

PetroFix Achieves Success at Delaware Service Station

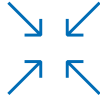
Site Closure Targets Rapidly Met
Through Innovative Remediation



Highlights



Site Type:
Commercial



Project Driver:
Offsite plume migration, within 2,000 feet of industrial pumping well



Contaminants:
Benzene up to 9,700 micrograms per liter (µg/L), toluene up to 14,000 µg/L and ethyl dibromide (EDB) of 0.05 µg/L.



Treatment:
Sorption-enhanced bioremediation along with *in situ* chemical oxidation (ISCO) applied to an excavation



Technologies:
PetroFix® and RegenOx®



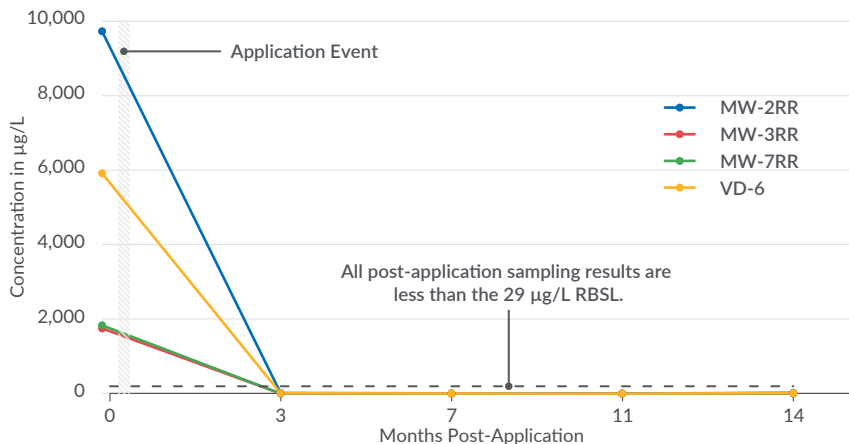
Geology:
Sand mixed with layers of low-permeability silty and clayey sand

Summary

PetroFix successfully remediated petroleum hydrocarbon contamination, first discovered in the 1980s, at a vacant, former retail service station in Delaware. The strategic application of PetroFix® through both grid and barrier injections as well as the direct application of RegenOx® during excavation of highly impacted soils, significantly reduced high concentrations of benzene and toluene, along with low levels of ethylene dibromide. These interventions brought contaminant levels below the final regulatory cleanup threshold needed to achieve site closure.

Results

- **By implementing PetroFix, the Delaware project achieved reductions in benzene, toluene, and EDB to near or below detection limits, securing an effective, long-term solution for groundwater remediation.**





Project Background

Historically utilized as a retail service station, this site had extensive contamination characterized by light non-aqueous phase liquids (LNAPL) and dissolved-phase hydrocarbons, which persisted despite previous remedial efforts spanning multiple decades, including soil excavation, pump-and-treat systems, and *in situ* chemical oxidation (ISCO).

The subsurface geology of the site featured predominantly fine to medium-grained sands interspersed with thin clay lenses. This composition, along with a fluctuating water table, complicated the effective implementation of conventional remediation methods. The heterogeneity of the soil matrix and the presence of extensive LNAPL pools required a targeted approach to remediation that could adapt to the site’s hydrogeological nuances.

The environmental challenges coupled with incomplete past interventions necessitated a shift to a more effective remedial technology. PetroFix was chosen for its proven effectiveness in numerous similar settings and its ability to be rapidly implemented.

Figure 1

Site Map

Site map depicting former UST and planned remedial excavation area.

Legend

- Monitoring Well
- Vapor Delineation Well
- Proposed Remedial Excavation
- Site Location
- Structure
- Former Tank Field
- Former Kerosene Dispenser
- Former Gasoline Dispenser
- Former UST Location



Remedial Strategy and Site Goals

Maximum Concentrations and Goals

Benzene	
Maximum Concentration Detected	9,700 µg/L
RBSL Cleanup Goal	29 µg/L
% Reduction Required	-99.7%

Toluene	
Maximum Concentration Detected	14,000 µg/L
RBSL Cleanup Goal	7,300 µg/L
% Reduction Required	-47.9%

EDB	
Maximum Concentration Detected	3 µg/L
RBSL Cleanup Goal	0.05 µg/L
% Reduction Required	-98.3%

The consultant team devised a comprehensive remedial strategy for the site located under the former fuel dispensers and adjacent tank field, aimed at addressing both the source area and the dissolved-phase hydrocarbon plume to meet established cleanup goals.

Site-Specific Cleanup Goals:

- **Wells Targeted:** Cleanup goals were based on selected attainment wells approved by DNREC, including MW-2RR, MW-3RR, MW-7R, VD-6, and MW-11.
- **Contaminants and Targets:**
 - Benzene: Reduce levels to below 29 µg/L.
 - Toluene: Reduce levels to below 7,300 µg/L.
 - Ethylene Dibromide (EDB): Reduce levels to 0.05 µg/L.
- **LNAPL Removal:** Eliminate measurable LNAPL detected at MW-11.

Remedial Actions:

- **Excavation and Direct RegenOx Application:** Targeted excavation was conducted to remove contaminated soils from the unsaturated and shallow saturated zones, followed by the direct application of RegenOx to the excavation’s base and sidewalls to quickly oxidize residual hydrocarbons.
- **Enhanced Dissolved-Phase Plume Control:** PetroFix was injected into the saturated zone outside the excavation limits using direct-push drilling methods.
- **Contingency Planning:** Installation of an Air Sparging/Soil Vapor Extraction (AS/SVE) system was proposed as a backup to address any remaining hydrocarbons if initial efforts did not achieve the RBSLs.

Adaptive Management Approach: The strategy included adaptive management provisions, allowing for real-time adjustments based on the effectiveness of the implemented measures or changes in site conditions. All proposed changes were structured to undergo a rigorous DNREC review and approval process to ensure compliance and efficacy.

Implementation

PetroFix Application Details	
Total PetroFix Applied	27,600 pounds*
Injection points	119*
Application Depths	Ranging from 10 to 25 feet
Injection Point Spacing	Ranging from 5 to 6.5 feet

*An additional 12,320 pounds of RegenOx were applied directly to excavation base and sidewalls

The PetroFix application, conducted in January 2020, was strategically executed using direct-push techniques to accommodate the site’s soil composition and target varying contamination levels:

Source Area Treatment: A total of 9,320 pounds of RegenOx was applied to the base and sidewalls of the excavation. After backfilling an additional 9,600 pounds of PetroFix were injected across 62 points in the excavated area, with injections reaching depths not excavated from 13 to 16 feet bgs.

Peripheral Contamination Area: Approximately 1,200 pounds of PetroFix were distributed across five locations near monitoring well VD-6 to stabilize moderate contamination and prevent hydrocarbon migration, with depths ranging from 13 to 25 feet.

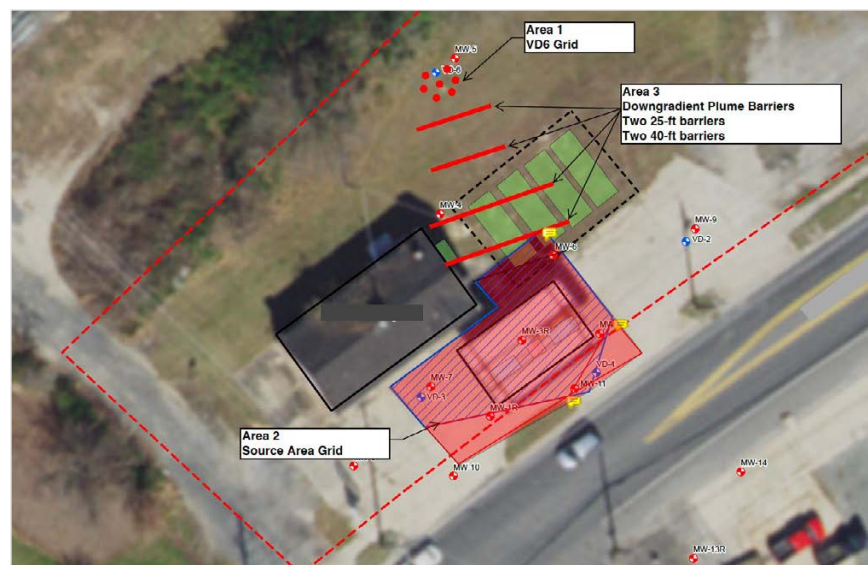
Downgradient Barrier Formation: 13,600 pounds of PetroFix were applied across 52 points along a series of barriers that intercepted and treated the dissolved-phase plume. The combined barrier length was 130 feet and injection depths ranged from 13 to 25 feet.

The PetroFix formulation included a blend of sulfate and nitrate electron acceptors to enhance anaerobic biodegradation and prevent long-term back diffusion of contaminants. PetroFix was injected using controlled flow and low pressures, ensuring efficient permeation of PetroFix through the heterogeneous soils.

Figure 2

Treatment Areas

Aerial site map depicting PetroFix treatment areas.





Results and Conclusion

The application of PetroFix led to significant reductions in petroleum hydrocarbon concentrations at the site, achieving compliance with all regulatory cleanup targets, including:

Benzene Reduction: Concentrations were reduced to below the 29 µg/L RBSL in monitoring wells MW-2RR, MW-3RR, MW-7R, and VD-6S, with these levels maintained across four consecutive quarterly sampling events.

Toluene Reduction: Levels fell to below the 7,300 µg/L RBSL in wells MW-2RR, MW-3RR, and MW-7R, consistently met over four quarters.

EDB Reduction: Concentrations dropped from 3 µg/L to below the 0.05 µg/L RBSL in well MW-3RR, sustained through four quarterly tests.

LNAPL Removal: Achieved and sustained LNAPL removal to the Maximum Extent Practicable (MEP) in well MW-11R through the first quarter of 2022.

Figure 3

Benzene in Performance Monitoring Wells

Graph showing benzene concentration in performance monitoring wells following PetroFix application. The graph illustrates the dramatic decrease in levels, consistently staying below the RBSLs for the selected performance monitoring wells.

- MW-2RR
- MW-3RR
- MW-7RR
- VD-6

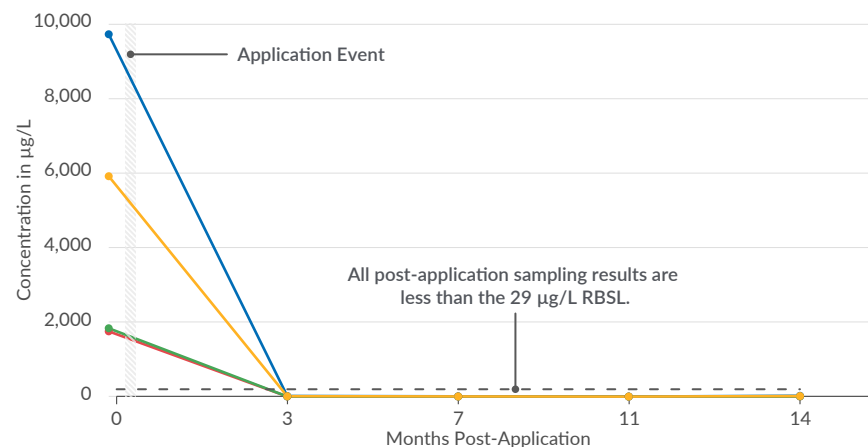
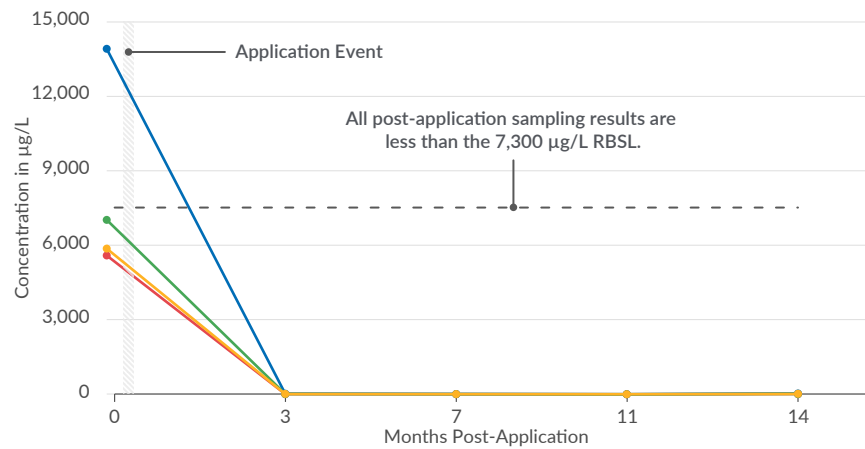


Figure 4
Toluene in Performance Monitoring Wells

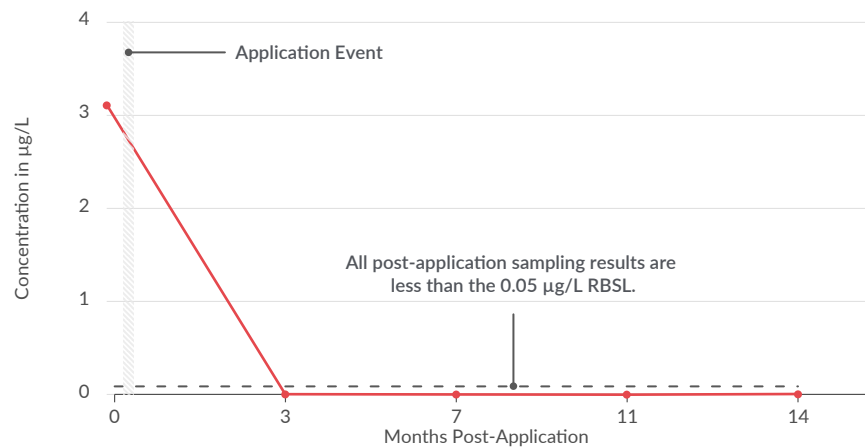
Graph showing toluene concentration in performance monitoring wells following PetroFix application. The graph illustrates the dramatic decrease in levels, consistently staying below the RBSLs for the selected performance monitoring wells.

- MW-2RR
- MW-3RR
- MW-7RR
- VD-6


Figure 5
EDB in MW-3

Graph showing EDB concentration in performance monitoring wells following PetroFix application. The graph illustrates the dramatic decrease in levels, consistently staying below the RBSLs for the selected performance monitoring wells.

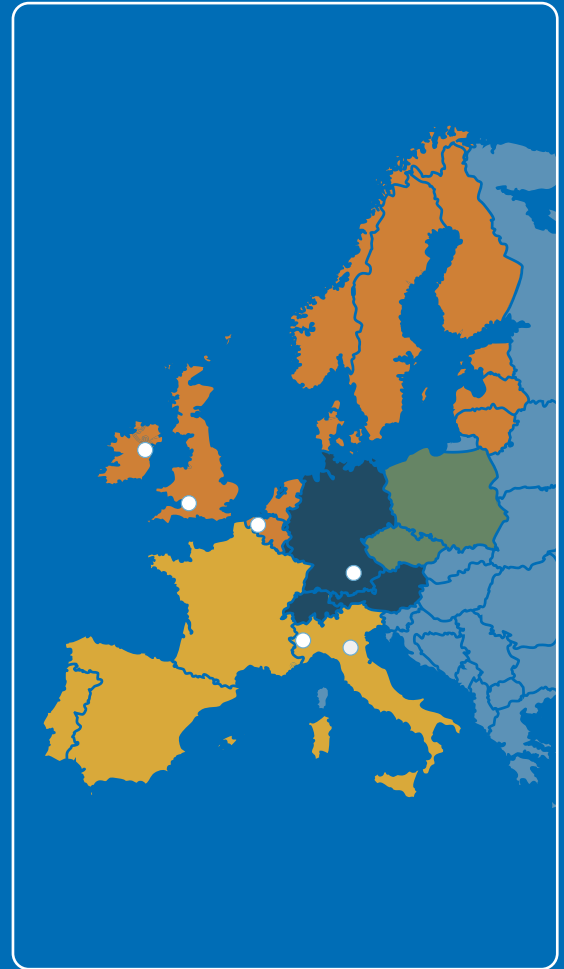
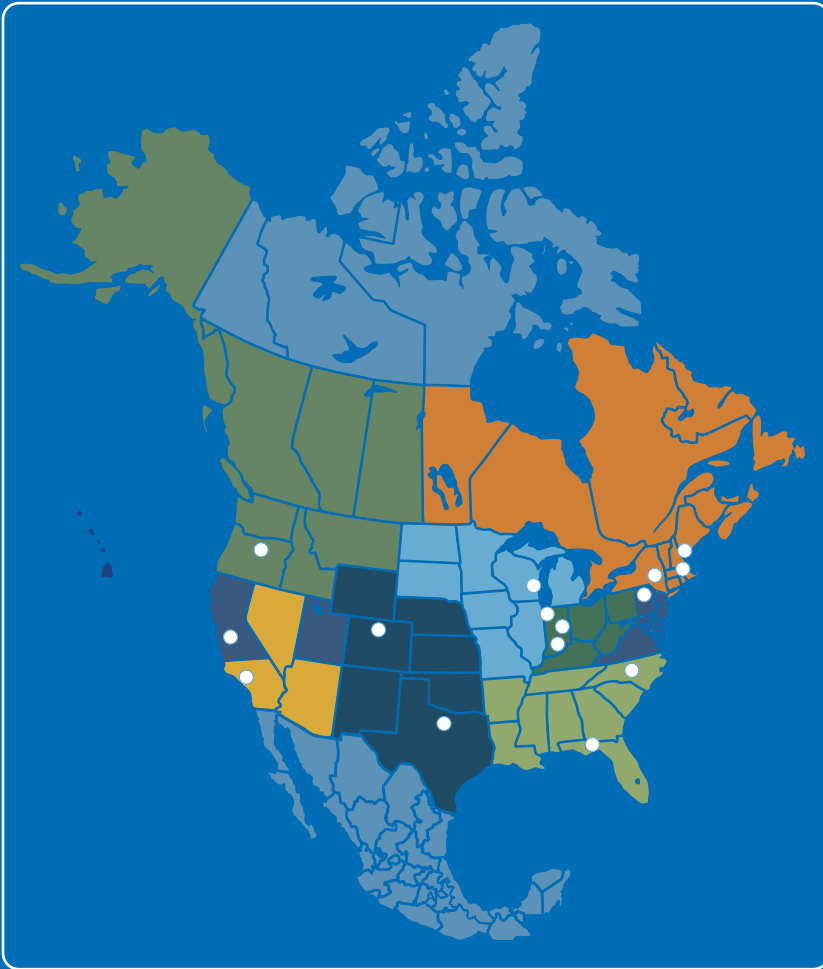
- MW-3RR



These results allowed for the abandonment of remediation equipment and performance wells in the PetroFix treatment area by the DNREC, positioning the site for future regulatory closure.

By implementing PetroFix, the Delaware project achieved reductions in benzene, toluene, and EDB to near or below detection limits, securing an effective, long-term solution for groundwater remediation. This case exemplifies the adaptability and efficacy of PetroFix in addressing complex hydrocarbon plumes, particularly at sites with stringent cleanup requirements.

We're Ready to Help You Find the Right Solution for Your Site



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