REGENESIS®

Innovative In Situ Approach Delivers Rapid Results and Eliminates Pump-and-Treat System

Targeted ISCR and ERD remediation approach quickly reduces PCE at redevelopment site

Summary

A redevelopment site impacted by a historical chlorinated solvent release, presented contaminant concentrations exceeding Nevada DEP regulatory thresholds. In collaboration, REGENESIS and Atlas designed a comprehensive *in situ* solution to rapidly and cost-effectively address contamination, supporting the site's redevelopment timeline. Injected amendments—including 3-D Microemulsion®, S-MicroZVI®, and Bio-Dechlor INOCULUM Plus® (BDI Plus), enabled accelerated progress toward site closure, eliminating the long-term need for a pump-and-treat system, which had already extracted 18 million gallons of groundwater and was unlikely to meet cleanup goals in the foreseeable future. Results demonstrated immediate and sustained reductions in PCE, without daughter product accumulation, as the site now advances quickly toward regulatory closure.

>16x to infinite
PCE degradation rate improvement

Zero
daughter product buildup as site approaches regulatory goals

Site type
Commercial/Industrial

Contaminants of concern
Primarily tetrachloroethene (PCE), up to 26,000 µg/L, with limited chlorinated volatile organic daughter compounds (CVOCs)

Geology
Clay-dominant, with discontinuous sand and gravel layers and caliche

Project driver
Redevelopment

Treatment
Enhanced reductive dechlorination (ERD) and *in situ* chemical reduction (ISCR)

Technologies applied
3-D Microemulsion, S-MicroZVI, BDI Plus

Background

Pending Redevelopment: PCE Cleanup Acceleration Needed

"The pump-and-treat system was working, but it's a very slow process. The results of the pilot test with REGENESIS were very promising. The responsible party was on board with saying, 'Let's clean this up.'"

Lynette McMonagle
Senior Technical Leader, Atlas

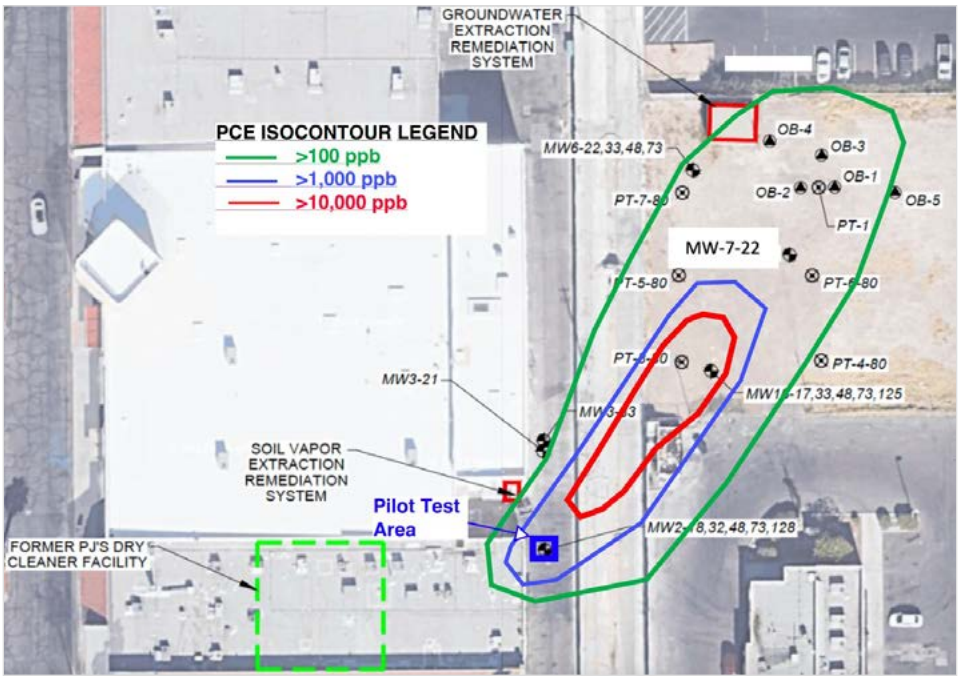
Chlorinated solvent contamination at the site was first discovered in 2009 during sewer repair work near a former dry-cleaning facility. Subsurface investigation revealed a plume of tetrachloroethene (PCE) in groundwater, prompting long-term remediation efforts. Figure 1 PCE concentrations in the plume were reported as high as 26,000 micrograms per liter, indicative of potential residual dense non-aqueous phase liquids (DNAPL). Since 2015, Atlas—a leading environmental consulting and engineering firm in the western U.S.—has overseen site management.

Beginning in 2017, a combination of pump-and-treat (P&T) and soil vapor extraction (SVE) systems was installed to control and reduce the extent of the plume. Despite treating 18 million gallons, the systems showed slow and uneven progress, with limited effectiveness in key zones.

With redevelopment pending, the team collaborated with REGENESIS to accelerate cleanup and achieve closure more efficiently.

Figure 1 Aerial View

Aerial view of the PCE plume, soil vapor and groundwater extraction treatment systems, and monitoring well network.



Remediation

In Situ Approach Chosen to Replace P&T

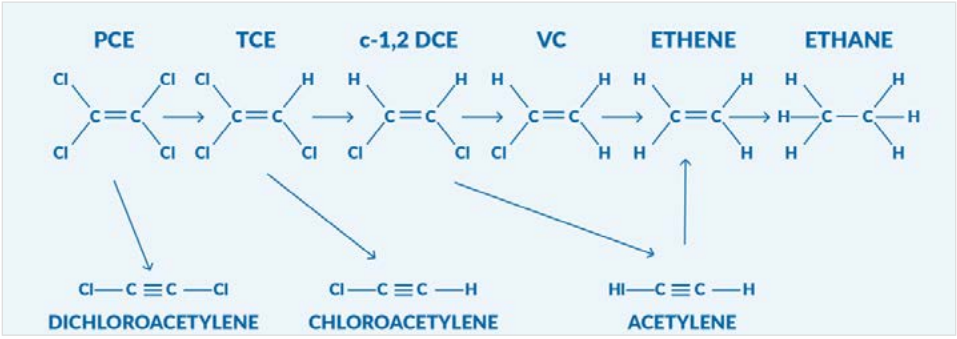
"This trio of technologies turns the aquifer anaerobic, and the S-MicroZVI provides both abiotic and biotic degradation pathways for chlorinated solvents, ensuring long-lasting effectiveness."

Keith Munsey
Technical Manager, REGENESIS

To tackle the site's CVOC impacts, REGENESIS and Atlas worked to develop a combined ISCR and ERD approach. Figure 2 The selected solution combined 3-D Microemulsion (organic electron donor), S-MicroZVI (abiotic reductant), and BDI Plus (bioaugmentation culture) to develop multiple degradation pathways in the subsurface for rapid degradation of chlorinated solvents to harmless end products. This approach has demonstrated effectiveness and substantially improved CVOC degradation compared to other technologies at many sites worldwide.

Figure 2 Degradation Pathways

Diagram showing degradation pathways for tetrachloroethene (PCE) and trichloroethene (TCE). The biologically mediated pathway is shown on the top row. The abiotic reactions, which largely bypass the formation of daughter products cis-1,2-dichloroethene (c-1,2-DCE) and vinyl chloride (VC), are indicated by the down-arrows. The combination of 3-D Microemulsion, S-MicroZVI and BDI Plus facilitates chlorinated solvent degradation via all these pathways.



Confronting Site Challenges

"We have a pretty large site with a very thick treatment interval, anywhere from about 30 feet below ground surface to 80 feet. It's an unusually large vertical treatment interval, but we intend to deliver success."

Isaac Gregg
Project Manager, REGENESIS
Remediation Services

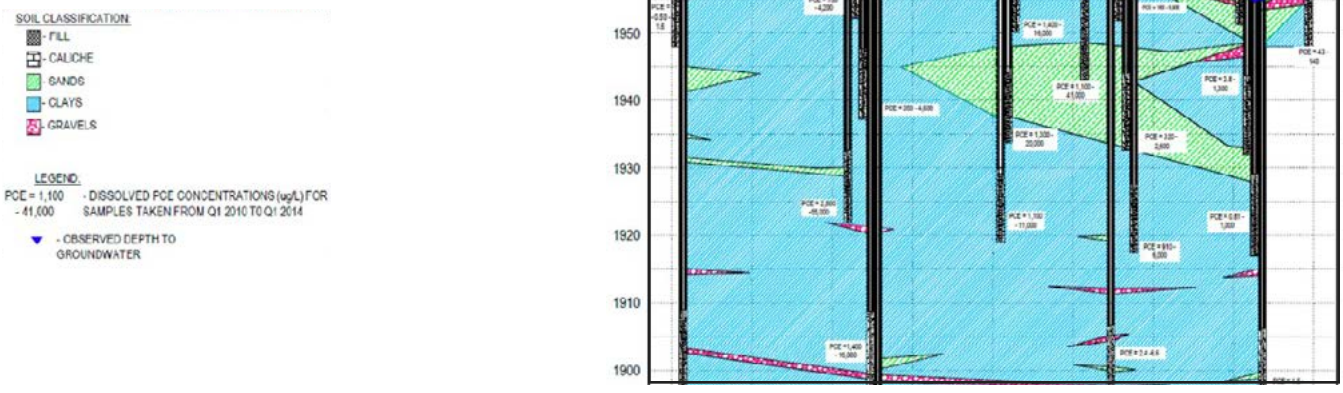
Before an *in situ* remediation strategy could be implemented, the project team needed to evaluate several site-specific challenges that could impact amendment delivery, cost-effectiveness, and overall performance. Key feasibility questions included:

Could progress be accelerated over pump-and-treat and how could this be demonstrated?	Redevelopment goals placed pressure on the team to reduce cleanup timelines and costs, requiring alternatives to conventional long-term pump-and-treat. Regulators and stakeholders required measurable evidence of treatment effectiveness over a compressed timeframe, favoring solutions with rapid-acting mechanisms.
Could injections be performed cost-effectively at the required depth?	The targeted treatment interval exceeded 80 feet below ground surface (bgs), with a subsurface profile consisting of interbedded clay and cemented caliche zones—posing challenges for deep injection. Figure 3
Could amendments overcome distribution challenges due to heterogeneity?	The subsurface was highly heterogeneous, complicating amendment distribution.

Given these challenges, a field-scale test was conducted to evaluate *in situ* injection feasibility and performance under site conditions. The pilot provided critical data on amendment distribution, contaminant mass reduction, and achievable injection flow rates, helping to establish the full-scale approach as a viable pathway toward more rapid closure.

Figure 3 Cross Section in Treatment Area

Cross section in treatment area. Clay dominant-matrix (blue-shading) with intermittent sand/gravel zones and caliche layers shows challenging geology for in situ remediation.



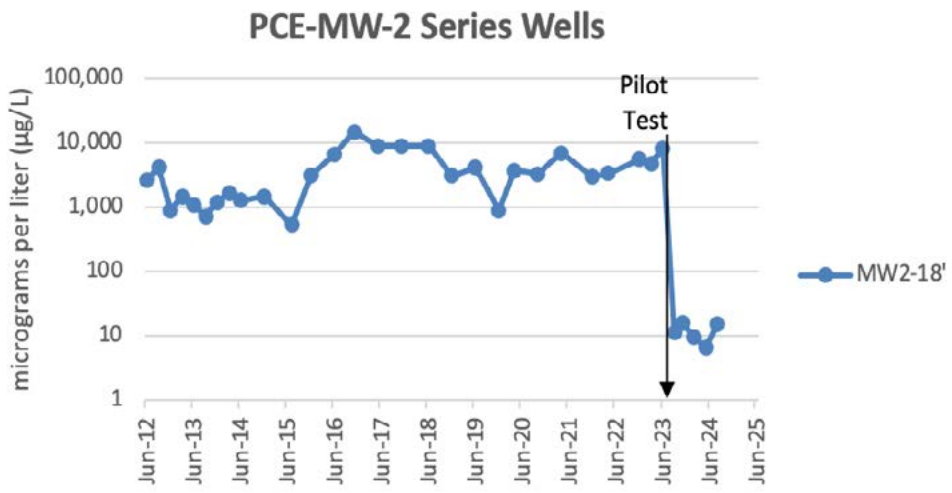
Field-Scale Application Test and Results

A limited field-scale application (i.e., pilot test) was conducted in August 2023 to evaluate the feasibility of ISCR and ERD. The amendment performance portion of the test included injecting S-MicroZVI, 3-D Microemulsion, and BDI Plus across the shallow interval of monitoring well MW2 (MW2-18'), historically one of the most heavily impacted zones with PCE concentrations exceeding 10,000 µg/L. The goal was to assess amendment distribution, delivery effectiveness, and treatment performance to guide the full-scale design. The other primary goal of the test was to demonstrate that the injection could be performed at depths greater than 80 feet to treat the deeper plume interval.

The results of the testing showed PCE concentrations at MW2-18' dropped by over 99%—from >10,000 µg/L to below 100 µg/L—within just 30 days of application. Prior to injection, this well showed no measurable degradation. Figure 4

Figure 4 PCE-MW-2 Series Wells

PCE concentrations at MW-2-18' before and after the ISCR/ERD field-scale pilot test injection.



Additionally, the test validated that injection was feasible at depths greater than 80 feet below ground surface—critical for minimizing the injection costs for the subsequent full-scale application. Lessons learned from this pilot directly guided the layout and approach of the broader remedial program.

Collaborative Efforts

The project's success hinged on strong communication and coordination between Atlas, REGENESIS, and regulatory authorities. To gain approval from the Nevada Division of Environmental Protection (NDEP), both teams participated in regular calls, providing site data, pilot test results, and ongoing updates to ensure transparency and alignment with regulatory standards.

Full-Scale Application

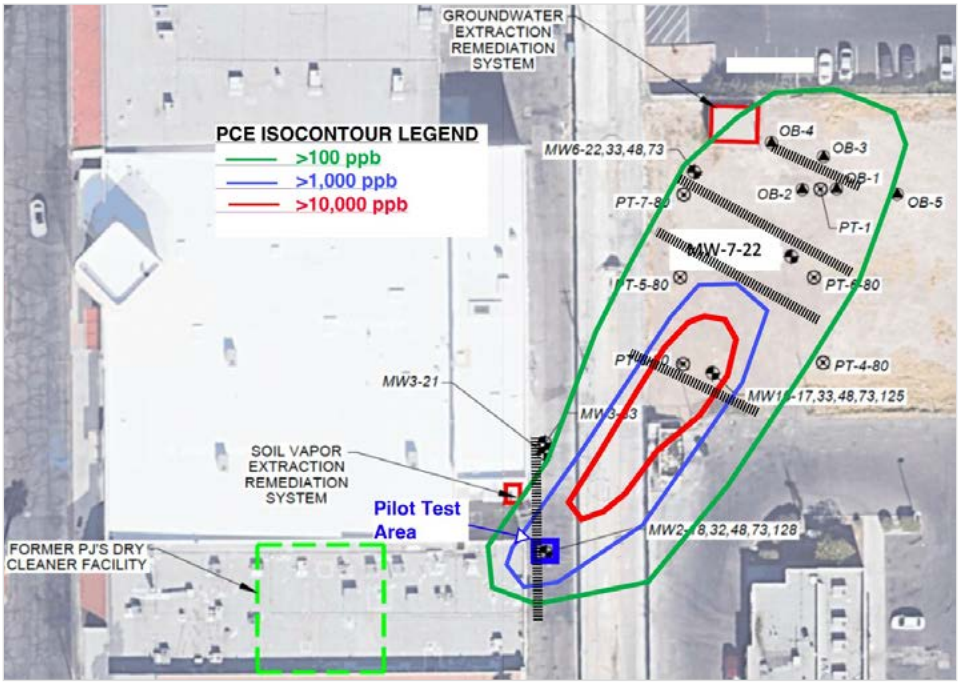
From October 10 through November 1, 2024, REGENESIS Remediation Services (RRS) completed the full-scale injection of 3-DME, S-MZVI, and BDI Plus to remediate the PCE plume, with Atlas oversight. These technologies were applied using 65 direct push technology (DPT) injection locations across an extensive treatment zone, ranging from 11 to 86 feet below ground surface. A total of 78,804 gallons of liquid amendments and 195 liters of BDI Plus were injected. Informed by the pilot test, the project succeeded despite deep injections in challenging lithology, requiring careful drilling and adjustment.

Application Details

Dates	October 10 – November 1, 2024 (17 days)
Injection Points	65 direct-push injection points
Treatment Interval	Ranging from 11 to 86 feet below ground surface (bgs), variable by location
Technologies Applied	3-D Microemulsion, S-MicroZVI, and BDI Plus
Total Amendment Volume Applied	Approximately 79,000 gallons

Figure 5 Injection Locations

3-D Microemulsion, S-MicroZVI and BDI injection locations in the PCE groundwater plume, with full-scale transects shown by blue lines and pilot test area shown by blue box.



Results

The combined pilot and full-scale application of 3-D Microemulsion, S-MicroZVI, and Bio-Dechlor INOCULUM Plus led to rapid and substantial improvements in contaminant degradation across both the source and plume areas. Figure 6 In the mid-plume, not under the direct influence of the injections, quantitative analysis showed a 16-fold increase in the PCE degradation rate Figure 7 compared to the pre-injection baseline, confirming accelerated attenuation driven by the treatment. Additional monitoring wells across the plume showed even greater reductions, with some achieving regulatory compliance levels within 12 months of the full-scale injection significantly shrinking the magnitude and extent of the plume. Figure 8

Figure 6 PCE Degradation Results

Charts showing PCE degradation before and after ISCR/ERD injections at source area well (MW-2) and plume well series wells MW-6, MW-16, and MW-7.

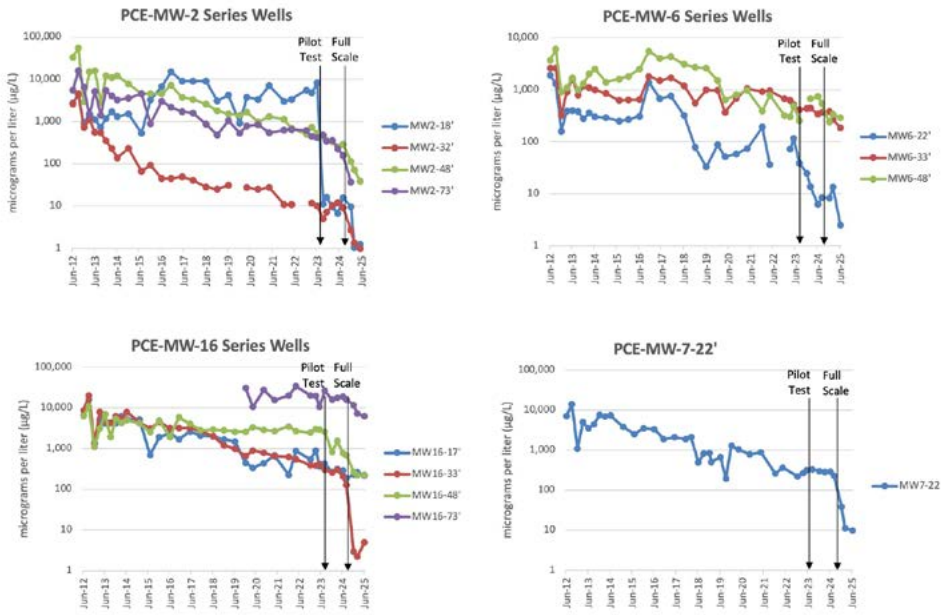
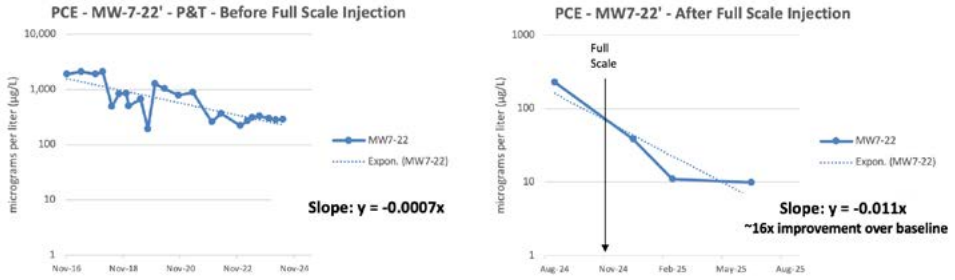


Figure 7

PCE Degradation Rates

Comparison of PCE degradation rates before and after ISCR/ERD injection at mid-plume well MW-7-22'.

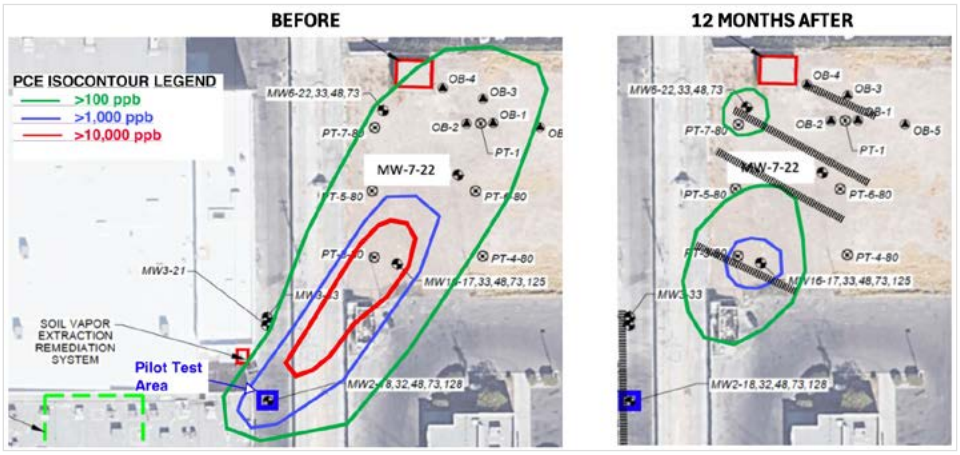


These results confirm that the *in situ* approach delivered rapid and sustained performance, even in a complex hydrogeologic setting.

Figure 8

PCE Plume Isocontour Maps

PCE Plume isocontour maps before and 12 months after in situ remediation, showing substantial shrinking of the plume in the first year post-treatment.

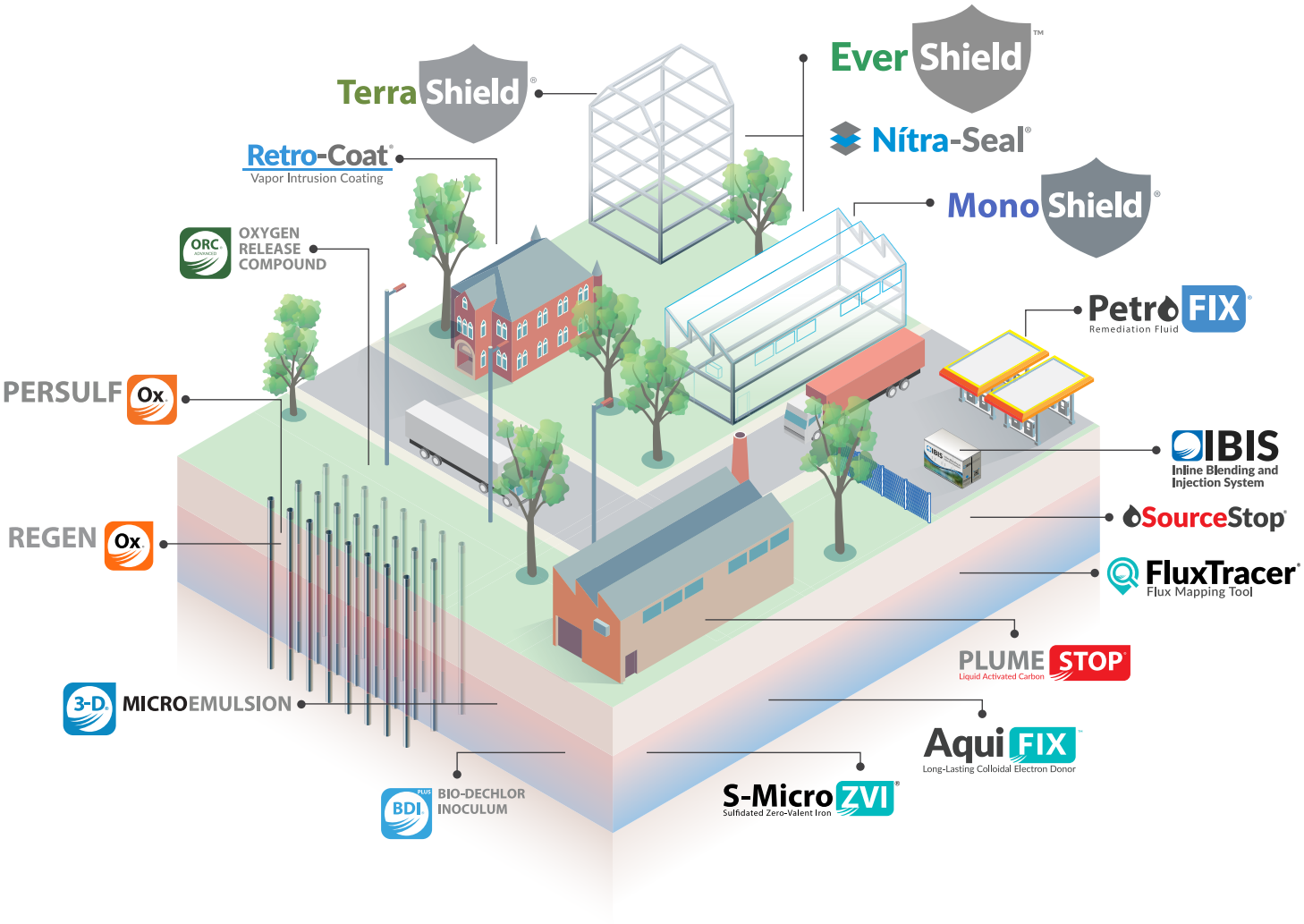


Conclusion

"The biggest benefit of this remedy was the (reduced) timeline to achieve our remediation goals. It shortens the project lifespan and provides sustainable outcomes."

Ron Santos
Principal Engineer, Atlas

The successful transition from pilot to full-scale *in situ* remediation of PCE at this site demonstrates the potential for rapid, cost-effective performance in challenging subsurface environments where other approaches, especially P&T systems, underperform. By replacing a system that extracted 18 million gallons of groundwater with targeted ISCR and ERD, the project achieved faster degradation, reduced daughter product formation, and accelerated progress toward closure. This outcome offers a scalable model for redevelopment-driven sites with similar challenges, validating the effectiveness of advanced *in situ* technologies in complex settings.



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.

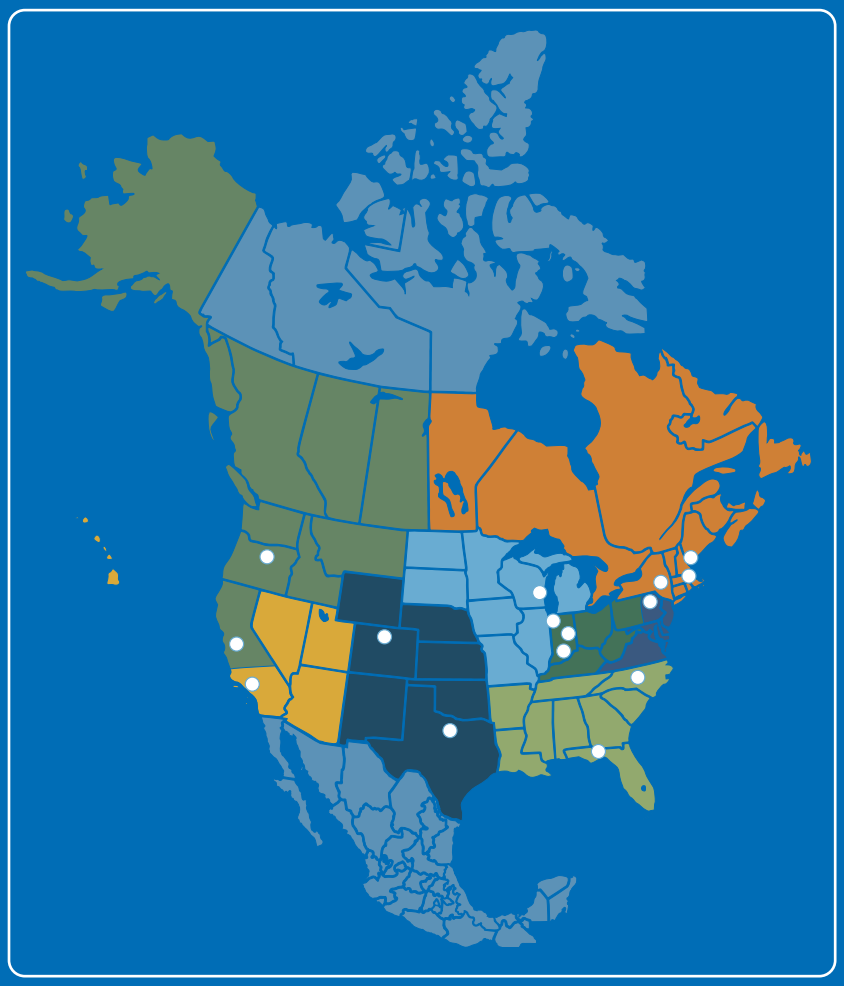
At REGENESIS we are driven by a strong sense of responsibility to the people charged with managing the complex environmental problems we encounter and to the people involved in developing and implementing our technology-based solutions. We are committed to investing in lasting relationships by taking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

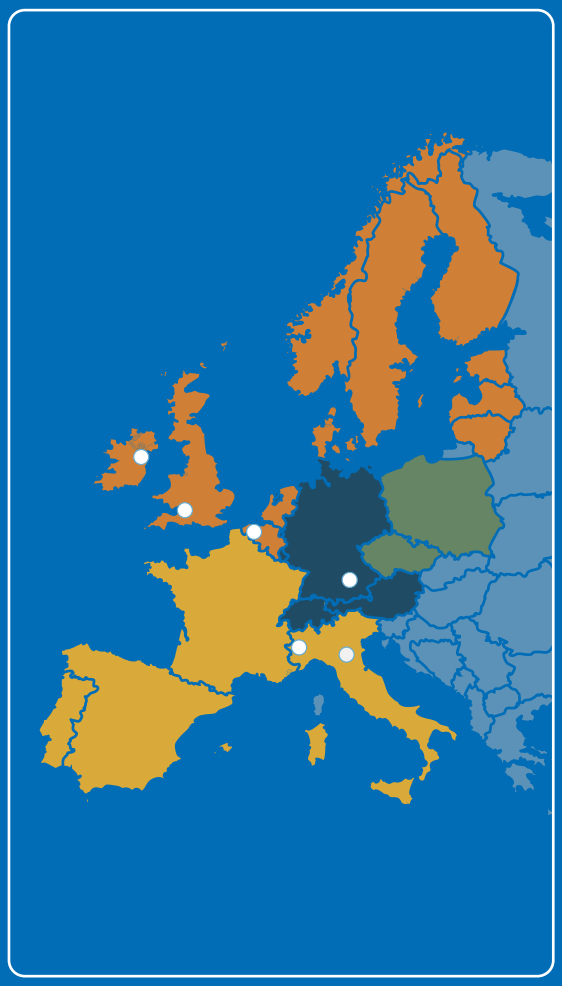
We believe that by acting under this set of values, we can work with our customers to achieve a cleaner, healthier, and more prosperous world.

REGENESIS®

Have a challenge? Let's solve it together.

Contact us today to discuss your specific needs.





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