

SUCCESSFUL ERD PILOT STUDY IN RESIDUAL DNAPL UTILIZING A SIMPLE ADDITIVE DELIVERY APPROACH

I. Richard Schaffner and Kevin J. Davis, P.E.; Pennoni Associates, Inc.
Kent C. Armstrong, BioStryke Remediation Products, LLC

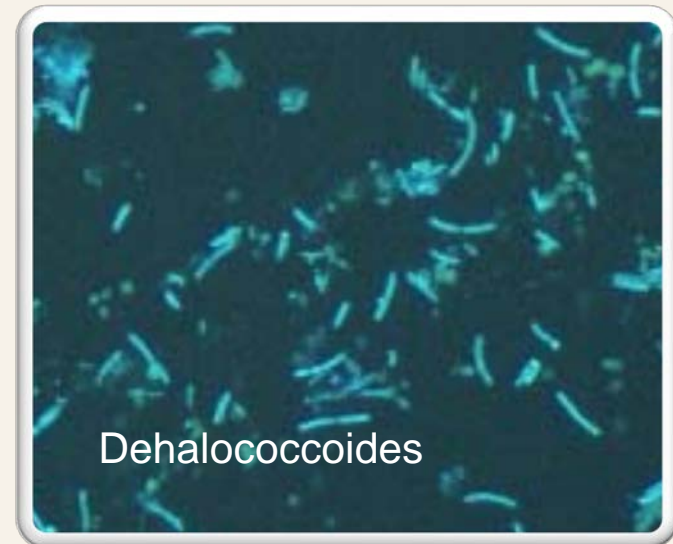
The logo for Pennoni, featuring the word "Pennoni" in a bold, italicized, dark green font. The text is enclosed within a thin, dark green oval outline that is slightly tilted.

Pennoni Associates Inc.
Consulting Engineers

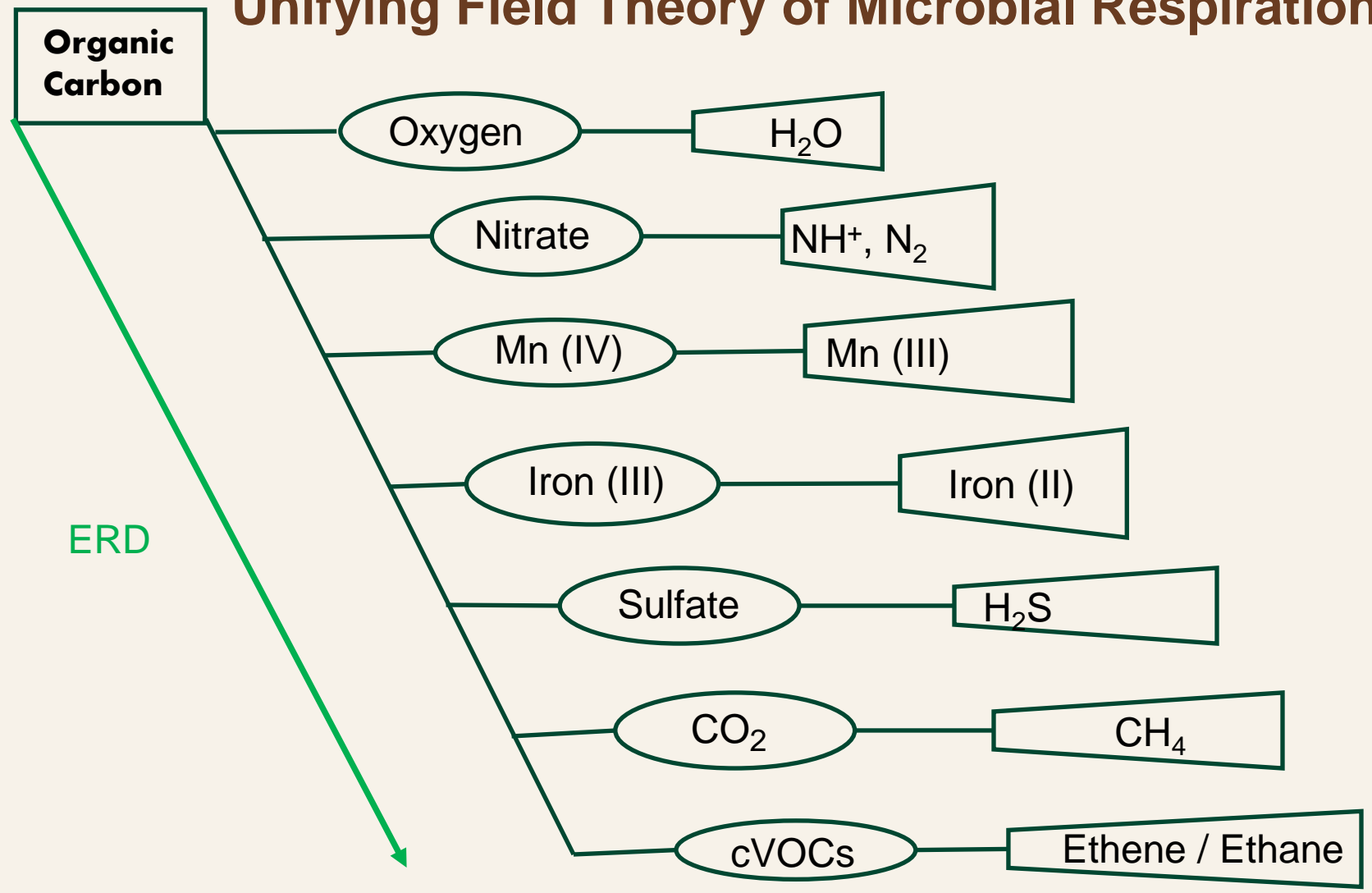
Providing Engineering Services Since 1966

- ERD Review
- Site Background
- Pilot Study Methods
- Results
- Conclusions

- RD = Substitution of H for Cl
- Environmental Conditions
 - Anaerobic (<0.5 mg/L DO)
 - Chemically Reducing (<50 mV)
 - Hydrogen
 - 'fuel for dechlorination'
- Mechanisms
 - Metabolic (Dehalorespiration)
 - Co-metabolic (minor mechanism)
 - Abiotic reactions (*e.g.*, FeS)
 - Solubilization (co-solvency)

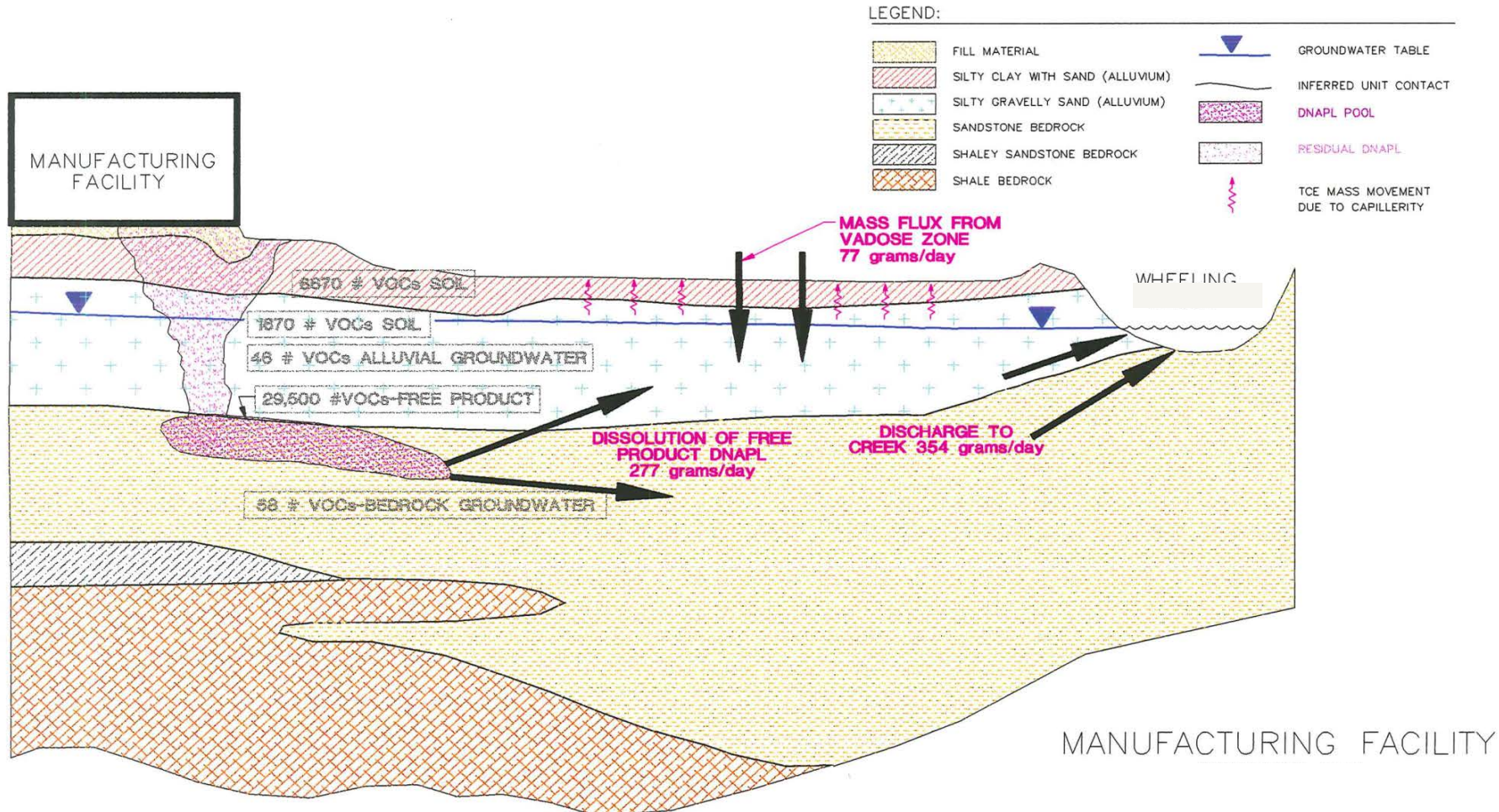


Unifying Field Theory of Microbial Respiration



- Site History:
 - Electronics Manufacturer, East Central Ohio
 - Incidental TCE Spillage
- Conceptual Site Model:
 - ~15' to ~20' of Overburden (Sand, Silt, Clay)
 - Fractured Sandstone / Shale contact at 15' to 20'
 - Bedrock Impacted Zone ~10 feet Thick
 - Baseline cVOC Signature:
 - Total Parents: ~50 - 550 ppm; TCE
 - Total Daughters: ~10 - 15 ppm; 1,2-DCE
 - Parent Fraction: 80% - 99%
- P&T Implemented to Manage Migration
 - Operational since 2005

Conceptual Site Model



NOTES

1. CONTRIBUTION OF RESIDUAL DNAPL TO AQUEOUS PHASE PLUME IN ALLUVIUM IS EXPECTED TO BE SMALL RELATIVE TO CONTRIBUTION FROM FREE PHASE DNAPL IN BEDROCK
2. DUE TO THE LENGTH OF TIME FROM THE RELEASE OF TCE (~15 YEARS), THE CURRENT ADSORPTION RATE OF TCE TO SOIL IS LOW.
3. TCE DEGRADATION RATE IS VERY LOW BASED ON CONCENTRATIONS OF TCE DAUGHTER PRODUCTS MEASURED IN WELLS
4. FOR PURPOSES OF AQUEOUS PHASE MASS FLUX ESTIMATES, THE CONTRIBUTION OF TCE FROM THE A SOILS IS EXPECTED TO BE ABOUT THE SAME AS THE DECREASE IN AQUEOUS PHASE TCE DUE TO ADSORPTION AND DEGRADATION AND IS THEREFORE IGNORED.

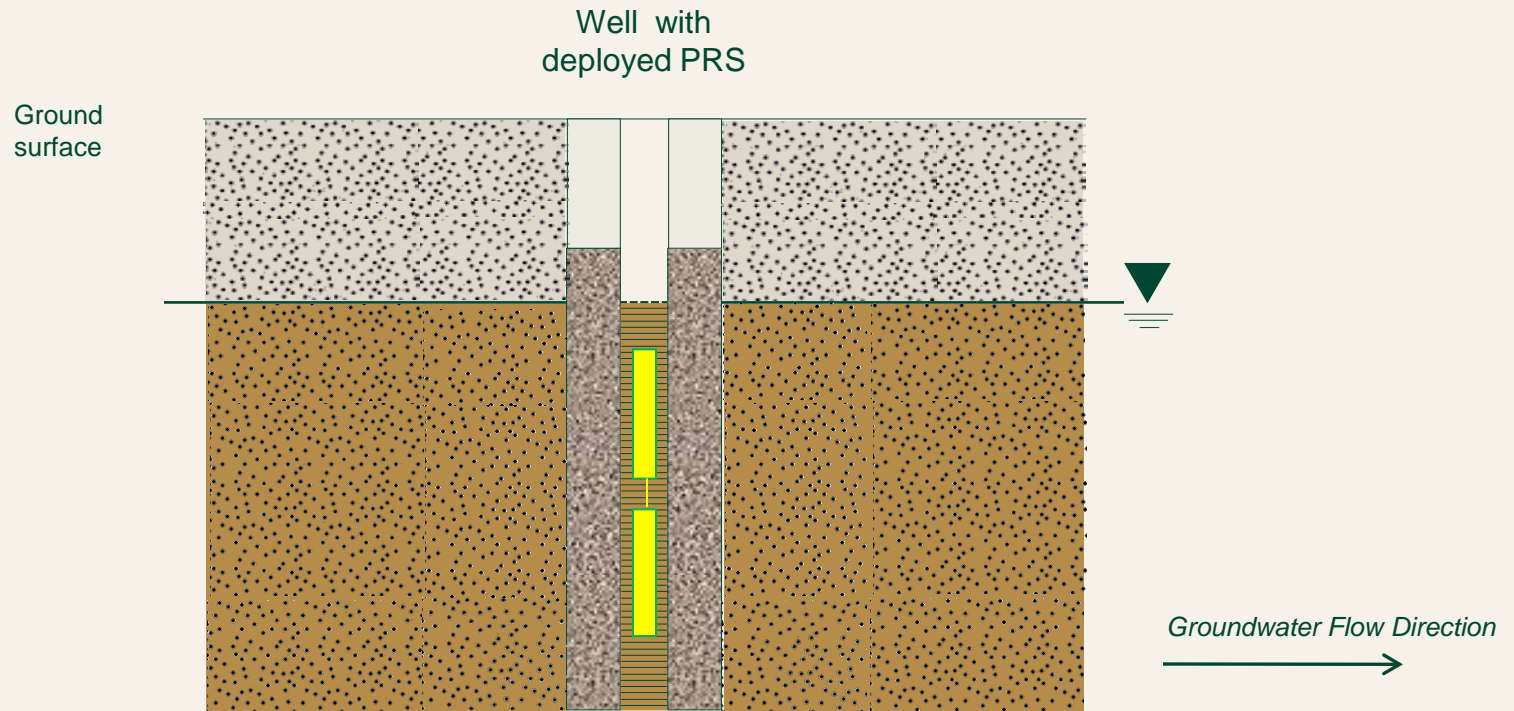


Pilot Study Methods

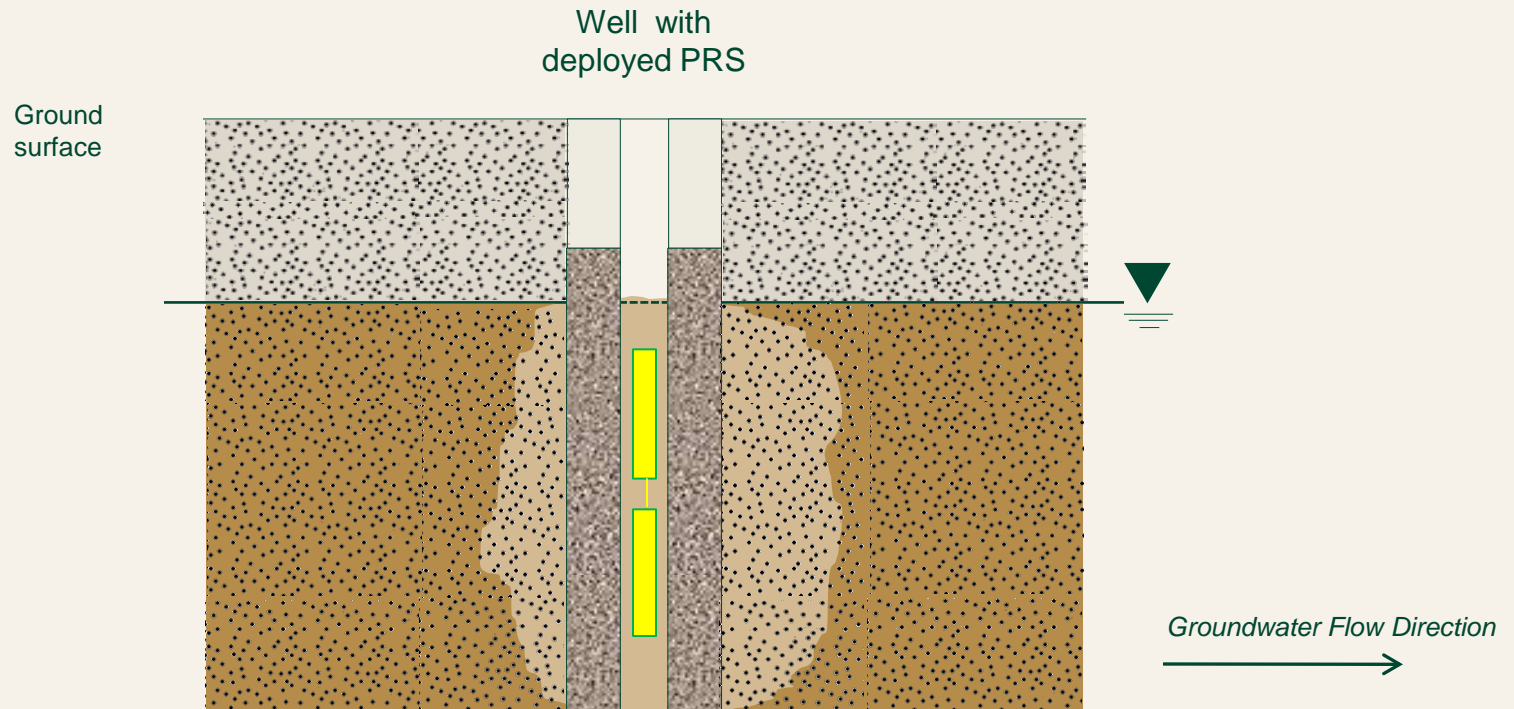
- PRSs with **ERD**_{ENHANCED}[™] (BioStryke Remediation Products, LLC)
 - Baseline no purge sampling
 - PRS deployment
 - No-purge perform. sampling
 - VOCs + MNA Indicators
 - CENSUS[®] Assay
- PRS deployment units replaced when depleted (every 6-8 weeks)
- Provides Go-No-Go Efficacy Evaluation
- Performed under actual site biogeochemical conditions



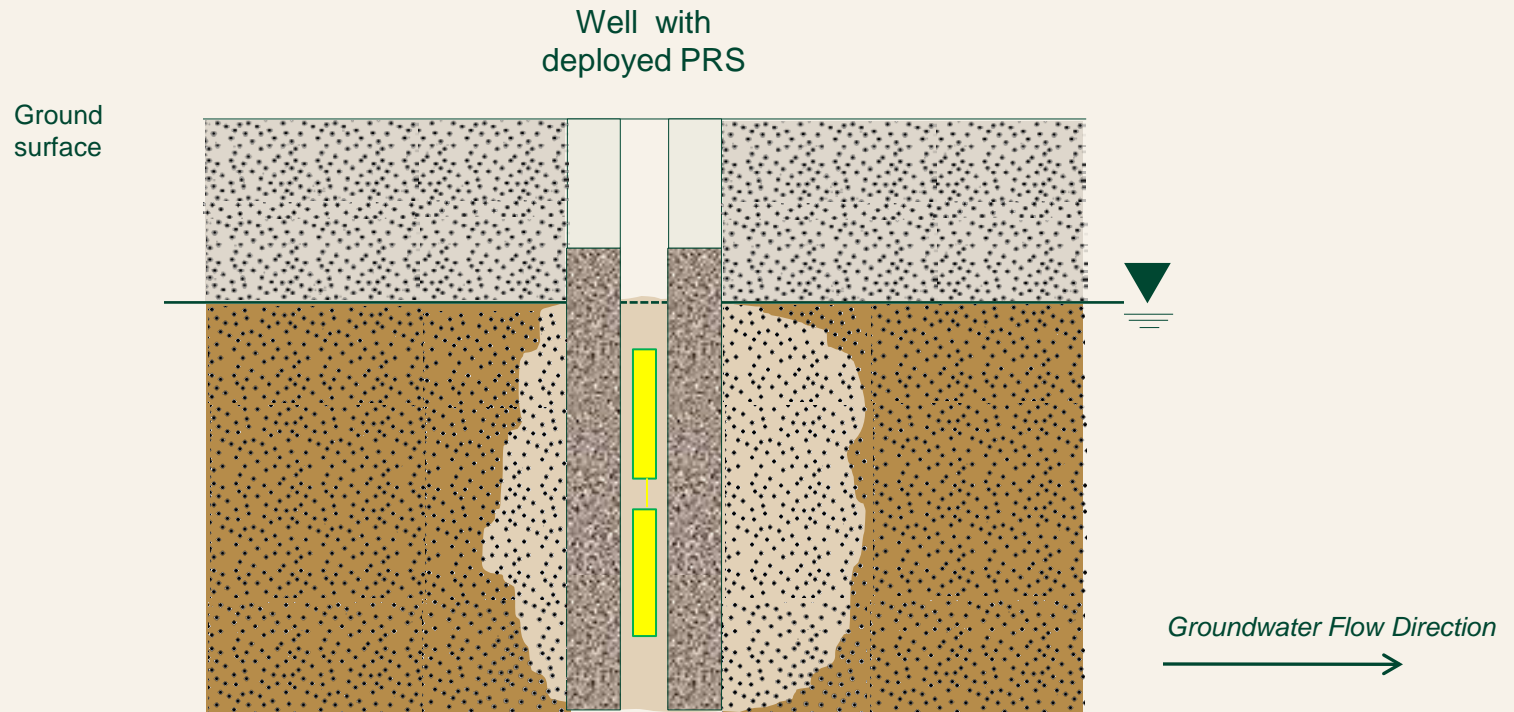
Graphical Representation, T_o



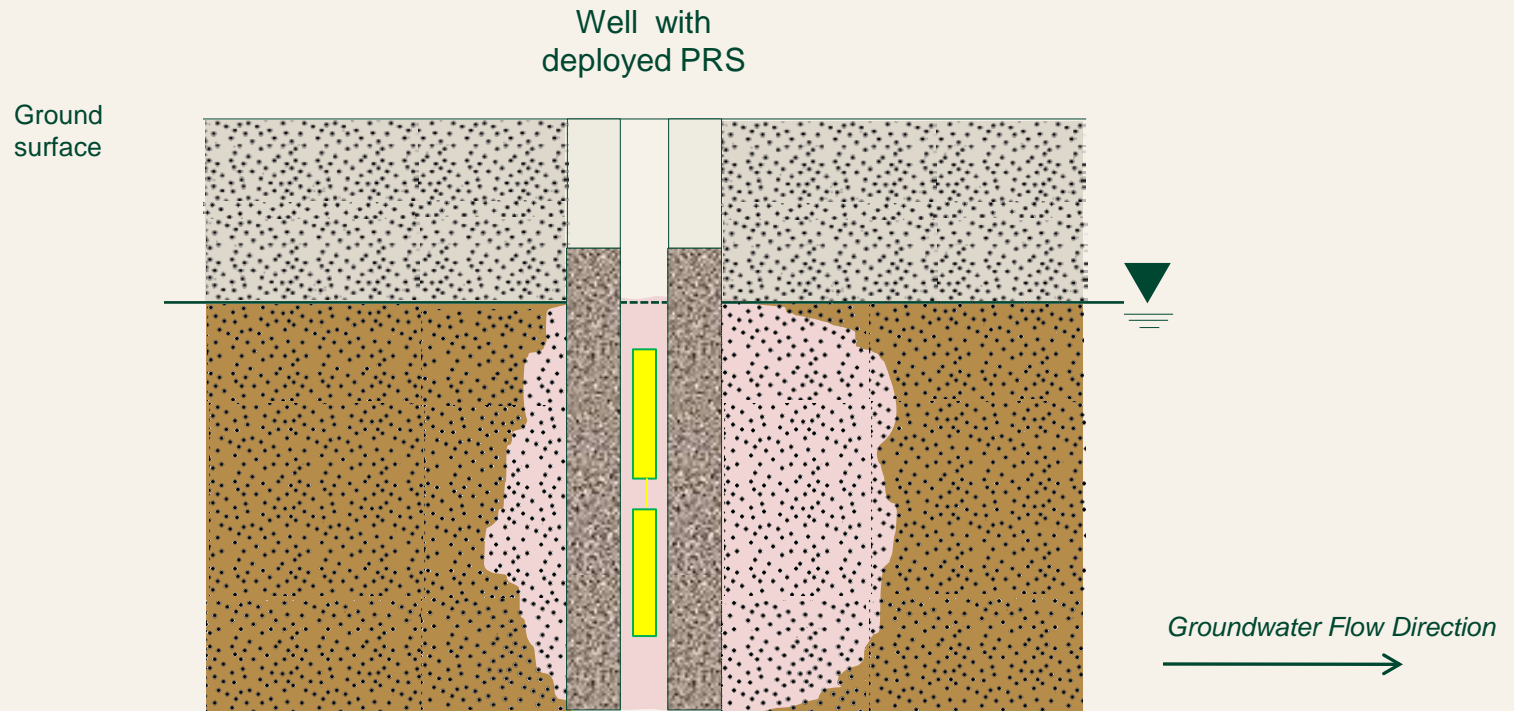
Graphical Representation, T_{o+1}



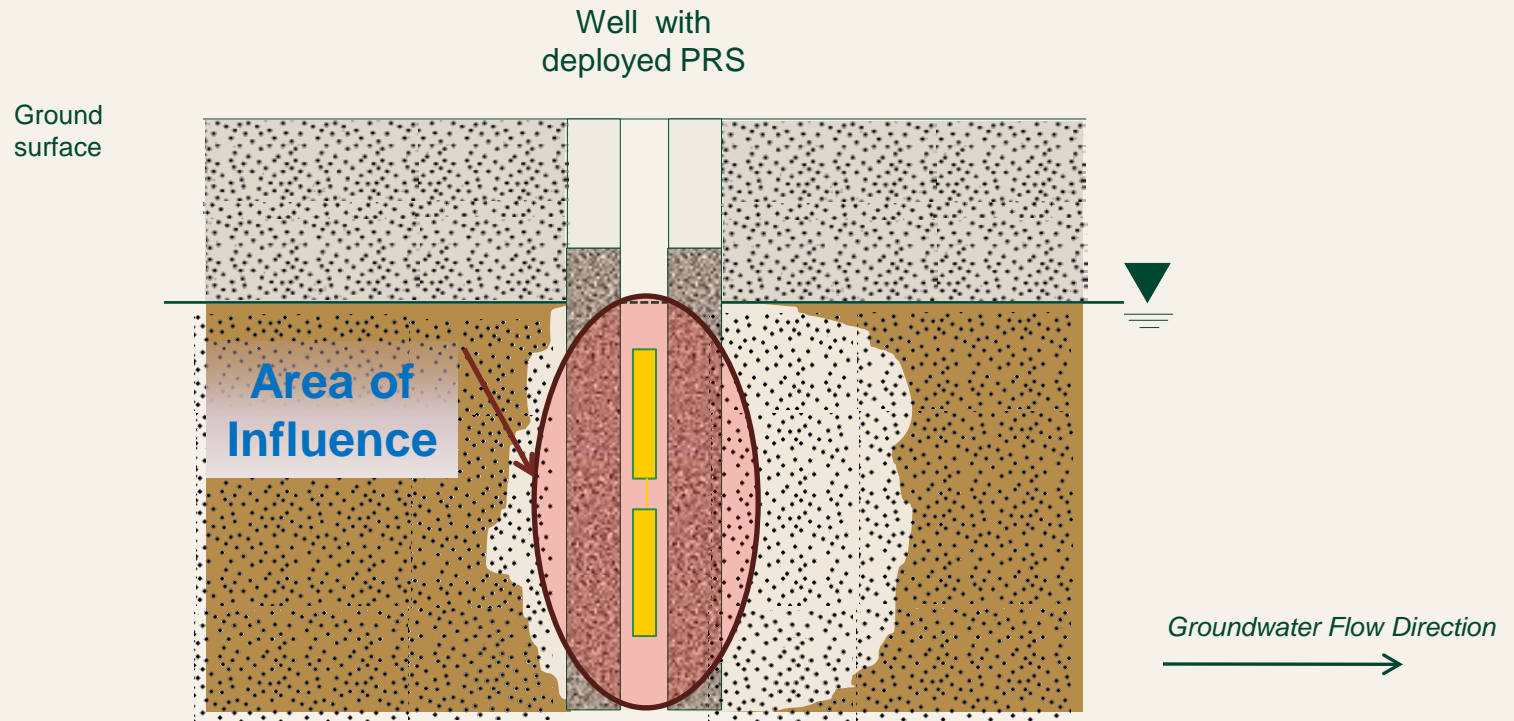
Graphical Representation, T_{o+2}



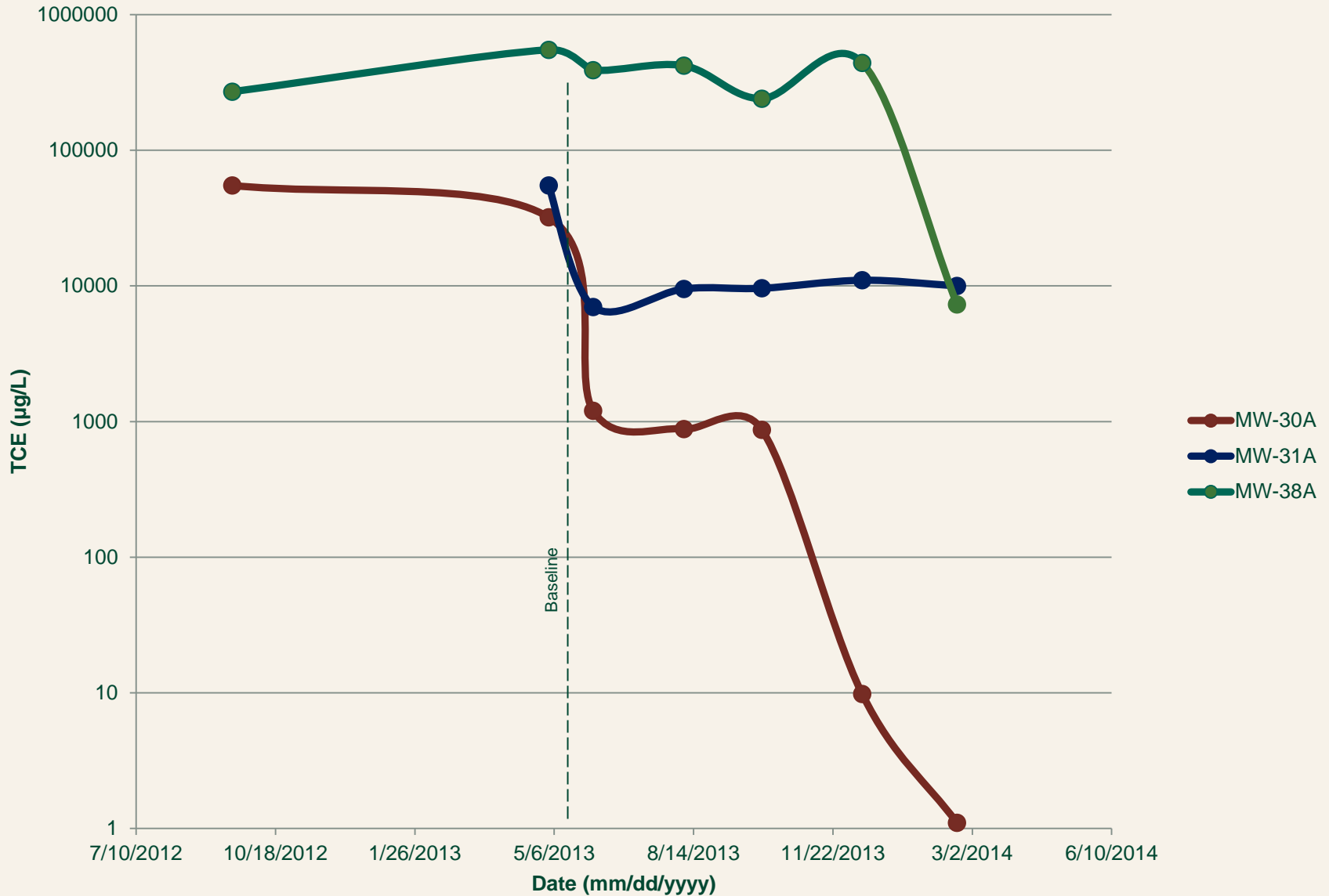
Graphical Representation, T_{o+3}



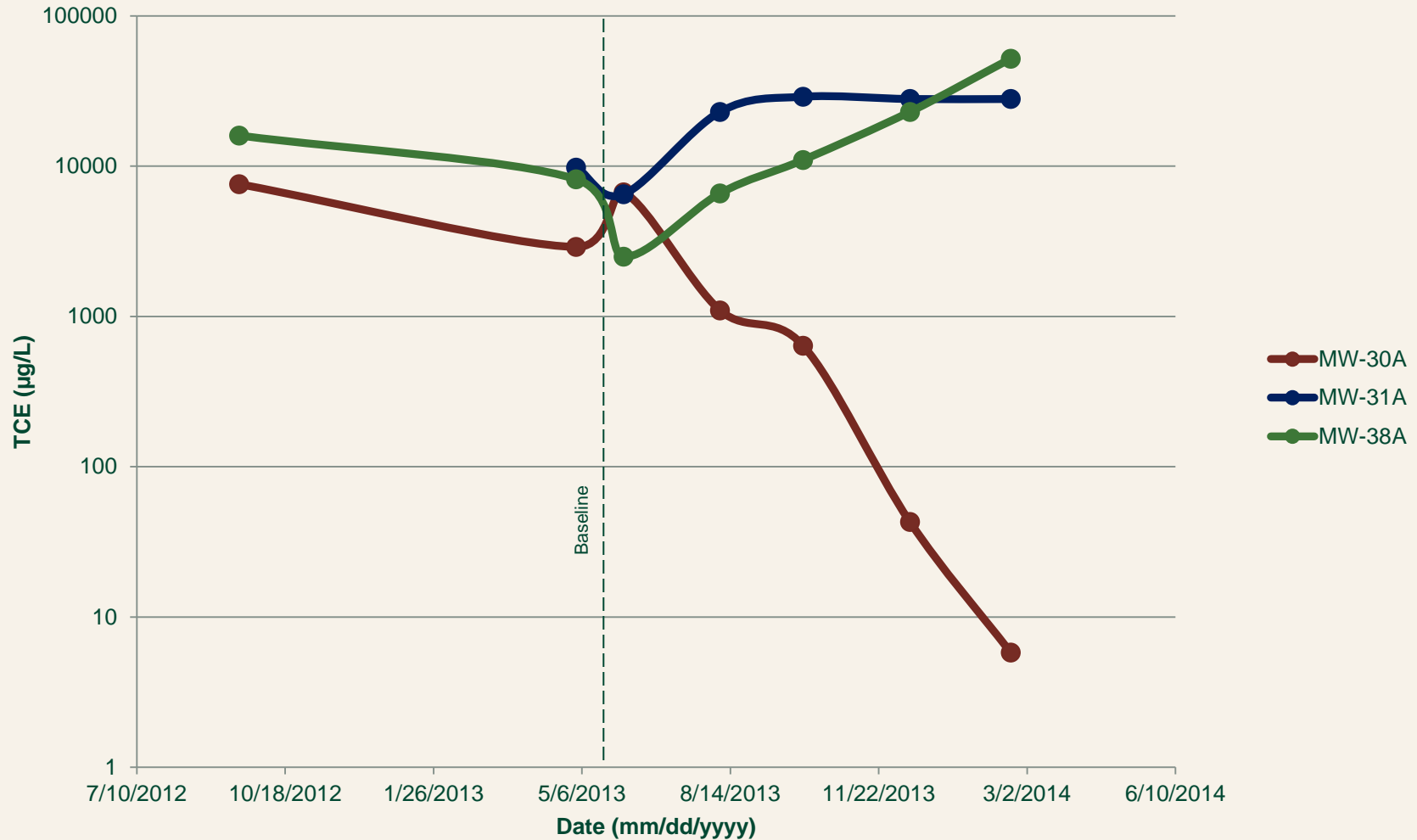
Graphical Representation, T_{o+4}



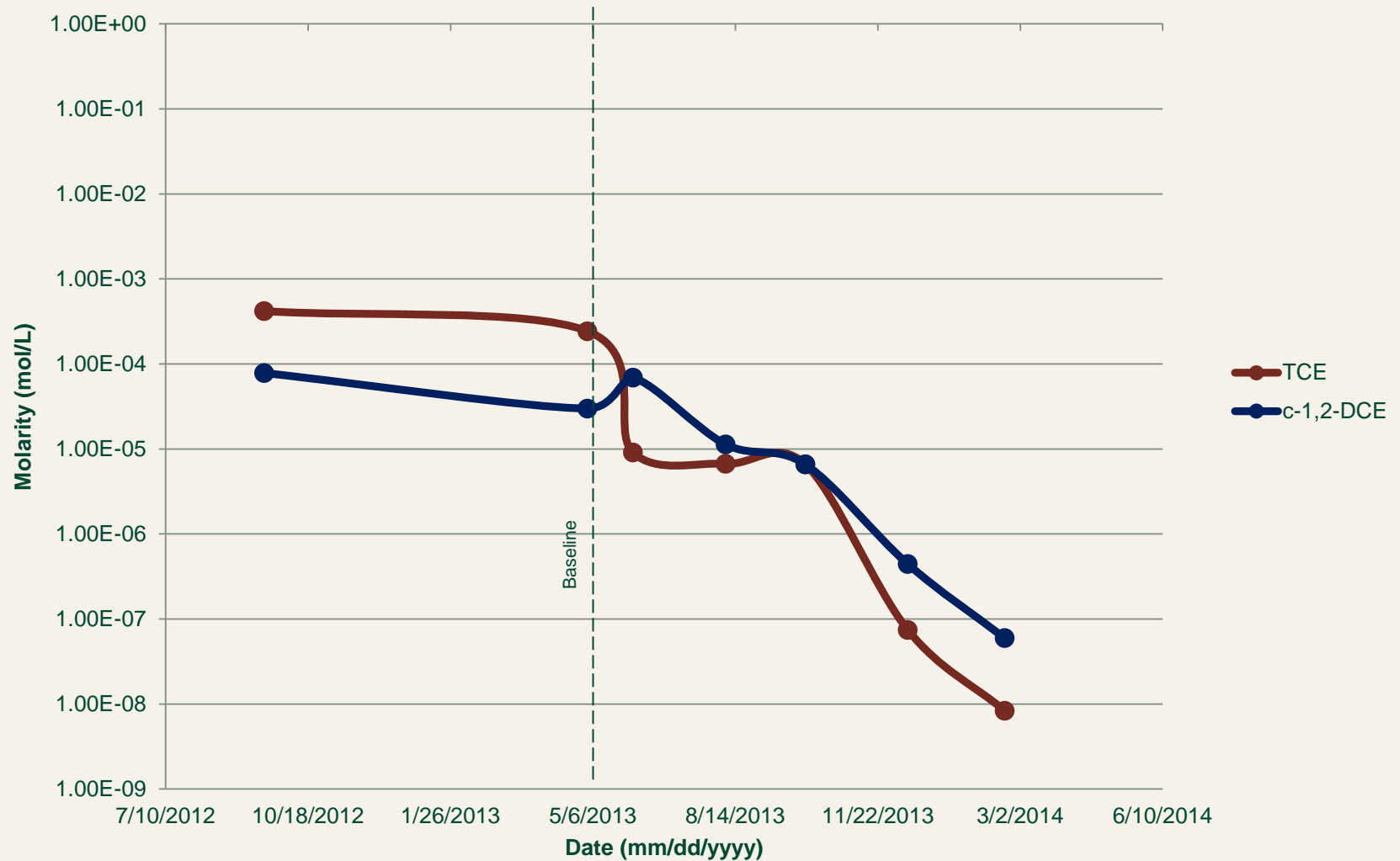
Results, TCE



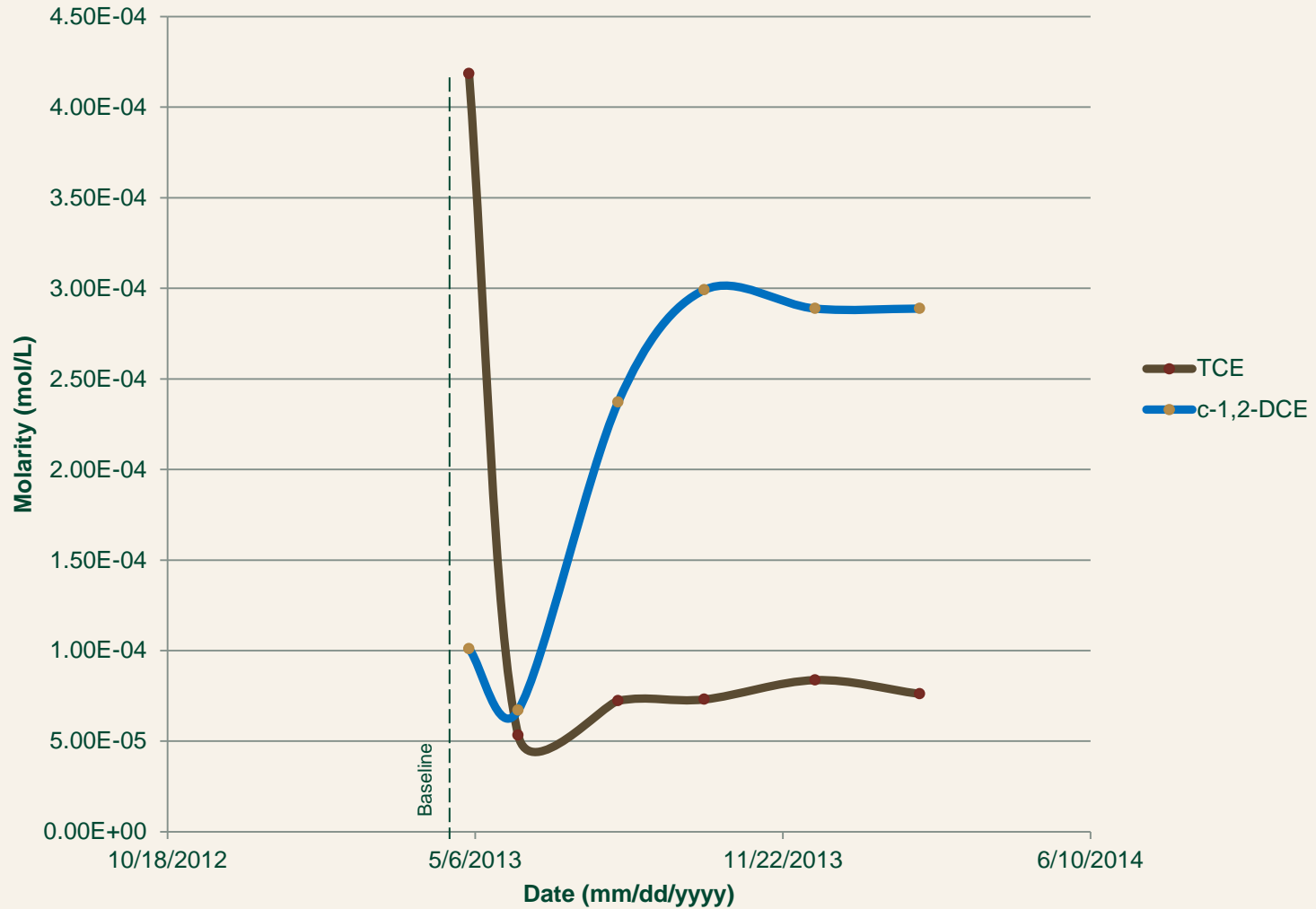
Results, c-1,2-DCE



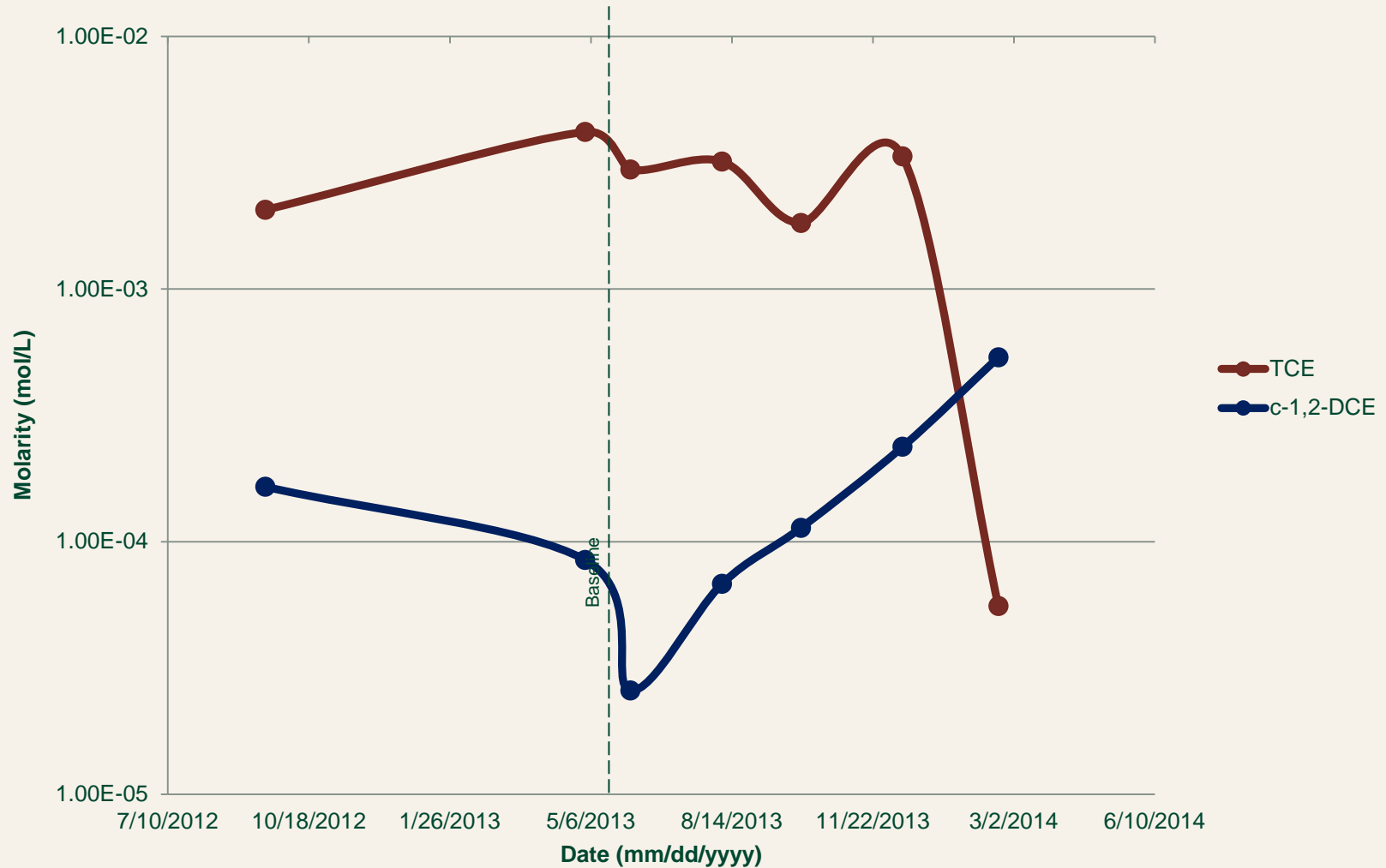
Results, MW-30A



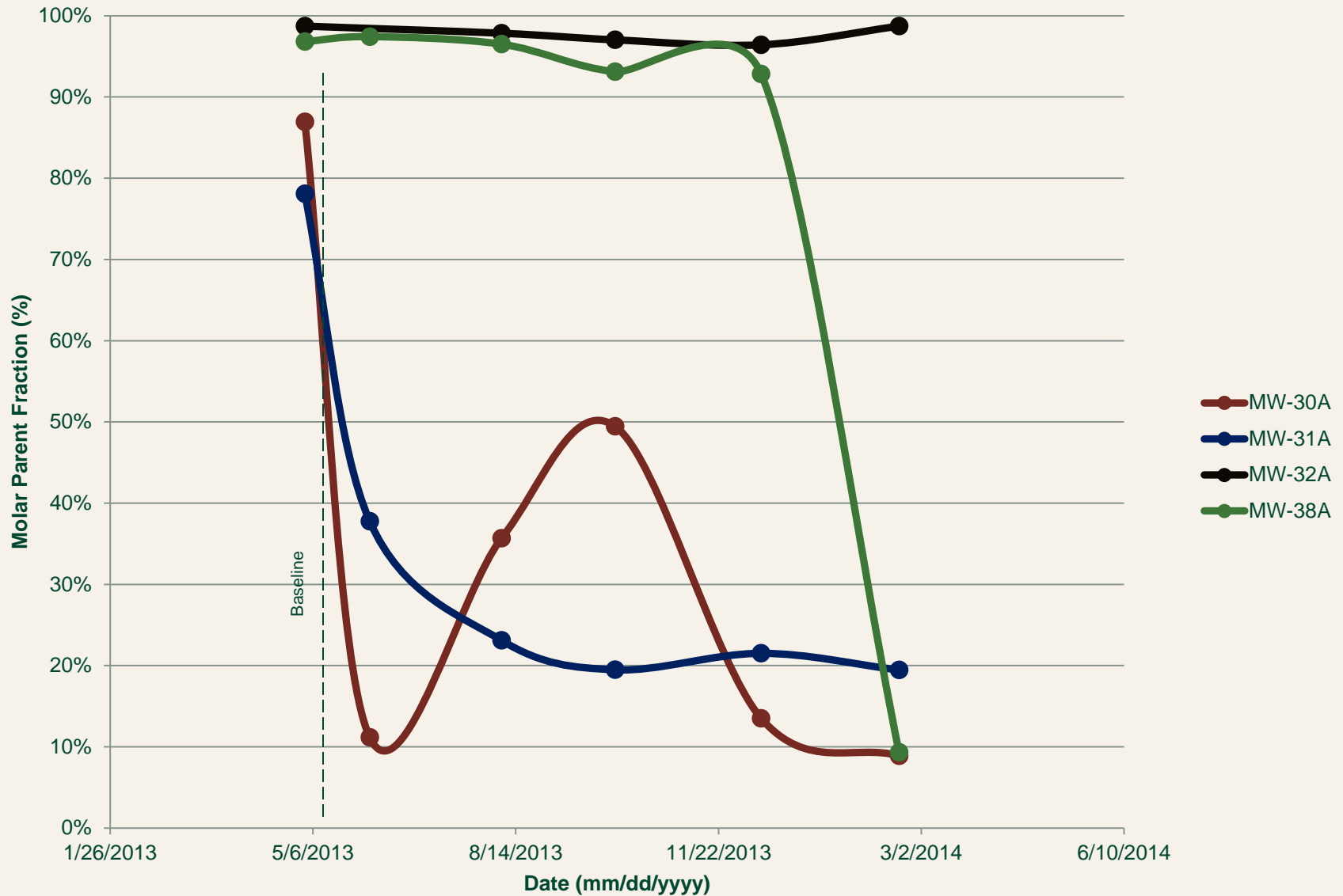
Results, MW-31A



Results, MW-38A



Results, Molar Parent Fraction



MNA Parameters:

- Up to 1,000X [diss Fe/Mn] increase
- General decrease in [sulfate]
- General decrease in ORP values
- General increase in [methane]
- Spiked increases in [TOC] following each PRS replacement-deployment event
- Elevated [Ethene] & [Ethane]

CENSUS® Assay:

- BioTraps® for each well amended with ERD^{ENHANCED}™ filled PRS deployment units
 - » Generally positive bio-indicator values
 - » tceA gene, bvcA gene, vcrA gene
- BioTrap® for background well non-detect for same parameters.

CONCLUSIONS

- ❑ Baseline [TCE] 55-550 mg/L
- ❑ 80-99.9%REDUCTION in [TCE] over ~1 year
- ❑ MNA indicator signatures consistent with reductive dechlorination
- ❑ Positive change in microbial community and treatment zone geochemistry to favor dechlorinators
- ❑ Evidence of both biotic and abiotic dechlorination

I. Richard Schaffner, Jr.
Senior Consultant / Hydrogeologist

Office 856-656-2887 | Mobile 603-703-3887
rschaffner@pennoni.com

Kent C. Armstrong
BioStryke[®] Remediation Products, LLC
karmstrong@biostryke.net