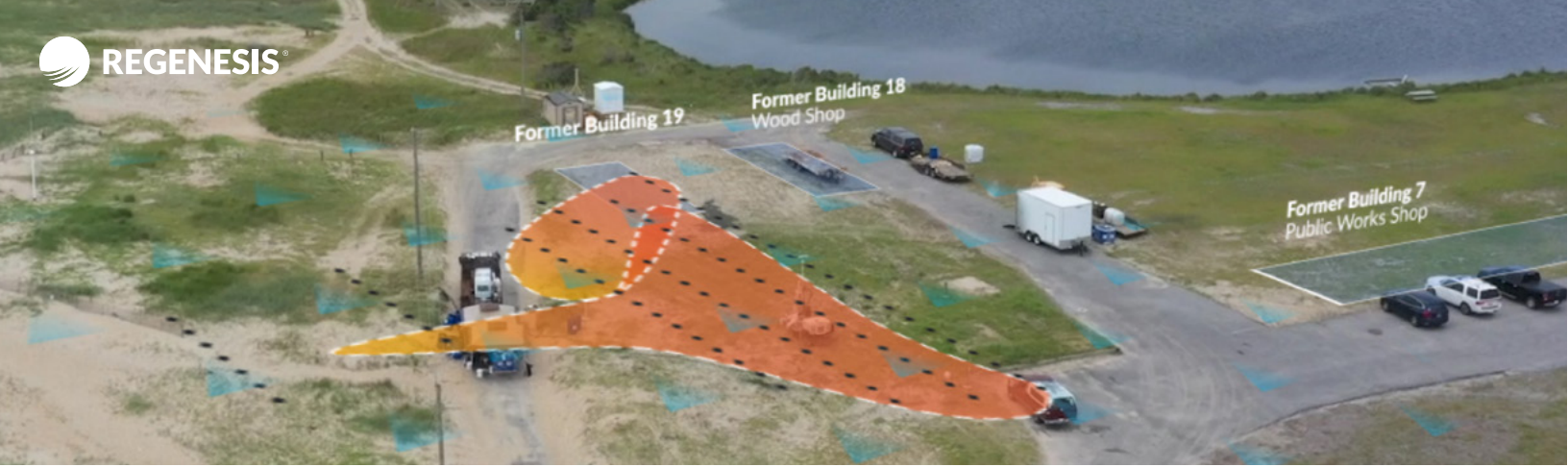


PETROFIX CHOSEN AS MOST COST-EFFECTIVE APPROACH

CASE STUDY:

In Situ Permeable Reactive Barriers Address Hydrocarbon Contamination at Former DoD Site



Overview

I-PRB Protects Sensitive Receptors at Former U.S. Naval Auxiliary Air Station (NAAS)



Pre and Post-injection cores taken on the first day of fieldwork to document PetroFix distribution



Pre-injection soil core (7.5 - 13.5 ft bgs.)
Soil color due to organic staining.



Post-injection soil core shows PetroFix distribution within the target treatment interval.



Based on visual confirmation of PetroFix in soil cores and monitoring wells, the crew was able to make real-time adjustments to injection volumes, pressure, tooling, and locations to accomplish the distribution goals



The responsible party plans on closely monitoring the site and is using PetroFix on other CERCLA/RCRA-funded sites to quickly reduce levels and accelerate site closure.

The former Buxton Naval Auxiliary Air Station is located within the bounds of the Cape Hatteras National Seashore (CHNS) on the North Carolina Outer Banks in Dare County, North Carolina. The site is located approximately 1,000 feet west-northwest of the historic Cape Hatteras Lighthouse, and within several hundred feet of the Atlantic Ocean. The US Navy utilized the site as a submarine monitoring station from 1956 to 1982. The US Coast Guard (USCG) acquired the facility after 1982 and used the site as a logistical, communication, medical, and supply support center.

The site contains four areas of investigation which encompass a total area of approximately 50,000 square feet in the southeast portion of the facility.

Area I	Area II	Area III	Area IV
included a former aboveground storage tank (AST) pad located south of former Bldg. 7	included the former Bldg. 9 (boiler house)	included the old Oil Change Ramp (OCR) located between Bldgs. 6 & 7	included the area east of the entrance road near former Bldg. 19

Since 2011, the site has been undergoing long-term monitoring. Although the monitoring shows natural attenuation occurring, persistent exceedances of petroleum hydrocarbons warranted additional remediation efforts. In the process of a thorough evaluation of viable remedies, the responsible party specified PetroFix micron-scale, liquid-carbon amendment to be applied to quickly and effectively address the contaminant levels and achieve their site goals of NFA. PetroFix Remediation Fluid was chosen because it is specifically designed to treat PHC plumes stemming from bulk storage, gas station, and UST spills.

Background

Routine Sampling Reveals Contamination

Primary Contaminants of Concern

Contaminant	Detected Levels
Napthalenes	3.4 µg/L
MADEP VPH	100 µg/L
MADEP EPH	110 µg/L

Massachusetts Department of Environmental Protection (MADEP)
 Volatile Petroleum Hydrocarbons (VPH)
 Extractable Petroleum Hydrocarbons (EPH)

Site Information

Plume Size	14,208 Sq. Ft.
Geochemistry	Low % Silty Sand
Area Zoning	Military / DoD
Soil Type	Sand / Silt
Nearby Sensitive Receptors	National Park & Residential Housing

At the former Buxton Naval Facility, between February 2009 and July 2011, four groundwater sampling events were conducted every nine months. At the conclusion of the fourth groundwater monitoring event, hydrocarbon concentrations above the NCDEQ Groundwater Quality Standards (GWQS) were still detected in samples from several site monitoring wells. Through discussions with NCDEQ, a determination was made to continue the long-term monitoring sampling until the analytical results were below the NCDEQ GWQS for four consecutive sampling events for contaminants of concern.

In October 2018, a Tier I meeting between the responsible party and the NCDEQ was held to determine the current status of this site and possibly optimize the current remediation method. This involved the installation of several new and replacement monitoring wells.

Further sampling events revealed 1-Methylnaphthalene detections above the Environmental Protection Agency (EPA) Tapwater Regional Screening Level (RSL) standard of 1.1 µg/L, Naphthalene detections above the NCDEQ standard of 6 µg/L, and Aromatic C9-C22 chain detections above the NCDEQ standard of 200 µg/L. During these sampling events, due to the close proximity to the Atlantic Ocean, each monitoring well was sampled once during the incoming tides and once during the outgoing tides in order to see if any tidal influence affected site conditions.





Timeline

PetroFix Was Chosen to Address COC's as the Most Cost-Effective Approach to Reach NCDEQ Standards



● 1956-1982

The U.S. Navy utilized the site as a submarine monitoring station until the U.S Coast Guard acquired the facility in 1982.



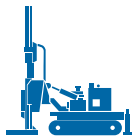
● 2009-2011

Four groundwater monitoring events take place at 9 month intervals. Sampling reveals hydrocarbon concentrations in excess of NCDEQ requirements.



● 2011-2020

All buildings are removed from the site in 2011. Long term monitoring continues through 2020.



● 2018

New monitoring wells are installed because previous wells had been destroyed by the elements, buried by wave action, or to alleviate concerns the existing wells showed contamination as a result of fouling (contaminants trapped in the screen openings and annulus space).



● June-September 2019

Two monitoring wells showed elevated 1-Methylnaphthalene levels. monitoring events were comprehensive and included, Incoming/outgoing GW sampling, slug testing, and in August 2019, tidal monitoring.



● June 2020

PetroFix Application takes place using an I-PRB approach. The responsible party plans on 4 quarterly monitoring events prior to requesting a NFA status.

Treatment Summary

Design Parameters

Treatment Interval	7.5-13 ft. bgs.
Injection Point Spacing	5 feet
Direct Push Injection Points	86
Remedial Approach	<i>In Situ</i> Permeable Reactive Barrier

Treatment

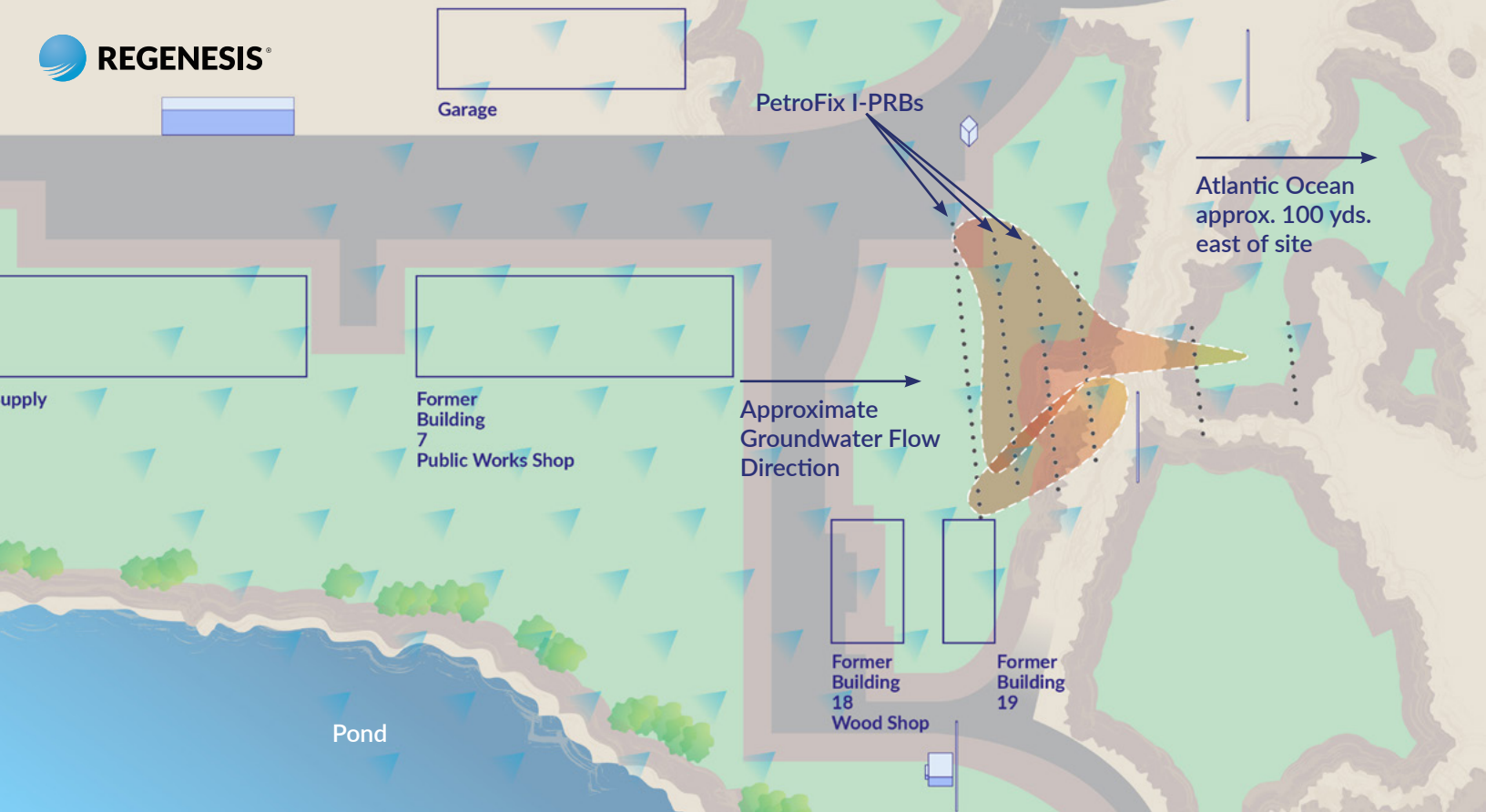
6 *In Situ* Permeable Barriers (I-PRBs) Were Installed to Effectively Mitigate the Plume

In coordination with the REGENESIS team, the responsible party determined that PetroFix would be effective in addressing the PAHs, volatile petroleum hydrocarbons, and extractable petroleum hydrocarbons to quickly and effectively reduce concentrations to achieve NCDEQ and EPA standards.

The design incorporated 6,000 pounds of PetroFix for a total of 18,648 gallons applied using direct-push injection at 86 points in an *in situ* permeable reactive barrier (I-PRB) design using 5 ft. spacing between points. The injections were placed at a vertical injection interval of 7.5 – 13 ft. below ground surface (bgs).

The reasoning for using a series of I-PRBs was to allow for the containment and long-term treatment of the hydrocarbon plume as contamination passed through each strategically placed I-PRB. This optimized design approach reduced total project cost as compared to a traditional grid injection while still providing a design to attain long-term treatment objectives.





PetroFix Amount	1,200 lbs	Total Volume	3,014 gal
Barrier Length	70 ft	Product Volume	122 gal
Delivery Points	14	Water Volume	2,892 gal
Point Spacing	5.0 ft	Injection Volume Per Point	215 gal
Top of Treatment Interval	7.5 ft bgs	Injection Volume Per Vertical Foot	31 gal
Bottom of Treatment Interval	13.0 ft bgs	Product/Point	8.7 gal
Treatment Area	490 ft ²	Water/Point	206.5 gal
PetroFix Dose	12.0 lb/ft ²	Soil Type	Coarse >75% Sand/Gravel
		Effective Pore Volume Fill %	60%
Mix Tank Volume	275 gal	AREA NOTES	
Dilution Factor	23.6		
PetroFix per Mix Tank	11.2 gal		
Water per Mix Tank	263.8 gal		
Electron Acceptor per Mix Tank	5.4 lbs		
Number of Batches Required	10.96		
Reported Groundwater Concentrations (mg/L)			
Benzene	0.000	Naphthalenes	0.003
Toluene	0.000	MTBE	0.000
Ethylbenzene	0.000	TPH-CRO	0.100
Xylenes	0.000	TPH-DRO	0.110
Trimethylbenzenes	0.000	TPH-ORO	0.000

In generating this design proposal REGENESIS relied upon professional judgment and site specific information provided by others. Using this information as input, we performed calculations based upon known chemical and geologic relationships to generate an estimate of the mass of product and subsurface placement required to effect remediation of the site. The attached design summary tables specify the assumptions used in preparation of this technical design. We request that these modeling input assumptions be verified by your firm.

It was also important to document whether PetroFix was successfully being injected and distributed through the subsurface. By using REGENESIS' detailed documentation on applying PetroFix, the field personnel oversaw that equipment needed for the injection was obtained, such as multi-port injection tooling and flow and pressure meters, and that observation soil cores were taken pre-and post-injection on the first day of field work to document PetroFix distribution at the site. Based on visual confirmation of PetroFix in soil cores or observed in monitoring wells the field crew was able to determine if PetroFix was being successfully distributed and if not to make real-time adjustments to injection tooling, injection volumes, and injection pressures to accomplish the distribution goals for the project.

Example PetroFix mixing and injection output provided for the Buxton project.

A field photoionization detector (PID) also was used to screen soils and identify higher and lower levels of contamination in the subsurface. At the Buxton site, the PID showed that a majority of the soil contamination was in the upper 3 to 4 feet of the injection interval and PetroFix was proportioned in-field to dose higher in this interval.



Pre-injection soil core (7.5 - 13.5 ft bgs.) Soil color is the result of organic staining.



Post-injection soil core shows PetroFix distribution within the target treatment interval.



Results

Compared to Thermal, and Air-Sparging Approaches, PetroFix was Considered Most Cost-Effective



Following the PetroFix application, the field crew plans on closely monitoring the site. Because of the proven ability of PetroFix to specifically sorb and biodegrade petroleum hydrocarbons (PHC), diesel, BTEX, MTBE, and MADEP-VPH/EPH, the field crew is using PetroFix on other CERCLA/RCRA-funded sites to quickly reduce levels and accelerate site closure.



After nearly a decade of persistent petroleum hydrocarbon exceedances, PetroFix was the chosen solution for the former Buxton Naval Facility because PetroFix offers an *in situ* approach designed specifically for sites where PHC levels are above regulatory standards for complete remediation, at the lowest total cost-to-closure.

Technology Used

PetroFix Remediation Fluid



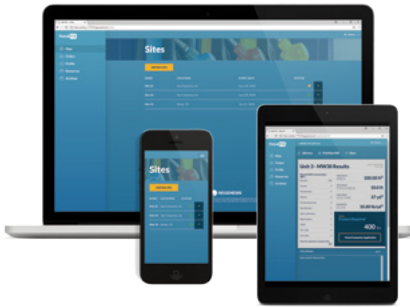
PetroFix Remediation Fluid is a concentrated, water-based, activated carbon suspension specifically designed to treat PHC plumes stemming from bulk storage, gas station and UST spills. Safe, fast, effective and easy-to-apply, PetroFix is designed to specifically sorb and biodegrade petroleum hydrocarbons (PHC), diesel, BTEX, MTBE, and MADEP-VPH/EPH. Composed of a mix of micron-scale activated carbon and electron acceptors to promote biodegradation, PetroFix offers an in-situ approach designed specifically for sites where PHC levels are above regulatory standards for complete remediation, at the lowest total cost-to-closure. PetroFix can also be applied to excavation sites.



Overhead view of this site depicting the PetroFix I-PRB application used to protect nearby sensitive receptors.



The PetroFix Design Assistant: You Design Use our Online Software to Generate an Estimate When you Need it



To make applying PetroFix simple and easy to use, REGENESIS created an innovative and effective online tool for developing recommended dosage and designs for your site. The PetroFix Design assistant equips environmental professionals with the tools to design individually-tailored remediation plans. This self-design, self-apply tool guides users toward effective designs that will yield the best results and allows users to easily order PetroFix through REGENESIS' customer service department. Educational resources and best practices are also offered along with an online video tutorial which walks the user step-by-step through the design and ordering process.

1 Create Your Account

Begin by creating an account with details about your site including the surface area and average vertical thickness and whether or not NAPL is present at this time.

2 Recommended Treatment

After providing the soil grain size and the groundwater contaminant levels, the Design Assistant will provide results showing the suggested treatment including the recommended volume, dosing, and product required for treatment.

3 Order PetroFix

Once all areas for the site are submitted, start the order process directly within the Design Assistant.



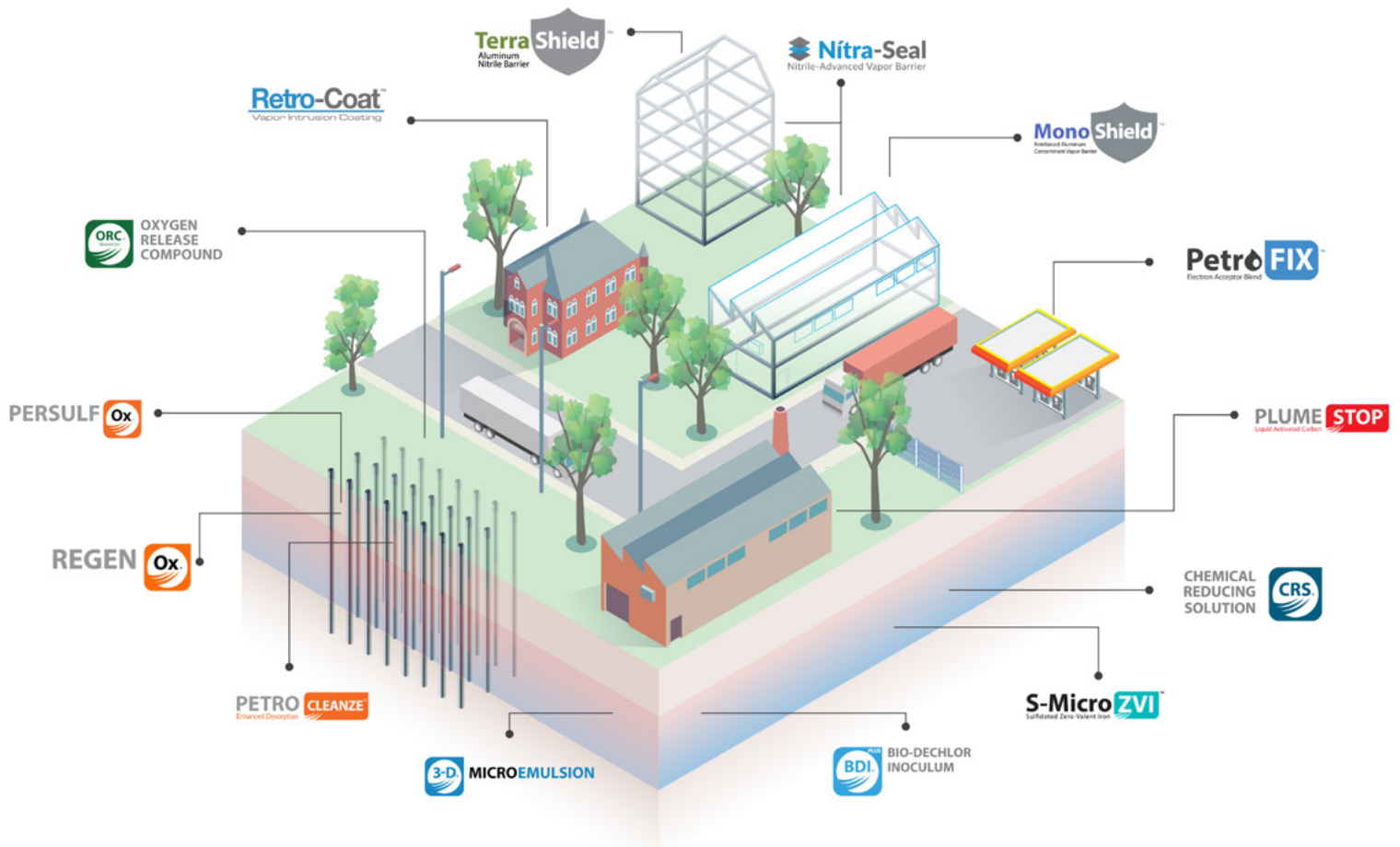
Simple
Easy to Use



Flexible
Designs Tailored
to Your Site



Fast
No Waiting
for a Design



REGENESIS[®]

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.

About REGENESIS

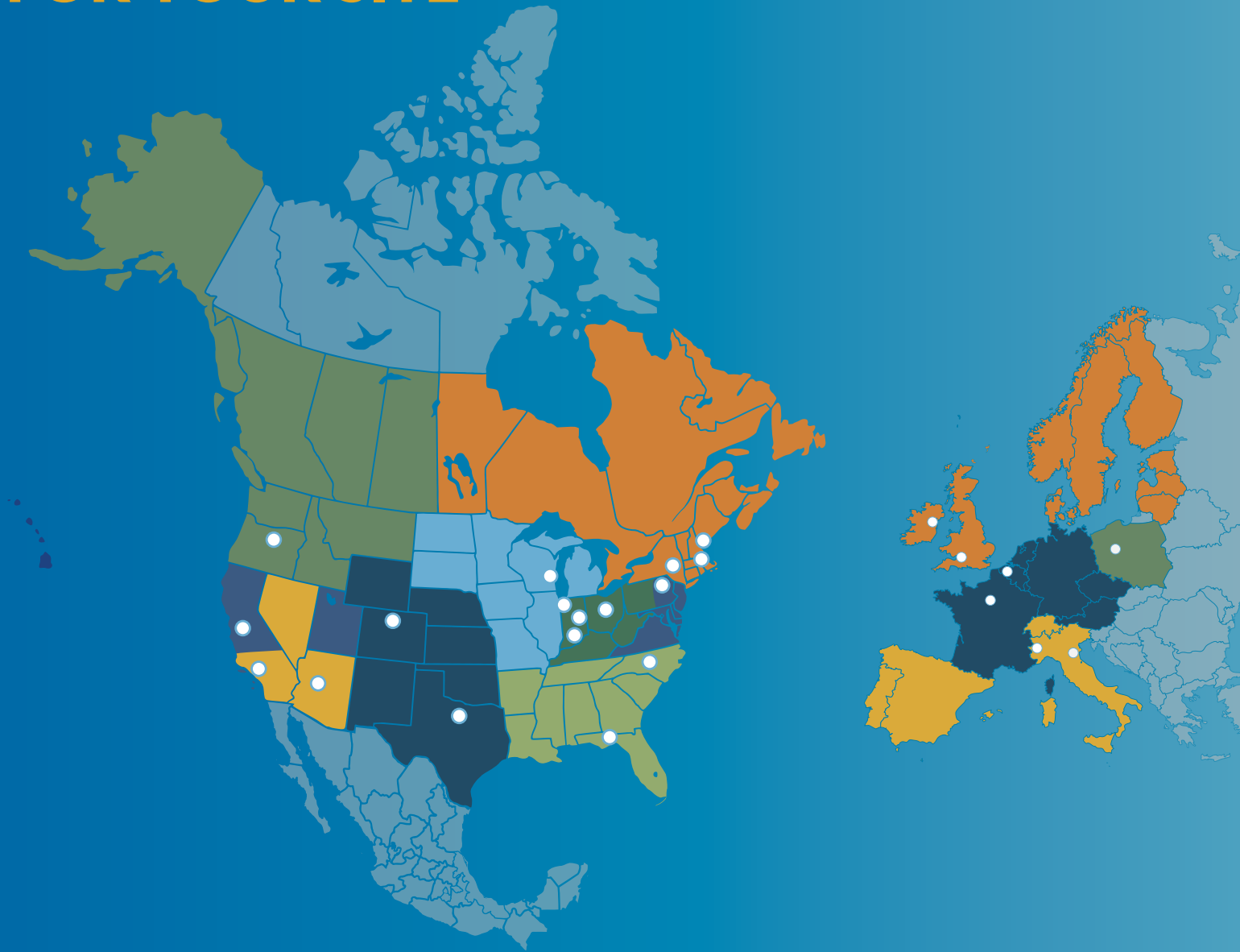
At REGENESIS we value innovation, technology, expertise and people which together form the unique framework we operate in as an organization. We see innovation and technology as inseparably linked with one being born out of the other.

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.

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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