

Active Industrial Drycleaning Facility, Little Hulton, UK

In-Situ Remediation of PCE DNAPL using Enhanced Natural Attenuation

with Hyder Consulting

Geology	Sandy Clay with Fine Sand lenses
Contaminant Of Concern	PCE
COC Range	very low (40µg/L) and very high (250mg/L)
Treatment Area	450 m ²
Treatment Depth	2-3m BGL to 9-11m BGL,
Former and Current Site Use	Dry Cleaning Facility
Project Driver	Voluntary Cleanup of Historic Spill
Product Design details:	HRC-primer®, HRC®, HRC-X® and 3DMe®
Project Cost:	£170,000



Summary

- High and low concentrations of PCE, in high and low permeabilities, were successfully treated by using a single platform technology.
- The in situ approach made was made capable by the RegenesiS HRC product range, which avoided the need for a multi-million pound excavation and disposal project.
- PCE DNAPL was successfully treated through stimulation of in situ biological degradation within 2 years, despite little evidence of naturally occurring reductive dechlorination in the previous 25 years.
- The injection works were undertaken by RegenesiS Remediation Services (RRS) and carried out in 2 weeks, with no disturbance to local neighbourhood, site users or industrial activities.



Project Location showing proximity to Residential Neighbourhood

Case History: Historic PCE Spill with several zones of DNAPL

Tetrachloroethene (PCE) is used as a dry cleaning fluid at an industrial dry cleaning facility near Manchester, in the northwest of England. In the early 1980s, prior to Johnsons Apparelmaster ownership, a delivery spill occurred. Most of the spill was captured by hardcover and within surface drainage but up to 2 tonnes was estimated to have entered the made ground and clay soils beneath the yard and factory, to depths of 10m BGL. As part of Johnson's CSR policy and liability provision, they investigated the historic spill and determined that remediation was required to protect off-site receptors and remove the potential for action under Part 2A.

The project had been commenced by another consultancy, who had proposed pollutant mass reduction via excavation. Hyder were asked to provide a peer review and were then retained to help deliver an alternative sustainable and cost effective in-situ remediation. They researched whether the degree of pollution present (several zones of DNAPL) and high impact to groundwater could be addressed by enhancement alone and considered it was viable to reduce risk to acceptable levels by using RegenesiS products.

**Brownfield
Briefing 2013
Award Winner**



in 2 Categories:
**'Best In Situ Remedial
Treatment'** and
**'Best Project Closure/
Verification Process'**



a) PCE Spill and Migration



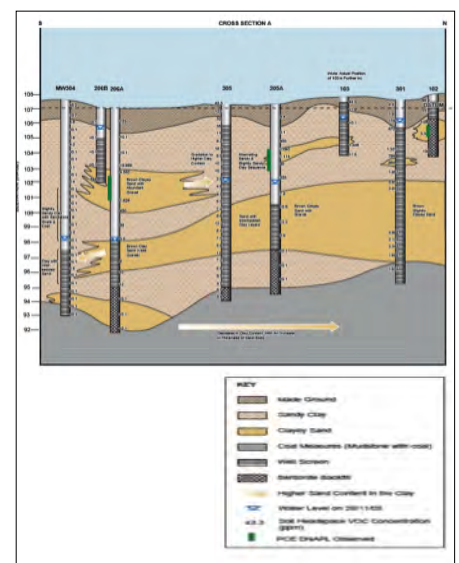
b) PCE Lateral Distribution and Concentration

Site Characterisation

Key facts of Site Characterisation of the Geology and Source zone were;

1. Groundwater was significantly polluted, but high purge sampling had over-predicted dissolved phase.
2. Within fine sand lenses there was clear visual / PID evidence of DNAPL hydraulic gradient was to the section left (south west)
3. PCE free phase appeared to have migrated via the sand lenses, but stayed local to spill.
4. Degradation in the oxygenated environment was extremely slow (virtually none in 25 years).
5. As the spill was of a mono-solvent (pure PCE) the presence of degradation products coincident with a historic diesel spill was evidence that bacterial degradation, given the right conditions, would occur.
6. Low organic carbon was the limiting factor.

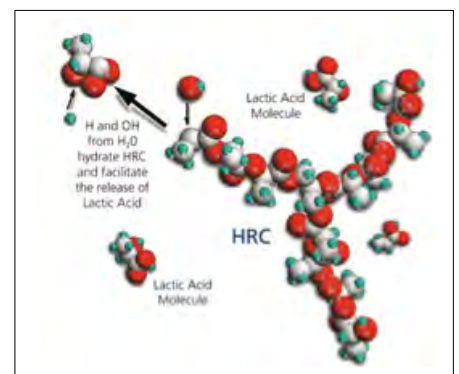
The presence of mudstone (Coal Measures) presented an effective barrier against downward migration. Thus the need to treat a free-product source zone and near field dissolved phase plume was well defined.



Cross Section showing sand lenses

Design Approach

Hyder and Regenesi's remediation treatment enhanced the reductive dechlorination of the chlorinated hydrocarbons (CHC's) through the injection of controlled release electron donor soluble substrates. Historic monitoring activity showed that there was little evidence of natural reductive dechlorination occurring. But through new quality sampling data collected by Hyder, Regenesi were able to implement a remedial design targeting each level of contamination and formation.



HRC Molecule

Design & Treatment Application

In the deep, low permeability clays, a combination of Regenesi's low volume Hydrogen Release Compound™ (HRC) products were used. A well spacing of 3m was used, based on experience, and the fact that the substrate itself does not need to make contact with the pollutant. Unlike Chemical Oxidation or Zero Valent Iron that must make chemical contact to be effective, it is the hydrogen released by early fermentation stages that then dissolves into the groundwater. Under a concentration gradient this naturally pervades low permeability soils and is the electron donor that enables dechlorinating bacteria to establish, substituting hydrogen for chlorine, gaining a small energy release in return.

HRC Primer provided a rapid, short-lived release of lactate in order to create anaerobic conditions and to remove competing electron acceptors on the site, including nitrates and particularly sulphates, which were measured at concentrations of up to 460mg/L, that could otherwise have hindered the remediation.

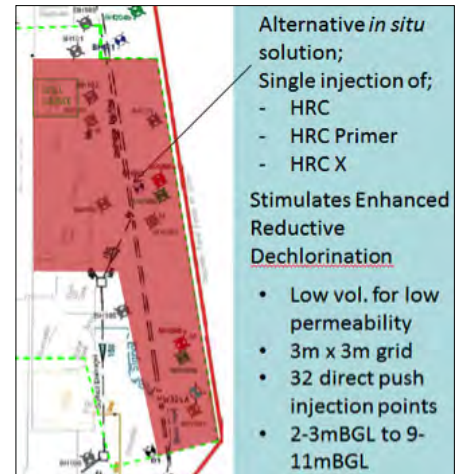
HRC was used to maintain suitable redox conditions (-150mV to -200mV) to allow reductive dechlorinating bacteria to flourish and out-compete other microbes that would use up the terminal electron donor supply from the product. The sequential production and degradation of daughter compounds results in full mineralisation of the contamination and the HRC leaves no residue.

HRC-X is a more condensed version of HRC, which promotes ERD for a period of 5 years from application, which was also included in the treatment in order to address the extra demand provided by the DNAPL within the sandy lenses.

The three products were mixed together and injected on a grid pattern across the target area in the yard of the facility, using a direct push injection rig. The low volume of the HRC products allowed the application to be made into this low permeability setting without any problems. The depth of the injection top and bottom were varied across the site based on the groundwater depth and the closest logs showing where the sandy lenses were located. The dose was also adjusted to match the contaminant concentrations at different depths, to ensure that an accurate and appropriate treatment was completed both laterally and vertically across the site. The injections were completed using a specially built direct push injection rig. The injection tip was driven to the top of the treatment zone and then the requisite dose was applied in a series of closely spaced aliquots through the vertical target thickness.

In the shallow, permeable made ground, the high-volume version of HRC, called **3D Microemulsion (3DMe)** was used to promote the ERD of the contamination. 3DMe provides three stages of donor release analogous to the mix of HRC-Primer, HRC and HRC-X used in the clay/sand. However 3DMe provides this from a single concentrate of specially designed polar molecules that when mixed with water on site, form a high-volume microemulsion, without the requirement of emulsifiers. Upon injection into the groundwater, 3DMe initially moves out into the formation and adsorbs to the soil particles. As the molecule is designed to be 'appropriately soluble', it then gradually dissolves back into the groundwater, where it ferments to drive ERD, but also reaches its critical micelle concentration (300ppm), reforms as a microemulsion and moves further out from the injection point.

This process repeats to 'self-distribute' the 3DMe over large distances within the subsurface, without it washing away. This process allowed the number of injection locations to be minimised within the dry cleaning facility; which avoided leaving untreated areas under inaccessible machinery i.e. the radii of influence of the product interlinked, reduced the cost of the treatment and minimised the disruption to the facility. To further ensure that the very busy operation was not affected, the internal injection was completed on an evening and weekend.



HRC Treatment Area



DP Injection Rig



3DMe Treatment Area

3DMe was also injected into the made ground in part of the yard that showed shallow as well as deep contamination; hence in some locations of the site, four variants of HRC were being used at different depths in different concentrations to provide the most accurate and cost-effective treatment.

The Acco drain was bunged and 3DMe was injected into the bedding in order to address any residual source that might still be found within the area. Any 3DMe entering the drain was sucked out and re-used elsewhere and the drain was re-opened.

Cost Effectiveness

The PCE spill event was a negative balance sheet liability for Johnsons. For geotechnical works to undertake an excavation to up to 13mBGL, shore up the buildings and third party boundary, and dispose arisings to hazardous landfill, a sum estimate of £500,000 to £1M had been set aside. Severe disruption was certain; structural damage was a possibility.

The injections of HRC were undertaken by RegenesiS in 2 weeks, including Saturday/Sunday working within the laundry building. Work was undertaken under our Mobile Treatment Permit and as disruption was low, no planning consent was required. The treatment was tailored to suit areas with widely differing contaminant concentrations and low and high permeabilities, by choosing different HRC variants and doses both laterally and vertically across the site. The cost of HRC injection was £177,000, including for staged performance related payment over a 2 year period. Monitoring of primary and secondary lines of evidence was undertaken on a monthly basis to match the Client's requirement to know at the earliest stage that the objectives would be secured, and enable success payments. Extra-over monitoring costs were estimated as £45,000. Project savings are estimated in the range £278,000 to £778,000, and were generally considered to be >£500k.

Durability over the Period of Operation

Durability is demonstrated in the significant reduction in PCE by comparison with Hyder's baseline of true dissolved phase (low flow sampling). To the question of "does rebound occur?" the data clearly shows it does, and critically this occurs from early stages. Rather than a negative, the early step-change increase in dissolved phase to 250,000 µg/l over baseline of 45,000 µg/l (i.e. to effectively full saturation), reflects PCE being actively mobilised out of the formation into the groundwater, which is where it needs to be to enable an effective remediation. As PCE is degraded, more is liberated and this is continued until the PCE is virtually exhausted (PCE < limit of detection). After 18 months of treatment, with no further supply of PCE parent, the degradation products quickly decline. Multiple lines of evidence supported regulatory closure, obtained in January 2013.

The treatment application minimised H&S risks and effect on the business activity by: a) Selecting a wide radius of influence product for the areas under the building – so contamination could be treated under large machines/inaccessible places; b) Carrying out the work inside buildings during evenings and weekends; c) Full application in a single injection.



Injection Rigs weekend working within active laundry to minimise disruption



Indoor injection between dry cleaning machinery

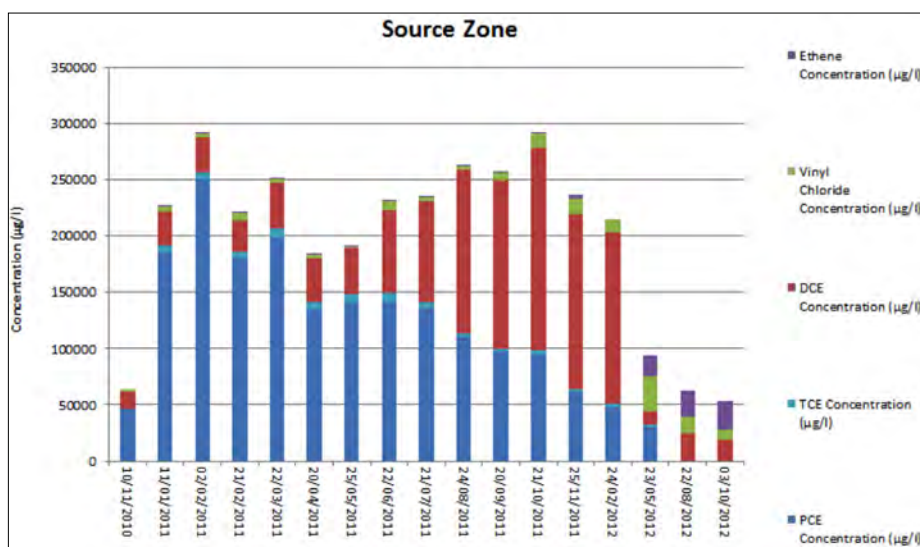


Remediation in full swing in the yard. Disturbance to business operations kept to a minimum

PCE DNAPL was removed in 18 months and regulatory closure was achieved in 2 years. Including HRC-X in the treatment will mean bio remediation will continue to reduce any residual (negligible risk) contamination for 5 years after injection.

Monitoring Evidence

The target contamination was degraded onsite with none of the pollution burden being transferred. The graph above presents the monitoring evidence at the Source (DNAPL) Zone, MW301. From a low purge baseline of >45,000 µg/l, the last 2 monitoring rounds (plus a QA/QC duplicate) recorded PCE < 6 µg/l (LOD). No stall of cis DCE or VC occurred, and dissolved ethene had risen from non-detect, to 25,600 µg/l, demonstrating the full dechlorination of the residual CHCs was ongoing. Ethene has a short half life and is not a risk driver.



Monitoring Evidence at Source (DNAPL) Zone, MW301

“ Great teamwork by Hyder and Regenesis has provided the best hoped for outcome, with minimal disruption to our operation and neighbourhood. ”

Client Quote

Compliance with H&S and Environmental Standards

Regenesis was Principal Contractor under CDM Regulations. Direct injection work was completed in accordance with the Design, Mobile Treatment Permit and Johnsons’ site specific working plan.

- The remedial works presented negligible health and safety hazards. There were no incidents or accidents during the injection or monitoring.
- No releases to the environment occurred, no exposure to operators or site users to excavations or operational equipment used: no adverse noise or dust was created and no measurable release of VOCs occurred to the laundry internal space.
- Down plume monitoring recorded no adverse off-site advection was created, with the injections liberating then degrading low levels of distal contamination to complete breakdown to ethene.
- Water Quality standards adopted were from drinking water regulations.

Conclusion

This project exemplifies a highly sustainable form of remediation, virtually devoid of environmental burden, low H&S risks, and with cost savings likely to have exceeded £500,000. The outcome was the best the Client could have hoped for and exceeded project sign-off goals proposed to the Regulators.

For more information or to discuss your project, please contact:

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