RTDF/NAPL Cleanup Alliance

"Bio-Chemical Oxidation Technology"

Richard T. Cartwright PE, CHMM

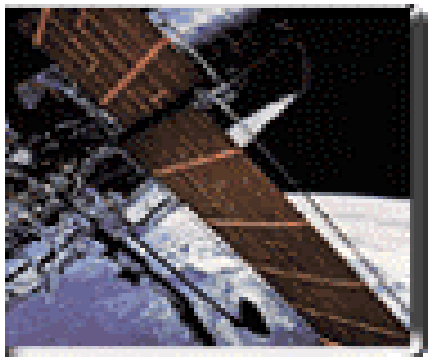
Isaac M. Aboulafia PE

ManTech International

Information Systems

Systems Security

Defense



Aerospace

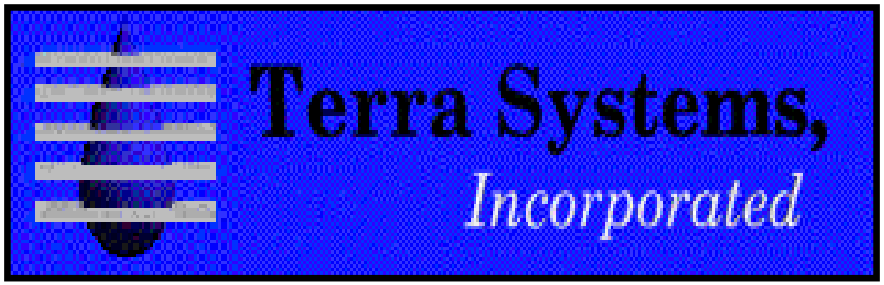
US EPA Technical Support

- **Subsurface Remediation Technology Evaluation**
- **Center for Subsurface Modeling**
- **Air Distribution Modeling**
- **Toxicology & Risk Assessment**


MEC^X


ENVIRONMENTAL
H2


C3 ENVIRONMENTAL LIMITED
Environmental Contractors & Engineers


Terra Systems,
Incorporated


M
microseeps


BLUE LIGHTNING
UNDER GROUND


BIONUTRATECH®


EIC


TERRATHERM®

Innovative Bio-Chem-OX Remediation Approach

- **Chemical Oxidation**
- **Aerobic Biotreatment**
- **Biostimulation**

Relative Power of 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

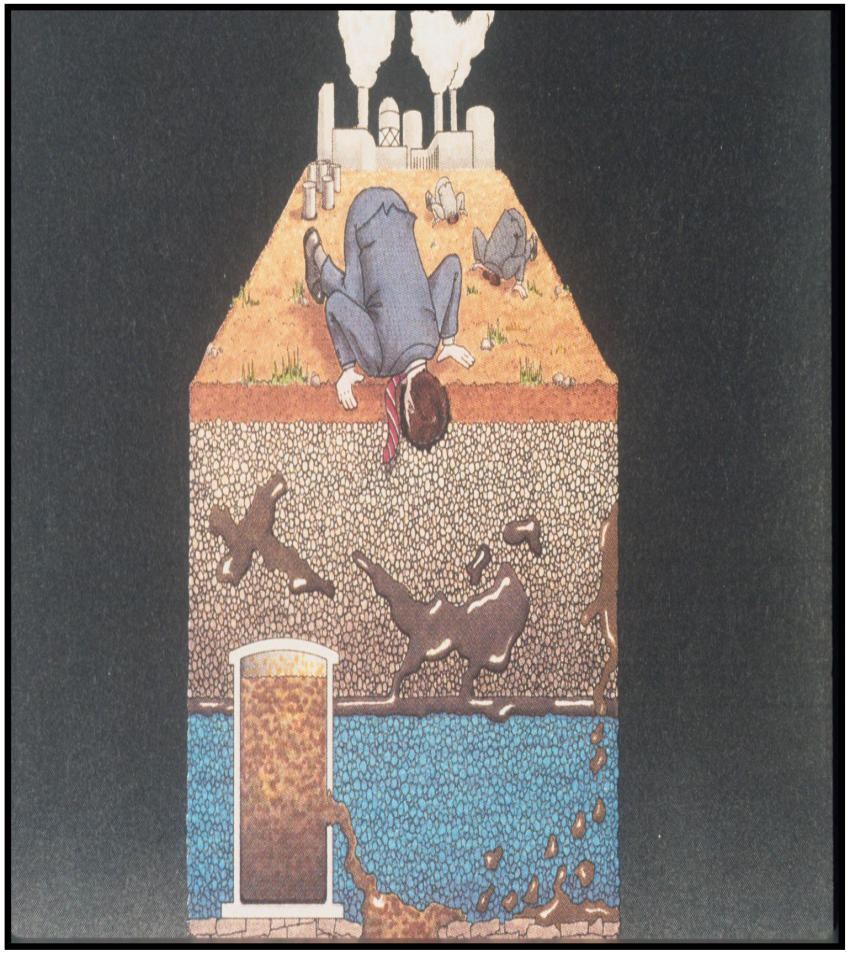
Exothermic Free Radical Chemistry

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

$$OH\bullet + \text{Organic Contaminant} \Rightarrow$$

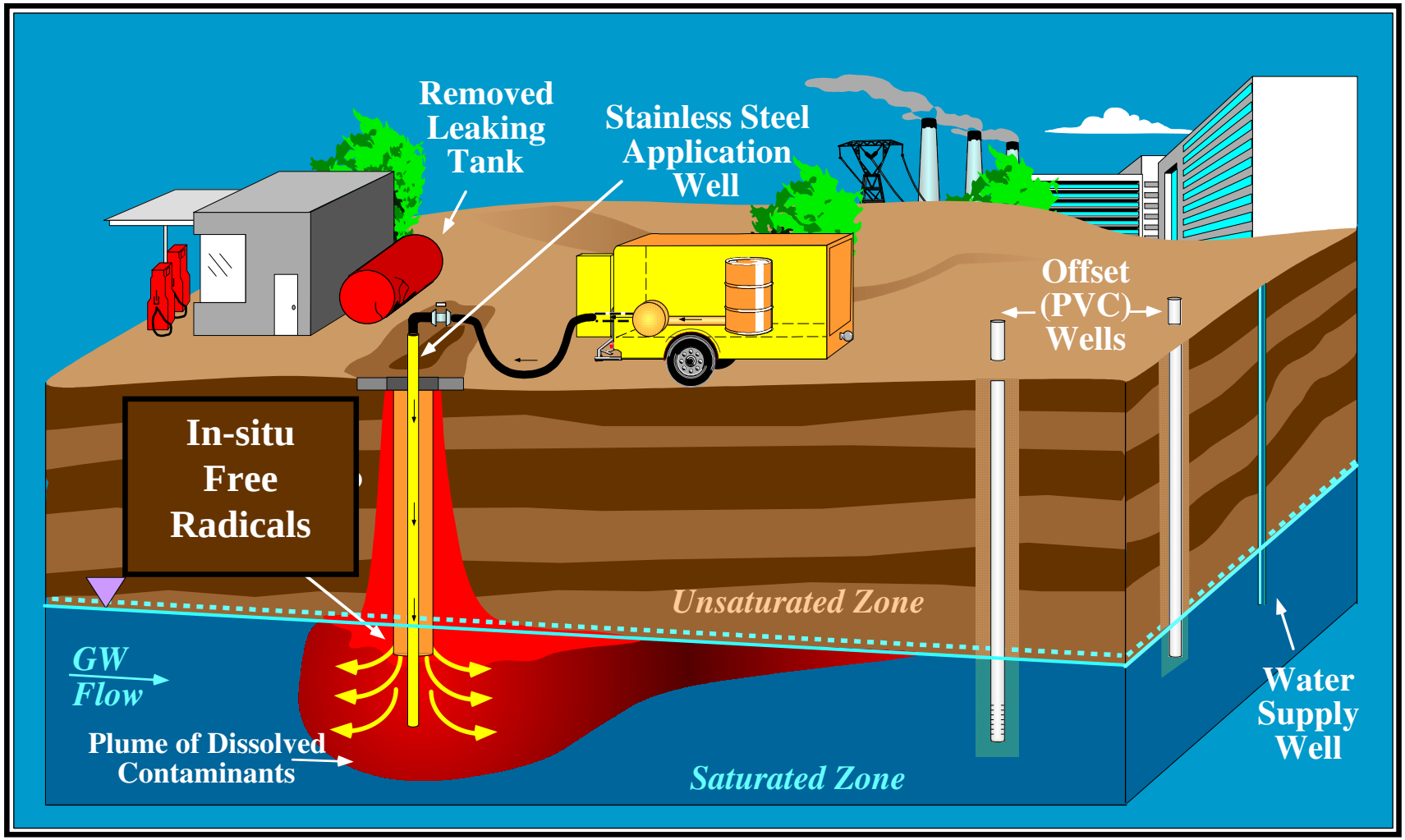
$$CO_2 + H_2O + \text{Heat}$$

Total Contaminant Mass Desorption Process



- **Dissolved**
- **Absorbed**
- **Non-aqueous**

ISCO Process Diagram



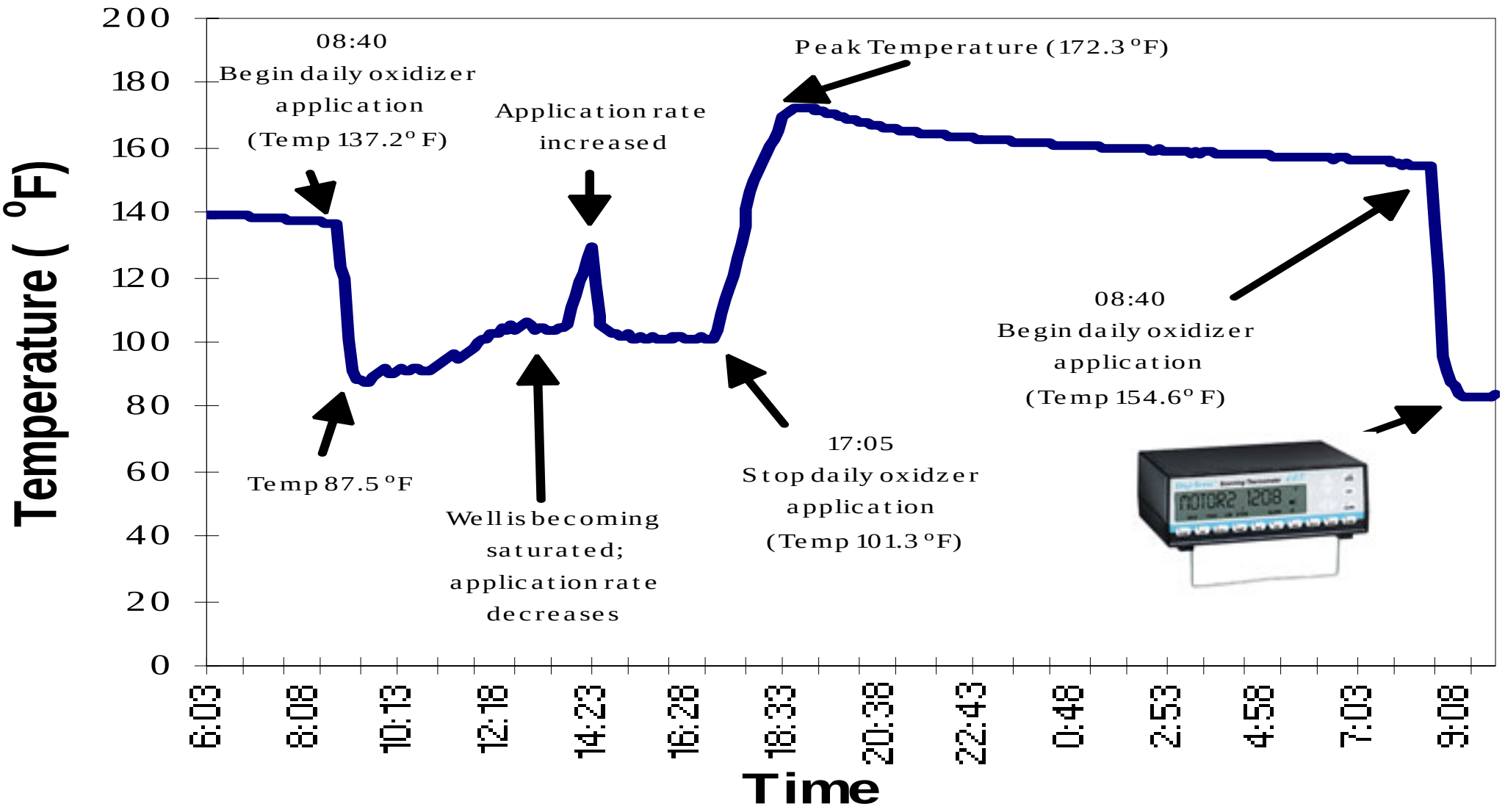
Health & Safety Precautions

- **Experienced Trained Personnel**
- **Sequential Reagent Application**
- **Low Pressure (Siphoning)**
- **Low Peroxide Concentration**
- **Proactive Field Data Monitoring**
- **In-situ Thermocouples**

Groundwater Optimization

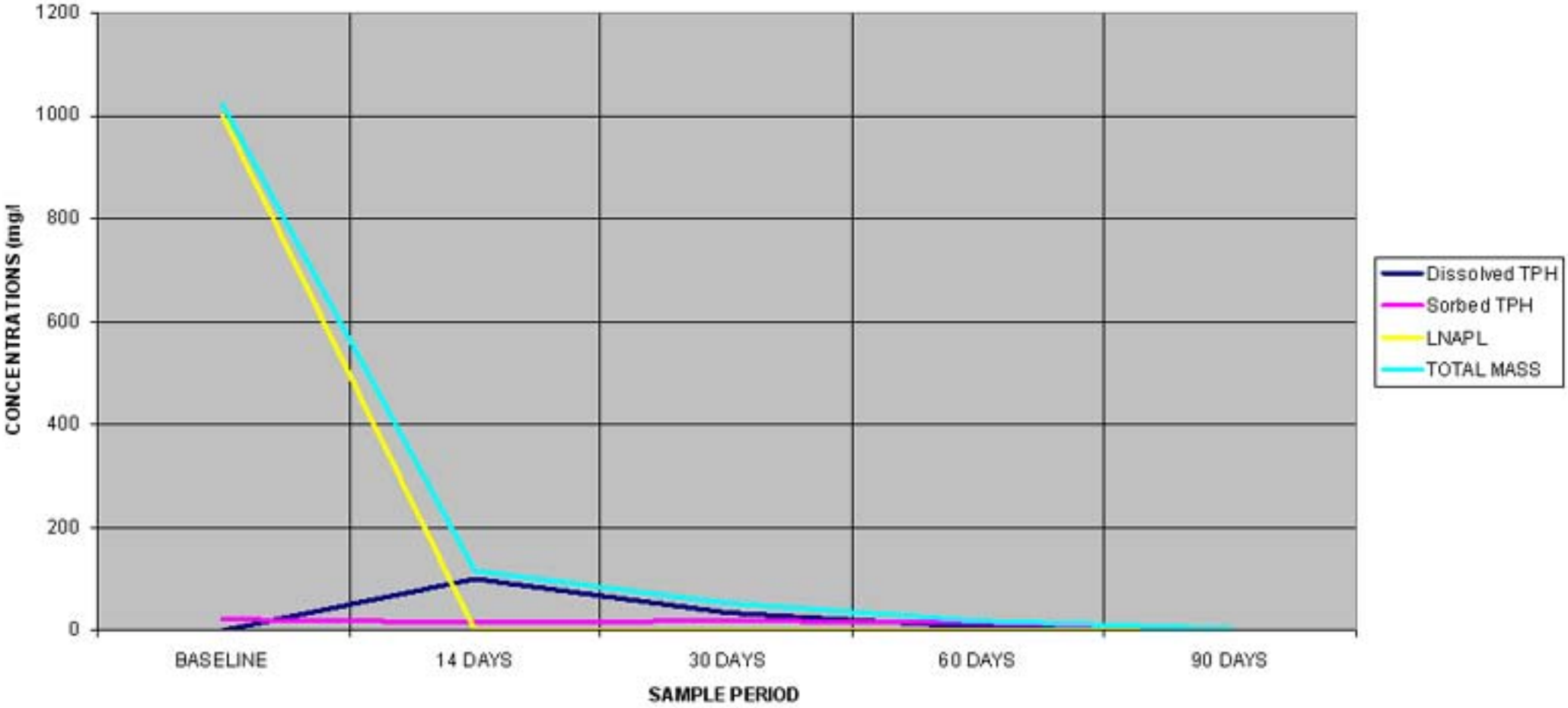
- **180-212ºF** High Temperature Range (excessive decomposition of peroxide)
- **140-170ºF** Optimal Temperature Range (optimal phase transfer desorption)
- **75-95ºF** Low Temperature Range (dissolved phase rebound problems)

MECX Temperature Trend



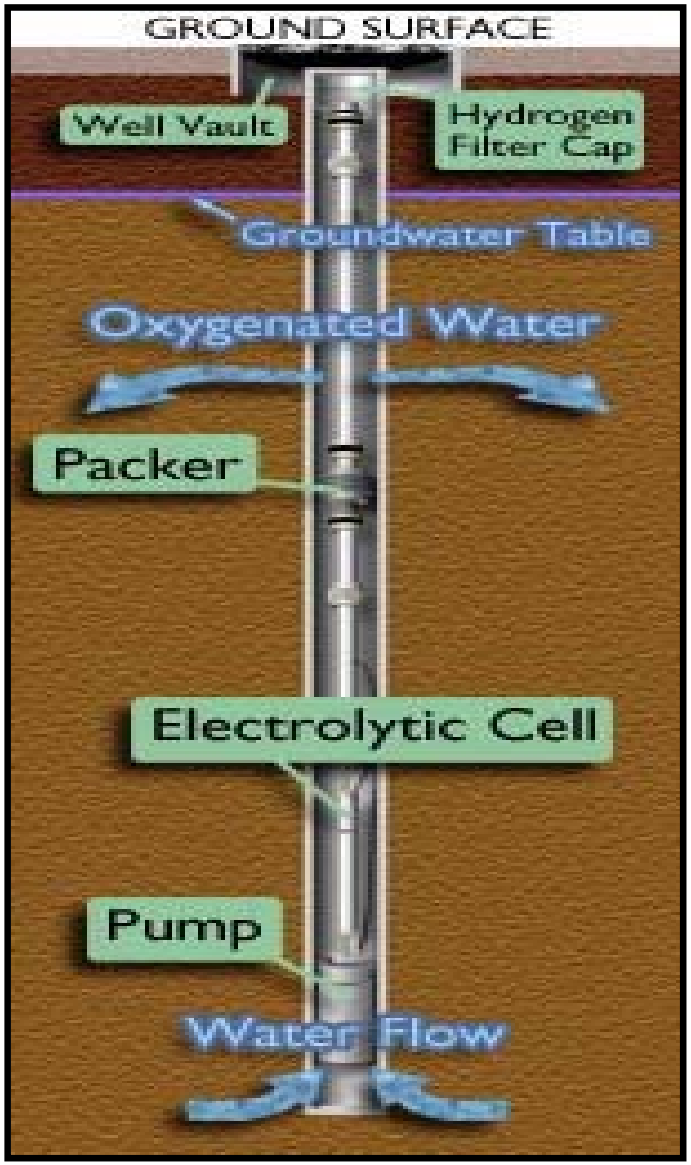
Chemical Oxidation

PETROLEUM HYDROCARBON SITE
TOTAL MASS DISTRIBUTION



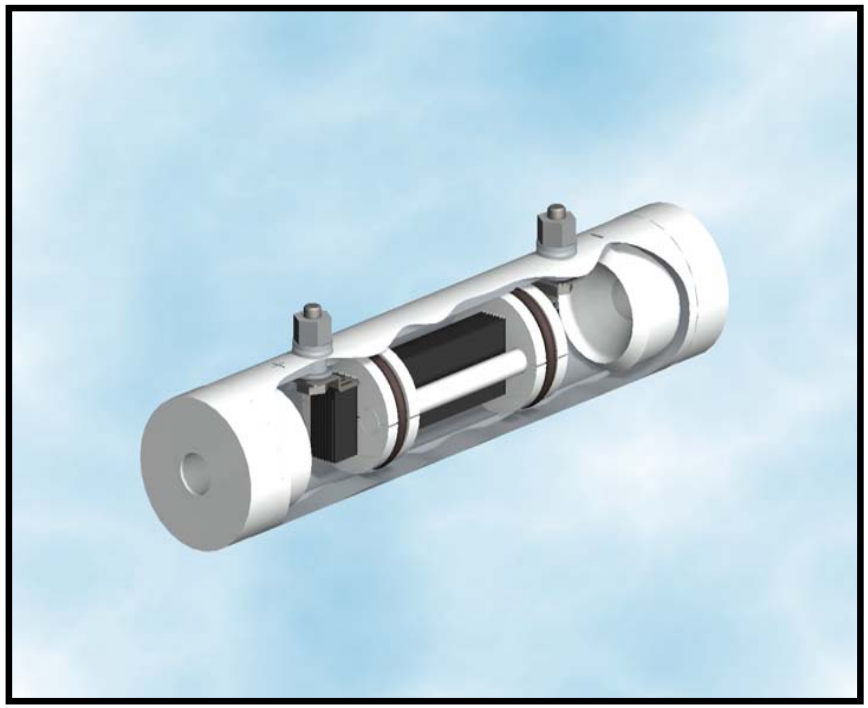
Desorption (Adsorption vs. Absorption)

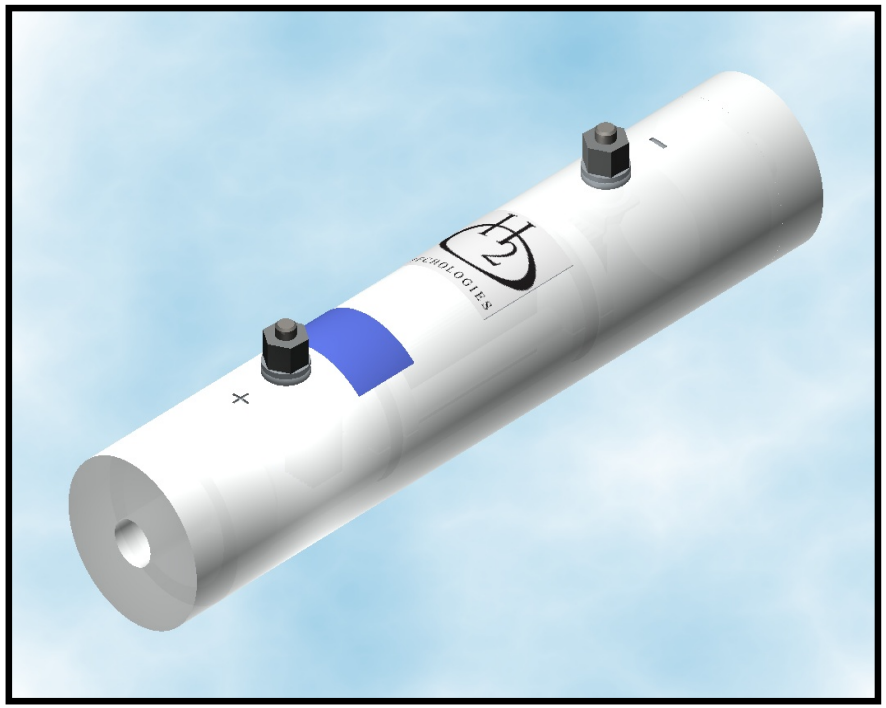
Dissolved Oxygen Diffusion



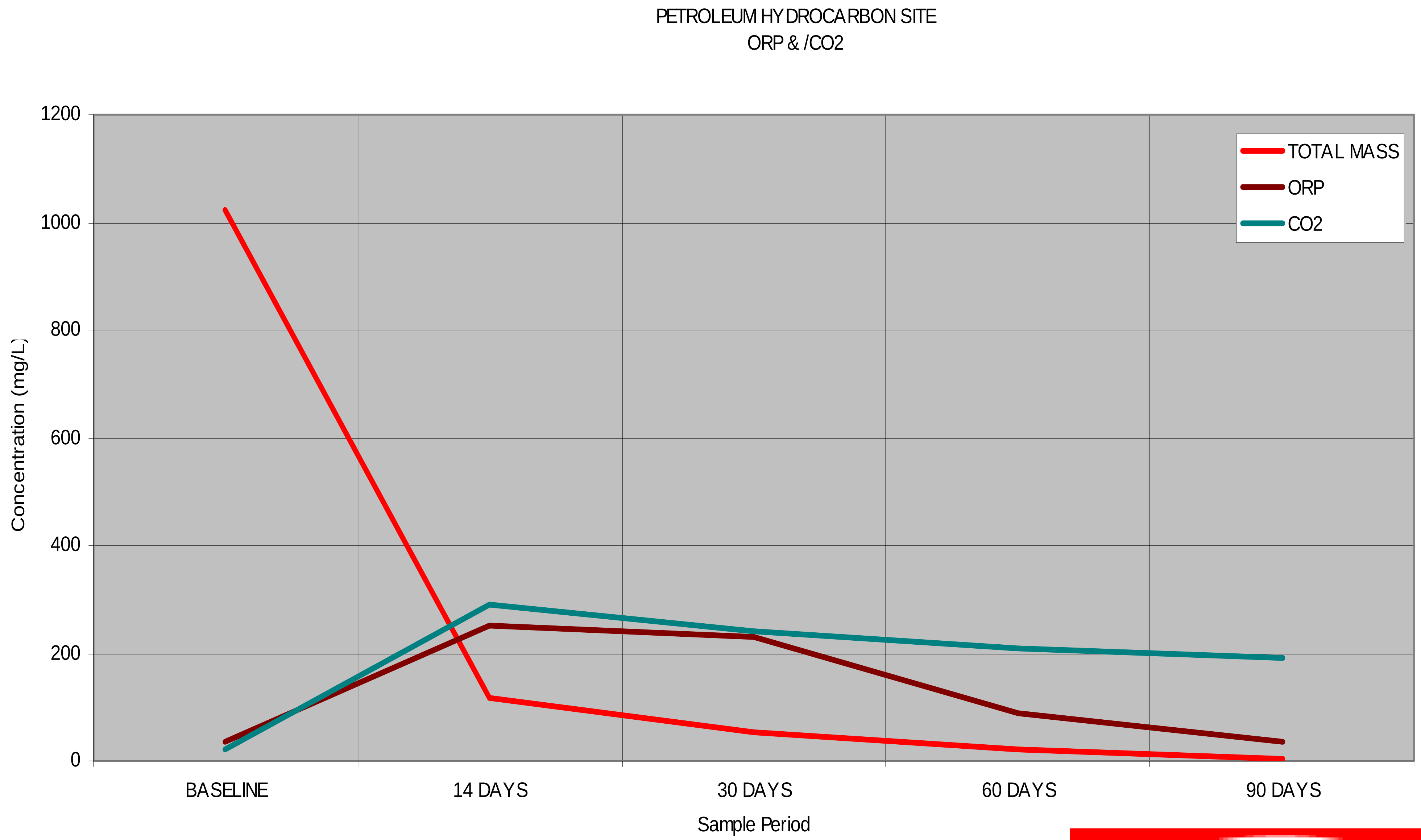
ENVIRONMENTAL H_2

Iso-Gen®





ENVIRONMENTAL H_2 ™


PETROLEUM HYDROCARBON SITE
ORP & /CO2
TOTAL MASS
ORP
CO2
Concentration (mg/L)
1200
1000
800
600
400
200
0
BASELINE
14 DAYS
30 DAYS
60 DAYS
90 DAYS
Sample Period

MECX Remedial Process

Pensacola Florida DOT Project

Achieved Florida MCL Criteria


CORROSIVE
8
HOT

ALL-WEATHER APPLICATION STYRENE NAPL

East Windsor, New Jersey

Los Angeles, California

- **High Traffic Area**
- **Sensitive Receptors**
- **Silty-Clay Soil**
- **CA Health Based Levels**

Lake Worth, Florida

Limited Site Access

Fiber Optics Sanitary Sewer

GASOLINE STATION (WISCONSIN)

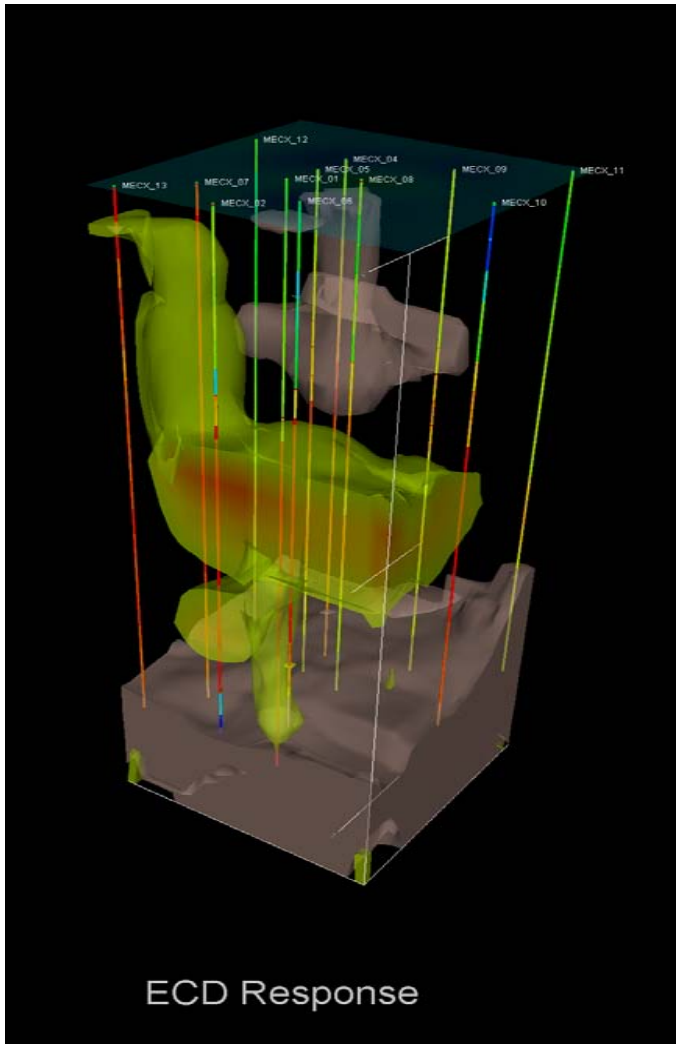
Location	Measured Free Product Thickness (H*o*)		Calculated Adjacent Formation Thickness (H*f*)	
	Feet	cm	Feet	cm
Pre-ISCO				
OW-5	0.74	22.56	0.49	15.06
OW-12	0.00	0.00	0.00	0.00
IW-1	0.00	0.00	0.00	0.00
IW-2	0.80	24.38	0.55	16.88
Post-ISCO				
OW-5	0.01	0.30	0.01	0.30
OW-12	0.00	0.00	0.00	0.00
IW-1	0.00	0.00	0.00	0.00
IW-2	0.00	0.00	0.00	0.00

Silty Sand Site

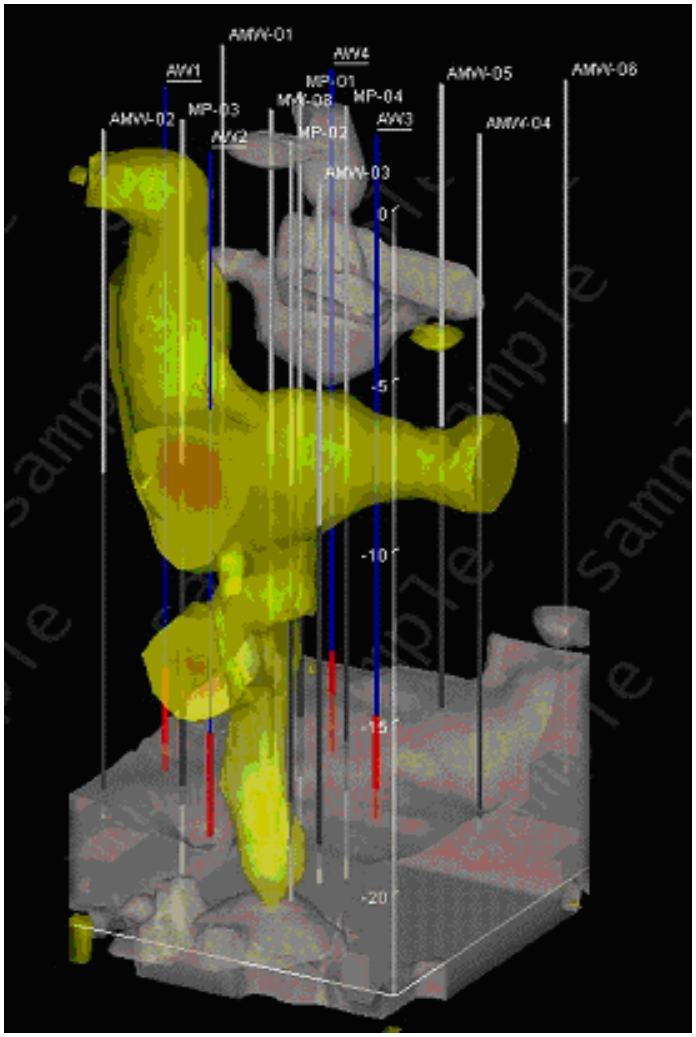
MECX Project Phases

1. **Bench test determines reagent formulation & applicability on soil & groundwater**
2. **Pilot phase field application in selected source area or hot spots**
   - **Verify reagent formulation for full-scale**
   - **Verify aquifer response & radial influence**
   - **Reduce contaminants within treatment area**
3. **Full-scale design and application**
   - **Optimize well placement, screened interval, & reagent formulation**

Site Characterization



Pre-ISCO



Post-ISCO

ISCO TECHNOLOGY PERFORMANCE

- ★ Mass Contaminant Destructions
- ★ Capabilities/Benefits
- ★ Limitations
- ★ Risks

POST-TREATMENT CONSIDERATIONS

- ★ Post-Treatment Contaminant Mass
- ★ Byproducts
- ★ Natural Attenuation Potential
- ★ Institutional/Management Considerations

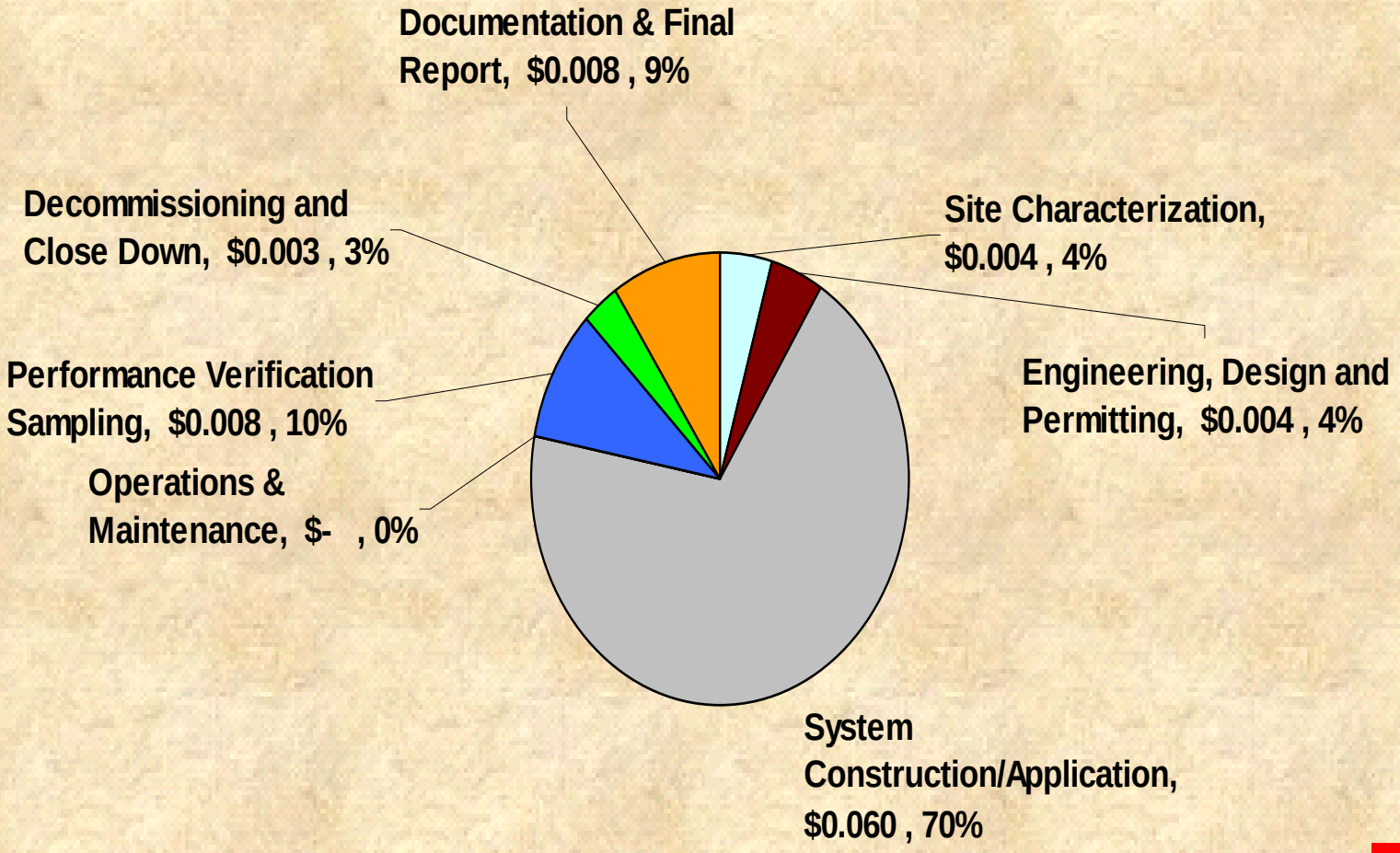
POST-TREATMENT SUBSURFACE CONDITIONS

- ★ Soil Matrix Effects
- ★ Effects of Natural Conditions on Treatment Effectiveness
  - – Minerals
  - – Native TOC
  - – Native Geochemistry
  - – Aquifer Heterogeneity

OPERATION & MAINTENANCE

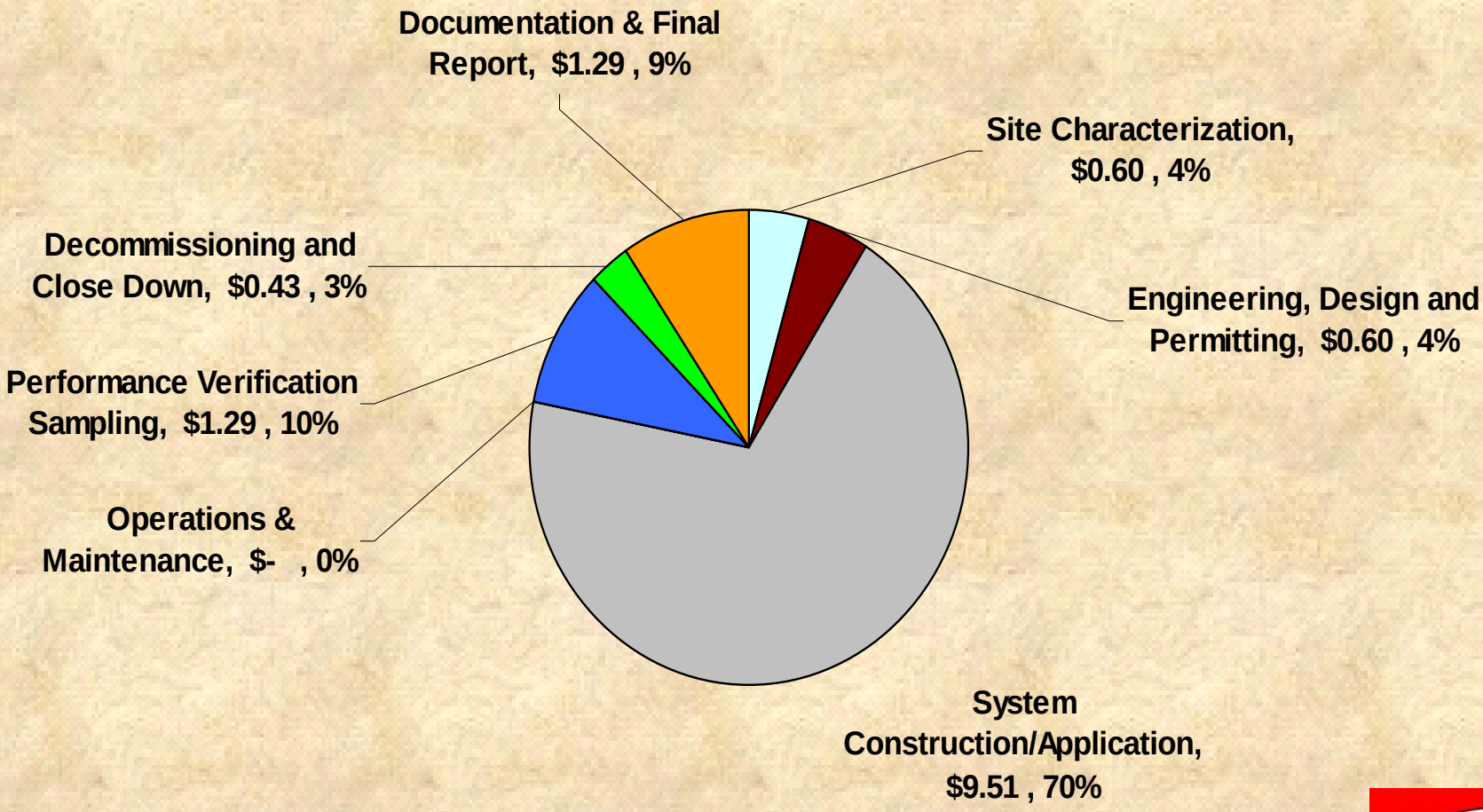
- ★ Pre-ISCO NAPL Removal (Traditional Methods)
- ★ Off-Gas
- ★ Land Use Considerations
- ★ Existing Subsurface Structures
- ★ Worker/Community Safety
- ★ Pilot Test Infrastructure Requirements
- ★ Pilot Duration
- ★ Scaling Up

MECX ISCO Field Pilot Program
Cost Per Kilogram of Contaminant Removed



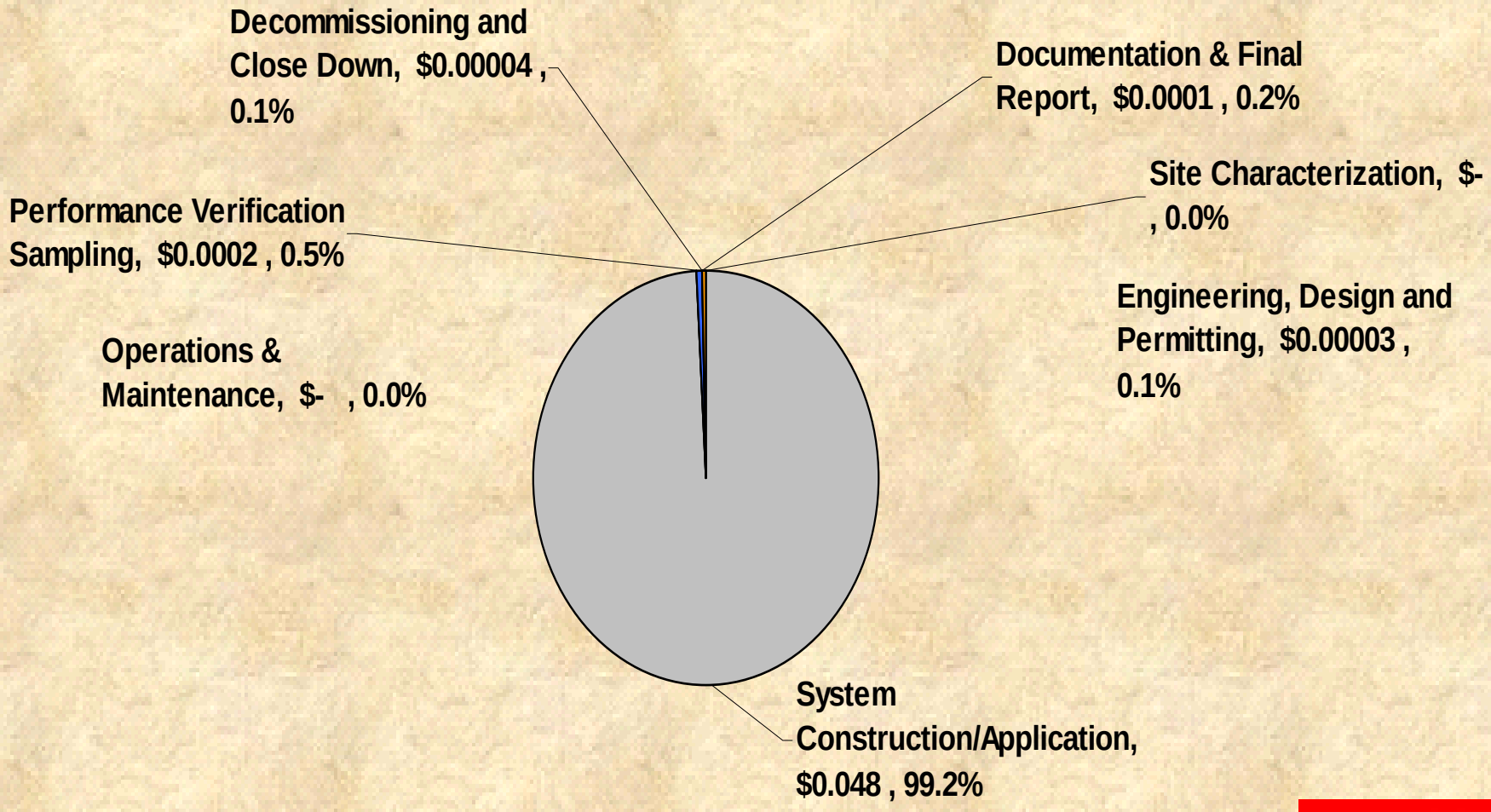
These costs are site-specific to the Casper site and are based on a significant set of assumptions. The prices are not universal to other sites/situations and should not be construed as a rule of thumb or other standard price.

MECX ISCO Pilot Field Program
Cost Per Cubic Yard of Smear Zone Treated



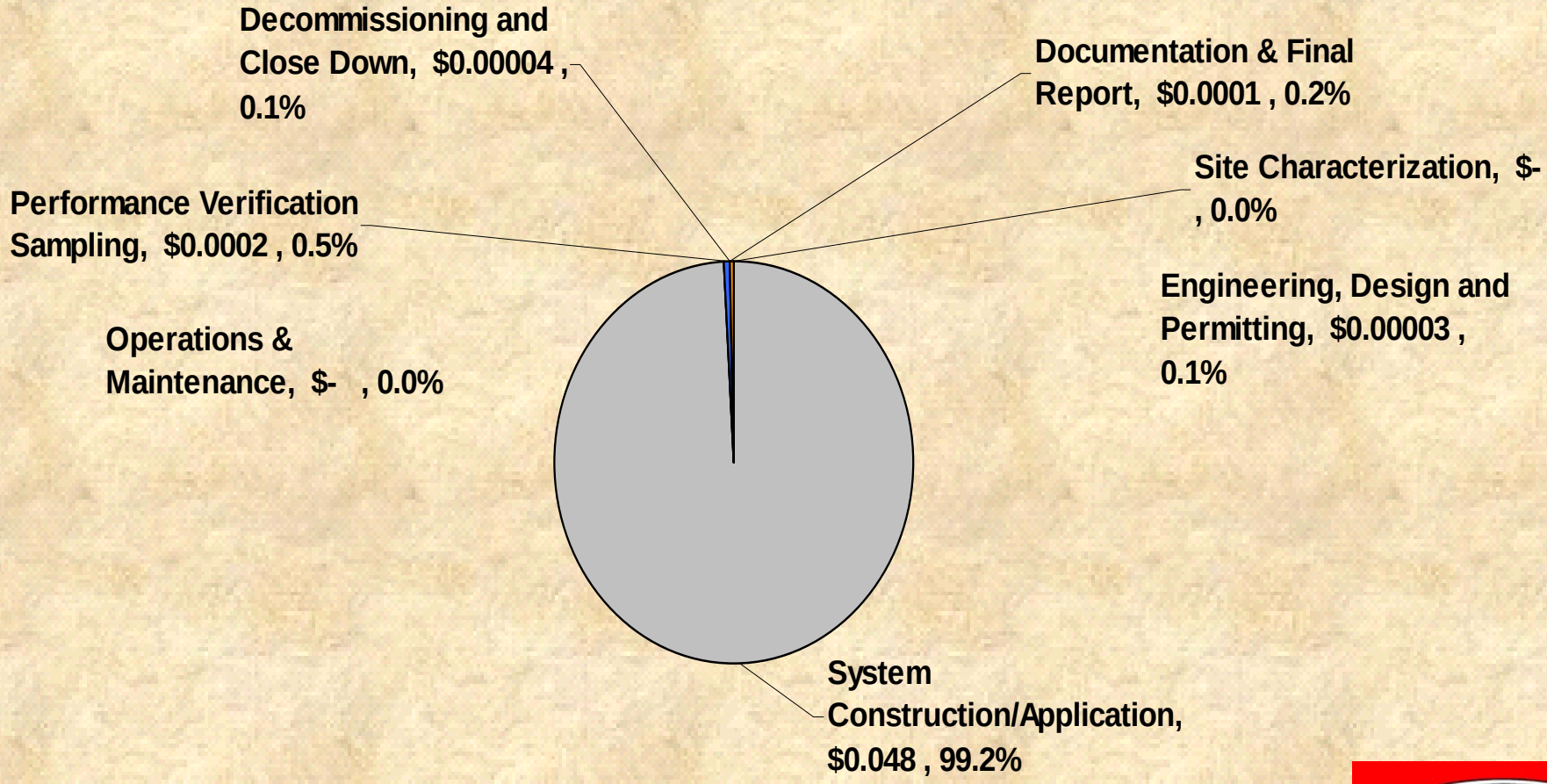
These costs are site-specific to the Casper site and are based on a significant set of assumptions. The prices are not universal to other sites/situations and should not be construed as a rule of thumb or other standard price.

MECX ISCO Full Scale Program
Cost Per Kilogram of Contaminant Removed



These costs are site-specific to the Casper site and are based on a significant set of assumptions. The prices are not universal to other sites/situations and should not be construed as a rule of thumb or other standard price.

MECX ISCO Full Scale Program
Cost Per Cubic Yard of Smear Zone Treated



These costs are site-specific to the Casper site and are based on a significant set of assumptions. The prices are not universal to other sites/situations and should not be construed as a rule of thumb or other standard price.

For additional information contact:

Richard T. Cartwright PE, CHMM

Isaac M. Aboulafia PE

MEC^{X}, LLC

Phone: (713) 412-9697

Email: richard.cartwright@mecx.net

www.mecx.net