REGENESIS

Remediation of chlorinated solvents under a commercial development, Belgium

CASE STUDY

Long term data of source and plume treatment using enhanced reductive dechlorination

SUMMARY

In Belgium, the former Ubell metal-working factory, which had stood abandoned since the 1990's, was chosen by **Spaque** to be redeveloped for commercial use. Significant amounts of chlorinated solvents had been observed in the groundwater, both widespread and with high concentrations in the source area. Reductive dechlorination was seen to be occurring naturally, but was stalling at cis-1,2 DCE due to a carbon-limited system. REGENESIS designed a remediation approach that would use a slow release electron donor to enhance and maintain full and effective reductive dechlorination (Enhanced Reductive Dechlorination (ERD)) of the target contamination. **3-D Microemulsion® (3DME)** is a **high-volume electron donor** that self-distributes in the subsurface following injection, allowing large areas to be treated with the minimum number of injection points.

SITE TYPE

Metalworking factory

GEOLOGY

Highly heterogeneous sandy and clayey silts

CONTAMINANTS

Chlorinated ethenes
COC range: 50µg/L-72,000µg/L

PROJECT DRIVER

Development for commercial use

TREATMENT

Enhanced reductive dechlorination

TECHNOLOGY

3-D Microemulsion®

TREATMENT

The 3DME was injected into the impacted groundwater between **5 and 11mBGL**. The injection was completed in a grid pattern, with interlocking radii or influence to target the entire contaminated zone. The injection grid was more closely spaced in the centre where the highest concentrations were located. Following injection, the construction works onsite were continued unimpeded by the remediation going on below.

Fig. 1 Direct push injection of 3DME

3-D MICROEMULSION

3DME provides three stages of electron donor release from a single formulation of specially designed polar molecules. Supplied as a pre-mixed emulsion, 3DME is simply diluted onsite to create a high-volume microemulsion. 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 (300 ppm), reforms as a microemulsion and moves further out from the injection point. The ability to 'self distribute' in the subsurface maximises the radius of influence from each injection location.

INJECTION GRID
Source 5x5m
Plume 7x7m

INJECTION POINTS
94 (1st Application)
8 (2nd Application)

TREATMENT ZONE
3,000 m²
5-11m BGL

REMEDIATION COST
€ 100k

Fig. 2 Plan of Injection locations

RESULTS

The application created the ideal conditions for ERD across the contaminated plume. The 'parent' trichloroethene (TCE) concentrations reduced to non-detect levels, with the sequential creation and destruction of 'daughter' products. In almost all locations in the plume and source areas, full reductive dechlorination occurred and concentrations dropped to non-detect where they have remained for **approx. 10 years** of monitoring.

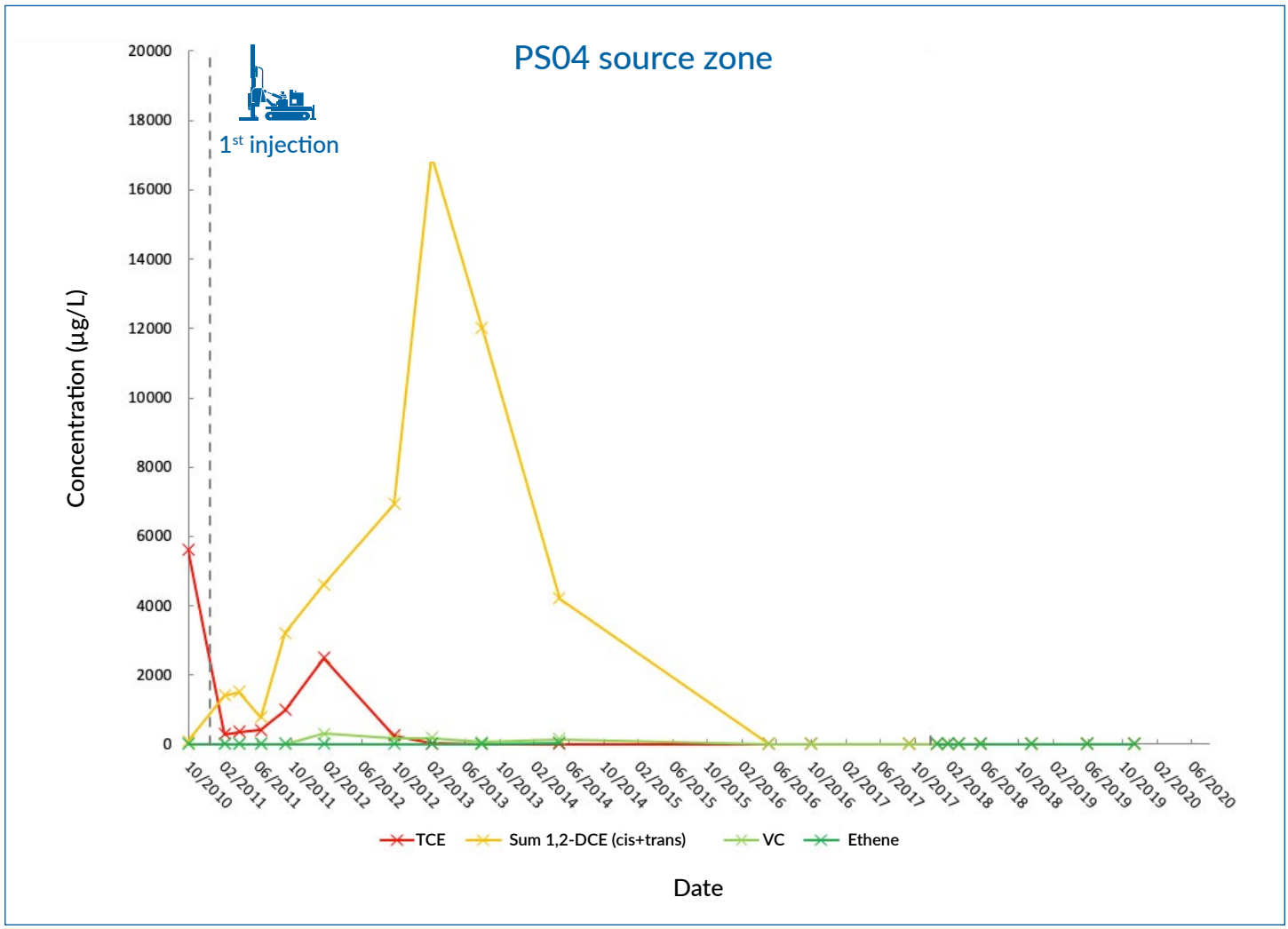

Fig. 3 Results from initial application showing full and sustained treatment

SITE DISTURBANCE

Treatment in the source zone was also proceeding very well, until two years after application, a significant increase in the parent compound (TCE) was observed in a small part of the source area. ERD is not a reversible process and so a contaminant influx must have occurred. It was discovered that ground disturbance when constructing a carpark above the source area, resulted in desorption from the vadose zone into the groundwater. Concentrations were indicative of dense non-aqueous phase liquid (DNAPL) influx. However, because 3DME is designed to last a long time, the new contamination moved into a treatment area where the geochemistry, dehalogenating bacteria and hydrogen were being maintained at a level ideal for its biological degradation. Contaminant concentrations dropped over the following years, as the unseen DNAPL source was depleted as it desorbed into the groundwater.

CONTINGENCY APPLICATION

In a small (150m^2) area of the source zone, it was seen that elevated parent compound concentrations remained after several years. Although these concentrations were reducing, treatment was now beyond the end of the expected lifespan of the 3DME application. Analysis showed that a healthy dehalogenating bacteria population still existed onsite, but that the 3DME was running out. This was resulting in a stall in the reductive dechlorination process due to a lack of carbon – reverting to geochemical conditions prior to treatment. A second, much smaller application was carried out by **Sodecon** approximately seven years after the initial treatment, targeting this residual source area.

> **"The advantage of this solution is that it could be completed on an active site, even with the parking lot in use. We could reapply on site with a small drilling machine, for a limited time and at limited costs compared to the total cost of the redevelopment."**
>
> ***Samuel Wildemeersch, Project Manager, SPAQUE***

RESULTS

The second application resulted in a rapid and sustained reduction of TCE in the groundwater in the source area. Large increases in ethene were observed showing that full reductive dechlorination is occurring. Monitoring is still ongoing and cis-1,2 DCE can still be observed, which is evidence of the residual parent compound influx being degraded. The present contaminant concentrations are not now considered to provide risk on the site. The proportion of DCE in the contaminant mix is now decreasing as the mass of residual TCE is degraded and the concentration of all compounds are expected to decrease as has been seen in all other locations on the site.

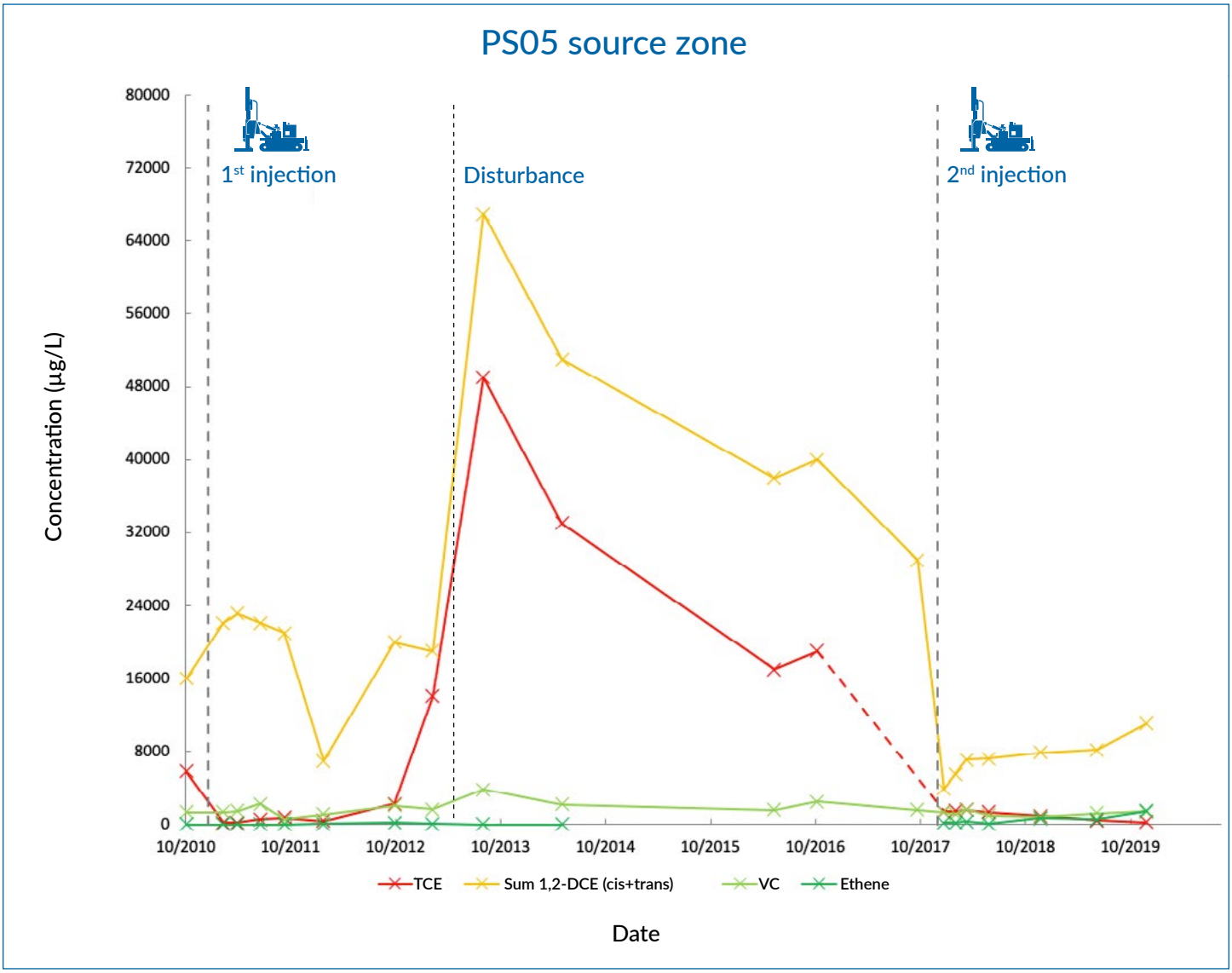

Fig. 4 Source area treatment showing injections and disturbance

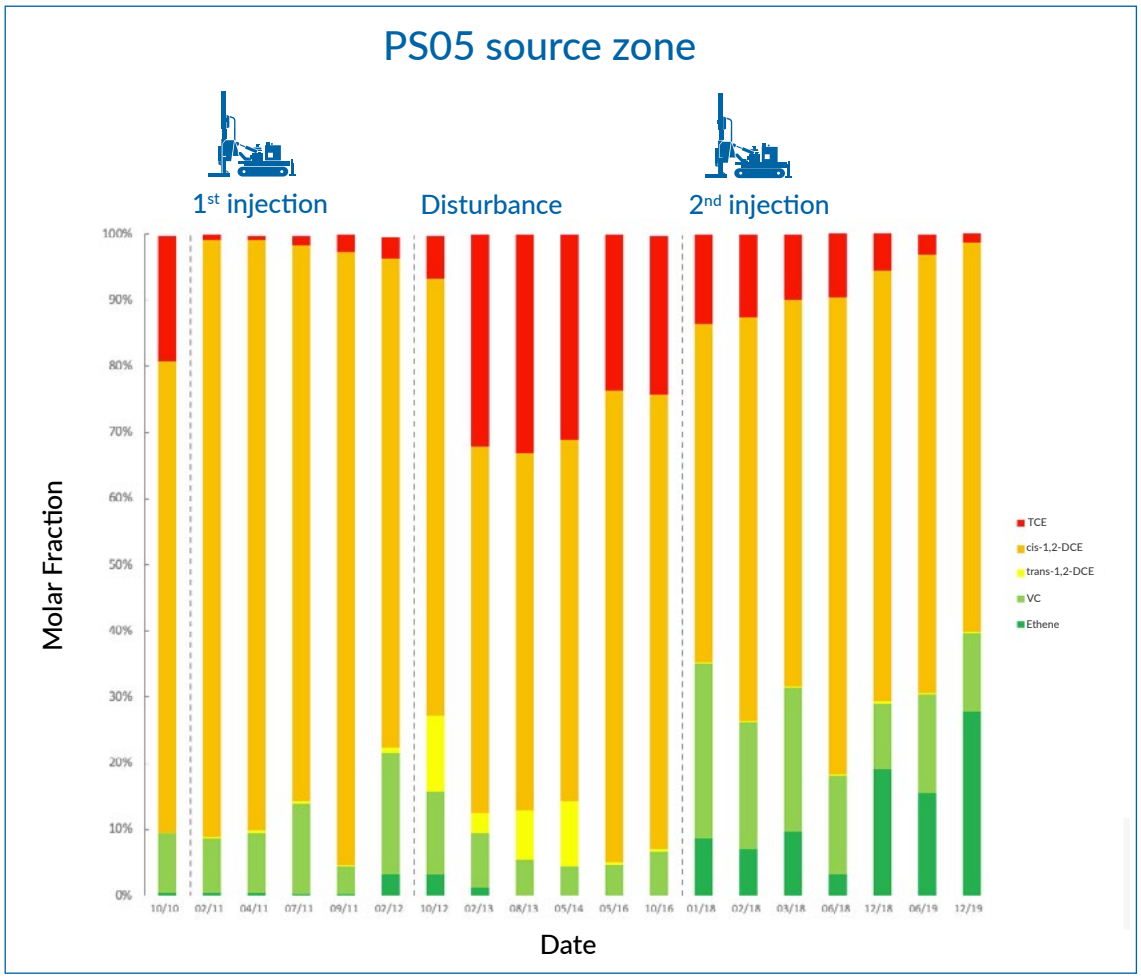

Fig. 5 Molar fraction of contaminant mass in source area, showing initial ERD, influx and treatment, then final application and more rapid ERD

CONCLUSION

Long term monitoring of the site shows that a single application of 3DME resulted in the full reductive dechlorination of a large plume of chlorinated solvents, achieving very low concentrations. Where an unexpected secondary source of DNAPL was encountered through disturbance of the vadose zone, the longevity of the 3DME meant that even after two years, the original application remediated much of the influx. A much smaller second application could be completed without preventing the use of the property. Targeting an area of persistent influx, this application immediately resulted in a rapid reduction of contaminant concentrations of the residual contamination. This simple and inexpensive treatment allowed the redevelopment of a highly impacted brownfield site, while allowing construction and economic use to go ahead unimpeded by the remediation occurred beneath the ground.

ABOUT SPAQUE

As a centre of excellence in Wallonia for the management of contaminated soil, SPAQUE plays a role in the economic and sustainable development of Wallonia. This role includes projects the reallocate the sites it has decontaminated.

To date, 59 sites have been rehabilitated: 23 sites (599 hectares) have been redeveloped and 26 (387 hectares) are undergoing redevelopment.

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