HISTORIC SITE ON TRACK TO REACH REMEDIATION GOALS

CASE STUDY:

Chlorinated Solvent Concentrations Significantly Reduced at Manufacturing Site By Utilizing Sorption and Biodegradation

REGENESIS®

REGENESIS®

HIGHLIGHTS

- Creative combined remedy approach addressed accumulated contaminants from over 100 years of manufacturing operations
- Innovative application approach using 1.5" diameter wells effectively accommodated low ceiling and tight spaces, allowing for successful reagent injection
- Daylighting around the well annulus avoided by high-pressure grouting through the drill rods with a tremie tube
- 180 days post-injection, all VOCs were measured at greatly reduced concentrations and geochemical conditions remain ideal for biodegradation
- Current results have prompted WSP to move toward an eventual unrestricted site closure

Successful Approach

Moving Towards Unrestricted Closure

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OVERVIEW

A manufacturing facility in the Ohio River Valley operated for over a century producing a range of products including everything from wooden pulleys to engine parts. Historical site operations included the use of chlorinated solvents, specifically tetrachloroethene (PCE) and trichloroethene (TCE), which have impacted as much as 7,500 square feet of shallow groundwater. To move the redevelopment of the site forward and reach unrestricted site closure from the regulatory agency, groundwater volatile organic compound (VOC) sample results must meet the U.S. Environmental Protection Agency maximum contaminant levels (MCLs) for four consecutive quarters.

A combined remedy of PlumeStop® with Hydrogen Release Compound® (HRC) and Bio-Dechlor Inoculum Plus® (BDI+) was selected to address groundwater in a recalcitrant portion of the plume where previous *in situ* treatment applications did not achieve remedial action goals. The PlumeStop-based remedy was selected for this area of the site because of its ease of delivery, adsorptive capacity for both contaminants, and its biostimulant effects. Following the application of the combined remedy, current results have prompted WSP, the consultant firm contracted to provide the remedial solution, to move the site forward and WSP is confident that the goal of unrestricted site closure will be met.

COMBINED REMEDY APPROACH

PLUME STOP® Liquid Activated Carbon — PlumeStop was needed to sorb dissolved phase contaminants

HRC® HYDROGEN RELEASE COMPOUND — HRC to promote anaerobic enhanced reductive dechlorination process of PCE and TCE

BDI® PLUS BIO-DECHLOR INOCULUM — BDI+ was used to treat daughter products such as dichloroethene (DCE) and vinyl chloride (VC)

BACKGROUND

Located in the Ohio River Valley, this manufacturing facility operated for more than one hundred years. The manufacturing operations began in 1890 and included tobacco, metal casting, and engine parts. After 2008, the site was used for warehousing and industrial storage. During the long industrial history of the property, chlorinated solvents were used and ultimately contaminated approximately 7,500 square feet of shallow groundwater.

Because of the magnitude and extent of groundwater contamination, remediation was necessary in order for the site to be safely used in the future. REGENESIS and WSP, a global environmental consulting firm, designed a combined remedy approach of PlumeStop with HRC and BDI+. This technology was selected to address the groundwater contamination at this site because of its ease of delivery, adsorptive capacity for both contaminants and its biostimulant effects.

PREVIOUS SITE USAGE

Tobacco Warehouse

Metal Casting & Engine Parts Mfg.

Manufacturing

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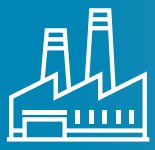
PROPERTY TIMELINE

Property History

1890-1900: Tobacco Warehouse
1900-1930: Wooden Pulley Manufacturer
1930-1970: Metal Casting Manufacturer
1970-2008: Engine Parts Manufacturer
2008-2014: Warehouse/Industrial Storage
2014-Present: Vacant

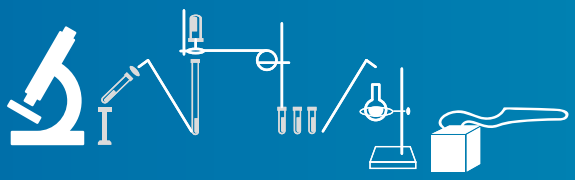


2004 Phase I

Environmental Site Assessment

2005-'09 Site Characterization

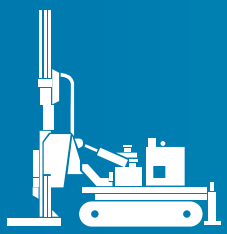
Soil, Groundwater,
Vapor Intrusion



2010 Remediation Begins

Biostimulation and
Bioaugmentation approach

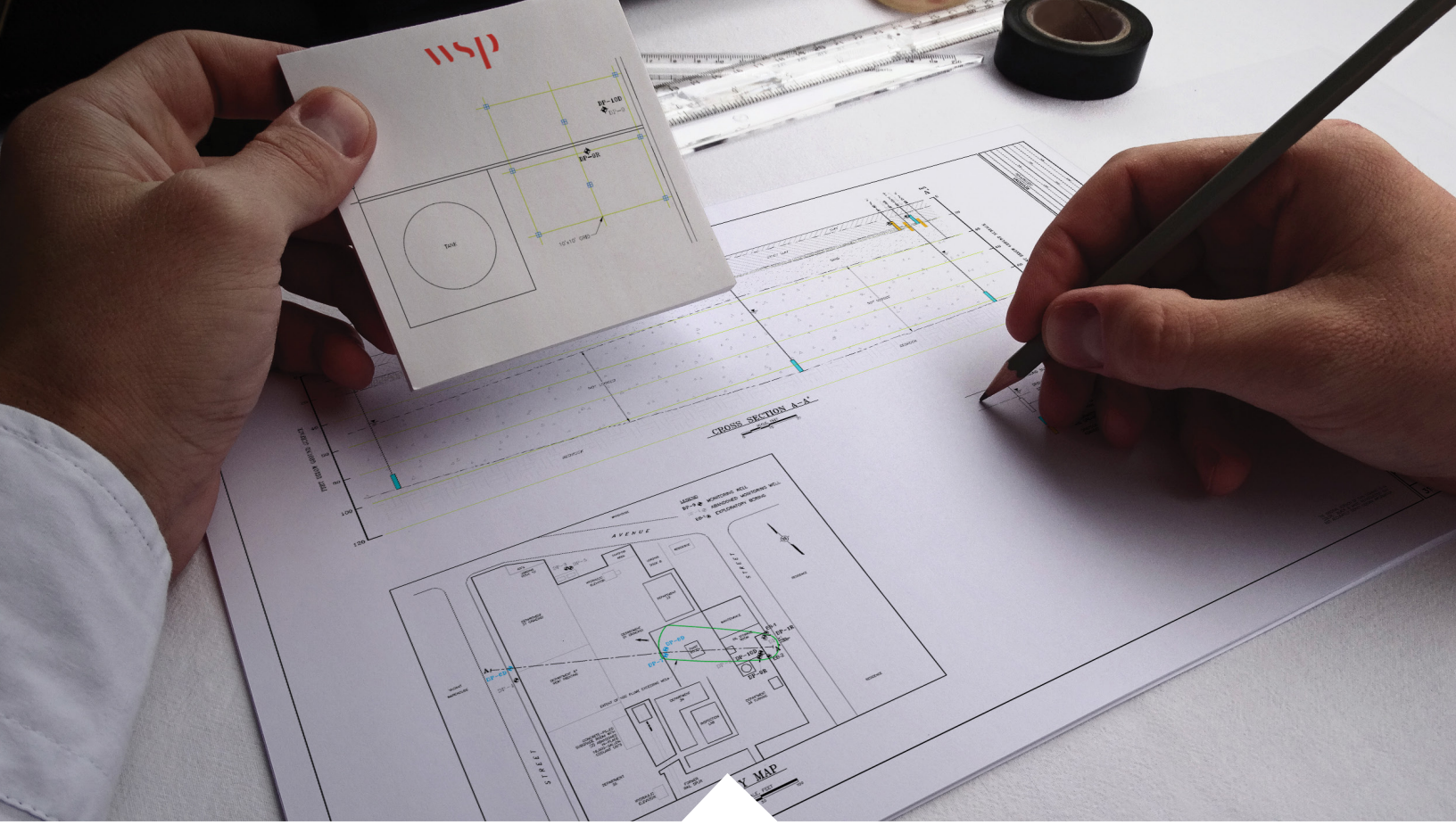
2014 EZVI Remedy Approach



2015 Bioaugmentation and Buffering (O&M)

2017 PlumeStop Combined Remedy Program

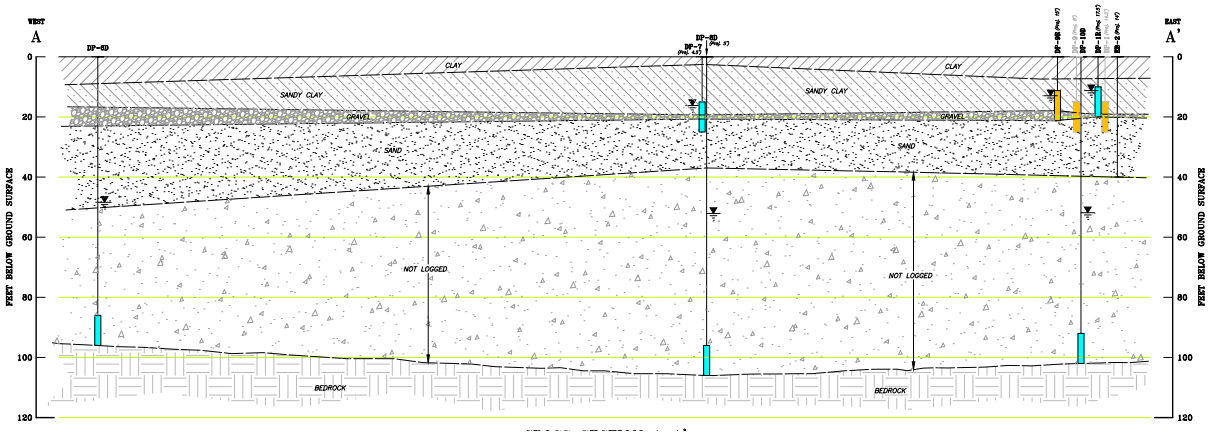
PLUME STOP® Liquid Activated Carbon
HRC® HYDROGEN RELEASE COMPOUND
BDI® PLUS BIO-DECHLOR INOCULUM



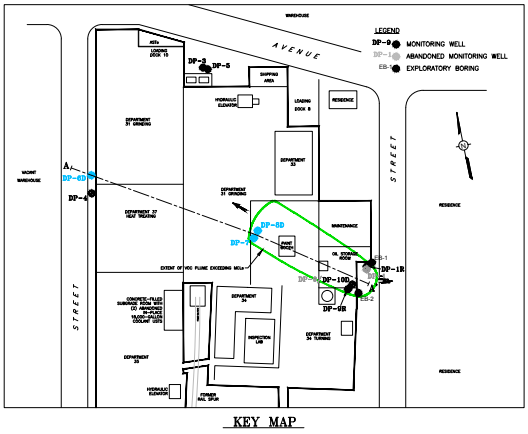
DESIGN EFFORTS

In order to apply the PlumeStop combined remedy solution, permanent Class V injection wells were installed in an offset grid, as allowed by building features, within the treatment area. This design allowed for follow up injections, as necessary. The fully penetrating wells were advanced to a confining unit and constructed of a 10-foot long, 1.5-inch diameter PVC pre-packed well screen and riser. Due to the low ceiling height, the wells were restricted to 1.5-inch diameter. To prevent daylighting around the well annulus, the wells were high pressure grouted through the drill rods with a tremie tube.

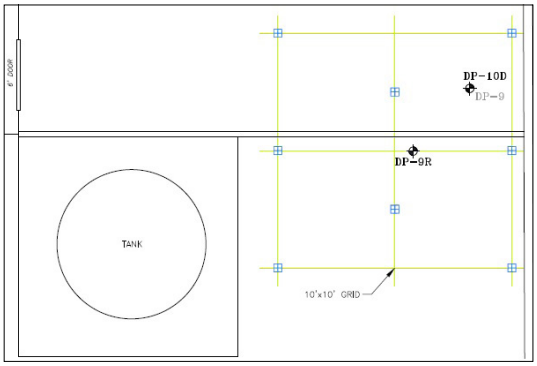
In addition to PlumeStop, the combined remedy solution also consisted of HRC which provides a controlled release of hydrogen in order to stimulate bioremediation of PCE and TCE, and BDI+ which provides a species of *Dehalococcoides sp.* (DHC) in order to completely dechlorinate the contaminants. Nutrients and buffers were also included to balance the pH and to enhance the biological degradation.



Cross-section of site elevation with injection points and depths shown



Site map indicates injection points and area of site where remedial efforts were focused



Injection Spacing Shown

Aerial view of site with injection points shown

RESULTS

After the treatment of PlumeStop, HRC, and BDI+, the site continues to be monitored and is rapidly moving toward the eventual goal of unrestricted closure. Approximately 180 days after amendment application, concentrations of all chlorinated VOCs were measured at concentrations significantly below baseline conditions. It is expected that concentrations will continue to decrease because organic carbon concentrations remain high, oxidation reduction potential and dissolved oxygen have decreased, and post-injection monitoring data show the generation of ketones (a transient fermentation byproduct and indicator of favorable conditions for biodegradation). Based on these results, WSP is moving the site forward and is confident that the site goals will be met and the site will achieve unrestricted closure.

Contaminant reduction 180 days post-application

All signs favorable for further biodegradation of site contaminants

Site closure expected to be achieved

TECHNOLOGY

PLUME STOP® Liquid Activated Carbon

PlumeStop is an innovative groundwater remediation technology designed to address the challenges of excessive time and end-point uncertainty in the *in situ* remediation of groundwater contaminants. PlumeStop is composed of very fine particles of activated carbon (1-2µm) suspended in water through the use of unique organic 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.

Key Benefits:

- *In Situ* remediation technology that rapidly reduces dissolved-phase plumes in days/weeks
- Distributes widely under low injection pressures
- Colloidal biomatrix completely biodegrades contaminants in-place
- Achieves stringent groundwater clean-up standards
- 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

HRC® HYDROGEN RELEASE COMPOUND

HRC is an engineered, hydrogen release compound designed specifically for enhanced, *in situ* anaerobic bioremediation of chlorinated compounds in groundwater or highly saturated soils. Upon contact with groundwater, this viscous, poly-lactate ester material becomes hydrated and subject to microbial breakdown producing a controlled-release of hydrogen for periods of up to 18-24 months on a single application.

Key Benefits:

- Provide controlled-release lactic acid to promote reducing conditions and optimize the anaerobic enhanced reductive dechlorination process
- A range of products, release profiles and applications to suit your project specific needs.
- A viable, long-term source of staged-release hydrogen, on the order of 2-5 years from a single application
- Highly compatible with anaerobic bioaugmentation approaches using BDI+
- Clean, low-cost, non-disruptive application (permanent wells, direct-push, excavations, etc.)
- No on-going operations and maintenance needed

BDI® PLUS BIO-DECHLOR INOCULUM

BDI+ is designed for use at sites where chlorinated contaminants are present and unable to be completely biodegraded via the existing microbial communities. BDI+ is an enriched, natural microbial consortium containing species of *Dehalococcoides sp.* (DHC) which are capable of completely dechlorinating contaminants during *in situ* anaerobic bioremediation processes.

Key Benefits:

- Rapid and effective treatment of undesirable anaerobic dechlorination intermediates such as dichloroethene (DCE) and vinyl chloride (VC)
- A low-cost means of enhancing the anaerobic biodegradation process
- Application can occur at almost any stage of a project, beginning, middle or end
- Highly compatible with a range of electron donors such as 3-D Microemulsion and HRC.
- Ease-of-application and handling

ABOUT THE ENVIRONMENTAL CONSULTANT

WSP is one of the world's leading engineering professional services consulting firms. They are dedicated to their local communities and propelled by international brainpower. Their reputation is built on helping clients worldwide mitigate risk, manage and reduce impacts, and maximize opportunities related to health and safety, sustainability, climate change, energy, water and the environment. They engineer projects that will help societies grow for lifetimes to come. Their 5,000 multidisciplinary environmental experts are part of their 36,000 talented people in more than 500 offices across 40 countries. Visit www.wsp.com for more information.

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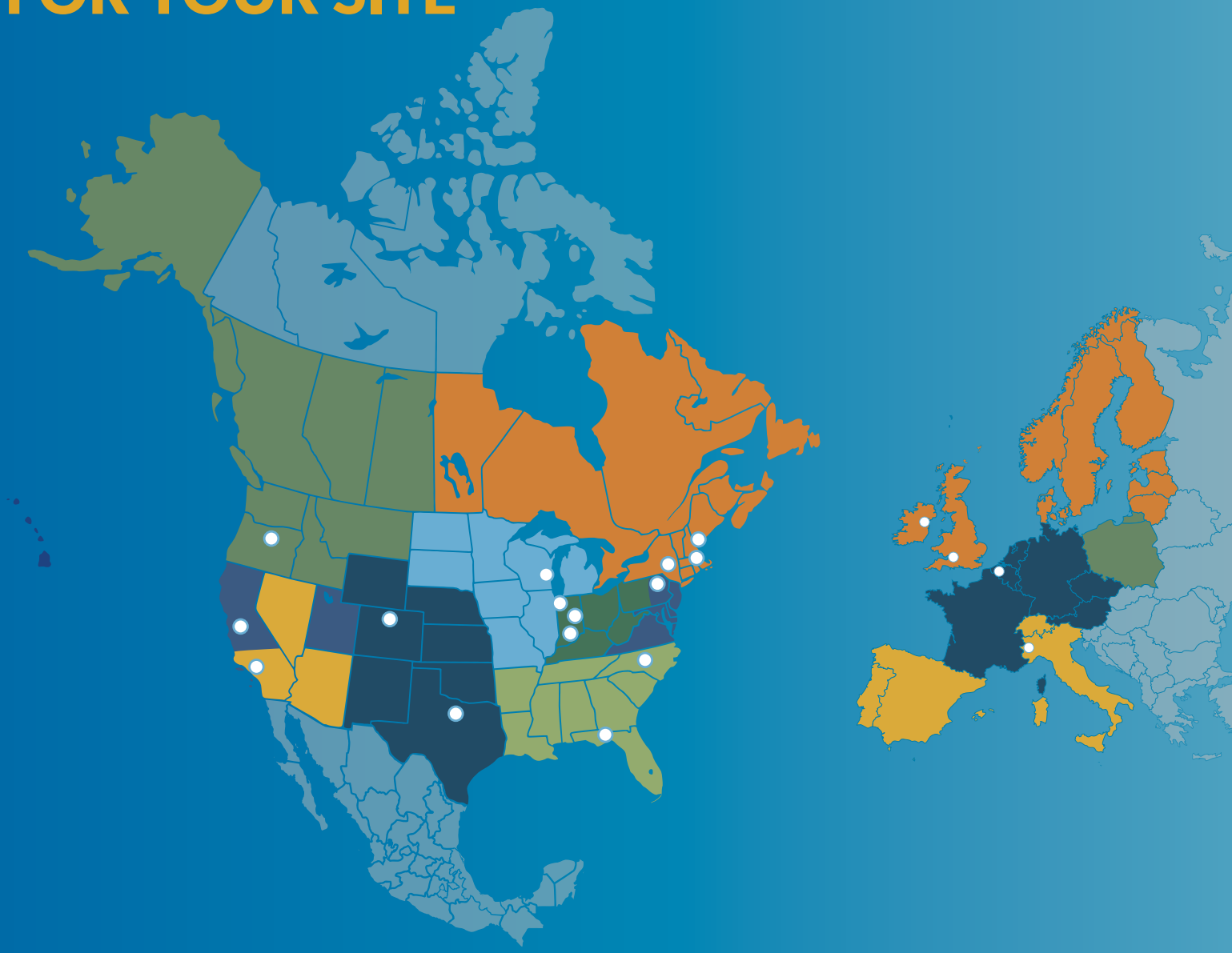
REGENESIS®

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



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