DNAPL Extraction/Oleofilter Test Report

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DOE Contract No. DE-AC09-96SR18500

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Publication Date: November 3, 1997

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Abstract

A short term, low flow DNAPL extraction test was performed from May 29 - 30, 1997, to gather additional information about the possibility of using monitoring well MSB-3D to recover source contamination from the M-Area Aquifer. Although no visible, free phase material was recovered, the groundwater did contain perchloroethylene (PCE) at and above aqueous solubility. Improvements in the pumping configuration were identified for future trials.

Prior to final treatment in the M1 air stripper, the groundwater was passed through an Oleofiltration system to evaluate its capability as a treatment technology. The Oleofilter uses a combination of conventional gravity assisted separation with coalescing plates and a final polishing filter using proprietary coated granules to remove hydrocarbons. Although free phase DNAPL was not processed through the Oleofilter, the groundwater containing high levels of dissolved PCE was treated efficiently. Initially the Oleofilter removed 99% of the PCE. As the test progressed, this removal rate decreased to 83% as the granules became loaded with PCE. Longer term testing, perhaps with periodic backflushing, is required to determine the effective granule capacity.

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Introduction

Well MSB-3D was installed near the M-Area Settling Basin inlet in September, 1990. Groundwater samples taken with a bailer in February, 1992, contained free phase perchloroethylene (PCE) and trichloroethylene (TCE). One gallon of free phase DNAPL (Dense Non-Aqueous Phase Liquid), can contaminate roughly three hundred million gallons of groundwater above the 5 parts per billion (ppb) drinking water standard. Consequently it is preferable to locate and recover free phase DNAPL whenever possible rather than to treat a much higher volume of groundwater after the DNAPL has dissolved. A few monitoring wells at SRS have yielded free phase DNAPL.

In continuing support of the A/M-Area groundwater corrective action at the Savannah River Site, a small scale DNAPL extraction and separation process was conducted. This action combined low flow groundwater pumping with the use of an Oleofiltration System, a physical separation/filtering process, to provide a baseline for remediation strategies on bulk removal of DNAPL from groundwater.

In order to minimize the volume of waste material requiring alternative storage or disposal methods, various concepts were investigated to directly treat groundwater containing large amounts of separate or emulsified DNAPL. The Oleofilter was chosen because of its innovative filtration media; amine coated ceramic particles, which are claimed to preferentially adsorb hydrocarbons.

Pumping water from one monitoring well, MSB-3D, has been observed to result in an accumulation of DNAPL in the well sump. The objectives of this study were to further investigate DNAPL capture in the sump of well MSB-3D and to determine the effectiveness of the Oleofiltration System in treating groundwater contaminated with DNAPL.

Background

The M-Area of Savannah River Site was a fuel and target fabrication facility, with the mission of processing uranium, lithium and other materials into fuel elements and targets for use in the nuclear production reactors. The processes used were primarily metallurgical and mechanical, such as casting, extrusion, plating, hot-die-sizing, welding and magneforming. Solvent cleaning and acid/caustic etching were used to prepare the materials.

From 1952 to 1982 an estimated 13 million pounds of chlorinated solvents, primarily trichloroethylene (TCE) and perchloroethylene (PCE), were used in the M-Area. Much of this solvent evaporated during use but residual solvent was discharged to a process sewer system. Approximately two million pounds are estimated to have

been released to the M-Area Settling Basin. Another one and one-half million pounds may have been released to the A-014 outfall.

The M-Area Settling Basin and associated areas (the overflow ditch, the adjacent Lost Lake, the seepage area, and the inlet process sewer line) have been designated as the M-Area Hazardous Waste Management Facility. DNAPL contamination of soils and groundwater occurred in the M-Area as a result of recharge from the settling basin, over flow to the Lost Lake and the Carolina Bay and breaks in the old process-sewer line. Other sources in A/M Area include the A-014 Outfall which received discharges from the M-Area, the solvent storage tank that maintained the SRS inventory of solvents, and surface discharges from various solvent user points at the former Savannah River Laboratory. The M-Area Settling Basin Hazardous Waste Management Facility has been capped and closed under RCRA and is a certified closure as a landfill. The work being proposed herein is intended to support the A/M Area groundwater corrective action per RCRA Postclosure requirements.

There have been a wide range of research and development activities performed in support of the A/M Area groundwater corrective action. Of the 3.5 million pounds of DNAPL disposed of in the A/M Area, a substantial portion of this effluent most likely entered the vadose zone under the area and contributes to contaminants in the groundwater. To date about 500,000 pounds have been recovered through remedial activities.

Extensive cone penetrometer testing has allowed refinement of our knowledge of the geology, specifically the "green clay" confining zone separating the water table aquifer from the uppermost confined aquifer. Undulations and other structural variations of the upper surface of this confining zone serve to control the movement of DNAPL below the water table. Intermediate clay lenses above the green clay have also impacted the movement and distribution of DNAPL. MSB-3D is a monitoring well located on the north side of the M-Area Settling Basin next to the process sewer line that discharged into the basin (refer to Figure 1). The screen interval for MSB-3D crosses an intermediate clay layer in the middle of the M-Area aquifer about 20' above the green clay. This well was installed in Sept., 1990. Routine samples of groundwater from MSB-3D began to show particulate matter and discoloration in 1991. Subsequently, the well was bailed and the sump was found to contain free phase DNAPL. The DNAPL was removed but continues to accumulate slowly over time.

Alternatives previously identified to explain this accumulation included seepage into the sump through the bottom plug (which is typically a slip fit plug, riveted in place); an upconing of DNAPL from a pool located directly below the sump; and the direct flow of disconnected ganglia into the well screen during pumping.

Figure 1: Well locations

Extraction/Separation Test

Oleofiltration System

The Oleofiltration System is a commercially available, pre-piped, skid-mounted assembly designed to separate free phase hydrocarbons from a stream of water and to polish the resulting effluent for direct discharge to surface waters. The Oleofilter was chosen for testing because it includes an innovative filter section utilizing coated ceramic chips. The proprietary amine coating is claimed to adsorb dissolved hydrocarbons from the waste stream, allowing higher cleanup efficiency. The Oleofilter was developed by Exxon Research and Engineering Company and is manufactured by InPlant Services of Houston, Texas. The initial application was actually for LNAPL (Light Non-Aqueous Phase Liquids) and it was demonstrated at a former oil reprocessing facility under the EPA Superfund Innovative Technology Evaluation (SITE) program. The design does not preclude its use for DNAPL. Free phase contaminant will be removed from the bottom drain instead of from the top port provided. Wastewater flowing into the Oleofilter first passes downward through an annulus to a settling chamber in the bottom of the unit to collect free phase material and sediment (refer to Figure 4

in the Appendix). The water then flows upward through coalescing fins intended to capture emulsified constituents. As the water leaves the coalescing fins it passes up the center of the unit and discharges onto the top of the filter bed which serves as a polishing filter. The polishing filter is a bed of ceramic particles coated with a proprietary amine based material intended to adsorb hydrocarbons. The filtrate is pumped to a storage tank through dual, inline 55 gallon carbon canisters installed to treat any residual contamination.

Well MSB-3D

Monitoring well MSB-3D is located on the north side of the M-Area settling basin adjacent to the process sewer line which leads to the basin (refer to Figure 3 in the Appendix). The basin lies over a water table aquifer (M-Area Aquifer) which in turn lies over a confined aquifer (the Lost Lake Aquifer). The lithology is coastal plain sediments with interbedded clay lenses. The two aquifers are separated by a clay confining unit (the Green Clay confining unit). The well bore penetrates an intermediate clay lens at a depth of approximately 135 feet. The screen zone of nearby MSB-22 is set at the top of this lens. MSB-3D is a 4" PVC well with a 19.5 foot long wire wrapped, PVC screen. The top of the screen is set at 128 feet below land surface. The groundwater level is about 127 feet below land surface. The bottom of the screen is below the intermediate clay lens and several feet above the green clay confining unit. Below the screen is a 2.9' sump.

For an unrelated, earlier test, a 2" internal casing was installed in MSB-3D with a packer. This casing consisted of 2" stainless steel pipe with a cap at the bottom and an inflatable packer at the top. A Grundfos RediFlo2 sample pump was installed inside of the casing at the very bottom. The pump wiring and discharge tubing exited the internal casing through water tight pass-through connections at the top of the packer. A series of holes was drilled through the 2" casing just above the bottom cap. One additional vent hole was drilled through the casing near the top to allow trapped air to escape when the casing was set in the well. The casing was positioned at the bottom of the well sump. This arrangement was intended to insure that all water that flowed to the pump came from the well sump first. This arrangement was used "as is" although the packer was not inflated.

This configuration was intended to insure that the pump drew from the bottom of the sump preferentially and that any DNAPL that flowed into the well would be picked up and pumped to the surface rather than pooling in the sump. Previous tests relied on bottom filling bailers to collect the DNAPL.

The pump discharge tubing was clear teflon and extended from the well head directly to the Oleofilter; a distance of approximately 30'.

Test Plan

The test consisted of two separate operating cycles ("runs") from well MSB 3D. Referring to Table 1, the first run involved pumping from the well at a 0.4 gal/min rate for 230 minutes. An overnight recovery period of 17 hours preceded run 2. For run 2 the pumping rate was reduced to 0.3 gal/min for 347 minutes. Water flow was measured using a graduated cylinder and a stopwatch.

Table1: PUMPING SCHEDULE

RUN	PUMPING RATE	TIME
1	0.4 gal/min	230 min..
2	0.3 gal/min	347 min.

Samples were taken at four points:

- Sample point 1 - as the water came from the well;
- Sample point 2 - from the bottom drain of the Oleofilter;
- Sample point 3 - as the water left the Oleofilter; and
- Sample point 4 - as the water left the carbon canisters.

A total of 106 samples were taken and analyzed for TCE and PCE concentrations using gas chromatography with a head space analyzer (modified EPA SW-846 method 5021).

Results

Extraction

No visible observation of free phase DNAPL was evident at any time during the test. DNAPL samples taken previously from this well had a distinctive amber color which would be readily discernible from the clear groundwater. The Grundfos pump is a turbine pump which might disperse any small amount of contaminant passing through it, but any significant amount of DNAPL would most likely present a visible color change. None of the 106 samples or the purgewater preceding each sample contained any visible, free phase material.

In hindsight, this may have been due to a small design detail in the 2" casing. As DNAPL is pulled into the well screen, it would tend to flow down the outer casing and accumulate in the sump. The Grundfos pump is designed with the inlet at the top of the pump. Thus, DNAPL could accumulate below the pump suction and above the drilled holes, creating a seal. The vent hole at the top of the 2" pipe may have been large enough to pass the low flows tested. Eventually, if DNAPL continued to flow in it would reach the pump suction, but this test was not long enough to see that.

Although free phase DNAPL was never observed, the analytical results indicate that the groundwater, as it came from the well (MSB -3D), contained high levels of TCE and PCE. PCE was the predominate contaminant with concentrations at approximately 150 to 220 ppm, close to the solubility level of PCE in water. The TCE concentration leveled off at approximately 25 ppm.

Oleofiltration System

The analytical data indicate that the Oleofilter performed as designed with progressive contaminant reduction. Because no free phase material was present, the first phase or settling phase of the Oleofilter did very little other than serve as a buffer zone where the contaminant concentration rose until reaching a more or less steady state. As a whole the Oleofilter removed almost all of the contaminants initially but as time went on the amount of contaminants passing through the system rose quickly (reference Table 2). The most likely explanation is that the filtration granules simply became loaded with organics. The residual solvent was satisfactorily removed by the carbon canisters.

Table 2: OLEOFILTER TREATMENT EFFICIENCY

Time	Influent Concentration (PCE ppb)	Effluent Concentration (PCE ppb)	Efficiency
8:20	213,925	2,667	99%
9:00	179,237	4,498	97%
9:30	204,198	6,818	97%
9:57	202,078	8,625	96%
10:57	177,135	11,680	93%
11:25	167,166	14,443	91%
11:58	180,235	16,361	91%
12:22	187,289	19,362	90%
12:54	184,579	23,823	87%
13:25	179,063	30,078	83%

Conclusions

Monitoring well MSB-3D remains a potential source of free phase DNAPL recovery. Pumping from the well at low flow rates (0.3 to 0.4 gpm) for short continuous durations (4 to 5 hours) did not produce sufficient DNAPL to be recovered by the sample pump itself, although it is possible that 8" or more of DNAPL could accumulate in the sump without being captured by the pump. The PCE concentration in the well is close to saturation, indicating the close presence of

source contamination. Minor modifications to the pump configuration and longer pumping cycles may well allow achieve the goal of free phase recovery. The Oleofilter is effective in treating highly contaminated groundwater. It does appear that the proprietary granules load up fairly quickly, indicating that this process may not be economically viable for higher flows. Additional operating trials are necessary to quantify granule life and the effect of periodic backflushing on treatment efficiency.

References

Looney, et al. *Assessing DNAPL contamination, A/M-Area, Savannah River Site: Phase I Results (U)*. WSRC-RP-92-1302. December, 1992.

InPlant Systems, Inc. SFC 0.5 Oleofiltration System. *Innovative Technology Evaluation Report*. EPA/540/R -94/525, March 1995.

APPENDIX

Figure 2: Test equipment arrangement

Figure 3: Well configuration

Figure 4: Oleofilter details

Figure 5: Analytical results from Sample Port 1

Figure 6: Analytical results from Sample Port 2

Figure 7: Analytical results from Sample Port 3

Figure 8: Analytical results from Sample Port 4