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for Australia's 1st Installation of Horizontal Wells for ISCO and Biosparging

First Use of Horizontal Wells in Australia for In Situ Chemical Oxidation (ISCO) and Biosparging

For the first time in Australia, 288 metres of horizontal wells were installed underneath an operational resin manufacturing facility in Botany Bay, NSW. The wells were installed to enable chemical oxidants and compressed air to be sequentially injected into the local aquifer to degrade contaminants present in the vadose and saturated zones.

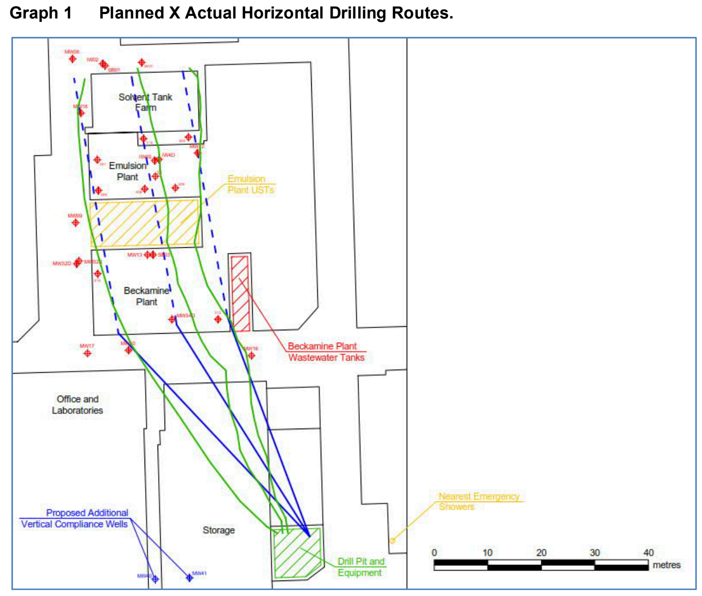
Background

A narrow and fast-moving plume mainly comprising toluene, ethylbenzene and xylenes was detected at the site in 1999, originating from three separate sources, above and below ground. The plume was migrating offsite, with the potential of reaching sensitive human and ecological receptors, therefore a containment system comprising of an Air Sparging / Soil Vapour Extraction Barrier (AS/SVE) was installed along the downgradient boundary of the site in 2011 and has been operating successfully since then.

The next natural step was to treat the contaminant source zones. A remediation options assessment (ROA) was conducted in 2017 and a horizontal approach was selected as the only effective method to reach and deliver oxidising reagents and compressed air to the whole extent of the contaminant plume. The reasons included:

- above and below ground operational infrastructure compromising the access to the source zones;
- the geometry of the plume. Due to the high local seepage velocity, the contamination plume was narrow, elongated to the north-south direction;
- the need for minimum above ground disturbance, as the site is still fully operational;
- the local sandy lithology, allowing for an easy drilling process and an efficient delivery of reagents via injection methods;
- a good knowledge of the local subsurface conditions. A high-resolution characterisation campaign (membrane interface probe (MIP) and hydraulic profiling tool (HPT)) was conducted back in 2015, showing the exact vertical extent of the impacts, as well as more details about the aquifer lithology.

Graph 1 Planned X Actual Horizontal Drilling Routes.



Methodology

Groundwater levels within the site range from 4.8 to 5.2 metres below ground level (mbgl) and the plume extends vertically to 8 mbgl. Therefore, the horizontal well screens were installed at a maximum depth of 8 mbgl, longitudinally to the plume movement direction (north-south). Three horizontal wells were installed, with a total combined screen length of 153 metres.

The drilling process was completed in only 9 days (July 2017) and consisted on three sequential stages:

- Pilot drilling: during this stage, Ø40mm rods were used to open the full extent of the horizontal well. The tip of the drill was equipped with accelerometers that provided orientation data to the surface, allowing for precise steering. Drilling mud was used to avoid the open hole from collapsing;
- Reaming: the purpose of this stage was to repeat the same trajectory determined during the pilot stage, but using a larger drill (Ø80mm), so that the resulting open hole could accommodate the casing and screens to be installed during the subsequent completion stage;
- Completion: blank and screened casing were finally pushed into the hole and installed at their target positions. The drilling mud was flushed out of the well and the first 12 metres of the annular space were sealed with concrete. The entry point area was reinstated and the wells were ready to be connected to the above ground equipment.

The injection equipment comprised a series of tanks, pumps, agitators and instrumentation that enabled the reagents to be mixed on site and injected into the horizontal wells. The first three ISCO events were completed in August 2017, November 2017 and February 2018 and together represented a combined volume of more than 500,000 litres of reagent injected so far. The reagents selected were the Modified Fenton Reagents (MFRs), a combination of stabilised hydrogen peroxide and chelated ferrous sulphate.

Results

The efficiency of the ISCO program was assessed during and after the injection events by using various tools, including:

- Comparison of the contamination plume modelled during the baseline period and after each of the post-injection groundwater monitoring events (GMEs);
- Assessment of the data obtained from 16 loggers installed around the site, measuring mounding and temperature levels. These two parameters indicate, respectively, the locations where reagent delivery and oxidation chemical reactions are occurring more efficiently;
- Ferrous anions and peroxide detection kits, that provided information on qualitative change detection for these two indicators across the site.

By the second post-injection groundwater monitoring event (GME), in November 2017, a comparison with baseline numbers showed that 36% of the total contaminant mass calculated for the target area had already been oxidised.

LNAPL observations

During the third post-injection GME, however, light non-aqueous phase liquid (LNAPL) was detected in two wells within the same area, halting the whole remediation program. Laser-induced fluorescence results from 12 different locations combined with chromatogram assessments demonstrated that the product found in the wells is a different contaminant, likely originated from a separate, more recent release.

Next steps

A series of LNAPL extraction techniques are being used on the site in an attempt of reducing the apparent LNAPL thickness to the extent practical, so that the remediation program can be resumed. Passive skimmers and sorbent socks are being deployed/replaced weekly since July 2018 and a multiphase vacuum extraction (MPVE) event is scheduled for February 2019.

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