



Combined Remedies

Jim Cummings

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Disclaimer

- Mention of Technology Vendors or Case Studies is for illustrative purposes only and does not constitute an endorsement



Combined Remedies – The ‘New Normal’

- Growing awareness that different tools may be most suitable to address different contaminant phases/ concentrations in different site ‘compartments’



‘Cut Off the Head and the Tail Will Die’

- It is Absolutely True that Addressing Source(s) is Essential
- Source Treatment is Necessary, But Not Necessarily Sufficient
 - Especially at sites where response was delayed
 - EPA MNA Guidance Expects Source Zone Treatment



Approaches

- **Temporal** – Adjust/change technologies at appropriate changeover points
- **Spatial** – Treat different zones with different technologies
- **'Package Deals'** – Some tools have more than one mechanism of action in a single product



Examples (Not Exhaustive)

- Thermal + Thermal
- Thermal + Bio
- Thermal + ISCO + Bio
- ISCO + ISCO
- ISCO + Bio
- **ISCO + ISCR... (Say What...?)**
- Surfactant + ISCO
- ISS + ISCO//ISS + Ex Situ Thermal Desorption
- Ex Situ + In Situ

Credit...



NAVFAC
Naval Facilities Engineering Command

ENGINEERING SERVICE CENTER
Port Hueneme, California 93043-4370

TECHNICAL REPORT
TR-2279-ENV

**FINAL REPORT – COST AND PERFORMANCE REVIEW OF
ELECTRICAL RESISTANCE HEATING (ERH) FOR
SOURCE TREATMENT**

Prepared by
Arun Gavaskar, Battelle
Mohit Bhargava, Battelle
Wendy Condit, Battelle

Prepared for
Naval Facilities Engineering Service Center

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Printed on recycled paper





Excerpt from NAVFAC Report Executive Summary

- “In addition to volatilization and steam stripping, *enhanced biodegradation and other abiotic reactions at elevated temperatures were an active mechanism at all five sites.*”

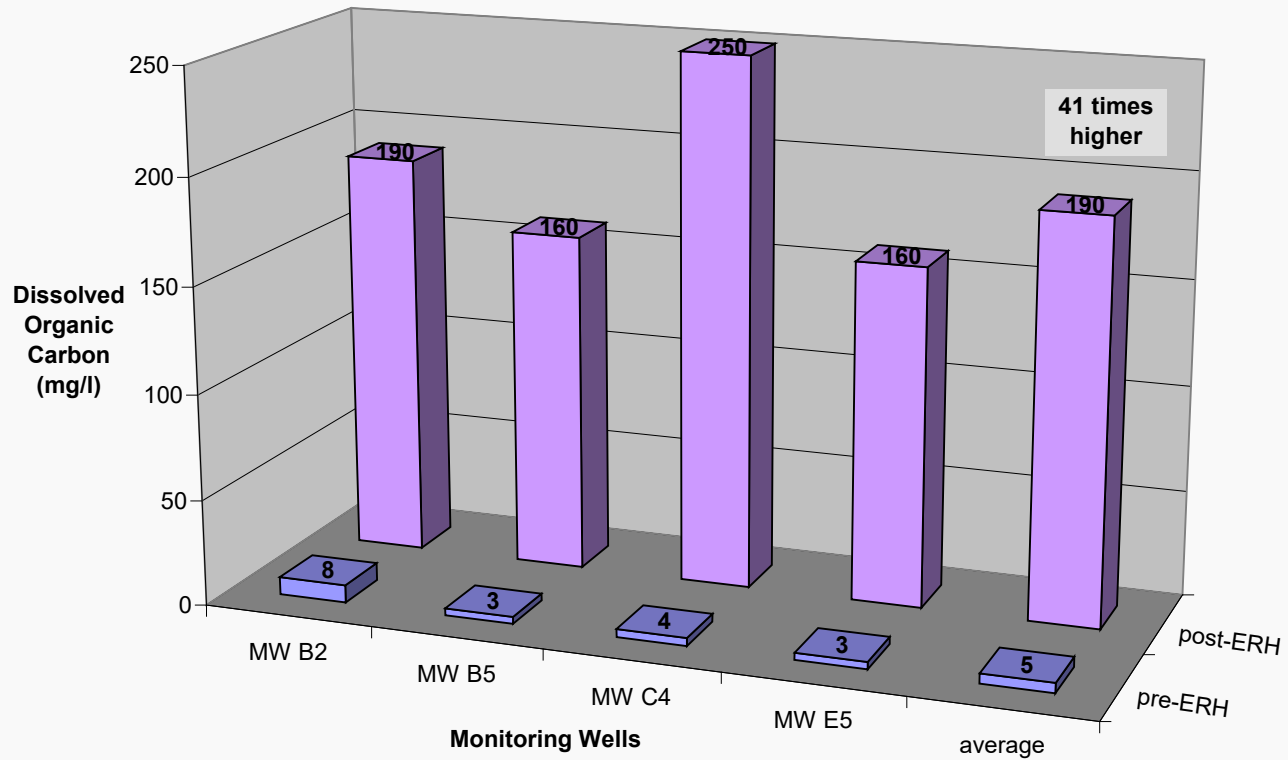


'Synergies'

- Thermal Source Zone – and ISCO - remedies can release Bio-available dissolved phase carbon
- Dechlorinating micro-organisms thrive at 30-35 C



Effect of ERH on Groundwater Dissolved Organic Carbon





In Situ Chemical Oxidation Vendors Have Morphed Into Chem+Bio Firms



In Situ Chemical Oxidation (ISCO) + Bio

- **‘...it is now clear to many that chemical oxidation is best coupled with accelerated bioremediation for more successful site management.’**

– *Regenesis ReGenOx Product and Design Manual*



FMC Corp^{}. -*Press Release***

- **FMC Launches Klozur[®] CR, A Combined Remedy Product That Couples Chemical Oxidation Plus Enhanced Aerobic Bioremediation**
- **** - Now Evonik**



‘Package Deals’

- “Following placement of EHC into the subsurface environment, **a number of physical, chemical and microbiological processes (*emphasis added*)** combine to create very strong reducing conditions that stimulate rapid and complete dechlorination of organic solvents and other recalcitrant compounds...”



Combined Remedies - Case Studies



Pemaco Solvent Site, Maywood, Ca

Fund-lead NPL Site

Pemaco Tank Removal





Pemaco Remedy Components

- **Dual Phase Extraction (DPE)** for shallow zone
- **Electrical Resistance Heating (ERH)** for >10ppm TCE contour at 35-100'
 - Flameless Thermal Oxidizer (FTO) for off-gas treatment – Community concerns about dioxin formation
- **Vacuum Enhanced Pump and Treat** for GW zone outside 10ppm contour
- **Enhanced In Situ Bio (EISB)** for down/cross-gradient zones



Grants, NM Dry Cleaner NPL Site – Inhabited Building

PROBLEM COMPONENT

Vapor Intrusion

Source Areas

Shallow Plume Core and Hot Spot

Shallow GW Plume periphery

Deeper GW Plume

REMEDY

Mitigation

**In Situ
Thermal Treatment**

**In Situ Chemical
Oxidation
and/or follow-on ERD***

ERD Bio-Barrier

ERD Bio-Barrier

*** Enhanced Reductive Dechlorination (Bio)**



ISCO+ISCO+Removal - Future Home of Orlando Magic NBA Team

- **Peroxide** – Cheap, Strong Oxidant
- **Permanganate** – Persistent Oxidant
- **Removal** – They (finally) found the source

- **Guaranteed, Fixed Price (50% at risk if MCL's not achieved)**
- **MCL's achieved/maintained**



Phased Remediation

- Catalyzed peroxide
 - Primary Source Reduction
- Permanganate
 - Polish to MCLs
 - Prevent back-diffusion
- Soil removal
 - 2 areas x 900 cu ft each





Floor Drain Pipe – Likely Source



Why Did They Keep Looking? – Guaranteed Fixed Price Contract. 50% of profit at risk if MCLs not maintained.



Closing Thought

- **How** You Do the Cleanup is As Important as **What** Tools You Use.
- **Flexible, Adaptive, Attentive**
 - *“Remedy Implementation Is Just the Next Phase of Site Characterization”*
 - *“Sources Begin To Reveal Themselves as the Remedy Progresses”*



Contact Information

Jim Cummings

cummings.james@epa.gov

202-566-0860

www.clu-in.org