

**SURFACTANT ENHANCED IN SITU REMEDIATION  
FORMER HESS OIL CO./ASH AND PAUL , PAUL'S VALLEY, OKLAHOMA**

In situ remediation is a specifically designed chemical treatment technology, whereby selected chemicals are sequentially injected into a targeted subsurface zone to treat phase-separated hydrocarbons (PSH) on the water table, adsorbed phase PSH in soils, and dissolved-phase groundwater contaminants leaching from those media. The injection treatments are specifically designed for each site to release PSH for chemical destruction while preventing it from migration from the source zones.

In situ remediation can be utilized at sites with limited physical access or aggressive completion schedules, eliminating some of the key obstacles of traditional remediation. Wright Environmental Services (WES) scientists have closed several remediation projects that would not have gained regulatory closure without the options in situ remediation provided. One of the benefits of in situ remediation technology is that it can be used to treat residual PSH, even in tight clay soil matrices. The residual PSH is usually a continuing source of groundwater contaminants and the primary obstacle to regulatory closure.

**BRIEF DESCRIPTION OF PROJECT:**

A former Hess Oil Co. service station in Paul's Valley, Oklahoma has been enrolled in the Oklahoma Corporation Commission's (OCC) LUST TRUST (Case #064-2090) program. The OCC has pursued multiple technologies to remediate affected soil and groundwater since 1997. Removal of the PST system and subsequent remediation work resulted in dissolved- phase petroleum hydrocarbon groundwater concentrations at acceptable at site-specific risk-based levels. However, after a decade of Mobile Dual Phase Extraction (MDPE), PSH continually and persistently recurred at measured thicknesses ranging from 0.08 ft to 0.30 ft in multiple wells in a 2,400 ft<sup>2</sup> area. Persistent recurrence of residual PSH prevented OCC site closure and issuance of No Further Action status.



**REMEDIAL IMPLEMENTATION:**

Wright was engaged to conduct Surfactant Enhanced In-Situ Chemical Remediation for the purpose of removing the persistent residual PSH within the 2,400 ft<sup>2</sup> area. The remediation was completed incorporating two distinct, synergistic technologies over a 16-day period in December of 2018. The initial treatment area was prepared by inoculating the smear zone, capillary fringe, and lower vadose zone. This treatment included 48 hand probes which injected reagents into the target zones to loosen the clay soils and desorb PSH. The second phase injected additional reagents in 28 additional hand probes, 31 GeoProbe points, and 8 previous remedial wells in the previously injected zones as well as the saturated zone. PSH desorption was immediately followed by the addition of oxidants to destroy the released PSH and associated chemicals. The treatment was specifically designed to maximize the injected oxidants' access to the PSH for its destruction. The process results were monitored in the field as they were conducted, allowing for real-time adjustments. This iterative field treatment approach prevented tight soil spots and heavily contaminated areas from avoiding a full oxidation treatment and cleanup.



## RESULTS OF REMEDIATION:

After the Surfactant Enhanced In-Situ Chemical Remediation, no measurable PSH was detected (<0.01 ft), no hydrocarbon sheen was observed, and no petroleum hydrocarbon odor was noted in any well at the Site. Removal of measurable PSH, sheen or petroleum odor has continued from 1-day post-remediation through a 90-day post-remediation gauging event. Subsequently, the site was closed by the the OCC and no further corrective actions were required.

While groundwater remediation was not a remedial goal for this site, monitoring for dissolved phase concentrations before and after treatment was conducted. Dissolved phase BTEX and TPH GRO concentrations in wells 26F and 27F (immediately below the PSH plume) were substantially higher than the average concentrations in the groundwater plume prior to treatment. Following in-situ remediation, BTEX and TPH GRO concentration reductions between 83% and 99% were achieved in both monitoring wells documenting substantial contaminant reduction. The analytical data is presented in the table below.

Table 1 – Summary of Groundwater Analysis; Pre- vs. Post- Remediation in Wells 26F & 27F

BEFORE PSH REMEDIATION		AFTER PSH REMEDIATION		REDUCTION
<b>Monitor Well 26F</b>		<b>Monitor Well 26F</b>		
sampled 12/03/18		sampled 02/04/19 48 days after completing remediation		
PSH Thickness = 0.10 ft		PSH Thickness = <0.001 ft *no sheen		100%
Groundwater Column in Monitor Well = 9.83 ft		Groundwater Column in Monitor Well = 9.89 ft		
Disposable Tubing Inlet Depth = 17.5 ft bgs		Disposable Tubing Inlet Depth = 17.5 ft bgs		
Groundwater Withdrawal Rate = 100 ml/min		Groundwater Withdrawal Rate = 125 ml/min		
Maximum Piezometric Drawdown = 12.41 ft bgs (during sampling)		Maximum Piezometric Drawdown = 12.49 ft bgs (during sampling)		
MTBE	<0.500 mg/L	MTBE	<0.050 mg/L	N/A
Benzene	0.754 mg/L	Benzene	0.123 mg/L	83.69%
Toluene	0.682 mg/L	Toluene	<0.050 mg/L 1/2 ND used for calculation	96.33%
Ethylbenzene	6.090 mg/L	Ethylbenzene	0.415 mg/L	93.19%
Xylenes (m,o &p)	50.000 mg/L	Xylenes (m,o &p)	2.270 mg/L	95.46%
TPH GRO (C6-C10)	87.400 mg/L	TPH GRO (C6-C10)	3.930 mg/L	95.50%
<b>Monitor Well 27F</b>		<b>Monitor Well 27F</b>		
sampled 12/03/18		sampled 02/04/19 48 days after completing remediation		
PSH Thickness = 0.08 ft		PSH Thickness = <0.001 ft *no sheen		100%
Groundwater Column in Monitor Well = 10.96 ft		Groundwater Column in Monitor Well = 9.83 ft		
Disposable Tubing Inlet Depth = 17.5 ft bgs		Disposable Tubing Inlet Depth = 17.5 ft bgs		
Groundwater Withdrawal Rate = 100 ml/min		Groundwater Withdrawal Rate = 125 ml/min		
Maximum Piezometric Drawdown = 12.62 ft bgs (during sampling)		Maximum Piezometric Drawdown = 12.67 ft bgs (during sampling)		
MTBE	<0.500 mg/L	MTBE	<0.005 mg/L	N/A
Benzene	0.685 mg/L	Benzene	<0.005 mg/L 1/2 ND used for calculation	99.64%
Toluene	0.660 mg/L	Toluene	<0.050 mg/L 1/2 ND used for calculation	99.62%
Ethylbenzene	13.800 mg/L	Ethylbenzene	0.015 mg/L	99.89%
Xylenes (m,o &p)	107.000 mg/L	Xylenes (m,o &p)	0.024 mg/L	99.98%
TPH GRO (C6-C10)	210.000 mg/L	TPH GRO (C6-C10)	0.731 mg/L	99.65%