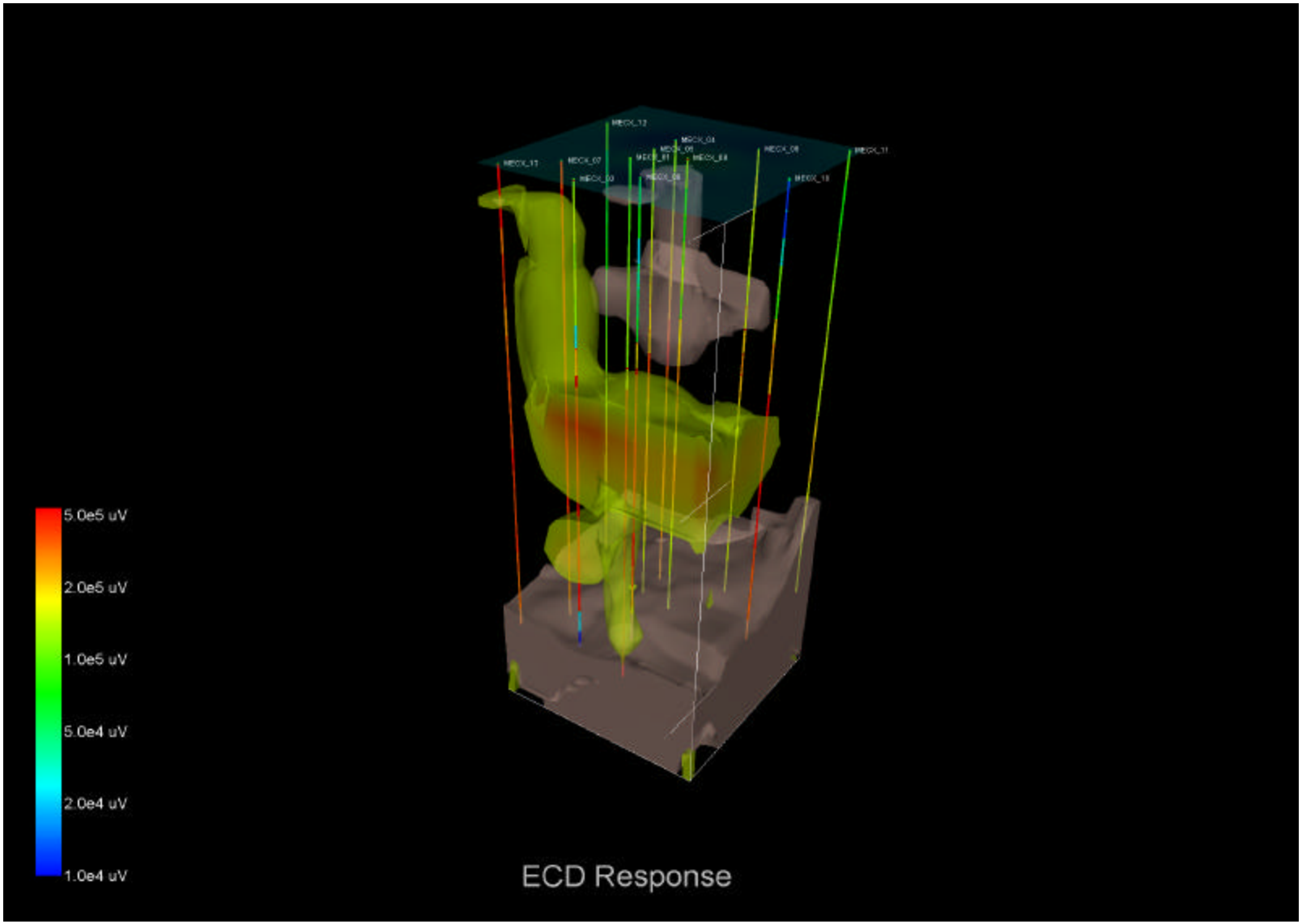
Remediation Technology Selection Made Simple!

Richard T. Cartwright PE, CHMM

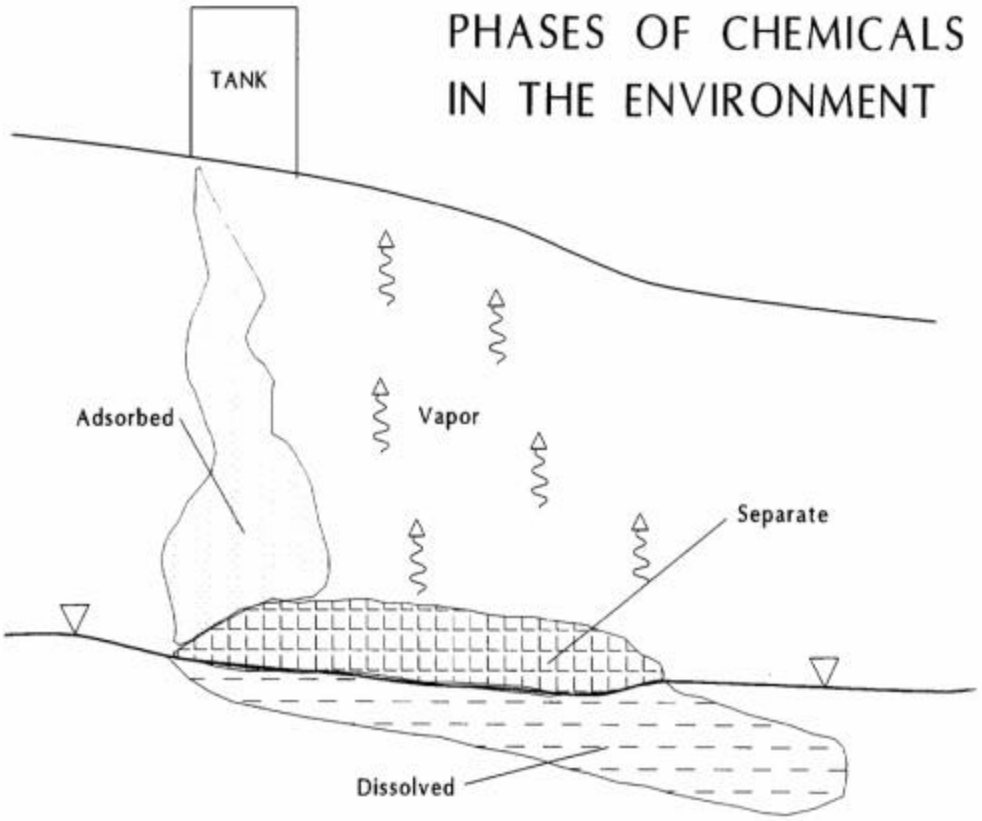
Vice President MECX, LLC

Where are the Contaminants?

Site Characterization!

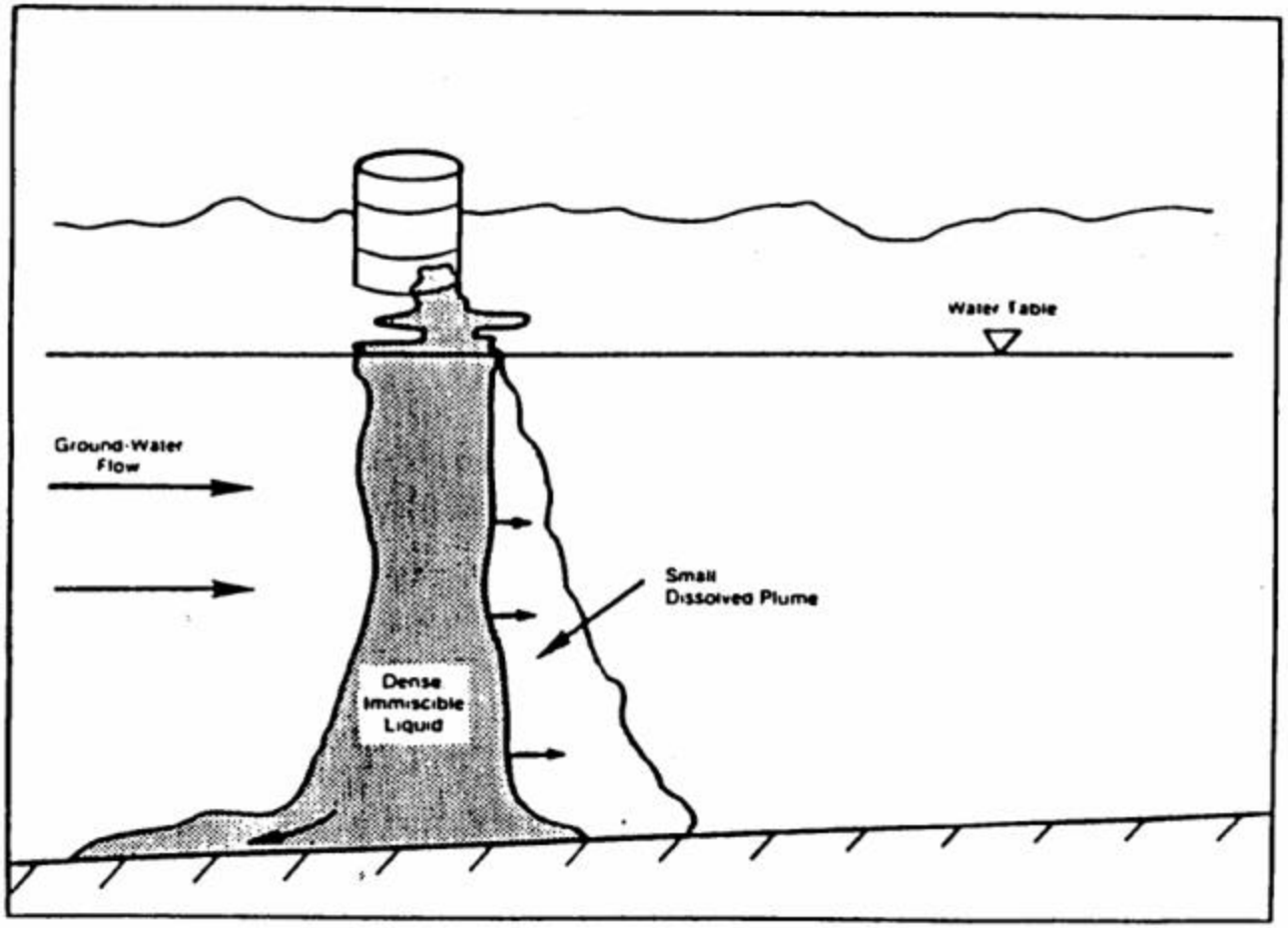


Which Phase?



- **Free Product**
- **Absorbed Phase**
- **Dissolved Phase**
- **Vadose Zone**
- **Saturated Zone**

Source or Plume?

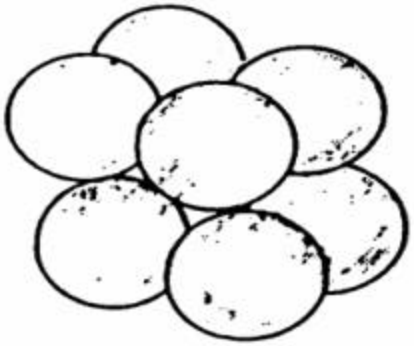


(EPA, 1991 b)

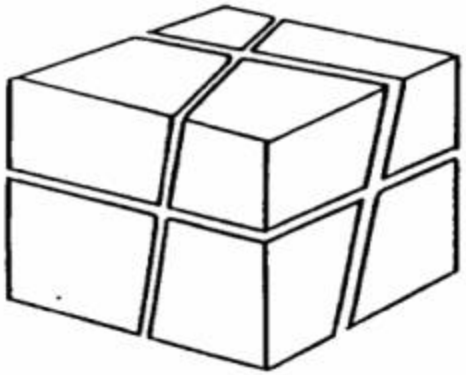
Plume Containment

C3 ENVIRONMENTAL LIMITED
Environmental Contractors & Engineers

What is the Permeability?



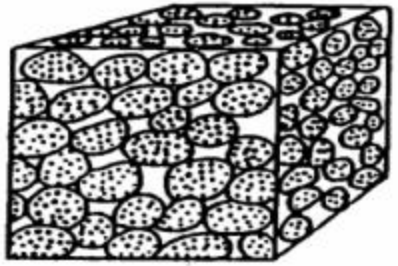
Porous Material



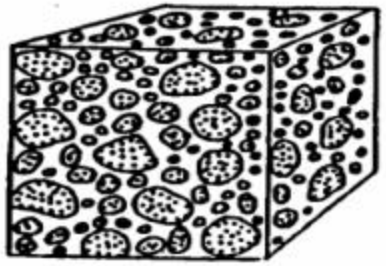
Fractured Rock

(Heath, 1980)

Primary Openings

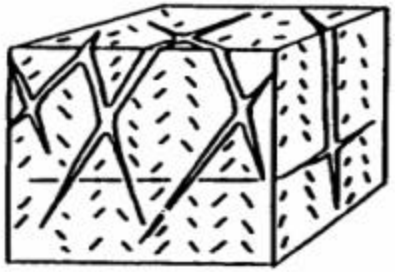


Well-Sorted Sand

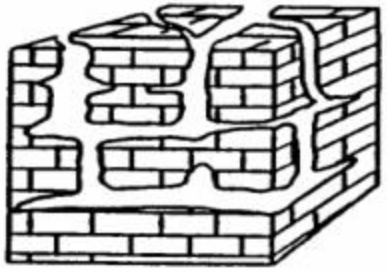


Poorly-Sorted Sand

Secondary Openings



Fractures in Granite



Caverns in Limestone

Reagent Fate and Transport

- **What is the fate of reagents?**
- **How do you transport reagents?**
- **How robust are the reagents?**

Proactive Propagation

- **Chemical Techniques**
  - **Soil Pre-Conditioning Agents**
  - **Soil Penetrating Surfactants**
  - **Chemical Dispersion Agents**
- **Mechanical Techniques**
  - **Direct Push Slurry Jetting**
  - **Vertical/Horizontal Mixing**
  - **Create Preferential Pathways**
  - **Push-Pull Reagent Transport**

Remediation Options- Unsaturated Soils

UNSATURATED SOIL

	8 $8 $8 $8 $8 $8 $		Contamination					Site Issues		Soils	Regulatory Issues	
Technology	Life Cycle Costs	Time	BETX	PAHs	MTBE	LNAPL	Solvents	Utilities	Operations	Permeability	$$$$$	Permitted
MNA												
Bio+												
SVE												
BioVenting												
ESVE												
Oxidation												
1-Permanganate												
2-Fenton's												
3-Other												
Excavation												

Remediation Options- Saturated Soils & Groundwater

	8 $8 $8 $8 $8 $8 $		Contamination					Site Issues		Soils	Regulatory Issues	
Technology	Life Cycle Costs	Time	BETX	PAHs	MTBE	LNAPL	Solvents	Utilities	Operations	Permeability	$$$$$	Permitted
MNA												
Bio+												
Sparging												
BioSparging												
Oxidation												
1-Permanganate												
2-Fenton's												
3-Other												

In-situ Remediation

- Chemical Oxidation
- Chemical Reduction
- Aerobic Decomposition
- Anaerobic Decomposition

How Robust are the Chemical Oxidants?

Reactive Species	Relative Oxidizing Power
Hydroxyl Radical	2.06
Activated Persulfate	1.91
Ozone	1.52
Persulfate	1.48
Hydrogen Peroxide	1.31
Permanganate	1.24
Chlorine Dioxide	1.15
Chlorine	1.00

Traditional Fenton's Chemistry

$$H_2O_2 + Fe^{+2}\,(acid) \rightarrow OH\bullet + OH^- + Fe^{+3}$$

$$OH\bullet + \text{Organic Contaminant} \rightarrow CO_2 + H_2O$$

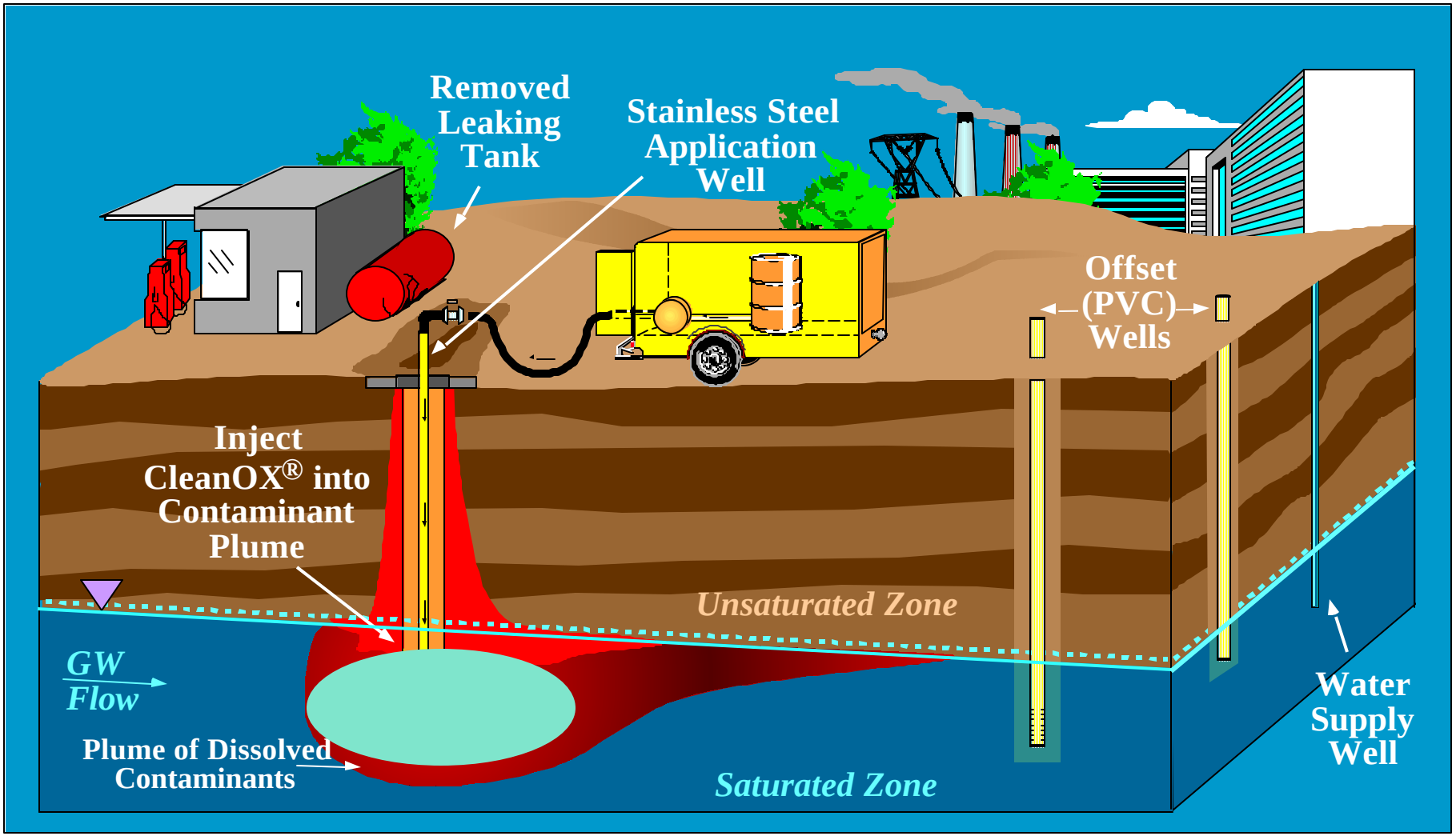
Chemical Oxidation Advantages

- **Take full advantage of oxidation power of hydroxyl free radicals**
- **Able to expedite real estate transfers**
- **Remediation is completed within weeks or months, not years**

Chemical Oxidation Destroys

- **BTEX, MTBE & TPH**
- **Gasoline & Diesel Fuel**
- **Chlorinated Solvents**
- **Polychlorinated Biphenyls**
- **Organic Pesticides**
- **TNT, PBX, & VX**

Remedial Process Diagram

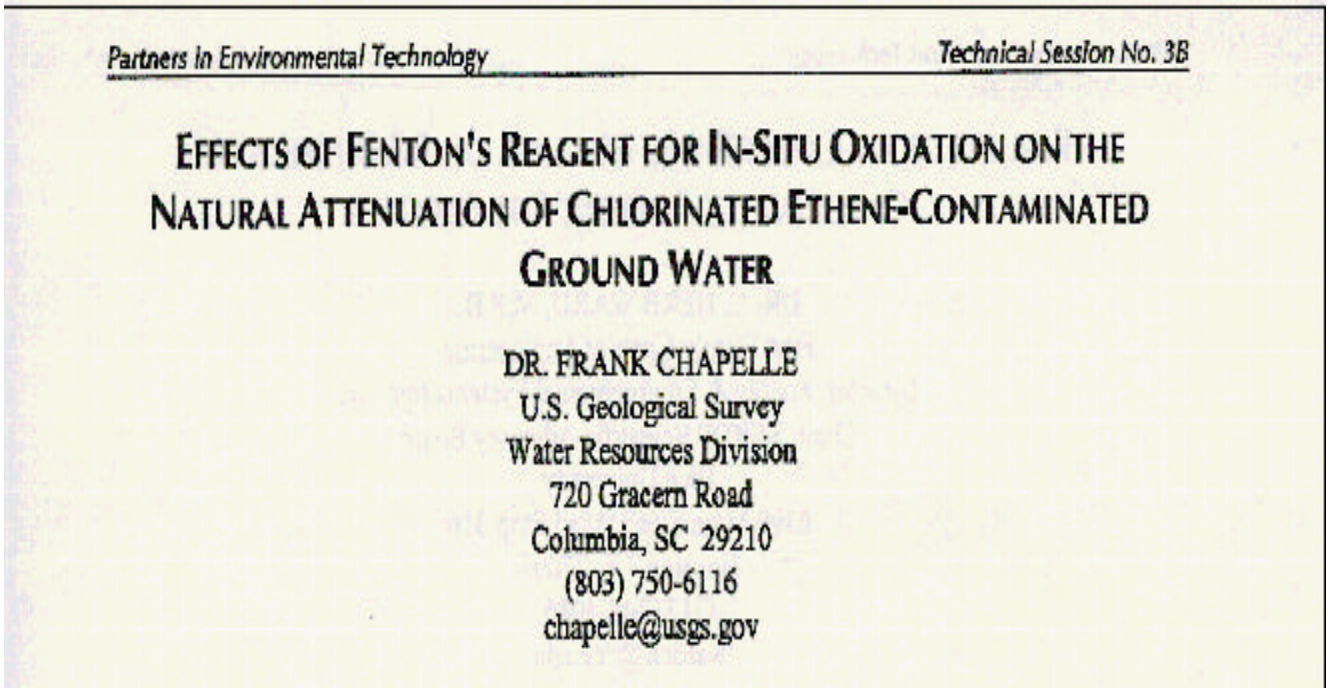


ChemOX Remedial Process

Chemical Enhancements

- **Sodium Persulfate ($Na_2S_2O_8$)**
  - **Activated by Fenton's Reagent**
  - **New Formulation (pH stabilized)**
- **Oxygen Releasing Compounds**
  - **Magnesium Peroxide (MgO_2)**
  - **Calcium Peroxide (CaO_2)**

Chemical Oxidation & Bioremediation



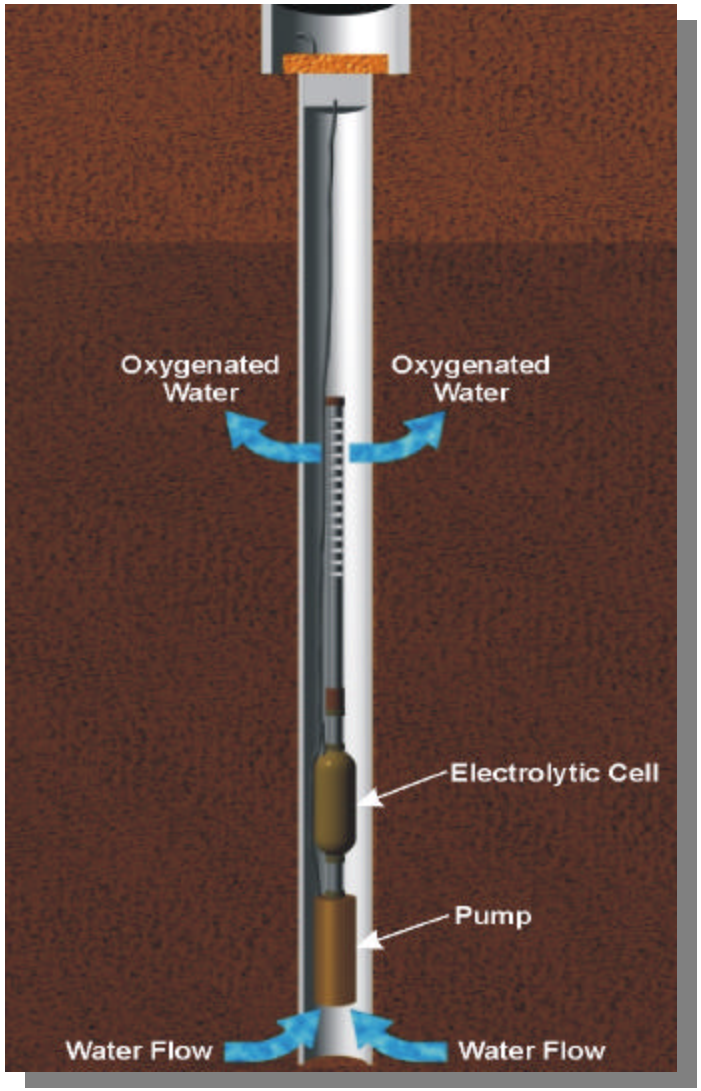
Partners in Environmental Technology *Technical Session No. 3B*

EFFECTS OF FENTON'S REAGENT FOR IN-SITU OXIDATION ON THE NATURAL ATTENUATION OF CHLORINATED ETHENE-CONTAMINATED GROUND WATER

DR. FRANK CHAPELLE
U.S. Geological Survey
Water Resources Division
720 Gracern Road
Columbia, SC 29210
(803) 750-6116
chapelle@usgs.gov

Long-term positive effect on biological activity by elimination of toxic mass in target area

Dissolved Oxygen Diffusion

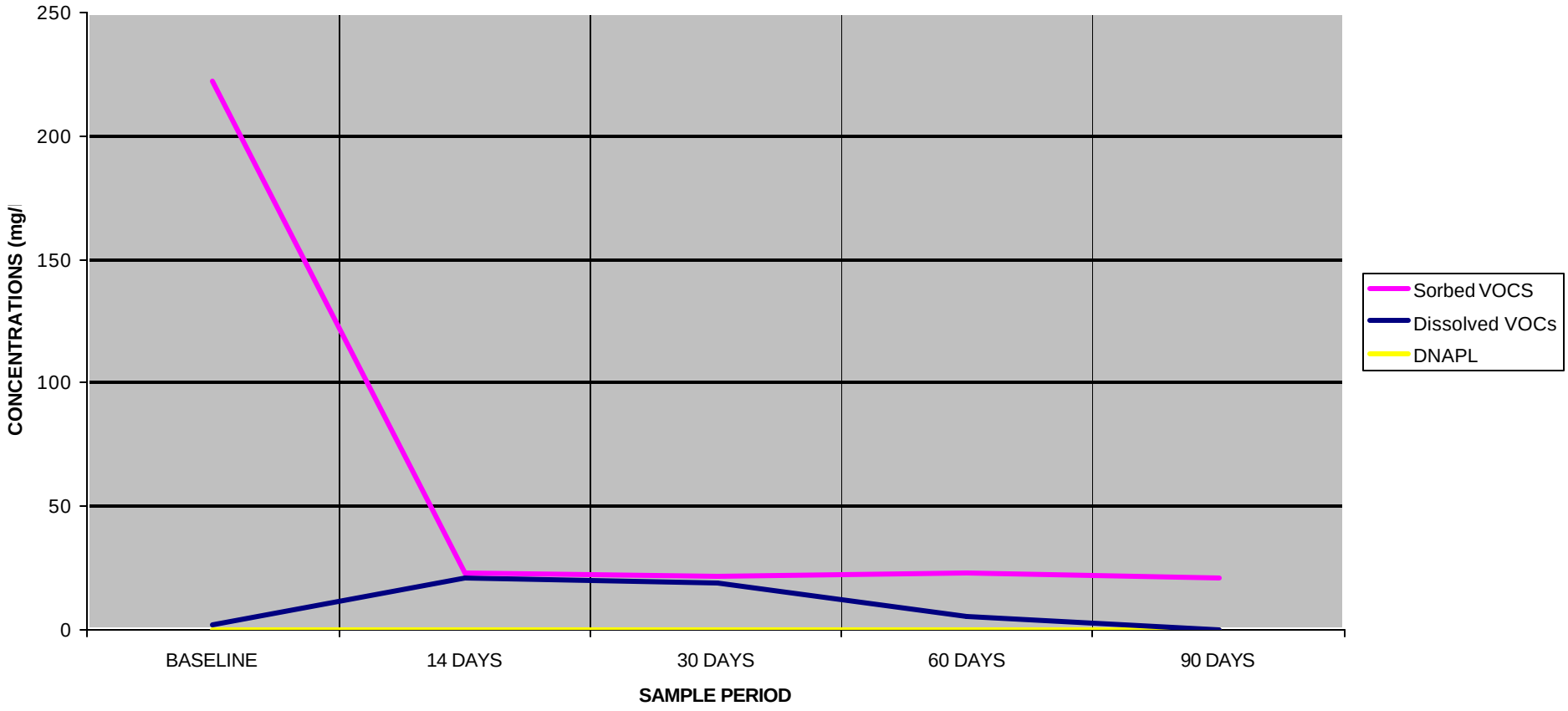


Anaerobic Bioremediation

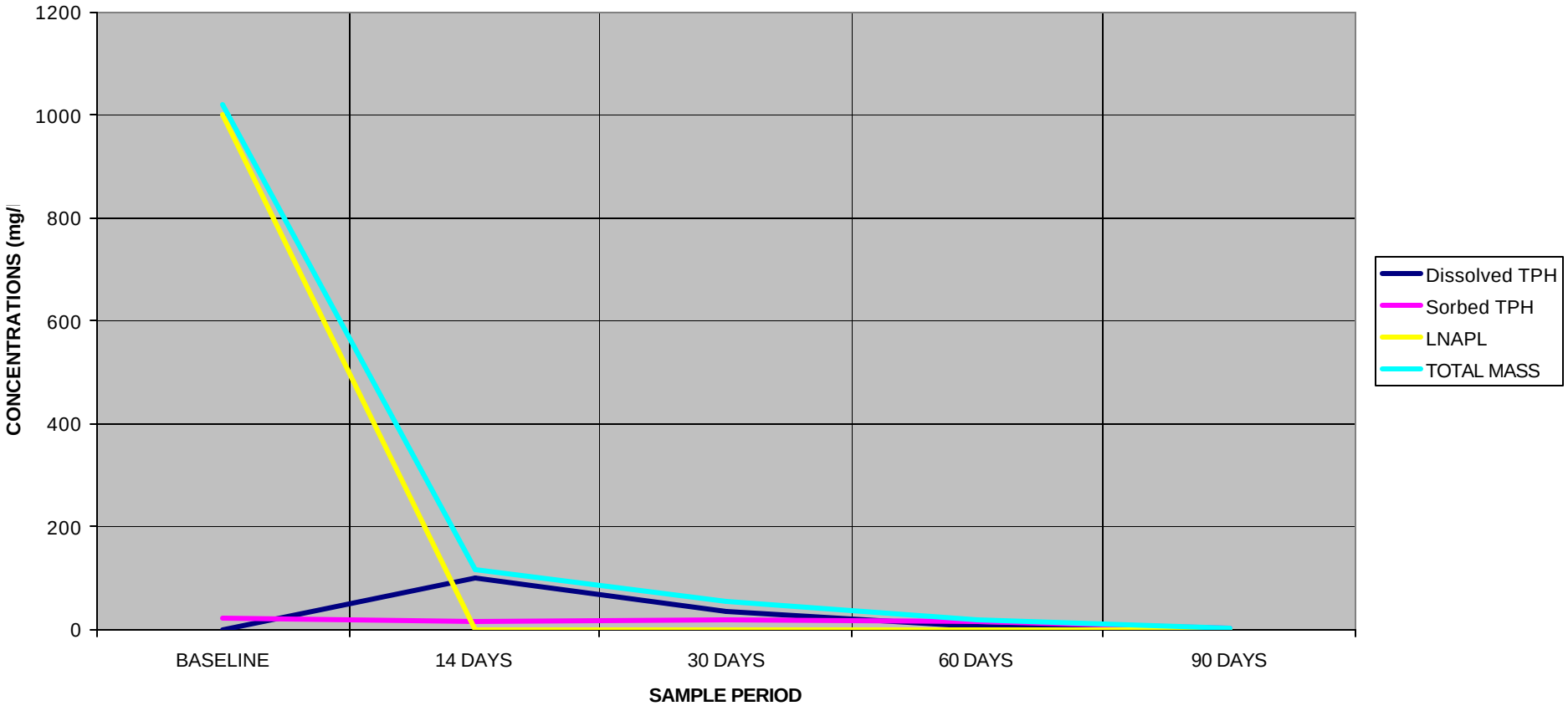
- Hydrogen Releasing Compounds
- Edible Oil Substrate
  - Emulsified Soybean Oil
  - Lactic acid
  - Yeast
  - Minerals
- In-situ & Ex-situ Systems

Terra Systems, Incorporated

CHLORINATED SOLVENT SITE
MASS DISTRIBUTION



PETROLEUM HYDROCARBON SITE
TOTAL MASS DISTRIBUTION



Conclusions

- **Remediation technology selection can be simplified through a systematic approach**
- **There really is no silver bullet!**
- **Optimal solutions often achieved by bundling several technologies**
- **Know when and where to apply bundled technologies**

For additional information contact:

Richard T. Cartwright PE, CHMM

MEC^{X}, LLC

Phone: (713) 412-9697

Email: richard.cartwright@mecx.net

www.mecx.net