

225m Permeable Reactive Barrier treats TCE and chromium (VI)

CASE STUDY

Sustainable and cost-effective remediation of a co-mingled plume in a sensitive chalk aquifer



INTRODUCTION

A 48 hectare site in the UK was to be redeveloped for mixed commercial and residential use. The existing site included a mix of historic and existing industrial land use, including a metal plating works, surrounding by agricultural land and residential housing.

Groundwater contamination was identified in the chalk formation below the site, in the area associated with the metal plating works, comprising **trichloroethene (TCE)** at a maximum concentration of 7mg/l, and **chromium (VI)** at a maximum concentration of 5.2mg/l. Although confirmed not to be an ongoing source, the concentrations presented a potential vapour risk to on-site workers, offsite residents and future site users. In addition, as the groundwater is a Chalk Principal aquifer, the **Environment Agency** had concerns about ongoing impacts to groundwater quality downgradient of the site.

A detailed remediation options appraisal and sustainability assessment was undertaken by **Mott MacDonald** under **SuRF UK** guidelines which was shared and discussed with multiple stakeholders including the client, developer, two local planning authorities (LPAs) and the **Environment Agency**.

Mott MacDonald engaged early with **REGENESIS** regarding potential options for remediation. **REGENESIS** gave input into the ongoing site investigation to ensure it was designed to delineate the extent of the contamination plume in more detail and obtain additional parameters to inform the full-scale remediation strategy.

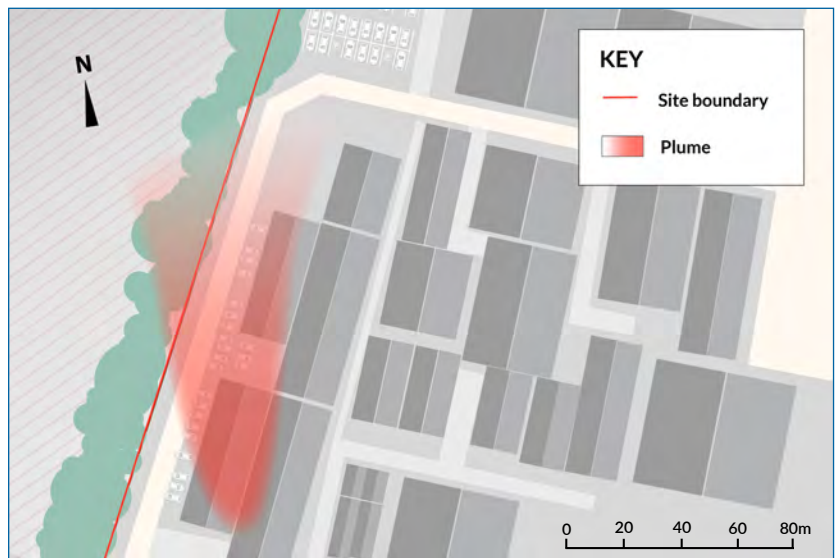


Fig. 1 Site plan showing plume location



Fig. 2 Site challenges: a busy industrial site and underground services

REMIEDIATION STRATEGY

The site, ground conditions and combination of contaminants presented challenges that required careful consideration and planning to ensure that the remediation technologies identified could be applied effectively. The main considerations were:

- How to treat a **co-mingled plume** comprising both chromium (VI) and TCE.
- How to apply the remediation in potentially unfavourable ground conditions comprising **low permeability chalk** recovered as a clay.
- **Limited evidence of natural attenuation** with significant cis-1,2 Dichloroethene (DCE) stall.
- Application of the technology in a **busy working industrial site** location without impacting land users and residents' gardens adjacent to the property boundary.
- Working around multiple **underground services**, including a service corridor close to the site boundary.
- Identification of **post-remediation monitoring boreholes** which would be accessible for both this project and the future development.
- Managing **multiple stakeholders** with diverse priorities to ensure agreement on the remediation activities and how success would be measured.

The most appropriate methodology identified to both treat solvents and mitigate ongoing risks at this site, was a combined in situ chemical reduction and enhanced biological dehalogenation barrier along the site boundary.

The practicalities of this solution and the possibilities of treatment for chromium (VI) alongside the TCE were discussed with **REGENESIS** and the **Environment Agency** and it was proposed to combine four propriety technologies with a nutrient blend to enhance the rate of in situ reductive dechlorination, chemically reduce the TCE contamination and transform chromium VI to chromium III, reducing its mobility and toxicity in situ.

These combined technologies comprised:

- **3-D Microemulsion**[®] – a self-distributing, controlled-release electron donor with a five-year release profile.
- **S-MicroZVI**[®] – a colloidal, sulfidated, <5µm scale zero valent iron technology.
- **BDI Plus**[®] – an inoculum comprising dehalogenation bacteria.
- A nutrient blend to assist the onset of microbial growth.



This targeted mix of technologies was injected in a barrier configuration on the downgradient edge of the site.

The treatment aims were:

- TCE would be chemically reduced to ethene, through a combination of enhanced biological degradation and chemical reduction. The use of S-MicroZVI would minimise the production of DCE and VC and the 3-D Microemulsion would ensure that any degradation products were rapidly dechlorinated. This combination would minimise daughter products from being produced and migrating offsite, which was a major concern for the local authority in ensuring there were no additional risks to offsite residents.
- Chromium(VI) reduction to insoluble and harmless chromium(III), which is deposited as a solid.
- The wide distribution capability of the substrates used, reduced the number of injection points needed and, as a result, the cost and disturbance of the remediation.
- The controlled release/long term nature of the technologies chosen allows the treatment to remain active in the sub-surface for up to five years in optimal conditions, reducing the potential for a rebound of contaminant concentrations.

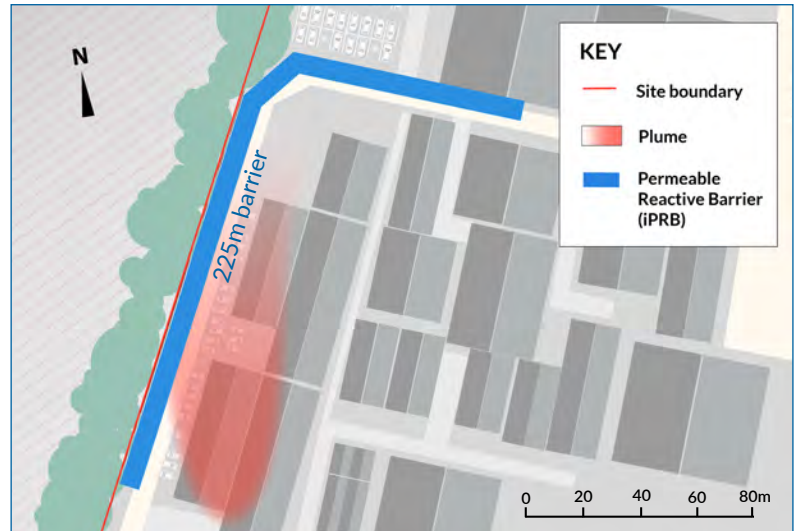


Fig. 3 Location of the injected Permeable Reactive Barrier (iPRB)

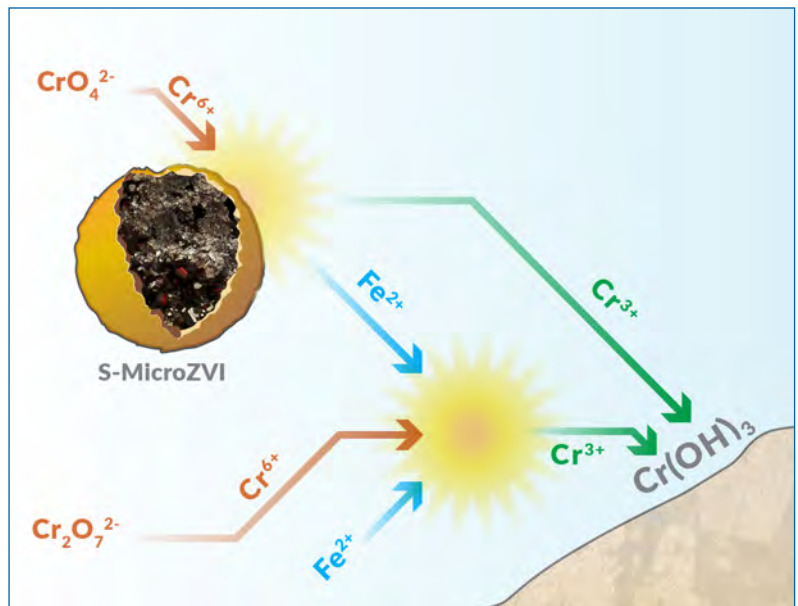


Fig. 4 Enhanced ISCR chromium (VI) removal

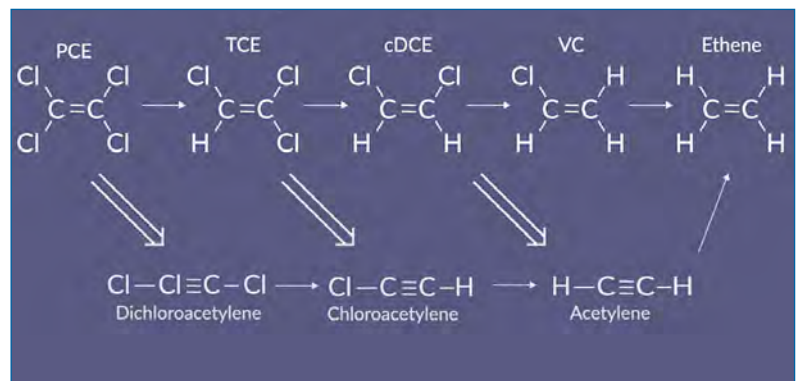


Fig. 5 Combined pathway degradation; upper route = biological dechlorination, lower route = chemical reduction

PILOT TRIAL

A pilot trial was used by **REGENESIS** and also by the **Environment Agency** to confirm the technique was appropriate for the ground conditions, including:

- The right injection technique.
- Suitable spacing of injections.
- That anaerobic conditions could be achieved in the subsurface to allow the breakdown of contaminants.

The pilot trial included four direct push injections near to one of the more easily accessible impacted boreholes on a 4m spacing. Concentrations in the borehole were monitored pre- and post- injection and showed immediate reductions in chromium VI followed by reductions in TCE. Although the process of TCE breakdown was slower than anticipated, supporting aquifer parameters confirmed that anaerobic conditions were being created and driving biodegradation.

The successful pilot trial allowed for the remediation strategy to be agreed and signed off with all parties involved.



Fig. 6-9 Details of the pilot trial undertaken by REGENESIS Remediation Services



Fig. 10 REGENESIS' mobile mixing station was used in the full-scale remediation works

FULL-SCALE TREATMENT

The full-scale remediation comprised the installation of a 225m long permeable reactive barrier constructed by applying S-MicroZVI, 3-D Microemulsion, BDI Plus and a nutrient blend into 75 injection points. REGENESIS Remediation Services injected each of the points 'bottom up' from 13m to 3m BGL.

A REGENESIS mobile mixing station was used on this project, which allowed the products to be co-mixed with water in the trailer in two large tanks, which were pumped directly to the injection locations via hydraulic hose lines. Over 145,000L of reagent was injected across a four-week program intercepting the TCE and chromium(VI) plume, estimated to be 20,000m³.



Fig. 11 Rigs on site



Fig. 12 Overview of injection activities along site boundary

RESULTS

Full scale injection works were undertaken and three rounds of post remediation groundwater monitoring have been completed to date.

This initial post remediation monitoring has confirmed a reduction in chromium(VI) of 75% and TCE is now below detection limits in the majority of verification locations, with minimal creation of degradation products.

Now that the parent compound is gone, the residual cis-1,2 dichloroethene is expected to decrease as the treatment progresses and validation programme continues.

Fig. 13 Pre- and post remediation monitoring results for VOCs

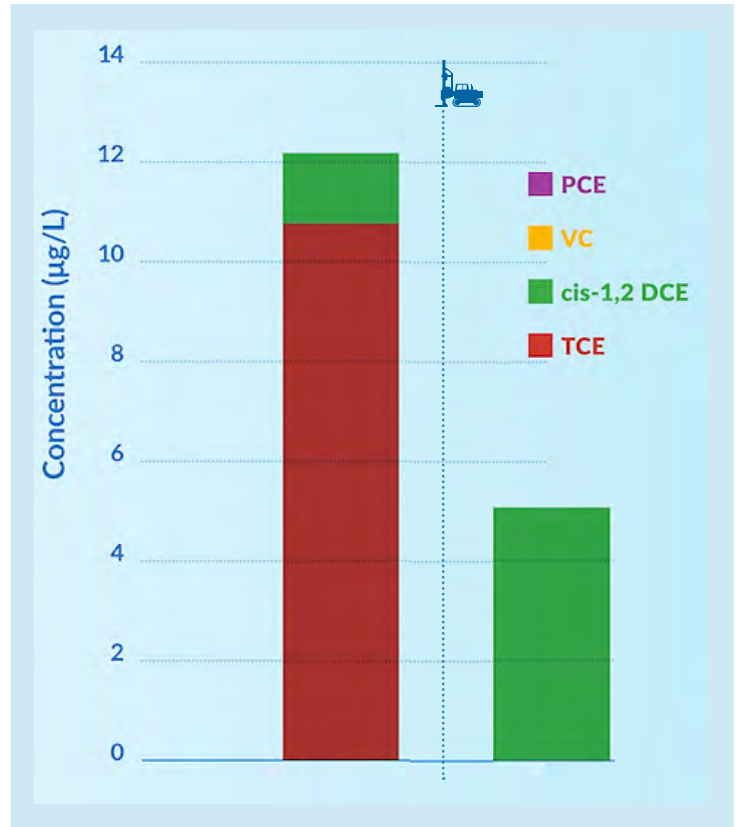
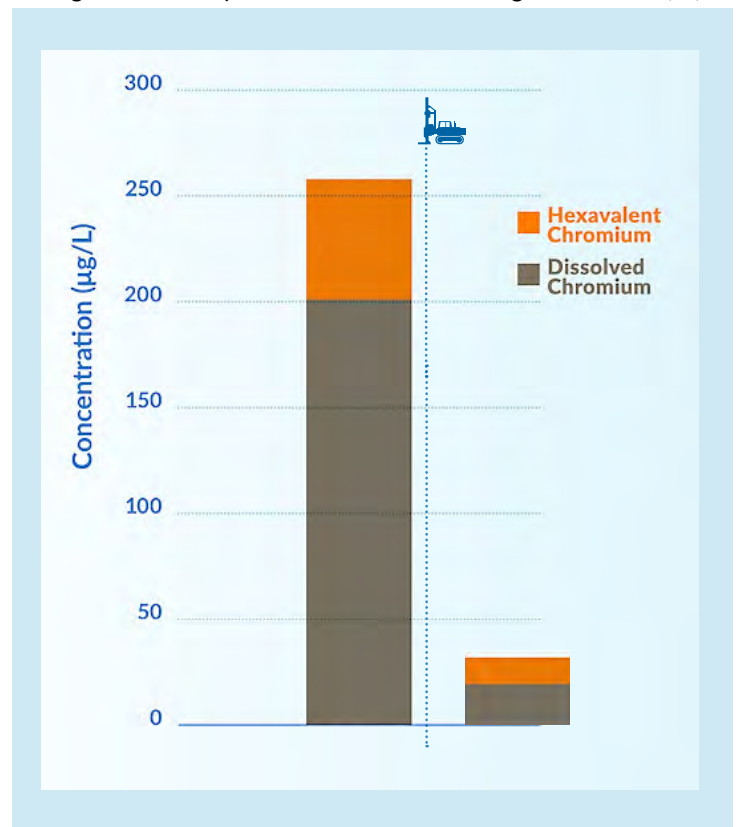


Fig. 14 Pre- and post remediation monitoring results for Cr(VI)





CONCLUSIONS

This innovative remediation project required no offsite disposal of hazardous waste and minimised the risk to both on- and offsite receptors, with no disruption to commercial operations.

In addition:

- The solution ensured both risks to the Principal aquifer were mitigated and that no additional risks to the nearby residents were created as a result of the treatment.
- The size and shape of the barrier ensures protection for the offsite residents and future site users following redevelopment.
- **Mott MacDonald's** early engagement with **REGENESIS** ensured that the correct combination of technologies were used across the site to ensure **maximum efficiency whilst keeping costs to a minimum.**
- The detailed phased ground investigation and pilot trial reduced the number of remediation design assumptions required and **increased the accuracy and efficacy** of the final design.
- The early discussions and well-defined communication throughout the project enabled concerns to be addressed quickly and ensure confidence in the approach from all parties. Agreement of the methodologies **allowed planning conditions to be discharged and the development to commence.**
- **Mott MacDonald's** use of the initial SuRF UK assessment ensured this was the **most sustainable and cost-effective solution** for the site.



CONTACT

europa@regenesiS.com
+44 (0)1225 61 81 61

WWW.REGENESIS.COM

