

Combined Remediation Approach – Dual Phase Vacuum Extraction with In-Situ Chemical Oxidation

Introduction

When redevelopment of an old service station was proposed, site investigations revealed a significant petroleum hydrocarbon impact within the soil and groundwater. The subsurface contamination threatened to derail the redevelopment program and a rapid remediation strategy was needed to reduce concentrations to acceptable levels. Geo² Remediation was contacted to remediate the site in order to allow safe development for luxury residential properties while ensuring no impact to local protected controlled waters.



Figure 1. Successful Site Remediation Leads to Luxury Residence Redevelopment

Project Background

Geo² Remediation carried out the treatment of a former service station following historic leakage from underground storage tanks (USTs). The tanks had been removed prior to the beginning of the site investigation. Free product was discovered at the surface of the saturated zone and elevated concentrations of total petroleum hydrocarbons (TPH) were observed within the groundwater. Concentrations of TPH as high as 290 mg/L were discovered within the source area.

In situ Physical Remediation

Geo² Remediation installed a dual phase vacuum extraction (DPVE) system, designed to rapidly remove phase separated product identified on the surface of the groundwater. The DPVE system began treatment in September 2007. Thicknesses of free product up to 50 mm, identified around the former tank farm, were removed within 1 month of commencing treatment. Within the groundwater, TPH concentrations were reduced to between 300 mg/L and 150 mg/L over a 5-month monitoring period. In order to increase the efficiency of the DPVE system, Geo² augmented the physical treatment system with RegenOx to provide a rapid reduction in soil and groundwater concentrations and allow redevelopment to proceed on schedule.

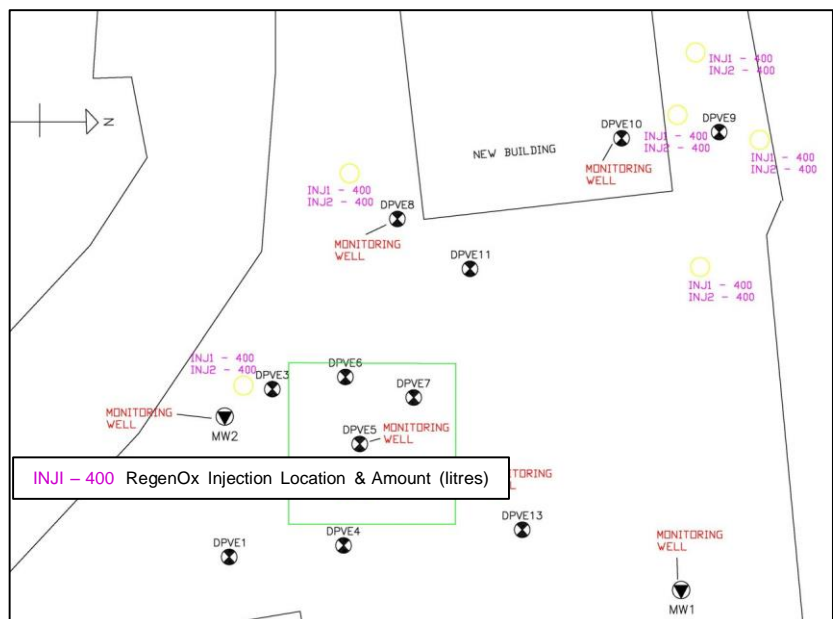


Figure 2. Site Plan Showing RegenOx Locations

Combined *In Situ* Physical Remediation and Chemical Oxidation

Geo² Remediation applied RegenOx™, a safe and easy to apply proprietary *in situ* chemical oxidation (ISCO) designed to provide rapid concentration reduction of contaminants without a violent exothermic reaction or other handling difficulties common to ISCO reagents. RegenOx was injected into the subsurface around the dissolved phase impact following DPVE system shutdown using a direct-push injection rig. Two applications were completed within one week of each other using a modest dose of 326 kg RegenOx to achieve sorbed-phase desorption and partial chemical oxidation of the residual hydrocarbons. The DPVE system was then restarted to remove the resulting desorbed contamination and partially oxidised hydrocarbon species from the groundwater – this enabled the Reagent requirements to be kept to a minimum (i.e. partial contaminant oxidation rather than full contaminant oxidation) whilst capitalising on the use of the DPVE system already in place. The total cost of the RegenOx application – including all fieldwork – was approximately £ 5,000, the cost of one month's DPVE operation at the site.

RegenOx™ Basics

RegenOx™ is a proprietary two-part chemical oxidation product developed and sold by Regenesis for *in situ* groundwater treatment. It combines the use of a controlled-release percarbonate-based oxygen compound with a proprietary multi-part catalyst to generate surface-mediated free-radical generation and contaminant oxidation (e.g. perhydroxyl radical, hydroxyl radical and superoxide radical), with reactive power comparable to that of Fenton's reagent but with greatly facilitated handling and subsurface delivery / longevity (up to 30 days). This provides an effective contaminant oxidation reaction without violent exothermic reaction, and can therefore be handled using a wide range of standard field equipment (e.g. direct push injection rigs) or applied directly to excavations. Furthermore, it is alkaline and can therefore be used in calcareous formations in addition to sands and gravels etc.

¹RegenOx-enhanced Contaminant Desorption

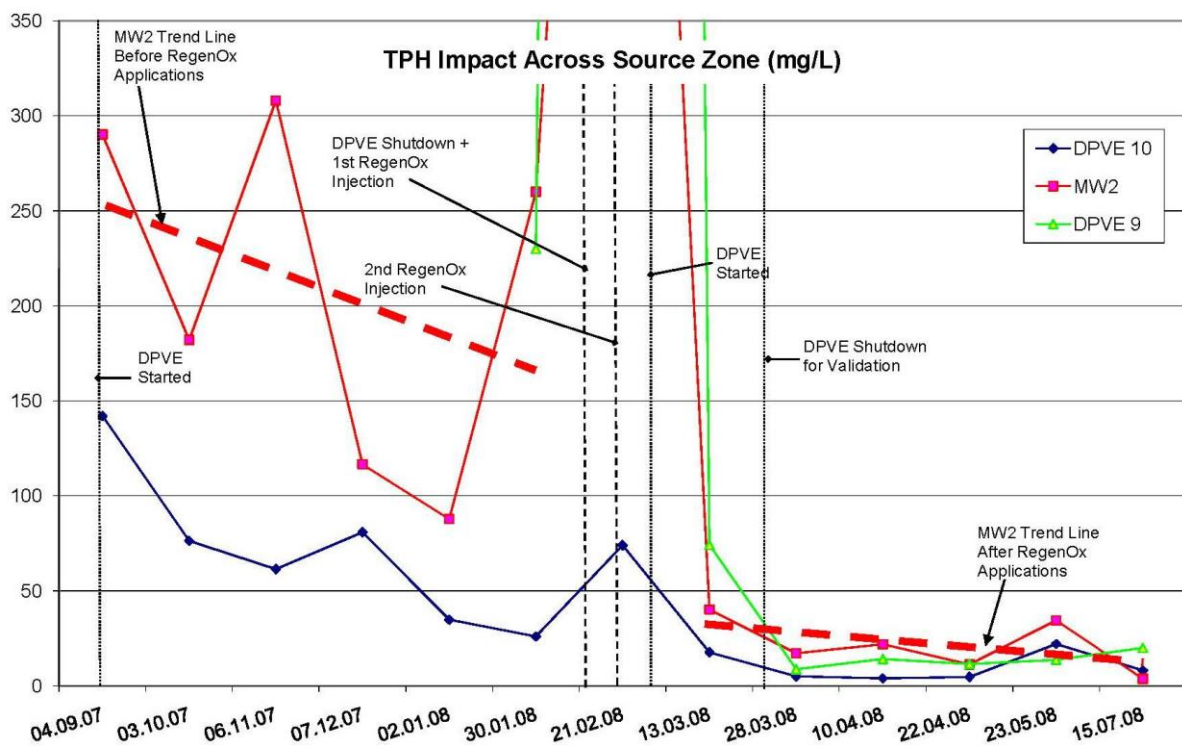
RegenOx has been designed as a bespoke remediation product to provide advantages in usage and application over commodity chemical products used for ISCO (e.g. permanganates, persulphates, peroxides). One of the design features it includes is reduced losses onto the aquifer matrix, commonly known as the matrix Natural Oxidant Demand (NOD). This is achieved by RegenOx through a powerful desorption / surfactant effect of the combined product (principally the catalyst) that draws the contaminant off the soil surface and into solution / onto the catalytic surface where localised free-radical generation occurs leading to focused contaminant destruction. This restricts the oxidant losses onto tightly bound and heavier soil organics such as humics, roots, and other natural or immobile fractions. At the same time, RegenOx is purely inorganic therefore adding no organic surfactant to the system that may prevent a competitive oxygen sink to on-going contaminant biodegradation.

The present project makes use of this product feature to combine in situ chemical oxidation with enhanced physical mass recovery. RegenOx-desorbed contaminant mass and partially oxidised (more soluble) organic species are recovered via groundwater abstraction using the DPVE system, whilst further contamination is destroyed in situ by oxidation.

¹ Standard RegenOx treatment typically comprises a sequence of applications, approximately one month apart, progressively desorbing and oxidising contaminants. This process is often followed by enhanced-bioremediation using Regenesis slow-release electron donors / acceptors (e.g. ORC Advanced®, 3-D Microemulsion (3DMe)™).

Results

Upon completing the RegenOx applications, desorption from the highly impacted soils produced a temporary increase in groundwater hydrocarbon concentrations to a maximum of 4,800 mg/L. One week after the second application was completed, the DPVE system was re-started, rapidly reducing the TPH concentrations in the groundwater to an average of 20 mg/L. The improved efficacy of the DPVE system can be seen in Graph 1 where the linear trendline of MW-2 before and after the RegenOx applications shows a conservative 80% reduction in contaminant concentrations within two months – effectively increasing the DPVE efficiency by more than 500% at this stage in its operation. Once the DPVE system was switched off, further monitoring showed that there was no rebound in groundwater hydrocarbon concentrations due to the augmentation process successfully reducing the sorbed TPH concentrations of the soils.



Regulatory Closure

By integrating chemical oxidation using RegenOx and a DPVE physical treatment system, Geo² Remediation was able to rapidly reduce high concentrations of hydrocarbons in the soils and groundwater of the site to the point where closure was negotiated with the regulatory authorities. Site closure was achieved within four months of the RegenOx injections, before the newly developed residential properties could reach the market place.

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