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7. Abstract

This report summarizes the methods and results of a soil-gas survey conducted near the 382 Pump House in the Hanford 300 Area. The soil-gas survey was conducted to assess the extent of petroleum products released from the 382-1 underground gasoline storage tank. The tank was discovered to have leaked when it was removed in 1992. The results will be used to guide cleanup and remediation of the site.

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## 1.0 SUMMARY

A soil-gas survey was conducted near the 382 Pump House in the 300 Area of the Hanford Site. The objective of the soil-gas survey was to characterize the extent of petroleum product contamination in the soil beneath the 382-1 underground gasoline storage tank excavation. The tank was discovered to have leaked when it was removed in September 1992.

Two types of soil-gas probes were used for the survey. Six shallow probes were driven to depths of about 4 to 6 ft around the perimeter of the 382 Building and adjacent to two active underground gasoline storage tanks at the facility. In addition, a deep soil-gas probe was driven to a depth of about 26.4 ft through the contaminated soil beneath the 382-1 tank excavation. Soil vapor samples were collected at regular intervals from the probe as it was driven into the soil. Soil vapors from both the shallow and deep probes were analyzed for total-volatile organic compound (VOC) concentrations and for specific volatile compounds characteristic of petroleum products using a portable gas chromatograph (GC).

None of the soil vapor samples collected from the shallow soil-gas probes contained significant quantities of VOC. These data suggest petroleum products released from the 382-1 tank have not migrated laterally from the contaminated soils beneath the tank excavation.

Soil vapors collected from the deep soil-gas probe contained significant quantities of VOC from a depth of 5.4 ft to about 20.5 ft below the soil surface. Below 23 ft, the VOC concentrations in the soil vapor decreased to low levels. These results suggest the soil immediately below the 382-1 tank excavation may contain petroleum hydrocarbons to depths of about 20 to 23 ft below the surface. Below 23 ft, the soil does not appear to contain significant quantities of petroleum hydrocarbons.

The results of this soil-gas survey indicate petroleum products released from the 382-1 tank are probably contained in a localized region of soil directly beneath the tank excavation site. The soil-gas data combined with earlier tests of groundwater from a nearby downgradient monitoring well suggest the spilled petroleum hydrocarbons have not penetrated the soil profile to the water table.

## 2.0 BACKGROUND

The 382-1 underground gasoline storage tank was excavated and removed on September 28, 1992. When the 145-gal tank was removed, an unknown quantity of contaminated soil was discovered under the south end of the tank. The south end of the excavation corresponded to the fill-pipe end of the tank. Soil samples and field-screening samples were collected from the tank excavation to confirm the leak. The field-screening samples were analyzed using an immunoassay field test kit for petroleum products. Soil collected from the south of end of the tank excavation contained greater than 1,000 parts-per-

million (ppm) Total Petroleum Hydrocarbons (TPH). Soil collected from the north end of the tank excavation was below the regulatory limit of 100 ppm TPH (Ecology 1991).

The contaminated zone of soil was marked with a sheet of plastic and the excavation was backfilled to grade. Because of the proximity to other buried tanks and utilities, no further testing or remediation was attempted at that time. Information on the tank removal and soil samples was transmitted to the Washington State Department of Ecology (Ecology) in the 90-day site assessment report (Hitt 1992).

The 382-1 tank was one of three 145-gal unleaded gasoline storage tanks located at the 382 Pump House in the 300 Area. The tank supplied fuel to operate emergency water pumps used in the 300 Area Fire Protection System. The 382-1 tank system was permanently closed and removed after failing a tightness test conducted on August 6, 1992. The remaining two active tanks are scheduled for removal as part of a facility upgrade scheduled for the end of 1993.

The soils beneath the 382-1 tank excavation consist of permeable sands, gravel, and cobble (Pasco Gravel Formation). The water table ranges from 45 to 55 ft beneath the ground surface and fluctuates seasonally. A groundwater well (399-3-6) located about 75 ft southeast of the spill site was sampled for petroleum products. This is the closest well downgradient of the site. No VOC associated with petroleum products were detected above the 5 parts-per-billion (ppb) detection levels of the analyses. This information has been transmitted to Ecology (Hitt 1992).

The main objective of this study was to evaluate the vertical extent of petroleum products released from the 382-1 tank. This was accomplished by driving a deep soil-gas probe through the contaminated soils beneath the tank excavation and collecting soil-gas samples at regular intervals. The soil-gas samples were analyzed for total-VOC and specific volatile compounds characteristic of petroleum products. The results provide an estimate of the contaminant levels in the soil. This information will be used to guide remediation of the spill site.

The second objective of this study was to evaluate potential lateral spread of contaminants from the spilled petroleum products. This was accomplished by installing shallow soil-gas probes at several locations around the perimeter of the spill site. In addition, shallow soil-gas probes were placed adjacent to the remaining two gasoline storage tanks.

### 3.0 METHODS

#### 3.1 SHALLOW SOIL-GAS SAMPLES

On April 21, 1993, locations for six shallow soil-gas probes were selected and marked. Four probes were located around the perimeter of the 382 Pump House to detect organic vapors which may indicate lateral migration of petroleum products released from the 382-1 tank. Two additional probes were located near the fill-pipe ends of the two remaining underground gasoline

storage tanks (382-2 and 382-3) (Figure 1). Underground utility drawings for the 382 Building were used initially to identify areas free of buried utilities. After the probe locations were identified, telephone lines were located and a ground-penetrating radar scan was conducted around each proposed probe location to ensure no buried utilities would be encountered when the probes were driven.

The six shallow soil-gas probes (numbers 382-S-2 through 382-S-7) were installed on April 30, 1993. The probes were installed in accordance with Environmental Investigations Instruction 5.9, "Soil-Gas Sampling" (WHC 1988). Each shallow soil-gas sampling probe consisted of a dedicated stainless-steel point connected to an 8-ft section of  $\frac{1}{4}$ -inch OD Teflon (a trademark of E. I. du Pont de Nemours & Company) tubing. Each soil-gas probe was driven to a depth of about 4 to 6 ft below ground surface using a PD-36 pneumatic post driver (manufactured by the Rhino Tool Company).

After each soil-gas probe was driven to depth, the steel probe-insertion rod was removed using a hydraulic hand jack, leaving the stainless-steel point and Teflon tube in the ground. The end of the tubing protruding from the ground was capped with a plastic cap. The soil around the tubing was then firmly packed to ensure minimal annular space between the tubing and the emplacement hole. Finally, the probe depth was recorded in the logbook and a marker flag indicating the probe number was placed next to each probe.

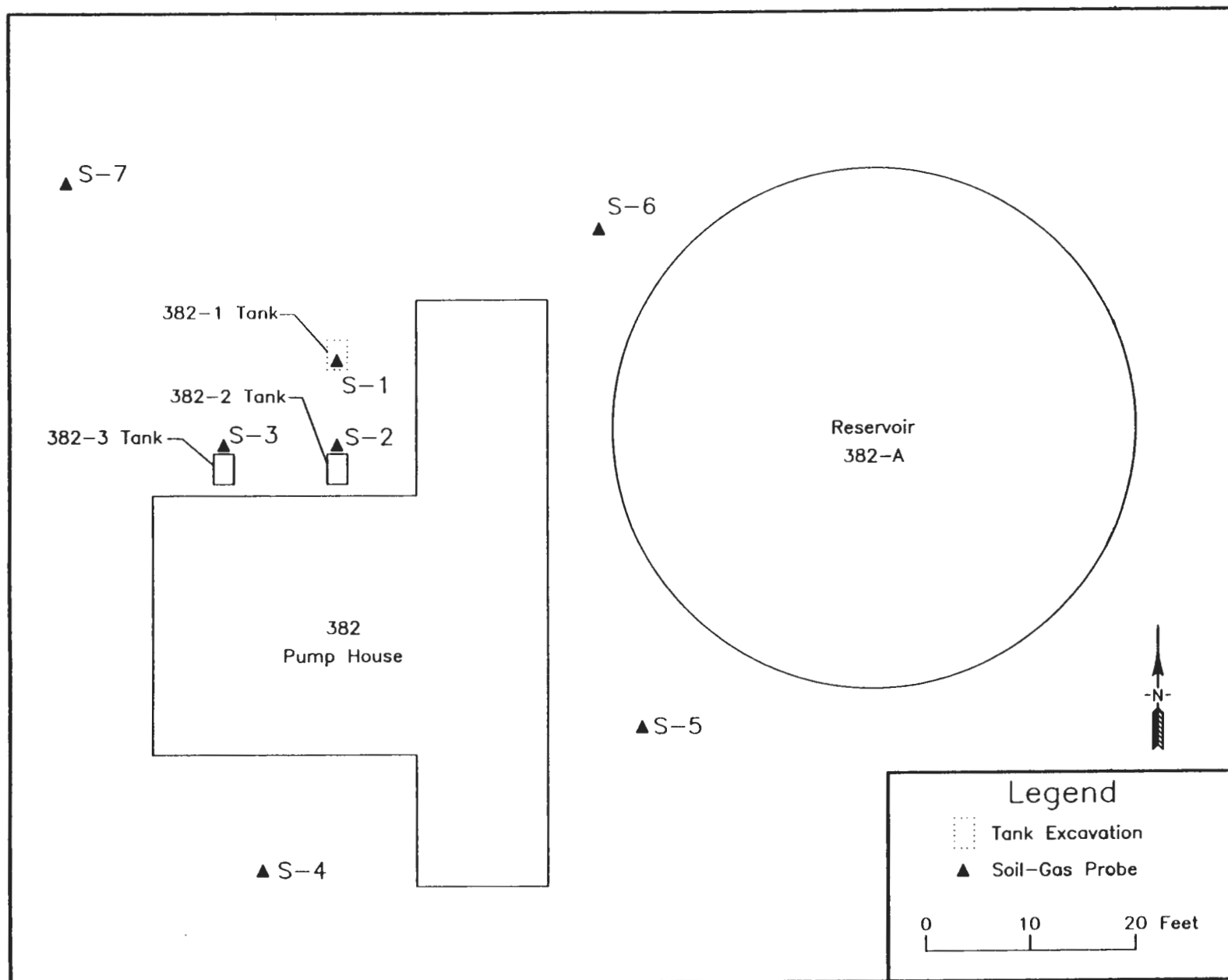
After the probes were installed, soil vapors from each probe were monitored for total VOC. The vapors were measured using a MicroTip HL-2000 (a trademark of Photovac International Inc.), which was equipped with a 10.6-eV lamp. A 10.6-eV lamp can detect several volatile compounds characteristic of petroleum products such as benzene, toluene, ethylbenzene, and xylene. Before use, the MicroTip HL-2000 was calibrated using ambient air filtered through a charcoal filter for zero air and 101 ppm isobutylene in air as the span gas. The low-range response of the instrument was then verified using 9.51 ppm isobutylene in air. All calibration measurements were within acceptable limits and were recorded in the field logbook. Total-VOC measurements for each probe were also recorded in the field logbook.

Before sampling for GC analysis, each soil-gas probe was purged for about 45 seconds using a small sample pump with a flow rate of approximately 500 mL/min. A 500  $\mu$ L sample was collected in a gas-tight syringe and immediately injected into a Photovac 10S Plus portable GC which was located onsite.

### 3.2 DEEP SOIL-GAS SAMPLES

On May 11, 1993, a deep soil-gas probe (number 382-S-1) was driven through the contaminated soil beneath the 382-1 tank excavation. The deep soil-gas probe consisted of 3-ft sections of  $\frac{7}{8}$ -inch OD soil-gas pipe with a  $\frac{1}{4}$ -inch ID opening. Soil-gas samples were drawn through a slotted section of pipe immediately following the solid drive point. The probe sections and accessories were manufactured by KV and Associates (KVA). The probe was driven to a depth of about 12 ft using a PD-50 pneumatic post pounder

Figure I. Location of Soil-Gas Probes at the 382 Pump House Site.



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(manufactured by the Rhino Tool Company). A PD-135 pneumatic post pounder (manufactured by the Rhino Tool Company) was used to drive the probe beyond the 12-ft depth.

The first probe installed reached refusal and broke at a depth of about 15 ft. A second probe was then installed about 1 ft east of the first probe. This second probe was driven to a depth of about 27 ft before it also encountered refusal and broke.

Soil-vapor samples were collected at regular intervals as the probes were driven through the contaminated soil. The first sample was collected at a depth of 5.4 ft. Successive samples were collected at about 3-ft intervals until the probe reached refusal. Total-VOC samples were measured using a Model 580B Organic Vapor Monitor (OVM) (a trademark of Thermo Environmental Instruments, Inc.). The OVM was equipped with a 10.6-eV lamp and was calibrated using filtered ambient air as the zero gas and 101 ppm isobutylene in air as the span gas. The low-level response of the instrument was checked using 9.51 ppm isobutylene in air. The instrument calibration and response were within acceptable levels.

Vapor samples for GC analysis were collected in 1-L Tedlar (a trademark of E. I. du Pont de Nemours & Company) bags from the exhaust port of the OVM. Each sample bag was marked with a unique sample number, total-VOC reading, sample depth, and the time of collection. After all vapor samples were collected, they were transported to the MO-926 field-screening laboratory and analyzed using a 10S Plus portable GC.

### 3.3 SOIL-GAS ANALYSIS

Analysis of soil-gas samples from both the shallow and deep probes was carried out on a Photovac 10S Plus portable GC. The 10S Plus is a self-contained, battery-powered portable GC, which incorporates a 10-m nonpolar wide-bore capillary column and a photoionization detector (PID) with a 10.6-eV lamp. Samples were injected directly to the column. The GC was operated isothermally at 40 °C using ultra high-purity air at a flow rate of 8 mL/min. Injection volumes were 500  $\mu$ L for the shall samples and 50  $\mu$ L to 250  $\mu$ L for the deep samples.

The Photovac 10S Plus is equipped with a library to detect a variety of compounds based on retention time. Quantification is based on peak areas, with appropriate response factors for various compounds of interest.

## 4.0 RESULTS AND OBSERVATIONS

The concentrations of VOC detected in soil vapors collected from the six shallow soil-gas probes are listed in Table 1. The VOC concentrations detected from soil gas collected from the deep soil-gas probe (382-S-1) at a similar depth (5.4 ft) are also shown for comparison. The total-VOC concentrations at each location were obtained using either a MicroTip HL-2000 or an OVM and are reported as isobutylene equivalent. The values of specific volatile compounds were obtained using a 10S Plus portable GC.

Table 1. Volatile Organic Compound Concentrations Detected at the 382 Pump House Site.

Volatile Organic Compounds (ppm-v)

Probe Number	Probe Depth (ft)	Total VOC*	Hexane	Benzene	n-Heptane	1-Heptene	Toluene	Octane	Ethylbenzene	m-Xylene	p-Xylene	o-Xylene	Comments
382-S-1	5.4	225.0	148	13	177	82	101	86	34	<0.01	<0.01	<0.01	382-1 tank excavation.
382-S-2	5.6	0.4	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	Adjacent to 382-2 tank.
382-S-3	4.5	<0.1	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	Adjacent to 382-3 tank.
382-S-4	4.4	<0.1	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	Southwest of 382-1 tank excavation.
382-S-5	5.0	<0.1	0.2	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	Southeast of 382-1 tank excavation.
382-S-6	5.4	<0.1	0.3	<0.01	<0.01	0.01	<0.01	<0.01	0.04	<0.01	<0.01	<0.01	Northeast of 382-1 tank excavation.
382-S-7	5.7	<0.1	<0.01	<0.01	<0.01	<0.01	<0.01	0.1	<0.01	<0.01	<0.01	<0.01	Northwest of 382-1 tank excavation.

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Quality Control Samples (ppm-v)

Probe Depth (ft)	Time Collected	Total VOC*	Hexane	Benzene	n-Heptane	1-Heptene	Toluene	Octane	Ethylbenzene	m-Xylene	p-Xylene	o-Xylene	Comments
382-S-0	1245	<0.1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	Ambient air sample.
382-S-7a	1216	<0.1	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	382-S-7 duplicate sample.

\* - Total Volatile Organic Compounds Isobutylene Equivalent

The VOC concentrations measured in soil vapors collected from the six shallow probes were near or below the level of detection of the instruments used. Soil vapors collected from probe 382-S-2 contained low levels of VOC associated with petroleum products. This probe was located near the fill-pipe end of the 382-2 tank and less than 10 ft south of the 382-1 tank excavation (see Figure 1). These values are in stark contrast to the VOC levels detected in soil gas collected at the same approximate depth from probe 382-S-1. The total-VOC concentration in vapors from the tank excavation was 225 ppm. In addition, several volatile compounds associated with petroleum products were detected in significant quantities.

The results of two quality control samples collected during this sampling episode are also listed in Table 1. These samples showed concentrations of VOC near or below the level of detection of the instruments used.

Table 2 contains total-VOC and specific VOC concentrations obtained from soil gas collected from the deep soil-gas probe (382-S-1) as it was driven through the soil beneath the 382-1 tank excavation. The first sample listed (depth of 0.0 ft) is an ambient air sample collected through the soil-gas probe before it was driven into the ground. This sample also served as an equipment blank.

The next sample was the first soil-gas sample collected from the 382-S-1 probe from a depth of 5.4 ft. This depth corresponded to the depth of samples collected from the six shallow soil-gas probes and the approximate depth of the tank excavation. Vapor samples were then collected from this probe at about 3-ft intervals to a depth of 14.2 ft. After that point, the probe met refusal and broke. A second probe was installed about 1 ft east of the first probe. The samples corresponding to depths of 17.5 to 26.4 ft were collected using the second probe. This probe also met refusal and broke. When the probe was removed, the sampling orifice contained soil but was not plugged to the point of preventing vapors from entering the probe. The soil in the probe end was dry and had no visual evidence or smell of petroleum products. There was not enough soil in the probe end to collect a sample for analysis.

Figure 2 shows the total-VOC and total-BTEX concentrations (calculated from the GC results) in soil gas collected from probe 382-S-1 at depth. The total-BTEX values are significantly higher than the total-VOC values at depths of 11, 14.2, and 17.5 ft. This may indicate that at higher concentrations the OVM detector lost sensitivity. This observation is supported by the similarity of the total-VOC and total-BTEX values at the lower concentration levels.

Figure 3 shows the concentrations of specific BTEX compounds (benzene, toluene, ethylbenzene, m-xylene, and o-xylene) detected in soil gas collected from 382-S-1 at depth. The data indicate toluene, m-xylene, and o-xylene are the principal compounds detected in the contaminated soil.

The soil vapors contained relatively high levels of VOC below a depth of 5.4 ft. This depth corresponds to the approximate depth of the bottom of the 382-1 tank. The VOC levels in the soil vapors continued to increase to a depth of 20 ft.

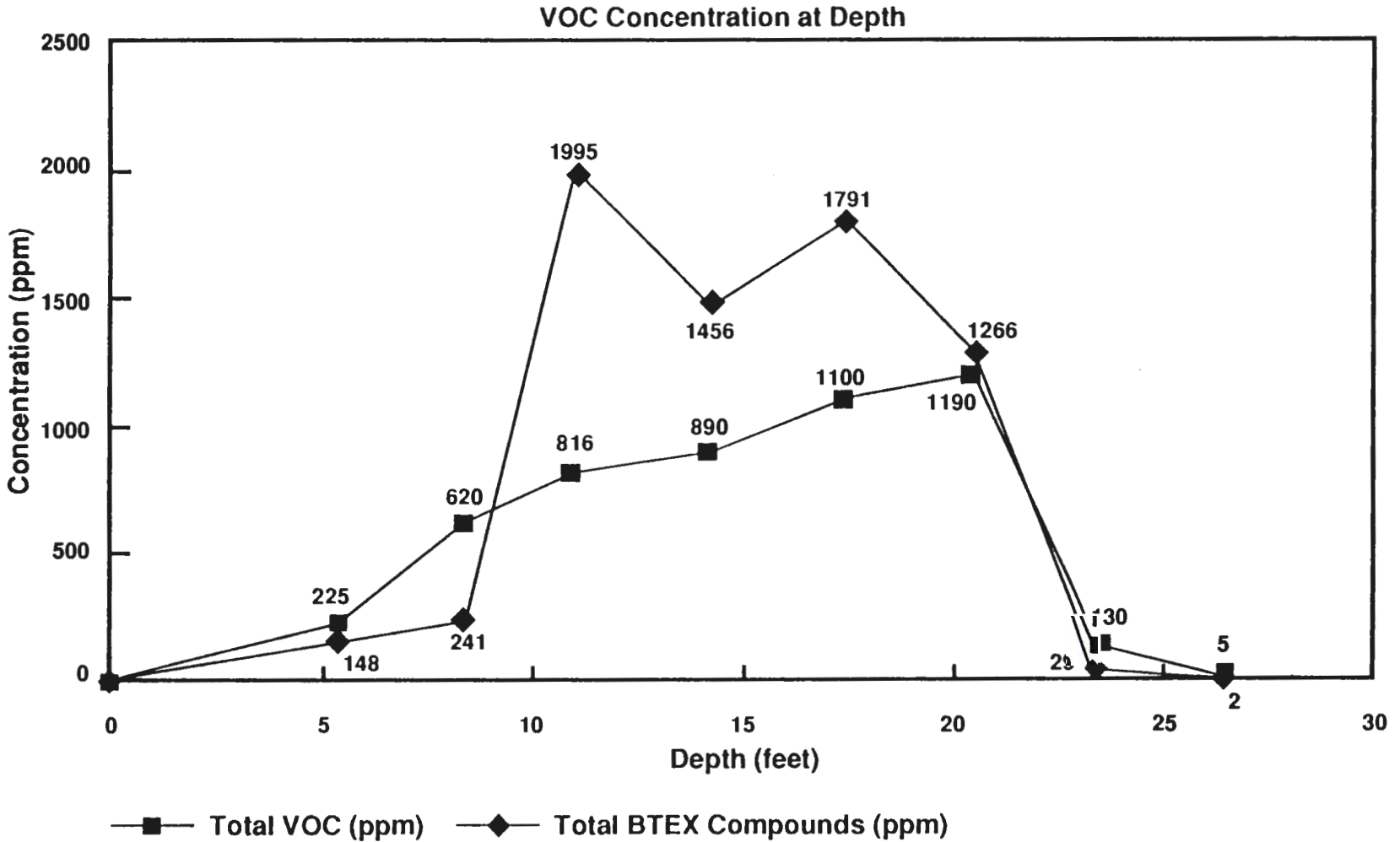
Table 2. Volatile Organic Compound Concentrations Detected  
Beneath the 382-1 Tank Excavation.

Volatile Organic Compounds (ppm-v)

Probe Depth (ft)	Time Collected	Total VOC*	Hexane	Benzene	n-Heptane	1-Heptene	Toluene	Octane	Ethyl - benzene	m-Xylene	p-Xylene	o-Xylene	Comments
0.0	0921	<0.1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	Equipment blank/ambient air sample.
5.4	0931	225	148	13	177	82	101	86	34	<0.01	<0.01	<0.01	Probe drove easily.
8.4	0939	620	697	44	327	99	162	8	3	20	0.2	12	Probe drove easily.
11.0	0946	816	109	12	195	70	583	270	128	708	3	561	Compact soil.
14.2	1024	890	80	12	158	62	431	209	74	432	3	504	Compact soil. Refusal of first probe.
17.5	1302	1100	78	6	220	122	426	291	53	557	39	710	Compact soil.
20.5	1315	1190	92	6	169	86	287	185	31	344	29	569	Compact, rocky soil.
23.4	1327	130	2	0.5	3	1	5	3	1	14	1	7	Compact, rocky soil.
26.4	1338	5	0.07	0.02	0.06	0.03	0.3	0.2	0.03	0.6	0.06	0.6	Refusal of second probe.

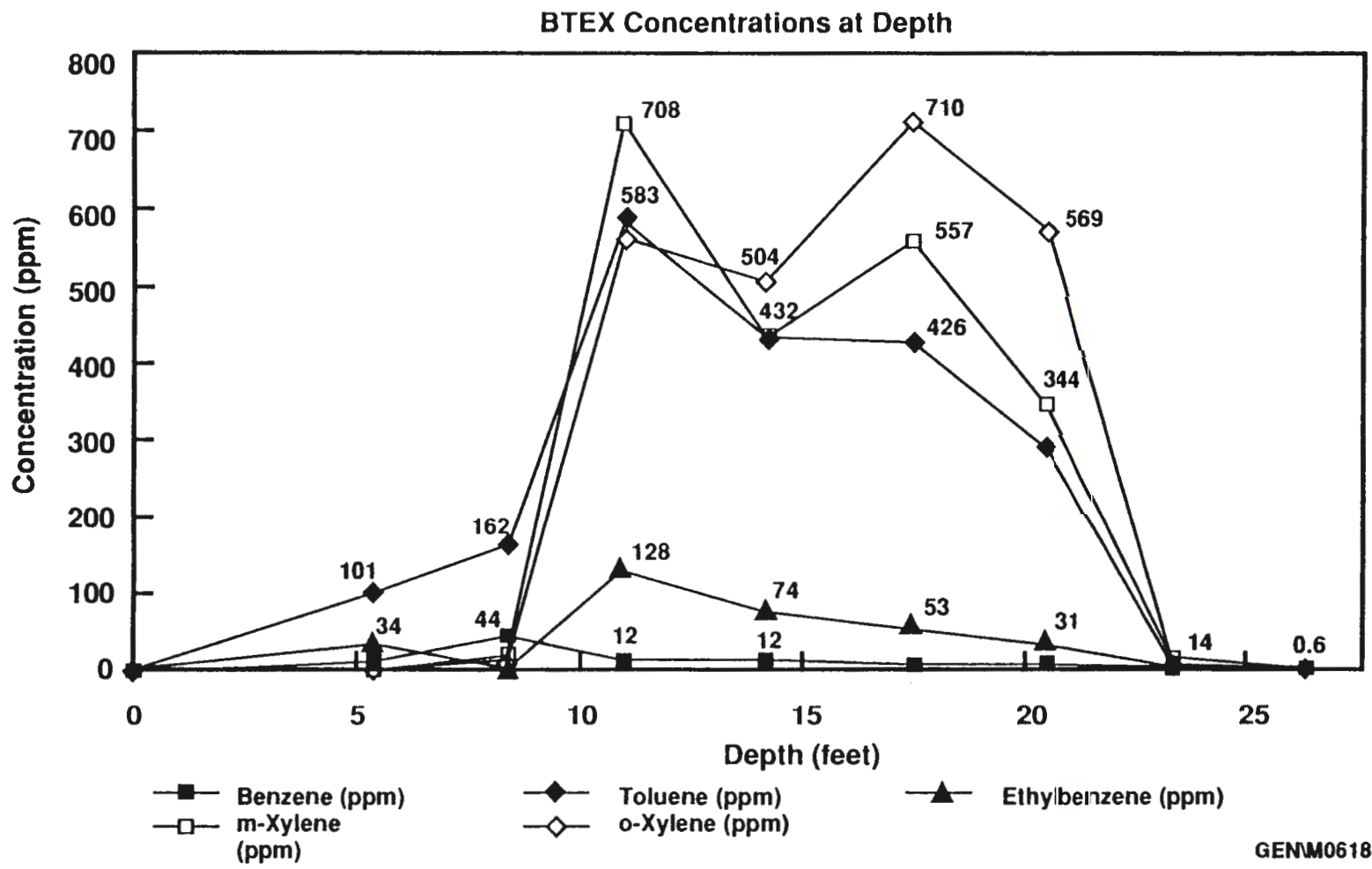
\* - Total Volatile Organic Compounds Isobutylene Equivalent

Figure 2. Volatile Organic Compound Concentrations Detected Beneath the 382-1 Tank Excavation.



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Figure 3. BTEX Concentrations Detected Beneath the 382-1 Tank Excavation.



At 23.4 ft, the VOC concentrations in the soil gas showed a significant decrease. This trend is evident in both the total-VOC and the total-BTEX values. The final sample collected at 26.4 ft contained low levels of VOC.

## 5.0 CONCLUSIONS

The concentration of VOC in soil vapors analyzed from the various soil-gas probes can be an indication of the relative concentrations of these constituents in the soil matrix. However, these values only represent the vapor phase concentration of each constituent in the soil pore spaces and are not direct measurements of actual soil concentrations. This is an important consideration since Ecology cleanup levels are based on soil concentrations, not vapor concentrations.

Soil vapors collected from the deep soil-gas probe (382-S-1) contained significant concentrations of VOC from a depth of about 5 ft to about 23 ft below the ground surface. These data indicate the soil in this region may be contaminated with petroleum hydrocarbons released from the 382-1 tank and probably exceeds the Ecology cleanup level of 100 ppm TPH.

Below a depth of about 23 ft, the vapor levels decreased significantly. These low levels indicate the majority of the spilled petroleum products are in the top 20 to 23 ft of the soil profile. There may be some degree of soil contamination to a depth of about 25 ft. It is uncertain if the petroleum products in these soils will exceed the 100 ppm TPH cleanup level.

Soil vapor collected from a depth of 26.4 ft contained only trace levels of VOC characteristic of petroleum products. These data indicate the soil in this region beneath the 382-1 tank excavation probably does not contain significant quantities of petroleum products. This conclusion is further supported by the soil observed in the opening of the soil-gas probe when it was withdrawn. This soil showed no indication of petroleum products.

The results from the shallow soil-gas probes indicate vapors from the petroleum products spilled from the 382-1 tank have not migrated from the spill site. No significant quantities of VOC were detected in any of the shallow soil-gas probes away from the spill site. These data suggest the spilled products have primarily seeped downward through the soil profile with little lateral migration. This conclusion is supported by the analysis of soil vapors collected from probe 382-S-2. Although this probe was located less than 10 ft from the 382-1 excavation, the VOC levels detected in the soil vapors were near the level of detection.

Soil vapors analyzed from the two probes (382-S-2 and 382-S-3) located adjacent to the active storage tanks contained VOC concentrations near or below the levels of detection.

Based on the rapid decrease in VOC levels detected in the deep soil-gas probe and the low levels of VOC detected in the shallow soil-gas probes, it is unlikely that petroleum products have penetrated the soil profile to the water table under the 382-1 tank excavation. This conclusion is further supported

by groundwater samples collected and analyzed from the nearby down-gradient monitoring well. These samples did not contain detectable quantities of VOC associated with petroleum products.

## 6.0 REFERENCES

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