



Case Study: When In-Situ Technologies Fail



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Vertex Environmental Inc.

SMART Remediation
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Vertex Environmental Inc.



Case Study: When In-Situ Techniques Fail

March 2020

Kevin French, B.A.Sc., P.Eng.

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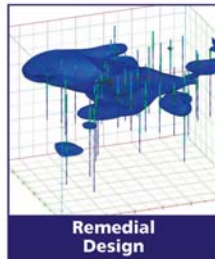
Outline

- Introduction
- How Can In-Situ Fail?
- Site Background
- Remediation
 - Colloidal Activated Carbon
 - Chemical Oxidation
 - Powdered Activated Carbon
- Lessons Learned
- Questions



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Vertex Environmental Inc. Specialized Contractors

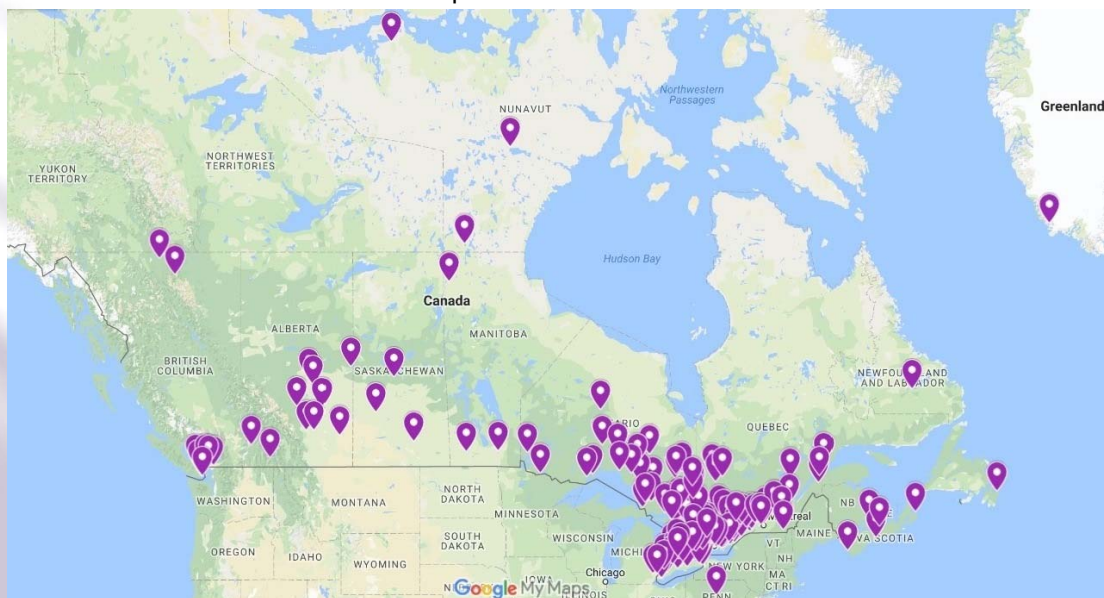


- Kevin French, P.Eng.
 - University of Waterloo
 - 30+ Years Environmental Consulting & Contracting
- Vertex founded in 2003
 - Specialized Environmental Remediation Contracting Firm
 - In-Situ & Ex-Site Remediation
 - High Resolution Site Characterization (HRSC)
 - Vapour & Water Treatment Systems



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Vertex Environmental Inc. Specialized Contractors



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How Can In-Situ Fail?

There are many ways that in-situ remediation technologies can fail:

- Contaminant Concentration / Distribution (LNAPL, etc.)
- Wrong Technology / Order of Application
- Under-Dosing the Amendment
- Poor Contact / Distribution in the Subsurface
- Baseline Geochemistry
- Age of Contamination
- Soil / Bedrock Characteristics
- Groundwater Flow Velocity
- Seasonal Water Table Fluctuations
- Etc.



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Background – The Situation

- Confidential Site
- Large REIT (real estate investment trust) purchasing portions of a block in large Canadian city. This Site was the key corner lot.
- Former gas station:
 - Operating 50+ years (1930s to 1980s)
 - At least 3 former USTs noted on Fire Insurance Plans
 - Late 1960s due to road widening, USTs and pump island relocated on Site
- Petroleum Hydrocarbon (PHC) contamination
- Full remediation in future (redevelopment of whole block)
- Short term:
 - Coffee chain set to lease existing building
 - **Lease contract detailed no contamination to migrate off-site during lease timeframe**



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Background – The Situation

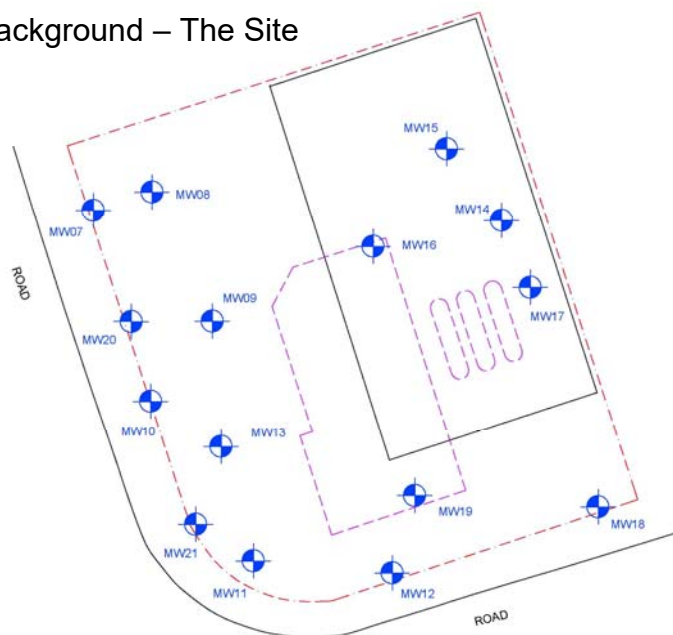


Large high rise condos are becoming common on major intersections in some Canadian cities.



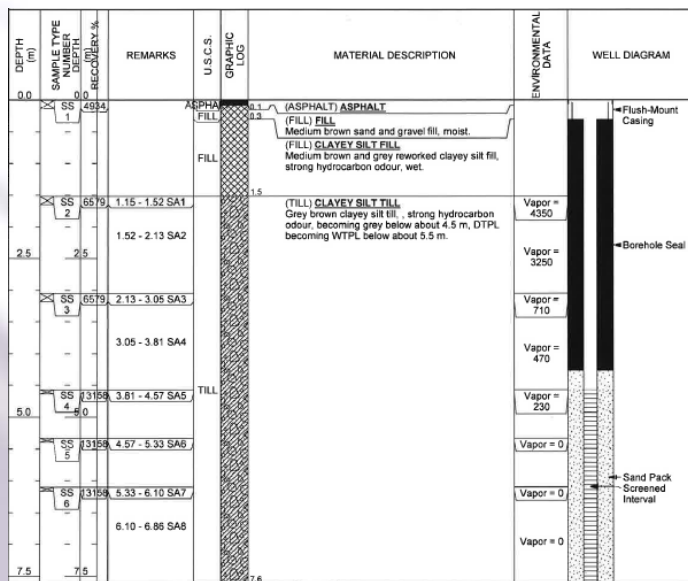
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Background – The Site



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Background – The Subsurface



- Soil:
 - Fill
 - Hard silty-clay till
 - Classified as fine grained
- Groundwater:
 - 5.2 to 5.9 m below grade
 - Flowing W, SW direction
- Contamination:
 - Mostly BTEX and F1 PHCs
 - Minor 12DCA
- Geochemistry:
 - Likely anaerobic



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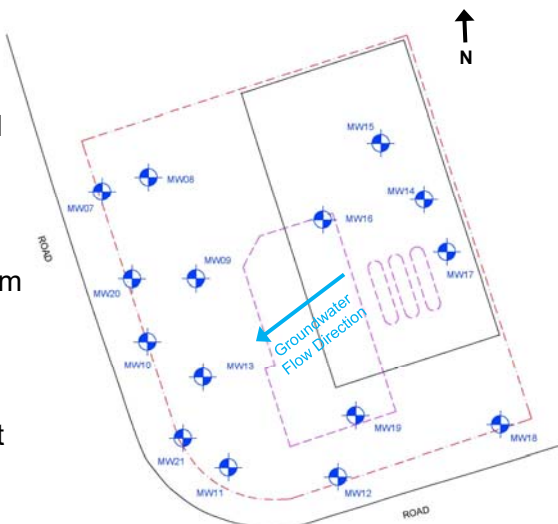
Background – The Subsurface

Comments in Phase II ESA (2017)

“On-site contamination appears to be located downgradient of the building” (no vapour intrusion issue)

“It is likely that soil and groundwater petroleum hydrocarbon impacts have moved off-Site to the west... and....southwest”

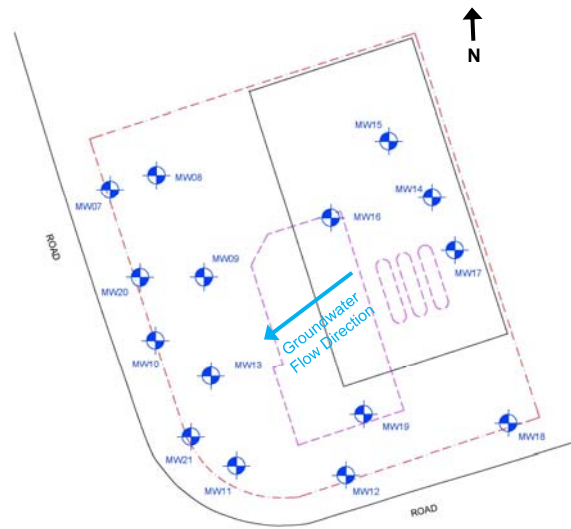
“Barrier options can be considered to prevent potential off-site movement of impacted groundwater.”



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Background – Remedial Recommendation

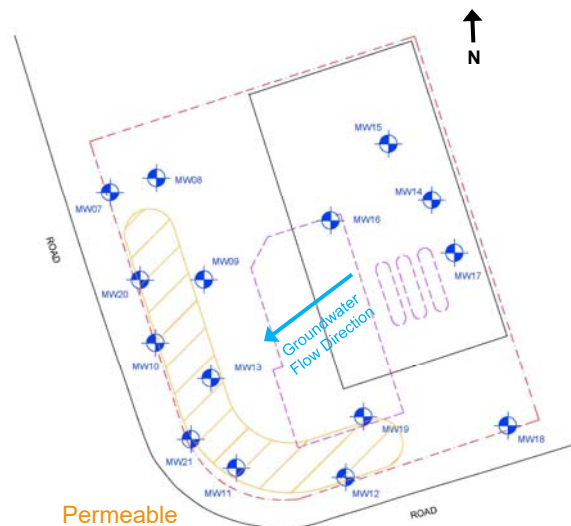
“Barrier options can be considered to prevent potential off-site movement of impacted groundwater.”



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Background – Remedial Recommendation

“Barrier options can be considered to prevent potential off-site movement of impacted groundwater.”

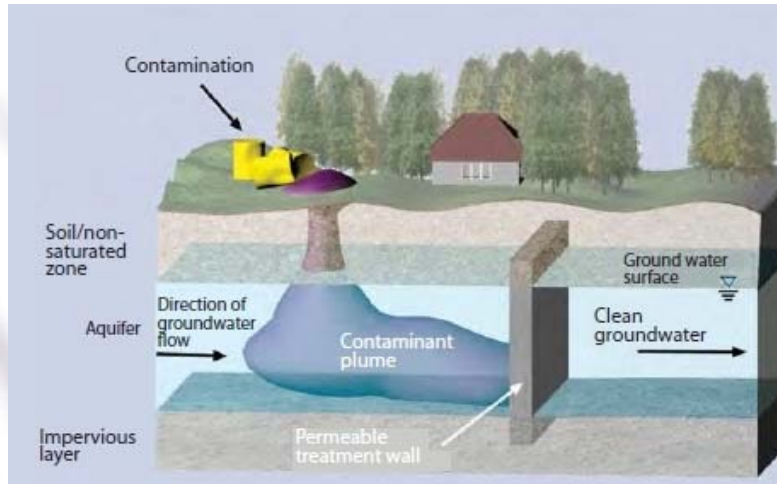


Permeable
Reactive Barrier
(PRB)



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Permeable Reactive Barrier (PRB)



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Background – Analytical

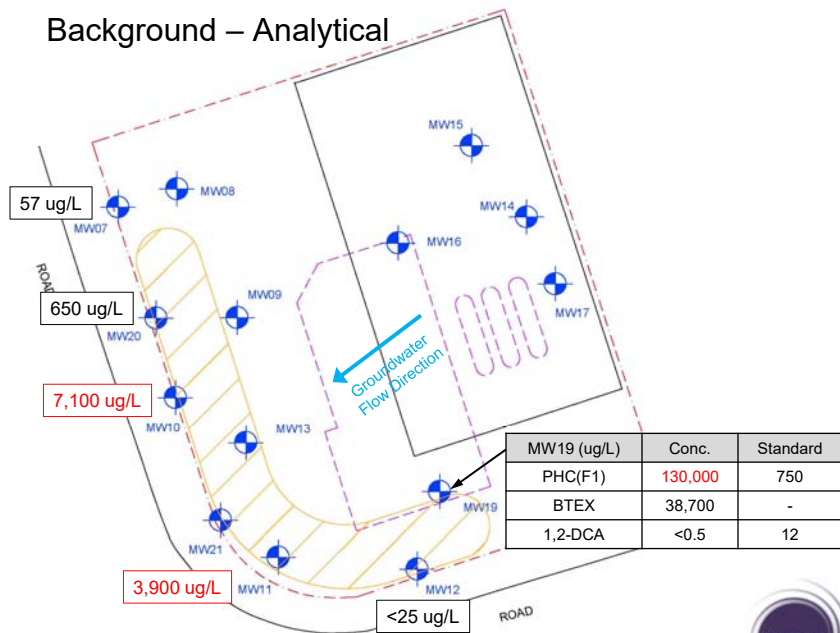
MW07 (ug/L)	Conc.	Standard
PHC(F1)	57	750
BTEX	14	-
1,2-DCA	<0.5	12

MW20 (ug/L)	Conc.	Standard
PHC(F1)	650	750
BTEX	650	-
1,2-DCA	<0.5	12

MW10 (ug/L)	Conc.	Standard
PHC(F1)	7,100	750
BTEX	4,100	-
1,2-DCA	15	12

MW11 (ug/L)	Conc.	Standard
PHC(F1)	3,900	750
BTEX	3,900	-
1,2-DCA	<4	12

MW12 (ug/L)	Conc.	Standard
PHC(F1)	<25	750
BTEX	<25	-
1,2-DCA	<0.5	12



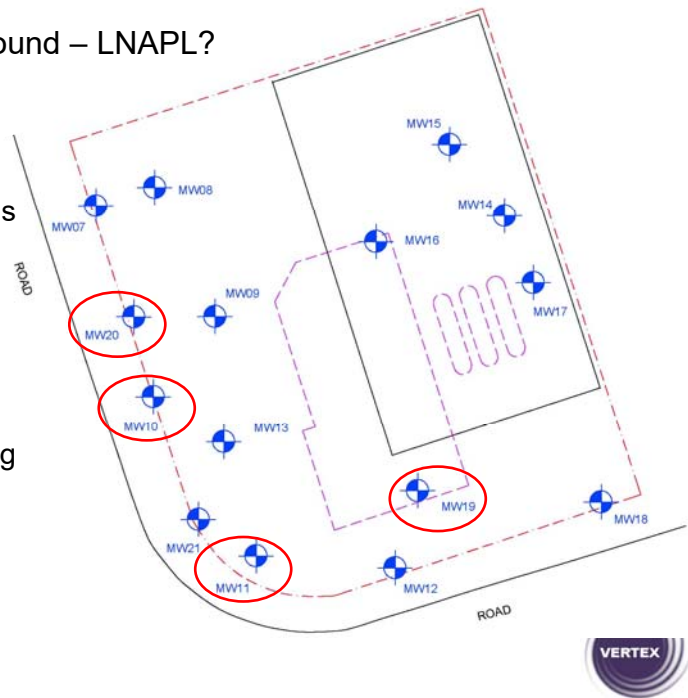
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Background – LNAPL?

Comment in Phase II ESA (2017)

“There was no measureable non-aqueous phase liquid detected in any of the groundwater monitoring wells, however, evidence of **liquid phase gasoline** was observed during the **drilling** in boreholes MW10, MW11, MW19 and MW20.”

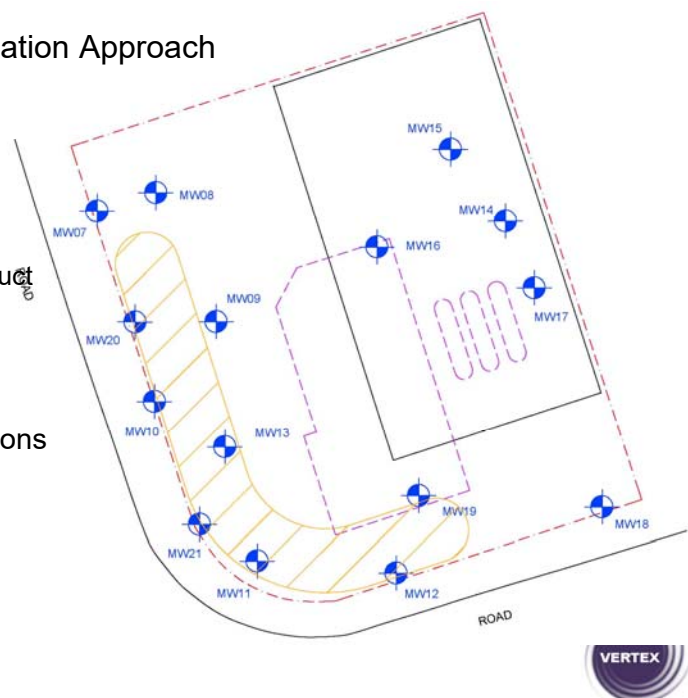
“It should be noted that during the purging of location MW19, **hydrocarbon product** was observed in the **purge water** and on the sample tubing.”



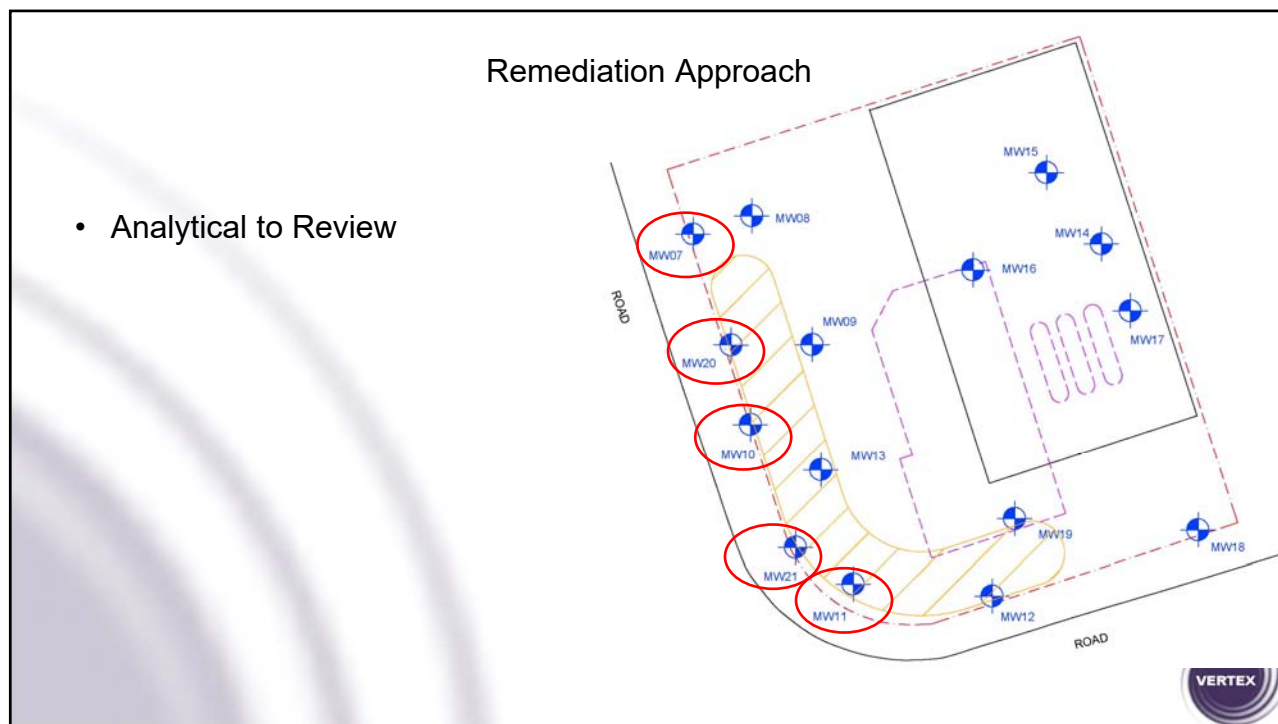
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Remediation Approach

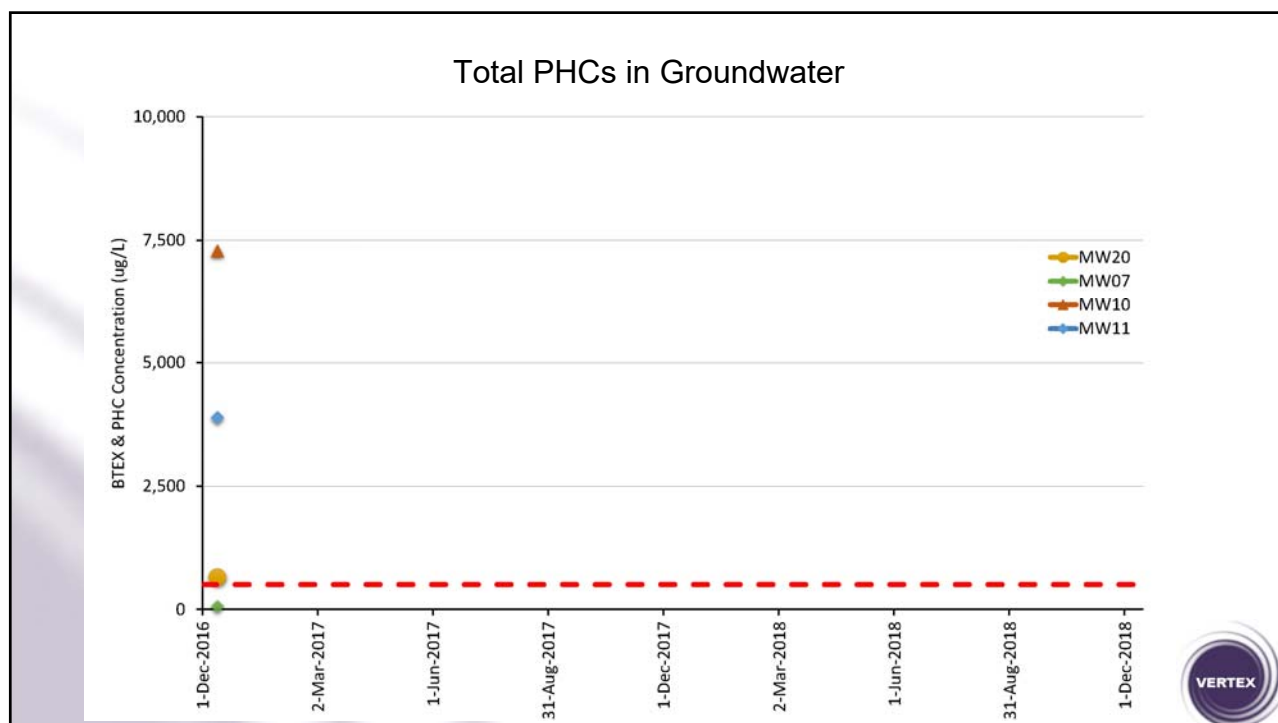
- Injected PRB
- Remedial Amendments:
 - Colloidal Activated Carbon (AC) Product
 - Oxygen Releasing Material (ORM)
- Design to treat to Generic Standards
- 24 m long by 3 m wide
- Twenty-four (24) Injection Point locations
 - Single line on a 1 m spacing
 - 3 discrete vertical intervals



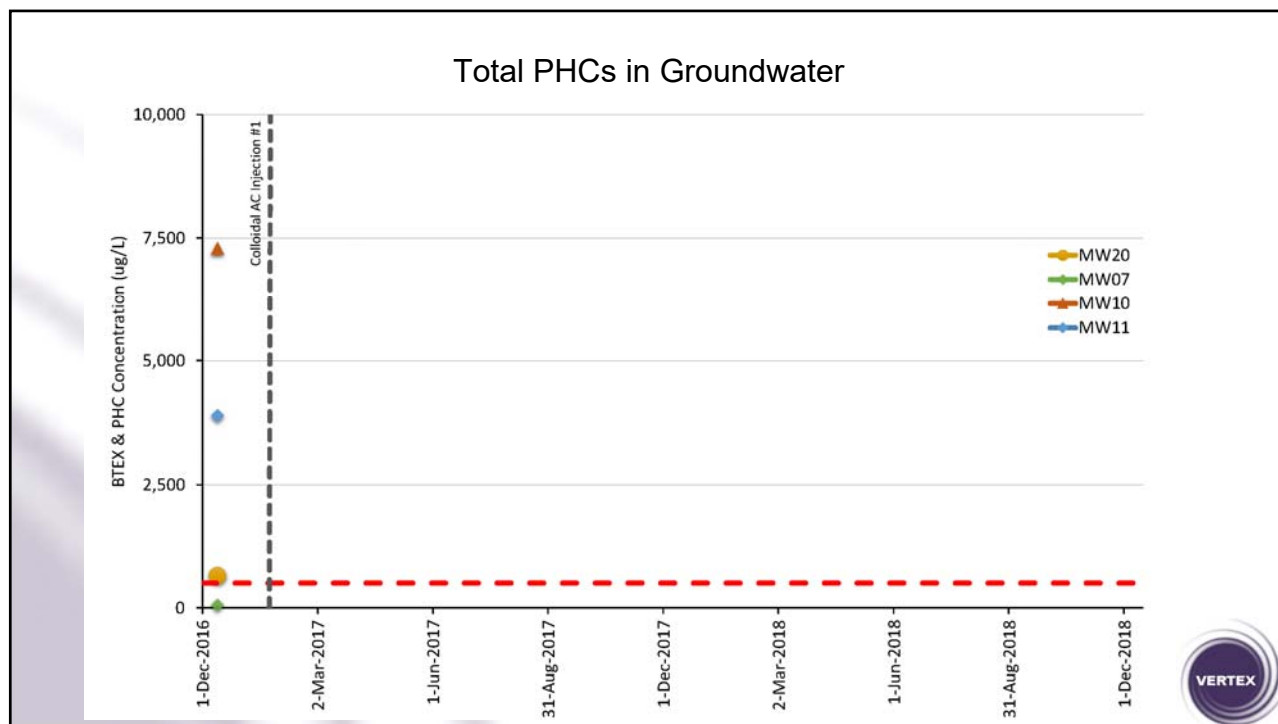
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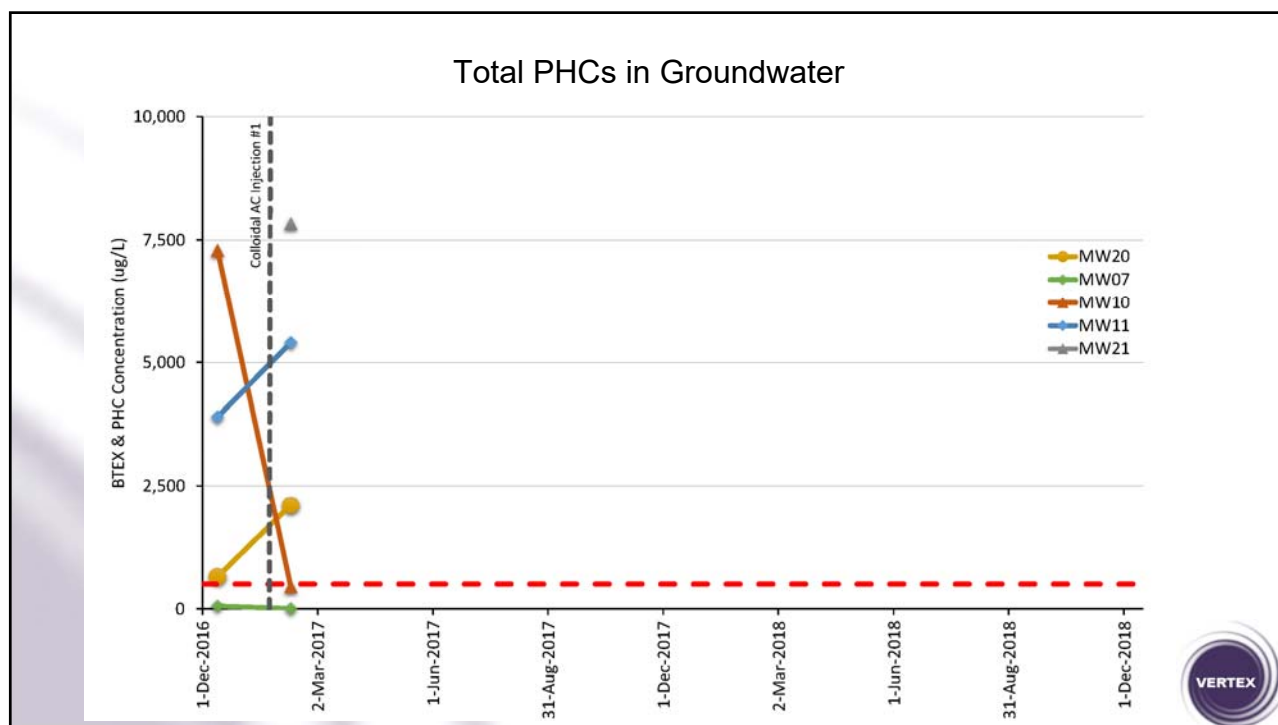
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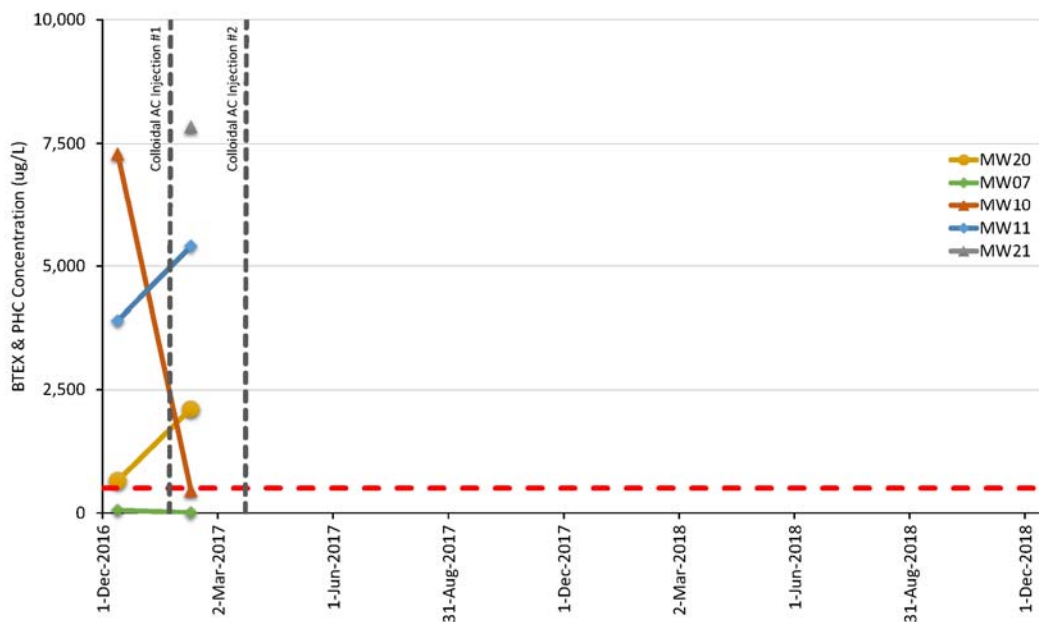
Remediation Approach

- Colloidal AC PRB Injection #1
- 24 m long by 3 m wide
- Twenty-four (24) Injection Point locations
 - Single line
 - 1 m spacing
 - 3 discrete vertical intervals
- Colloidal AC Product
 - Dilute Colloidal AC solution injected
 - Some ORM
- Colloidal AC PRB Injection #2
- 24 m long by 3 m wide
- Seventeen (17) Injection Point locations
 - Single line
 - 1.5 m spacing
 - 1 to 2 discrete vertical intervals
- Colloidal AC Product
 - Dilute Colloidal AC solution injected
 - Some ORM

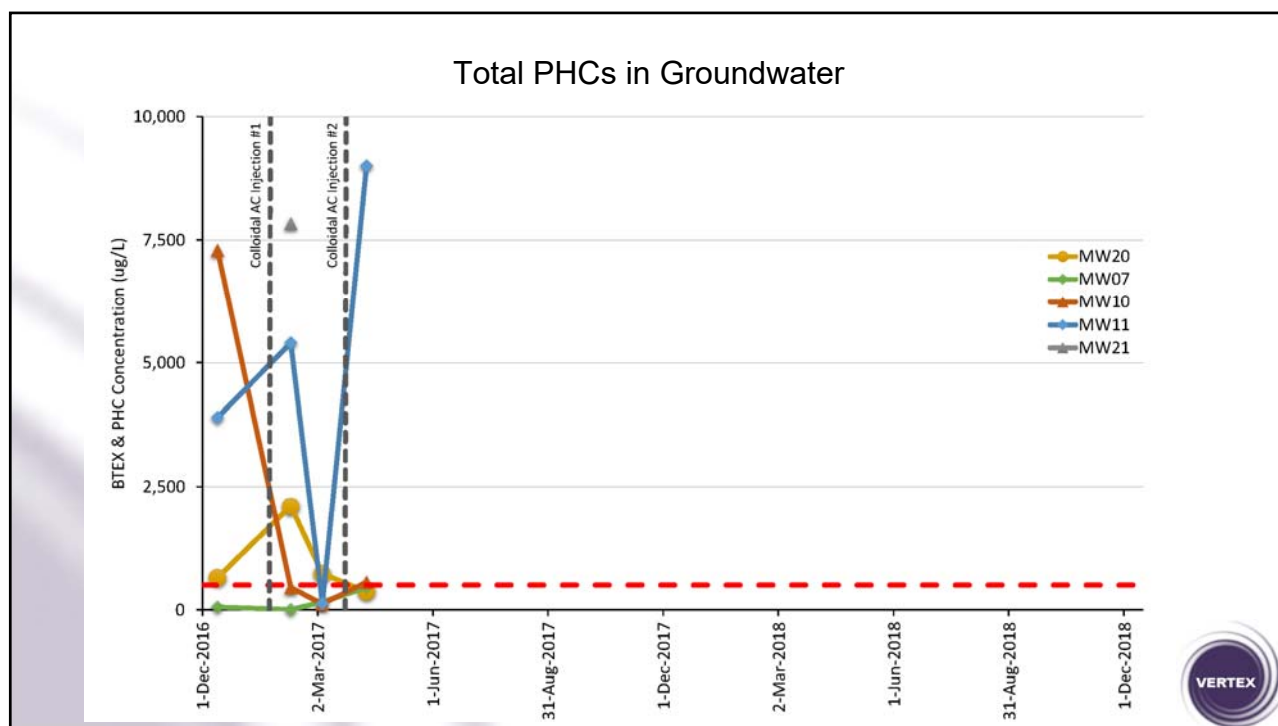


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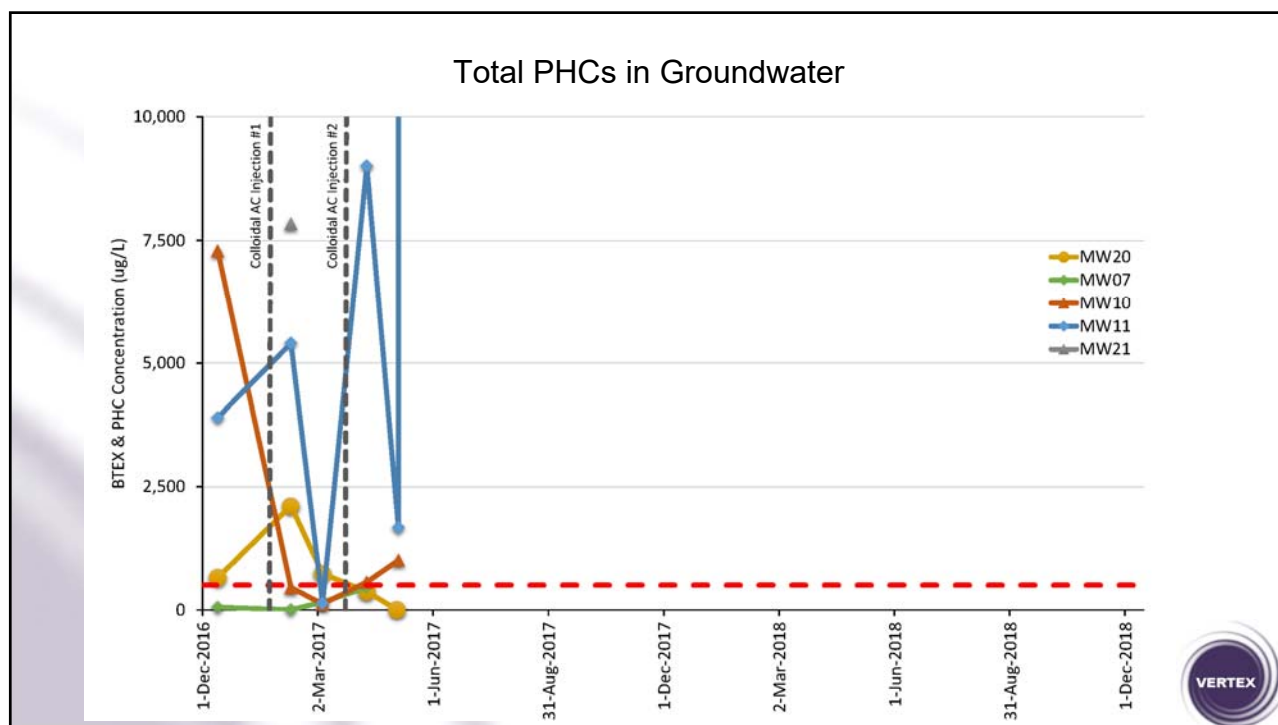
Total PHCs in Groundwater



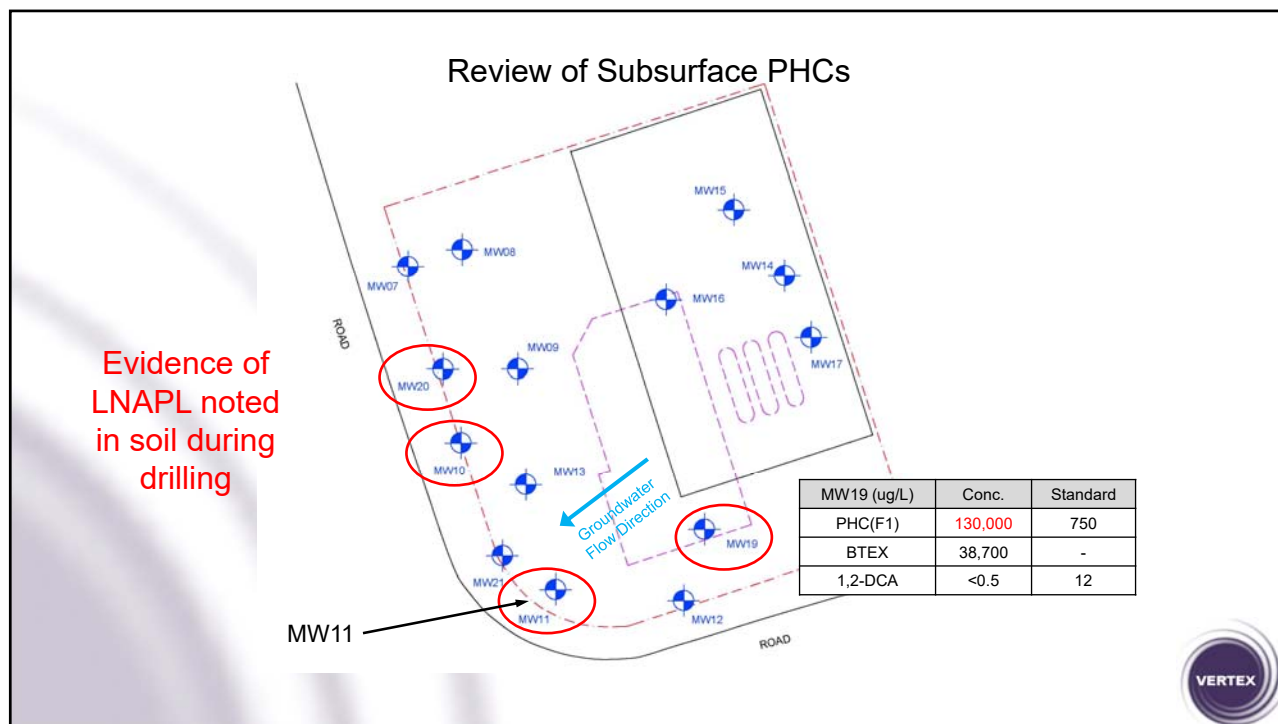
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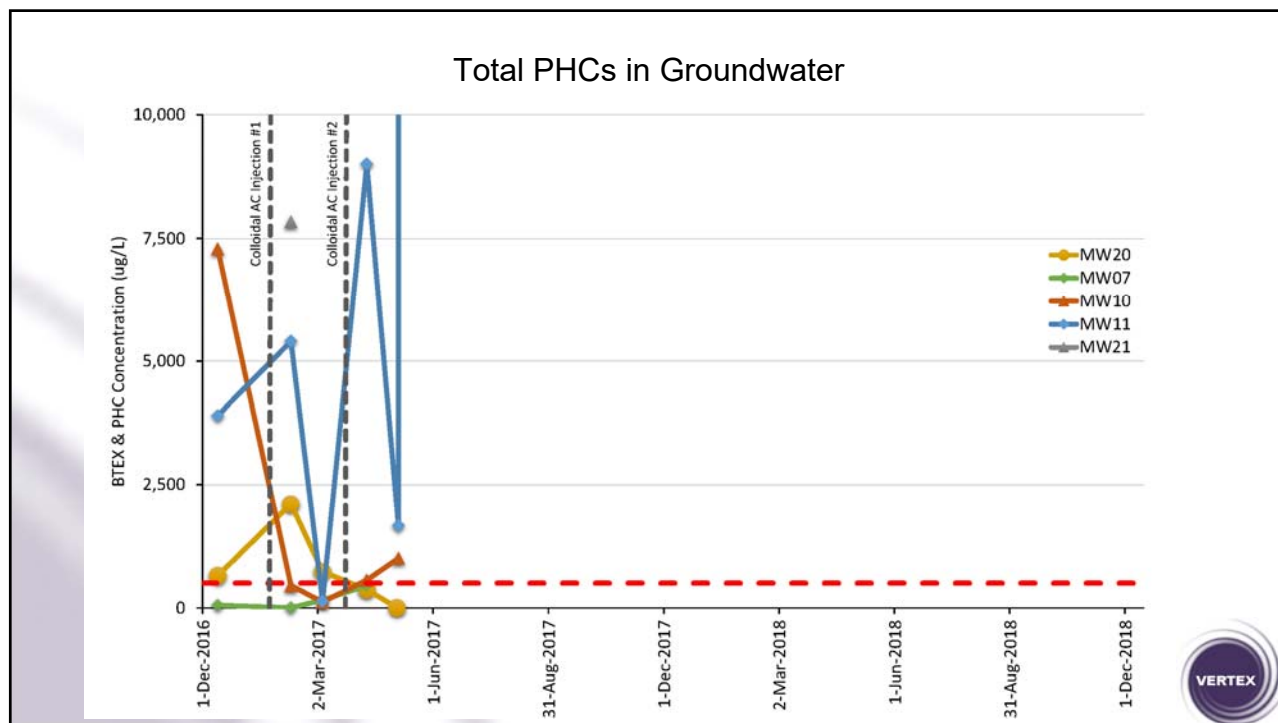
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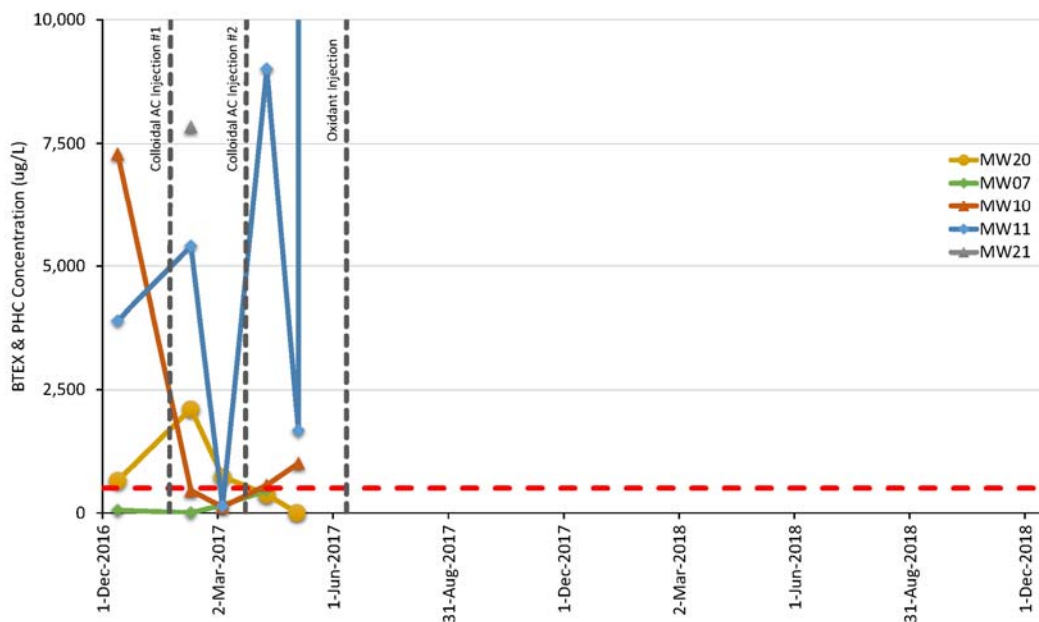
Remediation Approach

- | | | |
|--|---|---|
| <ul style="list-style-type: none"> • Colloidal AC PRB Injection #1 • 24 m long by 3 m wide • 24 Injection Points <ul style="list-style-type: none"> – Single line – 1 m spacing – 3 discrete vertical intervals • Colloidal AC Product <ul style="list-style-type: none"> – Dilute Colloidal AC solution – Some ORM | <ul style="list-style-type: none"> • Colloidal AC PRB Injection #2 • 24 m long by 3 m wide • 17 Injection Points <ul style="list-style-type: none"> – Single line – 1.5 m spacing – 1 to 2 discrete vertical intervals • Colloidal AC Product <ul style="list-style-type: none"> – Dilute Colloidal AC solution – Some ORM | <ul style="list-style-type: none"> • Oxidant Injection • Targeted (MW10, MW11) • 8 Injection Points <ul style="list-style-type: none"> – Single line – random spacing – 2 discrete vertical intervals • Sodium persulfate product <ul style="list-style-type: none"> – Oxidant solution – Some ORM |
|--|---|---|

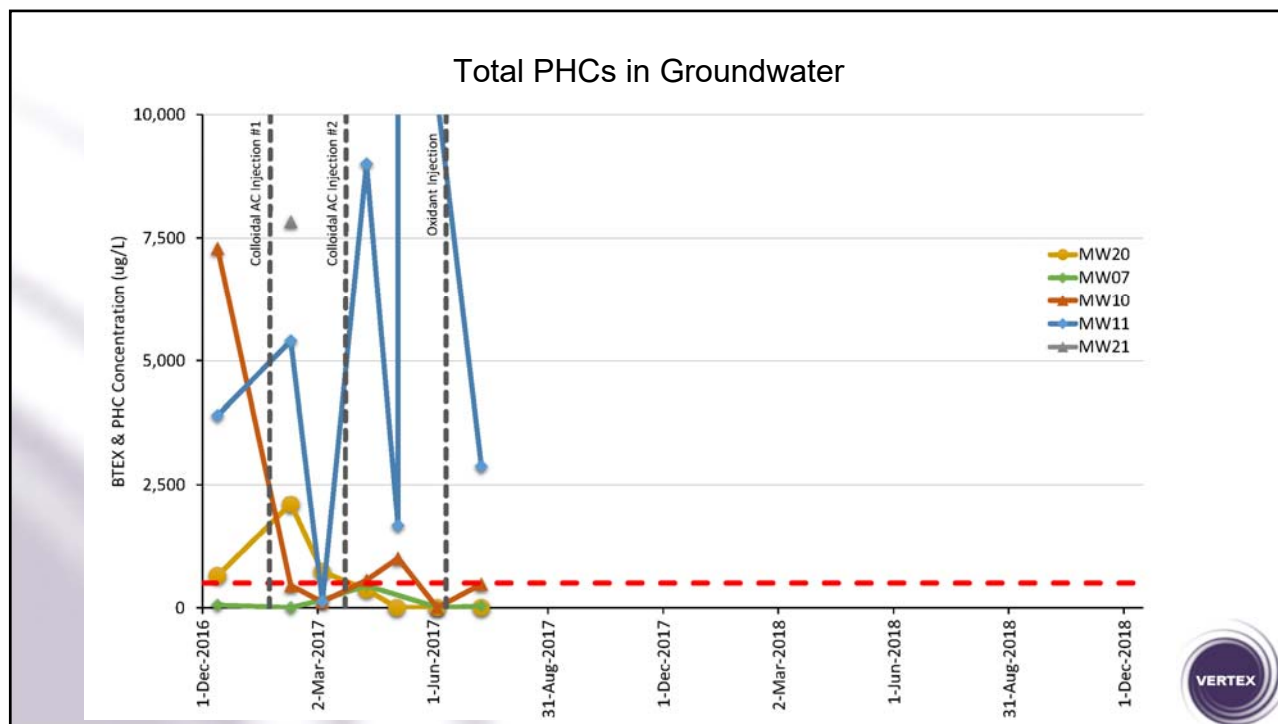


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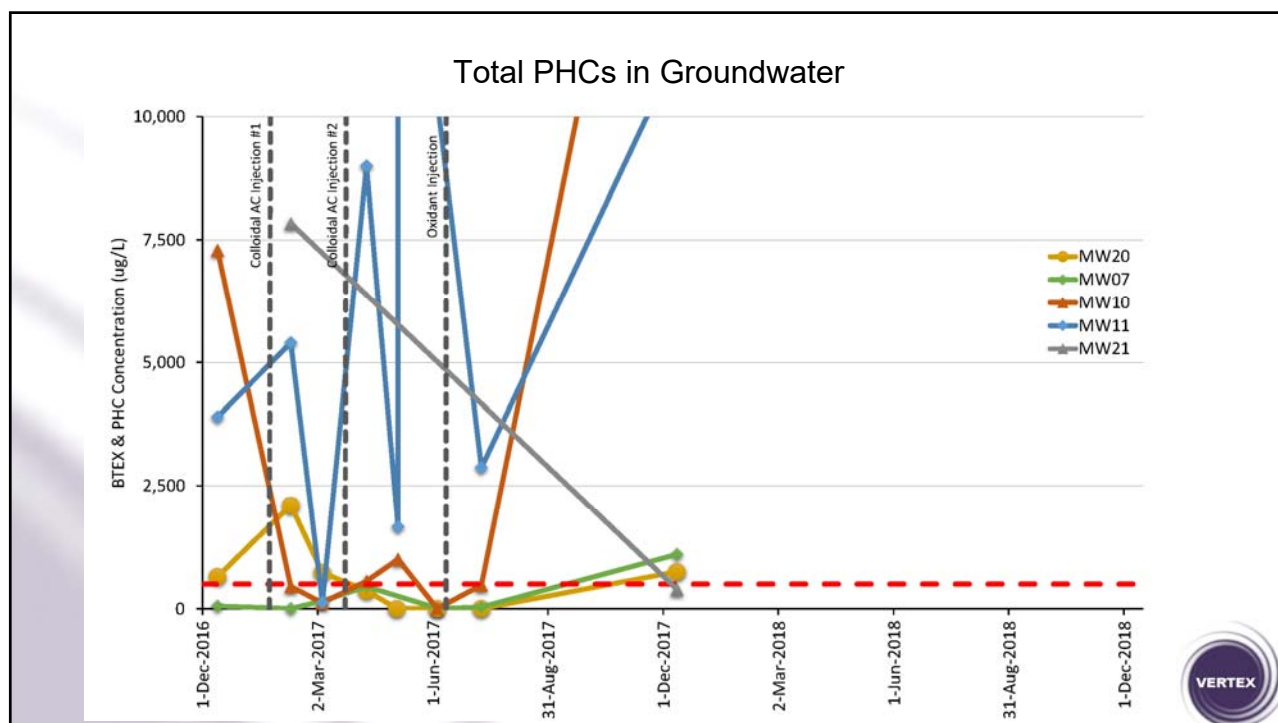
Total PHCs in Groundwater



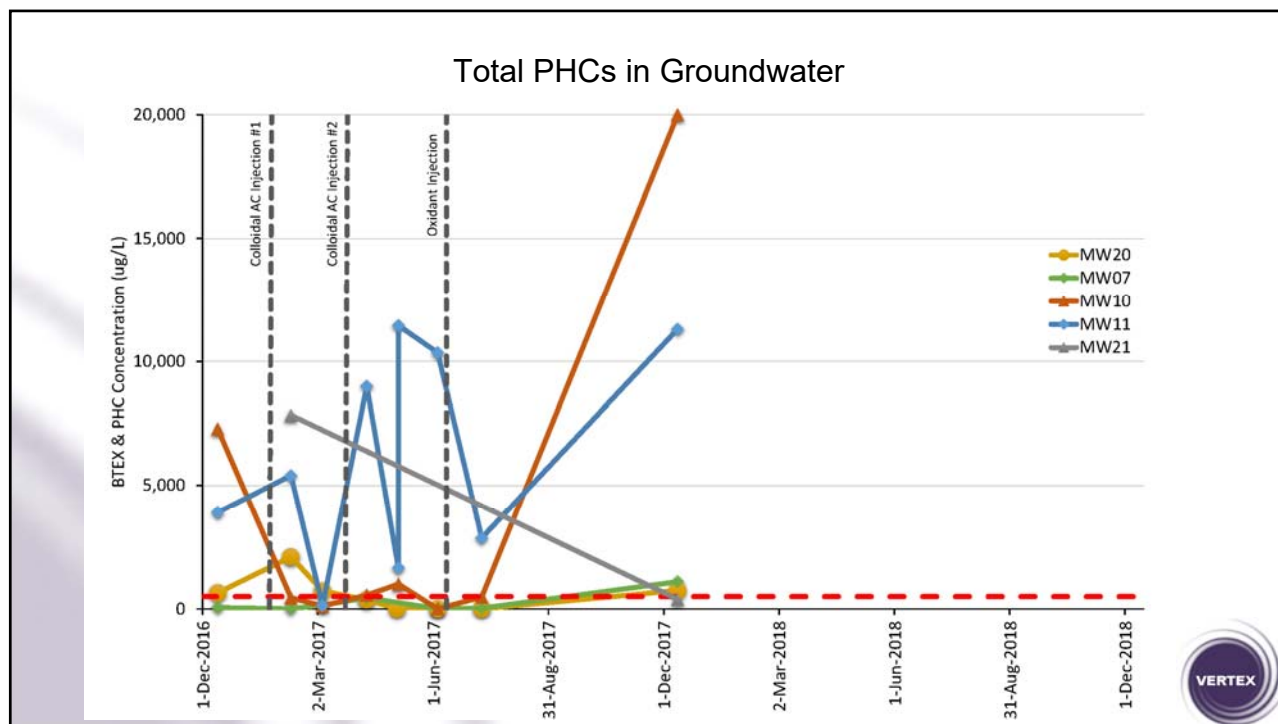
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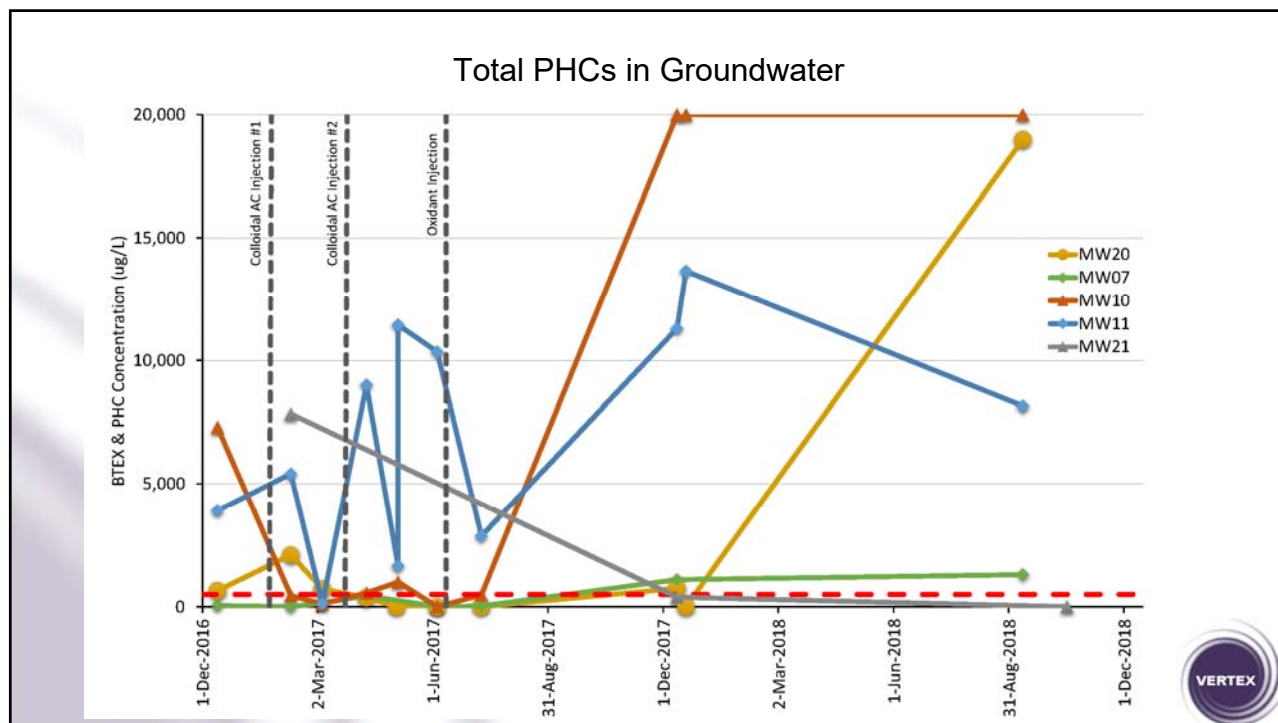
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How Can In-Situ Fail?

There are many ways that in-situ remediation technologies can fail:

- **Contaminant Concentration** / Distribution (**LNAPL**, etc.)
- Wrong Technology / **Order of Application**
- **Under-Dosing the Amendment**
- **Poor Contact / Distribution in the Subsurface**
- **Baseline Geochemistry**
- Age of Contamination
- Soil / Bedrock Characteristics
- Groundwater Flow Velocity
- Seasonal Water Table Fluctuations
- Etc.



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How to Help In-Situ Succeed

A good approach to maximize the chances that in-situ remediation will succeed:

- Review all characterization data available for the Site
 - Soil and groundwater contaminant chemistry and distribution, subsurface geology, hydrogeology, geochemistry, etc.
- Identify data gaps (physical / chemical)
- Complete additional, targeted data collection (e.g. RDC)
- Prepare a remedial approach focusing on selecting the correct technology, applying it properly, in adequate amounts, and in appropriate locations
- Interim QA/QC monitoring
- Plan for contingencies



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Background – Analytical (2017 Phase II ESA)

Soil

(mg/kg)	Maximum Concentration	Standard
PHC(F1)	3,900	65
PHC(F2)	770	250
Benzene	150	0.4
Toluene	970	78
Ethylbenzene	250	19
Xylenes	1,100	30
1,2-DCA	0.50	0.05

Dec 2016 Data

Groundwater

(ug/L)	Maximum Concentration	Standard
PHC(F1)	130,000	750
PHC(F2)	18,000	150
Benzene	6,500	430
Toluene	12,000	18,000
Ethylbenzene	5,500	2,300
Xylenes	25,000	4,200
1,2-DCA	15	12

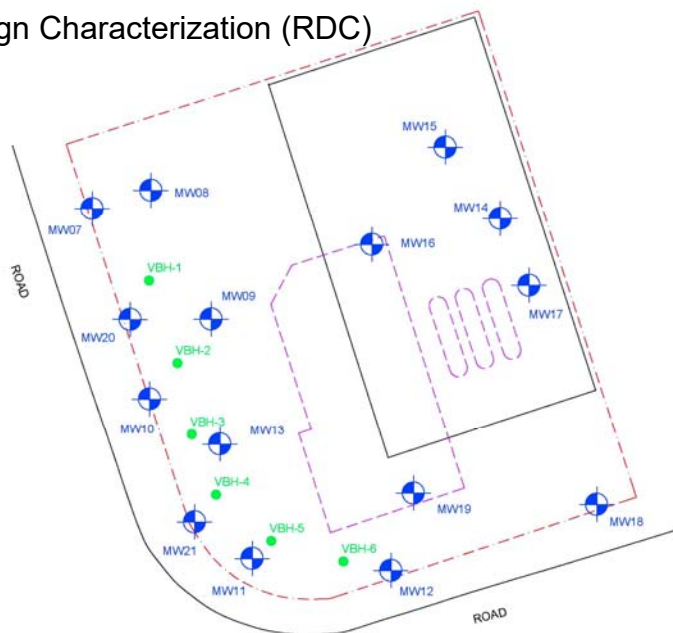
Dec 2016 Data



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Remedial Design Characterization (RDC)

- Six (6) boreholes
- 1 day of work
 - Sept 2018
- 27 soil samples
 - Detailed analysis of PHCs with depth
- 12 groundwater samples
- Allowed for detailed understanding of PHC contaminated zones



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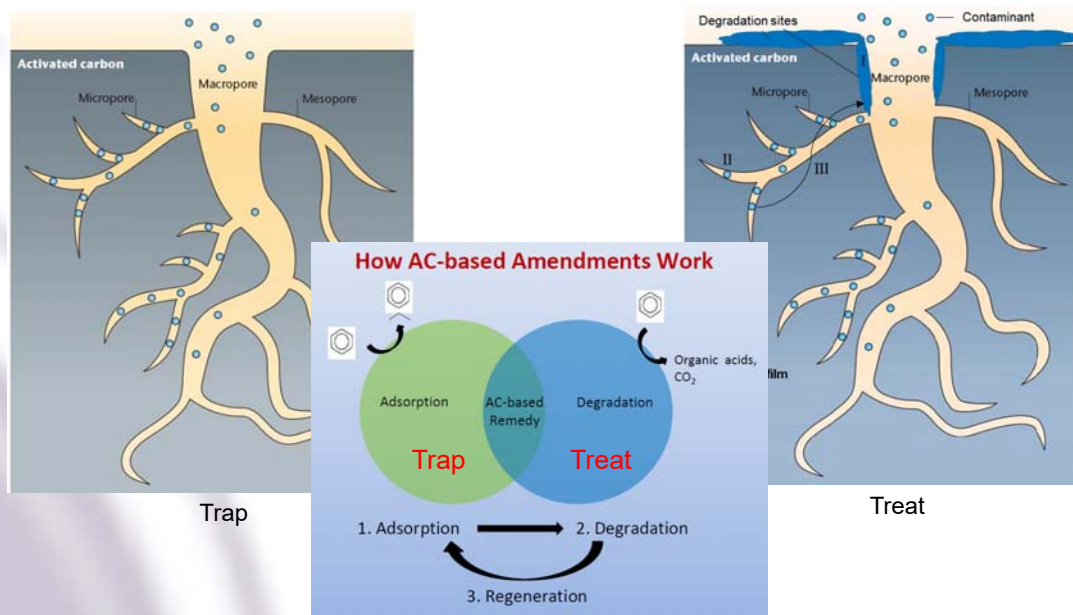
Remediation Approach – Updated

- Colloidal AC PRB Injection #1
- 24 m long by 3 m wide
- 24 Injection Points
 - Single line
 - 1 m spacing
 - 3 discrete vertical intervals
- Colloidal carbon
 - Dilute Colloidal AC solution
 - Some ORM
 - Aerobic bio
- Powdered AC Injection
- 25 m long by 3 m wide
- 81 Injection Points
 - 3 Rows forming Triangular Grid
 - 1 m spacing
 - 9 discrete vertical intervals
- Powdered carbon
 - Concentrated powdered AC product
 - Sulphate added
 - Anaerobic bio



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Activated Carbon-Based Remedial Amendments



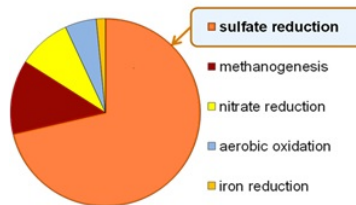
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PHC Treatment & Geochemistry – What is Best for PRBs?

Trap and Treat BOS200®

Significance of Sulfate

Sulfate reduction is the predominant electron accepting process for the degradation of hydrocarbons



Oxygen Solubility = 12 mg/L
Sulfate Solubility = 10,000 mg/L

Oxygen : Benzene bio = 3.1 : 1
Sulfate : Benzene bio = 4.6 : 1

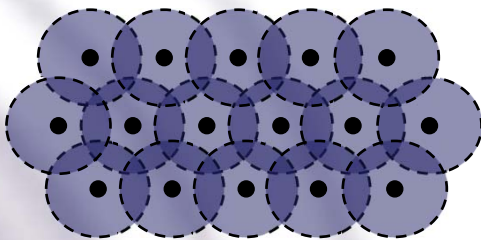


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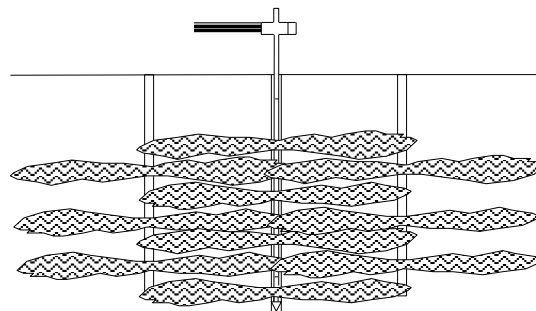
Injected PRB – Planning the IP Layout

The Goal:

- Uniform Distribution
- Intimate contact between remedial amendment and contaminants



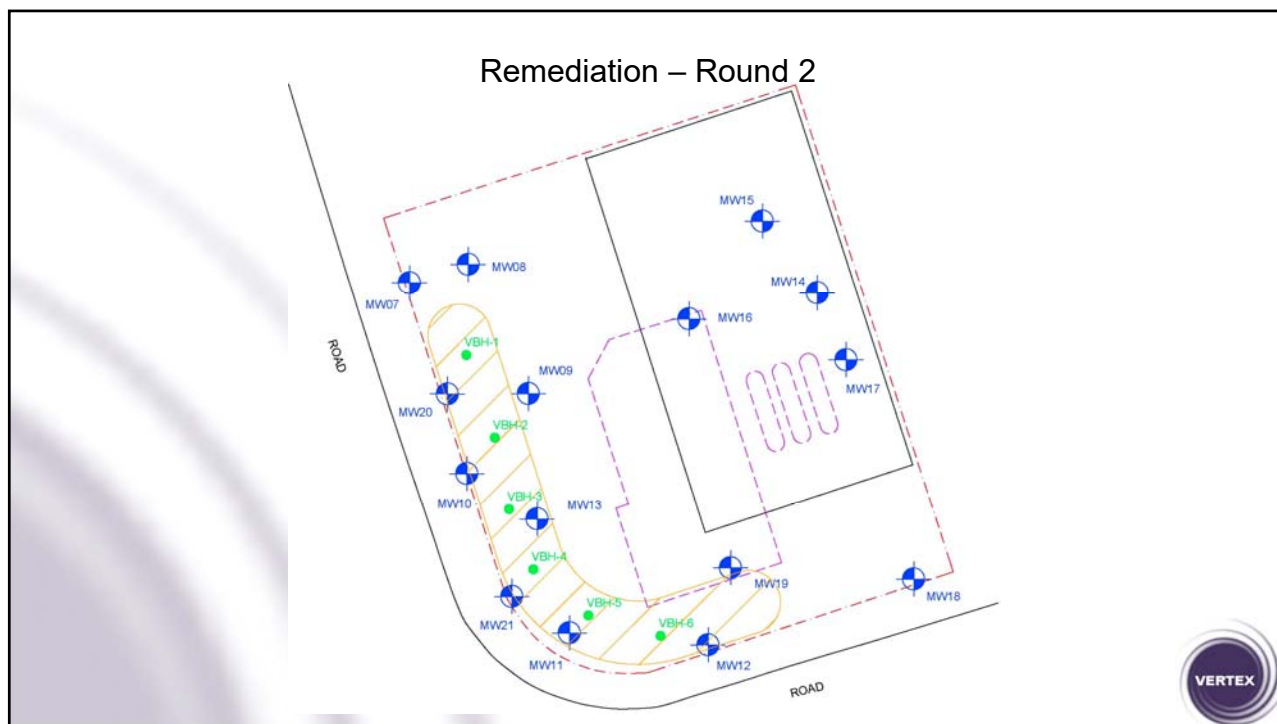
Plan View



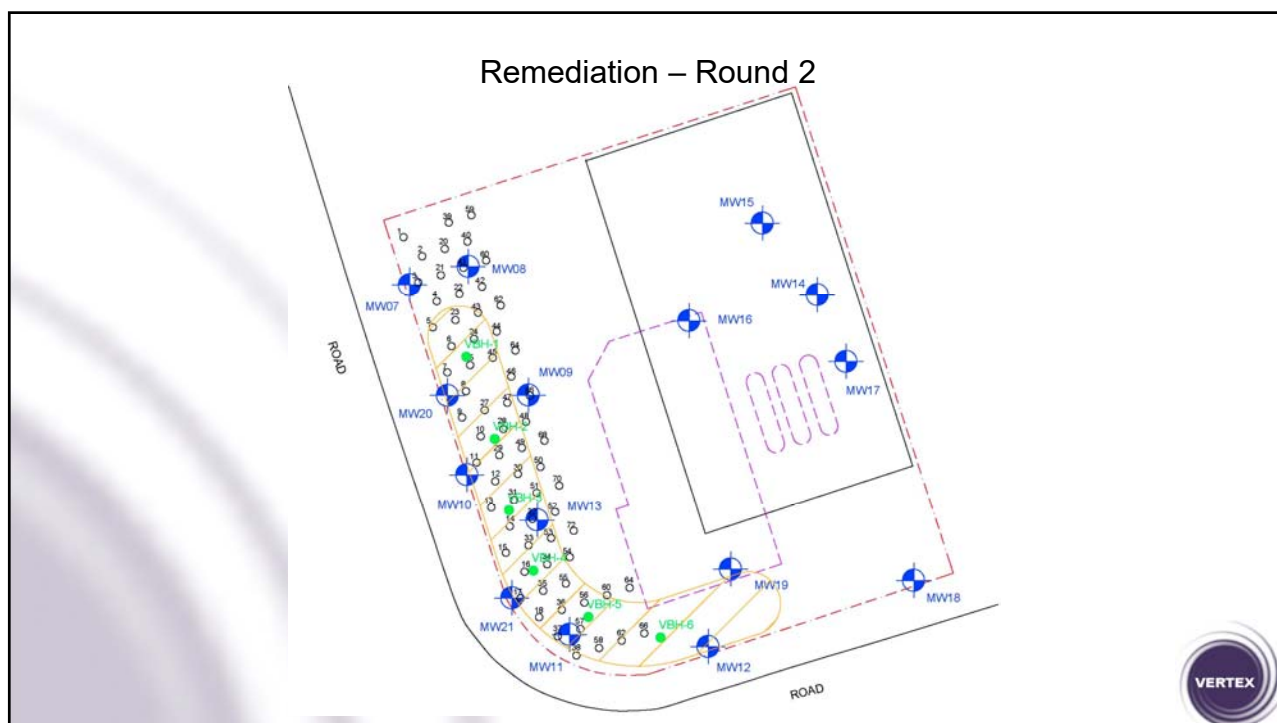
Profile View



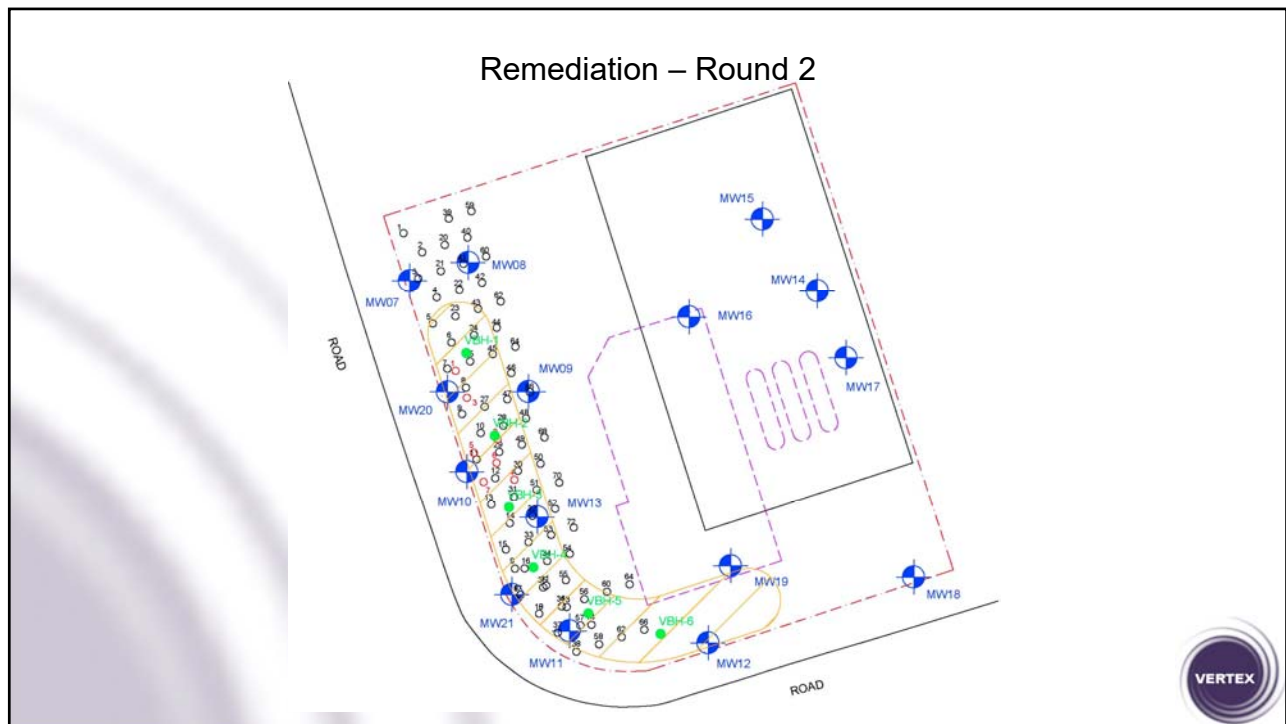
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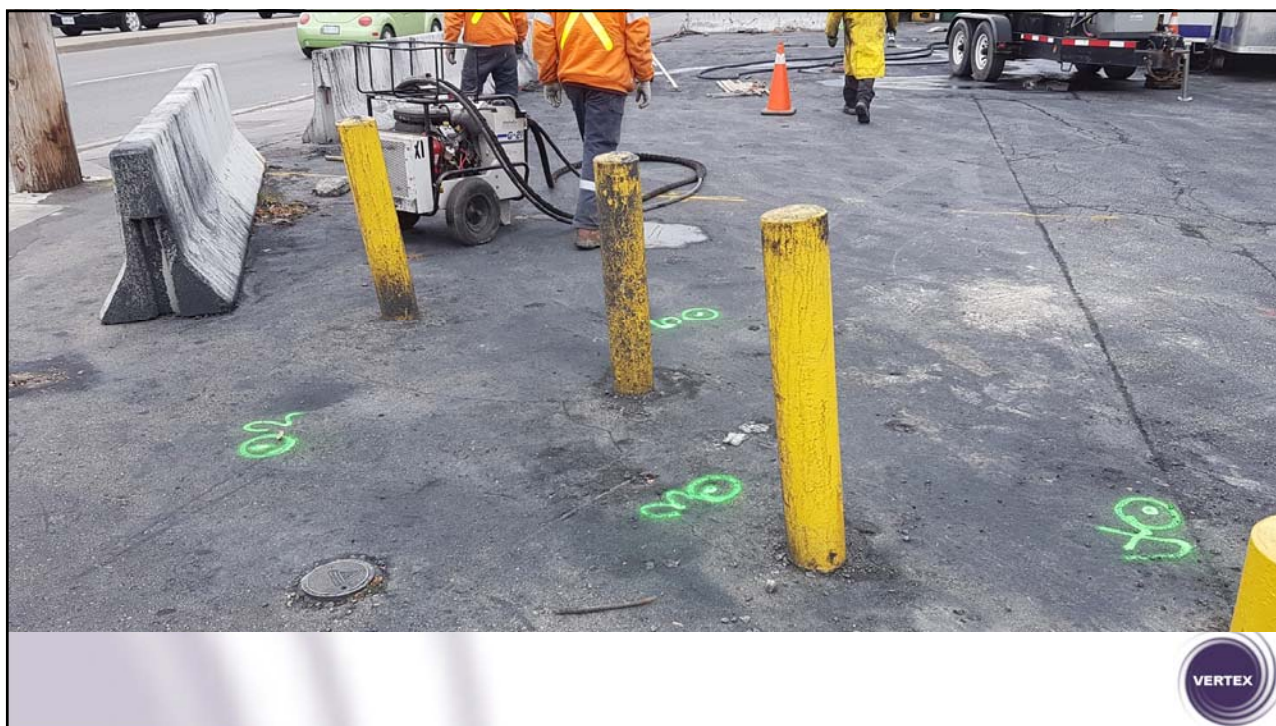
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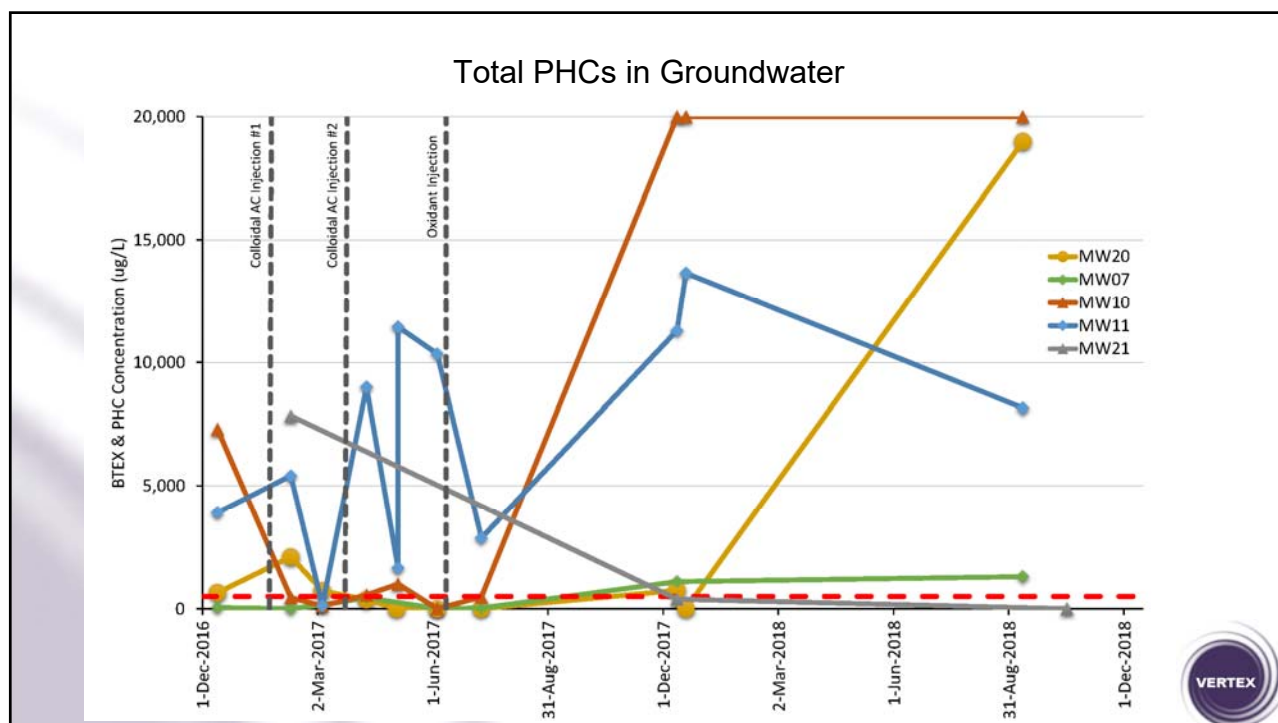
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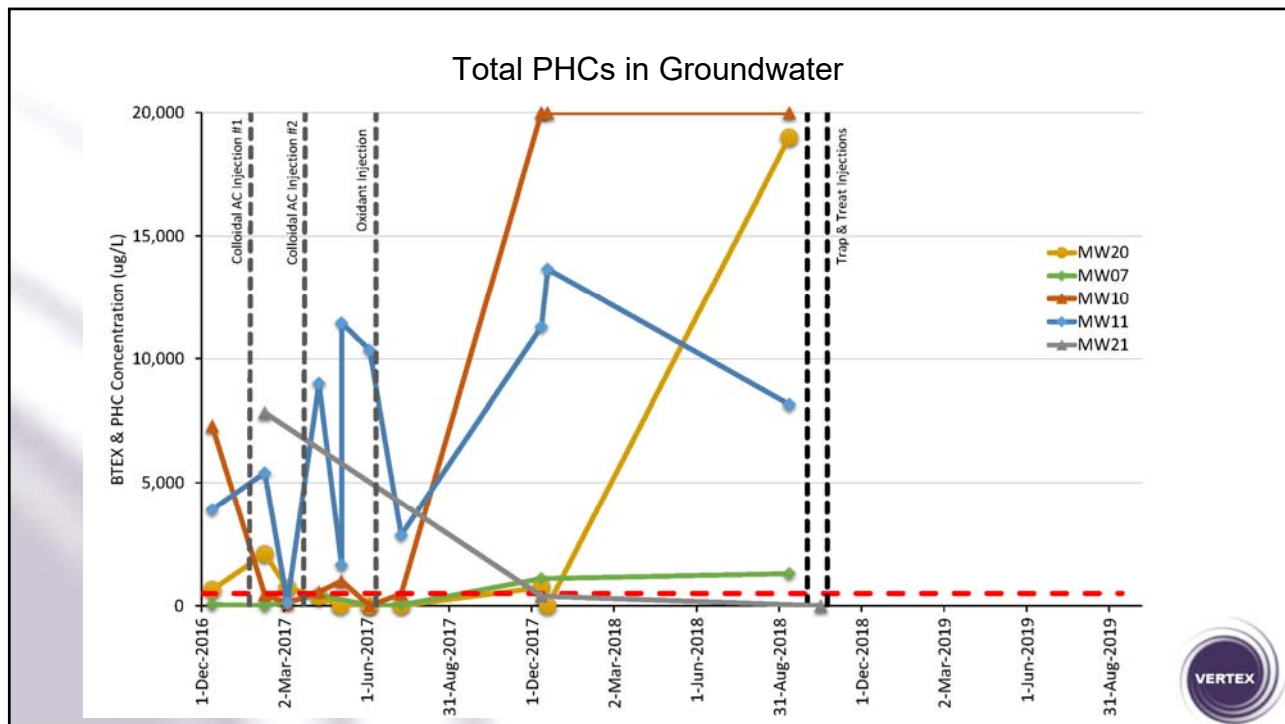
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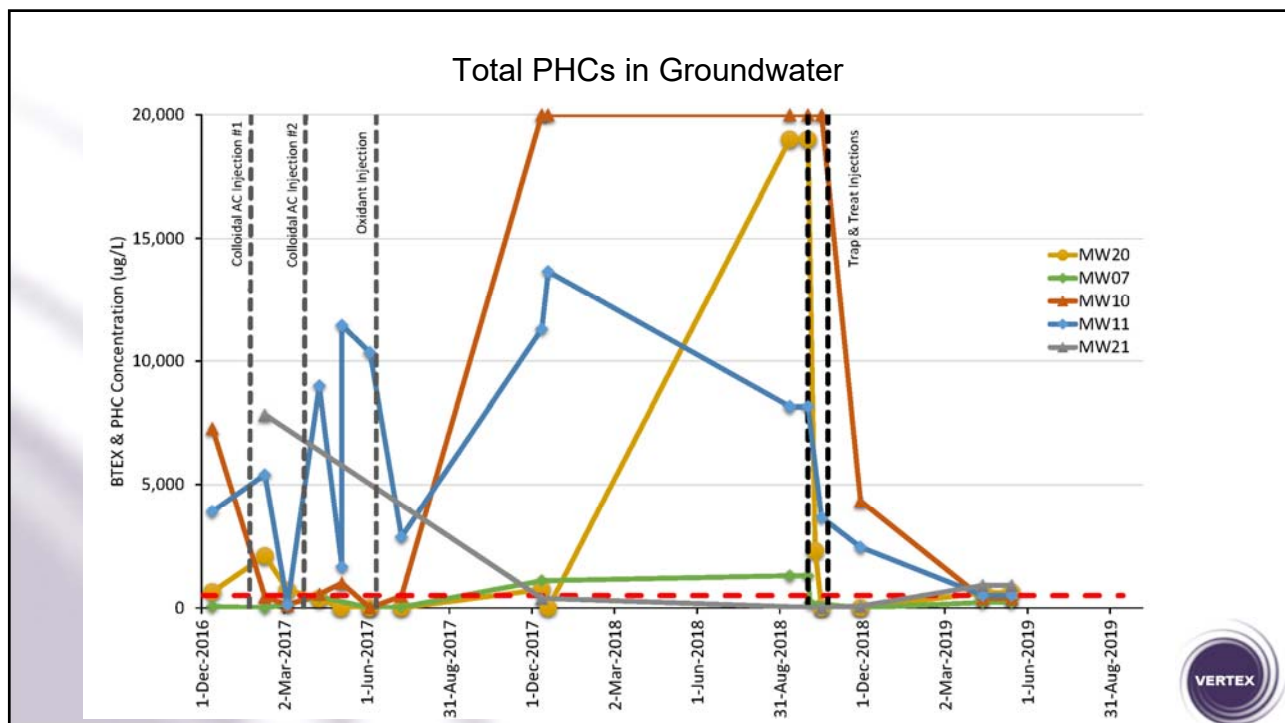
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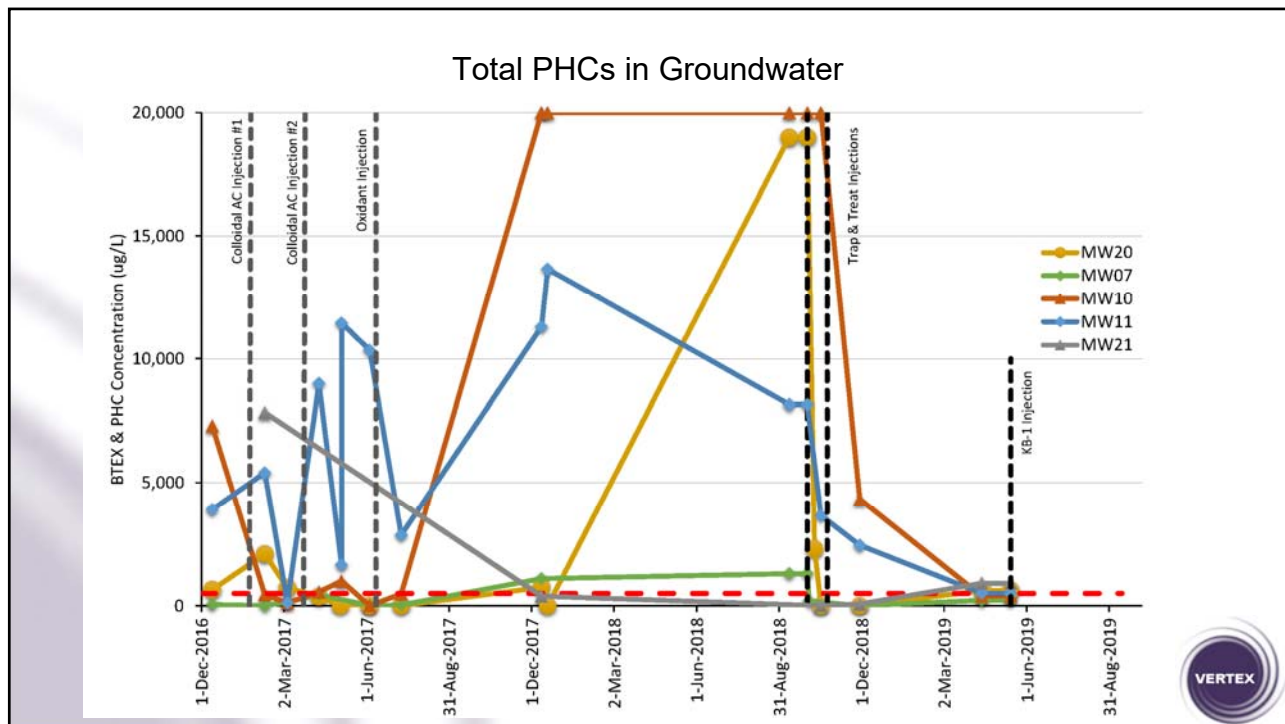
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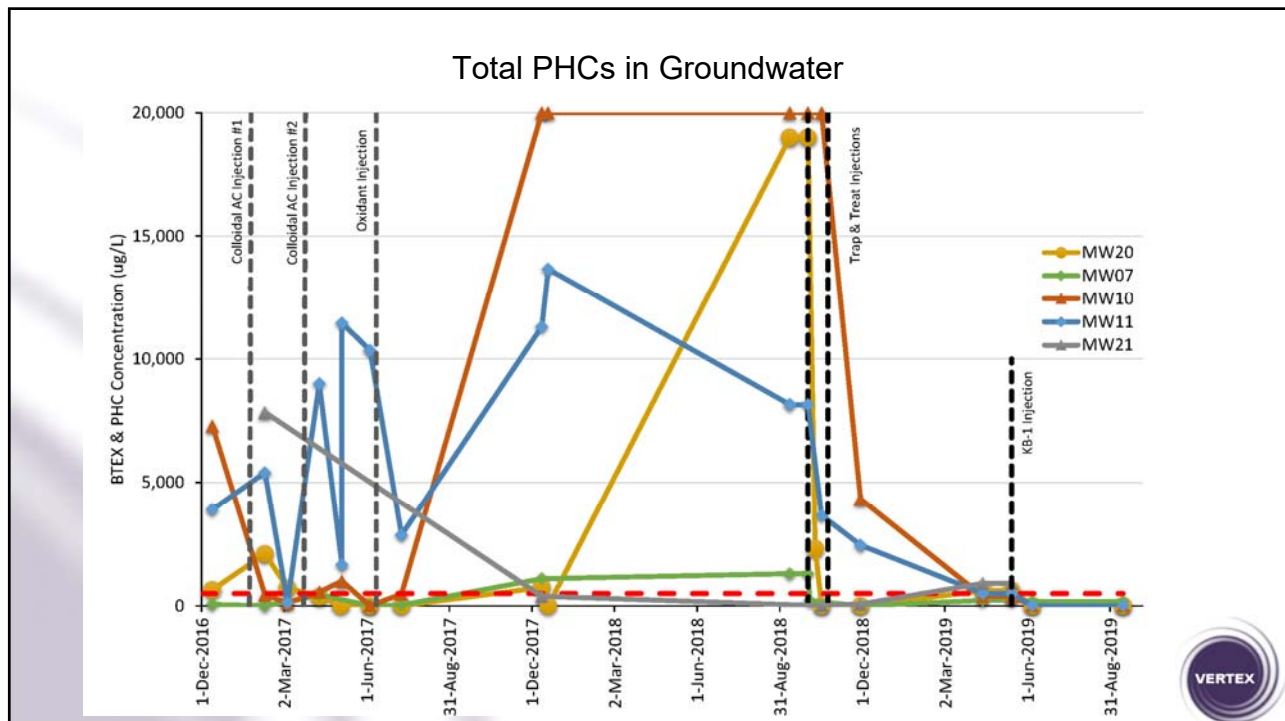
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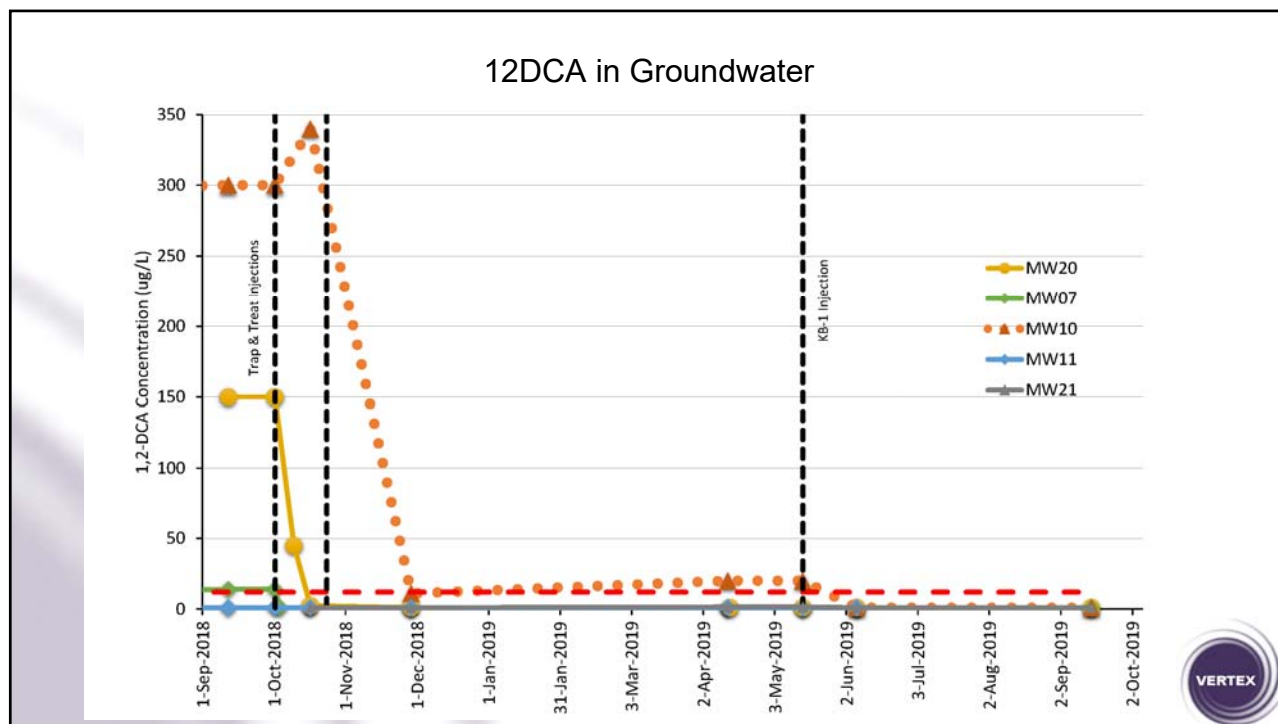
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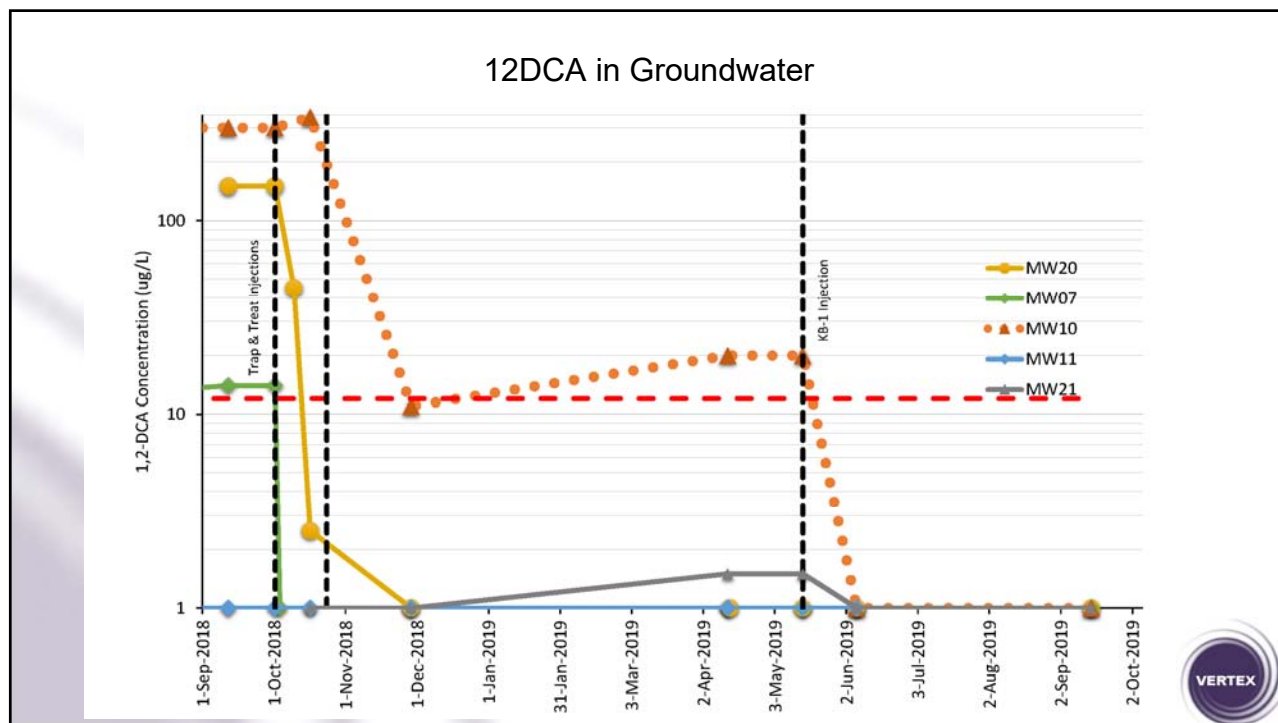
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Lessons Learned

There are many ways that in-situ remediation technologies can fail:

- Contaminant Concentration / Distribution (LNAPL, etc.)
 - Evidence of LNAPL possibly not taken into account during initial design
- Wrong Technology / Order of Application
 - ISCO completed after AC injection
- Under-Dosing the Amendment
 - Apparent low mass of AC and ORM injected relative to contaminant mass present
- Poor Contact / Distribution in the Subsurface
 - Insufficient number of IPs and vertical intervals for an injected PRB
- Baseline Geochemistry
 - Hard to try to maintain aerobic conditions over the long term

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Closing

Plume containment demonstrated.

Effective PRBs for PHCs are possible.

One just needs to design and install them properly.



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Questions?

Thank You for
your Time!

Kevin French

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