## Abiotic/Biotic Reduction of Trichloroethene and Perchlorate: Laboratory Treatability Study for a Superfund Site

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#### Phoenix-Goodyear Airport North (PGAN) Superfund Site, Goodyear, AZ



- Added to the NPL in 1983
- Groundwater impacted by trichloroethene (TCE), perchlorate, methyl ethyl ketone, and acetone
- Chromium, cadmium, aluminum, and copper in certain source area soils
- Subunit A Interbedded sands, silty sands, and clayey sands with localized sand and gravel sequences; groundwater depth 90-140 feet bgs; groundwater flow direction north-northwesterly
- Subunit B/C unconsolidated and interbedded mixtures of silty sands, clayey sands, and fine- to coarse-grained sands

#### **Proposed source area remediation**



- Five groundwater pump and treat systems returning cleaned water using reinjection, infiltration and irrigation. time
- In situ chemical reduction has been employed on a limited scale time
- Treatability Study: develop design-related insights for a potential remedy for Subunit A source area groundwater (approved by the EPA and contained in the Record of Decision Amendment Sep 2014)

# Combined remedy using zero-valent iron and microbial reductive dechlorination



#### **Semi-batch microcosm study – TCE reduction**

Microcosms:





#### # = non-detect

SDC-9 and ZARA-10: Dehalococcoides mccartyi bioaugmentation cultures



SDC-9 and ZARA-10: *Dehalococcoides mccartyi* bioaugmentation cultures

# Growth of Dehalococcoides mccartyi in the presence of ZVI and Fe (II)



- 15 g L<sup>-1</sup> mZVI &
  1.5 g L<sup>-1</sup> nZVI
- 0.25 g L<sup>-1</sup> Fe (II)

#### **Microbial communities enriched in microcosms**



Mohana Rangan et al. (in prep.)

#### **Continuous flow-through soil column study**



#### Pre-treatment of aerobic groundwater in ZVI columns





Column dimensions: 5.1 cm ID x 51 cm L Effective porosity: 28-33% Flow rate: 17 mL d<sup>-1</sup> Hydraulic retention time = 15 day TCE spiked in influent at 175  $\mu$ M

#### **TCE reductive dechlorination**



Time (Days)

#### **Electron donor and carbon source limitation**



Rao et al. (in prep.)





Time (Days)



◆ Column A NO3-N ◆ Column B NO3-N ◆ Column C NO3-N ◇ Influent NO3-N

Rao et al. (in prep.)

### Sulfate reduction was the most significant microbial process utilizing the electron donor and carbon sources



#### **Complete TCE and perchlorate reduction at pH 8.5-9**



Rao et al. (in prep.)

# Dehalococcoides mccartyi colonization and growth in soil columns



D. mccartyi not detected before bioaugmentation with SDC-9 and ZARA-10 enrichment cultures

#### **TCE reductive dechlorination in aerobic groundwater**



#### Lessons learned from treatability study

- Abiotic TCE reduction to ethene and ethane was highly effective at high ZVI concentrations
- ii. Microbial perchlorate reduction was partially inhibited at high ZVI and Fe (II) concentrations
- iii. Biotic TCE reductive dechlorination not a significant process at high ZVI concentrations but *D. mccartyi* likely survive
- iv. Synergy between abiotic and biotic reduction processes observed under flow-through conditions
- v. Biostimulation/bioaugmentation (no ZVI) could achieve similar outcomes in terms of

complete TCE dechlorination to ethene

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### Thank you!

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