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Sorption-Supported Biological Dechlorination: Laboratory and Field Lines of Evidence

Paul Erickson, Kristen Thoreson, Sophia Nguyen, John Freim (REGENESIS), Joel Parker (Hamp, Mathews & Associates)

Overview

- Enhanced Reductive Dechlorination
- Coupling ERD With CAC
- Lab Study
- Field Demonstration
- Conclusions

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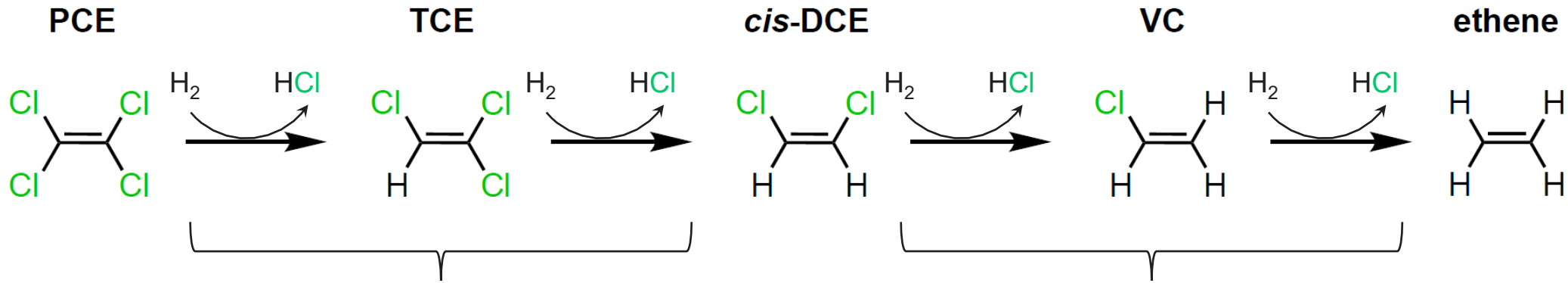
Enhanced Reductive Dechlorination (ERD)

Bioremediation of halogenated contaminants

- Select microbes facilitate CVOC dechlorination
- Require H_2, produced by fermenters



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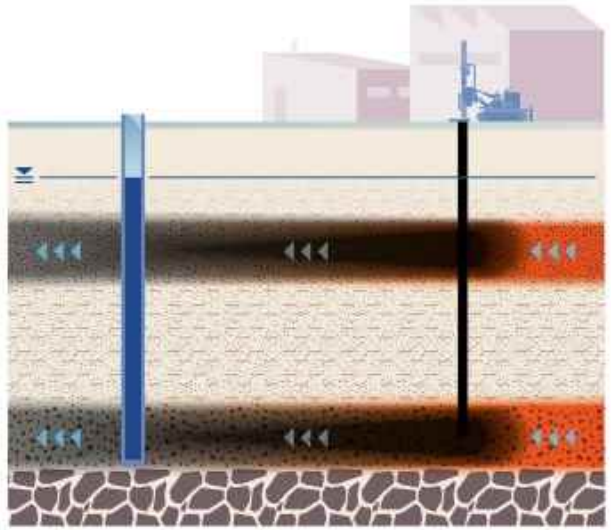
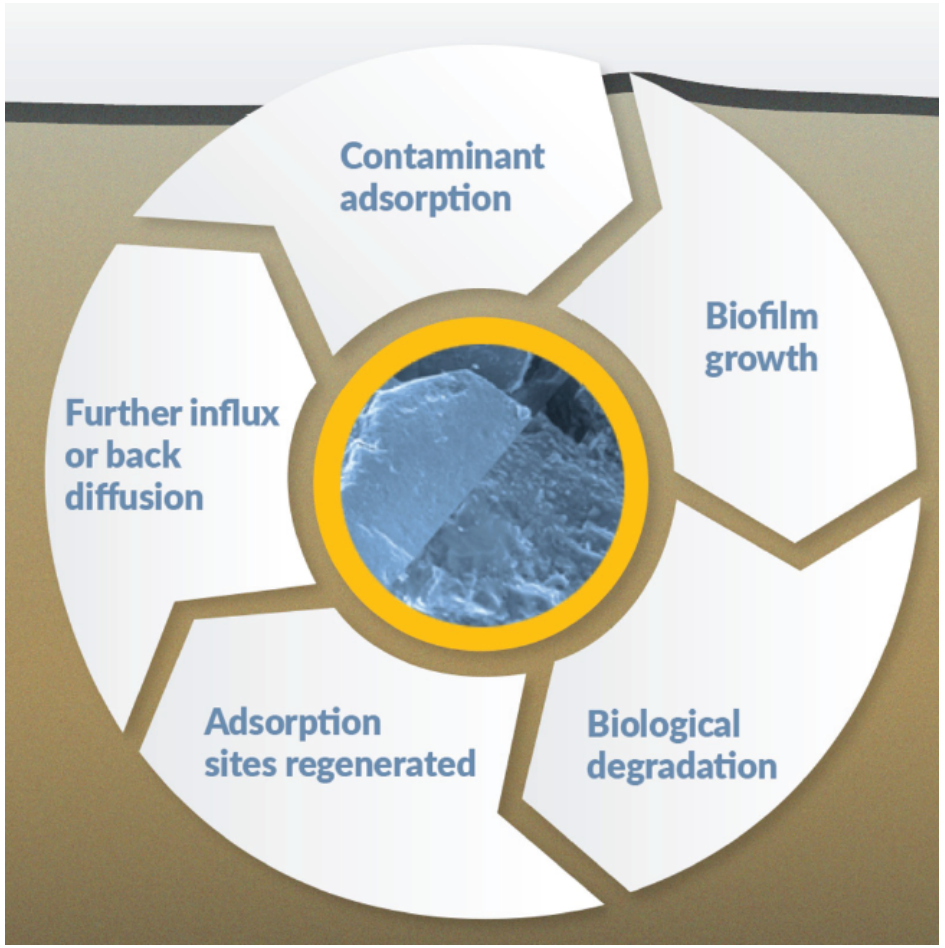
ERD + Colloidal Activated Carbon (CAC)

- Rapid sorption, immediate reduction in concentrations, mass flux
- Minimal flux of CVOC daughters
- Allows for biodegradation within smaller footprint

- **Long-term CVOC treatment through <u>biotic</u> and abiotic degradation pathways**





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Lab Study: Experimental Design

1. Forward diffusion to saturate low k zones with TCE:
   a. TCE saturated water flowed through tanks (~30 days) until $TCE_{out} = TCE_{in}$
2. Back diffusion:
   a. Influent switched to clean water until effluent TCE <5 mg/L
3. Inject remediation amendments

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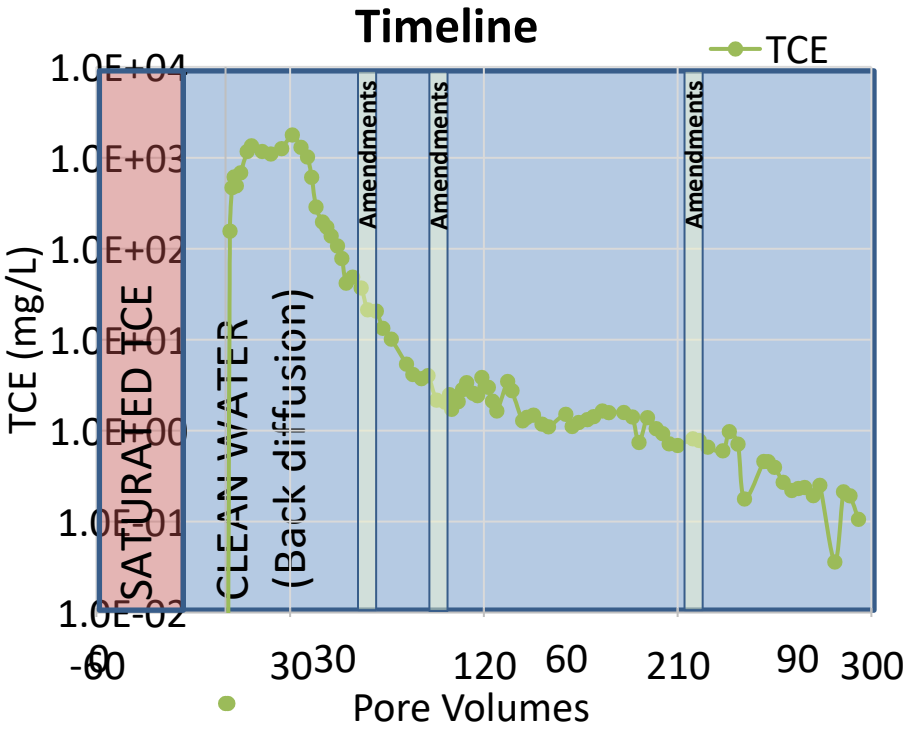

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Analyses

Control Tank

Effluent

FLOW

Influent

CAC Tank

- Effluent samples collected throughout experiment for VOCs
- **qPCR analysis** of water and soil upon completion of experiment

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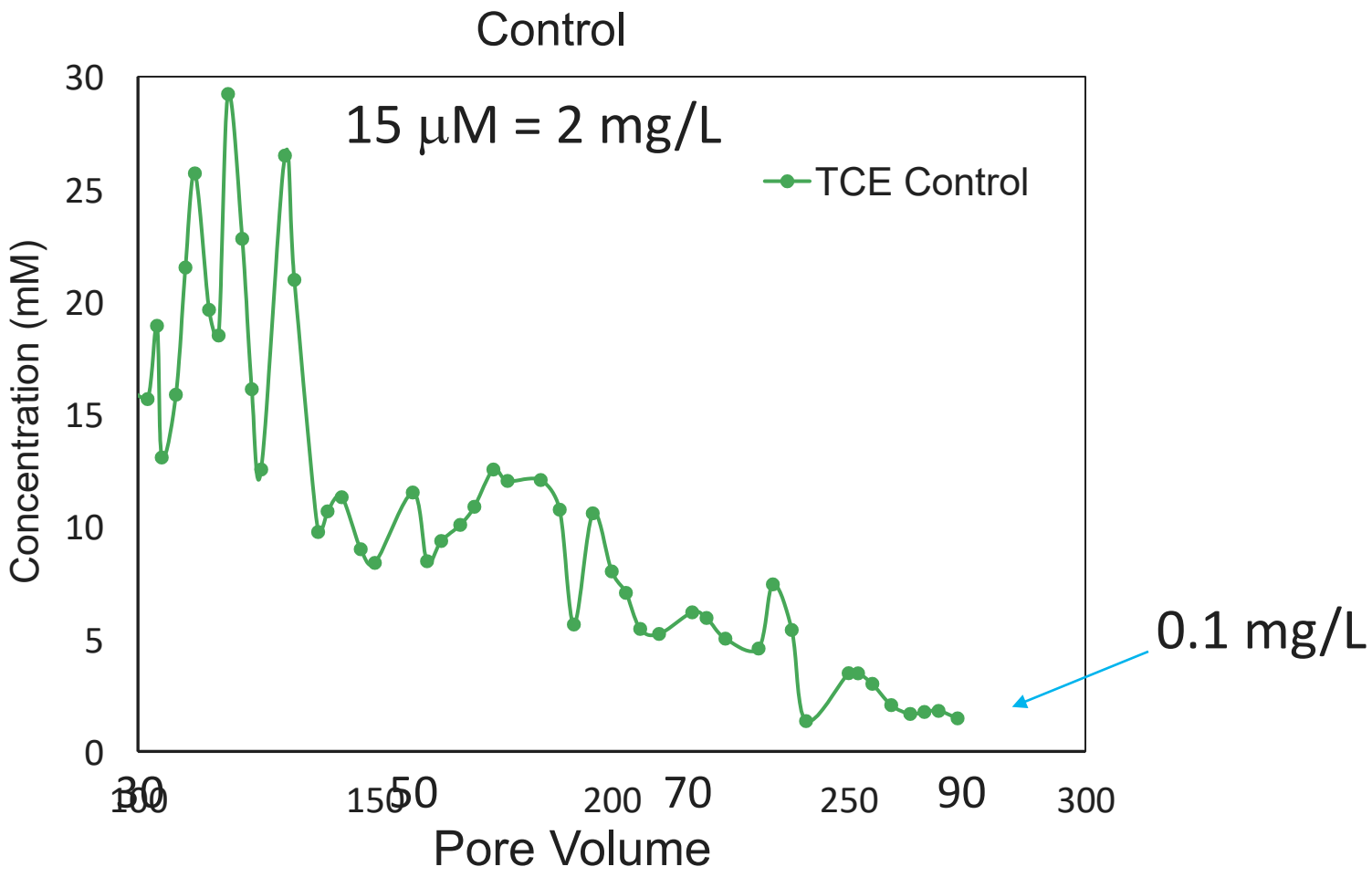
Tank Study: Effluent Results



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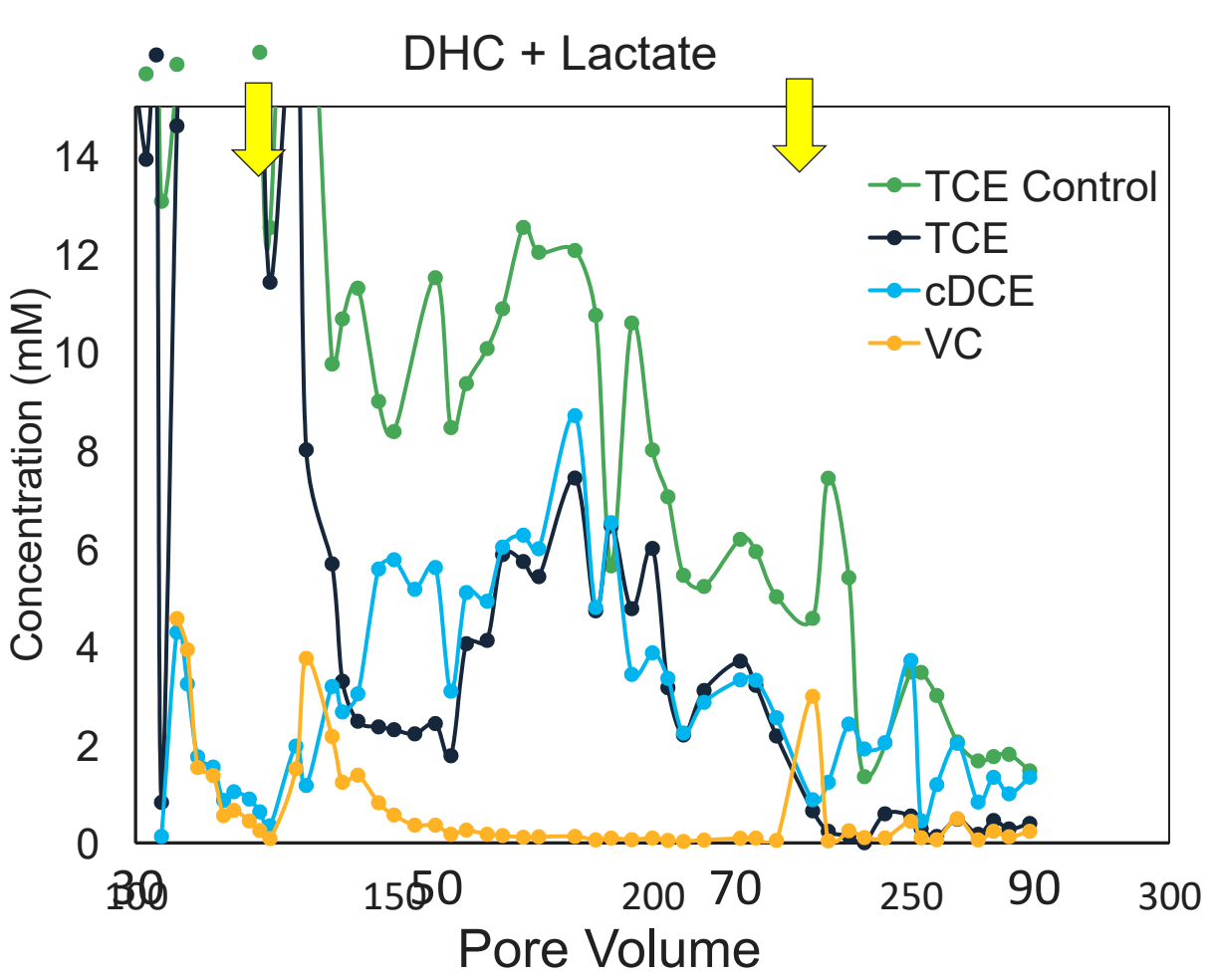
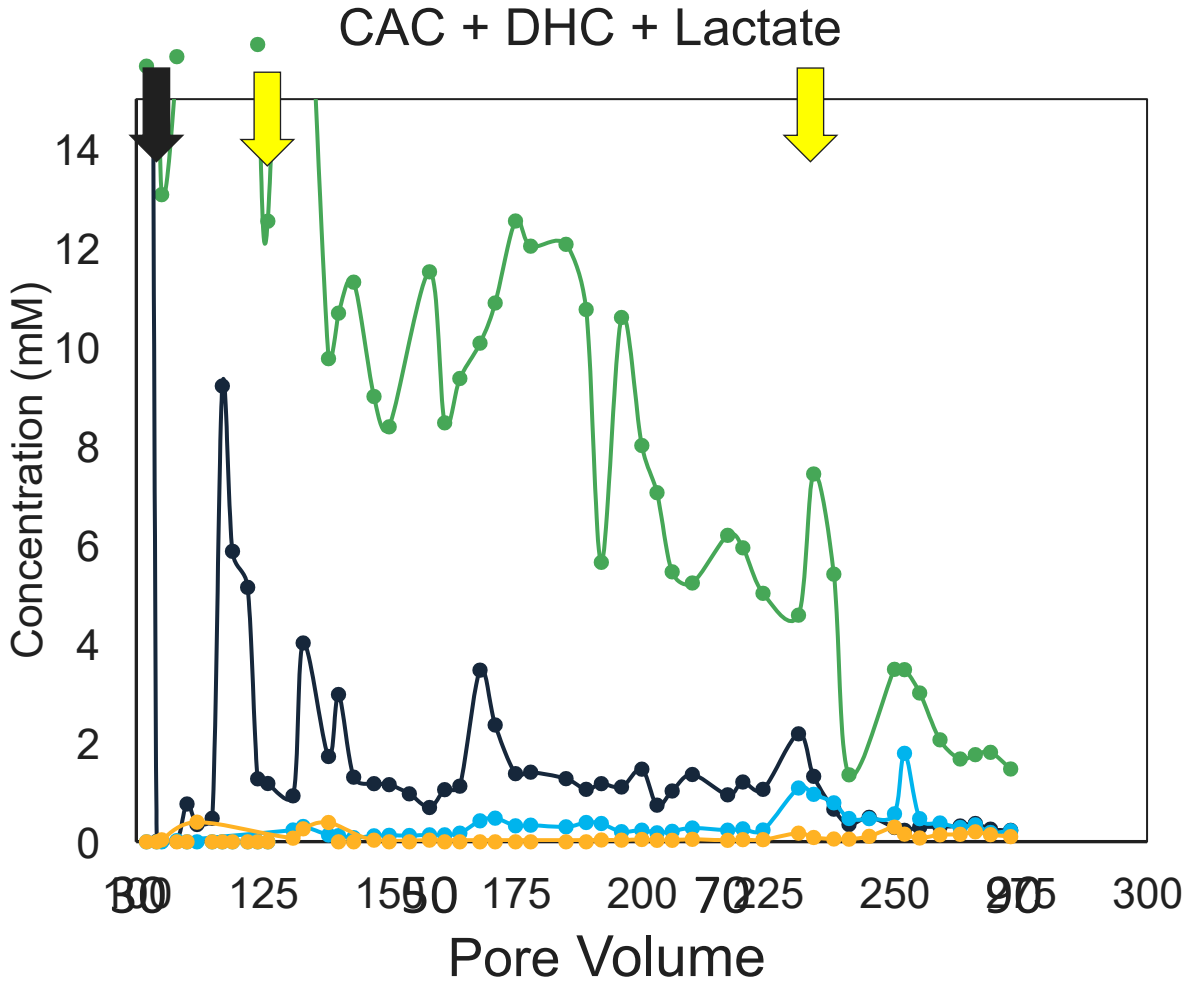
Tank Study: Effluent Results





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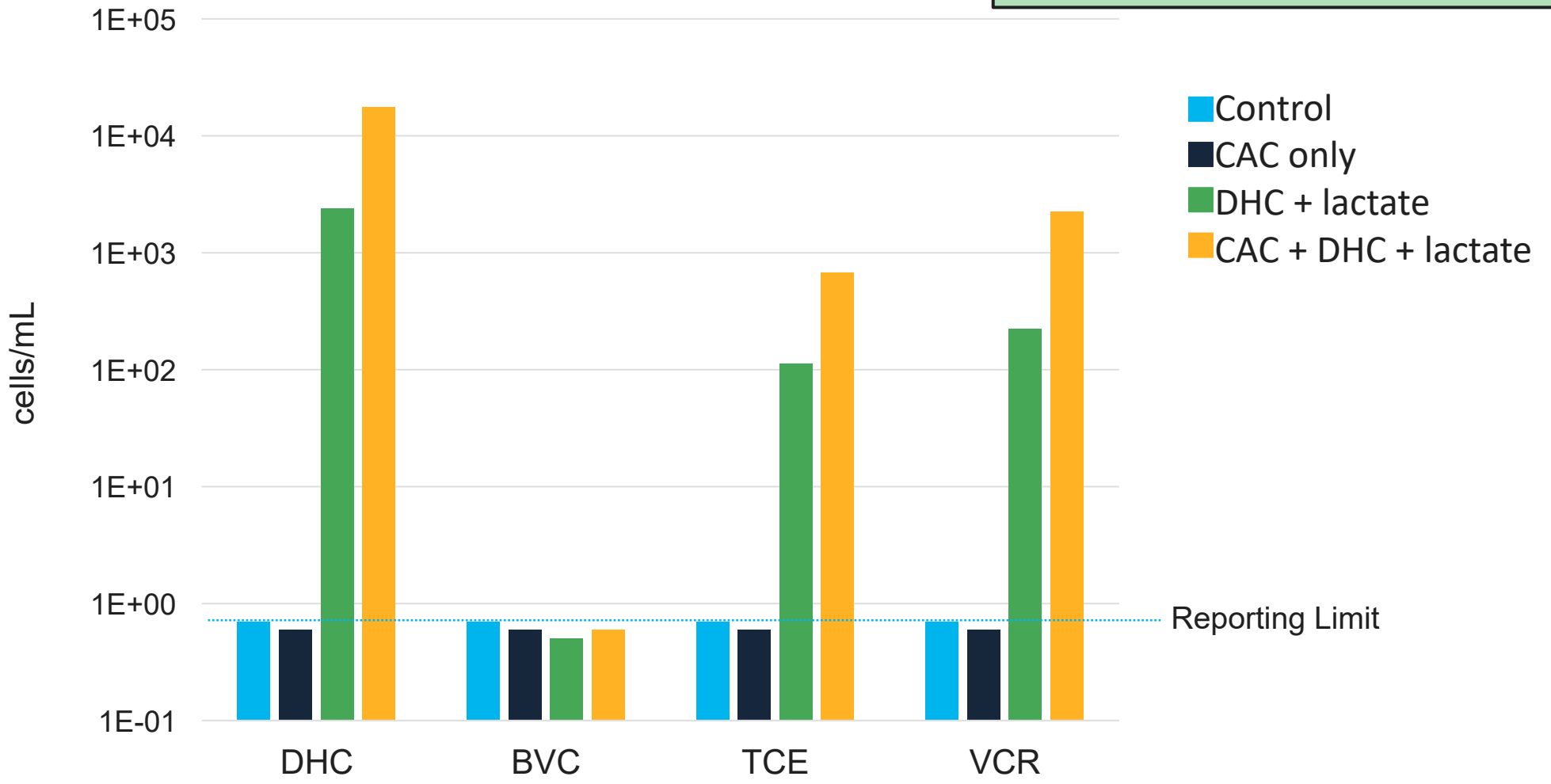
qPCR Data: Water

Enhanced DHC + functional gene populations measured in CAC + ERD tank.



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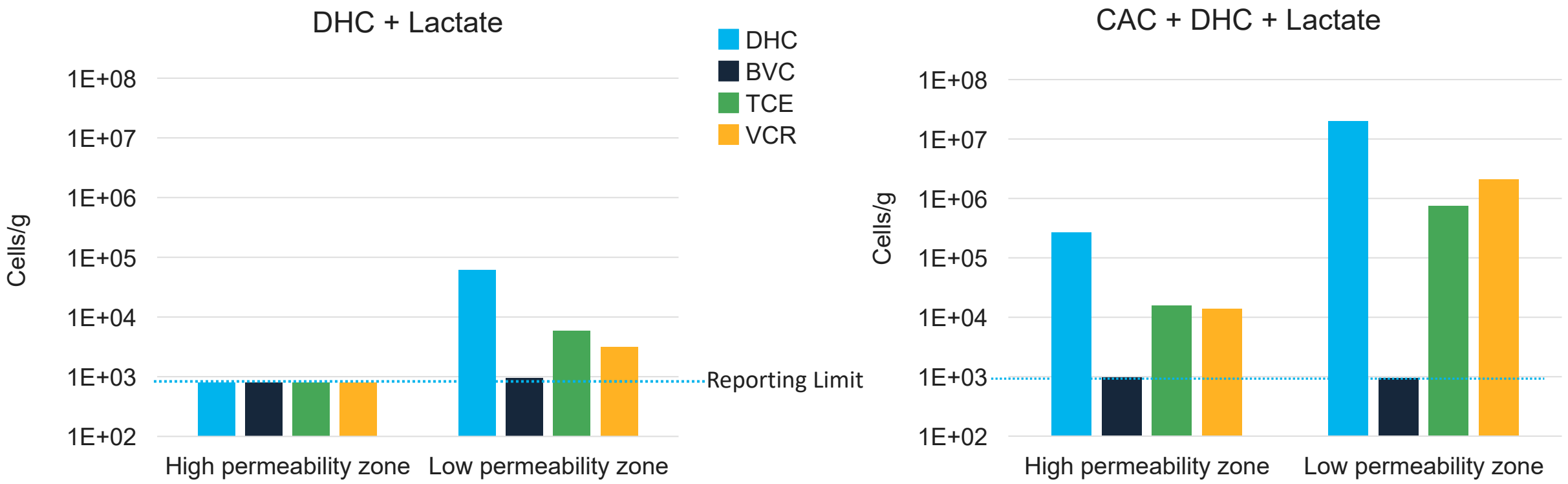
qPCR Data: Soil



Over 2 orders of magnitude DHC population increases in presence of CAC

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CAC+ Solid Donor Field Site

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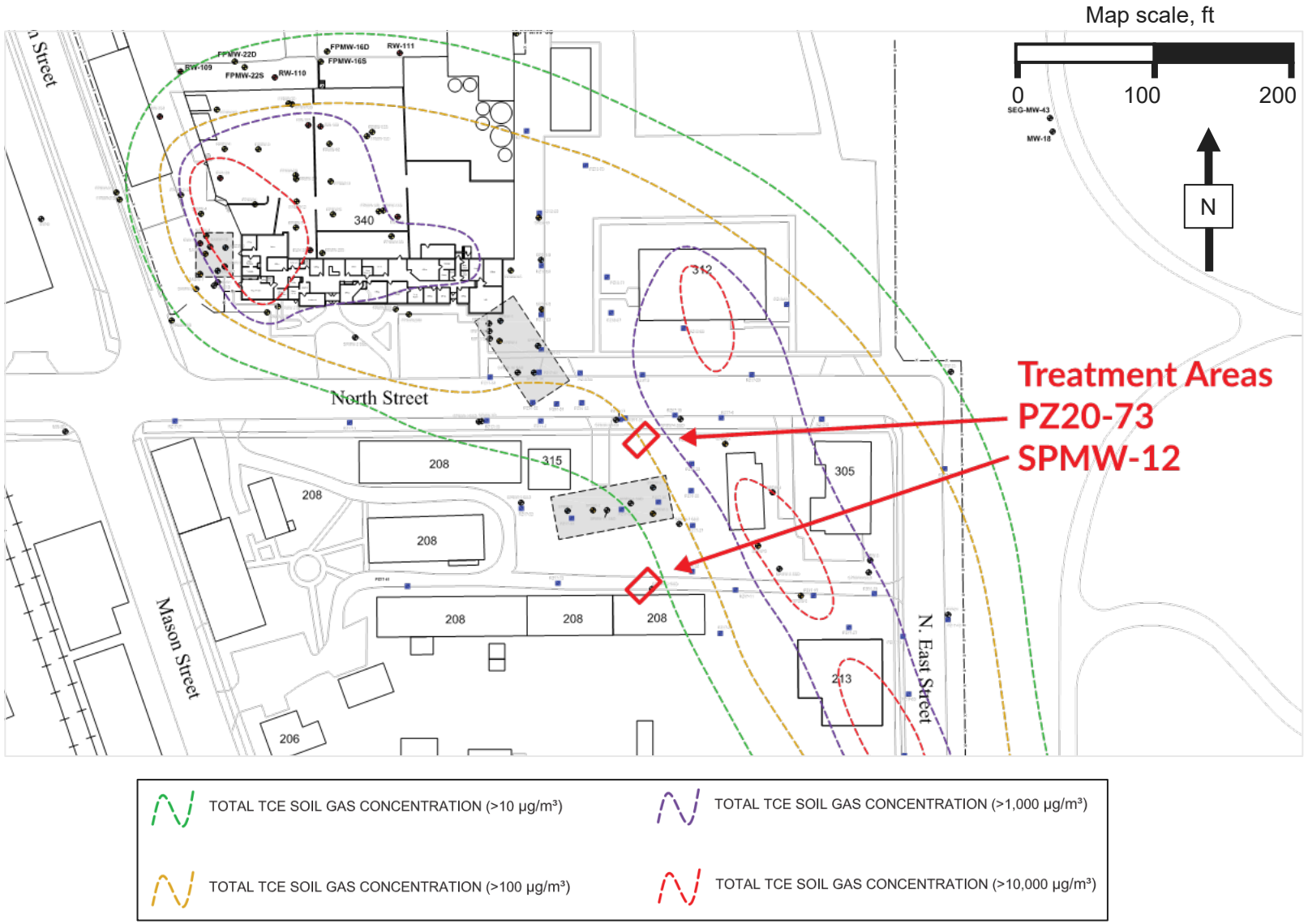
Case Study
Site Overview

- Site in Michigan
- Large Plume
  - High mg/L CVOC, 1,1,1-TCA and 1,1-DCE
- Comingled plume with LNAPL in some locations



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Bioremediation Amendment Candidates

Comparing Hydrogen Sources

Donor Type	Examples	Application Method	Distribution	Persistence	Compatible with Activated Carbon
Soluble	Lactate, Molasses	Low Pressure	Excellent	Poor	Yes
Emulsion	EVO, 3DME	Low Pressure	Excellent	Moderate to Good	No
Solids	Cellulose, Chitin	High Pressure	Poor	Excellent	Yes
Colloidal Solid	AquiFIX Long-Lasting Colloidal Electron Donor	Low Pressure	Excellent	Excellent	Yes

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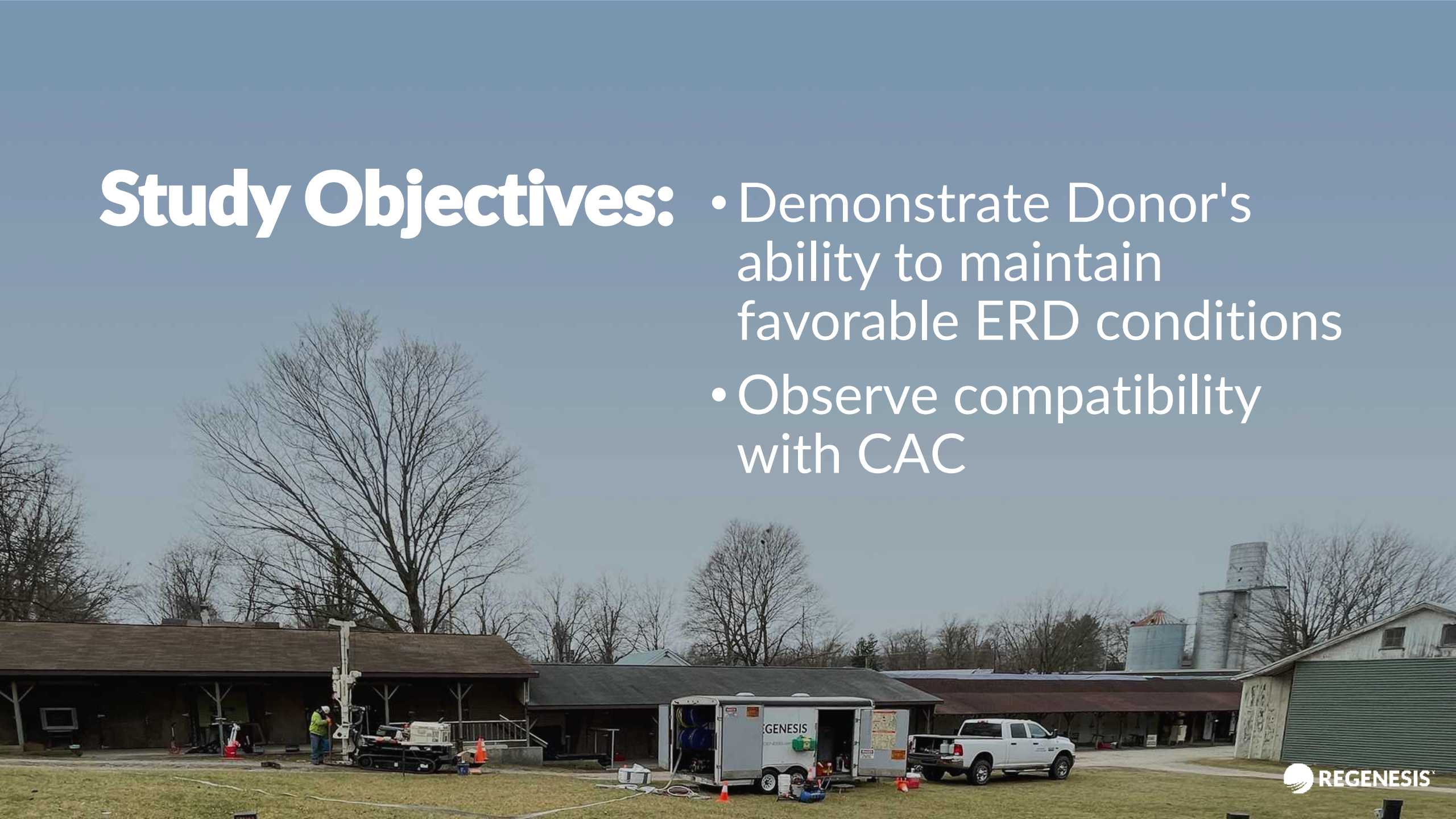
Study Objectives:

- Demonstrate Donor's ability to maintain favorable ERD conditions
- Observe compatibility with CAC



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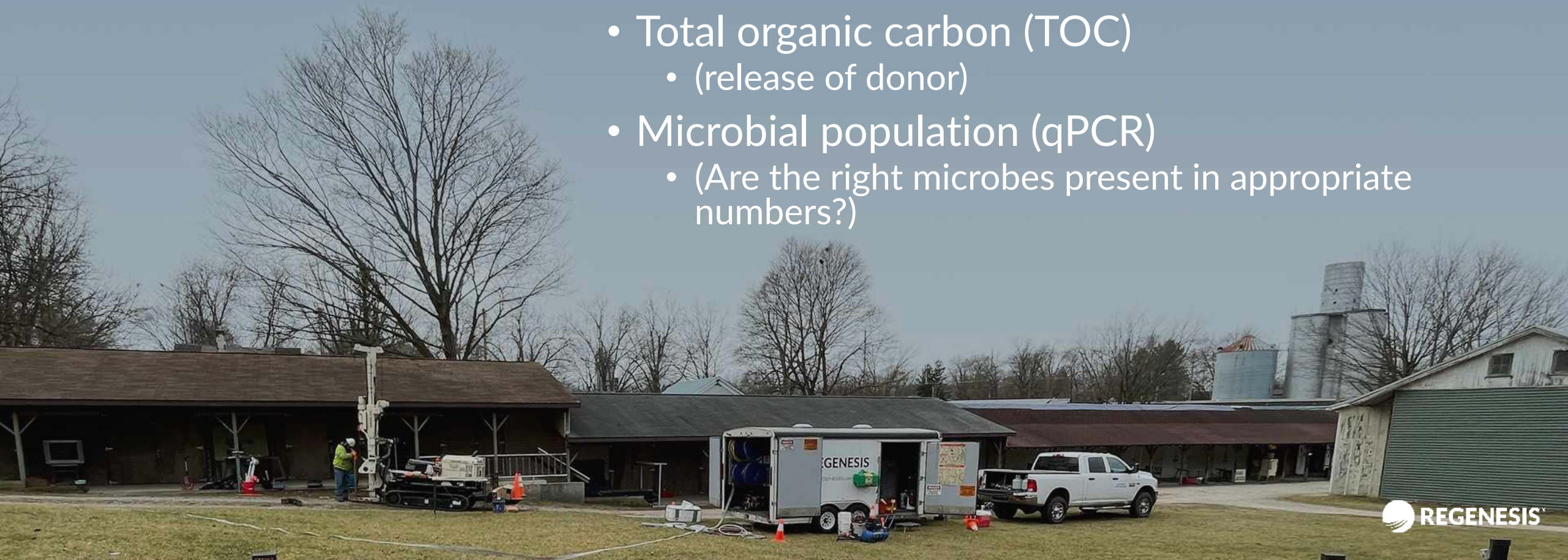
Evaluation:

- CVOCs (performance)
- Dissolved gases, including methane and ethene
  - (complete mineralization, bio)
- Total organic carbon (TOC)
  - (release of donor)
- Microbial population (qPCR)
  - (Are the right microbes present in appropriate numbers?)



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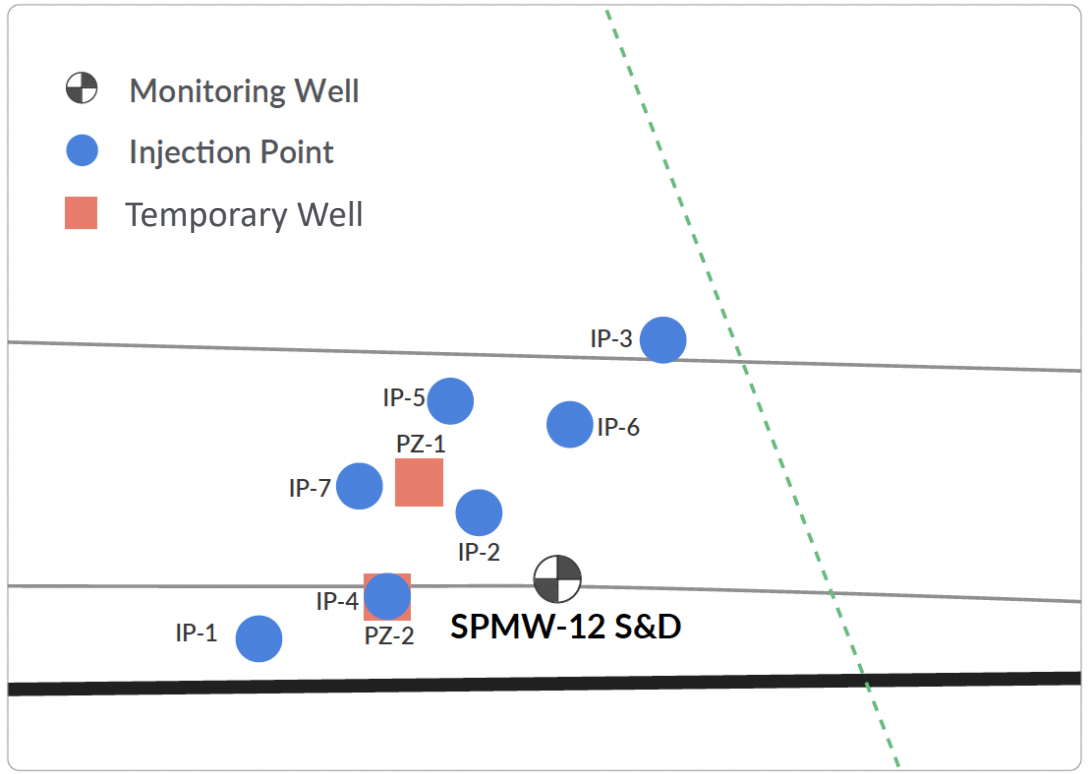
Application Details
SPMW-12

AquiFIX™ Long-Lasting Colloidal Electron Donor

BDI PLUS BIO-DECHLOR INOCULUM

PRB Length	20 feet
Injection Interval	17.5 – 27.5 feet bgs
Amendments	
AquiFix	2,000 lbs
BDI	9 liters
Total Mix Volume Applied	1,475 Gallons



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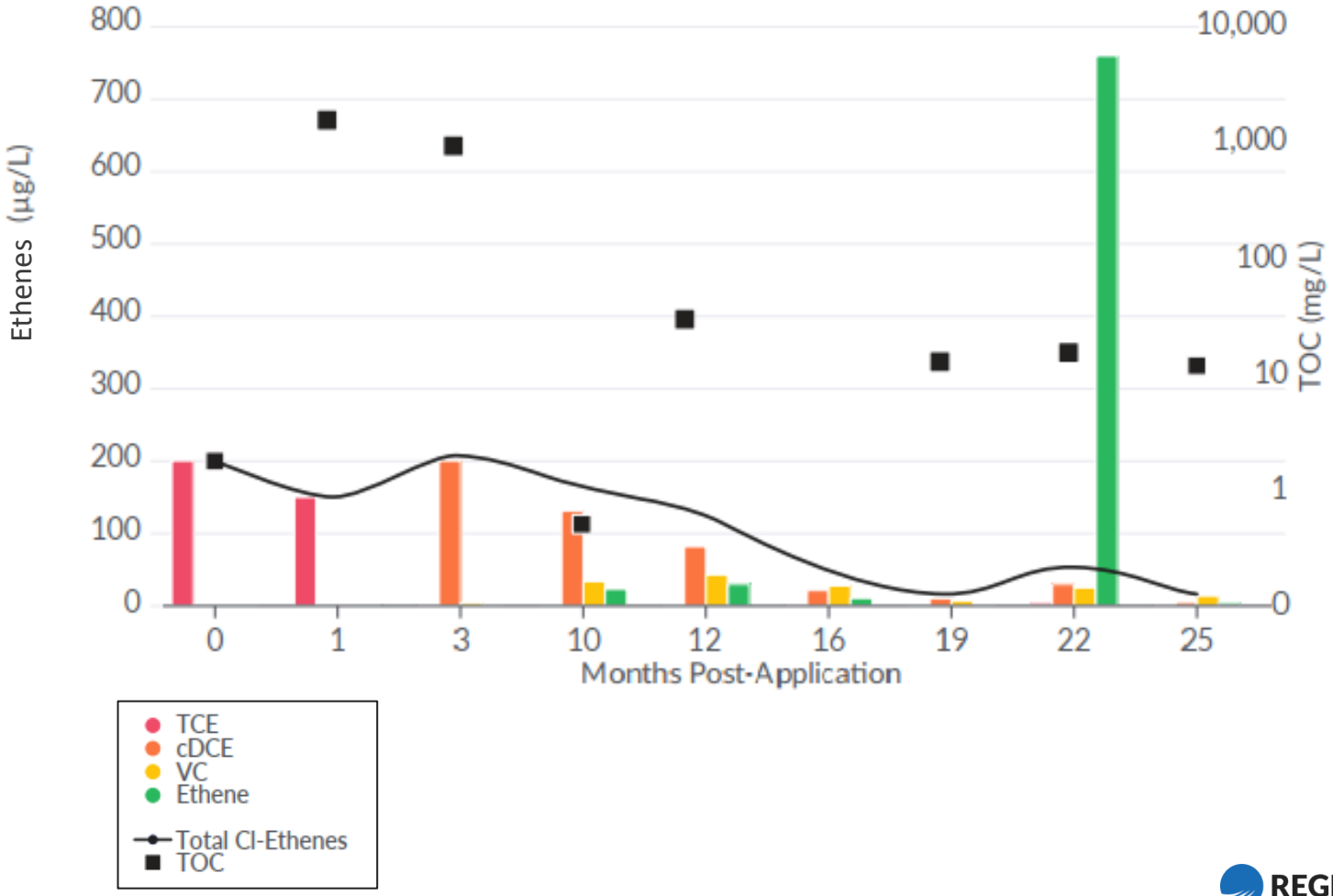
Results

SPMW-12 (Donor and Bioaugmentation)

- TCE transformed after 3 months
- Over 90% CVOC removal after 2 years, steady TOC
- Vinyl chloride reductase (VCR), DHC look strong



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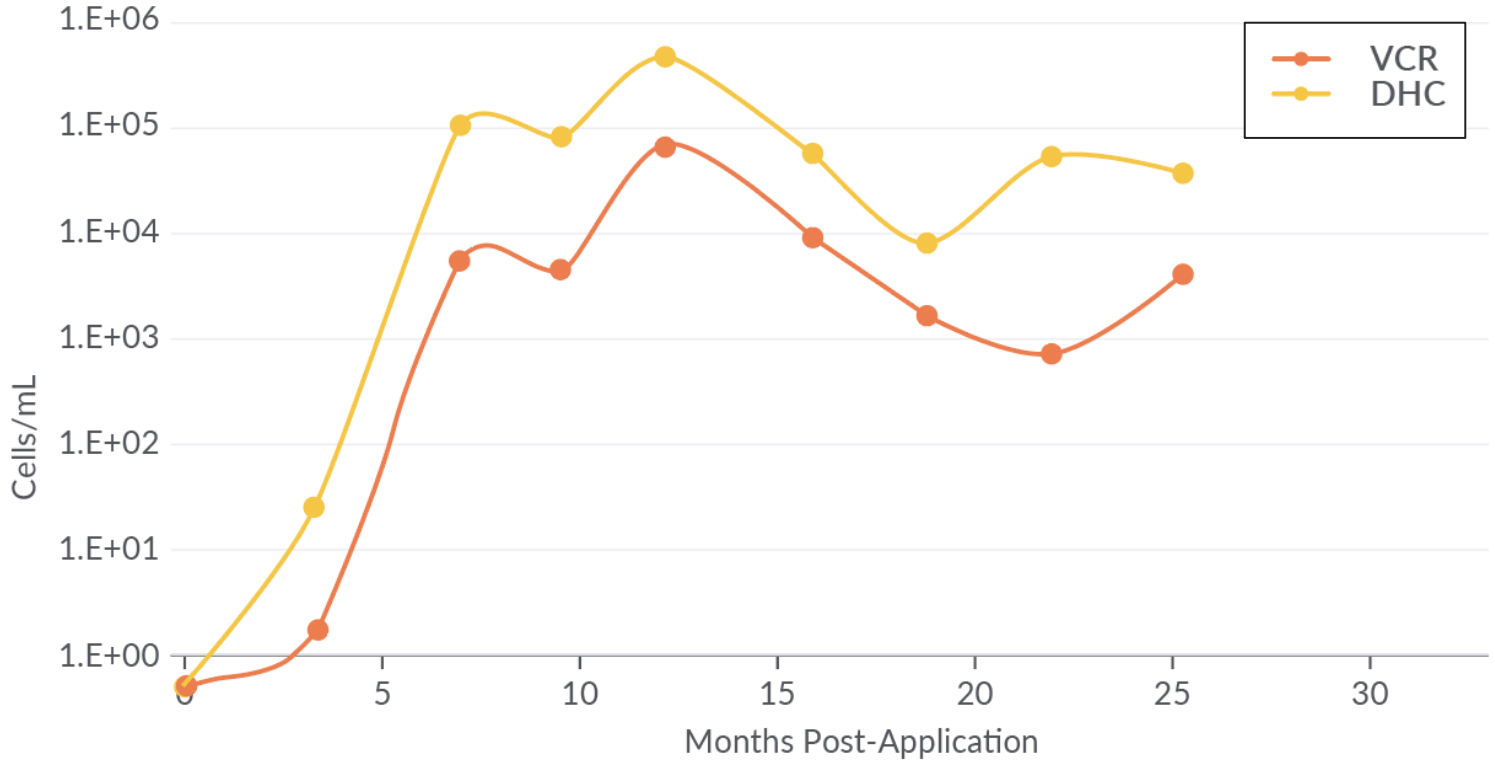

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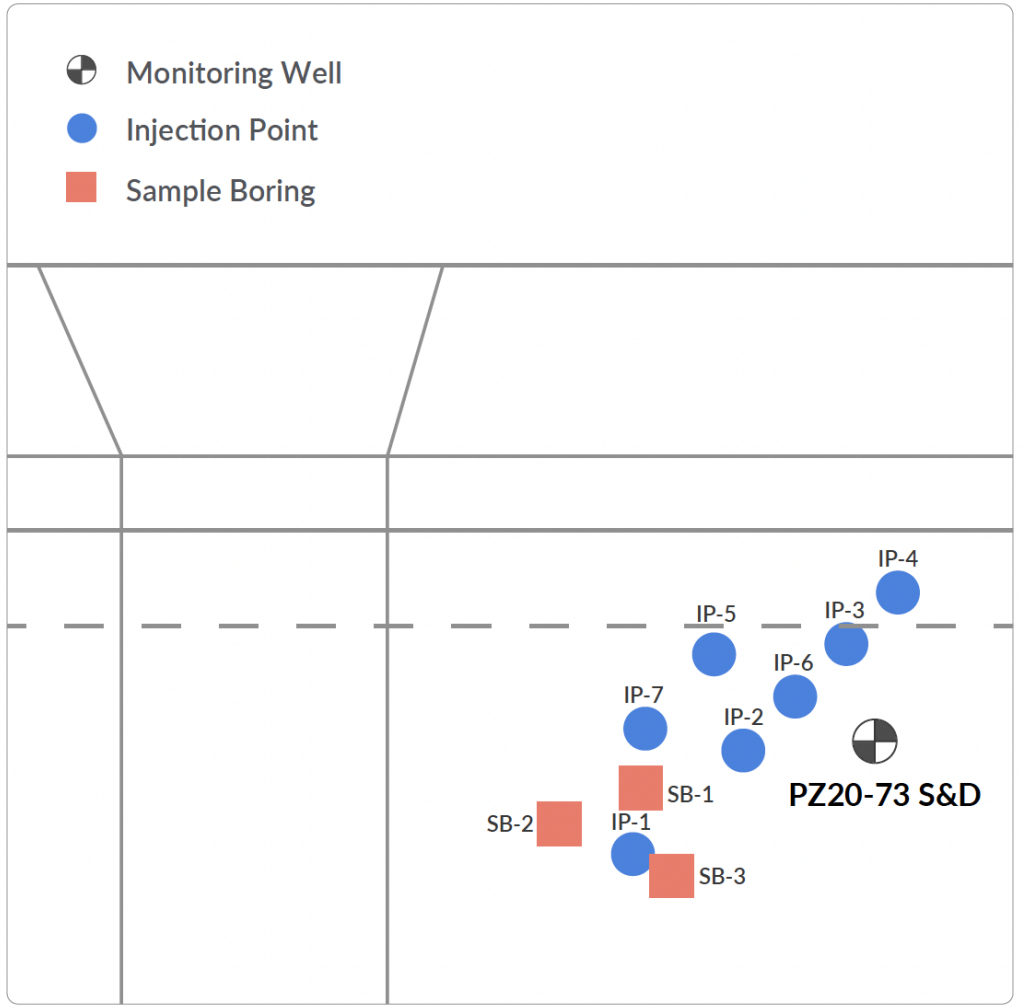
Application Details
PZ20-73

AquiFIX™ Long-Lasting Colloidal Electron Donor

PLUME STOP® Liquid Activated Carbon

BDI® PLUS BIO-DECHLOR INOCULUM

PRB Length	20 feet
Injection Interval	17.5 – 27.5 feet bgs
Shallow, high-mass flux zone	17.5 – 22.5 feet bgs
Deep, extreme mass-flux zone	22.5 – 27.5feet bgs
Amendments	
AquiFix	2,000 lbs
PlumeStop	1,434 lbs
BDI	9 liters
Total Mix Volume Applied	1,887 Gallons



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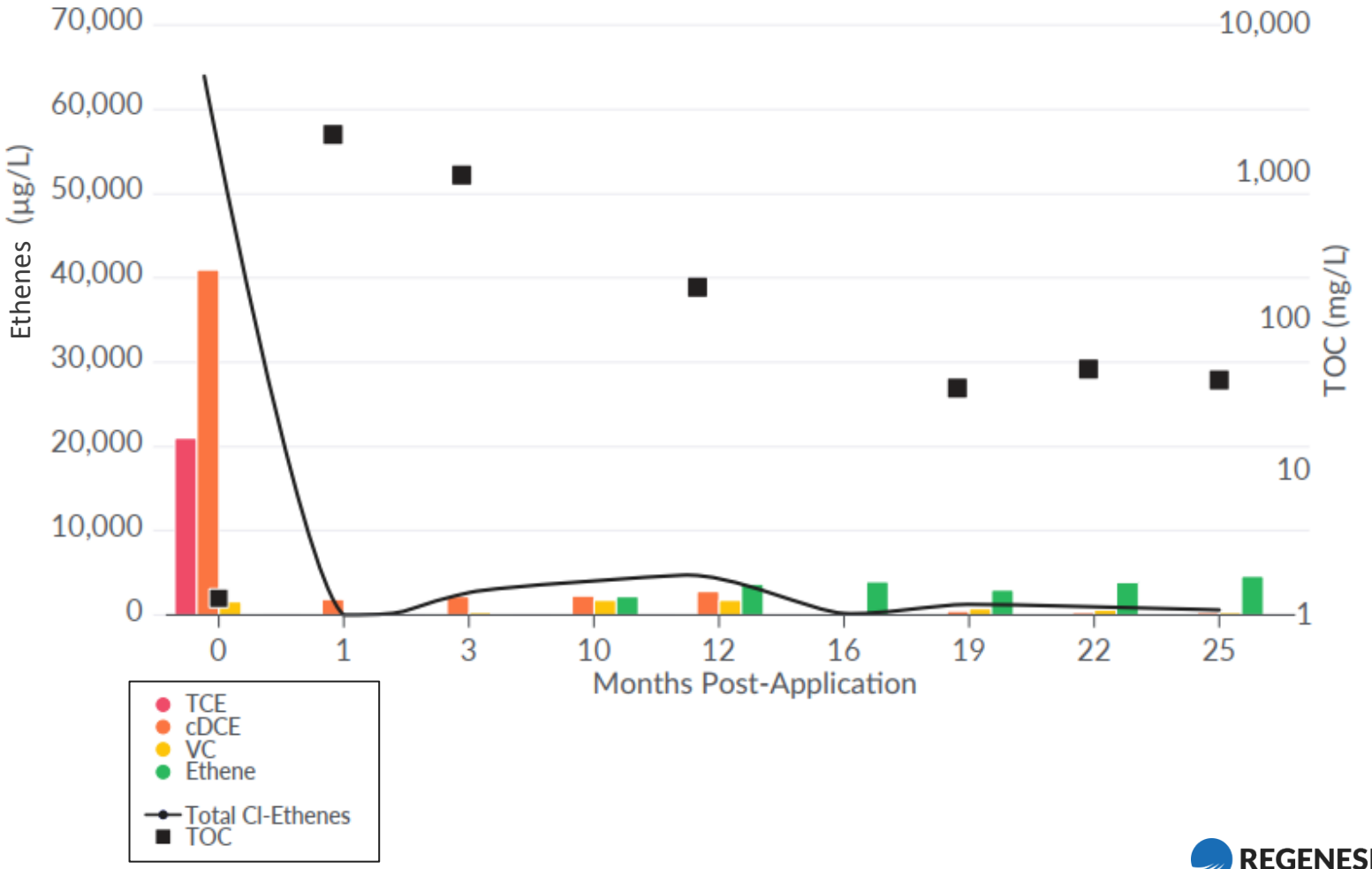
Results

PZ20-73D (Donor, CAC, Bioaugmentation)

- Near immediate CVOC mass flux elimination
- Elimination of CVOCs (ethene formation) observed
- Vinyl chloride reductase (VCR), DHC favorable



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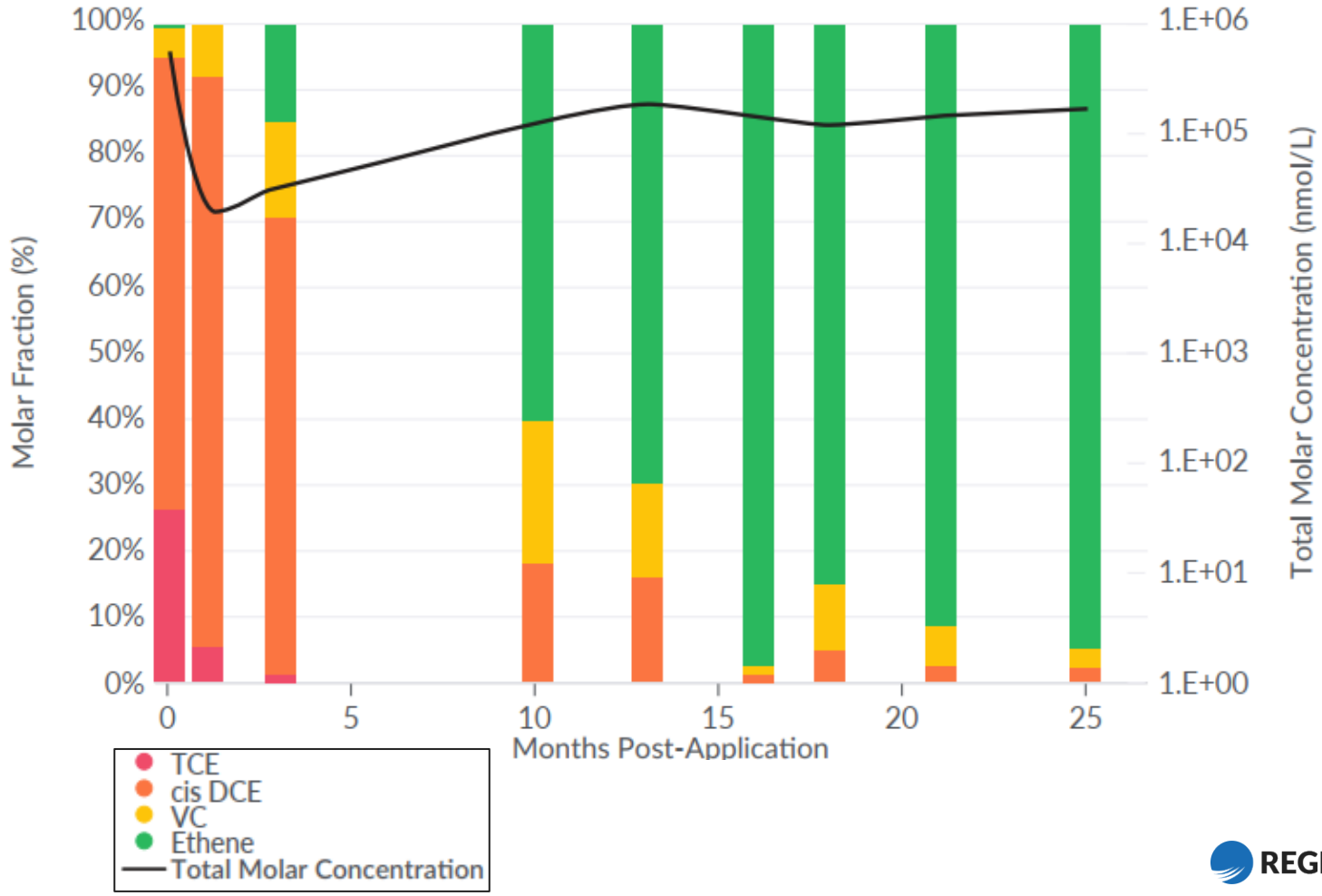

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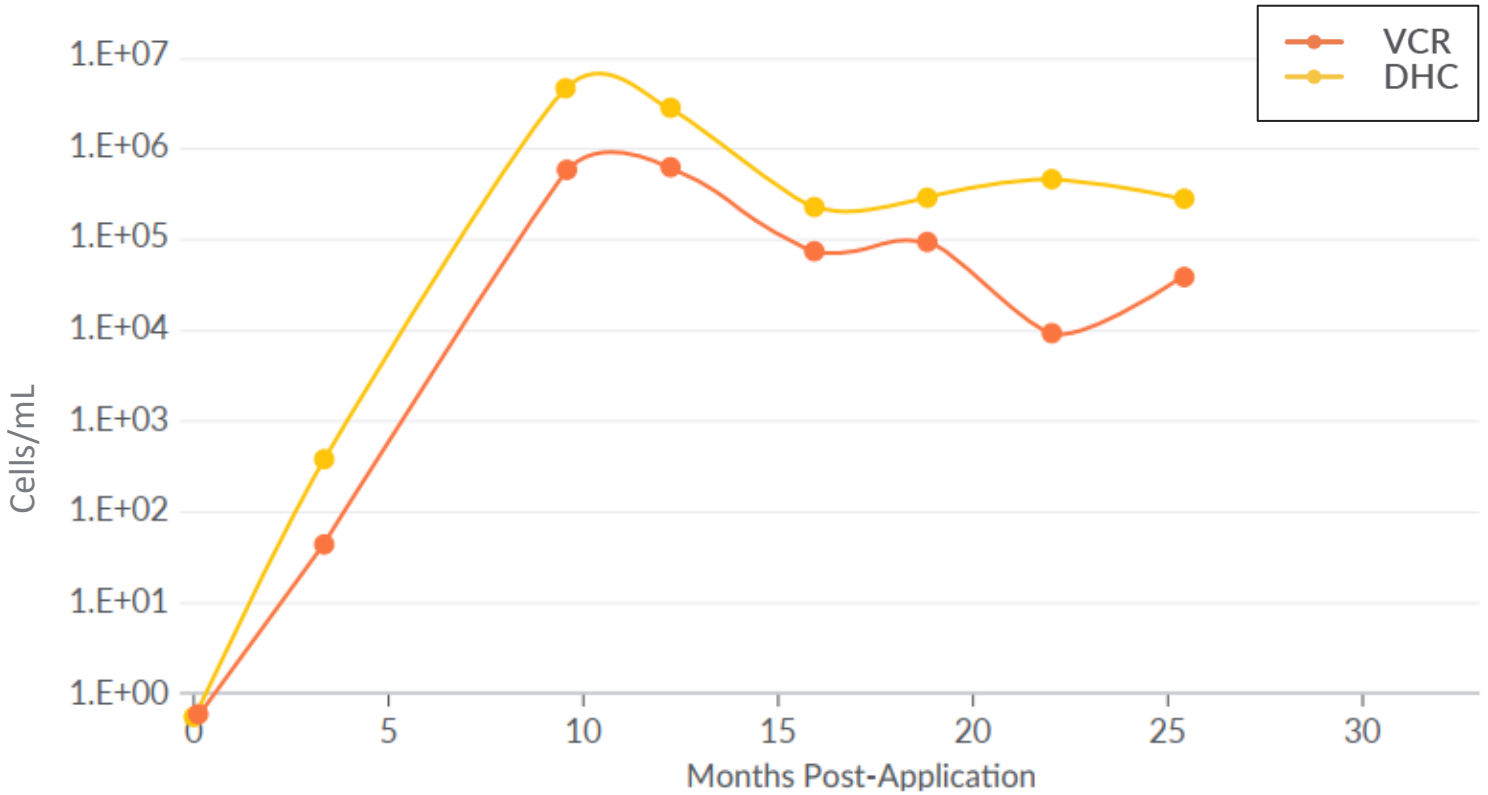

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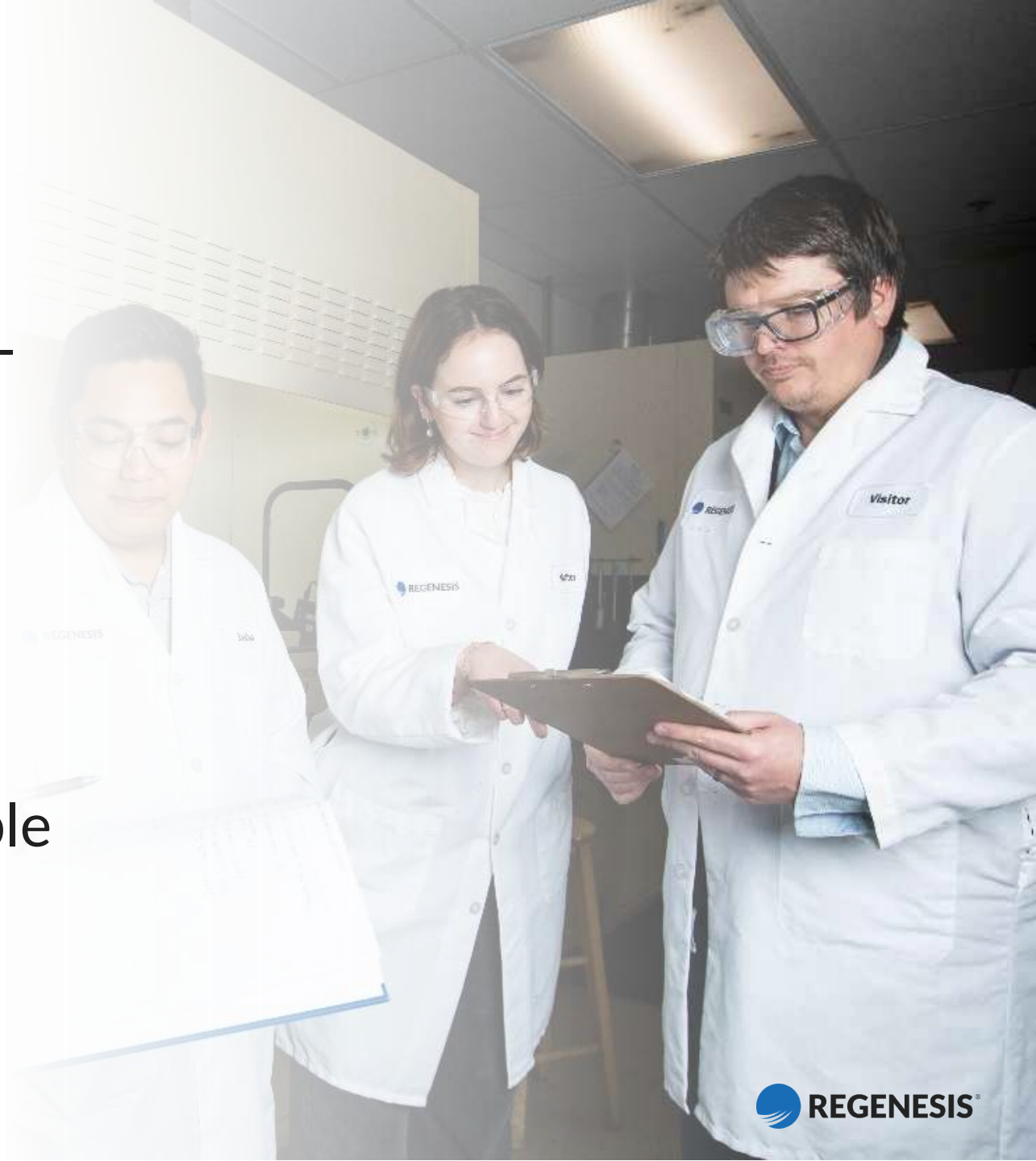
Conclusions

- CAC + ERD is a highly effective flux-management strategy
- Multiple lines of evidence for biotic transformation + adsorption

- Capable of long-term performance
- Addition of **abiotic** path (ZVI) possible



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Thank you!
Questions?

Paul Erickson, PhD

VP of Research and Development

perickson@regenesis.com

949-366-8000

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