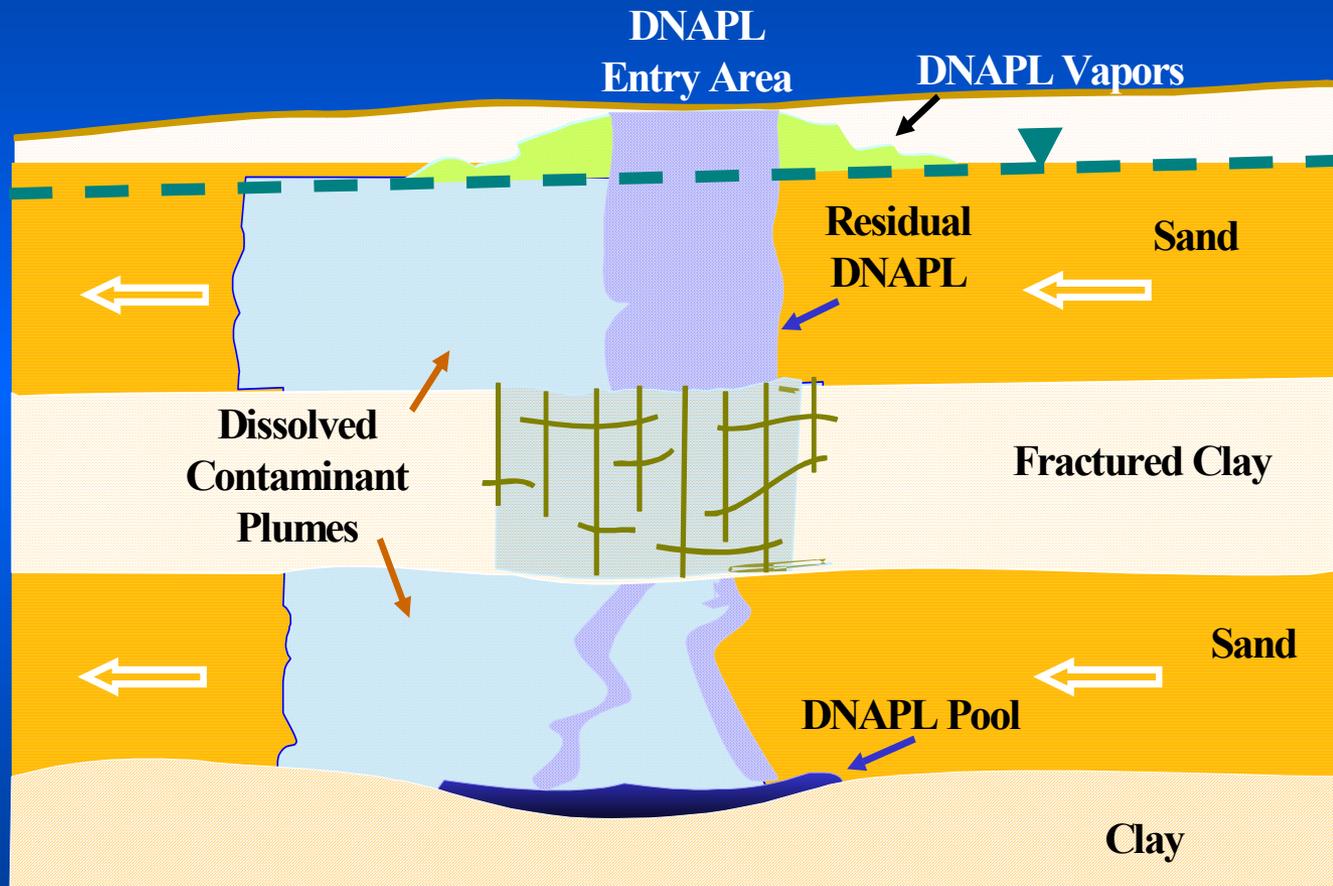


Semi-passive Permanganate Oxidation Schemes for the Long-term Treatment of Chlorinated Solvents

Eung Seok Lee and Franklin W. Schwartz
Department of Geological Sciences
The Ohio State University

DNAPL Contamination

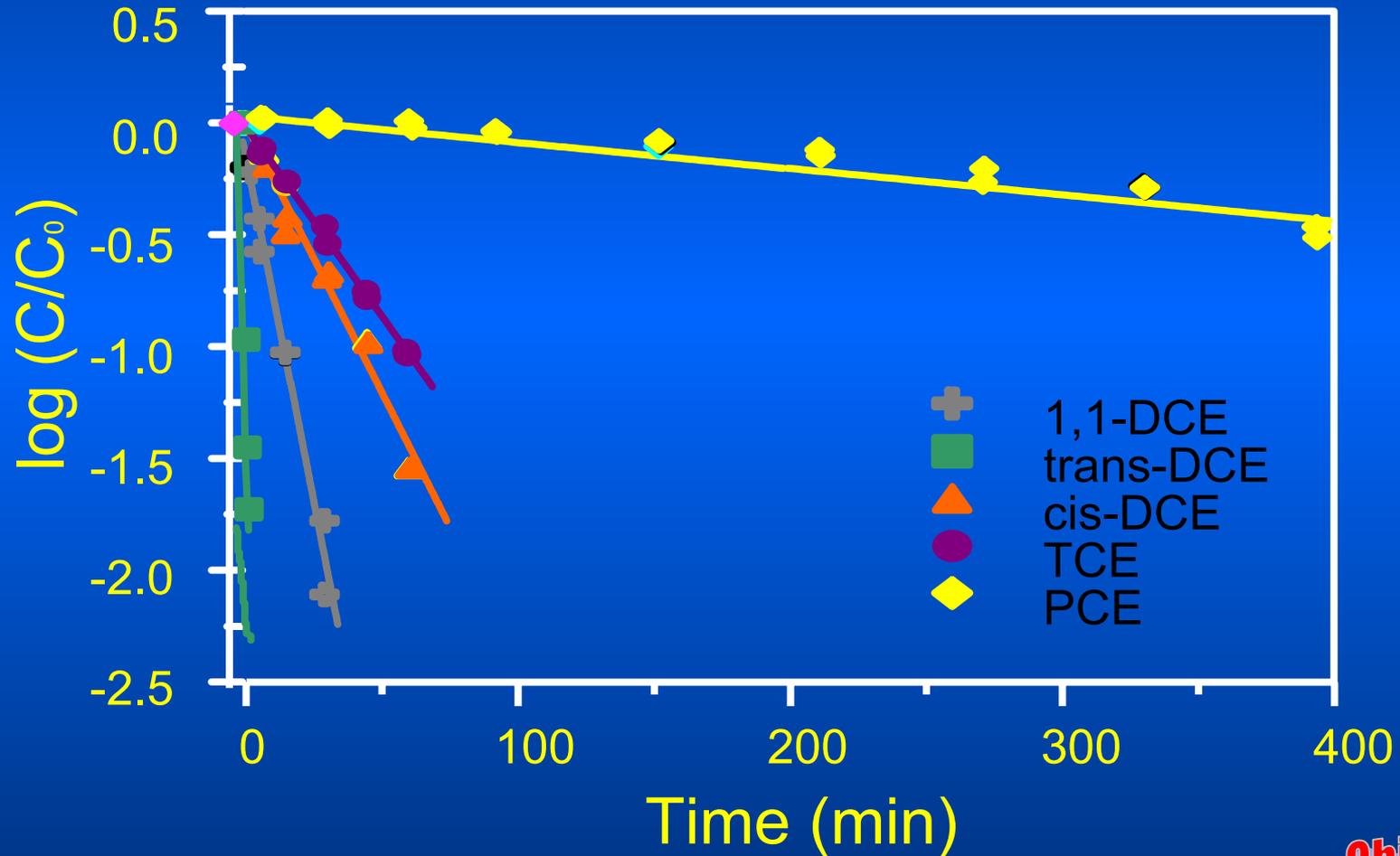


Potassium Permanganate

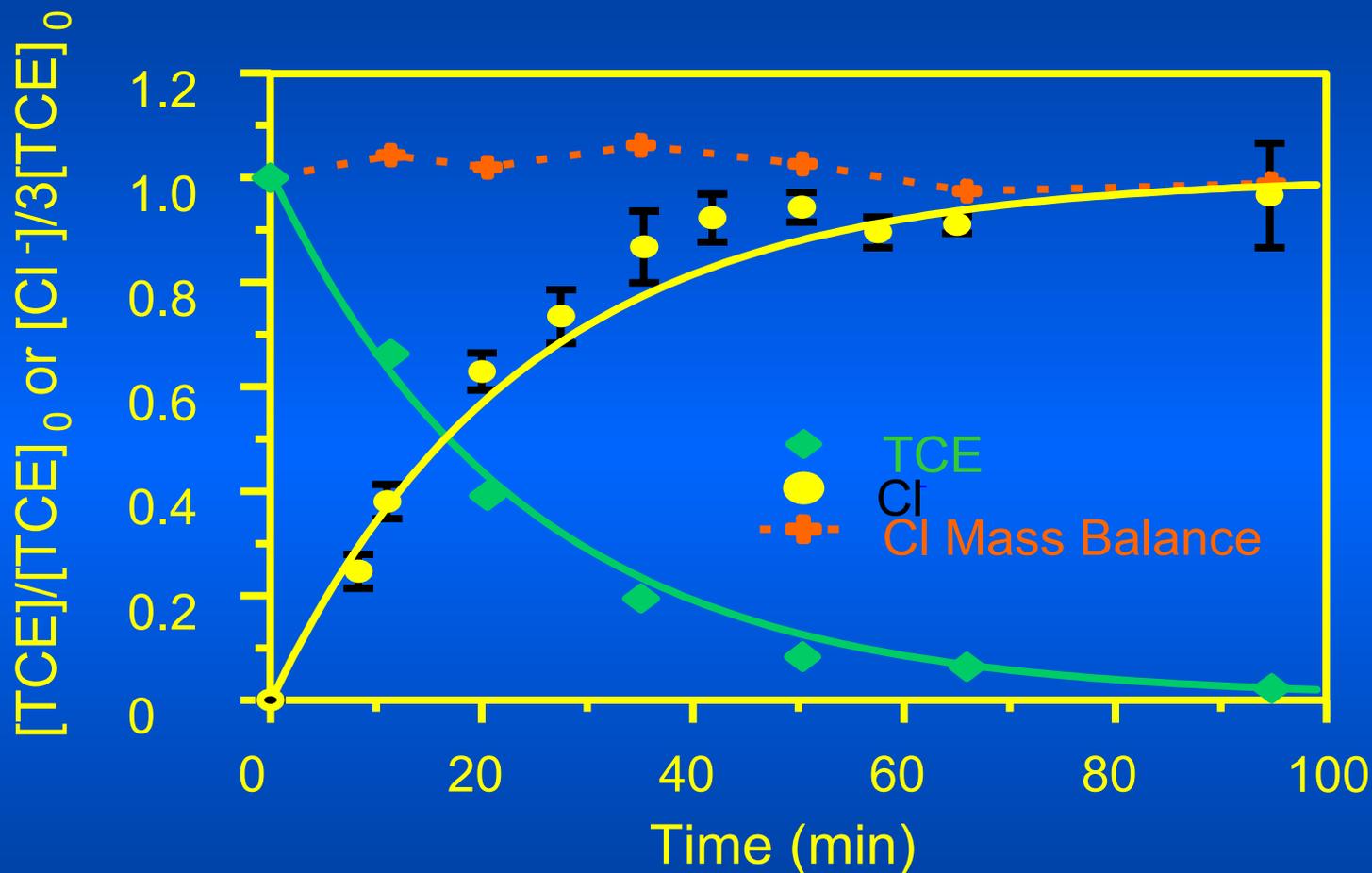
(KMnO₄)

- Metal oxo-reagent: Strong oxidant, attack C=C bonds (i.e., chlorinated ethylenes)
- Solubility: 36g/L
- Color: Purple
- Inexpensive – \$3/kg
- Easy to implement
- Reacts only with the dissolved phase 

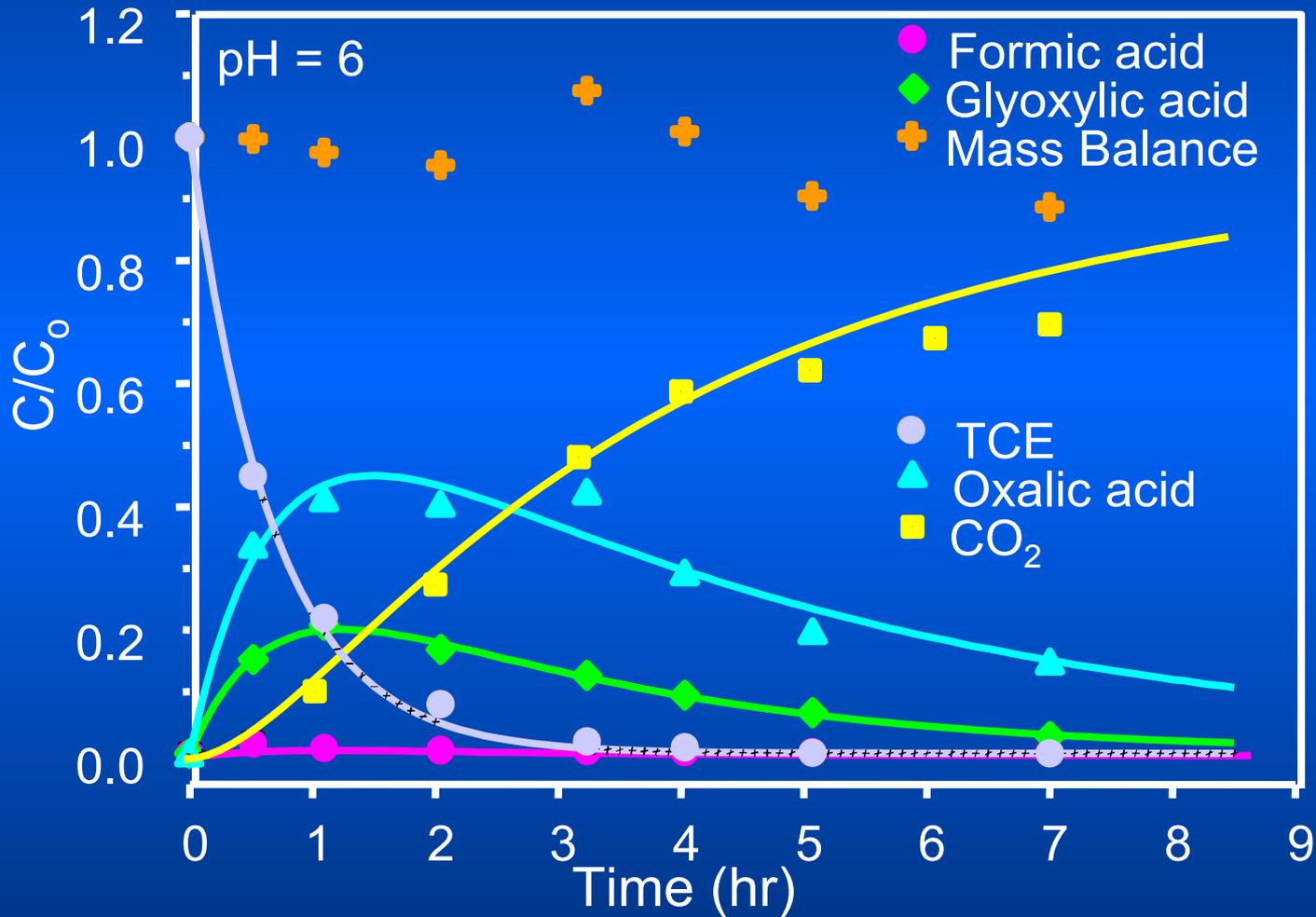
Permanganate Oxidation of Chlorinated Ethylenes



Dechlorination of TCE



Oxidation of TCE



KMnO₄ Flushing Scheme



Reaction Front Formation

15-cm
depth



30-cm
depth



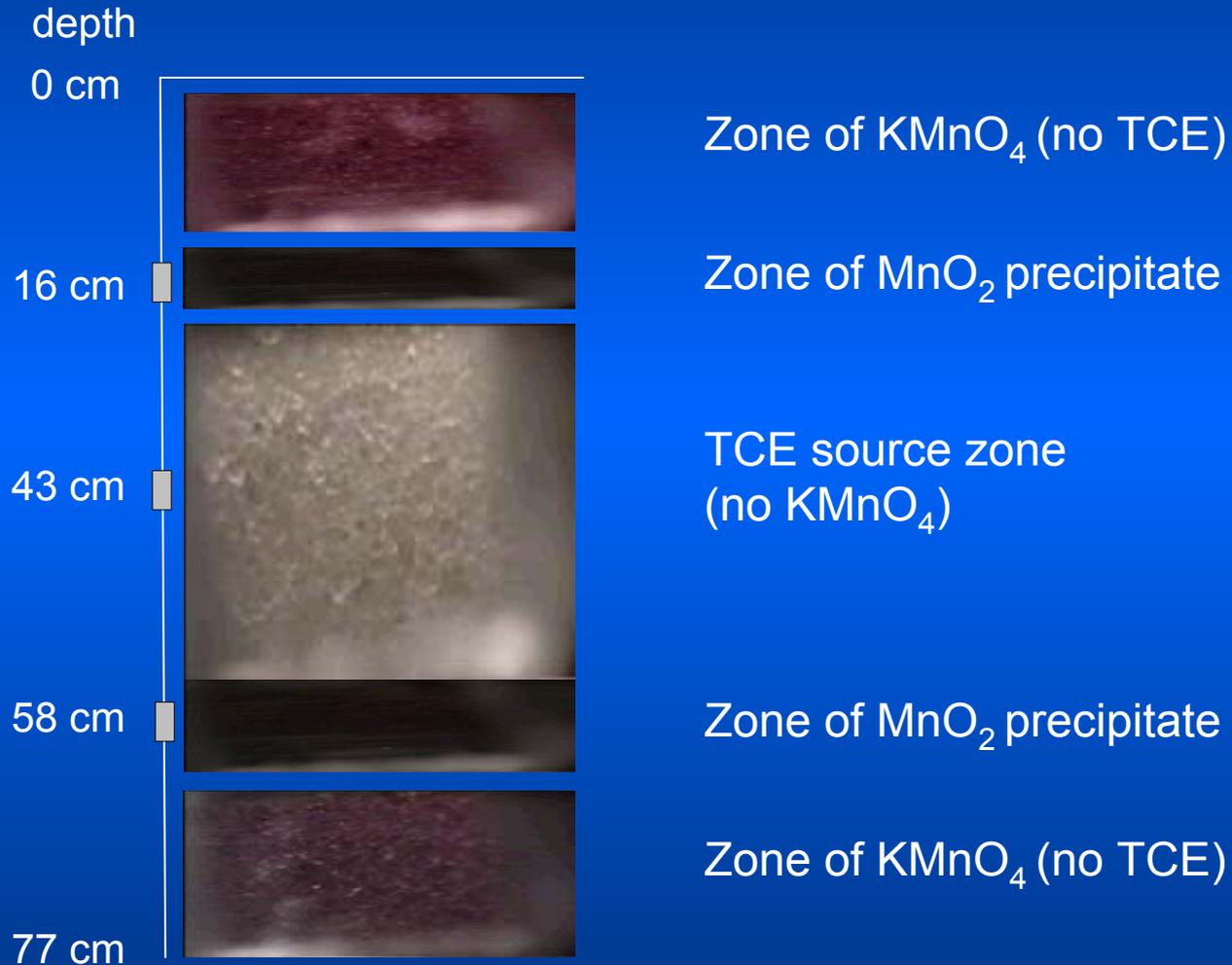
45-cm
depth



60-cm
depth



Reaction Front Formation



Reaction Front Dynamics



MnO₂ precipitates

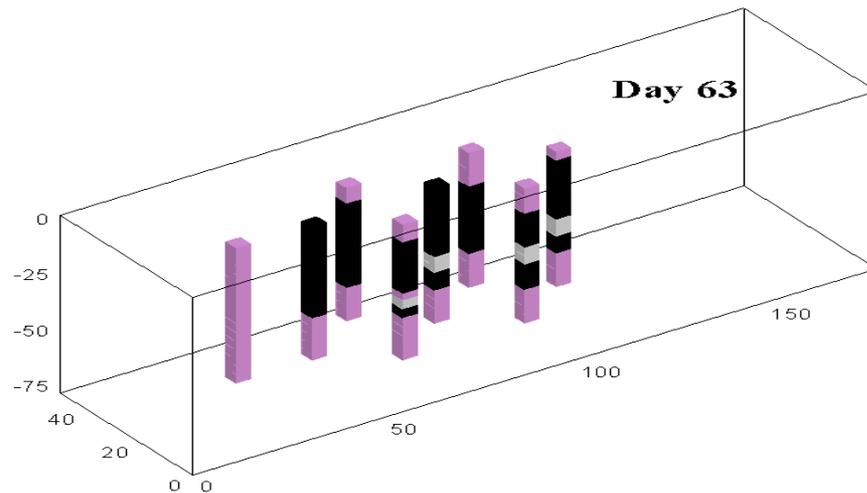
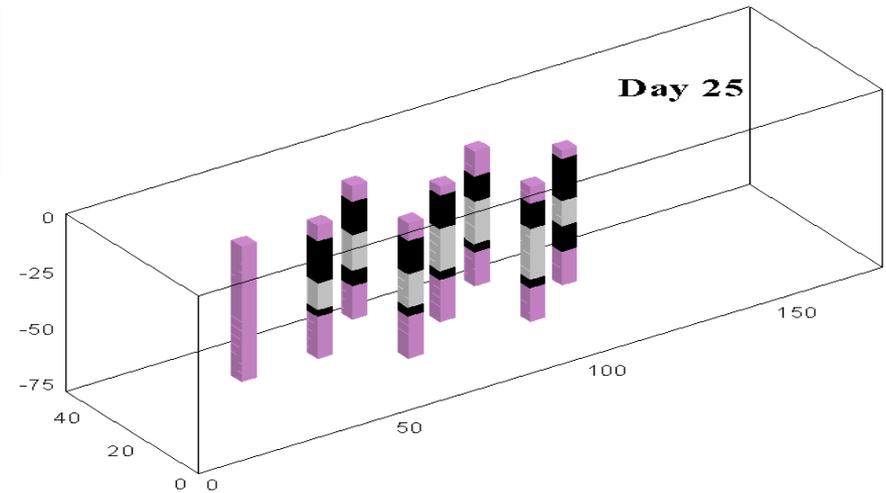
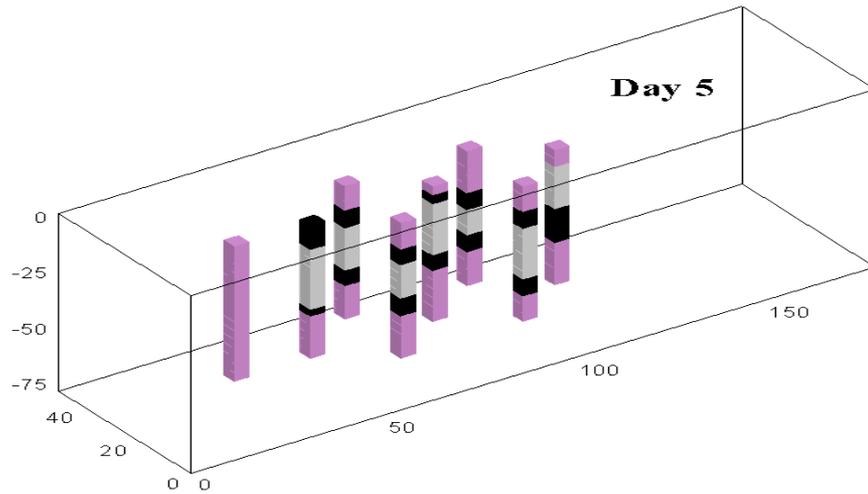


Reaction front
(density-driven
diffusion and advection)



TCE zone

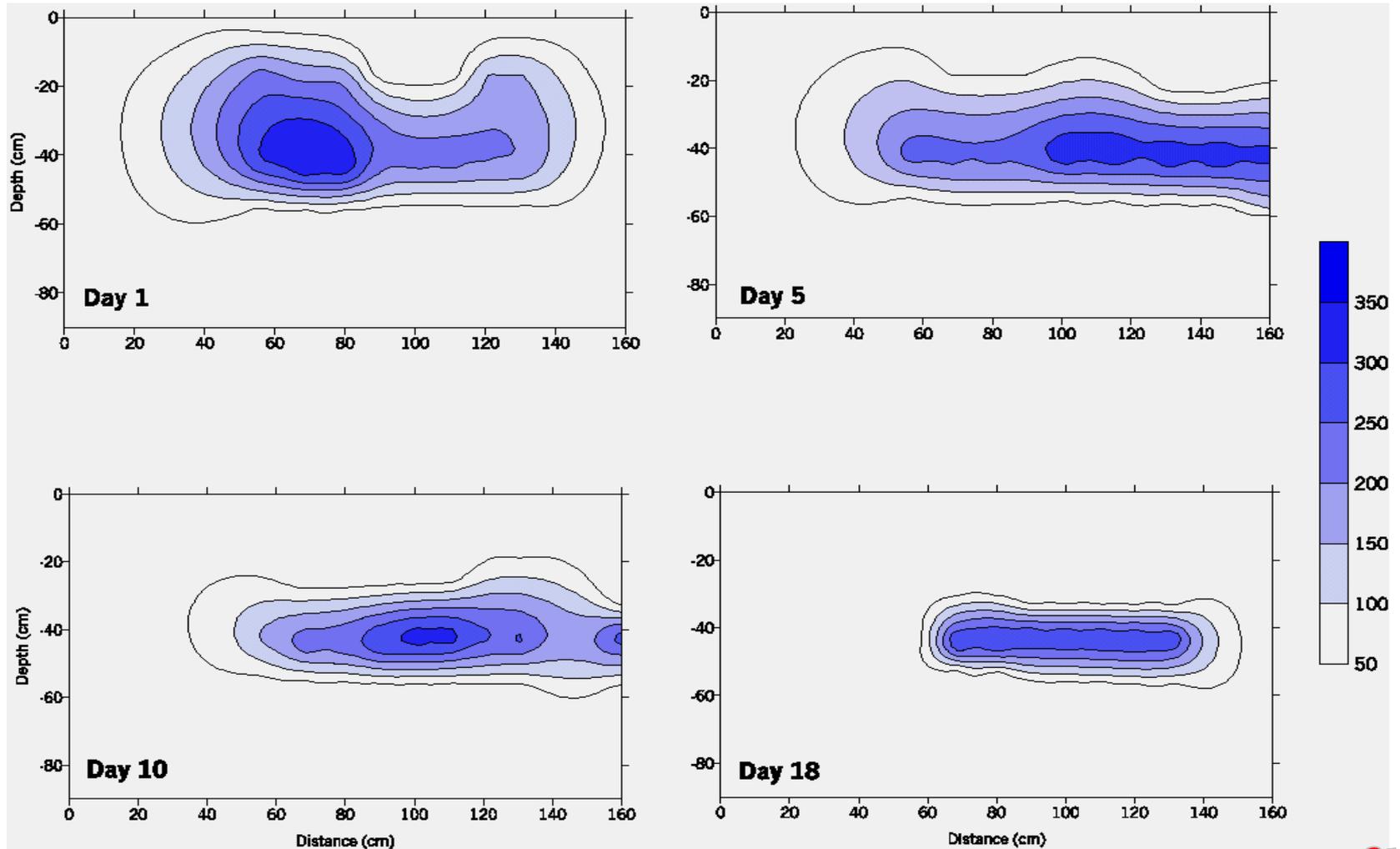
Reaction Front Dynamics



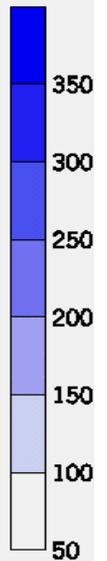
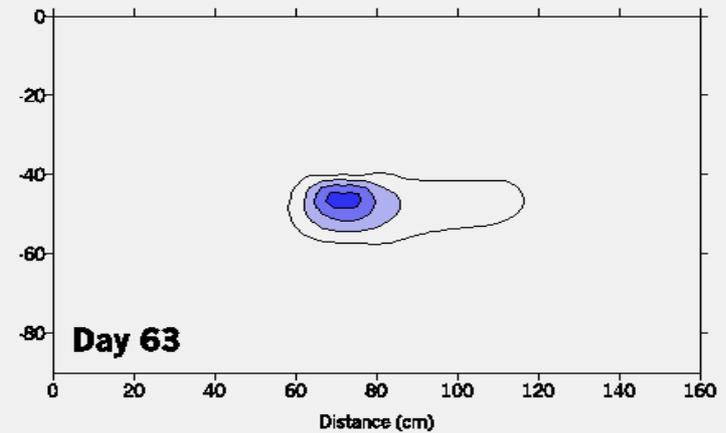
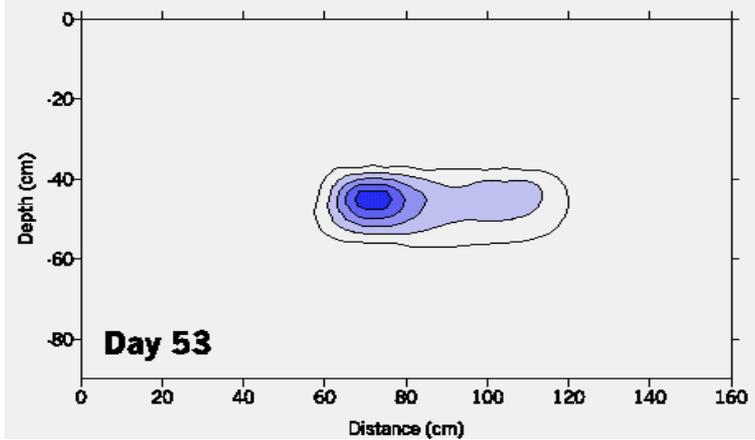
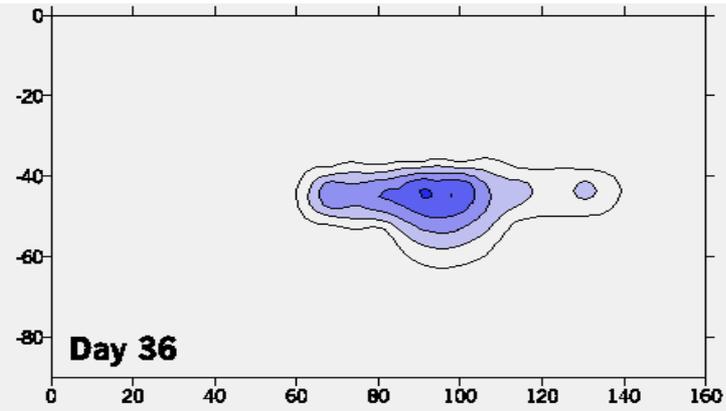
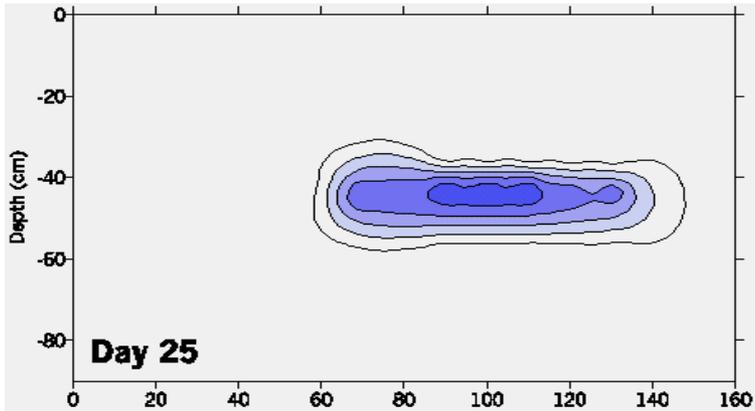
Destruction Efficiency

	Destruction Rate (cm/day)	
Days	Source zone	Downstream
18	1.2	0.9
18	0.3	0.2
27	0.2	0.2

Fate of TCE Plume



Fate of TCE Plume – cont.



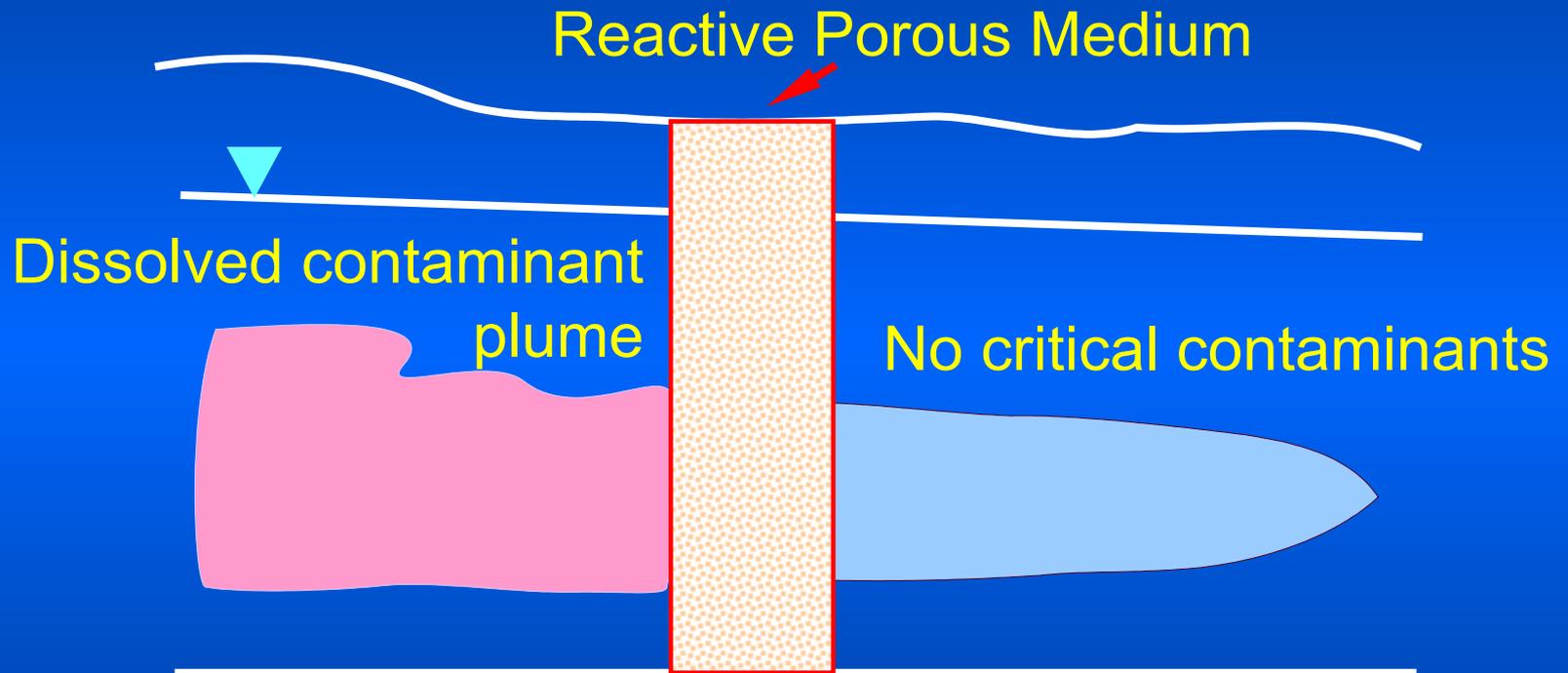
Efficiency of the KMnO_4 Flushing Scheme

- About 41% of TCE ($\sim 297\text{g}$) was oxidized by flushing about 3,213 L of KMnO_4 (1,250 mg/L)
- Only 18% ($\sim 570\text{ L}$) of KMnO_4 was used for the oxidation reaction.
- The efficiency of KMnO_4 flushing scheme diminished with time due to MnO_2 precipitates.

Passive Treatment Techniques

- Utilize PRB to destroy contaminants by chemical or biological processes as ground water flows through the treatment zones.
- Low-cost, long-term treatment.

Permeable Reactive Barrier



Semi-passive KMnO_4 Oxidation Scheme

- Provide dissolved KMnO_4 in a controlled-release fashion to promote the oxidation of the dissolved contaminants.
- Needs to develop delivery system and slow-release KMnO_4 .

Column with KMnO_4



Column with KMnO_4 and $\text{Na}_2\text{S}_2\text{O}_3$



Column Discharge

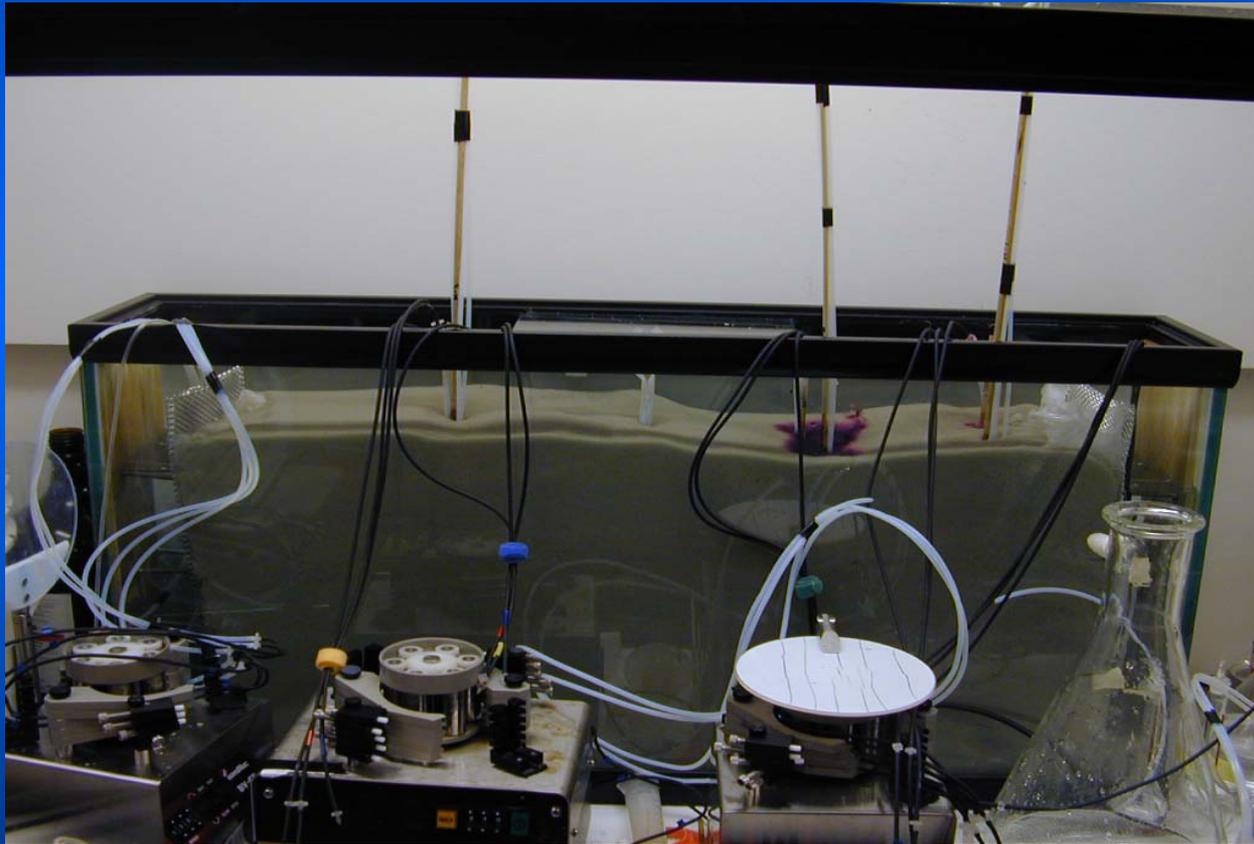


KMnO_4

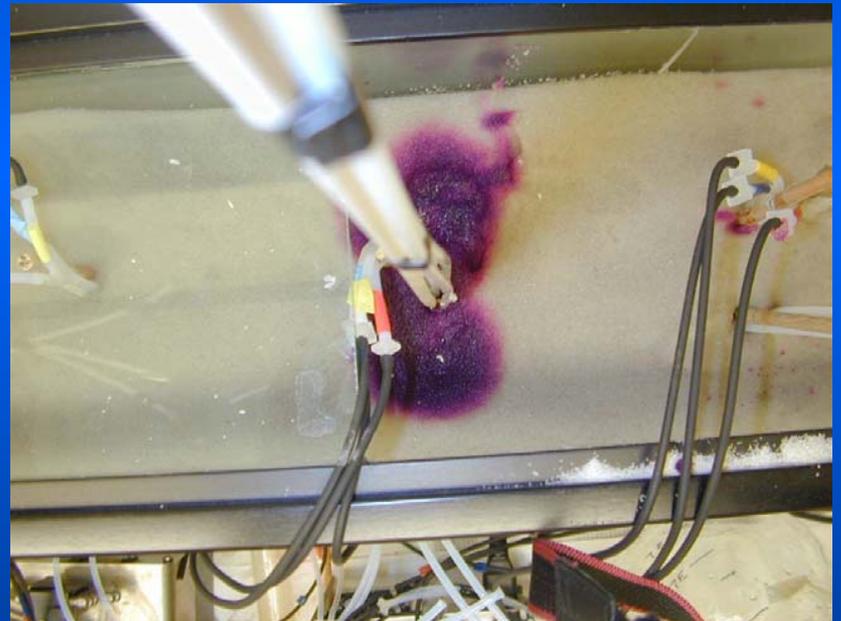
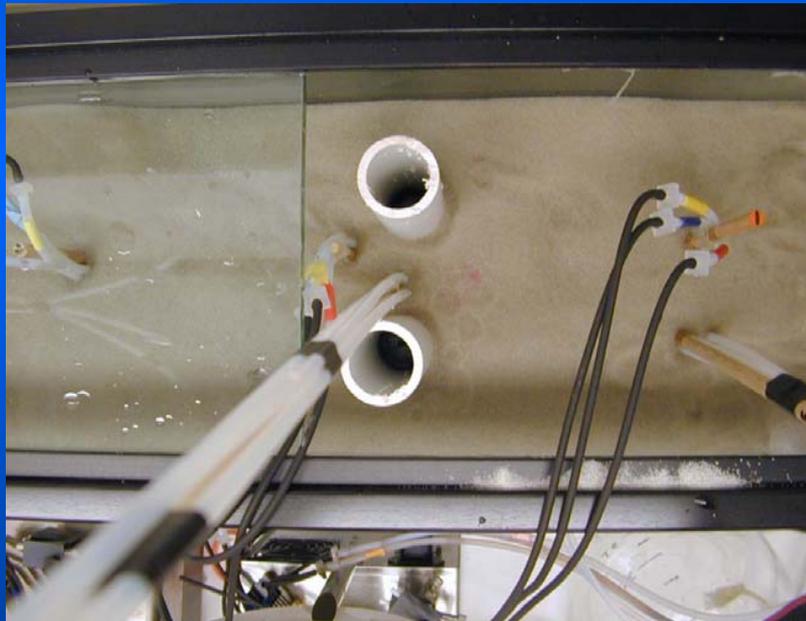


KMnO_4 and $\text{Na}_2\text{S}_2\text{O}_3$

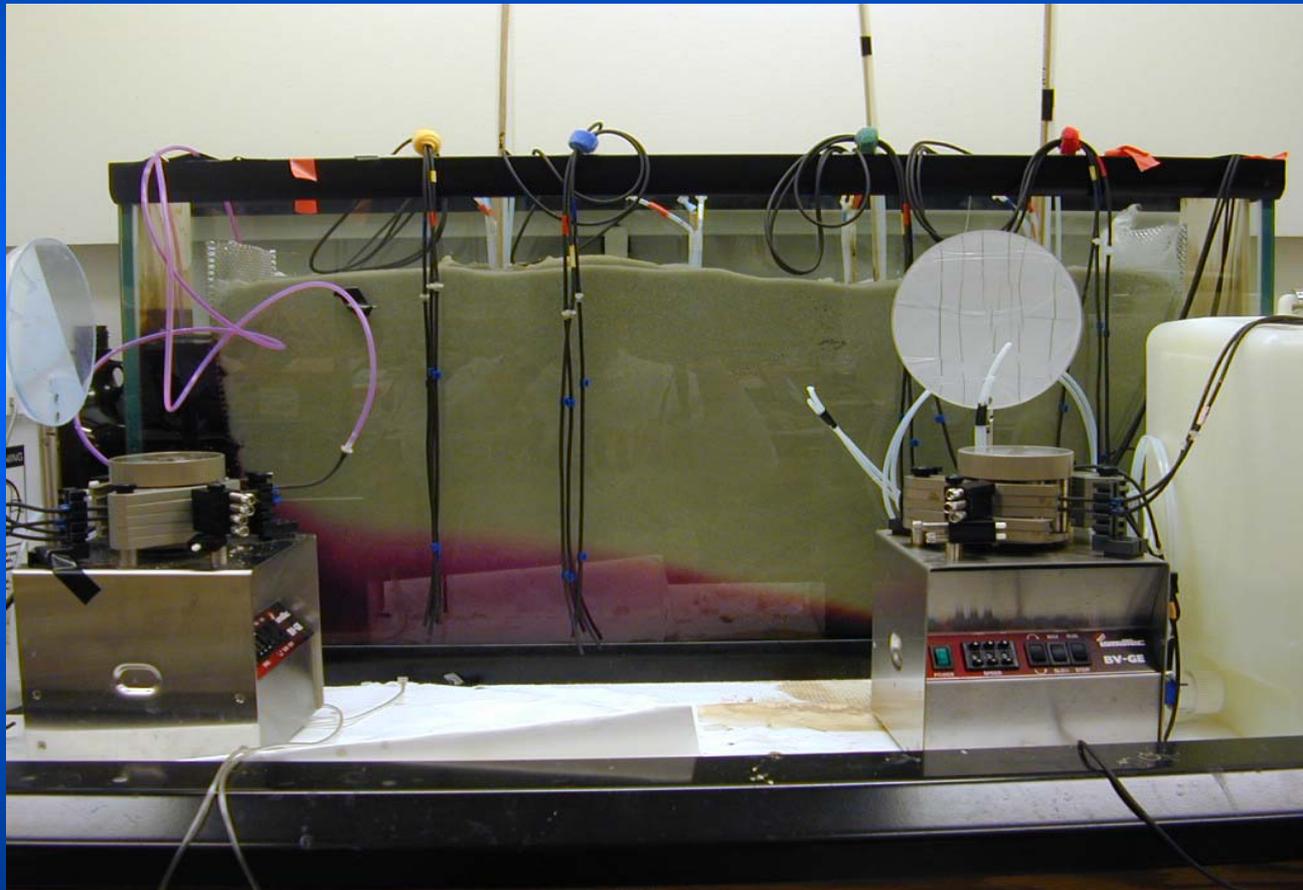
2-D Flow Tank with KMnO_4 PRB



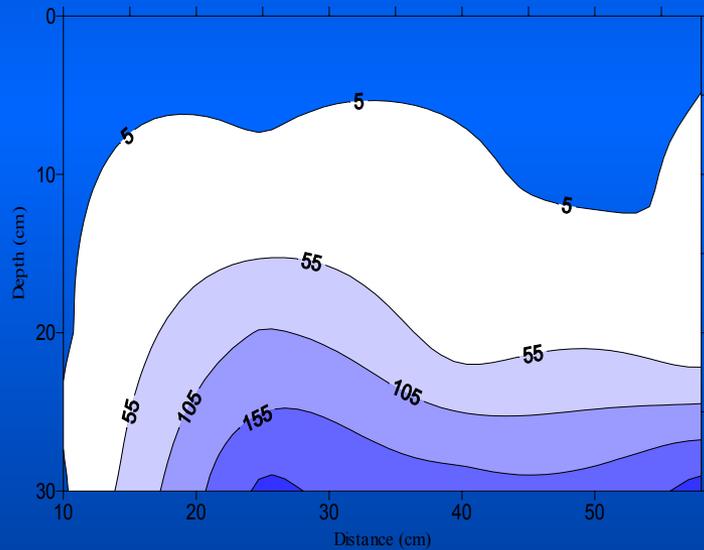
KMnO₄ Delivery



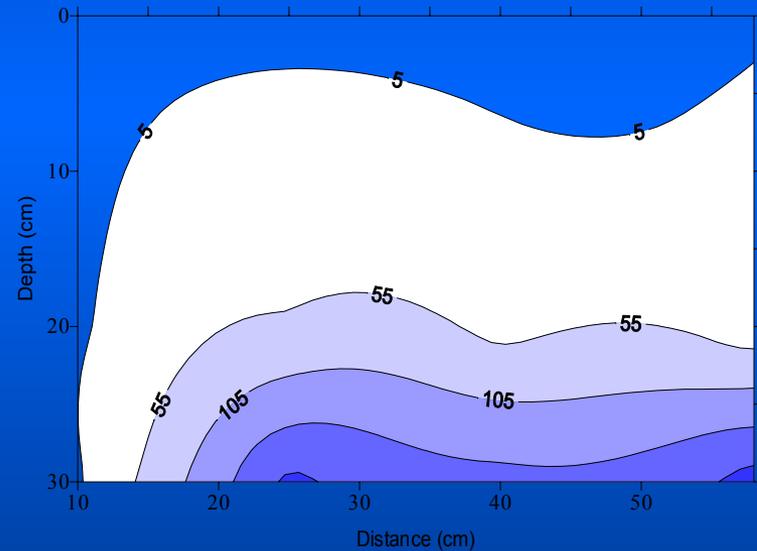
Flow Tank After 9 Days



MnO₄⁻ Contours



Day 2



Day 9

Semi-passive KMnO_4 Oxidation Scheme

- KMnO_4 PRB successfully destroyed TCE plume ($70 \mu\text{g/L}$).
- PRB delivers KMnO_4 for a prolonged period of time.
- KMnO_4 release rate is too high → **New slow release KMnO_4 has been developed.**

New Slow-release KMnO_4

<Column Test Results>

