

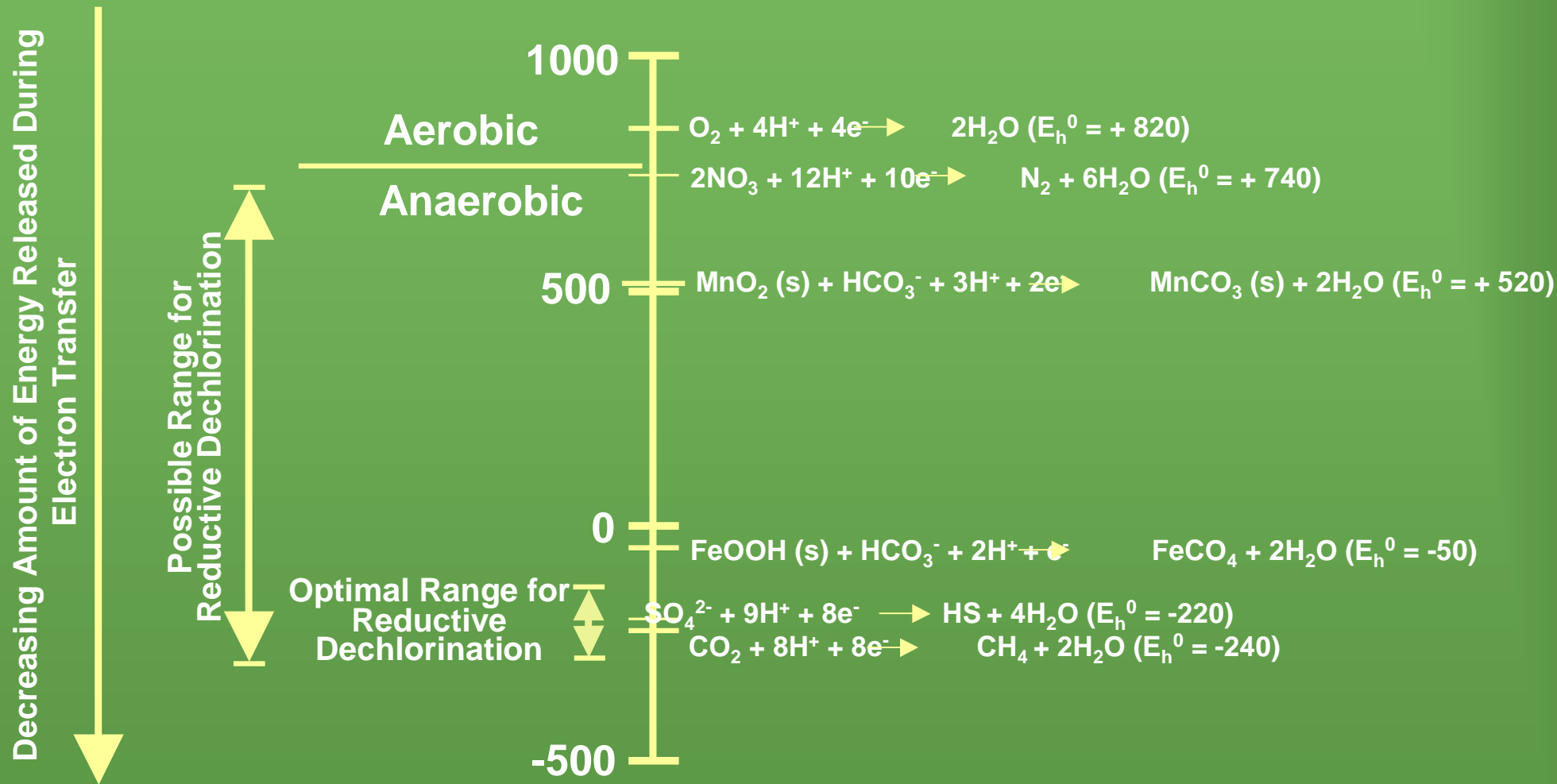
Bioremediation of Chlorinated Solvents Under Aerobic Conditions: Opportunities to Improve Remediation Effectiveness

**Michael Saul
CL Solutions, LLC**

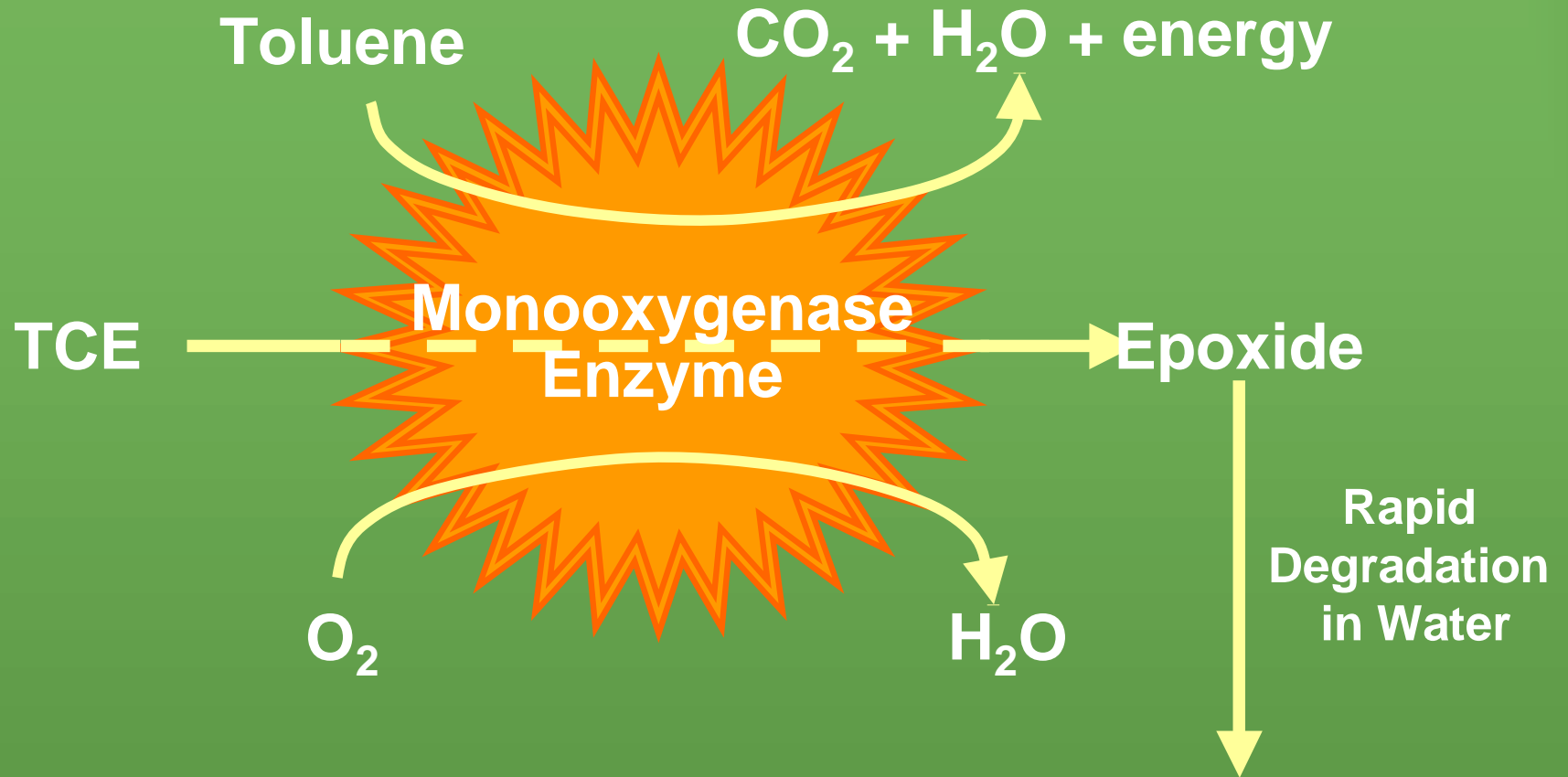
**Presentation to the Southeastern In-Situ Soil
and Groundwater Remediation Conference**

February 26-27, 2008

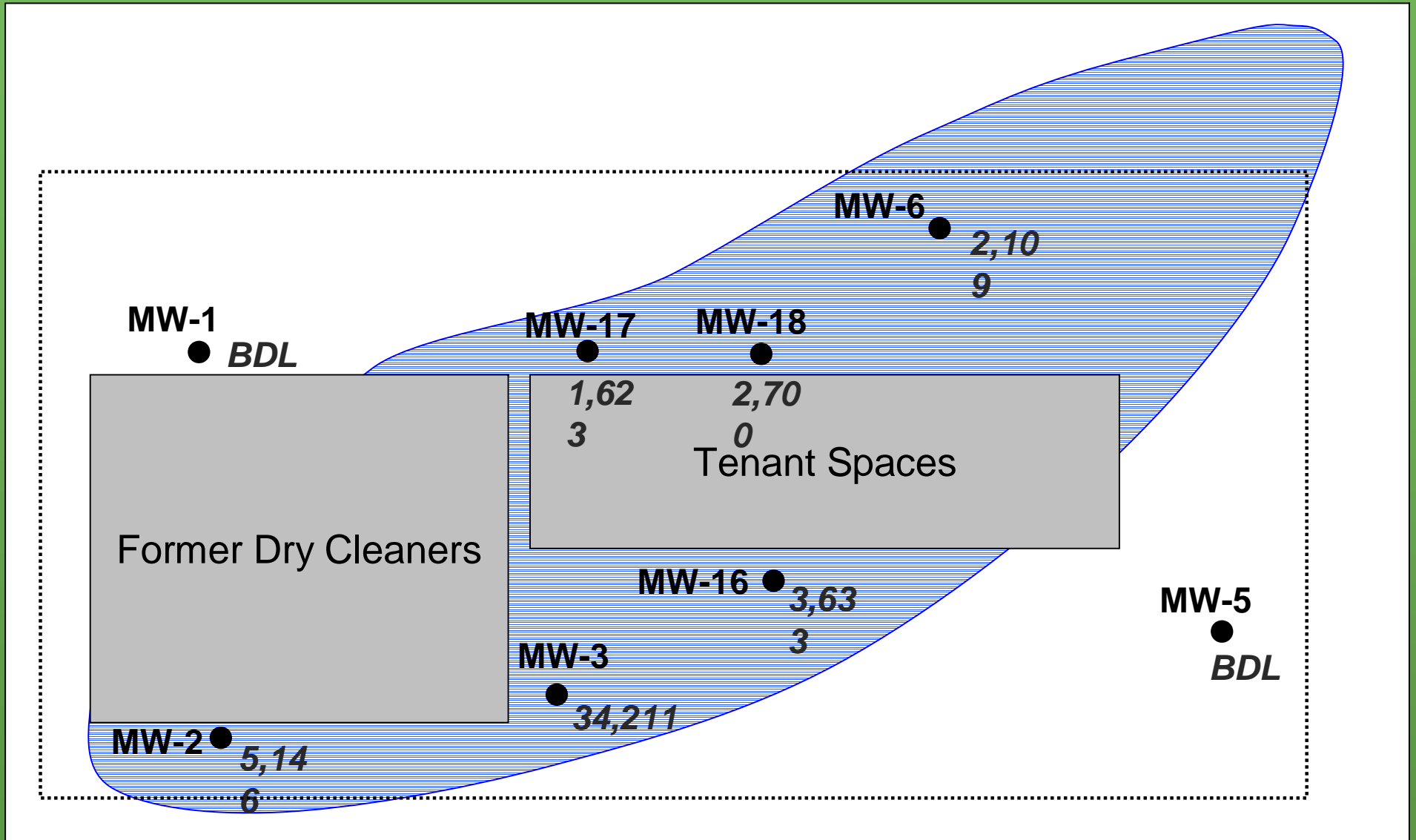
Eh Range and Bioremediation



Aerobic cometabolism



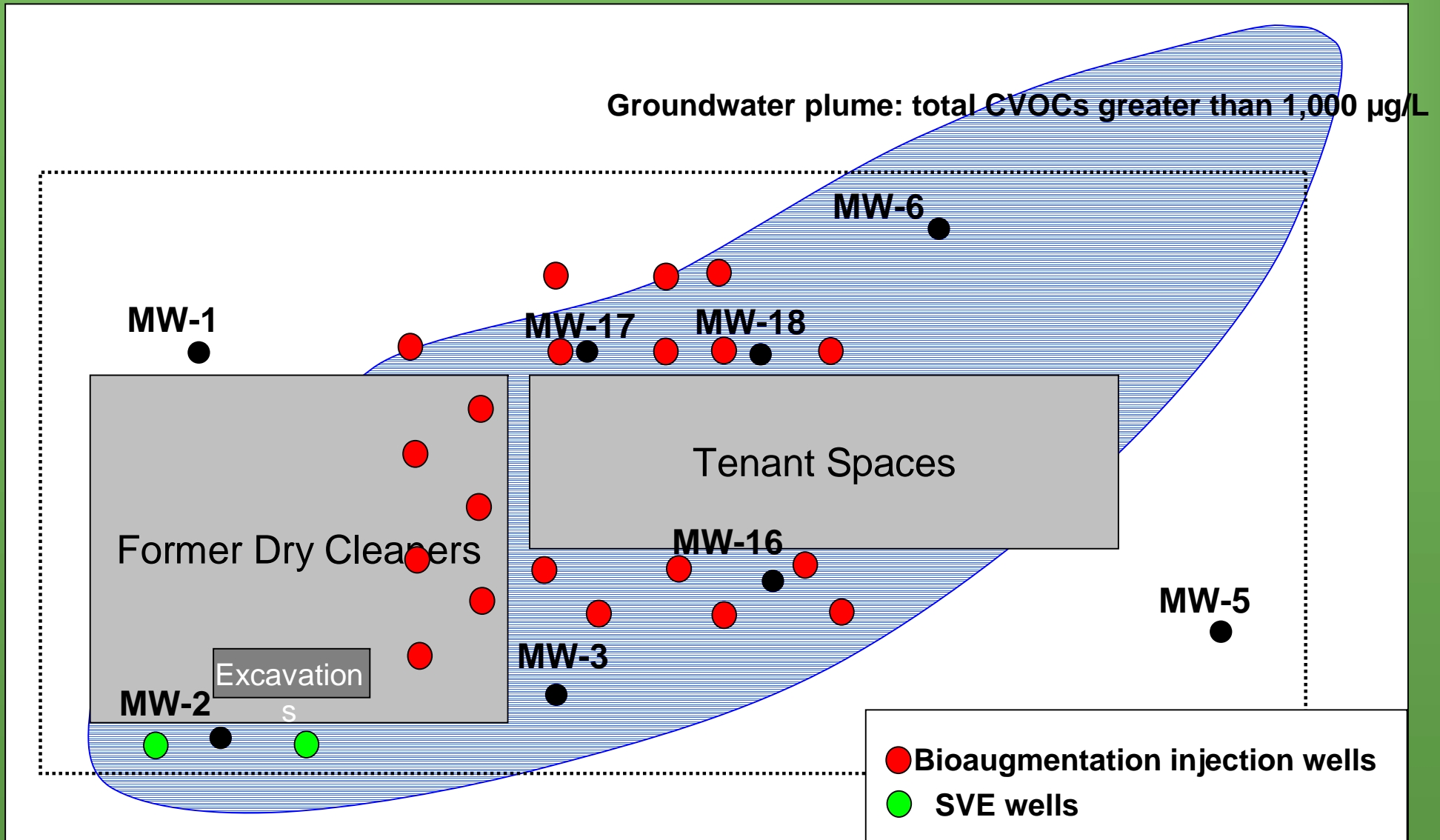
Total CVOCs Prior to Remediation



Remediation History

- Soil excavation August 2000 - 30 yd³ soil removed
- Soil vapor extraction August to December 2000
- Second source area soil excavation May 2003 – 42 yd³ soil removed
- Source potassium permanganate injection into the second excavation – 3 injections in November and December 2002, and January 2003
- Potassium permanganate injected into 6 interior injection points in April 2003
- CL-Out bioaugmentation June, August and October 2003
- ORC socks placed in MW-2 and MW-3 to maintain

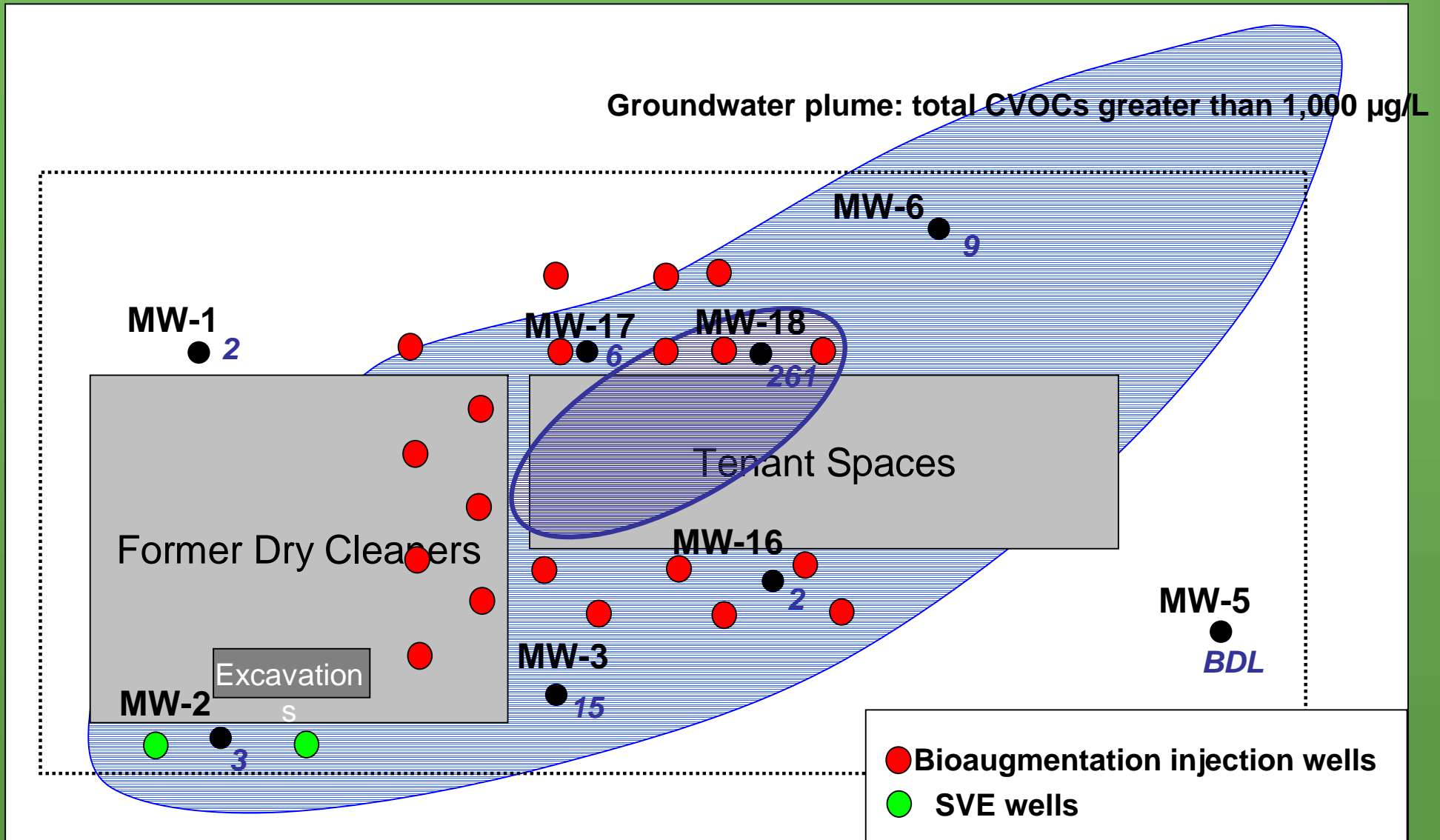
Treatment Area Locations



Bioaugmentation Procedure

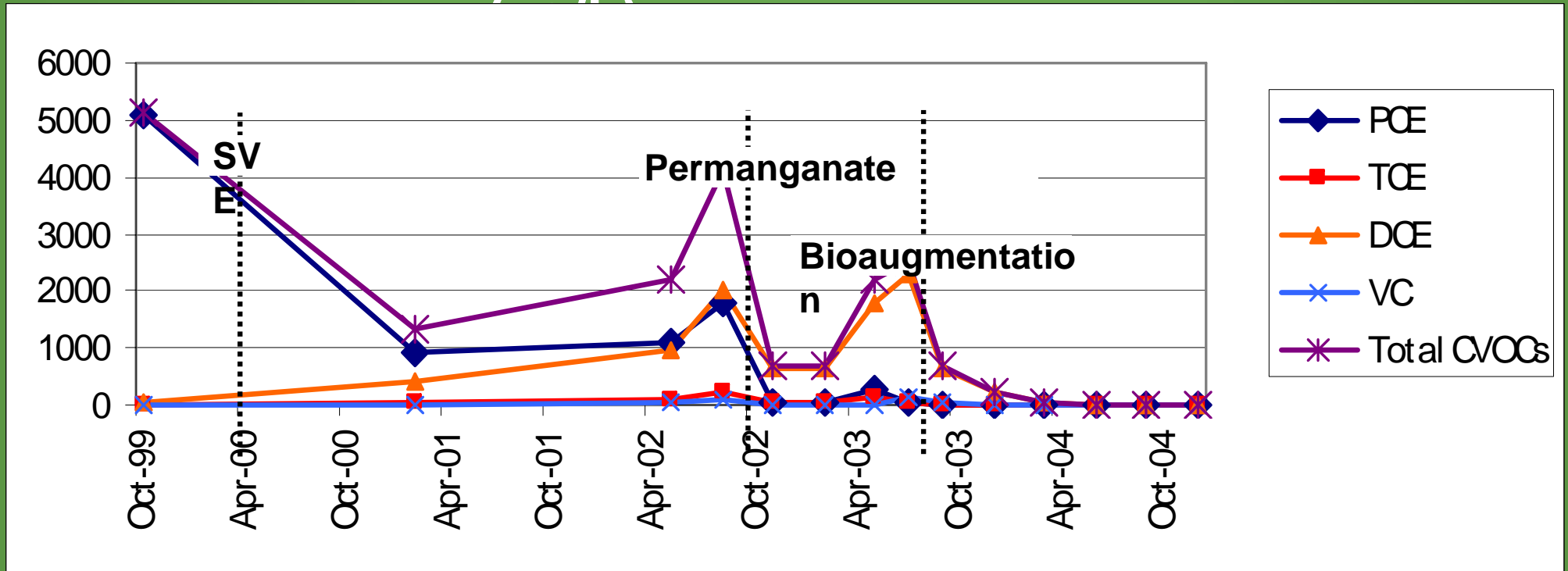
- Inoculated 20 injection wells downgradient
 - ✓ 25 ft spacing
 - ✓ Approximately 10,000 square feet
- Injected the following with each inoculation
 - ✓ 110 gallons of microbial slurry
 - ✓ 100 pounds of dextrose

Post-Remediation Plume Map



Source Area Concentrations Trend

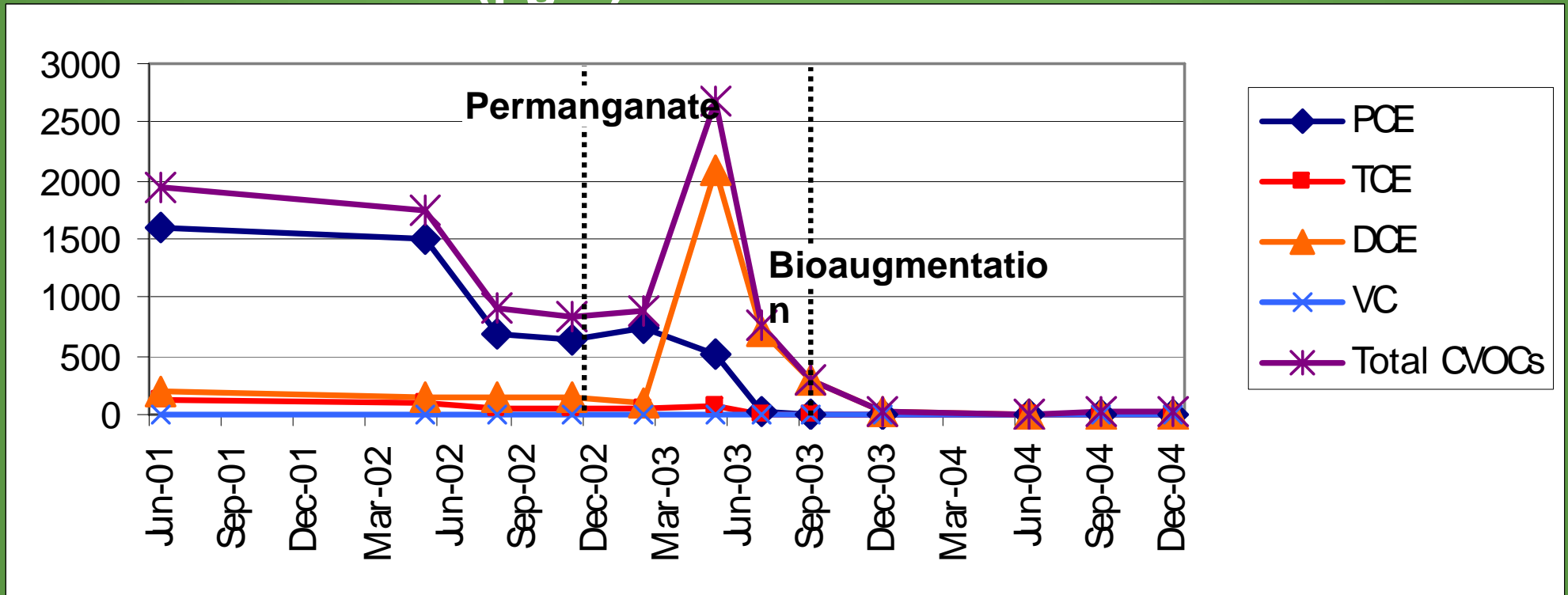
Contaminant concentrations in MW-2



- Post SVE equal concentrations of PCE and DCE
- Transformation of PCE to DCE after permanganate treatment
- Bioremediation completes transformation of DCE without production of vinyl chloride

Source Area Concentrations Trend

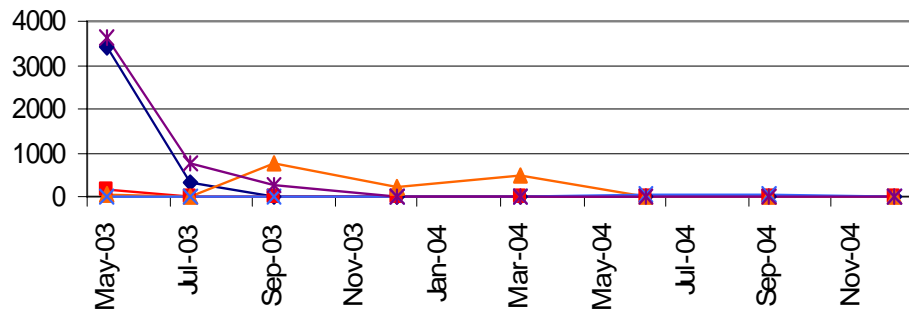
Contaminant concentrations in MW-3 ($\mu\text{g/L}$)



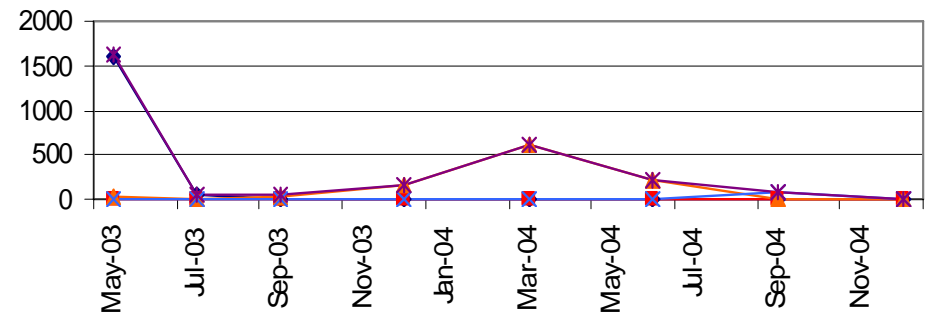
- Transformation of PCE to DCE after permanganate treatment
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Plume Treatment Results

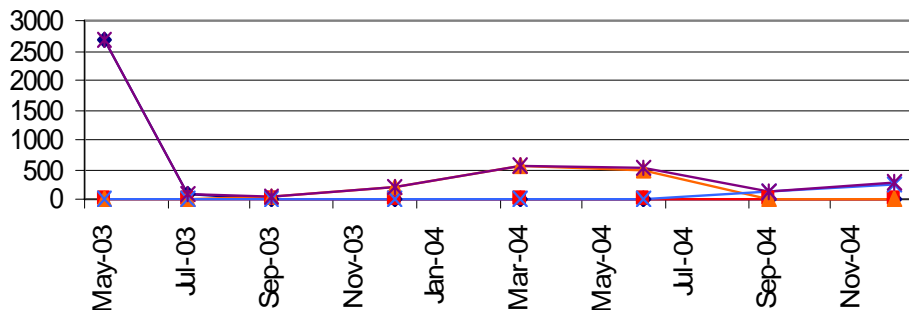
MW-16



MW-17

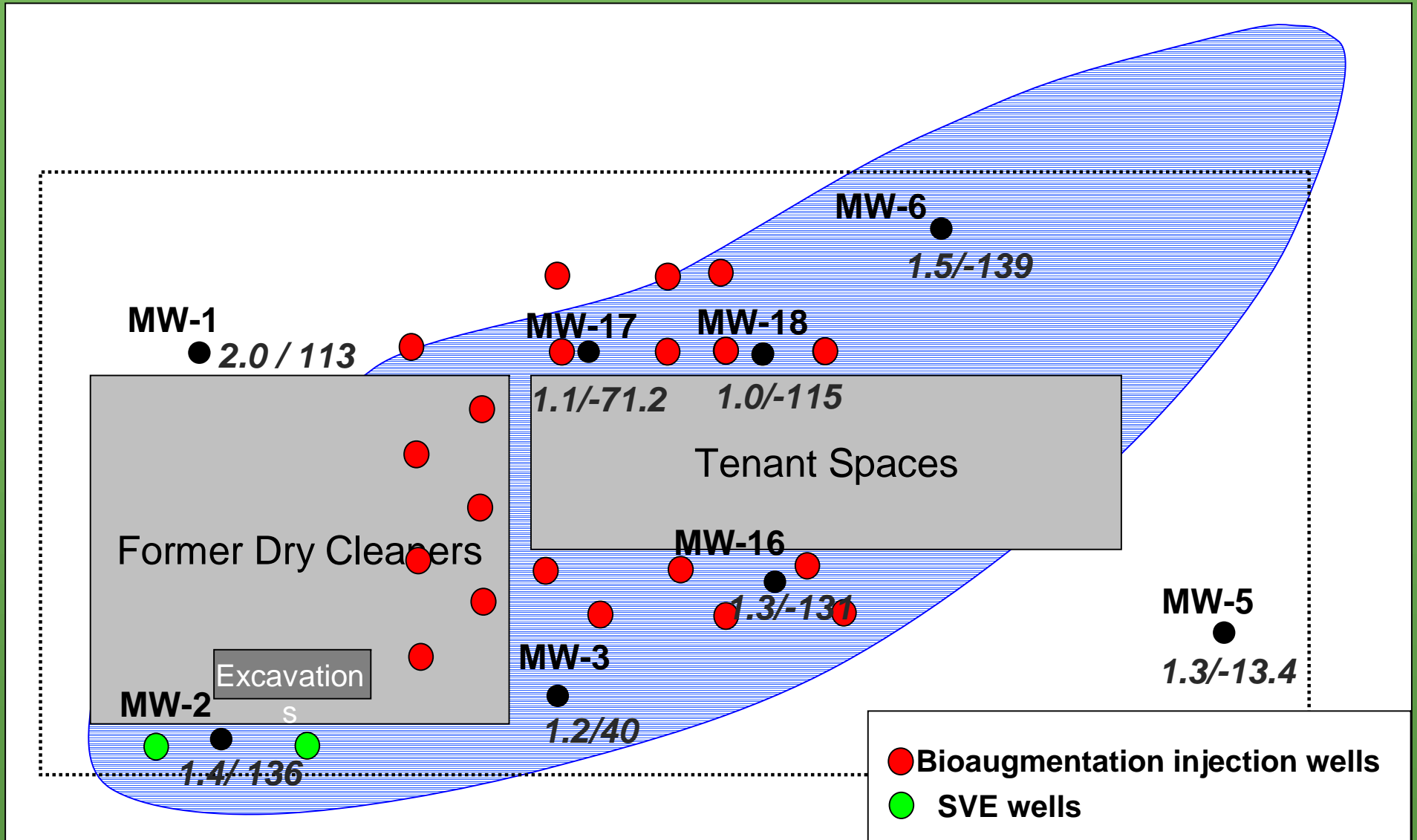


MW-18

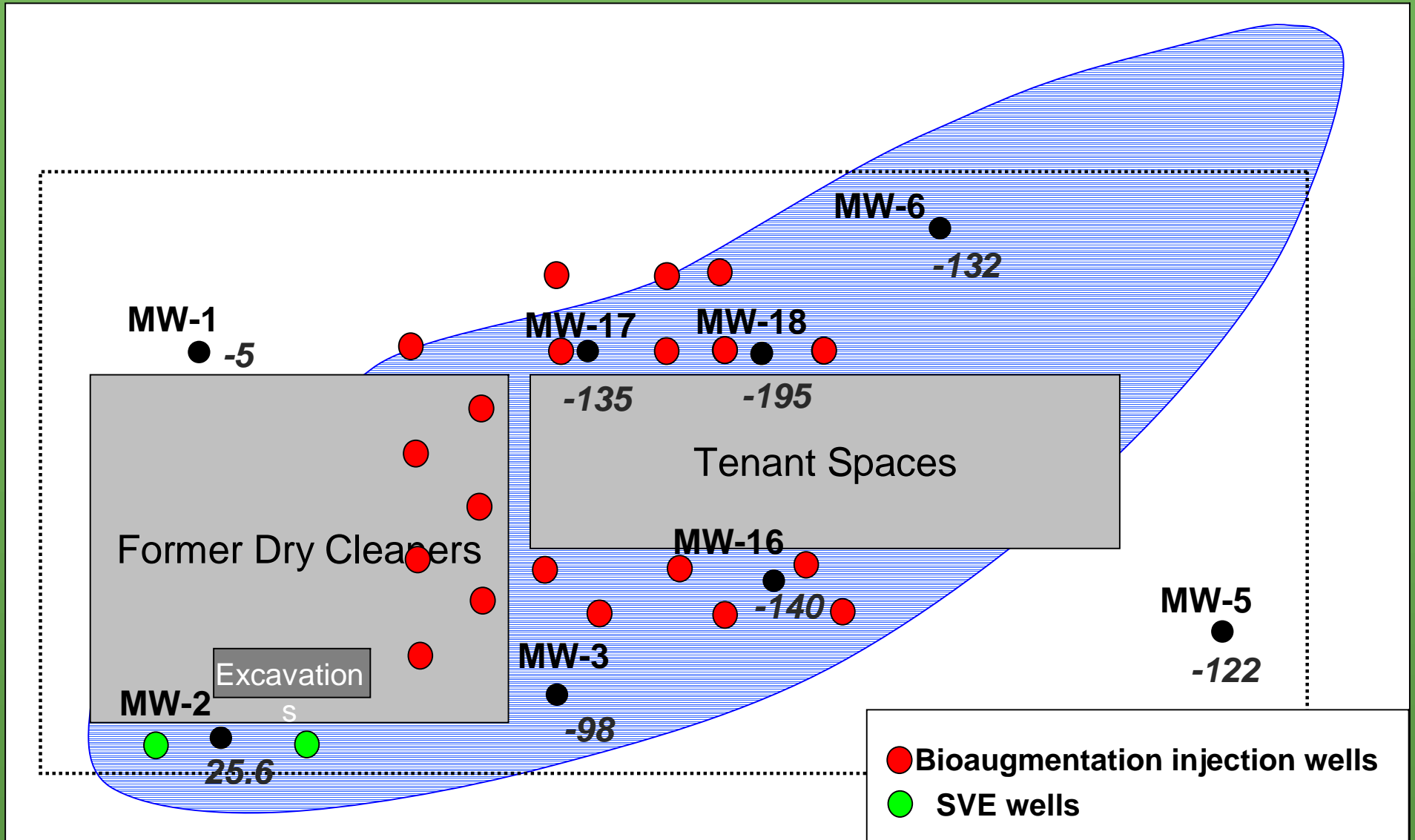


- PCE removal without TCE formation
- Maximum DCE accumulation < 1/3 original concentration
- Lag time in DCE accumulation
- Increase in DCE suggests reductive dechlorination
- Transformation of DCE by dechlorination or oxidation

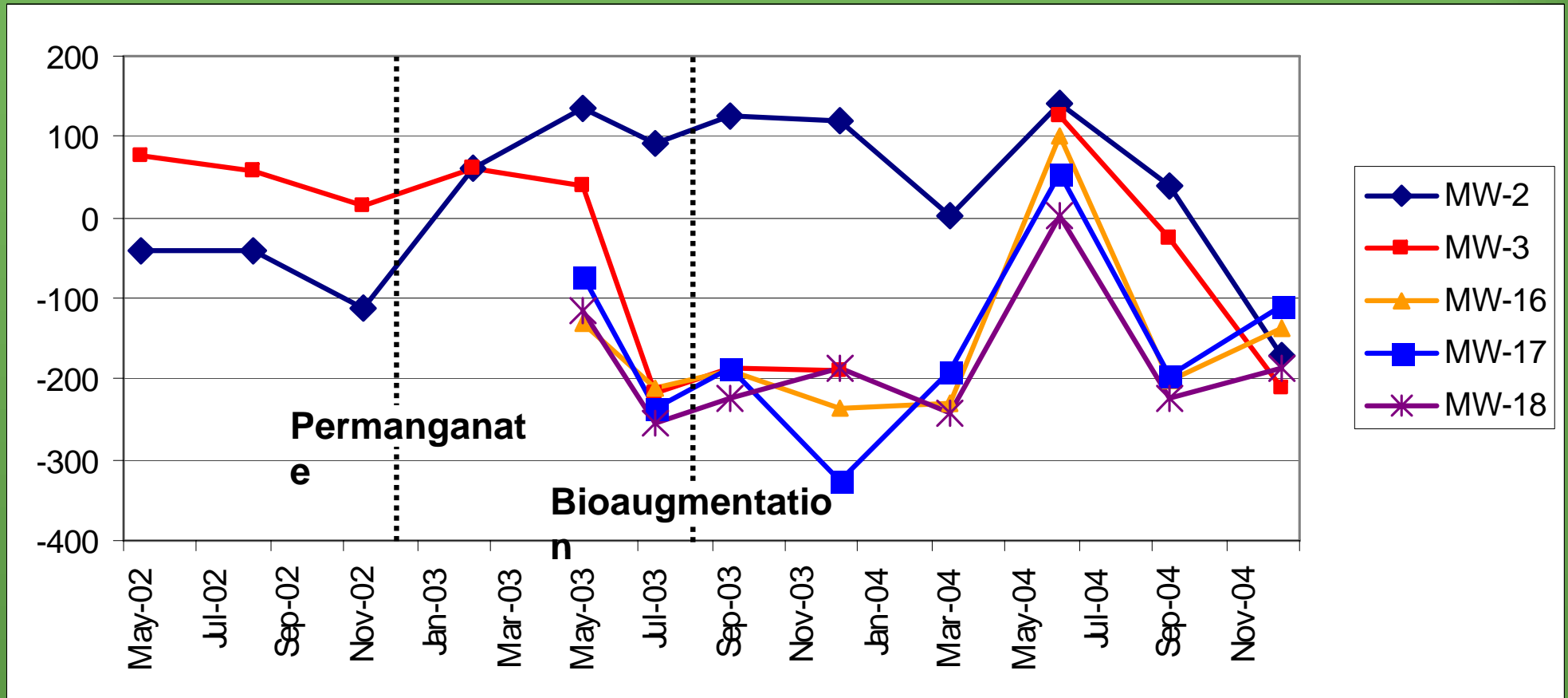
DO/Eh Before Bioaugmentation



Eh After Bioaugmentation

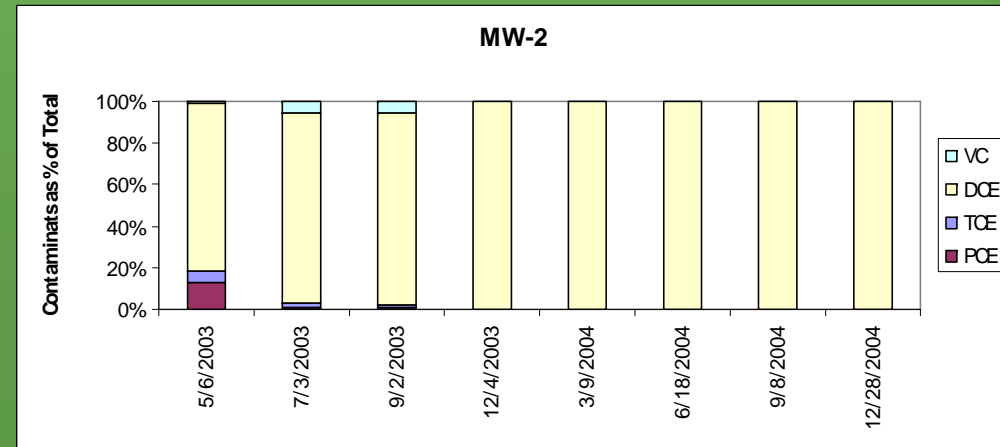
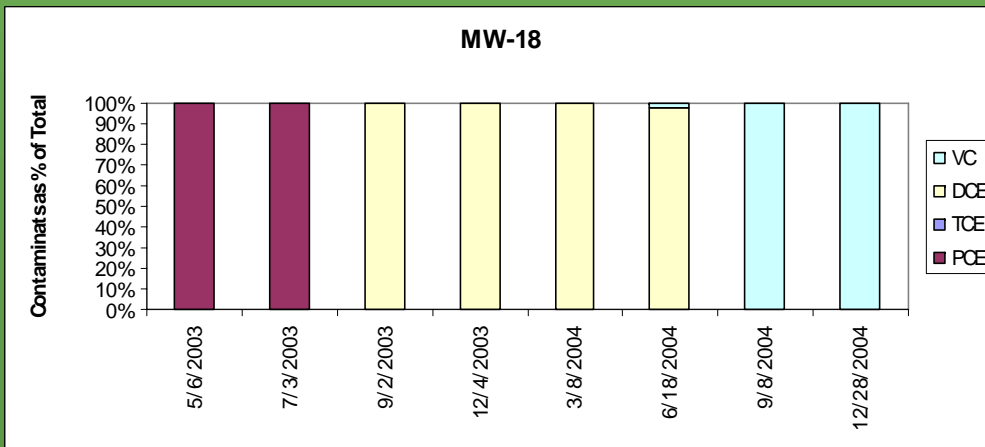
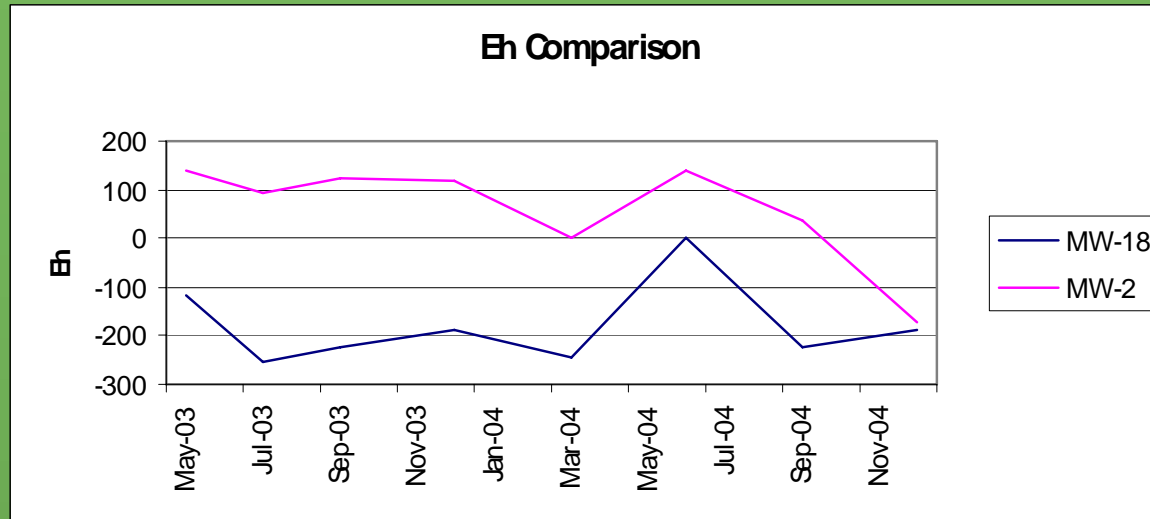


Eh Trends During Remediation

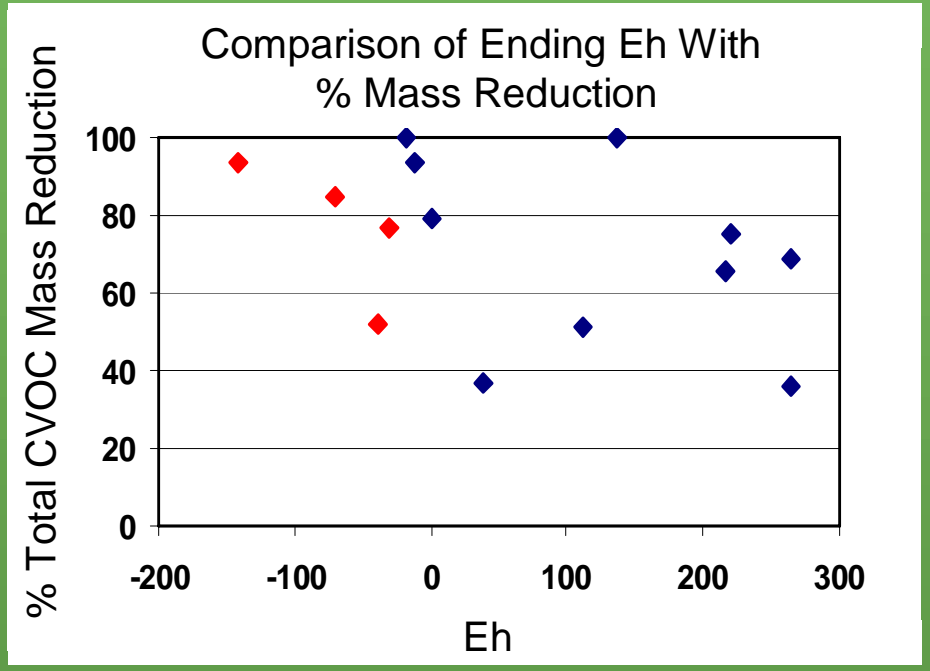
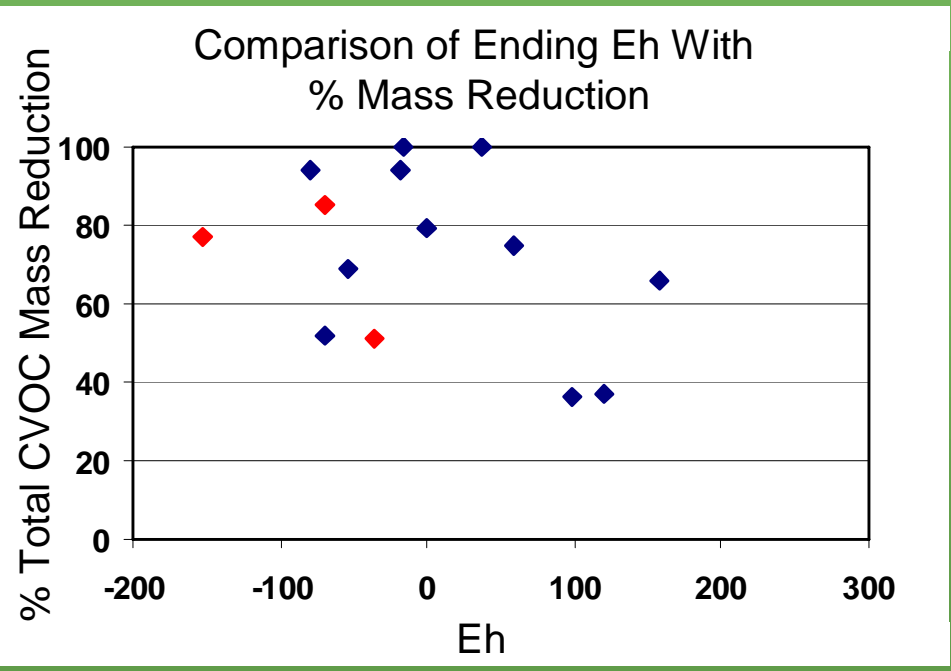


Eh and Contaminant Trends

Comparing MW-2 with MW-18



Comparison of Mass Reduction with Starting or Ending Eh at Multiple Sites



Conclusions

- **Aerobic cometabolism provides an option for treatment compatible with potassium permanganate.**
- **Aerobic conditions are favorable for avoiding the production of vinyl chloride.**
- **Aerobic cometabolism may combine reductive dehalogenation with oxidation.**

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