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Targeted CVOC Remediation Achieves 99.9% Reduction while saving $3.7M

Advanced Conceptual Site Model and Combined Remedy Accelerate Path to Closure

Summary

A former dry cleaning and grocery store site in Seattle was impacted with high levels of chlorinated solvents within complex subsurface geology. Aestus' GeoTrax Survey™ methodology was used to build an ultra-high-resolution conceptual site model (CSM), which significantly enhanced the understanding of the site's hydrogeology—particularly the role of a newly identified sand channel in contaminant transport. This insight enabled optimal placement of remediation technologies, including electrical resistance heating (ERH) in the source zone and 3-D Microemulsion® and S-MicroZVI® injections throughout the downgradient plume. Following these actions, chlorinated ethenes were reduced by 99.9% plume-wide, with much of the plume reaching non-detect levels. The application of state-of-the-art tools for both characterization and remediation led to an estimated $3.7 million in cost savings compared to conventional strategies as the site progresses toward regulatory closure and redevelopment.

99.9%
Reduction in total CVOC groundwater concentrations

$3.7 Million
Estimated cost savings

Site type
Brownfield site undergoing mixed-use redevelopment (residential and retail)

Contaminants of concern
Perchloroethylene (PCE), Trichloroethylene (TCE), cis-1,2-dichlorethene (DCE), and Vinyl Chloride (VC)

Geology
Recessional Outwash: a high-permeability sand channel 20–35 feet bgs, bounded by glacial till and shallow bedrock

Project driver
Redevelopment of contaminated brownfield into 380-unit mixed-income housing with 32,000 sq ft of retail

Technologies applied
S-MicroZVI and 3-D Microemulsion to promote *in situ* chemical reduction (ISCR) and enhanced reductive dechlorination (ERD) in Groundwater Plume

GeoTrax Survey™ using advanced electrical resistivity imaging to develop a high-resolution CSM

Electrical Resistance Heating (ERH) with Soil Vapor Extraction (SVE) in Source Zone

Site location map. Image credit Urban Environmental Partners.

Background

The site is a 2.3-acre brownfield located in Seattle, Washington, formerly home to three dry cleaners (1930–1968) and a grocery store (1967–1998) built atop creosote-treated timber piles. Historical operations contributed to extensive subsurface contamination, including a plume of chlorinated volatile organic compounds (CVOCs) in groundwater which was migrating offsite. CVOCs detected in soil and groundwater at levels exceeding Washington State's Model Toxics Control Act (MTCA) cleanup standards, included:

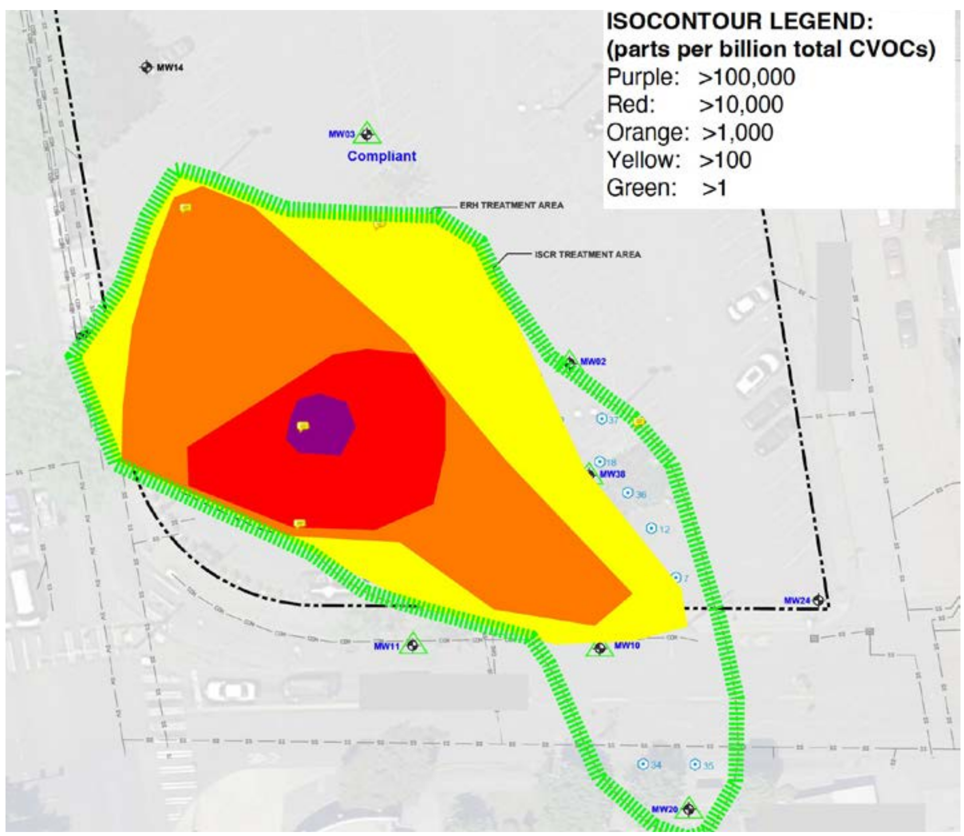
- Perchloroethylene (PCE)
- Trichloroethylene (TCE)
- cis-1,2-Dichloroethylene (cis-1,2-DCE)
- Vinyl Chloride (VC)

Nearly two decades after contaminant discovery, Urban Environmental Partners Consulting (UEP), a leading Northwest US environmental consultant, began managing the site. UEP determined that an enhanced understanding of the subsurface hydrogeology and contaminant distribution was needed to improve remediation targeting and outcomes.

Figure 1

Isoconcentration map

Isoconcentration map depicting total CVOCs in groundwater (baseline: 2020-2022 data)



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Advanced remedial design characterization

Targeted approach reduces footprint saving millions in costs

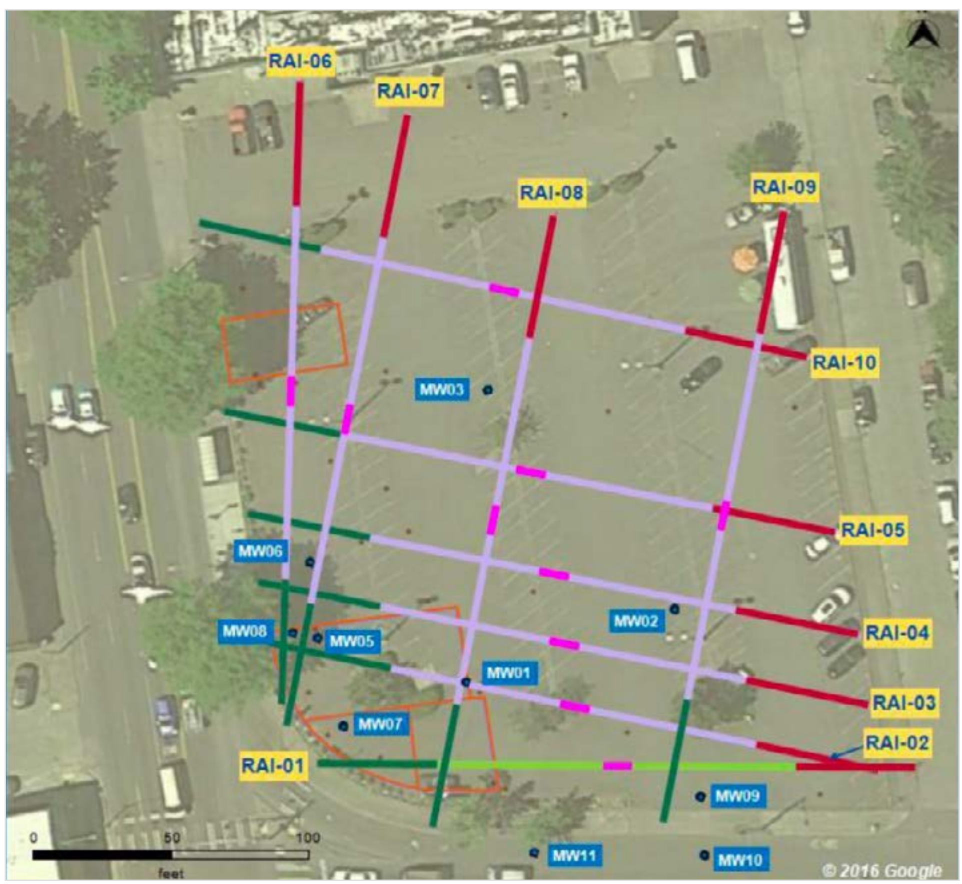
To accelerate remediation and reduce costs, UEP contracted Aestus to perform its GeoTrax Survey™ specialty electrical resistivity imaging to update the CSM. Aestus completed a series of electrical surveys to provide 2-D cross-sections and 3D visualizations of the subsurface hydrogeology (Figures 2 and 3). This surface-deployed mapping technique enabled:

- Precise delineation of contaminant transport pathways, including a paleochannel that was influencing contaminant migration
- Strategic confirmation drilling focused in critical flow paths
- Significantly reduced treatment footprint

Figure 2

GeoTrax Survey™

Map of Aestus GeoTrax Survey™ transects. Image credit - Aestus.

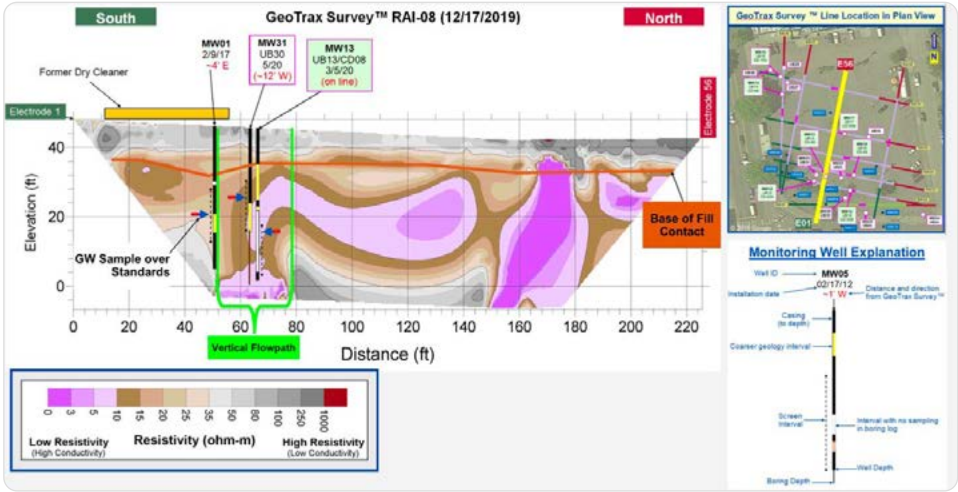


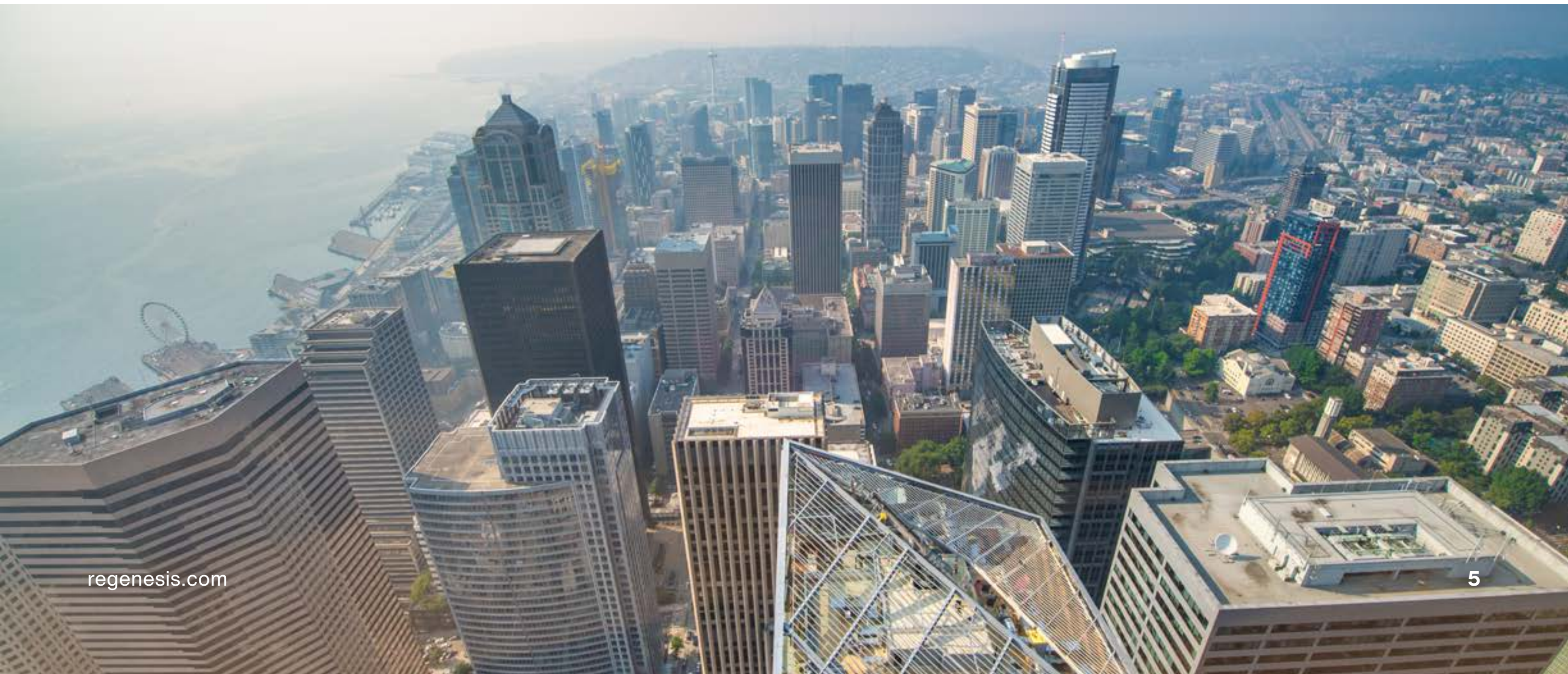
High concentrations of total chlorinated ethenes were discovered through this process with over 160,000 micrograms per liter (µg/L) detected in the plume core. However, no evidence of DNAPL was observed during the investigation.

This advanced remedial design characterization paved the way for developing a cost-effective remedial strategy. Following Aestus' imaging and important CSM updates, UEP completed a comprehensive Remedial Investigation/ Feasibility Study (RI/FS), recommending a targeted combined remedy approach as the most cost-effective solution.

Figure 3 Cross-sectional resistivity RAI-08

Cross section of GeoTrax Survey™ electrical resistivity mapping of line RAI-08, showing a diving plume of chlorinated ethenes in the proposed remediation area. Image provided by Aestus.





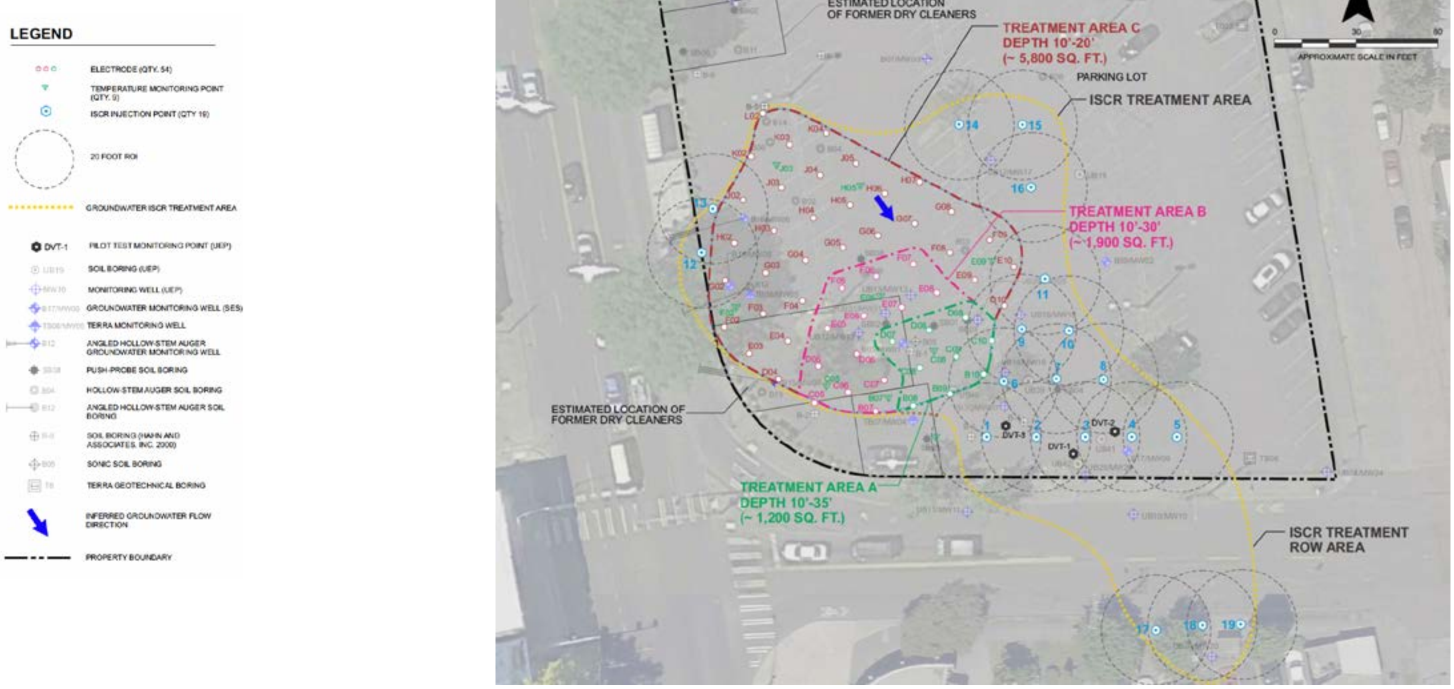
Remediation

Technology selection

The Washington Department of Ecology (WDOE) evaluated five cleanup alternatives under MTCA criteria and selected the most feasible protective option, combining multiple technologies to address both source and plume conditions. This included electrical resistance heating (ERH) along with soil vapor extraction (SVE) to aggressively remediate the source zone, combined with *in situ* chemical reduction (ISCR) and enhanced reductive dechlorination (ERD) to mitigate CVOC contamination in the wider plume. S-MicroZVI and 3-D Microemulsion were proposed to facilitate a dual ISCR-ERD approach, eliminating the CVOCs through both abiotic and biotic pathways.

Figure 4 Target remediation areas

Plan view map depicting target remediation areas.



ISCR/ERD application

To address CVOC mass in the dissolved-phase plume, a targeted *in situ* treatment program was implemented using a blend of S-MicroZVI, 3-D Microemulsion and Bio-Dechlor INOCULUM Plus. These amendments were mostly applied within a permeable sand channel located between 20 and 35 feet below ground surface, with additional injections performed around localized hot spots. A supplemental application was completed in the ERH remediation area as a polishing step to address remaining CVOCs.

Application Details

Target zone	Approximately 10,000 square feet surface area and 20–35 feet depth	
Quantities Applied	S-MicroZVI	9,800 lbs
	3-D Microemulsion	14,000 lbs
	Bio-Dechlor INOCULUM Plus	51 Liters
Total Volume Injected		~40,000 gallons
Injection Points		64 (direct-push technology)

Results

Both the high-resolution site characterization and remediation performance data confirm the effectiveness of the data driven, targeted approach at the site.

Design and implementation outcomes

Using Aestus' GeoTrax Survey™, the project team completed a high-resolution scan of the CVOC plume, enabling precise delineation of both vertical and horizontal contaminant mass. This advanced imaging allowed for a significantly reduced remediation footprint, with ERH, SVE, and ISCR/ERD treatments strategically focused along known flow paths and within a key sand channel. By targeting only areas of active mass transport, the team achieved effective treatment while avoiding unnecessary over-application—resulting in projected cost savings of up to $3.7 million compared to more conventional, broad-scale approaches.

Remediation performance (through March 2025)

The combined remedial application reduced the chlorinated ethenes by 99.9%, shrinking the magnitude and footprint of the CVOC plume to a small residual area. To date, only a few wells in the former plume core have concentrations remaining above Washington's stringent MTCA cleanup levels for VC (0.2 µg/L) or cis-1,2-DCE (16 µg/L).

Figure 5

Median total CVOC concentrations

Chart showing median CVOC concentrations from 11 performance monitoring wells in the target treatment zone at baseline (2020-2022) vs March 2025.

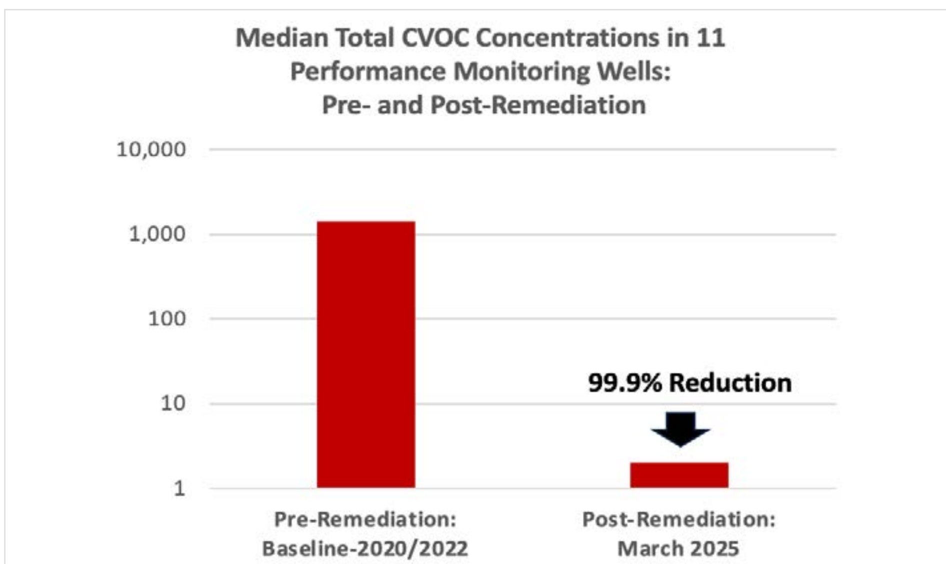


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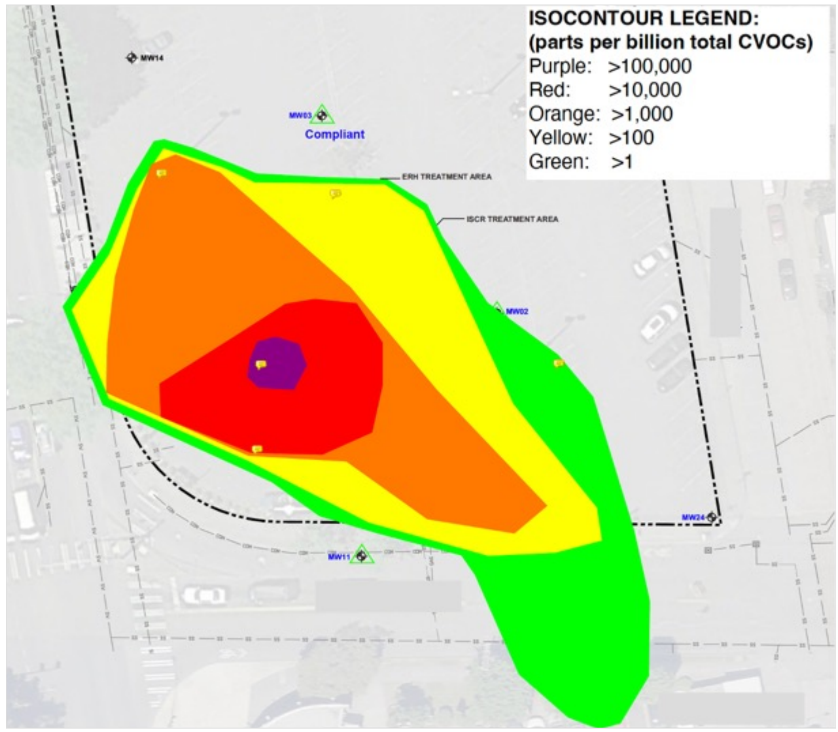
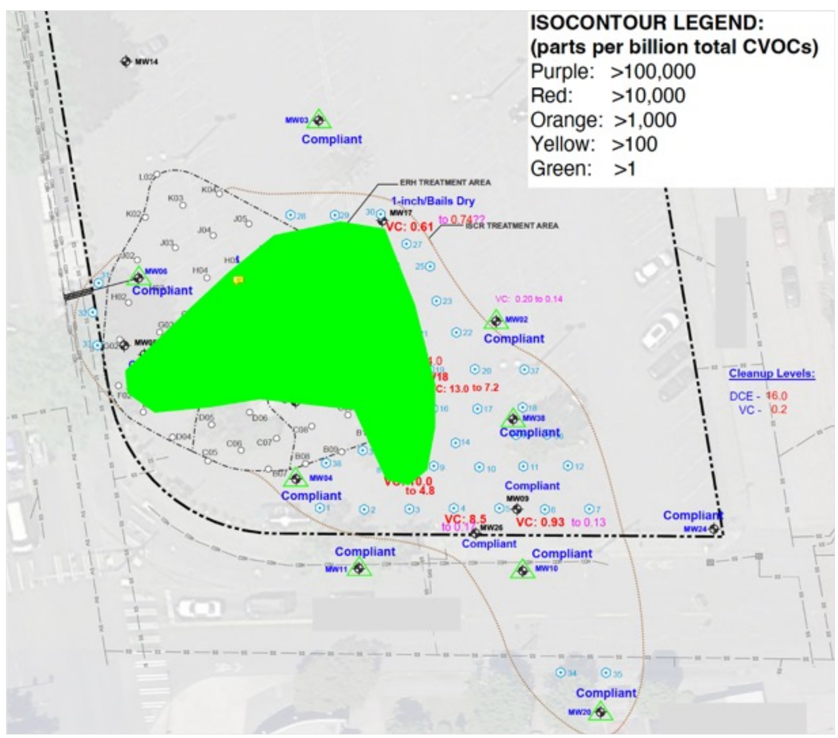
Figure 6

Total CVOC isoconcentration maps

Total CVOC isoconcentration maps at baseline pre-remediation (2020-2022) at left and post-remediation (March 2025) at right





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Conclusion

The Seattle brownfield redevelopment project demonstrates how strategically integrating advanced site characterization with targeted *in situ* remediation technologies can deliver exceptional outcomes—even at complex urban sites with high contaminant mass. By leveraging Aestus' GeoTrax Survey™ data to develop a high-resolution CSM, the project team was able to accurately delineate contamination, understand subsurface transport pathways, and design a highly focused remediation approach.

The chlorinated solvent source zone was effectively mitigated using ERH and remediation of the residual dissolved phase plume has been rapidly achieved using REGENESIS's state-of-the-art sulfidated ZVI (S-MicroZVI) and electron donor (3-D Microemulsion) technologies.

The result -total chlorinated ethenes were reduced by 99.9%, with most wells reaching or approaching non-detect levels. This performance was achieved without excavation or infrastructure removal, resulting in $3.7 million in projected cost savings.

The success of the project highlights the power of innovation, precision design, and cross-disciplinary collaboration. The site is now positioned for successful redevelopment, providing affordable housing and community-serving retail, and moving confidently toward regulatory closure.

About Urban Environmental Partners Consulting

Urban Environmental Partners (UEP) is a specialized environmental consulting firm providing expert support in site assessment, remediation strategy, and regulatory navigation for complex contaminated properties. With decades of experience, UEP works closely with developers, attorneys, brokers, landowners, and property buyers to deliver actionable solutions that move projects forward.

UEP's expertise spans the full lifecycle of environmental due diligence and remediation—from Phase I and Phase II assessments to remedial investigation, cleanup planning, and implementation oversight. The firm offers deep technical capabilities in contaminant fate and transport, cost estimating, and forensic evaluations, including petroleum age-dating and PCB source identification. UEP is recognized for its strategic insights, technical rigor, and proven ability to support redevelopment of challenging brownfield sites.

"This in-situ injection project exemplified the power of collaboration and innovation between multiple professionals. By ensuring detailed site condition communication among various technology providers, we successfully developed a comprehensive remedial approach to achieve our remedial targets in all impacted media. Partnering with REGENESIS and utilizing a synergistic treatment method incorporating S-MicroZVI, 3-D Microemulsion, and Bio-Dechlor Inoculum worked to effectively meet our cleanup criteria for soil and groundwater. The results pave the way for the redevelopment of this legacy site."

John Funderburk, MSPH
Managing Partner, Principal
Urban Environmental Partners, LLC

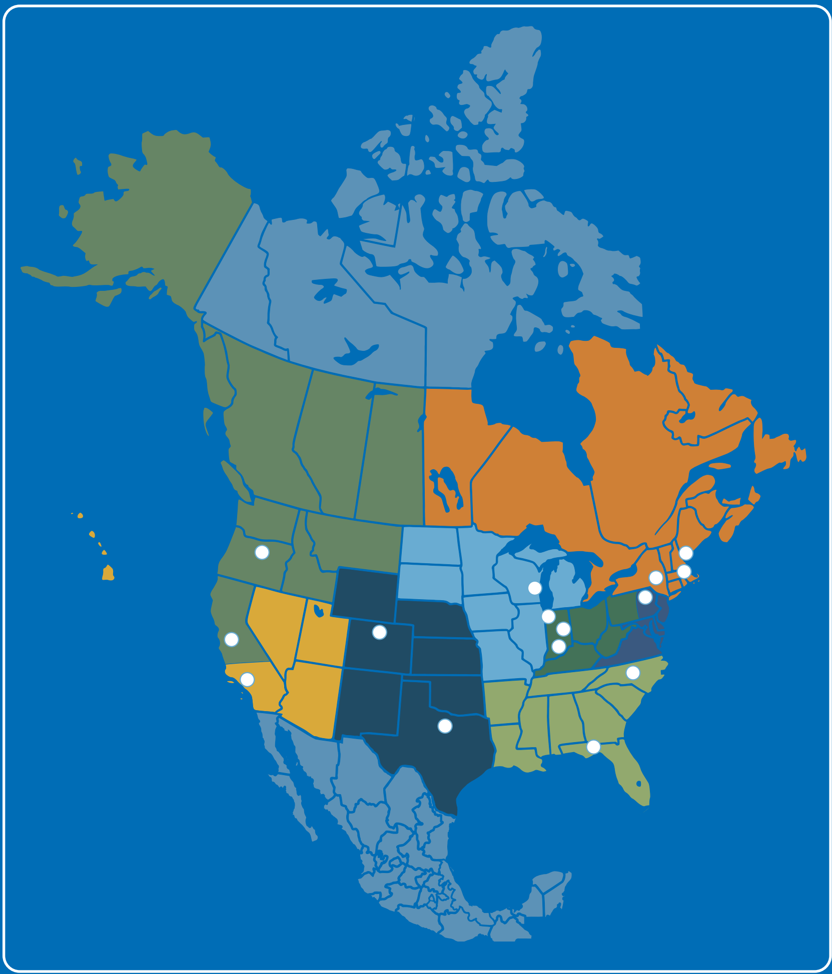
About Aestus

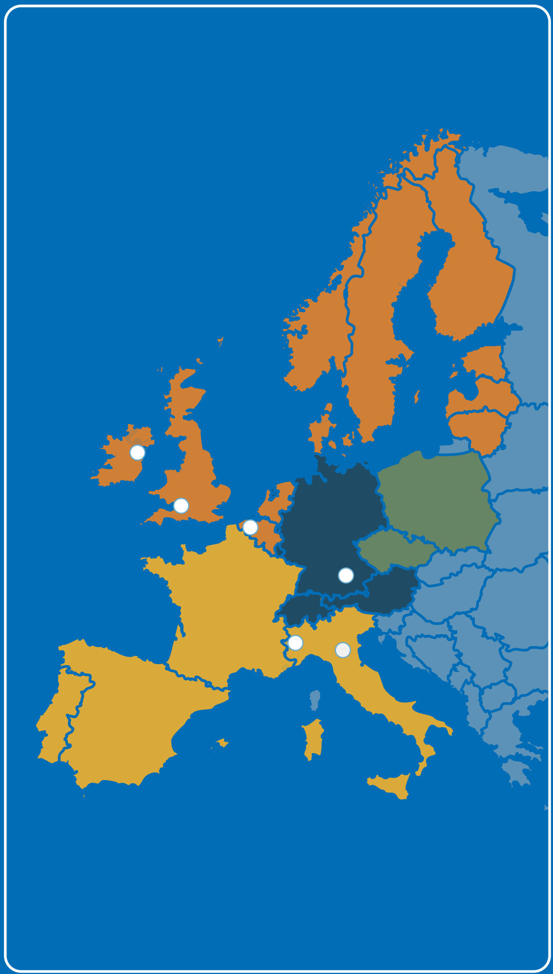
Aestus is a leader in ultra-high-resolution subsurface characterization, helping project teams make faster, more cost-effective decisions. For more than 20 years, Aestus has supported over 100 clients—including environmental consultants, industry, the U.S. military, and regulatory agencies—with advanced geophysical tools that bring clarity to complex sites.

Using proprietary methods such as the GeoTrax Survey™, Aestus integrates geophysical, geologic, and chemical data into robust conceptual site models (CSMs) that drive focused, defensible remediation strategies. By reducing uncertainty and avoiding unnecessary drilling, Aestus helps clients optimize remediation performance and reduce long-term project costs.

Have a challenge? Let’s solve it together.

Contact us today to discuss your specific needs.





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