Texaco Refining
and Marketing Inc

108 Cutting Boulevard
Richmond CA 94804

April 21, 1993

ENV-STUDIES, SURVEYS & REPORTS
930 Springtown Blvd., Livermore, CA

Ms. Eva Chu
Alameda County Department of Environmental Health
80 Swan Way, Room 200
Oakland, CA 94621

Dear Ms. Chu:

Enclosed are the following reports for the former Texaco Service Station located at the above referenced site:

1) Quarterly Groundwater Monitoring Letter Report, dated February 4, 1993, covering the third quarter 1992

2) Quarterly Groundwater Monitoring Letter Report, dated March 31, 1993, covering the fourth quarter 1992

3) Extraction Well Installation and Feasibility Testing Report, dated January 5, 1993

If you have any questions, I may be reached at (510) 236-3611.

Sincerely,
Texaco Environmental Services

Karel Detten

Karel Detterman, R.G.
Project Coordinator

KLD:kld

C:\KLD\COVER1.WKB
A:\COVER\COVER1.WKB
C:\KLD\CC

Attachments

cc: HRPearson-RRZielinski

Regional Water Quality Control Board
2101 Webster Street, Suite 500
Oakland, CA 94612

Mr. Bob Vasquez
The Southland Corporation
5820 Stoneridge Mall Road, Suite 310
Pleasanton, CA 94588-3201

pr: GRT

Weiss Associates
Environmental and Geologic Services
5500 Shellmound Street, Emeryville, CA 94608-2411
Fax: 510-547-5043 Phone: 510-547-5420

EXTRACTION WELL INSTALLATION AND FEASIBILITY TESTING REPORT

at

Former Texaco Service Station
930 Springtown Boulevard
Livermore, California

prepared for

Ms. Karel Detterman
Environmental Geologist
Texaco Environmental Services
108 Cutting Boulevard
Richmond, CA 94808

prepared by

Weiss Associates
5500 Shellmound Street
Emeryville, California 95608

January 5, 1993

Weiss Associates

EXTRACTION WELL INSTALLATION AND FEASIBILITY TESTING REPORT

at

Former Texaco Service Station
930 Springtown Boulevard
Livermore, California

prepared for

Texaco Environmental Services
108 Cutting Boulevard
Richmond, CA 94808

Bob Riddell

Bob Riddell, P.E. #C049629
Project Engineer

Weiss Associates work for the Former Texaco Service Station, 930 Springtown Boulevard, Livermore, California, was conducted under my supervision. To the best of my knowledge, the data contained herein are true and accurate and satisfy the scope of work prescribed by the client for this project. The data, findings, recommendations, specifications or professional opinions were prepared in accordance with generally accepted professional engineering and geologic practice. We make no other warranty, either expressed or implied.

Joseph P. Theisen
No. EG-1645

Joseph P. Theisen, C.E.G. #1645
Senior Hydrogeologist

CONTENTS

CONTENTS (continued)

TABLES

FIGURES

APPENDICES

SUMMARY

In October and November 1992, Weiss Associates' installed three wells and conducted feasibility testing at the Former Texaco Service Station located at 930 Springtown Boulevard, Livermore, California. The objective of the well installation and feasibilty testing was to assess the effectiveness of ground water extraction, vapor extraction and air sparging technologies at this site and to obtain data necessary to properly design and operate a future remediation system.

During the well installation phase, WA drilled two soil borings and installed one ground water extraction well, one vapor extraction well and one air sparge well. Sediments encountered during drilling consisted of sand, gravelly sand and silty sand interbedded with silty and clayey units. The highest hydrocarbon concentration detected in soil was 1,200 ppm TPH-G in boring B-1 at 14.4 ft depth. The highest hydrocarbon concentrations were detected just below the water table, which was at about 13 ft below grade.

Aquifer test results indicate that ground water extraction from well EW-1 may capture most of the hydrocarbon-bearing ground water beneath the site. Also, because EW-1 may be screened in a coarse-grained channel deposit, extracting ground water from this zone should mitigate offsite migration of hydrocarbons. If ground water extraction from well EW-1 is implemented, we recommend continued monitoring of ground water levels and contaminant concentrations in onsite and offsite monitoring wells to assess whether ground water extraction from EW-1 sufficiently removes and/or contains the dissolved contaminants beneath the site.

Vapor extraction test results indicate that soil vapor extraction (SVE) from existing wells should effectively remove hydrocarbons from the subsurface, but that the effectiveness of SVE varies in site wells. For example, SVE from well MW-5 achieved a hydrocarbon removal rate of about 127 pounds per day (ppd) while SVE from wells MW-B and VE-1 achieved about 12 and 0.3 ppd, respectively. A comparison of these recent test results with the previous testing indicates that hydrocarbon concentrations in vapor extracted during the recent tests were higher from both well MW-5 and MW-B, with the concentrations from MW-B significantly exceeding the previous test results. Although the effective radii of influence are considered low to moderate, SVE from site wells would remove hydrocarbons most readily from the high permeability materials and would encourage *diffusion* from the low permeability materials and ground water into the high permeability materials within the SVE system's zone of influence. Additional wells may be required to effect the entire subsurface area of concern. Also, oxygen circulation caused by SVE should enhance natural biodegradation of subsurface hydrocarbons in ground water and soil.

Air sparging test results indicate that air sparging with vapor extraction effectively removes hydrocarbons from the subsurface at this site. During this air sparging testing the hydrocarbon concentrations in extracted vapor increased about ten-fold and then decreased when air sparging ceased. The effective radius of influence for air sparging from air sparge well SP-1 is about 8 to 15 ft based on subsurface pressure/vacuum and water level measurements. Air sparging effectiveness based on other monitored parameters was essentially inconclusive since these parameters usually require testing for one week or longer to be effective indicators. Test results indicate air sparging would be effective at this site, although

it would be more effective if site soils were more permeable and if higher vapor extraction flow rates were achievable.

Because each technology is relatively effective at this site, the chosen technology or combination of technologies depends on remediation goals and schedule and extent of hydraulic control desired. The technology comparison in Section 7 presents information for selecting the desired remediation approach for this site.

1. INTRODUCTION

This report presents the results of Weiss Associates' extraction well installation and feasibility testing at the former Texaco Service Station located at 930 Springtown Boulevard, Livermore, California (Figure 1). The primary objective of the well installation and feasibilty testing was to assess the effectiveness of ground water extraction, vapor extraction and air sparging technologies at this site and to obtain data necessary to properly design and operate a future remediation system.

1.1 SCOPE OF WORK

Weiss Associates' scope of work for this project was to:

- Prepare a Site Safety Plan,
- Install one ground water extraction well, one vapor extraction well and one air sparge well,
- Develop ground water extraction well EW-1 and analyze the water samples for TPH-G and BETX,
- Conduct an aquifer test for 24 hours from ground water extraction well EW-1 and analyze an effluent ground water sample,
- Conduct a vapor extraction test from vapor extraction well VE-1, ground water extraction well EW-1, and existing monitoring wells MW-A, MW-B and MW-5,
- Conduct an air sparging test from the air sparge and vapor extraction well,
- Analyze selected soil samples for total petroleum hydrocarbons as gasoline (TPH-G) and benzene, ethylbenzene, toluene and xylenes (BETX),
- Provide suitable off-gas control for the vapor extraction and air sparging testing,

- Provide temporary surface protection to the installed wells and restore the site,
- Interpret the data and make recommendations for future site remediation, and
- Prepare a report suitable for regulatory submittal which presents the results of the well installation and feasibility testing.

1.2 SITE HISTORY AND PREVIOUS INVESTIGATIONS

The former Texaco service station is located adjacent to Highway 580 in a mixed residential and commercial neighborhood in northeast Alameda County in Livermore. The station retailed regular leaded, regular unleaded and premium unleaded gasoline from three underground storage tanks via one pump island. The underground storage tanks were removed on June 26, 1985. The site is currently owned by Southland Corporation and operated as a 7-11 convenience store.

Several subsurface investigations have been primarily conducted at the site. A total of twelve soil borings were drilled at the site. Ground water monitoring wells were installed in ten of the soil borings. All soil and water sample analytic results from these investigations are summarized in the Soil and Ground Water Remediation Work Plan prepared by Groundwater Technology Incorporated (GTI, 1991). The boring logs, well construction details and geologic cross-section from this work plan are presented in Appendix B. Analytic results suggest that hydrocarbons are present in soil near the underground storage tanks and in saturated soil near monitoring wells MW-A, MW-B, and MW-5, and soil boring SB-1. Analytic results for ground water suggest that elevated hydrocarbons in ground water occur mainly beneath the planter area between wells MW-5 and MW-B.

2. WELL INSTALLATION

On October 19 and 20, 1992, WA installed ground water extraction well EW-1, soil vapor extraction well VE-1 and air sparge well SP-1. The objective of the well installation was to allow testing of the effectiveness of ground water extraction, vapor extraction and air sparging technologies at this site and to obtain information for the future design of a remediation system. The wells were installed near the locations of the highest detected historical hydrocarbon concentrations in ground water and soil and were located at strategic distances from each other and existing wells for influence monitoring during the feasibility testing. The ground water extraction well was screened to recover hydrocarbons from the upper 15 to 20 ft of saturated soils. The air sparging well was screened above a low permeability zone that may have prevented the upward migration of injected air and caused spreading of hydrocarbons laterally. The vapor extraction well was screened immediately above the sparging well to recover hydrocarbon-bearing vapors displaced during air sparging. Since the air sparging and vapor extraction wells were completed in the same borehole, a hydrated bentonite seal was placed between the screened zones to prevent short circuiting of air between the screened zones in the borehole annulus. This section describes well installation activities and site restoration.

2.1 SITE SETTING

Geographic Location:	The site is located in Livermore, California, about one-quarter mile northeast of Arroyo Seco.
Topography:	The site is about 520 ft above mean sea level and situated near the base of a small hill. Local topography slopes eastward.
Surroundings:	Mixed commercial and residential development.
Site Geology:	The shallow sediments in the site vicinity are primarily alluvial sands and silty sands interbedded with clayey and silty units.

2.2 DRILLING AND SOIL SAMPLING

Drilling Dates:	October 19 and 20, 1992.
Drilling Geologist:	Eric Anderson, Weiss Associates Senior Staff Geologist.
Drilling Method:	Six-inch diameter hollow-stem augers for sampling the borings and twelve-inch diameter hollow-stem augers for well installation. Drilling and sampling procedures are described in Appendix A.
Number of Borings:	2 (one boring B-1 for well EW-1, and boring B-2 for both VE-1 and SP-1) (Figure 1).
Boring Depths:	19 to 33.5 ft.
Soil Sampling Method:	Steam-cleaned, split-barrel drive samplers lined with steam-cleaned brass or stainless steel tubes (Appendix A).
Soil Analyses:	TPH-G and BETX by EPA Methods 5030 using gas chromatography (GC) with flame ionization detection (FID) and by EPA Method 8020 using GC with photo ionization detection (PID).
Sediments Encountered:	Sand and silty sands interbedded with clayey silt and silty clay units. The boring logs and well construction details are presented in Appendix B.
Waste Disposal:	Soil cuttings were stored on plastic sheeting and covered by additional sheeting, then hauled to Zanker Road Landfill in San Jose, California after chemical characterization. Steam clean rinsate, purge water, and well development water were stored in 55-gallon drums, then pumped through granular activated carbon (GAC) with the aquifer test effluent and discharged to the sanitary sewer according to discharge permit requirements.

2.3 WELL CONSTRUCTION, DEVELOPMENT AND GROUND WATER SAMPLING

Number of Wells:	3 (Figure 1).
Well Materials:	Ground water extraction well (EW-1): 6-inch diameter Schedule 40 PVC well casing with 0.020-inch slotted screen; Monterey #3 sand. Air sparge well (SP-1): 1-inch diameter Schedule 80 PVC well casing with 0.010-inch slotted screen; Monterey #3 sand. Vapor extraction well (VE-1): 2-inch diameter Schedule 40 PVC well casing with 0.020-inch slotted screen; Monterey #3 sand.
Screened Interval:	Ground water extraction well: Approximately 8 to 33 ft depth (Appendix B). Air sparge well: Approximately 16 to 18 ft depth (Appendix B). Vapor extraction well: Approximately 7 to 12 ft depth (Appendix B).
Well Development Method:	The ground water extraction well was developed by surge block agitation and air-lift evacuation. Well development and sampling procedures are described in Appendix A. The vapor extraction and air sparge wells do not require development.
EW-1 Ground Water Evacuation Rate:	8.5 gallons per minute during well development.
Ground Water Sampling Method:	Steam-cleaned Teflon bailer. Sample collected on October 27, 1992 before aquifer and air sparge testing.
Analyses for Ground Water:	TPH-G and BETX by EPA Methods 5030, GC/FID, and 2by EPA Method 602, GC/PID.
Ground Water Depth:	Approximately 13 below grade.
Ground Water Flow Direction:	Generally northward with a gradient of 0.005 ft/ft.

2.4 ANALYTIC RESULTS FOR SOIL

Based on the results of this investigation, the highest hydrocarbon concentration detected in soil was 1,200 ppm TPH-G in boring B-1 at 14.5 ft depth (Table 1, Appendix C). The highest hydrocarbon concentrations for the previous and this investigation were generally detected downgradient of the former underground fuel storage tanks near the water table, which was about 13 ft below grade on the date of the drilling for our investigation. No hydrocarbons were detected in low permeability soil samples at 9.7 ft and 18.5 ft, but TPH-G (at 3.0 ppm) was detected in a high permeability soil unit at 24.7 ft depth, but was not detected in the same soil unit at 29.7 ft depth.

2.5 SITE RESTORATION

Site restoration consisted of disposing of all waste soil, and relandscaping by planting new ivy to match the existing ivy and replacing the wooden planter edging.

3. AQUIFER TESTING

WA conducted aquifer testing of well EW-1 on November 17 and 18, 1992. The test objectives were to determine the hydraulic characteristics of the shallow water-bearing zone beneath the site and to determine the optimal number and placement of ground water extraction wells for future site remediation. The aquifer test results indicate that ground water extraction from well EW-1 should capture most of the hydrocarbon-bearing ground water beneath the site.

3.1 PERMITTING

Aquifer test effluent was treated and discharged to City of Livermore, Water Reclamation Plant in accordance with a ground water discharge permit dated November 3, 1992 and presented in Appendix D.

3.2 AQUIFER TEST ANALYSIS AND GROUND WATER FLOW MODELING

A 24-hour drawdown test was conducted on November 17 and 18, 1992. Ground water was extracted from well EW-1 at an average flow rate of about 7.85 gallons per minute (gpm). Water level changes were recorded in test well EW-1, and monitoring wells MW-A, MW-B, MW-1, MW-2, MW-3, MW-5, and MW-7. The initial flow rate of 8 gpm was reduced to 7.5 gpm for the last 5 hours of the test to prevent dewatering the test well.

The pump test data was analyzed using the Cooper-Jacob (Cooper, 1946) semi-log method. The hydraulic responses in the monitoring wells are shown in Figure 2. Estimates of the hydraulic parameters from each well, and the distances to the extraction well are provided in Table 2. As shown in Table 2, the average transmissivity of the aquifer is estimated to be 3,400 gallons per day per foot (gpd/ft). Although most of the monitoring wells are screened over a length of 20 feet, boring logs indicate that the more permeable, sandy gravel zone is about 15 ft thick. Using this thickness, an average hydraulic conductivity value of 225 gpd/ft^2

(0.021 ft/min), and a specific storage of 0.001 ft^{-1} are estimated for this aquifer. Monitoring well MW-7 did not show any response during the extraction test, therefore, no hydraulic analysis was conducted for this well. The drawdown in the extraction well, EW-1, was significantly larger (15.5 ft) than that observed in the monitoring wells, which are very close to the test well. The excessive drawdown in the pumping well is probably due to poor well efficiency, and large well losses across the screen and within the borehole. For these reasons, the hydraulic parameters estimated for well EW-1 were not used in estimating average aquifer values.

To estimate the long term effects of pumping well EW-1, ground water extraction from the well was simulated using the analytical element models, EQUIPLOT and CAPTURE (McEdwards, 1986). EQUIPLOT calculates water level changes in a gridded area due to pumping using the Theis (1935) transient drawdown equation and by superimposing the effects of extraction at every grid cell. CAPTURE also uses the same relation but reports resulting flow paths due to pumping. Both programs require hydraulic conductivity (ft/min), regional gradient (ft/ft), direction of regional flow, specific storage (ft^{-1}), location and pumping rates (gpm) of extraction wells as input parameters.

Estimates of the hydraulic parameters from the hydraulic test analysis described above were used for model input (i.e. a hydraulic conductivity of 0.021 ft/min, a specific storage value of 0.001 ft^{-1}, and an aquifer thickness of 15 ft). The regional ground water gradient was reported as 0.05 ft/ft (GTI, 1991). This steep gradient is considered to be the result of consistently higher ground water elevations in monitoring well MW-7, which is upgradient from the other wells. Because monitoring well MW-7 did not respond to the extraction test, this well is believed to be completed in a lower hydraulic conductivity zone that is not in hydraulic communication with the wells on the northern portion of the site. This interpretation is supported by the lithologies at the site. The boring log of MW-7 in Appendix B indicates that sediments screened by this well are clay and clayey gravel, whereas the remaining site wells screen more permeable sediments. If the water level for MW-7 is disregarded, a much smaller gradient of 0.005 ft/ft is obtained from the remaining water level elevation data. The direction of regional flow is generally to the north.

The model was calibrated using EQUIPLOT and simulating the 24-hour extraction test with an average flow rate of 7.85 gpm. We compared the observed and simulated drawdowns to check the accuracy of the selected model parameters. As previously discussed, estimates of the drawdown within well EW-1 were disregarded, because of the apparent extensive well losses. Agreement between the observed and predicted drawdowns indicate that the parameters determined from the hydraulic test analyses are representative of the simulated aquifer.

Using the hydraulic parameter values from the calibrated model (listed in Table 3), a long term pumping and capture area simulation was conducted using CAPTURE. The modelling results show that a long term pumping flow rate of 5 gpm may be sustainable without dewatering extraction well EW-1. We assumed a long-term, sustainable flow rate of 5 gpm because long-term pumping rates are usually less than pumping rates obtained during short-term testing. As shown in Figure 3, the capture area predicted for this flow rate covers the entire region east of Lassen Road and south of Springtown Boulevard. In addition, the downgradient part of the capture zone nearly extends to monitoring well MW-5.

If a steeper regional gradient of 0.05 ft/ft is used with the same hydraulic parameters used to create Figure 3, a much narrower capture zone is obtained. The capture area encompasses monitoring wells MW-A, MW-B, MW-1, MW-2, and MW-3, but does not extend to monitoring wells MW-5 or MW-7. Because a gradient of 0.05 ft/ft is calculated with emphasis on a single data point (from MW-7), it is not considered to be realistic for the entire aquifer.

However, during the aquifer test, the largest drawdowns were observed in MW-1 and MW-3, suggesting these wells may be in better hydraulic communication with the extraction well, EW-1, as compared to the other monitoring wells. Therefore, ground water extraction from EW-1 may preferentially withdraw ground water from a possible channel deposit, which would result in a smaller capture than that shown in Figure 3. However, the third largest drawdown was observed in MW-5, suggesting this well may also be screened near a potential channel deposit.

4. VAPOR EXTRACTION TESTING

WA conducted vapor extraction testing on October 27, 1992 to provide information for possible SVE remediation system design and to select cost-effective vapor treatment. Although, the test results indicate that vapor extraction from existing wells should effectively remove hydrocarbons from the subsurface, the effectiveness of vapor extraction varies in site wells. In addition to evaluating vapor extraction effectiveness from new wells VE-1 and EW-1, our test also provided data to re-evaluate vapor extraction effectiveness in wells MW-A, MW-B and MW-5. These wells were tested previously on July 24, 1991 (GTI, 1991).

4.1 TEST CRITERIA AND PROCEDURES

WA conducts vapor extraction testing to obtain data on vapor extraction flow rates, vacuum requirements, hydrocarbon concentrations in extracted vapor, hydrocarbon removal rates and extent of vacuum influence. The extraction locations and durations, test equipment, and data collection and interpretation methods for our October 27 test are described below.

4.1.1 Extraction Locations and Durations

WA extracted soil vapor from vapor extraction well VE-1, ground water extraction well EW-1, and existing monitoring wells MW-A, MW-B and MW-5. We monitored vacuum influence in these and other site wells (Figure 1). These wells are located adjacent to the underground storage tanks near the highest detected hydrocarbon concentrations in soil.

We extracted soil vapor for about 15 to 30 minutes from each well, except VE-1. We performed a 2.5 hour step test on VE-1 that involved initially determining the maximum achievable extraction flow rate from the well, and then reducing the flow rate to about half this initial flow. We then resumed extraction at the full flowrate. We tested from well VE-1 longer than the other wells to help stabilize hydrocarbon concentrations in extracted vapor before air sparge testing on the following day.

4.1.2 Equipment

The test extraction equipment included a positive-displacement vacuum pump powered by a 3 horsepower explosion-proof motor, rated to produce a vacuum of 160 inches of water at various flow rates. For off-gas control, we routed extracted vapor through the test system's moisture collection drum and two 200 lb GAC adsorption vessels connected in series in accordance with vapor extraction testing requirements of the Bay Area Air Quality Management District.

4.1.3 Data Collection and Interpretation

Data collection included recording the test system's operation parameters, collecting influent and effluent vapor samples, and measuring the induced vacuum and/or pressure in site wells. The influent vacuum gauge indicated the vacuum applied to each test well. We estimated vapor extraction flow rates based on applied vacuum, differential pressure gauge readings and performance curves supplied by the vacuum equipment manufacturer.

To record vacuum influence, we sealed site wellheads and measured the induced vacuum in each location with a differential pressure gauge which indicates the difference between well pressure and atmospheric pressure. Before and after each extraction event, we measured background vacuum in all sealed wells to distinguish between pressure differences induced by atmospheric change versus pressure differences induced by vapor extraction.

To normalize vacuum influence data from each well, we subtracted the initial measured background vacuum from the final vacuum influence measurement. In some cases the background vacuum influence did not fully stabilize due to residual vacuum, atmospheric fluctuations, subsurface conditions and brief intervals between extraction tests, so we noted this on the vacuum influence data table.

WA measured hydrocarbon concentrations in extracted vapor and after each carbon adsorption vessel with a portable organic vapor analyzer/flame ionization detector (OVA/FID). We also submitted one-liter vapor samples to a state-certified analytical laboratory for analysis for TPH-G by modified EPA Method 5030 and for BTEX by modified EPA Method 8020. We collected samples for laboratory analysis near the end of each extraction event. We collected one sample at the end of both step test intervals for extraction from vent point VE-1.

Hydrocarbon removal rates were calculated using data on stabilized hydrocarbon concentrations in extracted vapor and vapor flow rates for each extraction event. Actual hydrocarbon removal rates for a dedicated SVE system may vary depending on the applied vacuum, extraction flow rates, and hydrocarbon concentration fluctuation during SVE project duration.

4.2 TEST RESULTS

The vacuum applied by the test equipment to each well ranged from 73 to 141 inches of water and induced vapor extraction flow rates ranging from about 1 to 20 standard cubic feet per minute (scfm). Hydrocarbon concentrations in extracted vapor ranged from 190 parts per million by volume (ppmv) to 20,450 ppmv TPH-G. Hydrocarbon removal rates ranged from 0.3 pound per day (ppd) to 127 ppd TPH-G.

During extraction from each well, the applied vacuum induced water upwelling into the equipment's water collection drum. Accordingly, we decreased the applied vacuum until vapor extraction flow rates maximized.

The hydrocarbon concentrations in extracted vapor were highest from MW-5 (at 20,450 ppmv TPH-G) and second highest in MW-B (at 18,450 ppmv TPH-G). However, vapor extraction is more effective from MW-5 than from MW-B because the vapor extraction flow rate was significantly higher from MW-5 (at 19.4 scfm) than from MW-B (at 2 scfm).

Table 5 summarizes test data and estimates hydrocarbon removal rates for extraction from each well. Table 6 presents test data and vacuum influence data for extraction from each well. Figure 4 presents the isobarometric contours for extraction from well VE-1. The analytical report and chain of custody forms are presented in Appendix C. We converted the hydrocarbon concentrations reported as milligrams per cubic liter of air to ppmv by dividing by the compound's molecular weight and multiplying by 24.45 which is the volume one gram-mole of perfect gas occupies at the standard temperature of 25 degrees centigrade and the standard pressure of 760 millimeters of mercury.

5. AIR SPARGING TESTING

WA conducted an air sparging test on October 28, 1992. Test results indicate that air sparging with vapor extraction effectively removes hydrocarbons from the subsurface at this site. During this air sparging testing the hydrocarbon concentrations in extracted vapor increased about ten-fold and then decreased when air sparging ceased. The effective radius of influence for air sparging from air sparge well SP-1 is about 8 to 15 ft based on subsurface pressure/vacuum and water level measurements. Air sparging effectiveness based on other monitored parameters was essentially inconclusive since these parameters usually require testing for one week or longer to be effective indicators. This longer term testing of air sparging effectiveness is often performed during a trial operation period of an installed system.

5.1 AIR SPARGING BACKGROUND

Air sparging involves injecting air below the water table to strip volatile organic compounds (VOCs) from the ground water. The VOC-laden vapors are then captured by a vapor extraction system. Air injection and vapor extraction is performed using either appropriately screened vertical wells, horizontal wells or trenches. The effective radius of influence from a vertical air sparging well is typically about 5 to 20 ft in coarse materials. Air sparging also oxygenates ground water, thereby possibly encouraging in-situ biodegradation of VOCs in ground water.

The effectiveness of air sparging is sensitive to the lithology and stratigraphy of the saturated and unsaturated zones, and to the effectiveness of vapor extraction. In highly stratified soils, injected air may travel laterally substantially before reaching the vadose zone. Generally, the lateral migration of air within the saturated zone spreads the dissolved contaminants in ground water laterally also. Vapor extraction should be designed to capture vapors emanating from the saturated zone.

Since, at the former Texaco site, an apparent confining layer from about 18 to 24 ft bgs separates the shallower, more contaminated, clayey sand and gravel unit from the deeper more permeable sand unit, hydrocarbon-bearing ground water would be remediated more efficiently from an air sparge well screened only in the shallower unit. Also, air sparging into the sandy unit below the apparent confining layer could produce air pockets which would laterally displace ground water and allow diffusion of vapor-phase hydrocarbons into previously uncontaminated ground water. Therefore, we installed the air sparge well only in the shallower clayey sand and gravel unit to reduce the risk of spreading hydrocarbons laterally below the confining layer. We screened the air sparge well from 16 to 17 ft below grade surface (bgs) based on an evaluation of the local lithology during well installation. This screen interval is about 3 to 4 ft below the static water level and is above the clayey silt sediments found at about 18 to 22 ft bgs in the bore hole. Air sparging from this well allowed more effective monitoring and evaluating of air sparging than installing and air sparging from a deeper well screened beneath the clayey silty sediments at 18 to 22 ft bgs.

For these reasons, we conducted a short-term air sparging test from a shallow air sparge well nested with a vapor extraction well to minimize the possible lateral spreading of hydrocarbons in the saturated zone.

5.2 TEST CRITERIA

WA performed the following tasks to evaluate air sparging effectiveness:

- Monitored the hydrocarbon concentration in extracted soil vapor,
- Monitored the subsurface pressure/vacuum regime,
- Monitored the water table to determine whether the air sparging caused rising water levels,
- Measured the dissolved oxygen concentrations in ground water, and
- Analyzed ground water samples from the adjacent well EW-1 for TPH-G and BTEX before and after the test.

5.3 PROCEDURES

WA extracted soil vapor from the vapor extraction well for about 2.5 hours to determine the background hydrocarbon concentrations in extracted soil vapor before air sparging. We then simultaneously injected air (sparging) and extracted vapors for about one hour while monitoring the extracted vapors for increasing hydrocarbon concentrations. We then ceased air sparging and monitored the extracted soil vapor for about one-half hour.

To help ensure full capture of the injected air, we first determined the vapor extraction rate using the test equipment, and then air sparged at a lower flow rate. This ensured that the volume of air injected was less that the total volume removed.

5.4 RESULTS

The vapor extraction flow rate from well VE-1 was about 3 scfm, therefore, we injected air at 1 scfm. The air pressure required to inject 1 scfm of air was 10 pounds per square inch (psi) initially but decreased to 5.5 psi within 10 minutes. During air sparging at about 1.1 scfm, the vapor extraction flow rate increased from 3.3 scfm to 3.7 scfm for the approximate constant applied vacuum of 95 inches of water. After air sparging the vapor extraction flow rate decreased to 3.6 scfm.

The hydrocarbon concentrations in extracted vapor increased about six-fold when air sparging started and then decreased when air sparging ceased. Figure 5 shows the TPH-G concentrations in extracted vapor before, during and after air sparging. After 2 hours of vapor extraction and before air sparging began, the hydrocarbon concentrations in extracted vapor were about 600 ppmv TPH-G. After one hour of air sparging, the hydrocarbon concentrations in extracted vapor increased to about 6,100 ppmv TPH-G. About 25 minutes after air sparging ceased, the hydrocarbon concentrations in extracted vapor decreased to about 3,500 ppmv TPH-G.

The subsurface pressure/vacuum changed most in nearby well EW-1, located about 8 ft from VE-1/SP-1, and significantly less in well MW-A, located about 20 ft away. The pressure/vacuum readings from EW-1 indicated a vacuum of 0.06 inches of water before air sparging, positive air pressure of 0.24 inches of water during air sparging, and a vacuum of 0.11

inches of water after air sparging. The pressure/vacuum readings from MW-A indicated a vacuum of 0.01 inches of water before air sparging and neither pressure nor a vacuum during air sparging. Air pressure measurements from wells EW-1 and MW-A are presented in Tables 7 and 8, respectively.

Similarly, the water levels responded most in nearby well EW-1 located about 8 ft from VE-1/SP-1 and significantly less in well MW-A located about 20 ft away. The water level in EW-1 rose 0.03 ft during vapor extraction before air sparging and rose further to 0.18 ft above the initial water level during the first 13 minutes of air sparging before lowering to 0.06 ft above the initial water level by the end of the air sparging. When air sparging ended, the water level dropped to 0.05 ft below the initial water table elevation. About one-half hour after vapor extraction and air sparging ended the water level was 0.11 ft above the initial water level elevation. The water level in well MW-A was essentially unchanged until the air sparging began, when the water level rose 0.07 ft above the initial water table elevation. After vapor extraction and air sparging the water level in MW-4 returned to the initial water table elevation. Water level measurements from wells EW-1 and MW-A are presented in Tables 7 and 8, respectively.

Dissolved oxygen concentrations in ground water fluctuated during feasibility testing as presented in Table 9. These concentration fluctuations are described in the conclusion section 6.3.

Ground water samples from well EW-1 contained 11 ppm TPH-G before the air sparging/vapor extraction test and 13 ppm TPH-G after the test.

6. CONCLUSIONS

This section discusses the conclusions of the aquifer, vapor extraction and air sparge testing.

6.1 AQUIFER TESTING

The modeling based on the aquifer test results suggests that pumping from extraction well EW-1 may be a sufficient remedial design alternative, because the capture zone should influence the regions of high contamination and much of the contaminated ground water may be extracted. Modeling results also indicate that EW-1 may be capable of a long-term, sustainable flow rate of 5 gpm. The predicted capture area for this flow rate covers the entire region east of Lassen Road and south of Springtown Boulevard. In addition, the downgradient part of the capture zone extends beneath Springtown Boulevard and nearly extends to monitoring well MW-5. Long-term pumping from EW-1 may capture ground water from well MW-5.

However, the extraction well may be screened within a channel deposit, hence the capture area may be smaller than that shown in Figure 3. A coarser-grained channel deposit would provide a preferred migration pathway for contaminants beneath the site. Extracting ground water from this zone would therefore mitigate further offsite migration of the contaminants.

In conclusion, we **recommend utilizing EW-1 as an extraction well to remove contaminated ground water beneath the site.** We also recommend continued monitoring of ground water levels and contaminant concentrations in onsite and offsite monitoring wells to assess whether ground water extraction from EW-1 sufficiently removes and/or contains the dissolved contaminants beneath the site.

6.2 VAPOR EXTRACTION TESTING

SVE test results indicate that SVE from existing wells should effectively remove hydrocarbons from the subsurface, but that the effectiveness of SVE varies in site wells. For example, SVE from well MW-5 achieved a hydrocarbon removal rate of about 127 pounds per day (ppd) while SVE from wells MW-B and VE-1 achieved about 12 and 0.3 ppd, respectively. Also, because the influence area from most wells is considered low to moderate, additional wells may be required to effect the subsurface area of concern. A comparison of these recent test results with the previous testing indicates that hydrocarbon concentrations in extracted vapor the recent tests were higher from both well MW-5 and MW-B, with the concentrations from MW-B significantly exceeding the previous test results.

The varying effectiveness and irregular vacuum influence measurements suggest that the coarser grained interbedded materials in the site subsurface may be acting as subsurface conduits for vapor flow. For example, the vacuum of 73 inches of water applied to MW-5 induced about 0.06 inches of water in well MW-B and MW-3, while it induced only 0.01 inches of water in MW-A, located closer to MW-5 than either MW-B or MW-3. Vacuum influence readings during extraction from well VE-1 were more predictable. The vacuum of 141 inches of water applied to VE-1 induced about 3.5 inches of water in well EW-1 and 0.1 inches of water in well MW-A. The effective radii of influence for extraction from MW-5 and VE-1, typically defined as one percent of the applied vacuum, is about 30 and 12 ft, respectively.

Although the effective radii of influence seem relatively low, SVE from site wells would remove hydrocarbons most readily from the high permeability materials and would encourage diffusion from the low permeability materials and ground water into the high permeability materials within the SVE system's zone of influence. Also, oxygen circulation caused by SVE should enhance natural biodegradation of subsurface hydrocarbons in ground water and soil.

SVE effectiveness could be enhanced by installing additional wells or a trench. However, trench installation would be very disruptive and vapor extraction from a trench would predominantly remove hydrocarbons from the higher permeability materials similar to extraction from the site wells. SVE effectiveness would also be enhanced if it were performed in conjunction with ground water extraction as described in Technology Comparison Section 7 below.

Selection of the most cost-effective vapor treatment method for SVE is based on the estimated vapor flow rates and hydrocarbon concentrations in extracted soil vapor over the anticipated project duration. Although it is not possible to predict long term hydrocarbon concentrations based on this one day test, hydrocarbon concentrations are expected to remain high initially and decrease with time. Since hydrocarbon mass removal rates experienced during the test peaked at 127 ppd TPH-G, we recommend using an available Texaco-owned catalytic or thermal/catalytic oxidizer until the hydrocarbon mass removal rates decrease to about 5 to 10 pounds per day. This may require about 30 to 60 days at this site. For a hydrocarbon mass removal rate of about 10 pounds per day, carbon adsorption is typically the most cost-effective vapor treatment method. However, it may be more cost-effective to use the oxidizer for the duration of the project than to design, permit and install a carbon adsorption system. Conversely, if Texaco does not have a catalytic or thermal/catalytic oxidizer available, it may be more cost-effective to permit, install and operate a carbon adsorption system for the project duration.

6.3 AIR SPARGE TESTING

Test results indicate that air sparging with vapor extraction effectively removes hydrocarbons from the subsurface at this site. During this air sparging testing the hydrocarbon concentrations in extracted vapor increased about ten-fold and then decreased when air sparging ceased. The **effective radius of influence for air sparging from air sparge well SP-1 is about 8 to 15 ft based** on subsurface pressure/vacuum and water level measurements. Air sparging effectiveness based on other monitored parameters was essentially inconclusive since these parameters usually require testing for one week or longer to be effective indicators.

Test results indicate air sparging would be effective at this site, although it would be more effective if site soils were more permeable and if higher vapor extraction flow rates were achievable.

The ten-fold increase in TPH-G concentrations in extracted vapor indicates that sparging increased hydrocarbon removal from the saturated zone. This suggests that hydrocarbons are removed by stripping them from ground water or by the creation of new vapor flow pathways through the saturated and unsaturated zones. The air sparging well may be essentially serving as an air inlet well within the saturated zone where hydrocarbons are adsorbed to soil. With this air sparging well, more air is drawn from within the saturated and lower unsaturated zone, and less air is drawn from the unsaturated zone and the ground surface.

Based on the subsurface pressure/vacuum and water level measurements, the effective radius for air sparging radius from SP-1 is between 8 to 15 ft. We estimate this range because the subsurface pressure/vacuum and water levels changed most in nearby well EW-1 located about 8 ft from VE-1/SP-1 and significantly less in well MW-A located about 20 ft away. In both monitored wells, the water level rose during air sparging despite the increased pressure within the wells. This suggests that the air sparging caused enough of a water table rise in this area to overcome the increased pressure in the wells caused by air sparging.

The subsurface pressure/vacuum and water levels may also suggest that air sparging caused more water table rise initially, but then as the injected air developed preferential flow paths it displaced ground water around the well and depressed water in the subsurface due to the increased subsurface pressure. This suggests that longer term testing at different flow rates could test the effectiveness of air sparging at different flow rates. This also suggests that air sparging effectiveness is enhanced by cycling operation on and off to create different flow paths thereby effecting more soil and ground water. Although this may also suggest that deeper air sparging wells would be more effective for air sparging, air sparging from deeper wells at this site may penetrate the apparent confining layer at 18 to 22 ft bgs and cause lateral spreading of hydrocarbons in ground water.

The effective radius for air sparging could be assessed further during a longer test or during system operation by evaluating the dissolved oxygen and hydrocarbon concentrations and hydrocarbon-degrading microbial populations in ground water. Increasing dissolved oxygen concentrations and hydrocarbon-degrading microbial populations, as well as decreasing hydrocarbon concentrations in monitored wells would indicate air sparging was effective in those wells.

If an air sparging system is installed at this site, we would recommend cycling the system on and off to vary the vapor flow paths within the saturated zone, to minimize the possible lateral spreading of hydrocarbons in the saturated zone, and to minimize energy costs. We would also recommend installing one or two additional air sparging and vapor extraction wells between MW-A and MW-5, and installing one air sparge well near MW-5.

7. TECHNOLOGY COMPARISON

Test results indicate that each of the evaluated technologies may be effective at this site. However, the remediation effectiveness of each technology will vary, depending on the specific advantages and limitations of the individual techniques. To select the optimal remedial approach for the site, WA compared each technology and combinations of technologies. The results of this review are presented below.

7.1 GROUND WATER EXTRACTION

Ground water extraction (GWE) is a proven and reliable remedial technology to hydraulically contain and remediate hydrocarbon-bearing ground water. GWE would remove hydrocarbons from the saturated zone, but would not remediate hydrocarbons in the unsaturated zone. Therefore, using this technique alone may allow hydrocarbons in unsaturated soil to continue to impact ground water quality. The effectiveness of this method is dependent upon the extraction well locations relative to the mass of hydrocarbon-bearing ground water and the subsurface hydrogeology.

The aquifer test results indicate that ground water extraction from EW-1 should hydraulically contain the hydrocarbon-bearing ground water at this site. If hydrocarbons have migrated off-site further than estimated, then GWE from EW-1 alone may not draw these off-site hydrocarbons back to the site. GWE typically requires a minimum of 5 years to achieve remediation objectives.

7.2 SOIL VAPOR EXTRACTION

SVE is a proven and reliable remedial technology for removing hydrocarbons from the unsaturated zone. SVE from site wells would remove hydrocarbons most readily from the high permeability materials and would encourage hydrocarbon diffusion from the low permeability materials into the high permeability materials within the SVE system's zone of influence. SVE should also improve ground water quality at the site by inducing benzene and hydrocarbon diffusion from ground water and possibly by supplying oxygen to naturally occurring micoorganisms that degrade organic materials, therefore, encouraging in situ biodegradation of hydrocarbons. Although SVE may improve ground water quality, it would not hydraulically contain hydrocarbon-bearing ground water at the site. Unfortunately, the SVE test results indicated limited SVE effectiveness except from well MW-5. SVE would be most effective with a series of extraction and air inlet trenches although this may not be very cost-effective and would certainly entail significant site disruption. SVE typically requires about 6 months to 2 years to achieve unsaturated zone remediation objectives.

7.3 COMBINED GROUND WATER AND SOIL VAPOR EXTRACTION

Combined ground water and soil vapor extraction is a proven technology for removing hydrocarbons from the saturated and unsaturated zones and achieving remediation objectives faster than ground water extraction alone. The vacuum applied by SVE would enhance ground water extraction flow rates thereby enhancing hydraulic control. Also, GWE would depress the water table, limiting the upwelling effects caused by SVE and exposing previously saturated soil to the air stream induced by SVE. This is especially useful since ground water fluctuations create a zone of high residual hydrocarbon-saturated soil both above and below the average water table elevation. Combined ground water and soil vapor extraction also offers the same advantages as the individual techniques discussed above.

7.4 AIR SPARGING WITH SOIL VAPOR EXTRACTION

Air sparging with soil vapor extraction is an innovative and relatively new technology for removing hydrocarbons from ground water and saturated soil. Test results indicate that air sparging would remove hydrocarbons from the saturated zone by stripping hydrocarbons from ground water or by creating vapor flow through the saturated zone. Air sparging should also oxygenate ground water, thereby, possibly encouraging in-situ biodegradation of VOCs in ground water.

A trial period of air sparging could be performed in conjunction with SVE to more fully evaluate air sparging effectiveness for this site. If air sparging with SVE effectively remediates the saturated zone then ground water extraction would be unnecessary. However, air sparging would not hydraulically contain the hydrocarbon-bearing ground water.

Test results indicate that the effective radius for air sparging is about 8 to 15 ft. Therefore, to implement this technology at this site, we would recommend installing one air sparge well near MW-5 and one or two air sparge and vapor extraction wells between MW-A and MW-5. We would recommend cycling the system on and off to vary the vapor flow paths within the saturated zone, to minimize the possible lateral spreading of hydrocarbons in the saturated zone, and to minimize energy costs. We would also recommend installing one or two additional air sparge and vapor extraction wells between MW-A and MW-5, and installing one air sparge well near MW-5.

Unfortunately, the effectiveness of air sparging is sensitive to the lithology and stratigraphy of the saturated and unsaturated zones, and to the effectiveness of vapor extraction. In the highly stratified soil at this site, injected air may travel laterally substantially before reaching the vadose zone, and spread the dissolved contaminant plume. Vapor extraction should be designed to capture vapors emanating from the saturated zone.

7.5 COMBINED GROUND WATER AND SOIL VAPOR EXTRACTION AND AIR SPARGING

Implementing all the technologies simultaneously should prove very effective and should achieve the remediation objectives quickly. However, this combination approach would probably be more expensive than the other approaches. This combined approach would have the advantages of each of the individual techniques discussed above.

8. REFERENCES

Cooper, H.,H., and C. E. Jacob, 1946, A generalized graphical method for evaluating formation constants and summarizing well field history, Am. Geophys. Union Trans. 27, pp. 526-534.

McEdwards, D., 1986, Equiplot: A program for generating a grid of ground water elevations for extraction wells in uniform ground water flow, Data Services, Petaluma, CA.

Groundwater Technology Inc., 1991, Work Plan for Soil and Ground Water Remediation at Former Texaco Service Station, 930 Springtown Boulevard, Livermore, California, 9 pp. and appendices.

Table 1. Analytic Results for Soil, Former Texaco Service Station, 930 Springtown Boulevard, Livermore, California

Boring/ Sample ID	Sample Depth (ft)	Date Sampled	Analytic Method	Sat/ Unsat	TPH-G	B	E	T	X
					<------------	------------	mg/kg (ppm)	------------	------------>
B-1	9.7	10/19/92	5030/8020	Unsat	<1.0	<0.005	<0.005	<0.005	<0.005
(EW-1)	14.5	10/19/92	5030/8020	Sat	1,200	6.6	15	21	50
	24.7	10/19/92	5030/8020	Sat	3	0.017	0.050	0.051	0.21
	29.5	10/19/92	5030/8020	Sat	<1.0	<0.005	<0.005	<0.005	<0.005
B-2	14.5	10/20/92	5030/8020	Sat	1,000	7.1	13	22	56
(VE-1/	16.7	10/20/92	5030/8020	Sat	990	2.9	14	15	53
SP-1)	18.5	10/20/92	5030/8020	Sat	<1.0	0.007	<0.005	0.029	<0.005

Abbreviations:

TPH-G = Total petroleum hydrocarbons as gasoline by Modified EPA Method 8015
B = Benzene by EPA Method 8020
E = Ethylbenzene by EPA Method 8020
T = Toluene by EPA Method 8020
X = Xylenes by EPA Method 8020
ppm = parts per million

Analytical Laboratory:

Mobile Chem Labs Inc., Martinez, California

Analytic Methods

5030 = Purge and trap by EPA Method 5030 with flame ionization detector (FID) for TPH-G

8020 = EPA Method 8020 for BETX

Table 2. Hydraulic Parameters Estimated Using Cooper-Jacob (1946).

Well	Transmissivity (gpd/ft)	Hydraulic Conductivity (gpd/ft2)	Specific Storage (ft^{-1})	Distance to Pumping well (ft)
EW-1*	340*	23*	-	-
MW-A	4,700	310	0.05	12
MW-B	5,600	370	0.004	50
MW-1	910	60	0.0002	78
MW-2	5,950	400	0.002	88
MW-3	920	61	0.0008	45
MW-5	2,200	150	0.0002	75
MW-7*	-	-	-	130
Average	3,400	225	0.001	-

*Not used in averaging.

Table 3. Hydraulic Parameters Used in EQUIPLOT and CAPTURE Models.

Parameter	Value used in the simulations
K - Hydraulic conductivity	0.021 ft/min
b - Aquifer thickness	15.0 ft
i - Local gradient	0.005 ft/ft to North
Q - Extraction rate	5.0 gpm at steady state

Table 4. Analytic Results for Ground Water - Former Texaco Service Station, 930 Springtown Boulevard, Livermore, California

Well	Date Sampled	Analytic Method	Analytic Laboratory	TPH-G	B	E	T	X
				<------------------------parts per billion (µg/l)-------------------->				
EW-1 Before Air Sparge Test	10/27/92	602/5030	MC	11,000	410	540	2,000	2,100
EW-1 After Air Sparge Test	10/27/92	602/5030	MC	13,000	840	580	2,400	1,900
EW-1 (Pump Test Effluent After 24 Hours Before Treatment)	11/18/92	602/5030	MC	4,300	140	96	340	560
EW-1 (Pump Test Effluent After 24 Hours After Treatment)	11/18/92	602/5030	MC	<50	<0.5	<0.5	<0.5	<0.5

Abbreviations:

TPH-G = Total petroleum hydrocarbons as gasoline by Modified EPA Method 8015
B = Benzene by EPA Method 602
E = Ethylbenzene by EPA Method 602
T = Toluene by EPA Method 602
X = Xylenes by EPA Method 602
<n = Not detected at detection limits of n ppb

Analytical Laboratory:

MC = Mobile Chem Labs, Inc., Martinez, California

Analytical Methods:

602 = EPA Method 602 for BETX
5030 = EPA Method 5030 for TPH-G

Table 5. Soil Vapor Extraction Test Data, Former Texaco Service Station, 930 Springtown Boulevard, Livermore, California

WELL ID	EXPOSED SCREEN DEPTH (a) (ft-ft)	VACUUM APPLIED (inches water)	FLOW (scfm)	ELAPSED TIME (min)	INLET HYDROCARBON CONCENTRATIONS(b) (ppmv)		MASS REMOVAL RATE(c) (lbs/day)	
					TPH-G	BENZENE	TPH-G	BENZENE
EW-1	8-12.0	101	5.6	0-18	425	4	0.8	0.007
MW-A	4-12.7	92	1.1	0-24	900	9	0.3	0.003
MW-B	4-11.6	84	2	0-14	18,450	350	11.8	0.204
MW-5	5-11.9	73	19.4	0-22	20,450	110	127.3	0.621
VE-1	7-12.0	79	2.2	0-34	1,300	18	0.9	0.012
		141	5.2	34-138	190	3	0.3	0.005

Notes:

(a) = Depth interval below grade surface between top of well screen and ground water (nearest 0.1 feet).

(b) = Analysis for Total Petroleum Hydrocarbons as Gasoline (TPH-G) and Benzene by Modified EPA Method 5030 and 8020. The concentrations reported as milligrams per cubic meter are converted to ppmv by dividing by the compound molecular weight and multiplying by 24.45 which is the volume one gram-mole of perfect gas occupies at the standard temperature and pressure of 25 degrees centigrade and 760 millimeters of mercury.

(c) = Mass removal rate based on Bay Area Air Quality Management District's Manual of Procedures for Soil Vapor Extraction dated July 17, 1991. Rate = concentration(ppmv) x flowrate(scfm) x (1 lb-mole/386ft3) x molecular weight (86 lb/lb-mole for TPH-G as Hexane, 78 for Benzene) x 1440 min/day.

scfm = Standard cubic feet per minute.

ppmv = Parts per million by volume.

Table 6. SVE Vacuum Influence Data, Former Texaco Service Station, 930 Springtown Boulevard, Livermore, California

Test Location (ID)			VE-1		VE-1		EW-1	
Step Test (#)			1		2		1	
Applied Vacuum ("H_2O)			79		141		101	
Flow Rate (scfm)			2.2		5.2		5.6	
Step Test Duration (min)			0-34		34-143		0-18	
Probe/ Well ID	Exposed Screen Depth[a] (ft-ft)	Est. Perm. in Exposed Screen[b]	Distance[c] from Test Point (ft)	Vacuum[d] Influence ("H_2O)	Distance[c] from Test Point (ft)	Vacuum[d] Influence ("H_2O)	Distance[c] from Test Point (ft)	Vacuum[d] Influence ("H_2O)
EW-1	8-12.0	L,M	8	1.0	8	3.5	---	---
MW-A	4-12.7	L	20	0.02	20	0.10	13	0.5
MW-B	4-11.6	L	42	0.005	42	0.005	51	0.005
MW-2	5-11.8	L,M	78	0.005	78	0.005	87	---
MW-3	5-12.8	L,M	39	0.005	39	0.005	45	0
MW-5	5-11.9	L	85	0.005	85	0.0075	76	0.005
MW-6	5-15.8	L,H	139	---	139	---	130	---
VE-1	7-12.0	L,M	---	---	---	---	8	P

Notes:

a = Depth interval below grade surface between top of well screen and ground water (nearest 0.1 feet).
b = Estimated permeability of materials in unsaturated zone around well screen expressed as low, moderate or high; L = Low; M = Moderate; H = High
c = Distances between well(s) were taken from site map.
d = Vacuum influence is reported at final recorded vacuum measurement minus initial background vacuum measurement.
P = Pressure measured or vacuum decreased at monitoring point during test.
--- = Not measured

Table 6. SVE Vacuum Influence Data, Former Texaco Service Station, 930 Springtown Boulevard, Livermore, California (continued)

Test Location (ID)			MW-A		MW-B		MW-5	
Step Test (#)			1		1		1	
Applied Vacuum ("H_2O)			92		84		73	
Flow Rate (scfm)			1.1		2		19.4	
Step Test Duration (min)			0-24		0-14		0-22	
Probe/ Well ID	Exposed Screen Depth[a] (ft-ft)	Est. Perm. in Exposed Screen[b]	Distance[c] from Test Point (ft)	Vacuum[d] Influence ("H_2O)	Distance[c] from Test Point (ft)	Vacuum[d] Influence ("H_2O)	Distance[c] from Test Point (ft)	Vacuum[d] Influence ("H_2O)
EW-1	8-12.0	L,M	13	0.025	51	0.02	76	P
MW-A	4-12.7	L	---	---	60	P	67	0.01
MW-B	4-11.6	L	60	e	---	---	126	0.06
MW-2	5-11.8	L,M	96	0	39	0	164	---
MW-3	5-12.8	L,M	50	P	30	0.01	115	0.055
MW-5	5-11.9	L	67	0.005	126	0	---	---
MW-6	5-15.8	L,H	120	---	182	---	60	---
VE-1	7-12.0	L,M	20	0.005	42	0	85	0.005

Notes:

a = Depth interval below grade surface between top of well screen and ground water (nearest 0.1 feet).
b = Estimated permeability of materials in unsaturated zone around well screen expressed as low, moderate or high; L = Low; M = Moderate; H = High
c = Distances between well(s) were taken from site map.
d = Vacuum influence is reported at final recorded vacuum measurement minus initial background vacuum measurement.
e = Vacuum influence measurements during test were less than the initial background reading.
P = Pressure measured or vacuum decreased at monitoring point during test.
--- = Not measured

Table 7. Air Pressure and Water Level Measurements in Well EW-1 During Air Sparging Test

Clock Time	Test Time (minutes)	Pressure ("H2O)	Depth to Water (ft)	Change From Initial H20 Level (ft)	Comments
01:15 PM	0	0.00	12.21	0	Soil Vapor Extraction Start
02:43 PM	88	-0.06	12.18	0.03	
03:29 PM	134	-0.06	---	---	
03:39 PM	144	---	---	---	Air Sparging Start
03:43 PM	148	0.07	12.08	0.13	
03:44 PM	149	0.105	12.03	0.18	
03:52 PM	157	0.13	12.04	0.17	
04:00 PM	165	0.145	12.09	0.12	
04:15 PM	180	0.175	12.12	0.09	
04:30 PM	195	0.23	12.14	0.07	
04:45 PM	210	0.24	12.15	0.06	
04:47 PM	212	---	---	---	Air Sparging Off
04:57 PM	222	-0.11	12.26	-0.05	
05:14 PM	239	---	---	---	Soil Vapor Extraction Off
05:45 PM	270	0.00	12.10	0.11	

Table 8. Air Pressure and Water Level Measurements in MW-A During Air Sparging Test

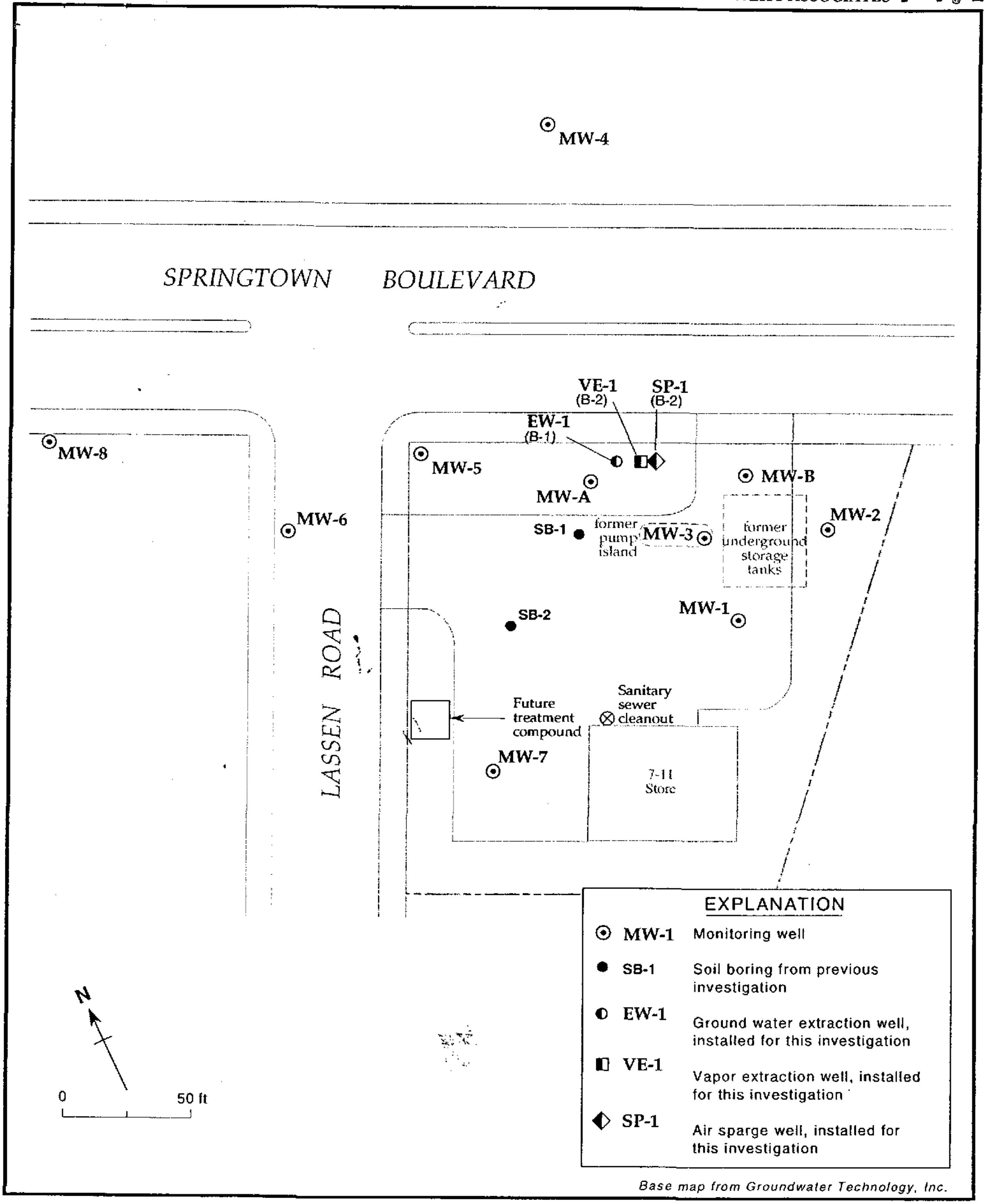
Clock Time	Test Time (minutes)	Pressure ("H2O)	Depth to Water (ft)	Change From Initial H20 Level (ft)	Comments
12:30 PM	0	-0.005	14.00	0	
01:00 PM	30	-0.01	14.03	-0.03	
01:15 PM	45	---	---	---	Soil Vapor Extraction Start
02:45 PM	135	-0.02	14.02	-0.02	
03:30 PM	180	-0.01	14.02	-0.02	
03:39 PM	189	---	---	---	Air Sparging Start
03:47 PM	197	0.00	13.93	0.07	
04:52 PM	262	---	---	---	Air Sparging Off
05:14 PM	284	---	---	---	Soil Vapor Extraction Off
05:20 PM	290	0.00	14.04	-0.04	

Table 9. Dissolved Oxygen Measurements During Air Sparge Testing

Well	Before SVE Test 10/27/92 11:00 AM	Before SVE/ Sparge Test 10/28/92 08:45 AM	After SVE/ Sparge Test 10/28/92 05:26 PM	Before Pump Test 11/09/92 01:25 PM
EW-1	5.5	3.7 a 4.9 b	5.2	4.2
MW-A	2.9	1.3	2.3	3.3
MW-B	3.9	2.8	2.4	3.7

Notes:

a = Prior to ground water sampling
b = After ground water sampling
SVE = Soil Vapor Extraction



Base map from Groundwater Technology, Inc.

Figure 1. Site Plan and Well Location Map - Texaco Refining and Marketing Inc., 930 Springtown Boulevard, Livermore, Califonia

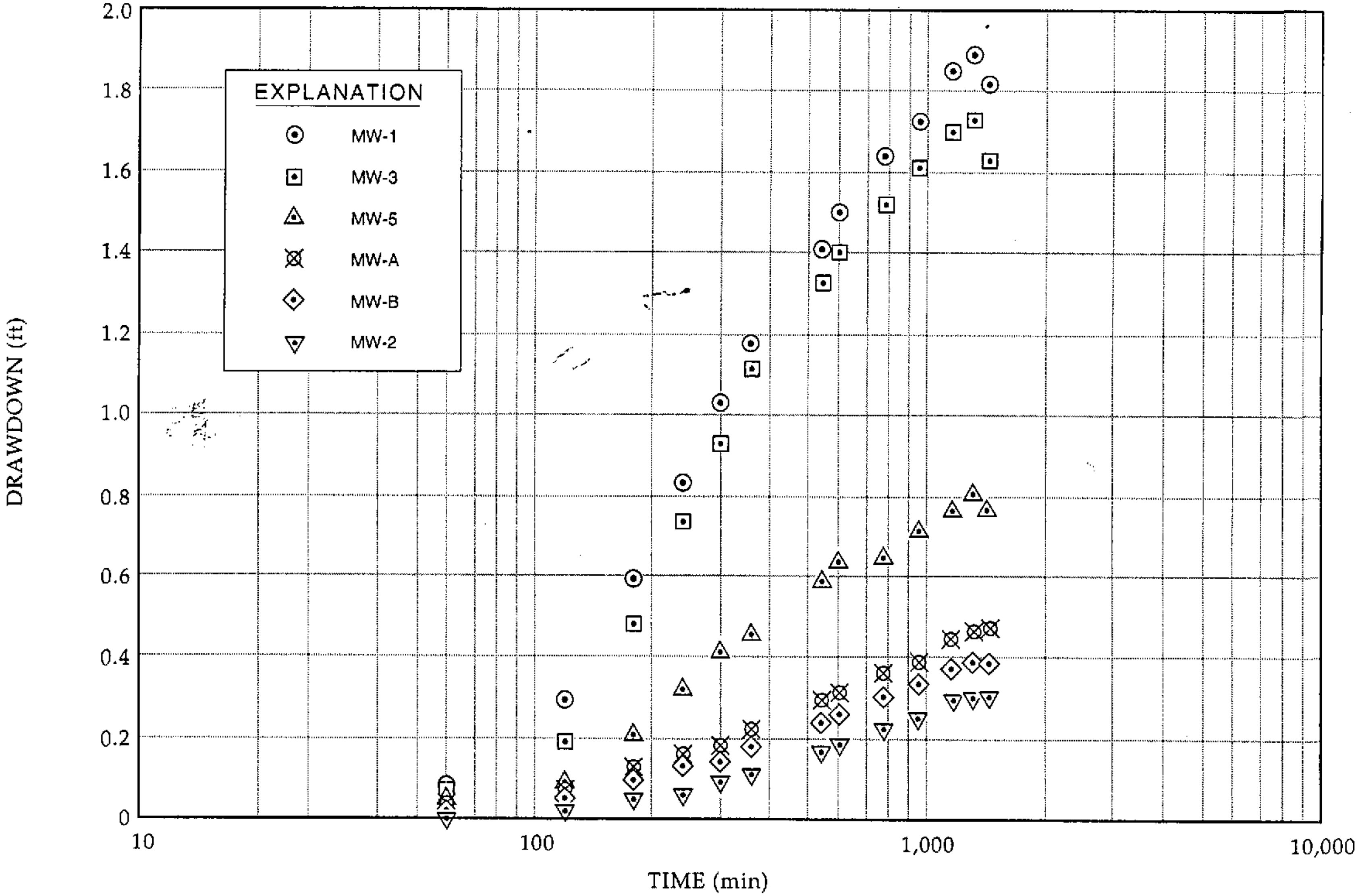
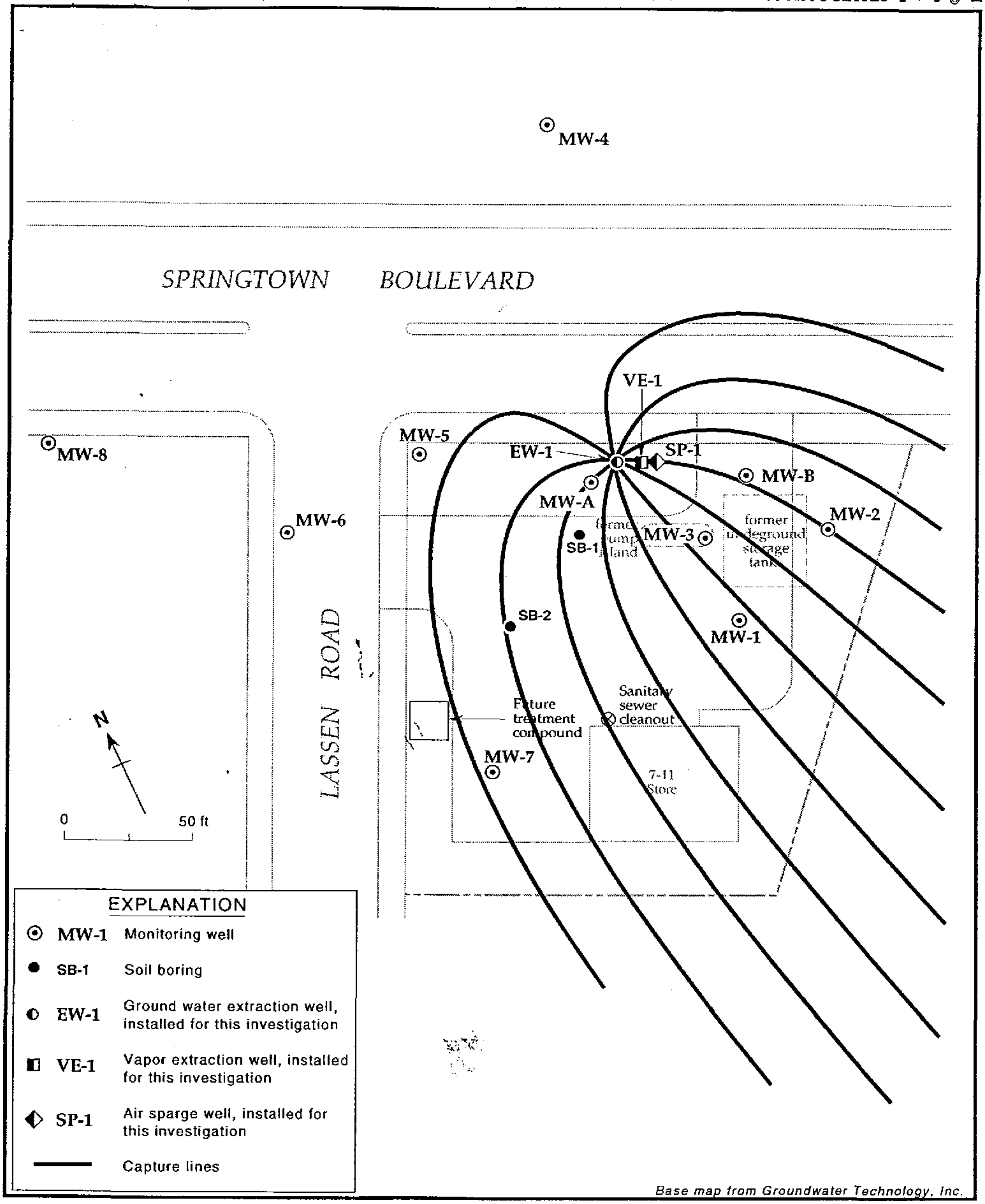


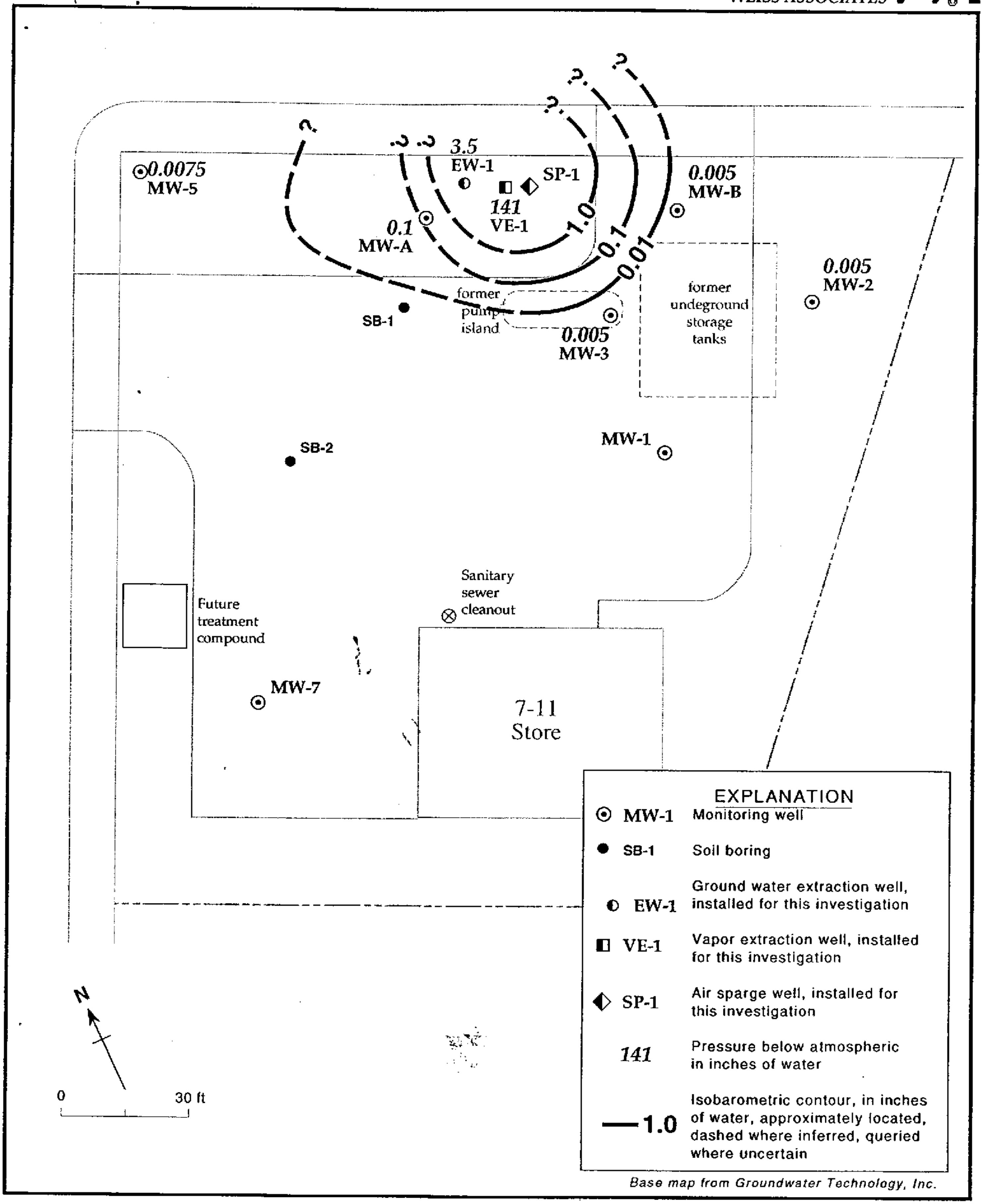
Figure 2. Monitoring Well Responses During EW-1 Pumping Test - November 17 through 18, 1992 - Former Texaco Service Station, 930 Springtown Boulevard, Livermore, California

12/31/92



Base map from Groundwater Technology, Inc.

Figure 3. Hydraulic Capture Area for Long Term Pumping of Well EW-1 at 5.0 gpm flow rate - Former Texaco Service Station, 930 Springtown Boulevard, Livermore, Califonia



Base map from Groundwater Technology, Inc.

Figure 4. Isobarometric Contour for Vapor Extraction from Well VE-1 - Texaco Refining and Marketing Inc., 930 Springtown Boulevard, Livermore, California

Figure 5. TPH-G Concentrations in Extracted Vapor During Air Sparging

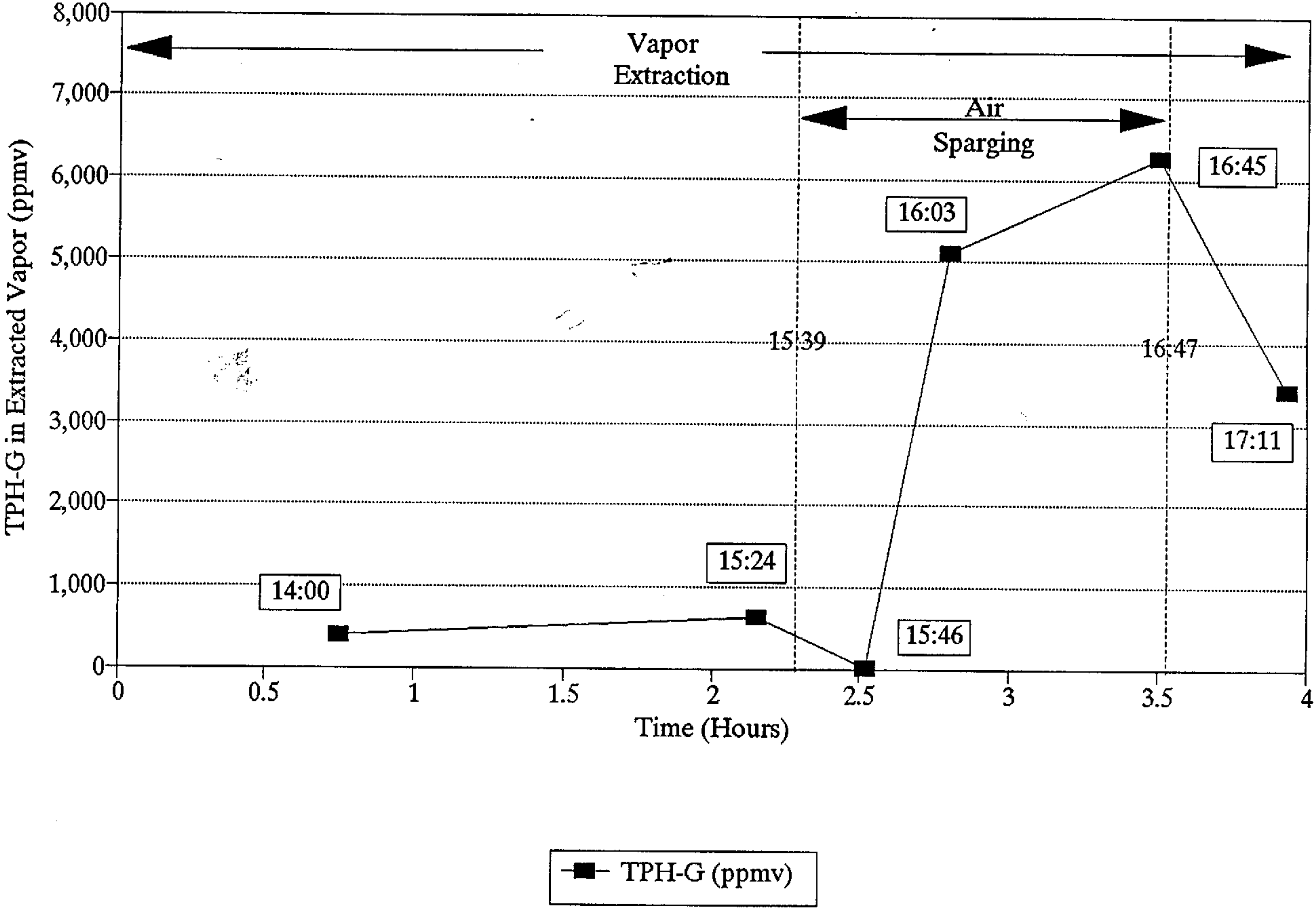
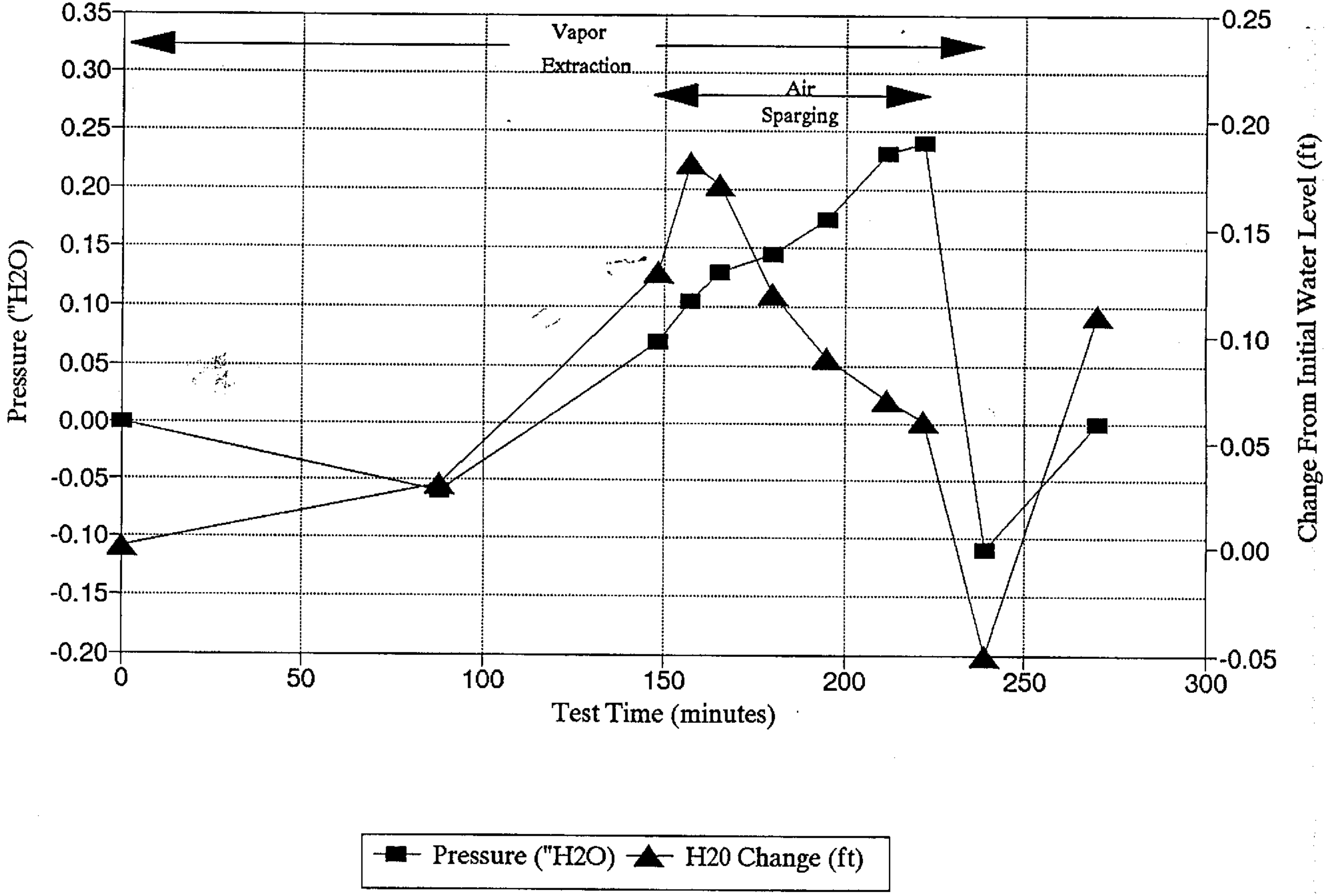


Figure 6. Air Pressure and Water Levels in Well EW-1 During Air Sparging



APPENDIX A

STANDARD FIELD PROCEDURES

STANDARD FIELD PROCEDURES

Weiss Associates (WA) has developed standard procedures for drilling and sampling soil borings and installing, developing and sampling ground water monitoring wells. These procedures comply with Federal, State and local regulatory guidelines. Specific procedures are summarized below.

SOIL BORING AND SAMPLING

Objectives/Supervision

Soil sampling objectives include characterizing subsurface lithology, assessing whether the soils exhibit obvious hydrocarbon or other compound vapor or staining and collecting samples for analysis at a State-certified laboratory. All borings are logged using the Unified Soil Classification System by a trained geologist working under the supervision of a California Registered Geologist (RG) or a Certified Engineering Geologist (CEG).

Soil Boring and Sampling

Soil borings are typically drilled using hollow-stem augers. To collect soil samples, split-barrel samplers lined with steam-cleaned brass or stainless steel tubes are driven through the hollow auger stem into undisturbed sediments at the bottom of the borehole using a 140 pound hammer dropped 30 inches. Soil samples can also be collected without using hollow-stem augers by progressively driving split-barrel soil samplers to depths of up to 20 ft.

Soil samples are collected at least every five ft to characterize the subsurface sediments and for possible chemical analysis. Near the water table and at lithologic changes, the sampling interval may be less than five ft.

Drilling and sampling equipment is steam-cleaned prior to drilling and between borings to prevent cross-contamination. Sampling equipment is washed between samples with trisodium phosphate or an equivalent EPA-approved detergent.

Sample Analysis

After noting the lithology at each end of the sampling tubes, the tube chosen for analysis is immediately trimmed of excess soil and capped with teflon tape and plastic end caps. The sample is labelled, stored at or below 4°C, and transported under chain-of-custody to a State-certified analytic laboratory.

Screening

One of the remaining tubes is partially emptied leaving about one-third of the soil in the tube. The tube is capped with plastic end caps and set aside to allow hydrocarbons to volatilize from the soil. Alternatively, soil from the tube is placed in a sealed plastic bag and set in the light. After ten to fifteen minutes, a portable photoionization detector (PID) measures volatile hydrocarbon vapor concentrations in the tube headspace, extracting the vapor through a slit in the cap or hole in the plastic bag. PID measurements are used along with the stratigraphy and ground water depth to select soil samples for analysis.

Grouting

If the borings are not completed as wells, the borings are filled to the ground surface with cement grout poured or pumped through a tremie pipe. If wells are completed in the borings, the well installation, development and sampling procedures summarized below are followed.

MONITORING WELL INSTALLATION, DEVELOPMENT AND SAMPLING

Well Construction and Surveying

Wells are installed to monitor ground water quality and determine the ground water elevation, flow direction and gradient. Well depths and screen lengths are based on ground water depth, occurrence of hydrocarbons or other compounds in the borehole, stratigraphy and state and local regulatory guidelines. Well screens typically extend 15 ft below and 5 ft above the static water level at the time of drilling. However, the well screen will generally not extend into or through a clay layer that is at least three to five ft thick.

Well casing and screen are flush-threaded, Schedule 40 PVC. Screen slot size varies according to the sediments screened, but slots are generally 0.010 or 0.020 inches wide. A rinsed and graded sand occupies the annular space between the boring and the well screen to about one to two ft above the well screen. A two ft thick hydrated bentonite seal separates the sand from the overlying sanitary surface seal composed of cement with 3-5% bentonite.

Well-heads are secured by locking well-caps inside traffic-rated vaults finished flush with the ground surface. A stovepipe may be installed between the well-head and the vault cap for additional security. The well top-of-casing elevation is surveyed with respect to mean sea level and the well is surveyed for horizontal location with respect to an onsite or nearby offsite landmark.

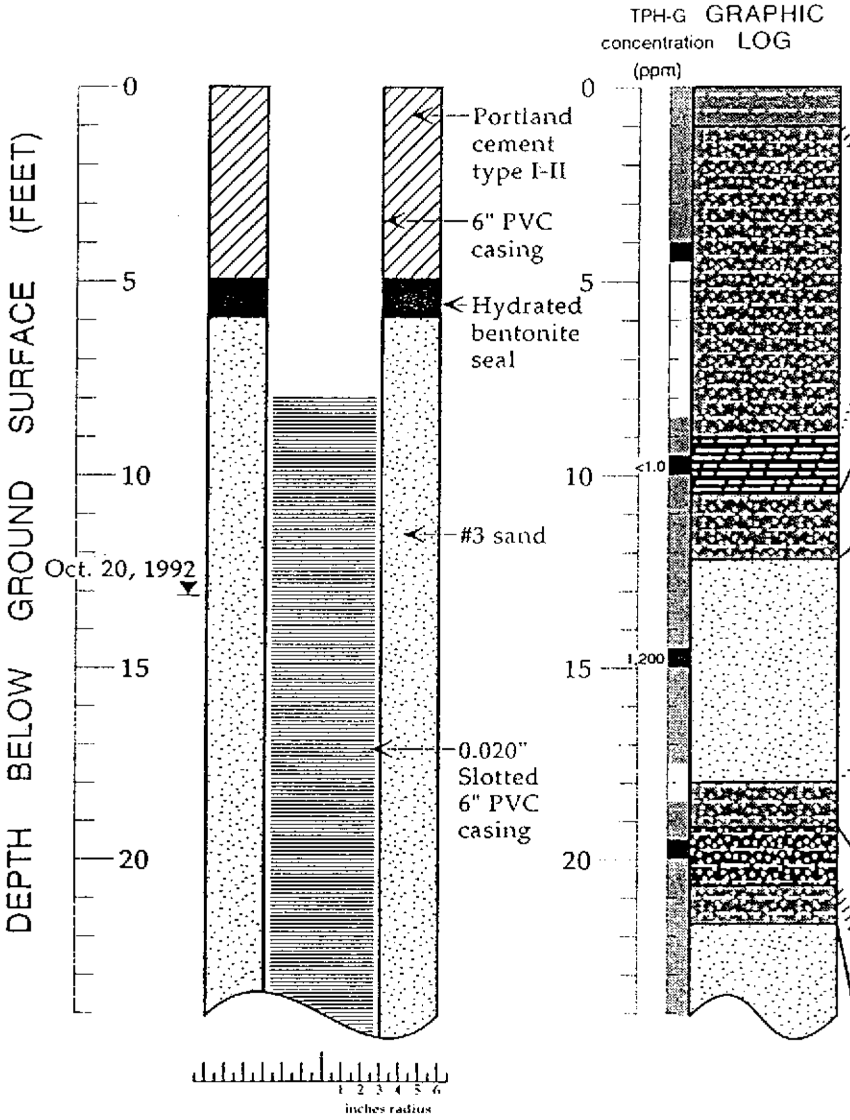
Well Development

After at least 24 hours, the wells are developed using a combination of ground water surging and extraction. Surging agitates the ground water and dislodges fine sediments from the sand pack. After about ten minutes of surging, ground water is extracted from the well using bailing, pumping and/or reverse air-lifting through an eductor pipe to remove the sediments from the well. Surging and extraction continue until at least ten well-casing volumes of ground water are extracted and the sediment volume in the ground water is negligible. All equipment is steam-cleaned prior to use and air used for air-lifting is filtered to prevent oil entrained in the compressed air from entering the well. Wells that are developed using air-lift evacuation are not sampled until at least 24 hours after they are developed.

Ground Water Sampling

Depending on local regulatory guidelines, three to four well-casing volumes of ground water are purged prior to sampling. Purging continues until ground water pH, conductivity, and temperature have stabilized. Ground water samples are collected using bailers or pumps and are decanted into the appropriate containers supplied by the analytic laboratory. Samples are labelled, placed in protective foam sleeves, stored at or below 4°C, and transported under chain-of-custody to the laboratory. Laboratory-supplied trip blanks accompany the samples and are analyzed to check for cross-contamination. An equipment blank may be analyzed if non-dedicated sampling equipment is used.

WELL EW-1 (B-1)



DESCRIPTION

Sandy SILT (ML); dark brown; medium stiff; damp; 70% silt; 30% fine to medium sand; non plastic; moderate K

Silty SAND (SM); orange; medium dense; damp; 40% silt; 60% fine to coarse sand; moderate K

Yellow at 3.5'

Clayey SILT (ML); light yellow; soft to firm; damp; 25% clay; 75% silt; non plastic; low K

Silty SAND/Sandy SILT (SM/ML); yellow-green; dense to hard; damp; <5% clay; 40-60% silt; 40-60% sand; non plastic; moderate K

SAND (SW); green; dense; moist; 10-20% silt; 80-90% fine to coarse sand; high K

2" layer medium to coarse sand at 12.8'

Wet at 14.0'

Coarse sand and gravel to 1.0" diameter at 15.0'

Silty SAND/Sandy SILT (SM/ML); orange; loose to medium dense/ medium stiff to stiff; wet; <5% clay; 40-60% silt; 40-60% very fine sand; low to moderate K

Clayey SAND/Silty SAND (SC/SM); light gray; very stiff; moist; 10-15% clay; 15-40% silt; 50-70% very fine sand; low K

Silty SAND/Sandy SILT (SM/ML); orange; dense to very stiff; moist; <5% clay; 40-60% silt; 40-60% very fine sand; low to moderate K

SAND (SP); orange; dense; moist; fine to medium sand; high K

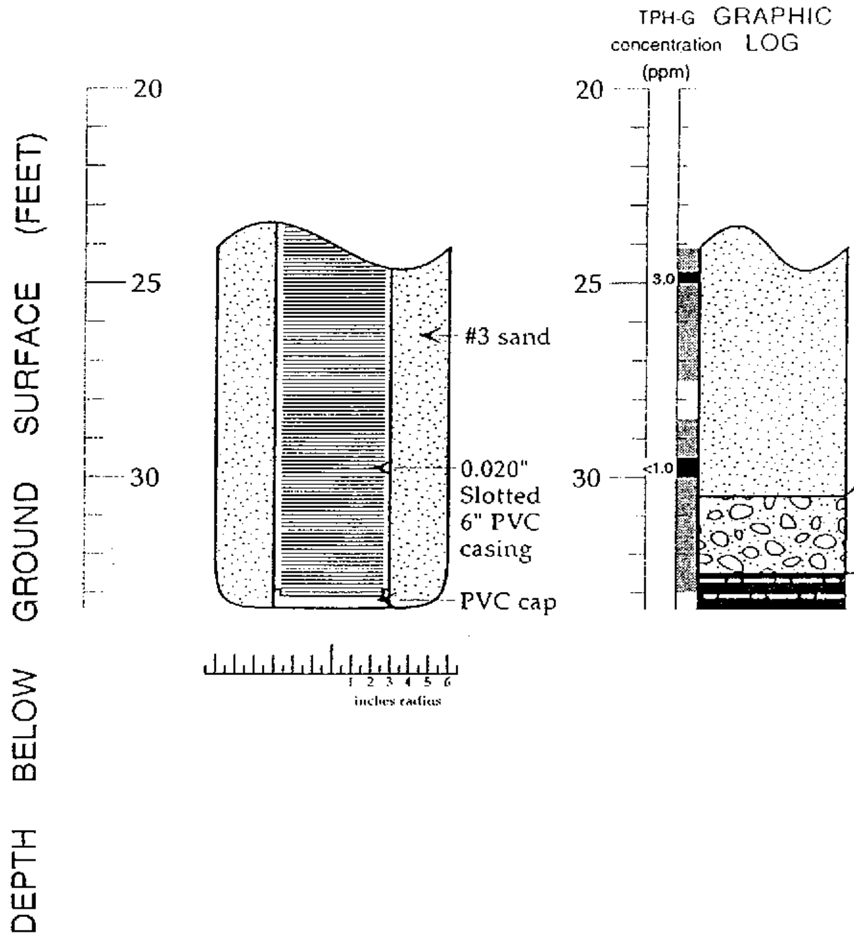
EXPLANATION

▼	Water level during drilling (date)
▽	Water level (date)
——······	Contact (dotted where approximate)
—?—?—	Uncertain contact
//////////	Gradational contact
▒	Location of recovered drive sample
■	Location of drive sample sealed for chemical analysis
▩	Cutting sample
K =	Estimated hydraulic conductivity

Logged By: Eric Anderson
Supervisor: Joseph P. Theisen; CEG 1645
Drilling Company: HEW Drilling, East Palo Alto, CA
License Number: C57-384167
Driller: Tomas Jaime
Drilling Method: 6" and 12" O.D. hollow-stem auger
Date Drilled: October 19-20, 1992
Well Head Completion: Temporary, traffic-rated vault
Type of Sampler: Split barrel (1.5", 2", 2.5" ID)
Ground Surface Elevation: Approximately 520 feet above mean sea level
TPH-G: Total petroleum hydrocarbon as gasoline in soil by EPA Method 5030 with GC/FID

Boring Log and Well Construction Details - Well EW-1 (B-1) - Former Texaco Service Station, 930 Springtown Boulevard, Livermore, California

WELL EW-1 (B-1) (cont.)



DESCRIPTION

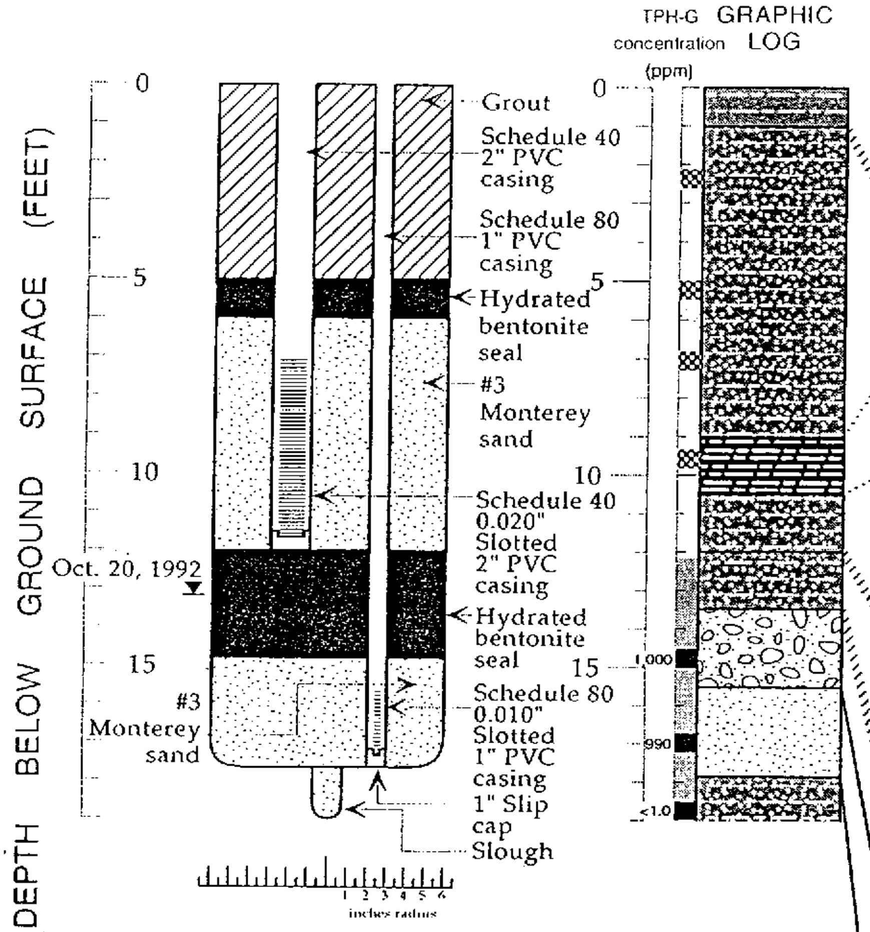
Wet; medium sand at 26.0'
Loose; medium to coarse sand at 26.5'

Gravelly SAND (SP); yellow-brown; dense to very dense; wet; 85-95% medium to coarse sand; 5-15% gravel to 1.0" diameter; high K

Silty CLAY (CL); orange; very stiff to hard; moist; 35-60% clay; 30-50% silt; 10-15% very fine sand; low K

Boring Log and Well Construction Details - Well EW-1 (B-1) - Former Texaco Service Station, 930 Springtown Boulevard, Livermore, California

WELL VE-1/SP-1 (B-2)



DESCRIPTION

Sandy SILT (ML); dark brown; medium stiff; damp; 70% silt; 30% fine to medium sand; non plastic; moderate K

Silty SAND (SM); orange; medium dense; damp; 40% silt; 60% fine to coarse sand; moderate K
Yellow at 3.5'

Clayey SILT (ML); light yellow; soft to firm; damp; 25% clay; 75% silt; non plastic; low K

Silty SAND/Sandy SILT (SM/ML); yellow-green; medium dense to dense to very stiff; damp; <5% clay; 40-60% silt; 40-60% sand; moderate K

Silty SAND (SM); green; medium dense to dense; moist; 10-20% silt; 80-90% fine sand; moderate to high K
Angular to subangular gravel to 1.0" diameter at 13.0'

Gravelly SAND/Silty SAND (SW); green; medium dense to dense; moist; 15% silt; 75% fine sand; 10% gravel to 0.5" diameter; high K

SAND (SP); green; medium dense to dense; wet; 95% medium sand; 5% gravel to 1" diameter; high K
Subangular to sub rounded gravel to 2.0" diameter at 16.5'
95% coarse sand; very high K at 16.7'

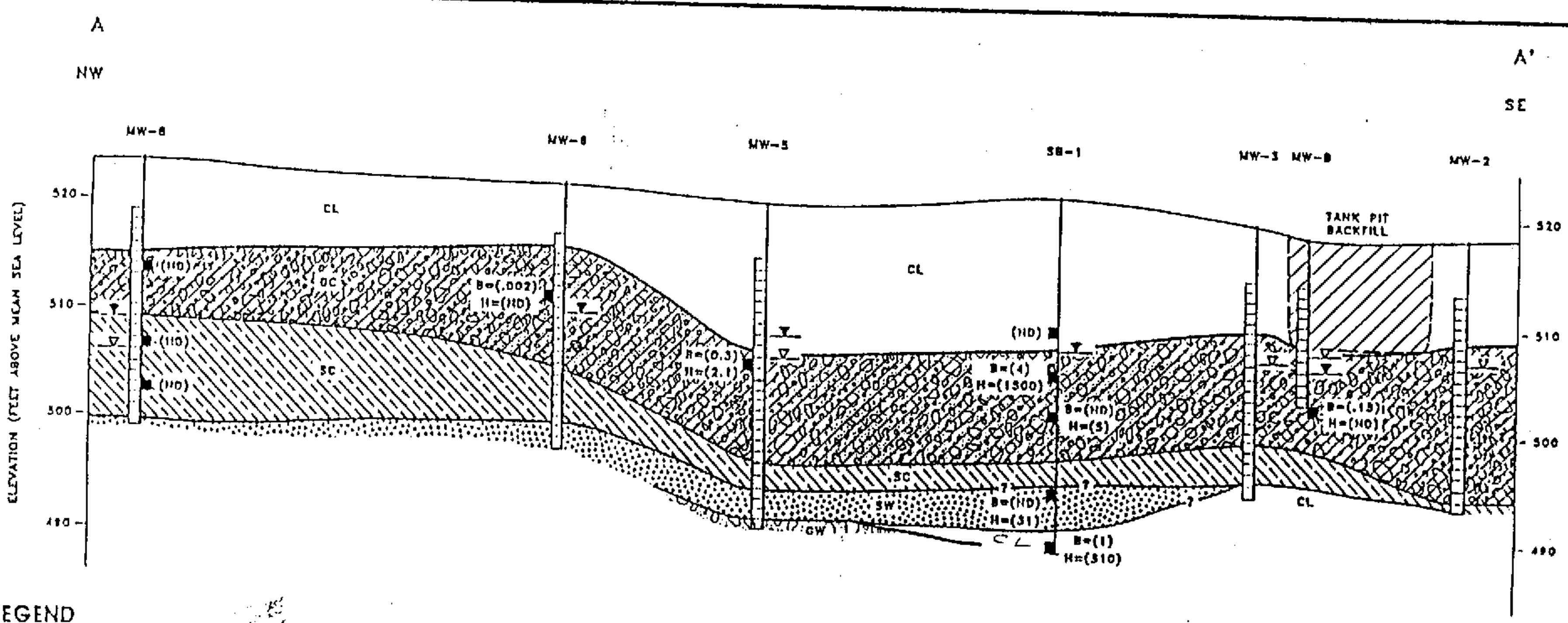
Silty SAND/Clayey SAND (SM/SC); orange;medium dense; damp; 10-15% clay; 15-40% silt; 50-70% very fine sand; low K

EXPLANATION

▼ Water level during drilling (date)
▽ Water level (date)
———······ Contact (dotted where approximate)
—?—?— Uncertain contact
////////. Gradational contact
▒ Location of recovered drive sample
■ Location of drive sample sealed for chemical analysis
▩ Cutting sample
K = Estimated hydraulic conductivity

Logged By: Eric Anderson
Supervisor: Joseph P. Theisen; CEG 1645
Drilling Company: HEW Drilling, East Palo Alto, CA
License Number: C57-384157
Driller: Tomas Jaime
Drilling Method: 6" and 12" O.D. hollow-stem auger
Date Drilled: October 20, 1992
Well Head Completion: Temporary, traffic-rated vault
Type of Sampler: Split barrel (1.5", 2", 2.5" ID)
Ground Surface Elevation: Approximately 520 feet above mean sea level
TPH-G: Total petroleum hydrocarbon as gasoline in soil by EPA Method 5030 with GC/FID

Boring Log and Well Construction Details - Well VE-1/SP-1 (B-2) - Former Texaco Service Station, 930 Sprintown Boulevard, Livermore, California



LEGEND

- CL SILTY SANDY CLAY
- SC CLAYEY SILTY SAND
- SW SAND
- GC CLAYEY SAND AND GRAVEL
- GW GRAVEL
- ▽ WATER LEVEL ON 7/12/91
- ▼ ENCOUNTERED WATER DURING DRILLING
- ■ SOIL SAMPLE
- ND HYDROCARBON NOT DETECTED
- B BENZENE CONCENTRATION (ppb)
- H TPH-G CONCENTRATION (ppb)
- SCREENED INTERVAL

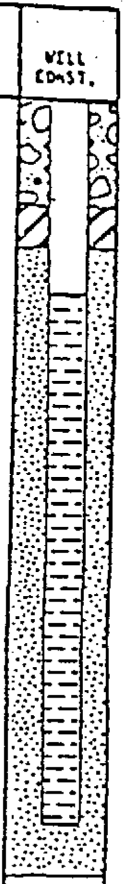
FIGURE 3
GENERALIZED GEOLOGIC
CROSS SECTION A-A'
TEXACO REFINING & MARKETING INC.
930 SPRINGTOWN BLVD.
LIVERMORE, CA
02320-1383

REVISIONS:
DATE: 8/29/91
REVISION: FINAL DRAFT
BY: DWS

SCALE IN FEET
10
0
25
VERTICAL EXAGGERATION=2.5x

GROUNDWATER TECHNOLOGY, INC.

Depth in Feet	Blow/Ft.	Sample No.	USCS	DESCRIPTION
				Asphalt
2				SANDY CLAY -Tan -Medium to fine grained
4	7 6 5			
6			CL	SANDY CLAY -Tan to brown -Medium to fine grained -Poorly sorted -Moist
8				
10	9 15 7		ML	CLAYEY SILT -Brown
12		▽		-Fine grained -Poorly sorted -Moist
14				-Strong gasoline odor Slow drilling
16	15 15 19	B3-15.0 =B	GW	GRAVEL -Black -Coarse -Loose -Angular to subangular -Well graded -Strong odor -Free gasoline on soil -Wet
				TOTAL DEPTH = 16'



H KLEINFELDER & ASSOCIATES
OTECHNICAL CONSULTANTS • MATERIALS TESTING

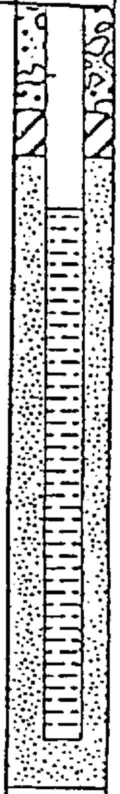
OJECT NO. B-1423-1

PROPOSED 7-11 STORE
SPRINGTOWN BLVD. AND LASSEN RD.
LIVERMORE, CA
LOG OF BORING NO. B-3
(MW-A)

PLATE
3

Depth In Feet	Blow/ Ft.	Sample No.	USCS	DESCRIPTION
				Asphalt
2				SANDY CLAY -Brown to tan -Poorly sorted -Medium to fine grained -Subangular
4 6 8	6 5 7		CL	SANDY CLAY -Brown -Poorly sorted -Medium to fine grained -Moist -Strong odor No free gasoline
10 12 14	8 6 15	∇	ML	CLAYEY SILT -Dark brown -Fine grained -Poorly sorted -Strong odor Slow drilling
16	15 22 13	B4-15 -B	GW	GRAVEL -Black -Coarse -Subangular -Loose -Wet -Free gasoline -Strong odor
				TOTAL DEPTH = 16'

WELL CONST.



H KLEINFELDER & ASSOCIATES
OTECHNICAL CONSULTANTS • MATERIALS TESTING
ROJECT NO. B-1423-1

PROPOSED 7-11 STORE
SPRINGTOWN BLVD. AND LASSEN RD
LIVERMORE, CA
LOG OF BORING NO. B-4
(MW-B)

PLATE
4

GROUNDWATER TECHNOLOGY
Division of Oil Recovery Systems, Inc.

Well Number 1

Drilling Log

Project Texaco/Livermore
Owner Southland Corp.
Location Springtown&Lassen
Project Number 20-4051
Date Drilled 6-20-85
Total Depth of Hole 25 ft.
Diameter 7.5 in.
Surface Elevation
Water Level, Initial
24-hrs. 11.68
Screen: Dia. 4-inch
Length 20-feet
Slot Size .020 in.
Casing: Dia. 4-inch
Length 5-feet
Type PVC
Drilling Company Sierra Pacific
Drilling Method H.S. Auger
Driller Lynn Pera
Log by Cori Condon

Sketch Map

Notes

Depth (Feet)	Well Construction	Notes Blow Counts	Sample Number	Graphic Log	Description/Soil Classification (Color, Texture, Structures)
1					Asphalt and fill sand and gravel.
					Brown sandy clay, damp, no odor.
2					
6					Brown-green fine sand with subangular white gravels, damp, no odor.
					Brown-green silty fine sand, stiff, damp, no odor.
7.5					
					Brown-green silty fine sand with rounded cobbles and gravels, moist, no odor.
10					
					Cobbles and gravels in fine sand, moist, no odor.
12					
					Gray brown fine sand and silt, less cobbles and pea size gravels, moist, no odor.
15		11-12-24	#1		
					Gray-brown coarse sand, wet, no odor.
20		12-18-18	#2		
					Gray-brown coarse sand, wet, no odor, contact with brown sandy clay.
25					
					Drilled 25 feet Cased 20 feet slotted, 5 feet blank Aquarium sand to 3 feet Cement seal to surface Finish with steel manhole

GROUNDWATER TECHNOLOGY
Division of Oil Recovery Systems, Inc.

Drilling Log

Well Number 2

Project Texaco/Livermore Owner Southland Corp.
Location Springtown & Lassen Project Number 20-4051
Date Drilled 6-20-85 Total Depth of Hole 24 ft. Diameter 7.5 in.
Surface Elevation ______ Water Level, Initial ______ 24-hrs. 10.30
Screen: Dia. 4-inch Length 20-feet Slot Size .020 in.
Casing: Dia. 4-inch Length 4-feet Type PVC
Drilling Company Sierra Pacific Drilling Method H.S. Auger
Driller Lynn Pera Log by Cori Condon

Sketch Map

Notes

Depth (Feet)	Well Construction	Notes Blow Counts	Sample Number	Graphic Log	Description/Soil Classification (Color, Texture, Structures)
1					Asphalt and fill.
					Red-brown clayey sand, occasional gravel, damp, no odor.
9.5					
10		21-33-35	#3		Gray sand and gravel, wet, no odor.
15		9-25-25	#4		
					Gray sand and gravel, grading to cobbles, wet, very slight gas odor.
20		14-56+	Lost Sample		
					Gray sand and gravel, wet, slight gas odor, contact with sandy clay.
25					
					Drilled 25 feet Cased 20 feet slotted, 4 feet blank Aquarium sand to 3 feet Cement seal to surface Finished with steel manhole.

GROUNDWATER TECHNOLOGY
Division of Oil Recovery Systems, Inc.

Drilling Log

Well Number 3

Project Texaco/Livermore Owner Southland Corp.

Location Springtown & Lassen Project Number 20-4051

Date Drilled 6-20-85 Total Depth of Hole 24 ft. Diameter 7.5 in.

Surface Elevation _____ Water Level, Initial _____ 24-hrs. 11.59

Screen: Dia. 4-inch Length 20-feet Slot Size .020 in.

Casing: Dia. 4-inch Length 4-feet Type PVC

Drilling Company Sierra Pacific Drilling Method H.S. Auger

Driller Lynn Pera Log by Cori Condon

Sketch Map

Notes

Depth (Feet)	Well Construction	Notes Blow Counts	Sample Number	Graphic Log	Description/Soil Classification (Color, Texture, Structures)
1					Asphalt and fill.
					Light brown sandy clay with occasional gravel, damp, no odor.
7					
					Light brown sandy clay with occasional gravel, moist, gasoline odor.
10		13-27-37	# 5		Gray sand and gravel, wet, slight gasoline odor.
15		6-9-19	# 6		Gray sand and gravel, wet, slight gas odor, contact with sandy clay.
20		5-7-12	# 7		Mottled sandy clay, moist, slight gasoline odor.
25		8-22-25	# 8		Gray sand, wet, no odor.
26.5					

Drilled 25 feet
Cased 20 feet slotted, 4 feet blank
Aquarium sand to 3 feet
Cement seal to surface
Finished with steel manhole

GROUNDWATER TECHNOLOGY, INC.
OIL RECOVERY SYSTEMS

Monitoring Well 5

Drilling Log

Project Texaco/Livermore Owner Texaco U.S.A.

Location 930 Springton Blvd Project Number 20-4051

Date Drilled 11/10/86 Total Depth of Hole 30 ft Diameter 7.5 in.

Surface Elevation ______ Water Level, Initial 12 ft. 24-hrs. ______

Screen: Dia. 2 in. Length 25 ft. Slot Size .020 in.

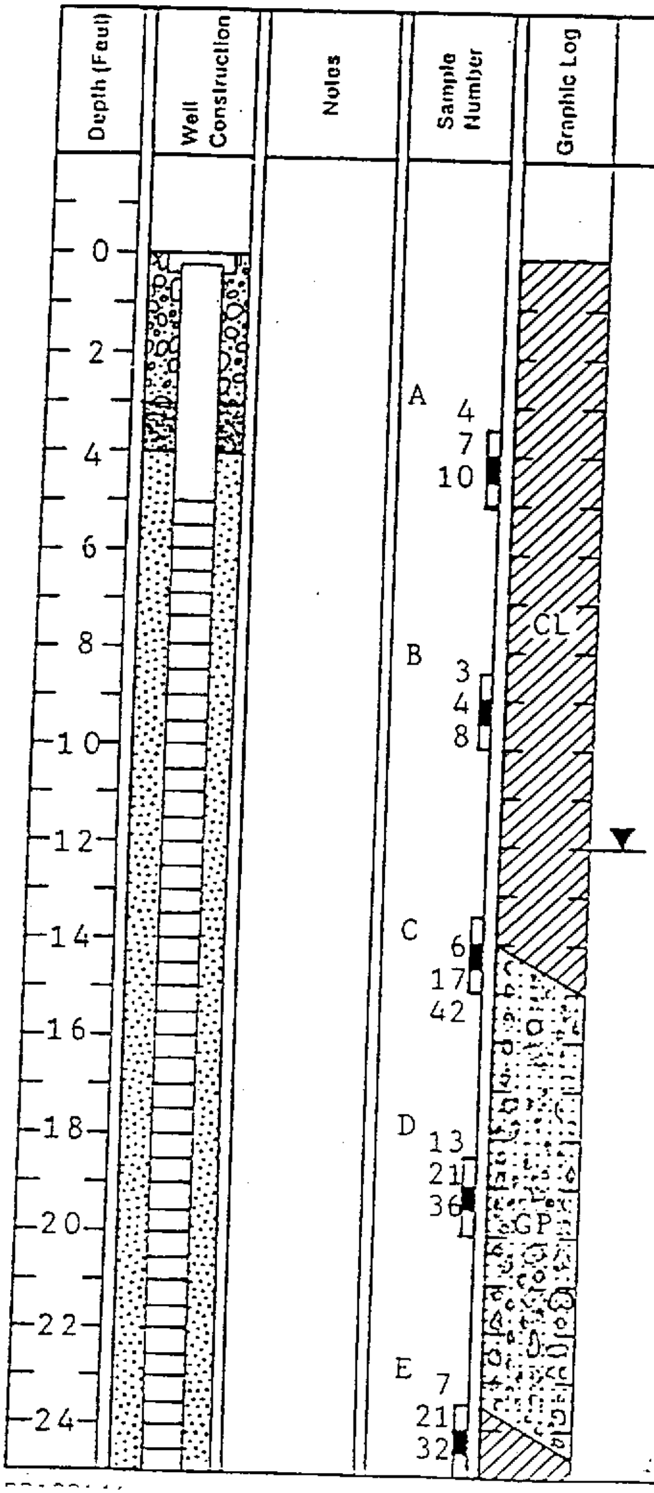
Casing: Dia. 2 in. Length 5 ft. Type PVC

Drilling Company Sierra Pacific Drilling Method hollow stem auger

Driller M. Isom Log by M. Winters

Sketch Map

Notes



Description/Soil Classification

Brown, silty clay, (some gravel and sand, very stiff, moist, no odor).

(Increase in sand, light brown color).

(Decrease in sand, increase in moisture).

(Increase in sand and silt, organics).

11/10/86 (1000)

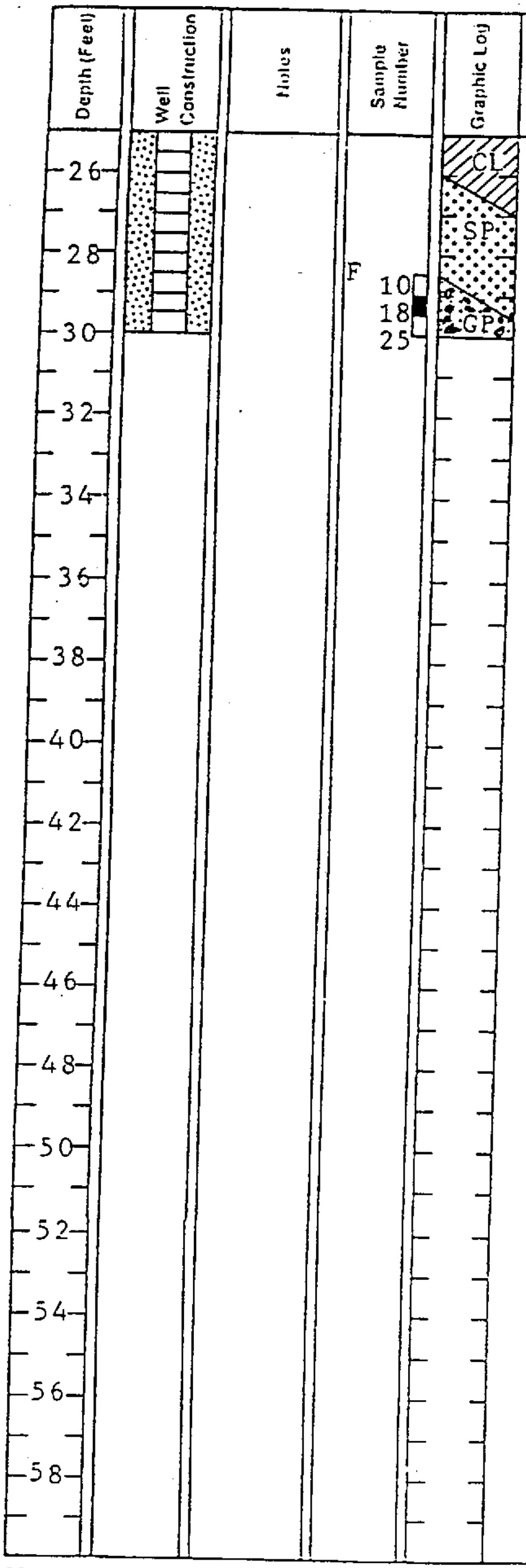
Multi-colored, fine to coarse gravel, (some sand, poorly sorted, very dense, wet, moderate product odor).

(Slight product odor).

GROUNDWATER
TECHNOLOGY, INC.
OIL RECOVERY SYSTEMS

Monitoring Well 5

Drilling Log



Description/Soil Classification
(Color, Texture, Structures)

Brown, sandy clay, (hard, wet, very slight product odor).

Light brown, medium sand, (wet, very slight product odor).

Multi-colored, sandy fine to coarse gravel, (some clay and silt, poorly sorted, dense, wet, very slight product odor).

Drilled to 30 feet.

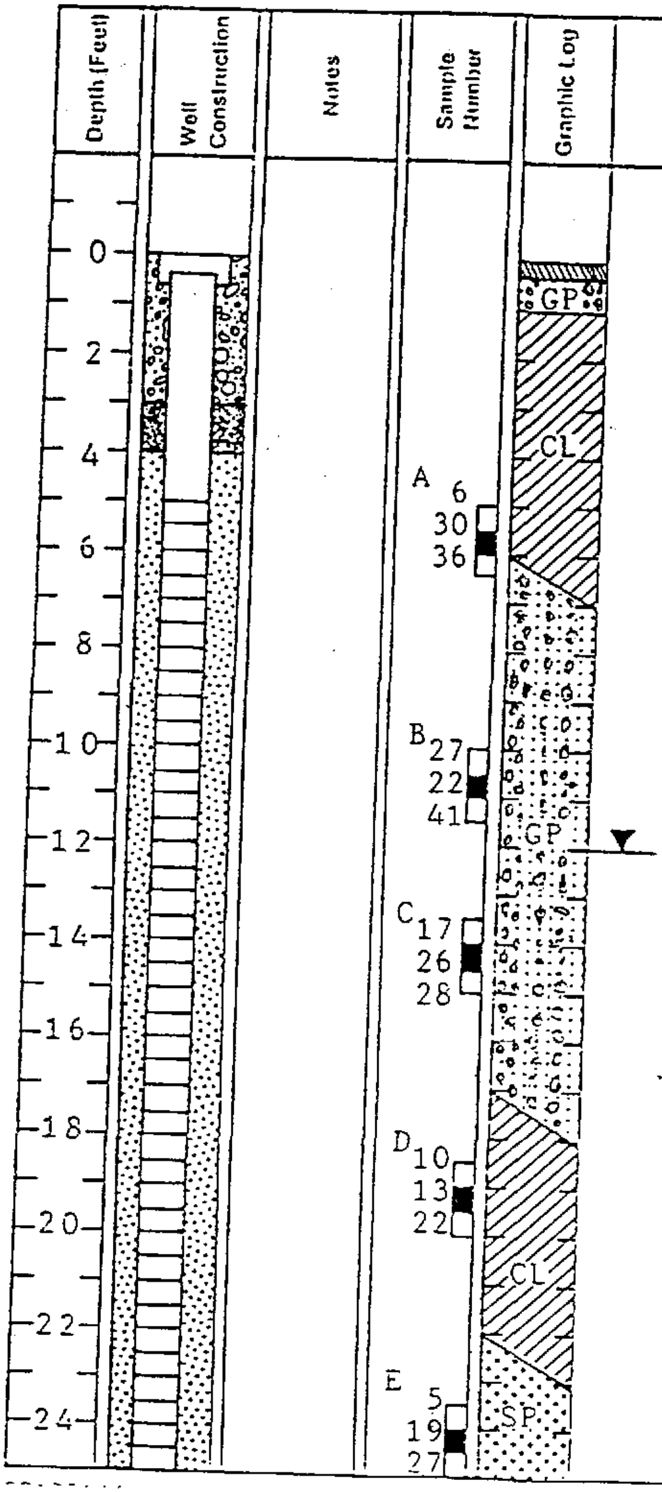
GROUNDWATER TECHNOLOGY, INC.
OIL RECOVERY SYSTEMS

Monitoring Well 6 Drilling Log

Project Texaco/Livermore Owner Texaco U.S.A.
Location 930 Springton Blvd. Project Number 20-4051
Date Drilled 11/10/86 Total Depth of Hole 25 ft Diameter 7.5 in.
Surface Elevation ______ Water Level, Initial 13 ft. 24-hrs. ______
Screen: Dia. 2 in. Length 20 ft. Slot Size .020 in.
Casing: Dia. 2 in. Length 5 ft. Type PVC
Drilling Company Sierra Pacific Drilling Method hollow stem auger
Driller M. Isom Log by M. Winters

Sketch Map

Notes



Description/Soil Classification

Asphalt

Brown, sandy gravel fill, (slightly moist, very slight product odor).

Brown, silty clay, (some gravel and sand, very stiff, moist, no odor).

(Light brown color)

Multi-colored, sandy fine to coarse gravel, (some clay and sand, poorly sorted, very dense, moist, no odor).

11/10/86 (1530)

(Decrease in sand and clay, wet).

Brown, sandy clay, (some silt, hard, wet, no odor).

Light brown, medium sand, (dense, wet, no odor).

Drilled to 25 feet.

Drilling Log

GROUNDWATER TECHNOLOGY, INC.

Monitoring Well 7

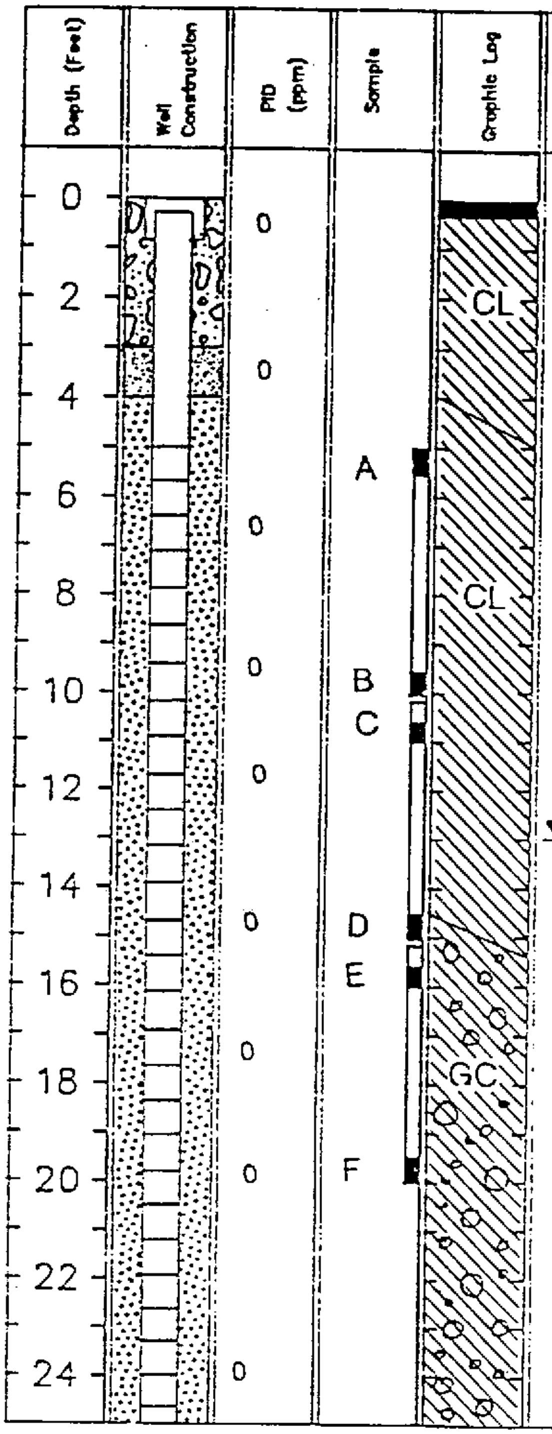
Project Texaco/Livermore Owner Texaco Refining and Marketing
Location Livermore Project Number 203 150 4051
Date Drilled 12/5/89 Total Depth of Hole 25 ft Diameter 10.5 in
Surface Elevation ____ Water Level Initial 13 ft 24-hour ____
Screen: Dia. 4 in Length 20 ft Slot Size 0.020 in
Casing: Dia. 4 in Length 5 ft Type Sch. 40 PVC
Drilling Company Sierra Pacific Drilling Method hollow stem auger
Driller Chris DeSocio Log by Steve Kranyak
Geologist/Engineer RBStorm License No. R64394

Sketch Map

SEE SITE MAP

Notes

Continuously sampled



Description/Soil Classification
(Color, Texture, Structure)

3 inches asphalt over 2 inches aggregate base

Brown gravelly, silty, sandy clay (soft, slightly moist, no product odor)

Brown sandy, silty, gravelly clay (stiff, slightly moist, stiff, no product odor)

(grades more stiff)

(grades light brown and tan)

▼ Encountered water 12/5/89 (15:30 hours)
(grades wet)

Brown and black mottled sandy, silty, clayey gravel (loose, wet, no product odor)

(grades coarser)

End of drilling, installed monitoring well to 25

GROUNDWATER TECHNOLOGY, INC.

Monitoring Well 8

Drilling Log

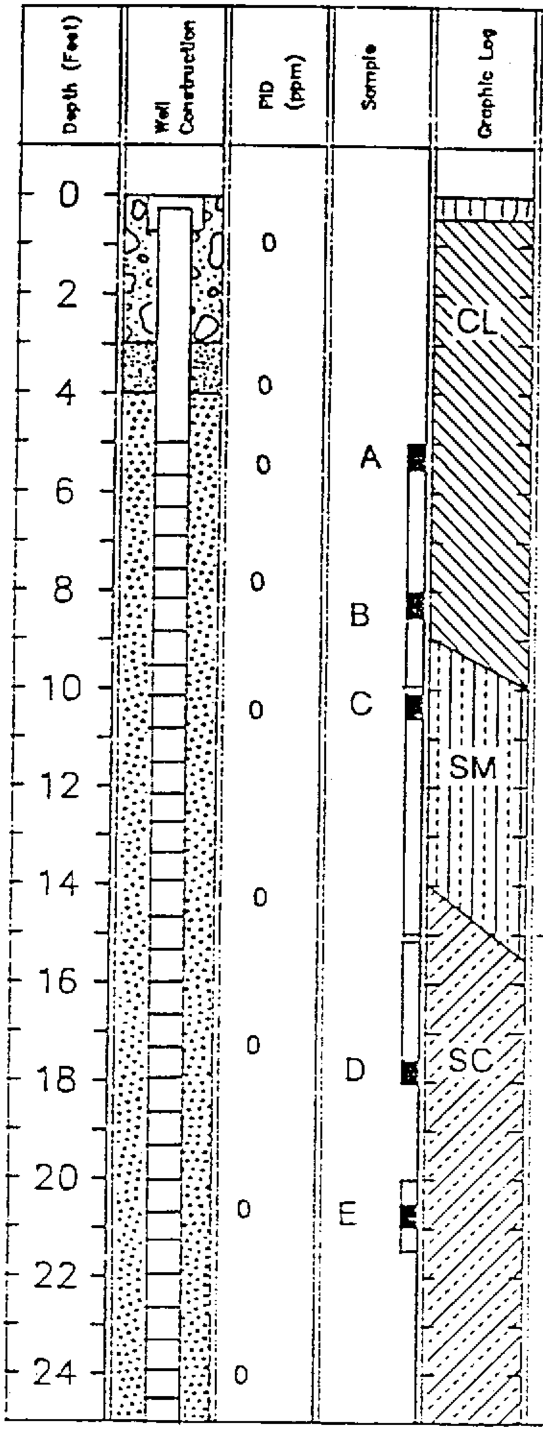
Project Texaco/Livermore Owner Texaco Refining and Marketing
Location Livermore Project Number 203 150 4051
Date Drilled 12/6/89 Total Depth of Hole 25 ft Diameter 10.5 in
Surface Elevation ____ Water Level Initial 15 ft 24-hour ____
Screen: Dia. 4 in Length 20 ft Slot Size 0.02 in
Casing: Dia. 4 in Length 5 ft Type ____
Drilling Company ____ Drilling Method hollow stem auger
Driller Chris DeSocio Log by Steve Kranyak
Geologist/Engineer ABStorm License No. RG4394

Sketch Map

SEE SITE MAP

Notes

Continuously sampled



Description/Soil Classification
(Color, Texture, Structure)

6 inches grass and roots

Tan silty clay with trace gravels (stiff, moist, no product odor)

(grades with no gravels)

Brown fine sand with trace clay, wilt and gravel

(grades with cobbles)

▼ Encountered water 12/6/89 (15:00 hours)

Tan, silty, clayey sand (medium dense, wet, no product odor)

End of drilling, installed monitoring well

APPENDIX C

ANALYTIC REPORTS FOR SOIL, GROUND WATER AND SOIL VAPOR

MOBILE CHEM LABS INC.
5021 Blum Road, Suite 3 • Martinez, CA 94553
Phone (415) 372-3700 • Fax (415) 372-6955

T69-677-01\1342\012201

Weiss Associates
5500 Shellmound St.
Emeryville, CA 94611
Attn: Eric Anderson
Project Manager

Date Sampled: 10-19-92
Date Received: 10-22-92
Date Analyzed: 10-27-92

Sample Number	Sample Description
102281	Project # T69-677-01 Texaco - Livermore 930 Springstown Blvd. B-1-9.7' SOIL

ANALYSIS

	Detection Limit	Sample Results
	ppm	ppm
Total Petroleum Hydrocarbons as Gasoline	1.0	<1.0
Benzene	0.005	<0.005
Toluene	0.005	<0.005
Xylenes	0.005	<0.005
Ethylbenzene	0.005	<0.005

QA/QC: Sample blank is none detected

Note: Analysis was performed using EPA methods 5030 and TPH LUFT with method 8020 used for BTX distinction.
(ppm) = (mg/kg)

MOBILE CHEM LABS

Ronald Evans

Ronald G. Evans
Lab Director

MOBILE CHEM LABS INC.
5021 Blum Road, Suite 3 • Martinez, CA 94553
Phone (415) 372-3700 • Fax (415) 372-6955

T69-677-01\1342\012201

Weiss Associates
5500 Shellmound St.
Emeryville, CA 94611
Attn: Eric Anderson
Project Manager

Date Sampled: 10-19-92
Date Received: 10-22-92
Date Analyzed: 10-27-92

Sample Number	Sample Description
102282	Project # T69-677-01 Texaco - Livermore 930 Springstown Blvd. B-1-14.5' SOIL

ANALYSIS

	Detection Limit	Sample Results
	ppm	ppm
Total Petroleum Hydrocarbons as Gasoline	1.0	1,200
Benzene	0.005	6.6
Toluene	0.005	21
Xylenes	0.005	50
Ethylbenzene	0.005	15

QA/QC: Sample blank is none detected

Note: Analysis was performed using EPA methods 5030 and TPH LUFT with method 8020 used for BTX distinction.
(ppm) = (mg/kg)

MOBILE CHEM LABS

Ronald G. Evans
Lab Director

MOBILE CHEM LABS INC.
5021 Blum Road, Suite 3 • Martinez, CA 94553
Phone (415) 372-3700 • Fax (415) 372-6955

T69-677-01\1342\012201

Weiss Associates
5500 Shellmound St.
Emeryville, CA 94611
Attn: Eric Anderson
Project Manager

Date Sampled: 10-19-92
Date Received: 10-22-92
Date Analyzed: 10-27-92

Sample Number	Sample Description
102283	Project # T69-677-01 Texaco - Livermore 930 Springstown Blvd. B-1-24.7' SOIL

ANALYSIS

	Detection Limit	Sample Results
	ppm	ppm
Total Petroleum Hydrocarbons as Gasoline	1.0	3.0
Benzene	0.005	0.017
Toluene	0.005	0.051
Xylenes	0.005	0.21
Ethylbenzene	0.005	0.050

QA/QC: Sample blank is none detected

Note: Analysis was performed using EPA methods 5030 and TPH LUFT with method 8020 used for BTX distinction.
(ppm) = (mg/kg)

MOBILE CHEM LABS

Ronald G. Evans
Lab Director

MOBILE CHEM LABS INC.

5021 Blum Road, Suite 3 • Martinez, CA 94553
Phone (415) 372-3700 • Fax (415) 372-6955

T69-677-01\1342\012201

Weiss Associates
5500 Shellmound St.
Emeryville, CA 94611
Attn: Eric Anderson
Project Manager

Date Sampled: 10-19-92
Date Received: 10-22-92
Date Analyzed: 10-27-92

Sample Number	Sample Description
102284	Project # T69-677-01 Texaco - Livermore 930 Springstown Blvd. B-1-29.5' SOIL

ANALYSIS

	Detection Limit	Sample Results
	ppm	ppm
Total Petroleum Hydrocarbons as Gasoline	1.0	<1.0
Benzene	0.005	<0.005
Toluene	0.005	<0.005
Xylenes	0.005	<0.005
Ethylbenzene	0.005	<0.005

QA/QC: Sample blank is none detected

Note: Analysis was performed using EPA methods 5030 and TPH LUFT with method 8020 used for BTX distinction.
(ppm) = (mg/kg)

MOBILE CHEM LABS

Ronald G. Evans
Lab Director

MOBILE CHEM LABS INC.

5021 Blum Road, Suite 3 • Martinez, CA 94553
Phone (415) 372-3700 • Fax (415) 372-6955

T69-677-01\1342\012201

Weiss Associates
5500 Shellmound St.
Emeryville, CA 94611
Attn: Eric Anderson
Project Manager

Date Sampled: 10-19-92
Date Received: 10-22-92
Date Analyzed: 10-27-92

Sample Number	Sample Description
102285	Project # T69-677-01 Texaco - Livermore 930 Springstown Blvd. B-2-14.5' SOIL

ANALYSIS

	Detection Limit	Sample Results
	ppm	ppm
Total Petroleum Hydrocarbons as Gasoline	1.0	1,000
Benzene	0.005	7.1
Toluene	0.005	22
Xylenes	0.005	56
Ethylbenzene	0.005	13

QA/QC: Sample blank is none detected

Note: Analysis was performed using EPA methods 5030 and TPH LUFT with method 8020 used for BTX distinction.
(ppm) = (mg/kg)

MOBILE CHEM LABS

Ronald G. Evans
Lab Director

MOBILE CHEM LABS INC.

5021 Blum Road, Suite 3 • Martinez, CA 94553
Phone (415) 372-3700 • Fax (415) 372-6955

T69-677-01\1342\012201

Weiss Associates
5500 Shellmound St.
Emeryville, CA 94611
Attn: Eric Anderson
Project Manager

Date Sampled: 10-19-92
Date Received: 10-22-92
Date Analyzed: 10-27-92

Sample Number	Sample Description
102286	Project # T69-677-01 Texaco - Livermore 930 Springstown Blvd. B-2-16.7' SOIL

ANALYSIS

	Detection Limit ppm	Sample Results ppm
Total Petroleum Hydrocarbons as Gasoline	1.0	990
Benzene	0.005	2.9
Toluene	0.005	15
Xylenes	0.005	53
Ethylbenzene	0.005	14

QA/QC: Sample blank is none detected

Note: Analysis was performed using EPA methods 5030 and TPH LUFT with method 8020 used for BTX distinction.
(ppm) = (mg/kg)

MOBILE CHEM LABS

Ronald G. Evans
Lab Director

MOBILE CHEM LABS INC.
5021 Blum Road, Suite 3 • Martinez, CA 94553
Phone (415) 372-3700 • Fax (415) 372-6955

T69-677-01\1342\012201

Weiss Associates
5500 Shellmound St.
Emeryville, CA 94611
Attn: Eric Anderson
Project Manager

Date Sampled: 10-19-92
Date Received: 10-22-92
Date Analyzed: 10-27-92

Sample Number	Sample Description
102287	Project # T69-677-01 Texaco - Livermore 930 Springstown Blvd. B-2-18.5' SOIL

ANALYSIS

	Detection Limit ppm	Sample Results ppm
Total Petroleum Hydrocarbons as Gasoline	1.0	<1.0
Benzene	0.005	0.007
Toluene	0.005	0.029
Xylenes	0.005	<0.005
Ethylbenzene	0.005	<0.005

QA/QC: Sample blank is none detected

Note: Analysis was performed using EPA methods 5030 and TPH LUFT with method 8020 used for BTX distinction.
(ppm) = (mg/kg)

MOBILE CHEM LABS

Ronald G. Evans
Lab Director

MOBILE CHEM LABS INC.
5021 Blum Road, Suite 3 • Martinez, CA 94553
Phone (415) 372-3700 • Fax (415) 372-6955

T69-677-01\1342\012201

Weiss Associates
5500 Shellmound St.
Emeryville, CA 94611
Attn: Eric Anderson
Project Manager

Date Sampled: 10-19-92
Date Received: 10-22-92
Date Analyzed: 10-27-92

Sample Number	Sample Description
102288	Project # T69-677-01 Texaco - Livermore 930 Springstown Blvd. SP1 SOIL

ANALYSIS

	Detection Limit	Sample Results
	ppm	ppm
Total Petroleum Hydrocarbons as Gasoline	1.0	66

QA/QC: Sample blank is none detected

Note: Analysis was performed using EPA methods 5030 and TPH LUFT with method 8020 used for BTX distinction.
(ppm) = (mg/kg)

MOBILE CHEM LABS

Ronald G. Evans
Lab Director

MOBILE CHEM LABS INC.
5021 Blum Road, Suite 3 • Martinez, CA 94553
Phone (415) 372-3700 • Fax (415) 372-6955

T69-677-01\1342\012201

Weiss Associates
5500 Shellmound St.
Emeryville, CA 94611
Attn: Eric Anderson
Project Manager

Date Sampled: 10-19-92
Date Received: 10-22-92
Date Analyzed: 10-27-92

Sample Number	Sample Description
102289	Project # T69-677-01 Texaco - Livermore 930 Springstown Blvd. SP-2 SOIL

ANALYSIS

	Detection Limit	Sample Results
	ppm	ppm
Total Petroleum Hydrocarbons as Gasoline	1.0	96

QA/QC: Sample blank is none detected

Note: Analysis was performed using EPA methods 5030 and TPH LUFT with method 8020 used for BTX distinction.
(ppm) = (mg/kg)

MOBILE CHEM LABS

Ronald G. Evans
Lab Director

MOBILE CHEM LABS INC.
5021 Blum Road, Suite 3 • Martinez, CA 94553
Phone (415) 372-3700 • Fax (415) 372-6955

T69-677-02\1342\012272

Weiss Associates
5500 Shellmound St.
Emeryville, CA 94611
Attn: Bob Riddell
Project Manager

Date Sampled: 11-17-92
Date Received: 11-19-92
Date Analyzed: 11-23-92

Sample Number	Sample Description
112301	Project # T69-677-02 Texaco - Livermore 930 Springtown Influent WATER

ANALYSIS

	Detection Limit	Sample Results
	ppb	ppb
Total Petroleum Hydrocarbons as Gasoline	50	4,300
Benzene	0.5	140
Toluene	0.5	340
Xylenes	0.5	560
Ethylbenzene	0.5	96

QA/QC: Sample blank is none detected
Duplicate Deviation is 6.8%

Note: Analysis was performed using EPA methods 5030 and TPH LUFT with method 602 used for BTX distinction.
(ppb) = (µg/L)

MOBILE CHEM LABS

Ronald G. Evans
Lab Director

MOBILE CHEM LABS INC.
5021 Blum Road, Suite 3 • Martinez, CA 94553
Phone (415) 372-3700 • Fax (415) 372-6955

T69-677-02\1342\012272

Weiss Associates
5500 Shellmound St.
Emeryville, CA 94611
Attn: Bob Riddell
Project Manager

Date Sampled: 11-17-92
Date Received: 11-19-92
Date Analyzed: 11-23-92

Sample Number	Sample Description
112302	Project # T69-677-02 Texaco - Livermore 930 Springtown Effluent WATER

ANALYSIS

	Detection Limit	Sample Results
	ppb	ppb
Total Petroleum Hydrocarbons as Gasoline	50	<50
Benzene	0.5	<0.5
Toluene	0.5	<0.5
Xylenes	0.5	<0.5
Ethylbenzene	0.5	<0.5

QA/QC: Sample blank is none detected

Note: Analysis was performed using EPA methods 5030 and TPH LUFT with method 602 used for BTX distinction.
(ppb) = (µg/L)

MOBILE CHEM LABS

Ronald G. Evans
Lab Director

WEISS ASSOCIATES
5500 Shellmound Street, Emeryville, CA 94608
Phone: 415-547-5420 Fax: 415-547-5043

Please send analytic results and a copy of the signed chain of custody form to:

BOB RIDDELL

Project ID: 69·677·02

Lab Personnel:

☐ PLEASE INCLUDE QA/QC DATA IF BOX IS CHECKED.

1) Specify analytic method and detection limit in report.
2) Notify us if there are any anomalous peaks in GC or other scans.
3) ANY QUESTIONS/CLARIFICATIONS: CALL US.

CHAIN-OF-CUSTODY RECORD AND ANALYTIC INSTRUCTIONS

Sampled by: D. CHARLES

Laboratory Name: MOBIL CHEM. LAB

No. of Containers	Sample ID	Container Type[1]	Sample Date	Vol[2]	Fil[3]	Ref[4]	Preservative (specify)	Analyze for	Analytic Method	Turn[5]	COMMENTS
3	INFLUENT	W/V	11-17-92	40 ml	N	Y	HCL	TPH·G/BETX	8015/8020	N	
3	EFFLUENT	"	"	"	"	"	"	" "	" "	"	

1
Released by (Signature), Date

Weiss Assoc. 11-17-92
Affiliation

2 Rob Hoffman 11/19/92
Received by (Signature), Date

2 Weiss
Affiliation

3 Rob Hoffman 11/19/92
Released by (Signature), Date

3 Weiss
Affiliation

4 X Oren Leone
Shipping Carrier, Method, Date

4 X Mobile Chem Labs Inc.
Affiliation

5
Released by (Signature), Date

5
Affiliation

6
Received by Lab Personnel, Date

x
Seal intact?

6
Affiliation, Telephone

1 Sample Type Codes: W = Water, S = Soil, Describe Other; Container Type Codes: V = VOA/Teflon Septa, P = Plastic, C or B - Clear/Brown Glass, Describe Other;
Cap Codes: PT = Plastic, Teflon Lined 2 = Volume per container; 3 = Filtered (Y/N); 4 = Refrigerated (Y/N)
5 Turnaround [N = Normal, W = 1 Week, R = 24 Hour, HOLD (write out)]

ADDITIONAL COMMENTS, CONDITIONS, PROBLEMS:

Page 1 of 1

D:\ALL\ADMIN\FORMS\COC.WP2

MOBILE CHEM LABS INC.
5021 Blum Road, Suite 3 • Martinez, CA 94553
Phone (415) 372-3700 • Fax (415) 372-6955

T69-677-02\1223\012220

Weiss Associates
5500 Shellmound St.
Emeryville, CA 94611
Attn: Bob Riddell
Project Manager

Date Sampled: 10-27-92
Date Received: 10-29-92
Date Analyzed: 11-11-92

Sample Number	Sample Description
102420	Project # T69-677-02 Texaco - Livermore 930 Springtown 102EW1B4 WATER

ANALYSIS

	Detection Limit ppb	Sample Results ppb
Total Petroleum Hydrocarbons as Gasoline	50	11,000
Benzene	0.5	410
Toluene	0.5	2,000
Xylenes	0.5	2,100
Ethylbenzene	0.5	540

QA/QC: Sample blank is none detected
Duplicate Deviation is 12.1%

Note: Analysis was performed using EPA methods 5030 and TPH LUFT with method 602 used for BTX distinction.
(ppb) = (μg/L)

MOBILE CHEM LABS

Ronald G. Evans
Lab Director

MOBILE CHEM LABS INC.
5021 Blum Road, Suite 3 • Martinez, CA 94553
Phone (415) 372-3700 • Fax (415) 372-6955

T69-677-02\1223\012220

Weiss Associates
5500 Shellmound St.
Emeryville, CA 94611
Attn: Bob Riddell
Project Manager

Date Sampled: 10-27-92
Date Received: 10-29-92
Date Analyzed: 11-11-92

Sample Number	Sample Description
102421	Project # T69-677-02 Texaco - Livermore 930 Springtown 102EW1AFTER WATER

ANALYSIS

	Detection Limit	Sample Results
	ppb	ppb
Total Petroleum Hydrocarbons as Gasoline	50	13,000
Benzene	0.5	840
Toluene	0.5	2,400
Xylenes	0.5	1,900
Ethylbenzene	0.5	580

QA/QC: Sample blank is none detected

Note: Analysis was performed using EPA methods 5030 and TPH LUFT with method 602 used for BTX distinction.
(ppb) = (µg/L)

MOBILE CHEM LABS

Ronald G. Evans
Lab Director

MOBILE CHEM LABS INC.
5021 Blum Road, Suite 3 • Martinez, CA 94553
Phone (415) 372-3700 • Fax (415) 372-6955

T69-677-02\1342\012219

Weiss Associates
5500 Shellmound Street
Emeryville, CA 94608
Attn: Eric Anderson
Project Manager

Date Sampled: 10-27-92
Date Received: 10-27-92
Date Reported: 10-29-92

Sample Number	Sample Description
102398	Project #T69-677-02 Texaco - Livermore 930 Springtown MW-A AIR

ANALYSIS

	Detection Limit	Sample Results
	mg/m^3	mg/m^3
Total Petroleum Hydrocarbons as Gasoline	2.0	3,200
Benzene	0.05	30
Toluene	0.05	7.8
Xylenes	0.05	34
Ethylbenzene	0.05	21

QA/QC: Sample blank is none detected

Note: Analysis was performed using EPA methods 5030 and TPH LUFT with method 8020 used for BTX distinction.

MOBILE CHEM LABS

Ronald G. Evans
Lab Director

MOBILE CHEM LABS INC.
5021 Blum Road, Suite 3 • Martinez, CA 94553
Phone (415) 372-3700 • Fax (415) 372-6955

T69-677-02\1342\012219

Weiss Associates
5500 Shellmound Street
Emeryville, CA 94608
Attn: Eric Anderson
Project Manager

Date Sampled: 10-27-92
Date Received: 10-27-92
Date Reported: 10-29-92

Sample Number	Sample Description
102399	Project #T69-677-02 Texaco - Livermore 930 Springtown **MW-D** **AIR**

ANALYSIS

	Detection Limit	Sample Results
	mg/m^3	mg/m^3
Total Petroleum Hydrocarbons as Gasoline	2.0	65,000
Benzene	0.05	1,100
Toluene	0.05	260
Xylenes	0.05	210
Ethylbenzene	0.05	150

QA/QC: Sample blank is none detected

Note: Analysis was performed using EPA methods 5030 and TPH LUFT with method 8020 used for BTX distinction.

MOBILE CHEM LABS

Ronald G. Evans
Lab Director

MOBILE CHEM LABS INC.
5021 Blum Road, Suite 3 • Martinez, CA 94553
Phone (415) 372-3700 • Fax (415) 372-6955

T69-677-02\1342\012219

Weiss Associates
5500 Shellmound Street
Emeryville, CA 94608
Attn: Eric Anderson
Project Manager

Date Sampled: 10-27-92
Date Received: 10-27-92
Date Reported: 10-29-92

Sample Number	Sample Description
102400	Project #T69-677-02 Texaco - Livermore 930 Springtown MW-5 [illegible]

ANALYSIS

	Detection Limit	Sample Results
	mg/m^3	mg/m^3
Total Petroleum Hydrocarbons as Gasoline	2.0	72,000
Benzene	0.05	360
Toluene	0.05	14
Xylenes	0.05	56
Ethylbenzene	0.05	5.3

QA/QC: Sample blank is none detected
Duplicate Deviation is 6.5%

Note: Analysis was performed using EPA methods 5030 and TPH LUFT with method 8020 used for BTX distinction.

MOBILE CHEM LABS

Ronald G. Evans
Lab Director

MOBILE CHEM LABS INC.

5021 Blum Road, Suite 3 • Martinez, CA 94553
Phone (415) 372-3700 • Fax (415) 372-6955

T69-677-02\1342\012219

Weiss Associates
5500 Shellmound Street
Emeryville, CA 94608
Attn: Eric Anderson
Project Manager

Date Sampled: 10-27-92
Date Received: 10-27-92
Date Reported: 10-29-92

Sample Number	Sample Description
102401	Project #T69-677-02 Texaco - Livermore 930 Springtown VE-1 Start AIR

ANALYSIS

	Detection Limit mg/m^3	Sample Results mg/m^3
Total Petroleum Hydrocarbons as Gasoline	2.0	4,600
Benzene	0.05	56
Toluene	0.05	67
Xylenes	0.05	60
Ethylbenzene	0.05	22

QA/QC: Sample blank is none detected

Note: Analysis was performed using EPA methods 5030 and TPH LUFT with method 8020 used for BTX distinction.

MOBILE CHEM LABS

Ronald G. Evans
Lab Director

MOBILE CHEM LABS INC.
5021 Blum Road, Suite 3 • Martinez, CA 94553
Phone (415) 372-3700 • Fax (415) 372-6955

T69-677-02\1342\012219

Weiss Associates
5500 Shellmound Street
Emeryville, CA 94608
Attn: Eric Anderson
Project Manager

Date Sampled: 10-27-92
Date Received: 10-27-92
Date Reported: 10-29-92

Sample Number	Sample Description
102402	Project #T69-677-02 Texaco - Livermore 930 Springtown VE-1 End AIR

ANALYSIS

	Detection Limit	Sample Results
	mg/m^3	mg/m^3
Total Petroleum Hydrocarbons as Gasoline	2.0	680
Benzene	0.05	8.4
Toluene	0.05	6.4
Xylenes	0.05	5.9
Ethylbenzene	0.05	2.6

QA/QC: Sample blank is none detected

Note: Analysis was performed using EPA methods 5030 and TPH LUFT with method 8020 used for BTX distinction.

MOBILE CHEM LABS

Ronald G. Evans
Lab Director

MOBILE CHEM LABS INC.
5021 Blum Road, Suite 3 • Martinez, CA 94553
Phone (415) 372-3700 • Fax (415) 372-6955

T69-677-02\1342\012219

Weiss Associates
5500 Shellmound Street
Emeryville, CA 94608
Attn: Eric Anderson
Project Manager

Date Sampled: 10-27-92
Date Received: 10-27-92
Date Reported: 10-29-92

Sample Number	Sample Description
102403	Project #T69-677-02 Texaco - Livermore 930 Springtown EW-1 AIR

ANALYSIS

	Detection Limit	Sample Results
	mg/m^3	mg/m^3
Total Petroleum Hydrocarbons as Gasoline	2.0	1,500
Benzene	0.05	12
Toluene	0.05	10
Xylenes	0.05	12
Ethylbenzene	0.05	5.0

QA/QC: Sample blank is none detected

Note: Analysis was performed using EPA methods 5030 and TPH LUFT with method 8020 used for BTX distinction.

MOBILE CHEM LABS

Ronald Evans

Ronald G. Evans
Lab Director

WA WEISS ASSOCIATES
5500 Shellmound Street, Emeryville, CA 94608
Phone: 415-547-5420 Fax: 415-547-5043

Please send analytic results and a copy of the signed chain of custody form to:

____

Project ID: T69-677-02

Lab Personnel:

☐ PLEASE INCLUDE QA/QC DATA IF BOX IS CHECKED.

1) Specify analytic method and detection limit in report.
2) Notify us if there are any anomalous peaks in GC or other scans.
3) ANY QUESTIONS/CLARIFICATIONS: CALL US.

CHAIN-OF-CUSTODY RECORD AND ANALYTIC INSTRUCTIONS

Sampled by: D.C.

Laboratory Name: MOBIL CHEM LAB
MARTINEZ, CA

No. of Containers	Sample ID	Container Type[1]	Sample Date	Vol[2]	Fil[3]	Ref[4]	Preservative (specify)	Analyze for	Analytic Method	Turn[5]	COMMENTS
2	MW-A	Air	10-27-92	1l	N	N	NONE	GAS, BETX	8015, 8020	N=72HRS	HOLD DUPE
2	MW-B	"	↓	"	↓	↓	↓	"	"	"	"
2	MW-5	"	↓	"	↓	↓	↓	"	"	"	"
2	VE-1 START	"	↓	"	↓	↓	↓	"	"	"	"
2	VE-1 END	"	↓	"	↓	↓	↓	"	"	"	"
2	EW-1	"	↓	"	↓	↓	↓	"	"	"	"

1 ______________________________
Released by (Signature), Date

1 Weiss Assoc. 10-27-92
Affiliation

2 Robyn L Brewer
Received by (Signature), Date

2 Weiss 10/27/92
Affiliation

3 Robyn L Brewer 10/28/92
Released by (Signature), Date

3 Weiss
Affiliation

4 ______________________________
Shipping Carrier, Method, Date

4 ______________________________
Affiliation

5 Dan C Rheune 10/28/92
Released by (Signature), Date

5 ______________________________
Affiliation

6 ______________________________
Received by Lab Personnel, Date

x ______________________________
Seal intact?

6 ______________________________
Affiliation, Telephone

1 Sample Type Codes: W = Water, S = Soil, Describe Other; Container Type Codes: V = VOA/Teflon Septa, P = Plastic, C or B - Clear/Brown Glass, Describe Other;
Cap Codes: PT = Plastic, Teflon Lined 2 = Volume per container; 3 = Filtered (Y/N); 4 = Refrigerated (Y/N)
5 Turnaround [N = Normal, W = 1 Week, R = 24 Hour, HOLD (write out)]

ADDITIONAL COMMENTS, CONDITIONS, PROBLEMS:

Page 1 of 1

MOBILE CHEM LABS INC.
5021 Blum Road, Suite 3 • Martinez, CA 94553
Phone (415) 372-3700 • Fax (415) 372-6955

T69-677-02\1342\012220

Weiss Associates
5500 Shellmound Street
Emeryville, CA 94608
Attn: Eric Anderson
Project Manager

Date Sampled: 10-28-92
Date Received: 10-29-92
Date Reported: 10-30-92

Sample Number	Sample Description
102422	Project #T69-677-02 Texaco - Livermore 930 Springtown VE-1 1400 AIR

ANALYSIS

	Detection Limit	Sample Results
	mg/m³	mg/m³
Total Petroleum Hydrocarbons as Gasoline	2.0	1,400
Benzene	0.05	11
Toluene	0.05	10
Xylenes	0.05	14
Ethylbenzene	0.05	4.4

QA/QC: Sample blank is none detected

Note: Analysis was performed using EPA methods 5030 and TPH LUFT with method 8020 used for BTX distinction.

MOBILE CHEM LABS

Ronald G. Evans
Lab Director

MOBILE CHEM LABS INC.
5021 Blum Road, Suite 3 • Martinez, CA 94553
Phone (415) 372-3700 • Fax (415) 372-6955

T69-677-02\1342\012220

Weiss Associates
5500 Shellmound Street
Emeryville, CA 94608
Attn: Eric Anderson
Project Manager

Date Sampled: 10-28-92
Date Received: 10-29-92
Date Reported: 10-30-92

Sample Number	Sample Description
102423	Project #T69-677-02 Texaco - Livermore 930 Springtown VE-1 1524 AIR

ANALYSIS

	Detection Limit	Sample Results
	mg/m^3	mg/m^3
Total Petroleum Hydrocarbons as Gasoline	2.0	2,200
Benzene	0.05	17
Toluene	0.05	8.1
Xylenes	0.05	13
Ethylbenzene	0.05	4.3

QA/QC: Sample blank is none detected

Note: Analysis was performed using EPA methods 5030 and TPH LUFT with method 8020 used for BTX distinction.

MOBILE CHEM LABS

Ronald G. Evans
Lab Director

MOBILE CHEM LABS INC.

5021 Blum Road, Suite 3 • Martinez, CA 94553
Phone (415) 372-3700 • Fax (415) 372-6955

T69-677-02\1342\012220

Weiss Associates
5500 Shellmound Street
Emeryville, CA 94608
Attn: Eric Anderson
Project Manager

Date Sampled: 10-28-92
Date Received: 10-29-92
Date Reported: 10-30-92

Sample Number	Sample Description
102424	Project #T69-677-02 Texaco - Livermore 930 Springtown VE-1 1546 AIR

ANALYSIS

	Detection Limit	Sample Results
	mg/m^3	mg/m^3
Total Petroleum Hydrocarbons as Gasoline	10.0	<10
Benzene	0.05	<0.05
Toluene	0.05	<0.05
Xylenes	0.05	<0.05
Ethylbenzene	0.05	<0.05

QA/QC: Sample blank is none detected

Note: Analysis was performed using EPA methods 5030 and TPH LUFT with method 8020 used for BTX distinction.

MOBILE CHEM LABS

Ronald G. Evans
Lab Director

MOBILE CHEM LABS INC.
5021 Blum Road, Suite 3 • Martinez, CA 94553
Phone (415) 372-3700 • Fax (415) 372-6955

T69-677-02\1342\012220

Weiss Associates
5500 Shellmound Street
Emeryville, CA 94608
Attn: Eric Anderson
Project Manager

Date Sampled: 10-27-92
Date Received: 10-29-92
Date Reported: 10-30-92

Sample Number	Sample Description
102425	Project #T69-677-02 Texaco - Livermore 930 Springtown VE-1 1603 AIR

ANALYSIS

	Detection Limit mg/m^3	Sample Results mg/m^3
Total Petroleum Hydrocarbons as Gasoline	2.0	18,000
Benzene	0.05	63
Toluene	0.05	10
Xylenes	0.05	10
Ethylbenzene	0.05	4.6

QA/QC: Sample blank is none detected

Note: Analysis was performed using EPA methods 5030 and TPH LUFT with method 8020 used for BTX distinction.

MOBILE CHEM LABS

Ronald G. Evans
Lab Director

MOBILE CHEM LABS INC.
5021 Blum Road, Suite 3 • Martinez, CA 94553
Phone (415) 372-3700 • Fax (415) 372-6955

T69-677-02\1342\012220

Weiss Associates
5500 Shellmound Street
Emeryville, CA 94608
Attn: Eric Anderson
Project Manager

Date Sampled: 10-27-92
Date Received: 10-29-92
Date Reported: 10-30-92

Sample Number	Sample Description
102426	Project #T69-677-02 Texaco - Livermore 930 Springtown VE-1 1645 AIR

ANALYSIS

	Detection Limit	Sample Results
	mg/m^3	mg/m^3
Total Petroleum Hydrocarbons as Gasoline	2.0	22,000
Benzene	0.05	260
Toluene	0.05	130
Xylenes	0.05	60
Ethylbenzene	0.05	29

QA/QC: Sample blank is none detected

Note: Analysis was performed using EPA methods 5030 and TPH LUFT with method 8020 used for BTX distinction.

MOBILE CHEM LABS

Ronald G. Evans
Lab Director

MOBILE CHEM LABS INC.
5021 Blum Road, Suite 3 • Martinez, CA 94553
Phone (415) 372-3700 • Fax (415) 372-6955

T69-677-02\1342\012220

Weiss Associates
5500 Shellmound Street
Emeryville, CA 94608
Attn: Eric Anderson
Project Manager

Date Sampled: 10-27-92
Date Received: 10-29-92
Date Reported: 10-30-92

Sample Number	Sample Description
102427	Project #T69-677-02 Texaco - Livermore 930 Springtown VE-1 1711 AIR

ANALYSIS

	Detection Limit mg/m^3	Sample Results mg/m^3
Total Petroleum Hydrocarbons as Gasoline	2.0	12,000
Benzene	0.05	170
Toluene	0.05	120
Xylenes	0.05	54
Ethylbenzene	0.05	29

QA/QC: Sample blank is none detected

Note: Analysis was performed using EPA methods 5030 and TPH LUFT with method 8020 used for BTX distinction.

MOBILE CHEM LABS

Ronald G. Evans
Lab Director

WEISS ASSOCIATES
5500 Shellmound Street, Emeryville, CA 94608
Phone: 415-547-5420 Fax: 415-547-5043

Please send analytic results and a copy of the signed chain of custody form to:

BOB RIDDELL

Project ID: T69-677-02

Lab Personnel:

☐ PLEASE INCLUDE QA/QC DATA IF BOX IS CHECKED.

1) Specify analytic method and detection limit in report.
2) Notify us if there are any anomalous peaks in GC or other scans.
3) ANY QUESTIONS/CLARIFICATIONS: CALL US.

CHAIN-OF-CUSTODY RECORD AND ANALYTIC INSTRUCTIONS

Sampled by: D.C./RRM.

Laboratory Name: MOBIL CHEM LAB, MARTINEZ, CA

No. of Containers	Sample ID	Container Type[1]	Sample Date	Vol[2]	Fil[3]	Ref[4]	Preservative (specify)	Analyze for	Analytic Method	Turn[5]	COMMENTS
3	102-EW1 BH	w/v	10-28-92	40 mL	N	Y	HCL	TPH-G/BETX	EPA 8015/8020	N = HRS.	~~S.V.E.~~ (x)
3	102-EW1-AFTER	"	↓	"	↓	"	"	↓	↓	↓	~~[illegible]~~
2	VE-1 1400	TEDLAR	↓	1 L.	↓	N	NONE	↓	↓	↓	S.V.E.
2	VE-1 1524	"	↓	↓	↓	↓	↓	↓	↓	↓	S.V.E.
1	VE-1 1546	"	↓	↓	↓	↓	↓	↓	↓	↓	S.V.E. + AIR SPARGII
1	VE-1 1603	"	↓	↓	↓	↓	↓	↓	↓	↓	" "
2	VE-1 1645	"	↓	↓	↓	↓	↓	↓	↓	↓	" "
2	VE-1 1711	"	↓	↓	↓	↓	↓	↓	↓	↓	S.V.E. ONLY

1 10/28/92
Released by (Signature), Date

1 Weiss Assoc. 1930
Affiliation

2 Robyn L. Brewer
Received by (Signature), Date 10/29/92

2 Weiss Assoc. 0200
Affiliation

3 Robyn L Brewer 10/29/92 1240
Released by (Signature), Date

3 WA
Affiliation

4
Shipping Carrier, Method, Date

4
Affiliation

5
Released by (Signature), Date

5
Affiliation

6 Dave R Levine 10-29-92 12:40
Received by Lab Personnel, Date

Seal intact?

6
Affiliation, Telephone

1 Sample Type Codes: W = Water, S = Soil, Describe Other; Container Type Codes: V = VOA/Teflon Septa, P = Plastic, C or B - Clear/Brown Glass, Describe Other;
Cap Codes: PT = Plastic, Teflon Lined 2 = Volume per container; 3 = Filtered (Y/N); 4 = Refrigerated (Y/N)
5 Turnaround [N = Normal, W = 1 Week, R = 24 Hour, HOLD (write out)]

ADDITIONAL COMMENTS, CONDITIONS, PROBLEMS:

Page 1 of 1

APPENDIX D

GROUND WATER DISCHARGE PERMIT

November 3, 1992

ADMINISTRATION BUILDING
1052 South Livermore Avenue
Livermore, CA 94550
(415) 373-5100
FAX (415) 373-[illegible]

Texaco Refining and Marketing
108 Cutting Blvd.
Richmond Ca, 94804

Attention: Bob Riddell

Subject: Groundwater Discharge Permit

Dear Mr. Riddell,

The City has reviewed your groundwater discharge permit application and has found it to be complete. Enclosed you will find the following information:

1. 1992-93 Groundwater Discharge Permit
2. Discharge Permit Fee Statement
3. Permit Conditions and Prohibitions

As we discussed, the city will require that one sample is collected at the completion of the pumping tests. This sample shall be analyzed for Total Petroleum Hydrocarbons, and the results must be submitted to:

City of Livermore Water Resources Division
10 Rickenbacker Circle
Livermore, CA 94550

Analytical results must include the volume of groundwater discharged to the sanitary sewer. For the purposes of this permit, a limit on Total Petroleum Hydrocarbons of 250 ug/L will be imposed. Based on the information in the permit application, this limit will be easily obtained with the proposed treatment technology.

This permit is being issued for a 24-hour pumping test only. If a treatment system and remediation plan are developed within the duration of this permit, the permit may be modified to cover discharges from this system. If you would like to pursue this option, please submit additional information on the treatment system when you are ready to begin remediation.

If you have any questions regarding the permit or any of the attached information, please contact me at (510) 373-5230.

Sincerely,

Darren Greenwood

Darren Greenwood
Source Control Inspector

LIVERMORE

WATER RECLAMATION PLANT
1250 Kitty Hawk Road
Livermore, California 94550
(510) 373-5230

CITY OF LIVERMORE
GROUNDWATER DISCHARGE PERMIT

AUTHORIZATION: The below named party is hereby authorized to discharge wastewater to the City of Livermore community sewer subject to compliance with the City of Livermore wastewater control ordinance and the conditions set forth in this permit.

PERMITTEE Texaco Refining and Marketing
ADDRESS 930 Springtown Blvd.
Livermore
California ZIP 94550

— PERMIT CONDITIONS —

☐ NONE ☒ SEE ATTACHED

The above named shall report to the City of Livermore Water Reclamation Plant any change, (permanent or temporary) to the premise or operation that significantly change the quality or volume of the Groundwater discharge or deviate from the terms and conditions under which this permit is granted.

EFFECTIVE DATE: November 3, 1992 EXPIRATION DATE: November 2, 1993
DATED: November 3, 1992 APPROVED BY:

POST PERMIT IN PLAIN VIEW

WASTEWATER PERMIT CONDITIONS
FOR GROUNDWATER DISCHARGER APPLICANTS

1. The City of Livermore Water Reclamation Plant issues the groundwater permit on a temporary and conditional basis only. The groundwater permit will not exceed one year in duration. The permit is conditional and may be revoked at any time by the WRP superintendent or his representative. The permit is non-transferrable.

2. Permittee shall abide by all applicable provisions of the City of Livermore Municipal Code or any applicable local, State, or Federal code or regulation. Any violation of any provision of said codes or regulations will be just cause for revoking this permit.

3. Permittee shall not discharge to the sanitary system any materials or liquid wastes which may be harmful to the system or create a hazard or nuisance as defined in Section 13.32.060. Permittee may be required to bear the costs of any damage to the sanitary system attributable to the permittee.

4. The pH shall be no lower than 6.0 or higher than 9.0 at any time.

5. Any accidental discharge to the City of Livermore sanitary system must be reported immediately. Non-reporting of spill or slug incidents will be cause for administrative permit review.

6. All liquid or solid waste stored or hauled from the permittee's premise must meet all applicable local, State, and Federal rules and regulations. Certain RCRA regulations may apply to hazardous waste treated, stored, or generated on permittee's premise.

7. Any sludge generated by permittee is specifically prohibited from introduction into the City of Livermore sanitary system.

8. Conditional pollutant concentration limits for specific pollutants may be temporarily established by the Water Reclamation Plant Superintendent, and are subject to review and change without prior notification.

9. Permittee shall not discharge wastewater containing in excess of:

0.06	mg/l	arsenic	0.20	mg/l	lead
0.14	mg/l	cadmium	0.01	mg/l	mercury
0.61	mg/l	nickel	0.20	mg/l	silver
0.62	mg/l	total chromium	3.00	mg/l	zinc
1.00	mg/l	copper	0.04	mg/l	cyanide
1.00	mg/l	total toxic organics			

From Section 13.32.100 of the Livermore Municipal Code