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From the Lab to the Field – How Treatability Testing Supports Successful Field Outcomes

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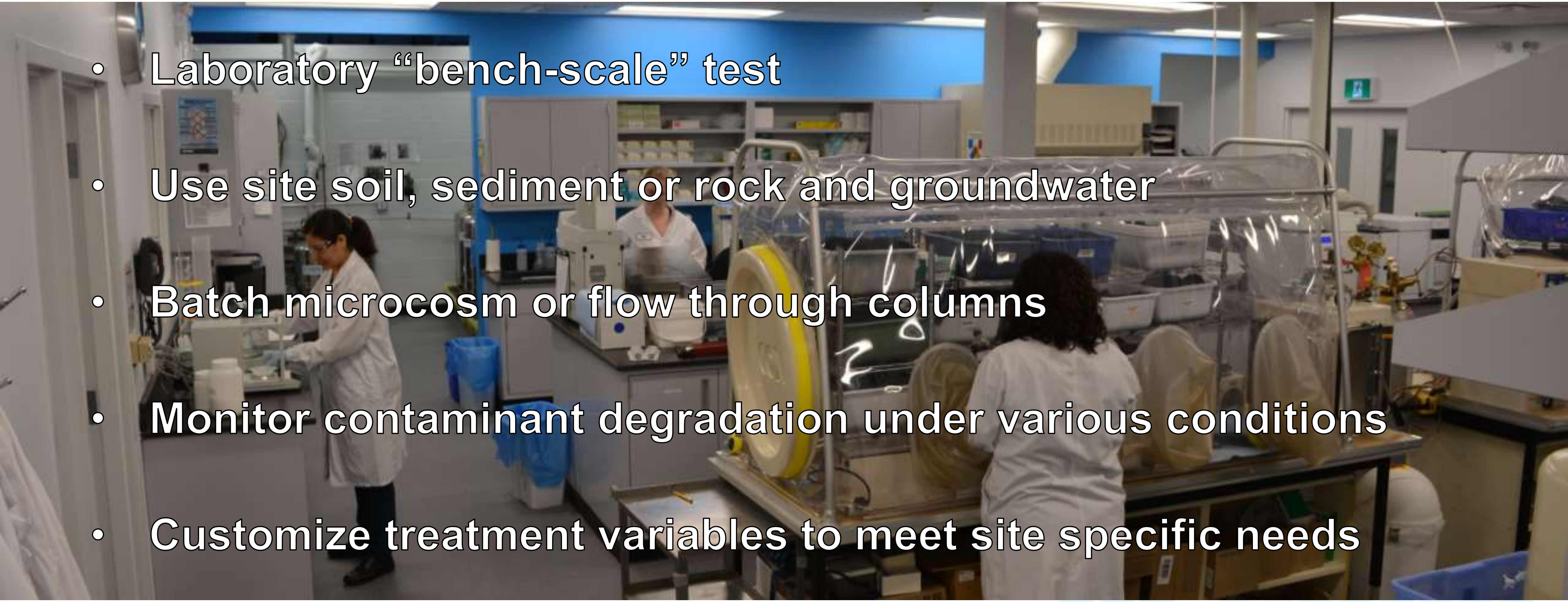
Two Key Questions

What is the best remediation approach?

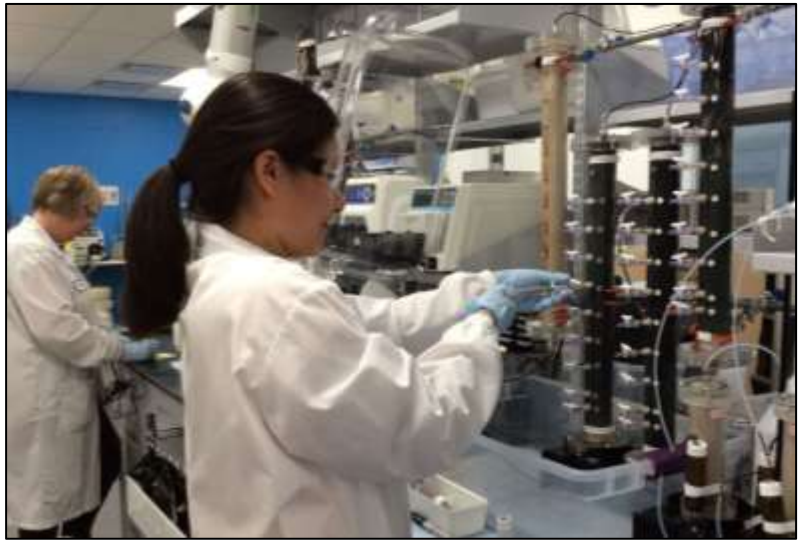
Once implemented is the remediation strategy working?

What is a Treatability Study?



- Laboratory “bench-scale” test
- Use site soil, sediment or rock and groundwater
- Batch microcosm or flow through columns
- Monitor contaminant degradation under various conditions
- Customize treatment variables to meet site specific needs

treatability studies



- Anaerobic and aerobic bioremediation
- In-situ chemical reduction (ISCR)
- In-situ chemical oxidation (ISCO)
- Sorptive Media
- In-situ stabilization (ISS)

What Can Treatability Studies Tell You?

- Electron donor/acceptor/cometabolite consumption
- Degradation intermediates/pathways
- Effect of controlling variables (e.g., pH, redox, amendment addition, inhibitory effects, oxidant demand, persulfate activators)
- Residence time/longevity for PRBs
- Contaminant degradation rates/lag times
- Insight into pilot–test design

Why Use a Treatability Test?

- Allows evaluation of multiple remedial options prior to field implementation
- Optimization of a selected remedy
- Studies are flexible allowing changes “on the fly” in the lab
- Manageable, incremental risk from lab to pilot to full-scale
- Reassures stakeholders that the selected remediation approach is feasible prior to field implementation

Batch vs Column Studies

Batch Reactors

- Test multiple technologies with smaller sample volumes from field
- Generally, less expensive to run than columns
- Closed system not as representative of field conditions

Flow Through Columns

- Provides detailed design data
- Observe geochemical changes along flow path
- Obtain estimates on treatment longevity in field
- Generally, more expensive to run than batch test

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CASE STUDY 1

Bench Scale Anaerobic Bioremediation with ISCR to Full Scale Field Pull-Push Anaerobic Bioremediation with Multiple Bioaugmentation Events

Bench Scale Design

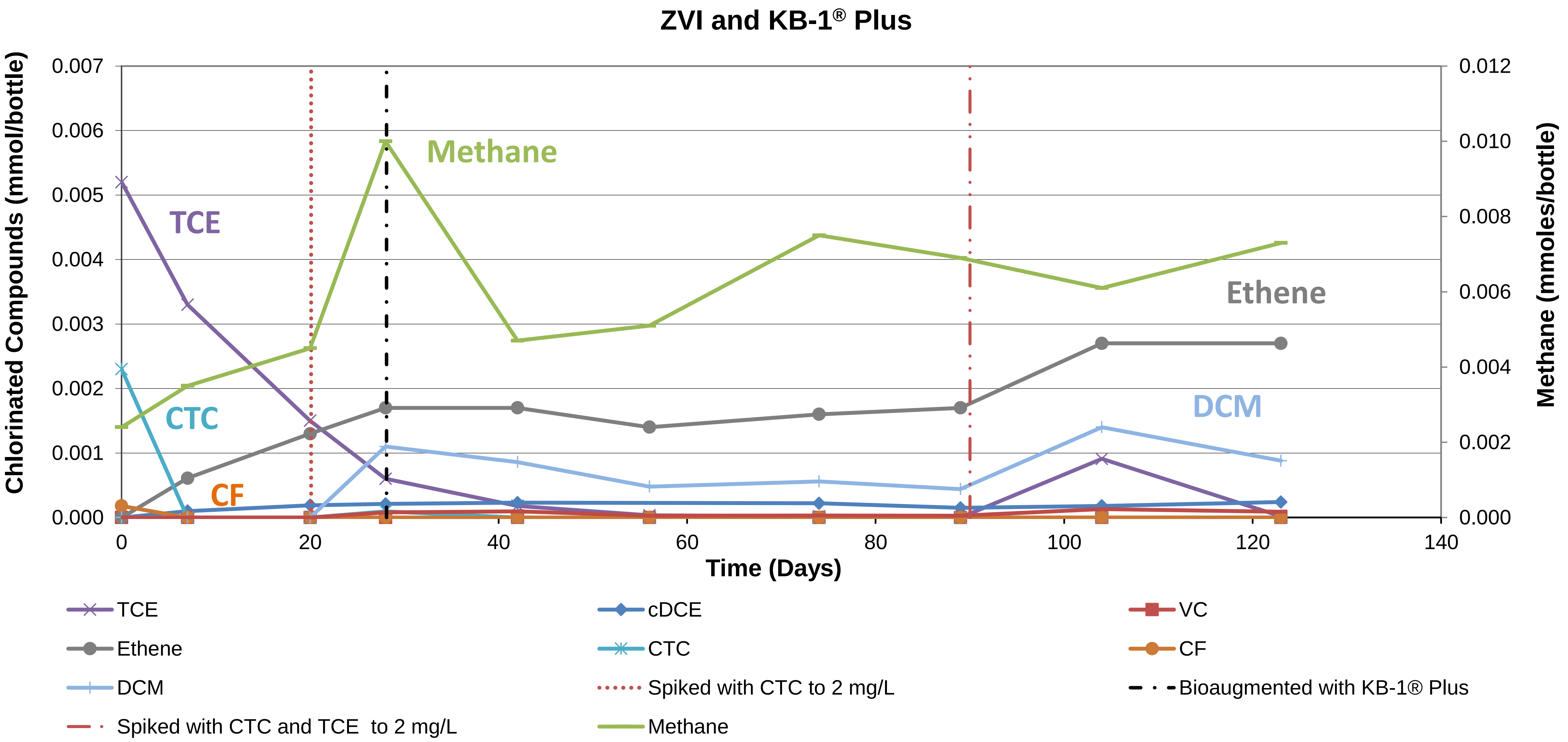
Site Details and Study Objectives:

- Mixed chlorinated methanes and ethenes
- CTC and TCE at 2 mg/L
- Assess the effectiveness of different donors as well as zero-valent iron (ZVI) and ferrous fumerate combined with bioaugmentation

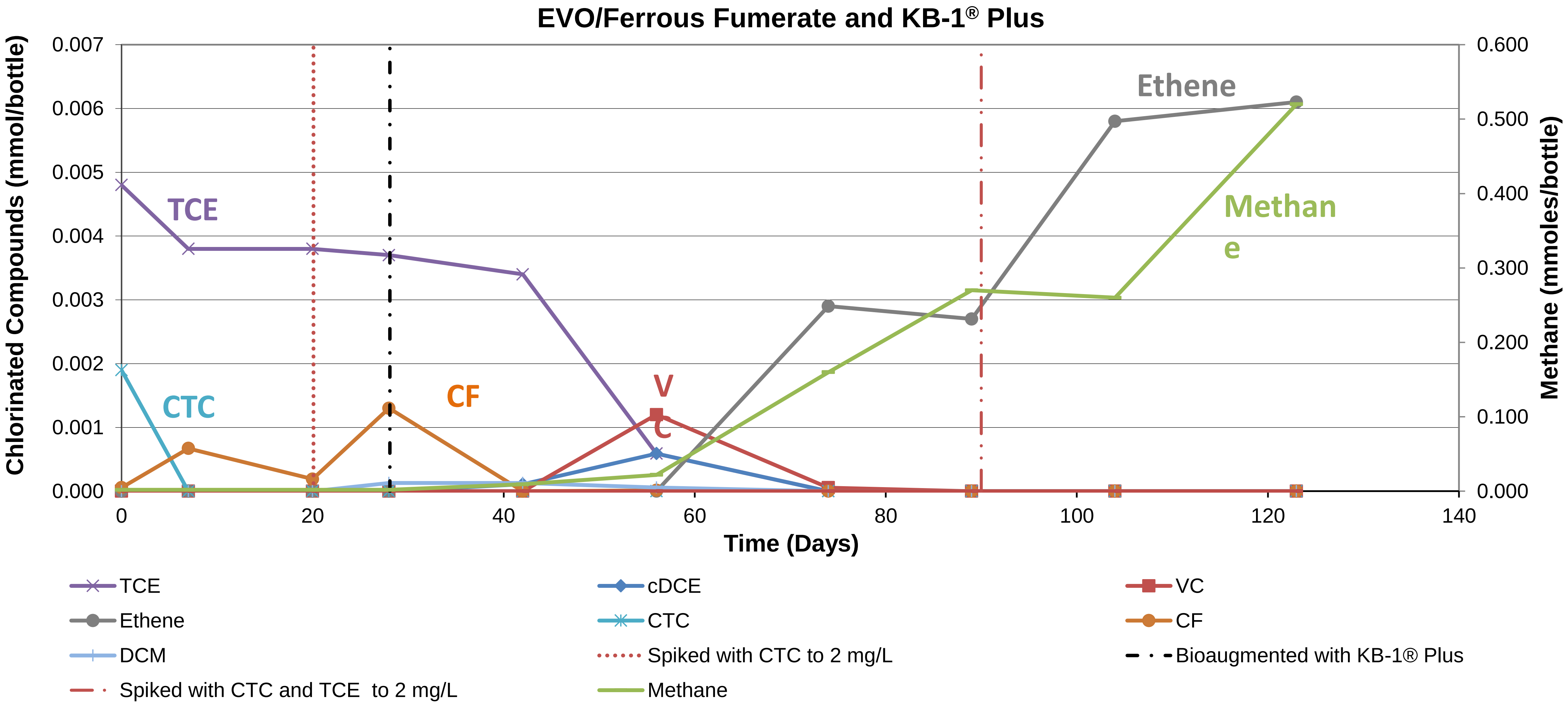
Study Design:

- Controls
- ZVI and KB-1® Plus
- EVO/ferrous fumerate/KB-1® Plus with and without ZVI
- EVO/KB-1® Plus

Bench Scale Study Results



Bench Scale Study Results



Bench Scale Study Conclusions

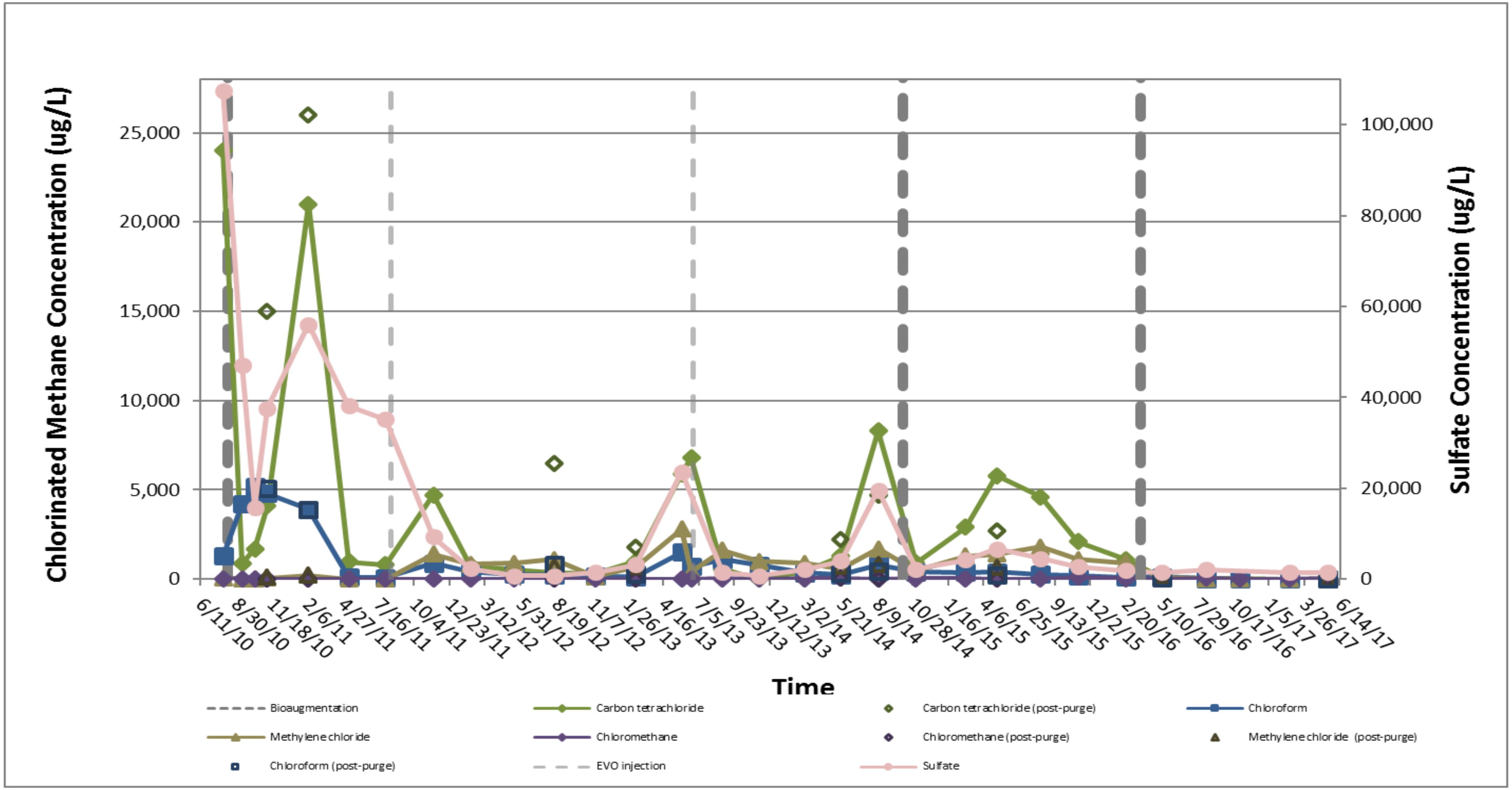
- cVOCs in the Controls remained stable
- ZVI promoted abiotic degradation of CTC and TCE, but inhibited biodegradation of DCM
- EVO with and without soluble iron promoted degradation of CTC and TCE to non chlorinated end products

Based on study results enhanced bioremediation was selected as site remedy

Field Implementation – Karst Aquifer

- Groundwater monitoring for a potential MNA remedy was being conducted at nine wells in three different SWMUs at a plant using many different chemicals in production operations
- Two wells in two separate SWMUs were found to have carbon tetrachloride concentrations indicative of DNAPL - MW-47D and HE-04
- Both screened approximately 55 to 65 ft bgs NOT connected hydraulically and additional wells could not be installed in the area
- Bench-scale treatability studies with KB-1® Plus Chlorinated Methane Formulation with emulsified vegetable oil as the electron donor indicated carbon tetrachloride could be degraded to innocuous end products
- A pull-push field pilot was initiated at MW-47D in 2010

Chlorinated Methanes and Sulfate versus Time



Field Case Study Conclusions

- cVOC sources existed upgradient of the biologically active zones (BAZ) and these periodically caused high concentrations of parent CVOCs
- Use of a bromide tracer showed that the initial decrease in CVOCs was primarily due to biodegradation, not dilution
- Sulfate proved to be a valuable tracer of upgradient groundwater entering the BAZ
- Initially low levels of methane increased as concentrations of the CVOCs decreased
- Bioaugmentation was conducted more often than typical reflecting karst geology

Summary

- CTC degrades readily cometabolically and abiotically to CF
- CF toxic and inhibitory to anaerobic processes - Bioaugmentation cultures available for CF dechlorination
- Labelled ^{14}C studies showed pathway is reductive dechlorination to DCM and then fermentation to organic acids
- Treatability testing indicated ZVI inhibited DCM degradation – Bioaugmentation successful for complete dechlorination
- Field study indicated successful bioremediation of CTC in difficult Karst geology

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CASE STUDY 2

Bench scale to Field scale Anaerobic Bioremediation of Chlorinated Ethenes

Site Background

- Former gold leaf manufacturing facility from 1955 – 1985.
  - Solvents used in production process.
- Cessation of operations in 1985 triggered NJDEP Environmental Cleanup Responsibility Act (ECRA), now known as the Industrial Site Recovery Act (ISRA).
- 12 USTs and contaminated soil removed.
- Groundwater impacted with cVOCs (Ethenes and Ethanes).
- Classification Exception Area (CEA) established in 1996 for 1,1-DCE, 1,1-DCA, benzene, vinyl chloride, 1,1,1-TCA and xylenes.

Site Background

- Site redeveloped in early 2000’s to house medical operations and offices.
- New owner in 2009 completed groundwater investigation. Higher concentrations of VOCs detected in 2011 and additional wells installed.
- RAW completed in 2015 for Reductive Dechlorination.
- Injections completed in March/April 2017.

Bench Scale Design

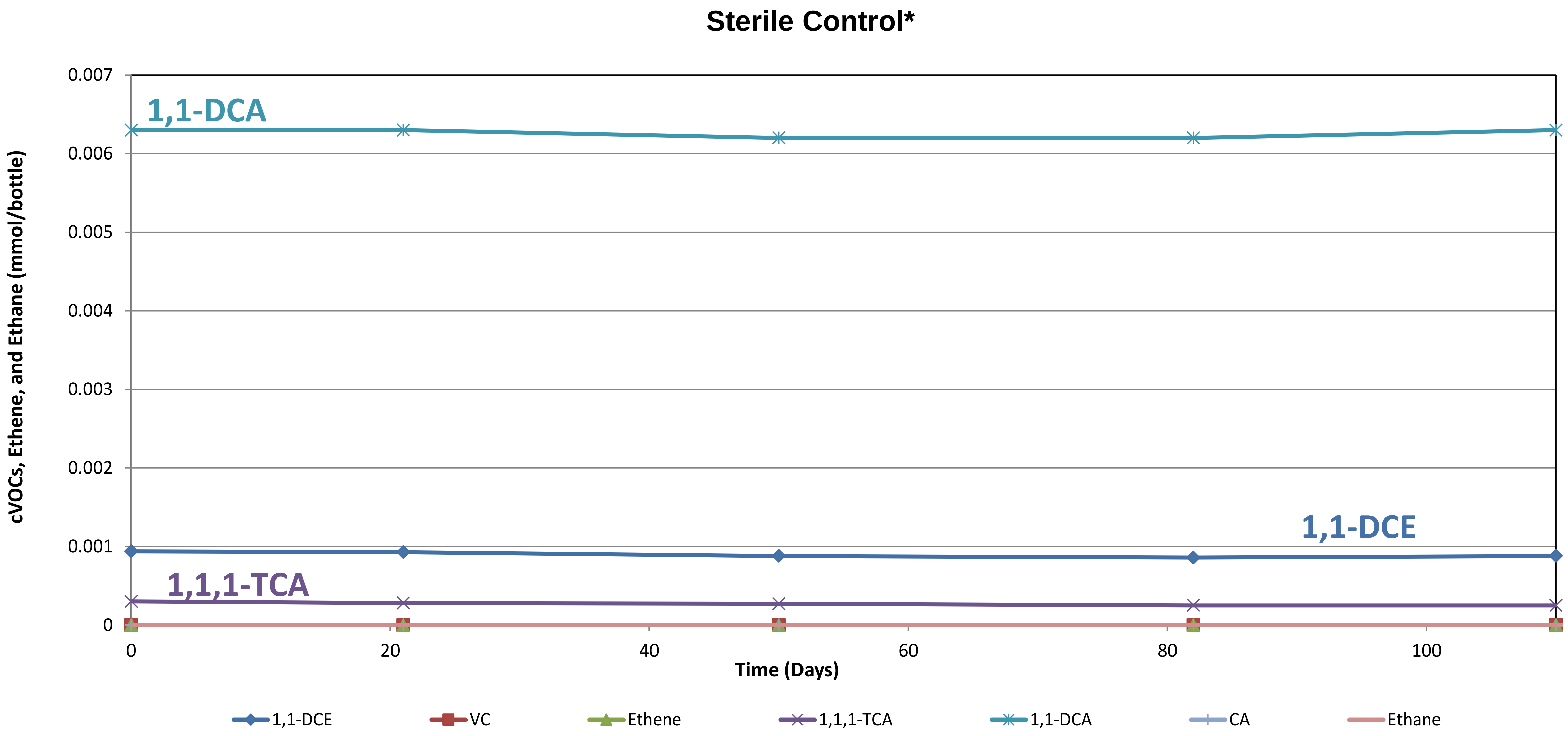
Site Details and Study Objectives:

- Mixed chlorinated ethenes and ethanes
- 1,1-DCE (0.2 mg/L), 1,1,1-TCA (0.2 mg/L), and 1,1-DCA (3.0 mg/L)
- Is anaerobic biodegradation a viable remedial option?

Study Design:

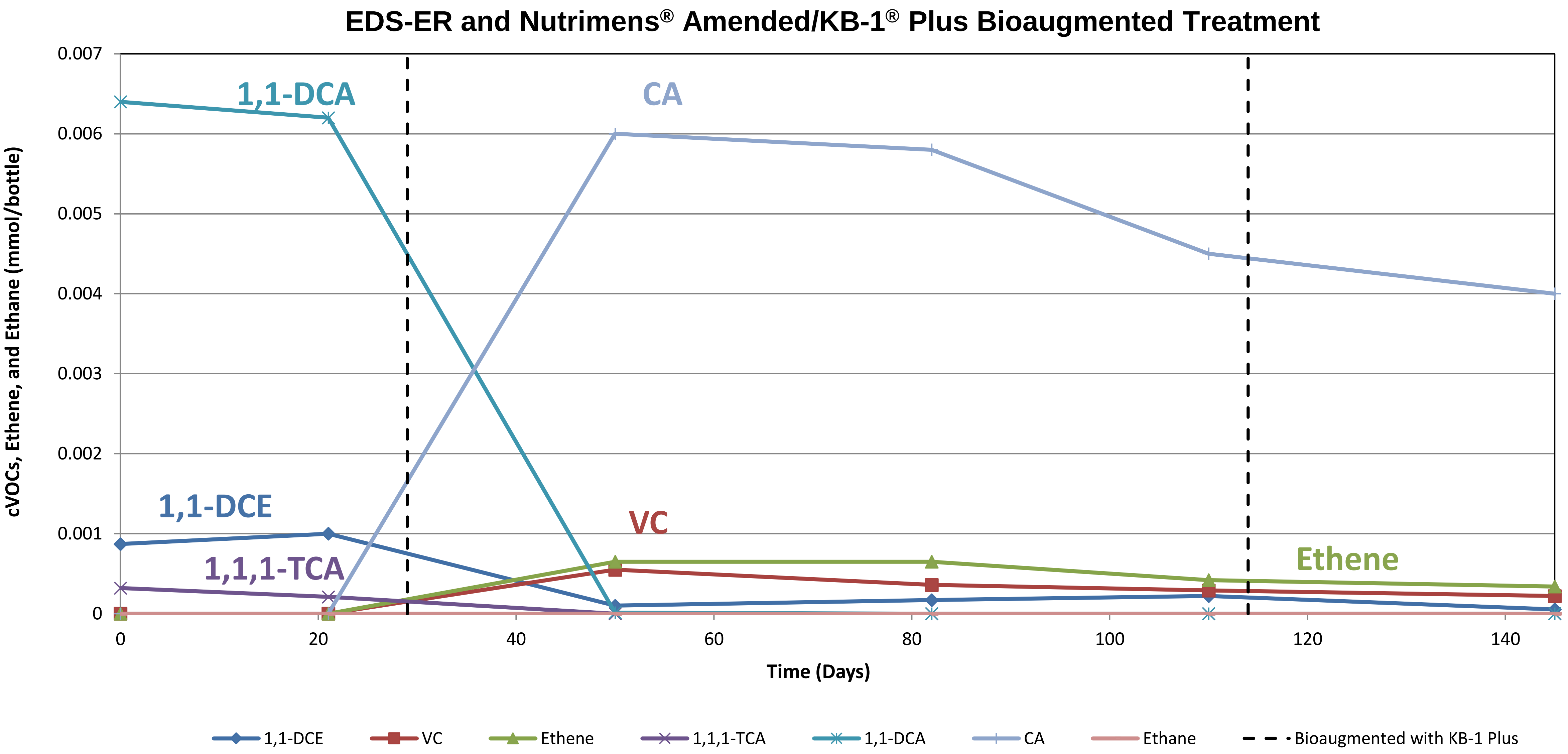
- Anaerobic Sterile Control
- Anaerobic Active Control
- EDS-ER and Nutrimens®
- EDS-ER and Nutrimens® Amended/KB-1® Plus Bioaugmented with sodium bicarbonate used to adjust pH

Bench Scale Study Results



*Active Control and Biostimulation Treatment had similar VOC profile

Bench Scale Study Results



Bench Scale Conclusions

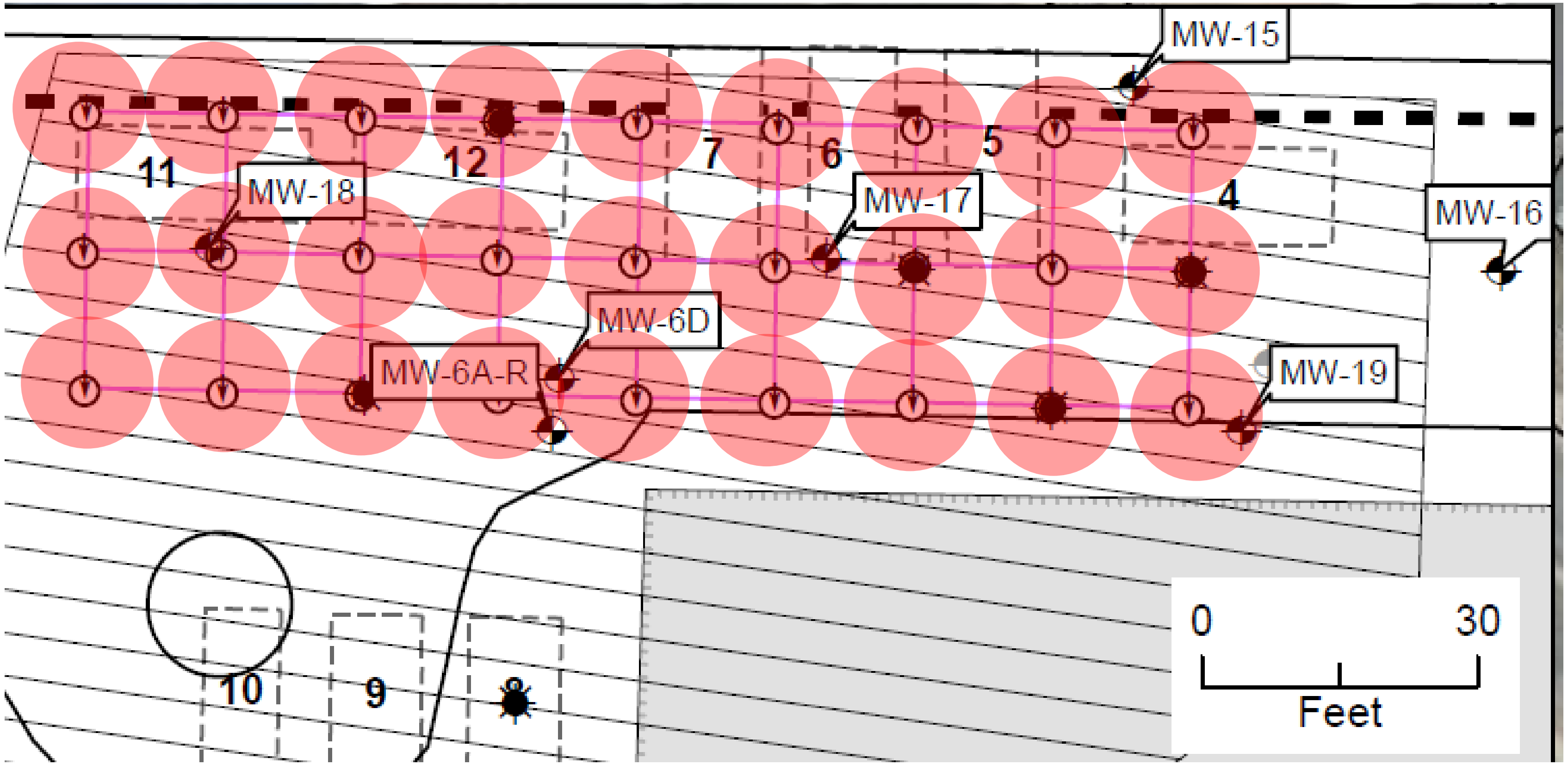
- cVOCs in the Controls remained stable
- 1,1-DCA and 1,1-DCE in the Biostimulation treatment remained stable
- Bioaugmentation was required to promote dechlorination of 1,1-DCA to CA and 1,1-DCE to ethene

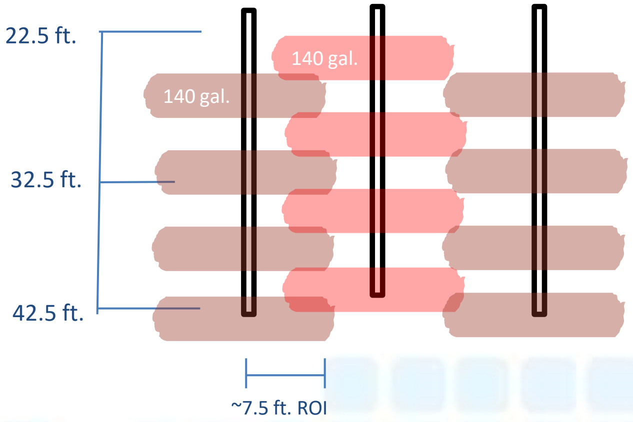
Based on study results enhanced bioremediation was selected as site remedy

Field Scale Remediation

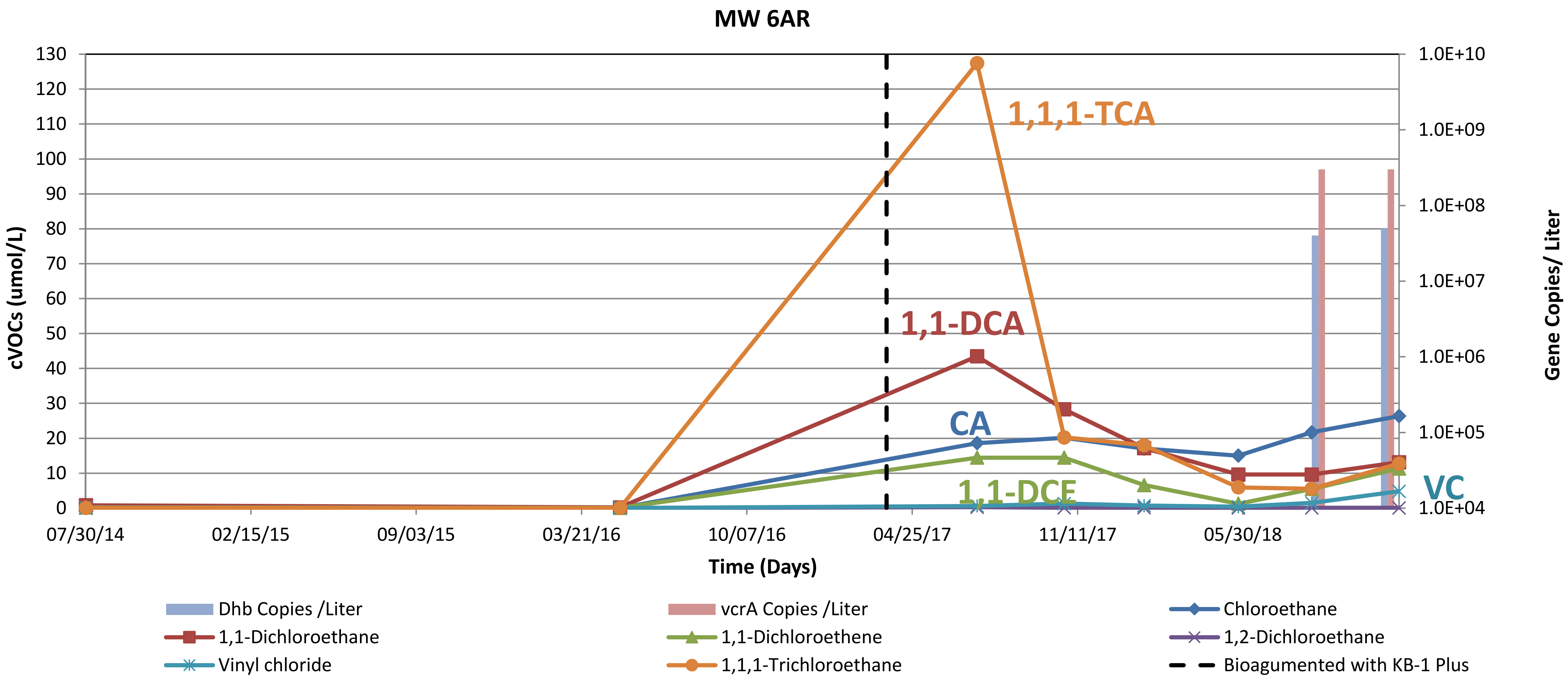
- Modified injection scope due to sensitivity of onsite operations.
- Completed pilot test to confirm injection depths to top of weathered bedrock and volumes could be achieved.
- Full-scale implementation included 27 temporary injection points over 3,600 sq ft area
  - 1,080 gallons EDS-ER™
  - 216 gallons Nutrimens®
  - 54 Liters KB-1® Plus bioaugmentation culture
  - >9,000 gallons of Anoxic water (prepared with KB-1® Primer)

Field Scale Remediation

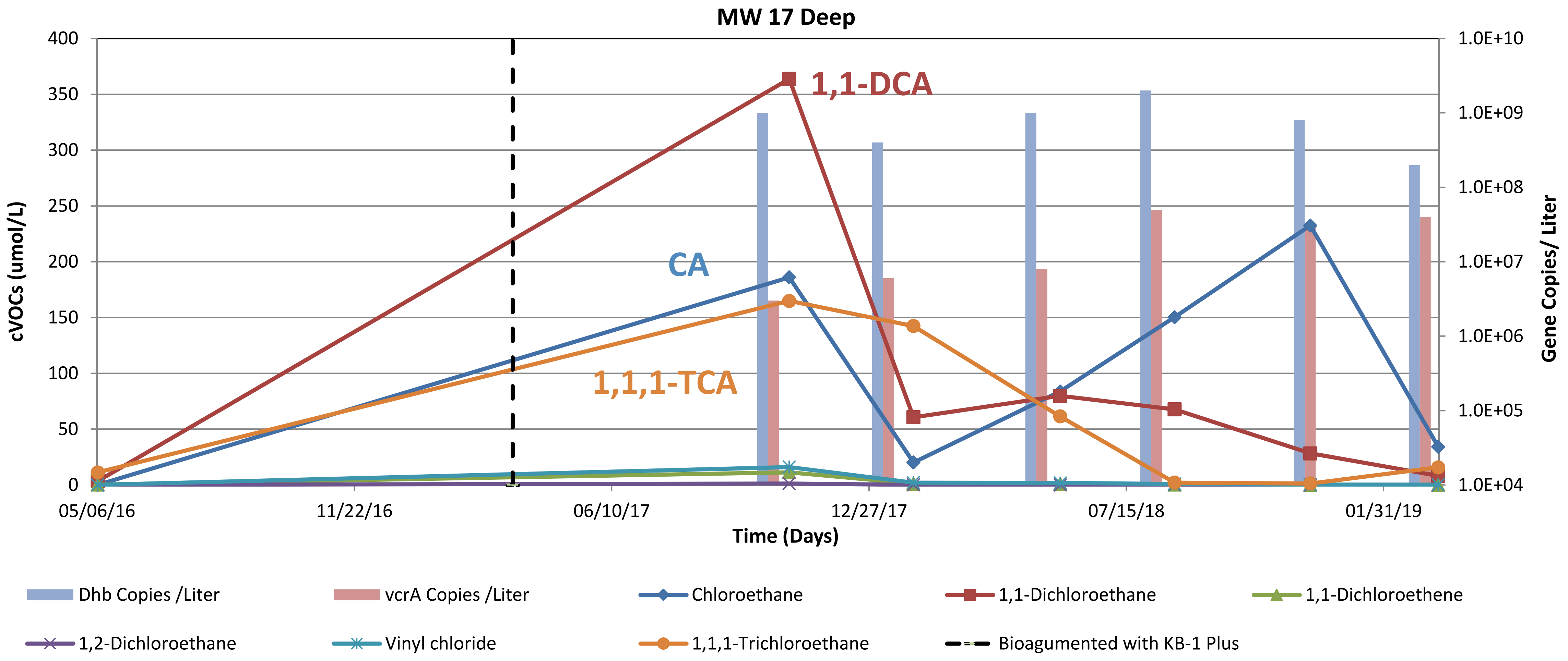




Field Scale Remediation



Field Scale Remediation



Summary and Future Work

- Treatability study indicated that bioaugmentation was required to promote complete dechlorination
- EDS-ER and Nutrimens injections at the Site created reducing conditions
- Initial increases in cVOCs after injections indicated release of sorbed mass
- Increases in Dhb correlated with decreases in chlorinated ethanes
- Sub slab and indoor air sampling indicated no VOCs above standards
- After cVOCs are remediated may switch to aerobic system to treat benzene/xylenes

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CASE STUDY 3

Bioremediation Bench Scale to Excavation @ Field

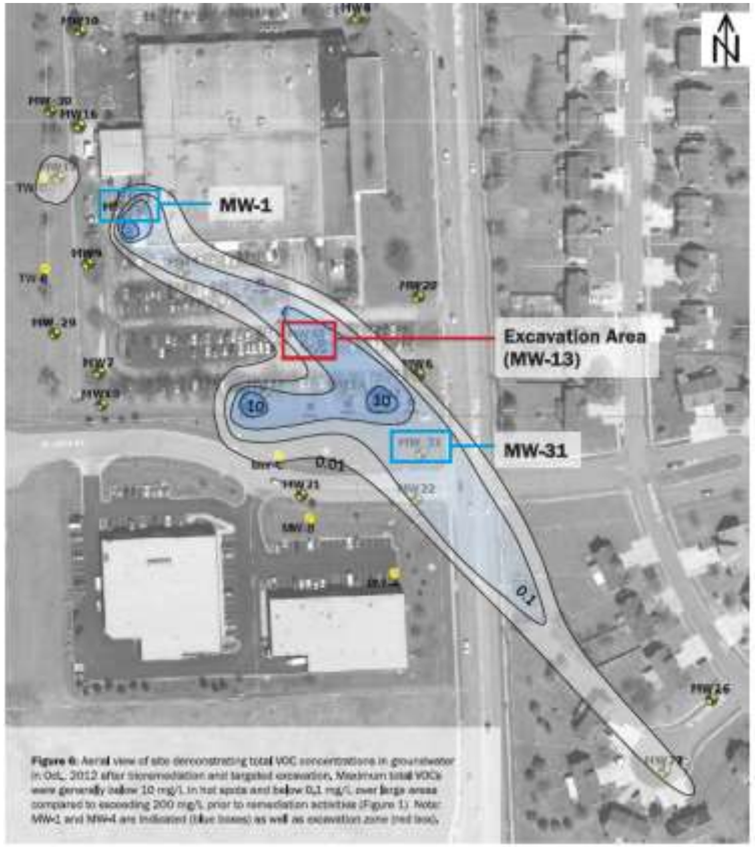
Bench Study Leading to Surprising Results

Kansas site with high concentration mixed VOCs including dichloromethane (DCM)

- MW-1:10 mg/L DCM attenuated successfully
  MW-13: 200 mg/L DCM-degradation not observed

- Treatability testing indicated that >160 mg/L DCM was not biodegradable with available bioaugmentation cultures

- 500 tons of soil in MW-13 area removed in 2009 to remove DCM source area



Study justified moving quickly to excavation saved time and money on potentially futile bioremediation attempt

Summary

- Treatability testing aid planning and assessment
- The costs of treatability tests are often offset by O&M savings due to improved planning & implementation
- Decreased uncertainty as treatability data provides preview of expected results prior to field implementation

Course Code: TMHS

FURTHER INFORMATION

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