

# BREAKTHROUGH TREATMENT FOR PFAS

**CASE STUDY:**  
**First Demonstrated**  
***In Situ* Treatment Solution**  
**For PFOA/PFOS At Former**  
**Industrial Site**





## OVERVIEW

This case study reviews a site impacted with petroleum hydrocarbons, perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA), and other perfluoroalkyl sulfonates (PFAS). The objective was to treat on-site groundwater and limit further contaminant migration.

A single application of PlumeStop resulted in a significant reduction of contaminant concentrations to below standards for 18+ months since the injection. Modeling indicates that the PlumeStop application event should keep the PFAS contained within the source area for upwards of 100 years. Details of the remedial design approach are provided along with results of its implementation.



## HIGHLIGHTS

- ➔ A single-injection of PlumeStop successfully immobilized TPH, PFOS, and PFOA in a source area and a down-gradient plume
- ➔ Eliminated future risk to public health as groundwater contaminants were contained, eliminating route of exposure
- ➔ Total cost was \$70,000 CDN
- ➔ Modeling indicates that PFOS and PFOA should remain contained within the source zone for decades with a single injection
- ➔ In the 18 months since PlumeStop was applied, TPH, PFOS, and PFOA have remained below guidance levels
- ➔ In the future, if required, a simple reinjection of PlumeStop is estimated to extend treatment for decades more



## BACKGROUND

Located in Central Canada, the site was a former industrial area impacted with petroleum hydrocarbons. Upon learning the history of the site, which included usage for firefighting training and fabric coating, the environmental service contractor, *In Situ Remediation Services Limited (IRSL)*, tested the groundwater for the presence of PFAS compounds and detected PFOS at 1,450 ng/L and PFOA at 3,260 ng/L. The contaminants, including the hydrocarbon, were located in a shallow area of an unconfined, silty sand aquifer with relatively high groundwater flow. The source had been excavated and IRSL was tasked with treating the remaining TPH to regulatory standards.



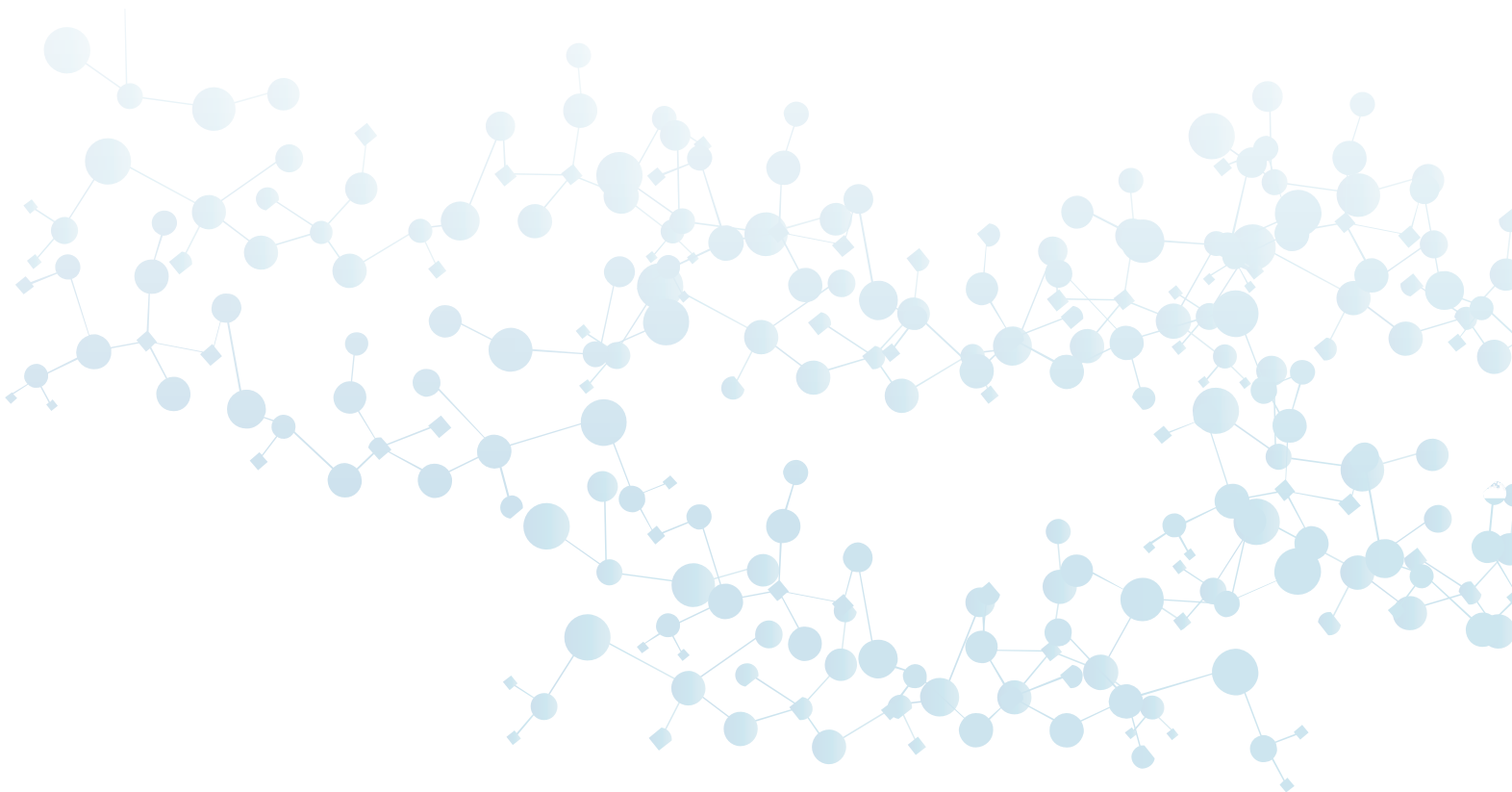
## WHAT IS PFAS?

Traditionally used in a variety of industrial applications, including carpeting, metal plating, and firefighting foam, perfluoroalkyl sulfonates (PFAS) are a class of chemical compounds which are considered emerging contaminants of concern as they are persistent, bioaccumulative, and toxic to people and wildlife. The United States Environmental Protection Agency (EPA) estimates that 6 million Americans have been exposed to PFAS.

Two such compounds, perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA), are particularly widespread. To provide a margin of protection against a lifetime of exposure to PFOS and PFOA in drinking water, the EPA set a Health Advisory Level at 70 ng/L. In addition, the fate and transport of these compounds is not well understood.

These compounds are typically treated using traditional pump and treat. Once extracted, the PFAS compounds are then removed from the impacted water with activated carbon, which requires disposal or regeneration, or anion exchange resins that are expensive to regenerate.

PFOS and PFOA are resistant to typical environmental degradation processes so *in situ* options for cleanup have been, to this point, limited.



## WHY PLUMESTOP?

In selecting a technology for this site, it is important to note that the primary objective was to clean up the petroleum hydrocarbon spill. The PFOS and PFOA was a secondary objective.

While other technologies were considered, ultimately PlumeStop was selected due to the need for a solution yielding rapid results, longevity to handle inevitable back-diffusion from the aquifer matrix, and create minimal disruption due to the site being in active use.

Although it would not destroy the PFAS, PlumeStop would remove it from groundwater, effectively cutting off the transport pathway, and thereby mitigating risk.

In choosing between PlumeStop and other injectable activated carbons, particle size was of particular importance. The small particle size of PlumeStop allows it to move freely through the pore space, follow contaminant pathways, and distribute effectively through the subsurface, overcoming aquifer heterogeneity. Additionally, the small particle size means it has higher surface area which translates to greater sorption capacity.

“The small particle size of PlumeStop allows it to move freely through the pore space”

By contrast, powdered activated carbon (PAC), which has larger particle sizes, would have lower sorption capacity, and can potentially create preferential pathways during the injection process, leading to less effective distribution, and therefore, less effective remediation. On a prior project site, IRSL demonstrated this in a side-by-side comparison of PlumeStop and PAC. The site target zone was 1.7m to 2.1m. On the same day as the injection, cores were taken at various distances from the injection points and samples at six-inch intervals were analyzed. Data for comparison is shown on page 7.

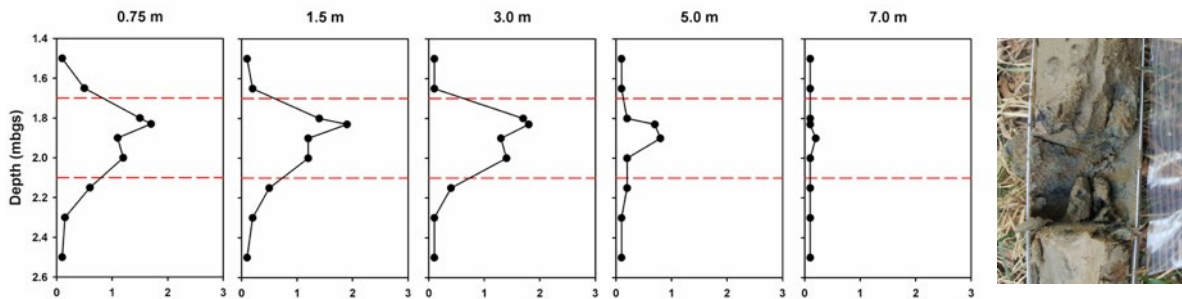
Results of the comparison showed that the PlumeStop distributed well both vertically and laterally, whereas the PAC channeled with limited vertical distribution.



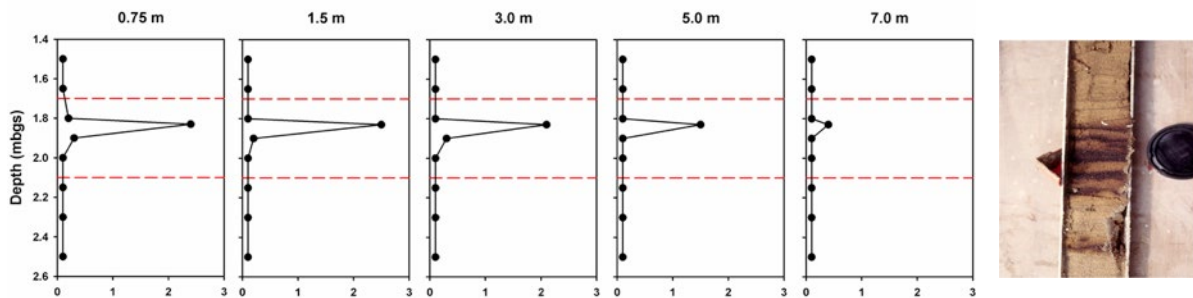


## SIDE-BY-SIDE COMPARISON

### LIQUID ACTIVATED CARBON



### POWDERED ACTIVATED CARBON



Given the results from data gathered at a recent site where IRSL compared the two carbon technologies, IRSL determined that PlumeStop was the only option that would meet the client's criteria as well as achieve the low concentrations necessary to meet both regulatory and voluntary standards.

Data shown originally presented at AEHS Amherst (2017) by Rick McGregor

## WHAT IS PLUMESTOP?

PlumeStop Liquid Activated Carbon is composed of very fine particles of activated carbon (1-2  $\mu\text{m}$ ) suspended in water through the use of a unique polymer dispersion chemistry.

Once in the subsurface, the material behaves as a colloidal biomatrix binding to the aquifer matrix, rapidly removing contaminants from groundwater, and expediting permanent contaminant biodegradation.

Specifically, PlumeStop:

- ➔ Rapidly reduces dissolved-phase plumes in days/weeks
- ➔ Distributes widely under low injection pressures
- ➔ Provides a colloidal biomatrix that completely biodegrades contaminants in-place
- ➔ Stops contaminant migration and protects sensitive receptors
- ➔ Provides a long-term means of addressing matrix back-diffusion
- ➔ Eliminates excessive time and end-point uncertainty associated with groundwater remediation

**PLUME** **STOP**<sup>®</sup>  
Liquid Activated Carbon







## DESIGN EFFORTS

### Pre-Remedial

IRSL collected both soil and groundwater samples following the injection event. Samples for PFOS and PFOA were taken according to United States Air Force (USAF) protocols. Tests were also done determining that the aquifer was pH neutral and anaerobic. Because the site was near a roadway, there were relatively high concentrations of salt, which raised concerns that it may affect adsorption.

The contaminant source mass flux was estimated to be 1.8 g/year, which is relatively low, but significant enough to be well above regulatory guidelines.

Based on the data gathered, IRSL worked with REGENESIS to generate a conceptual side model and used that to create a remedial plan that included dosage, product volume, and injection spacing.

# DESIGN EFFORTS

## Remedial

The design called for a single injection of PlumeStop to immobilize the TPH and PFAS. An oxygen releasing compound, ORC Advanced® (ORC-A) was also applied to promote aerobic biodegradation of the TPH.

There were two plumes considered: The hydrocarbon plume and, contained within it, a smaller PFOA and PFOS plume. Coverage of both plumes were attained using a grid of 50 total injection points, spaced 3m on center.

### PHC Plume Summary

- ➔ Injection Points = 50
- ➔ PlumeStop Injected = 725 kgs
- ➔ ORC-A Injected = 440 kgs
- ➔ Water Required = 7,800 litres

### PFOS and PFOA Plume Summary

- ➔ Injection Points = 20
- ➔ PlumeStop Injected = 290 kgs
- ➔ ORC-A Injected = 176 kgs
- ➔ Water Required = 3,120 litres

## Performance Monitoring

Performance monitoring has taken place at 3 month intervals over the course of 18 months post-injection.

# RESULTS

Initial monitoring returned non-detect results for BTEX, F1, and F2. After 18 months, BTEX and F1 was detected, but at concentrations below regulatory standards.

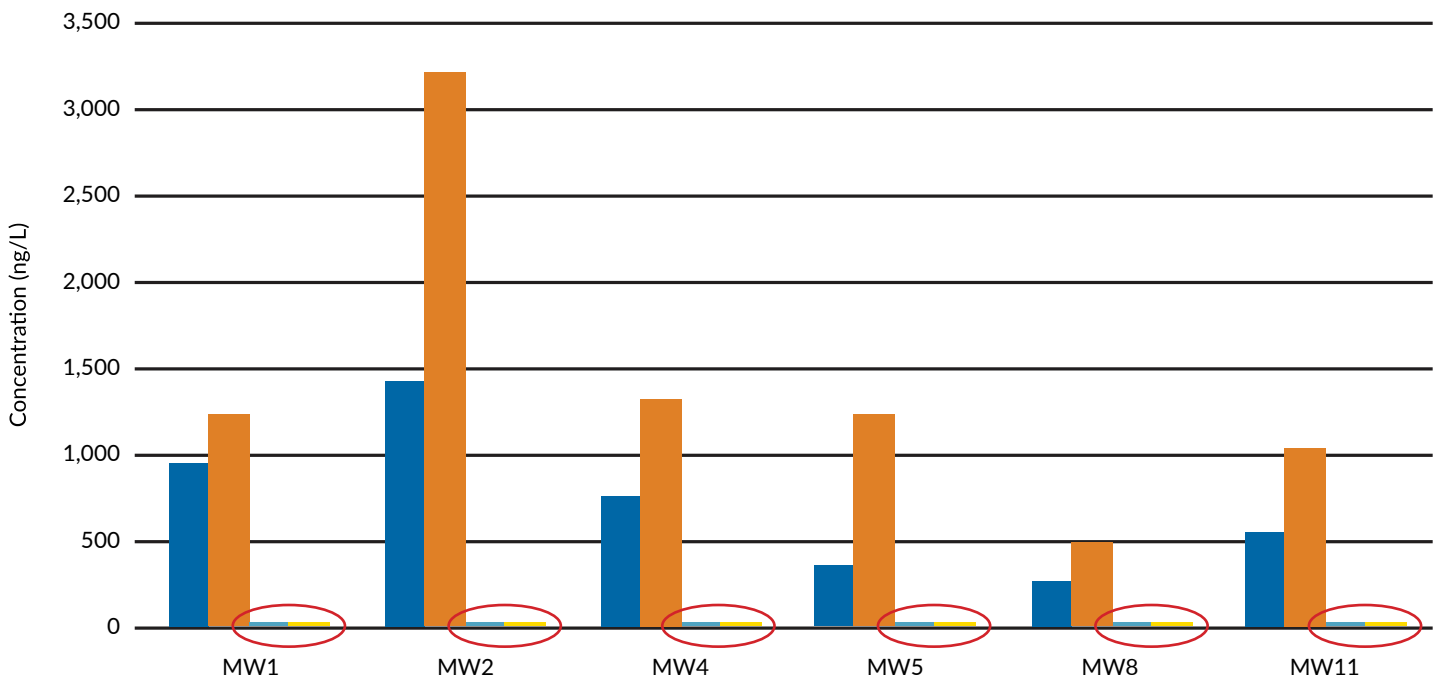
PFOS and PFOA concentrations stayed at non-detect for over a year. After 18 months, PFOA remained non-detect.

# COST

The entire treatment was accomplished for \$70,000 CDN. This is a fraction of the cost of a pump and treat installation, which would require ongoing costly operation and maintenance.



## SITE DATA MODELED



Key: ■ PFOS Pre ■ PFOA Pre ○ Monitoring data shows significant reductions in PFOS and PFOA levels post injection.  
 ■ PFOS Post ■ PFOA Post

While the remedy has been successful thus far, the question is whether or not PlumeStop will keep the PFAS contained over an extended time horizon, especially with mass flux re-entering the source zone via back-diffusion, desorption, and infiltration.

Using conservative assumptions, long-term modeling estimated that the PFAS contaminants would be contained for decades with a single injection and PFOA would be strongly adsorbed and, after 100 years, would result in concentrations of only  $1 \times 10^{-6}$  ng/L in the source zone. PFOS would not adsorb as strongly and, after 100 years, would be detected at 24 ng/L, still far below guidelines.

The model was also used to determine the efficacy of PlumeStop on sites with higher flux, assuming mass discharge a hundred times higher than actual site concentrations. They found that a single PlumeStop injection would be effective for 75 years, after which time PlumeStop can be re-injected or the PFAS can be treated *in situ* with future technology.

### ABOUT THE MODEL

IRSL approached Dr. Grant Carey, to evaluate the data using ISR-MT3DMS™, a reactive transport model which was updated to simulate the performance of PlumeStop® Liquid Activated Carbon™. The proprietary program modeled the performance and longevity of PlumeStop using the reactive transport model developed effectively showing long-term performance.

### ABOUT POREWATER SOLUTIONS

Porewater Solutions (PWS) is recognized as an industry leader in modeling consulting services for contaminated sites and water resources, with specialization in litigation and environmental forensics.



Dr. Grant Carey, PhD  
 President, Porewater Solutions

## APPLICATION SUMMARY

PlumeStop was implemented with a 50-point injection grid, successfully treating a plume of TPH and PFAS. Both the TPH and PFAS concentrations have remained below their applicable standards in the 18 months since injection. Modeling has shown that PlumeStop will be effective at keeping contaminants contained on this site for up to 100 years. The first of its kind, this project demonstrates that a single injection of PlumeStop can be very effective at immobilizing PFOS and PFOA *in situ* and mitigating their risk to human health.



## PLUME STOP

Liquid Activated Carbon

PlumeStop rapidly removes contaminants from groundwater and stimulates their permanent degradation.

### KEY BENEFITS:

- Rapid reduction of dissolved-phase plumes.
- Distribution of widely under low injection pressures.
- Achievement of stringent groundwater clean-up standards.
- Providing a long-term means of addressing matrix back-diffusion, so contaminants do not return.
- Elimination of excessive time and end-point uncertainty associated with groundwater remediation



## OXYGEN RELEASE COMPOUND

Oxygen Release Compound (ORC Advanced) is specifically designed and used for the enhanced or accelerated, *in situ* aerobic biodegradation of a wide-range of petroleum hydrocarbons or any aerobically degradable substance.

### KEY BENEFITS:

- Decreased time to site closure, degradation rates accelerated up to 100 times faster than natural attenuation.
- A single application can support aerobic biodegradation for up to 12 months.
- Minimal site disturbance, no permanent or emplaced aboveground equipment, piping, tanks, and power sources.
- Lower costs and greater efficiency/reliability than engineered mechanical systems, oxygen emitters and bubblers.
- Simple and easy application using a variety of available methods.

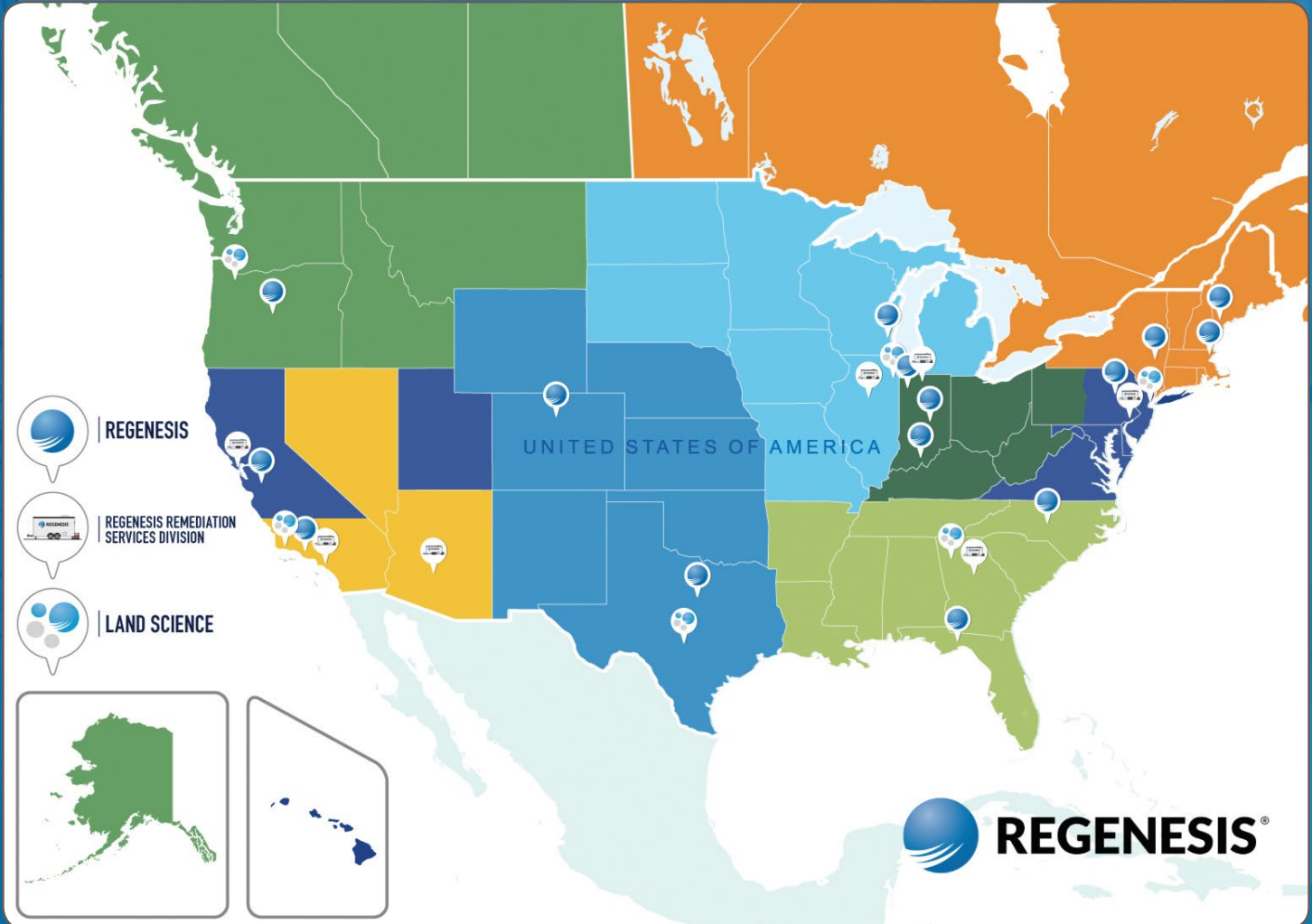


## ABOUT THE CONTRACTOR

One of Canada's most experienced remediation companies, [INSITU Remediation Services Ltd. \(IRSL\)](#) has designed, implemented, and maintained soil and groundwater remediation programs in diverse geological environments in North, Central, and South America, Europe and the Middle East.

Rick McGregor, President IRSL

# REGENESIS IS READY TO ASSIST YOU IN DETERMINING THE RIGHT SOLUTION FOR YOUR SITE



## Contact Us:

### Global Headquarters

1011 Calle Sombra  
San Clemente, CA 92673 USA  
Ph: (949) 366-8000  
Fax: (949) 366-8090

### European Offices

Bath, United Kingdom  
Ph: +44 (0) 1225 731 447  
  
Dublin, Ireland  
Ph: +353 (0) 1 9059 663

Torino, Italia  
Ph: +39 (0) 11 19781549  
  
Ieper, België  
Ph: +32 (0) 57 35 97 28





[www.regenesis.com](http://www.regenesis.com)

1011 Calle Sombra, San Clemente, CA 92673 | T: 949.366.8000

©2018 All rights reserved. REGENESIS, PlumeStop, and ORC Advanced, are registered trademarks of REGENESIS Bioremediation Products.

All other trademarks are the property of their respective owners.

