Environmental Solutions

Case Study

Remediation of BTEX, TPH, and Naphthalene with a Formulated Oxygen Release Product at an Active Gas Station

Site Overview

Site: Active Gas Station – Kassel, Germany
Lead Consultant: HPC AG

Soil and groundwater at a gas station in Kassel Germany was impacted by the contaminants of concern (COCs) that included BTEX, TPH and naphthalene. The COCs originated from defects on fuel pumps and underground storage tanks from former USTs.

Contaminated soil was excavated from the unsaturated zone during renovation in 1996. From 1999 to 2006 soil vapor extraction and pump-and-treat (P&T) measures were conducted at the station for remediation of the source area. The plume could be delineated but remained unaffected by P&T. Regulators required measures to decrease the groundwater pollution downstream, as concentrations of around 3000 µg/l BTEX and 100 µg/l naphthalene were detected.

The petrol station of interest was built in the 1950s. In the 1970s, defects in fuel pumps and underground storage tanks caused soil and groundwater contamination by BTEX, TPH and naphthalene. The plume migrated off-site with the groundwater flow spreading under a main road and rail line to a public park area. The underground lithology comprised gravely sand and silt covered by made ground. The quaternary layers form an approximately six-meter-thick aquifer, with medium permeability limited by a basal clay layer. Contaminated soil was excavated from the unsaturated zone during renovation in 1996.

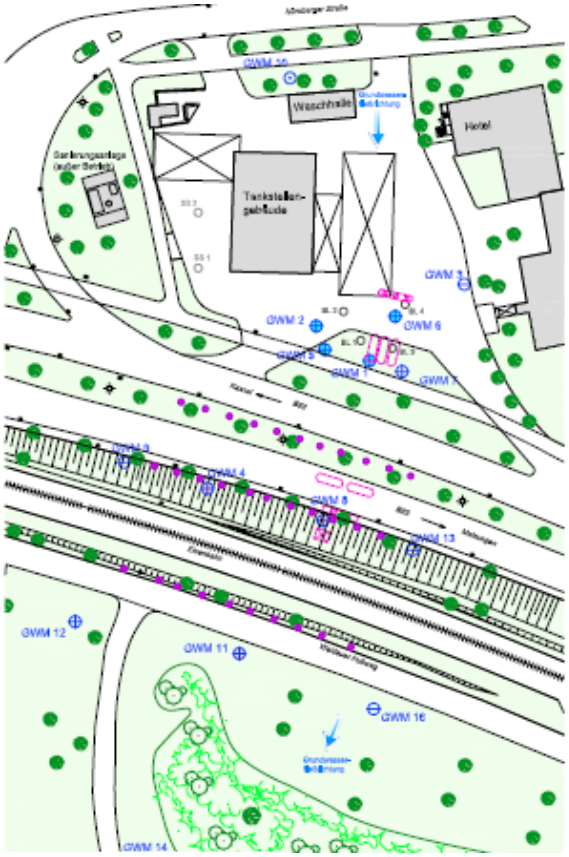

Figure 1. Site Map

From 1999 to 2006, soil vapor extraction (SVE) and pump-and-treat (P&T) measures were conducted at the station for remediation of the source area. The plume could be delineated but remained unaffected by P&T. Regulators required measures to decrease the groundwater pollution downstream, as concentrations of around 3000 µg/l BTEX and 100 µg/l naphthalene were detected.

Solution

Monitored natural attenuation (MNA) was abandoned as an acceptable solution because concentrations of pollutants in the plume were increasing after termination of P&T. Further, a significant degradation of pollutant within the next decade could not be predicted with sufficient certainty. The consulting engineers determined that microbiological degradation should be enhanced using an *in situ* technology for oxygen input. The selection of an applicable technique

was guided by the expected efficiency, and especially by the technical feasibility due to the constrained site conditions in the treatment area. An input of hydrogen peroxide to the groundwater via small-scale wells for extraction and infiltration was considered but discarded due to the numerous installations that would have been required adjacent to a main roadway, along with technical issues and potential safety concerns. Injection of a formulated calcium peroxide oxygen release product was ultimately selected as the preferred remedy because *in situ* remediation eliminated any ongoing maintenance obligations and was more feasible than running above ground systems.

The slow-release source of oxygen, nutrients and a pH buffering agent stimulates indigenous microorganisms to aerobically biodegrade petroleum hydrocarbons and other organic constituents amenable to aerobic biodegradation. Prior to field application a successful laboratory test had been performed.

In April 2010 2,600 kg of the formulated oxygen release product was mixed with site water and injected at 40 locations, by direct push techniques in three rows perpendicular to the groundwater plume. After the first application only, a limited decrease (30-40%) in COCs were observed. This was due to a combination of high COC concentrations, strong background anoxic conditions and limited site access.

A second injection of 1,300 kg, in April 2011, led to distinct degradation of BTEX and naphthalene. Concentrations decreased by 98 to 99.5% in the portion of the plume area with the highest contamination at the start of the project. (Figure 3).

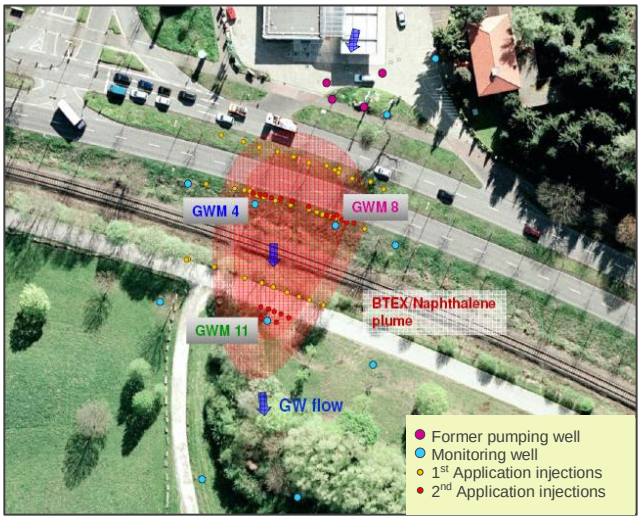

Figure 2. Phase 1 and Phase 2 Injections

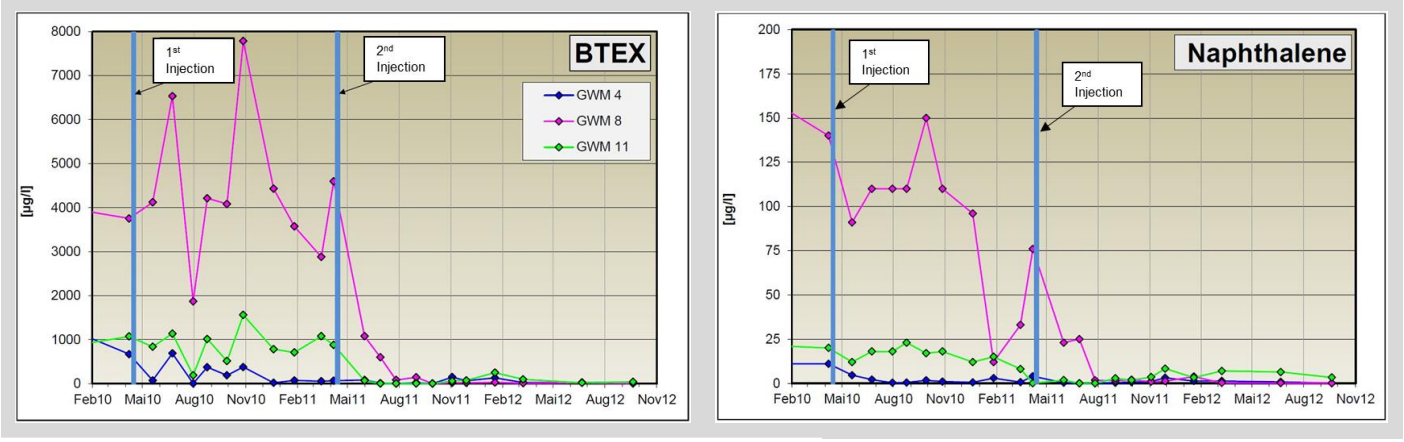

Figure 3. BTEX and Naphthalene concentrations post Injections

Results

Baseline geochemical data (Figure 4) indicated that the aquifer was anoxic, with highly reducing conditions that required sufficient amounts of the formulated oxygen release product to drive the conditions oxic and thereby sustain aerobic degradation of petroleum hydrocarbons. Following the injections, the oxidation-reduction potential (ORP) increased from -100 mV to >+100 mV and the Dissolved Oxygen (DO) concentrations increased from <1mg/L to >7mg/L in wells GWM-08 and GWM-011, thus confirming that aerobic conditions were established within the injection zone. Given high Chemical Oxygen Demand (COD; data not shown), the decrease in DO/ORP after 6-9 months was attributed to the consumption of oxygen by other sinks (reduced metals) and strong background reducing conditions. Furthermore, an initial increase in pH suggested that hydroxyl ions were released during the hydration of peroxygen compounds in GWM-08, before reverting to background levels due to natural soil buffering, and possibly due to the built-in buffering capacity of the product.

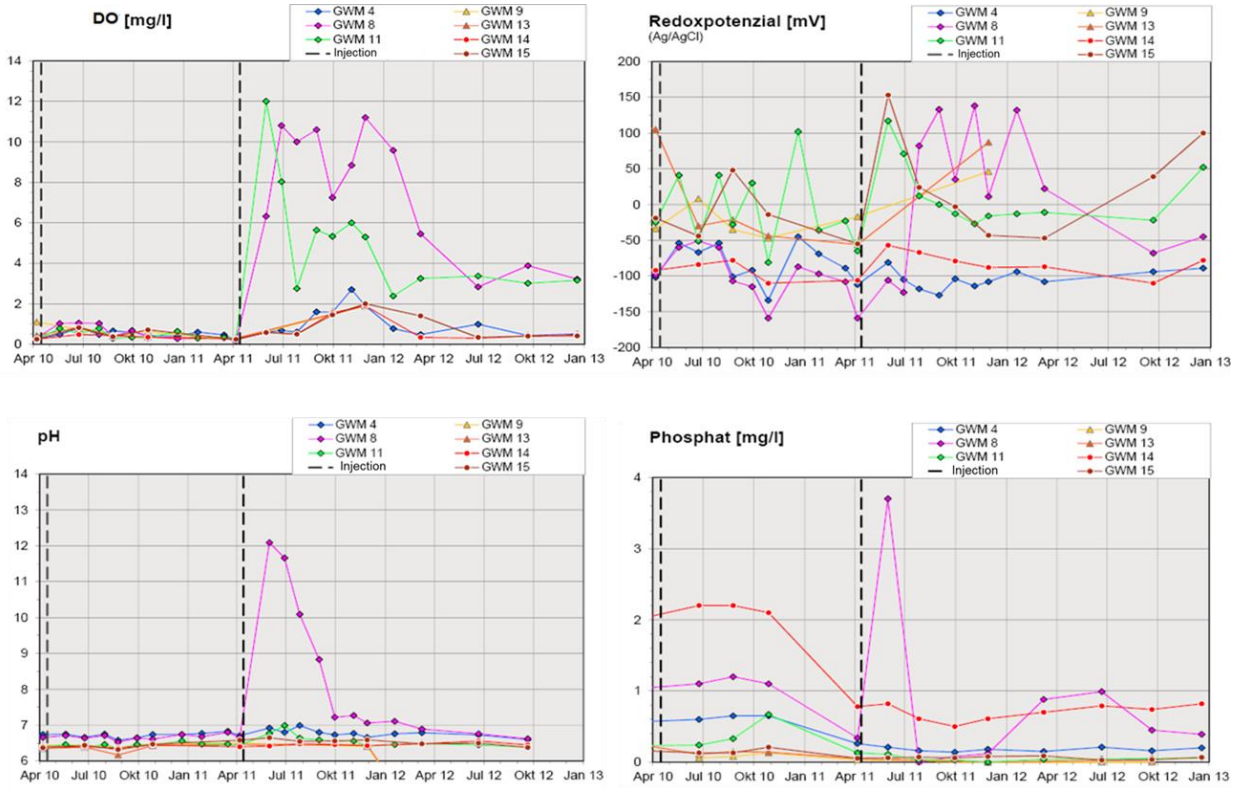

Figure 4: Effect on geochemical parameters within the treatment area.

Evaluation of the application by regulators was based on the achieved degradation rates in the laboratory and on the long-term efficacy of the groundwater treatment. Both key factors are supported by the elimination of O&M, which would otherwise be required but for the deployment of a sustainable in situ technology for oxygen input. A total of 3,900 kgs of the formulated calcium peroxide product was emplaced. The injections were completed in a total of 8 days in 2 events approximately one year apart.

Summary

Two years post implementation of enhanced aerobic bioremediation using the formulated oxygen release product the COCs decreased by >98% within the treatment area of interest. The timely and cost-effective remedial action facilitated significant reduction of VOCs. The danger to receptors was also eliminated, as the plume extended into a public park area.