PROGRESS REPORT NO. 1

REMEDIAL ACTION CONSULTATION SERVICES

SUBSURFACE FUEL VAPOR EXTRACTION PROGRAM

SERVICE STATION 5353

SEATTLE, WASHINGTON

FOR

UNOCAL

GeoEngineers

July 27, 1988

Consulting Geotechnical
Engineers and Geologists

Unocal
P.O. Box 76
Seattle, Washington 98111

Attention: Mr. Leigh Carlson

Re: Environmental Loss Number: 1496426 (04/05/88)

Gentlemen:

We are submitting five copies of Progress Report No. 1 for our remedial action consultation services at the site of Unocal Station 5353 in Seattle, Washington. This initial progress report provides information for the period through July 20, 1988. Future progress reports will be issued to update the information presented in this initial report.

We appreciate the opportunity to be of continued service to Unocal. Please call if you have any questions regarding this report.

Yours very truly,

GeoEngineers, Inc.

James A. Miller

James A. Miller
Principal

SCP:JAM:cs

File No. 0161-013-4

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Geo Engineers

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SERVICE STATION 5353, SEATTLE, WASHINGTON
FOR
UNOCAL

INTRODUCTION

This progress report summarizes site remediation efforts and monitoring activities at Unocal Service Station 5353 for the period of February 14, 1988 through July 20, 1988. The site is located northeast of the intersection between Mercer Street and Westlake Avenue in Seattle, Washington (Figure 1). Service Station 5353 is the site of an estimated 80,000 gallon gasoline leak that occurred prior to 1980. The information presented in this report describes activities related to the design, installation, activation and operation of a vapor recovery system (VRS) on the site. The purpose of the VRS is to further reduce the levels of residual hydrocarbons in soils in the vicinity of the site.

Figure 1 shows the main features of the site and the locations of monitor wells and recovery wells. Field data collected during this reporting period are presented in Appendix A. Laboratory analytical data are presented in Appendix B. Pertinent regulatory documents are presented in Appendix C.

SITE HISTORY

In May 1980 a gasoline leak was detected at Service Station 5353. Based upon inventory records, it was estimated that approximately 80,000 gallons of leaded premium gasoline had been lost during the prior four months. Site characterization activities at that time included 15 soil borings with monitor wells and eight excavated wells. Seven of the eight excavated wells were used to recover free (floating) gasoline. Product recovery from these recovery wells began in mid-June using product skimmers and ground water depression pumps. Additional monitor wells were installed between June and November 1980 to bring the total number of monitor wells to 24.

Monitoring during the free product recovery efforts consisted of frequent measurement of all monitor wells and recovery wells for ground water elevation, product thickness, and combustible vapors.

A total of 34,500 gallons of liquid gasoline had been recovered at the site by December 1981. Recovery of free product was terminated in October 1982 due to very slow recovery rates. A total of 41,900 gallons of gasoline was recovered during the 28-month recovery effort.

SUBSURFACE CONDITIONS

Service Station 5353 and nearby areas currently contain eight recovery wells (large diameter wells installed by excavation) and 16 accessible monitor wells (small-diameter wells installed by drilling). We have adopted the convention of preceding the well designation number with "RW" for recovery wells or "MW" for monitor wells. This report and future progress reports will use this convention.

Soil borings advanced for the installation of monitor wells in 1980 generally extended to depths of 15 to 20 feet. Most borings encountered silty sand fill through their entire depths. Occasionally the fill soils contained wood fragments and gravel. Some of the borings encountered thick sequences of sawdust fill.

Two borings, MW-29 and MW-31, were drilled to depths of 65 and 70 feet, respectively. Based upon those borings, it was estimated that the site is underlain by 35 to 40 feet of fill.

Ground water is generally encountered at a depth of about 10 feet below the ground surface at the site. Annual changes in ground water levels at the site correlate with changes in the level of Lake Union. The Corps of Engineers manages the lake level with an annual fluctuation of about two feet. Ground water flow at the site is generally northward, but suspected buried foundations and utility trenches control the movement of ground water locally.

The recovery wells were installed by placing large-diameter corrugated metal pipe (CMP) well casings in excavated trenches or pits and backfilling around the well casings with porous granular soils. Two-foot-diameter CMP was installed at each recovery well location. The CMP was

slotted above and below the water table zone by cutting slits in the pipe with a cutting torch. The configuration of the excavations for each recovery well is not clear. Based upon recollections and photography, Wells RW-7 and RW-26 were installed in a large, roughly circular pit. Wells RW-8, RW-9, and RW-10 were installed in a long narrow trench. The other three recovery wells (RW-4, RW-5 and RW-28) appear to have been installed in smaller, excavated pits. Each recovery well was provided an electrical outlet for operation of recovery equipment and a common 3-inch product/water collection pipe connected to an underground holding tank located east of the service station building. After installation of the recovery wells, the areas of excavation were repaved with asphaltic concrete.

1988 PRELIMINARY SITE CHARACTERIZATION

We visited the site on February 14, 1988 to measure the thickness of free product and vapor concentrations in the monitor wells. Our well inventory located all eight of the recovery wells and 16 of the 24 monitor wells. The fate of the missing monitor wells is unclear, but it appears that several have been buried under pavement. Product thicknesses measured on February 14 are listed in Table 1.

TABLE 1

FREE PRODUCT THICKNESS, 2/14/88(1)

Well	Thickness
MW-01	0.22 Feet
RW-04	0.17 Feet
RW-07	0.23 Feet
MW-17	0.07 Feet
MW-19	0.23 Feet

(1) Free product was not present in other wells at the site.

Hydrocarbon vapor concentrations in the well casings were measured using a Bacharach TLV Sniffer instrument calibrated to hexane. This instrument operates on the same principal as the instruments used to

measure vapor concentrations by prior investigators in the early 1980s. The TLV Sniffer has a maximum range of 10,000 parts per million (ppm) which corresponds to about 91 percent of the Lower Explosive Limit (LEL) of gasoline. Vapor concentrations measured in the well casings on February 14 were generally very high, as indicated in Figure 2. Of 23 wells measured, 12 resulted in vapor concentrations that exceeded 10,000 ppm.

We returned to the site on May 15, 1988 to measure the vapor concentrations in the monitor wells. A similar pattern of vapor concentrations was observed in the wells measured on that date.

We returned to the site on May 16, 1988 to collect vapor samples from three of the monitor wells for analysis of total volatile hydrocarbons and methane. The purpose of this sampling was to gain a better understanding of the composition of the subsurface vapors to evaluate further remedial options. The results of those analyses are presented in Table 2. Analytical data are presented in Appendix B.

TABLE 2

ANALYSIS OF VAPORS FROM SELECTED MONITOR WELLS, 5/16/88

	MW-01	MW-17	MW-29
Methane(1)	36,000 ppm	120,000 ppm	300,000 ppm
Total Volatile Hydrocarbons(2)	12,000 ppm	49,000 ppm	160,000 ppm
Benzene(3)	66 ppm	190 ppm	41 ppm
Ethylbenzene(3)	8 ppm	8 ppm	8 ppm
Toluene(3)	24 ppm	18 ppm	12 ppm
Total Xylenes(3)	14 ppm	14 ppm	13 ppm
TLV Reading(4)	>10,000 ppm	>10,000 ppm	>10,000 ppm

(1) Analysis by GC/FID expressed as ppm methane (vol/vol)

(2) Analysis by GC/FID expressed as ppm hexane (vol/vol)

(3) Analysis by GC/FID expressed as ppm (vol/vol)

(4) Field measurement using a Bacharach TLV Sniffer calibrated to hexane

The methane and total volatile hydrocarbon (TVH) concentrations were very high in the monitor wells that were sampled. The vapor from well MW-29 consisted of over 45 percent by volume methane and TVH. The TVH can be attributed to residual gasoline.

The concentrations of benzene, ethylbenzene, toluene, and xylenes (BETX) in the sampled gas were relatively low. BETX are among the lighter, more volatile constituents of gasoline. It would be expected that their concentrations would be diminished due to eight years of evaporation and degradation by naturally occurring bacteria.

The source of the methane in the well casings is not clear. Methane is generated by anaerobic decomposition of organic material. It is a common byproduct of decomposition in solid waste landfills and wood waste fills. The methane found at Service Station 5353 may be in part attributable to decomposition of the wood debris and sawdust in the fill. However, we believe that most of the methane can be attributed to anaerobic decomposition of the subsurface gasoline at this site. Under aerobic (oxygenated) conditions, fuel hydrocarbons are broken down by bacteria forming carbon dioxide and water. When oxygen or other critical nutrients are removed, anaerobic decomposition becomes the predominant mode of bacterial decomposition. Anaerobic decomposition proceeds at a much slower rate than aerobic decomposition. Methane and carbon dioxide would be produced as a result of anaerobic decomposition of gasoline.

We reviewed the vapor monitoring data from the period of active free product recovery in the early 1980s. If the methane was present as a result of decomposition of pre-existing wood waste material, we would have expected similar high vapor concentrations at that time. However, the concentrations of hydrocarbon vapors in 1980 were much lower than those measured in 1988, especially in outlying areas distant from the source of the leak. Based on a comparison of the 1980 and 1988 vapor data, we feel that the current high methane concentration is the result of vapor accumulation due to prolonged anaerobic decomposition of the subsurface gasoline. We expect that carbon dioxide represents much of the balance of the accumulated subsurface vapors.

VAPOR RECOVERY SYSTEM DESIGN AND OPERATION

DESIGN

Subsurface vapor removal was selected as the most viable remedial alternative to further mitigate the effects of the gasoline leak. The VRS consists of two main elements: (1) the vapor collection equipment, and (2) the vapor destruction equipment. Vapor destruction (incineration) is required at this site because of the high concentration and potentially flammable nature of the subsurface vapors.

A schematic diagram of the vapor collection system is presented in Figure 3. Vapor collection is accomplished by using the existing recovery wells at the site as vapor collection points. The recovery wells were retrofitted to minimize the inward leakage of ambient air, and the 3-inch steel water/product collection pipes were retrofitted to serve as the vapor collection lines. The VRS is divided into four segments which can be individually controlled. This facilitates adjustment of the system to allow for removal of vapors from those areas where removal activities are most productive. The four segments of the system are as follows:

NW: Collection from Well RW-7, which was installed in a large excavated pit that also encompasses the site of RW-26. The exact dimensions of the pit are unknown, but it may have been up to 20 feet in diameter. The pit was backfilled with coarse gravel.

NE: Collection from Well RW-9, which is located in an east-west trench that is approximately 6 feet wide and 80 feet long. The two other recovery wells located in the trench (RW-8 and RW-10) are not directly connected to the vapor collection system. Because this trench is backfilled with coarse gravel, the entire trench acts as a collection gallery for subsurface vapors.

SW: Collection from Well RW-5, which was installed in an excavated pit that was backfilled with coarse gravel.

SE: Collection from Well RW-4, which was installed in an excavated pit that was backfilled with coarse gravel.

The four segments are controlled with valves that are installed in below-grade vaults near Wells RW-7 and RW-9. The valves at RW-7 control flow from the NW and SW segments, and the valves at RW-9 control flow from the northeast and southeast segments. The collection lines join to form one common collection line near Well RW-9. This line emerges from below grade within the fenced incinerator enclosure (Figure 1).

The single collection line is connected to a flame arrestor, an in-line air filter to remove any particulate material, and to the blower unit. Figure 3 shows a schematic drawing of the entire VRS. The blower unit is powered by a 1-1/2 horsepower electric motor. The blower has been able to provide a flow rate of 100 to 115 CFM at a vacuum of 14 to 16 inches water column. From the blower, the vapors pass (under pressure) through another flame arrestor and into the incinerator unit. Sample ports are provided at various locations along the sample collection line.

VRS instrumentation consists of two magnahelic air pressure/vacuum gauges, one to measure system vacuum at the blower, and another to measure pressure drop across the in-line air filter. The latter magnahelic gauge is used to determine when the air filter requires replacement. A thermometer is mounted between the flame arrestor and the air filter to measure the temperature of the incoming air stream. Flow rate is measured with a flow indicator/transducer which is mounted near the outlet of the blower. This instrument can be read visually and is also wired to a continuously recording strip chart recorder.

A recirculation loop is installed around the blower to allow for the gradual introduction of source air to the incinerator. During normal operation of the system, the dilution valve is fully closed. A dilution valve is also provided to allow the introduction of clean ambient air. The dilution valve is equipped with a muffler to minimize noise from the blower unit.

Vapors collected by the system are destroyed by one of two units, (1) the thermal incineration unit, and (2) the catalytic reactor unit. Initially, vapor destruction will be done by thermal incineration. After vapor levels are reduced to below 4000 ppm, the catalytic reactor unit will be used.

The thermal incinerator unit is designed to burn vapors with hydrocarbon concentrations of 4000 ppm or greater. For vapor concentrations of between 4000 and 10,000 ppm, accessory fuel is required to maintain combustion. Hydrocarbon destruction efficiencies of 99 percent or greater are typical for this unit. The auxiliary fuel for the thermal incinerator is natural gas supplied by Washington Natural Gas Company. Manual adjustment of the natural gas feed rate is required at times when the source gas composition changes. The thermal incineration unit has numerous safeguards for automatic shut down of the entire system in the event of flame-out, power loss, or abnormalities in the natural gas and vapor delivery rates.

The catalytic reactor unit uses a platinum catalytic reactor bed operating at relatively low temperatures to oxidize hydrocarbon vapors. Instrumentation provides continuous operation information about the catalyst bed temperature to assure proper operation. The catalyst bed is provided with an electronically controlled pre-heater to maintain proper operation temperature. Temperature sensors connected to a continuously recording strip chart recorder provide information about catalyst bed temperature and the heat of combustion attained by the source vapors. The heat of combustion obtained from the source vapors can be correlated to the hydrocarbon concentration of the vapor. A destruction efficiency of 95 percent is typical for this unit. Dilution of collected vapors may be required during the operation of the catalytic reactor unit to prevent high vapor concentrations from adversely affecting the catalyst beds.

Both vapor destruction units are the subject of permits issued by the Seattle Fire Department and the Puget Sound Air Pollution Control Agency. Copies of those permits are included in Appendix C of this report.

OPERATION

Vapor recovery was initiated on June 24, 1988 with a brief trial operation of the VRS using the thermal incineration unit. The catalytic reactor unit has not yet been installed at the site. The system began continuous operation on June 28, 1988 and operated through the end of this reporting period with only brief shutdowns for maintenance and instrument

installation. The system has been operated through a series of different vapor withdrawal configurations to evaluate the performance of the system and to determine the most productive operational configuration.

MONITORING ACTIVITIES

Monitoring activities were performed frequently following the onset of vapor removal efforts. We expect the intensity of monitoring to decrease as the recovery system operation and subsurface vapor conditions become more predictable. At the present time, we are performing two kinds of monitoring: (1) We are closely observing the performance of the VRS by collecting data about vapor chemistry, vapor concentrations, flow rates, and other pertinent operational data, and (2) we are periodically measuring subsurface conditions in the monitor wells, specifically those conditions that are indicative of the effectiveness of the VRS.

VRS MONITORING AND SAMPLING

The performance of the VRS has been monitored by regular measurement of a number of different operational parameters. Because the VRS has been designed to allow withdrawal of vapors from different parts of the site, much of the monitoring has been directed toward evaluating the effectiveness of the system in different withdrawal modes. Measurements of total system flow rate, system vacuum, combustible vapor concentration, and supplementary fuel consumption are taken each time the pattern of vapor withdrawal is adjusted. Vapor samples are also collected from the VRS for chemical analysis of total volatile hydrocarbons (TVH) and methane. All vapor samples have been collected at the sample ports located between the blower unit and the incinerator (Figure 3). Table A-1 in Appendix A presents all of the VRS monitoring data collected during this reporting period. Our interpretation of the significance of the VRS data is discussed later in this report.

SUBSURFACE VAPOR AND VACUUM MONITORING

Subsurface vapors and vacuum in monitor wells were measured on six occasions after the start-up of the VRS. Measurements were made on June 29, June 30, July 8, July 11, July 14, and July 18, 1988. Testing of all of the monitor wells is very difficult due to heavy traffic on

Mercer Street and Westlake Avenue. Monitoring activities in the streets are completed prior to 7:00 a.m. to minimize traffic conflicts.

Subsurface vapors have been monitored in the well casings using a Bacharach TLV Sniffer. The measurements are made in a manner which prevents the entry of ambient air into the well (which could cause dilution and result in erroneous readings). The results of subsurface vapor monitoring are presented in Table A-2 in Appendix A. Much of this field data is incomplete due to unexpected inconsistencies in the operation of the field vapor detection instruments. Data which are clearly in question are not reported. This is discussed in more detail later. At the end of this reporting period, we found that the instrumentation became more reliable as the subsurface vapors began to change in character.

Ground vacuum was measured using magnahelic gauges that have a resolution of about 0.005 inches water column vacuum. The results of ground vacuum monitoring are presented in Table A-3 in Appendix A.

FREE PRODUCT

On June 24, and June 27, 1988 B&C Equipment Company used a vacuum truck to remove free product and water from those recovery wells that had measurable amounts of free product (Table 1). On the two days, a total of approximately 125 gallons of product and approximately 2000 gallons of water were removed. We returned to the site on July 20, 1988 to measure free product levels in the recovery wells. All eight recovery wells had a hydrocarbon sheen on the ground water surface. Only one recovery well, RW-26, had a measurable thickness of free product (0.01 foot).

DISCUSSION

The fuel-related contamination at and near Service Station 5353 appears to consist mainly of hydrocarbon vapors and product that is immobilized within soil in the water table zone. This layer of soil contamination may have a vertical thickness of several feet. Very little free product appears to remain at the site, as was evidenced by the lack of recovery of free product in those wells that were pumped on June 24 and 27.

Subsurface vapor measurements on February 14, 1988 showed that high concentrations of hydrocarbon vapors were present off of Unocal property. Analytical testing of vapors from three of the wells showed that the vapors contained both methane and volatile hydrocarbons. We believe that the methane is largely derived from anaerobic decomposition of gasoline at this site.

The composition and high concentration of the subsurface vapors have severely limited the effectiveness of the field vapor monitoring using our Bacharach TLV Sniffers. The vapors are known to contain very high concentrations of hydrocarbons (volatile hydrocarbons and methane). The vapors probably also contain relatively high concentrations of carbon dioxide and low levels of oxygen. Oxygen would be depleted in the subsurface environment due to the action of aerobic bacteria combined with minimal exchange with ambient air. The Bacharach TLV Sniffer actually measures the capacity of the gas to release heat when it passes by a heated filament (the element) and the gas is oxidized. The reliability of the instrument is affected both by the absence in oxygen and by the presence of carbon dioxide. We have found that the element of the instrument can become "poisoned" while taking readings at this site. It can take the instrument up to several hours to recover from the effect of the poisoning. We believe that many of the low vapor concentration readings shown in Table A-2 are not representative of actual conditions; however, during this reporting period, we have seen a tendency toward more stability in subsurface vapor readings. This can be attributed largely to the introduction of ambient air into the subsurface environment due to VRS operation. The tendency towards stability in readings is most evident in those measurements made in the recovery wells (Table A-2). We believe that during the next reporting period, the Bacharach TLV Sniffer instrument will become a more reliable indicator of the concentration of subsurface vapors at this site.

A significant amount of flammable vapor was removed by the VRS during this reporting period, during which approximately 3,500,000 cubic feet of vapor was withdrawn from the subsurface. Assuming an average effective soil porosity of 10 percent and a depth to ground water of about 10 feet,

this volume of air is equivalent to exchanging the air beneath the entire block occupied by Unocal, Denny's and Brace Lumber a total of 35 times. However, inefficiencies inherent in vapor collection allow a significant amount of ambient air to leak into the recovery system through porous backfill, utility trenches, and on-site structures. Measurement of the system vacuum and ground vacuum is one method to identify where those inefficiencies may be located.

Based upon the vacuum monitoring data, the most effective mode of operation of the recovery system is to draw vapors from the southwest and southeast recovery wells. When the system is operated with withdrawal from these wells there is a significant measurable vacuum in the system and in wells surrounding Wells RW-4 and RW-5. The zone of influence during recovery from these wells extends to the south across Mercer Street, to southwest across Westlake Avenue, and north to the property boundary.

When the system is operated with withdrawal from all segments of the system, it is evident that there is a significant loss in system vacuum. This can be attributed to inefficiencies (air leaks) in the northern part of the system. It is likely that a major part of the loss is through the backfill of utilities in Westlake Avenue which intercept the backfill of the northern recovery trenches. There may also be losses through connections with other subsurface conduits, such as the backfill around electrical lines or the product lines. When the entire system is operated, the area of influence of the VRS is greater, but the effective vacuum within the system is substantially lower. This translates into a slower recovery rate in this mode of operation. We believe that VRS operation with simultaneous withdrawal from all four collection areas is best suited for a later time when the catalytic reactor unit is brought online.

Significant progress has been made toward depletion of the existing "reservoir" of accumulated vapors beneath the site during this reporting period. We have estimated the approximate equivalent volume of hydrocarbons that have been removed from the subsurface by the VRS. Table 3 shows the approximate equivalent volume of gasoline (in gallons) and

methane (in cubic feet) that have been removed and destroyed. These calculations are based upon measured flow rates and vapor concentrations. During this 23-day period, hydrocarbon vapors equivalent to about 350 gallons of liquid gasoline have been removed and destroyed by the VRS. In addition, about 50,000 cubic feet (ambient temperature and pressure) of methane has been removed and destroyed. If further testing indicates that biodegradation of the gasoline is the source of the methane, then we will develop rough estimates of the volume of gasoline that this quantity of methane represents. Approximately 100,000 cubic feet (delivery temperature and pressure) of natural gas have been used as supplemental fuel during this period.

TABLE 3

VAPOR COLLECTION SYSTEM OPERATION SCHEDULE AND VAPOR RECOVERY

Start Date	Duration (Days)	Equivalent Total Recovery Gasoline (gallons)	Equivalent Total Recovery Methane (F3)	Recovery System Configuration
06/28/88	1.1	26.9	7,696	All Open
06/29/88	1.0	78.8	8,954	South
06/30/88	1.0	71.4	7,782	South
07/01/88	4.0	31.2	8,631	East
07/05/88	0.8	9.0	1,401	All Open
07/06/88	2.0	44.8	7,577	South
07/08/88	4.0	38.5	8,918	Southeast
07/12/88	3.2	17.2	1,244	All Open
07/15/88	5.0	31.7	1,159	South
Totals:	22.1	349.5	53,362	

Figures 4 and 5 show the progress made in depletion of the existing "reservoir" of hydrocarbon vapors beneath the site. These figures also show that the operation of the southern part of the collection system is presently the most effective mode of operation. Figure 5 shows a steady decrease in the average daily recovery of methane. Once depleted, methane is not expected to be generated in great quantities during the

remainder of the recovery effort. The volatile hydrocarbons, on the other hand, will continue to evaporate from those soils with residual gasoline contamination. The recent increase in volatile hydrocarbon concentration from the southern part of the system (Figure 4) may be attributed to the introduction of warmer, "clean" air into to the subsurface. This air would have a greater capacity to evaporate residual gasoline. Continued monitoring and analytical testing will help determine if such a trend is developing.

There is another very significant beneficial effect VRS operation- the introduction of ambient air into the ground. The introduced oxygen stimulates aerobic biodegradation of the residual gasoline by naturally occurring bacteria. The beneficial effects of this additional fuel destruction can exceed the rate of hydrocarbon removal by evaporation.

FUTURE ACTIONS AND MONITORING

VAPOR RECOVERY SYSTEM OPERATION

We plan to continue operation of the vapor recovery system under a program of reduced monitoring and adjustments to the system. We will withdraw vapors primarily from the southern part of the system with periodic shorter periods of withdrawal from the entire system.

MONITORING

During the next month, we plan to continue monitoring subsurface conditions on a weekly basis, being sure to obtain one set of readings during each different operation mode of the collection system. After one month, the frequency of monitoring will be reduced. Vapor samples for TVH and methane analysis will be obtained upon each change in the vapor withdrawal configuration.

Vapor concentrations will continue to be monitored to determine when to make the transition to vapor destruction by the catalytic reaction unit. This transition will occur when vapor concentrations entering the VRS remain below 4000 ppm. It is possible that this will be achieved during the next two months.

OTHER ACTIVITIES

Transition to use of the catalytic reactor unit will require additional site construction activities. This will include the installation of additional electrical service, installation of the catalytic reactor unit, and training in its use. We will work closely with Unocal, the incinerator manufacturer, and B&C Equipment Company to make this transition as smooth as possible.

We plan to sample and analyze vapors in Wells MW-1, MW-17 and MW-29 to evaluate changes in vapor chemistry that have occurred in the vicinity of those wells since the initiation of vapor recovery. We also plan to perform additional chemical testing to ascertain the origin of the methane beneath the site. We will discuss this with Unocal before proceeding with any special sampling and analytical testing.

FUTURE REPORTING

We plan to continue to issue further progress reports on a frequency of once every four months. The next progress report will cover the period from July 21, 1988 through mid-November 1988. This reporting period may be modified at your request, especially if the progress of operation of the catalytic reactor unit or collection of significant data warrants an earlier report.

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Please contact us if there are any questions regarding this progress report.

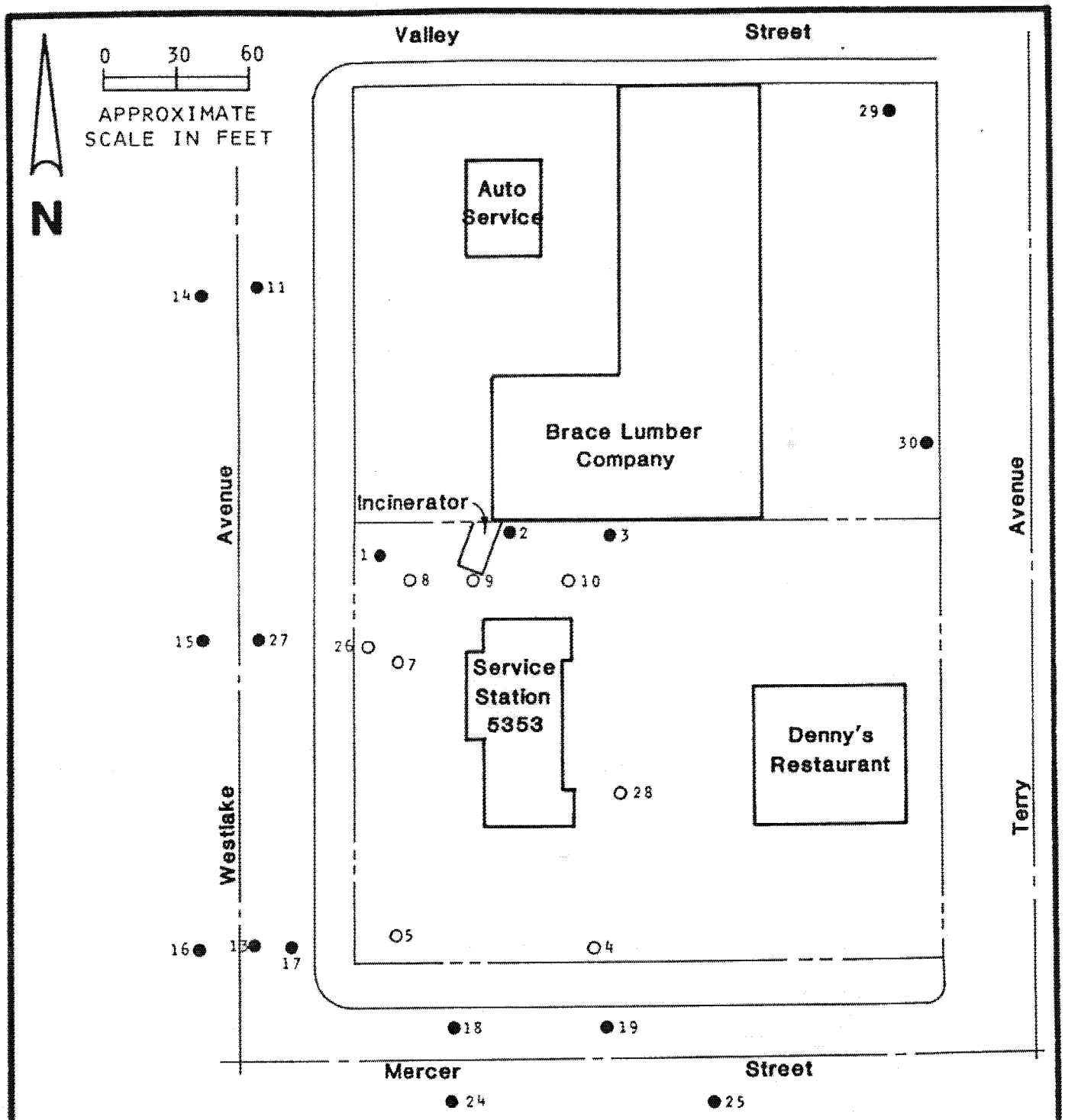
Yours very truly,

GeoEngineers, Inc.

Stephen C. Perrigo
Waste Management Specialist

James A. Miller
Principal

SCP:JAM:cs



EXPLANATION:

- ● MONITOR WELLS
- ○ RECOVERY WELLS WITH MANHOLE COVERS

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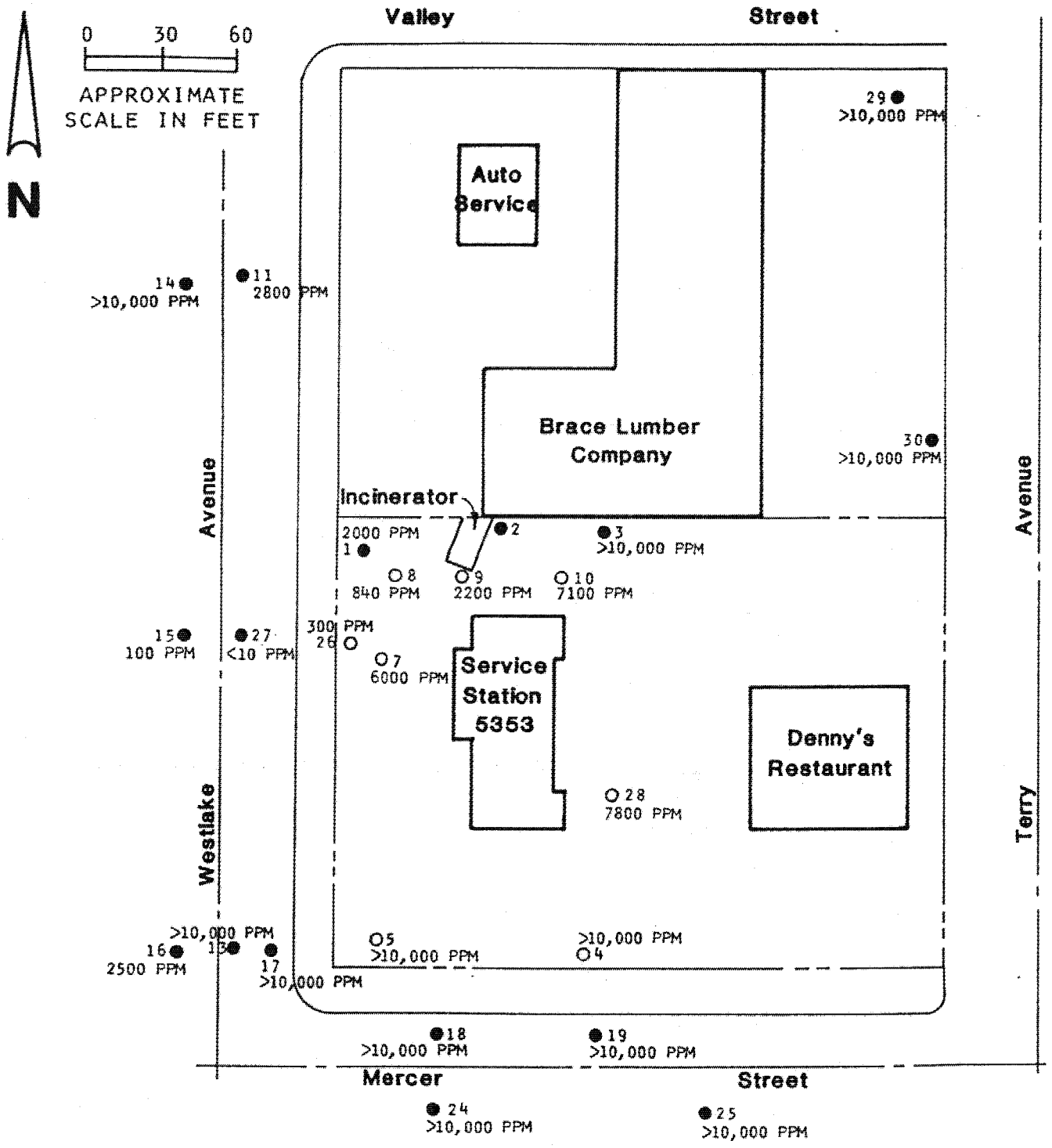
SITE PLAN

FIGURE 1



EXPLANATION:

VAPOR CONCENTRATION MEASURED IN EACH WELL IS NOTED NEXT TO EACH WELL LOCATION.

● MONITOR WELLS

○ RECOVERY WELLS WITH MANHOLE COVERS

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VAPOR CONCENTRATIONS 2/14/88

FIGURE 2

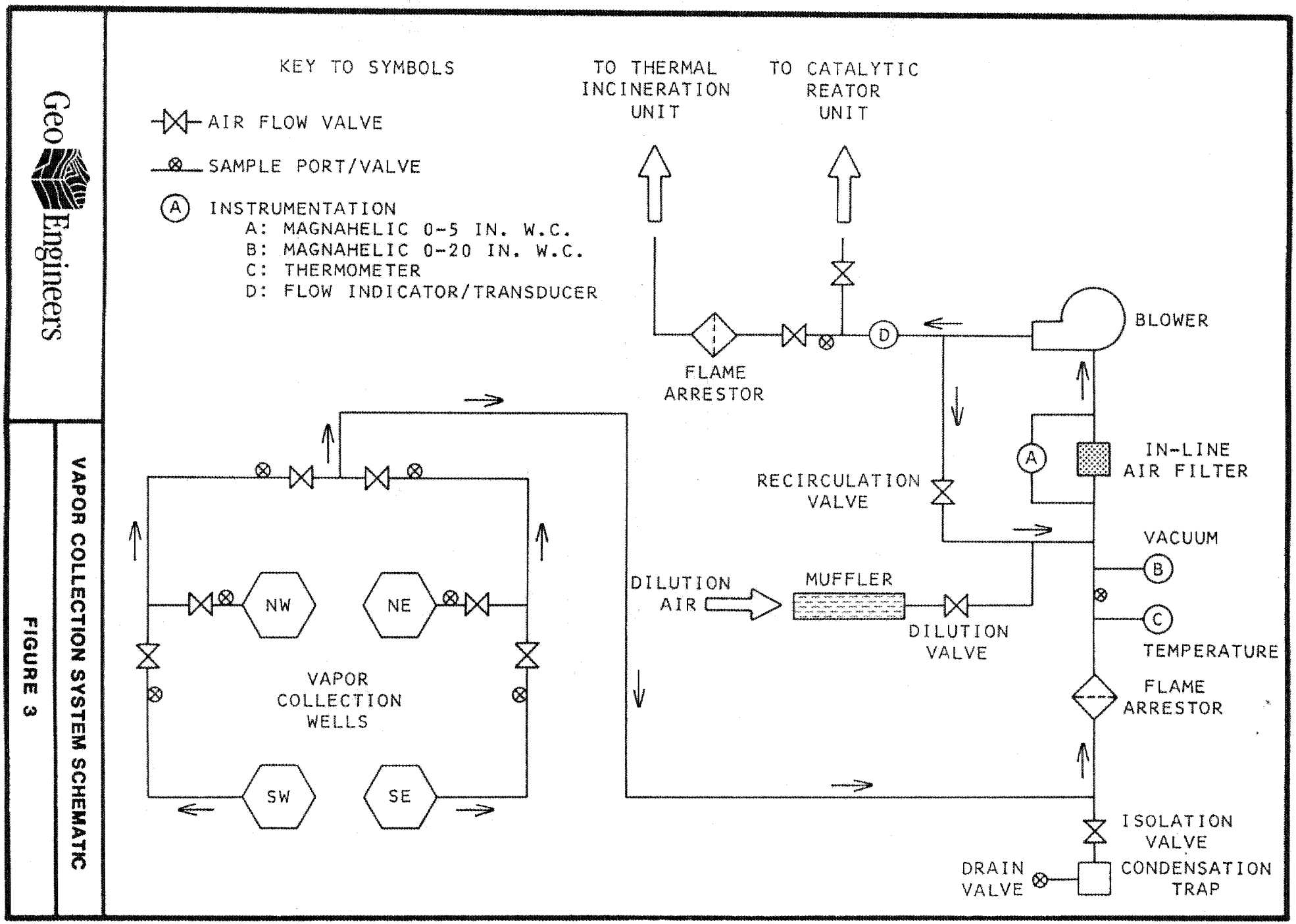

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FIGURE 3

VAPOR COLLECTION SYSTEM SCHEMATC

AVERAGE DAILY VOLATILE HYDROCARBON DESTRUCTION RATES[1]

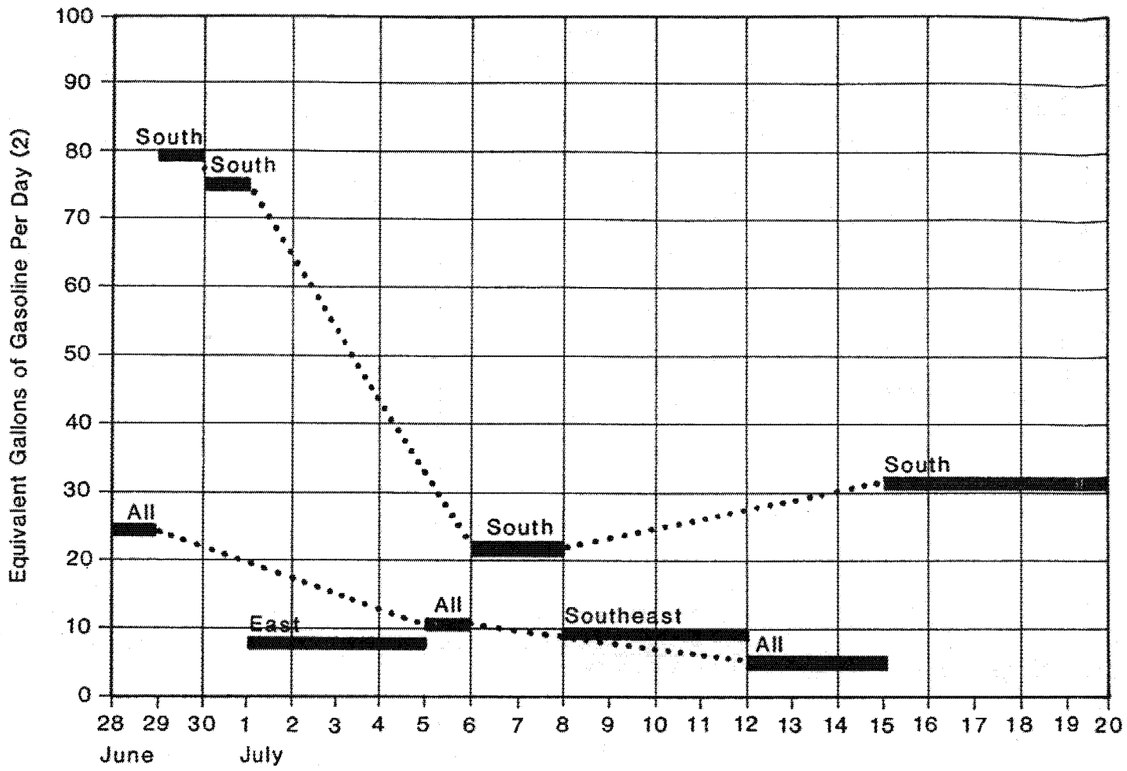

FIGURE 4

AVERAGE DAILY METHANE DESTRUCTION RATES[1]

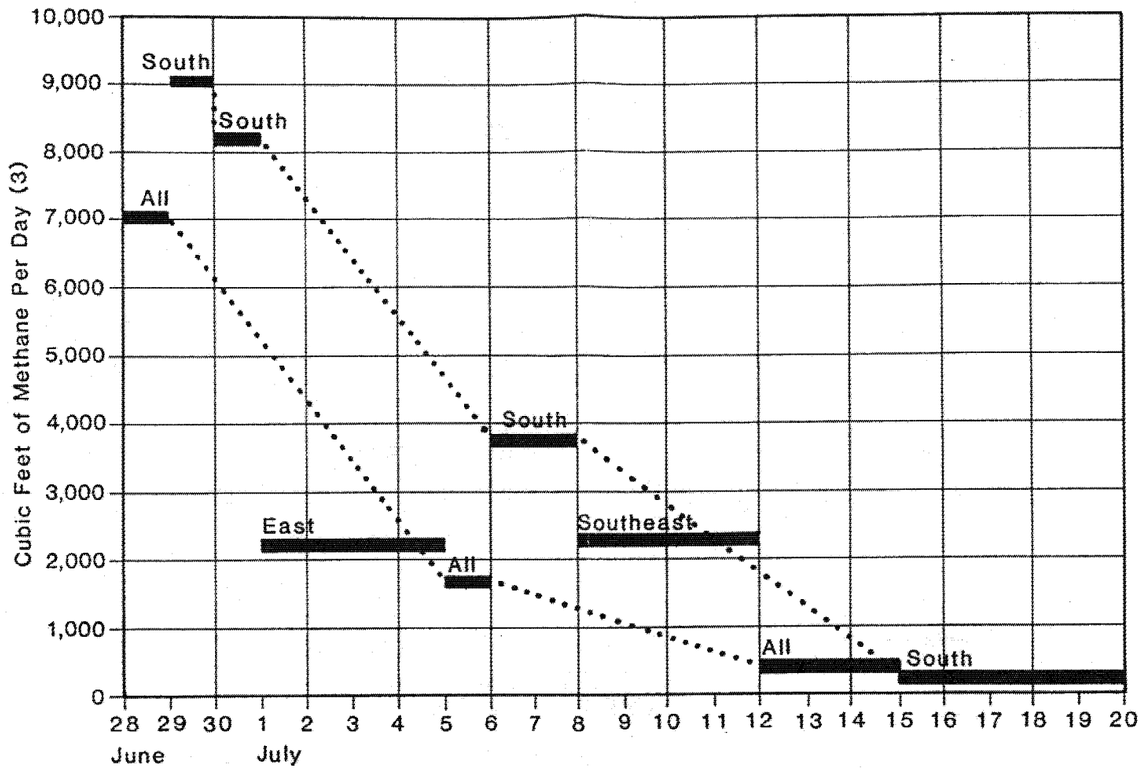

FIGURE 5

NOTES: (1) SOLID BARS REPRESENT AVERAGE DAILY HYDROCARBON DESTRUCTION RATES FOR THE PERIOD OF OPERATION IN THE SYSTEM CONFIGURATION NOTED. FOR EXAMPLE, SOUTH SIGNIFIES WITHDRAWAL FROM THE SE AND SW SEGMENTS OF THE VAPOR COLLECTION SYSTEM. DOTS CONNECTING SOLID BARS ARE ONLY TO ASSIST THE READER IN IDENTIFYING TRENDS WITHIN THE OPERATING CONFIGURATION.

(2) AVERAGE TVH DESTRUCTION RATE BASED UPON AVERAGE TVH CONCENTRATION, FLOW RATE AND AN APPROXIMATE CONVERSION FACTOR (SEE TEXT). EXPRESSED AS GALLONS OF LIQUID GASOLINE.

(3) AVERAGE SOIL VAPOR METHANE DESTRUCTION RATE BASED UPON AVERAGE METHANE CONCENTRATION AND FLOW RATE. EXPRESSED AS CUBIC FEET OF PURE METHANE AT AMBIENT TEMPERATURE AND PRESSURE.

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AVERAGE HYDROCARBON DESTRUCTION RATES

FIGURES 4 & 5

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Appendix A – Monitoring Data

Table A-1

VAPOR RECOVERY SYSTEM MONITORING DATA

Date	Time	Flow Rate (CFM)	Vacuum (Note 1)	Fuel Use (CFM) (Note 2)	System Configuration (Note 3) NW	NE	SW	SE	TLV Reading (Note 4)	TVH (ppm) (Note 5)	Methane (ppm) (Note 6)
06/24/88	1305	110	---	---	-	-	0	0	> 10,000	600	110,000
06/24/88	1408	110	---	---	-	-	0	0	> 10,000	520	110,000
System Shut Down 06/24 through 06/28/88											
06/28/88	1320	System Started									
06/28/88	1334	115	---	---	0	0	0	0	> 10,000	6,500	75,000
06/28/88	1412	105	---	---	-	-	-	0	> 10,000	1,400	110,000
06/28/88	1415	105	---	---	-	-	-	0	> 10,000	1,600	95,000
06/28/88	1421	115	---	---	-	0	-	-	615	7,600	58,000
06/28/88	1429	110	---	---	0	-	-	-	700	5,400	43,000
06/28/88	1435	110	---	---	-	-	0	-	> 10,000	450	17,000
06/28/88	1440	115	---	3.5	0	0	0	0	> 10,000	---	---
06/29/88	1512	118	5.6	---	0	0	0	0	> 10,000	780	6,600
06/29/88	1554	115	>10.0	---	-	-	0	0	> 10,000	8,800	46,000
06/30/88	1535	115	---	---	-	-	0	0	> 10,000	15,000	63,000
07/01/88	1358	110	---	---	-	-	0	0	---	8,000	38,000
07/01/88	1418	110	---	---	-	0	-	0	---	410	4,900
07/05/88	1325	115	---	---	-	0	-	0	---	2,000	22,000
07/05/88	1330	---	---	---	0	0	0	0	---	---	---
07/06/88	0955	110	7.0	---	0	0	0	0	---	1,600	10,000
07/06/88	1010	105	16.0	---	-	-	-	0	---	5,900	55,000
07/06/88	1025	110	10.0	---	-	0	-	-	---	820	11,000
07/06/88	1100	110	11.0	---	0	-	-	-	---	1,200	5,900
07/06/88	1130	110	15.5	---	-	-	0	-	---	5,200	31,000
07/06/88	1130	110	15.5	---	-	-	0	0	---	---	---
07/08/88	1020	110	11.0	---	-	-	0	0	>10,000	1,700	16,000
07/08/88	1040	105	16.8	3.3	-	-	-	0	>10,000	2,200	25,000
07/12/88	0920	105	16.0	---	-	-	-	0	4,700	990	4,600
07/12/88	0940	115	7.5	3.3	0	0	0	0	2,000	490	930
07/15/88	1505	115	7.0	---	0	0	0	0	4,100	1,100	3,700
07/15/88	1525	112	10.5	2.9	-	-	0	0	>10,000	550	1,400
07/20/88	1550	110	10.5	3.0	-	-	0	0	4,700	9,000	1,500

Notes: (1) Vacuum expressed as inches Water Column vacuum
(2) Supplementary fuel consumption (cubic feet per minute)
(3) "-" = Closed and "0" = Open
(4) See text for a further discussion
(5) Total Volatile Hydrocarbon analysis by GC/FID, expressed as ppm (vol/vol)
(6) Methane analysis by GC/FID, expressed as ppm (vol/vol)
"---" signified "no reading taken" ">" signifies "greater than"

Table 4-2

Subsurface Vapor Monitoring Data

Well	06/29/88	06/30/88	07/01/88	07/08/88	07/11/88	07/14/88	07/18/88
MW-1	---	<100	<100	NV	>10,000	300	5400
MW-2	---	<100	<100	100	>10,000	<100	360
MW-3	---	>10,000	<100	660	0	---	---
MW-11	---	1600	<100	NV	>10,000	NV	>10,000
MW-13	NV	<100	<100	<100	>10,000	NV	<100
MW-14	NV	3000	<100	<100	NV	>10,000	>10,000
MW-15	NV	<100	<100	<100	NV	NV	<100
MW-16	NV	<100	<100	<100	NV	NV	<100
MW-17	NV	<100	<100	NV	NV	NV	<100
MW-18	NV	<100	<100	<100	NV	NV	<100
MW-19	NV	<100	<100	<100	NV	NV	8400
MW-24	NV	<100	<100	NV	NV	NV	<100
MW-25	NV	<100	<100	NV	>10,000	>10,000	<100
MW-27	NV	<100	<100	<100	NV	NV	<100
MW-29	---	<100	NV	NV	>10,000	>10,000	>10,000
MW-30	---	<100	<100	NV	>10,000	---	9700
EW-4	---	5100	<100	---	4900	7100	3800
EW-5	---	2300	<100	---	<100	1600	1600
EW-7	---	<100	120	---	940	3700	320
EW-8	---	<100	<100	300	180	760	230
EW-9	---	<100	<100	<100	<100	400	<100
EW-10	---	2100	<100	740	310	150	400
EW-26	---	<100	220	---	1200	<100	260
EW-28	---	<100	<100	---	<100	100	<100

Notes: Vapor concentrations were measured using a Bacharach TLV Sniffer calibrate to hexane
Results are expressed as parts per million (vol/vol)
Most of the readings of >100 ppp are suspect. This is discussed in the text.
"NV" signifies that a measurement was taken but the value was not valid.
"<" signifies "less than"
">" signifies "greater than"
"---" signifies "no reading taken"

Table A-3

Ground Vacuum Monitoring Data

Well	06/29/88	06/30/88	07/01/88	07/08/88	07/11/88	07/14/88	07/18/88
MW-1	0.010	0.005	0.010	0.010	0.000	0.030	0.000
MW-2	0.065	0.010	0.000	0.000	0.000	0.000	0.000
MW-3	0.055	0.015	0.000	0.000	0.000	---	---
MW-11	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MW-13	0.020	0.050	0.055	0.010	0.005	0.005	0.000
MW-14	0.015	0.010	0.000	0.000	0.000	0.000	0.000
MW-15	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MW-16	0.025	0.000	0.025	0.000	0.015	0.000	0.000
MW-17	0.075	0.250	0.050	0.050	0.025	0.010	0.025
MW-18	0.190	1.300	1.000	0.540	0.460	0.120	0.380
MW-19	0.200	0.580	1.000	0.740	0.720	0.130	0.600
MW-24	0.015	0.250	0.260	0.120	0.070	0.015	0.080
MW-25	0.050	0.045	0.120	0.025	0.000	0.000	0.075
MW-27	0.010	0.000	0.005	0.000	0.000	0.000	0.005
MW-29	0.005	0.000	0.000	0.000	0.000	0.000	0.000
MW-30	0.000	0.000	0.000	0.000	0.000	---	0.000
EW-4	---	8.500	9.400	7.400	>10.000	1.400	6.600
EW-5	---	9.200	10.000	5.400	0.230	1.200	8.200
EW-7	---	0.030	0.010	0.005	0.000	0.029	0.000
EW-8	---	0.000	0.010	0.000	0.000	0.027	0.000
EW-9	---	0.025	0.010	0.000	0.000	0.027	0.000
EW-10	---	0.000	0.005	0.000	0.000	0.300	0.000
EW-26	---	0.000	0.000	0.002	0.000	0.270	0.000
EW-28	---	0.035	0.050	0.020	0.035	3.000	0.010
Vapor Collection System Operational Status							
Northwest	0	-	-	-	-	0	-
Northeast	0	-	-	-	-	0	-
Southwest	0	0	0	0	-	0	0
Southeast	0	0	0	0	0	0	0

Notes: Measurements were made using magnehelic gauges with a resolution of 0.005 inches water column
">" signifies "greater than"
"---" signifies "no reading taken"
Vapor collection system operational status shows the configuration of vapor withdrawal at the time the vacuum readings were taken. "0" = Open and "-" = Closed.

GeoEngineers

Appendix B – Laboratory Analytical Data

FARR, FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

James K. Farr, Ph.D.
Andrew John Friedman
James E. Bruya, Ph.D.

3008 B - 16th West
Seattle, WA 98119
(206) 285-8282

May 24, 1988

Steve Perrigo, Project Coordinator
GeoEngineers, Inc.
2405-140th Avenue N.E., Suite 105
Bellevue, WA 98005

Dear Steve:

Enclosed are the results of the analyses of samples submitted on May 16, 1988 from Project 0161-13-4.

We appreciate this opportunity to be of service to you on this project. If you have any questions regarding this material, or if you just want to discuss any aspect of your projects, please do not hesitate to contact me.

Sincerely,

James K. Farr, Ph.D.

JKF/cag

Enclosures

Date of Report: May 24, 1988
Date Submitted: May 16, 1988
Project: 0161-13-4

RESULTS OF ANALYSES OF ENVIRONMENTAL SAMPLES FOR BTX AND ETHYLBENZENE
Results Reported as nL/mL (ppm)

Sample #	Benzene	Toluene	Et-Benzene	Xylene *m,p*	Xylene *o*
MW-1 air	66	27	8	7	7
MW-17 air	190[a]	18	8	7	7
MW-29 air	41	12	8	6	7
Quality Assurance					
Method Blank	<5	<5	<5	<5	<5
MW-17 (Replicate)	190[a]	17	8	7	8

a - Value reported exceeded the calibration range established for the sample.

Date of Report: May 24, 1988
Date Submitted: May 16, 1988
Project: 0161-13-4

RESULTS OF ANALYSES OF ENVIROMENTAL SAMPLES FOR METHANE BY GC/FID

Sample #	Methane (ppm)
MW-1 air	36,000[a]
MW-17 air	120,000[a]
MW-29 air	300,000[a]
Quality Assurance	
Method Blank	<10
MW-17 (Replicate)	120,000[a]

a - Value reported exceeded the calibration range established for the sample.

Date of Report: May 24, 1988
Date Submitted: May 16, 1988
Project: 0161-13-4

RESULTS OF ANALYSES OF ENVIRONMENTAL SAMPLES FOR TOTAL HYDROCARBONS AS n-HEXANE

Sample #	(ppm)
MW-1 air	12,000[a]
MW-17 air	49,000[a]
MW-29 air	160,000[a]
Quality Assurance	
Method Blank	<10
MW-17 (Replicate)	47,000[a]

a - Value reported exceeded the calibration range established for the sample.

FARR, FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

James K. Farr, Ph.D.
Andrew John Friedman
James E. Bruya, Ph.D.

3008 B - 16th West
Seattle, WA 98119
(206) 285-8282

June 27, 1988

Steve Perrigo, Project Manager
GeoEngineers, Inc.
2405-140th Avenue N.E., Suite 105
Bellevue, WA 98005

Dear Steve:

Enclosed are the results of the analyses of samples submitted on June 24, 1988 from Project 0161-13-4.

We appreciate this opportunity to be of service to you on this project. If you have any questions regarding this material, or if you just want to discuss any aspect of your projects, please do not hesitate to contact me.

Sincerely,

James K. Farr, Ph.D.

JKF/cag

Enclosures

Date of Report: June 27, 1988
Date Submitted: June 24, 1988
Project: 0161-13-4

RESULTS OF ANALYSES OF ENVIROMENTAL SAMPLES FOR METHANE BY GC/FID

Sample #	Methane (ppm) v/v
062488-#1 gas	110,000
062488-#2 gas	110,000
Quality Assurance	
Method Blank	<10
062488-#1 Replicate	100,000
062488-#2 Replicate	100,000

Date of Report: June 27, 1988
Date Submitted: June 24, 1988
Project: 0161-13-4

RESULTS OF ANALYSES OF ENVIRONMENTAL SAMPLES FOR TOTAL VOLATILE HYDROCARBONS AS *n*-HEXANE

Sample #	(ppm)
062488-#1 gas	600
062488-#2 gas	520

Quality Assurance

Method Blank	<1

FARR, FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

James K. Farr, Ph.D.
Andrew John Friedman
James E. Bruya, Ph.D.

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(206) 285-8282

July 1, 1988

Steve Perrigo, Project Manager
GeoEngineers, Inc.
2405-140th Avenue N.E., Suite 105
Bellevue, WA 98005

Dear Steve:

Enclosed are the results of the analyses of samples submitted on June 28, 1988 from Project 0161-13-4.

We appreciate this opportunity to be of service to you on this project. If you have any questions regarding this material, or if you just want to discuss any aspect of your projects, please do not hesitate to contact me.

Sincerely,

James K. Farr

James K. Farr, Ph.D.

JKF/cag

Enclosures

Date of Report: July 1, 1988
Date Submitted: June 28, 1988
Project: 0161-13-4

RESULTS OF ANALYSES OF ENVIROMENTAL SAMPLES FOR METHANE BY GC/FID

Sample #	Methane (ppm)
880628-1	75,000[a]
880628-2	110,000[a]
880628-3	95,000[a]
880628-4	58,000[a]
880628-5	43,000[a]
880628-6	17,000[a]
Quality Assurance	
Method Blank	<10

a - Value reported exceeded the calibration range established for the sample.

Date of Report: July 1, 1988
Date Submitted: June 28, 1988
Project: 0161-13-4

RESULTS OF ANALYSES OF ENVIRONMENTAL SAMPLES FOR TOTAL VOLATILE HYDROCARBONS AS n-HEXANE

Sample #	Total Volatile Hydrocarbons As n-Hexane (ppm)
880628-1	6,500
880628-2	14,000
880628-3	18,000
880628-4	7,800
880628-5	5,400
880628-6	450
Quality Assurance	
Method Blank	<1

FARR, FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

James K. Farr, Ph.D.
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3008 B - 16th West
Seattle, WA 98119
(206) 285-8282

July 1, 1988

Steve Perrigo, Project Manager
GeoEngineers, Inc.
2405-140th Avenue N.E., Suite 105
Bellevue, WA 98005

Dear Steve:

Enclosed are the results of the analyses of samples submitted on June 29, 1988 from Project 0161-13-4.

We appreciate this opportunity to be of service to you on this project. If you have any questions regarding this material, or if you just want to discuss any aspect of your projects, please do not hesitate to contact me.

Sincerely,

James K. Farr, Ph.D.

JKF/cag

Enclosures

Date of Report: July 1, 1988
Date Submitted: June 29, 1988
Project: 0161-13-4

RESULTS OF ANALYSES OF ENVIROMENTAL SAMPLES FOR METHANE BY GC/FID

Sample #	Methane (ppm) v/v
880629-1 gas	8,600
880629-2 gas	46,000a

Quality Assurance

Method Blank	<10
880629-1 (Duplicate)	8,000

a - Value reported exceeded the calibration range established for the sample.

Date of Report: July 1, 1988
Date Submitted: June 29, 1988
Project: 0161-13-4

RESULTS OF ANALYSES OF ENVIRONMENTAL SAMPLES FOR TOTAL VOLATILE HYDROCARBONS AS n-HEXANE

Sample #	Total Volatile Hydrocarbon As n-Hexane (ppm) v/v
880629-1 gas	760
880629-2 gas	8,800
Quality Assurance	
Method Blank	<1
880629-1 (Duplicate)	720

FARR, FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

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3008 B - 16th West
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(206) 285-8282

July 1, 1988

Steve Perrigo, Project Manager
GeoEngineers, Inc.
2405-140th Avenue N.E., Suite 105
Bellevue, WA 98005

Dear Steve:

Enclosed are the results of the analyses of samples submitted on June 30, 1988 from Project 0161-13-4.

We appreciate this opportunity to be of service to you on this project. If you have any questions regarding this material, or if you just want to discuss any aspect of your projects, please do not hesitate to contact me.

Sincerely,

James K. Farr

James K. Farr, Ph.D.

JKF/cag

Enclosures

Date of Report: July 1, 1988
Date Submitted: June 30, 1988
Project: 0161-13-4

RESULTS OF ANALYSES OF ENVIROMENTAL SAMPLES FOR METHANE BY GC/FID

Sample #	Methane (ppm) v/v
880630-1	63,000[a]

Quality Assurance

Method Blank	<10
880630-1 (Duplicate)	57,000[a]

a - Value reported exceeded the calibration range established for the sample.

Date of Report: July 1, 1988
Date Submitted: June 30, 1988
Project: 0161-13-4

RESULTS OF ANALYSES OF ENVIRONMENTAL SAMPLES FOR TOTAL VOLATILE HYDROCARBONS AS n-HEXANE

Sample #	Total Volatile Hydrocarbon as n-Hexane (ppm)
880630-1	15,000
Quality Assurance	
Method Blank	<1
880630-1 (Duplicate)	14,000

FARR, FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

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(206) 285-8282

July 6, 1988

Steve Perrigo, Project Manager
GeoEngineers, Inc.
2405-140th Avenue N.E., Suite 105
Bellevue, WA 98005

Dear Steve:

Enclosed are the results of the analyses of samples submitted on July 1, 1988 from Project 0161-13-4.

We appreciate this opportunity to be of service to you on this project. If you have any questions regarding this material, or if you just want to discuss any aspect of your projects, please do not hesitate to contact me.

Sincerely,

James K. Farr

James K. Farr, Ph.D.

JKF/cag

Enclosures

Date of Report: July 6, 1988
Date Submitted: July 1, 1988
Project: 0161-13-4

RESULTS OF ANALYSES OF ENVIRONMENTAL SAMPLES FOR METHANE BY GC/FID

Sample #	Methane (ppm)
880701-1	38,000a
880701-2	4,900

Quality Assurance

Method Blank	<10
880701-2 (Replicate)	5,700

a - Value reported exceeded the calibration range established for the sample.

Date of Report: July 6, 1988
Date Submitted: July 1, 1988
Project: 0161-13-4

RESULTS OF ANALYSES OF ENVIRONMENTAL SAMPLES FOR TOTAL VOLATILE HYDROCARBONS AS N-HEXANE

Sample #	Total Volatile Hydrocarbons (ppm) v/v
880701-1	8,000
880701-2	410
Quality Assurance	
Method Blank	<1
880701-2 (Replicate)	450

FARR, FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

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(206) 285-8282

July 12, 1988

Steve Perrigo, Project Manager
GeoEngineers, Inc.
2405-140th Avenue N.E., Suite 105
Bellevue, WA 98005

Dear Steve:

Enclosed are the results of the analyses of samples submitted on July 5, 1988 from Project 0161-13-4.

We appreciate this opportunity to be of service to you on this project. If you have any questions regarding this material, or if you just want to discuss any aspect of your projects, please do not hesitate to contact me.

Sincerely,

James K. Farr, Ph.D.

JKF/cag

Enclosures

Date of Report: July 12, 1988
Date Submitted: July 5, 1988
Project: 0161-13-4

RESULTS OF ANALYSES OF ENVIROMENTAL SAMPLES FOR METHANE BY GC/FID

Sample #	Methane (ppm)
880705-3	22,000
Quality Assurance	
Method Blank	<100
880705-3 (Replicate)	23,000

Date of Report: July 12, 1988
Date Submitted: July 5, 1988
Project: 0161-13-4

RESULTS OF ANALYSES OF ENVIRONMENTAL SAMPLES FOR TOTAL VOLATILE HYDROCARBONS AS N-HEXANE

Sample #	Total Volatile Hydrocarbons (ppm)
880705-3	2,000
Quality Assurance	
Method Blank	<10
880705-3 (Replicate)	2,100

FARR, FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

James K. Farr, Ph.D.
Andrew John Friedman
James E. Bruya, Ph.D.

3008 B - 16th West
Seattle, WA 98119
(206) 285-8282

July 12, 1988

Steve Perrigo, Project Manager
GeoEngineers, Inc.
2405-140th Avenue N.E., Suite 105
Bellevue, WA 98005

Dear Steve:

Enclosed are the results of the analyses of samples submitted on July 6, 1988 from Project 0161-13-4.

We appreciate this opportunity to be of service to you on this project. If you have any questions regarding this material, or if you just want to discuss any aspect of your projects, please do not hesitate to contact me.

Sincerely,

James K. Farr, Ph.D.

JKF/cag

Enclosures

Date of Report: July 12, 1988
Date Submitted: July 6, 1988
Project: 0161-13-4

RESULTS OF ANALYSES OF ENVIROMENTAL SAMPLES FOR METHANE BY GC/FID

Sample #	Methane (ppm)
880706-1	10,000
880706-2	55,000
880706-3	11,000
880706-5	5,900
880706-6	31,000
Quality Assurance	
Method Blank	<100

Date of Report: July 12, 1988
Date Submitted: July 6, 1988
Project: 0161-13-4

RESULTS OF ANALYSES OF ENVIRONMENTAL SAMPLES FOR TOTAL VOLATILE HYDROCARBONS AS N-HEXANE

Sample #	Total Volatile Hydrocarbons (ppm)
880706-1	1,600
880706-2	5,900
880706-3	820
880706-5	1,200
880706-6	5,200
Quality Assurance	
Method Blank	<10

FARR, FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

James K. Farr, Ph.D.
Andrew John Friedman
James E. Bruya, Ph.D.

3008 B - 16th West
Seattle, WA 98119
(206) 285-8282

July 12, 1988

Steve Perrigo, Project Manager
GeoEngineers, Inc.
2405-140th Avenue N.E., Suite 105
Bellevue, WA 98005

Dear Steve:

Enclosed are the results of the analyses of samples submitted on July 8, 1988 from Project 0161-13-4.

We appreciate this opportunity to be of service to you on this project. If you have any questions regarding this material, or if you just want to discuss any aspect of your projects, please do not hesitate to contact me.

Sincerely,

James K. Farr

James K. Farr, Ph.D.

JKF/cag

Enclosures

Date of Report: July 12, 1988
Date Submitted: July 8, 1988
Project: 0161-13-4

RESULTS OF ANALYSES OF ENVIROMENTAL SAMPLES FOR METHANE BY GC/FID

Sample #	Methane (ppm)
880708-1	16,000
880708-2	25,000
Quality Assurance	
Method Blank	<100
880708-1 (Replicate)	15,000

Date of Report: July 12, 1988
Date Submitted: July 8, 1988
Project: 0161-13-4

RESULTS OF ANALYSES OF ENVIRONMENTAL SAMPLES FOR TOTAL VOLATILE HYDROCARBONS AS *n*-HEXANE

Sample #	Total Volatile Hydrocarbons (ppm)
880708-1	1,700
880708-2	2,200
Quality Assurance	
Method Blank	<10
880708-1 (Replicate)	1,700

FARR, FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

James K. Farr, Ph.D.
Andrew John Friedman
James E. Bruya, Ph.D.

3008 B - 16th West
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(206) 285-8282

July 12, 1988

Kathy Killman, Project Manager
GeoEngineers, Inc.
2405-140th Avenue N.E., Suite 105
Bellevue, WA 98005

Dear Kathy:

Enclosed are the results of the analyses of samples submitted on July 12, 1988 from Project 0161-13-4.

We appreciate this opportunity to be of service to you on this project. If you have any questions regarding this material, or if you just want to discuss any aspect of your projects, please do not hesitate to contact me.

Sincerely,

James K. Farr

James K. Farr, Ph.D.

JKF/cag

Enclosures

Date of Report: July 12, 1988
Date Submitted: July 12, 1988
Project: 0161-13-4

RESULTS OF ANALYSES OF ENVIROMENTAL SAMPLES FOR METHANE BY GC/FID

Sample #	Methane (ppm)
880712-1	4,800
880712-2	930
Quality Assurance	
Method Blank	<100

Date of Report: July 12, 1988
Date Submitted: July 12, 1988
Project: 0161-13-4

RESULTS OF ANALYSES OF ENVIRONMENTAL SAMPLES FOR TOTAL VOLATILE HYDROCARBONS AS N-HEXANE

Sample #	Total Volatile Hydrocarbons (ppm)
880712-1	990
880712-2	490
Quality Assurance	
Method Blank	<10

FARR, FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

James K. Farr, Ph.D.
Andrew John Friedman
James E. Bruya, Ph.D.

3008 B - 16th West
Seattle, WA 98119
(206) 285-8282

July 18, 1988

Steve Perrigo, Project Manager
GeoEngineers, Inc.
2405-140th Avenue N.E., Suite 105
Bellevue, WA 98005

Dear Steve:

Enclosed are the results of the analyses of samples submitted on July 15, 1988 from Project 0161-13-4.

We appreciate this opportunity to be of service to you on this project. If you have any questions regarding this material, or if you just want to discuss any aspect of your projects, please do not hesitate to contact me.

Sincerely,

James K. Farr, Ph.D.

JKF/cag

Enclosures

Date of Report: July 18, 1988
Date Submitted: July 15, 1988
Project: 0161-13-4

RESULTS OF ANALYSES OF ENVIROMENTAL SAMPLES FOR METHANE BY GC/FID

Sample #	Methane (ppm)
880715-1	3,700
880715-2	1,400

Quality Assurance

Method Blank	<100
880715-1 (Replicate)	3,700

Date of Report: July 18, 1988
Date Submitted: July 15, 1988
Project: 0161-13-4

RESULTS OF ANALYSES OF ENVIRONMENTAL SAMPLES FOR TOTAL VOLATILE HYDROCARBONS AS *n*-HEXANE

Sample #	Total Volatile Hydrocarbons (ppm)
880715-1	1,100
880715-2	860
Quality Assurance	
Method Blank	<10
880715-1 (Replicate)	1,000

FARR, FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

James K. Farr, Ph.D.
Andrew John Friedman
James E. Bruya, Ph.D.

3008 B - 16th West
Seattle, WA 98119
(206) 285-8282

GeoEngineers

JUL 25 1988

Routing: SCP gP

File

July 21, 1988

Steve Perrigo, Project Manager
GeoEngineers, Inc.
2405-140th Avenue N.E., Suite 105
Bellevue, WA 98005

Dear Steve:

Enclosed are the results of the analyses of samples submitted on July 20, 1988 from Project 0161-13-4.

We appreciate this opportunity to be of service to you on this project. If you have any questions regarding this material, or if you just want to discuss any aspect of your projects, please do not hesitate to contact me.

Sincerely,

James K. Farr, Ph.D.

JKF

Enclosures

Date of Report: July 21, 1988
Date Submitted: July 20, 1988
Project: 0161-13-4

RESULTS OF ANALYSES OF ENVIROMENTAL SAMPLES FOR METHANE BY GC/FID

Sample #	Methane (ppm)
880720-1 gas	1,500

Quality Assurance

Method Blank	<100
880720-1 (Duplicate)	1,300

Date of Report: July 21, 1988
Date Submitted: July 20, 1988
Project: 0161-13-4

RESULTS OF ANALYSES OF ENVIRONMENTAL SAMPLES FOR TOTAL VOLATILE HYDROCARBONS AS N-HEXANE

Sample #	Total Volatile Hydrocarbons (ppm)
880720-1 gas	9,000a
Quality Assurance	
Method Blank	<1
880720-1 (Duplicate)	8,800a

a - Value reported exceeded the calibration range established for the sample.

GeoEngineers

Appendix C – Regulatory Documents and Permits

Date This Permit Expires: 5-15-89/NEW

PERMIT

SEATTLE FIRE DEPARTMENT

301 SECOND AVENUE SOUTH
SEATTLE, WASHINGTON 98104

Date: 5-17-88
Station:
Occupancy File No.:
Permit No.: 65652
Receipt No.: 132707

1989

Serial No. 117653

Unocal
3131 Elliott Avenue
Seattle, WA 98121

Operation Address:
600 Westlake Ave N
Westlake Union Service Station
Phone Number:
623-8272

TITLE: COMBUSTIBLE VAPOR INCINERATOR

CODE: 999

TYPE OF MATERIAL	U.N. NUMBERS	AMOUNT	LOCATION

Permission is hereby granted under the provisions of the Fire Code (Ord. 111001) to

Install multimode combuster for vapor Incineration.

SEE ATTACHED CONDITIONS.

THIS PERMIT MUST BE POSTED IN A CONSPICU

NOT TRANSFERAE

Issued by: Capt. Davis : DF

CHIEF OF THE FIRE DEPARTMENT

1989	1990	1991	1992	1993
Serial No. 117653	Serial No.	Serial No.	Serial No.	Serial No.

C - 1

Permit Conditions

1. The Entire area to be protected by security fence.
2. Incinerator to be 25' from tank vents and dispensing.
3. Incinerator to be 10' from property line and combustible structures
4. Install remote shutoff in station.
5. Install remote shutoff at fenced area.
6. Installation to be properly grounded.
7. Automatic shut down with alarm for:
    a. Gas pressure too high
    b. Gas pressure too low.
    c. Fan off.
    d. Incinerator operating over temperature.
8. Tank manholes to be tested for L.E.L. prior to business operation. If operation is shut down for any reason manholes shall be retested for L.E.L.

Puget Sound Air Pollution Control Agency

HEREBY ISSUES AN ORDER OF APPROVAL TO CONSTRUCT, INSTALL, OR ESTABLISH

Notice of Construction No. 3088

Date JUN 27 1988

One Vapor Removal System controlled by a King, Buck/Hasstech Multi-Mode Combustor Model MMC-5 with a Hasstech Vapor Control Processor Model VCP-100 and a Catalytic Reactor Model MMC-5-CAR.

APPLICANT
Mr. Leigh Carlson
Unocal
NAME
3131 Elliott Ave.
STREET
Seattle, WA 98101
CITY STATE ZIP

OWNER
Same
NAME
STREET
CITY STATE

INSTALLATION ADDRESS
600 Westlake Ave. N., Seattle, WA 98101
STREET CITY STATE

THIS ORDER IS ISSUED SUBJECT TO THE FOLLOWING RESTRICTIONS AND CONDITIONS

1. Approval is hereby granted as provided in Article 6 of Regulation I of the Puget Sound Air Pollution Control Agency to the applicant to install, alter or establish the equipment, device or process described hereon at the INSTALLATION ADDRESS in accordance with the plans and specifications on file in the Engineering Division of PSAPCA.
2. Compliance with this ORDER and its conditions does not relieve the owner or operator from the responsibility of compliance with Regulations I or II, RCW 70.94, or any other emission control requirements, nor from the resulting liabilities and/or legal remedies for failure to comply.
3. This approval does not relieve the applicant or owner of any requirement of any other governmental agency.

GeoEngineers

RECEIVED
JUL 1988
MAINT. & CONT.

JUL 11 1988
Routing
File

Harry A. Watters
Reviewing Engineer

cvm

K. Boyd Knechtel
~~A. R. Dammkoehler~~
(Acting) Air Pollution Control Officer

Form 50-118, (1/85)

NOTICE OF COMPLETION

WARNING:

Regulation I, Section 6.09(a), requires that the owner or applicant notify the Agency of the completion of the work covered by the application and when its operation will begin. This form is provided for your convenience to assist you in complying with this part of the Regulation.

APPLICANT or OWNER SECTION

Mail to: Puget Sound Air Pollution Control Agency
Plan Review Section
200 West Mercer Street, Room 205
Seattle, Washington 98119-3958

Gentlemen:

The project described below was completed on _____ and will be in operation on _____.

_____ _____ _____
Signature of Owner and/or Applicant | Title | Date

FOR AGENCY USE ONLY

Notice of Construction No. 3088

Project Description: One Vapor Removal System controlled by a King, Buck/Hasstech Multi-Mode Combustor Model MMC-5 with a Hasstech Vapor Control Processor Model VCP-100 and a Catalytic Reactor Model MMC-5-CAR

☐ Conditions On Reverse Side

Owner's Name Mr. Leigh Carlson, Unocal, 3131 Elliott Ave., Seattle, WA 98101

Location 600 Westlake ave. N., Seattle, Wa 98101

☒ Inspector check ☐ Engineer _____ and Inspector check

Follow-up _____ (Estimated Completion Date Plus 7)

Date Inspected _____ Inspector _____

REMARKS: _____

☐ See Attachment

ORM 63-11.1 (4/88)

Unocal Refining & Marketing Division
Unocal Corporation
3131 Elliott Avenue, P.O. Box 76
Seattle, Washington 98111
Telephone (206) 281-7666

GeoEngineers

UNOCAL 76

JUN 14 1988

Routing

File 161-13

June 13, 1988

Mr. Craig S. Baker
Washington Dept. of Ecology
Northwest Regional Office
4350 - 150th Avenue Northeast
Redmond, Washington 98052-5301

Dear Mr. Baker:

Re: SERVICE STATION 5353
Remedial Operations

UNOCAL is presently planning to resume remedial operations at the site of a leak of gasoline from our Service Station 5353 at Westlake and Mercer Street in Seattle, Washington. The spill occurred prior to May, 1980. Your department was involved at that time. From 1980 through October, 1982 a recovery system was able to recover about 41,000 gallons of fuel. Recovery efforts were terminated in 1982 with Washington Department of Ecology's concurrence.

As we all know, environmental standards have changed considerably since 1982. Based on UNOCAL's current corporate policies, we feel that it is necessary to return to the site and implement further remedial measures. We plan to install and operate a vapor extraction/incineration system to remove and treat hydrocarbon vapors that are present in the soil beneath the site. The duration of the vapor extraction program is not known at this time, but we are tentatively planning on operating such a system for up to two years.

We have contacted GeoEngineers, Inc., to assist with the design, operation and monitoring of the vapor recovery system. Attached to this letter is a brief overview of the design and operation of the system planned for this site. We expect to begin system operation during mid to late June.

We will keep Ecology informed of the operation and effectiveness of this sytem. Regular progress reports submitted by GeoEngineers will be forwarded to Ecology.

We request that you review this proposed program to determine if it satisfies the requirements of Ecology for remediation at this site. If you have any further questions about our plans for this vapor recovery system, please contact Mr. Steve Perrigo of GeoEngineers at 746-5200. Please concur with our plans by executing and returning one copy of this letter to UNOCAL.

Yours very truly,

V. L. CARLSON
Construction Engineer

VLC:ct

Attachment

cc: J. L. Ashlock
A. L. Barone
J. Miller, GeoEngineers, Inc. (w/attach)

Proposal accepted this _____ day of _____, 1988

_____
Department of Ecology

GeoEngineers

June 8, 1988

Consulting Geotechnical Engineers and Geologists

Unocal
P.O. Box 76
Seattle, Washington 98111

Attention: Mr. V.L. Carlson

Gentlemen:

Vapor Extraction System Overview
Subsurface Gasoline Leak
Unocal Service Station 5353
Westlake Avenue & Mercer Street
Seattle, Washington
File No. 0161-13-4

INTRODUCTION

This letter briefly describes the design, installation and operation of a vapor extraction system that is currently under construction at Unocal Service Station 5353 in Seattle, Washington. The purpose of the vapor extraction system is to remove hydrocarbon vapors trapped in the soil beneath the service station site and surrounding areas. The vapors have been generated as a result of volatilization of residual gasoline from contaminated soils near the water table. Methane vapors are also present beneath the site and surrounding areas. The source of the methane is probably from decomposition of sawdust fill and other organic material that is unrelated to the service station.

Service Station 5353 was the site of an 80,000-gallon leak of gasoline that occurred prior to May 1980. A free product recovery system was installed at the site and operated until October 1982. The recovery system consisted of a network of ground water/product recovery wells on the service station property. The total volume of liquid gasoline

GeoEngineers, Inc.
2405 140th Ave. NE, Suite 105
Bellevue, WA 98005
Telephone (206) 746-5200
Fax. (206) 746-5068

recovered with this system was about 41,900 gallons. Natural processes of evaporation and biodegradation have also contributed to removal of product from the site. Residual contamination still remains at the site, including soil contamination, subsurface fuel vapors, and a limited amount of free product in several monitor wells. A number of options for further site mitigation have been considered, including continued free product recovery, ground water pumping, in-situ biodegradation and soil vapor extraction. The vapor extraction option is considered to be the most practical and cost effective for this site.

VAPOR EXTRACTION SYSTEM DESIGN AND OPERATION

GENERAL

The vapor extraction system will utilize the existing free product recovery wells and recovery galleries for the collection of subsurface hydrocarbon vapors. The vapors will be collected from the large-diameter product recovery wells using a vacuum blower system. The recovered vapors will be incinerated with a Multimode Combustor unit (MMC) supplied by King, Buck/Hasstech of San Diego, California. The initial MMC unit will consist of a thermal incinerator unit to burn the high-concentration combustible gases that are expected during the first few months of system operation. As the vapor recovery program progresses, vapor concentrations in the ground are expected to decrease gradually. The initial thermal incinerator unit will be replaced with a catalytic reactor when vapor concentrations decrease to levels that are impractical to treat by direct combustion.

VAPOR COLLECTION SYSTEM

Five existing large diameter ground water/product recovery wells will be used for the collection of subsurface vapors. These wells currently have well casing perforations that extend above the water table and a gravel pack surrounding each well screen. An air-tight seal will be fitted on the manhole opening of each recovery well. Existing 3-inch-diameter pipes that are connected to each well will be extended to the

new vacuum blower. Vapor flow rates from each recovery well will be controlled by individual valves to allow flexibility in system operation. Vapor sampling ports will also be installed at each recovery well.

BLOWER SYSTEM

The vacuum system will be powered by a three-horsepower motor designed to provide a flow of about 100 CFM from the collection system. Flow from the blower system can be controlled manually if reduced flow rates are needed. Instrumentation will provide continuous information regarding flow from the blower. The blower system and the MMC will be installed within a secured fenced area along the northern edge of the service station property.

MULTIMODE COMBUSTOR UNITS

Incineration Unit: The initial thermal incineration unit is designed to treat vapors with hydrocarbon concentrations of 4000 ppm or greater. For vapor concentrations of between approximately 4000 ppm and 10,000 ppm, accessory fuel will be required to maintain combustion. Hydrocarbon destruction efficiencies of greater than 99 percent are typical for this unit. The auxiliary fuel will be natural gas supplied by Washington Natural Gas. We expect that the incineration unit will used for about 2 to 4 months at which time vapor hydrocarbon concentrations are expected to drop to below 4000 ppm. The thermal incinerator unit will then be replaced with a catalytic reactor unit.

Catalytic Unit: The catalytic unit uses a platinum catalytic reactor bed to oxidize hydrocarbon vapors at relatively low temperatures. Instrumentation will provide continuous information about the catalyst bed temperature to assure proper operation. A destruction efficiency of 95 percent is typical for this unit. The catalyst bed will be provided with an electric pre-heater to maintain proper operation temperature.

Safety: Both the thermal incinerator and catalytic units have numerous safeguards and automatic shut-off systems. Installation and operation will be performed under conditions of permits issued by the Seattle Fire Department and the Puget Sound Air Pollution Control Agency.

MONITORING

Approximately 30 subsurface monitoring points exist on the service station property and surrounding areas. These monitoring points consist of small diameter slotted PVC well screens that were installed in 1980 and 1981 to design and monitor the former free product recovery program. These monitor wells were installed to intercept the water table and are screened above the water table. We propose to monitor vapor concentrations and ground vacuum using these wells. Periodically, vapor samples will be collected to determine the ratio of fuel-derived hydrocarbon vapors to methane. Also, certain wells may be selected for the monitoring of water levels and remaining free product thickness.

We plan frequent monitoring during the initial stages of system operation to understand the dynamics of the vapor extraction system and to observe expected changes in vapor concentrations. Ultimately we plan to monitor conditions at the site on a monthly basis. Monitoring of all wells at this site is very difficult because 11 monitoring points are located in Mercer Street or Westlake Avenue and traffic on these roadways is heavy.

- o O o -

We anticipate that progress reports will be prepared for Unocal on a frequency of once every four months. Verbal reporting or interim written reports may be prepared if significant changes are noted at the site.

Yours very truly,

GeoEngineers, Inc.

Stephen C. Perrigo/by JAM

Stephen C. Perrigo
Waste Management Specialist

James A. Miller

James A. Miller
Principal

SCP:JAM:wd

V.L. CARLSON

STATE OF WASHINGTON

DEPARTMENT OF ECOLOGY

GeoEngineers JUN 23 1988

4350-150th Ave. N.E. • Redmond, Washington 98052-5301 • (206) 867-7000

JUN 27 1988

Routing OCD SF

File 0161-13-4

June 22, 1988

Mr. V. L. Carlson
Unocal Corporation
3131 Elliott Avenue
P.O. Box 76
Seattle, Washington 98111

Dear Mr. Carlson:

On June 14, 1988, we received your proposal for vapor recovery and incineration at service station 5353, located at Westlake and Mercer.

Upon review of the subject document, our approval has been given.

Sincerely,

Craig S. Baker

Craig S. Baker
Spill Response Manager
Environmental Quality

CSB:gm

RECEIVED
JUN 23 1988
MAINT. & CONT.

GeoEngineers

June 8, 1988

Consulting Geotechnical
Engineers and Geologists

Unocal
P.O. Box 76
Seattle, Washington 98111

Attention: Mr. V.L. Carlson

Gentlemen:

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Unocal Service Station 5353
Westlake Avenue & Mercer Street
Seattle, Washington
File No. 0161-13-4

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GeoEngineers, Inc.
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Bellevue, WA 98005
Telephone (206) 746-5200
Fax. (206) 746-5068

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Yours very truly,

GeoEngineers, Inc.

Stephen C. Perrigo/by JAM

Stephen C. Perrigo
Waste Management Specialist

James A. Miller

James A. Miller
Principal

SCP:JAM:wd

GeoEngineers
Incorporated

(206) 881-7900
2020 124th Ave. N.E.

P.O. Box 6325
Bellevue, WA 98008

Consulting Geotechnical
Engineers and Geologists

November 14, 1985

Union Oil Company
2901 Western Avenue
Seattle, Washington 98121

Attention: Mr. Andy Barone

Gentlemen:

Summary of Geotechnical Consultation
Subsurface Gasoline Leak
Service Station No. 5353
Westlake Avenue and Mercer Street
Seattle, Washington
File No. 161-13

INTRODUCTION AND BACKGROUND

The results of our geotechnical consultation regarding subsurface conditions at Service Station No. 5353 are presented in this letter. Our services were authorized verbally by Mr. Barone on October 17, 1985.

Service Station No. 5353 experienced an underground leak of leaded super gasoline in the spring of 1980. The total volume of gasoline lost was estimated at approximately 80,000 gallons. Subsequent gasoline recovery operations were successful in removing approximately 42,000 gallons of liquid gasoline from the subsurface. Gasoline recovery and monitoring efforts were suspended in October 1982.

Several of the monitor wells and recovery wells in the leak area had liquid gasoline floating on the water table when the recovery program was suspended. The gasoline recovery rate decreased to approximately five gallons per day at that time, and the risk of off-site migration of the remaining liquid gasoline was judged to be small.

The City of Seattle is presently evaluating options for improving the transportation system in the immediate vicinity of Station 5353. The City is also considering land use changes in association with transportation improvements. The transportation plan currently preferred by the City of Seattle involves widening of Mercer Street, combined with the construction of two reversible traffic lanes below grade. The below-grade lanes would likely be at least 15 feet deep, with approximately the lower 4 feet of the excavation extending below the present water table.

GeoEngineers was contacted by Mr. Barone with regard to potential safety hazards which may exist with future deep excavations beneath Mercer Street in the immediate vicinity of Station 5353. These hazards are related to the potential presence of liquid gasoline and/or gasoline-contaminated soil in the excavation. Mr. Barone requested that GeoEngineers review the present conditions at the site in consideration of the City's plans and advise Union Oil regarding available options.

SITE MEASUREMENTS

We visited the service station on October 25 and October 27 to assess current conditions within the monitor wells and recovery wells located on the service station property and nearby streets. Wells located in streets were measured on Sunday morning (October 27) to minimize disruption of local traffic. The thickness of liquid gasoline floating on the water table (if any) was measured, and the air space within the wells was tested for flammable vapors with an explosimeter. The results of the field measurements are tabulated below.

Results of October 1985 Well Measurements

Well No.	Gasoline Thickness (feet)	Explosimeter Reading (% Lower Explosive Limit)
1	0.17	100+
2	0.00	100+
3	0.03	100+
4A	0.37	100+
5A	0.00	100+
6	0.41	100+
7	0.30	100+
8	0.06	100+
9	0.09	100+
10	0.10	100+
11	0.00	100+
13	0.00	100+
14	0.00	100+
15	0.00	100+
16	0.00	100+
17	0.09	100+
18	0.09	100+
19	0.41	100+
24	dry	—
25	0.00	100+
26	0.04	100+
27	0.00	100+
28	0.05	100+

The well measurements indicate the presence of more than 3 inches of liquid gasoline floating on the water table in Recovery Wells 4A and 7 and in Monitor Wells 6 and 19. Lesser thicknesses of gasoline were measured in other wells, as listed above. The pattern of gasoline distribution is similar to that which existed during the later stages of the 1980-82 gasoline

recovery program. This suggests that the remaining free gasoline is relatively immobile. The explosimeter readings indicate that the gasoline vapor plume is very extensive. The boundaries of the vapor plume extend beyond the limits of the existing monitor well network.

CONCLUSIONS

Our site measurements indicate that liquid gasoline remains in the ground at and near Station 5353, despite the passing of more than five years since the occurrence of the leak and three years since termination of gasoline recovery operations. Liquid gasoline and soils contaminated by gasoline presently exist in the immediate area of excavations proposed by the City of Seattle for Mercer Street improvements.

In our opinion, if Mercer Street improvement excavations are made with subsurface conditions as they currently exist, there would be a strong likelihood of encountering liquid gasoline on the water table in portions of the excavation. The City may design the project such that the subsoils are dewatered prior to excavation. If dewatering is done, liquid gasoline could be encountered in dewatering wells located near Station 5353. Special handling or treatment may be required for water removed from the dewatering wells and the excavation area. Even if liquid gasoline is not encountered, gasoline vapors undoubtedly will be generated by excavation of contaminated soils. Confined conditions with liquid gasoline or gasoline vapors imply significant hazards to workers located in and near the excavation area.

We understand that it may be years before actual construction begins for the proposed Mercer Street improvements. The subsurface gasoline will gradually diminish during the intervening planning and design period. However, it is our opinion that the subsurface gasoline contamination associated with Station 5353 will take many years to be fully dissipated by natural processes. Excavation within soils contaminated by gasoline could present fire and explosion hazards for many years into the future, until complete dissipation occurs.

RECOMMENDATIONS

GENERAL

The technology presently exists for accelerating the rate of dissipation of subsurface gasoline through bioreclamation and soil venting. Bioreclamation was evaluated by Union Oil on a preliminary basis in 1982. Although bioreclamation may be of definite benefit in accelerating hydrocarbon dissipation, there are a number of factors which limit its practicality at this site. These include:

1. Nutrient solutions would need to be injected around the perimeter of the contaminant plume and recovered near the middle of the plume. This would necessitate construction of below-grade nutrient lines to connect with existing or new monitor wells located in Mercer Street and Westlake Avenue. The construction would require lane closures and "off-hours" work. In our opinion, public knowledge of the reasons for the work would be inevitable, and press coverage likely.
2. Effective treatment of contaminated soils in the water table zone could take 2 years or longer if full-time water pumping, nutrient injection and soil venting is done. An even longer treatment period would be necessary for contaminated soils located above the water table zone.
3. Total treatment of contaminated soil cannot be guaranteed.
4. Bioreclamation is very expensive.

In consideration of these constraints, and the uncertainties as to whether the Mercer Street improvements will ever be constructed, we do not recommend implementation of a bioreclamation program. We do recommend that efforts toward recovery of remaining liquid product be made and that site conditions be monitored and evaluated periodically. Details of these recommendations are presented later in this letter.

Gasoline contamination will likely remain in the ground for many years if bioreclamation is not done. It appears to us that it would be in Union Oil's best interest to resist plans by the City of Seattle to construct below-grade streets or underpasses in the vicinity of Station 5353. Union

Oil should keep informed of the City's plans and be prepared to disclose potential hazardous conditions to the City when the Mercer Street improvement project gets to the detailed planning or design phase. Once this disclosure has been made, it may be in your best interest to work with the City to resolve design and construction problems related to the presence of subsurface gasoline contamination.

ADDITIONAL GASOLINE RECOVERY

Recovery Wells 4A, 5A, 7, 8 9, 10 and 28 are constructed with power and plumbing to allow gasoline removal with floating "Scavenger" oil recovery pumps. The gasoline lines that are connected to these wells lead to a buried 10,000-gallon tank that is not presently used. This buried tank is equipped with a high-level float switch and alarm to prevent overfilling of the tank.

Several of the recovery wells are not deep enough to allow simultaneous gasoline recovery and water pumping. Water table depression in these wells would require deepening the wells. Water pumping would also necessitate periodic removal of the pumped water from the site or construction of new water treatment/handling facilities. In our opinion, water table depression is no longer essential for this site due to the apparent limited volume of liquid gasoline that remains in the ground and the apparent immobility of that gasoline.

We recommend that additional gasoline recovery be accomplished in Wells 4A, 7, 10 and 28 in order to increase the rate of ultimate dissipation of the gasoline and to reduce fire and explosion hazards associated with future excavations in the vicinity of Station 5353. We recommend that a single Scavenger unit be rotated through each of these four wells. The Scavenger should be operational in one of the wells for a period of one week, and then removed and placed in the next well. This rotational pumping program would result in recovery within each of the listed wells for at least one week a month.

All of the gasoline recovery lines and electrical systems should be checked prior to implementing the recommended gasoline recovery operations.

MONITORING

We recommend that the monitor wells and recovery wells be measured monthly for the presence of liquid gasoline and flammable vapors. Liquid gasoline should be removed (bailed) from all monitor wells that have gasoline thickness of 0.05 feet or greater. We have found that bailing of product from monitor wells after each round of well measurements results in more reliable data regarding product distribution and thickness than repetitive measurement of "static" wells. The gasoline and water that is removed from the monitor wells should be poured into the recovery well that currently has an active Scavenger unit. We would be pleased to provide monthly monitoring services, if you desire.

We recommend that the 10,000-gallon holding tank be measured weekly for the volume of water and gasoline. The contractor responsible for rotating the Scavenger pump should be responsible for making these stick gage measurements. The results of the weekly tank measurements will provide the basis for evaluating the performance of the recovery program and the need for pumping out the holding tank.

LIMITATIONS

We have prepared this letter for exclusive use by the Union Oil Company in evaluating response options related to subsurface gasoline contamination at Service Station No. 5353. Our interpretations of existing and future conditions at the site are based on review of 1980-82 data, evaluation limited recent data and the past experience of our firm.

Within the limitations of scope, schedule and budget, our services have been executed in accordance with generally accepted practices in this area at the time the report was prepared. No other conditions, express or implied, should be understood.

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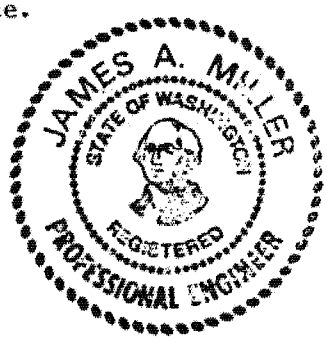
We appreciate the opportunity to be of service. Please call if you have any questions regarding this letter or if we may be of additional assistance.



Yours very truly,

GeoEngineers, Inc.

James A. Miller

James A. Miller
Associate

JAM:wd

Three copies submitted