REGENESIS

DNAPL to Non-Detect: 6 Orders of magnitude reduction of chlorinated solvents

CASE STUDY

Combined *in situ* sorption and biological degradation lead to site closure of large manufacturing site, Northern Italy

Summary

Chlorinated solvents were used for many years at a former manufacturing facility in Northern Italy. This resulted in contamination of the groundwater underlying a large proportion of this 60,000 m^2 site. Groundwater concentrations of up to 155,000 µg/L TCE meant there was a suspected presence of Dense Non Aqueous Phase Liquid (DNAPL) on parts of the site. The contamination posed an unacceptable risk to both on- and off-site receptors and it was determined that active remediation was required on a large proportion of the site.

Initially two secondary source areas were identified and removed by excavation and disposal of impacted soil. Temporary containment was required to regulatory compliance and a pump and treat system installed at the downgradient site boundary, directly adjacent to a river.

For the wide on site aquifer treatment, the environmental consultant determined that an *in situ* approach would be the most cost effective. REGENESIS created a strategy comprising Enhanced Reductive Dechlorination (ERD) tailored to contaminant concentrations and local geology, across the entire impacted area. This was coupled with an injectable Permeable Reactive Barrier at the site boundaries using PlumeStop® Colloidal Activated Carbon™ (CAC), where extremely stringent targets needed to be reached (<0.5 µg/l VC; <1.5 µg/l TCE).

Project Overview

SITE TYPE

Former manufacturing site

GEOLOGY

Silty sand with silty lenses

TREATMENT

Enhanced Reductive Dechlorination, *In Situ* Sorption

TECHNOLOGIES

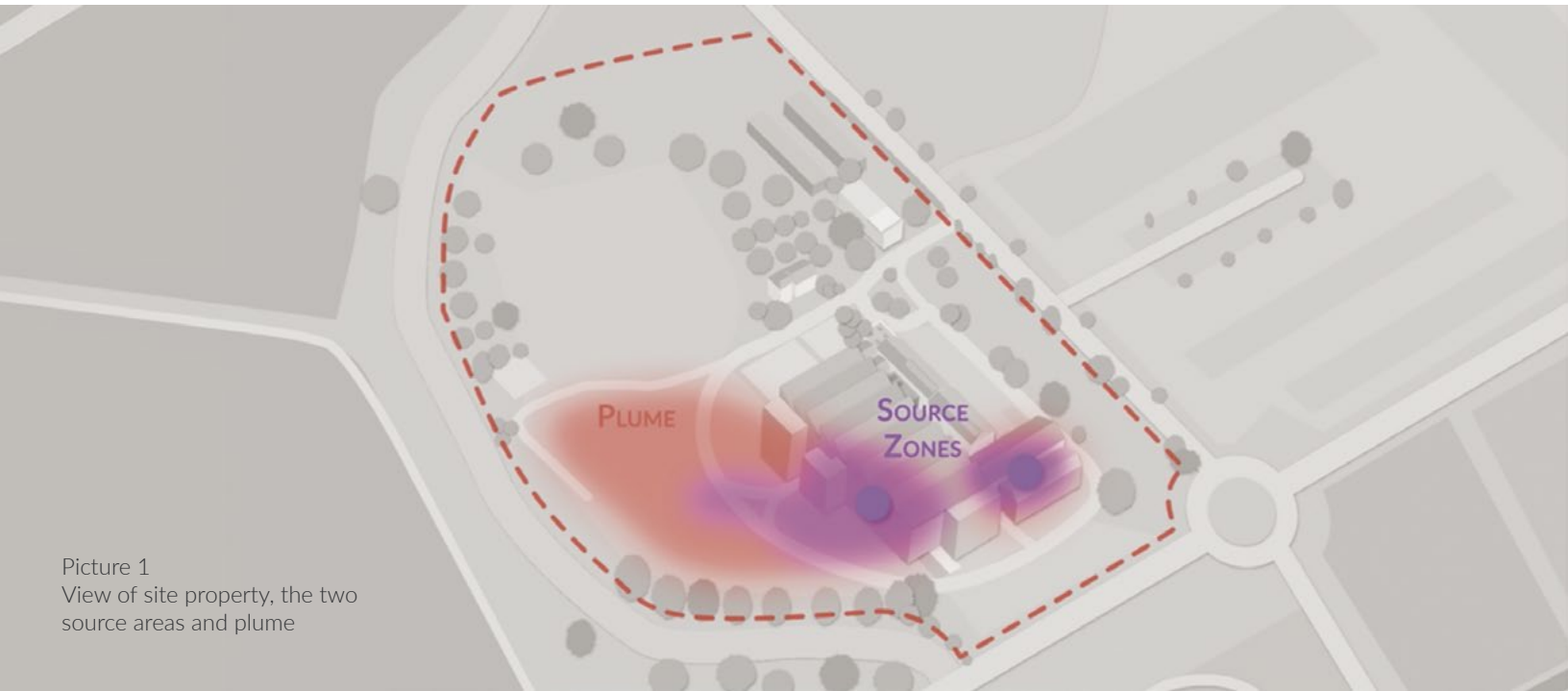
3-D Microemulsion®, HRC®, HRC-X®, HRC Primer®, PlumeStop®

CONTAMINANTS

Chlorinated solvents (mainly TCE, DCE, VC): Up to 250,000 µg/L CHC in source areas and up to 50,000 µg/L CHC at boundaries

PROJECT DRIVER

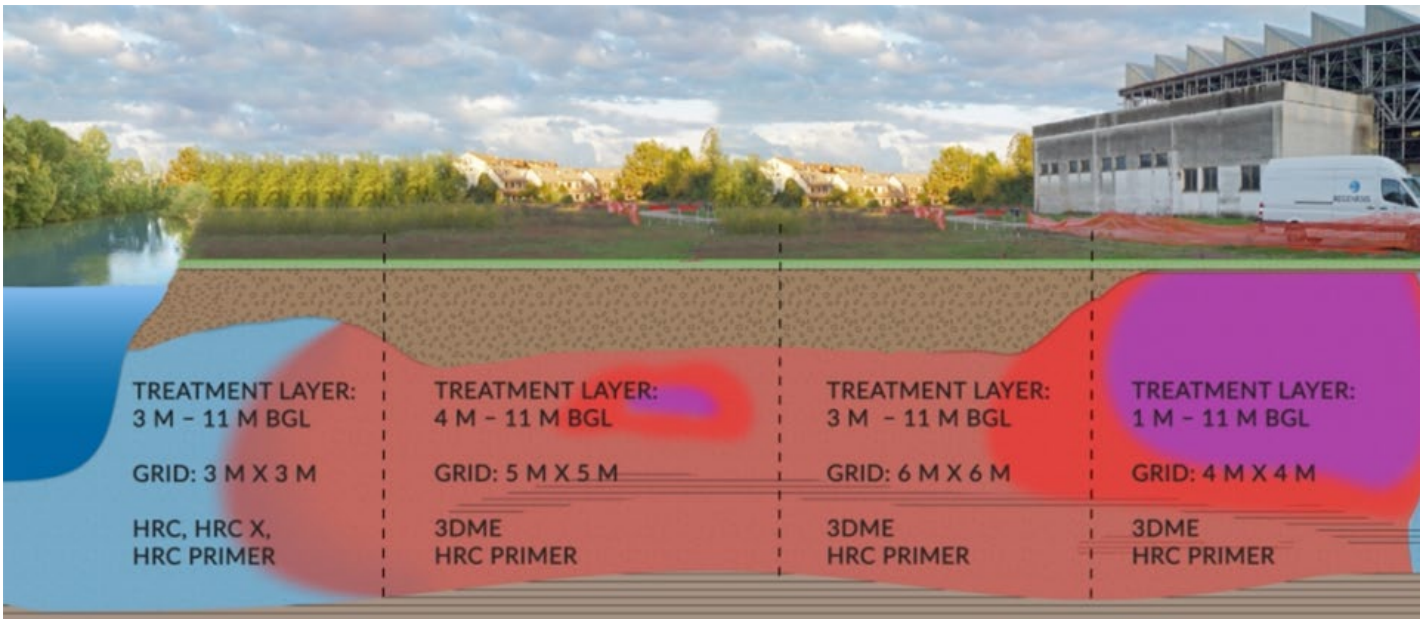
Removal of on-site human health risk and protection of off-site sensitive receptor (river) for future sale of the area



Picture 1
View of site property, the two source areas and plume

Enhanced Reductive Dechlorination Treatment

ERD of the chlorinated solvents was achieved through a grid of direct push injections, introducing a suite of REGENESIS electron donor substrates into the subsurface. The site was first divided into different areas based on the distribution of contamination and differing permeabilities. A tailored product mix and dosage was then created for each area. Our wide-distribution substrate 3-D Microemulsion® (3DME) was used in the up-gradient zones on a widely spaced injection grid (up to 6m x 6m), which minimized injection cost, while providing optimum treatment of the contamination. The downgradient treatment zone required application very close to the river at the site boundary. A mixture of low volume, high viscosity Hydrogen Release Compound® (HRC) products were used here to prevent contaminant egress from the site for up to five years from a single injection.



Picture 2 Cross-section with different sub-areas for ERD treatment

The injection activities lasted for 6 months using 2 Geoprobe rigs working in parallel to complete over 500 direct push injections. The rigs were supplied by one central mixing area where the products were mixed as required and then pumped to the injection area through flexible pipework. In situ remediation then occurred over several years, with no further site attendance or operational costs beyond validation sampling.

Picture 3 Direct push injection at the site

Application Overview

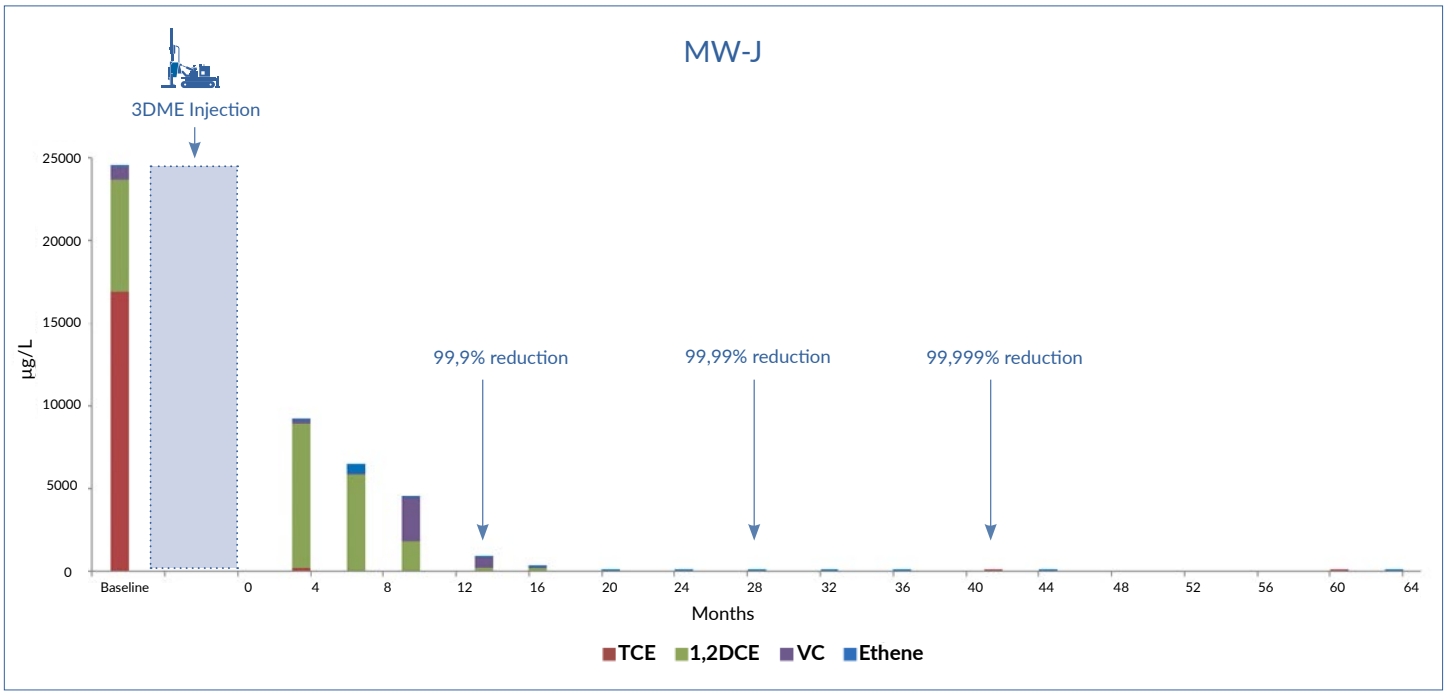
Area:
6,600 m²

Depth:
Main treatment average
8 m (3 to 11 m BGL)

Number of points:
Approximately 650

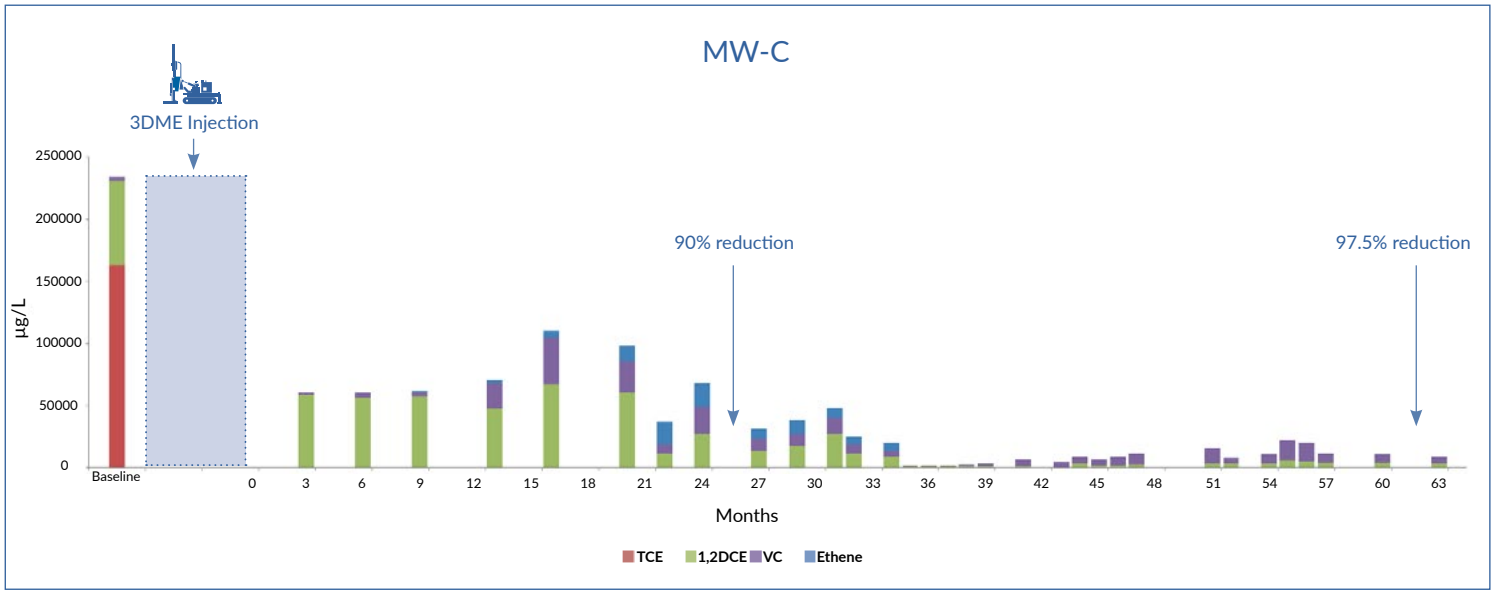
ERD Results

Validation monitoring shows complete destruction of the contaminant mass from the aquifer with full reductive dechlorination occurring. The precise tailoring of the dose successfully targeted each area. In areas where starting concentrations were high, the remediation took 1.5-2 years to reach onsite targets. In less impacted areas of the plume the desired remediation was achieved within months. Ongoing validation has shown in almost all areas that concentrations have continued to reduce towards non-detection. Rebound of concentrations has not occurred in any location and the contamination has been fully degraded.



Graph 1 Results at source area over time (well MW-J)

One location in the source area (identified by well MW-C) had starting concentrations of total chlorinated solvents of approximately 250,000 µg/L, which certainly indicated the presence of DNAPL. Remediation in this area took longer due to the amount of mass at the location. Monitoring shows that parent compounds in the groundwater were rapidly removed, however the daughter products took longer to degrade. This pattern is due to the ongoing desorption and dissolution of parent compound into the groundwater from residual DNAPL and sorbed phase contamination at the location. However, due to the extremely long-term donor release provided by the 3DME the ideal conditions for full reductive dechlorination were maintained, therefore as the TCE influx became spent, the concentrations of daughter products then decreased. A small amount of contamination has remained at this location over the validation period, but the levels are very low and is expected to continue to degrade further.



Graph 2 Results in hot spot within source area over time (well MW-C)

Picture 4 HRC tubs in heating bath

Picture 5 Mixing of products

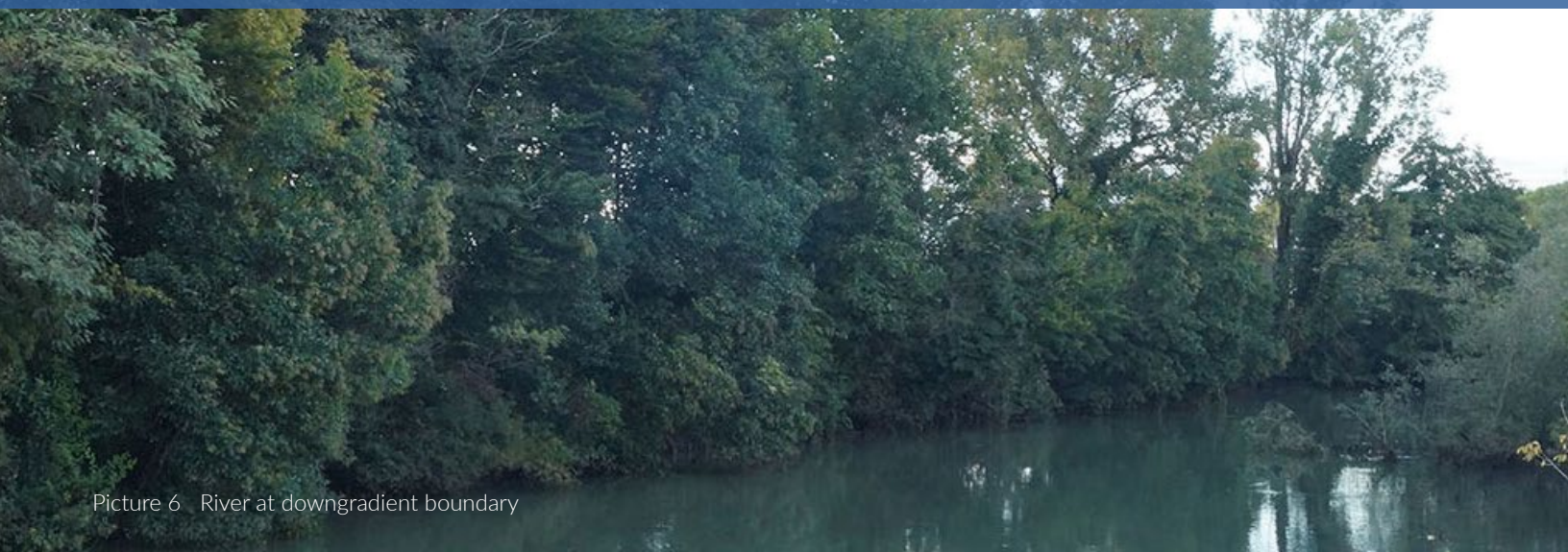
PlumeStop injectable Permeable Reactive Barrier (i-PRB) Treatment

Immediately beyond the downgradient site boundary, a river presents a sensitive receptor. This, plus national legislative rules, determine that the site boundary targets are very stringent (TCE: 1.5 µg/l, VC: 0.5 µg/l). In order to achieve and maintain such low concentrations over the long-term, an additional approach to ERD along was required. In situ sorption using PlumeStop Liquid Activated Carbon® was combined with ERD using the substrates HRC®, HRC-X® and HRC Primer®. This application adsorbs the contamination and provides a biomatrix on which the dehalogenating bacteria come into contact with the chlorinated solvents. This combination of sorption and biodegradation provides an enhanced reduction in contaminant concentrations, which will then be sustained. Further contaminant influx is adsorbed and degraded, as the biodegradation promotes the self-regeneration of the sorption sites on the liquid activated carbon.

To provide the most appropriate and effective treatment during the remediation project, the application of PlumeStop was not just considered spatially across the site, but also temporally through the programme of works. Early in the project very high concentrations at the boundaries (typically several thousand µg/l, with peaks up to 50,000 µg/L) were treated with ERD alone. As the concentrations became lower and biological degradation by itself would become less efficient, PlumeStop was applied to sorb the contamination and further reduce the groundwater concentrations to below target levels.

A PlumeStop i-PRB installation was completed along a length of 90m along the site boundary, using approx. 150 direct push injection points, performed using two Geoprobe rigs. Continuity of the barrier was verified through onsite sampling as the installation was progressed. The dosage was tailored along the length of the barrier, based upon the contamination concentration and heterogeneity of the alluvial subsurface. No addition of electron-donors was needed at the moment of PlumeStop application, due to long-term hydrogen release of the compounds injected three years previously.

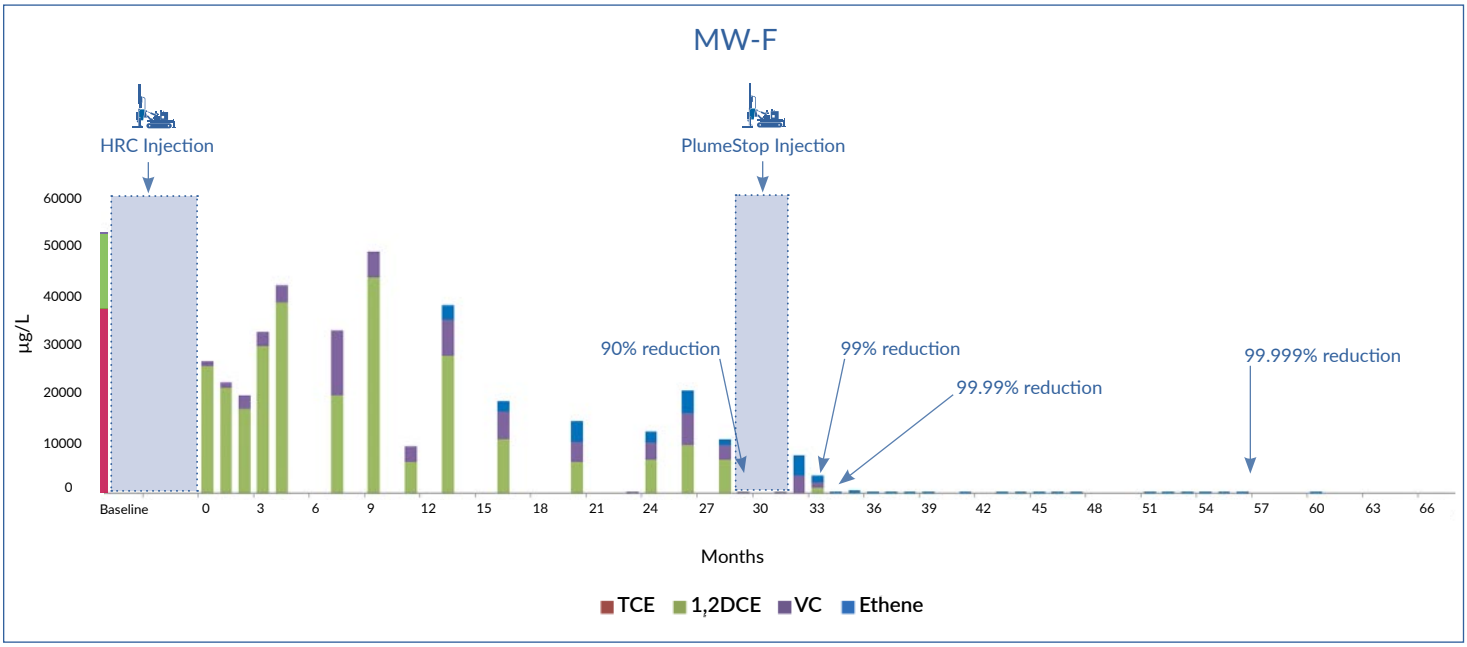
PLUME STOP
Liquid Activated Carbon



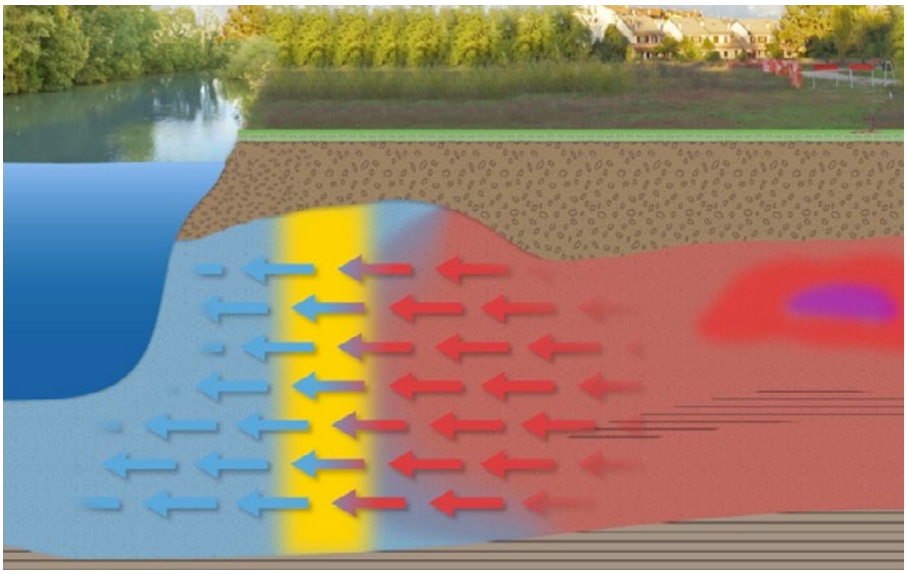
Picture 6 River at downgradient boundary

PlumeStop i-PRB Results

The 9 compliancy monitoring wells at the downgradient boundary have all shown a significant decrease in contaminants concentrations. The extremely stringent targets have been achieved in all wells over a period of several months, after which the low concentrations have been maintained.



Graph 3 i-PRB results over time (well in central part of the plume, highest contamination)



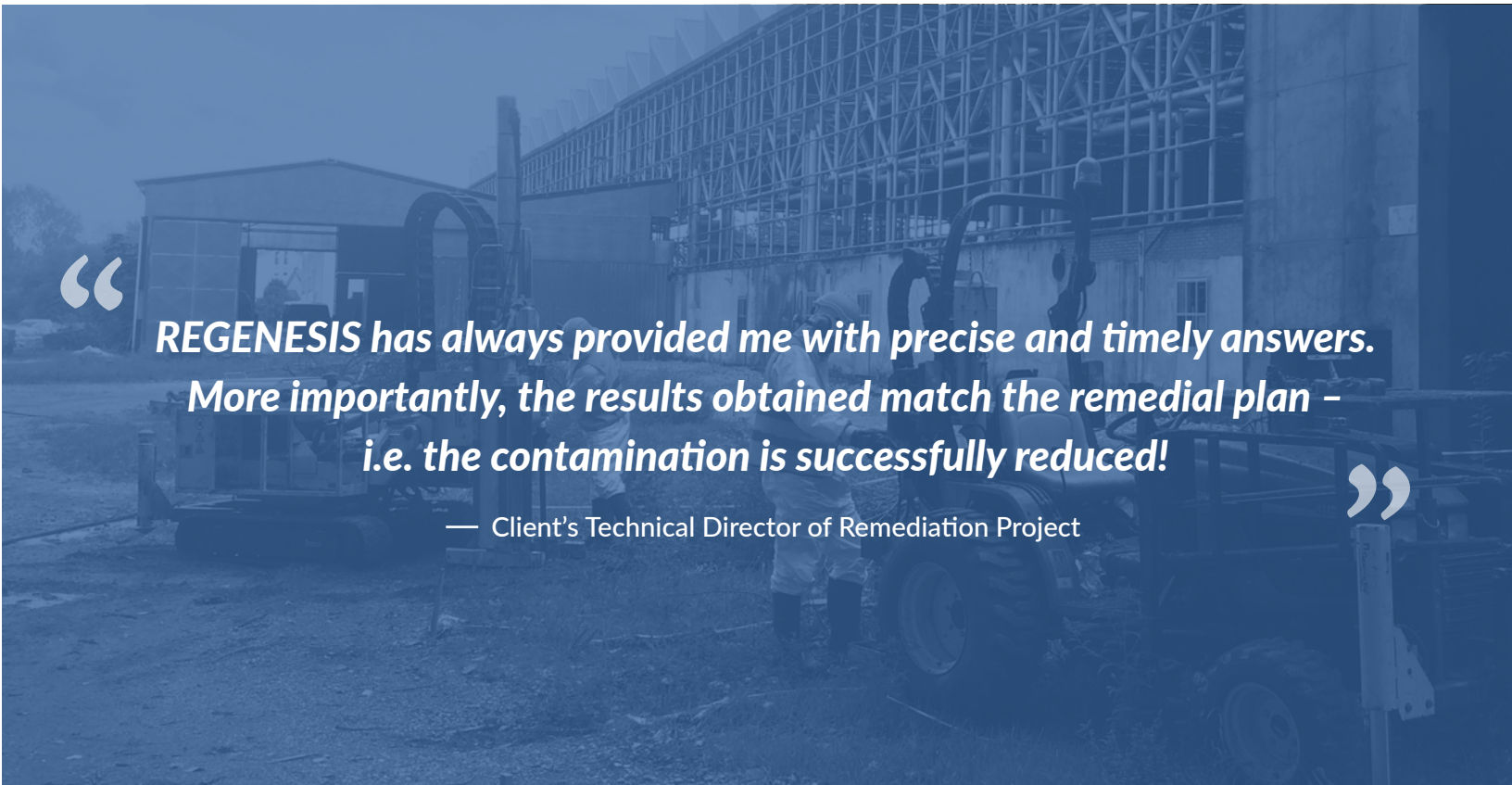
Picture 7 Cross-section showing PlumeStop i-PRB treatment

Ethene production has remained detectable through the entire monitoring period even with no detected chlorinated compounds in the dissolved phase, confirming sustained ongoing biodegradation of the contaminants sorbed to the activated carbon. The successful PlumeStop barrier application has allowed the switch-off of a costly Pump & Treat system that has been operational at the site boundary for over 10 years.

Conclusion

This case study shows how the intelligent design of injectable substrates can be used to provide cost effective treatment of chlorinated solvent sites. Key aspects of the remediation are:

- *In situ* treatment was cost effective over a very large area and volume of contaminated aquifer
- ERD was effective at degrading very high levels of contamination, indicative of a considerable mass of DNAPL on the site
- A combination of sorption and ERD allows very low targets to be achieved
- Overall a reduction of 6 Orders Of Magnitude was achieved on the site on parent compound, and 5 to 6 Orders of Magnitude on total chlorinated
- Low concentrations were then maintained for a prolonged and demanding validation period:
  - High number of monitoring wells
  - Wide array of analytes
  - Extremely stringent targets
  - Requirement for simultaneous compliance of all conditions in all wells
- Tailoring of the type of substrate, dose and volume provided an accurate and effective solution across the highly heterogeneous site
- REGENESIS provided a fixed price, turn-key solution to guarantee success
- The site is receiving formal regulatory closure



“REGENESIS has always provided me with precise and timely answers. More importantly, the results obtained match the remedial plan – i.e. the contamination is successfully reduced!”

— Client’s Technical Director of Remediation Project

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