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ENVIRONMENTAL ALLIANCE, INC.
Engineering • Remediation • Consulting

Bioaugmentation for Enhanced Anaerobic Degradation of a Mixed cVOC Plume on a Commercial Property

Battelle Symposium
Baltimore , MD
April 16, 2019

Presented by:
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Contributors:
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Let's Talk About…

1. Site Background
2. Mixed Contaminant Dechlorination
3. Treatability Study
4. Field Scale Remediation
5. Summary and Future Work

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 VOCs (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.

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MIXED CONTAMINANT DECHLORINATION

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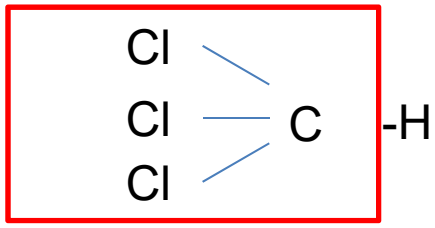
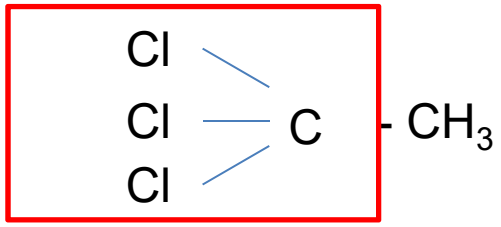
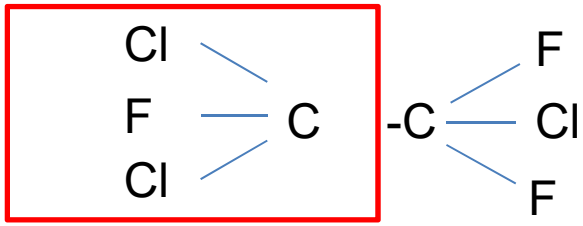
Inhibition of Reductive Dechlorination







Tri-halogenated Compounds:

Chloroform
(also inhibits fermenters and methanogens)

1,1,1-trichloroethane

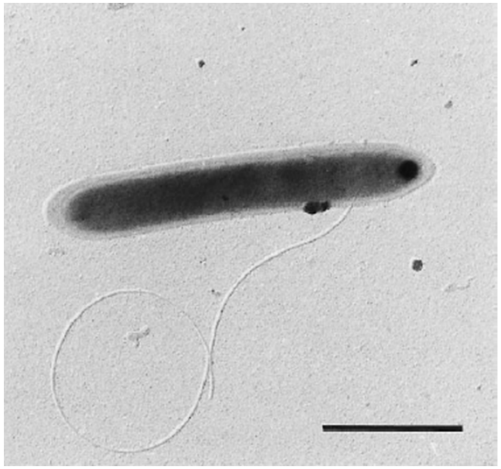
Chlorofluorocarbon (CFC 113)

Inhibit *Dehalococcoides* by binding to reductive dehalogenases

Dehalobacter (*Dhb*)

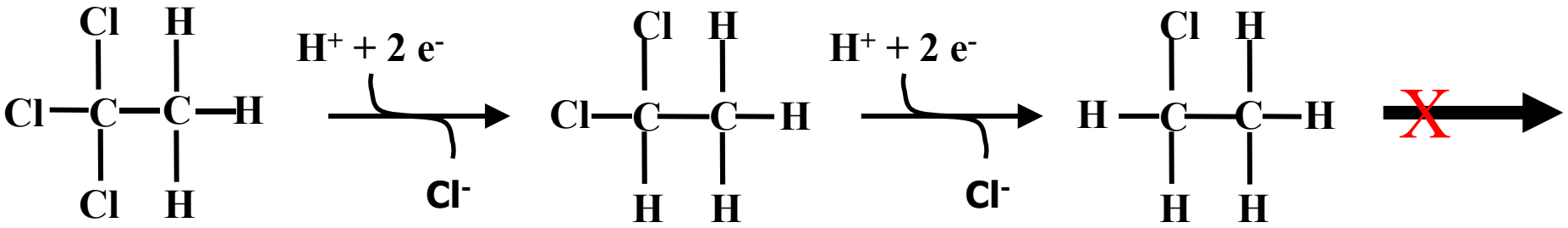
Dehalobacter activities include:

- 1,1,1-TCA degradation to CA
  (Grostern and Edwards, 2006)
- Chloroform to Dichloromethane *(cfrA)*
  (Grostern, Edwards, Duhamel and Dworatzek, 2010)
- DCM to acetate
  (Justicia-Leon et al., 2011)
- 1,1,2,2-TeCA to ethene
  (Manchester et al., 2012)

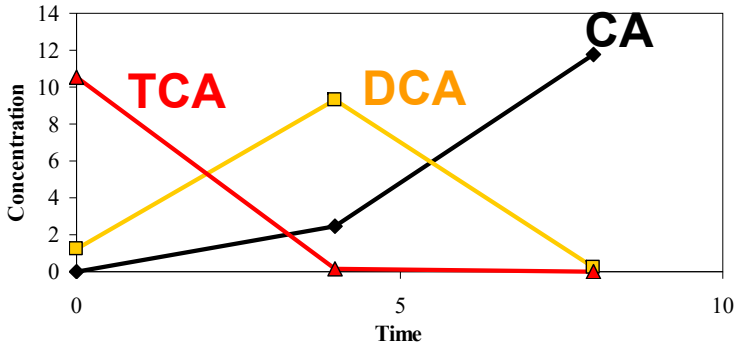


Dehalobacter restrictus

Anaerobic biodegradation of 1,1,1-TCA



1,1,1-TCA Reductive dechlorination **1,1-DCA** Reductive dechlorination **Chloroethane**



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TREATABILITY STUDY

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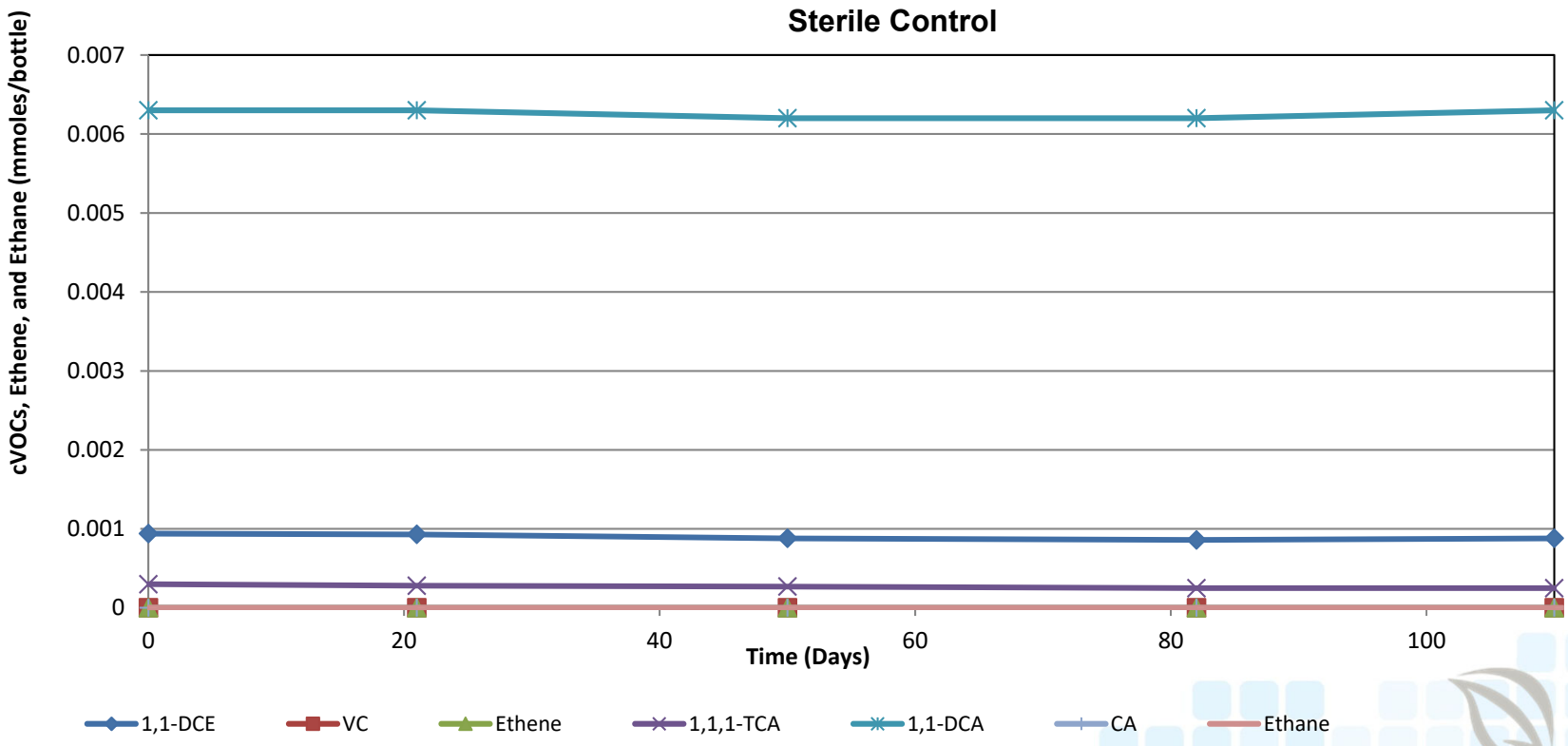
Case Study: NJ Site

- 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?

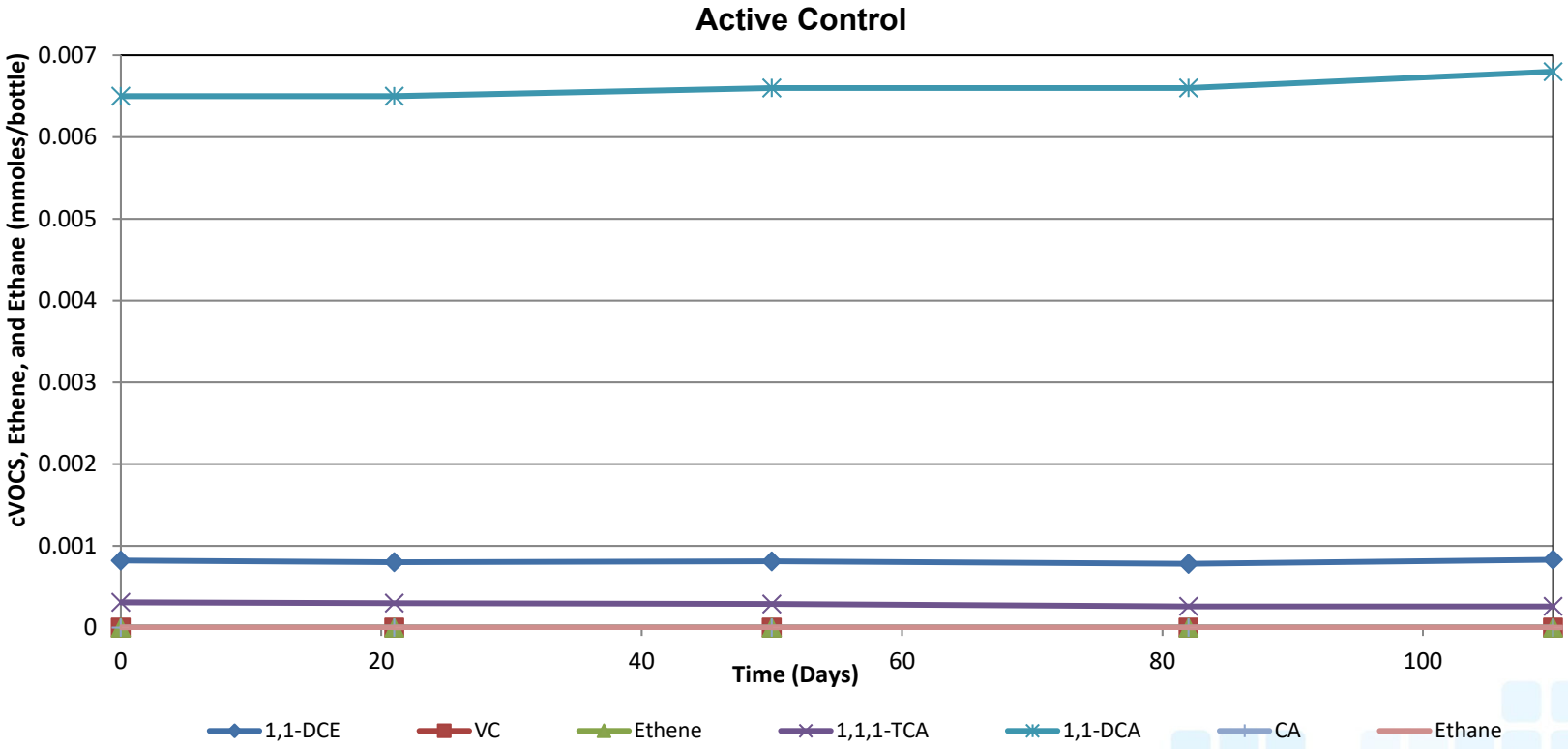
Study Design:

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

Case Study: NJ Site



Case Study: NJ Site



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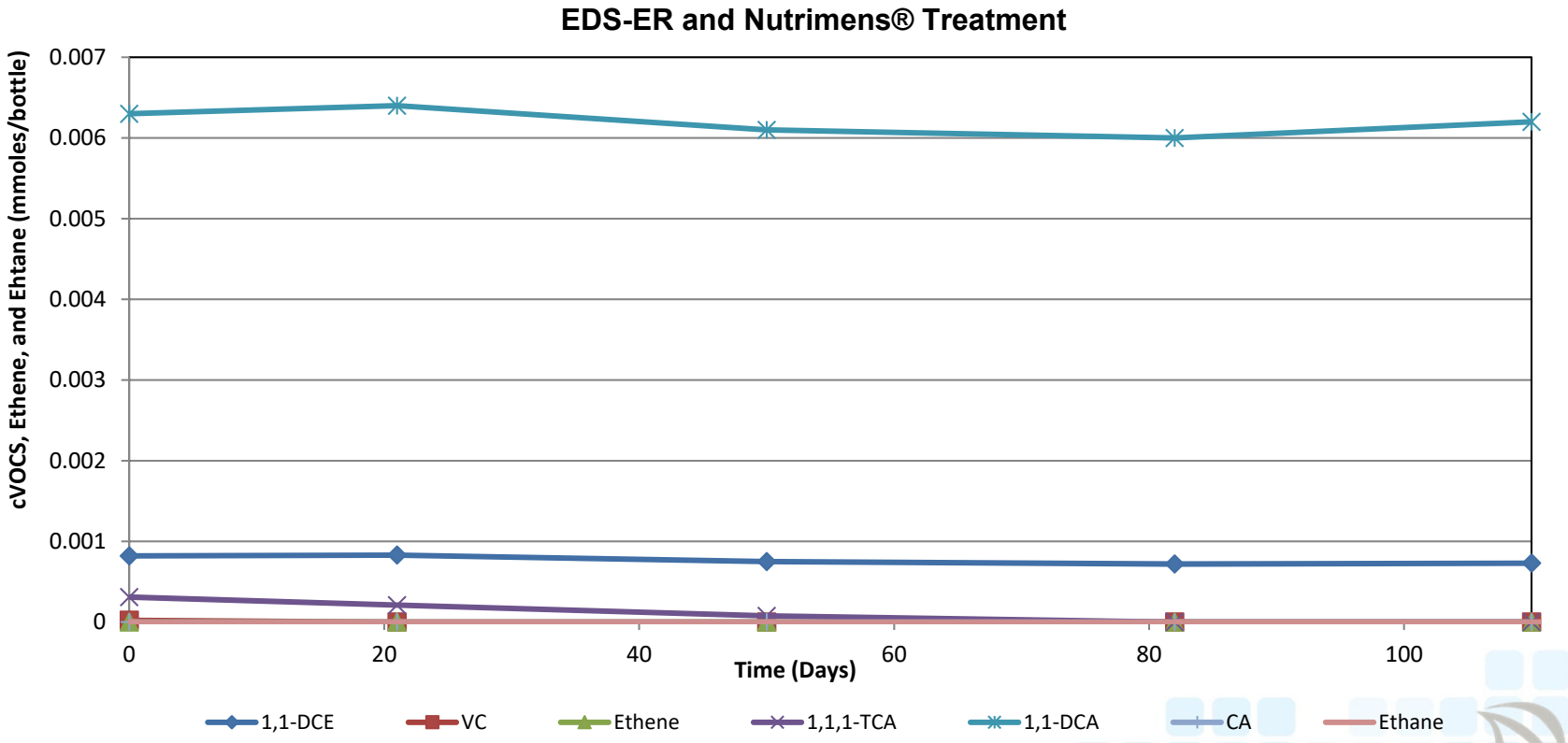
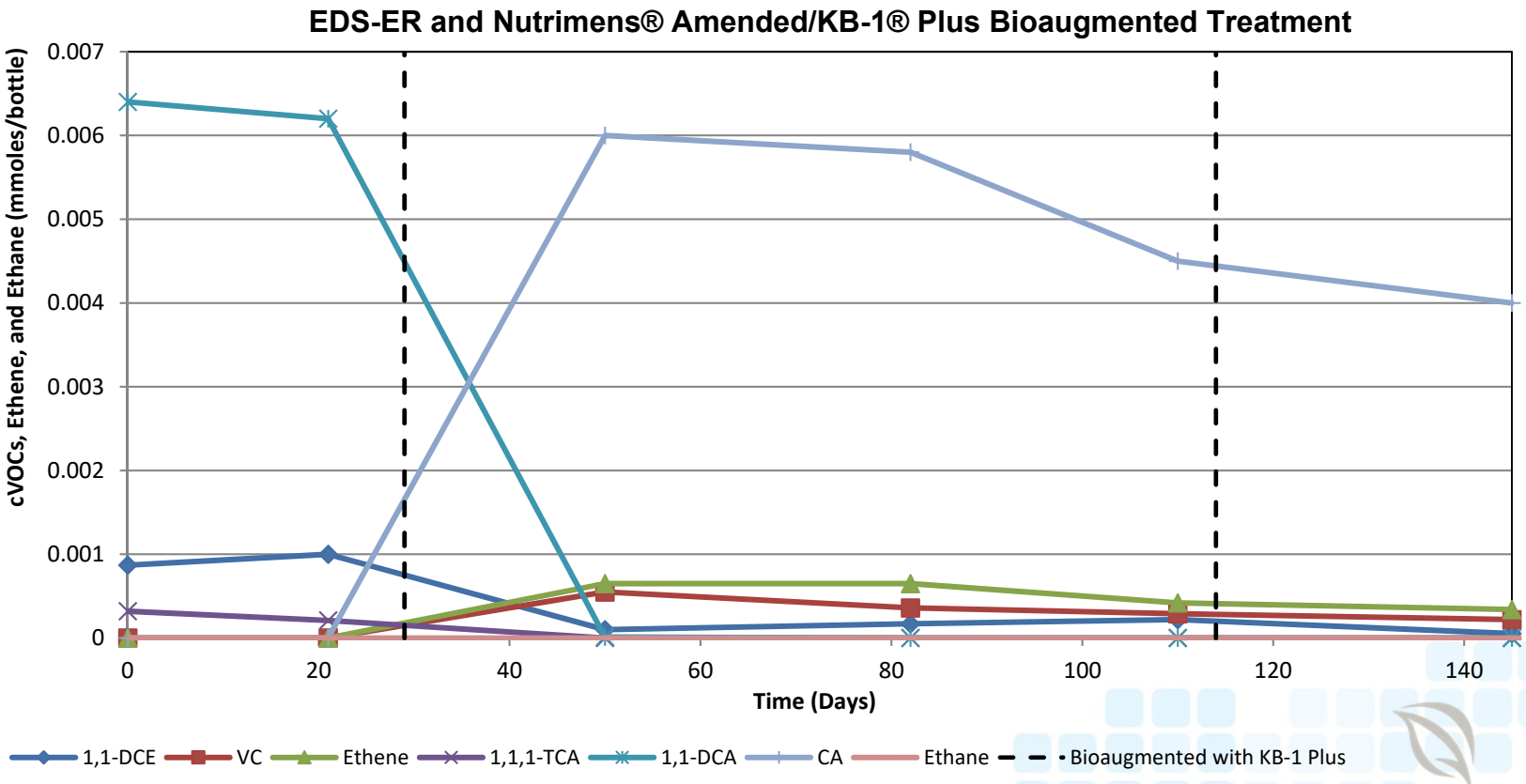


Case Study: NJ Site



Conclusions: NJ Site Treatability Study

- 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

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FIELD SCALE REMEDIATION

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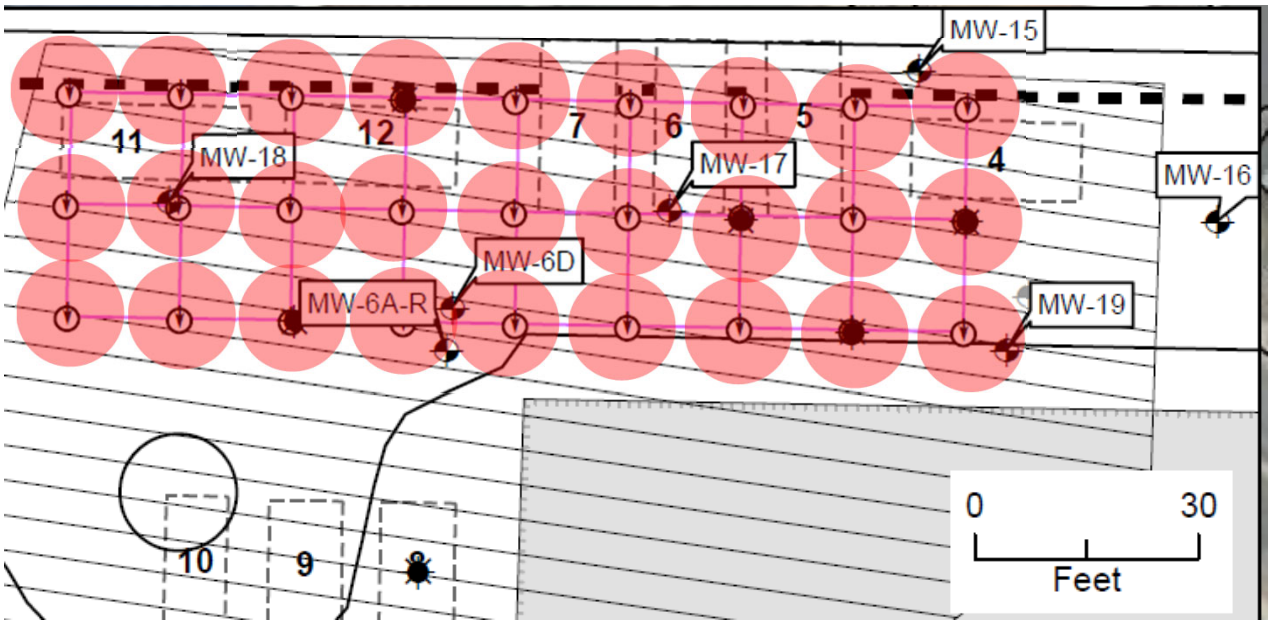
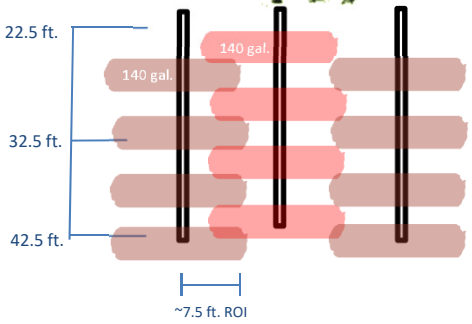
Field Scale Remediation: NJ Site

- 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: NJ Site





Field Scale Remediation: NJ Site

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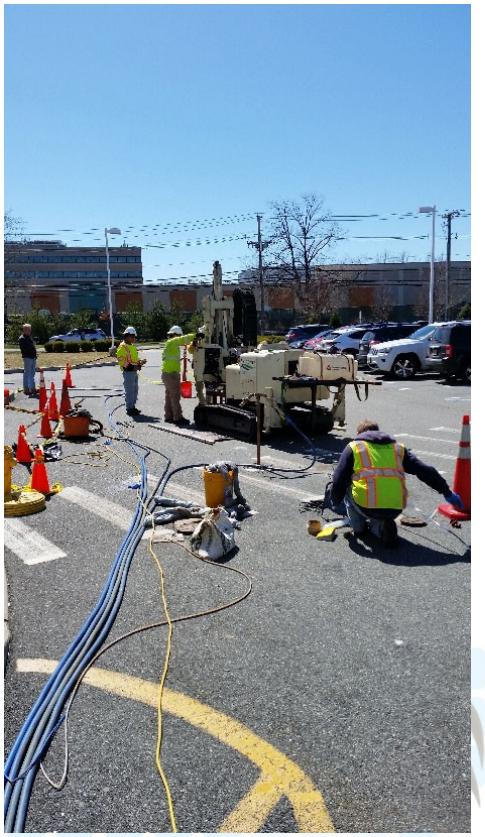
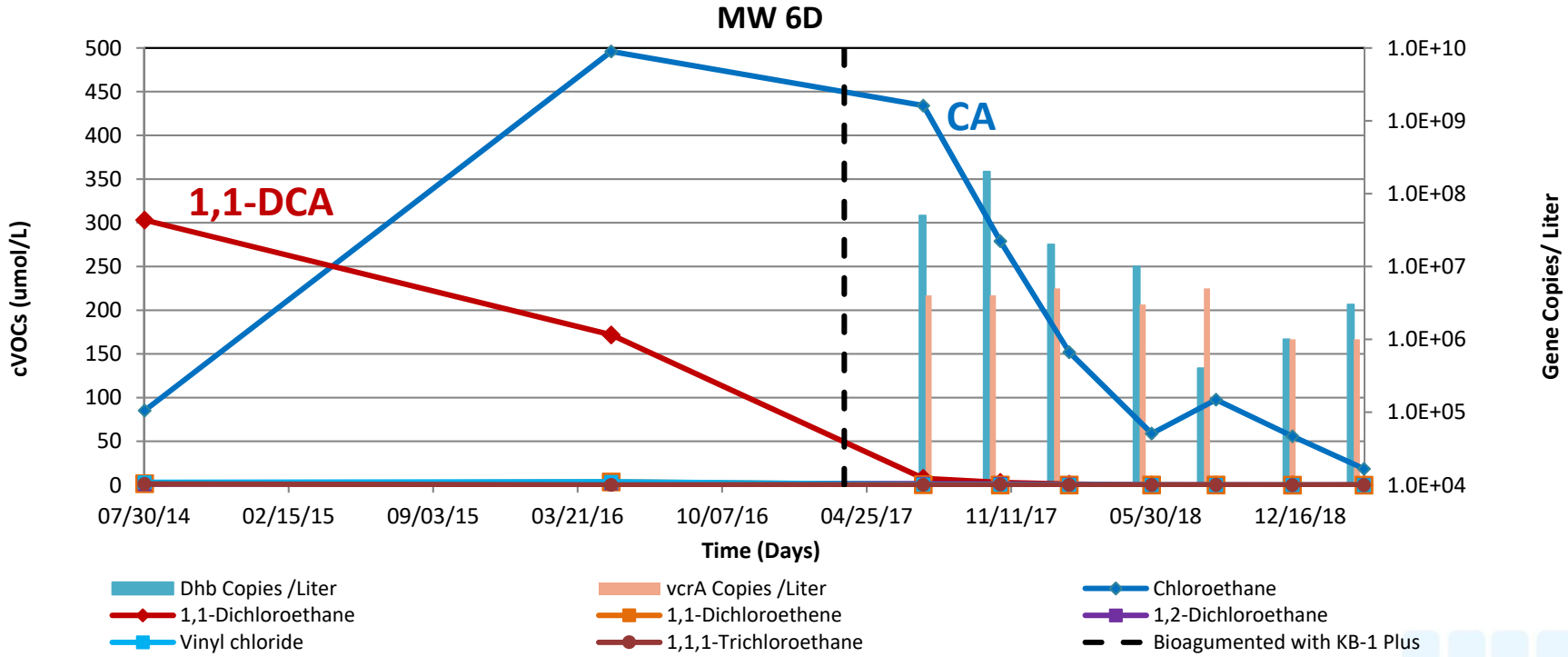


Field Scale Remediation: NJ Site

Field Scale Remediation: NJ Site - Geochemistry

Date	MW 6AR			MW 6D			MW 17 Deep			MW 18 Deep		
	DO mg/L	ORP mV	pH	DO mg/L	ORP mV	pH	DO mg/L	ORP mV	pH	DO mg/L	ORP mV	pH
05/06/16	1.63	12	7.11	1.4	-126	6.63	0.0	152	7.52	0.0	161	7.60
03/29/17	0.00	-51	6.42	0.0	-64	6.97	6.6	-100	7.18	1.3	54	6.38
04/10/17	0.00	-84	6.13	7.4	-109	6.89	0.8	-56	7.07	0.0	-28	6.34
04/17/17	9.40	-87	6.35	7.6	-58	6.35	8.0	-90	6.96	7.0	-51	6.03
04/24/17	0.00	-72	8.02	0.5	37	6.72	0.0	-28	7.47	0.0	-1	6.98
05/02/17	0.00	12	6.03	0.0	105	5.38	1.4	30	6.07	0.0	59	6.19
06/02/17	0.00	-17	5.64	0.0	-15	5.97	6.1	-29	6.21	0.0	-13	5.75
07/12/17	0.00	-69	5.38	0.0	-129	6.11	0.0	-81	6.02	0.0	-70	5.49
10/26/17	0.00	-37	4.93	0.0	-103	6.21	0.0	-150	6.41	0.0	-120	6.35
01/30/18	0.00	21	5.36	0.0	-66	6.5	0.0	-53	6.32	0.0	-77	6.54
05/24/18	1.39	-57	5.71	0.0	-137	6.82	0.0	-86	6.31	0.0	-170	6.84
08/21/18	1.52	-60	6.06	0.0	-139	7.01	0.0	-80	6.67	0.0	-143	7.16
12/05/18	1.32	-72	6.85	4.1	-68	7.35	1.9	-17	6.73	1.1	-102	7.29
03/14/19	0.00	-82	6.17	0.0	-113	6.64	0.0	-108	6.62	0.0	-158	6.78

Field Scale Remediation: NJ Site



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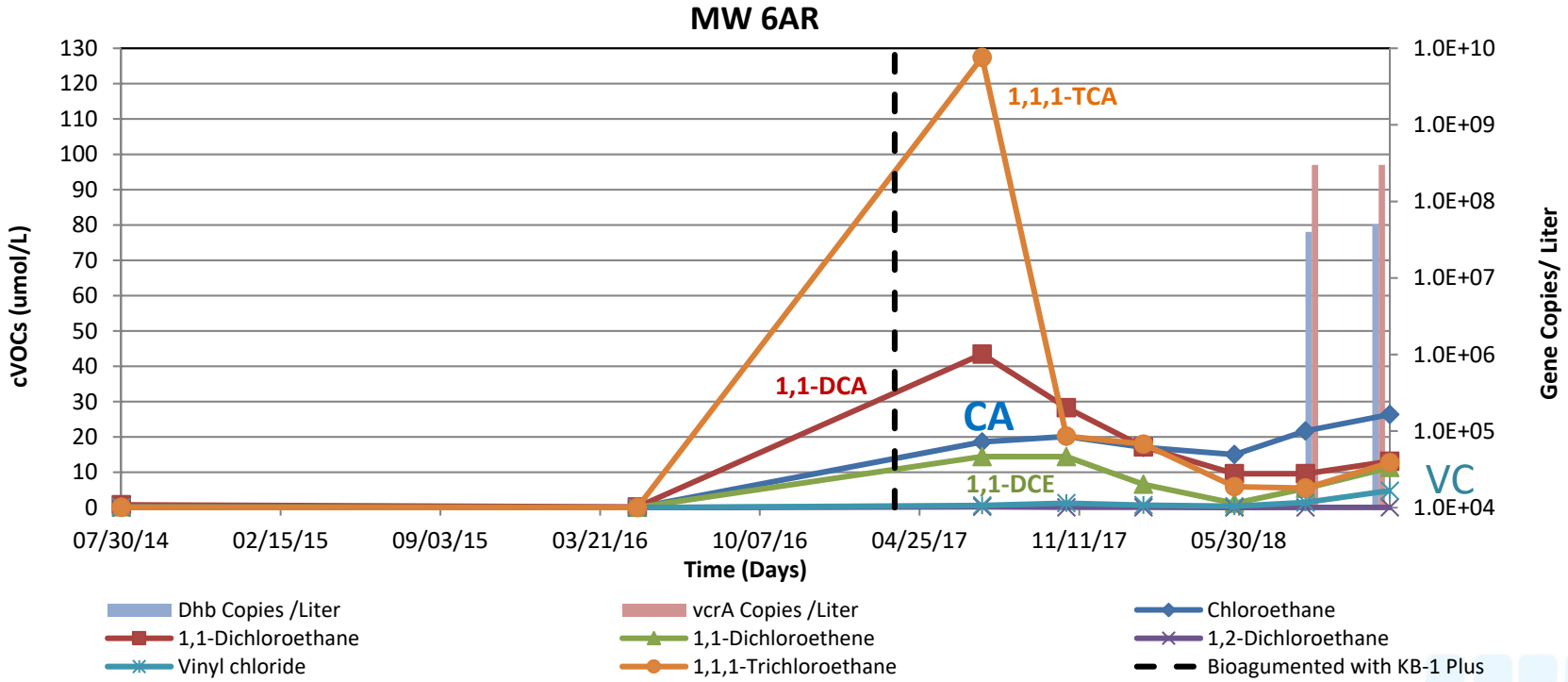
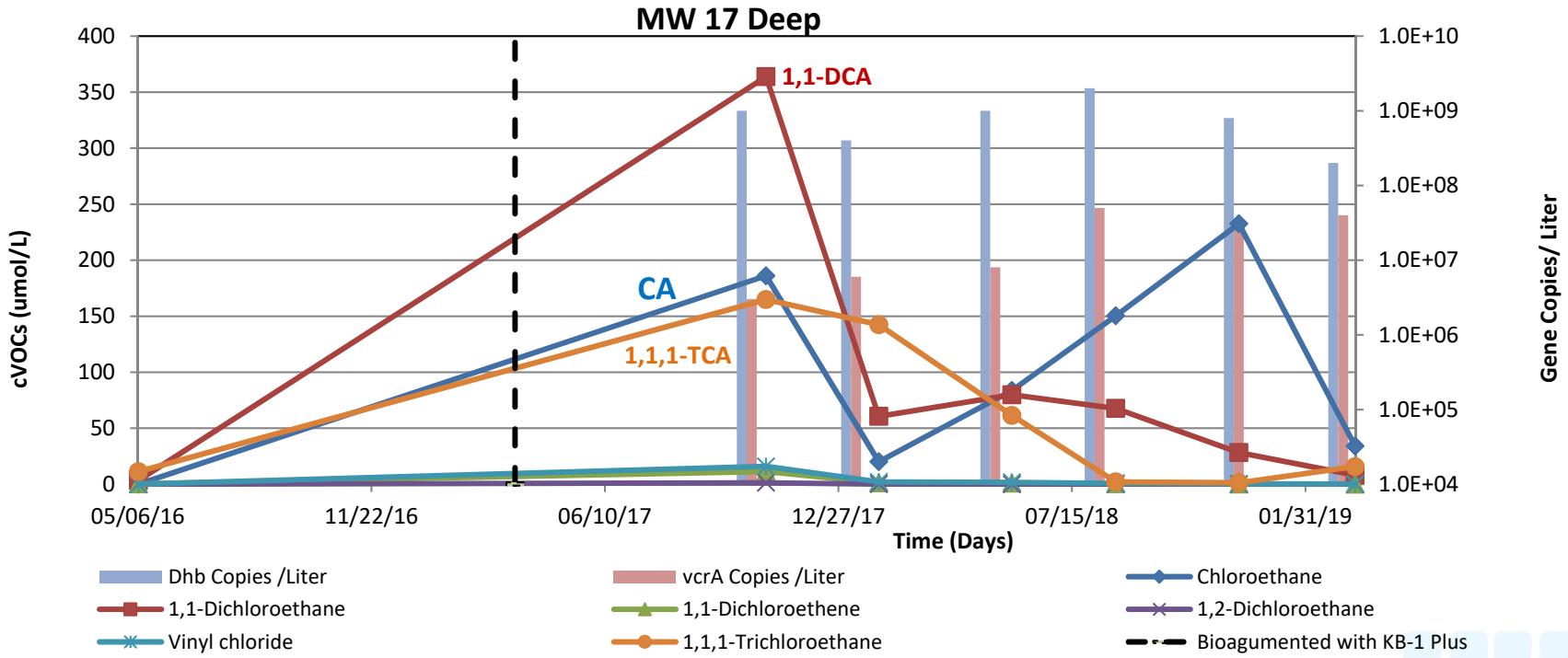


Field Scale Remediation: NJ Site



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

Summary and Future Work

- Additional delineation in bedrock confirmed no vertical migration into the bedrock
- Sub slab and indoor air sampling indicated no VOCs above standards
- Quarterly monitoring continuing for at least the next year
- After cVOCs are remediated may switch to aerobic system to treat benzene/xylenes

Questions

Further Information

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