Vertex Environmental Inc.

Case Study:
When In-Situ Techniques Fail

October 18, 2019

RemTech

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

Outline

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

Vertex Environmental Inc.

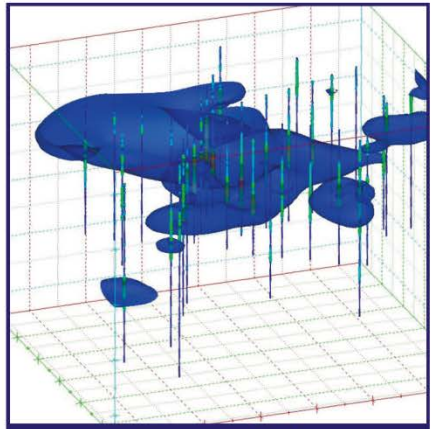
Specialized Contractors


In-Situ Remediation

Ex-Situ Remediation


High Resolution Characterization


Treatment Systems


Remedial Design

Bench-Scale Testing

- 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
  - Water Treatment Systems

VERTEX

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.

Background – The Situation

- Confidential Site
- Client 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:
  - Tenant set to lease existing building
  - Lease contract detailed no contamination to migrate off-site during lease timeframe

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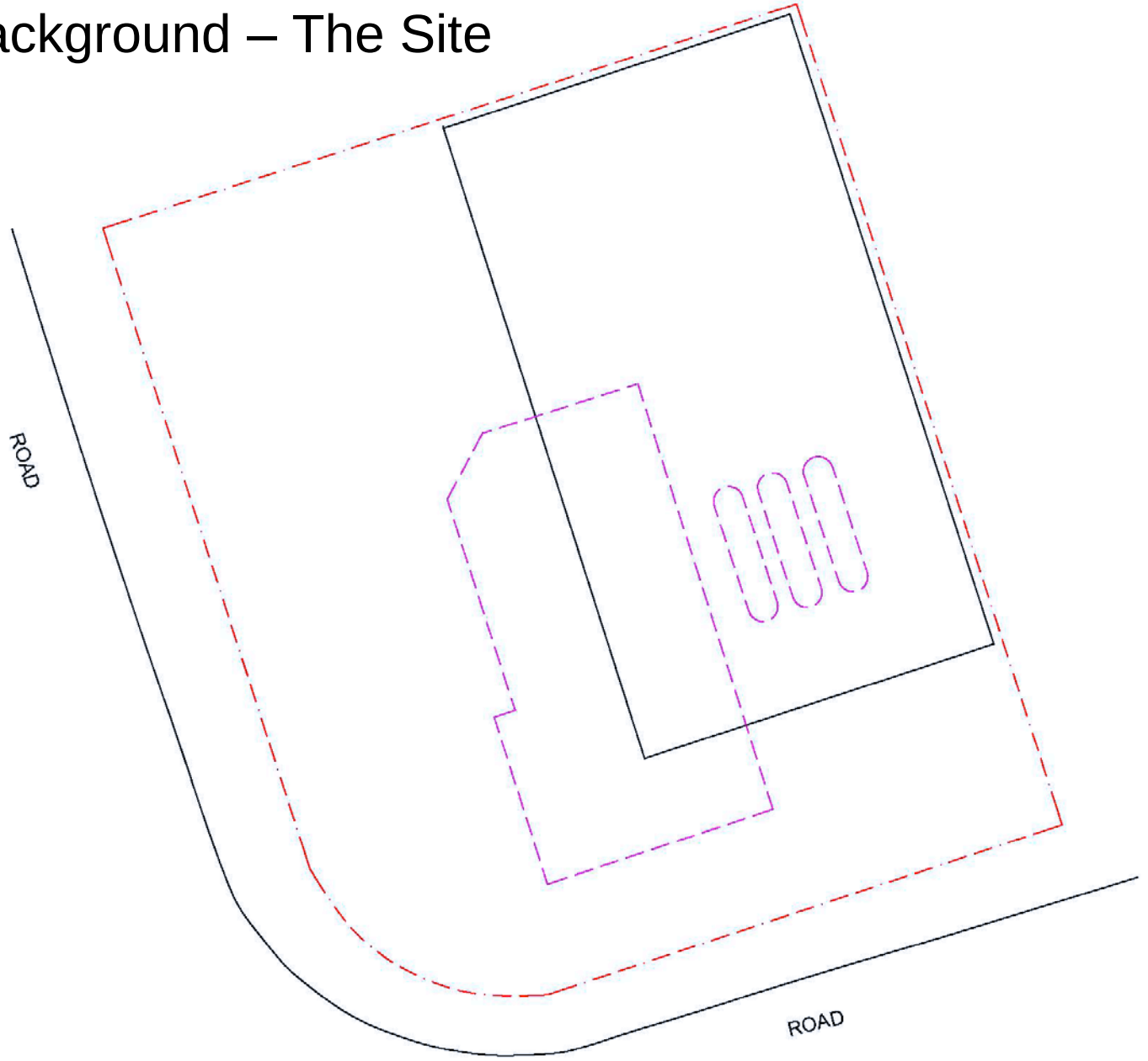
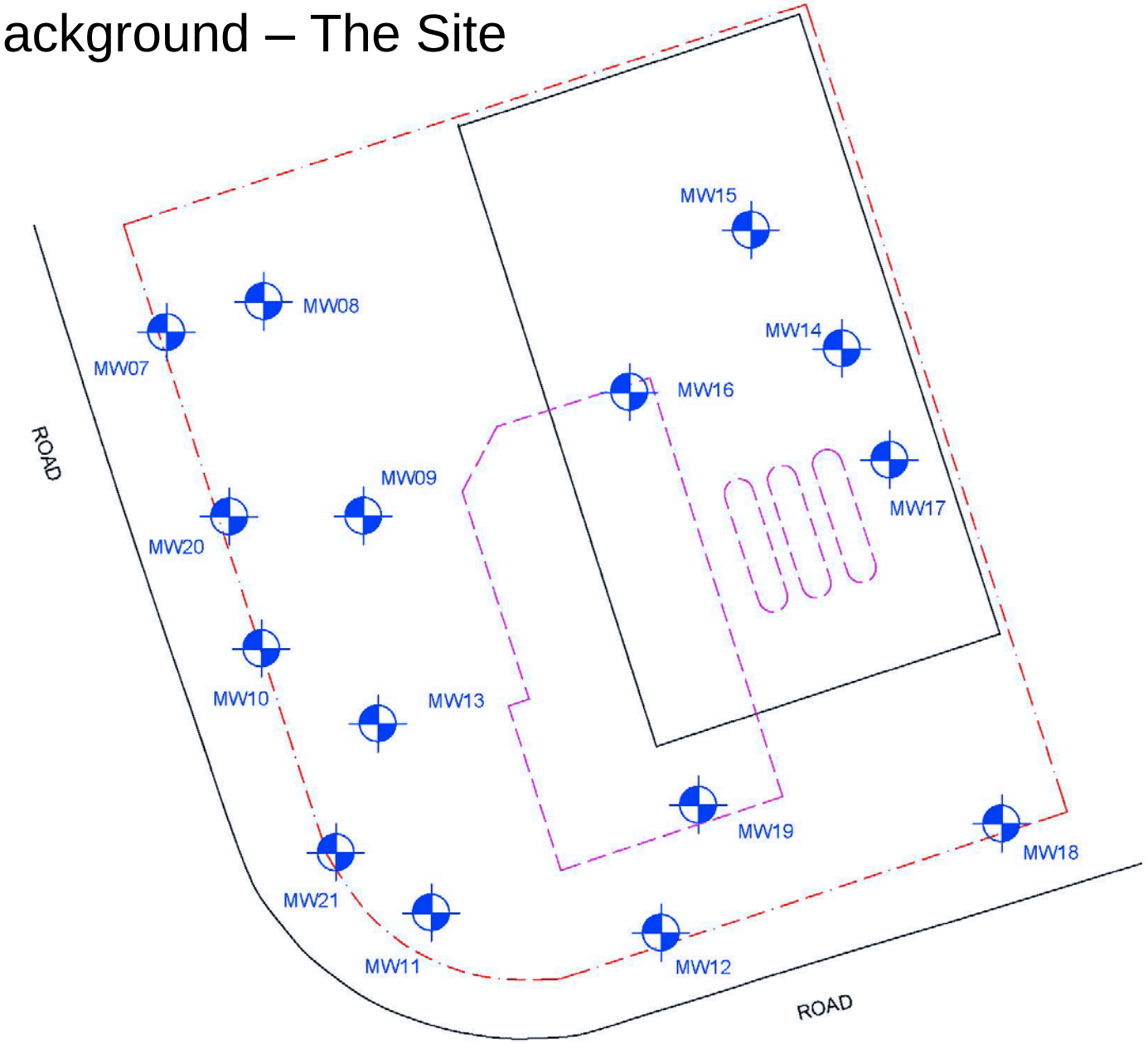
Background – The Situation

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

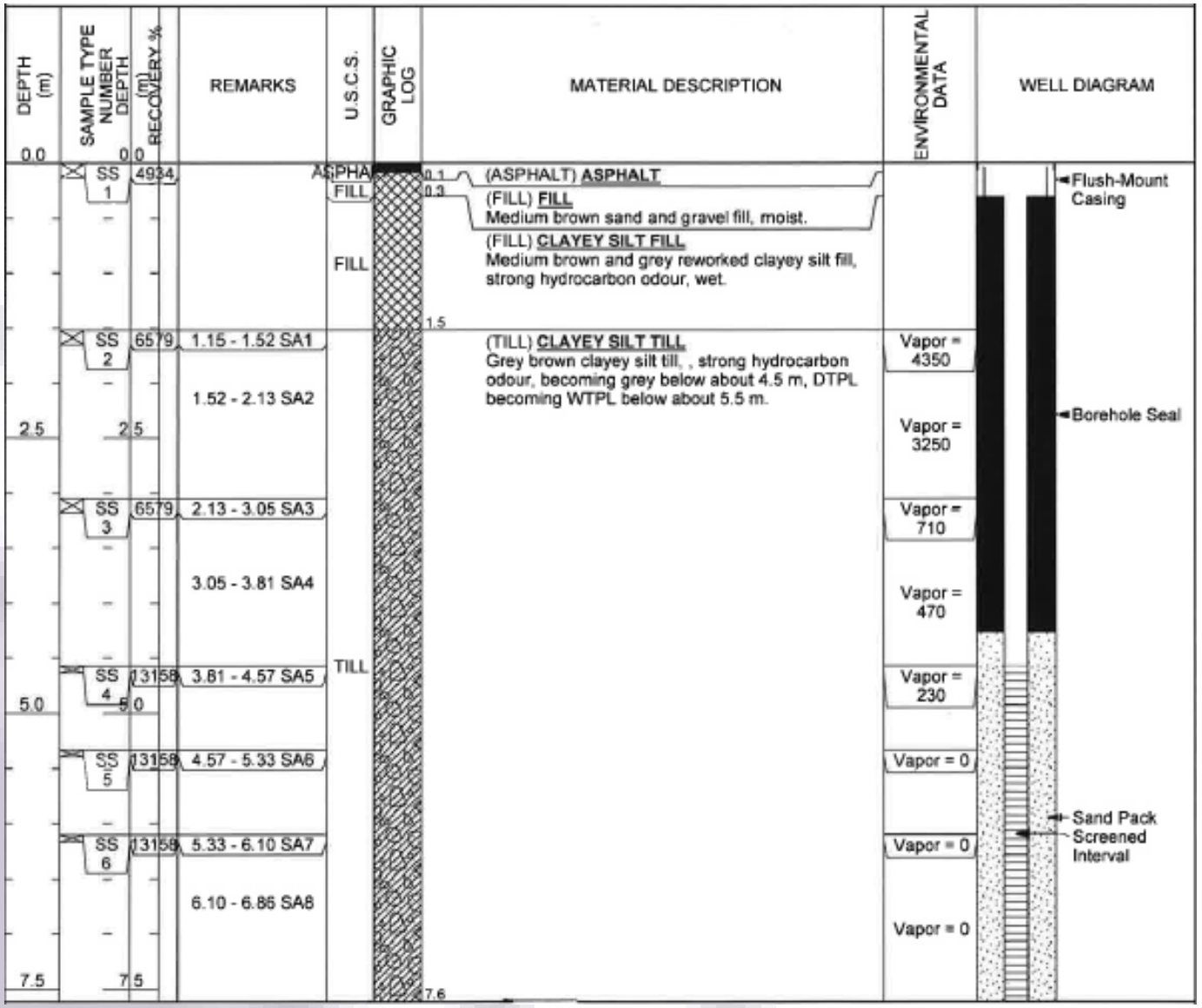
Background – The Site



Background – The Site



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

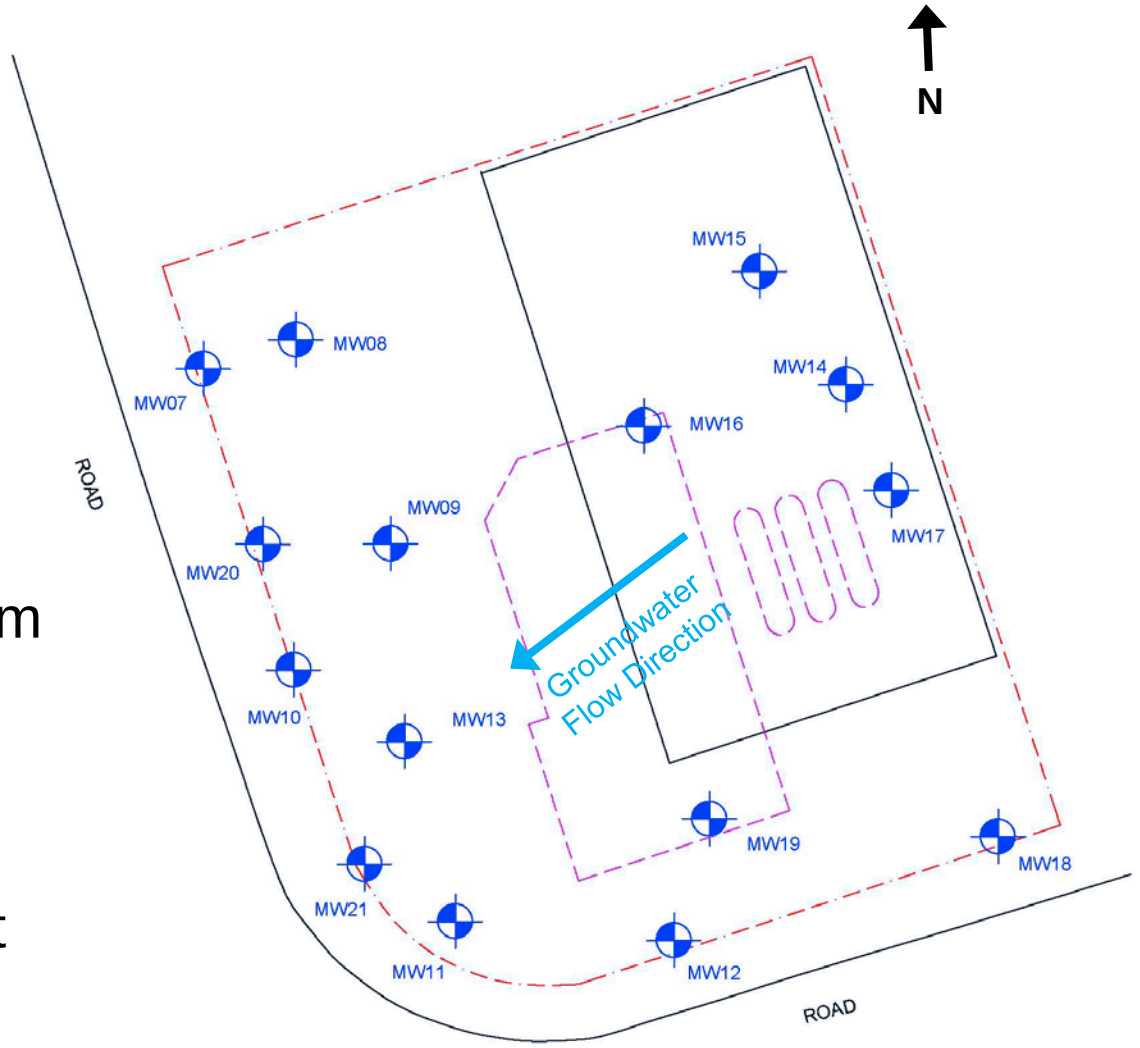
Background – The Subsurface

Comments in Phase II ESA (2017)

"On-site contamination appears to be located downgradient of the building" (no contamination beneath on-site building – no vapour intrusion issue)

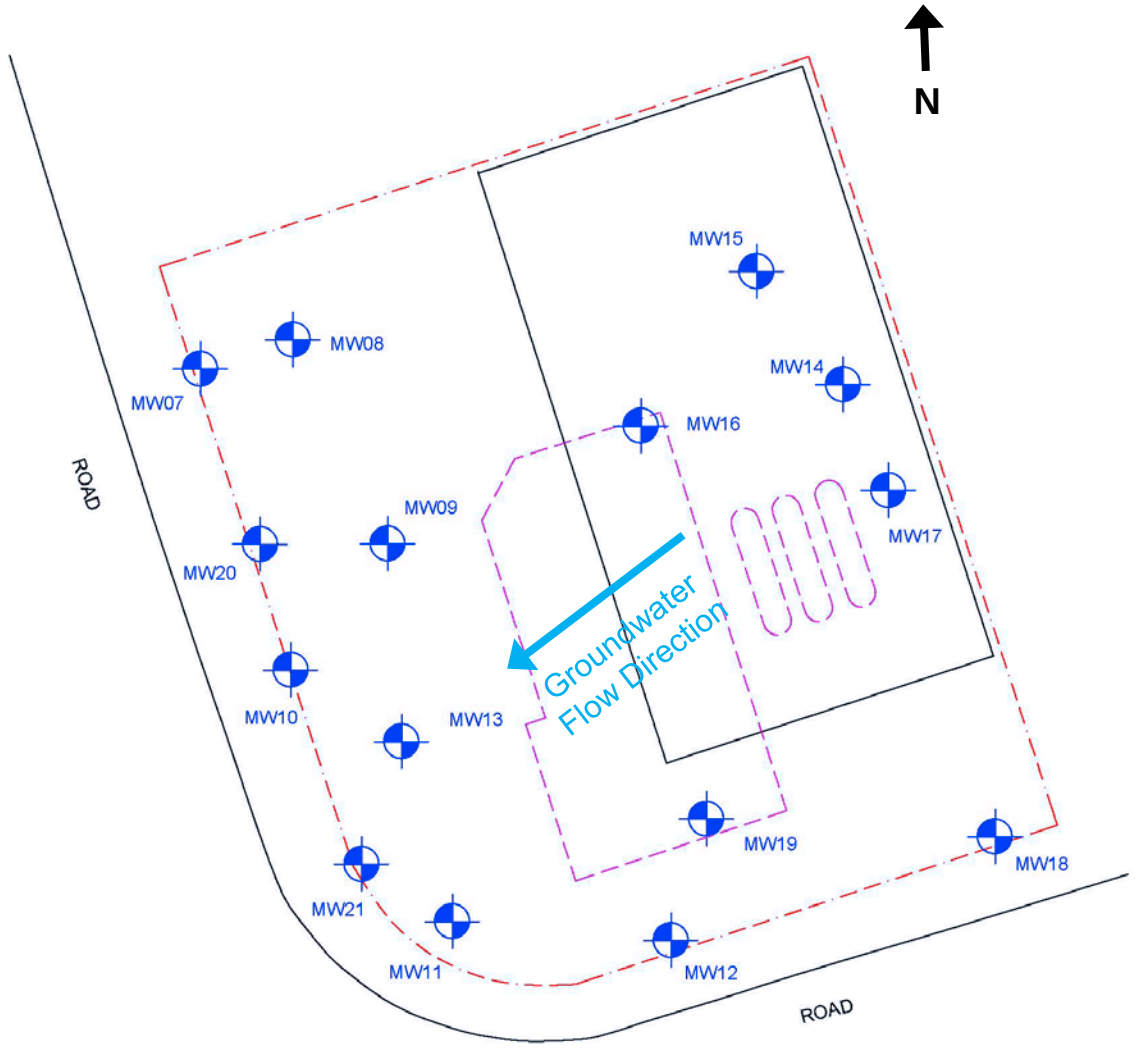
"It is likely that soil and groundwater petroleum hydrocarbon impacts have moved off-Site to the west… and….southwest"

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



Background – Remedial Recommendation

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



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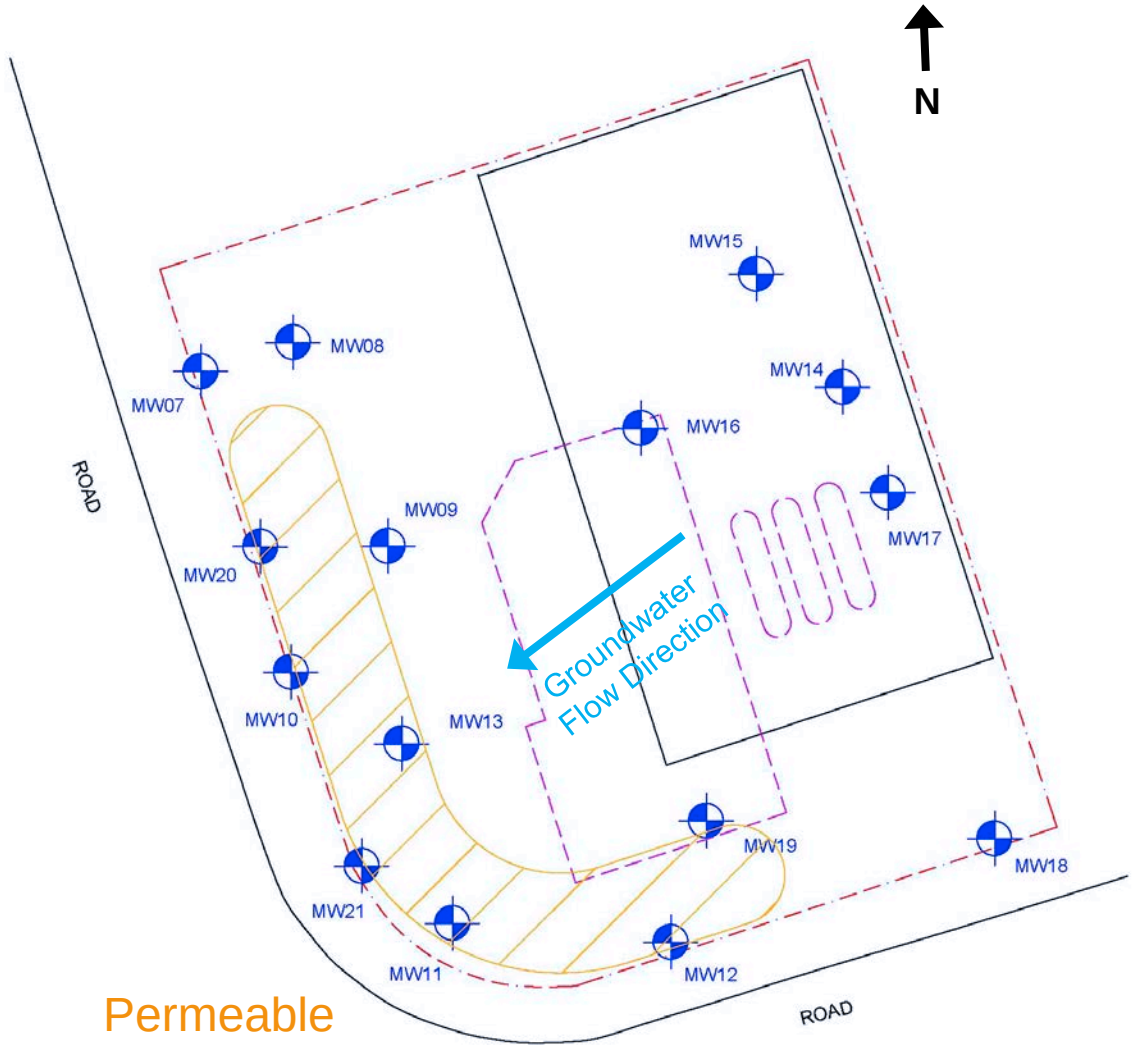

Permeable Reactive Barrier (PRB)

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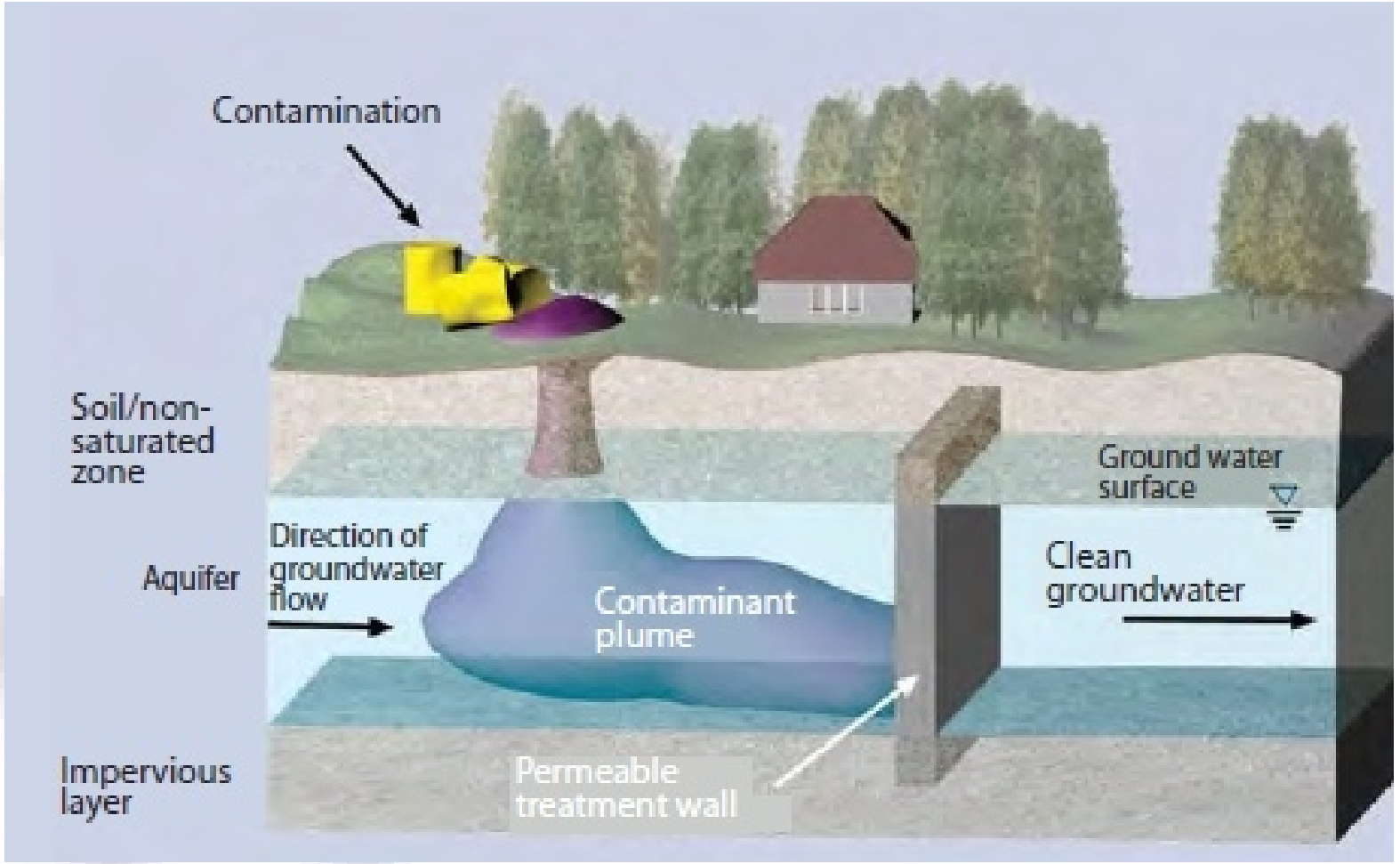


Background – Analytical

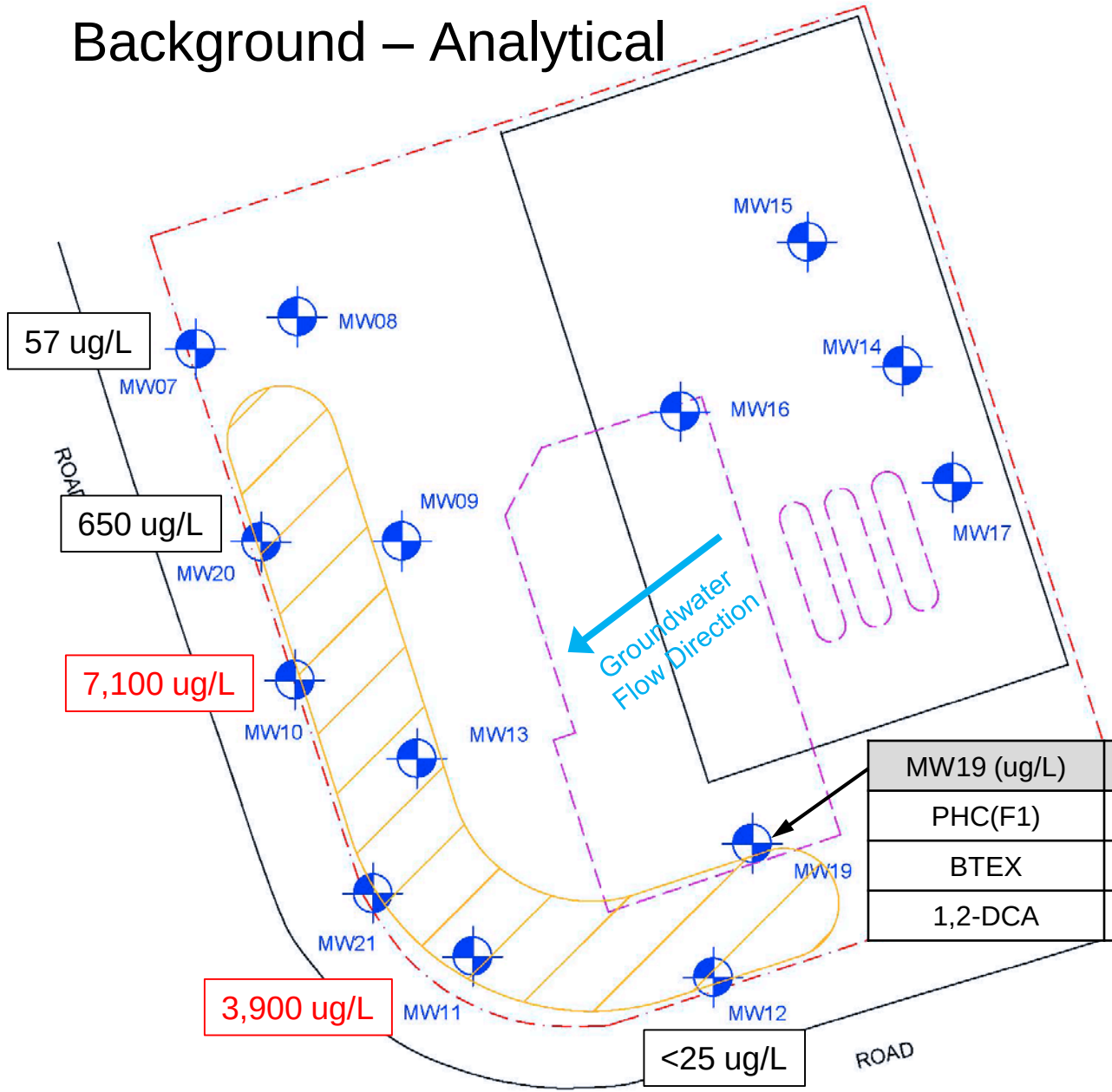
MW07 (ug/L)	Conc.	Standard
PHC(F1)	57	750
BTEX	14	-
1,2-DCA	<0.5	12

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



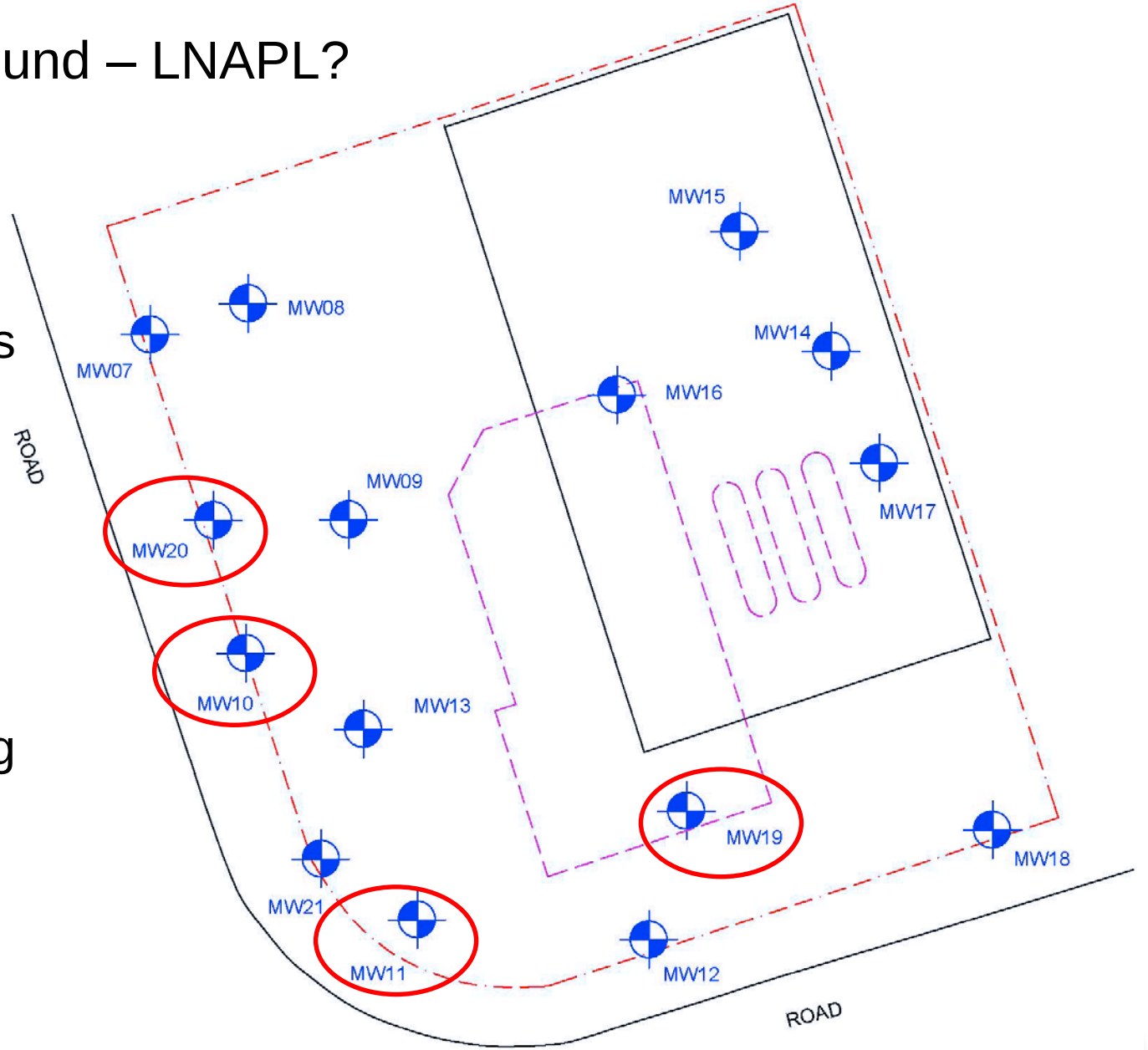
MW19 (ug/L)	Conc.	Standard
PHC(F1)	130,000	750
BTEX	38,700	-
1,2-DCA	<0.5	12

Background – LNAPL?

Comment in Phase II ESA (2017)

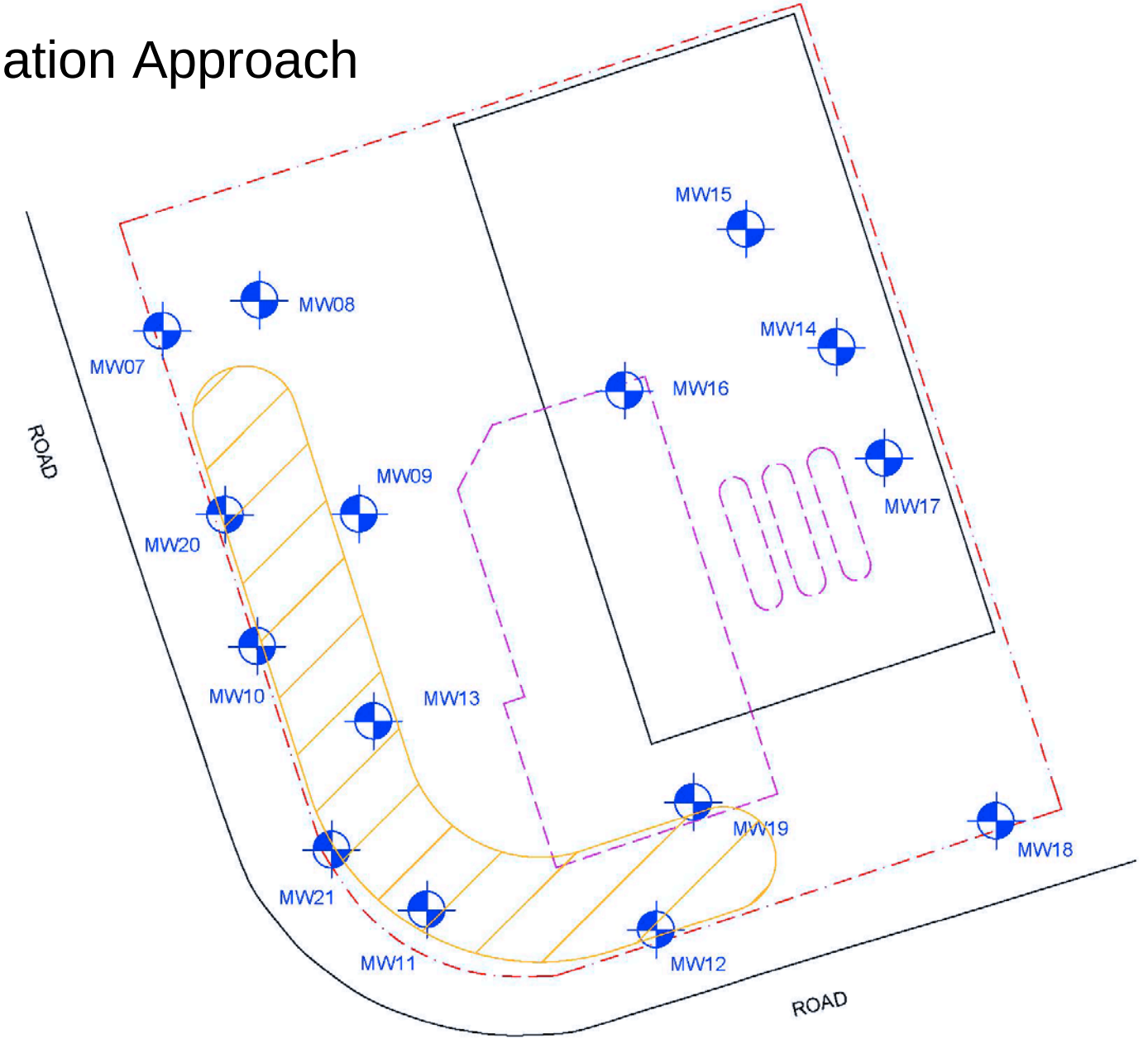
"There was no measureable non-aqueous phase liquid detected in any of the groundwater monitoring wells, however, evidence of liquid phase gasoline was observed during the drilling in boreholes MW10, MW11, MW19 and MW20."

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



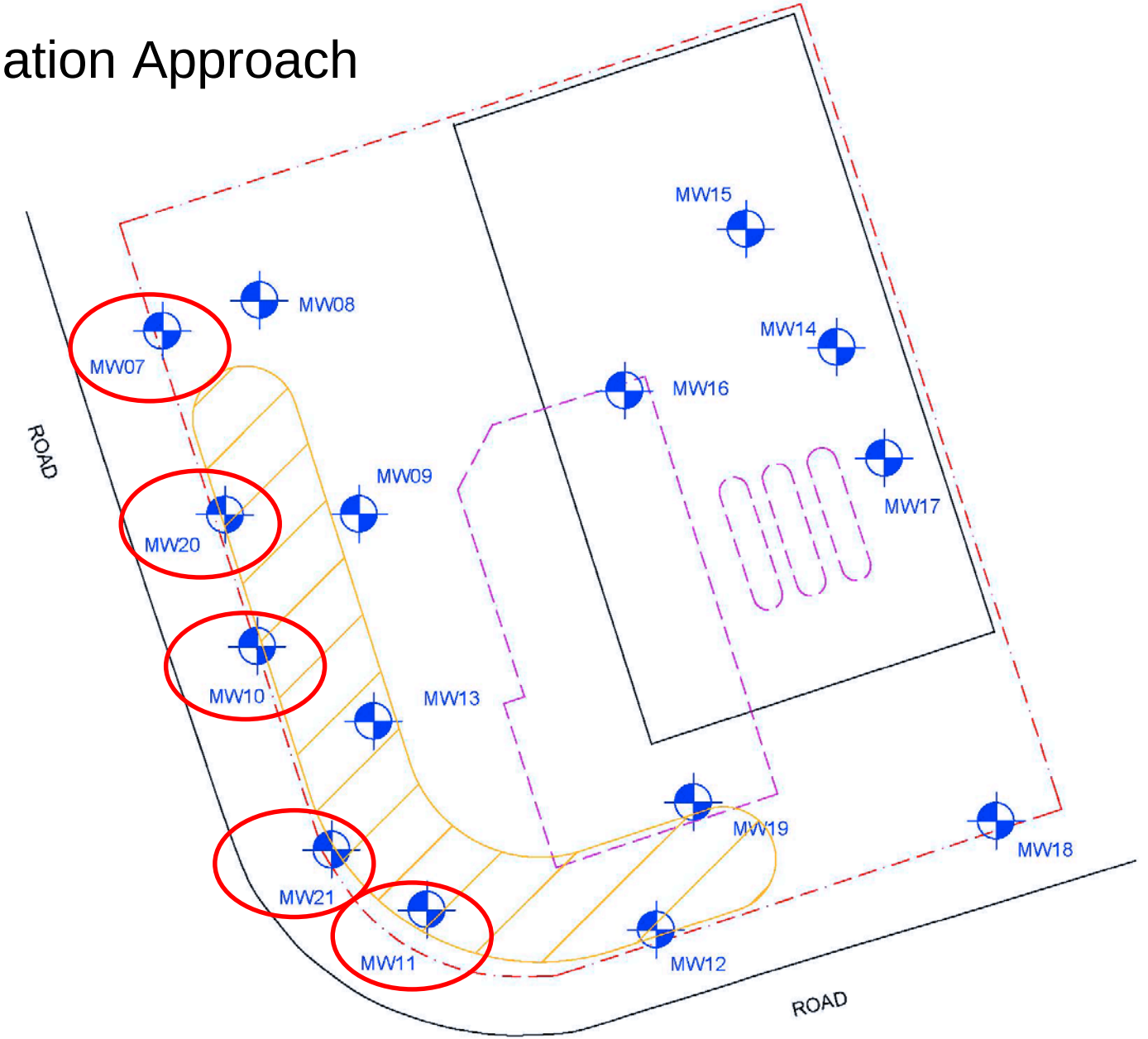
Remediation Approach

- 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

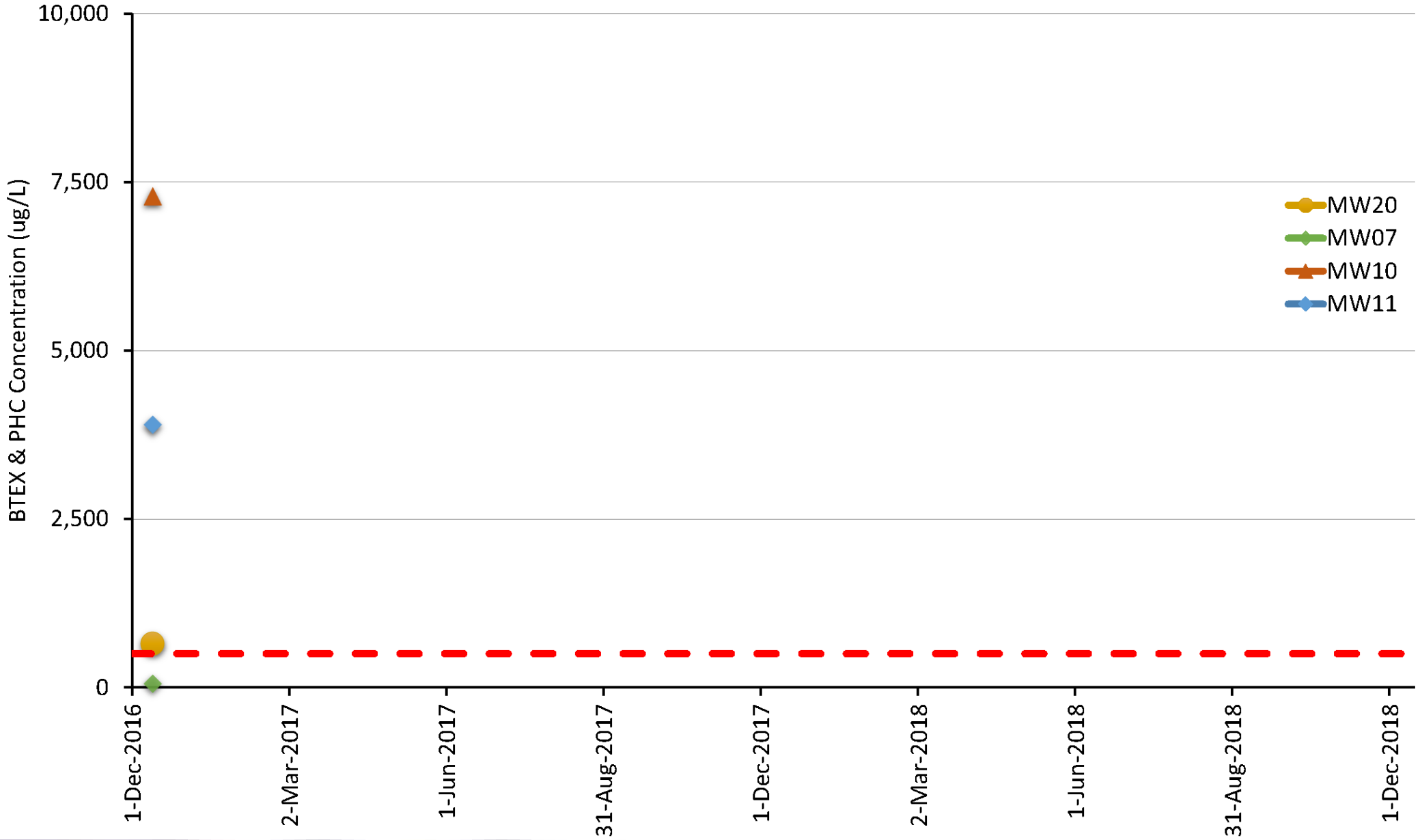


Remediation Approach

- Analytical to Review



Total PHCs in Groundwater



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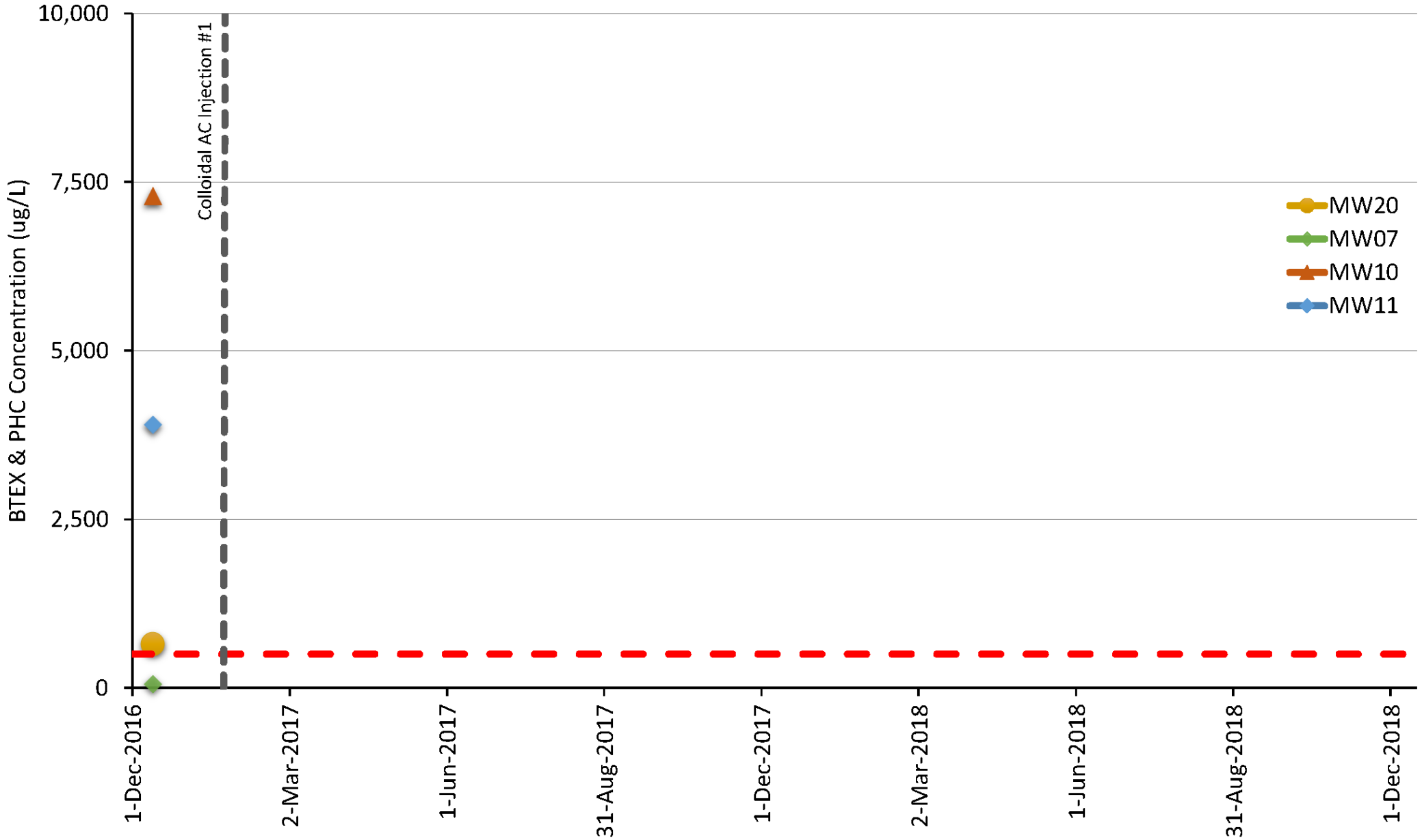

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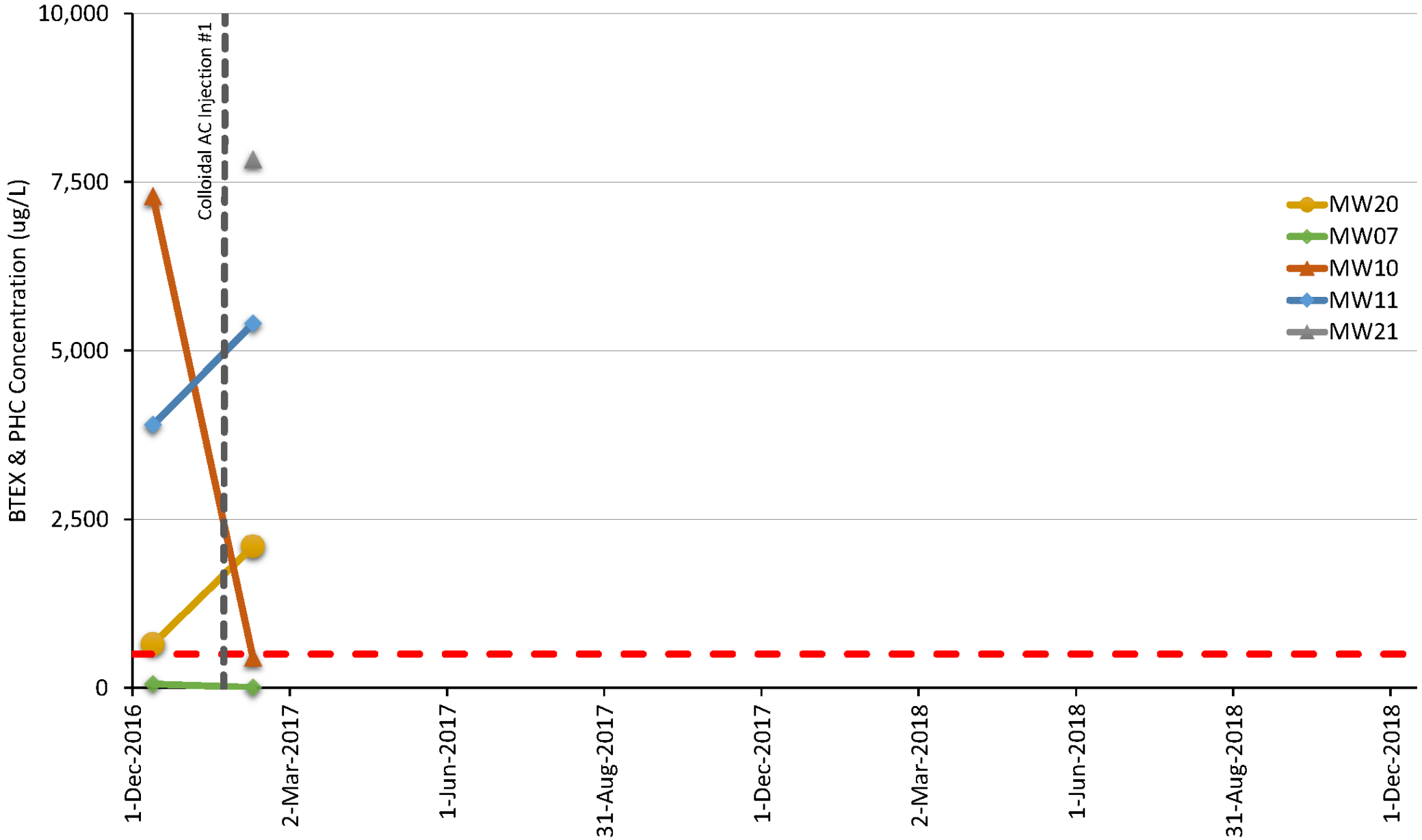
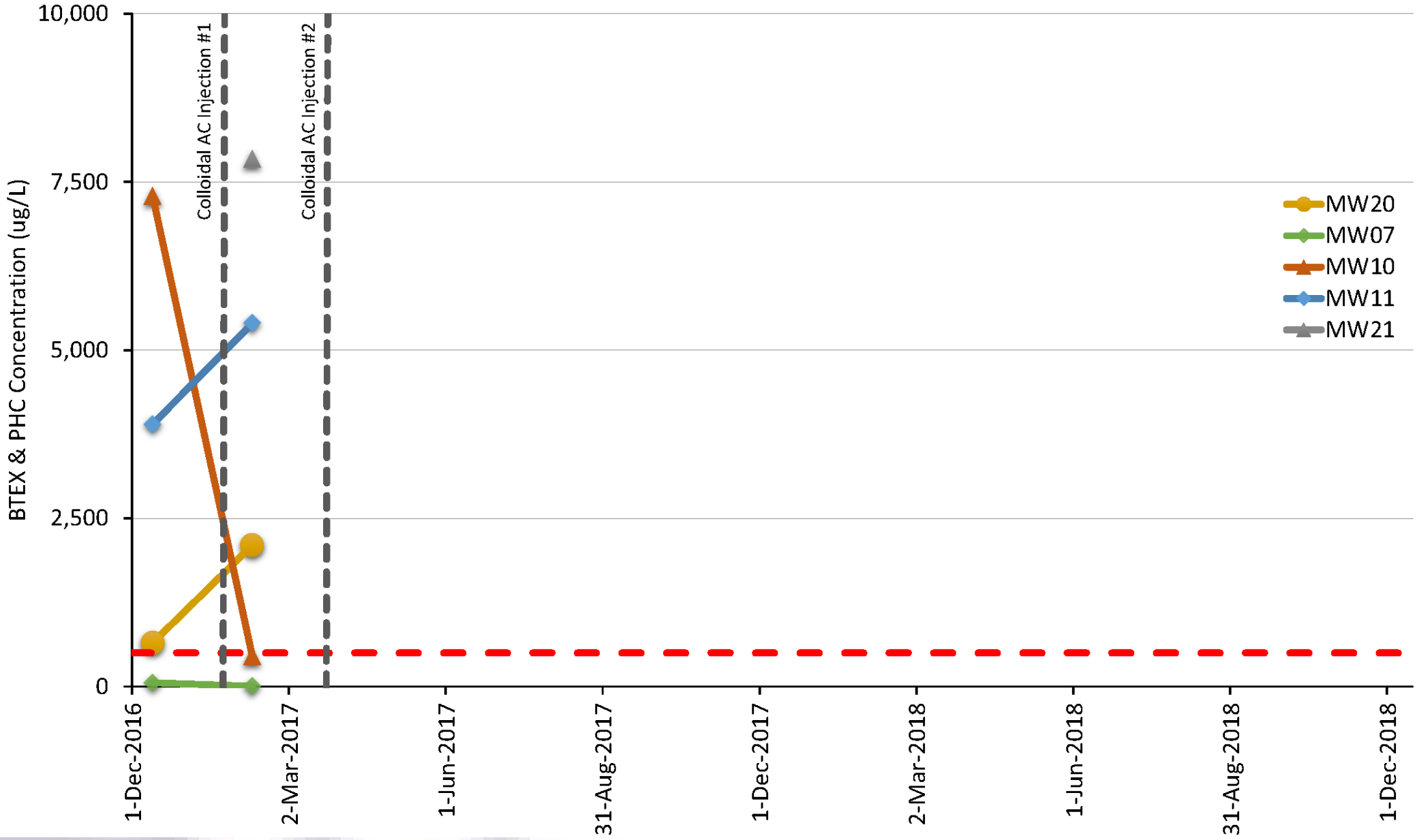


Remediation Approach

- 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

Total PHCs in Groundwater



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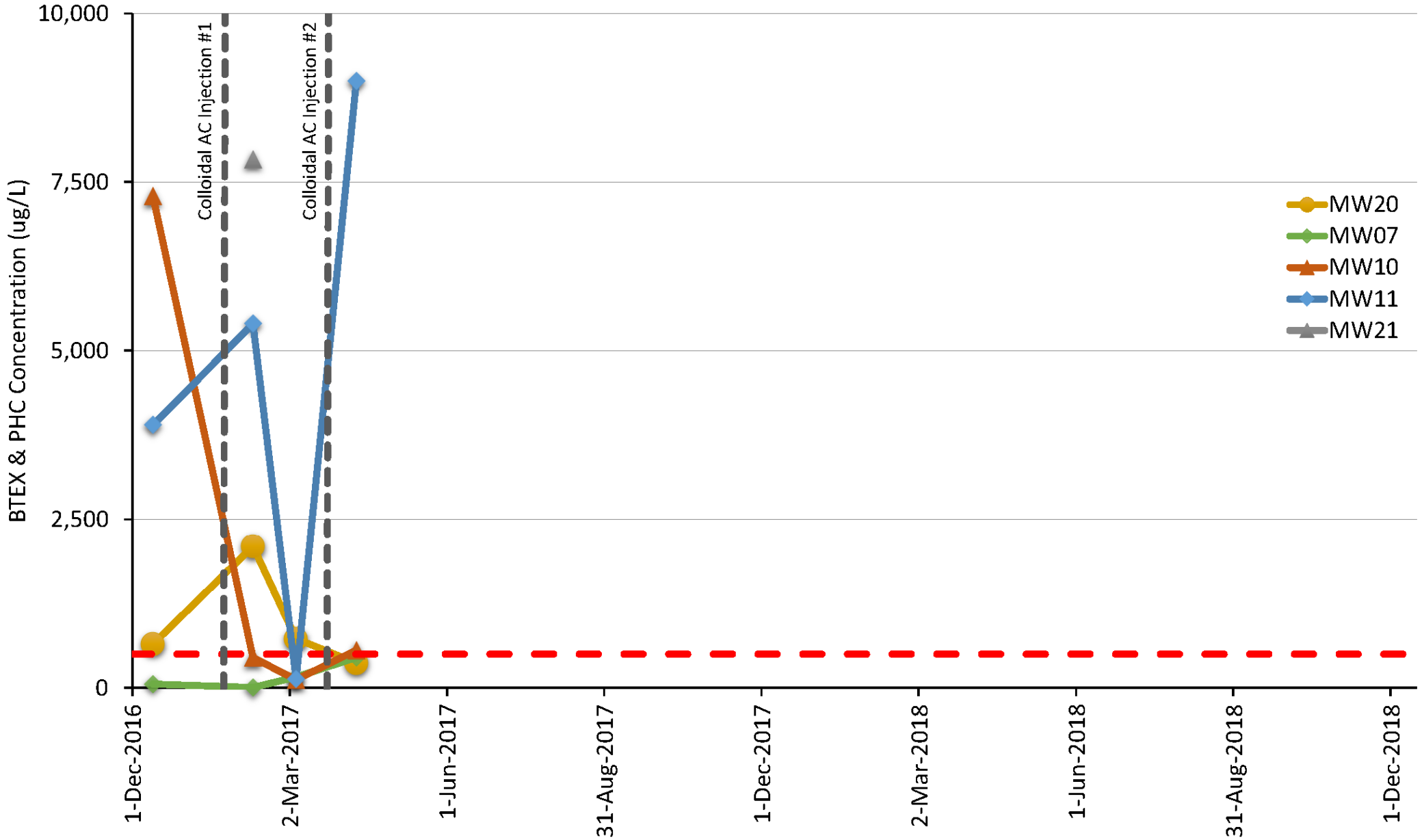

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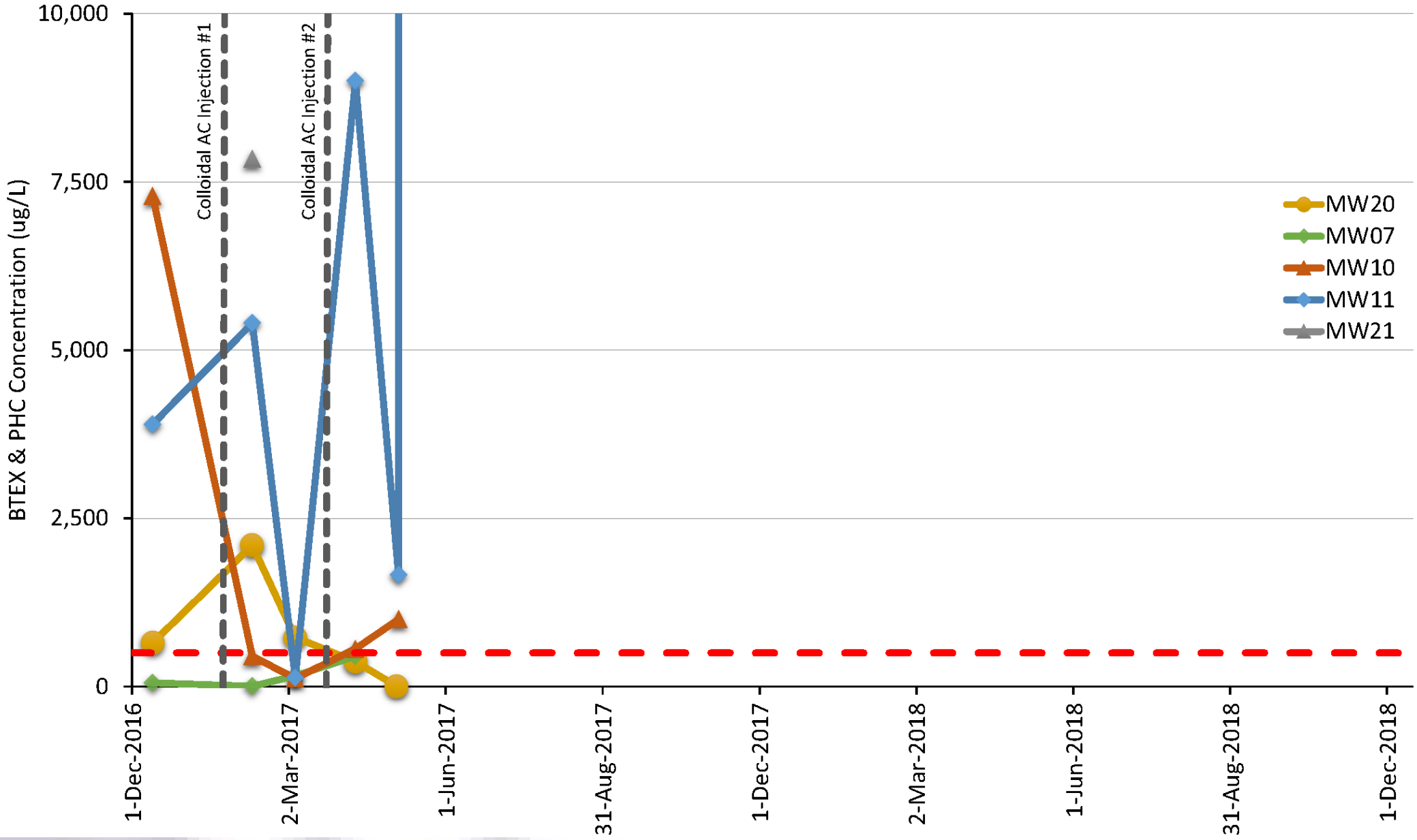
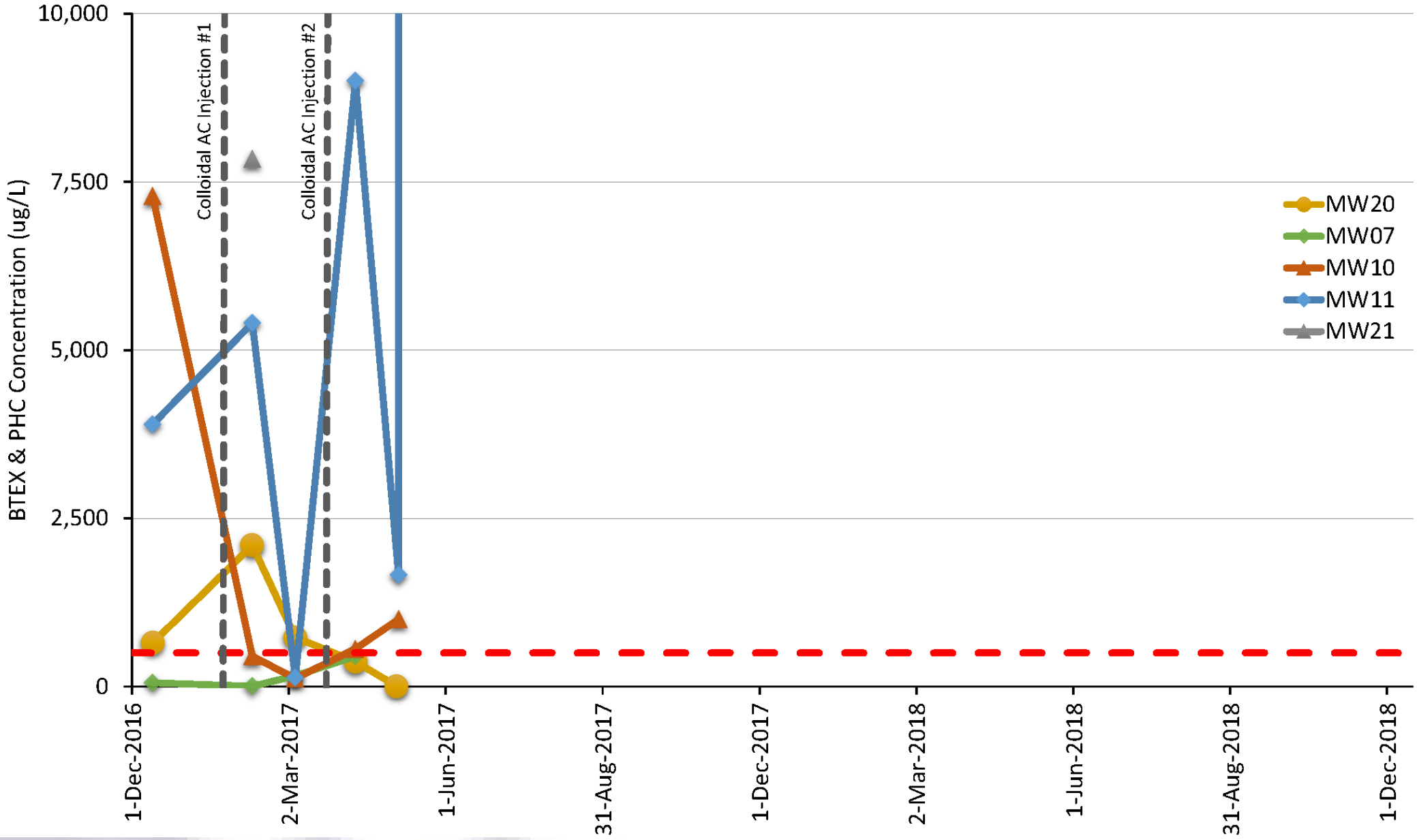


Review of Subsurface PHCs

Evidence of LNAPL noted in soil during drilling

MW19 (ug/L)	Conc.	Standard
PHC(F1)	130,000	750
BTEX	38,700	-
1,2-DCA	<0.5	12

Total PHCs in Groundwater



Remediation Approach

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  - 3 discrete vertical intervals
- Colloidal AC Product
  - Dilute Colloidal AC solution
  - Some ORM

- Colloidal AC PRB Injection #2
- 24 m long by 3 m wide
- 17 Injection Points
  - Single line
  - 1.5 m spacing
  - 1 to 2 discrete vertical intervals
- Colloidal AC Product
  - Dilute Colloidal AC solution
  - Some ORM

- Oxidant Injection
- Targeted (MW10, MW11)
- 8 Injection Points
  - Single line
  - random spacing
  - 2 discrete vertical intervals
- Sodium persulfate product
  - Oxidant solution
  - Some ORM

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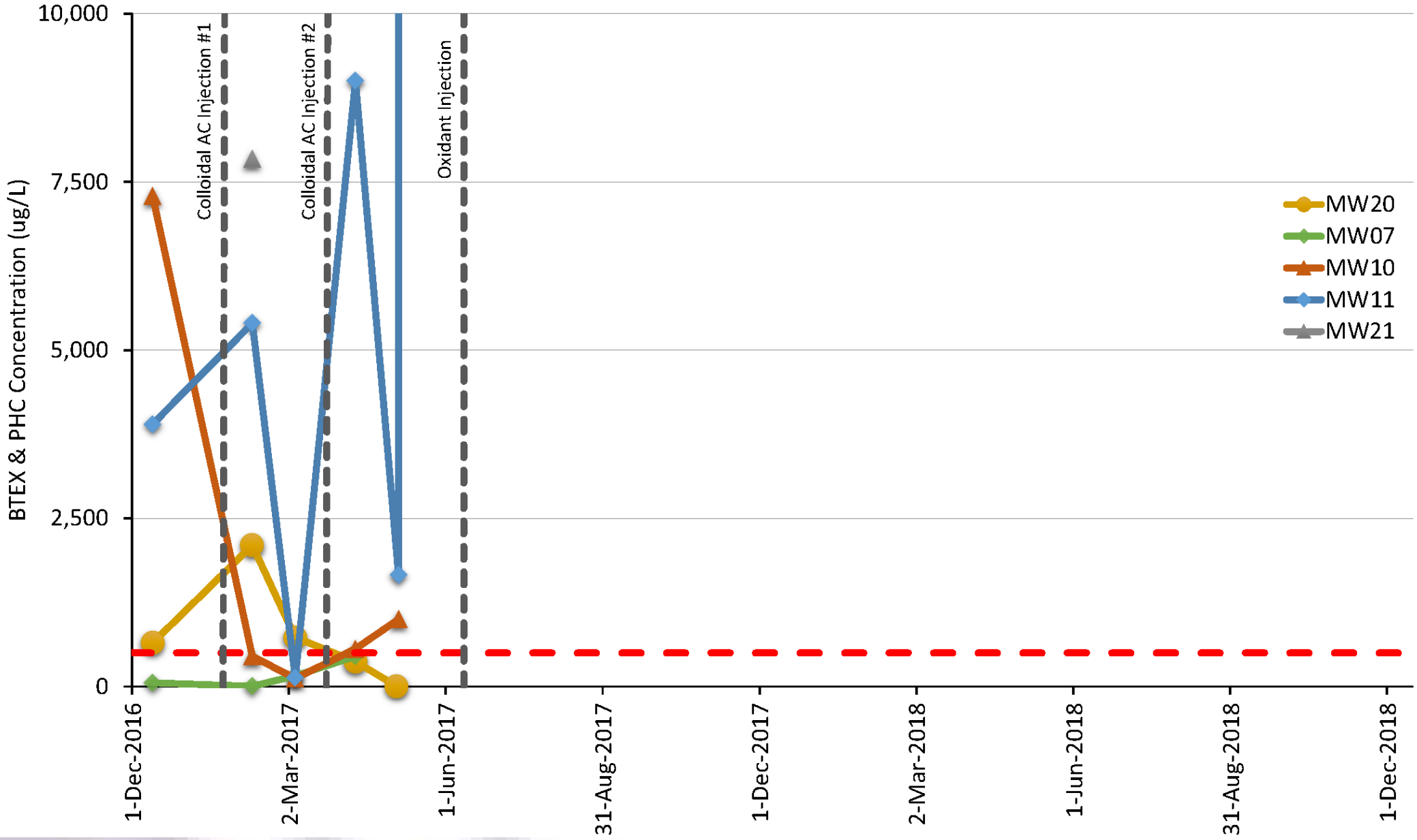

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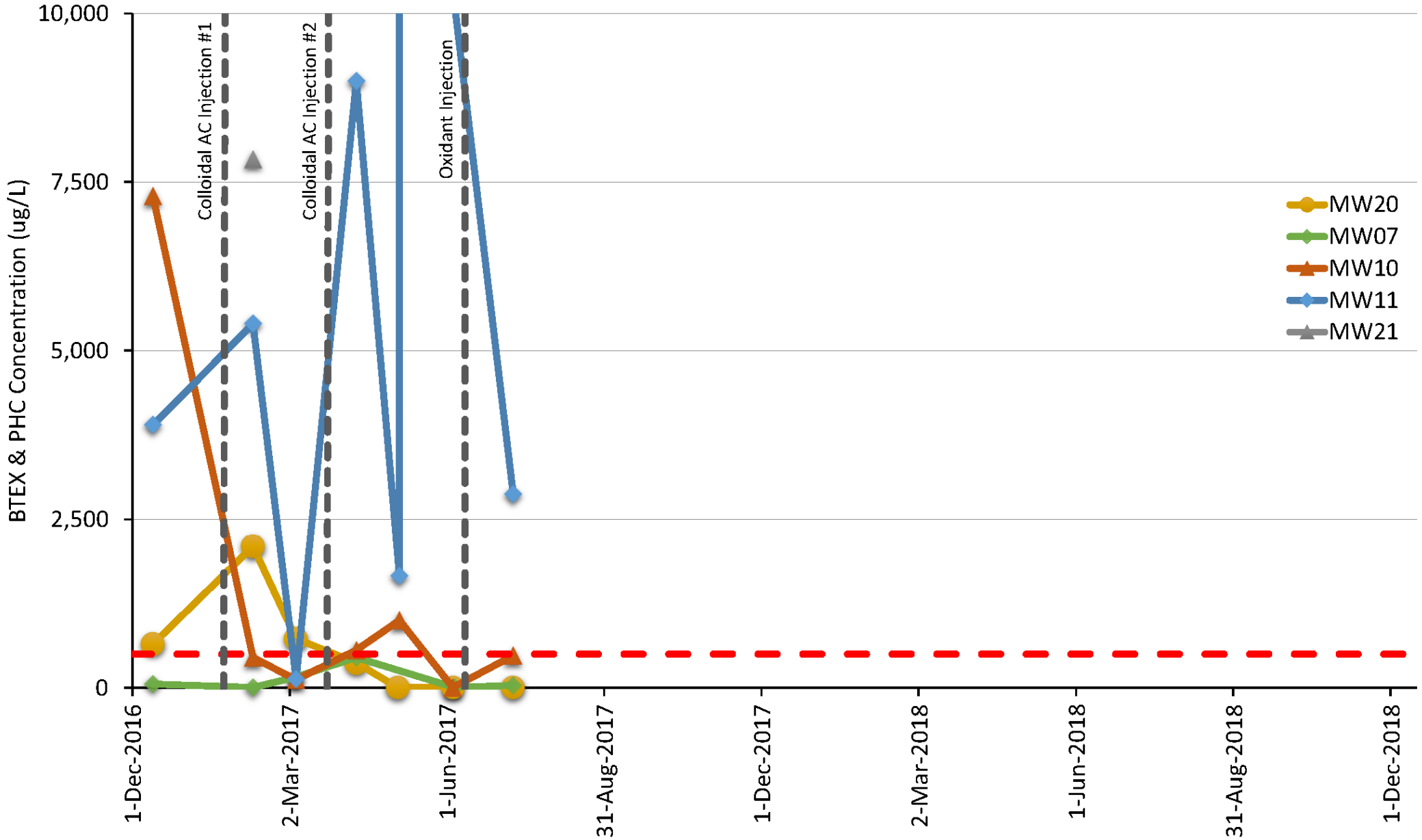

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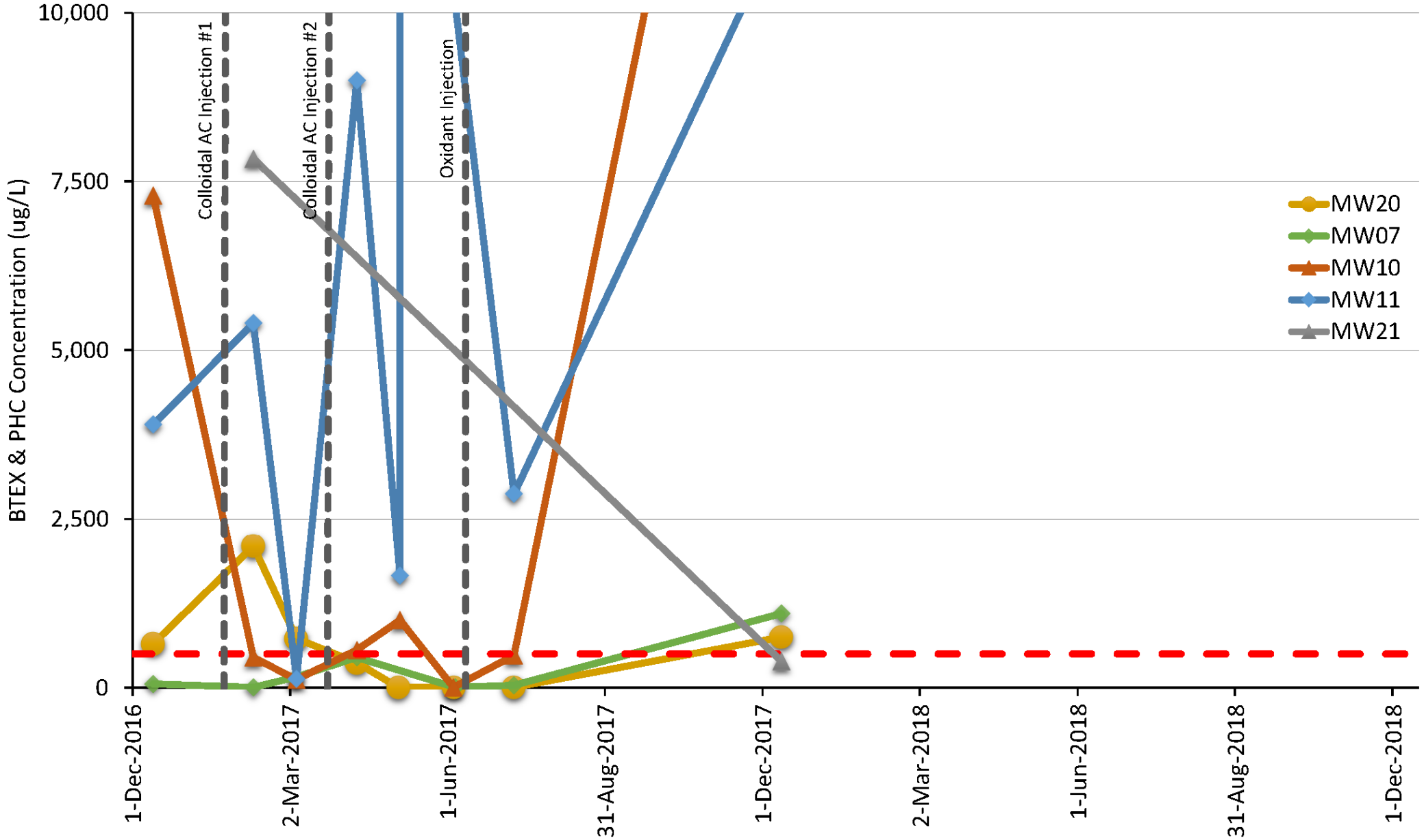

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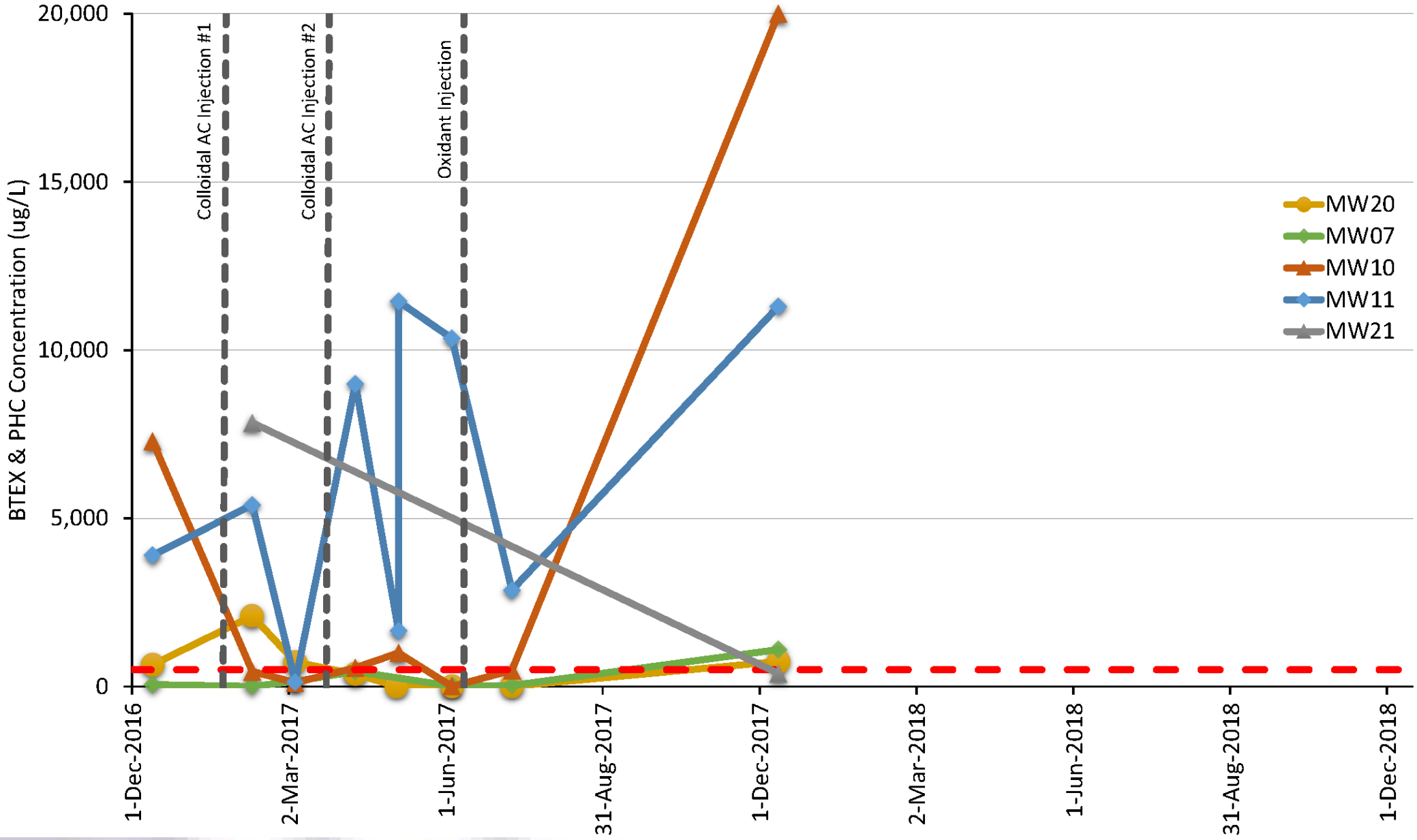

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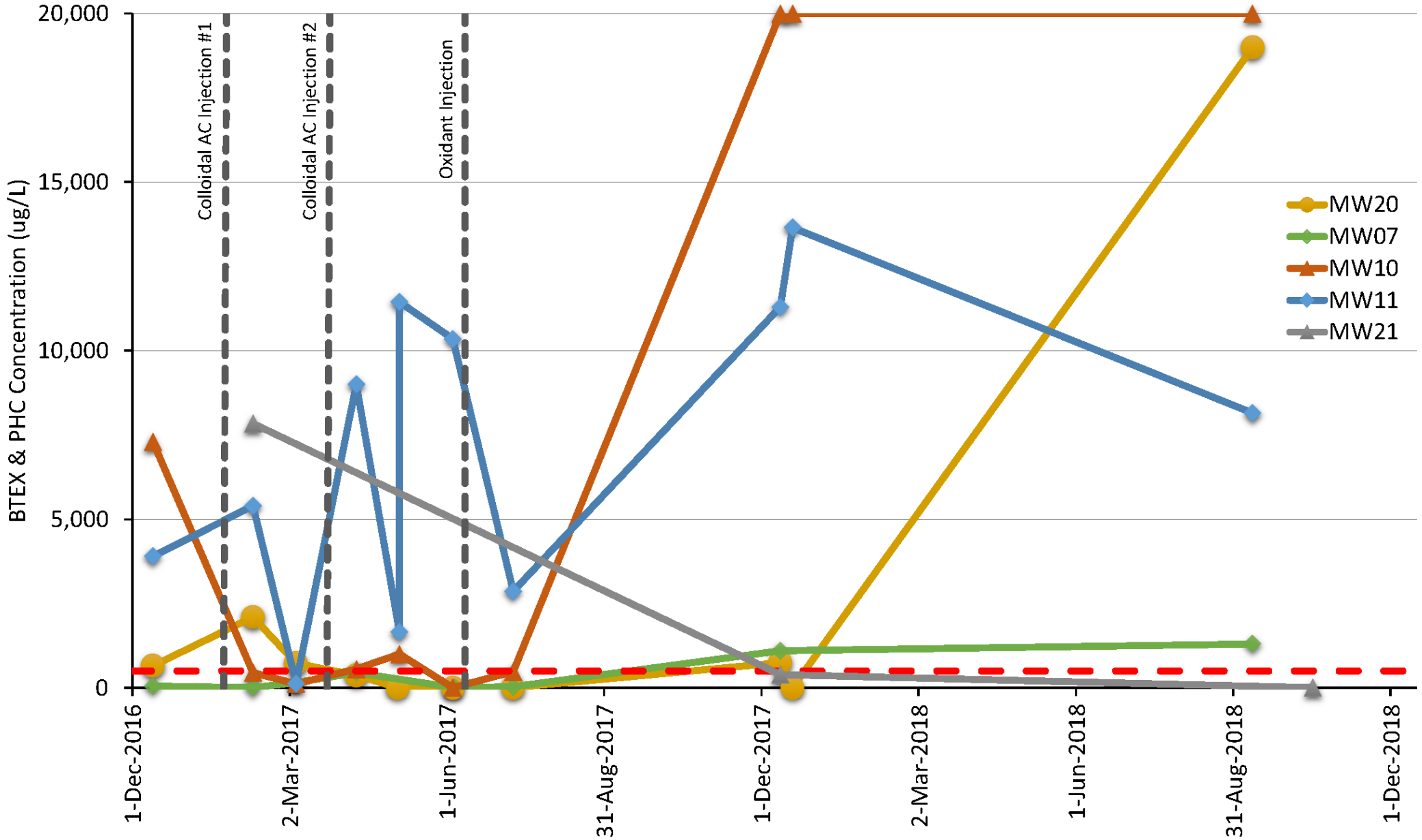

How Can In-Situ Fail?

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
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- Age of Contamination
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- Groundwater Flow Velocity
- Seasonal Water Table Fluctuations
- Etc.

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- Etc.

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

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

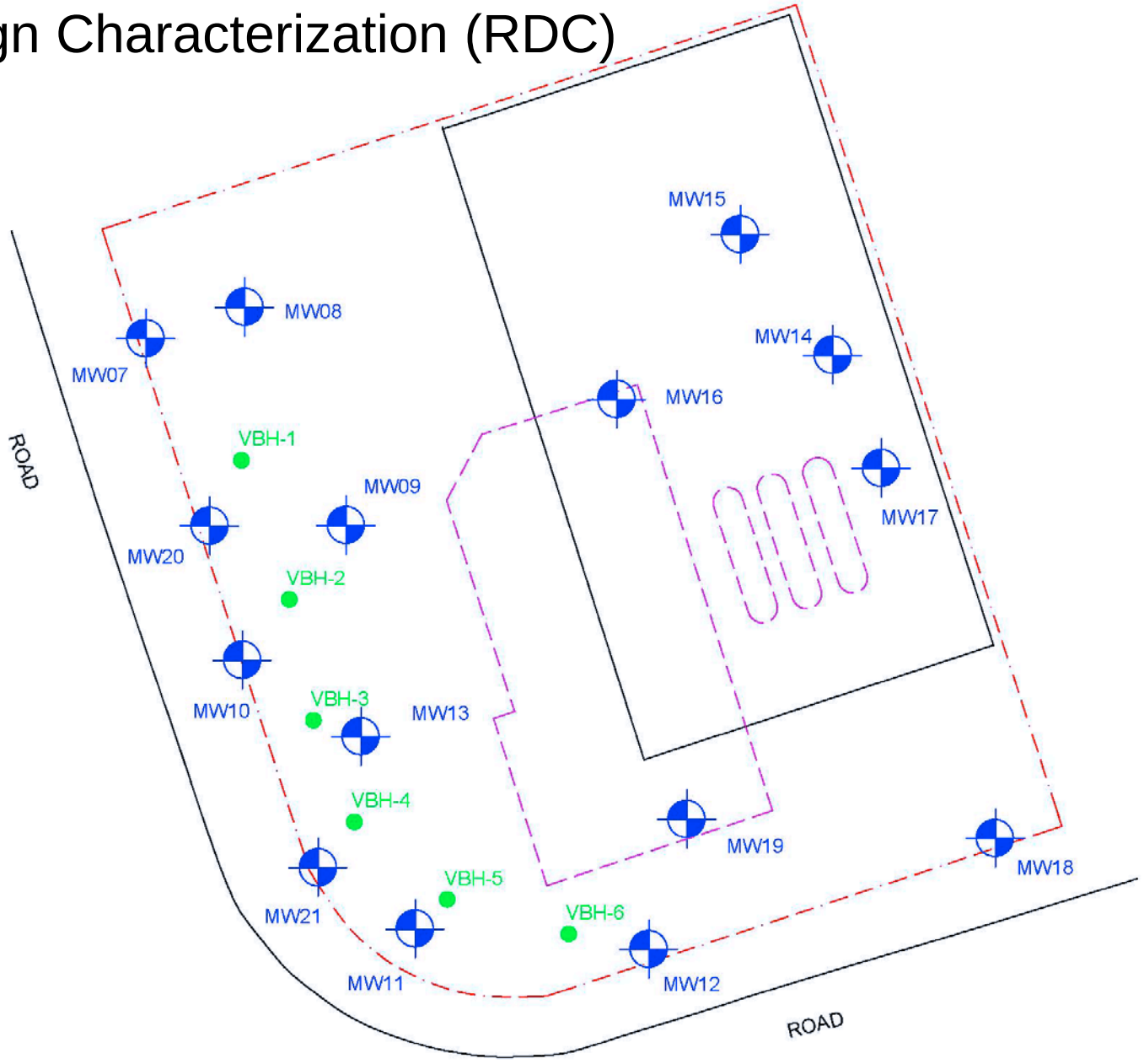
Groundwater

(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

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



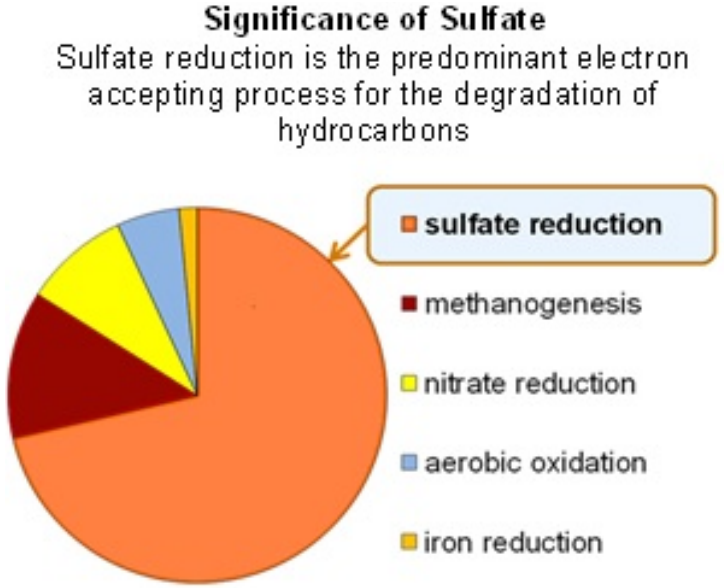
Remediation Approach – Updated

- 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

PHC Treatment & Geochemistry – What is Best for PRBs?

Trap and Treat BOS200®



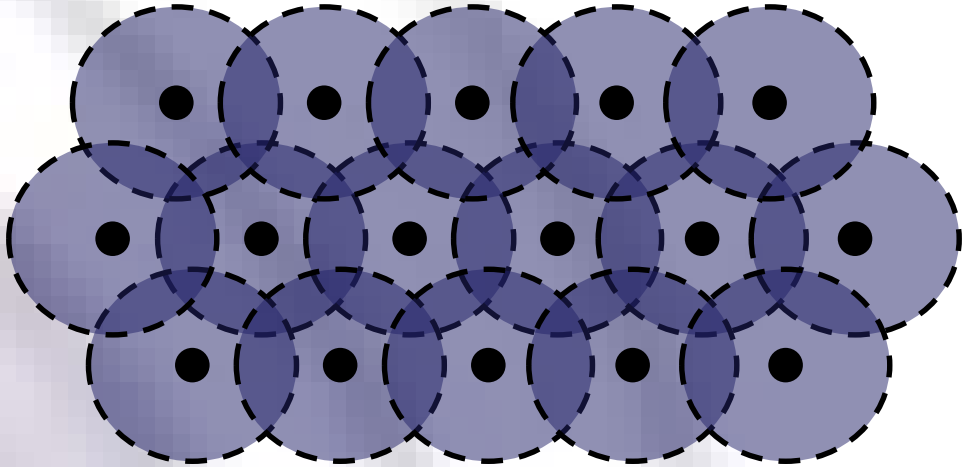
Oxygen Solubility = 12 mg/L
Sulfate Solubility = 10,000 mg/L

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

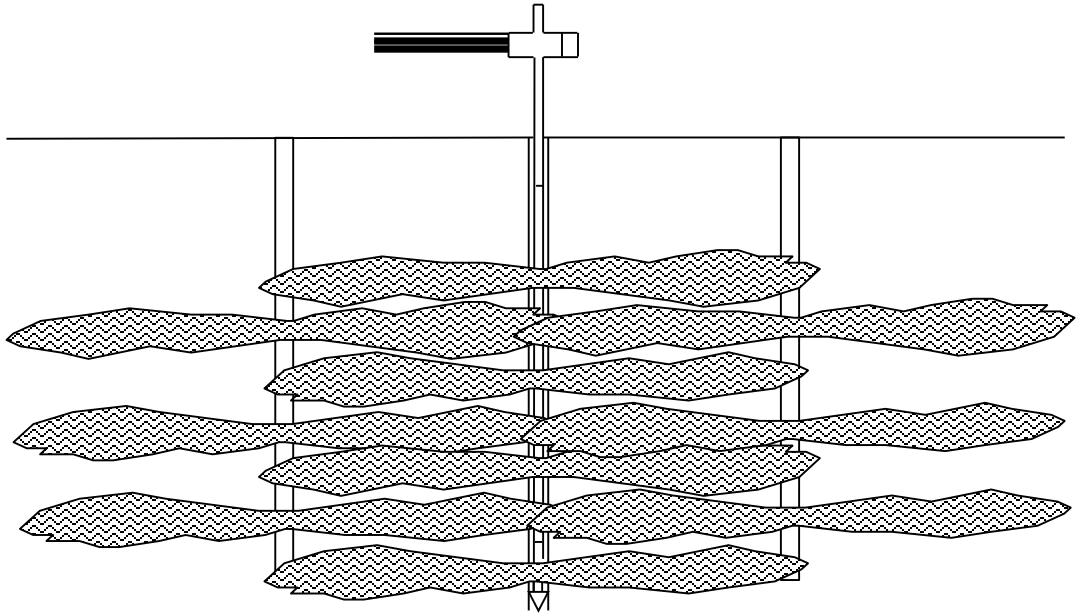
Injected PRB – Planning the IP Layout

The Goal:

- Uniform Distribution
- Intimate contact between remedial amendment and contaminants

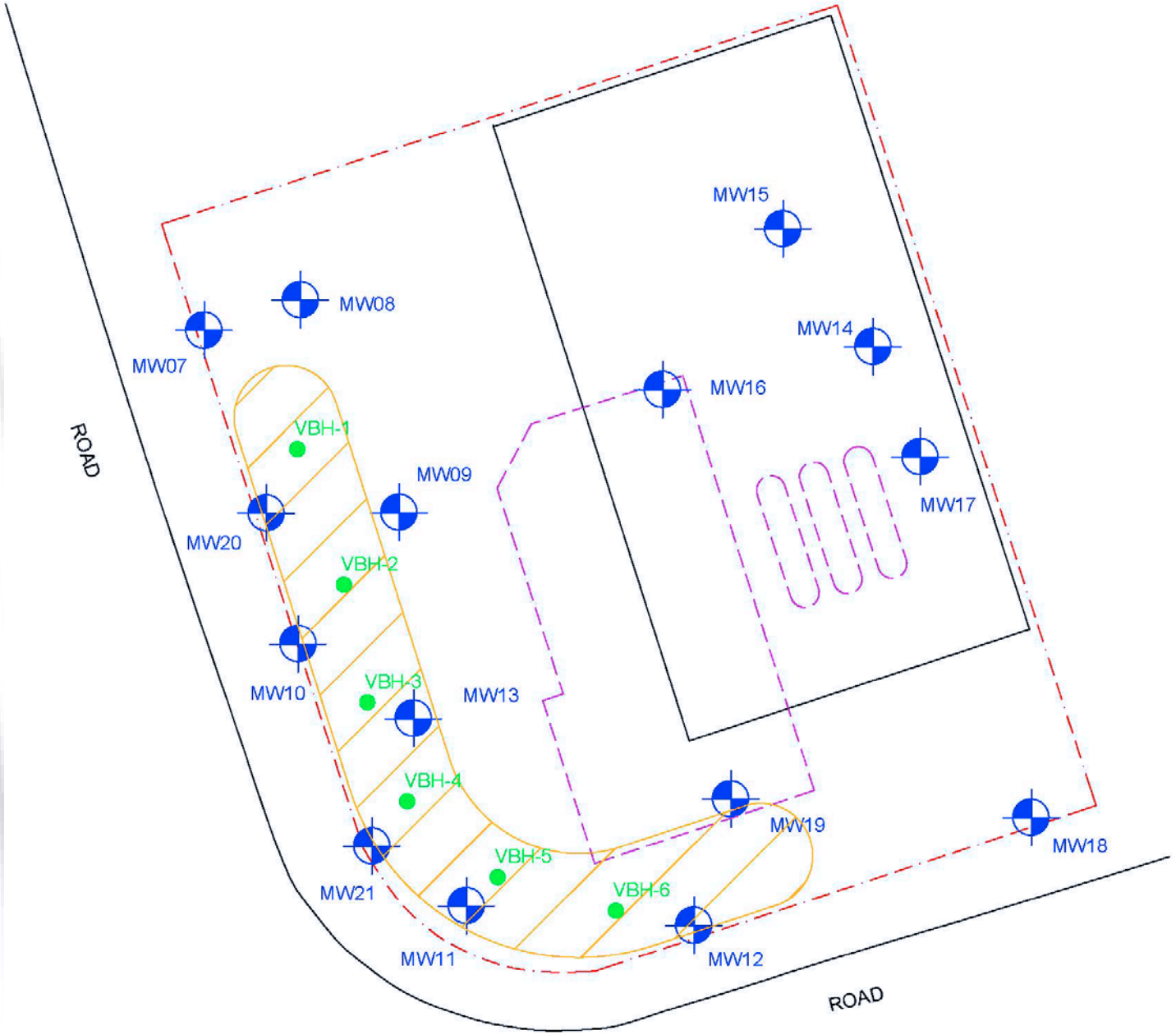


Plan View



Profile View

Remediation – Round 2



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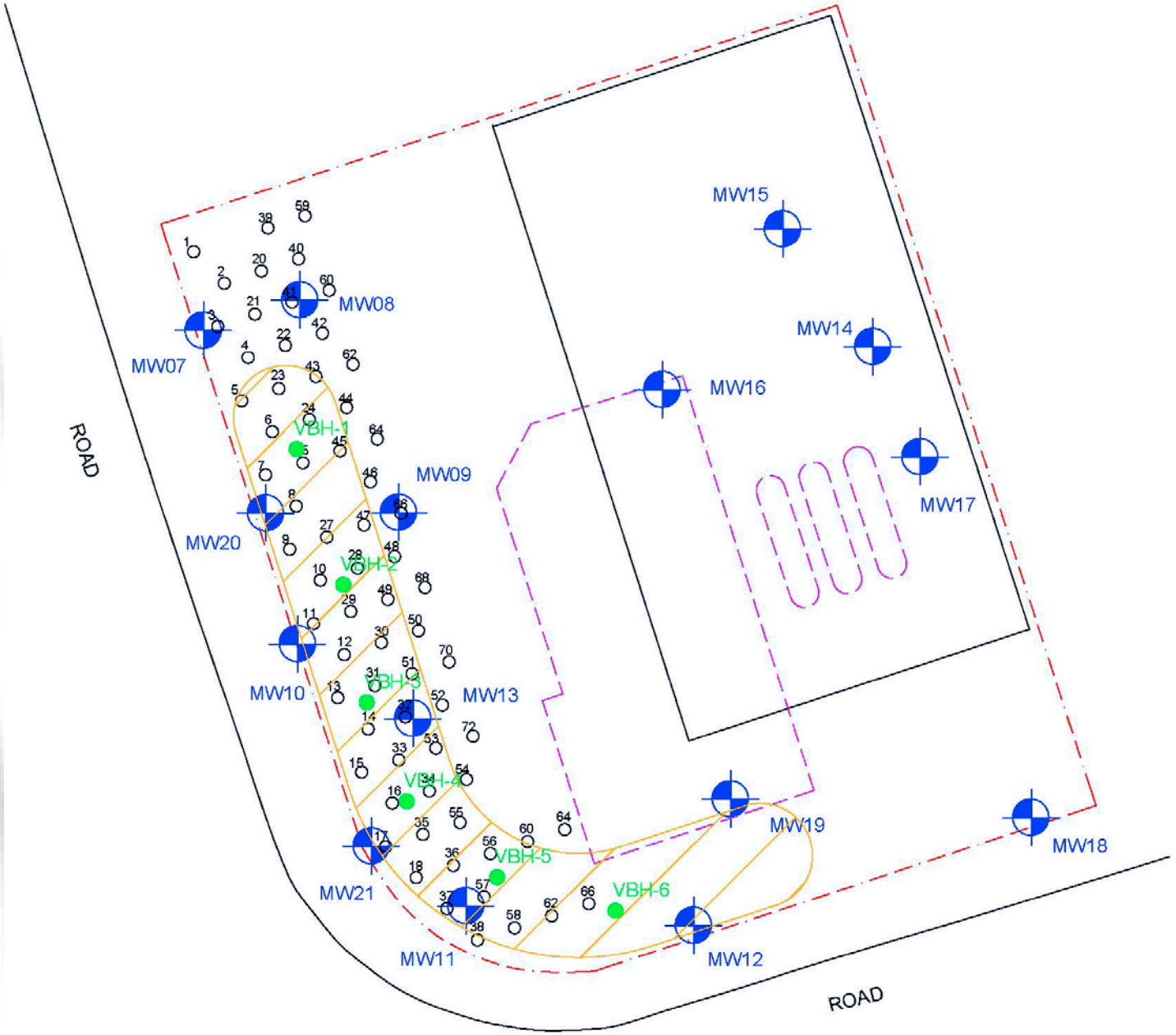

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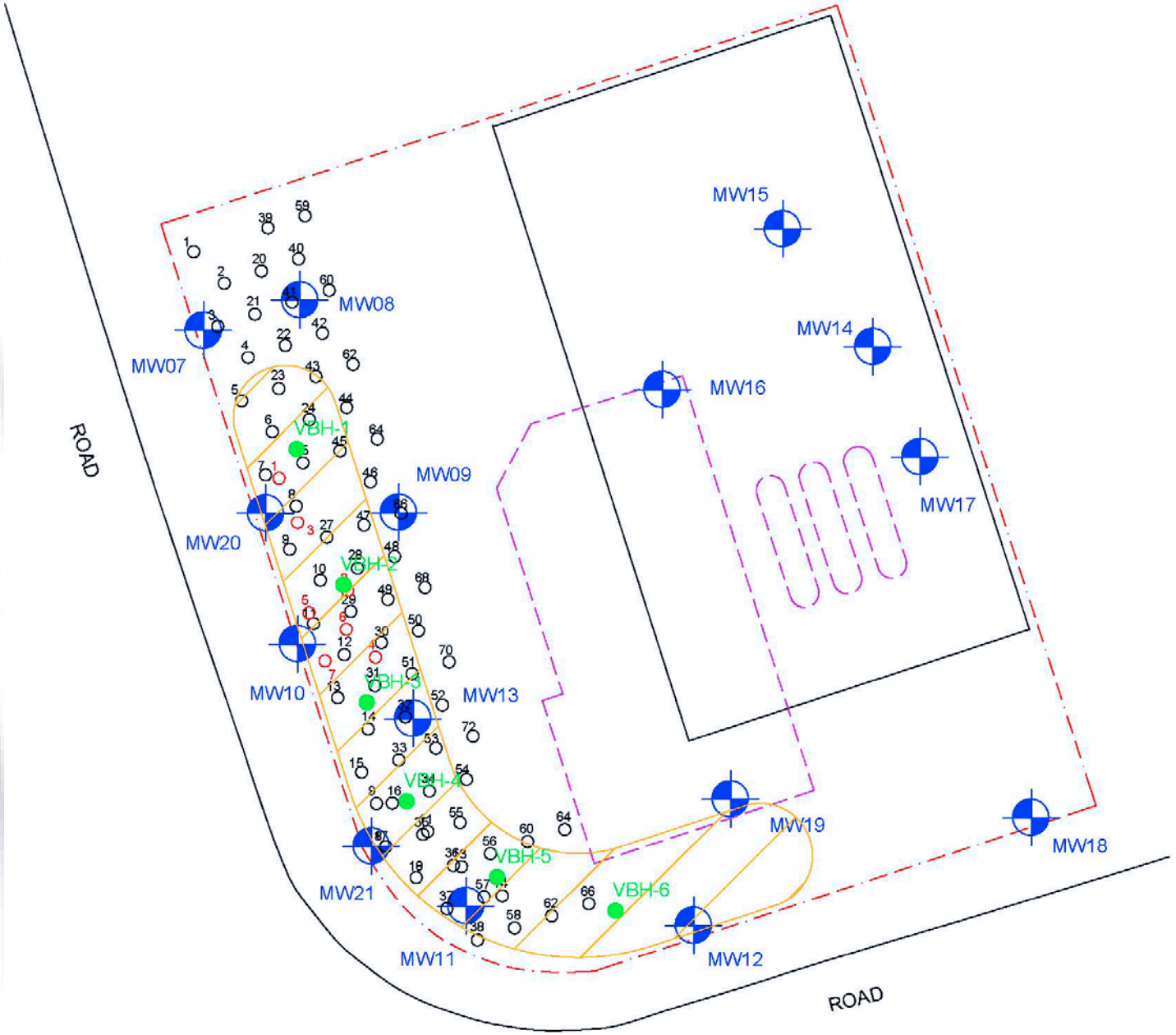


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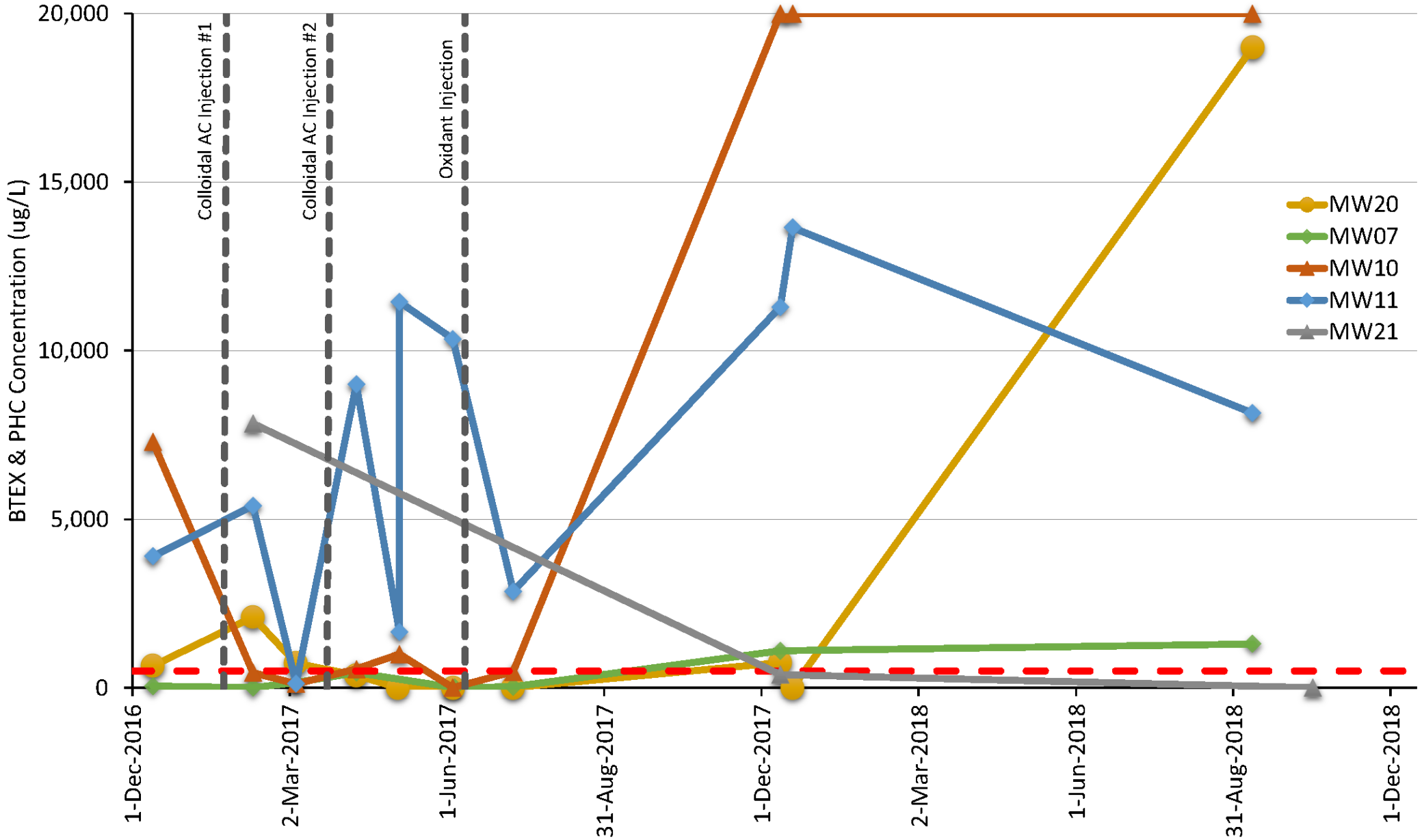
Total PHCs in Groundwater



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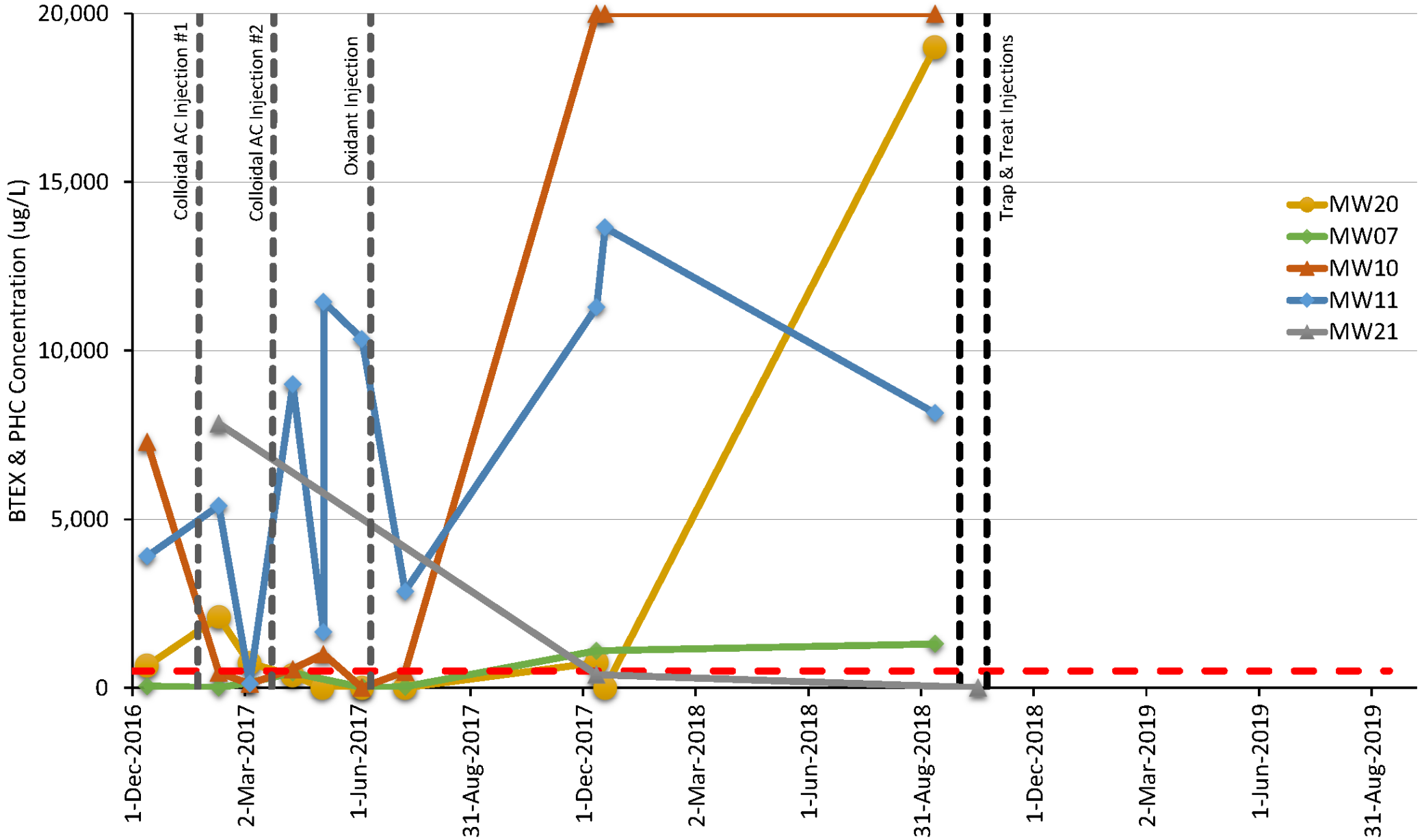

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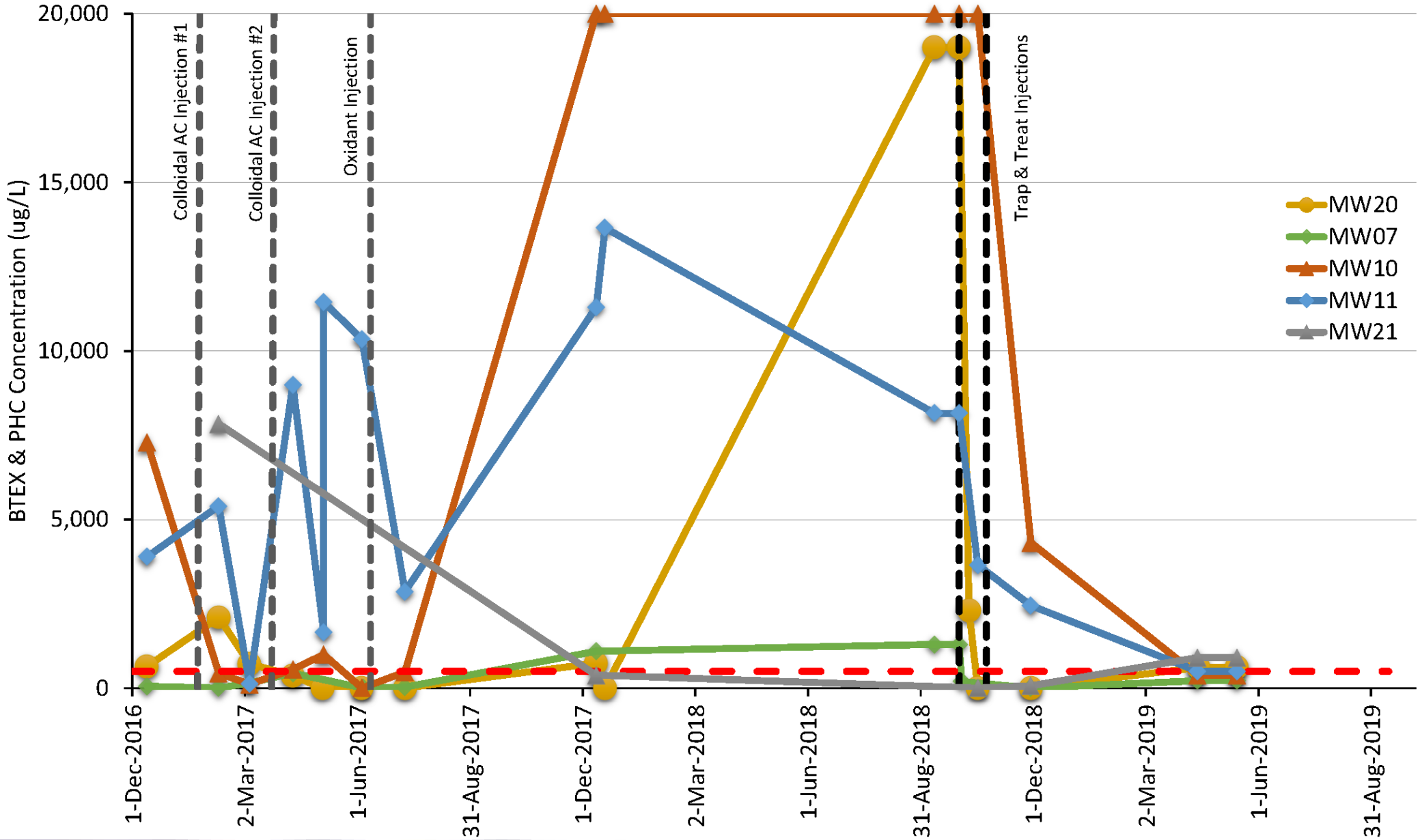

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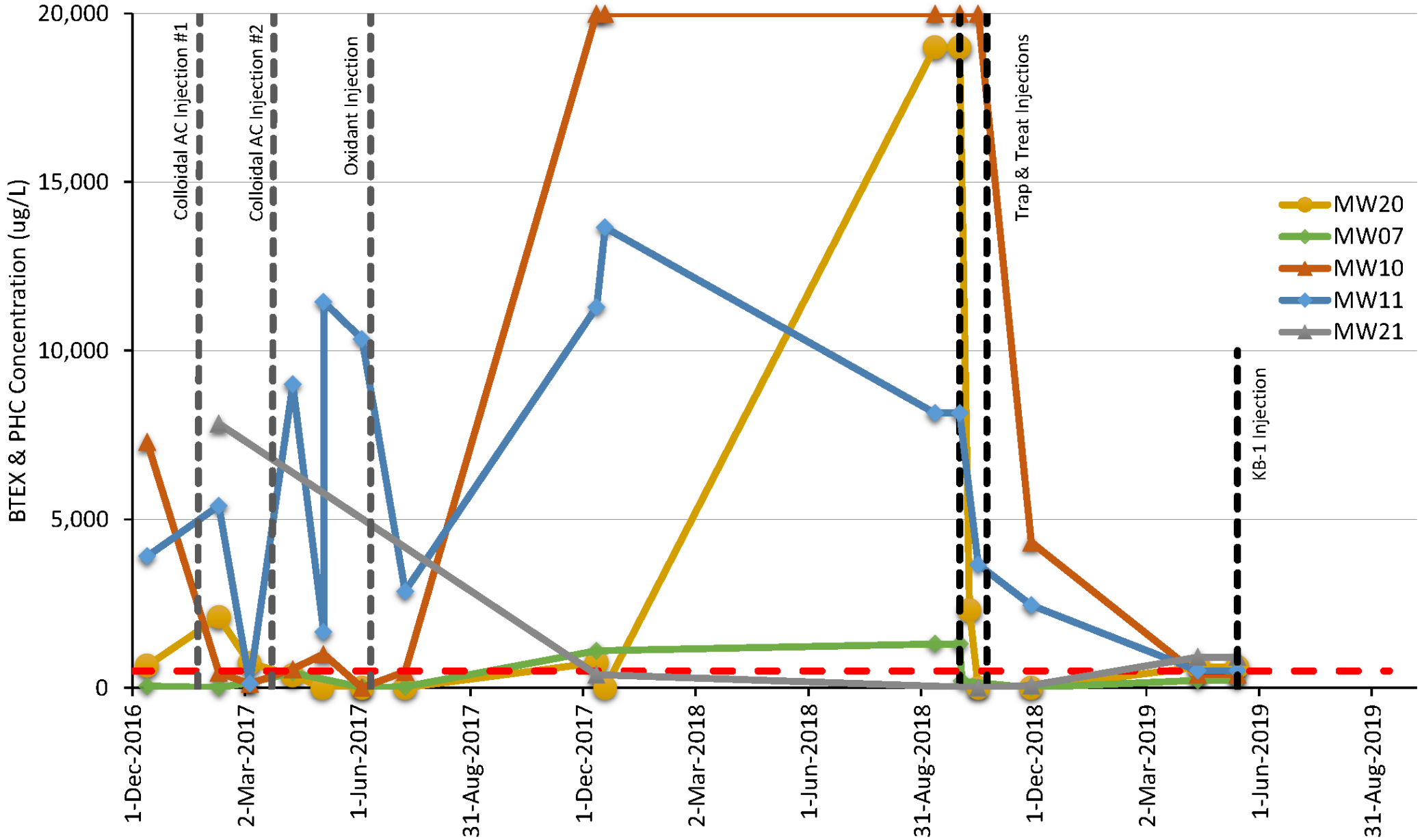

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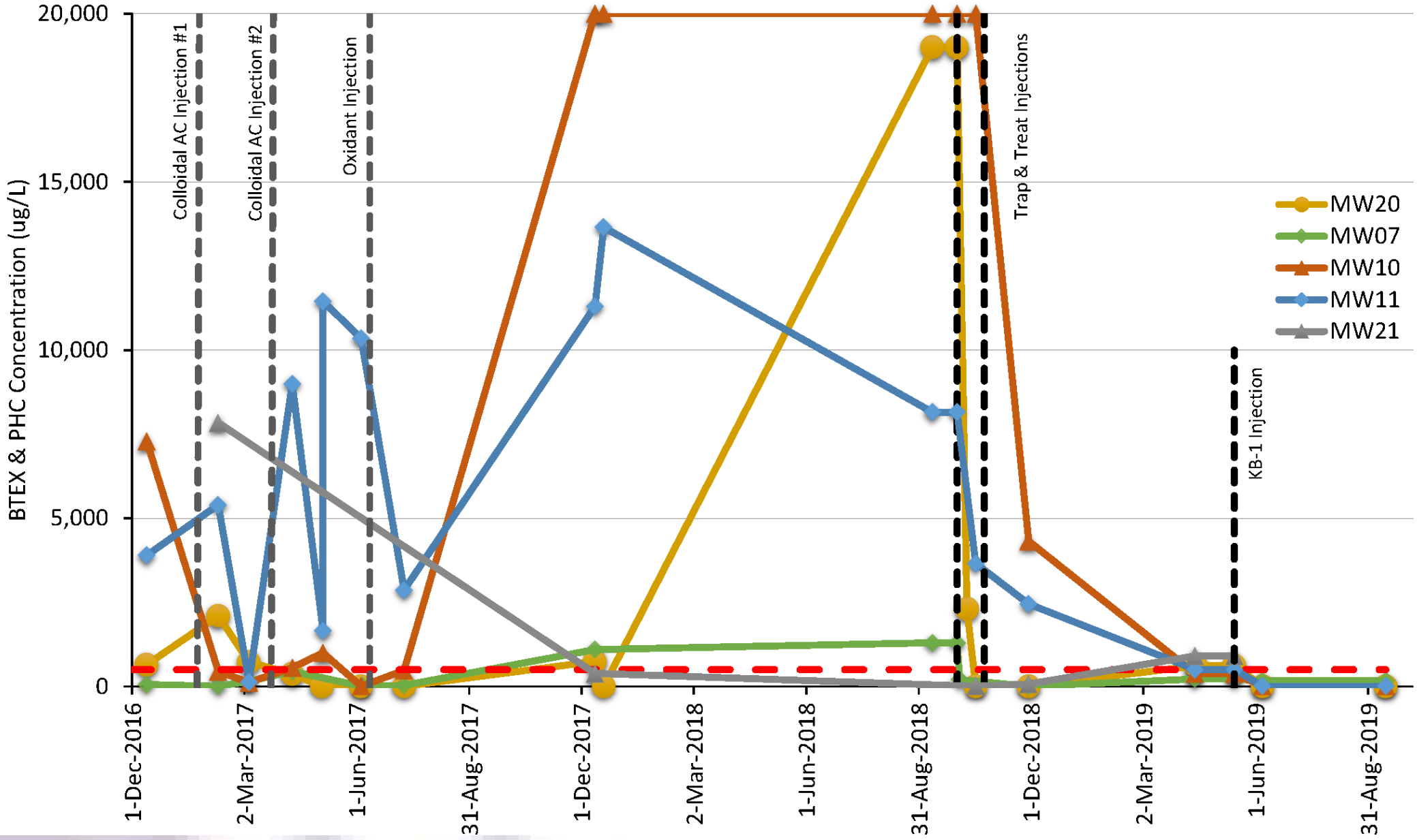
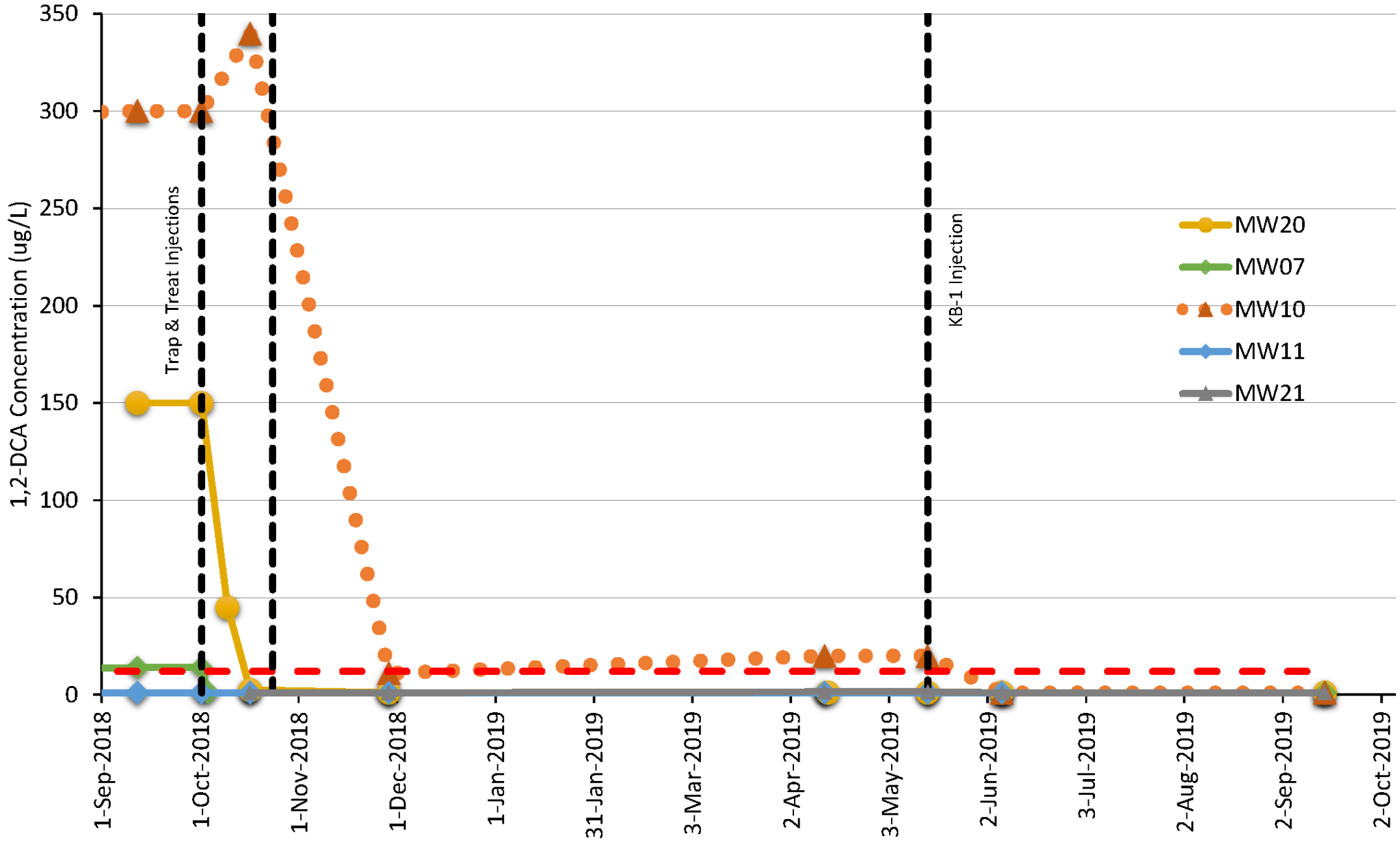
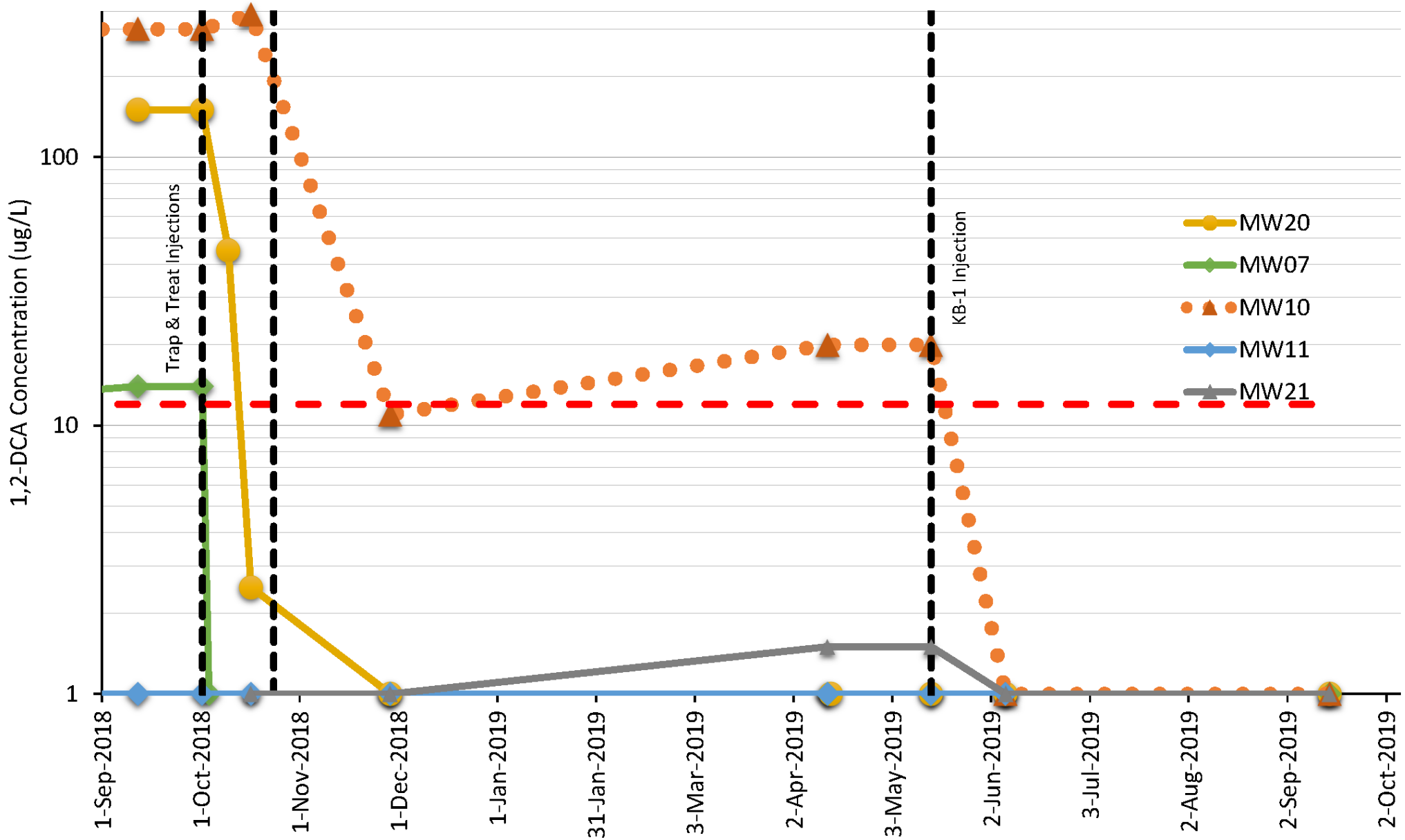


12DCA in Groundwater



12DCA in Groundwater



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

Closing

Plume containment demonstrated so site redevelopment could proceed

Effective PRBs for PHCs are possible.

One just needs to design and install them properly.

Questions?

Thank You for your Time!

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