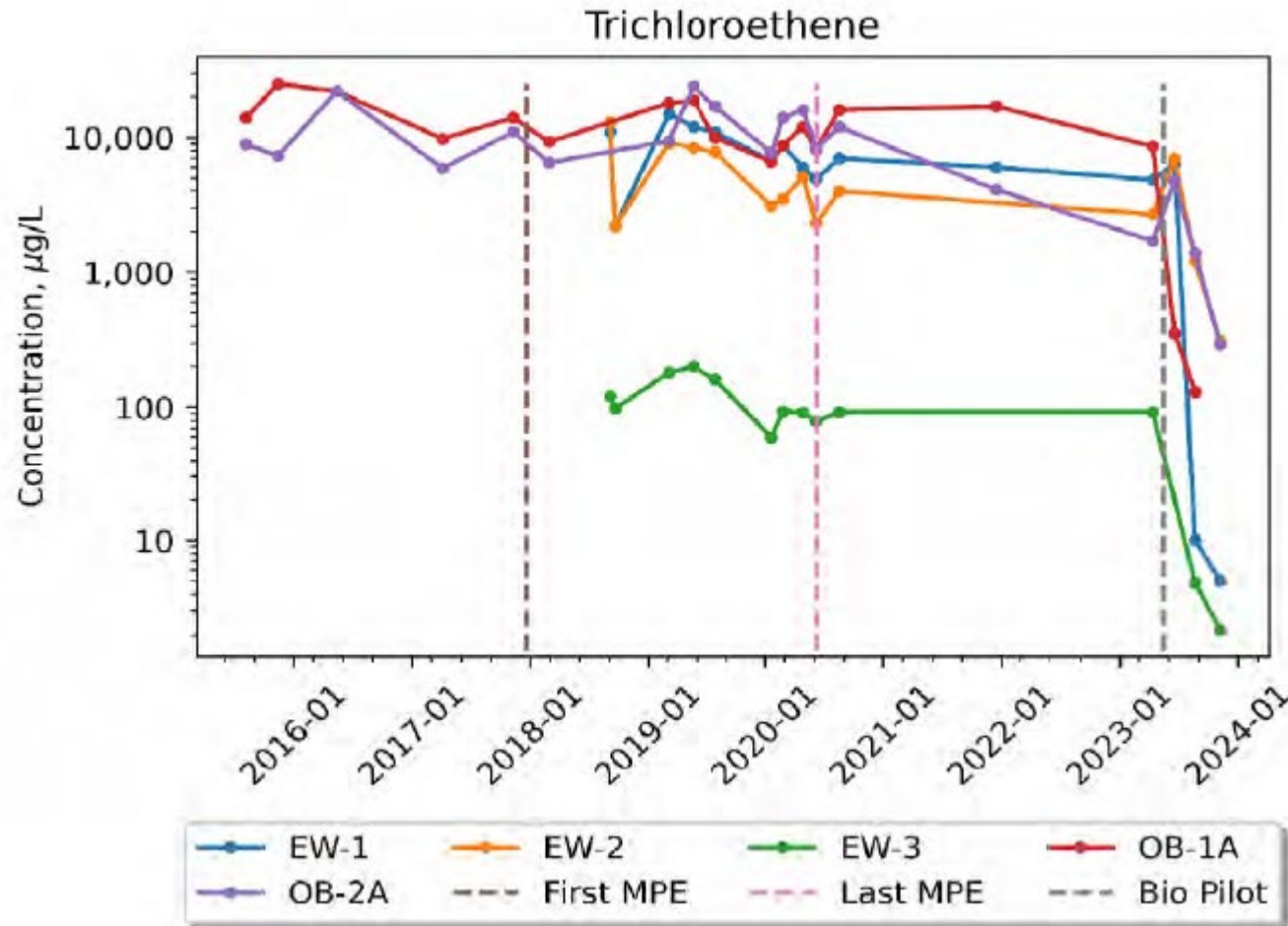


Step 2:
DPT Rig drills
temporary injection
point

Pilot Study Design and Installation



Pilot Study Results

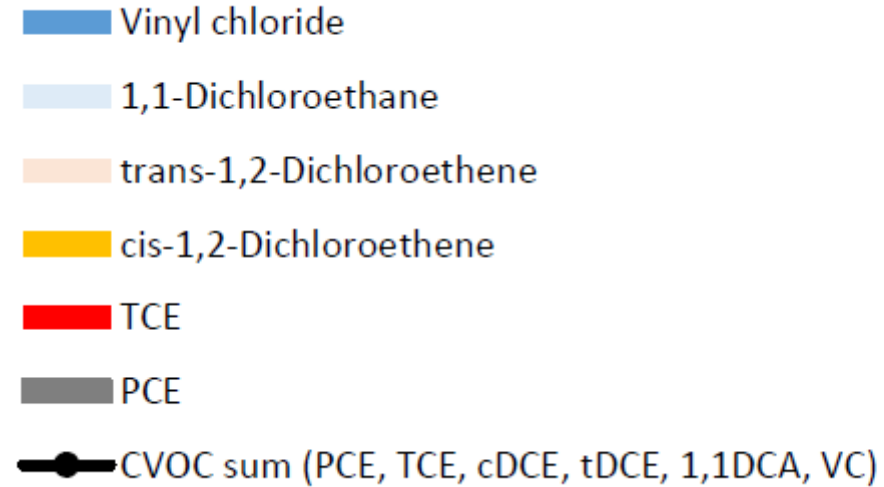
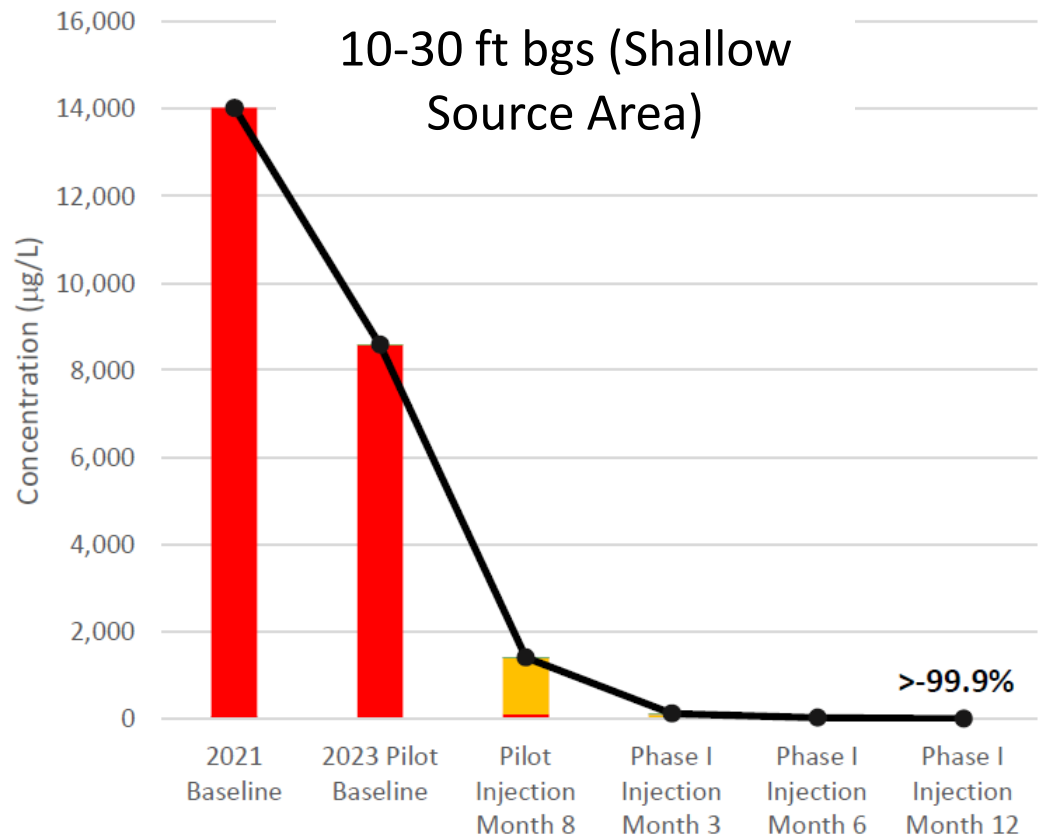


- 2 of 4 boreholes reached target depth
- Up to 25 ft ROI
- Excellent TCE reduction, but incomplete dechlorination to ethene
- *DHC* bacteria only moderate; suspect pH acidification
 - Average $1.3E+06$ gene copies/L
 - Target is $>1E+07$ gene copies/L

Leverage Lessons Learned → Full-Scale

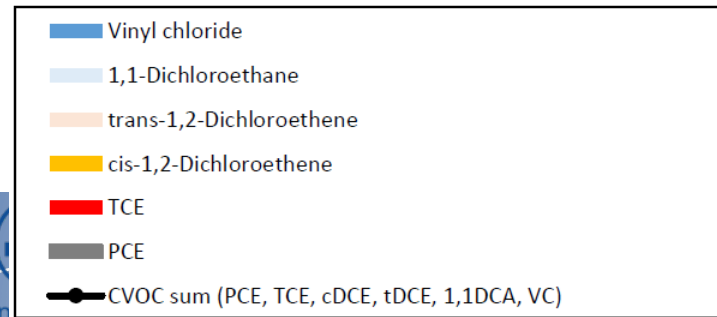
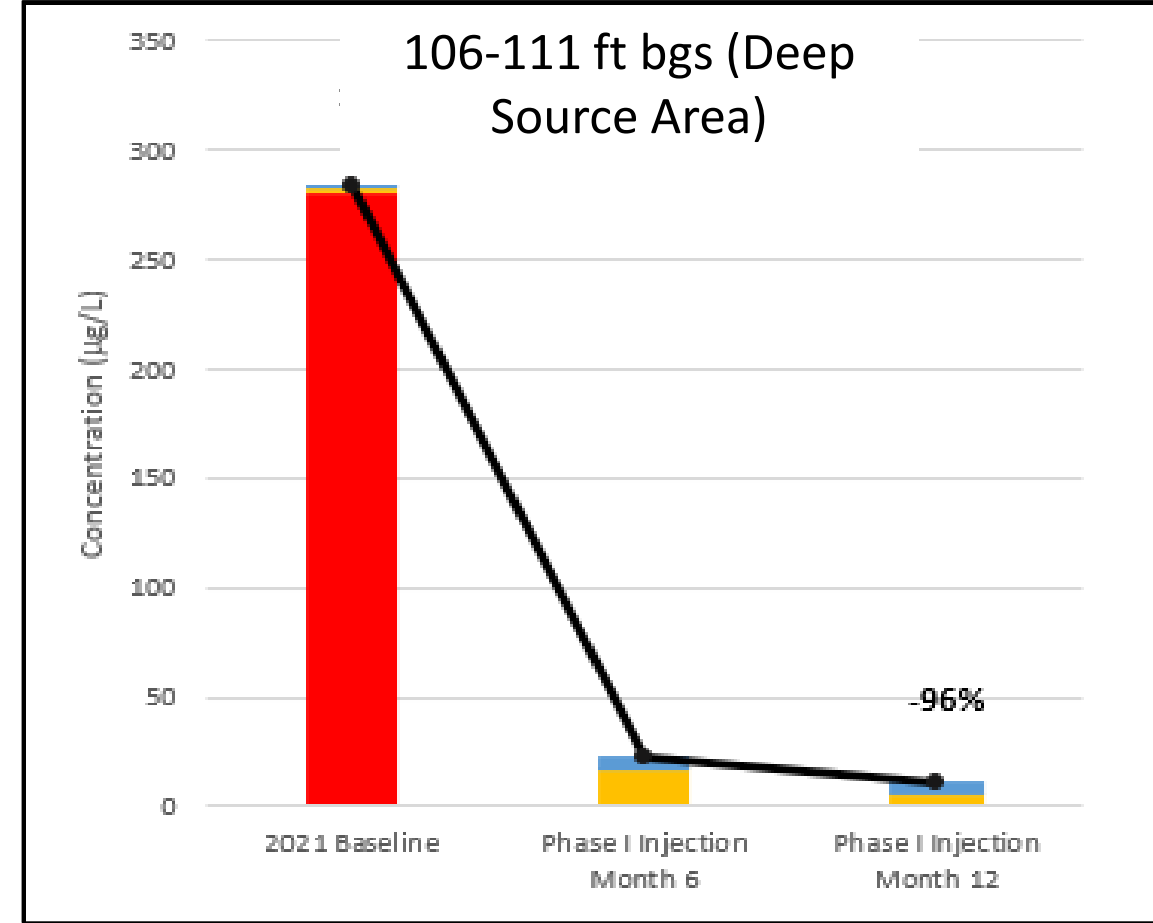
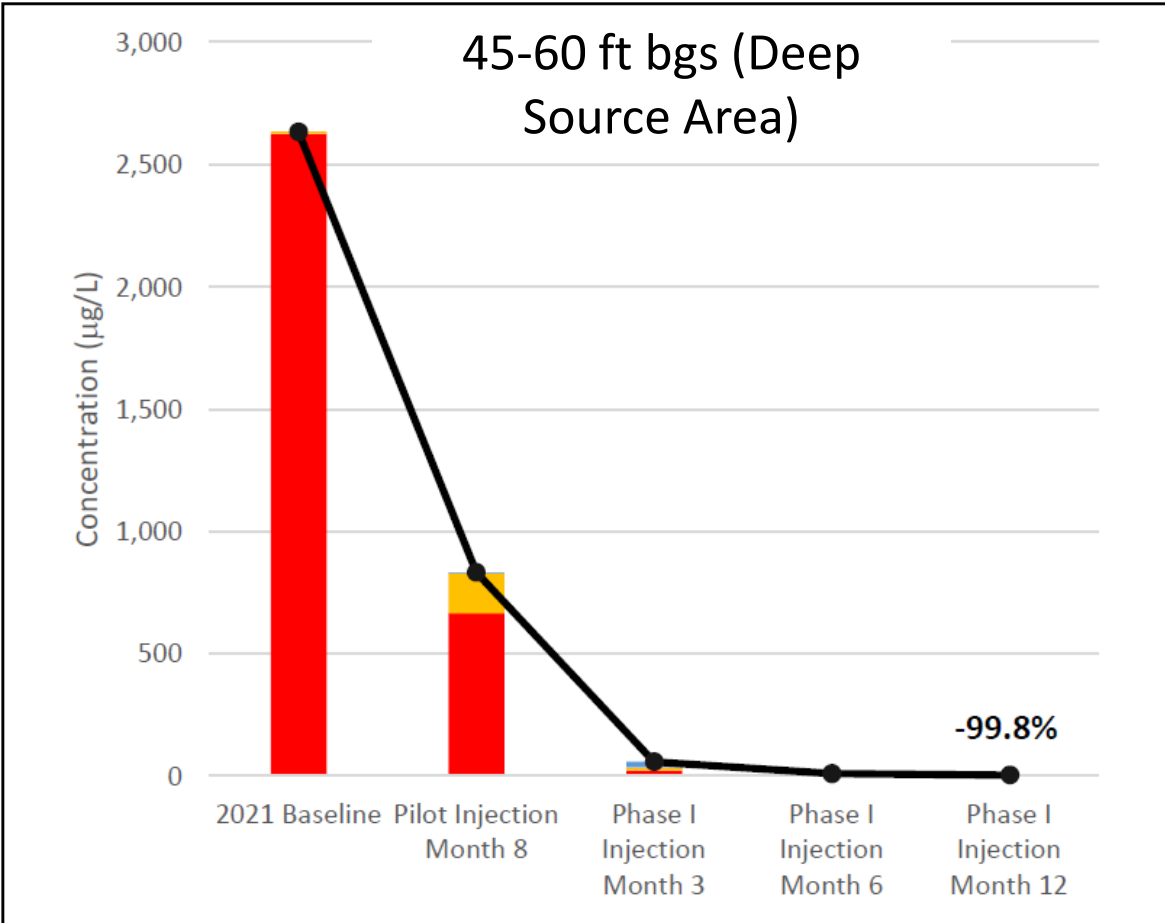
Lesson Learned from Pilot	Full-Scale Design Decision
Target Depth Limitations with Sonic Tooling	Permanent injection wells, isolated in PWR, even if dry
pH challenges	Significant increase to Buffer dose and utilize KB-1 Plus [®] bacteria over KB-1 [®]
<i>Dhc</i> bacteria failure to thrive	Significant increase in dosage

Full-Scale Results – Typical Source Area – 1YR Later



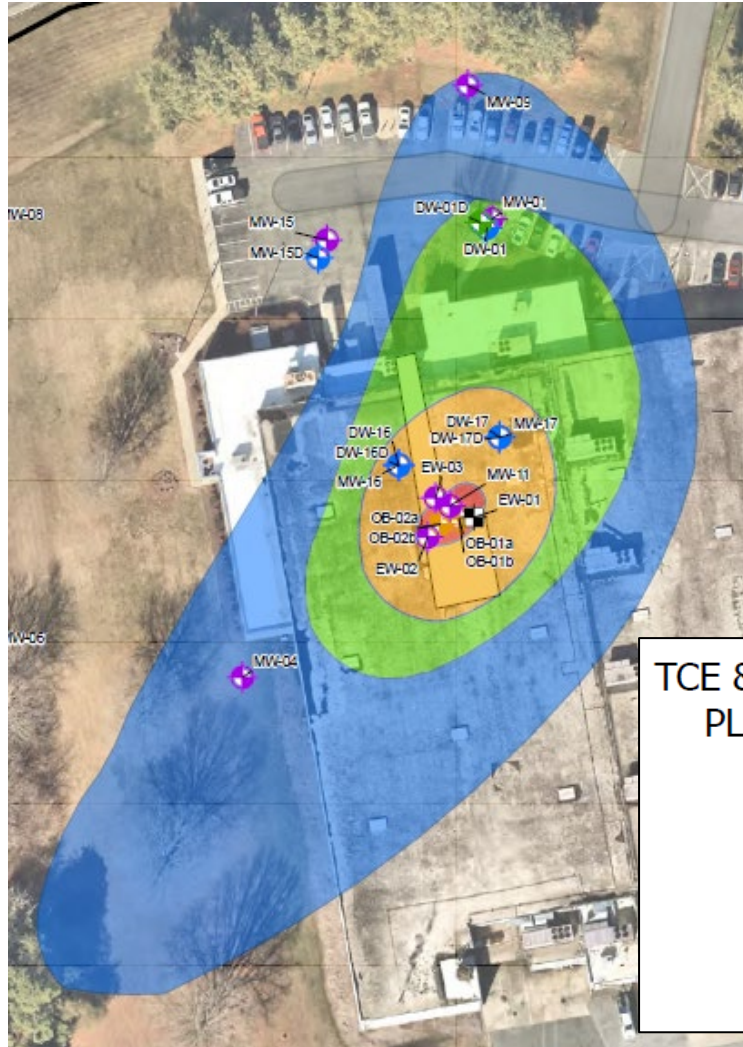
- Average *Dhc* in source area: 1.3×10^8 gene copies/liter
 - Target is 10^7

Full-Scale Results – Deeper Zones – 1YR Later

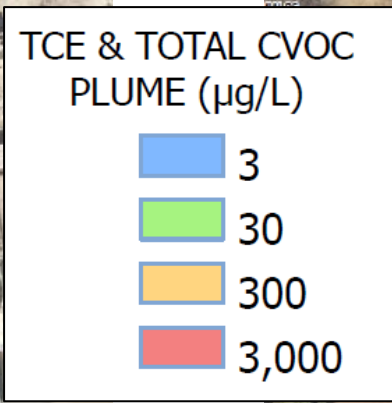
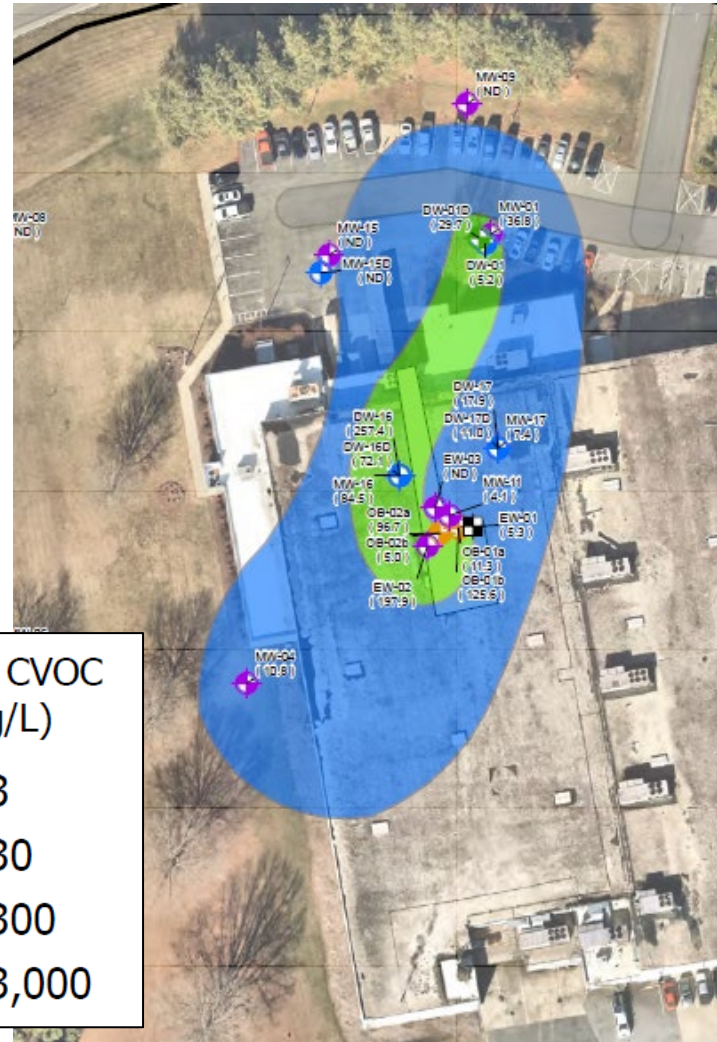


Full-Scale Results – Overall Plume

BASELINE – TCE ONLY



1-YEAR LATER – TOTAL CVOCs



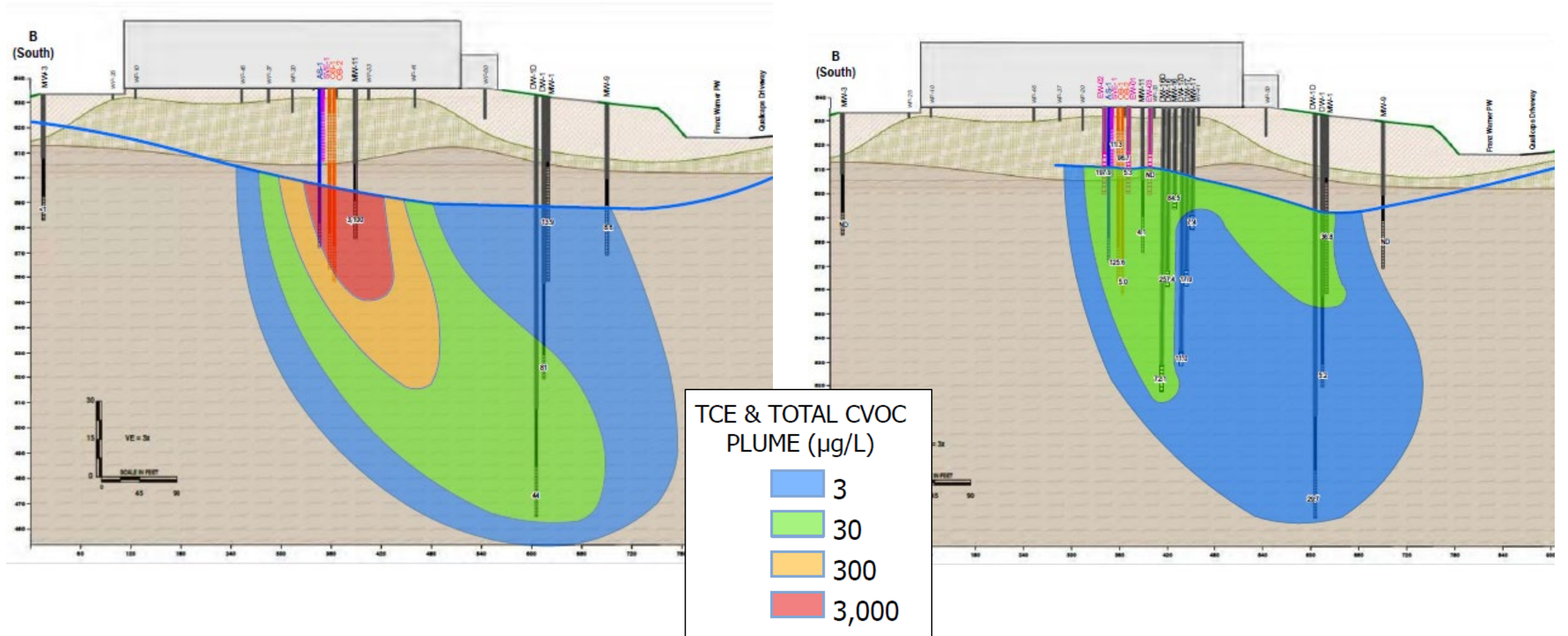
- Core of plume (300 and 3,000 contours) are gone
- With source area depleted, dissolved-phase beginning to contract



Full-Scale Results – Overall Plume

BASELINE – TCE ONLY

1-YEAR LATER – TOTAL CVOCs



Summary of Lessons Learned

1. Target the source, even if difficult to isolate. Be bold
2. Leverage CSM data, hit the hot spots, don't flood the zone
 - By the #s: 4,600 total gallons of dilute EVO, 8 days → risk-based closure
3. Bioremediation projects need bugs more than they do electron donor
4. Don't undersize the pilot – it might lead to unfair judgment of the technology
5. Leverage contractors and state of the industry – make lots of calls

Acknowledgements - Partners



www.Redox-Tech.com



www.ISOTEC-Inc.com



www.TerraSystems.net



www.SiremLab.com

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