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Colloidal Zero-Valent Iron Injection for Enhanced Biotic/Abiotic Degradation of TCE DNAPL Source

Clint Jacob and Erin Waibel, October 2022

Outline:

- General Approach
- Project Overview
- Bio with Abiotic Enhancement
- Source Progress and Next Steps

General Approach

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Biotic + Abiotic

Biodegradation:

- Electron donor (food for bacteria)
- Native bacteria

  -reduced aquifer redox

  -sequential reductive dechlorination of TCE

Chemical Degradation:

- Reactive iron (ferrous or zero-valent)

  -short cut dechlorination

Project Overview

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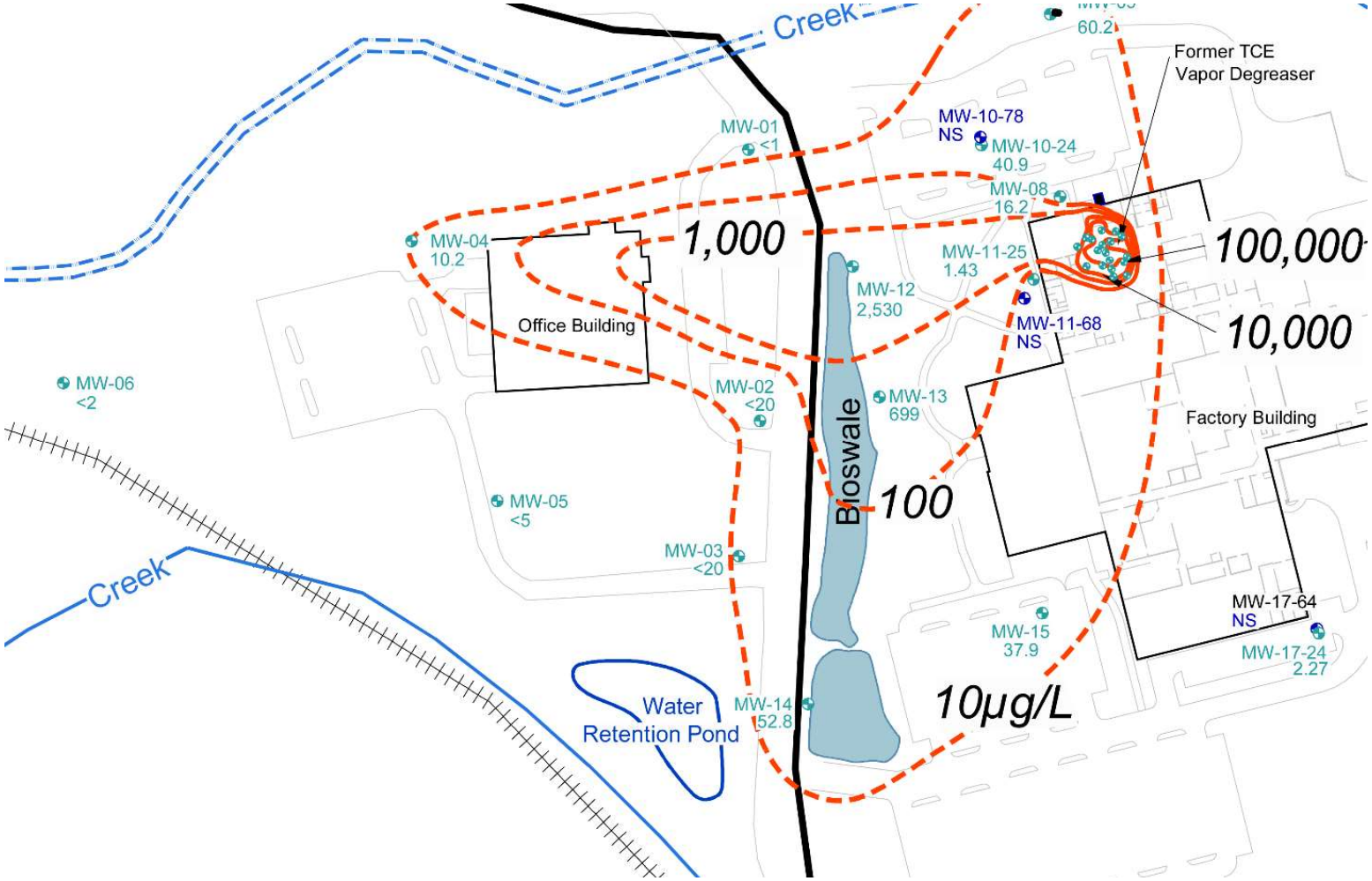
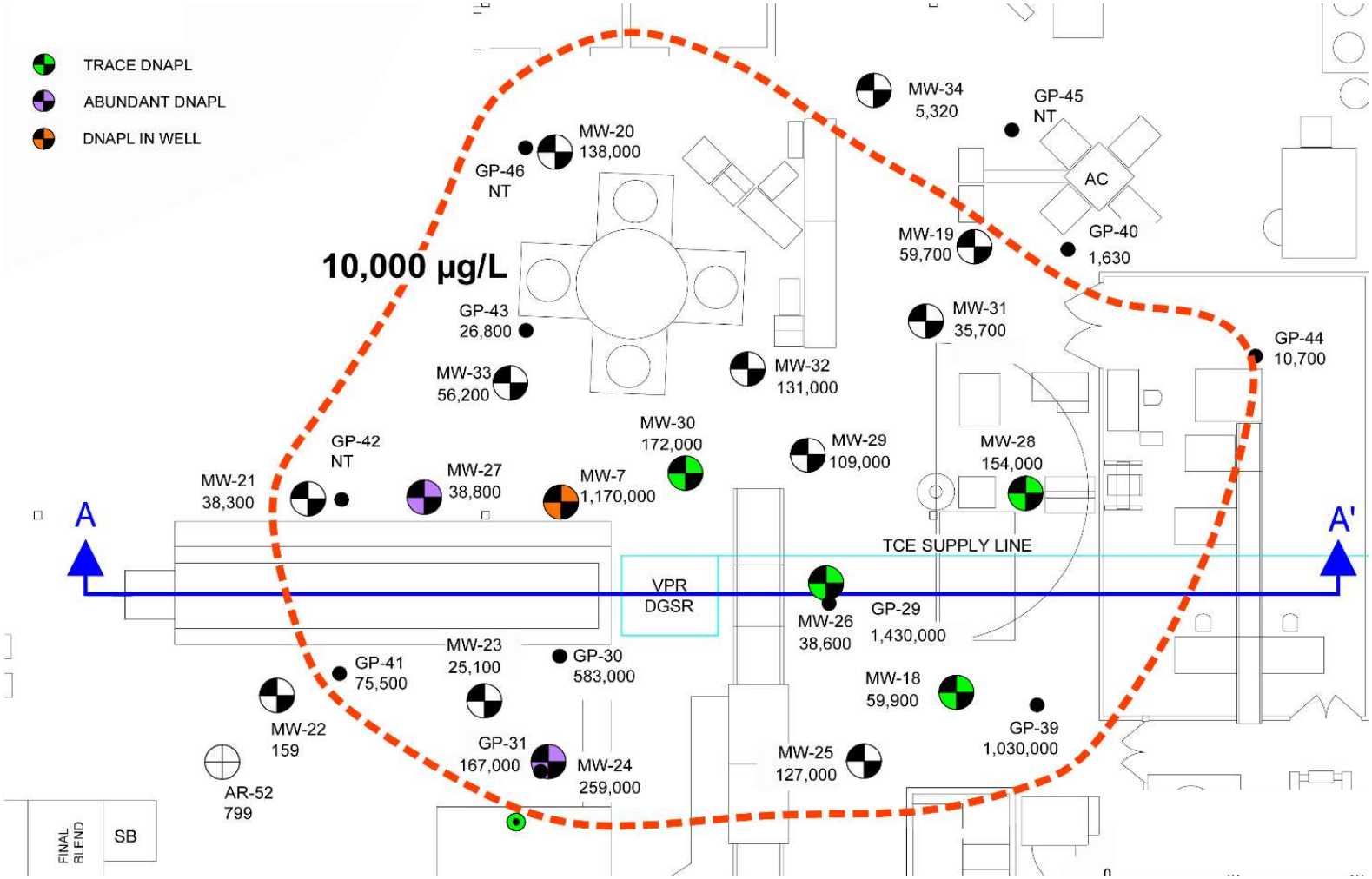
The Problem

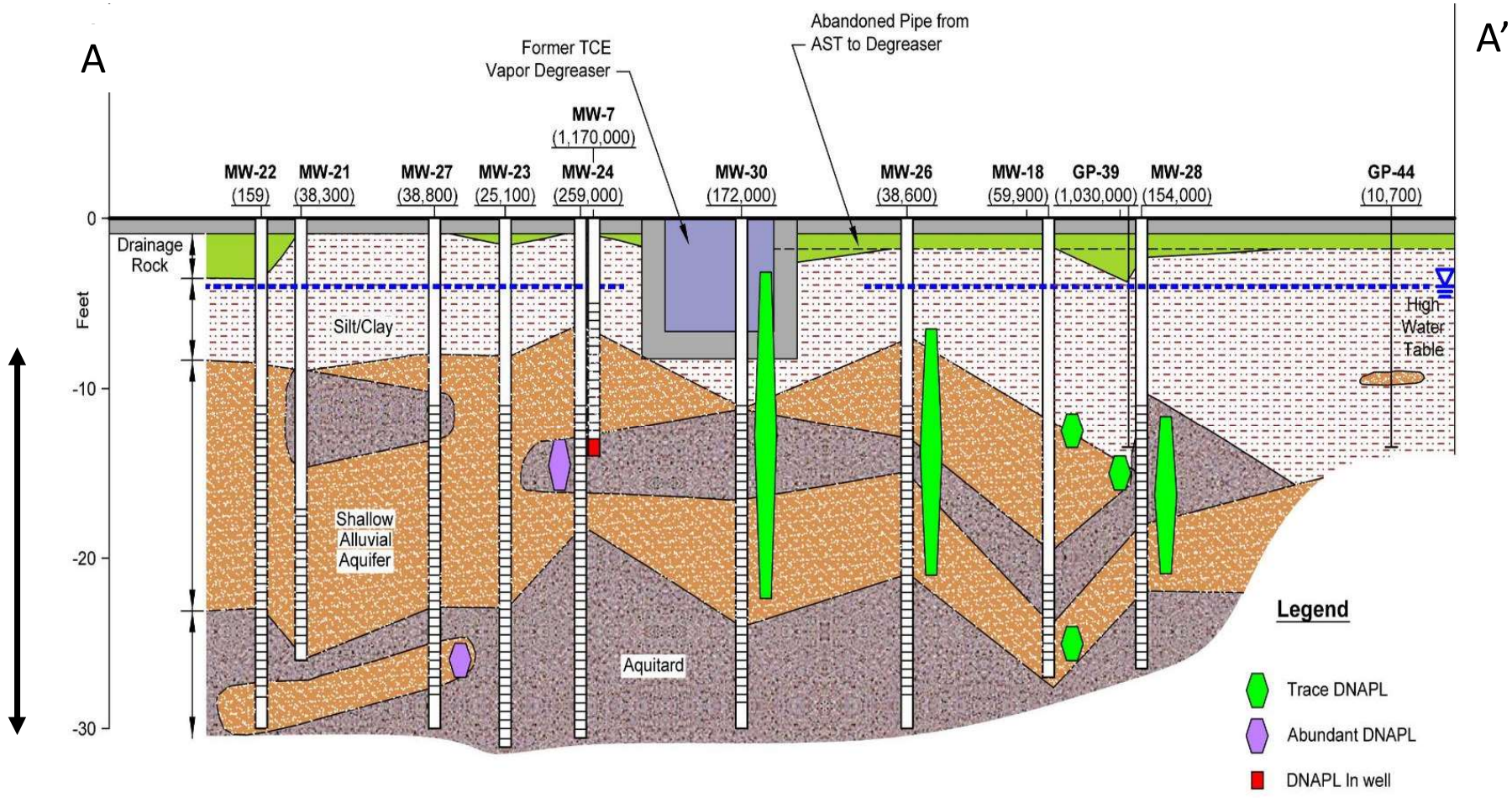

Creek
Creek
60.2
Former TCE
Vapor Degreaser
MW-10-78
NS
MW-10-24
40.9
MW-01
<1
MW-08
16.2
1,000
MW-04
10.2
Office Building
MW-11-25
1.43
100,000
MW-12
2,530
MW-11-68
NS
10,000
MW-06
<2
MW-02
<20
MW-13
699
Factory Building
Broswale
100
MW-05
<5
MW-03
<20
MW-17-64
NS
MW-15
37.9
MW-17-24
2.27
Water
Retention Pond
MW-14
52.8
10µg/L

The Problem


TRACE DNAPL
ABUNDANT DNAPL
DNAPL IN WELL
10,000 µg/L
MW-34
5,320
GP-45
NT
MW-20
138,000
GP-46
NT
AC
MW-19
59,700
GP-40
1,630
GP-43
26,800
MW-31
35,700
GP-44
10,700
MW-33
56,200
MW-32
131,000
MW-30
172,000
GP-42
NT
MW-29
109,000
MW-28
154,000
MW-21
38,300
MW-27
38,800
MW-7
1,170,000
A
A'
TCE SUPPLY LINE
VPR
DGSR
MW-26
38,600
GP-29
1,430,000
MW-23
25,100
GP-30
583,000
GP-41
75,500
MW-18
59,900
MW-22
159
GP-39
1,030,000
GP-31
167,000
MW-24
259,000
MW-25
127,000
AR-52
799
FINAL
BLEND
SB

The Problem

Target:
8-30’

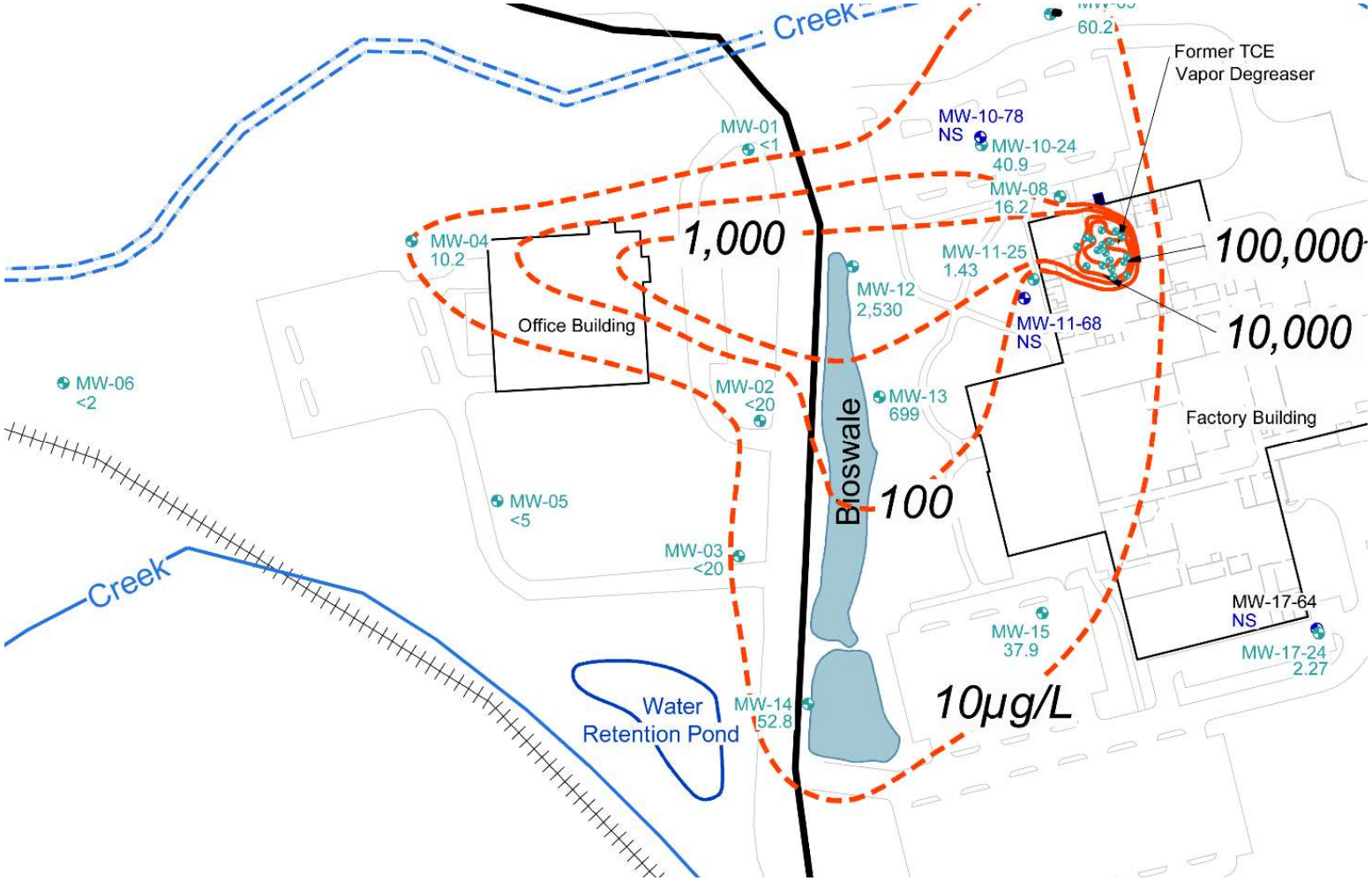


Bioremediation Approach

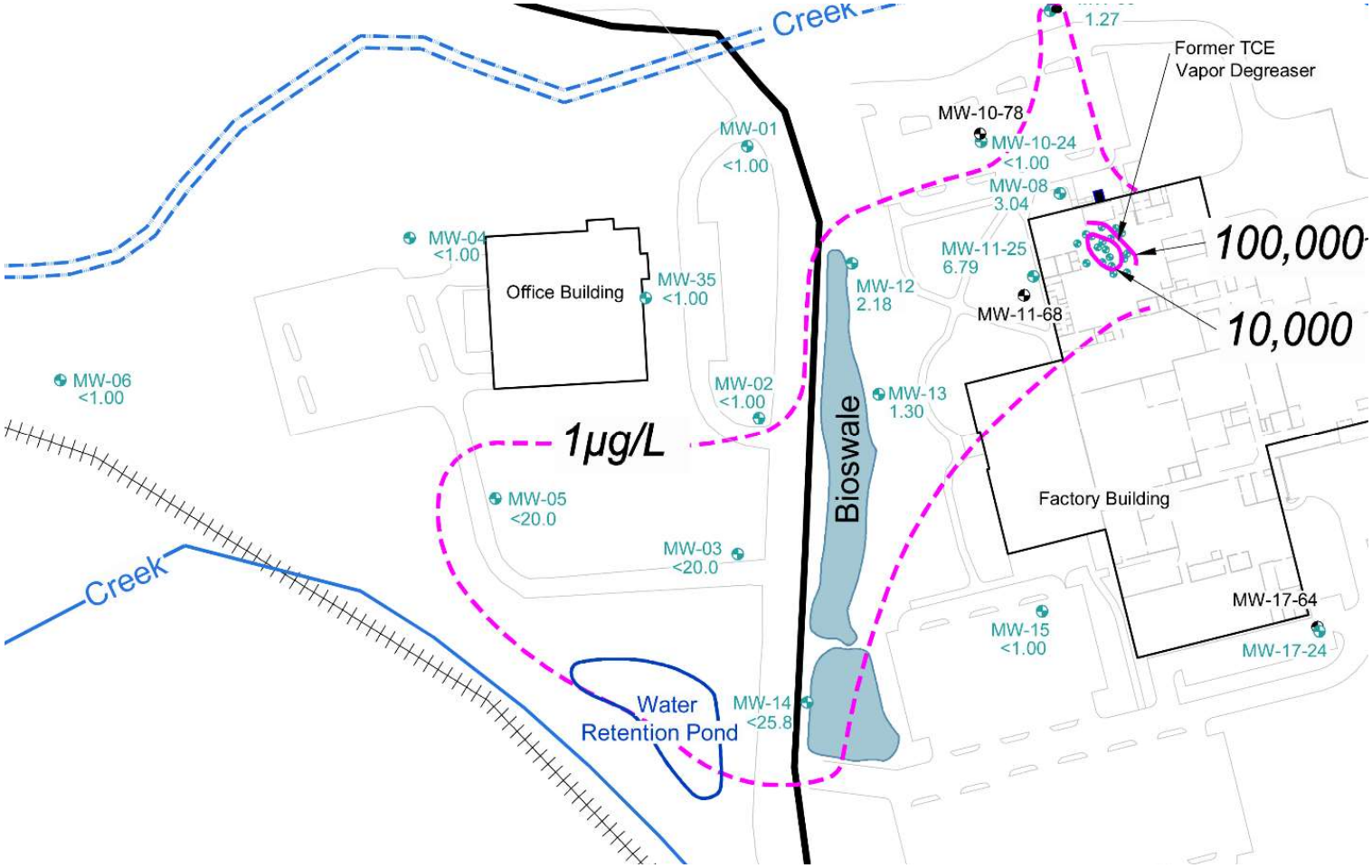
Concentrated EVO (>20%) to sequester and treat mass in Source (Henry et al 2005):

1. Reduced source K and flux to plume
2. Partitioning and dissolution of TCE to EVO
3. Long term electron donor for ERD

Baseline TCE



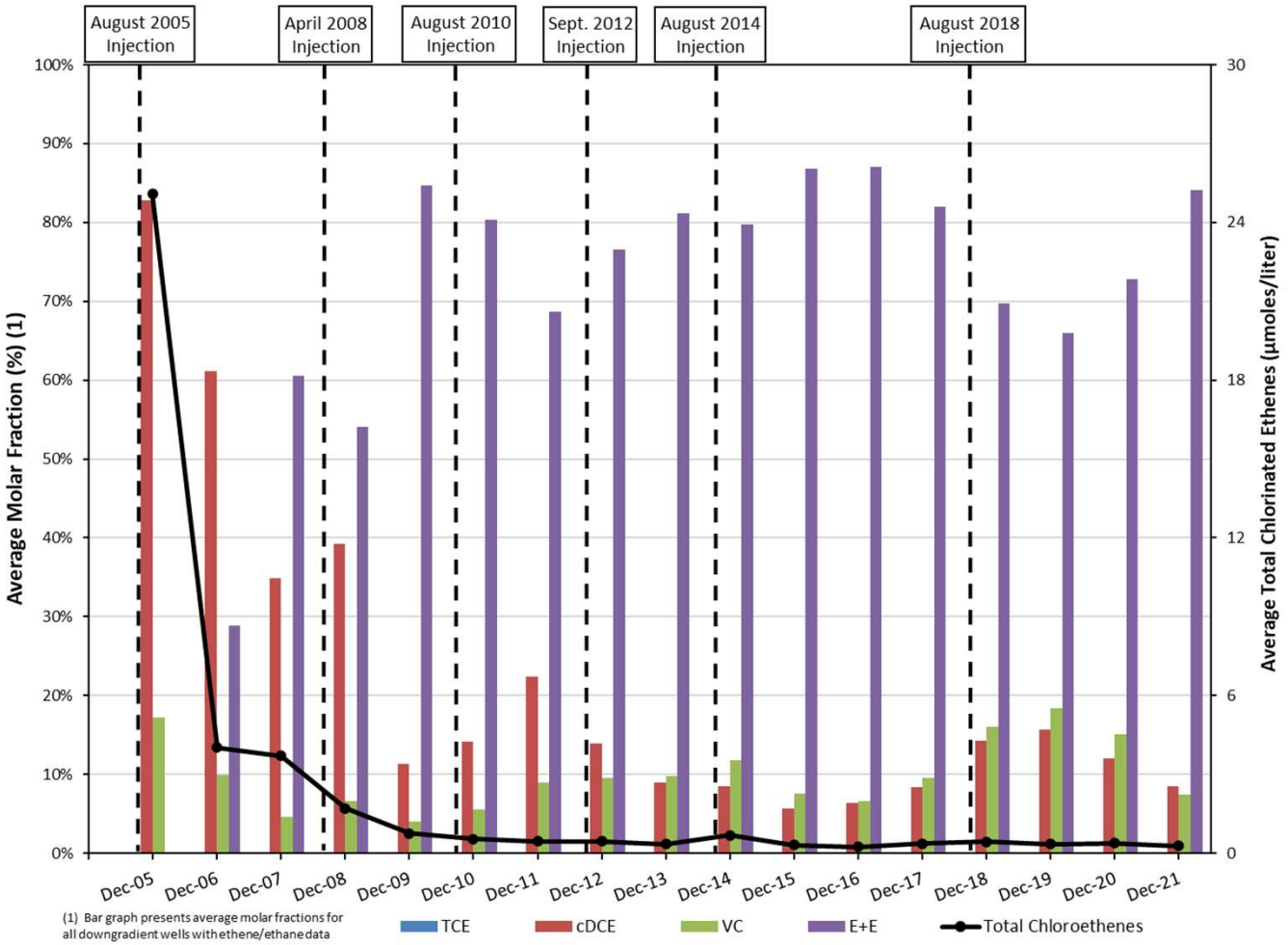
TCE – 16 Months



Rapid Plume Treatment

Reduced Flux And ERD

…but Persistent DNAPL Source



Bio with Abiotic Enhancement

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Bio Injections – Ongoing Source Treatment

32,000 to 53,000 gal of 20%+ EVO
15-17 source wells

- 2005
- 2008
- 2010
- 2012
- 2014
- 2018

Abiotic Enhancement

2014 :

- LactOil
- **Ferrous sulfate**

2018 :

- 60% larger volume
- LactOil
- **cZVI**

Bio = Sequential Reductive Dechlorination

PCE → TCE → *c*DCE → VC

→ Ethene → Ethane → CO_2 and H_2O

Abiotic = Reductive Elimination

PCE → Dichloro**acetylene**

TCE → Chloro**acetylene**

DCE → **Acetylene**

→ Ethene→ Ethane→ CO_2 and H_2O

Concurrent, complimentary

No VC

Ferrous Sulfate vs cZVI

2014—Ferrous Sulfate

- 2,800 gallons (23,350 lbs) of 25%wt ferrous sulfate heptahydrate
- 1,350 lbs reactive iron emplaced
- $ 3.55 /lb iron

2018—cZVI

- 110 gallons (1,500 lbs) AquaZVI
- 600 lbs reactive iron
- $ 20.33 /lb iron

Ferrous Sulfate vs cZVI

Acetylene

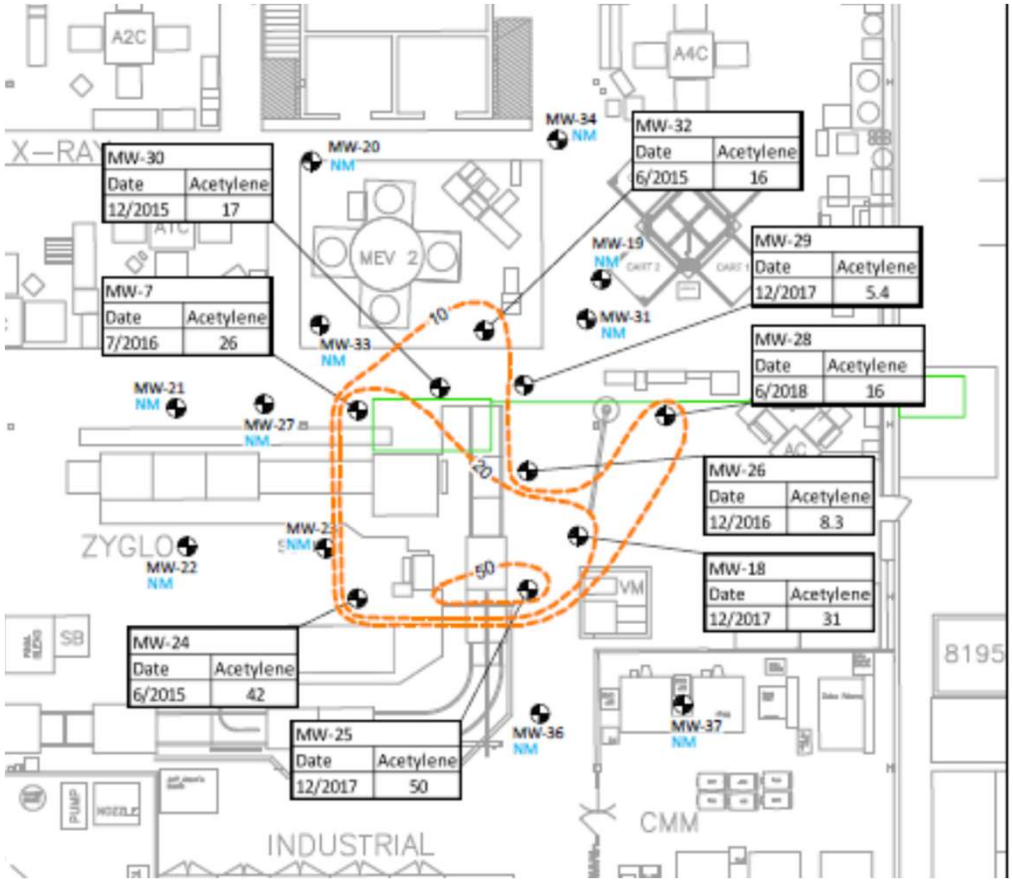
Labile degradation product, commonly not detected

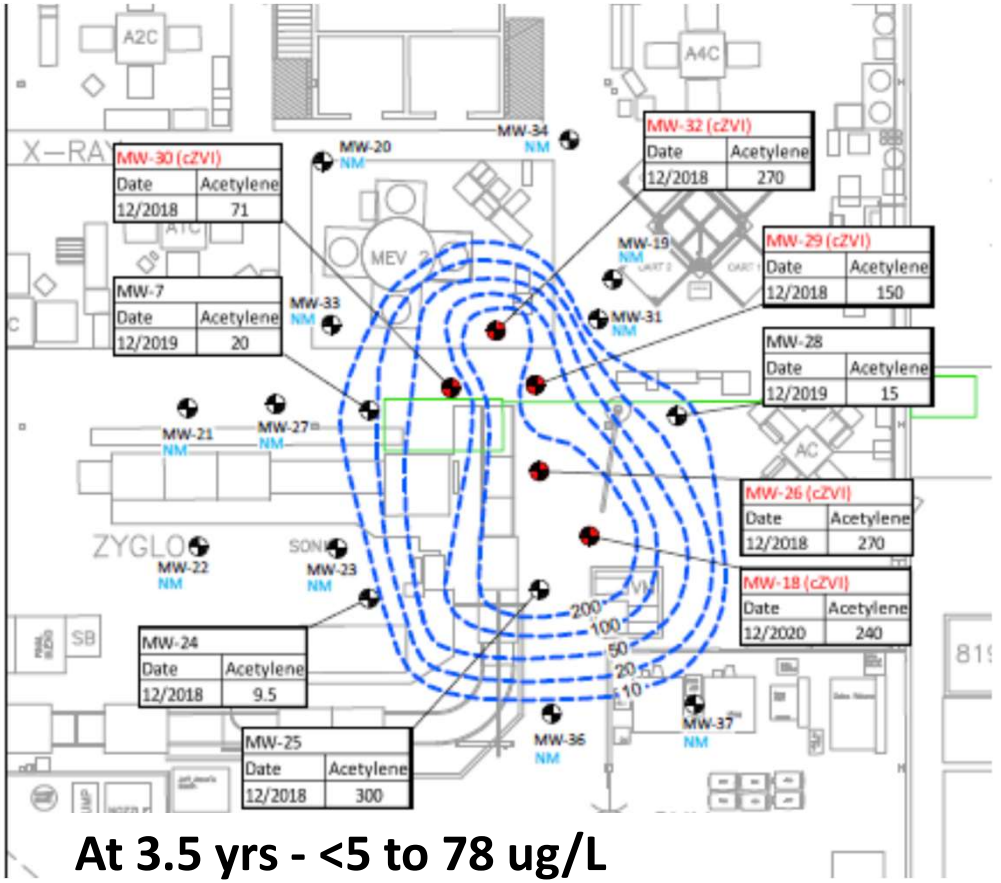
DETECTIONS = FRACTION OF PRODUCTION

Site Detections:

- Pre- ferrous sulfate-- 6 to 24 ug/L
- Pre- cZVI-- 5 to 50 ug/L
- Post- cZVI-- 9 to 300 ug/L

Max Acetylene Pre- and Post- cZVI





At 3.5 yrs - <5 to 78 ug/L

TCE decrease to near min at cZVI wells

Source Progress and Next Steps

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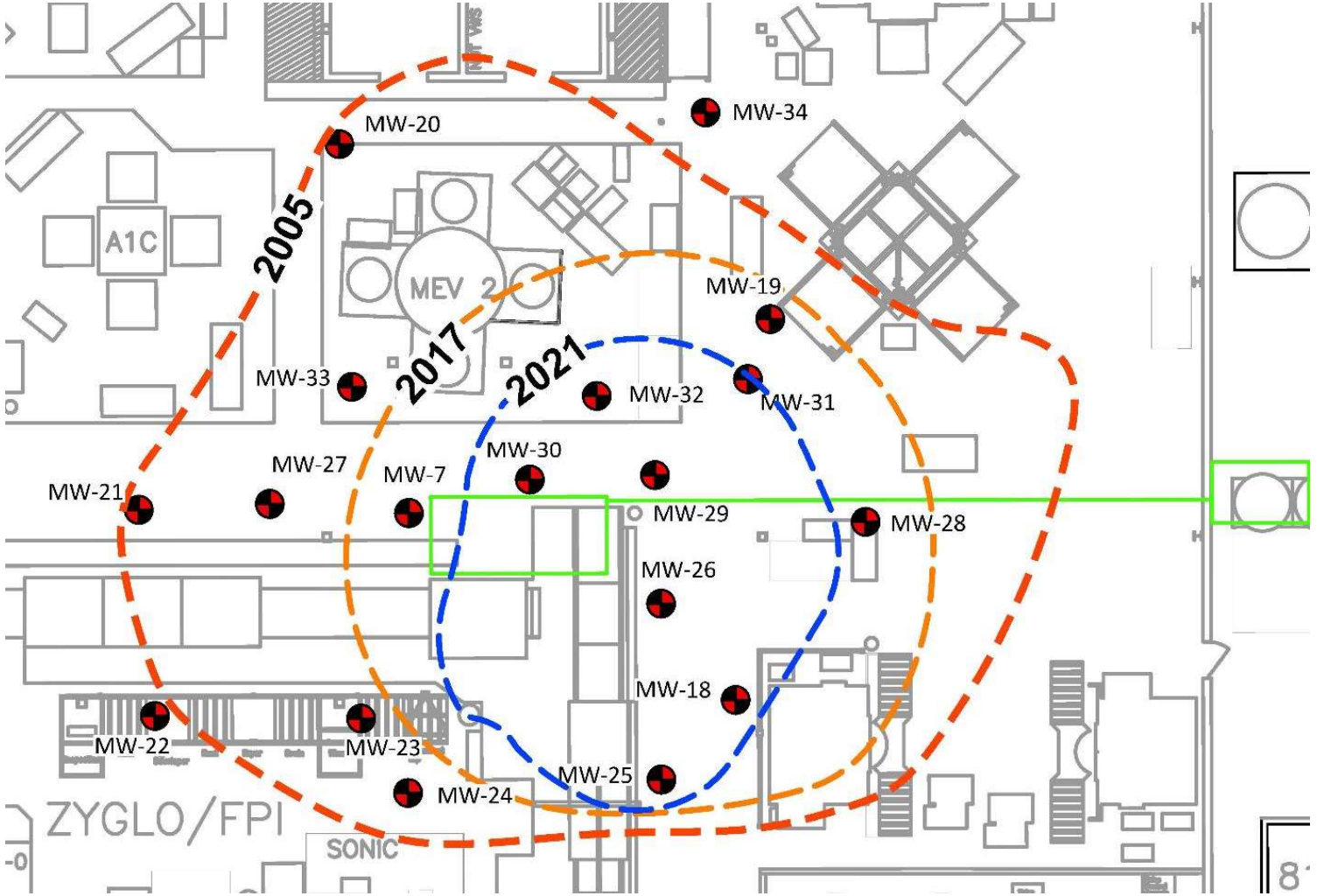
Shrinking Source

Source =
10,000 ug/L



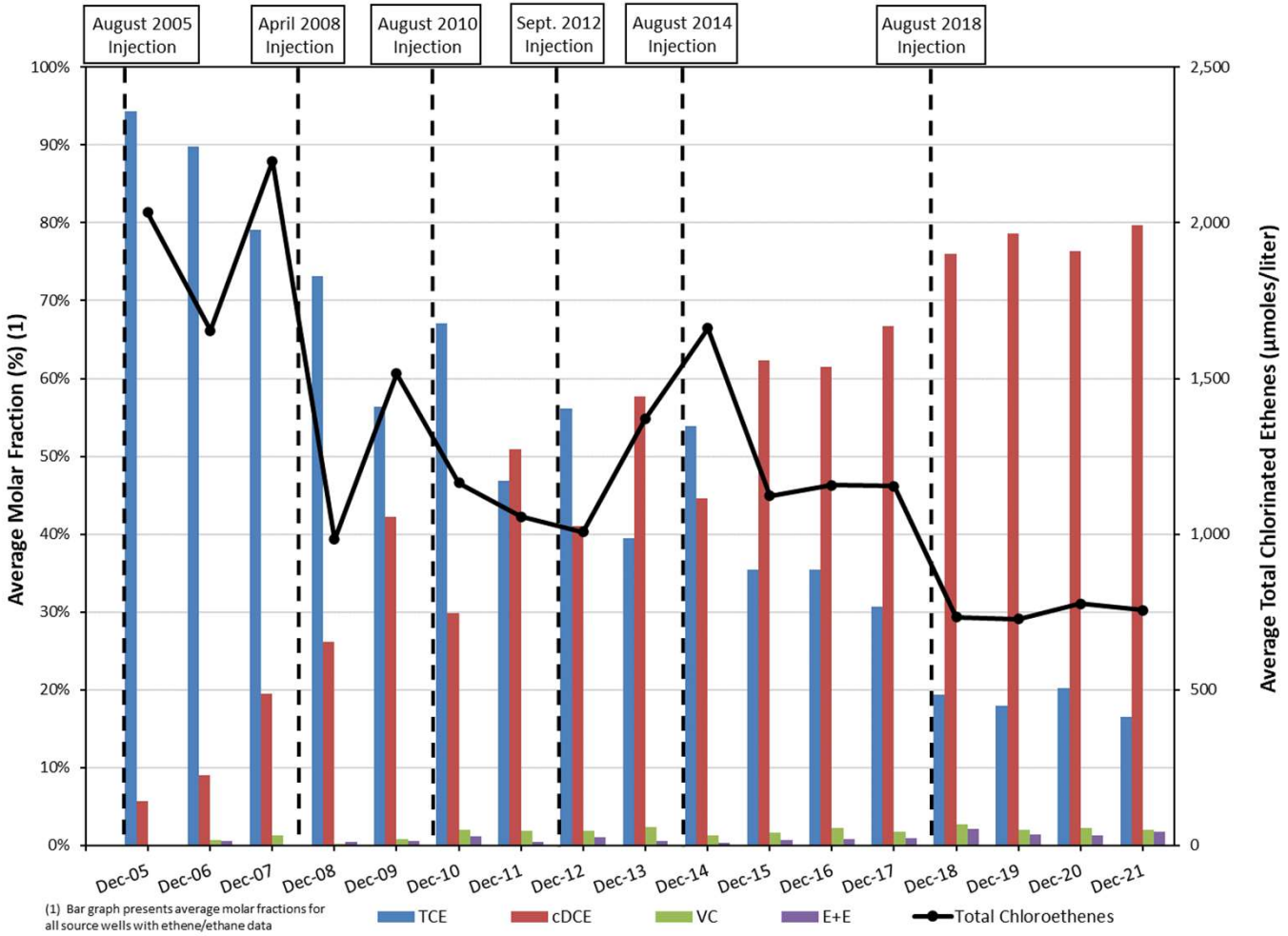
Source Treatment

Tot cVOCs
66% reduction

94% TCE to
84% breakdown
and end product

DCE-stall

cZVI



Cost Effective

$2.3M over 17 yrs

- RI/FS/RA
- GW and SV interim actions, monitoring and reporting
- Plume treated
- Source shrinking – extent and concentration
- **MINIMIZED DISRUPTION TO PRODUCTION**

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2022 Enhancements

1. Low Temperature Thermal – 30 deg C since May

2. August Injection

- 2.3x ZVI -- 7 wells > 10,000 ug/L TCE
- pH buffer 11 wells >100 ug/L TCE

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Thank You
Questions?

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