



## CATALYZED PERSULFATE OXIDATION TREATMENT - **UPDATE**

### FORT BELVOIR MILITARY GARRISON BUILDING 324 - NORTHERN VIRGINIA

**Clients:** SpecPro, Inc.  
Mactec Engineering and Consulting, Inc.  
US Army Corps of Engineers

**Contaminants:** Total Petroleum Hydrocarbons - Gasoline Range Organics

**Impacted Matrix:** Saturated Soils and Ground Water

**Augmentations:** Catalyzed Persulfate (Klozur™) and Proprietary Catalyst



#### PROJECT OVERVIEW:

Specialty Earth Sciences, LLC was contracted to provide the rapid reduction of BTEX hydrocarbon mass present within impacted soils and ground water at the Building 324 site, inside the Fort Belvoir Garrison.

In-situ persulfate oxidation was selected as an aggressive supplement to current mechanical methodologies (6 years of operation, 2002-present; dual phase extraction - DPE) to attain an accelerated site closure.

#### SITE BACKGROUND:

The Building 324 site is a military generator testing and research facility located south of Beach Road on the U.S. Army Garrison Fort Belvoir, in Fairfax County, Virginia. The target area of concern is a former fuel tank farm, located south of and adjacent to Building 324. Historical fuels included gasoline, diesel, fuel oil and jet fuels (e.g., JP5, 6, 7 and 8).

Tank farm closure activities (1996) and subsequent site characterization investigations revealed extensive liquid phase hydrocarbon (LPH) impact and wide spread dissolved phase total petroleum hydrocarbon (TPH) impact of soils and ground water.

### PERSULFATE OXIDATION TECHNOLOGY OVERVIEW:

Persulfates are the most powerful oxidants of the peroxygen family. They exist as salts and are available in a sodium, potassium, or ammonium form. Persulfates are commonly used for many industrial purposes including cosmetics and pharmaceuticals (such as the preparation of antibiotics). The use of persulfates in ground water treatment applications is a relatively new technology, developed for use with contaminants that are typically not amenable to oxidation using other, more traditional oxidants such as ozone or permanganate.

Modified advanced oxidation technology (*mAOT-persulfate*) relies on the enhanced delivery of a catalyzed persulfate compound within the subsurface providing recalcitrant contaminant remediation; with final benign reaction products of carbon dioxide, water, inorganic salts, and chloride ions via free radical and anion radical processes.

Sodium persulfate is very stable and can persist in an optimum ground water environment for substantial lengths of time. The long lasting effects of the oxidant compound coupled with its high level of solubility can typically provide greater in-situ influence than more traditional oxidant compounds.

### PERSULFATE OXIDATION INJECTION EVENT:

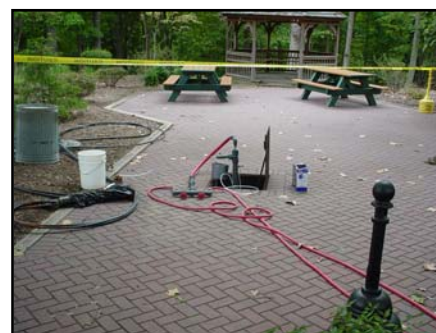
Chemical injections were implemented for a period of one week utilizing a combination of Klozur™ persulfate oxidant, hydrogen peroxide, and proprietary catalyst solution; in conjunction with Subterranean Hydrocarbon Oxidation Circulation (SHOC) in-situ delivery techniques. Inoculate mixtures and concentrations were derived from historical site data, site geology, stoichiometry, FMC (Klozur™ persulfate manufacturer) correspondence, and experience at similar sites within the region.

A total of 5,225 lbs. of sodium persulfate, 1,000-*approx.* of hydrogen peroxide, and 975 lbs.-*approx.* of hydrated proprietary catalyst compounds were injected into the subsurface formation (42' - 47' vertical interval) over the course of a 5 day period (Aug. 26 - 30, 2007).

The subsurface formation consisted of silty sands with intermittent cobble and gravel deposits.



MOBILE INJECTION UNIT



INJECTION POINT



INJECTION POINT



CHEMICAL STAGING AREA.

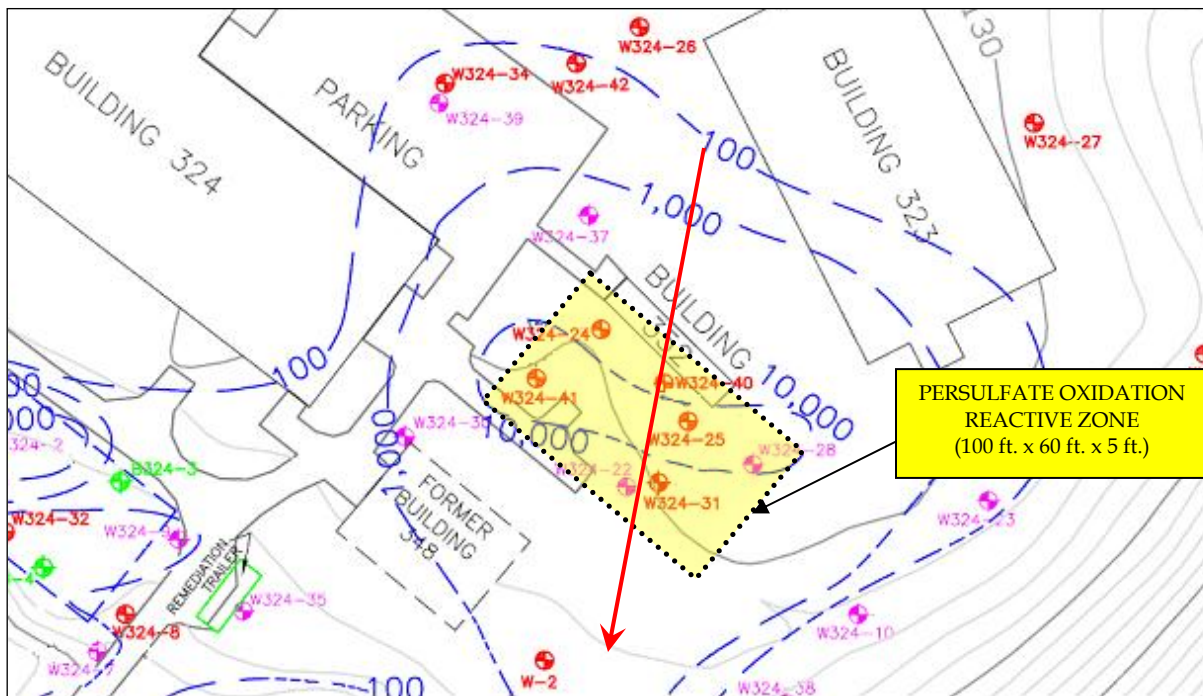
**PERSULFATE OXIDATION INJECTION EFFECTIVENESS:**

Post 7-Day and Post 30-Day: analytical results demonstrated a 99% to 88% concentration reduction (total BTEX) in 5 of the 7 monitored wells.

**NEW**

Post 100-Day: analytical results demonstrated consistency with previous concentration reduction levels in 6 of the 7 monitored wells.

Monitored well W324-40 demonstrated a significant BTEX concentration increase during the 100-Day sampling event; indicating the need for persulfate reactive zone expansion to include areas beneath and upgradient of building 352, suspected of additional BTEX impact.



**TOTAL BTEX BASELINE CONCENTRATION ISOPLETH MAP  
WITH PERSULFATE OXIDATION REACTIVE ZONE; AND HISTORIC  
GROUND WATER FLOW DIRECTION.**

W324-22	Sample Date	Benzene	Toluene	Ethylbenzene	Xylenes	Total BTEX
	12/5/2007	58	5.3	11	6.5	81
	9/27/2007	<2.0	<2.0	3.5	4.9	8.4
	9/7/2007	<1.0	<1.0	5.9	1.0	6.9
	<i>Persulfate Oxidation Event (8-26-07)</i>					
	4/2/1999	7,820	6,080	1,930	8,260	24,090
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W324-24	Sample Date	Benzene	Toluene	Ethylbenzene	Xylenes	Total BTEX
	12/7/2007	150	18	19	<5.0	187
	9/27/2007	310	350	280	1,000	1,940
	9/7/2007	58	<2.5	28	<2.5	86
	<i>Persulfate Oxidation Event (8-26-07)</i>					
	6/6/2007	3,100	4,200	1,400	7,200	15,900
	3/19/2007	2,900	4,300	1,400	7,100	15,700
	6/22/2006	6,000	8,100	1,900	8,200	24,200

W324-25	Sample Date	Benzene	Toluene	Ethylbenzene	Xylenes	Total BTEX
	12/5/2007	260	1,400	180	720	2,560
	9/27/2007	180	<20	40	340	120
	9/7/2007	<1.0	7.2	<1.0	9.8	2.6
	<i>Persulfate Oxidation Event (8-26-07)</i>					
	6/6/2007	4,600	7,100	1,800	8,000	21,500
	3/19/2007	2,200	1,600	1,300	5,300	10,400
	6/22/2006	1,800	3,000	1,200	5,500	11,500

W324-28	Sample Date	Benzene	Toluene	Ethylbenzene	Xylenes	Total BTEX
	12/5/2007	29	140	69	260	498
	9/27/2007	83	160	140	280	663
	9/7/2007	30	<1.0	<1.0	<1.0	30
	<i>Persulfate Oxidation Event (8-26-07)</i>					
	3/12/2002	4,000	5,600	1,100	4,400	15,100
	3/22/2000	9,100	28,000	2,100	10,000	49,200
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W324-31	Sample Date	Benzene	Toluene	Ethylbenzene	Xylenes	Total BTEX
	12/5/2007	850	<50	640	2,200	3,690
	9/27/2007	1,300	<100	780	4,100	6,180
	9/7/2007	1,400	89	750	3,200	5,439
	<i>Persulfate Oxidation Event (8-26-07)</i>					
	6/6/2007	1,500	100	800	4,500	6,900
	3/19/2007	950	370	300	1,400	3,020
	6/22/2006	550	180	610	3,700	5,040

W324-40	Sample Date	Benzene	Toluene	Ethylbenzene	Xylenes	Total BTEX
	12/7/2007	2,800	4,000	1,300	6,400	14,500
	9/27/2007	9.3	<1.0	4.6	9.5	23.4
	9/7/2007	11	<1.0	2.1	<1.0	13.1
	<i>Persulfate Oxidation Event (8-26-07)</i>					
	6/6/2007	2,900	540	460	2,100	6,000
	6/22/2006	280	480	110	640	1,510
	6/15/2005	3,400	3,000	2,400	11,000	19,800

W324-41	Sample Date	Benzene	Toluene	Ethylbenzene	Xylenes	Total BTEX
	12/7/2007	1,500	2,200	1,100	4,900	9,700
	9/27/2007	1,800	2,000	920	4,200	8,920
	9/7/2007	2,200	2,200	1,100	4,700	10,200
	<i>Persulfate Oxidation Event (8-26-07)</i>					
	6/6/2007	24	62	17	100	203
	6/22/2006	2,300	3,000	970	4,500	10,770
	6/15/2005	5,700	8,900	2,000	9,200	25,800

**COSTS SAVINGS:**

Projected Cost Savings (5 years):

**\$625,000**

*(\$125,000 annually; remediation system O&M, performance monitoring, and reporting)*

**CURRENT SITE STATUS:**

Larger scale application proposed to include areas beneath and adjacent to Bldg. 352.