

# PETROFIX PILOT STUDY LEADS TO SUCCESSFUL FULL-SCALE APPLICATION

## CASE STUDY:

Groundbreaking Application of a  
Micron-Scale Carbon Suspension  
Successfully Stabilizes Large  
Petroleum Hydrocarbon Plume





## Overview

# Full-Scale PetroFix Application Follows Successful Pilot Test



Previous pilot testing results provided promising results leading to a full-scale application



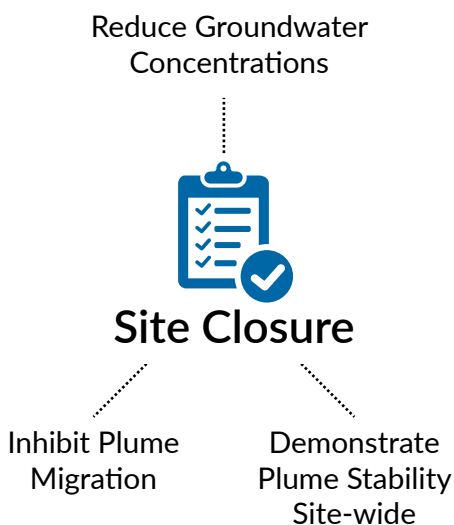
PetroFix is designed to remediate petroleum contamination completely at the lowest total cost to closure.

Following a successful field pilot test, a full-scale PetroFix® remediation was designed and implemented at seven locations to treat petroleum hydrocarbons (PHCs). Three locations targeted source areas onsite while the other four locations addressed PHC contaminants that had migrated offsite. PetroFix was applied through direct push injection in all areas.

One of the onsite locations contained very high PHC concentrations in soil and groundwater, with suspected light non-aqueous phase liquids (LNAPL). These conditions were beyond a cost-effective treatment range for PetroFix, requiring a combined *in situ* chemical oxidation (ISCO) and enhanced aerobic bioremediation pretreatment step utilizing PersulfOx® and ORC® Advanced, respectively.



## Site Closure Strategy



## Remedial Design

### Site Closure Strategy and Treatment Goals

The site closure strategy is to:

- ➔ Reduce overall dissolved-phase concentrations,
- ➔ Inhibit further downgradient plume migration, and
- ➔ Demonstrate site-wide plume stability with post-injection monitoring.

Thus, in the source area locations, the goal was to substantially reduce dissolved-phase PHC mass and attaining low-concentration end-points was unnecessary. At the offsite locations, the goal was to inhibit PHC plume expansion and migration. Multi-row intercept barriers, strategically placed to remove and biodegrade dissolved PHCs, were used to achieve this goal.

## Application Design Summary

### Remedial Application

Treatment Locations	7
Application Area	6,500 ft <sup>2</sup>
Injection Points (Direct Push)	120
Spacing (On Center)	6-7.5 ft
Treatment Interval:	7-25 ft bgs

### Products Applied

PetroFix	22,000 lbs
Electron Acceptor Blend	820 lbs
PersulfOx	6,500 lbs
ORC Advanced	1,970 lbs

## Project Details

The initial PetroFix and PersulfOx/ORC-A injection event was completed in May 2019. The products were injected into each point under moderate pressure using a Geoprobe® equipped with a pump optimally suited for this compound. The amendments were distributed uniformly over the entire injection interval in each injection point. The injection crew maintained injection pressure at a level sufficient to overcome the hydraulic head but low enough to promote a uniform radial distribution of the products around each injection point and avoid channeling or short-circuiting in one direction.

Two post-injection groundwater sampling events were completed in June and September 2019. In December 2019, a supplemental PetroFix injection was completed in the PHC source area onsite following the PersulfOx and ORC-A pretreatment step and groundwater equilibration. Additionally, a new treatment area was added where a small quantity of PetroFix was injected.

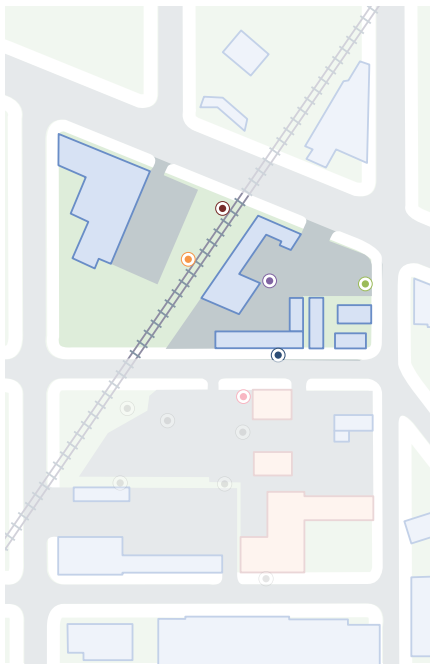


## Results

### Intercept Barrier Results (Off Site)

**99.9%** Sustained Reduction

Two locations have achieved and maintained 99.9% reductions 18 months post-application



Results shown in this section were collected from the highlighted region.

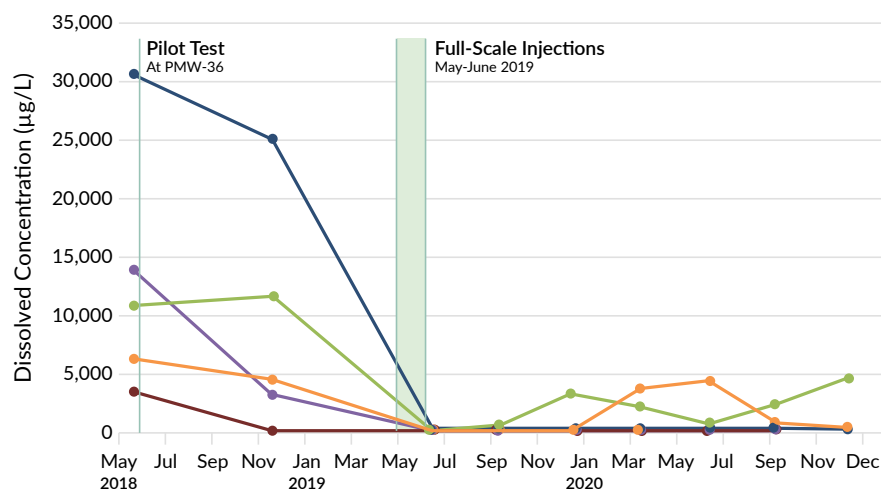
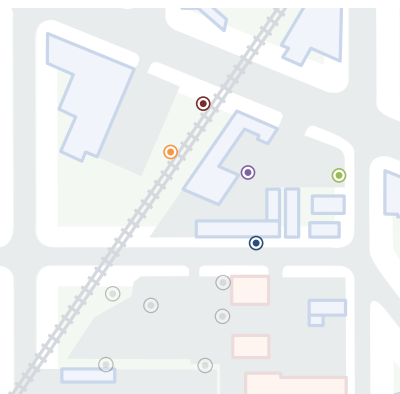
Results for the off site barriers show outstanding performance based on the following:

- ➔ two locations have achieved 99.9% reductions and remain at or near non-detect for 21 months post-injection as measured by six consecutive monitoring events,
- ➔ at one of these locations (PMW-35 barrier), starting BTEX concentrations of 31 milligrams per liter (mg/L) were immediately reduced to and remained non-detect for most sampling events,
- ➔ two other barrier areas achieved 57.9% and 91.7% reductions, respectively, in the first 21 months after injection,
- ➔ a fifth area (PWM-36) is the original pilot test area and has maintained a 99.4% BTEX reduction of BTEX after two years and seven consecutive quarters of monitoring, and
- ➔ naphthalene has been reduced by 98.8%, on average across all areas.

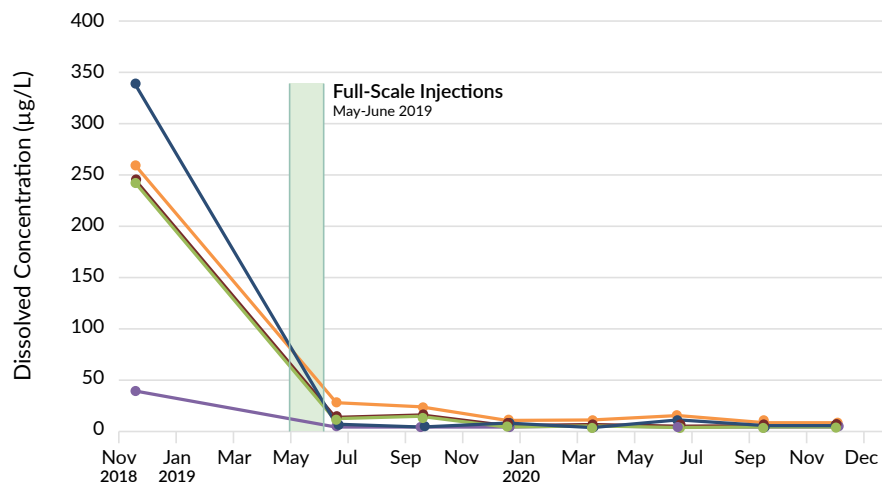
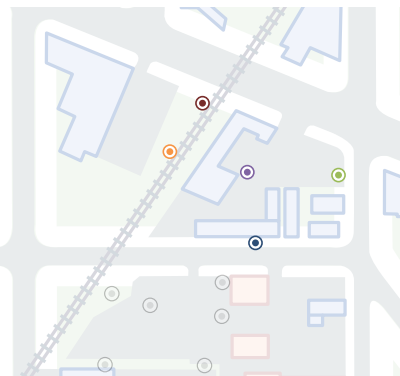
As a result of above-average rainfall in the first half of 2019, groundwater elevations increased in most wells by approximately 1.5 feet since the previous sampling event in November 2018. These elevations were at historic highs since the monitoring program was resumed in 2017. This condition was expected to cause increases in contaminant concentrations; however, no such spike was observed following the PetroFix application.



### Total BTEX for Off Site Contamination



### Total Napthalene for Off Site Contamination



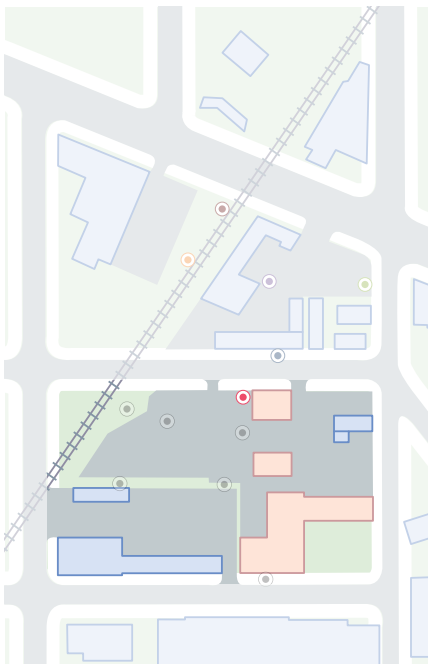
Key: ● PMW-29    ● PMW-30    ● PMW-34    ● PMW-35    ● PMW-36  
*Pilot Test Well*

## Results

### Source Area Barrier Results (On Site)

**99%** BTEX Reductions  
in Source Area

**97%** Napthalene  
Reductions



Results shown in this section were collected from the highlighted region.

Of the three source areas, the PMW-37 area achieved the highest reduction following full-scale treatment. This combined treatment has achieved reductions of 99% for dissolved phase BTEX and 97% for naphthalene. The PersulfOx and ORC Advanced pretreatment was completed in this area for initial PHC mass-reduction prior to the PetroFix application.

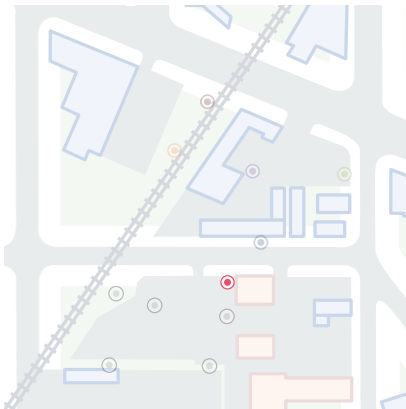
The PMW-25 area (graph not shown) has shown limited reductions in concentration. It is speculated that a combination of high-mass, heterogeneity, and insufficient product distribution were the main reasons behind poor performance in this area. The complete distribution of PetroFix, even if underdosed, usually produces a response and partial contaminant reduction.

The third source area had an average 52% total BTEX reduction although results were obfuscated because these wells were dry for much of the Fall of 2018 and Spring of 2019. New, deeper wells were subsequently installed in the area and exhibited dissolved-phase concentrations like pre-injection levels for the previous wells. The installation of deeper wells in this location indicates groundwater contaminants are likely moving below the emplaced PetroFix, despite the substantial reductions observed initially.

It should be noted that the full-scale application relied on spacing and injection volumes derived from an earlier pilot test. However, given the large area of impact, the local geology variations were likely different enough from the pilot test that higher volumes or slightly tighter spacing would likely have incrementally improved results.

Overall, the post-application results are considered excellent sitewide, and the remedial goal of achieving plume stability mostly obtained site wide. A supplemental injection at MW-26 (leading edge of plume) is being considered to improve currently attained reductions and stability.

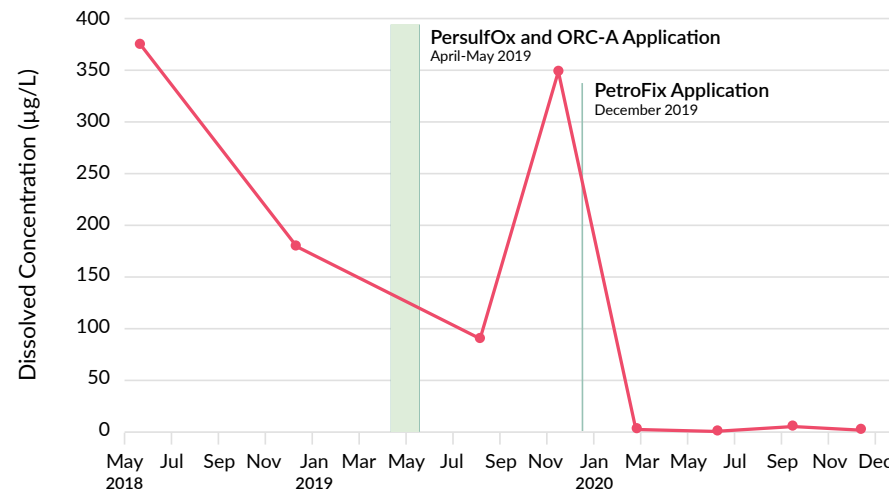
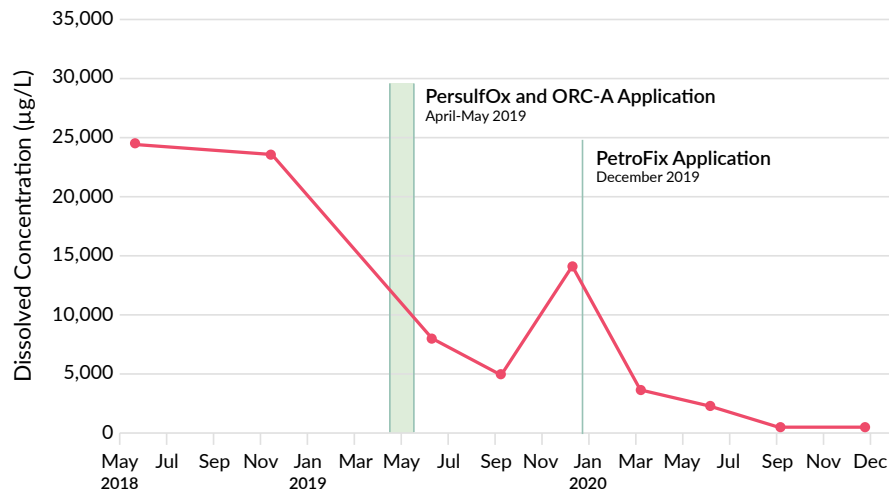
### Total BTEX for Source Area Contamination



### Total Napthalene for Source Area Contamination



**Key:** ● PMW-37



Upon completion of the final plume-stability groundwater monitoring event in Spring 2022, a plume-stability evaluation will be performed for all parameters that exceed applicable IDEM screening criteria in each well with such detections. If the plume-stability data shows a stable or shrinking plume, a No Further Action (NFA) request will be prepared and submitted to IDEM for review and approval. The NFA request will likely include an institutional control in the form of an Environmental Restrictive Covenant (ERC) for the site and the immediate downgradient property, prohibiting groundwater use and limiting the property use to commercial/industrial purposes.

## About The Consultant

# Patriot Engineering and Environmental



Patriot Engineering and Environmental, Inc. (Patriot) is a diverse engineering firm providing geotechnical, environmental, and construction materials testing services and consultation to commercial, industrial, and governmental clients. Patriot provides the specific information needed to make informed, cost-effective business decisions which will help reduce net cost, decrease risk, and improve the quality of your project outcomes. With decades of experience, Patriot's staff has the technical expertise needed to address most environmental, geotechnical, or construction materials testing projects. Senior engineers and technical professionals serve as actual project managers and not just advisors, which is common practice with most consulting companies. They have the full responsibility for getting the job done and the authority and resources to ensure the work is completed quickly, correctly, and economically.



## About The Project Manager

### Steve Sittler, LPG

Steve Sittler has more than 35 years of technical experience in applied hydrogeology, with specialized experience in remedial strategy development and implementation. He has managed and performed hundreds of site investigations, audits and assessments at industrial facilities, service stations, petroleum and chemical refineries, and landfills in more than 20 states and has expertise in all aspects of remedial strategy development and remedial system design, installation and operation. He has coordinated, designed and managed more than 1,000 hydrogeologic assessment / remediation projects involving both implementation of innovative closure strategies and unique applications of conventional technologies for petroleum hydrocarbons and chlorinated solvents. Mr. Sittler holds a BS in Earth Sciences from the University of Indianapolis, an MS in Geology from Purdue University, and is a Licensed Professional Geologist in Indiana.





## Technologies Used

### PetroFix, PersulfOx, ORC Advanced



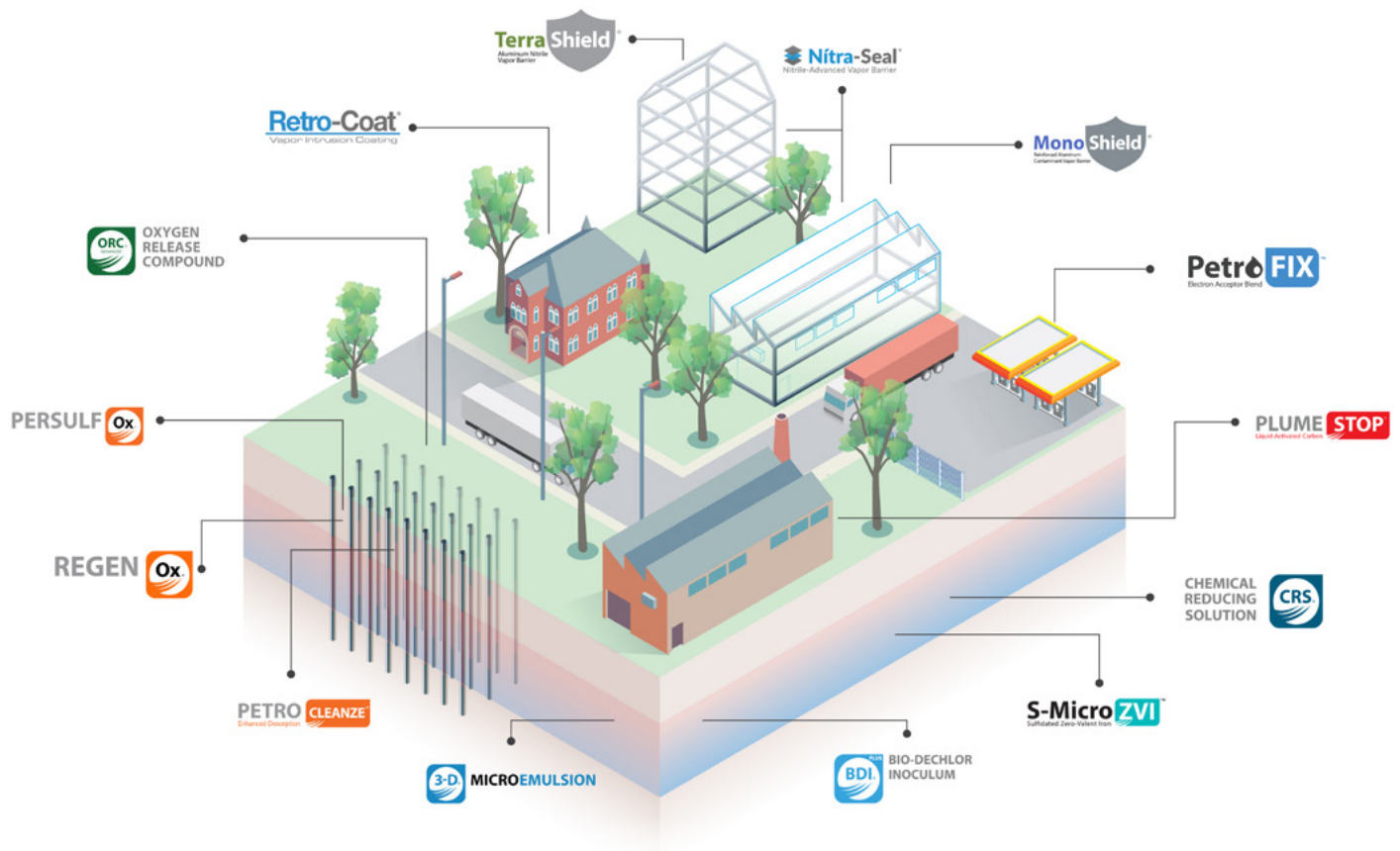
PetroFix™ is a cost-effective solution for petroleum spills that equips environmental professionals with tools to take control of the remediation process. This technology works hand-in-hand with the PetroFix Design Assistant™, an online tool that enables users to design and apply individually-tailored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



PersulfOx® is an advanced *in situ* chemical oxidation (ISCO) reagent that destroys organic contaminants found in groundwater and soil through abiotic chemical oxidation reactions. It is an all-in-one product with a built-in catalyst which activates the sodium persulfate component and generates contaminant-destroying free radicals without the costly and potentially hazardous addition of a separate activator. The patented catalyst enhances the oxidative destruction of both petroleum hydrocarbons and chlorinated contaminants in the subsurface.



ORC Advanced® is an engineered, oxygen release compound designed specifically for enhanced, *in situ* aerobic bioremediation of petroleum hydrocarbons in groundwater and saturated soils. Upon contact with groundwater, this calcium oxy-hydroxide based material becomes hydrated producing a controlled-release of molecular oxygen (17% by weight) for periods of up to 12 months on a single application.



## About REGENESIS

At REGENESIS we value innovation, technology, expertise and people which together form the unique framework we operate in as an organization. We see innovation and technology as inseparably linked with one being born out of the other.

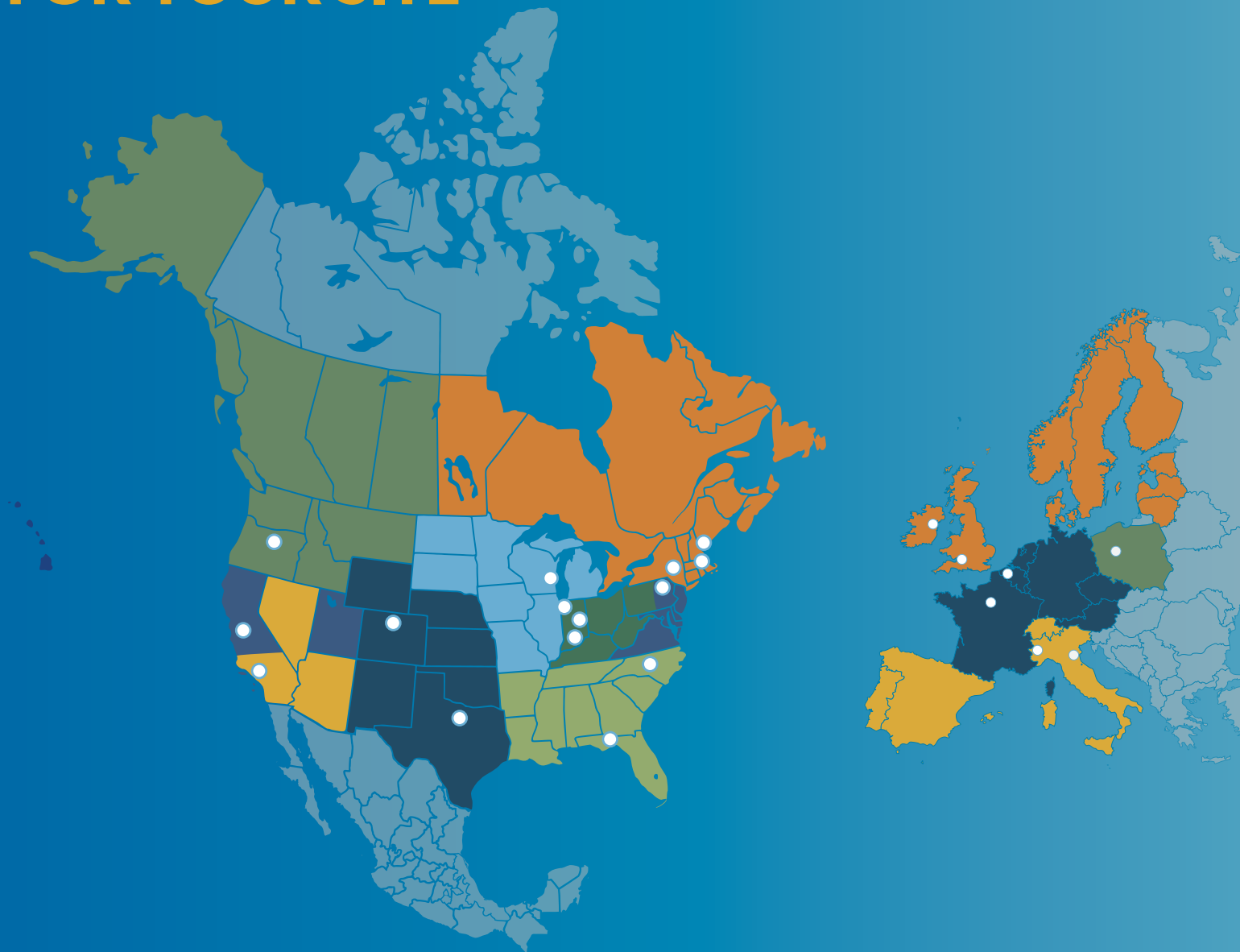
Inherently, innovation imparts new and better ways of thinking and doing. For us this means delivering expert environmental solutions in the form of the most advanced and effective technologies and services available today.

We value expertise, both our customers' and our own. We find that when our experienced staff collaborates directly with customers on complex problems there is a high potential for success including savings in time, resources and cost.

At REGENESIS we are driven by a strong sense of responsibility to the people charged with managing the complex environmental problems we encounter and to the people involved in developing and implementing our technology-based solutions. We are committed to investing in lasting relationships by taking time to understand the people we work with and their circumstances. We believe this is a key factor in achieving successful project outcomes.

We believe that by acting under this set of values, we can work with our customers to achieve a cleaner, healthier, and more prosperous world.

# WE'RE READY TO HELP YOU FIND THE RIGHT SOLUTION FOR YOUR SITE



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