

Prospects that Abiotic Degradation of TCE by Naturally Occurring Magnetite Can be Important for Monitored Natural Attenuation

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Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites

U.S. Environmental Protection Agency
Office of Solid Waste and Emergency Response
Directive 9200.4-17P

Three tiers of site-specific information, or
“lines of evidence”, for MNA are:

- (1) Historical groundwater and/or soil chemistry data that demonstrate a clear and meaningful trend of decreasing **contaminant mass and/or concentration** over time at appropriate monitoring or sampling points.
- (2) Hydrogeologic and geochemical data that can be used to demonstrate indirectly the type(s) of natural attenuation processes active at the site, and the rate at which such processes will reduce contaminant concentrations to required levels. For example, characterization data may be used to quantify the rates of contaminant sorption, dilution, or volatilization, or to demonstrate and quantify the rates of biological degradation processes occurring at the site.

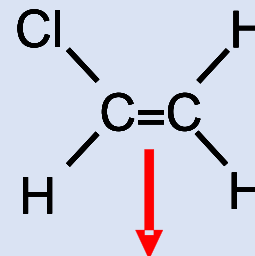
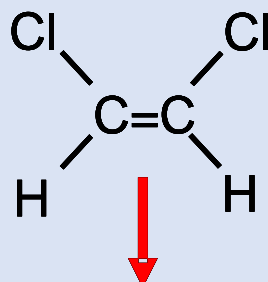
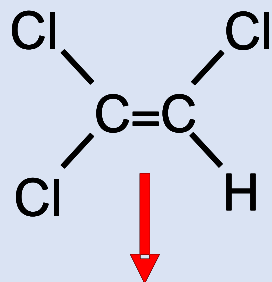
(2) Hydrogeologic and geochemical data that can be used to demonstrate indirectly the type(s) of natural attenuation processes active at the site, and the rate at which such processes will reduce contaminant concentrations to required levels.

For example, characterization data may be used to quantify the rates of contaminant sorption, dilution, or volatilization, or to demonstrate and quantify the **rates of biological degradation processes** occurring at the site.

Rate estimates are usually obtained by calibrating a transport and fate model to the field data.

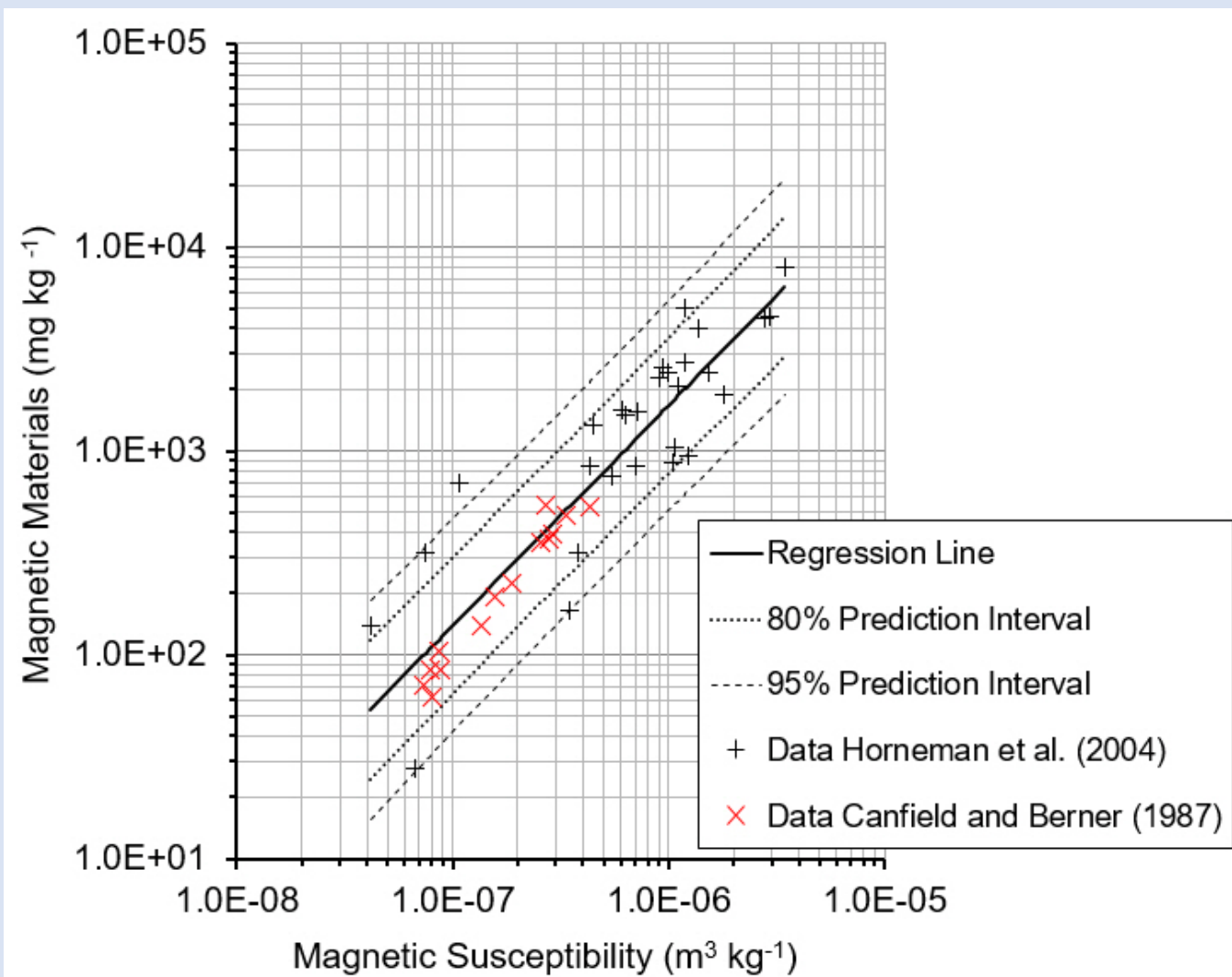
(3) Data from field or microcosm studies (conducted in or with actual contaminated site media) which directly demonstrate the occurrence of a particular natural attenuation process at the site and its ability to degrade the contaminants of concern (typically used to demonstrate biological degradation processes only).

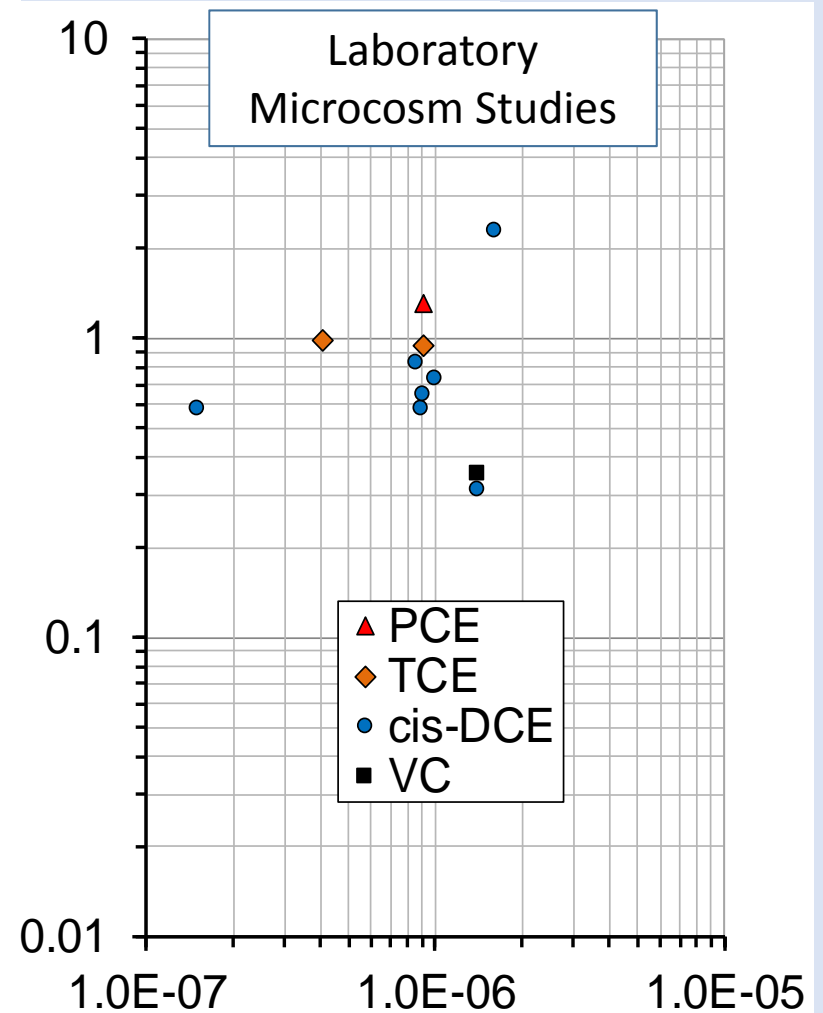
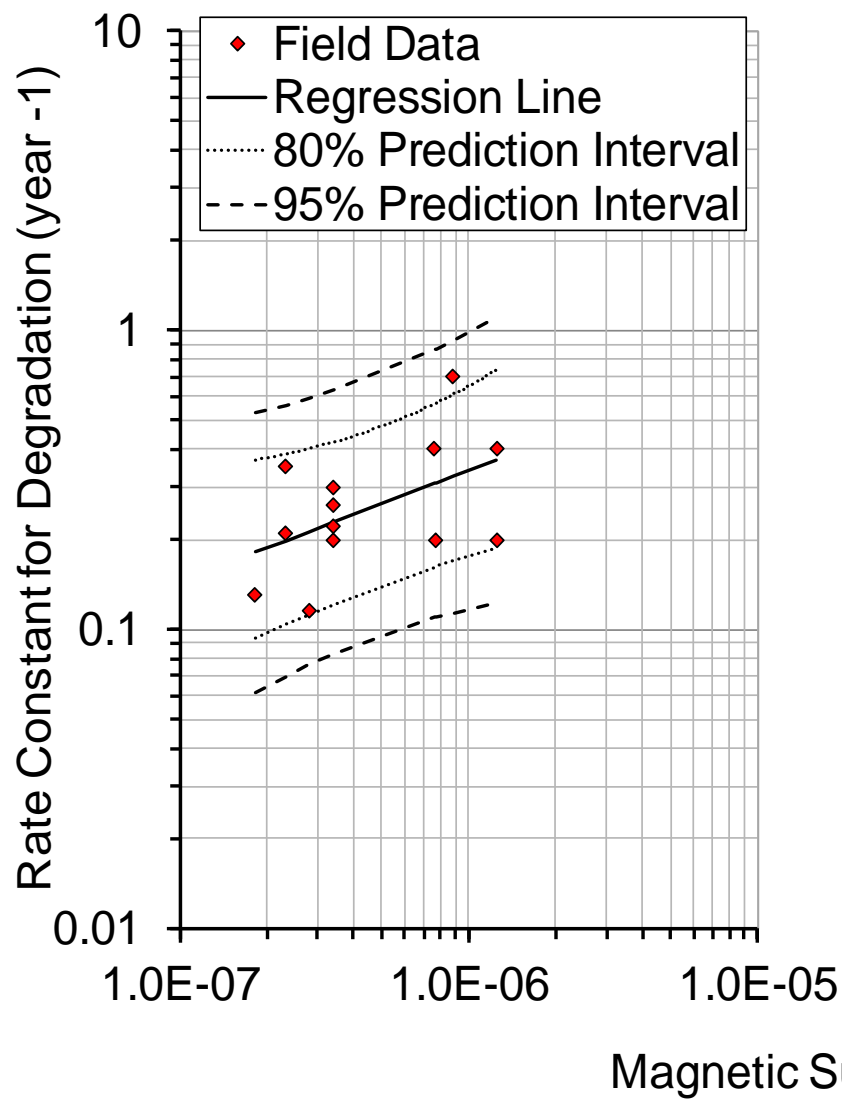
Abiotic Degradation Carried out by Magnetite



CO_2 and other oxidized products

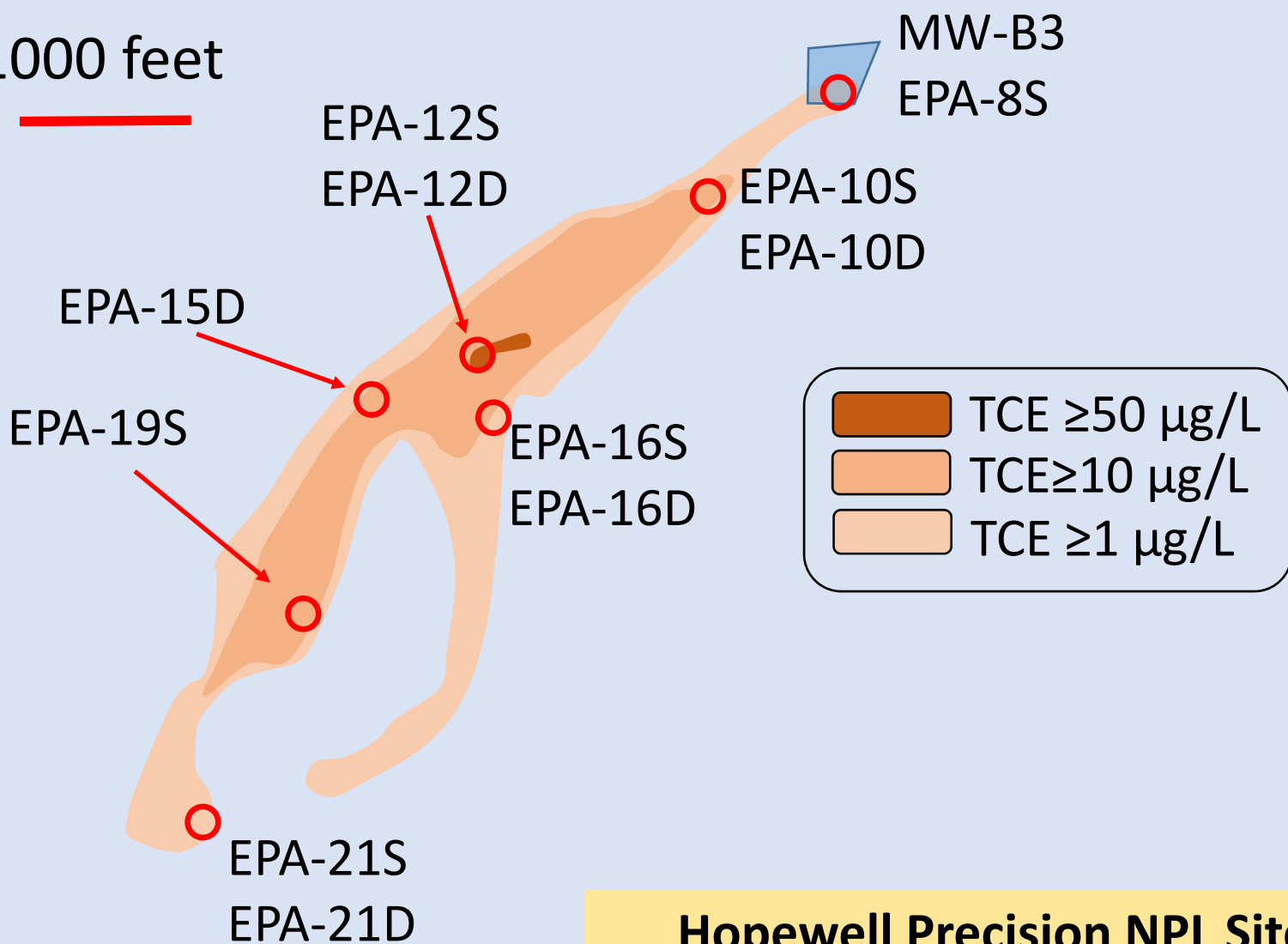
Mass Magnetic Susceptibility to Estimate Magnetite in Aquifer Material



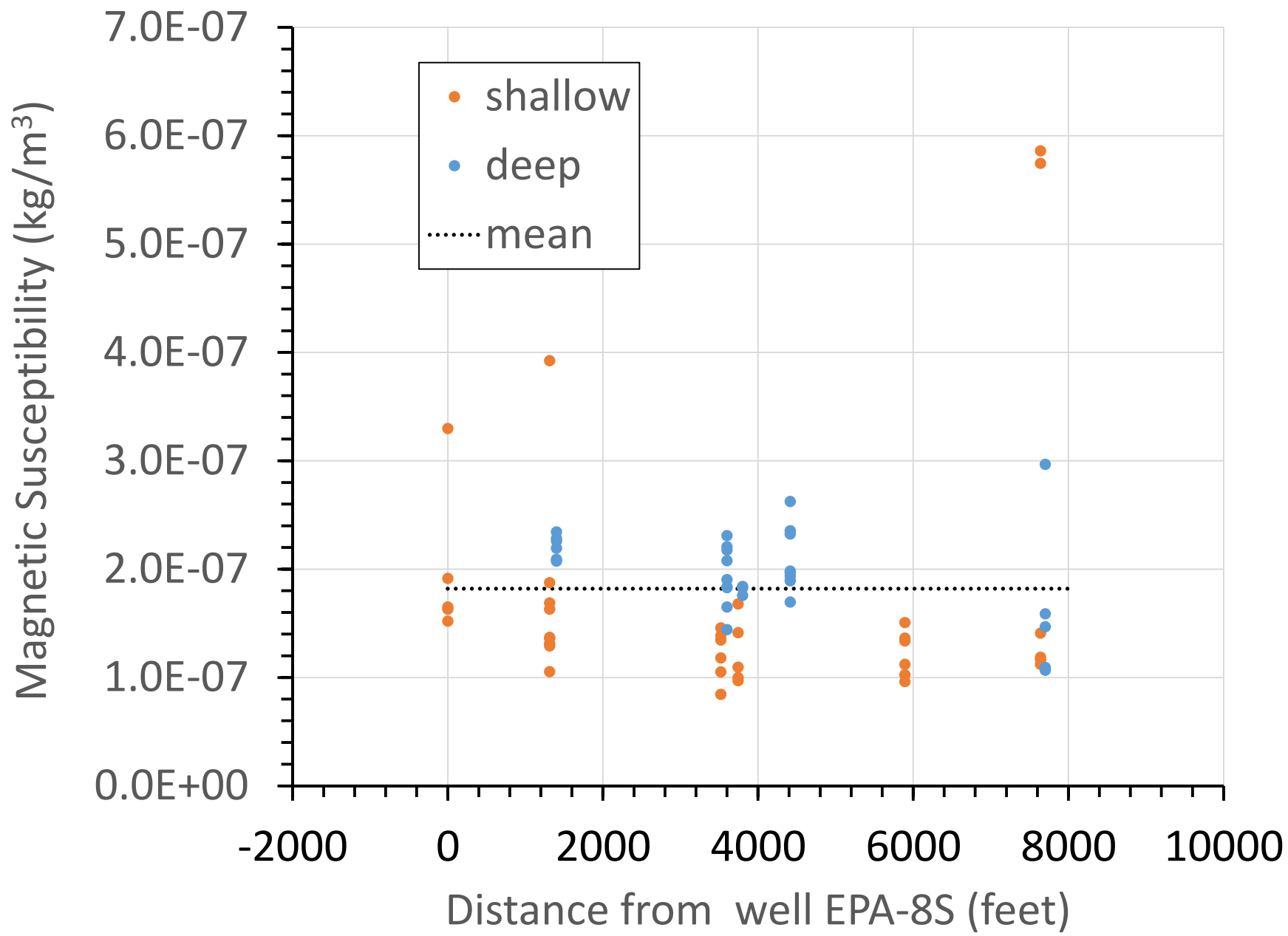


Groundwater Monitoring & Remediation 37(2):25–34 (2017)

1000 feet



**Hopewell Precision NPL Site,
Hopewell Junction, NY**

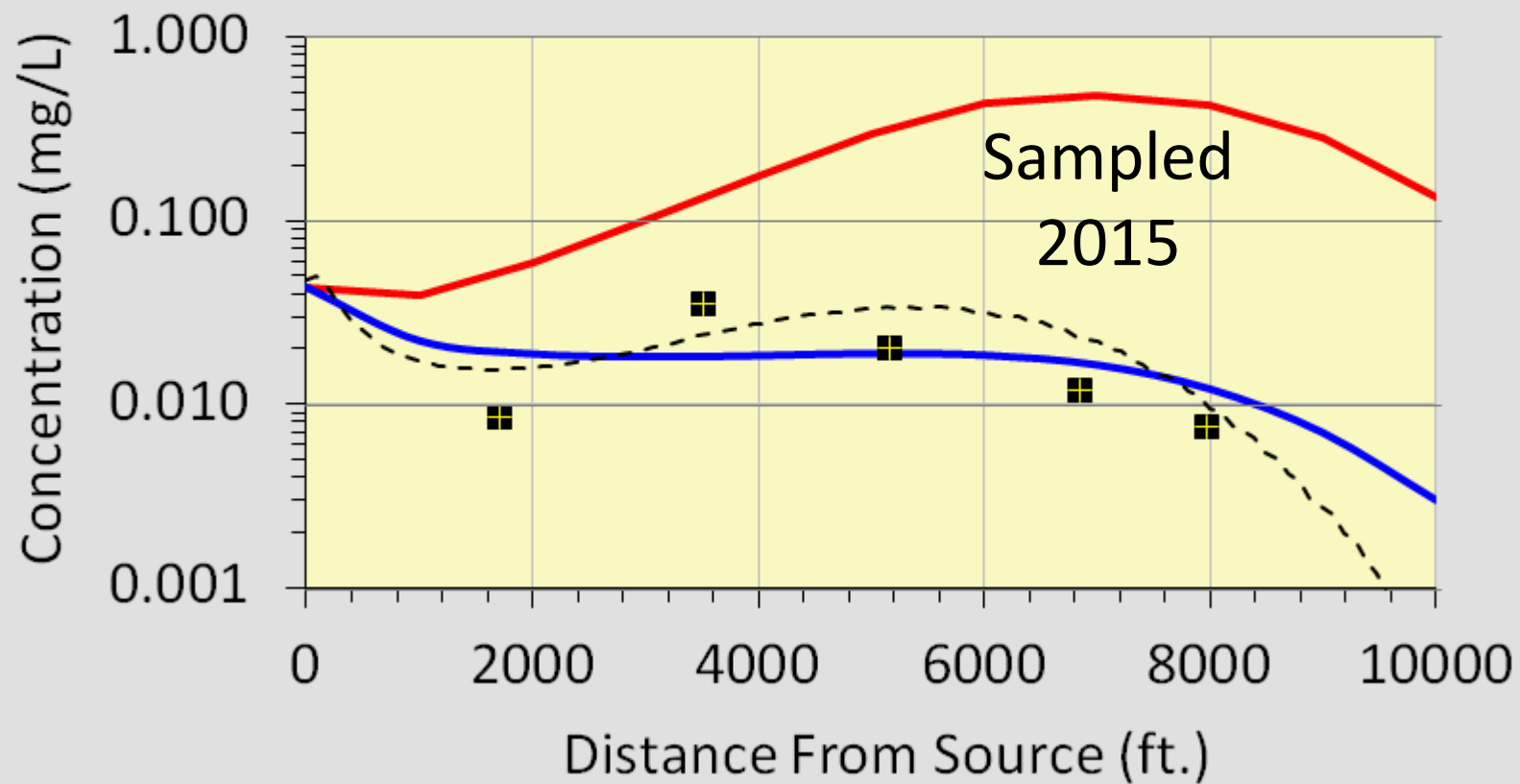


--- REMChlor Simulation 1st Order Decay

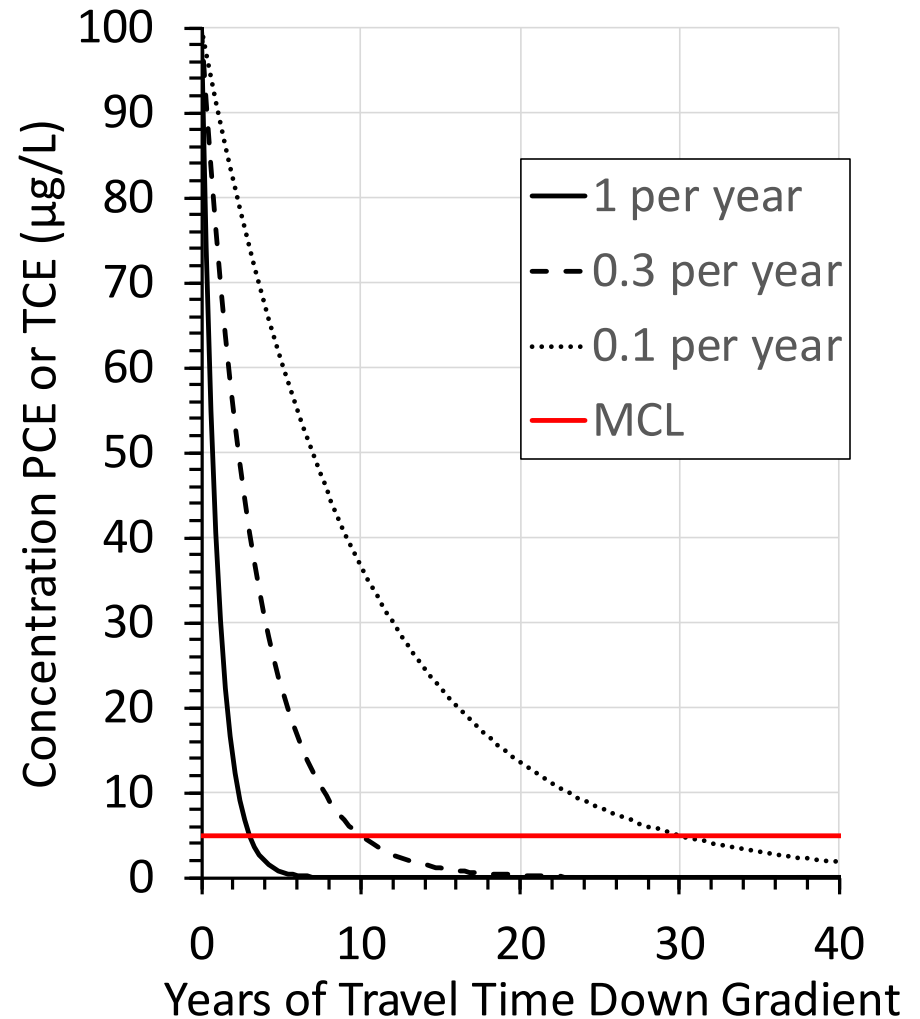
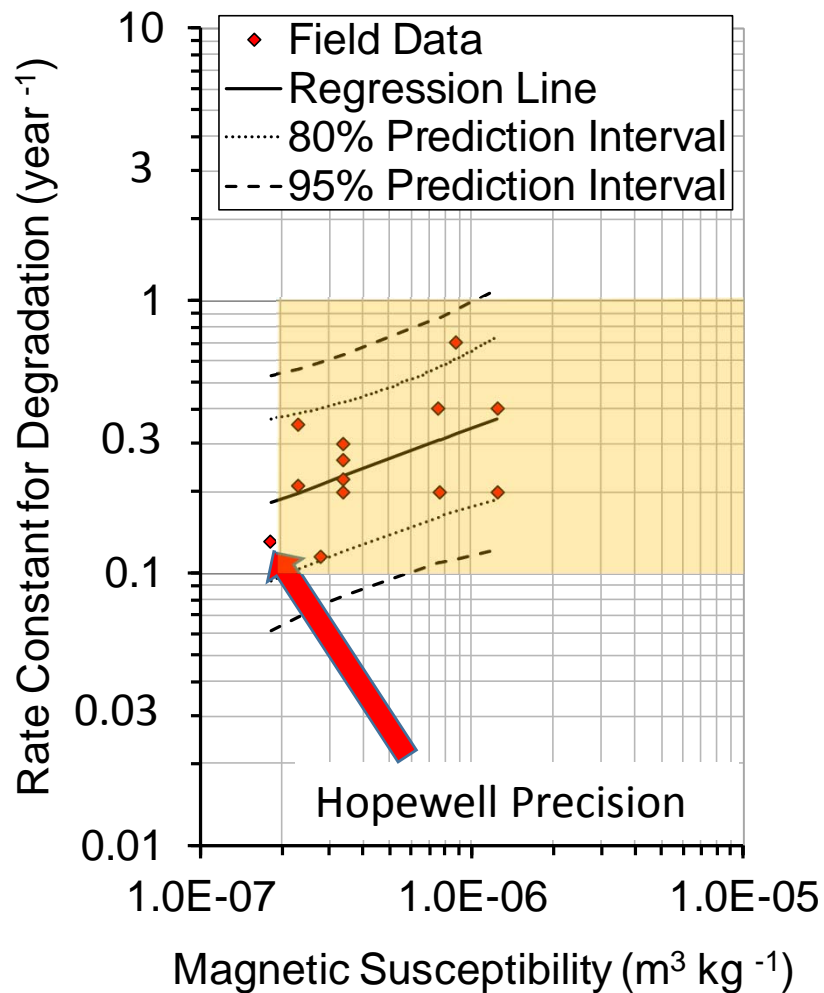
— No Degradation/Production

— BIOCHLOR Simulation 1st Order Decay

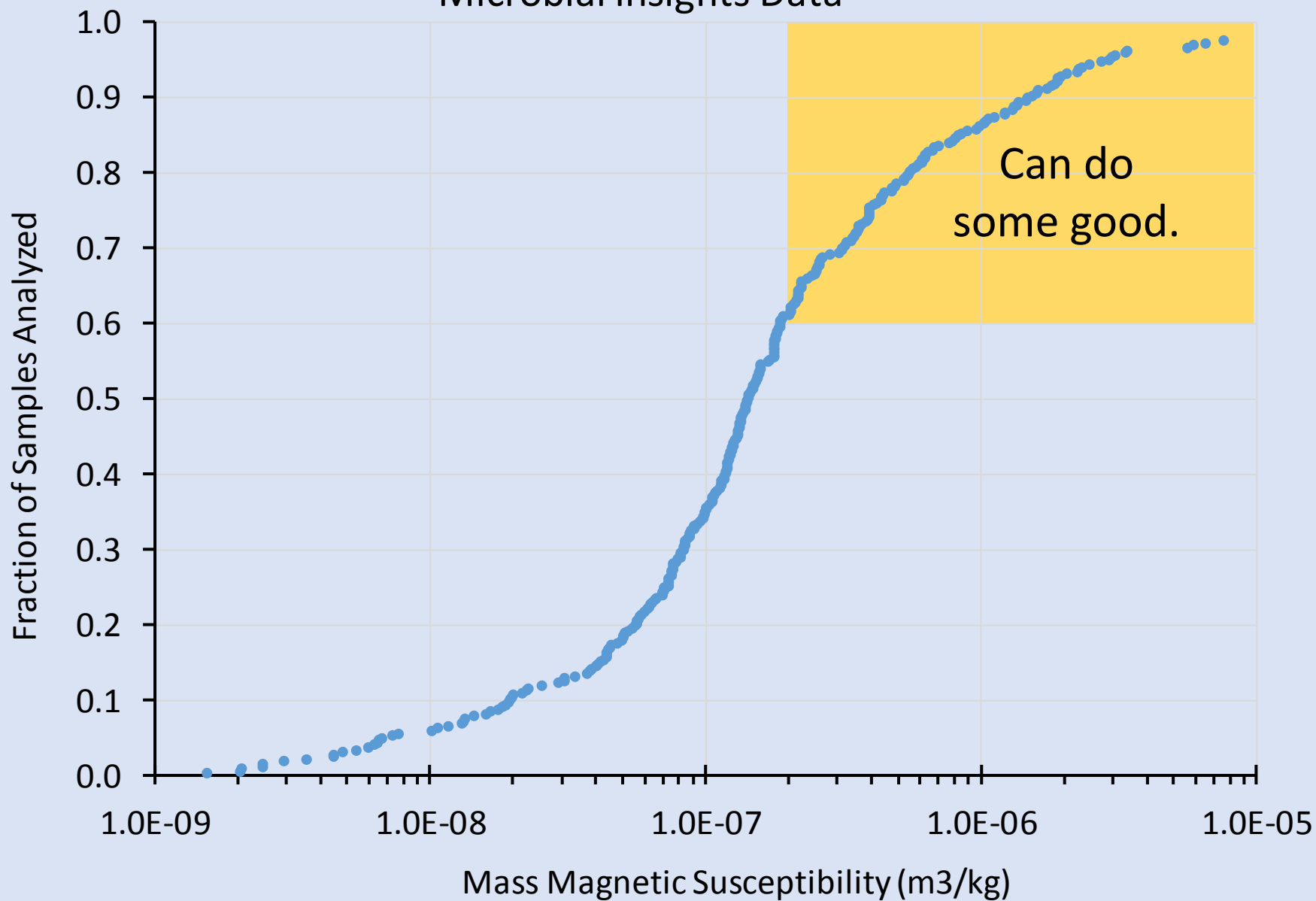
■ Field Data from Site



Contribution of Rate Constants to Monitored Natural Attenuation

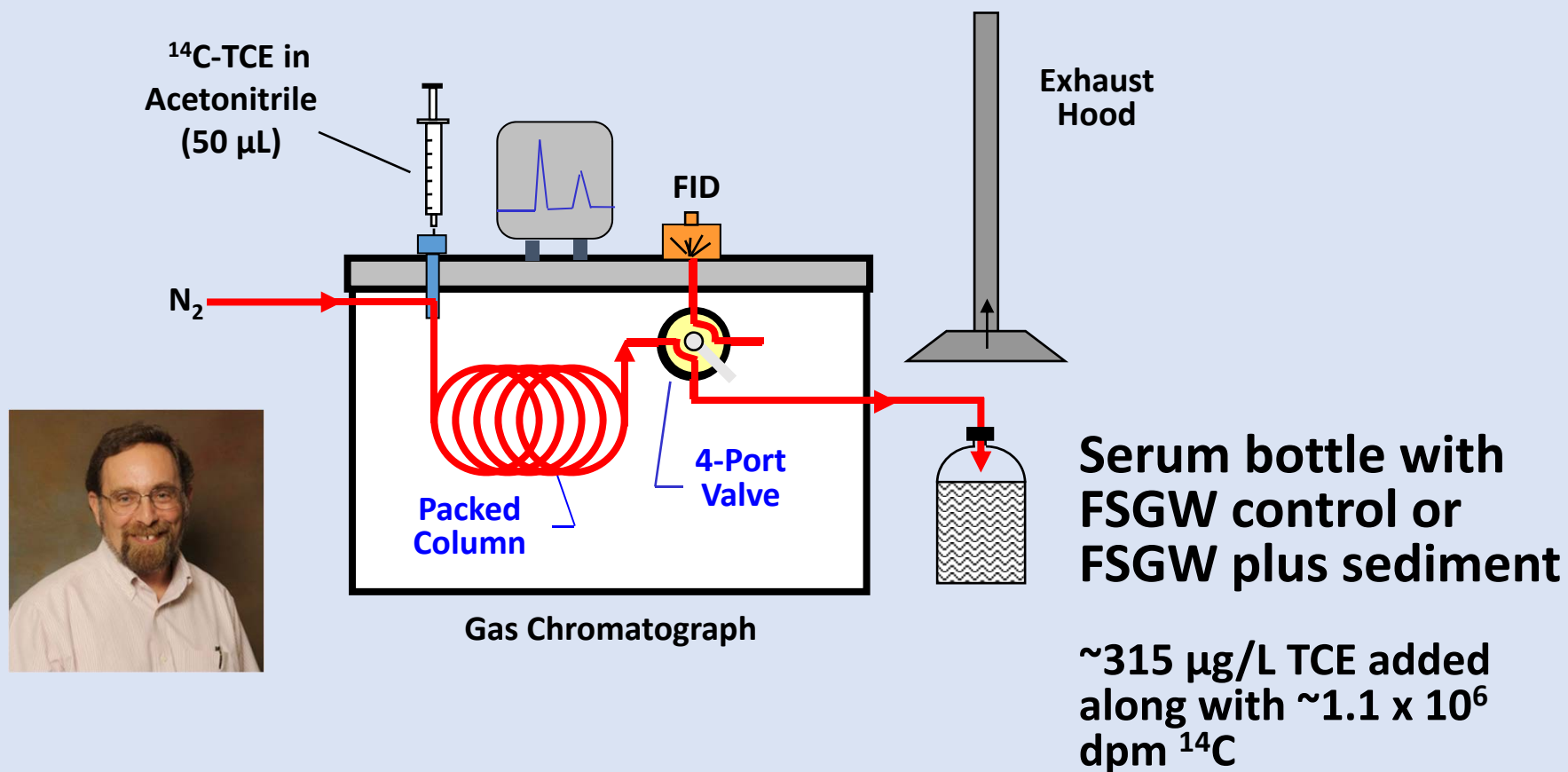


Microbial Insights Data



(3) Data from field or microcosm studies (conducted in or with actual contaminated site media) which directly demonstrate the occurrence of a particular natural attenuation process at the site and its ability to degrade the contaminants of concern (typically used to demonstrate biological degradation processes only).

Clemson Approach: Abiotic Degradation Using ^{14}C -TCE



Periodically, a small aliquot (3 mL) is taken from the microcosm containing 92 mL of liquid.

The pH of the aliquot is adjusted with base.

The TCE is purged out of the water with a stream of nitrogen.

Then the remaining ^{14}C activity is determined using liquid scintillation counting.

The accumulation of ^{14}C over time is assumed to be degradation products of the TCE.

A second small aliquot (3 mL) is taken from the microcosm containing 92 mL of liquid.

The pH of the aliquot is adjusted with **acid**.

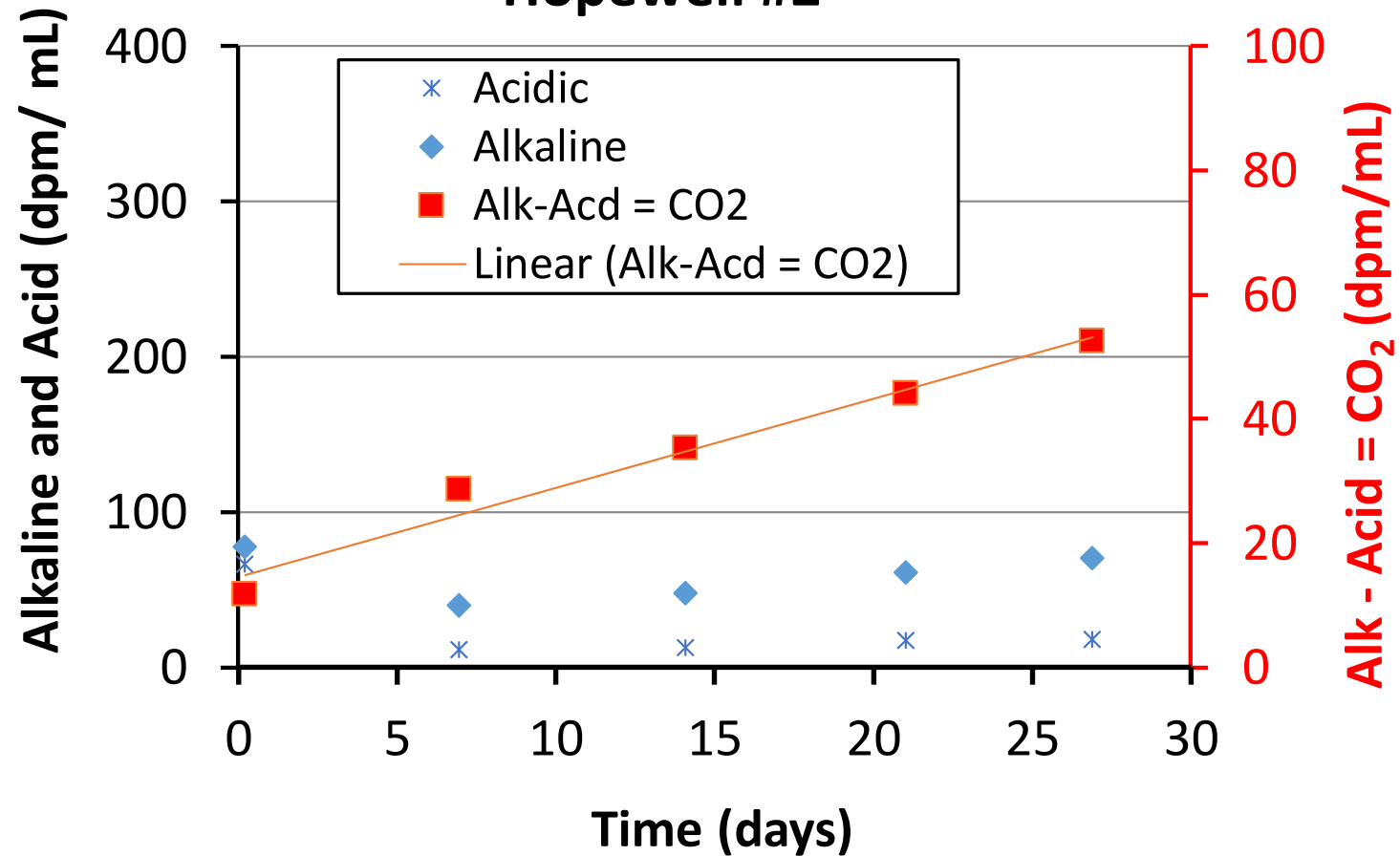
CO₂ is volatile from acidic by not from basic solutions.

The TCE is purged out of the water with a stream of nitrogen.

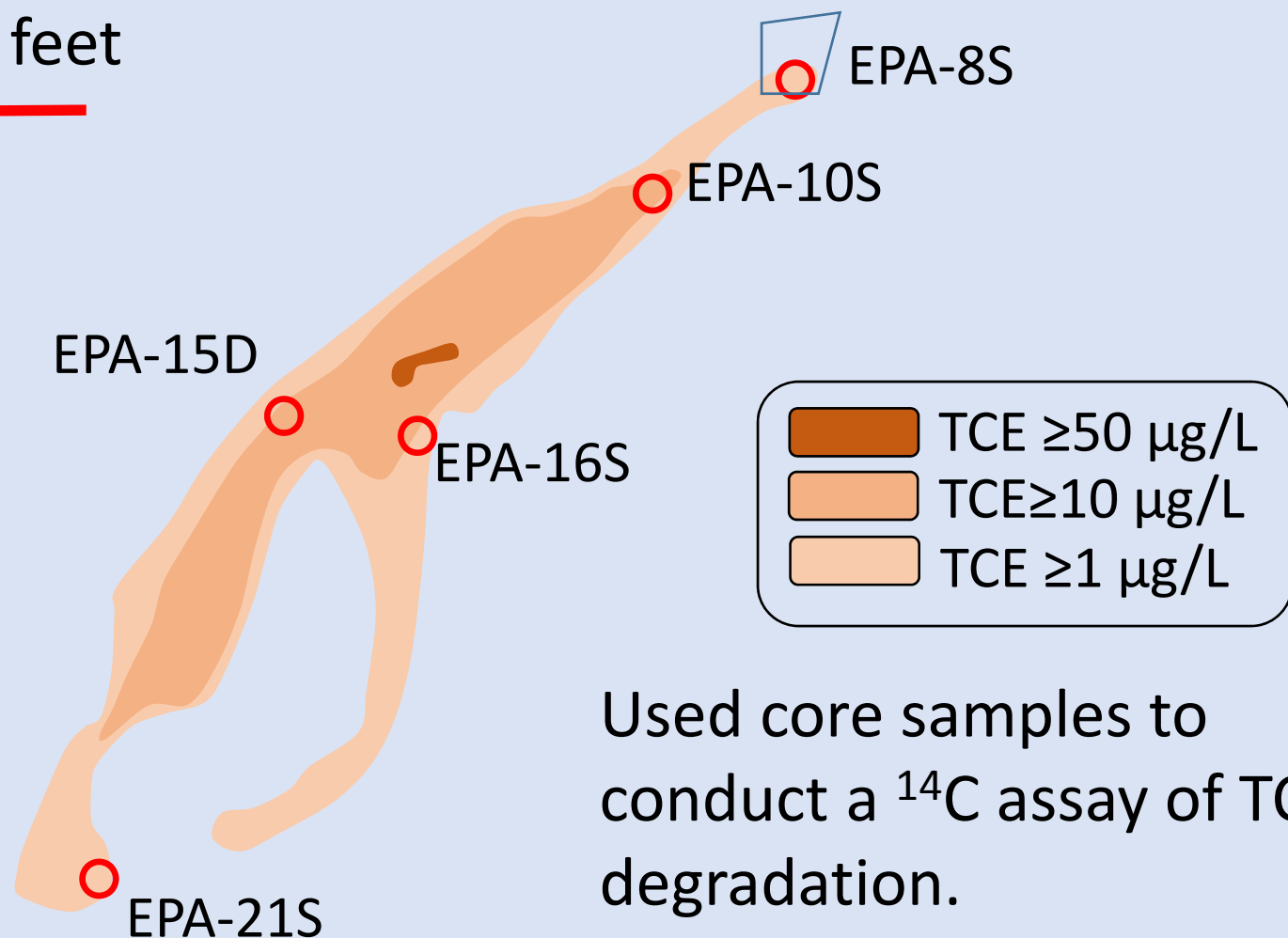
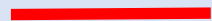
Then the remaining ¹⁴C activity is determined using liquid scintillation counting.

The difference in the ¹⁴C activity remaining after purging from acid and purging from base is ¹⁴C-CO₂ produced by abiotic degradation of ¹⁴C TCE.

Hopewell #2

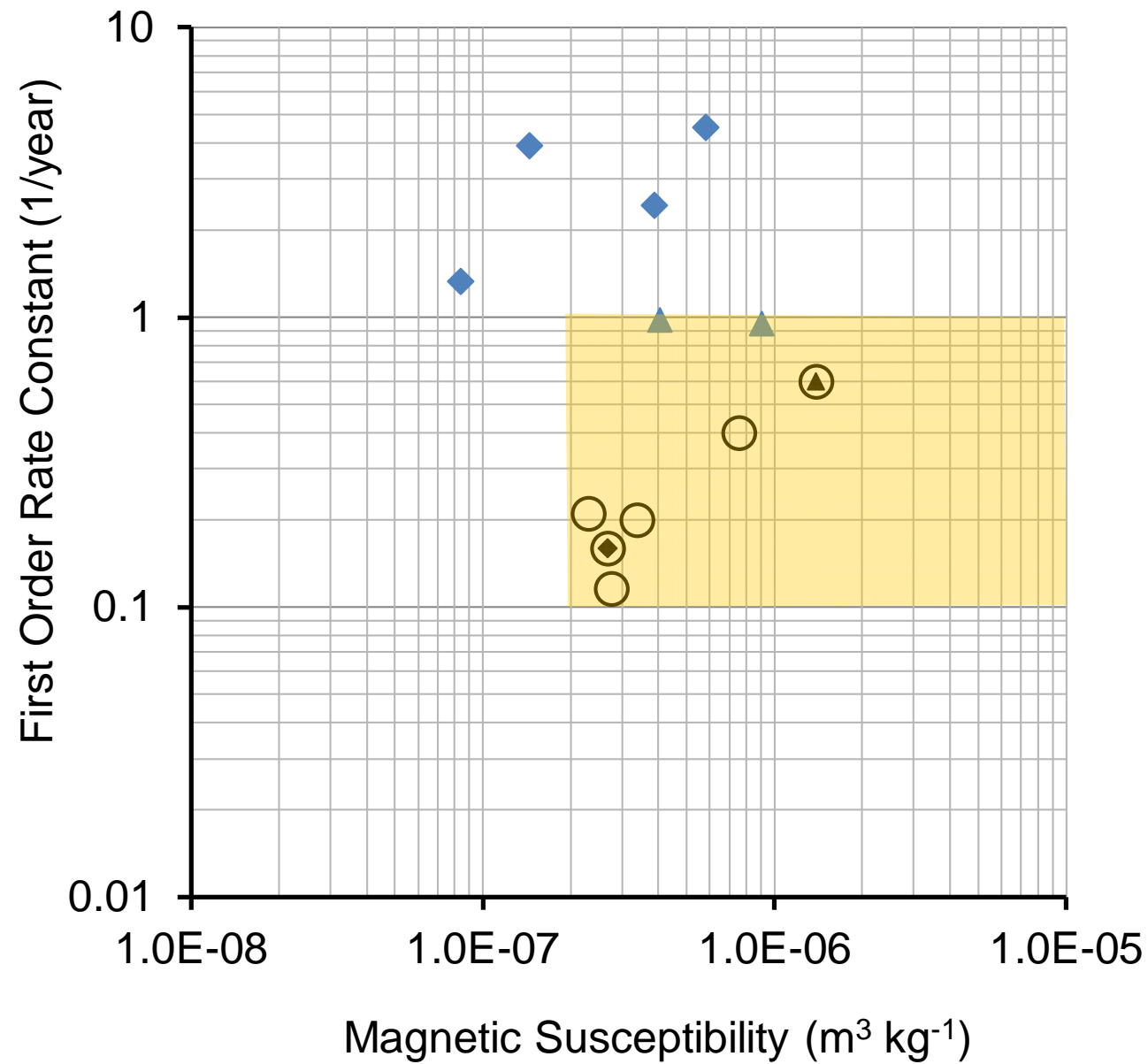


1000 feet



Used core samples to conduct a ^{14}C assay of TCE degradation.

**Hopewell Precision NPL Site,
Hopewell Junction, NY**



○ TCE at Field Scale

◆ TCE Hopewell Field Scale

▲ TCE TCAAP Field Scale

◆ TCE in Hopewell 14C microcosms

▲ TCE in TCAAP conventional microcosms

Summary:

Magnetic susceptibility in aquifer sediment is associated with bulk rate constants for TCE degradation in several groundwater plumes. Mass magnetic susceptibility in the range of $2\text{E-}07 \text{ m}^3/\text{kg}$ to $2\text{E-}06 \text{ m}^3/\text{kg}$ are associated with degradation rate constants from 0.1 to 1 per year.

Approximately 40% of samples submitted to Microbial Insights have mass magnetic susceptibility $\geq 2\text{E-}07 \text{ m}^3/\text{kg}$.

A microcosm study using ^{13}C -labelled TCE can determine rate constants for abiotic degradation of TCE to CO_2 in aquifer sediment.