

# LESSONS LEARNED FROM FIELD-SCALE RDX BIOREMEDIATION AT THE IOWA ARMY AMMUNITION PLANT: Comprehensive Analysis of Treatment and MNA Determination Assisted with Advanced Microbiological Tools

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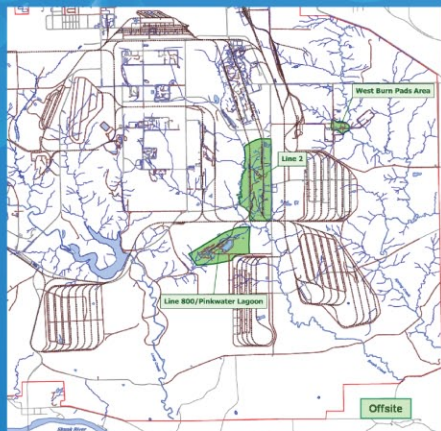
## SITE INFORMATION

### The Facility - Iowa Army Ammunition Plant (IAAAP)

- Government-owned, contractor-operated facility (American Ordnance)
- 19,000 acres in Middletown, Iowa
- 1941: Beginning of munition production at IAAAP
- Current production activities include loading, assembling, and packaging of munitions
- One-third of IAAAP occupied by active or formerly active production/storage facilities
- Contamination of soil and groundwater onsite and offsite
- 1990: Placed on Superfund National Priorities List
- 2004-Present: Tetra Tech in charge of remediation

### Onsite Groundwater 3 Locations HFCS Amendment

- Line 2, Line 800, West Burn Pads
- DPT injection grid
- 2 injection campaigns (2007-2009)
- Concentrations up to 4910 µg/L
- Up to 99.9% RDX reduction



### Offsite Groundwater Acetate Amendment

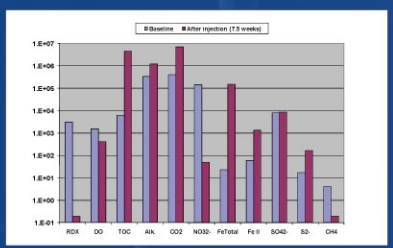
- Upgradient transect injection
- 5 injection campaigns (2007-2009)
- Concentrations up to 118 µg/L
- Up to 90.2% RDX reduction

### Common Site Characteristics

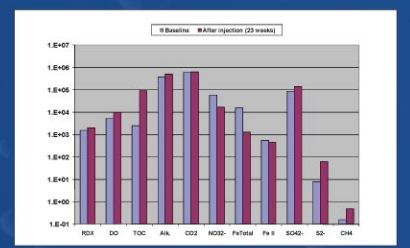
- Aerobic and oxidative aquifer
- Low TOC (1 - 2 mg/L)
- Moderate to very high nitrate (1 - 481 mg/L)
- Adequate microbial inventories (> 10<sup>4</sup> cells/mL)

## DATA ANALYSIS

### Best Case Scenario



### Worst Case Scenario



### Microbial Activity

**F.I.S.H. (Fluorescence In Situ Hybridization)**

**Microbial Profile at WBP-TTMW-11**

**T.R.F.L.P. (Terminal Restriction Fragment Length Polymorphism)**

Greater resolution and rapidity than DGGE

Demonstrated that:

- Microbial communities were similar prior to biotreatment
- Significant shift in microbial diversity after injections

Microbiological database currently being analyzed for patterns

Groundwater biota concentrated by filtration on membrane filters

DNA extracted using commercial kit

16S Prokaryote PCR

Restriction digestion of PCR product

Fragment size determined using automated DNA sequencer

Phylogroups assigned based on predicted peak sizes

**HFCS and acetate both promoted microbial growth and spurred shifts in microbial diversity**

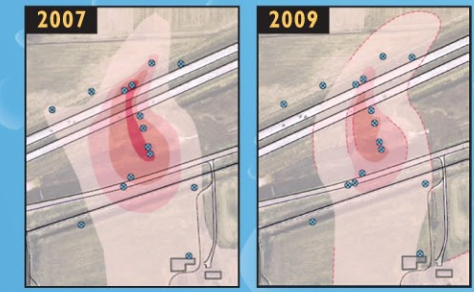
### Parameters of Interest

- Amendment Efficiency HFCS vs. Acetate** → Both able to yield reducing conditions. Dosage needs to be commensurate with nitrate inventory.
- Injection Method Transect vs. DPT** → DPT is preferred for more uniform delivery of the substrate, on wider area.
- Degradation Method RDX, MNX, DNX, TNX** → Reliance on nitroso degradation by-products (MNX, DNX, TNX) severely underestimates treatment efficiency.
- Geochemical**
  - Nitrate → Nitrate removal is paramount to efficient RDX destruction.
  - Iron (II/III) → High levels of iron favor RDX depletion.
  - Sulfate → Sulfate reduction (methanogenesis) did not seem to interfere with RDX biodegradation.
  - Methane → Alkalinity increases correlated with TOC, may indicate increased microbial metabolism/RDX mineralization.
  - Alkalinity →

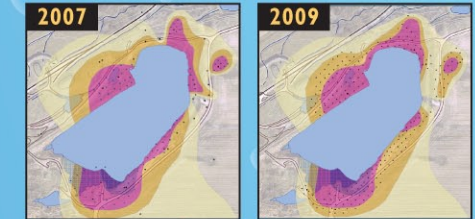
## CONCLUSIONS

## RDX PLUMES

### Offsite



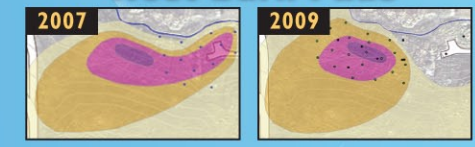
### Line 800



### Line 2



### West Burn Pads



### Plume Legend



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