Site-Specific Reductive Dechlorination Designs Using a Full Toolbox of Abiotic with Biotic Reagents

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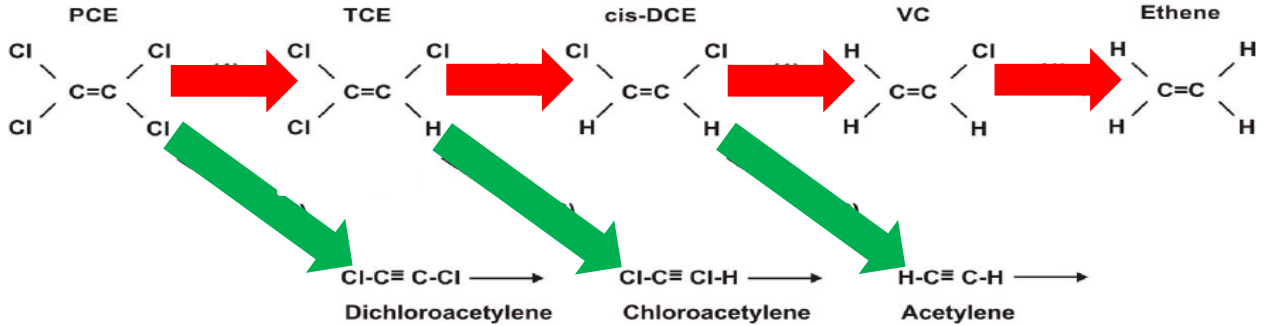
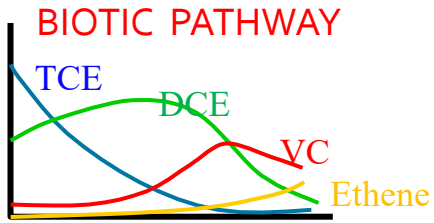
ISOTEC REMEDIATION TECHNOLOGIES

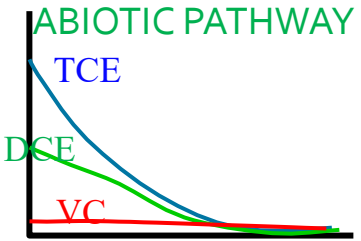
Enhanced Bioremediation

- **Biotic** Dechlorination in presence of e⁻ donor only
- **Biotic** & Abiotic Dechlorination in presence of ZVI & e⁻ donor





- Multiple reaction processes
- Reduce lesser chlorinated CVOCs
- Lower reducing conditions
- Extend reactivity
- pH buffering



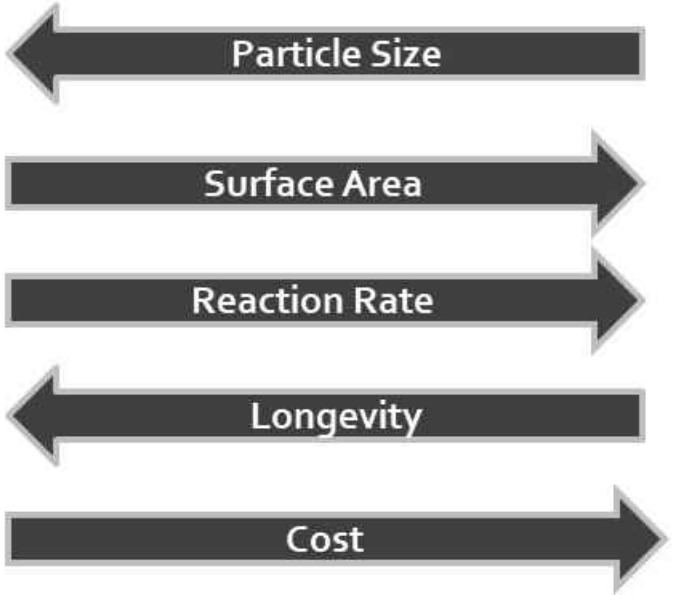
CARBON SUBSTRATE Electron Donors

- **Soluble/Quick Release**
  - Lactate, methanol, molasses, fructose corn syrup — high
- **Slow-Release**
  - Emulsified vegetable oil, lecithin, neat oil
    - Different droplet sizes
- **Solid products**
  - Mulch, compost, shells

Zero Valent Iron

- Remediation Objectives
- Hot Spot Treatment
  - Smaller ZVI – rapid reaction
- Permeable Reactive Barriers
  - Larger ZVI - persistence
- Combinations of reactive iron
  - Sulfidation

(Photo Credit: Hepure)



Injection Delivery

- Injection Wells
  - Liquid e- donor solutions
  - Dissolved Fe and S
  - ZVI (<4 micron)
- Temporary Injection Points
  - Low pressure (<10-100 psi)
    - ZVI up to ~44 micron
  - Higher pressure / fracturing
- Bedrock boreholes
- Soil blending
- Slurry ratio

Reductive dechlorination combinations

Carbon Substrate(s)

+

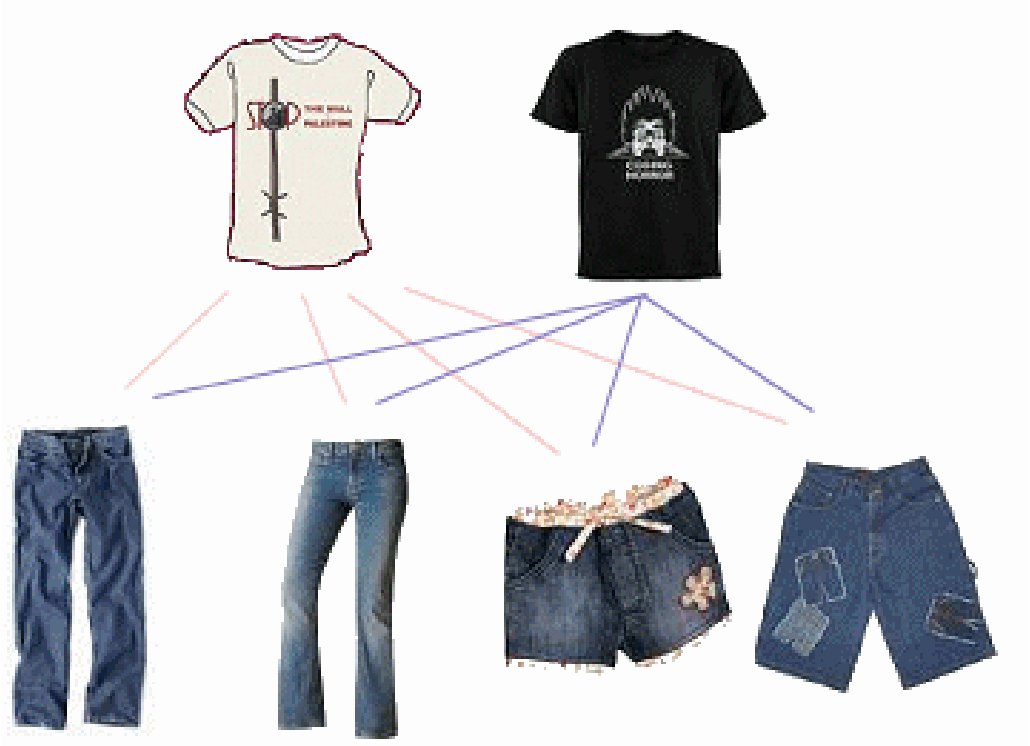
Reactive Iron(s)

+

Nutrients?

+

pH buffer?

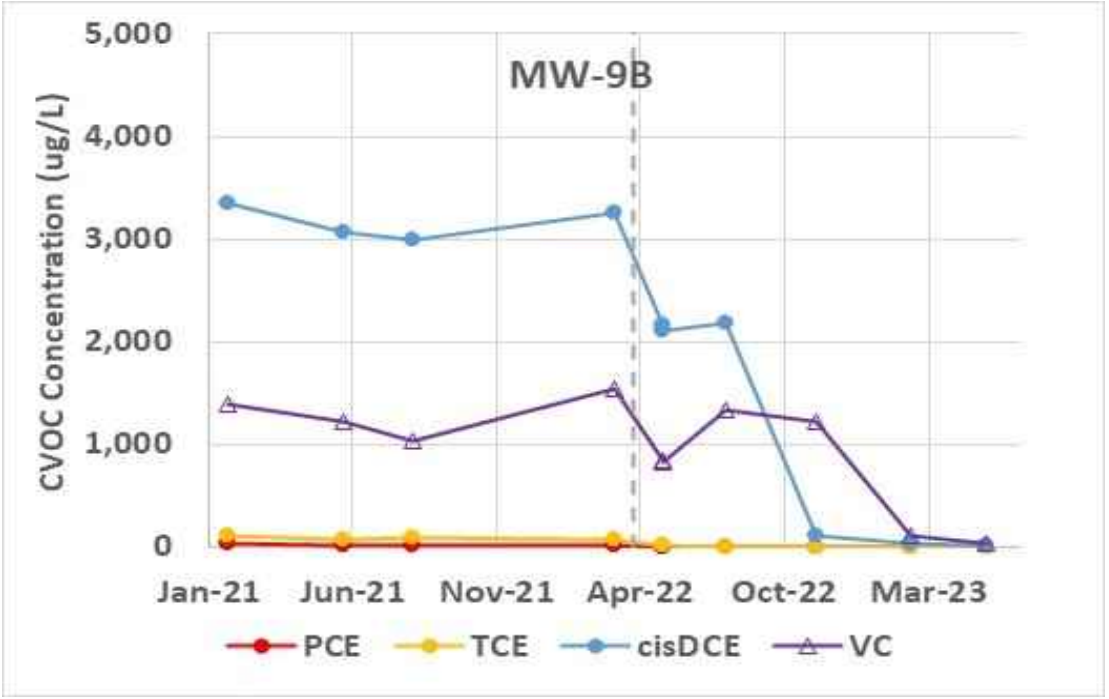


Injection Wells Case Study

- CVOCs migrated downgradient of a former dry cleaner
  - Downgradient property being redeveloped
  - Rapid CVOC reduction + ongoing dechlorination polishing
- 10 injection wells installed by Sonic drill rig
  - Depth + dense silt with sand and gravel
  - 20 slot openings
- Remedial Design
  - EVO (small droplet)
  - EVO with ZVI (4 micron)
  - FeS + Sulfate
  - Bioaugmentation

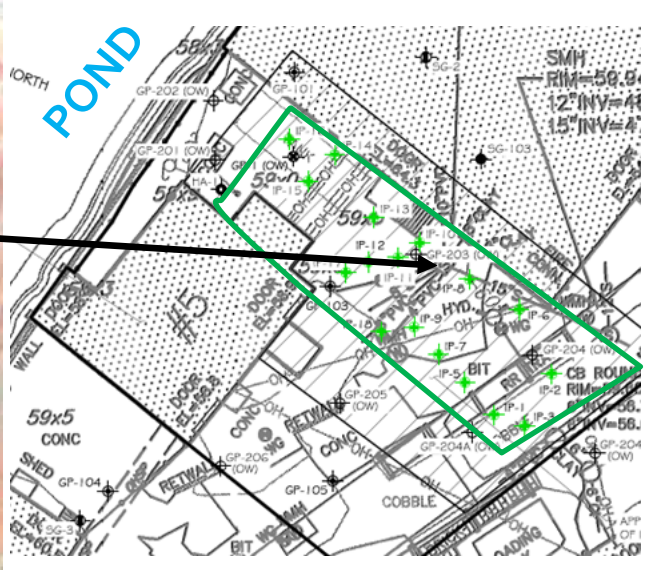
Injection Wells Case Study

- 13 months after injection
- Total CVOCs reduced 95% to >99%
- Anaerobic conditions favorable for ongoing biodegradation



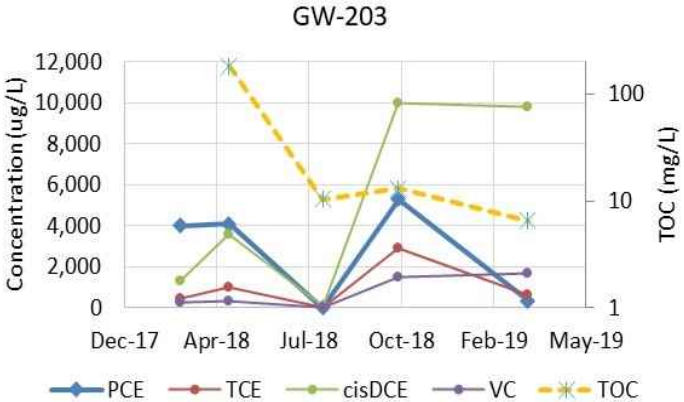
New England Mill Site

- Redevelopment at former textile mill
  - Soils impacted by PCE & TCE
  - Adjacent to pond
  - Numerous utilities
- Treatment Area ~ 2,500 ft^2
- Regulatory and public concern for water quality the pond



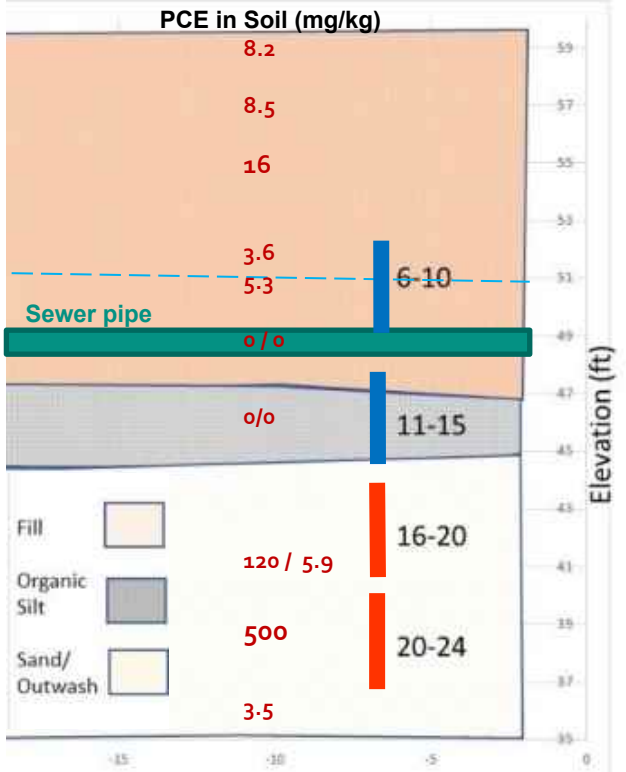
New England Mill Site

- Water soluble donors selected
  - Due to proximity to the pond
  - Glycerol with ZVI (2-3 μm) near hot spot Soils impacted by PCE & TCE
  - Sodium lactate in downgradient area
- Dechlorination successful, but…
  - Anaerobic conditions faded after 10-12 months
  - Higher CVOCs in deeper zone
- Focused area for additional treatment (600 ft^2)
  - Desire longer persistence

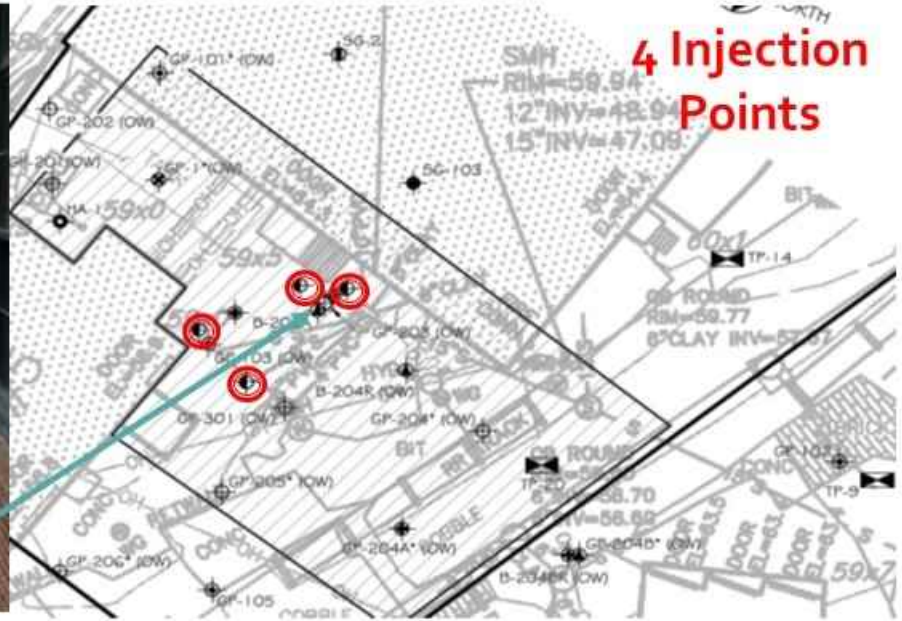


New England Mill Site

- Rapid remobilization based on construction
- Shallow interval
  - ELS (Lecithin)
  - Water soluble, but longer lasting than lactate
- Deep interval (>12,000 µg/L CVOCs)
  - SRS®-NR-ZVI (15% ZVI by mass)
    - SRS®-NR = formulated to be stickier for high K soils
    - First ever application of SRS®-NR with ZVI
    - Prevent migration to pond or utilities
- Bioaugmentation in both intervals

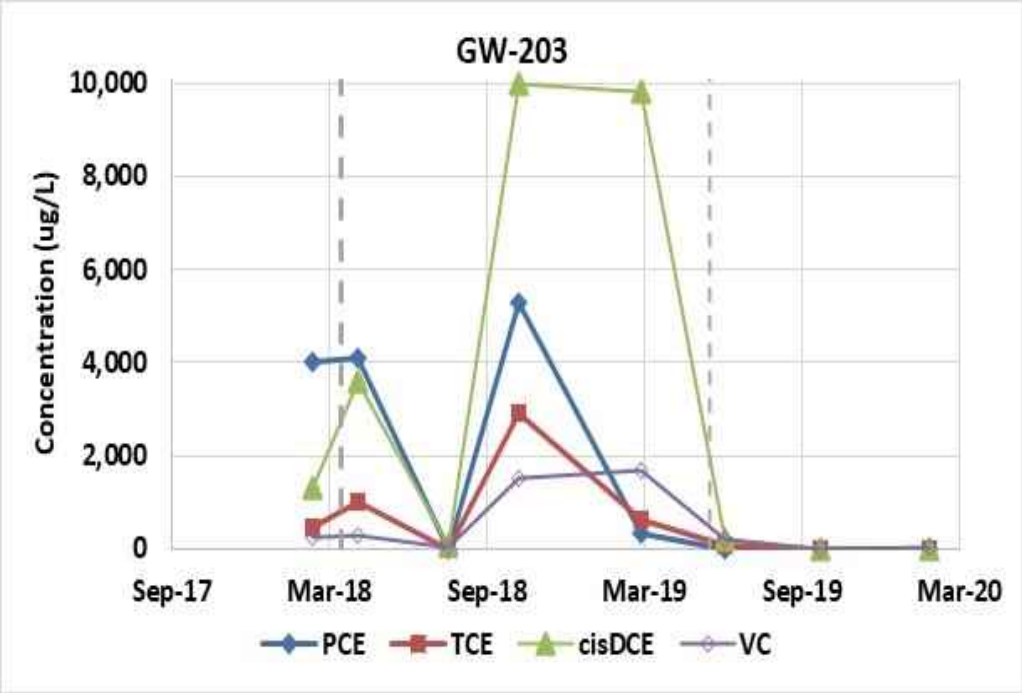


New England Mill Site



Impacted Monitoring Well

New England Mill Site



- Site was closed with historic mill converted to 100+ affordable rental units
- 4 different EISD reagents for different zones and vertical intervals

Redevelopment Site

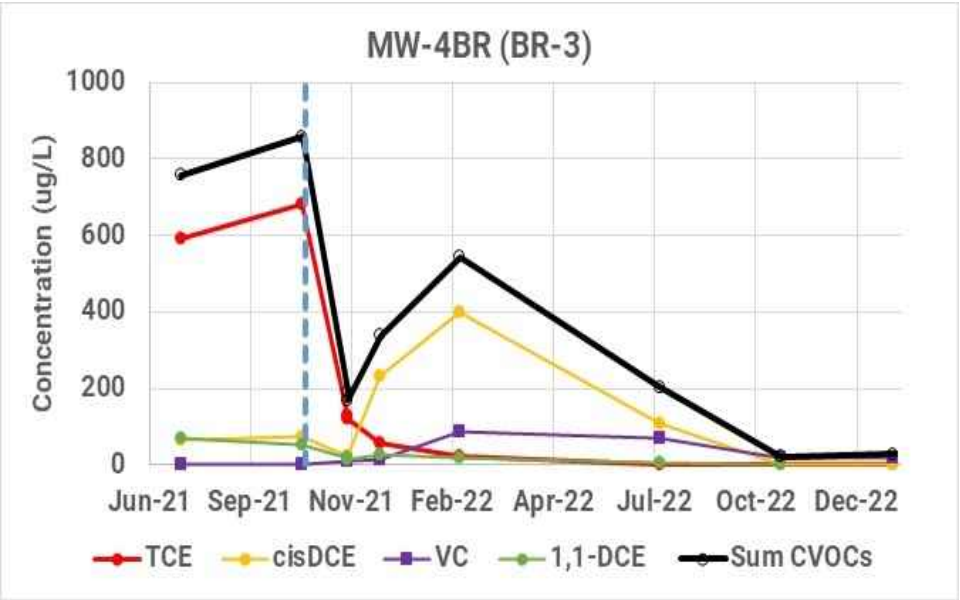
- 23-acre parcel
  - Manufacturing ceased in the 1980s
  - Chlorinated VOCs and 1,4-dioxane in overburden and bedrock
- New property owner wanted to initiate construction ASAP
  - Remedial objective - effectively reduce contaminant concentrations with a single injection mobilization to advance the site into the state MNA program.

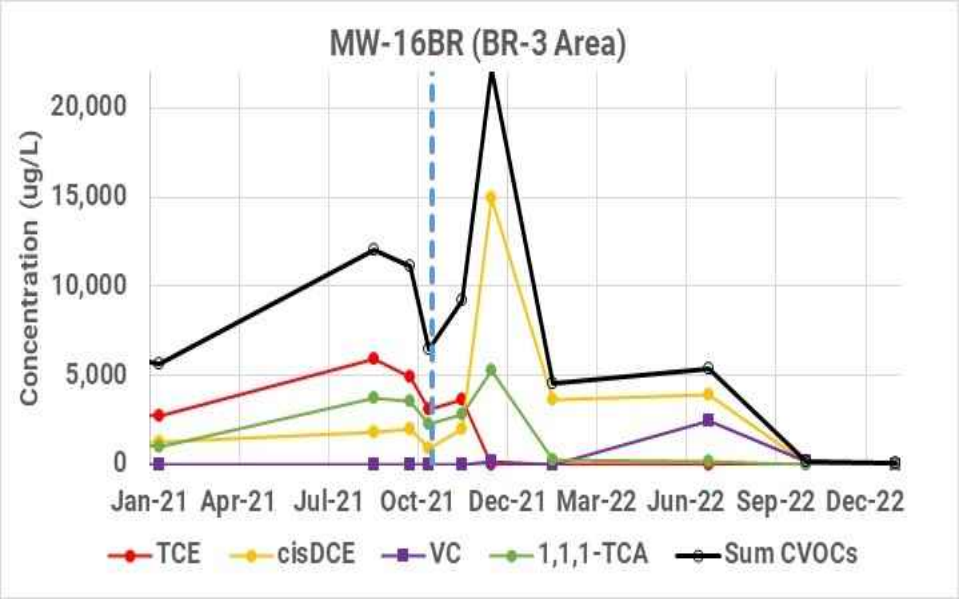
Enhanced In-Situ Dechlorination - Bedrock

- 51,000 square feet (65-90’ bgs)
  - 11 injection boreholes
- EISD focused for treating fractures
  - Large Droplet EVO
  - Sulfidated ZVI (SRS®-Z)
    - ~11% 4 micron
    - ~89% 44 micron
  - Bioaugmentation (DHC+DHB)
  - Nutrient blend (N, P) + sulfate
- Open-Hole Bedrock Injection Wells
  - Straddle packers to target identified fractures

Enhanced In-Situ Dechlorination - Bedrock

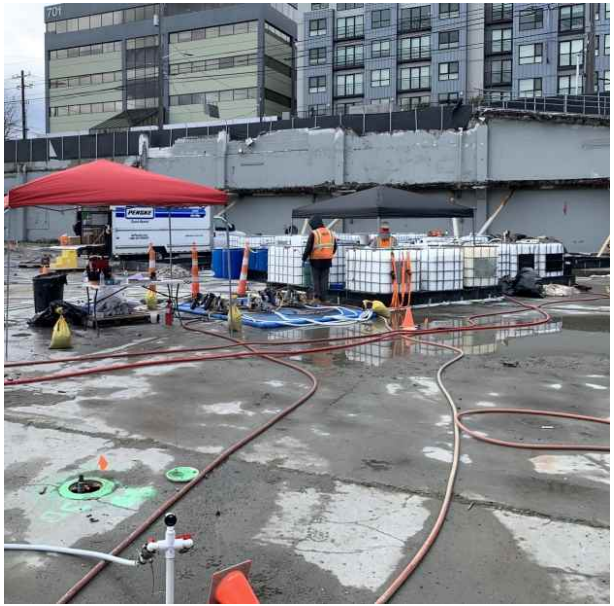
- 2 months post-injection
  - 4/4 monitoring wells – TOC> 20 mg/L & TCE reduced by >90%
- 15 months post-injection
  - 4/4 monitoring wells –96% - 99% reduction in total CVOCs





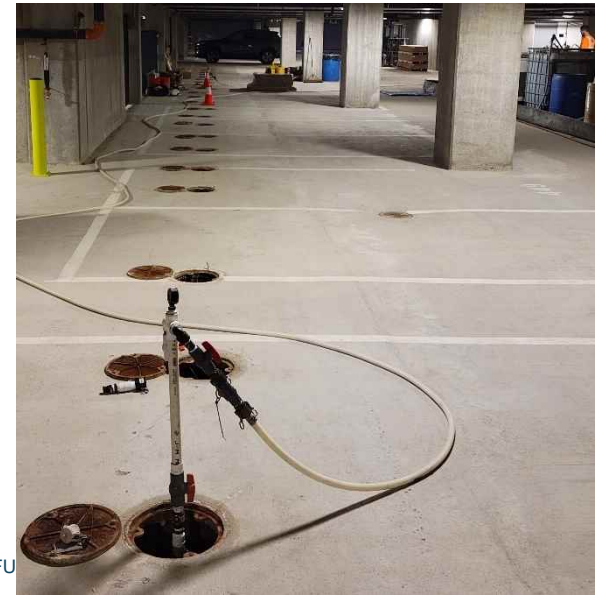
Basement Case study

- Redevelopment of former industrial laundry
  - ISOTEC performed ISCO + ERD into 130+ injection wells
- Excavation to install below grade parking
  - 63 injection wells installed at base of excavation
- Re-injection planned prior to building occupation
  - ~3.5 years after EVO injection
- Total CVOCs reduced site wide
  - Cis-1,2-DCE and VC predominate
  - Elevated PCE remaining in area where initial injection wells did not have adequate coverage



Basement Case study

- Re-injection Goals
  - Establish reductive dechlorination for an extended period
  - Preserve injection well integrity for future injection (if needed)
- Remediation Design
  - EVO (small droplet)
  - Bioaugmentation (KB-1)
  - Enhance abiotic dechlorination
    - FeS
    - Sulfate
- Low-flow, low-pressure injection
  - Ample deoxygenated chase water for injection wells



Bundling The Key points

- Different carbon substrates and iron reagents have advantages & disadvantages, strengths & limitations

- Tailor remediation reagents to site-specific needs
  - Geology
  - Contaminant concentration/range
  - Plume size
  - Sensitive receptors
  - Design duration (fast reaction vs. long lasting)
  - Budget

Thank You

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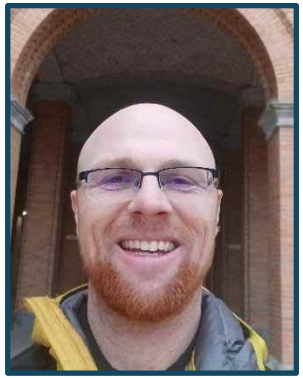

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