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Biotic, Abiotic and Adsorption Source Area Treatment Pilot Tests of Dissolved Chlorinated Ethenes

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PRESENTATION OUTLINE

- Pilot Test Objectives
- Site Characterization Summary
- Mixing and Delivery System for the Amendment
- Implementation of the Pilot Tests
- Performance Monitoring Results
- Conclusions

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Pilot Test Objectives

- Inject three different amendment into the saturated zone in the former degreaser area
- Evaluate TCE, Cis-DCE, and VC reduction capabilities of the three different amendments for Full-Scale Design below vapor intrusion applicable criteria
- Collect data required to complete a Full-Scale Design for the Site

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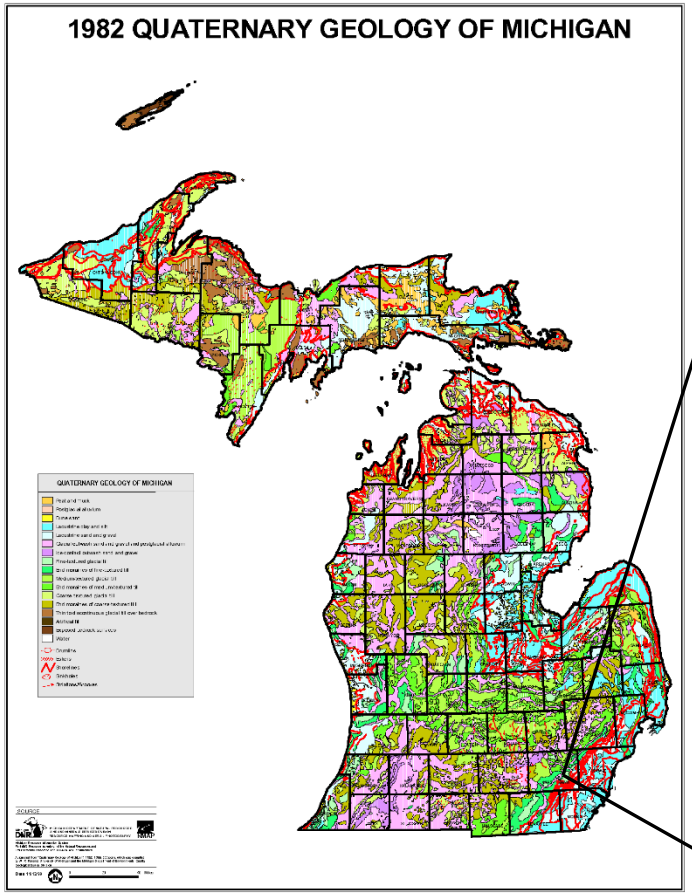
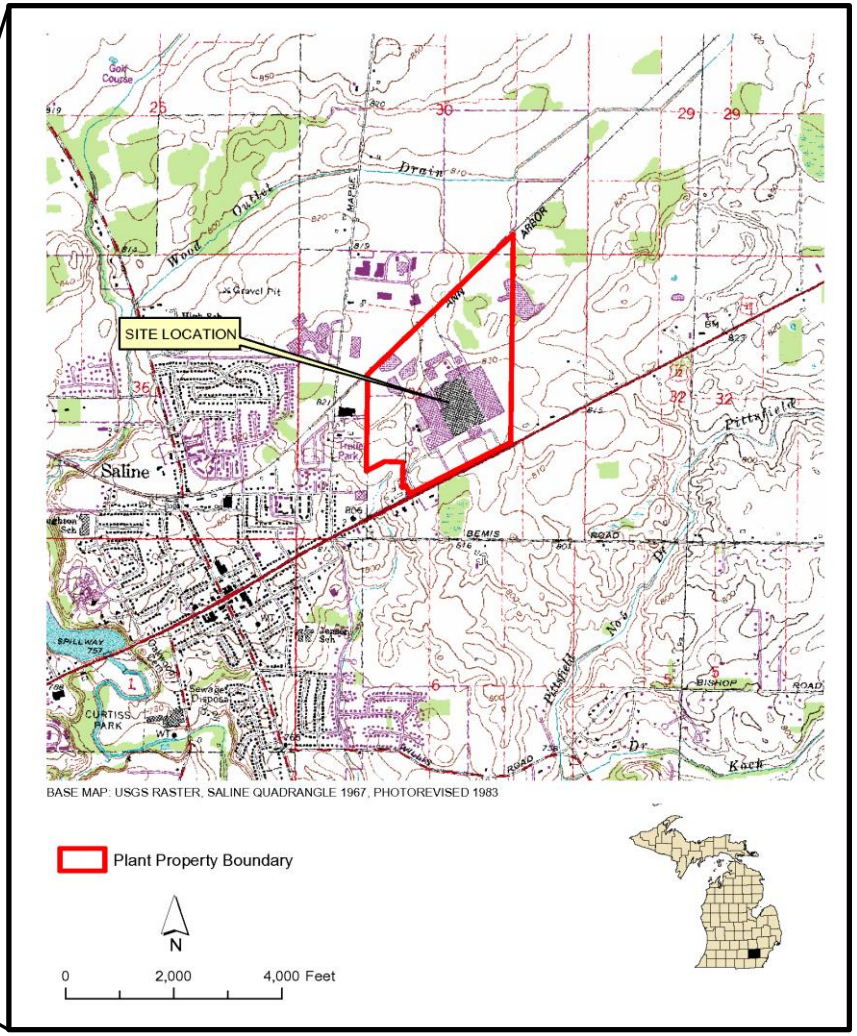
Site Characterization Summary

- The Site is a active manufacturing facility
- The Pilot Test area is located around a former degreaser UST
- Former Interim Actions included; EOS injection through a vertical well, SVE/AS with horizontal wells
- Current Interim Actions included SVE and the three Pilot Tests
- Highest TCE Concentration at Baseline was 21,000 µg/L
- DHC and anaerobic conditions are present in the pilot test area at Baseline

Site Characterization

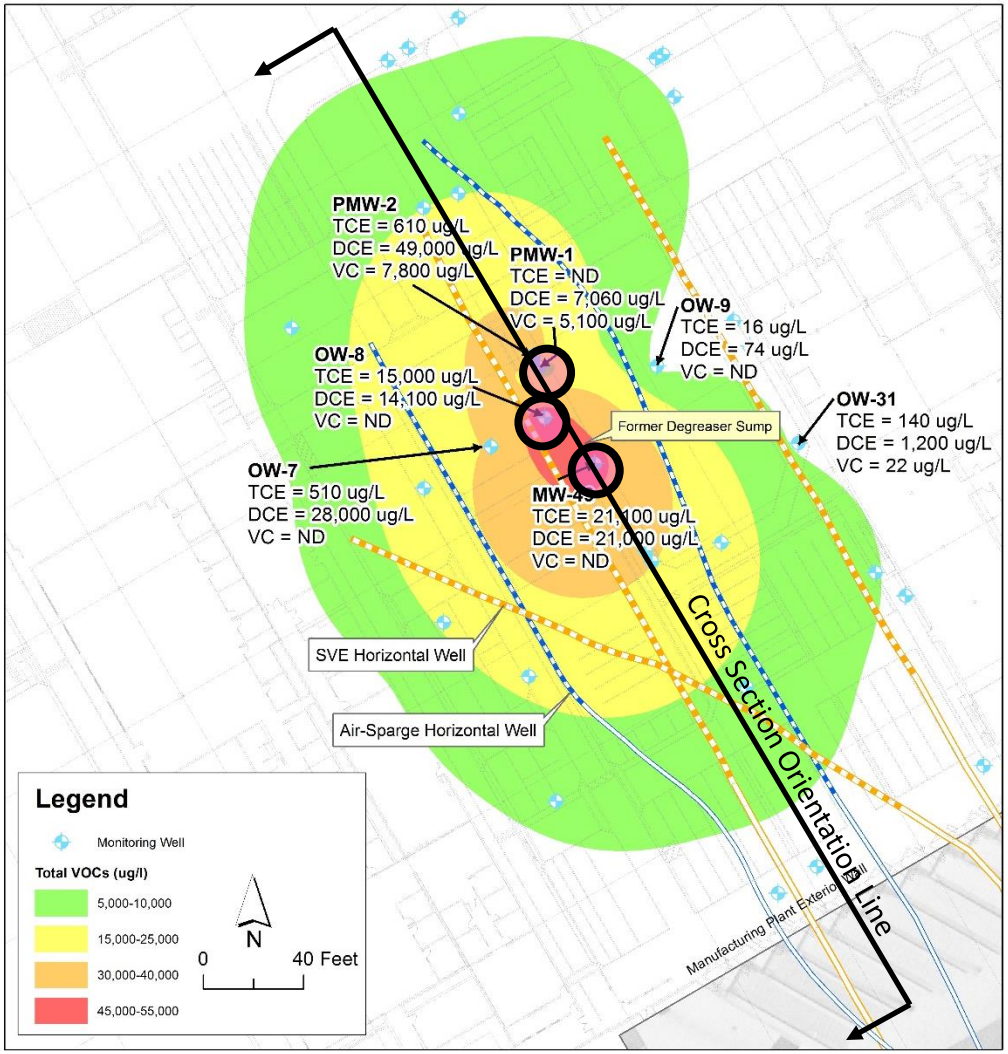
Pilot Test Geology and Location





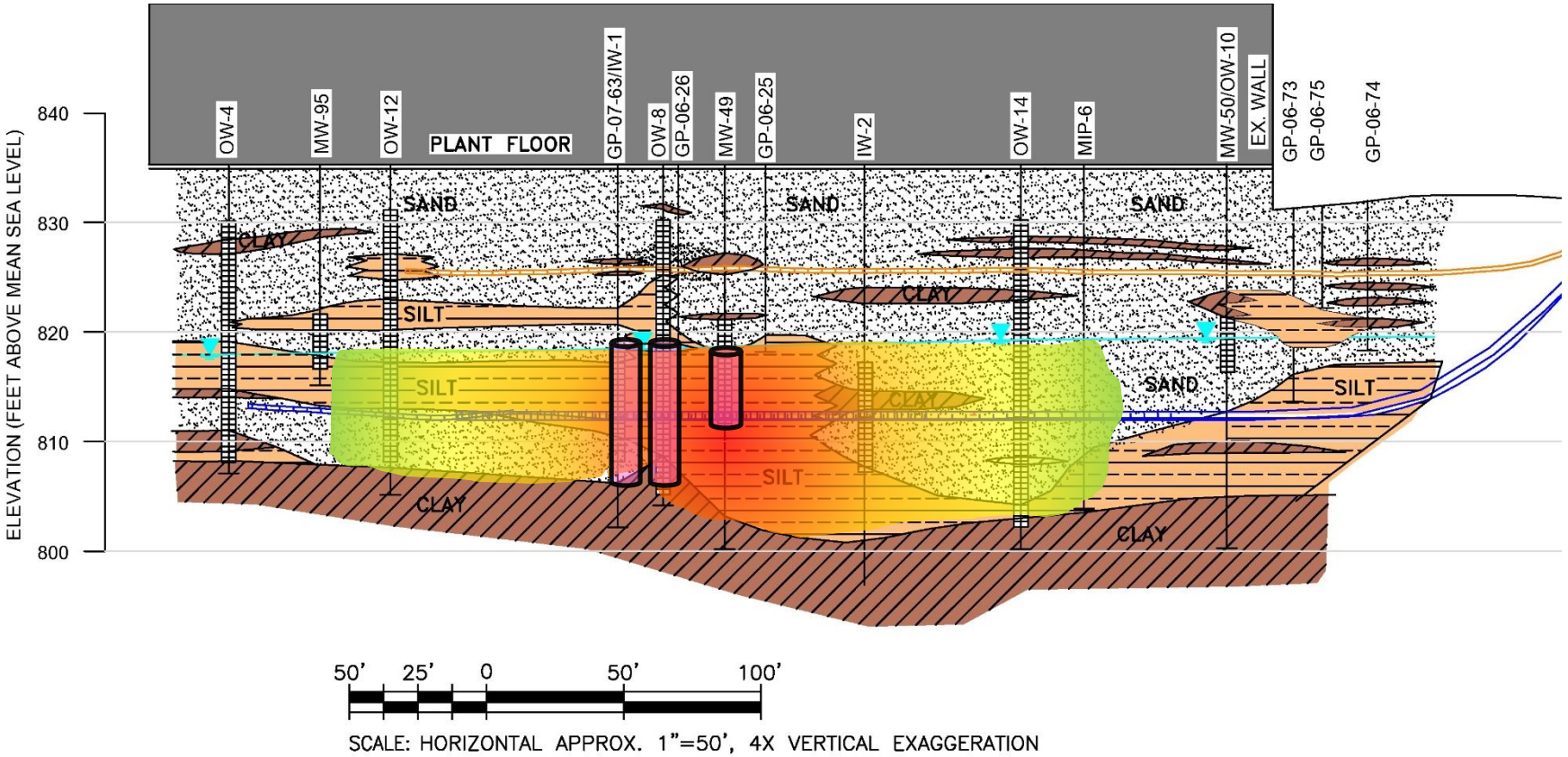
Site Characterization

2015 Baseline cVOCs



Site Characterization

Cross Section



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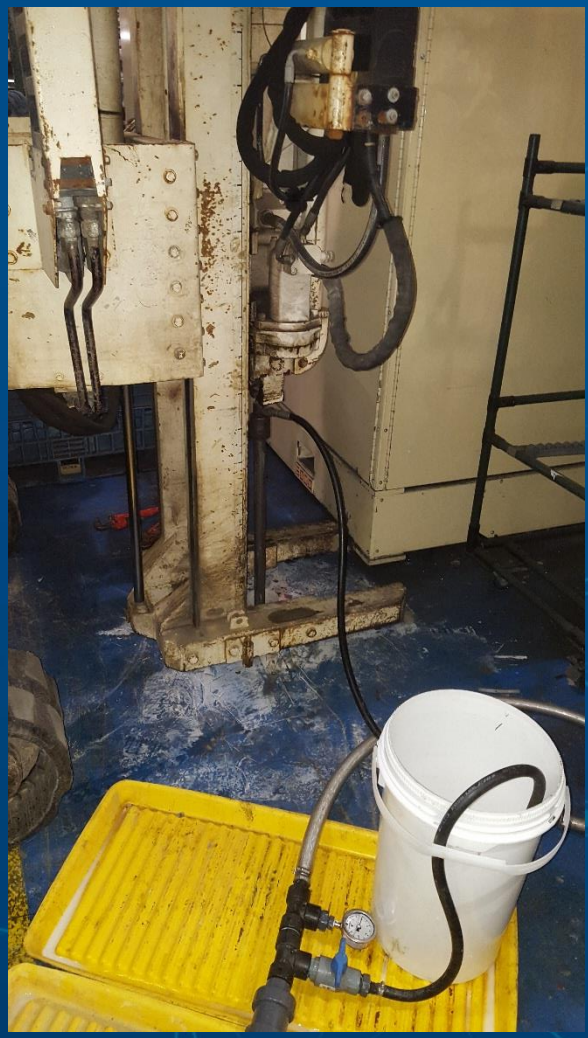
Mixing and Delivery System for the Amendment

- EOS amendment contains soybean oil and emulsifiers
  - Emulsified Vegetable Oil (EVO) promotes biotic degradation
- ABC+ amendment contains lactates, fatty acids, alcohols and a phosphate buffer with zero-valent iron
  - lactates, fatty acids, alcohols and a phosphate buffer promotes biotic degradation
  - Zero-valent iron promotes abiotic degradation
- BAM amendment contains adsorbent carbon media
  - Micron scale activated carbon promotes adsorption onto the its surface



Mixing and Delivery System for the Amendment

- Amendment was mixed in batches to the following specifications:
  - EOS; 420 lbs in 550 gallons at an average of 10 % solution
  - ABC+; 1000 lbs in 720 gallons at an average of 16 % solution
  - BAM; 320 lbs in 600 gallons at an average of 29 % solution
- Stainless Steel mixer was used to continuously mix amendments
- Diaphragm pump was used to deliver the amendments

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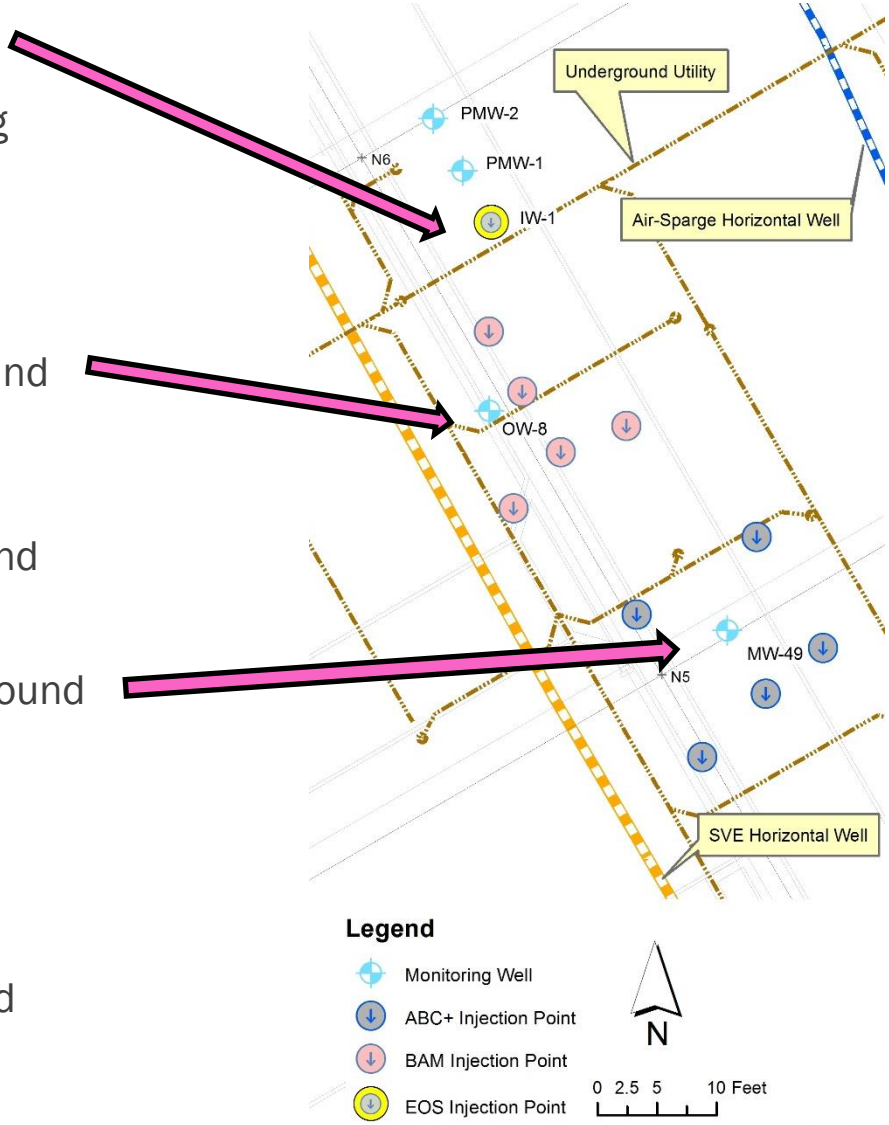
Implementation of the Pilot Tests

- Target injection interval was 17 to 27 feet bgs
- Injection Points (IPs) were completed at 2 foot lifts from bottom to top
- Eight IPs were proposed around each well
- Due to daylighting concentrations were increased and volumes were decreased at all injections
- Injections were completed in two days

Implementation of the Pilot Tests

- Injected 420 lbs of the EOS into IW-1
  - 16 gpm at 6.3 psi during injection
  - 50 gal of chase water
  - 10 % solution
- Injected 320 lbs of the BAM around OW-8 into 5 IPs
  - 4 gpm at 35 psi during injection
  - 18% solution for 2 IPs and 36% solution for 3 IPs
- Injected 1000 lbs of the ABC+ around MW-49 into 5 IPs
  - 8 gpm at 16 psi during injections
  - 100 lbs of ZVI
  - 900 lbs of ABC
  - 10% solution for 2 IP and 20% solution for 3 IPs



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Performance Monitoring Results

- Three quarterly post-injection performance monitoring events were completed
- Laboratory analysis included volatile organic compounds, ethene, ethane, and methane, total organic carbon, sulfate, nitrate, volatile fatty acids, and dissolved iron
- Field geochemical parameters included; oxygen reduction potential, dissolved oxygen, pH, and specific conductance

Performance Monitoring Results

EOS					
		Baseline	Post Injection		
PMW-1	units	2/5/15	10/5/16	1/5/17	4/5/17
TOC	mg/L	28	1,500	1,100	680
ORP	mV	-264	-83	-59	-92
Dissolved Oxygen	mg/L	0.20	0.34	0.28	0.44
Nitrate	mg/L	ND	ND	ND	ND
Dissolved Iron	mg/L	na	81	69	69
Sulfate	mg/L	10	7.5	ND	5.0
pH	SU	6.95	5.99	6.29	5.51
Specific Cond.	mS/cm	10.46	7.30	10.71	10.41
VFAs	mg/L	69	1,860	1,010	1,010

BAM					
		Baseline	Post Injection		
OW-8	units	2/6/15	10/5/16	1/5/17	4/5/17
TOC	mg/L	1.4	45	32	15
ORP	mV	-27	-241	-215	-220
Dissolved Oxygen	mg/L	0.24	0.21	0.19	0.47
Nitrate	mg/L	ND	ND	ND	ND
Dissolved Iron	mg/L	na	12	7.9	2.8
Sulfate	mg/L	240	140	130	160
pH	SU	6.78	6.73	6.77	6.24
Specific Cond.	mS/cm	12.61	10.78	12.39	11.32
VFA	mg/L	na	83	54	21

EOS					
		Baseline	Post Injection		
PMW-2	units	2/5/15	10/5/16	1/5/17	4/5/17
TOC	mg/L	1.6	1.6	2.1	17.0
ORP	mV	-96	-86	-60	-104
Dissolved Oxygen	mg/L	0.22	0.46	0.19	0.44
Nitrate	mg/L	ND	ND	ND	ND
Dissolved Iron	mg/L	na	8.2	5.5	18
Sulfate	mg/L	150	150	94	13
pH	SU	6.66	6.73	6.87	5.76
Specific Cond.	mS/cm	9.62	10.42	11.99	10.99
VFAs	mg/L	ND	340	ND	35

ABC+					
		Baseline	Post Injection		
MW-49	units	2/5/15	10/5/16	1/5/17	4/5/17
TOC	mg/L	1.8	3,000	2,700	1,800
ORP	mV	-28	-85	-24	-86
Dissolved Oxygen	mg/L	0.29	0.26	0.30	0.45
Nitrate	mg/L	660	ND	ND	ND
Dissolved Iron	mg/L	na	490	440	430
Sulfate	mg/L	380	28	ND	42
pH	SU	6.65	5.95	5.81	5.38
Specific Cond.	mS/cm	8.41	8.92	10.93	9.59
VFAs	mg/L	na	3,613	4,500	2,940

Performance Monitoring Results

EOS					
		Baseline	Post Injection		
PMW-1		2/5/15	10/5/16	1/5/17	4/5/17
PCE	(ug/L)	ND	ND	ND	ND
TCE	(ug/L)	ND	ND	1.4	ND
cis-DCE	(ug/L)	6,900	59	37	17
VC	(ug/L)	5,100	240	140	79
Ethene	(ug/L)	na	300	170	130
Methane	(ug/L)	na	4,400	3,700	1,600
DHC	(cells/mL)	5.06.E+07	6.12.E+06	4.31.E+05	1.32.E+05

BAM					
		Baseline	Post Injection		
OW-8		2/6/15	10/5/16	1/5/17	4/5/17
PCE	(ug/L)	ND	ND	ND	ND
TCE	(ug/L)	15,000	3,500	1,400	790
cis-DCE	(ug/L)	9,800	49,000	31,000	42,000
VC	(ug/L)	ND	ND	ND	600
Ethene	(ug/L)	na	13	17	48
Methane	(ug/L)	na	130	650	520
DHC	(cells/mL)	3.55.E+03	6.00.E+00	5.29.E+02	2.98.E+04

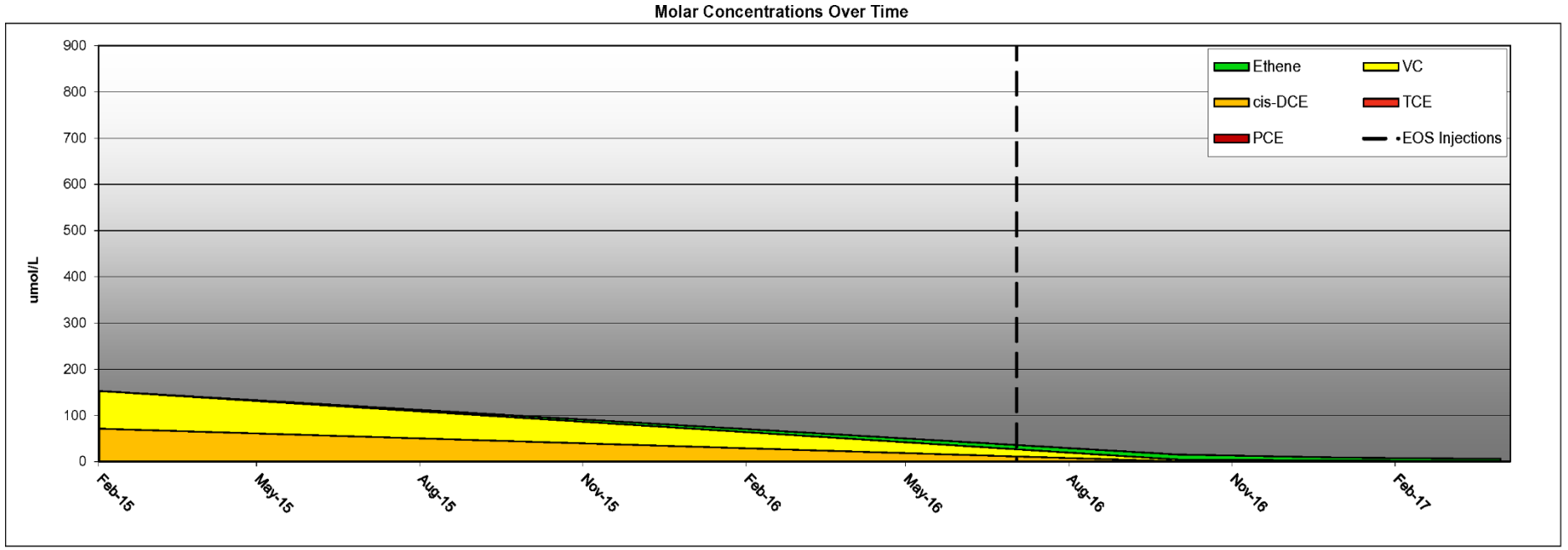
EOS					
		Baseline	Post Injection		
PMW-2		2/5/15	10/5/16	1/5/17	4/5/17
PCE	(ug/L)	ND	ND	ND	ND
TCE	(ug/L)	610	710	ND	ND
cis-DCE	(ug/L)	49,000	29,000	34,000	29,000
VC	(ug/L)	7,800	8,500	7,800	14,000
Ethene	(ug/L)	na	1,800	1,400	910
Methane	(ug/L)	na	5,500	5,200	3,400
DHC	(cells/mL)	1.46.E+06	1.73.E+06	2.78.E+06	7.34.E+06

ABC+					
		Baseline	Post Injection		
MW-49		2/5/15	10/5/16	1/5/17	4/5/17
PCE	(ug/L)	ND	ND	ND	ND
TCE	(ug/L)	21,000	3,100	320	ND
cis-DCE	(ug/L)	21,000	50,000	68,000	1,600
VC	(ug/L)	ND	ND	9,700	22,000
Ethene	(ug/L)	na	11	210	3,000
Methane	(ug/L)	na	8.1	1,300	2,300
DHC	(cells/mL)	2.50E+02	3.60E+00	2.17E+05	1.65E+07

Performance Monitoring Results

EOS

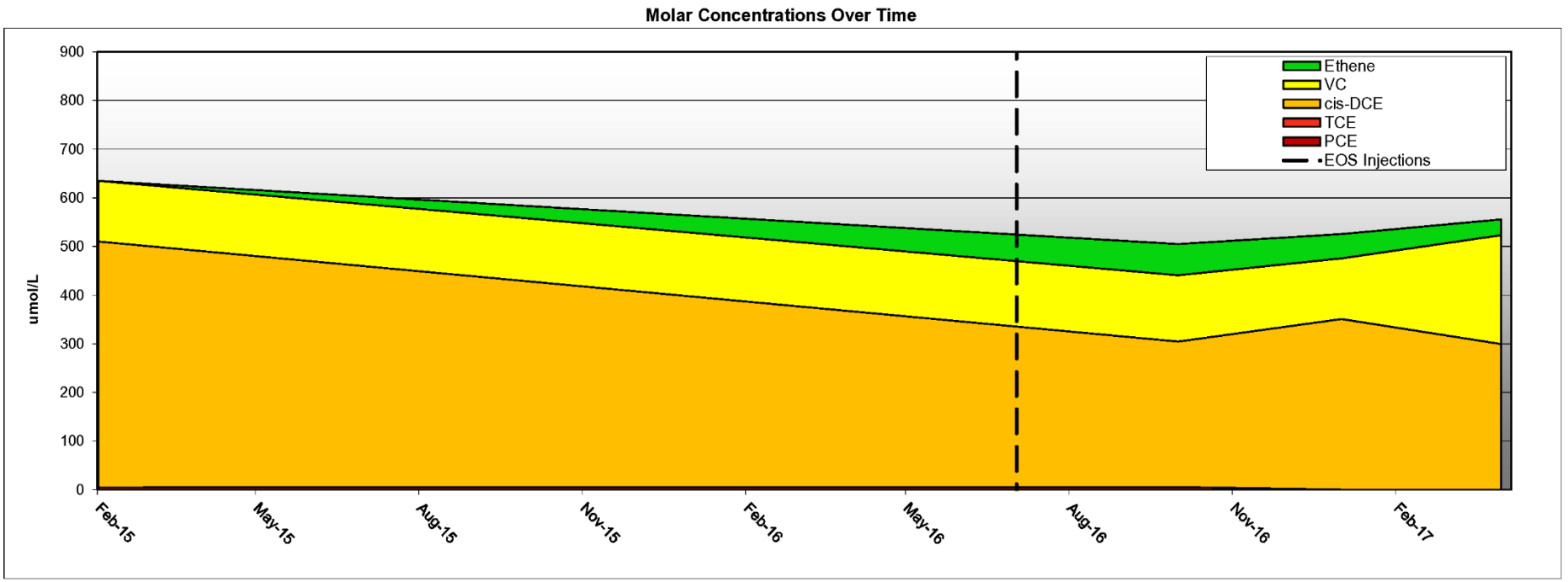
PMW-1



Performance Monitoring Results

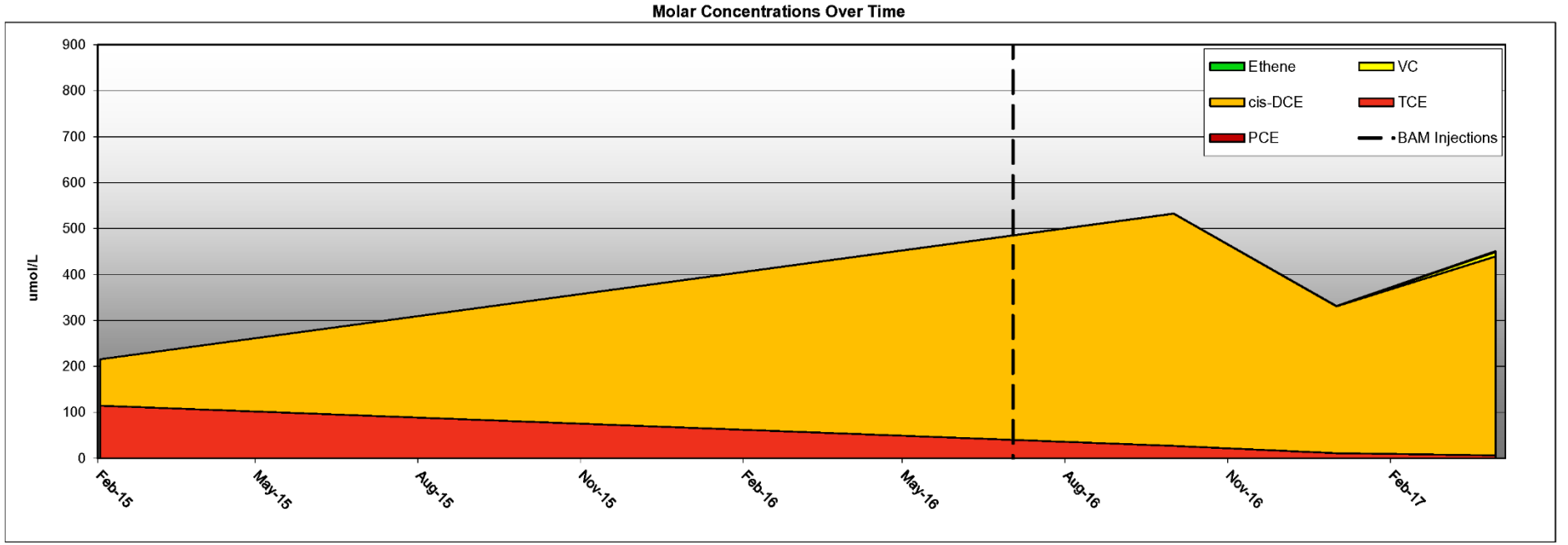
EOS

PMW-2



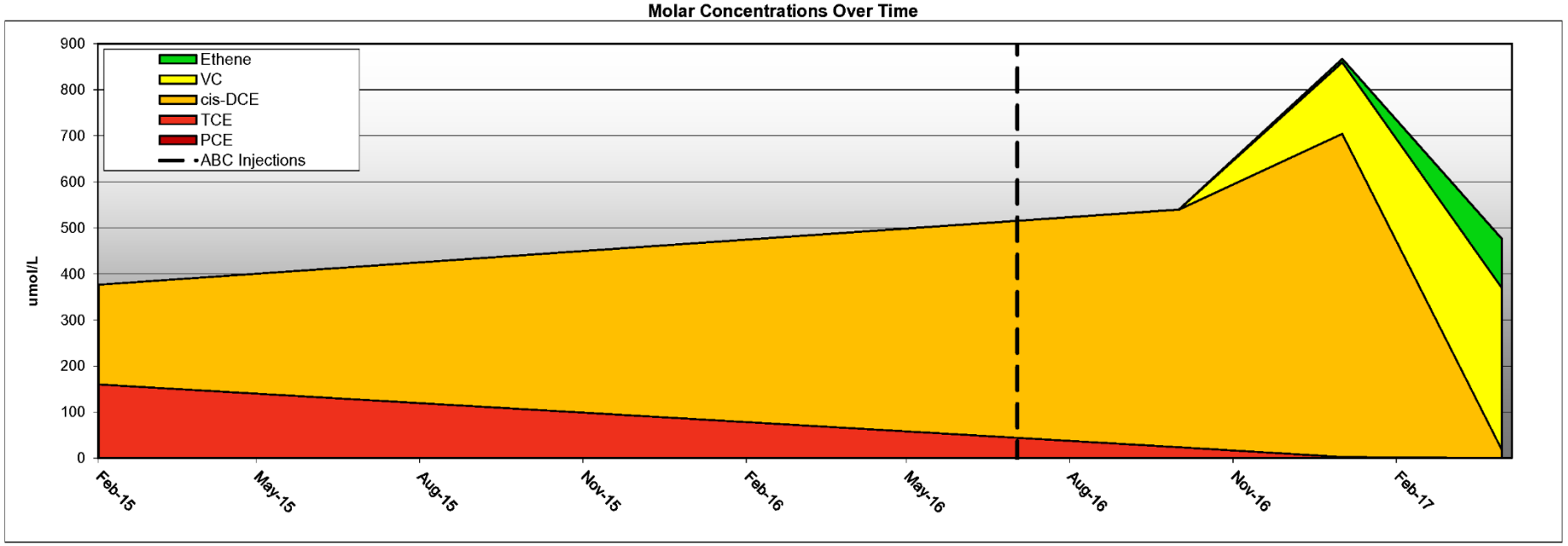
Performance Monitoring Results

BAM
OW-8



Performance Monitoring Results

ABC+
MW-49



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Conclusions

- Successfully injected all amendment into the target intervals
- Field observations and VFA indicated 12 to 20 foot radius of influence
- Post-injection cVOC analytical results indicate the amendment injections were successful in abiotic and biotic reductive dechlorination and adsorption
- Post-injection geochemical results indicate favorable reduced conditions for enhanced complete reductive dechlorination

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Conclusions

- Post-injection DHC results indicate favorable conditions for complete reductive dechlorination
- TCE has shown a substantial decrease in all monitoring wells with daughter products cis-1,2-DCE and VC increasing indicating biotic reductive dechlorination
- ABC^{+} reduced cVOC concentration at a faster rate than EOS and BAM

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Thank You!

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