Limited-Access Bioremediation in a Factory Setting

PART I: Bioremediation

Chapter 1

LIMITED-ACCESS BIOREMEDIATION IN A FACTORY SETTING

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ABSTRACT

A factory in New Hampshire had a volatile organic compound (VOC) release detected in a storm-water outfall pipe. Hydrogen Release Compound (HRC) injection was determined to be the best remedial solution. Tight soils, shallow water table, access limitations, and pending property sale complicated remediation. Groundwater was directly below the floor slab. The plume was centered on the storm-water drain which carries runoff from the upgradient parking lot under the building. The VOCs are believed to have entered the subsurface in the central area of the building through spillage; the storm drain system was a preferential pathway.

The groundwater contamination was addressed through bioremediation using HRC. Application required many injection points and applications, due to the low permeability of the soil. Due to interference with operations and property sale, repeated openings of the floor for injections using a drill rig were not feasible. Permanent injection points were installed, but would not be accessible for direct injection. Therefore, a trench was cut into the concrete floor slab between each point and the wall. Piping ran from the injection point to the wall, terminating at a standpipe with a quick-connect fitting. Each trench was then fillled with concrete to restore the floor slab.

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Since starting HRC treatment, VOC levels at the outfall have dropped to below the state regulatory standard. One well had levels of 1800 ug/L and 1200 ug/L of Cis-1,2 Dichloroethene and Vinyl Chloride in April, 2008. By January, 2009, both were below MCLs. Site closure is expected to be completed in a reasonable timeframe. The treatment has not interfered with Site activities or with sale of the Site.

Keywords: Remediation, HRC, chlorinated solvents, VOC, site assessment, property transaction

1. INTRODUCTION

A manufacturing facility in New Hampshire was the site of a chlorinated volatile organic compound (VOC) release first detected in a stormwater outfall pipe at the downgradient side of the facility. The compounds detected were Trichloroethene (TCE) and its daughter products. TCE was formerly used in degreasing during the manufacturing process, but had not been used for many years.

1.1 Conceptual Site Model

Groundwater at the site is shallow; in some locations it was encountered immediately below the floor slab. The groundwater contaminant plume was centered around a storm sewer which carries stormwater from the upgradient parking lot, under the building, to the downgradient side of the property, where it discharges to a small stream. The VOCs are believed to have entered the subsurface in the central area of the building through small spillages over many years; the storm drain system acted as a preferential pathway for contaminant migration. Site soils consisted mainly of silts and clays below foundation fill which consists of fine to coarse brown sand with some gravel. Groundwater contamination was present in both fill and native materials.

The source area for groundwater and surface water contamination appears to be in the area surrounding well MW-21, located in a former machine area near the drain line. Near this area, contaminated groundwater entered the drain line through cracks and joints in the sewer line, as indicated by manhole samples upgradient and downgradient of this area. Once in the drain line, the VOC contaminants flowed directly to the outfall area, where TCE was present in water at 16 ug/l. VOC levels in the stream continue to drop downgradient of the outfall at sampling location SS-1, with TCE at 10.6 ug/l.

Groundwater VOC levels trended downward along the path of the storm drain; the backfill surrounding it appears to have acted as a preferential pathway. From MW-21S, with the highest level of total VOCs at 314 ug/L, the nearest well downgradient is MW-18S, which had a total VOC load of 226 ug/l; next is MW-15S, with total VOCs of 52.9 ug/l; MW-13D, with total VOCs of 24 ug/l; and finally T-01, with total VOCs of 7.9 ug/l. Only the monitoring wells located east of the drain line appeared to be affected; this is the natural downgradient groundwater flow direction.

Groundwater within the backfill immediately surrounding the drain line is assumed to generally follow the line south as a preferential pathway; other groundwater on the site flows towards an unnamed stream located east of the site.

The VOC contamination consists of trichloroethene and its daughter products. Natural attenuation appears to be occurring, based on the presence of daughter products such as cis(1,2)dichloroethene and vinyl chloride.

2. MATERIAL AND METHODS

Based on hydrogeological characterization of the site and the extent and magnitude of contamination, four remedial alternatives were identified that would reduce contaminant concentrations to levels at or below DES established limits. Those four alternatives were:

1. Natural Attenuation
2. Groundwater sparging with soil vapor extraction
3. Enhanced Natural Attenuation of groundwater hot-spot and In-Pipe Sparging of surface water in storm drain
4. Containment for water leaving the property

In addition, it was decided to repair the drain line to prevent groundwater infiltration, regardless of which alternative was selected.

The alternatives were compared for their effectiveness, feasibility or implementability, treatment time, and cost. Costs were based on capital expenditures (including pilot tests, construction, land, buildings, equipment, engineering, startup, and permits) and annual operating costs (including labor, materials, power, disposal of residues, monitoring, and equipment replacement). Costs had an accuracy of +/- 30 percent. A present worth analysis was used to evaluate the costs using a 5% interest rate.

The selected remedial technology was Alternative 3 in combination with the drain line repair. This alternative was selected based on the fact that Enhanced Natural Attenuation with HRC was found to be the most cost-efficient and effective solution, while repair of the drain line was a low-cost endeavor which would prevent future surface water contamination.

After conducting as much repair to the drain pipe as was possible, HRC was injected through a grid of both temporary and permanent points installed using direct-push technology. HRC application required a large number of injection points and repeated applications, particularly due to the low permeability of the majority of the soil. Repeated openings of the floor to conduct repeated injections using a drill rig were not desired by the client, due to potential interference with plant operations and with pending sale of the property. Therefore, permanent injection points were required. An HRC trench system was designed that would allow repeated injection of HRC yet not require access to the floor of the plant.

3. HRC INJECTION AND TRENCH SYSTEM

Initially, the permanent injection wells were installed using a direct-push rig and completed with roadboxes. When the trench system was installed, the wells had to be retrofitted. At each of the 22 permanent injection point locations, a trench of approximately 4” wide by 4” deep was cut into the floor slab using wet sawing techniques from the wellhead to the nearest wall. The concrete in each trench was broken out by the contractor. The trenches did not penetrate the total thickness of the concrete. MyKroWaters personnel then removed the roadbox and expansion plug from each well. A PVC 90 degree elbow was used to join the existing well to new PVC piping which ran horizontally from the well to the wall. Couplings were used in cases where more than 10’ of pipe was needed. At the wall, a second elbow was used to connect the horizontal pipe to a vertical standpipe. In several cases, multiple elbows were needed to plumb the piping all the way to the standpipe, due to obstacles at the base of the wall. Each standpipe rose approximately 2’ above floor grade, as close to the wall as was feasible, and was equipped with a ball valve to close the system when not in use, and a quick-connect fitting for future HRC injection. All PVC was 1” Schedule 80, and all fittings were glued using PVC primer and cement. Each finished standpipe, where feasible, was collared to the wall with metal strapping. Each point was further protected with a steel bollard.

Prior to pouring concrete, all dust and chips were removed from the trenches using brushes and industrial vacuums to allow a better seal of the new concrete to the sidewalls and floor of the trenches. Each trench was backfilled with concrete. The trenches were sealed with a clear-coat sealant.

After the installation of the trench system, the buyer was willing to move forward with purchase of the property, knowing that they would be able to place machinery where it was needed, without concern for allowing access to the injection points.

4. RESULTS

VOC levels have been reduced dramatically since the start of HRC treatment. Most importantly, VOC levels in the surface water at the outfall where TCE was originally detected have dropped to below the Ambient Groundwater Quality Standard (AGQS). One of the most contaminated wells had levels as high as 1800 ug/L cis-1,2 dichloroethene (cis-1,2 DCE) and 1200 ug/l vinyl chloride (VC), respectively, in April, 2008. By January, 2009, VC was below the laboratory detection limit, following a steady decline; and cis-1,2 DCE was at 1.4 ug/L, an order of magnitude below the AGQS.

Two wells, MW-73 and MW-21S, are examples of the results of the HRC injection program as discussed below.

MW-73 was sampled in January, 2008, prior to the first HRC injection in February. It contained levels of cis-1,2 DCE at 1500 ug/L; VC at 700 ug/L; 1,1-DCE at 14 ug/L; and trans-1,2 DCE at 120 ug/L, all of which were above AGQS. It was next sampled in April, 2008, two months after HRC injection. Cis-1,2 DCE had increased to 1800 ug/L, and VC had increased to 1200 ug/L, with 1,1-DCE and trans-1,2 DCE essentially unchanged. By May, 2008, three months after injection, cis-1,2 DCE had begun to drop, at 1400 ug/L. Since then, with monthly or bi-monthly sampling, the level of cis-1,2 DCE in MW-73 dropped steadily and has been below 5 ug/L since October, 2008 – a reduction by a factor of about 300 in less than one year. 1,1 DCE dropped below the AGQS in June, 2008, and has been non-detect since July 2008. Trans-1,2 DCE has been below AGQS since May, 2008 and non-detect since December 2008. VC continued to rise to its highest level in May 2008, at 1600 ug/l, more than double its original level, and then began to drop; by December 2008 it was below 5 ug/l and had been non-detect since April.

MW-21S contained levels of both cis-1,2 DCE and VC above AGQS in January 2008, at 244 ug/L and 69.7 ug/L, respectively. In April 2008, two months after injection, levels of both had doubled. Levels of cis-1,2 DCE steadily decreased after that, and were at 62.6 ug/L in December 2008, below AGQS. Since then, levels of cis-1,2 DCE in the well have rebounded slightly but remain at less than half of what they were in the corresponding month in 2008. VC increased to its highest level in May 2008, at 190 ug/L, and then began to decline steadily, also reaching its lowest level in December 2008. As with cis-1,2 DCE, the levels of VC have since increased. The increases in both cis-1,2 DCE and VC may be due to desorption of contamination from the aquifer solids as well as due to the increased bacterial activity forming the degradation of TCE, the principal contaminant.

In both cases, there is clear evidence of reductive dechlorination occurring. Both wells followed a similar timeline, with cis-1,2 DCE spiking two months after HRC injection, in April, 2008, and then reducing, and with VC spiking in May.

5. DISCUSSION AND CONCLUSION

Out of the 9 monitoring wells which started off above AGQS, three are well below AGQS for their primary contaminant; three have shown steadily reducing contaminant levels; and three have not shown improvement. The areas surrounding the three which have not improved were not thoroughly treated with HRC during the first injection events, and are now being treated more completely. Similar results are expected to the rest of the treatment areas.

Most importantly, the surface water contamination that was the original indicator of the release has been fully remediated. Some air sparging within the drainage pipe was conducted; however, the in-pipe sparging system has been inactive for several months. VOC levels at the outfall began to decline in November of 2008 and are now below detection limits. Surface water samples from downstream of the outfall began to decline in December of 2008 and are now also below detection limits.

Site closure is fully expected to be completed in a reasonable timeframe. The treatment method has not interfered with Site activities or with the sale of the Site.