Use of Enhanced Reductive Dechlorination to treat PCE in a Shallow Sand and Silt Aquifer

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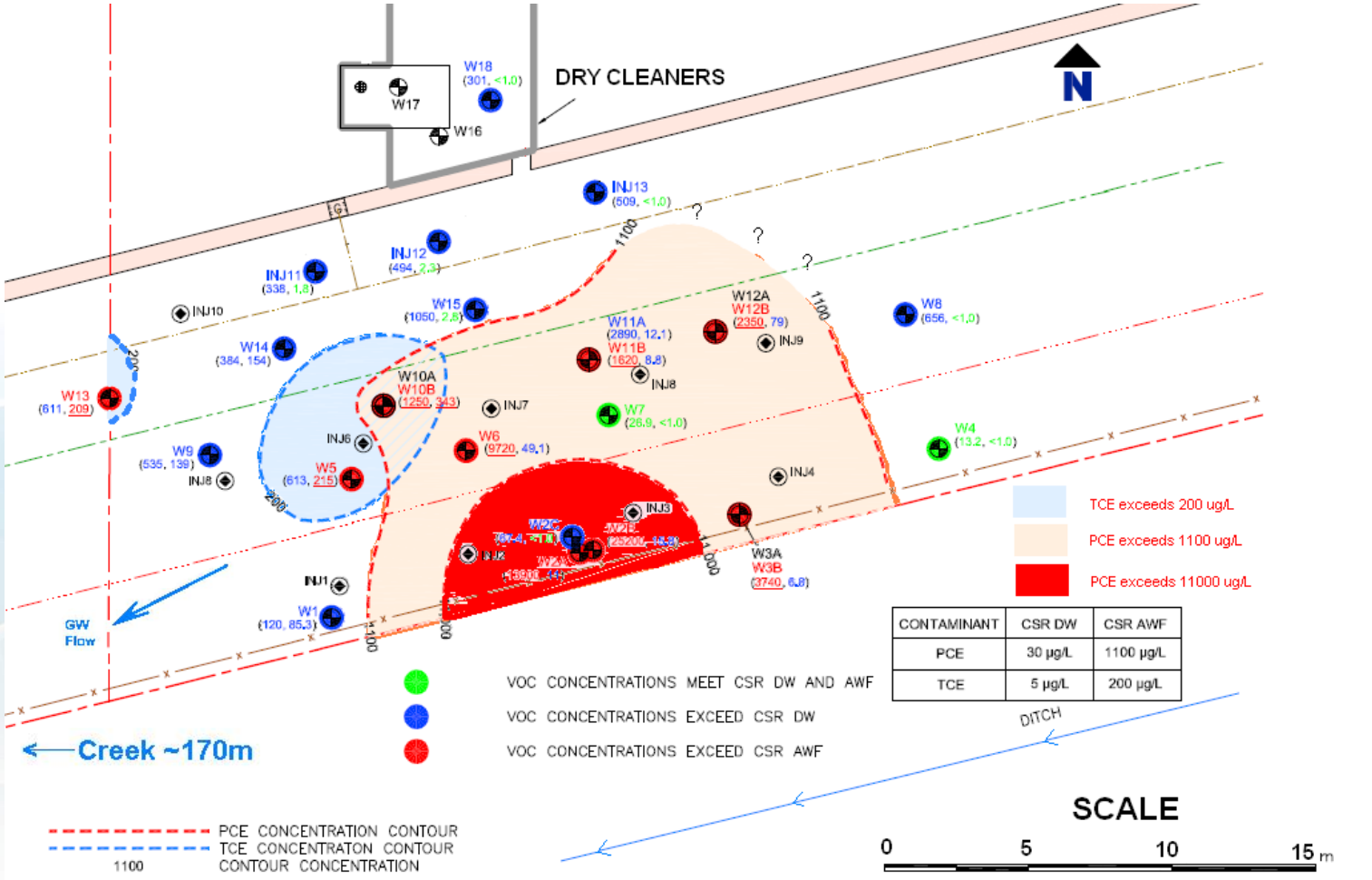
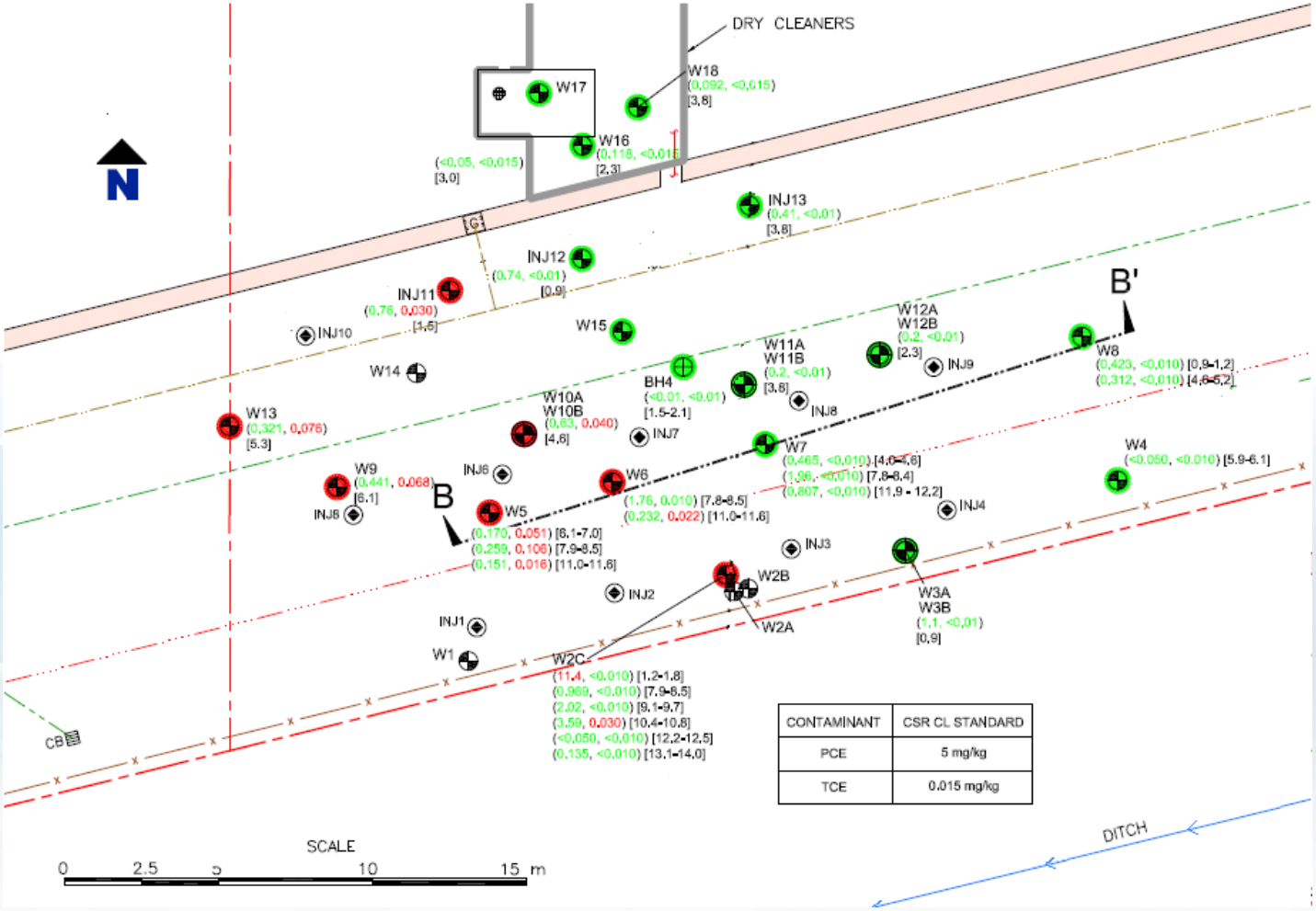
Outline

- Project Site Overview
- Enhanced Reductive Dechlorination (ERD) Basics
- Injection Program
- Challenges
- Results

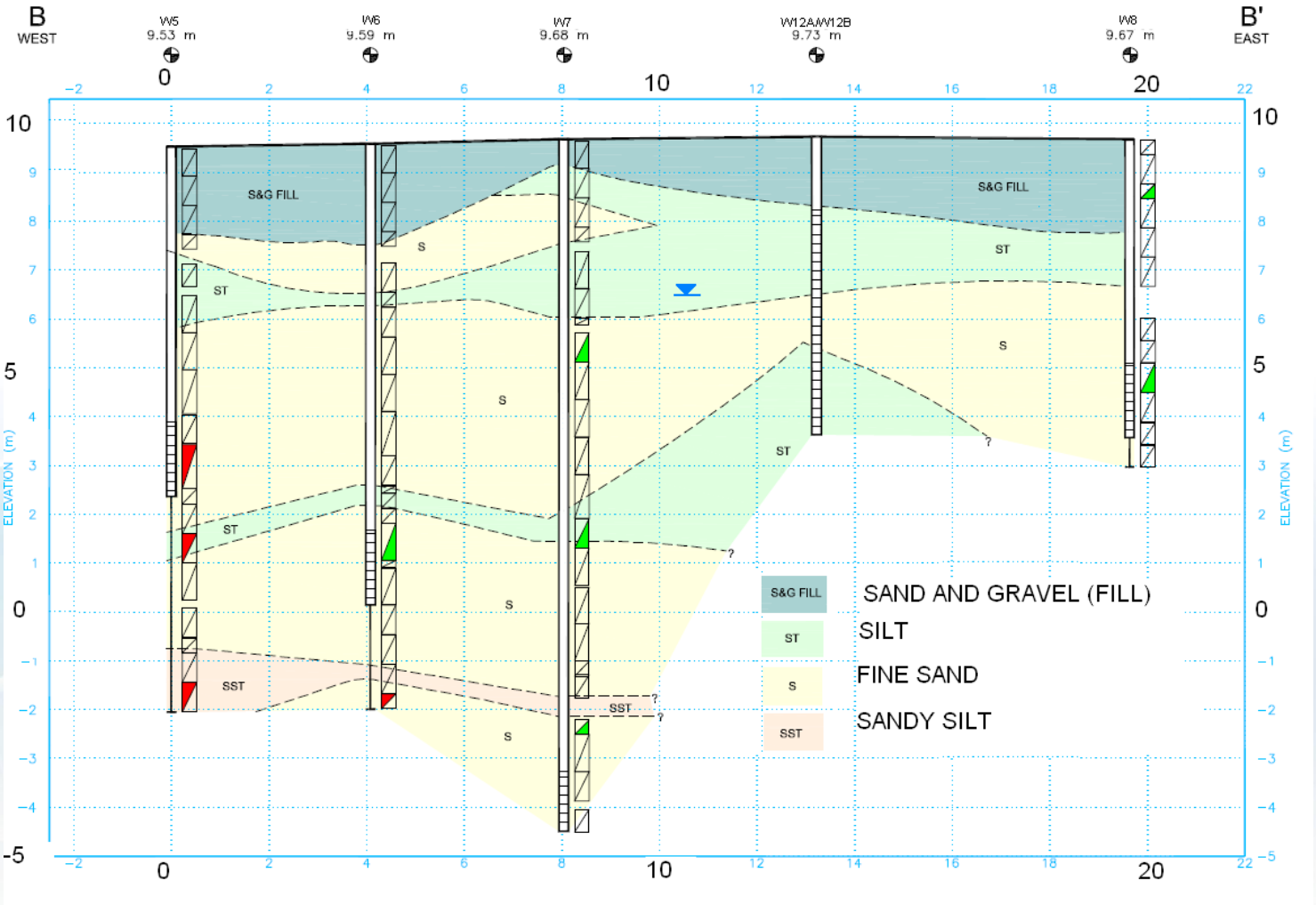
Pre Injection Groundwater [PCE, TCE]



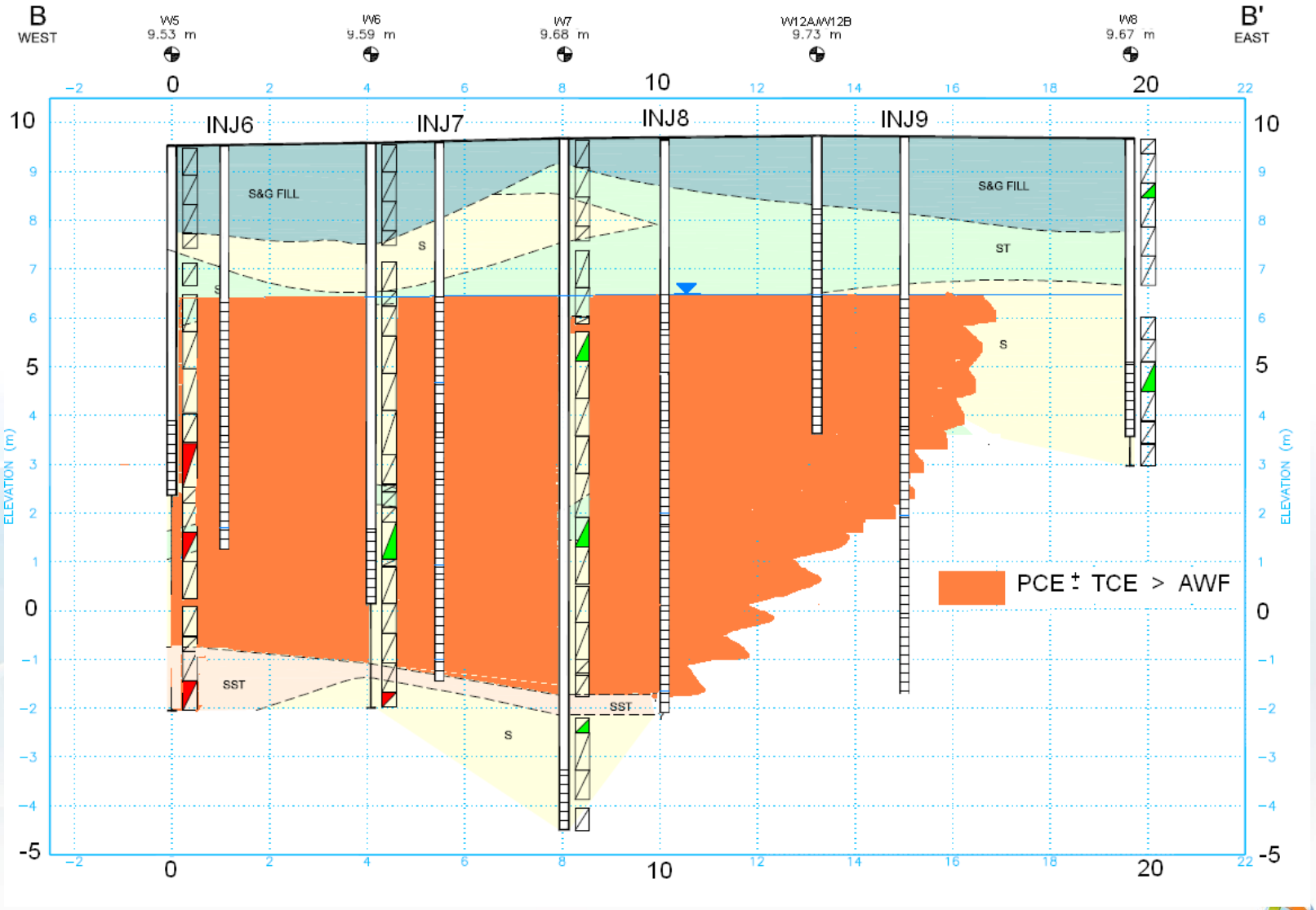
Pre Injection Soil Conditions



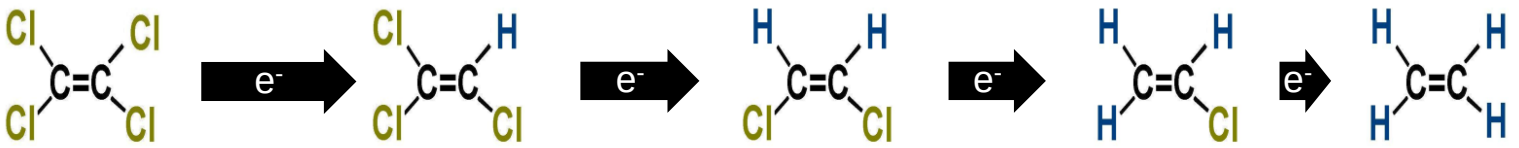
Stratigraphy



Cross Section – GW Contamination



Enhanced Reductive Dechlorination (ERD)



Tetrachloroethylene (Perchloroethylene) (PCE)

Trichloroethyene (TCE)

cis-1,2-dichloroethylene (cDCE)

Vinyl chloride (VC)

Ethene

Electron donors

Dehalococcoides sp. bacteria

Injection Ingredients

- Electron donors
- Dehalococcoides bacteria (Dhc)
- H_2O (chase water)

Electron Donors

- denatured ethanol (~200L)

Electron Donors

- denatured ethanol (~200L)

- emulsified soy bean oil (~800 L)

Electron Donors

- denatured ethanol (~200L)
- **fresh cheese whey (69,000 L) pH~3.5**
- emulsified soy bean oil(~800 L)

Chase Water

- Municipal H_2O – 105,000 L chase water
  - + 800 kg Zero Valent Iron (ZVI) powder
  - ~ 2 days to knock out O_2

Injection Equipment

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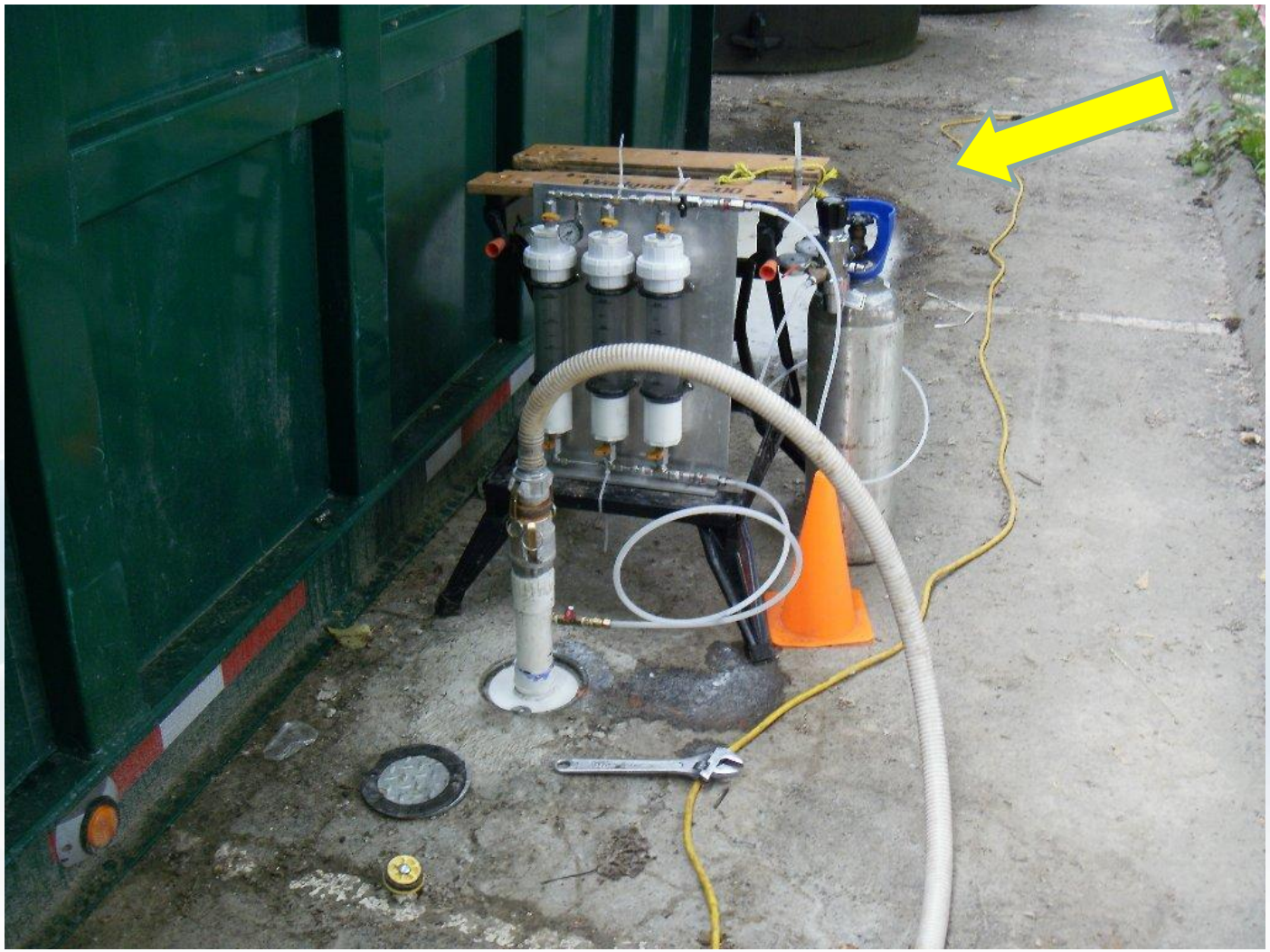
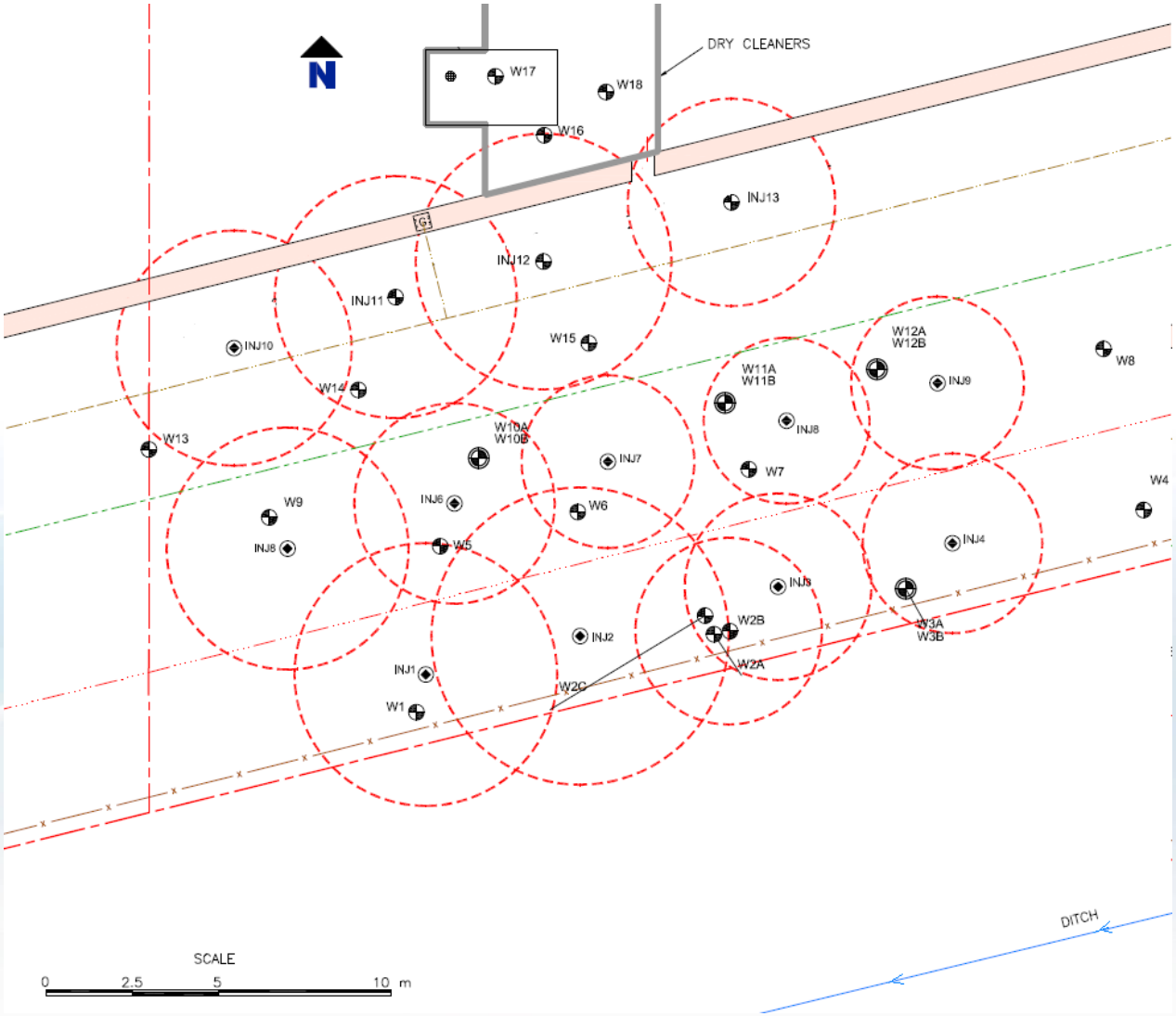
Injection Equipment – KB-1® dispenser

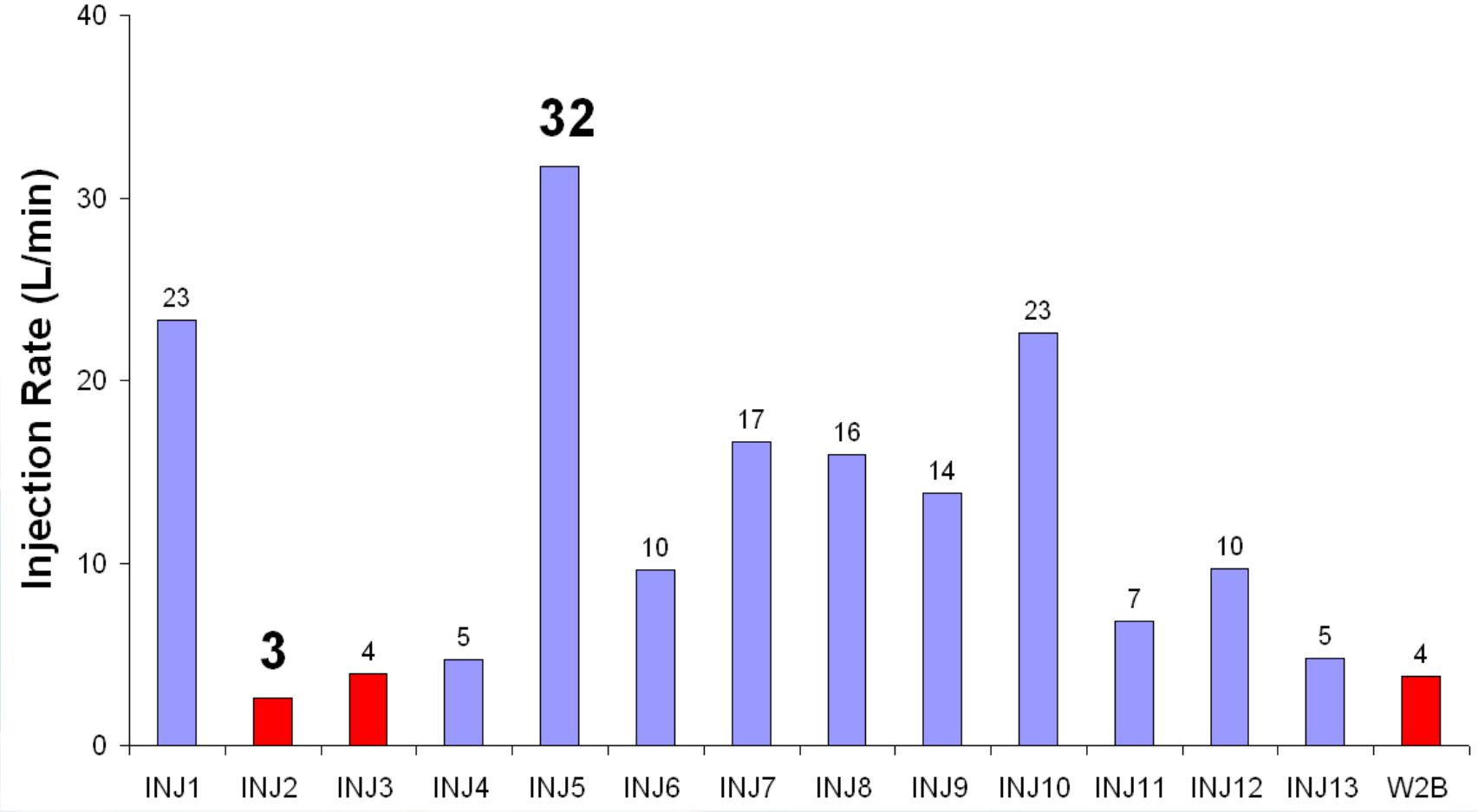
Injection Fluids Surfacing



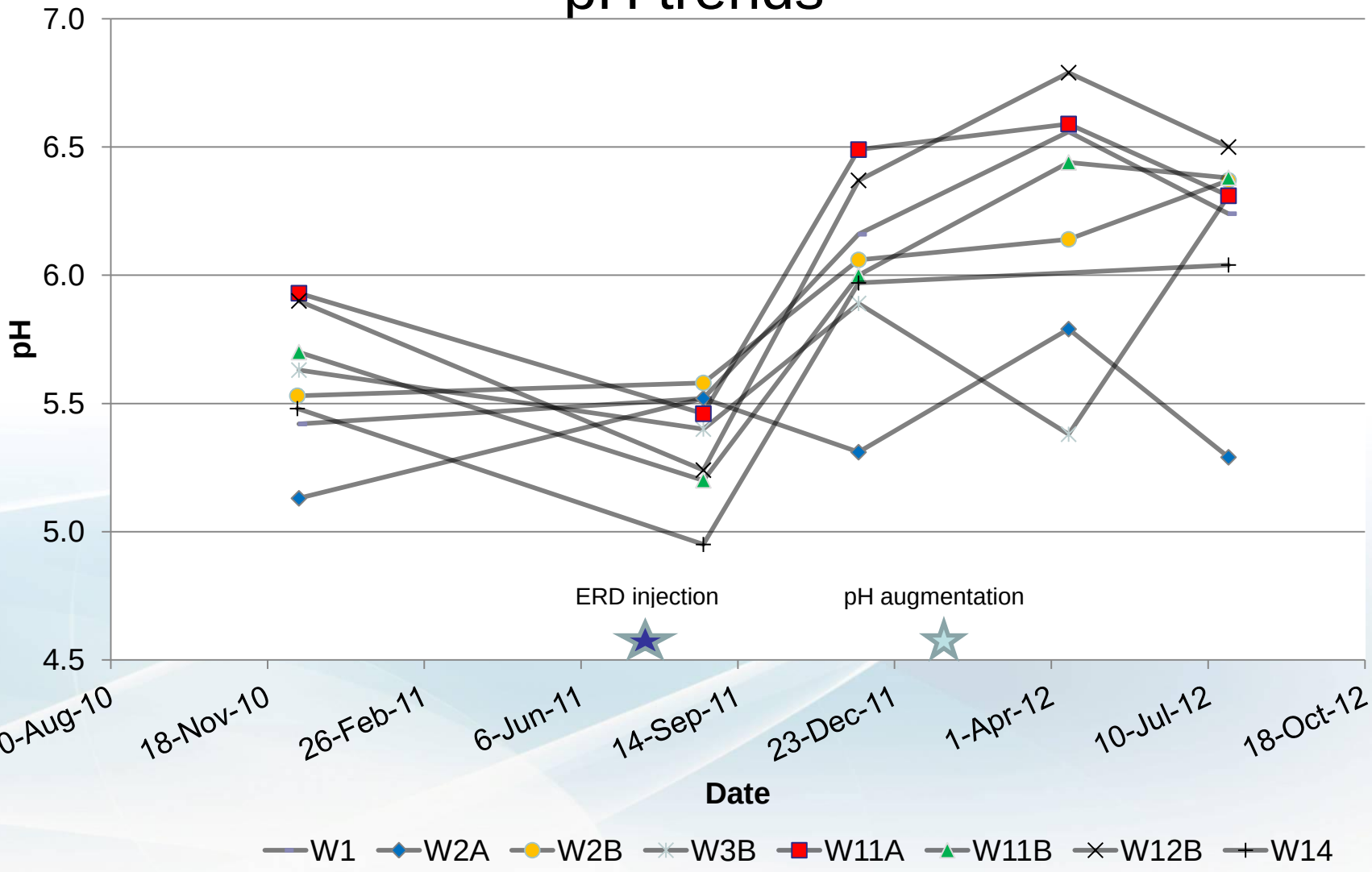
Injection Radius (Φ_e ~ 0.2)



Injection Flow Rates (L/min)



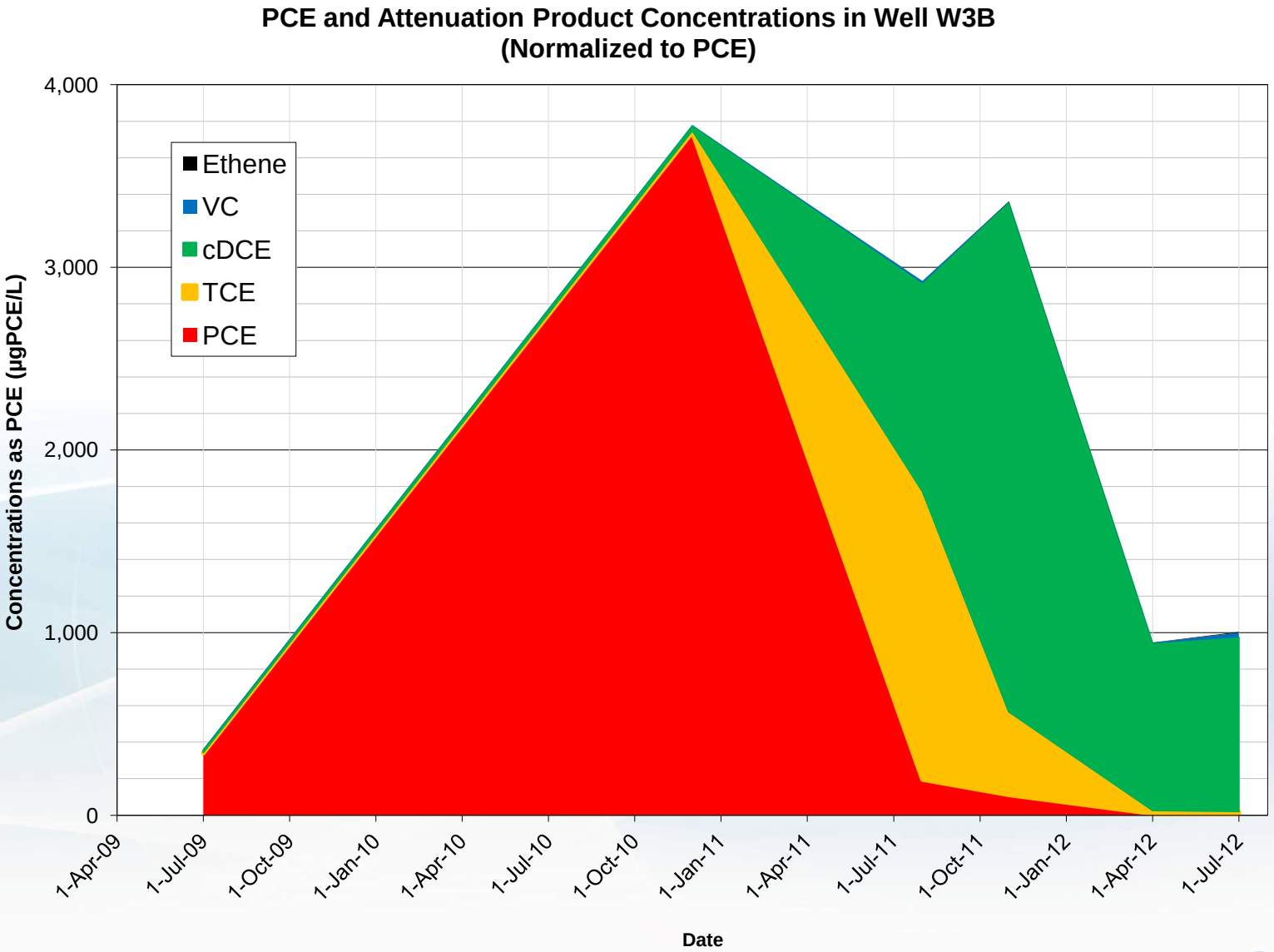
pH trends


7.0
6.5
6.0
5.5
5.0
4.5
pH
ERD injection
pH augmentation
10-Aug-10
18-Nov-10
26-Feb-11
6-Jun-11
14-Sep-11
23-Dec-11
1-Apr-12
10-Jul-12
18-Oct-12
Date
W1
W2A
W2B
W3B
W11A
W11B
W12B
W14

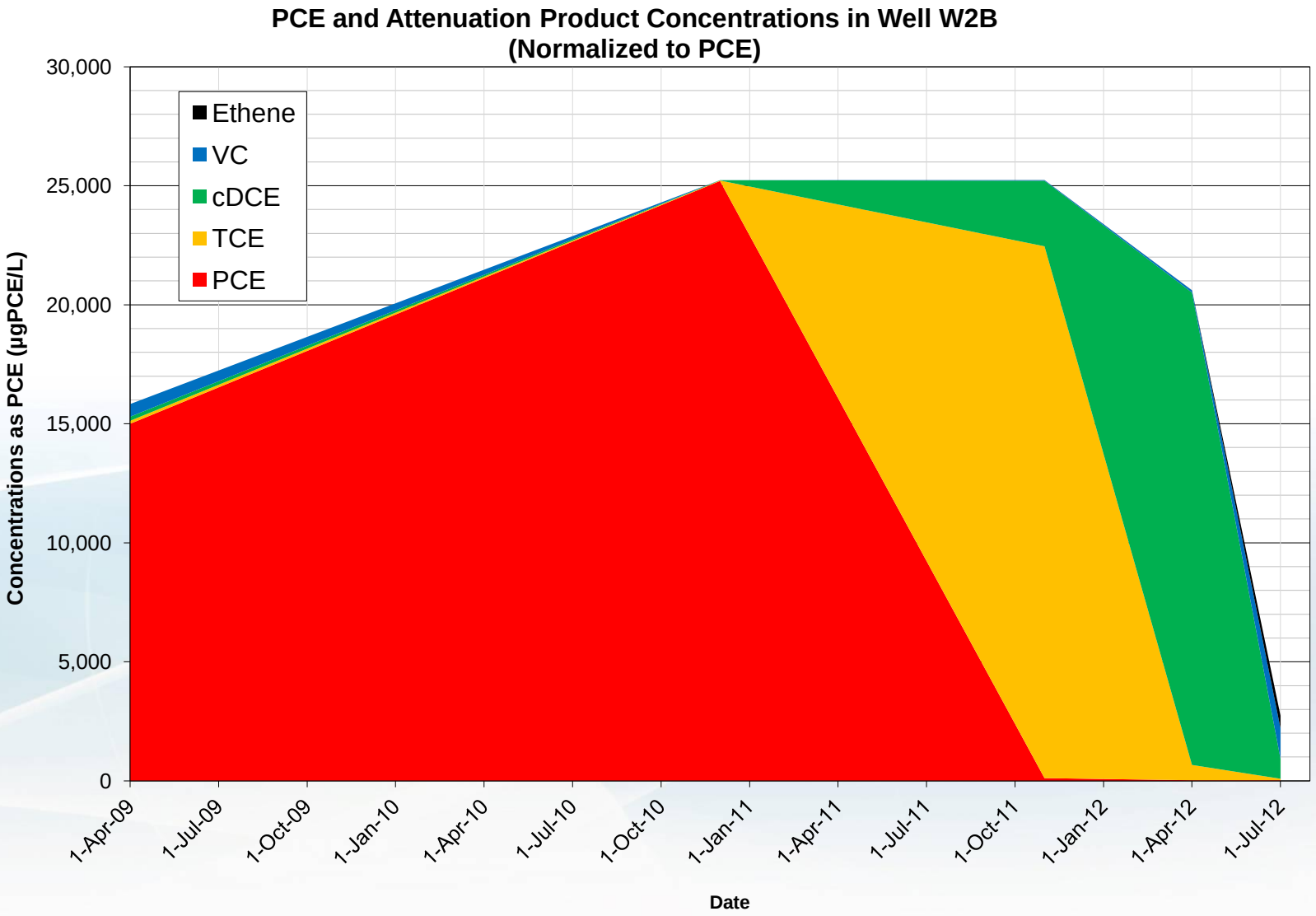
Challenges

- Reduction of dissolved O_2 in chase water
- pH
  - injection fluids (cheese whey ~pH 3.5)
  - groundwater (background ~ pH 5.5 – 6.0)
- Surfacing of injected fluids
  - Injection Flow Rates

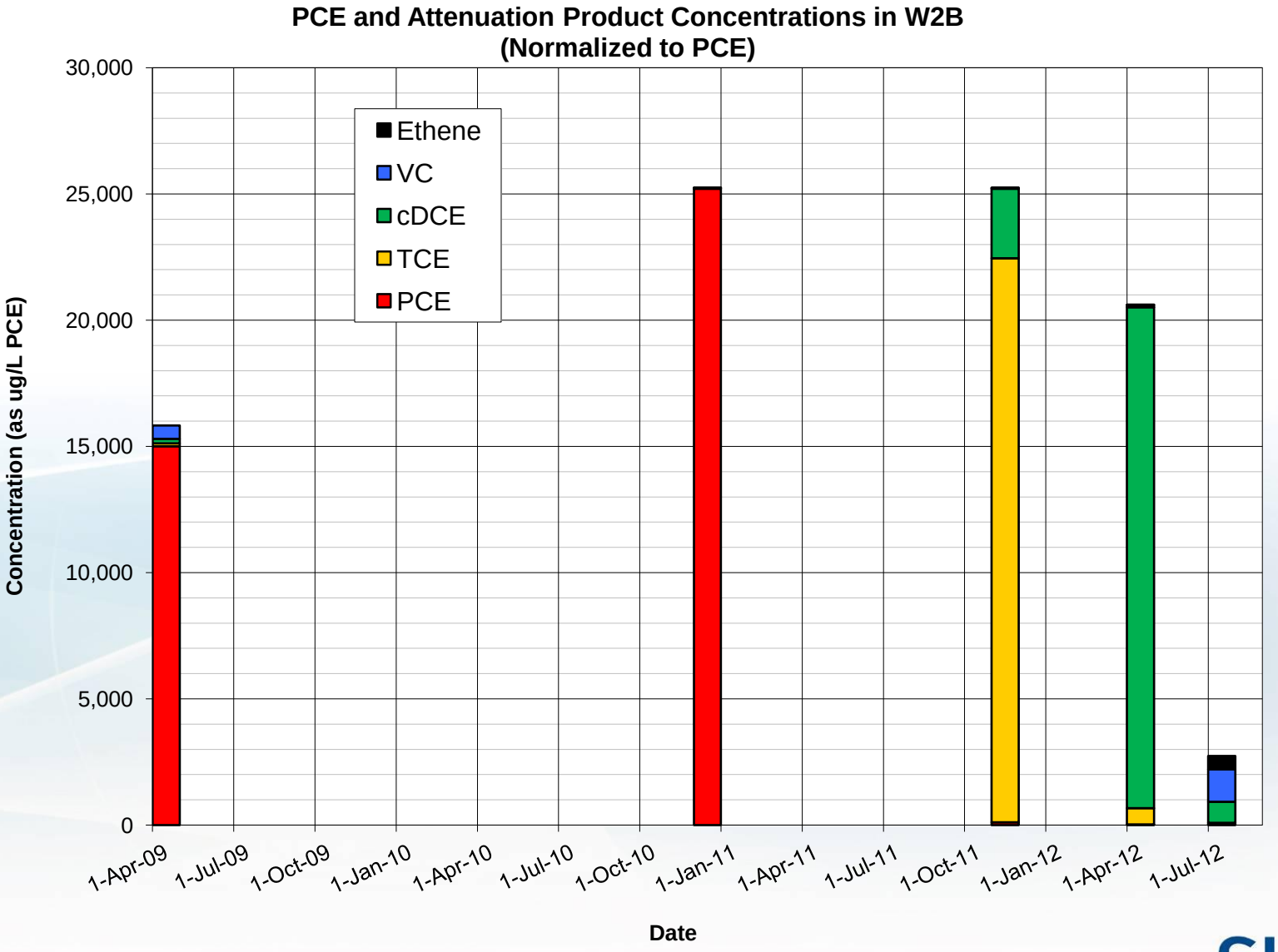
Example 1 - recalcitrant response



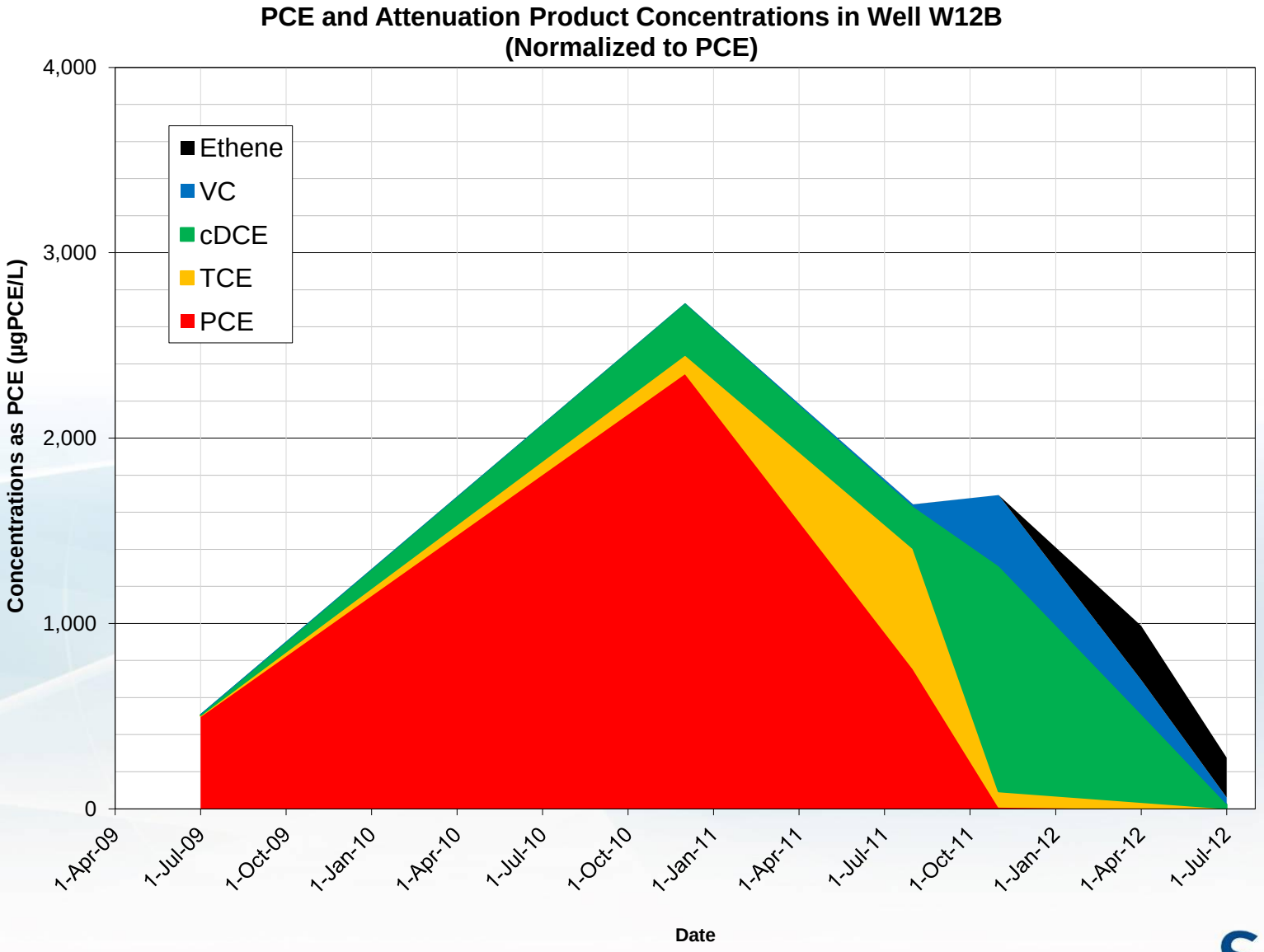
Example 2 – temporary stall



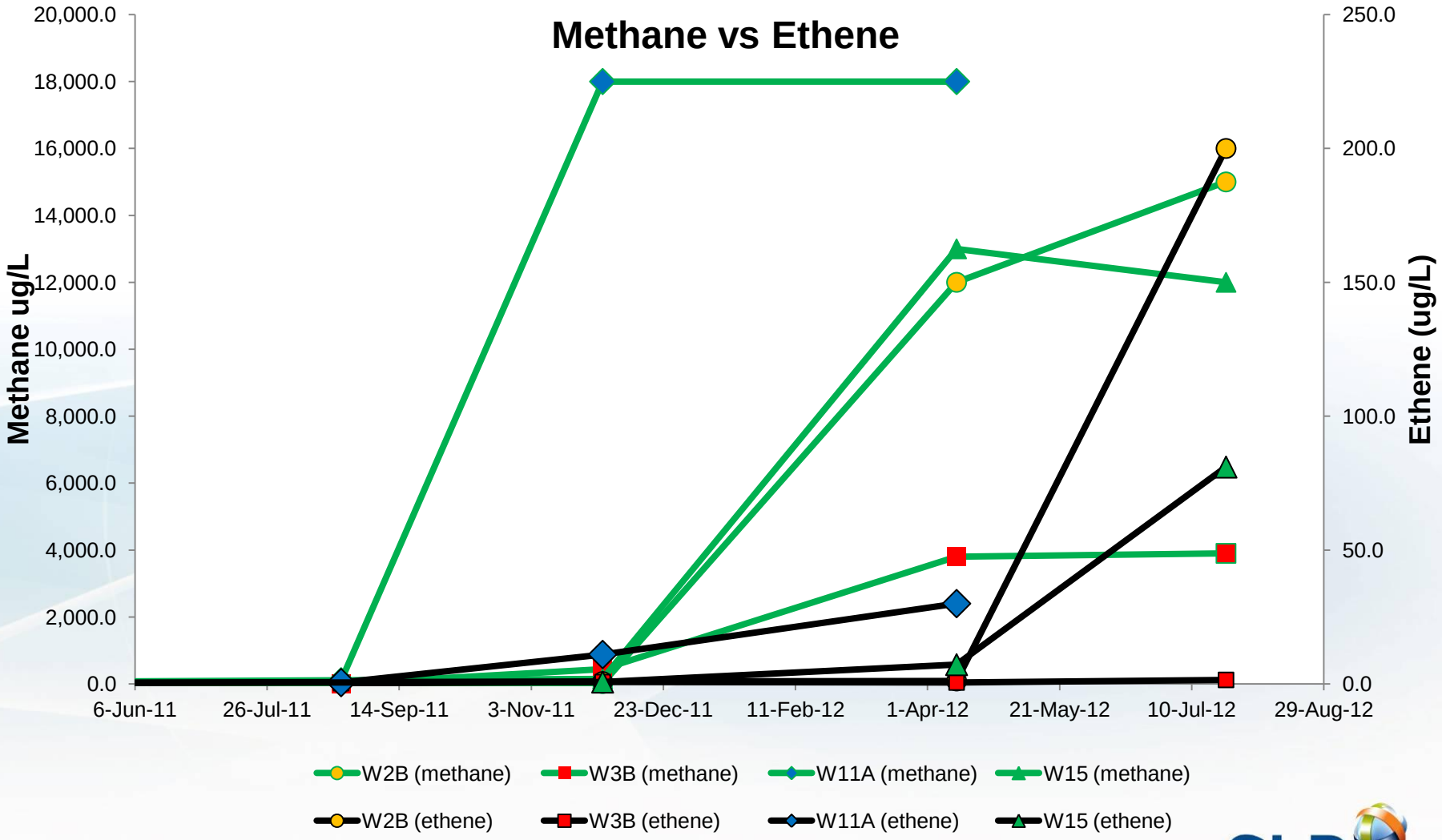
Example 2 – temporary stall



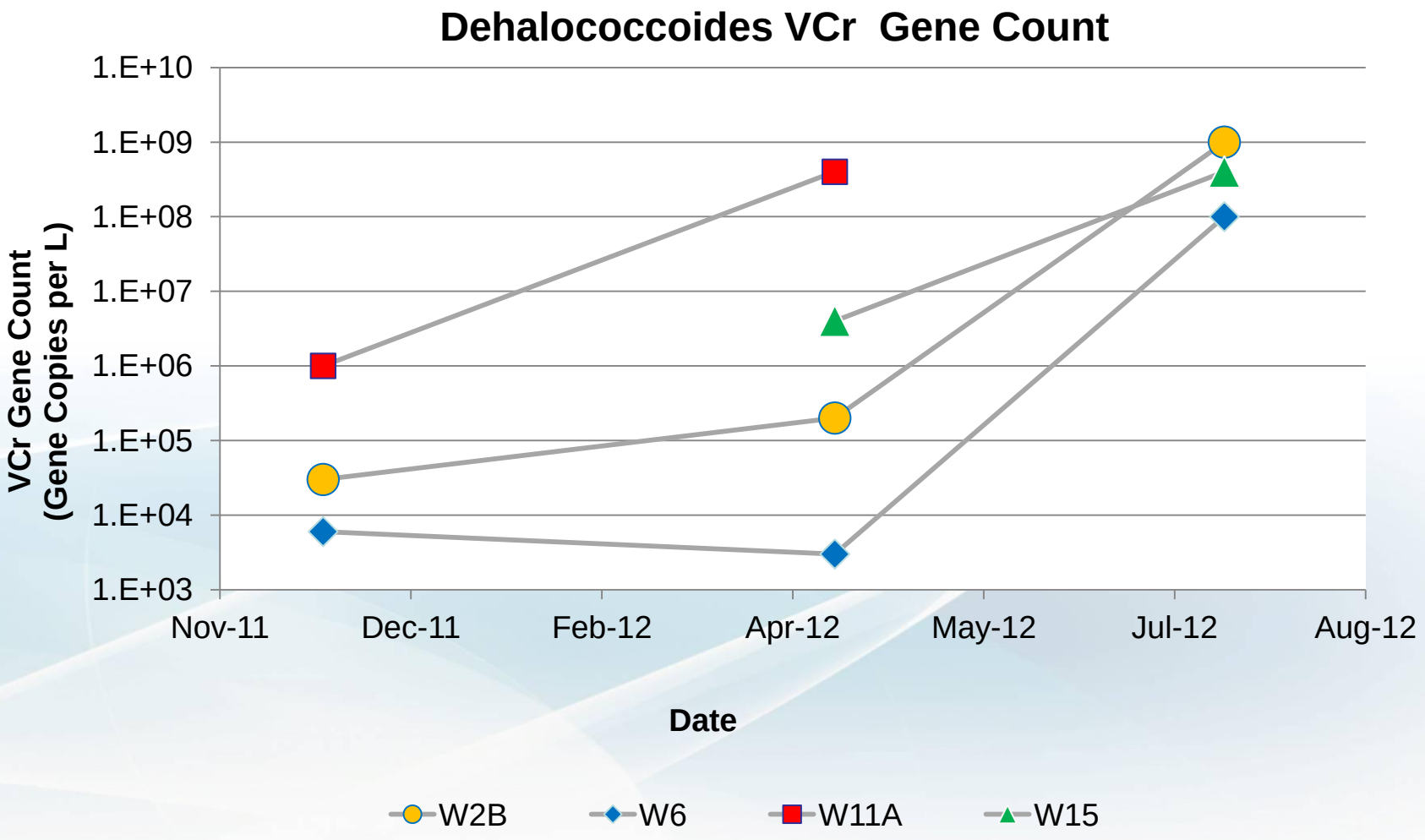
Example 3 – early positive response



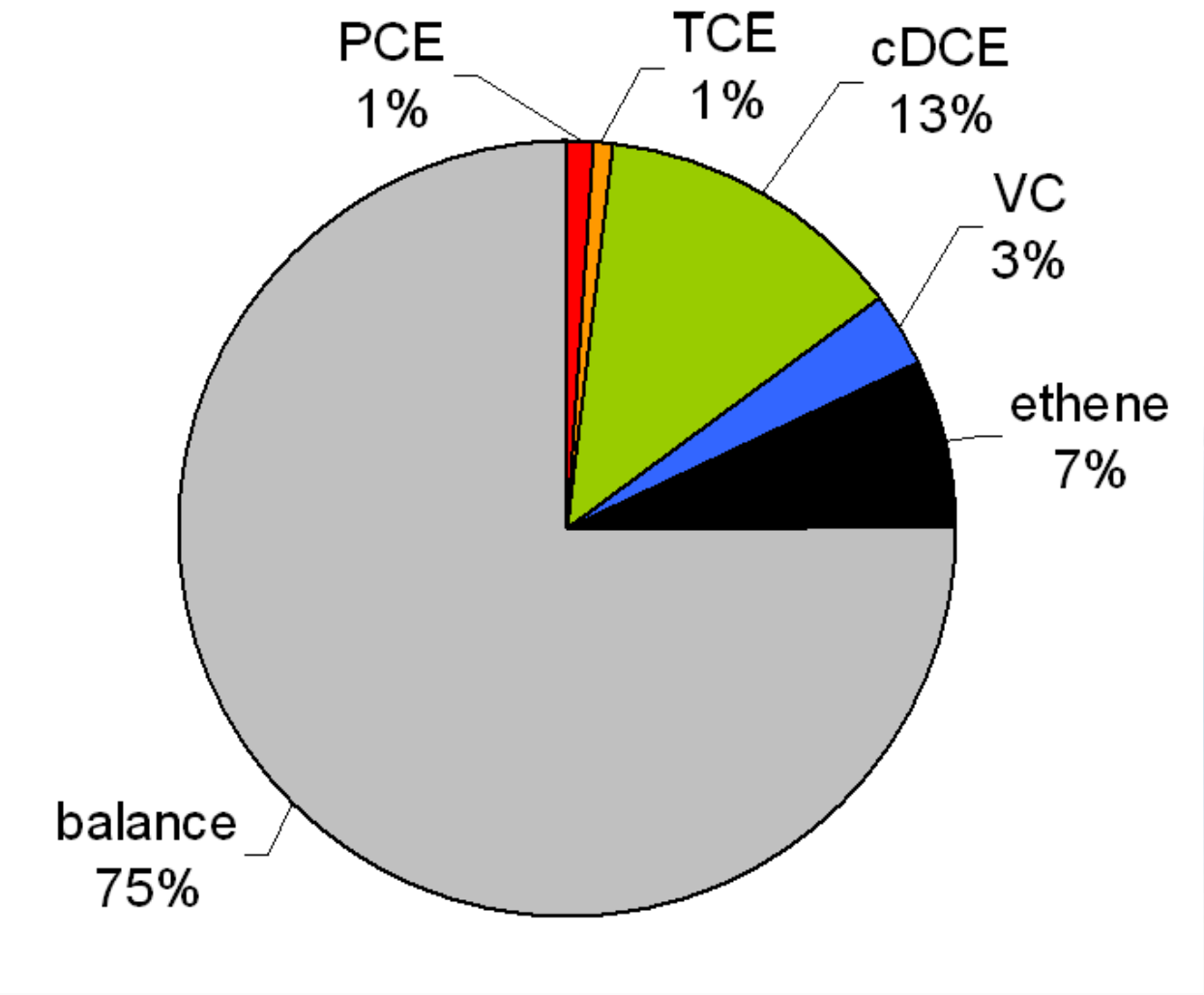
Methanogenesis Stabilization



Vinyl Chloride Reductase (VCr)



PCE Fate at 12 Months



What we learned

- Allow several days for reduction of dissolved O_2 in chase water.
- Consider pH buffering strategy of injection fluids and natural pH of aquifer.
- Budget for unexpected injection flow rates. Consider pilot study.
- Consider the potential for methanogenesis to delay full dechlorination.
- Allow time for the injection time to work.

Questions?

Supplemental Slides

Volatile Fatty Acids
April 2012