

Free-Product Recovery and Site Remediation

Using Horizontal Trenching, Soil Vapor Treatment and Groundwater Extraction

Case Study

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Overview

Sites with soil and groundwater impacted by petroleum hydrocarbons have been remediated using a variety of traditional techniques. However, when the site impacted lies within a very confined downtown area of an expanding metropolitan city, a more complex array of technologies must be considered. The Law Enforcement Center (LEC) site is the worst known underground storage tank (UST) released to date in the city of Charlotte, N.C. A cost-effective free-product recovery, soil vapor and groundwater extraction system is being piloted using new horizontal trenching technologies and state-of-the-art equipment.

On-site low permeability soil required that an alternative to standard recovery wells be developed for groundwater recovery and vapor extraction. Operation and maintenance of the large number of recovery wells required would have been extremely costly over the expected lifetime of the project. Although horizontal trenching was the best solution to the operation and maintenance cost, many problems

were encountered during installation.

The system installed consists of a series of seven interconnected horizontal trenches varying from 18 to 23 feet in depth. These horizontal trenches were installed using new technology developed by Horizontal Wells, a division of Horizontal Dewatering Systems. The trenches installed through approximately 8 feet of free-product were placed around the perimeter of the site, and spaced evenly throughout the site to ensure total capture of the product and dissolved contaminant plumes.

Site History

The LEC underground storage tank site is located within the downtown area of Charlotte, N.C. This site was used by the city of Charlotte police department as a fueling facility from approximately 1975 to 1990. Two 10,000-gallon USTs resided at this facility within an approximate annual throughput of 750,000 gallons. In the spring of 1990, the tanks were identified as leaking and were removed. During the removal operation, approximately 4,500 gallons of gasoline filled

the excavation. The examination of the USTs following removal indicated the presence of many holes approximately 3/4- to 1-inch diameter in both tanks. Also, the fittings of the associated piping exhibited gross corrosion and were leaking.

Initial borings and monitoring-well installations conducted in June 1990 indicated a substantial amount of free-floating petroleum product on the groundwater table, together with an associated amount of soil vapor contamination. Subsequent to this discovery, remedial action in the form of free-product recovery and a site characterization/assessment were initiated.

Site Specific Geology and Hydrogeology

The site is located in the Charlotte Belt of the Piedmont physiographic province of North Carolina (Meinzer, 1923; Brown, et al., 1985). This region is characterized by an igneous intrusive bedrock of the Precambrian and Paleozoic age underlain with a layer of soil and weathered rock, ranging in thickness from 0 to 150 feet (Aller, et al.,

1987; LeGrand, 1967).

The groundwater source for this area is the unconfined soil and crystalline rock aquifer system, with the larger porosity soil and weathered rock regolith acting as an undergrown reservoir and the fractured bedrock acting as an interconnected system of pipelines transmitting water to springs, streams or wells. Well yields in the Charlotte area ranged from 9 to 50 gallons per minute (gpm) (LeGrand and Mundorff, 1952; Aller, et al., 1987.).

Site specific borings indicate red-brown to tan and orange-tan silty sand with weathered rock fragment extending a depth of 12 to 25 feet below land surface (bls). A clay soil lense was evident in the surficial sediments in the northern portion of the site. A light grey to medium grey granitic type igneous rock was encountered on the average from 25 feet bls to a depth of 188 feet bls. Water bearing fractures were evident in the rock at depth of 30, 50, 85 and 185 feet. The surface of the rock encountered was highly weathered.

Site specific permeability data for the unconsolidated soils ranged from a low of 0.022 feet per day to a high of 81 feet per day.

Contamination Assessment

Twenty-two shallow monitoring wells ranging in depth from 17.5 to 37.5 feet were installed on-site between June 1990 and February 1992. The shallow wells were installed in stages, until the horizontal extent of free-product and dissolved petroleum constituents in the groundwater were delineated. In addition, three deep-monitoring wells of 53 feet, 87 feet and 188 feet were installed, to delineate the vertical extent of dissolved petroleum constituents in groundwater.

In coordination with monitoring-well installations, a series of soil borings were also initiated, to further delineate the extent of soil contamination in key areas on-site. As a result of the soil and groundwater assessment, the extent of free-product, soil and groundwater contamination was delineated for the site.

As a result of the installation of groundwater monitoring wells on-site, a detailed map indicating the direction of groundwater flow was developed. The water table elevations on-site

ranged from 10.5 bls to 22 bls, and the general direction of groundwater flow was estimated to be toward the south.

Corrective Action Plan

In addressing the petroleum hydrocarbon contamination found in the soil and groundwater at the site, the low permeability soils and fractured bedrock made it difficult to apply common vertical recovery well theory and methodology. As a result, horizontal trenches were determined to be the most effective and feasible alternative.

A three-phase Corrective Action Plan (CAP) was proposed for the remediation of the site. Phase one consists of free-product recovery, soil vapor recovery, and containment of the down gradient side of the dissolved plume. Phase two includes recovery of the contaminated groundwater in the shallow aquifer. Phase three involves recovery of the deeper groundwater contamination.

Free-product recovered during phase one of the CAP is pumped through a 25-gallon-per minute (gpm) oil/water separator where the product and groundwater are separated by specific gravity. The free-product is temporarily stored on-site for eventual recycling and the groundwater sent to the groundwater treatment system. A vacuum pump is used to recover the contaminated soil vapor as well as aid in the recovery of free-product through vaporization.

The recovered soil vapor is treated with a 500-cubic feet per minute (cfm) Baker Furnace, Inc. thermal oxidizer before venting to the atmosphere. Once a majority of the free-product has been removed from the ground, the groundwater can continue to be recovered with a minimum amount of product smearing onto the native soils.

Both QED SOLO Model SP4000A pneumatic and Grundfos Model 5-E electric submersible groundwater recovery pumps are used in phase two of the CAP to recover the contaminated groundwater in the shallow aquifer. Total fluids are pumped from two of the trenches to the oil/water separator and the separated groundwater is then pumped through the groundwater treatment system. Groundwater from the remaining five trenches is pumped directly through the treatment system

because no free-product has been detected in the areas of influence of these trenches. Once contaminant concentrations are significantly reduced, phase three of the remediation is initiated. During phase three, one deep vertical recovery well is used to recover contaminated groundwater in the deep aquifer. This well is placed in an area where it intersects the maximum number of known fractures to ensure capture of the deeper plume.

A low profile air stripper was chosen as the primary remediation technique for the contaminated groundwater treatment. Shallow tray strippers are more compact in design than common air stripping towers, thus offering a less obtrusive presence at the site. The 3/16-inch aeration holes on each tray are designed to minimize fouling due to iron or bacteria. This feature is essential at this site due to the high iron concentration. The treated groundwater is discharged to the sanitary sewer system on-site; however, due to stringent permitting conditions, a NPDES discharge permit for surface disposal is presently being sought as an alternative.

CAP Implementation

Implementation brought several challenges. The first challenge was adequately and effectively communicating the project scope for all bidders by requesting bids in a format that was necessary for comparison. The project scope also had to allow for flexibility on the part of the respective bidders for system installation and field changes. To assist in this effort, a typical Construction Specification Institute formatted project manual was used.

The second challenge surfaced in weighing financial savings/costs against less traditional, potentially safer installation methods. This proved to be a rather simple solution as safety (both to workers and the general public) and public perception were deemed of greater importance over more traditional approaches.

The third challenge was not identified until construction had begun. The trenching machine's inability to effectively operate in the partially weathered rock zone, and in several cases, even in the dense silty sands at the site was further complicated by the high variability in depth to the competent

Free-Product Recovery

rock. As a result, a track hoe mounted steel punch was used to remove the materials too dense or hard to trench through successfully.

These prepared trenches were back-filled with washed sand and subsequently trenched for horizontal well placement. Upon completion of the trenching activities, much of the trenching was accomplished under similarly prepared conditions due to dense material, rock or extremely poor backfill previously disposed of at the site (car axles, tree limbs and stumps, tires, commodes, brick and rock fragments).

As a result, seven horizontal trenches were strategically placed across the site to ensure complete capture of the free-product and the dissolved plume. Each trench was installed with a soil vapor extraction (SVE) well and/or a horizontal groundwater recovery well. Both pneumatic and electric submersible groundwater recovery pumps were employed to accommodate the complex and varied geology of the site. A vacuum pump was used to recover contaminated soil vapor. Free-product was skimmed from the water table using the existing monitoring wells and the sumps of horizontal recovery trenches RT-5 and RT-6.

Preliminary Results

Free-product is currently being recovered via two methods. The first free-product recovery system consists

of three pneumatically driven, flexible axial peristaltic pumps, deployed in monitoring wells MW-1, MW-3 and MW-13. These pumps have been operating constantly since March 1991, with the exception of a 12-week downtime during the installation of the horizontal trenches.

The second free-product recovery system consists of the total fluids recovery from recovery trenches RT-5 and RT-6. Free-product is recovered from these two locations and pumped through the oil/water separator, where the petroleum hydrocarbons and water are separated and directed to their appropriate destinations.

The SVE system applies a vacuum of 600 to 100 inches of water over the horizontal trenches. The air stream created by this vacuum is then directed into a thermal oxidizer where the vapor phase hydrocarbons present in the air stream are thermally destroyed. The soil vapor extraction unit has been operating intermittently since February 1993.

During this operational period, the lower explosive limits (LEL) in trenches RT-5 and RT-6 have declined from a high of approximately 60 percent to less than 10 percent. It has been observed that when the groundwater treatment system is operational, the LEL readings from all of the trenches is significantly elevated. It is believed that these elevated LEL readings are the result of groundwater agitation that occurs during the pumping operations and the subsequent volatilization of

liquid and dissolved phase hydrocarbons into the vapor phase.

As of September 1993, approximately 11,000 gallons of free-product have been recovered. No calculations have been made to date for the estimated amount of free-product recovered via vapor phase capture and destruction. Groundwater from designated recovery trenches is pumped from the vertical headers of each recovery trench and directed towards the low profile tray aerator where the groundwater is air-stripped.

During the initial start-up of the groundwater recovery system, a pumping rate of approximately 12 gpm (50 percent of capacity) was maintained for a period of approximately 12 hours. During this start-up phase, effluent and influent samples were collected and analyzed to test the system's efficiency. (See sidebar for the results of this analysis).

Summary

The free-product recovery system and the soil vapor extraction system at the site have been operational since mid-February 1993. The groundwater extraction system has been operating since the end of May 1993. All three systems are operating at or above projected levels. Currently, free-product is being recovered from one well due to the reduced thicknesses caused by the efficiency of the system. The total product recovered to date, through free-product recovery and soil vapor extraction is estimated to be approximately



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11,000 gallons.

The groundwater system has been able to achieve all of the strict discharge effluent concentrations established by the receiving POTW, with the exception of MTBE, toluene and 2-Butanone. The levels of these three constituents are exceeding the permitted effluent concentrations by 30 ppb, 3 ppb and an average of 27 ppb, respectively.

The 2-Butanone was not present in any of the samples analyzed during the preparation of the contamination assessment report or corrective action plan. This constituent is suspected to have been introduced from the glue used to connect the PVC pipes in the horizontal recovery trenches. Concentrations are expected to diminish significantly following further operation of the system. Even though the system was not designed to remove elevated concentrations of 2-Butanone, the system is removing the compound effectively.

The true effectiveness of the system will not be available for some time,

however, to date the system has worked as well as, if not better, than anticipated. □

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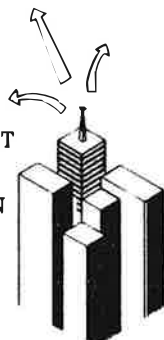
TESTING THE SYSTEM EFFICIENCY

Compound	Influent*	Effluent
Benzene	12,000	4.1
Toluene	19,000	7.4
Ethylbenzene	2,400	<1.0
Total Xylenes	12,500	5.0
Total BTEX	45,900	16.5

* all units reported in micrograms per liter (ug/l.)


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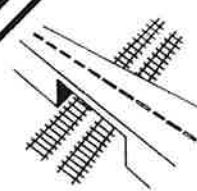
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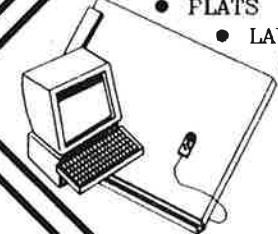
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