EFFECTIVELY ENGINEERING RAPID SITE CLOSURES

CASE STUDY:
PetroFix Used to Drive UST Release Closures Across the US

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Overview

Closing Sites With Unprecedented Efficiency

Antea®Group, a world leader in global environmental, health, safety, and sustainability solutions, applied PetroFix®, an innovative colloidal activated carbon remedial fluid, at numerous gasoline station sites in the US to establish an unprecedented rate of remedial closures and pending closures. Over the last two years, PetroFix has been applied at eight petroleum underground storage tank (UST) sites, with five already attaining regulatory closure. Of the remaining three sites, two are currently meeting performance objectives, with agency closure review pending or additional performance monitoring events needed. The last site of the eight has progressed significantly toward the closure goal, with more than 99 percent contaminant concentrations reductions observed.

In most cases, these sites have had open UST releases for more than a decade, and most have had one or more alternate *in situ* remediation approaches completed historically. In the brief period PetroFix has been available (less than three years), substantial improvements to remedial timeframes and cost-to-closure have been realized at these sites, with many located in diverse geographical and geological environments.

Antea Group applied PetroFix using *in situ* application methods which included direct push injections through grid and barrier arrays and excavation emplacement. Contaminant concentrations for the various petroleum hydrocarbons (PHCs) spanned multiple orders of magnitude from tens of micrograms per liter (µg/L) to more than ten milligrams per liter (mg/L).

The level of success achieved from these PetroFix applications is a promising development for Antea Group's clients, managing sites with legacy UST releases worldwide which have yet to achieve regulatory closure.

Introduction

Antea Group Readily Adopts a Promising New Remedial Amendment for Site Closures

60,000

"60,000 open sites remain, most of which are either undergoing remediation or where remediation is required..."

According to the Environmental Protection Agency (EPA), 559,000 releases have been reported from UST sites through September 2020. Although most sites have been cleaned up and received closure, more than 60,000 open sites remain, most of which are either undergoing remediation or where remediation is required for one or more contaminants of concern (COCs).

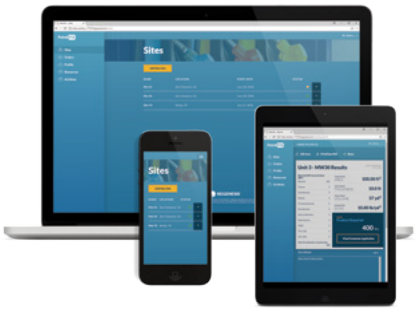
The most common COCs requiring remediation include:

- Aromatic compounds such as benzene, toluene, ethylbenzene, and xylenes (BTEX) or trimethylbenzenes (TMBs),
- Polycyclic aromatic compounds (PAHs) such as naphthalene,
- Fuel oxygenates like methyl-tert butyl ether (MTBE), and
- Undifferentiated fuel contaminants typically included in a total petroleum hydrocarbons (TPH) analysis.

Remedial Challenges

Many of these open sites have undergone sustained remediation using fixed mechanical systems, *in situ* injections, soil excavation, or a combination of these remedial approaches. While these remedial efforts have effectively removed or eliminated bulk contaminant mass in soil and groundwater, their usage has not resulted in a no-further-action designation at many of these sites. The reality is that these sites are just challenging to remediate fully. More specifically, it is most often because these approaches have been unable to reduce and sustain groundwater concentrations below the part-per-billion-level action levels commonly required for the most risk-sensitive COCs (e.g., benzene). There is an asymptotic remediation boundary that most technologies cannot cross in an acceptable timeframe. This boundary often entails small "hotspots" encompassing a few hundred to a few thousand square feet of surface area, with only a single well or two needing to reach remediation targets.

A New Remedy



The PetroFix Design Assistant is an online software too ldeveloped specifically for PetroFix designs. It provides users with simple yet sophisticated design tools that calculate product dosing requirements and guide application design schemas.

Recognizing the technical challenge in the petroleum UST marketplace, REGENESIS introduced PetroFix Remediation Fluid in 2018 to provide a highly effective, easy-to-apply, and cost-efficient tool for consultants to address difficult-to-close gasoline service station sites. The amendment is injected into a contaminated zone, providing an immense surface area of 1 to 2-micron scale activated carbon. The activated carbon surface results in rapid sorption kinetics, immediately and sustainably eliminating petroleum COCs from the dissolved phase. The inorganic electron acceptors (i.e., sulfate and nitrate) in PetroFix promote the safe, biological transformation of COCs to non-toxic end products. Using the PetroFix Design Assistant™, an online software tool developed specifically for PetroFix designs, provides users with simple yet sophisticated design tools that calculate product dosing requirements and guide application design schemas.

Antea Group has over 30 years of experience managing remediation at petroleum UST release sites for a wide array of national and multi-national gasoline station operators and owners. Their experience led them to be early adopters of the PetroFix, readily applying it to these recalcitrant problems based on its ease of use, affordability, effectiveness, and the option to self-complete the design and application.

Sites Treated

Site Name City, State	Contaminants of Concern	Max. Conc. in Treatment Area	Remediation Goal	Treatment Areal Extent	Application Method/ Array
Former UST Site Salem, OH	1,2-dichloroethane Napthalene	1,000 µg/L (Total VOCs)	5 µg/L (1,2-DCA) 14 µg/L (Nap.)	1,925 sq ft	DPT/Grid
Former UST Site Hardinsburg, KY	Benzene	33 µg/L	5 µg/L	2,000 sq ft	DPT/Grid
Former Holiday #48 Fort Dodge, IA	Benzene	16,200 µg/L	290 µg/L	2,000 sq ft	Excavation
Former UST Site Naugatuck, WV	Benzene	10 µg/L	5 µg/L	200 sq ft	DPT/Grid
Former UST Site Wilmington, NC	Benzene Xylenes Napthalene	20 µg/L 669 µg/L 140 µg/L	1 µg/L 500 µg/L 6 µg/L	1,900 sq ft	DPT/Grid
Former UST Site Clendenin, WV	Benzene	60 µg/L	5 µg/L	600 sq ft	DPT/Grid
Former UST Site Williamsburg, WV	Benzene	45 µg/L	5 µg/L	225 sq ft	DPT/Barrier
Active Service Station Site Longview, WA	TPH-Gasoline Range	10,200 µg/L	1,000 µg/L	225 sq ft	DPT/Grid

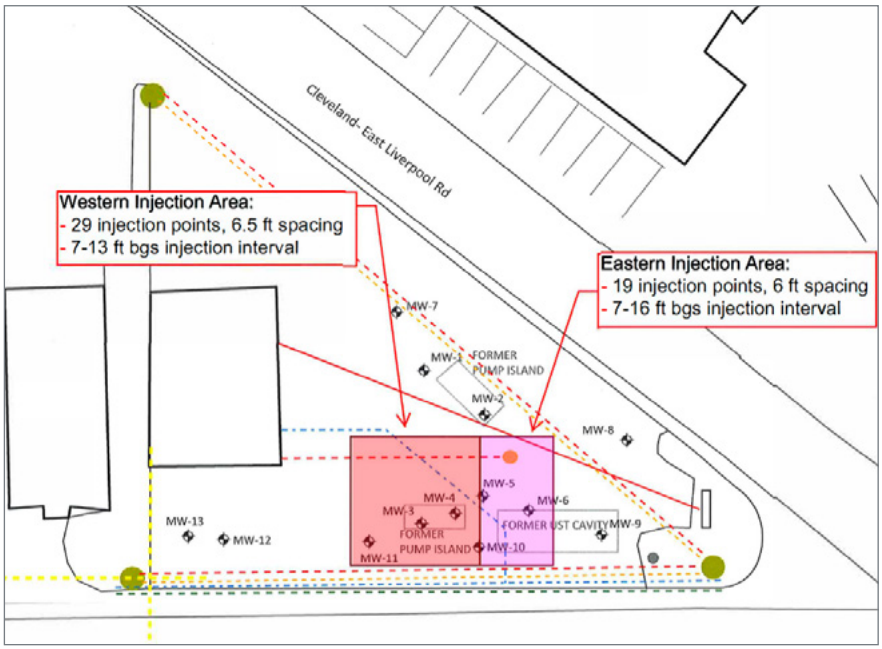
Eight UST Sites: Closed or On-Track For Site Closure

Former UST Site - Salem, OH

Closure Achieved

Residual PHCs were discovered during an environmental site assessment performed as part of a property transaction, resulting in the Ohio Bureau of Underground Storage Tank Regulations (BUSTR) assigning an environmental release for this long-inactive, former gasoline station site. Before the PetroFix application, naphthalene and 1,2-dichloroethane remained above action levels in groundwater. To remedy this, PetroFix was injected into two areas totaling 1,925 square feet. Following the application, concentrations of 1,2-dichloroethane and naphthalene were reduced below the BUSTR action levels in groundwater. Additionally, soil confirmation samples were collected, which demonstrated reductions in benzene and TPH. Based on these results, BUSTR issued a no further action (NFA) status for the site, officially closing the book on this post-operational environmental incident.

Plan view map depicting injection area - Salem, OH

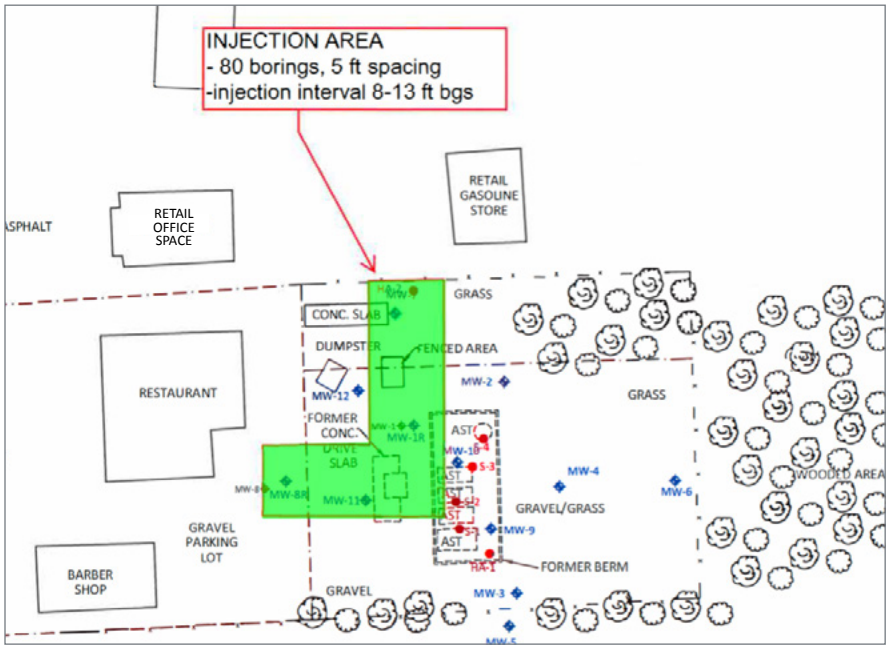


Former UST Site - Hardinsburg, KY

Closure Achieved

Benzene was the only contaminant of concern at this former UST release site in western Kentucky. The benzene concentration had reduced over time but appeared to reach an asymptotic condition, remaining in the low tens of µg/L range in an area downgradient of the source. PetroFix was applied in an eighty-point grid array covering approximately 2,000 square feet and targeting saturated soils above the soil/bedrock interface. Groundwater performance data demonstrated that the application of PetroFix was successful in reducing benzene concentrations below EPA Maximum Contaminant Levels (i.e., the action levels) in all site monitoring wells. The successful cleanup resulted in the Kentucky Department of Environmental Protection (KDEP) issuing NFA for the site.

Plan view map depicting injection area - Hardinsburg, Kentucky.



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About West Virginia UST Release Sites

In West Virginia, the Risk-Based Corrective Action option for closing UST release sites is costly and time consuming. Consequently, numerous legacy UST releases remain open, many with only low benzene concentrations in groundwater hovering above the West Virginia Department of Environmental Protection (WVDEP) cleanup level. These small, low-concentration benzene plumes are often the sole cause for prohibiting the closure of the incidents. The stringent benzene action level of 5 µg/L is equivalent to the EPA maximum contaminant level (MCL) for drinking water - a costly and challenging metric for most remedial approaches to attain. Three legacy UST release sites fitting this profile are now on track to achieve closure in WV following Antea Group's economic application of PetroFix to treat these residual, low-concentration benzene plumes.

Former UST Site - Naugatuck, WV

Closure Achieved

After many years of monitoring, this former gasoline station site in Naugatuck, West Virginia had only a small area with benzene concentrations remaining slightly above the action level of 5 µg/L. Antea Group applied the PetroFix treatment in a grid array encompassing the area of residual contamination. Following the treatment, benzene was reduced below the 5 µg/L cleanup goal for four consecutive quarters. The site has met the closure objectives and has recieved an NFA from WVDEP.

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Former UST Site - Clendenin, WV

Closure Achieved

Located 100 miles to the northeast of Naugatuck, this former fueling station in Clendenin, WV exhibited a similar impediment to regulatory closure: a small impacted area near the UST release source with benzene remaining above the action level, reaching concentrations up to 60 µg/L. The PetroFix application targeted this area and is currently meeting remedial objectives with further performance monitoring needed to demonstrate continued attainment of the 5 µg/L WVDEP action level for benzene.

Former UST Site - Williamsburg, WV

Closure Achieved

A PetroFix permeable reactive barrier (PRB) was installed to prevent offsite migration of BTEX at this former fueling station in Williamsburg, WV, nearly 100 miles to the southeast of Clendenin, WV. The PRB was placed between a roadway adjacent to the site and the property on the downgradient side of the roadway to cut off a narrow residual BTEX plume. Performance monitoring has demonstrated the effectiveness of the PetroFix PRB, with contaminants being sorbed and subsequently degraded biologically. The treatment has performed as designed, with clean water discharging on the downgradient side of the PRB.

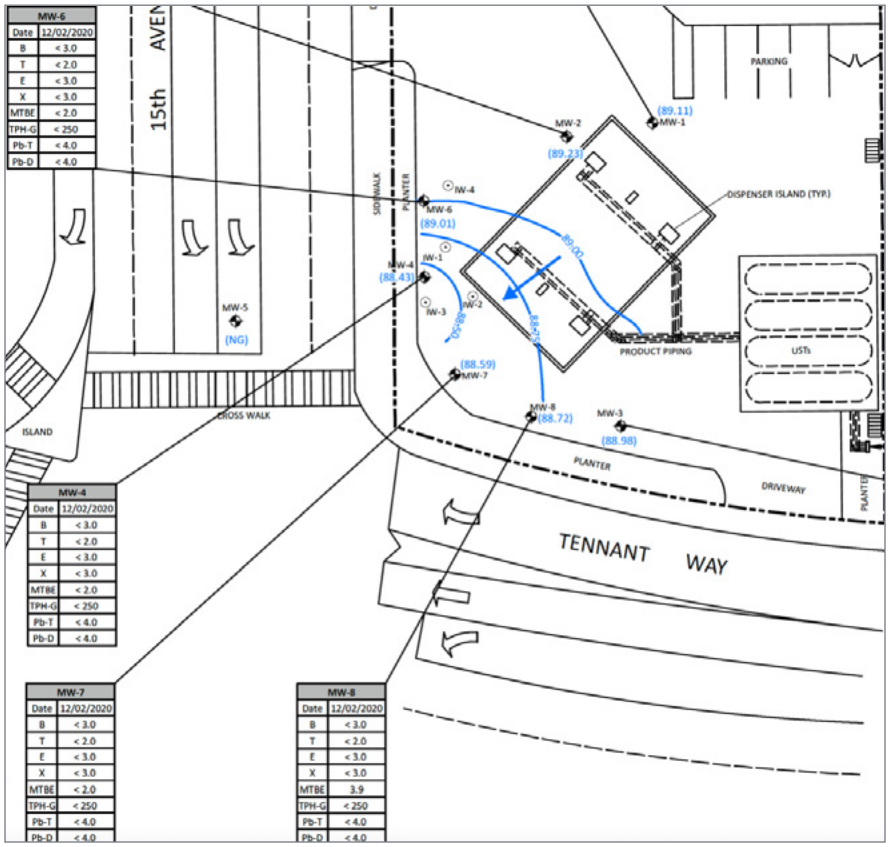
Injection of PetroFix and well influence monitoring.

Active Service Station Site - Longview, WA

Has Met Remedial Objectives
Closure Pending

Up until the 2019 PetroFix injection event, TPH-G (i.e., gasoline range hydrocarbons) had consistently been detected in groundwater above the cleanup level, reaching concentrations as high as 10,000 µg/L in a limited area onsite. Due to its high sorption potential, PetroFix was viewed as an ideal solution to reduce TPG-G significantly. Following Antea Group's PetroFix injection treatment, TPH-G has not been detected over the action levels or above the laboratory method reporting limits (MRLs) for a minimum of four consecutive quarterly sampling events. Accordingly, the remediation performance objectives have been met, paving the way for closure of the UST release.

TPH-G reduced and all COCs maintained below action levels following PetroFix injection at the Longview, Washington Site.

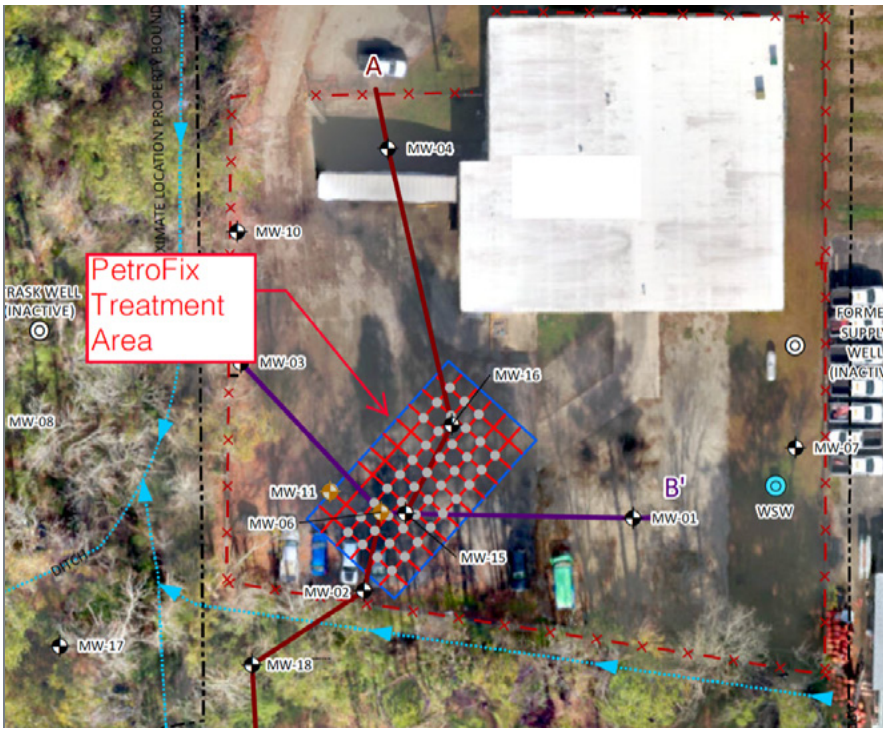


MW-6	
Date	12/02/2020
B	< 3.0
T	< 2.0
E	< 3.0
X	< 3.0
MTBE	< 2.0
TPH-G	< 250
Pb-T	< 4.0
Pb-D	< 4.0

MW-4	
Date	12/02/2020
B	< 3.0
T	< 2.0
E	< 3.0
X	< 3.0
MTBE	< 2.0
TPH-G	< 250
Pb-T	< 4.0
Pb-D	< 4.0

MW-7	
Date	12/02/2020
B	< 3.0
T	< 2.0
E	< 3.0
X	< 3.0
MTBE	< 2.0
TPH-G	< 250
Pb-T	< 4.0
Pb-D	< 4.0

MW-8	
Date	12/02/2020
B	< 3.0
T	< 2.0
E	< 3.0
X	< 3.0
MTBE	3.9
TPH-G	< 250
Pb-T	< 4.0
Pb-D	< 4.0



Former UST Site - Wilmington, NC

Signficant Progress Toward Remedial Objectives Additional Monitoring Needed

Two 4,000-gallon gasoline underground storage tanks (USTs) and one 4,000-gallon diesel fuel UST were excavated and removed in 1985. A Comprehensive Site Assessment was conducted at the site in 1997 and a Corrective Action Plan (CAP) was submitted in 1999.

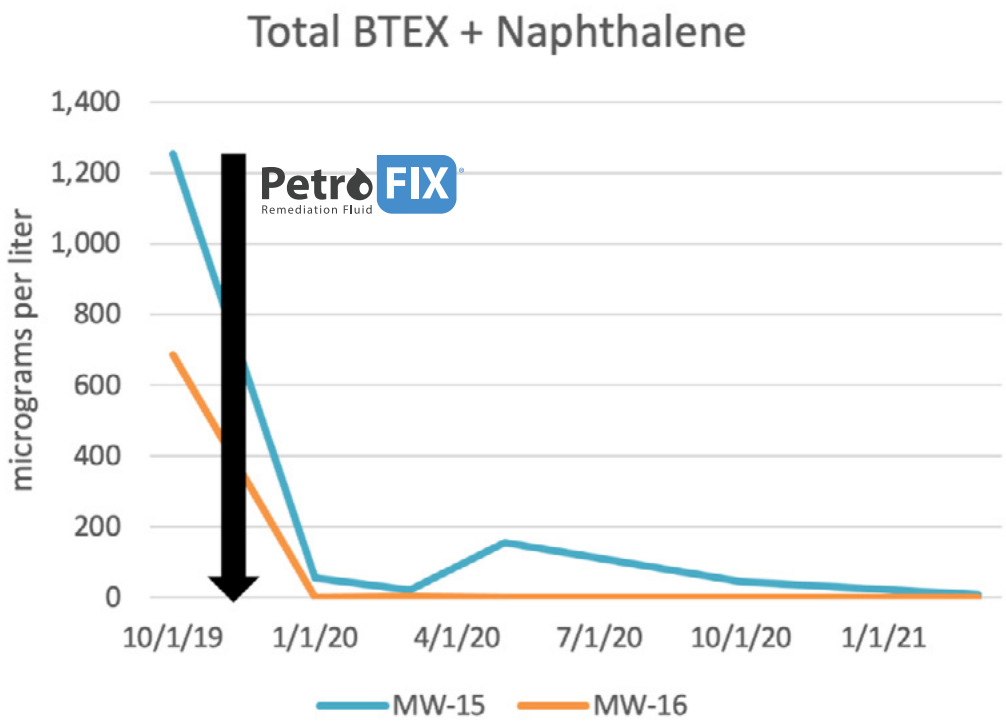
Following a site assessment conducted in the late 90s, this UST release site in Wilmington was ranked as High Risk by the North Carolina Department of Environmental Quality (NCDEQ) due to water supply wells in the area. For this reason, the remedial goal for benzene is a stringent 1 µg/L. Prior remedial activities included:

- Excavating impacted soils from the former UST basin,
- Applying Oxygen Release Compound®, and
- Conducting a series of magnesium sulfate injections.

These efforts were successful in reducing contaminants concentrations by approximately 90 percent. However, several compounds, including benzene and naphthalene, remained above the closure criteria.

PetroFix was considered as an alternate remedial technology to reduce the PHC concentrations below standards. In 2019, following a technical review and approval process for new remedial technologies, PetroFix was formally approved by the NCDEQ. The application was completed in December 2019, marking the first PetroFix application in North Carolina.

PetroFix was applied in a grid array over an approximate 2,000 square foot area. Two performance monitoring wells – MW-16 and MW-15 – were within the treatment area. Following the application, BTEX and total naphthalene concentrations were reduced by 98 percent after 30 days and are 99.7 percent reduced after 5 monitoring events, moving the site much nearer to closure eligibility.



Former Holiday Station #48 - Fort Dodge, IA

Closure Achieved

This gasoline station site in Iowa is the first site where PetroFix and ORC Advanced pellets were co-applied in an excavation treatment. Due in part to the hard clay soils at the site, there had been little attempt made in the past to aggressively treat the petroleum hydrocarbon contaminants using an *in situ* approach. The tight soil conditions led to high contaminant concentrations near the UST system release, including benzene, the primary risk driver. Immediately before excavation, the benzene concentration was 1,290 µg/L. However, a maximum concentration of 16,200 µg/L had been observed historically.

Eventually, the acceptance of and need for remediation was realized when the property sale hinged on reducing contaminants to meet regulatory guidelines. Working with the REGENESIS team, Antea Group specified the application of PetroFix in conjunction with the excavation. The remediation design called for mechanical mixing of PetroFix and ORC Advanced pellets--to promote aerobic microbial degradation of the PHCs--into the bottom few feet of the excavation. In addition, PetroFix was spray-applied to the sides of the excavation pit.

The site was granted regulatory closure for the environmental incident by the Iowa Department of Natural Resources. The goal for the application has thus been achieved, allowing the site owner to move forward with the property sale. Although PetroFix was designed as an injectable carbon product for direct push or well injections, the treatment at this site demonstrates its utility for soil excavations.

Aerial view of PetroFix and ORC Advanced applied to the excavation pit prior to backfilling with clean fill

Site Name City, State	Contaminants of Concern	Max. Conc. in Treatment Area	Remediation Goal	PetroFix Qty. Applied	Closure Status
Former UST Site Salem, OH	1,2-dichloroethane Napthalene	1,000 µg/L (Total VOCs)	5 µg/L (1,2-DCA) 14 µg/L (Nap.)	2,400 lbs	**Closed**
Former UST Site Hardinsburg, KY	Benzene	33 µg/L	5 µg/L	2,400 lbs	**Closed**
Former Holiday #48 Fort Dodge, IA	Benzene	16,200 µg/L	290 µg/L	3,600 lbs	**Closed**
Former UST Site Naugatuck, WV	Benzene	10 µg/L	5 µg/L	400 lbs	**Closed**
Former UST Site Williamsburg, WV	Benzene	45 µg/L	5 µg/L	1,200 lbs	**Closed**
Former UST Site Clendenin, WV	Benzene	60 µg/L	5 µg/L	800 lbs	**Closed**
Former UST Site Wilmington, NC	Benzene Xylenes Napthalene	20 µg/L 669 µg/L 140 µg/L	1 µg/L 500 µg/L 6 µg/L	4,000 lbs	**Objectives Nearly Met Monitoring Phase**
Active Service Station Site Longview, WA	TPH-Gasoline Range	10,200 µg/L	1,000 µg/L	400 lbs	**Meeting Objectives Monitoring Phase**

Conclusion

Antea Group is amongst the first environmental consulting companies to recognize and adopt PetroFix as a tool to rapidly reduce PHC impacts and achieve remedial objectives in groundwater. Applying PetroFix with economic efficiency, the company successfully advanced a portfolio of legacy UST release sites through the closure process over a short timeframe. In this effort, Antea Group sought and obtained approvals through multiple state regulatory agencies, self-completed the designs to determine dosing and injection layouts, implemented PetroFix treatments using different *in situ* application methods, and conducted performance monitoring to demonstrate remedial objective attainment. With many sites already closed and the remaining sites poised to achieve closure soon, the Antea Group team has proactively and responsibly managed these projects by assimilating PetroFix, the latest technological innovation to address PHC contamination, into their closure strategy. Having quickly become experts on PetroFix's proper application for these sites, many more successes are sure to follow.

About The Consultant

About Antea Group

With over 30 years of experience, we develop and execute remediation liability strategies on time and on budget, preserving and enhancing our clients' reputations with both the community and regulatory agencies. Our experienced engineers, geologists, and scientists are committed to extinguishing your remediation and legacy liability -- we close sites. Antea Group has a proven track record of providing quality assurance, a safe work environment, and consistent results by leveraging our strong regulatory relationships and project management capabilities.

Antea Group has the financial strength and flexibility to stand behind program cash and investment requirements, and our regional and local experts set strategies that minimize operational costs and design programs to drive down liability. Above all, Antea Group understands how a company evaluates, manages, and resolves environmental risk affects its reputation, financial performance, and competitive advantage.

About The Team

Jack Sheldon
Senior Remediation Specialist

Jack Sheldon is a Senior Remediation Specialist with Antea Group located in West Des Moines, Iowa. He has over 39 years of experience in the fields of environmental microbiology and remediation. Jack has a BS in Bacteriology & Public Health and an MS in Environmental/Industrial Microbiology from Wagner College in Staten Island, NY. In his current role, he advises on remediation technology selection, performance, and optimization across the US and abroad. His key technology areas are bioremediation and chemical oxidation. Jack has authored numerous papers and posters, and co-authored two best-selling books on bioremediation.

About The Team

Rob Thompson, PG, RSM
Senior Professional

Rob is a Professional Geologist and Registered Site Manager (RSM) located in Antea Group's Charlotte, North Carolina office. He has more than 27 years of industry experience with a focus on site characterization and remediation, Conceptual Site Model development, project management, and planning and organization. He has provided assessment and remediation solutions to private, commercial, industrial, and municipal clients throughout the USA. Rob has conducted remedial investigations, soil and groundwater remediation, remedial strategy evaluation and optimization, Vapor Intrusion (VI) assessments, geophysical surveys, and soil gas surveys at retail underground storage tank (UST), petroleum bulk terminal, solid waste landfill, manufacturing, Resource Conservation and Recovery Act (RCRA), and Superfund remediation projects ranging from $300 to $3 million. Rob completed the design and implementation of the largest application of PlumeStop® at a manufacturing site in North Carolina contaminated with Freon 11 and chlorinated solvents. This is globally the largest PlumeStop application at a site where the dominant constituent in the groundwater plume was Freon 11. Rob provides senior technical support for subsurface injection and remedial evaluations for UST, RCRA and Superfund sites in Alabama, Georgia, Minnesota, Mississippi, North Carolina, Pennsylvania, South Carolina, Tennessee, Virginia, and Washington.

As a subject matter expert on the firm's Probabilistic Modeling team, Rob supports internal and external clients by assessing and defining work scopes and endpoints to help clients evaluate which risks to take and which to avoid when facing uncertain scenarios that could significantly impact their bottom line. By using industry-leading software Palisade Decision Tools, the team can model, simulate and understand the full range of possible outcomes, probabilities and, most importantly, the costs associated with each, ensuring optimal decision making.

About The Team

Chris Vandegrift, PE, LSP
Senior Remediation Engineer

Chris is a Professional Engineer(PE), Licensed Remediation Specialist (LSP), and office leader for Antea Group in the Pittsburgh, PA office. He has over 25 years of experience in the environmental consulting and contracting field. Chris has managed all facets of project work from initial assessment activities through site closures. He is responsible for remedial action at a variety of facilities including dairies, retail and bulk petroleum, manufacturing, mining, chemical distribution and aviation located across the eastern United States and California.

Chris' experience includes managing large-scale remedial actions including landfill caps, secondary containment structures, excavations, impoundment closures, system installations, and facility decontamination and demolition. He has specified and implemented detailed remedial design approaches with multiple remedial technologies including single and multiple well extraction, ozone injection, air-sparging, soil vapor extraction and bio-sparge/venting processes. Remedial designs also include various vapor treatment process including granular activated carbon, air-stripping, thermal/catalytic oxidation and internal combustion engines. He also provides remedial performance evaluations typically accompanied by recommendations for system optimization.

About The Team

Todd Herrington, PE
Global PetroFix Product Manager

Todd serves as the Global PetroFix Product Manager for REGENESIS, directing the expansion of the new hydrocarbon treatment line in the global marketplace and provides industry-leading support to REGENESIS customers. Todd has over 24 years of environmental remediation experience primarily focused on *in situ* remediation. He has been involved with thousands of contaminated site remediation projects during his tenure at REGENESIS and has expertise with enhanced bioremediation, chemical oxidation, chemical reduction, and carbon sorption. He earned his B.S. in Civil Engineering from Colorado State University and his M.S. in Environmental Engineering from the University of Cincinnati. Todd also received his Professional Engineer (PE) license in his home state of Colorado.

Technology Used

About PetroFix

PetroFix® Remediation Fluid

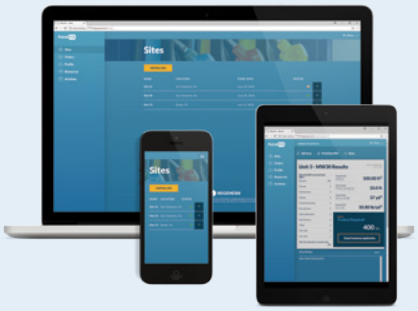
Key Benefits

PetroFix Remediation Fluid

- Fast, Safe, Affordable and Reliable Results
- Excellent Distribution Properties
- Simple Online Design Assistant and Full Customer Support

PetroFix Design Assistant: You Design

Use our Online Software to Generate an Estimate When you Need it.



Simple
Easy to Use

Flexible
Designs Tailored to Your Site

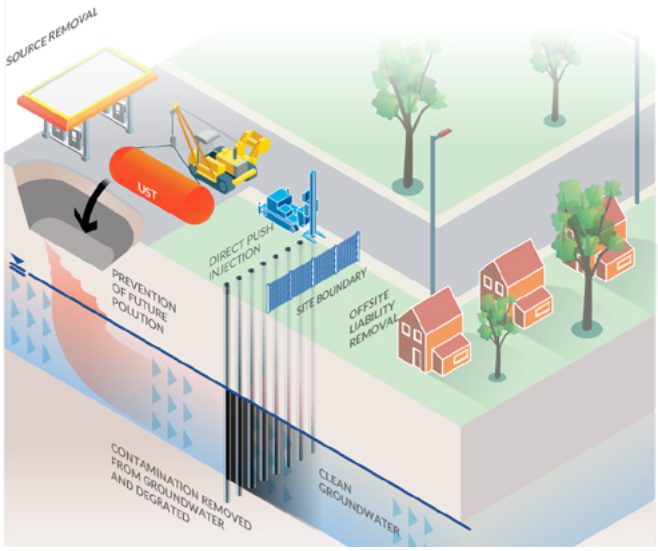
Fast
No Waiting for a Design

Technology

PetroFix® is a cost-effective solution for petroleum spills that equips environmental professionals with tools to take control of the remediation process. This technology works hand-in-hand with the PetroFix Design Assistant™, an online tool that enables users to design and apply individually-tailored remediation plans.

A Dual-Functioning, Activated Carbon Remedial Technology for Treating Petroleum Hydrocarbons

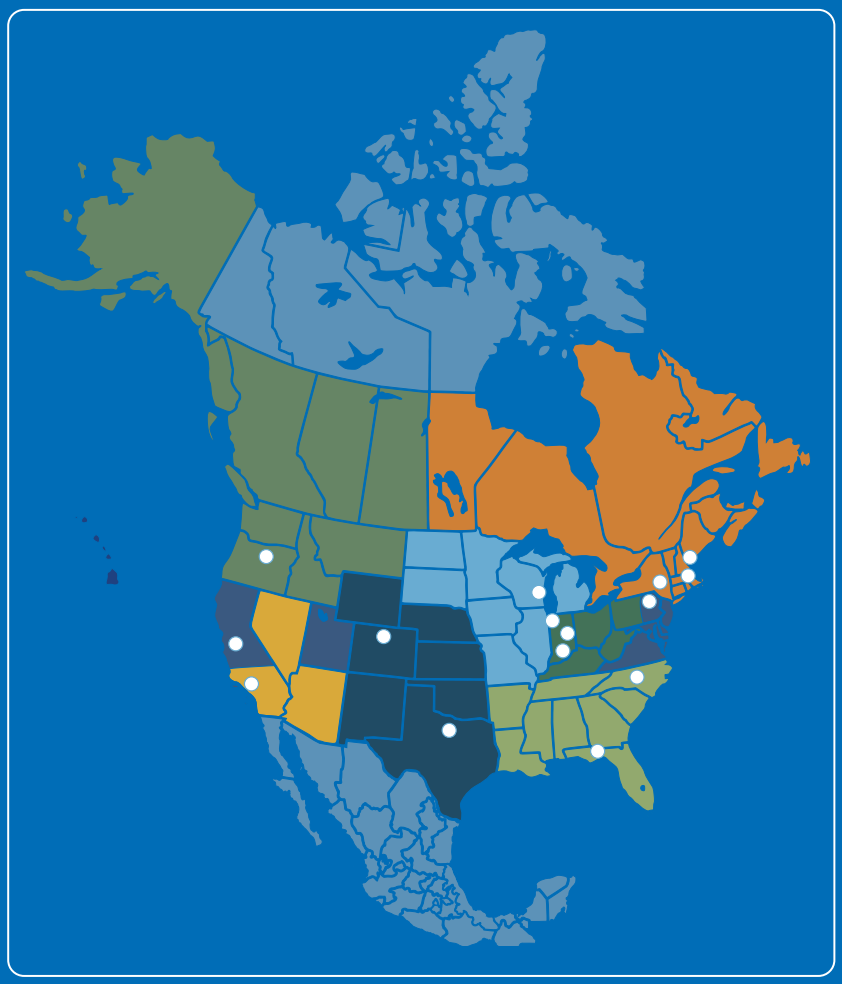
PetroFix has a dual function: it removes hydrocarbons from the dissolved phase by adsorbing them onto activated carbon particles then stimulates hydrocarbon biodegradation by adding electron acceptors. The environmentally-compatible formulation of micron-scale activated carbon (1-2 microns) is combined with both slow and quick-release inorganic electron acceptors. Practitioners can select between a sulfate and nitrate combination blend (recommended) or sulfate only for the additional electron acceptors required.

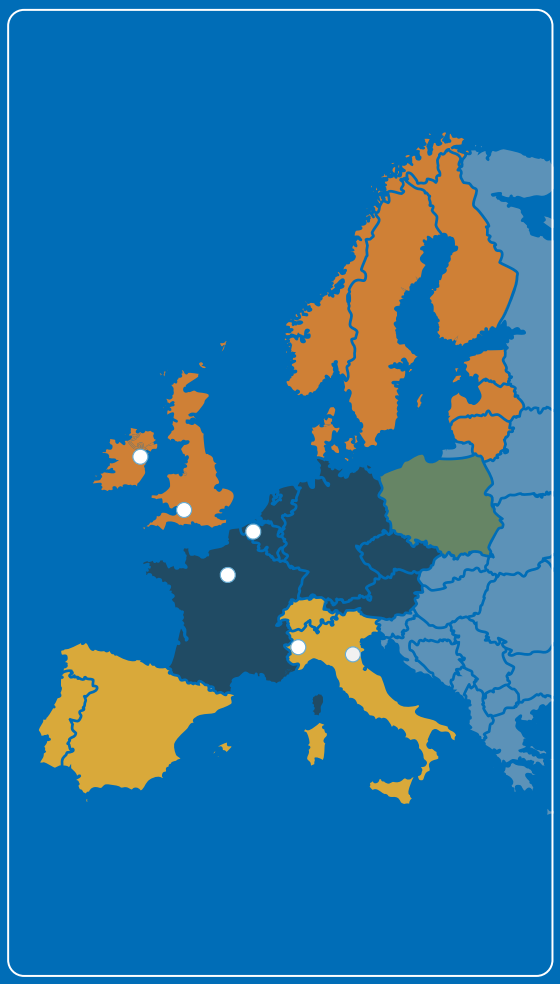


REGENESIS®

We're Ready to Help You

Find the Right Solution For Your Site





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Visit www.REGENESIS.com to learn more.

antea® group

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