

CH2MHILL

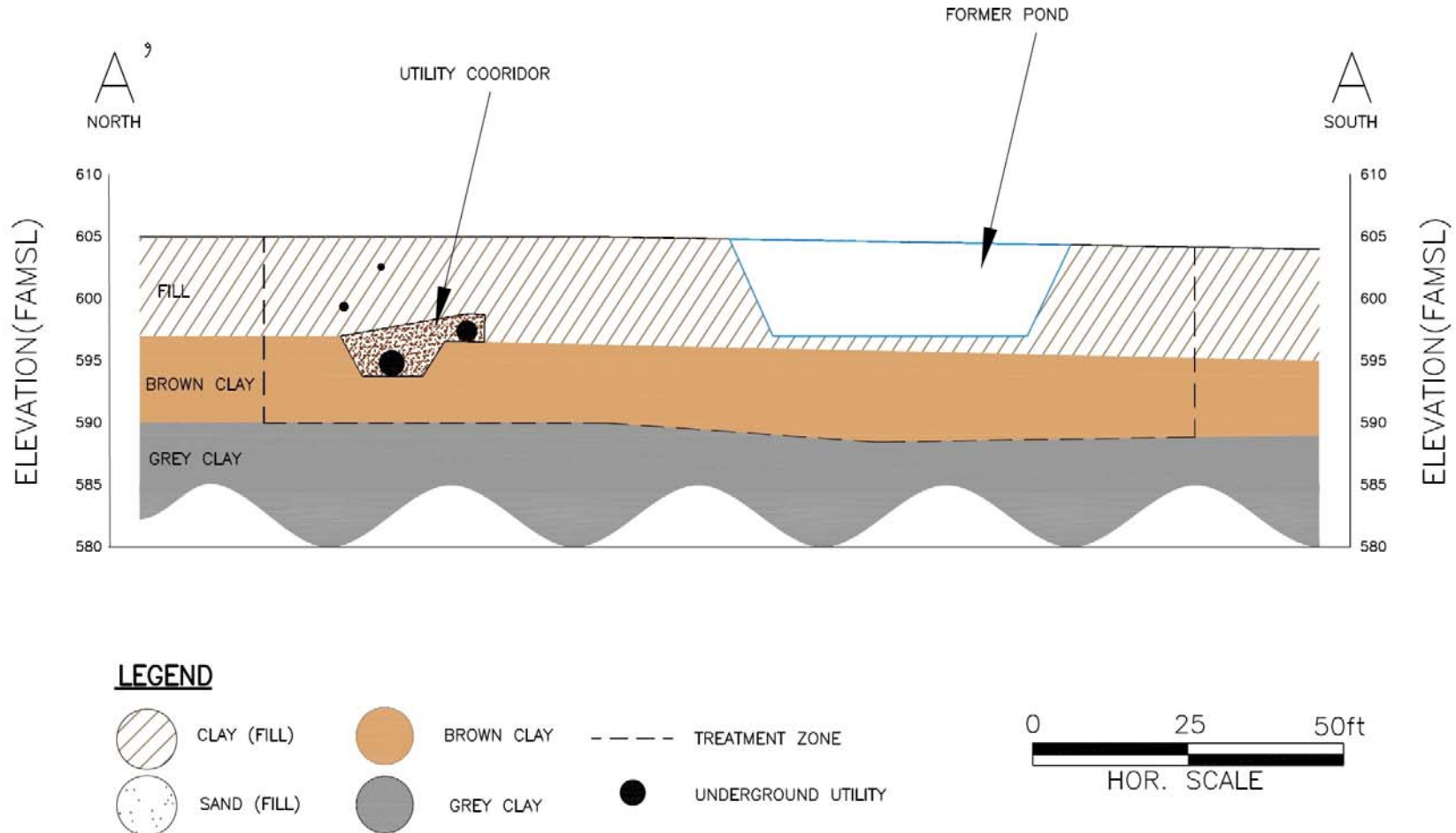
**Leanne Murdie Austrins
Christopher Peace**

Integrated Approach to the Remediation of Chlorinated Organic Compounds in Low Permeability Soils – A Field Study

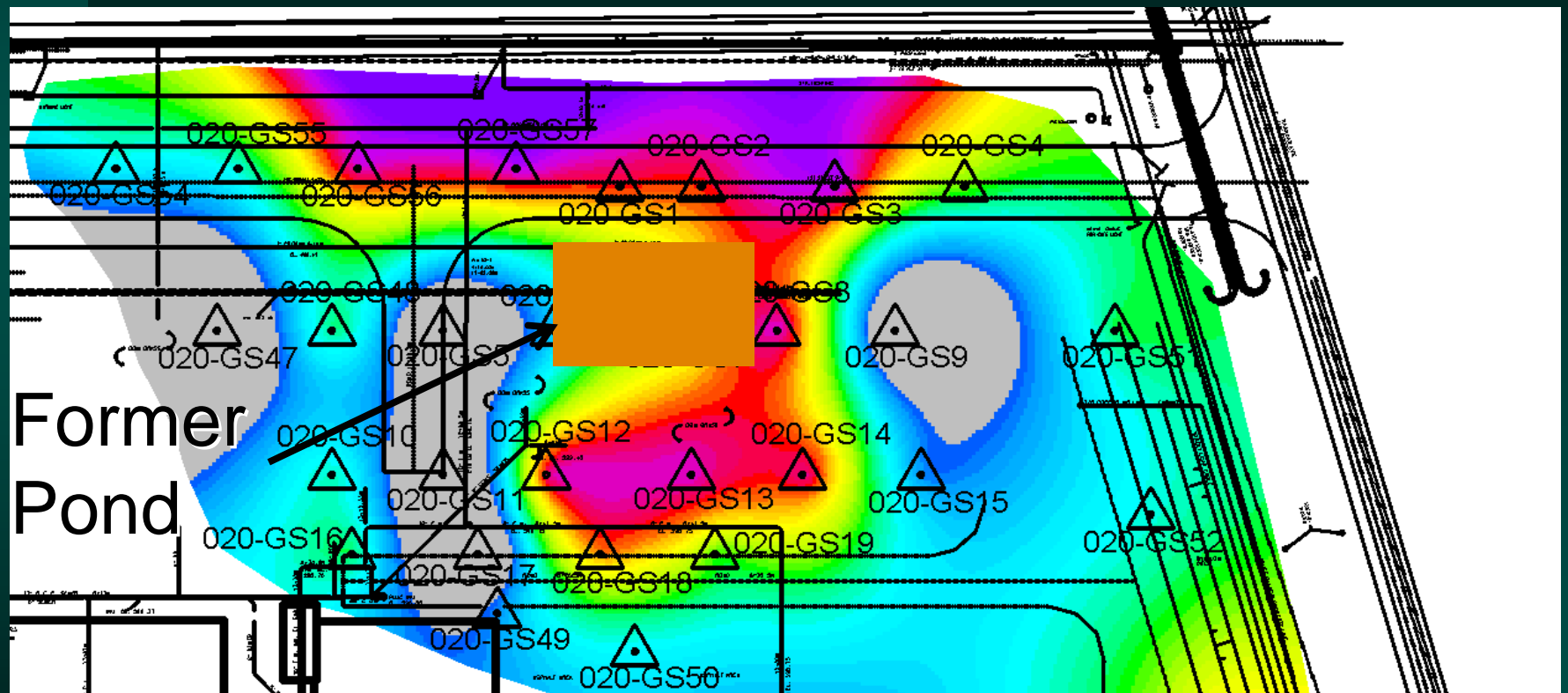
Site Information

- **Chemical production plant in operation from 1950s to recently.**
- **Former pond which held waste water from an adjacent chlorinated organic production facility.**
- **Volatile Organics Compounds present for over 20 years.**

Conceptual Site Model



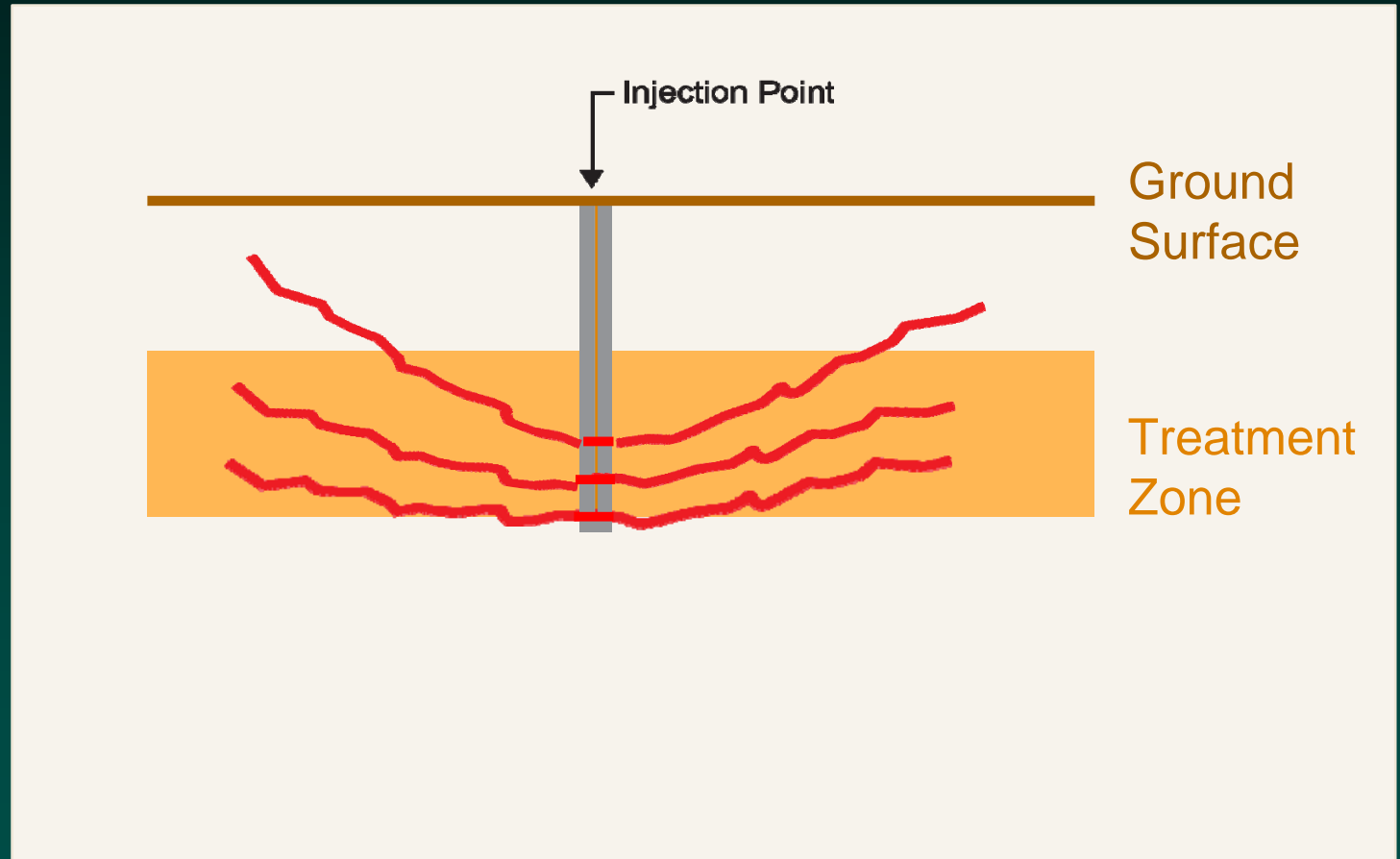
VC concentrations from GoreSorbers™

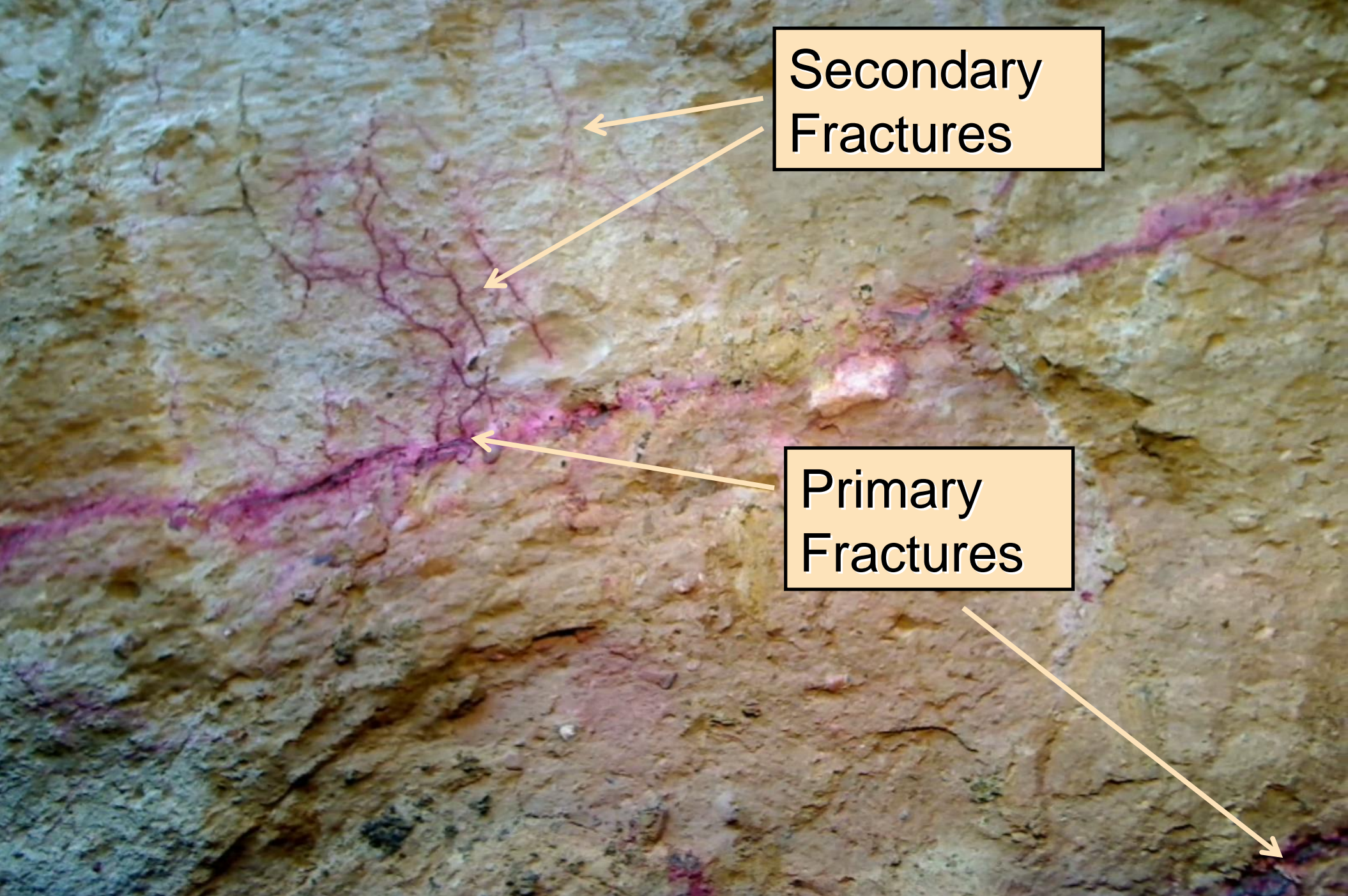


Design of Remedial Strategy

- **Want to reach target concentrations in 5 – 7 years**
- **Must be cost effective based on volume of soil to be treated (22,000 cubic yards)**
- **Selected amendment must be able to treat DNAPL and dissolved phase contamination in soil and groundwater**
- **Amendment application technology must be able to treat low permeability soils**

Amendment Application Technology – Fracture and Injection



A photograph of a rock surface showing various fractures. The rock is light brown and yellowish. There are several distinct fracture lines, some of which are highlighted with a pinkish-red stain. Two labels with arrows point to specific fractures: 'Secondary Fractures' points to a network of fine, branching fractures in the upper left, and 'Primary Fractures' points to a single, thick, dark fracture line running horizontally across the middle. A third arrow points to a fracture in the lower right.

Secondary
Fractures

Primary
Fractures

Amendment Composition

- **Macroscale Zero Valent Iron for propant (20/40)**
- **Microscale Zero Valent Iron (LT80/120)**
- **Microscale emulsified Zero Valent Iron**
- **Guar**
- **glycol**

Iron Reactions

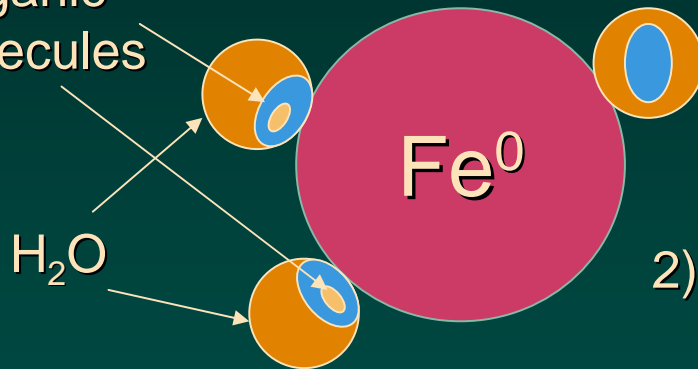
4) Aerobic iron corrosion:



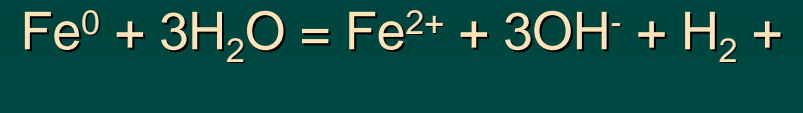
3) Reductive dehalogenation by hydrogen gas:



Chlorinated Organic
Compound Molecules



2) Anaerobic iron corrosion:

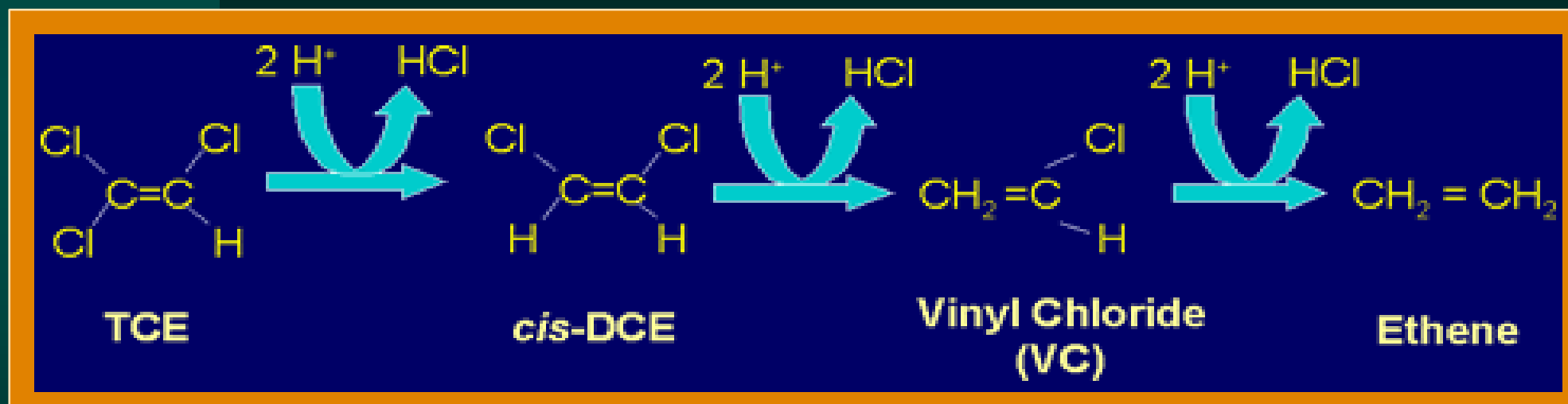


1) Direct reduction on metal surface:



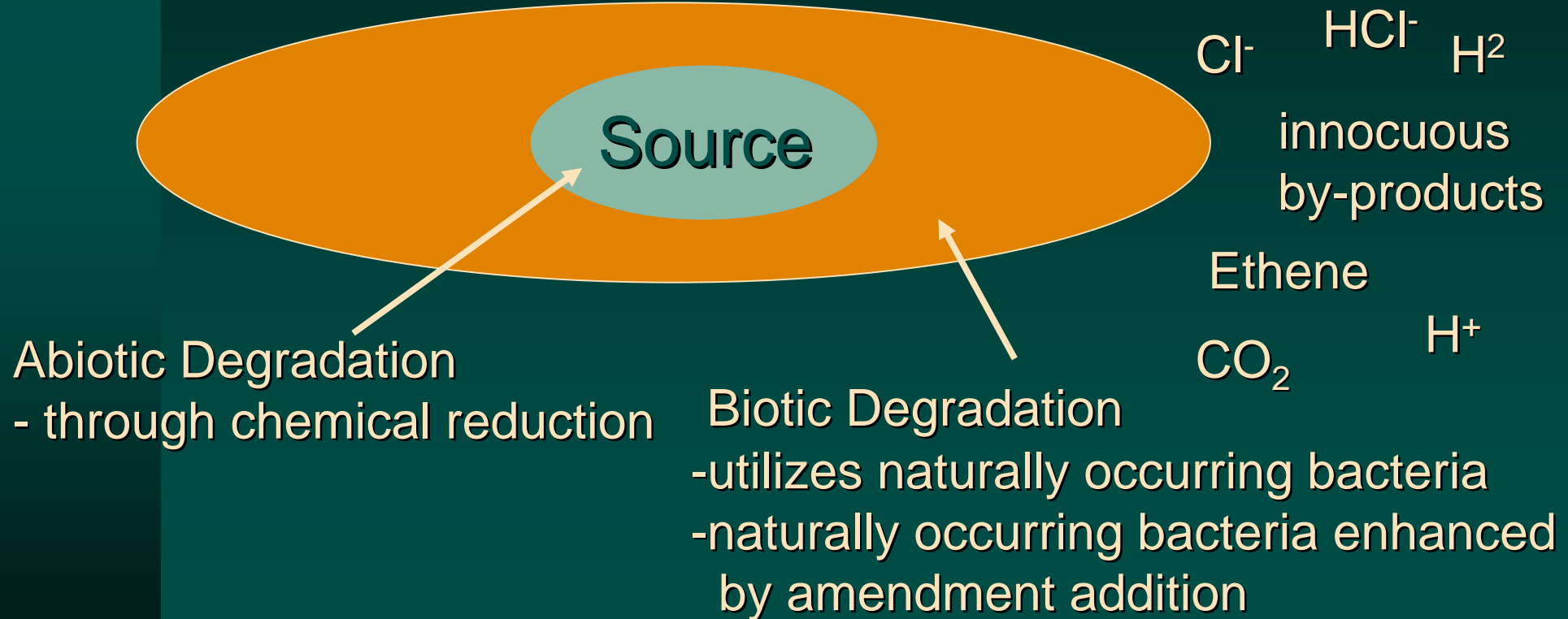
Bioremediation Process

- enhanced reductive dechlorination (biotic reaction)
- utilizes naturally occurring bacteria



- TCE/ cis-DCE/ VC/Ethene are daughter products and electron acceptors.
- Carbon is electron donor and food for native bacteria
- Fermentation of organic compounds produces H₂ which serves as an additional electron donor (Gossett et al., 1997).

In-situ Degredation of Chlorinated Organic Compounds

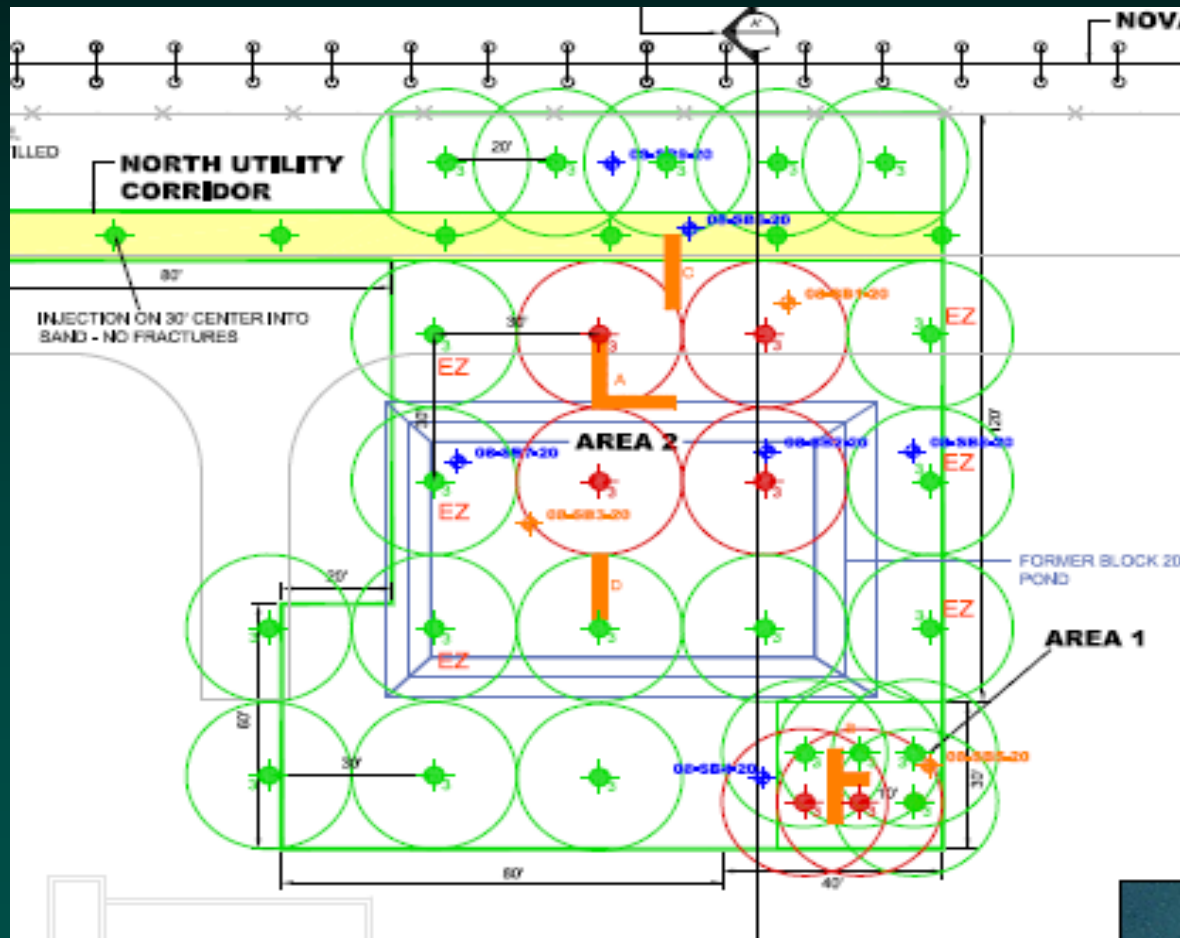


Draft

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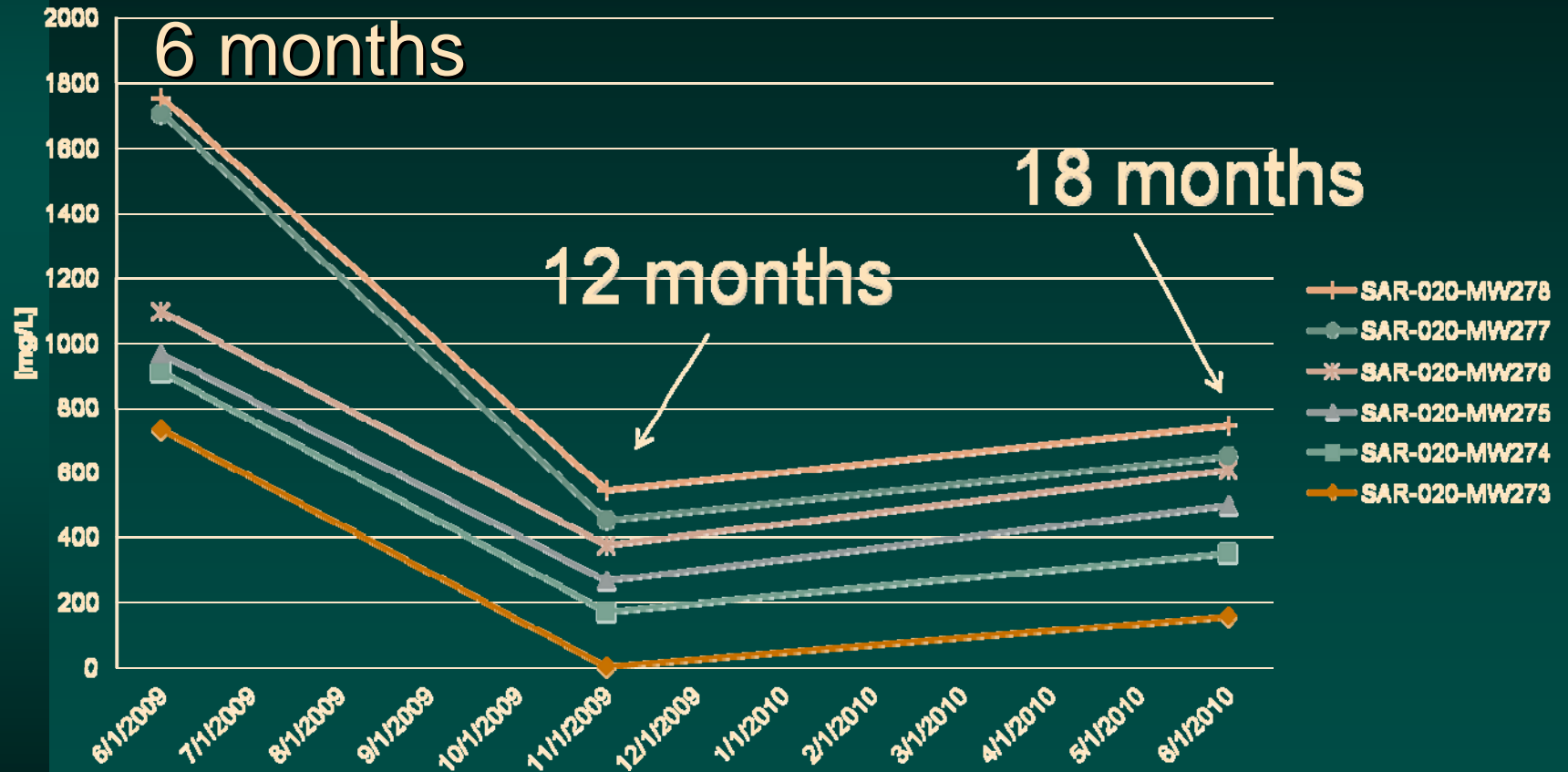
Remedial Design



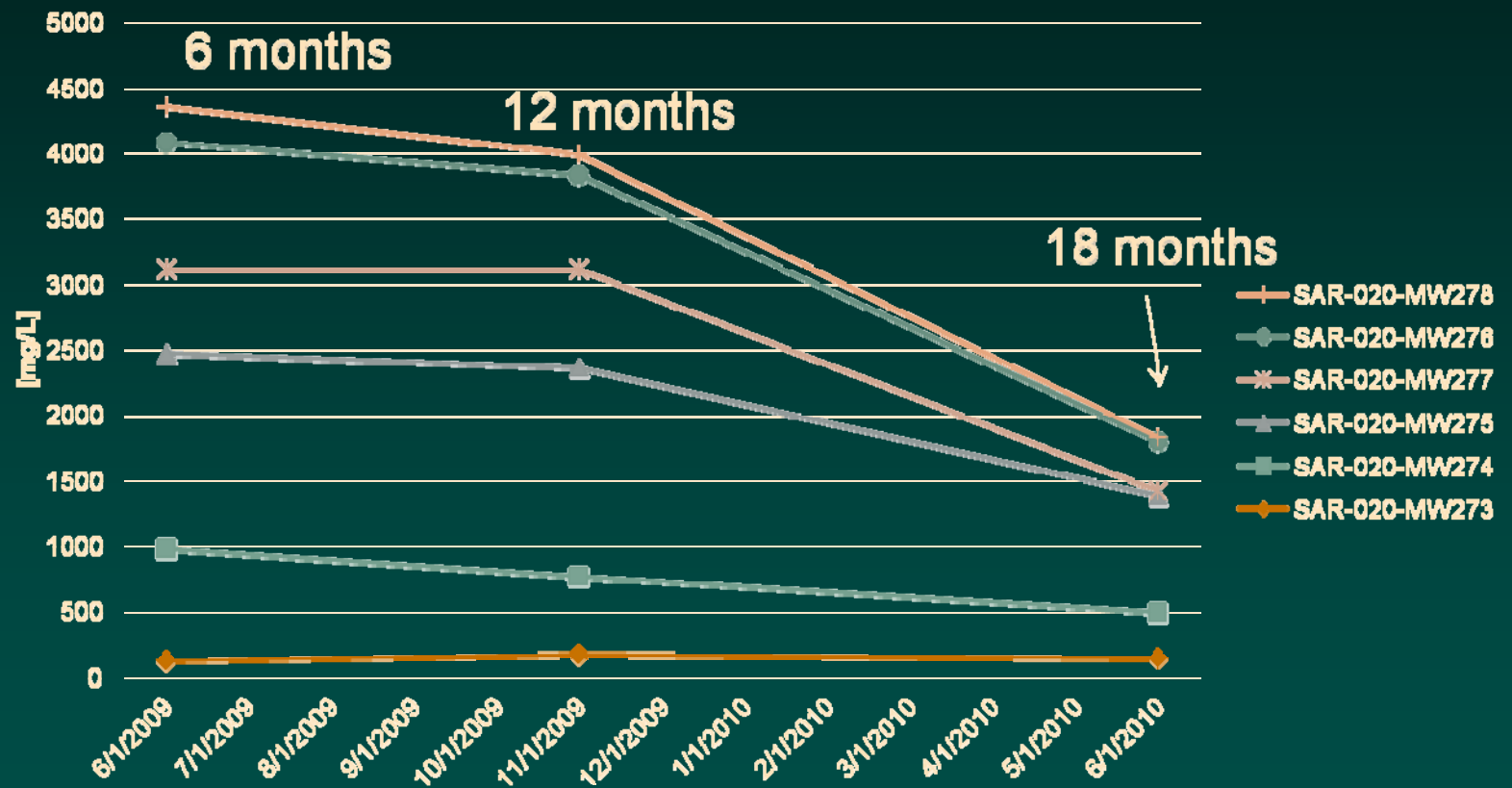
Amendment Volumes

- 2,300 lbs Iron per fracture
- 168,000 lbs Total iron injected
- Average of 234 gal of Injectate material (Guar, Water, and Glycol) per Fracture
- 16,457 gal of Injectate total

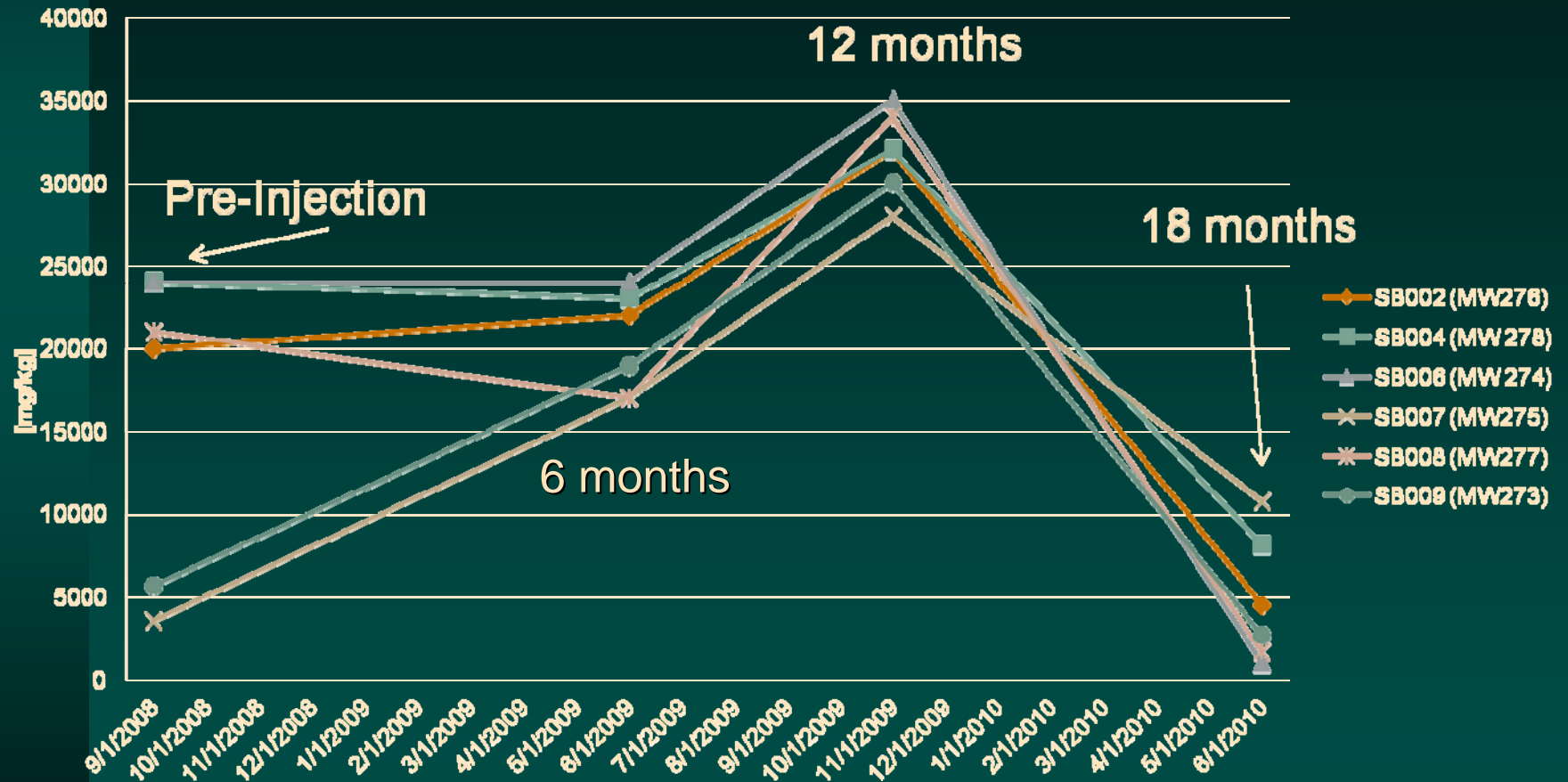
Total Iron in Groundwater



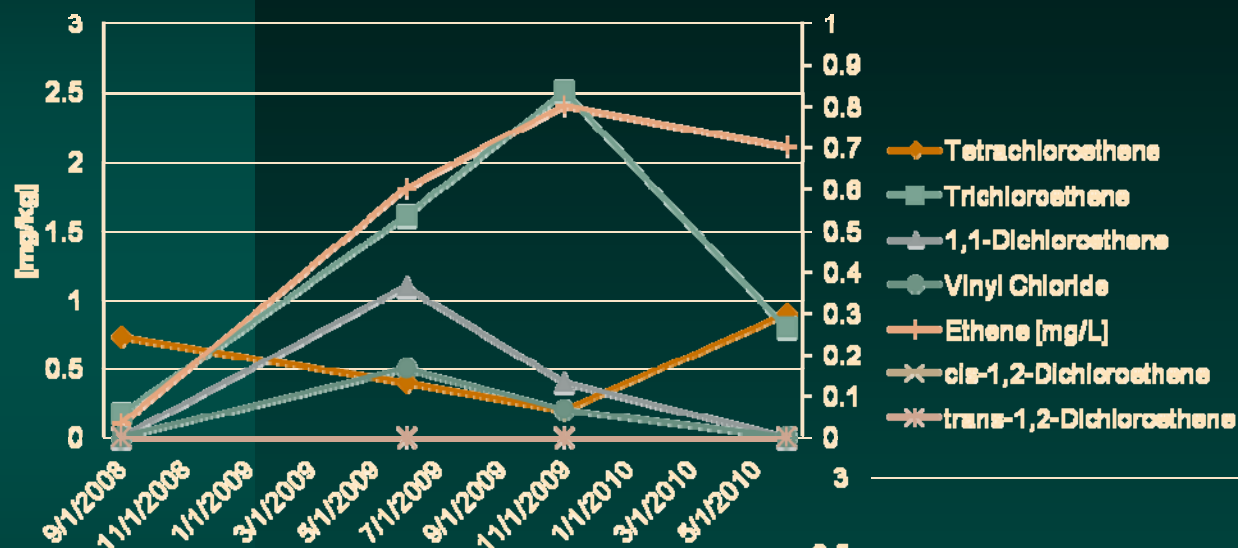
Total Organic Carbon in Groundwater



Total Organic Carbon in Soil

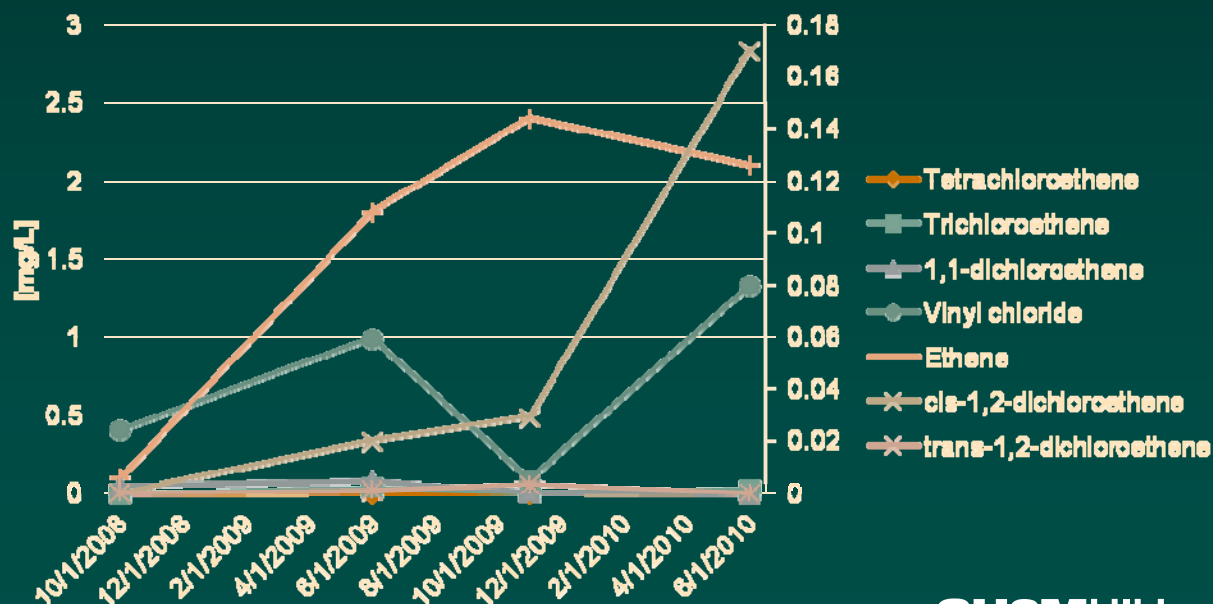


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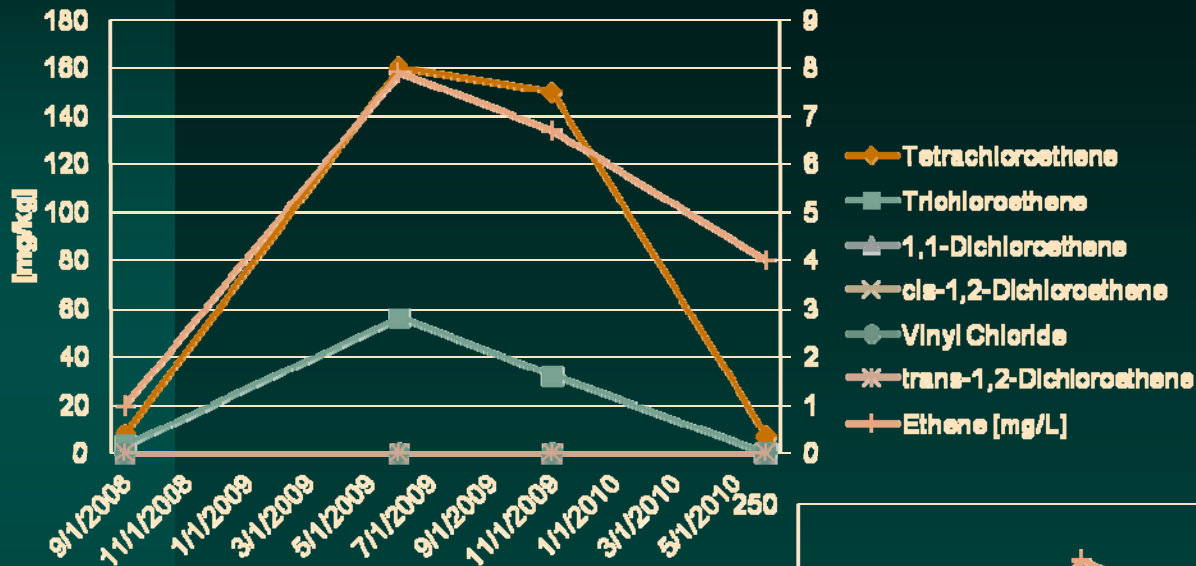


Groundwater

Soil (12-13 feet bgs)

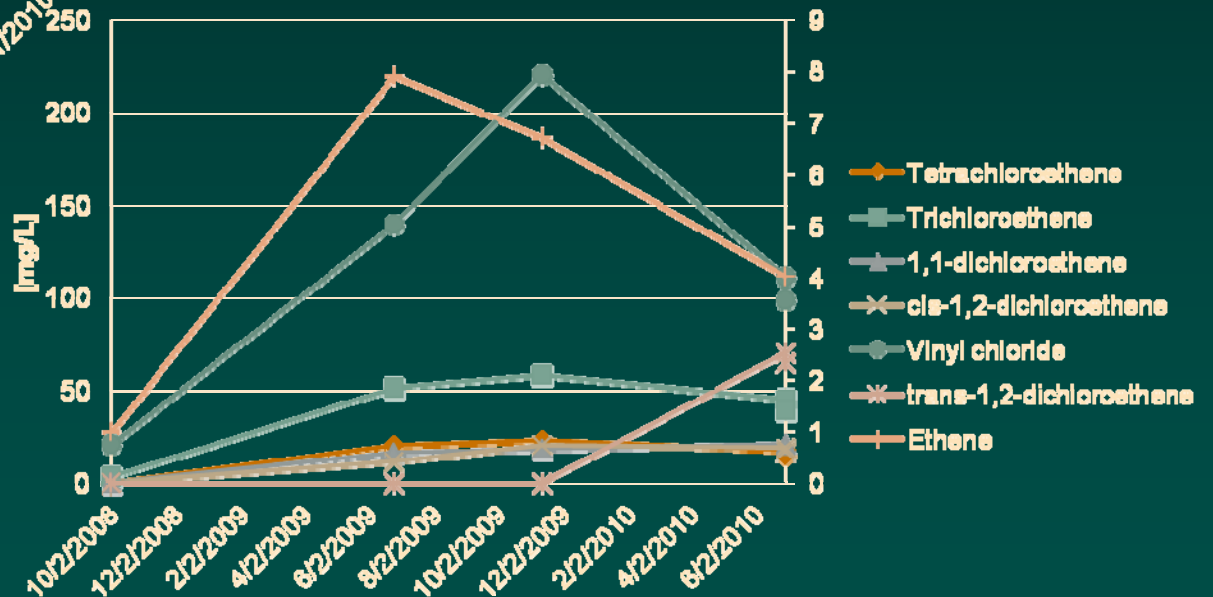


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Soil (12 – 13 feet bgs)

Groundwater



Results

- **Iron was successfully added to the subsurface through the F&I work and has resulted in the destruction of some CVOCs**
- **Organic carbon was successfully added to the subsurface and has been utilized for biodegradation as indicated by the reduction in total organic carbon and increases in end products.**
- **Data set still requires development to determine long term trends and predict timeframes for achieving desired endpoints**
- **Additional carbon source can now be added**

Lessons Learned

- **Baseline sampling should be collected before and immediately after injections to account for mobility and changed conditions created by the pressures of injections**
- **Diffusion into the clay matrix will be a long process**
- **Groundwater results are indicative of processes occurring in soils, but can not be directly correlated to concentration reductions in soils, but useful for less expensive screening**
- **Samples at 6 month intervals may not have great value for a large scale project**

Acknowledgements

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Questions?

