Attenuation of a Large Dilute Plume after Source Treatment Protecting a Municipal Supply Well

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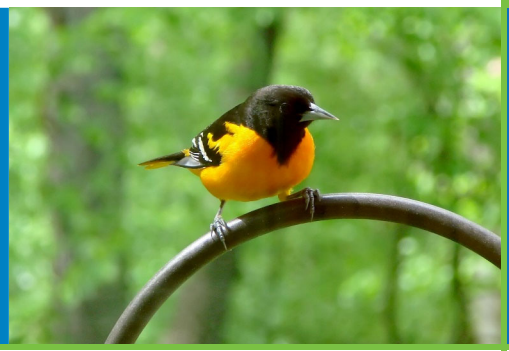

CDM Smith

Fifth International Symposium on Bioremediation and Sustainable Environmental Technologies

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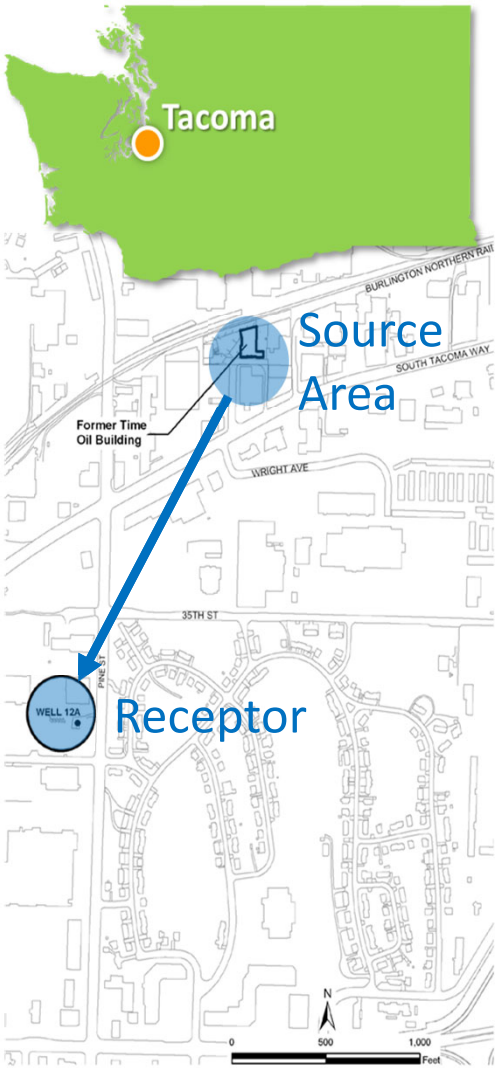
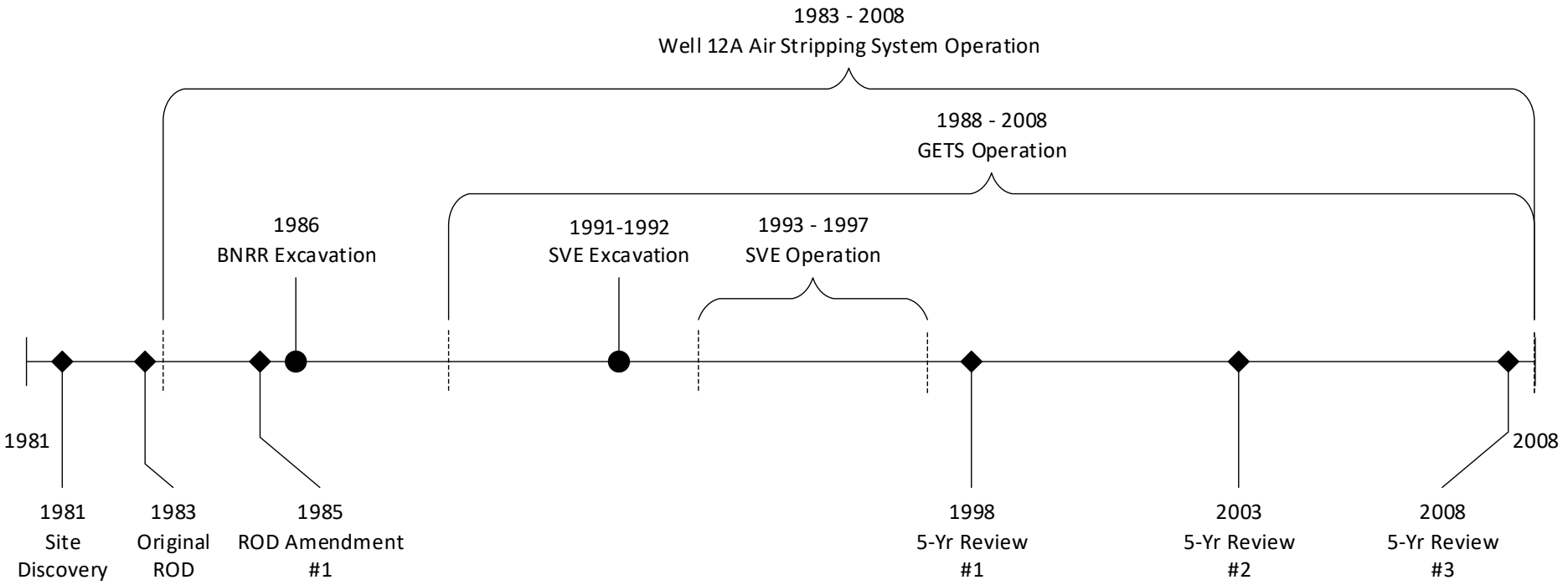
Baltimore, MD

Time Oil/Well 12A Superfund Site

- Paint and lacquer thinner manufacturing (1924-1964)
- Waste oil recycling (1924-1976)
- Oil canning (1976-1991)
- Six primary COCs in soil and groundwater
  - 1,1,2,2-Tetrachloroethane (PCA)
  - Tetrachloroethene (PCE)
  - Trichloroethene (TCE)
  - cis- and trans-1,2-dichloroethene (DCE)
  - Vinyl Chloride (VC)
- TCE contamination impacting the City of Tacoma municipal supply Well 12A

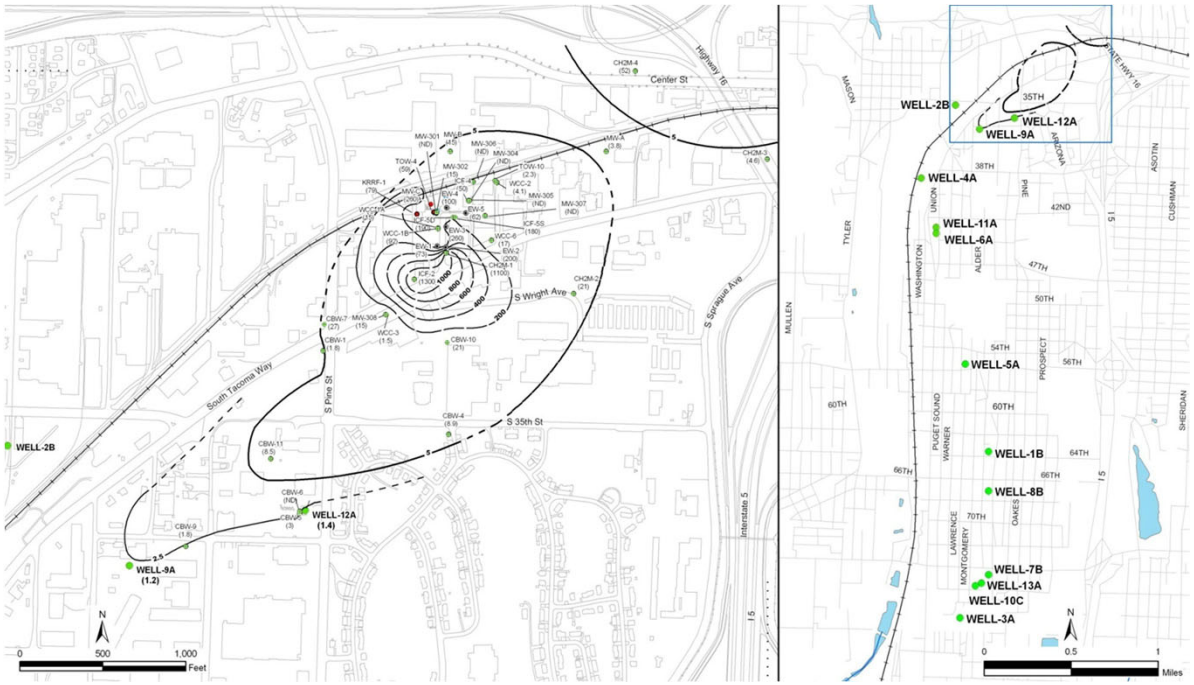


Regulatory and Remedial History, 1981-2008



2009 Focused Feasibility Study and ROD Amendment #2

- 2008 5-Year Review: Remedy not meeting objectives
- 2009 ROD Amendment #2 established a 90% mass discharge reduction goal for additional source treatment
- First known use of contaminant mass discharge reduction as a compliance goal in a ROD

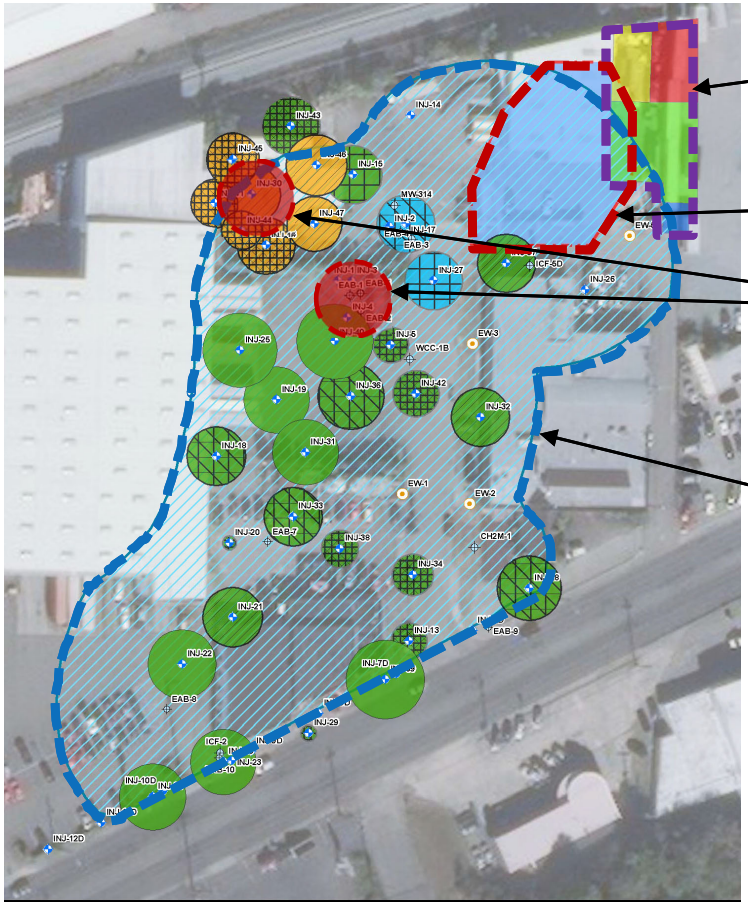


90% Mass Discharge Reduction Goal

- Transition from active treatment to long-term monitoring
- Remedy considered operational and functional
- Transfer O&M to the State of Washington
- Based on fate and transport modeling
  - Steady-state transport solution along the centerline of a plume (Domenico 1987)
  - TCE transport and attenuation from anaerobic source area to proposed compliance points in the downgradient aerobic plume
- Concluded 50-80% reduction in TCE concentrations discharging from the anaerobic source area needed to achieve the 5 µg/L MCL at Well 12A
- Significant uncertainty in this estimate due to site heterogeneities

Remediation Summary, 2011-2016

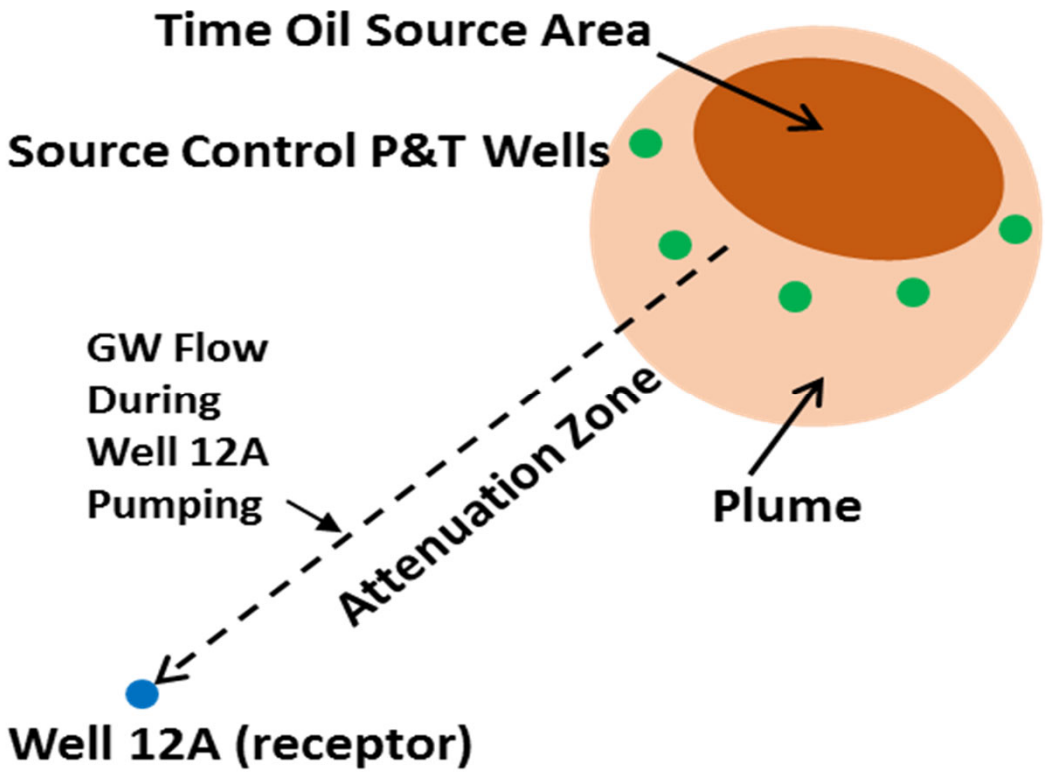
- 2,130 tons of contaminated shallow soil and filter cake removed
- Two USTs removed
- Building demolition
- ISTR of ~400 lbs. COCs and >22,000 lbs. non-target petroleum compounds
- Bioremediation of high-concentration GW plume
- Thermally enhanced bioremediation of two DNAPL areas



- Mass Discharge Reduction
  - 87.5% total COCs
  - 99% parent compounds
  - 67% degradation compounds
- Five of six COCs reduced to below MCLs in GETS influent
- Intent of 90% MD reduction RAO met
- GETS shutdown

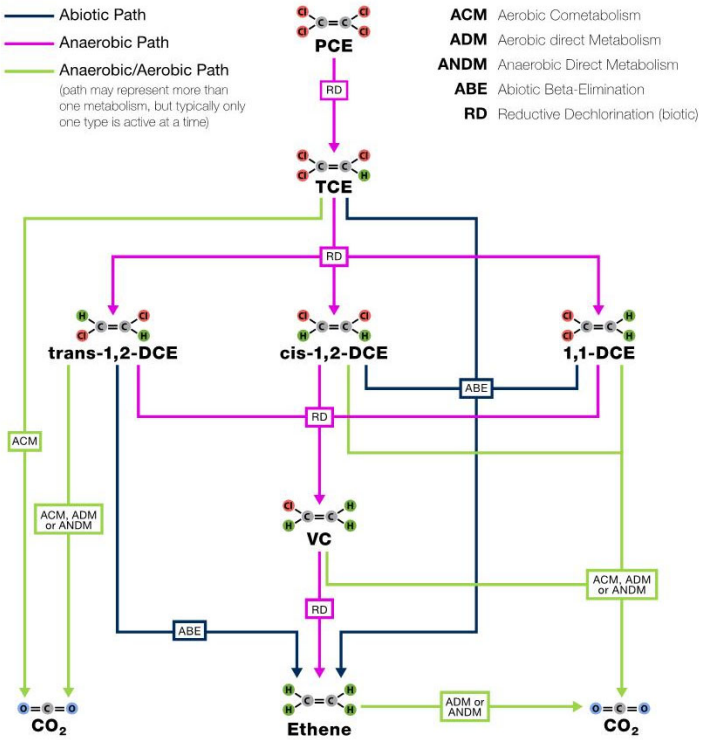
Post-RA Fate and Transport Modeling

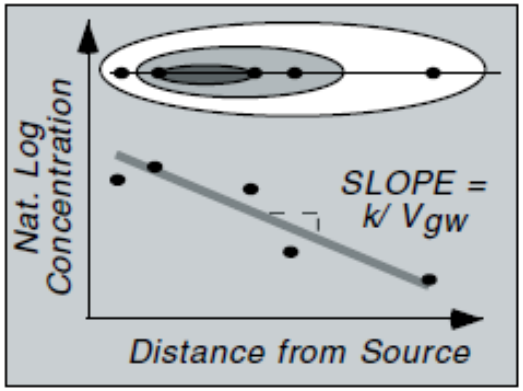
- Analytical modeling approach
- Evaluate the aquifer attenuation capacity between the source and supply well
- Determine if the on-site P&T system is required to protect the supply well

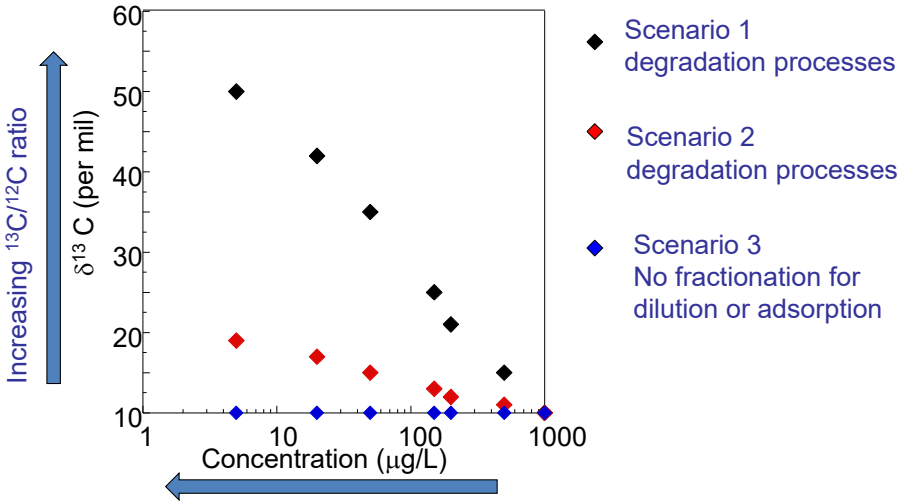


Evaluating the Potential for Biodegradation

Anaerobic and Aerobic Degradation Pathways

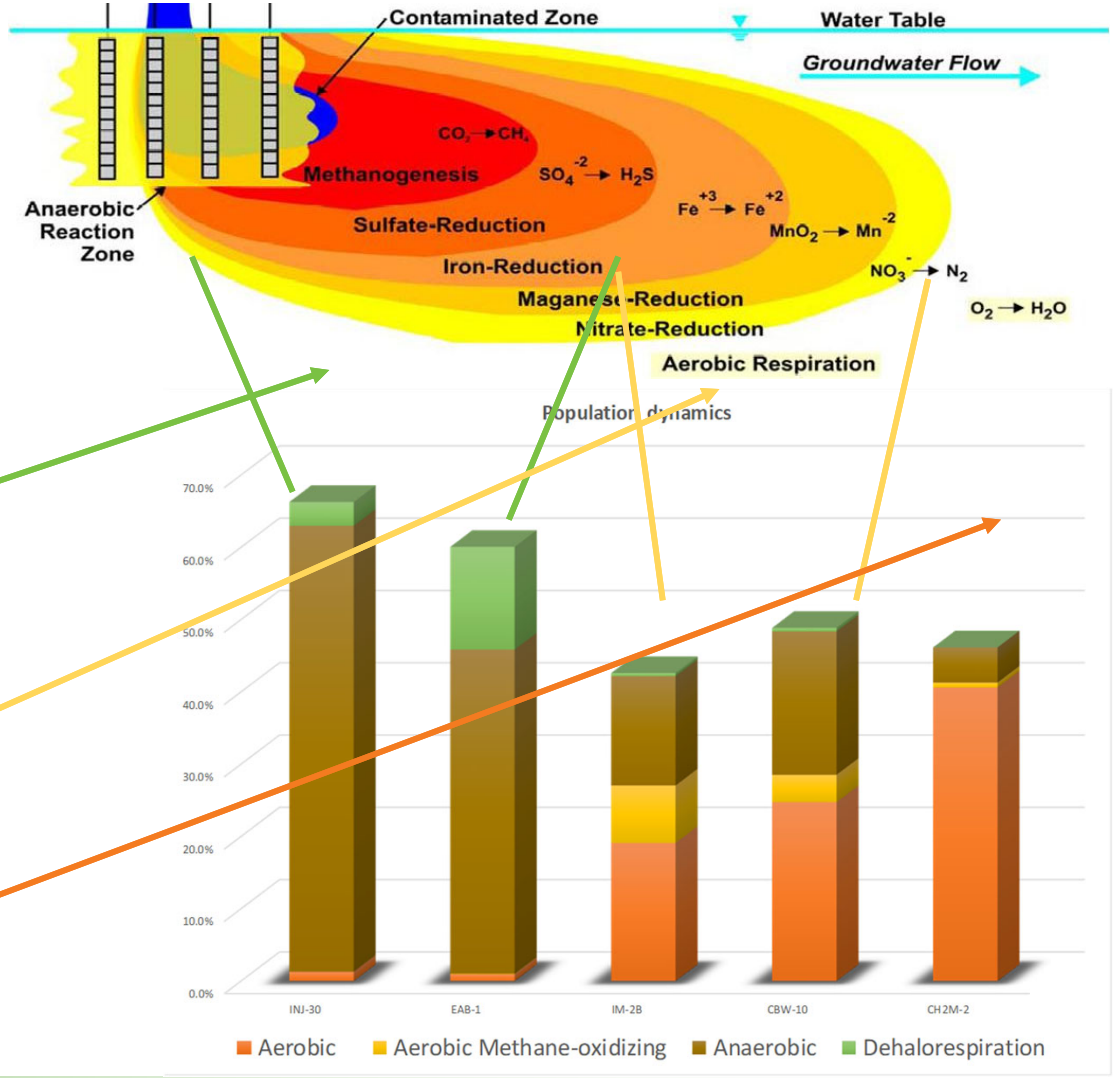






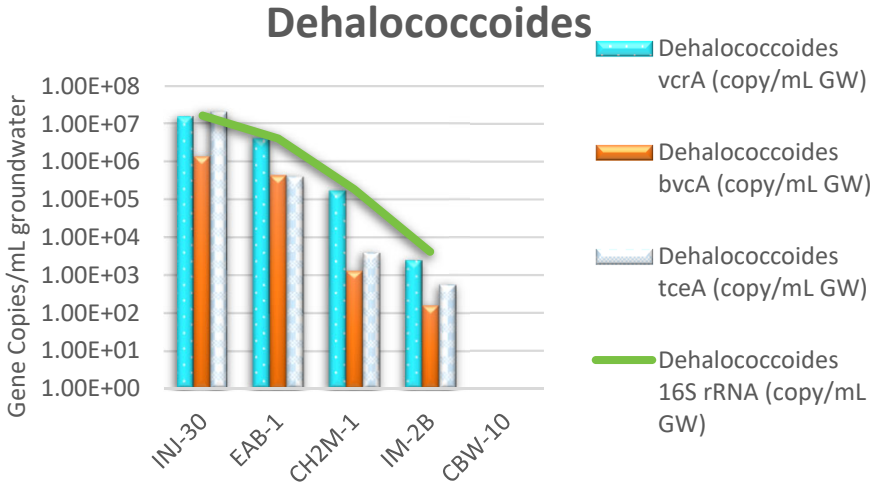
Biodegradation

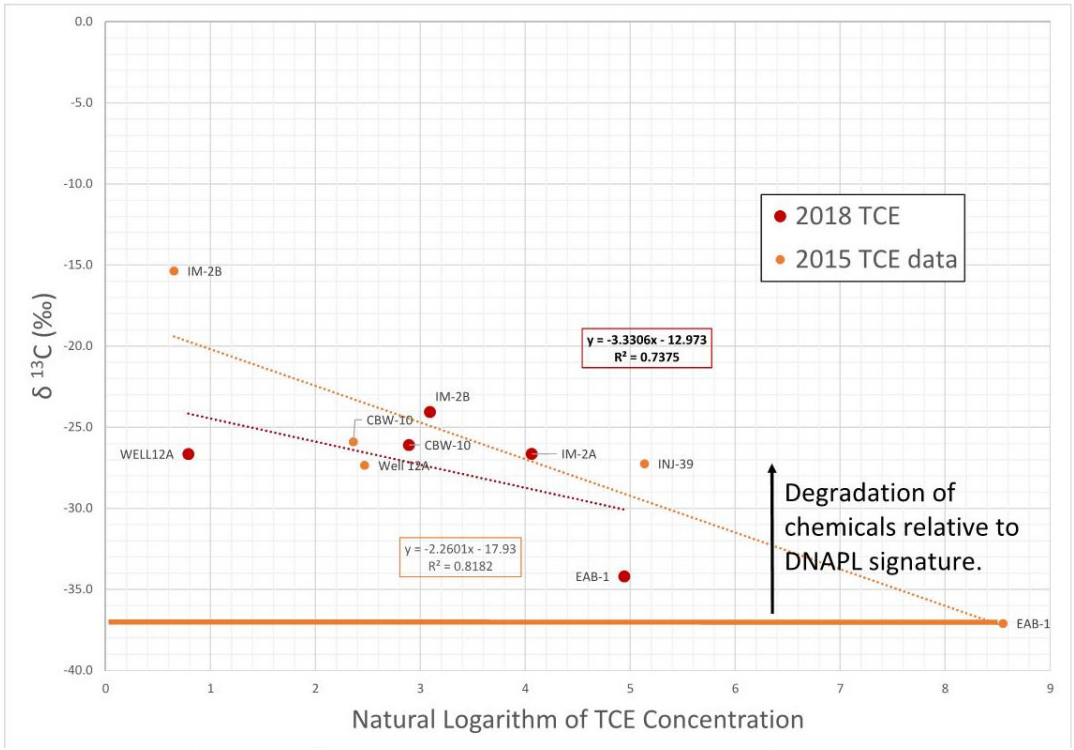
- Robust biodegradation observed throughout the EAB treatment and transition zones
  - Anaerobic EAB zone predominated by dehalorespiration
  - Transition zone had significant dehalorespiration and methane oxidation (cometabolism of VOCs)
  - Distal zone had no dehalorespiration and some methane oxidation



Compound-Specific Isotope Analysis Results

- 2015 Estimated TCE half-life: 22-31 days
- 2018 estimated TCE half life: 16-22 days

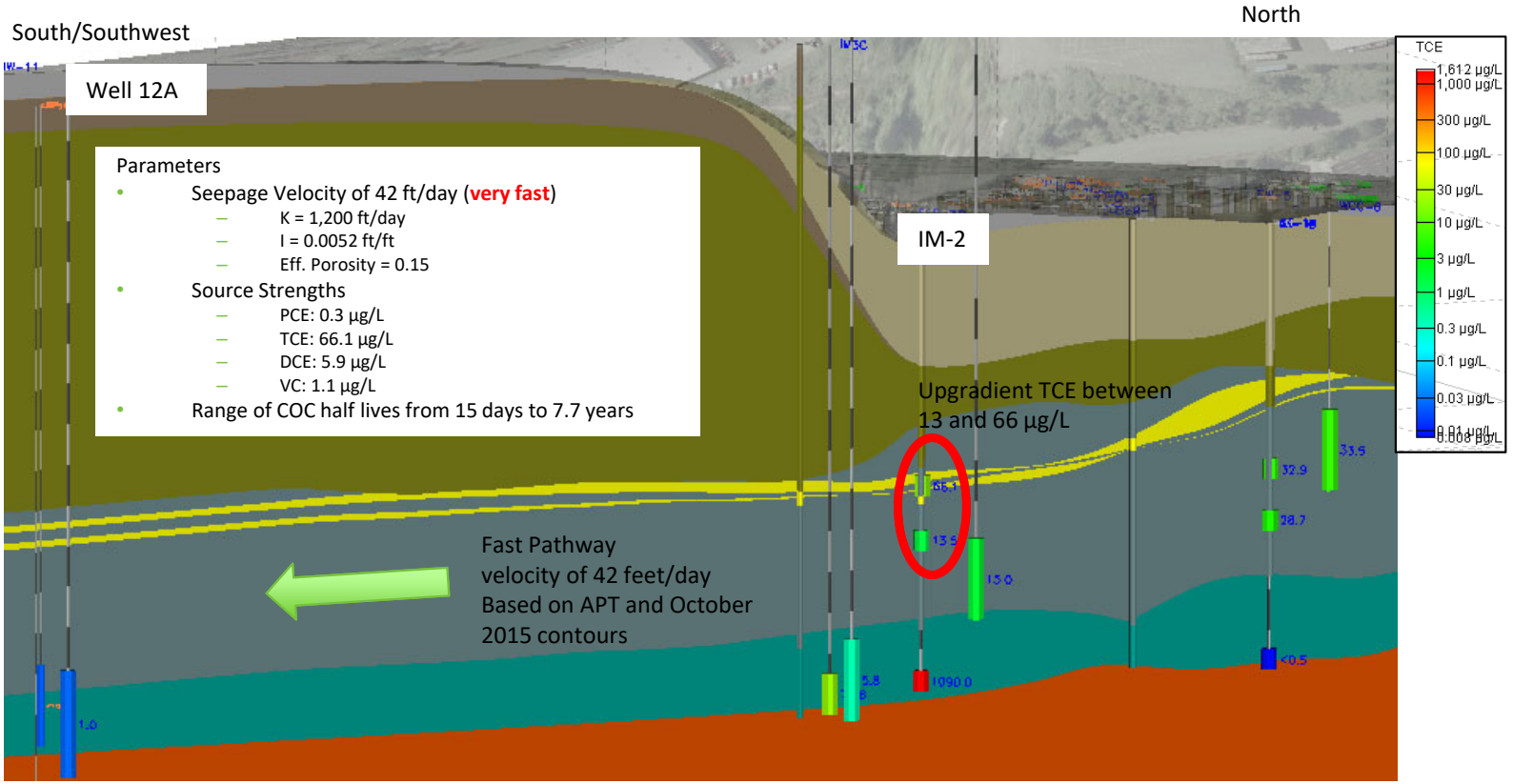




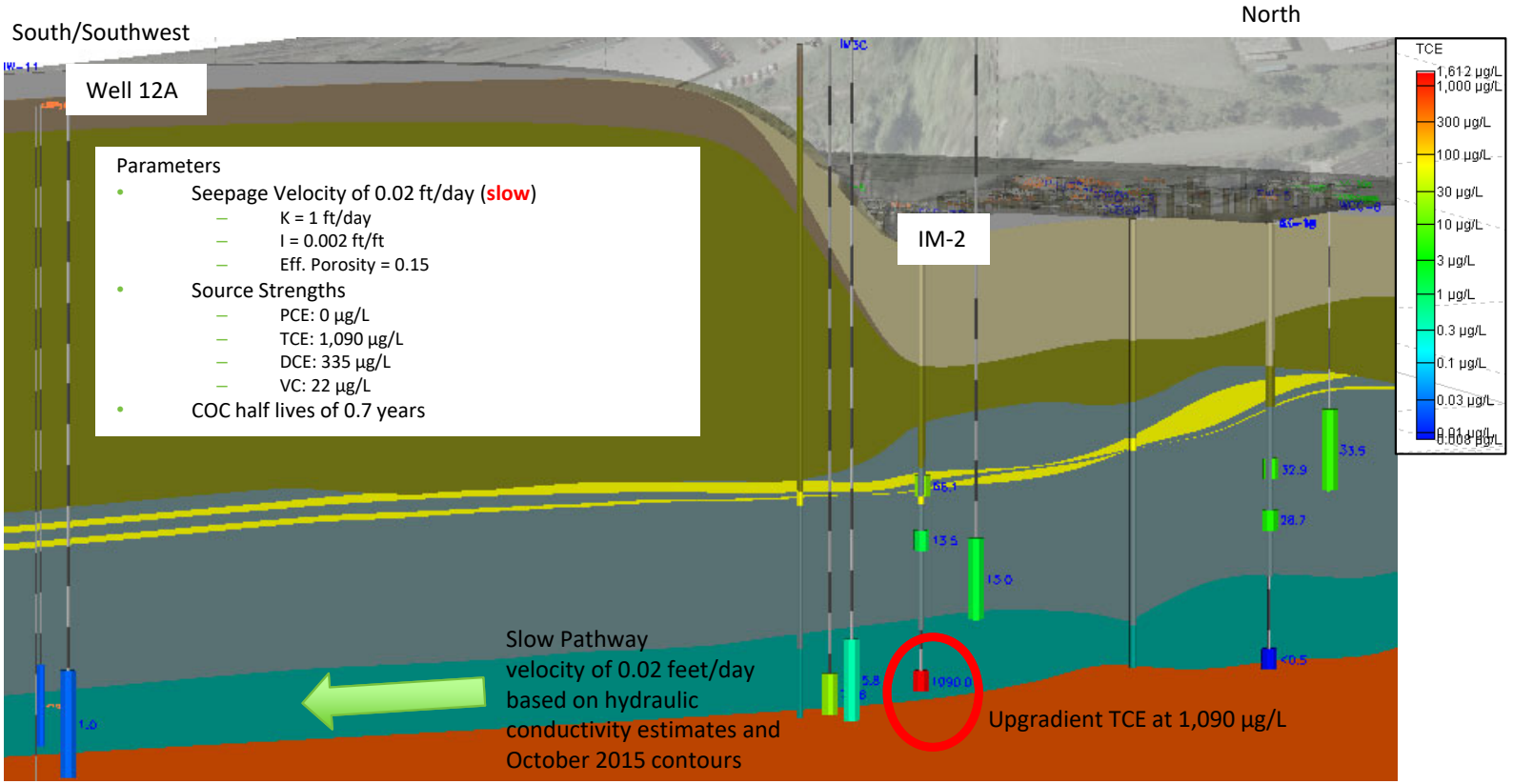
Fate and Transport Modeling Approach

- Identify COC transport pathways
- Estimate parameter values
- Use BIOCHLOR simulations to estimate COC concentrations along each pathway
- Use CRAFLUSH to estimate the mass flux attributable to vertical diffusion

Fast, Shallow Pathway



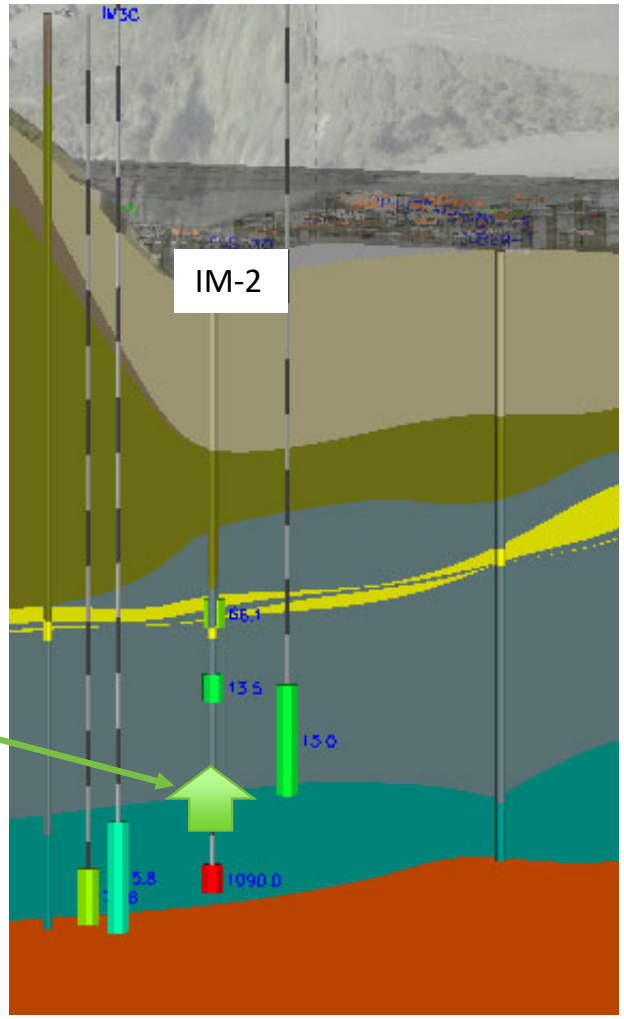
Slow, Deeper Pathway



Estimate Vertical Diffusion

- CRAFLUSH used to estimate COC contribution to the shallow pathway from the deeper pathway via vertical diffusion
- Diffused mass concentrations estimated as:
  - TCE: 5 µg/L
  - DCE: 1.5 µg/L
  - PCE and VC: negligible

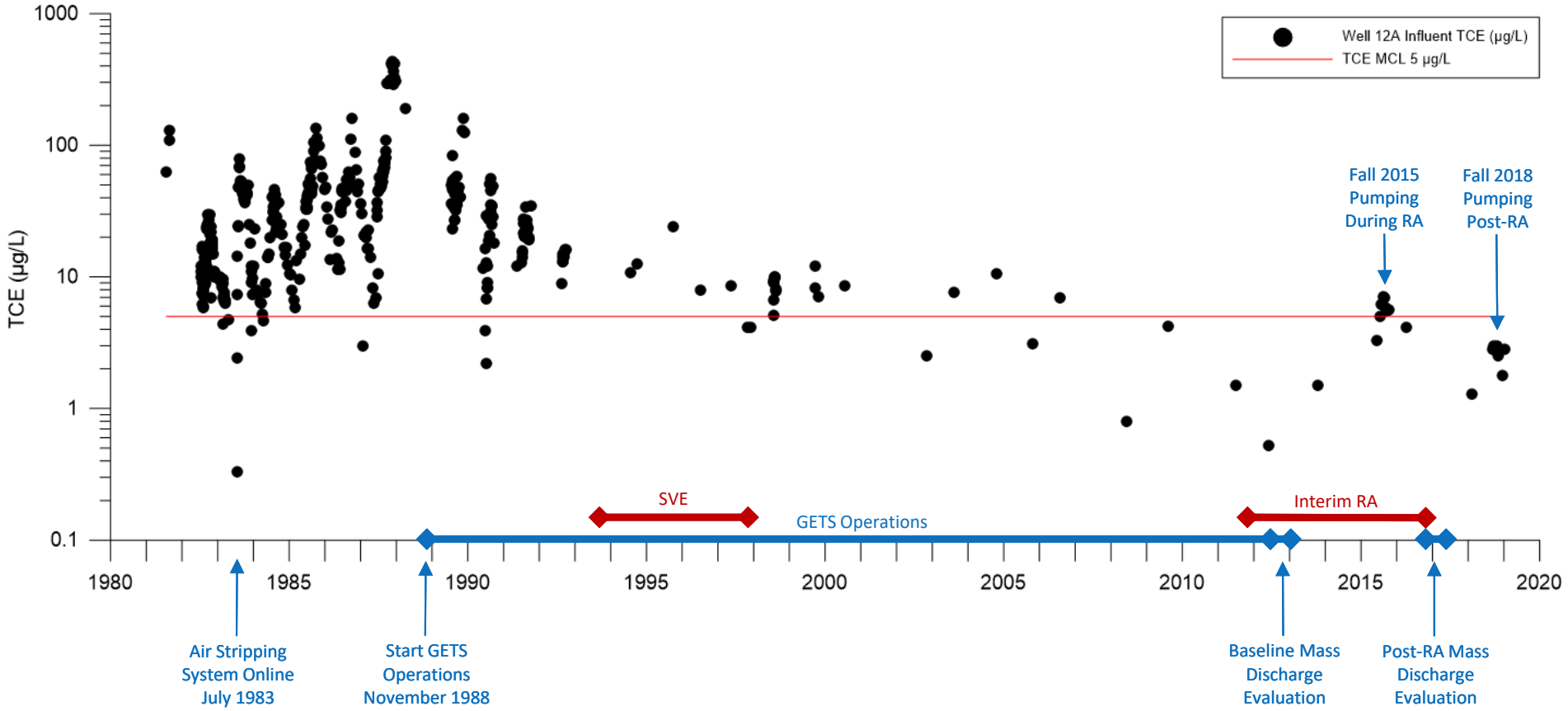
Vertical diffusion from low permeability layer to high permeability layer



Fate and Transport Modeling Results

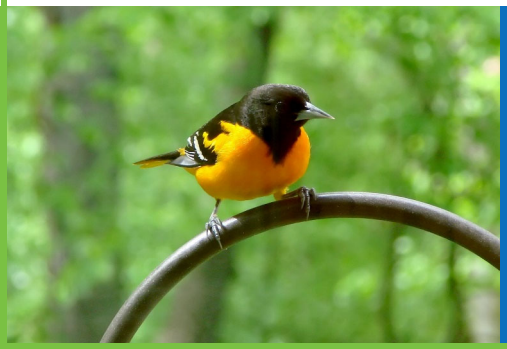
- Fast, Shallow Pathway
  - PCE, DCE, and VC below MCLs at Well 12A under all conditions simulated
  - TCE in the vicinity of Well 12A ranged from 3-13 µg/L, depending on decay rate
  - > 330 day half life = 'no decay'
  - Pumped concentrations expected to be further diluted
- Slow, Deeper Pathway
  - Attenuation capacity is estimated to be sufficient to prevent horizontal mass transport to Well 12A
  - Applies to all decay rates tested (7.7 years being the most conservative)
  - Transport along the pathway is limited by low permeability

Well 12A Influent TCE



Findings and Conclusions

- Mass discharge reduction was sufficient to achieve protection of Well 12A without active source control (i.e., GETS)
- BIOCHLOR modeling demonstrated
  - Degradation along the slower, deeper pathway attenuates the plume before reaching Well 12A
  - Due to the high seepage velocities measured in the faster, shallower pathway, degradation is not a significant attenuation factor
- Modeling results validated with analytical data collected during recent municipal wellfield operations
  - All post-RA results < MCLs
- Robust EAB treatment ongoing five years after full-scale injections
  - Robust populations of anaerobic reductive dehalogenating bacteria
  - Significant production of anaerobic reductive daughter products
  - CSIA – TCE half life is 20-30 days
- Remaining COCs in the distal plume are also attenuating, but at slower rates
- Relatively high populations of methane-oxidizing bacteria suggested aerobic cometabolism may be significant in the distal plume



Questions?

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