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November 25, 1996

Mr. Scott Seery
Alameda County Environmental Health
1131 Harbor Bay Parkway, 2nd Floor
Alameda, CA 94502

Mr. Kevin Graves
San Francisco Bay Regional Water Quality Control Board
2101 Webster St., Suite 500
Oakland, CA 94612

97 FEB -4 PM 3:27
ENVIRONMENTAL PROTECTION

Re: Former Chevron Station # 9-5607, 5269 Crow Canyon Road, Castro Valley, CA
Attached Soil Vapor Survey and Risk Assessment Results (Weiss, 1/20/97)

Dear Gentlemen:

Please find attached a report dated January 20, 1997 that was prepared by Chevron's consultant, Weiss Associates (Weiss), to describe the results of soil, soil vapor, and groundwater sampling that was performed downgradient from the subject site during August, 1996. The acquired data were used in an ASTM RBCA evaluation to determine the health risk to adjacent property owners from a release of motor fuel hydrocarbons at the subject site. In addition, Weiss' report presents a comparison of in-situ groundwater conditions to the SFBRWQCB's criteria for a low risk groundwater case (12/8/95) and issues recommendations for the subject site based on the comparison results.

The attached document represents the final version of this RBCA evaluation. As soon as you have had a chance to review it, I would like to get your feedback and/or discuss any issues you might have before the document is distributed to the adjacent property owners. Please call Mike Cooke (Weiss Assoc.) at (510) 450-6150 or myself at (510) 842-8695 to arrange a meeting or discuss further.

Sincerely,

Brett L. Hunter

Brett L. Hunter
Environmental Engineer
Site Assessment and Remediation

Attachment

cc: Mike Cooke, Weiss Associates, 5500 Shellmound St., Emeryville, CA 94608-2411 (w/o attach)
Curt Peck, Chevron Research and Technology Company, Richmond, CA (w/o attach.)
John Randall, Chevron Products Company, San Ramon, CA (w/o attachment)
Bette Owen, Chevron Products Company, San Ramon, CA (w/o attachment)

Weiss Associates

Environmental and Geologic Services

5500 Shellmound Street, Emeryville, CA 94608-2411 FAX: 510-547-5043 Phone: 510-450-6000

TRANSMITTAL

TO:	Scott Seery	**DATE:**	March 3, 1997
COMPANY:	Alameda County Health Services Agency Department of Environmental Health 1131 Harbor Bay Parkway, 2nd Floor Alameda, CA 94502	**PROJECT #:**	4-1129-70
FROM:	Tim Utterback, (510) 450-6193		

ENCLOSED PLEASE FIND: **Reference Documents for Soil Vapor Survey and Risk Assessment Report, Former Chevron Service Station #9-5607, 5269 Crow Canyon Road, Castro Valley CA**

VIA:	**FAX:**	**AS:**	**FOR:**
☐ Fax	# of pages: _____ (including this cover)	☐ Per our phone call	☑ Your information
☑ 1st Class Mail	☐ Hard Copy to follow	☑ You requested	☐ Return to you
☐ Overnight Delivery		☐ Is required	☐ Your action
☐ UPS (Surface)		☐ We believe you may be interested	☐ Your review & comments
☐ Courier			

COMMENTS:

Enclosed are the reference documents you requested for the above referenced site. Please call me at (510) 450-6193 if you have any questions

Please call (510) 450-6000 if there are any problems with transmission.

J:\CHEVRON\1129\CORRESPO.97\038EET1.DOC

Weiss Associates Environmental and Geologic Services

5500 Shellmound Street, Emeryville, CA 94608-2411 Fax: 510-547-5043 Phone: 510-450-6000

January 20, 1997

Mr. Scott Seery
Alameda County Health Care Services Agency
Department of Environmental Health
1131 Harbor Bay Parkway, 2nd Floor
Alameda, California, 94502

RE: Soil Vapor Survey and Risk Assessment Results
Former Chevron Service Station #9-5607
5269 Crow Canyon Road
Castro Valley, California
WA Job #4-1129-70

Dear Mr. Seery:

On behalf of Chevron Products Company (Chevron), Weiss Associates (WA) has completed a soil vapor survey and American Society for Testing and Materials Risk-Based Corrective Action (ASTM RBCA)[1] analysis for the above referenced site. The soil vapor survey results and ASTM RBCA analysis are presented as Attachments A and B, respectively. The soil vapor survey was conducted to collect vadose zone hydrocarbon vapor concentration data and to measure soil physical properties for determining the extent of vapor transport to indoor building air and ambient outdoor air. The soil vapor survey data were used in conservative vapor transport models to determine whether petroleum hydrocarbons pose significant risk to the residents of the Forest Creek Townhomes condominium complex. In addition, the measured vapor concentrations were compared to vapor concentrations predicted by ASTM RBCA models to assess whether these models are representative of conditions at this site (Attachment C).

Summarized below are the RBCA results followed by a comparison of site conditions and RBCA results to the Regional Water Quality Control Board (RWQCB) Interim Guidance on Required Clean Up at Low Risk Fuel Sites[2], and a proposed Future Action Plan.

---

[1] ASTM 1995. Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites, E 1739-95.

[2] California Regional Water Quality Control Board, December 8, 1995. Interim Guidance on Required Cleanup at Low Risk Fuel Sites.

Summary of RBCA Results.

The results of the RBCA evaluation indicate that subsurface hydrocarbons do not pose significant risk to the residents located along Waterford Place in Castro Valley, California. In summary the results are:

- Concentrations of toluene, ethylbenzene and xylenes in soil and ground water are less than the Tier 1 Risk-Based Screening Levels (RBSL) for all exposure pathways. Benzene in ground water is below the RBSL for transport to outdoor air.

- Benzene vapor concentrations measured in vadose zone soil [illegible] by [illegible] indoor or outdoor air is estimated to be 3.8×10^{-9} and 4.7×10^{-12}, respectively. These results indicate the indoor air vapor pathway health risk is nearly four orders of magnitude below the acceptable 10^{-5} target risk level. Concentrations of benzene in shallow soil would have to increase nearly four orders of magnitude before the indoor air vapor pathway would become a concern. A concentration of benzene in soil vapor of 107,000 parts per billion by volume (ppbv) at 3 ft below ground surface (bgs) would result in 10^{-5} incremental risk via the indoor inhalation pathway calculated using site-specific parameters while still making the conservative assumption that vapors don't attenuate due to the structural floor of the building. The highest detected concentration of benzene in soil vapor was 39,000 ppbv at 25 ft bgs.

- WA and Chevron believe that the data collected to date are sufficient in both quantity and quality for use in this analysis. The existing worst case data clearly shows the vapor pathway is not a concern. The soil vapor survey to collect Tier 2 vapor pathway data was performed during the driest part of the year (August) when the maximum vapor flux from impacted soil and ground water is predicted to occur. Diffusive vapor transport is greatest when volumetric air filled porosity is greatest[3]. Site-specific data indicated relatively low air filled porosity in the soil cores collected on August 19, 1996 at sample location SV-1. Air filled porosity will be lower during other seasons of the year due to infiltration from rainfall. Thus diffusive vapor transport is expected to be less and the associated vapor pathway risk would be less.

- Alternative points of exposure were selected for benzene for the direct ingestion pathway based on evaluation of dissolved concentrations and ground water use in the vicinity of the impacted area. Wells C-10B, C-15 and C-16 were selected as alternative points of exposure with SSTLs set at the Tier 1 RBSL concentrations to protect down gradient receptors. As long as the dissolved hydrocarbon concentrations in wells C-10B, C-15 and C-16 remain below the Tier 1 RBSLs, no significant health risk to receptors down gradient of these wells is predicted.

[3] See the expression for the effective diffusion coefficient in soil listed in the ASTM RBCA guidance document (ASTM 95) table X2.5.

- Ground water fate and transport modeling calculations (Attachment B, Appendix C) indicate that Crow Creek is not likely to be impacted by dissolved benzene concentrations above 0.001 mg/L (California Department of Toxic Substances Control's maximum contaminant level).
- The results of the RBCA evaluation indicate further operation of the ground water extraction system at the subject site is unnecessary. A contingency plan with respect to the ground water extraction system is presented below.

The RBCA evaluation results indicate that the subsurface petroleum hydrocarbons in the residential area pose no demonstrable long-term threat to human health, safety or sensitive environmental receptors. Therefore, a ground water monitoring program and contingency plan is appropriate to manage the subsurface hydrocarbons at this time. A future action plan including the proposed ground water monitoring schedule and contingency plan is presented following the low-risk ground water case comparison presented below.

Low Risk Groundwater Case Comparison

This site meets the six Regional Water Quality Control Board, San Francisco Bay Regional criteria of a "low-risk ground water case," as defined in the Supplemental Instructions to State Water Board December 8, 1995, Interim Guidance on Required Cleanup at Low-Risk Fuel Sites. Each low-risk ground water case definition, taken directly from the interim guidance, is presented below, followed by a response to each:

1. *"The leak has been stopped and ongoing sources, including free product, have been removed or remediated."*
   - The former underground storage tanks (USTs) and lines were replaced with double-walled fiberglass tanks and lines in April 1985, shortly after the release was discovered. In October 1990, all gasoline storage tanks and piping were removed from the site and the service station was abandoned.
   - As of September 1987, 194 pounds of separate-phase hydrocarbons were removed from the site wells by bailing. Separate-phase hydrocarbons have not been observed in any of the site wells since October 22, 1992.
   - In October 1990, approximately 300 cubic yards of hydrocarbon-bearing soil was overexcavated.
   - The ground water extraction system has been removing dissolved-phase hydrocarbons from below the site since June 1985.

2. *"The site has been adequately characterized."*
   - Chevron currently uses 17 ground water monitoring wells to characterize the extent of dissolved hydrocarbons (Figure 2).

- Wells C-1, C-2, C-3, C-6, C-9, C-12 and RW-1 characterize the impacted area adjacent to and immediately downgradient of the former USTs. During the first and second quarter 1996 monitoring events, these wells contained dissolved benzene concentrations ranging from 0.029 to 26 mg/L.
- Wells C-5, C-7, C-8, C-10A, C-10B, C-11 and C-13 through C-16 surround the impacted area and define the upgradient, crossgradient and downgradient boundaries. Dissolved benzene concentrations in these wells are currently near or below laboratory detection limits.
- Since April 24, 1995, dissolved benzene concentrations have been below laboratory detection limits in the wells located between the impacted area and Crow Creek (wells C-10A, C-10B, C-15 and C-16), with the exception of the third quarter 1996 benzene detection in well C-15 which will be confirmed during future monitoring events.

3. *"The dissolved hydrocarbon plume is not migrating."* not sampled since 1/96

- Dissolved benzene concentrations in downgradient well C-9 have declined since September 13, 1989 and dissolved benzene concentrations in well C-12 have remained steady since installation in February, 1990.
- The benzene concentrations in ground water from downgradient plume boundary wells C-10A, C-10B, C-15 and C-16 were below laboratory detection limits during the first and second quarters of 1996.

4. *"No water wells, deeper drinking water aquifers, surface water or other sensitive receptors are likely to be impacted."*

- On September 11, 1996, WA requested a 1/2 mile radius well survey for the subject site from Alameda County Department of Public Works to determine the location of wells that may be used for drinking water consumption. We found no drinking water supply wells located between the former USTs and Crow Creek or nearby vicinity. Future drinking water well installations between the former USTs and Crow Creek are unlikely due to the current use and availability of municipal water.
- Ground water monitoring in wells C-10A, C-10B, C-15 and C-16 indicates that hydrocarbons should be below the California maximum contaminant levels (MCLs) in the vicinity of Crow Creek.
- Previously conducted ground water transport modeling indicates the dissolved benzene plume is not likely to impact Crow Creek regardless of whether the ground water extraction system is operated. The ground water modeling report is attached in the RBCA evaluation (Appendix C, Attachment B).

- Hydrocarbon migration to deeper drinking water aquifers is unlikely due to the presence of an underlying rock formation. The rock has been described as a well cemented claystone or siltstone in many of the site boring logs.

5. *"The site presents no significant risk to human health."*

- The results of the attached RBCA evaluation indicate that subsurface petroleum hydrocarbons in the residential area pose no demonstrable long term threat to human health or safety. The attached RBCA evaluation presents a detailed assessment of risk to human health.

6. *"The site presents no significant risk to the environment."*

- The hydrocarbons are located at approximately 20 ft bgs. Microorganisms are the only known environmental receptors capable of coming into contact with hydrocarbons at that depth. The presence of microorganisms enables biodegradation of the hydrocarbons.
- Ground water transport modeling calculations indicate that the dissolved benzene plume is not likely to impact Crow Creek regardless of whether the ground water extraction system is operated.

Therefore, the site meets all of the definitions for classification as a low-risk ground water case as defined in the Supplemental Instructions to State Water Board December 8, 1995, Interim Guidance on Required Cleanup at Low-Risk Fuel Sites. Passive bioremediation is the preferred management strategy for this site. Modeling calculations have shown that hydrocarbon concentrations above the California MCLs are not likely to impact Crow Creek regardless of whether the existing ground water extraction system is operated. The ground water extraction system should be shut-down and remain off unless monitoring data indicates that hydrocarbons are migrating to the creek. A management strategy incorporating passive bioremediation is outlined in the future action plan presented below.

Proposed Future Action Plan

Chevron and WA propose continued monitoring to verify plume stability and the effectiveness of remediation by natural attenuation at this site. The proposed initial action, monitoring schedule and contingency plan are:

Proposed Initial Action

- Shut down the existing ground water extraction system.

Monitoring Schedule

- Monitor wells C-6, C-9, C-10B, C-15, C-16 on a bi-annual basis for the next 2 years and annually thereafter.

- Immediately discontinue monitoring in all other wells.

Contingency Plan

- The ground water extraction system will be restarted if an increasing dissolved hydrocarbon concentration trend above the California MCLs is detected in wells C-10B, C-15 or C-16 for more than two consecutive monitoring events.
- The ground water extraction system will be shut off when dissolved hydrocarbon concentrations in wells C-10B, C-15 and C-16 are again below the California MCLs.

Summary

The RBCA assessment shows that subsurface petroleum hydrocarbons in the residential area pose no demonstrable long-term threat to human health or safety. Conservative alternative points of exposure for ground water ingestion were established based on ground water use in the vicinity of the site. Dissolved hydrocarbon transport modeling and historical ground water monitoring data indicates that Crow Creek, the nearest sensitive environmental receptor, will not likely be impacted.

At the request of the Alameda County Health Care Services Agency and RWQCB, Chevron originally committed to collecting site specific soil, ground water and hydrocarbon vapor concentrations and physical parameters during two separate sampling events. The objective being that two sets of data would increase the confidence that the site posed no risk to residential receptors. However, it is our opinion that the available data is sufficient to conservatively evaluate potential health risks, and that collecting more data is unlikely to show significant potential health risks due to the residual hydrocarbons.

The RBCA evaluation performed at this site used conservative models and assumptions to calculate potential health risk values. The data input into these models included the highest benzene concentration detected in soil vapor at the shallowest depth from 8 sample locations and the highest benzene, ethylbenzene, toluene and xylene concentrations historically detected in soil and in ground water over the last year in the vicinity of the residences. The results of the risk model calculations indicated that benzene vapor concentrations in shallow soil (approximately 3 feet bgs) would have to be almost 4 orders of magnitude (10,000 times) greater than the highest benzene vapor concentration measured in shallow soil at this site before the target 10^{-5} risk levels would be exceeded.

Extensive soil vapor sampling performed by the Lawrence Berkeley National Laboratory to research vapor transport to indoor air have shown that the temporal variations of soil-gas concentrations at a given depth were small and varied by less than a factor of two at their study site[4]. Still others have concluded that "transience, leaching and advection do not seem to play a major role

[4] Fischer, M.L., et al, 1996. Factors Affecting Indoor Air Concentrations of Volatile Compounds at a Site of Subsurface Gasoline Contamination, Environmental Science and Technology, Vol. 30, No 10, 1996.

over long time periods"[5]. Based on the conservativeness of the models used, the quantity of the data available, the almost four orders of magnitude difference between the risk value determined using soil vapor data and the 10^{-5} acceptable risk objective and the results of other investigations, we see no compelling or scientifically reasonable justification to collect additional data. read: don't want to spend the $$

The site meets the RWQCB low-risk ground water case definitions, therefore, passive bioremediation, the RWQCB's prescribed management strategy for low risk ground water case sites such as this one, is proposed to manage the remaining subsurface hydrocarbons. The proposed future action plan and conservative ground water monitoring schedule and contingency plan was developed to incorporate passive bioremediation as the management strategy. Therefore, based on the work performed at this site, WA and Chevron respectfully request that Alameda County Health Care Services Agency approve the above future action plan.

We appreciate the attention that Alameda County Health Services Agency has shown this case. If you have questions please don't hesitate to call us at (510) 450-6000 or Brett Hunter with Chevron Products Company at 842-8695.

Sincerely,
Weiss Associates

Tim Utterback
Senior Staff Engineer

Mike Cooke
Project Geologist

Jerry McHugh, P.E.
Principal Engineer

Attachments: Attachment A. Soil Vapor Survey Results
Attachment B. ASTM RBCA analysis.
Attachment C. Vapor Concentration Profile Comparison.

cc: Brett Hunter, Chevron Products Company, PO Box 5004, San Ramon, CA 94583-0804

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[5] Ostendorf, D. W., 1991. Biodegradation of Hydrocarbon Vapors in the Unsaturated Zone, Water Resources Research, Vol. 27, No 4, pp 453-462, April 1991.

ATTACHMENT A

SOIL VAPOR SURVEY RESULTS

Weiss Associates *Environmental and Geologic Services*

5500 Shellmound Street, Emeryville, CA 94608-2411 *Fax: 510-547-5043 Phone:* ***510-450-6000***

Soil Vapor Survey Sampling Report

for

Former Chevron Service Station #9-5607
5269 Crow Canyon Road
Castro Valley, California

prepared by

Weiss Associates
5500 Shellmound Street
Emeryville, CA 94608

WA Job # 4-1129-70

prepared for

Chevron Products Company
P.O. Box 5004
San Ramon, California 94583-0804

January 20, 1997

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FIGURES

Figure 1. Site Location Map.

Figure 2. Vapor, Soil and Ground Water Sample Locations and Analytical Methods.

Figure 3. Vapor Sample Collection Configuration.

TABLES

Table 1. Analytic Results for Vapor Samples.

Table 2. Analytic Results for Soil Samples.

Table 3. Physical Parameter Results for Soil Samples.

Table 4. Analytic Results for Ground Water Samples.

APPENDICES

Appendix A. Lithological Logs

Appendix B. Laboratory Analytical and Geotechnical Results

1. OBJECTIVE

The objective of the soil vapor survey was to determine the [illegible] concentration of petroleum hydrocarbons in soil gas, soil pore air, vadose zone soil and ground water, and to collect soil physical parameters. The vapor, soil and ground water analytical results and soil physical parameters were used to determine the potential health risk associated with hydrocarbon vapor transport from the subsurface soil and ground water to indoor and outdoor air. The health risk analysis is presented as Attachment B of this submittal.

1.1 Scope of Work

The Soil Vapor Survey included:

- Collecting vapor, soil and ground water samples from eight soil sample locations;
- Recording the soil type encountered in each sample location;
- Submitting the vapor, soil and ground water samples to analytical laboratories for analysis and submitting additional soil samples to a geotechnical laboratory for physical property measurements; and,
- Reporting the results.

1.2 Parties Present

During the performance of the soil vapor survey, the following individuals were onsite either all or part of the time:

- Amy Leech, Hazardous Materials Specialist, Alameda County Health Care Services Agency;
- Brett Hunter, Chevron Products Company (Chevron);
- Ted Hogan and Paul Rogers, Gregg Drilling and Testing Inc. (Gregg Drilling); and,
- Tim Utterback and Brian Busch, Weiss Associates (WA).

1.3 Sampling Dates

August 19 and 20, 1996.

1.4 Location

The former Chevron Service Station is located on the southeast corner of Crow Canyon Road and Waterford Place in Castro Valley, California (Figure 1). The samples were collected adjacent to the residential buildings along the southwest corner of Crow Canyon Road and Waterford Place (Figure 2).

2. SOIL VAPOR SAMPLING RESULTS

2.1 Sample Locations

Twelve vapor samples were collected from the eight locations. One sample each was collected from SV-1, SV-2, SV-5, SV-6, SV-7 and SV-8. Vapor concentration profile samples were collected from SV-3 at 8 feet and 25 feet below ground surface (bgs) and SV-4 at 3 feet, 8 feet, 11 feet and 25 ft bgs.

Vapor samples from sample location SV-2 at 3 and 20 ft bgs and sample location SV-3 at 3 ft bgs were not successful due to lack of vapor flow from these points. The vapor sample from boring location SV-5 at 3 ft bgs was not successful due to water saturation from irrigation. Vapor sample collection from SV-5 was successful at 12 ft bgs.

2.2 Vapor Sampling Method

Vapor samples were collected by advancing the vapor sampling rod to a specified depth with a hydraulically powered Geoprobe, inserting post run tubing (PRT) and connecting the tubing to the vapor sample collection assembly. Gregg Drilling (License No. C-57 485165) operated the Geoprobe equipment and vapor sampling rod and connected the PRT. WA collected the samples with the vapor sample collection assembly. The PRT was connected to the vapor sample collection configuration as depicted in Figure 3. The vapor sample lines were purged by opening the ball valve, and actuating the vacuum pump (hand operated Nalgene Mityvac air pump) to fill the 1 liter Tedlar bag approximately 1/4 full (250 ml). The ball valve was closed and the sample collection valve on the 1 liter Summa canister was slowly opened while monitoring the vacuum gauge. The Summa canister valve was closed when the vacuum in the line dropped to approximately 1 inch of mercury. After sample collection, the configuration was disconnected and the summa canister was labeled and stored for shipment. Before collecting the next vapor sample, the tubing and tee were replaced, the probe rod assembly cleaned, the vacuum gauge and ball valve purged with ambient air and a new Summa canister was connected.

2.3 Analytical Laboratory

Vapor samples were shipped under chain-of-custody to Air Toxics Ltd. of Folsom, California for analysis.

2.4 Analytical Methods

Vapor samples were analyzed for benzene, toluene, ethylbenzene, and xylenes by EPA Method TO-14 and oxygen, carbon dioxide and methane by ASTM Method D3416.

2.5 Analytical Results

The maximum benzene concentration in saturated zone pore vapor was 38 parts per million by volume (ppmv) from sample location SV-4 at 25 ft bgs. The benzene concentration in pore vapors at 3, 8, and 11 ft bgs in sample location SV-4 were all below laboratory detection limits. The highest benzene concentrations in pore vapor from shallow (3 ft bgs) samples was 0.029 ppmv and 0.040 ppmv from sample locations SV-6 and SV-8, respectively. The percent oxygen by volume was depressed (<21%) in boring locations SV-2 at 8 ft bgs, and SV-4, SV-6, and SV-8 at 3 ft bgs. The percent carbon dioxide by volume was elevated (>0.036%) in all of the vapor samples. The percent methane by volume was highest in boring locations SV-2 at 8 ft bgs, SV-4 at 11 ft bgs and SV-6 at 3 ft bgs with 0.010%, 0.007%, and 0.005% by volume, respectively. The vapor sample analytical results are summarized in Table 1.

3. SOIL SAMPLING RESULTS

3.1 Sample Locations

33 soil boring samples were collected from the eight boring locations. 25 of these samples were collected for hydrocarbon analysis, 6 samples were collected for fraction of organic carbon analysis and 2 samples were collected for density and porosity measurements. Please refer to Figure 2 for the location and depth of each sample.

3.2 Soil Sampling Method

Soil samples were collected by advancing a 1-inch diameter soil sampling rod using a hydraulically powered Geoprobe. Soil samples were collected in clean polyethylene terephthalate[1] tubes. The tubes were immediately cut and sealed with Teflon squares, capped and refrigerated for transport to the laboratory.

3.3 Analytical Laboratory

Soil samples were shipped under chain-of-custody to Sequoia Analytical Laboratory of Redwood City, California for petroleum hydrocarbon analysis and fraction of organic carbon analysis. Sequoia Analytical shipped the density and porosity samples to Core Laboratories of Bakersfield, California for geotechnical analysis.

3.4 Analytical Methods

25 soil samples were analyzed for total petroleum hydrocarbons as gasoline (TPH-G) by modified EPA Method 8015 and benzene, toluene, ethylbenzene and xylenes (BTEX) by EPA Method 8020. 6 soil samples were analyzed for fraction of organic carbon by the Watley-Black method. 2 soil samples were analyzed for grain density, dry density, natural density and total

[1] On August 20, 1996, Amy Leech, ACHCSA requested Tim Utterback, WA, to verify whether the polyethylene terephthalate liners are appropriate for petroleum hydrocarbon sample collection. On September 4, 1996, Tim Utterback called Geoprobe Inc., requesting information about the liners. Geoprobe stated the liners have a history of no detectable concentrations of chemicals except terephthalate and that the liners are commonly used by the California EPA and Federal EPA for environmental sampling projects.

porosity by American Petroleum Institute (API) RP-40, API Recommended Practice for Core-Analysis Procedure, 1960.

3.5 Analytical Results

TPH-G and benzene concentrations were below lowest laboratory detection limits in soil boring samples collected between 3 and 10 ft bgs. TPH-G and benzene concentrations were detected in various soil boring samples collected between 21 and 25 ft bgs. The maximum TPH-G and benzene concentrations in soil were 400 mg/kg and 2.3 mg/kg, respectively from boring location SV-7 at 25 ft bgs. Fraction of organic carbon ranged from 0.14% in soil boring SV-4 at 23 ft bgs to 0.30% in soil boring SV-2 at 3 ft bgs. Soil boring location SV-1 at 6 ft bgs had a measured dry density, natural density, grain density and porosity of 1.94 g/cc, 2.21 g/cc, 2.68 g/cc and 0.277 cc/cc, respectively. TPH-G and BTEX analytical results for soil borings samples are presented in Table 2 and fraction of organic carbon, dry density, natural density, grain density and porosity measurements are presented in Table 3.

4. GROUND WATER SAMPLING RESULTS

4.1 Sample Locations

One ground water sample was collected from boring location SV-1. The depth to water was 23 ft bgs.

4.2 Ground Water Sampling Method

A 1-inch diameter soil sampling rod was driven using a hydraulically powered Geoprobe to depths ranging from 22 to 25 ft bgs. Temporary PVC well casings were inserted into each boring to allow ground water seepage. The borings were monitored for depth to ground water on a periodic basis after installation of the PVC casing. On August 19, 1996, at 15:00, the depth to water in sample location SV-1 was 23 ft bgs. Ground water samples were collected from boring SV-1 with a clean teflon bailer, transferred to VOA vials containing hydrochloric acid preservative, and placed in an iced cooler for transport to the laboratory. Ground water was not encountered in borings SV-2 through SV-8.

4.3 Analytical Laboratory

Ground water samples were shipped under chain-of-custody to Sequoia Analytical Laboratory of Redwood City, California.

4.4 Analytical Methods

Ground water sample WS-1 was analyzed for TPH-G by modified EPA Method 8015 and BTEX by EPA Method 8020.

4.5 Analytical Results

TPH-G and benzene concentrations in ground water sample WS-1 from boring location SV-1 were 0.61 mg/L and 0.028 mg/L, respectively.

5. BORING LOG RESULTS

Lithological logging of soil cores collected from the 8 soil sample locations indicate that soil below the residential buildings consist primarily of interbedded layers of silty clay and clayey silt with trace sand to at least 25 ft bgs, the total depth explored. Previously prepared boring logs indicate similar lithology with the exception of a well cemented sandstone located at about 30 ft bgs in the location of several borings. Lithological logs for the eight soil sample locations are included in Appendix A.

6. CONCLUSIONS

Hydrocarbon concentrations in soil vapor were highest in the vicinity of the saturated zone soil (approximately 25 ft bgs) and low or below detection limits at shallower depths. Ground water was not recovered at sample locations SV-2 through SV-8 due to the limited depth capabilities of the Geoprobe (approx. 25 ft bgs max). Low dissolved hydrocarbon concentrations were detected in ground water from sample location SV-1.

Depleted soil vapor oxygen concentrations, and elevated methane and carbon dioxide concentrations indicate that the hydrocarbons b[redacted] indication of biodegradation appears to be occurring at depths [redacted] is significantly depleted and carbon dioxide concentrations are highest. The depleted oxygen and elevated carbon dioxide vapor concentrations measured in shallow soil may be due to phytoremediation occurring within the shallow soil where much larger numbers of bacteria and fungi are likely to occur. However, elevated carbon dioxide and methane concentrations in samples SV-3 and SV-4 at 25 ft bgs indicate that biodegradation is occurring within the hydrocarbon impacted soil and ground water as well. The collected soil vapor data are consistent with the previously collected and evaluated dissolved sulfate and ferrous iron data which suggest that biodegradation is occuring[2].

Laboratory analytical and geotechnical results are included in Appendix B.

[2] Chevron Research and Technology Corporation, October 27, 1995. Interoffice memorandum, Estimation of the downgradient migrational extent of dissolved benzene originating at Chevron Service Station #9-5607, 5269 Crow Canyon Road, Castro Valley, California.

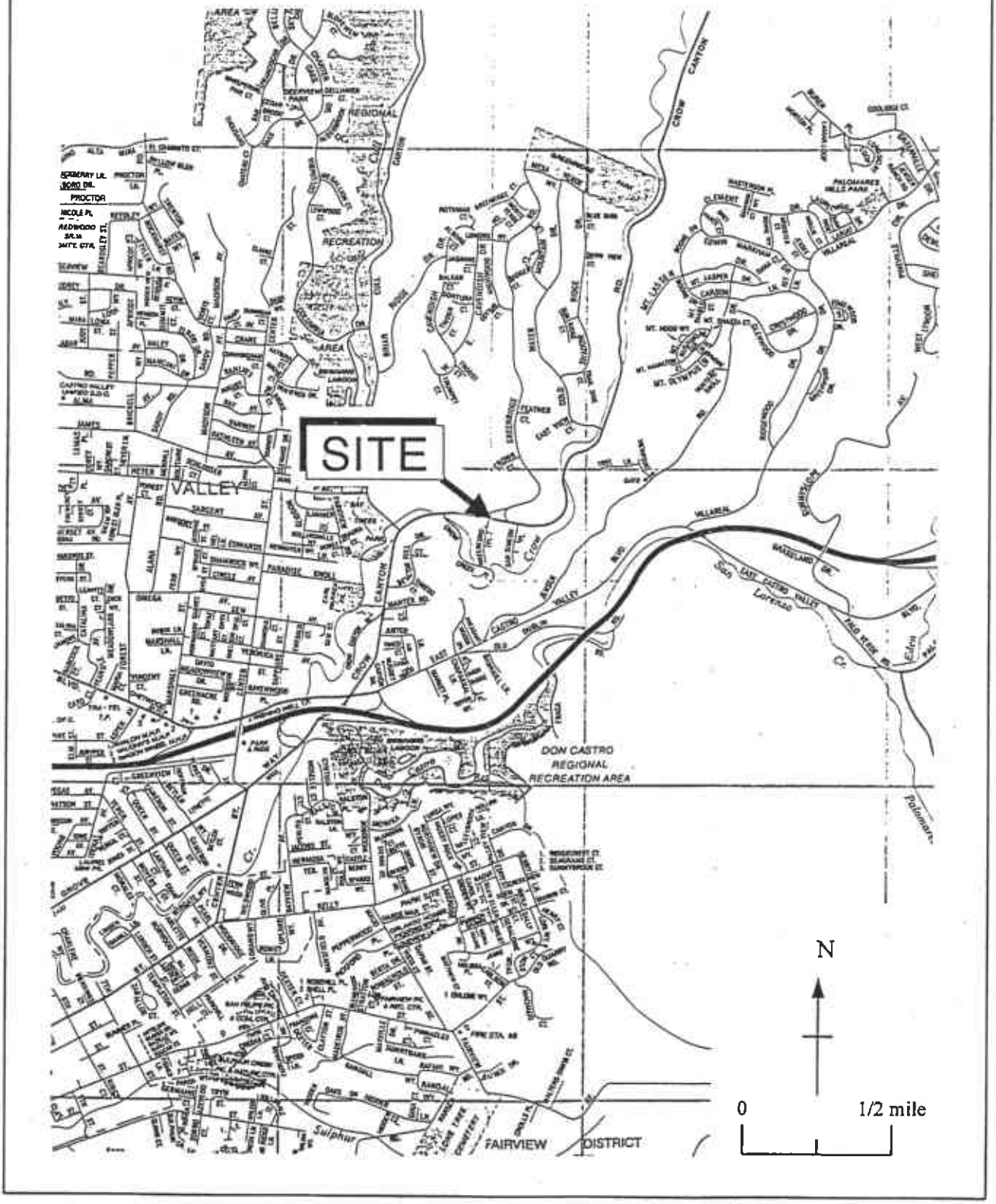
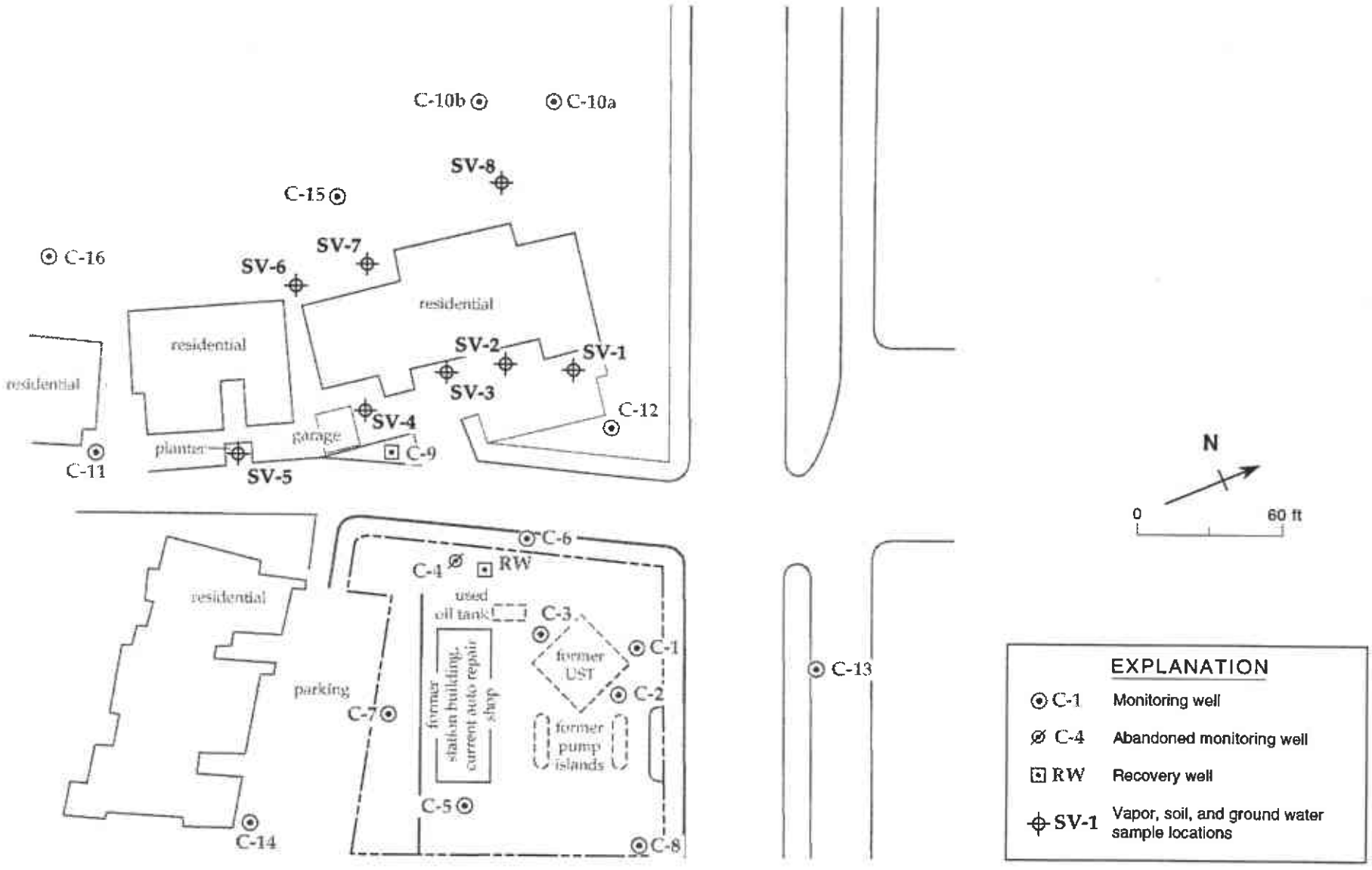


Figure 1. Site Location Map - Former Chevron Service Station #9-5607, 5269 Crow Canyon Road, Castro Valley, California



Sample Location	VAPOR SAMPLES		WATER SAMPLES	SOIL SAMPLES			
	Sample Depths	Analysis Methods	Hydrocarbon Analysis	Hydrocarbon Sample Depth	Hydrocarbon Analysis Method	Modeling Parameter Sample Depth	Modeling Parameter Analysis Method
SV-1	3, feet bgs,	benzene by EPA Method TO-14 and O_2, CO_2, CH_4 by ASTM Method D3416	BTEX and MTBE by EPA method 8020 (1 sample)	5, 10, and 21 feet bgs	BTEX and MTBE by EPA Method 8020	6 and 10 feet bgs	Density and Porosity by ASTM Methods D2850 and D4612 respectively
SV-2	8 feet bgs	benzene by EPA Method TO-14 and O_2, CO_2, CH_4 by ASTM Method D3416	Water table not encountered to depth expl.	3, 8, 10, and 21 feet bgs	BTEX and MTBE by EPA Method 8020	3 and 15 feet bgs	Fraction of Organic Carbon by Watley Black Method
SV-3	8 and 25 feet bgs	benzene by EPA Method TO-14 and O_2, CO_2, CH_4 by ASTM Method D3416	Water table not encountered " " "	5, 10, and 21 feet bgs	BTEX and MTBE by EPA Method 8020	3 and 21.5 feet bgs	Fraction of Organic Carbon by Watley Black Method
SV-4	3, 8, 11 and 25 feet bgs	benzene by EPA Method TO-14 and O_2, CO_2, CH_4 by ASTM Method D3416	Water table not encountered " " "	6, 9.5, and 23.5 feet bgs	BTEX and MTBE by EPA Method 8020	5 and 23 feet bgs	Fraction of Organic Carbon by Watley Black Method
SV-5	12 feet bgs	benzene by EPA Method TO-14 and O_2, CO_2, CH_4 by ASTM Method D3416	Water table not encountered " " "	5, 10, and 24.5 feet bgs	BTEX and MTBE by EPA Method 8020	None	None
SV-6	3 feet bgs	benzene by EPA Method TO-14 and O_2, CO_2, CH_4 by ASTM Method D3416	Water table not encountered wrong (23')	5, 10, and 25 feet bgs	BTEX and MTBE by EPA Method 8020	None	None
SV-7	3 feet bgs	benzene by EPA Method TO-14 and O_2, CO_2, CH_4 by ASTM Method D3416	Water table not encountered to depth expl	5, 10, and 25 feet bgs	BTEX and MTBE by EPA Method 8020	None	None
SV-8	3 feet bgs	benzene by EPA Method TO-14 and O_2, CO_2, CH_4 by ASTM Method D3416	Water table not encountered " " "	5, 10, and 25 feet bgs	BTEX and MTBE by EPA Method 8020	None	None

Notes:

bgs = Below ground surface
BTEX = Benzene, toluene, ethylbenzene and xylenes
O_2 = Oxygen
CO_2 = Carbon dioxide
CH_4 = Methane

Figure 2. Vapor, Soil, Ground Water Sample Locations and Analytical Methods - Chevron Station 9-5607, 5269 Crow Canyon Road, Castro Valley, California

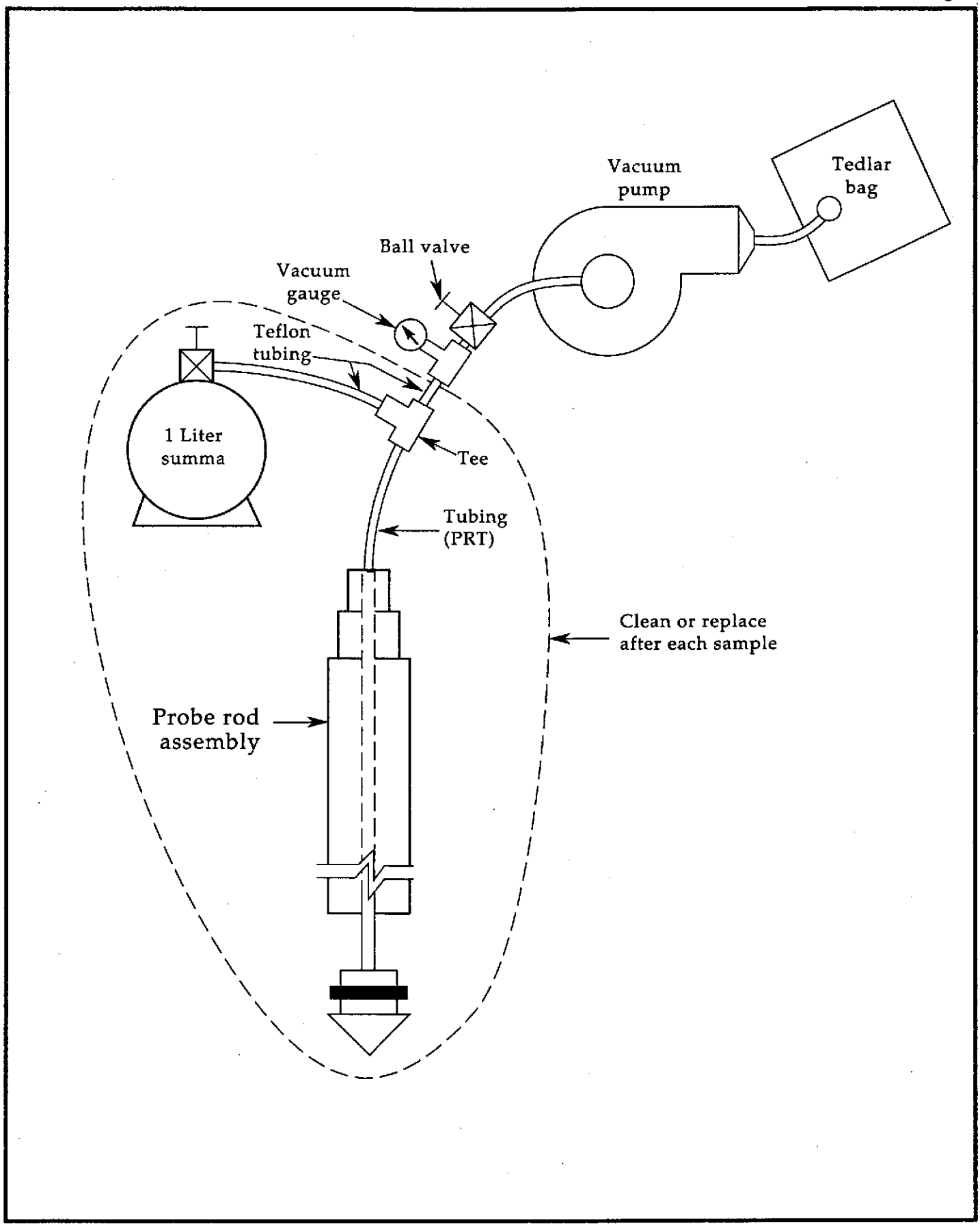


Figure 3. Vapor Sample Collection Configuration - Former Chevron Service Station #9-5607, 5269 Crow Canyon Road, Castro Valley, California

Table 1. Analytic Results for Vapor Samples - Chevron Service Station #9-5607, 5269 Crow Canyon Road, Castro Valley, California.

Sample ID	Sample Depth (ft)	B	E	T	X	O_2	CO_2	CH_4
		← parts per billion by volume (ppbv) →				← percent by volume →		
SV-1	3	<4.3	<4.3	<4.3	<8.6	22	0.076	<0.002
SV-2	8	<6.1	<6.1	<6.1	<12.2	1.4	28	0.010
SV-3	8	<4.4	7.6	<4.4	6.7	21	0.25	<0.002
SV-3	25	2,100	3,800	680	2,300	21	0.58	0.004
SV-4	3	<4.3	<4.3	<4.3	<4.6	14	9.3	<0.002
SV-4	8	<4.2	<4.2	<4.2	5.7	21	0.35	<0.002
SV-4	11	<4.2	6.0	<4.2	<8.4	21	0.80	0.007
SV-4	25	38,000	140,000	20,000	83,000	21	0.37	0.002
SV-4	25[dup]	39,000	140,000	22,000	87,000	21	0.35	0.002
SV-5	12	6.2	32	11	39	22	0.091	<0.002
SV-6	3	29	42	6.4	25.4	0.51	0.054	0.005
SV-7	3	<4.2	5.1	<4.2	6.8	21	0.47	<0.002
SV-8	3	40	83	9.5	59	19	3.6	<0.002

Abbreviations:

B = Benzene by EPA Method TO-14
E = Ethylbenzene by EPA Method TO-14
T = Toluene by EPA Method TO-14
X = Xylenes by EPA Method TO-14
O_2 = Oxygen by ASTM Method D3416
CO_2 = Carbon dioxide by ASTM Method D3416
CH_4 = Methane by ASTM Method D3416
<n = Not detected at detection limits of n ppbv

Notes:

Samples collected on 8/19/96 and 8/20/96 by Weiss Associates and analyzed by Air Toxics, Folsom, California.

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Weiss Associates

Table 2. Analytic Results for Soil Samples - Chevron Service Station #9-5607, 5269 Crow Canyon Road, Castro Valley, California.

Sample ID	Depth Collected Below Ground Surface (ft)	TPH-G	B	E	T	X
		← parts per million (mg/kg) →				
SV-1	5	<1.0	<0.005	<0.005	<0.005	<0.005
SV-1	10	<1.0	<0.005	<0.005	<0.005	<0.005
SV-1	21	<1.0	<0.005	<0.005	<0.005	0.014
SV-2	3	<1.0	<0.005	<0.005	<0.005	<0.005
SV-2	8	<1.0	<0.005	<0.005	<0.005	<0.005
SV-2	10	<1.0	<0.005	<0.005	<0.005	<0.005
SV-2	21	<1.0	<0.005	<0.005	<0.005	<0.005
SV-3	5	<1.0	<0.005	<0.005	<0.005	<0.005
SV-3	10	<1.0	<0.005	<0.005	<0.005	<0.005
SV-3	21	17	0.67	0.74	0.38	1.2
SV-4	6	<1.0	<0.005	<0.005	<0.005	0.012
SV-4	9.5	<1.0	<0.005	<0.005	<0.005	<0.005
SV-4	23.5	97	0.59	<0.010	1.0	2.9
SV-5	5	<1.0	<0.005	<0.005	<0.005	<0.005
SV-5	10	<1.0	<0.005	<0.005	<0.005	<0.005
SV-5	24.5	<1.0	<0.005	<0.005	<0.005	<0.005
SV-6	5	<1.0	<0.005	<0.005	<0.005	<0.005
SV-6	10	<1.0	<0.005	<0.005	<0.005	<0.005
SV-6	25	61	0.85	0.65	1.2	3.6
SV-7	5	<1.0	<0.005	<0.005	<0.005	<0.005
SV-7	10	<1.0	<0.005	<0.005	<0.005	<0.005
SV-7	25	400	2.3	2.7	9.3	40

Table 2. Analytic Results for Soil Boring Samples - Chevron Service Station #9-5607, 5269 Crow Canyon Road, Castro Valley, California.

Sample ID	Depth Collected Below Ground Surface (ft)	TPH-G	B	E	T	X
		← parts per million (mg/kg) →				
SV-8	5	<1.0	<0.005	<0.005	<0.005	<0.005
SV-8	10	<1.0	<0.005	<0.005	<0.005	<0.005
SV-8	25	<1.0	<0.005	<0.005	<0.005	<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
<n = Not detected at detection limits of n ppb

Notes:

Samples collected on 8/19/96 and 8/20/96 by Weiss Associates and analyzed by Sequoia Analytical, Redwood City, California.

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Table 3. Physical Property Measurements for Soil Samples - Chevron Service Station #9-5607, 5269 Crow Canyon Road, Castro Valley, California.

Sample ID	Depth Collected Below Ground Surface (ft)	foc %	Dry Density (g/cc)	Natural Density (g/cc)	Grain Density (g/cc)	Porosity (cc/cc)
SV-1	6	---	1.94	2.21	2.68	0.277
SV-1	10	---	1.84	2.16	2.69	0.315
SV-2	3	0.30	---	---	---	---
SV-2	15	0.23	---	---	---	---
SV-3	3	0.20	---	---	---	---
SV-3	21.5	0.14	---	---	---	---
SV-4	5	0.29	---	---	---	---
SV-4	23	0.14	---	---	---	---

Abbreviations:

foc = Fraction of Organic Carbon by Watley-Black Method
g/cc = grams per cubic centimeter
cc/cc = porous volume/total volume of soil
Dry density by American Petroleum Institute RP-40
Natural density by American Petroleum Institute RP-40
Grain density by American Petroleum Institute RP-40
Porosity by American Petroleum Institute RP-40

Notes:

Samples collected on 8/19/96 and 8/20/96 by Weiss Associates and analyzed by Sequoia Analytical, Redwood City, California and Core Laboratories, Bakersfield, California.

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Table 4. Analytic Results for Ground Water Samples - Chevron Service Station #9-5607, 5269 Crow Canyon Road, Castro Valley, California.

Boring Location	Sample ID	TPH-G	B	E	T	X
		← parts per million (mg/L) →				
SV-1	WS-1	0.610	0.028	0.0082	0.025	0.10

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

Notes:

Sample collected on 8/19/96 by Weiss Associates and analyzed by Sequoia Analytical, Redwood City, California.

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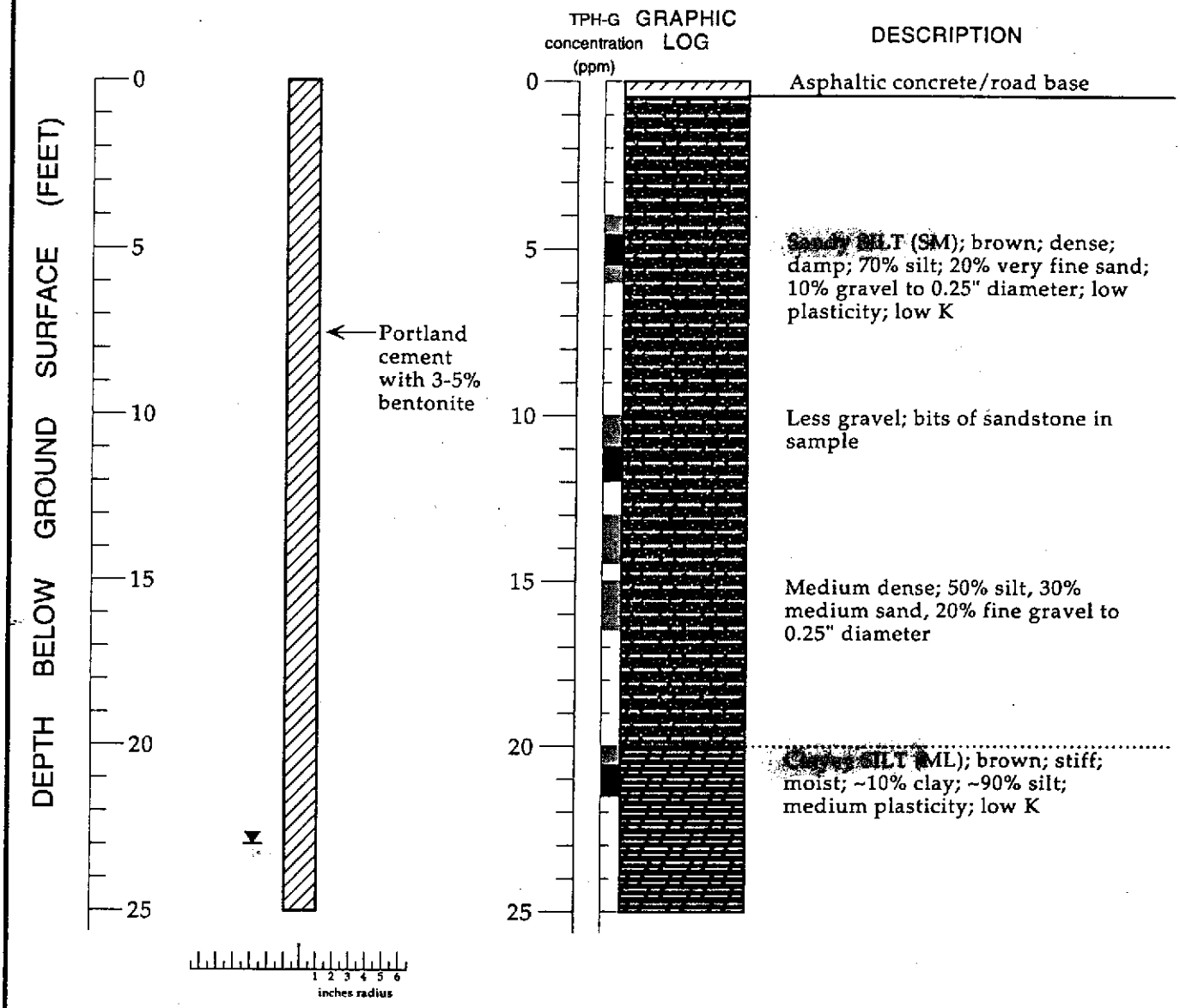
APPENDIX A

LITHOLOGICAL LOGS

SAMPLE LOCATION SV-1



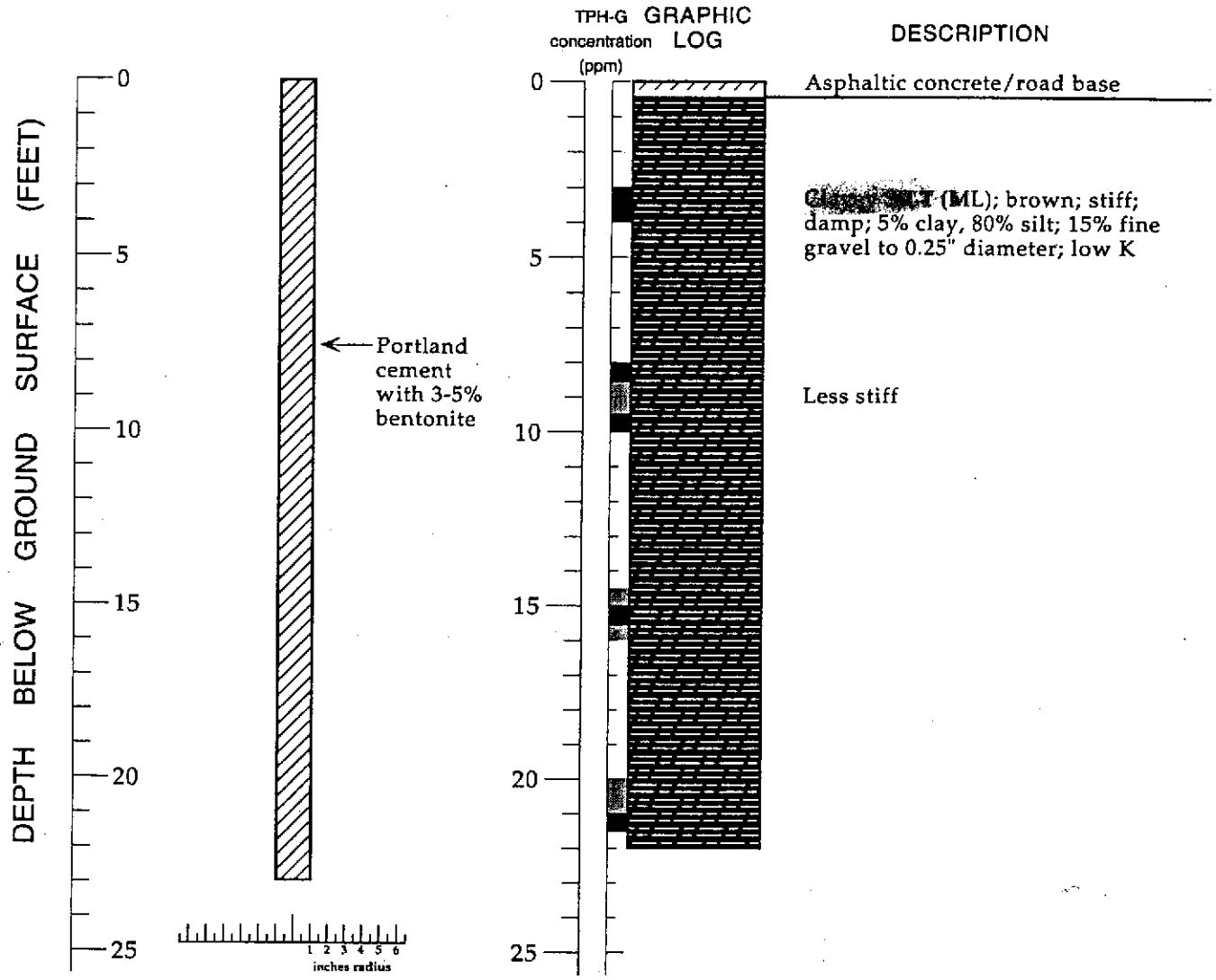
EXPLANATION

- Water level during drilling (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: Brian Busch
Supervisor: Michael Cooke
Drilling Company: Gregg Drilling, Martinez, CA
License Number: C57-485165
Driller: Ted Hogan
Drilling Method: Hollow-stem auger
Date Drilled: August 19, 1996
Type of Sampler: Geoprobe sampler
Ground Surface Elevation: feet above mean sea level

Lithologic Log - Sample Location SV-1 - Former Chevron Service Station #9-5607, 5269 Crow Canyon Road, Castro Valley, California

SAMPLE LOCATION SV-2



EXPLANATION

- Water level during drilling (date)
- Contact (dotted where approximate)
- Uncertain contact
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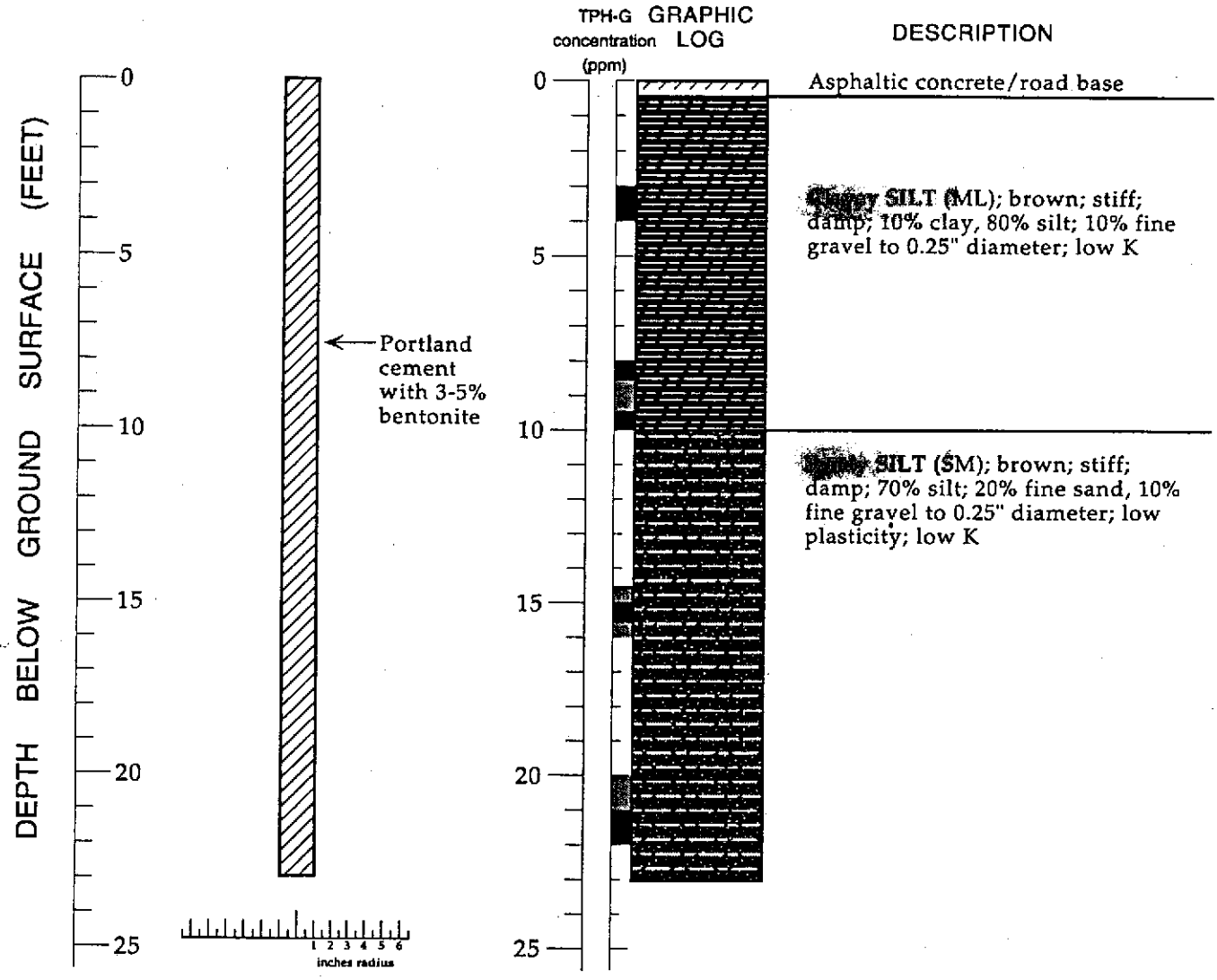
- Location of recovered drive sample
- Location of drive sample sealed for chemical analysis
- Cutting sample
- K = Estimated hydraulic conductivity

Logged By: Brian Busch
Supervisor: Michael Cooke
Drilling Company: Gregg Drilling, Martinez, CA
License Number: C57-485165
Driller: Ted Hogan
Drilling Method: Hollow-stem auger
Date Drilled: August 19, 1996
Type of Sampler: Geoprobe sampler
Ground Surface Elevation: feet above mean sea level

Lithologic Log - Sample Location SV-2 - Former Chevron Service Station #9-5607, 5269 Crow Canyon Road, Castro Valley, California

SAMPLE LOCATION SV-3



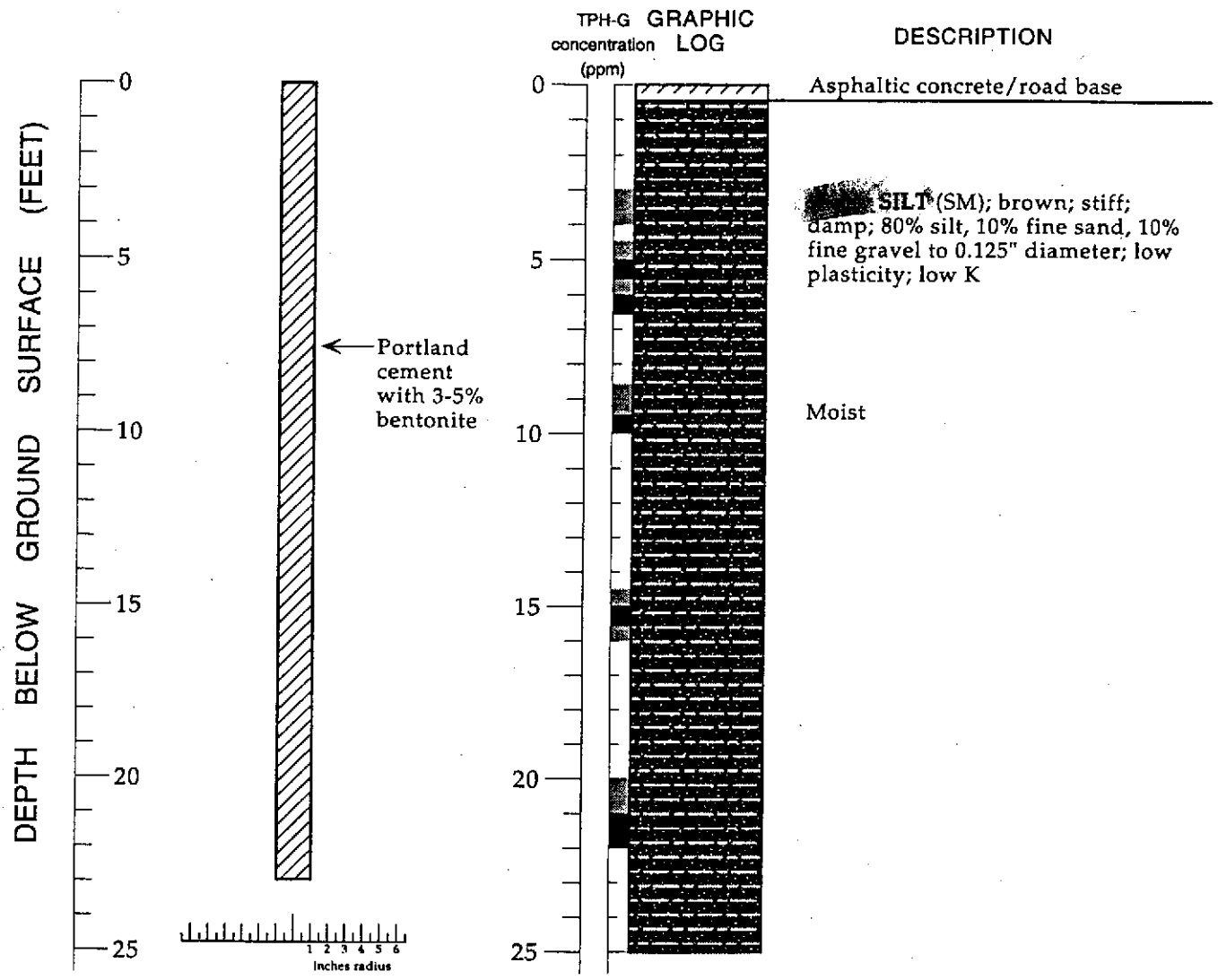
EXPLANATION

- ?▼ Water level during drilling (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: Brian Busch
Supervisor: Michael Cooke
Drilling Company: Gregg Drilling, Martinez, CA
License Number: C57-485165
Driller: Ted Hogan
Drilling Method: Hollow-stem auger
Date Drilled: August 19, 1996
Type of Sampler: Geoprobe sampler
Ground Surface Elevation: feet above mean sea level

Lithologic Log - Sample Location SV-3 - Former Chevron Service Station #9-5607, 5269 Crow Canyon Road, Castro Valley, California

SAMPLE LOCATION SV-4



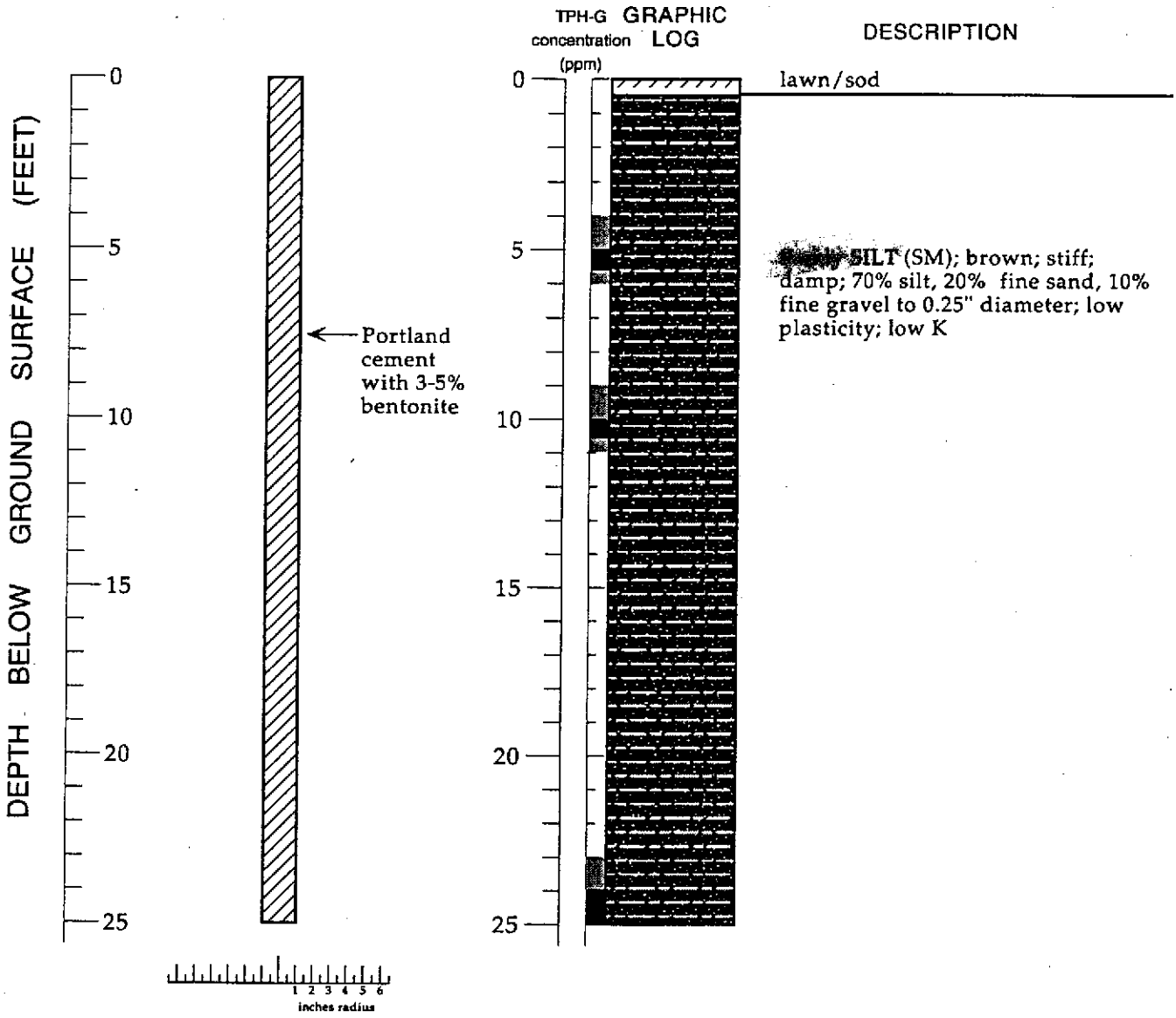
EXPLANATION

- ▼ Water level during drilling (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: Brian Busch
Supervisor: Michael Cooke
Drilling Company: Gregg Drilling, Martinez, CA
License Number: C57-485165
Driller: Paul Rogers
Drilling Method: Hollow-stem auger
Date Drilled: August 20, 1996
Type of Sampler: Geoprobe sampler
Ground Surface Elevation: feet above mean sea level

Lithologic Log - Sample Location SV-4 - Former Chevron Service Station #9-5607, 5269 Crow Canyon Road, Castro Valley, California

SAMPLE LOCATION SV-5



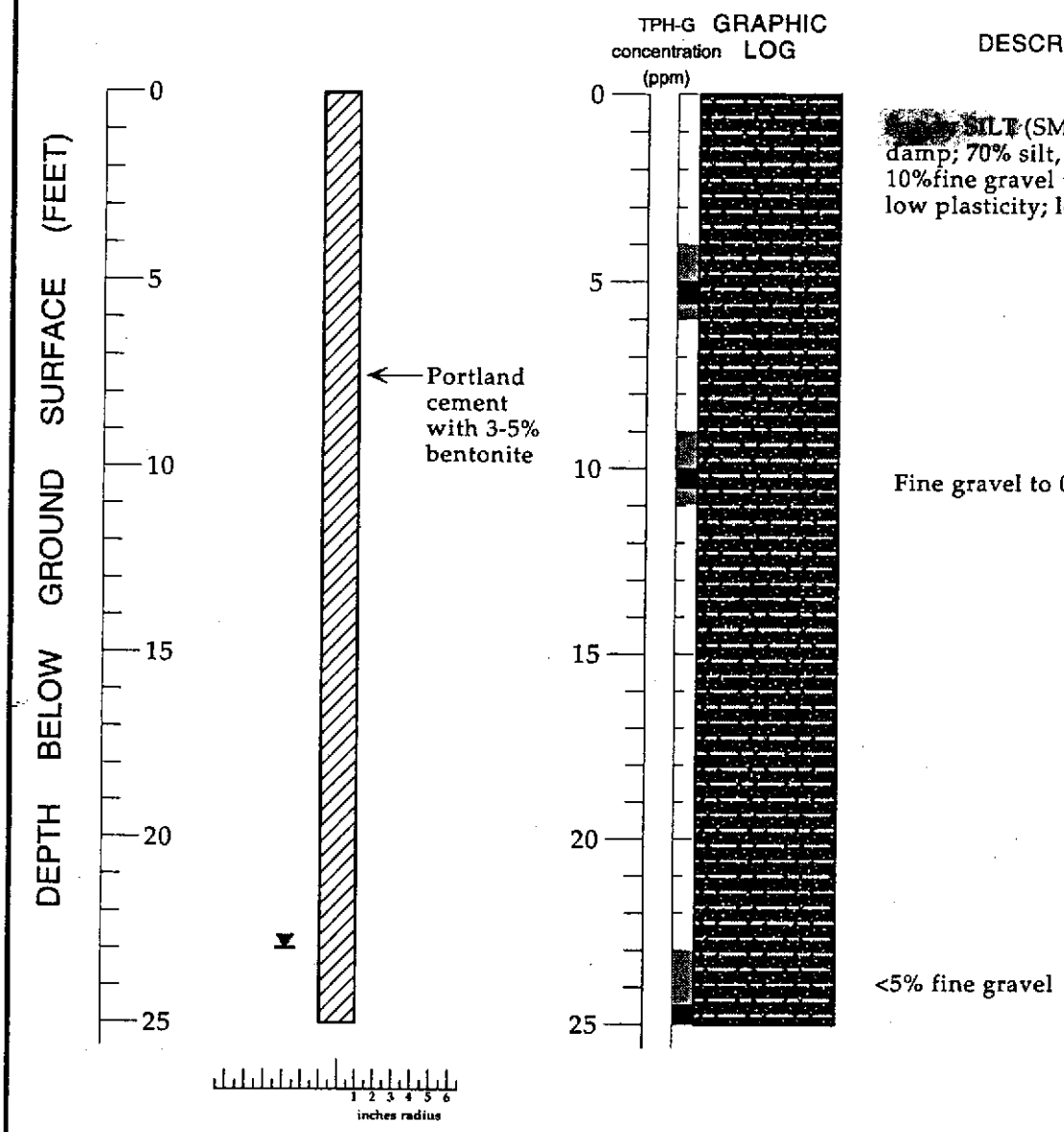
EXPLANATION

- ▼ Water level during drilling (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: Brian Busch
Supervisor: Michael Cooke
Drilling Company: Gregg Drilling, Martinez, CA
License Number: C57-485165
Driller: Ted Hogan
Drilling Method: Hollow-stem auger
Date Drilled: August 20, 1996
Type of Sampler: Geoprobe sampler
Ground Surface Elevation: feet above mean sea level

Lithologic Log - Sample Location SV-5 - Former Chevron Service Station #9-5607, 5269 Crow Canyon Road, Castro Valley, California

SAMPLE LOCATION SV-6



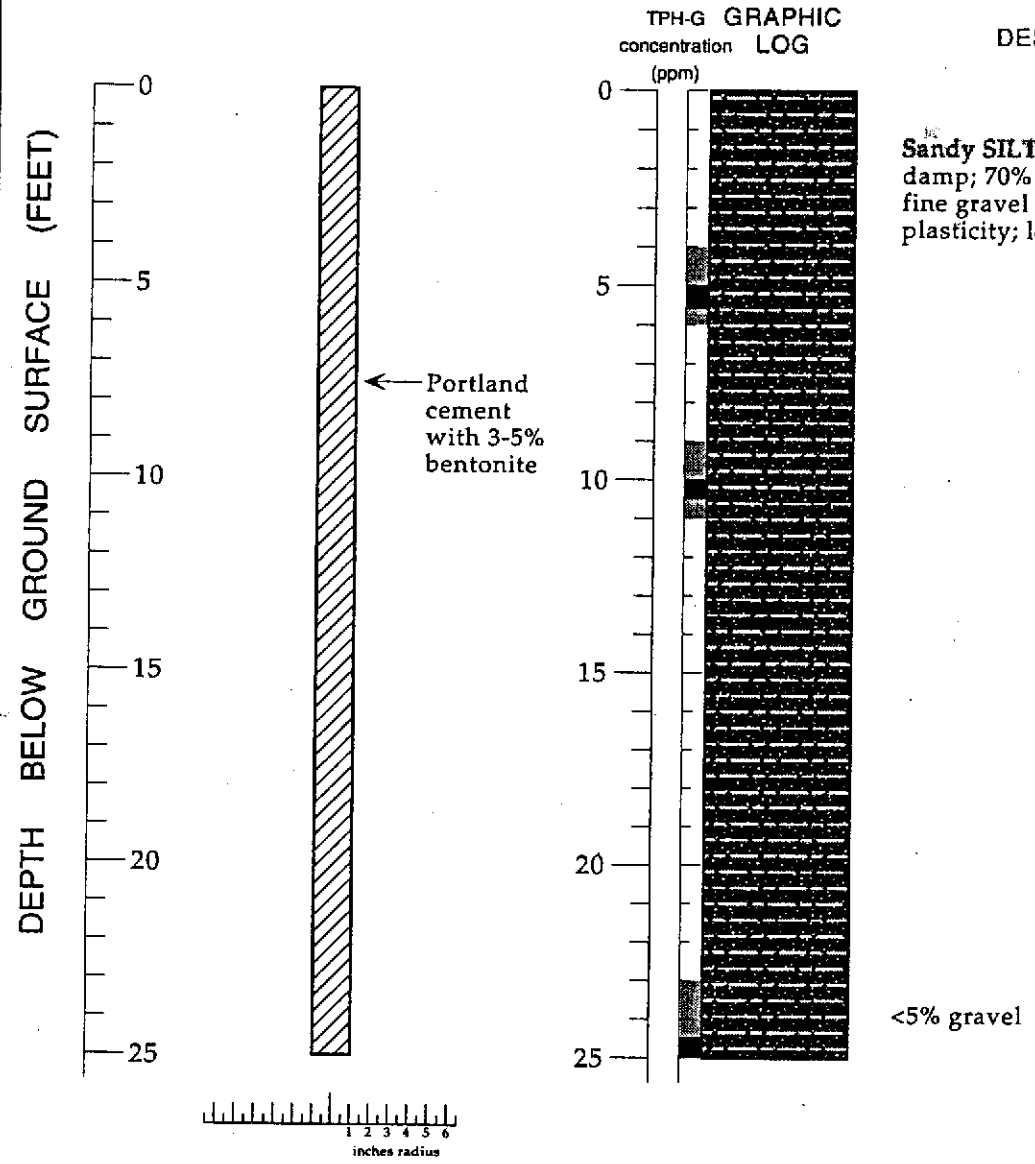
EXPLANATION

- ?▼ Water level during drilling (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: Brian Busch
Supervisor: Michael Cooke
Drilling Company: Gregg Drilling, Martinez, CA
License Number: C57-485165
Driller: Ted Hogan
Drilling Method: Hollow-stem auger
Date Drilled: August 20, 1996
Type of Sampler: Geoprobe sampler
Ground Surface Elevation: feet above mean sea level

Lithologic Log - Sample Location SV-6 - Former Chevron Service Station #9-5607, 5269 Crow Canyon Road, Castro Valley, California

SAMPLE LOCATION SV-7



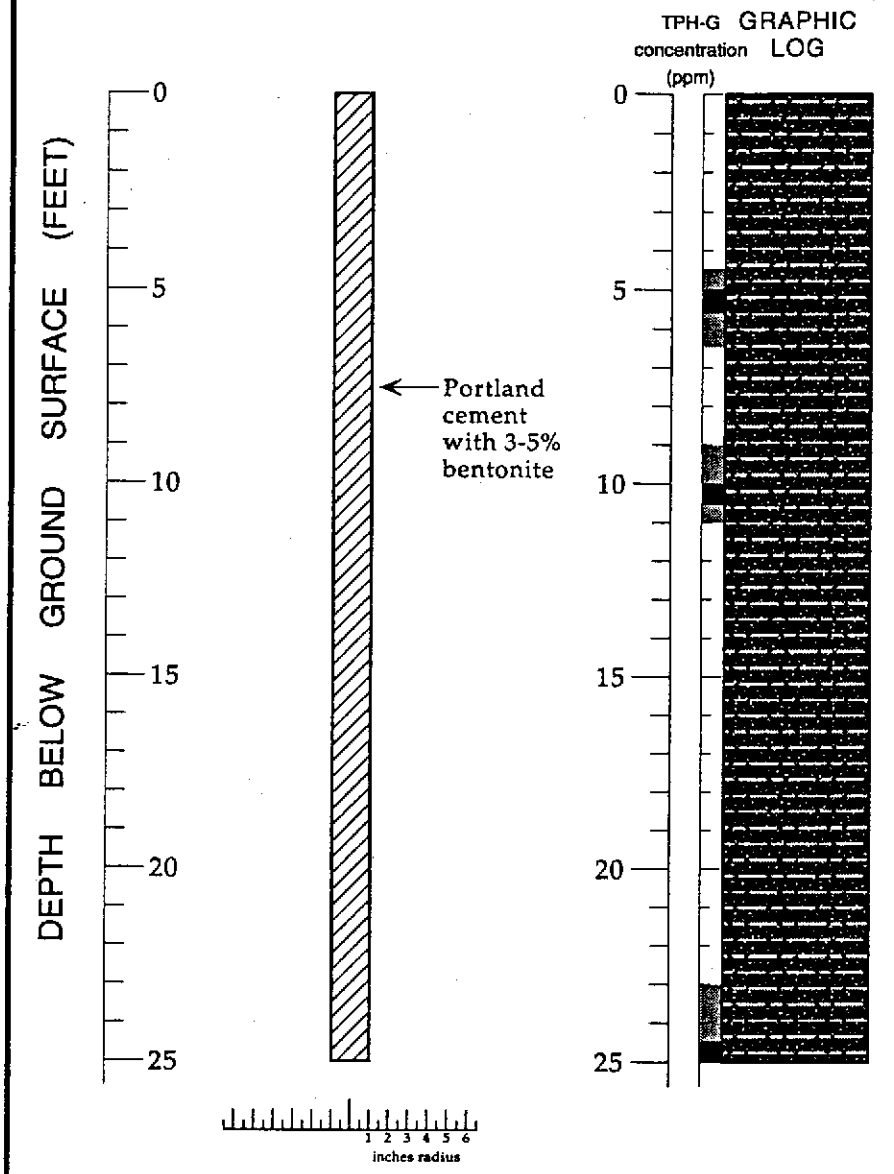
EXPLANATION

- ?▼ Water level during drilling (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: Brian Busch
Supervisor: Michael Cooke
Drilling Company: Gregg Drilling, Martinez, CA
License Number: C57-485165
Driller: Ted Hogan
Drilling Method: Hollow-stem auger
Date Drilled: August 20, 1996
Type of Sampler: Geoprobe sampler
Ground Surface Elevation: feet above mean sea level

Lithologic Log - Sample Location SV-7 - Former Chevron Service Station #9-5607, 5269 Crow Canyon Road, Castro Valley, California

SAMPLE LOCATION SV-8



EXPLANATION

- ?▼ Water level during drilling (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: Brian Busch
Supervisor: Michael Cooke
Drilling Company: Gregg Drilling, Martinez, CA
License Number: C57-485165
Driller: Ted Hogan
Drilling Method: Hollow-stem auger
Date Drilled: August 20, 1996
Type of Sampler: Geoprobe sampler
Ground Surface Elevation: feet above mean sea level

Lithologic Log - Sample Location SV-8 - Former Chevron Service Station #9-5607, 5269 Crow Canyon Road, Castro Valley, California

APPENDIX B

LABORATORY ANALYTICAL AND GEOTECHNICAL RESULTS

@ AIR TOXICS LTD.

AN ENVIRONMENTAL ANALYTICAL LABORATORY

WORK ORDER #: 9608280A

Work Order Summary

CLIENT: Mr. Tim Utterback
Weiss Associates
5500 Shellmound Street
Emeryville, CA 94608

BILL TO: Same

PHONE: 510-450-6193
FAX: 510-547-5043
DATE RECEIVED: 8/22/96
DATE COMPLETED: 9/13/96

INVOICE # 11617
P.O. # 4-1129-70 TRU
PROJECT # 4-1129-70 Chevron CU II
AMOUNT$: $2,400.00

FRACTION #	NAME	TEST	RECEIPT VAC./PRES.	PRICE
01A	SV-3 @ 25 ft	TO-14	1.0 "Hg	$200.00
02A	SV-4 @ 3.0 ft	TO-14	2.0 "Hg	$200.00
03A	SV-4 @ 8 ft	TO-14	1.0 "Hg	$200.00
04A	SV-4 @ 11 ft	TO-14	1.0 "Hg	$200.00
05A	SV-4 @ 25 ft	TO-14	0.5 "Hg	$200.00
05AA	SV-4 @ 25 ft Duplicate	TO-14	0.5 "Hg	NC
06A	SV-5 @ 12 ft	TO-14	0.5 "Hg	$200.00
07A	SV-6 @ 3 ft	TO-14	9.5 "Hg	$200.00
08A	SV-7 @ 3 ft	TO-14	1.0 "Hg	$200.00
09A	SV-8 @ 3 ft	TO-14	1.5 "Hg	$200.00
10A	SV-1-3 ft	TO-14	1.5 "Hg	$200.00
11A	SV-2 @ 8 ft	TO-14	1.5 "Hg	$200.00
12A	SV-3 @ 8 ft	TO-14	2.5 "Hg	$200.00
13A	Method Spike	TO-14	NA	NC
14A	Lab Blank	TO-14	NA	NC
14B	Lab Blank	TO-14	NA	NC
Misc. Charges	1 Liter Summa Canister Preparation (12) @ $15.00 each.			$180.00
	Shipping (8/14/96)			$62.95

CERTIFIED BY: Linda J. Truman
Laboratory Director

DATE: 9/13/96

180 BLUE RAVINE ROAD, SUITE B • FOLSOM, CA 95630
(916) 985-1000 • FAX (916) 985-1020

AIR TOXICS LTD.

SAMPLE NAME: SV-3 @ 25 ft

ID#: 9608280A-01A

EPA METHOD TO-14 GC/MS Full Scan

File Name:	**9082722**	**Date of Collection:**	**8/20/96**
Dil. Factor:	**69.7**	**Date of Analysis:**	**8/27/96**

Compound	Det. Limit (ppbv)	Amount (ppbv)
Benzene	35	2100
Toluene	35	3800
Ethyl Benzene	35	680
m,p-Xylene	35	1600
o-Xylene	35	700

Container Type: 1 Liter Summa Canister

Surrogates	% Recovery	Method Limits
Octafluorotoluene	105	70-130
Toluene-d8	113	70-130
4-Bromofluorobenzene	115	70-130

AIR TOXICS LTD.

SAMPLE NAME: SV-4 @ 3.0 ft

ID#: 9608280A-02A

EPA METHOD TO-14 GC/MS Full Scan

File Name:	**9082713**	**Date of Collection:**	**8/20/96**
Dil. Factor:	**8.64**	**Date of Analysis:**	**8/27/96**

Compound	Det. Limit (ppbv)	Amount (ppbv)
Benzene	4.3	Not Detected
Toluene	4.3	Not Detected
Ethyl Benzene	4.3	Not Detected
m,p-Xylene	4.3	Not Detected
o-Xylene	4.3	Not Detected

Container Type: 1 Liter Summa Canister

Surrogates	% Recovery	Method Limits
Octafluorotoluene	99	70-130
Toluene-d8	111	70-130
4-Bromofluorobenzene	115	70-130

AIR TOXICS LTD.

SAMPLE NAME: SV-4 @ 8 ft

ID#: 9608280A-03A

EPA METHOD TO-14 GC/MS Full Scan

File Name:	**9082712**	**Date of Collection:**	**8/20/96**
Dil. Factor:	**8.36**	**Date of Analysis:**	**8/27/96**

Compound	Det. Limit (ppbv)	Amount (ppbv)
Benzene	4.2	Not Detected
Toluene	4.2	Not Detected
Ethyl Benzene	4.2	Not Detected
m,p-Xylene	4.2	5.7
o-Xylene	4.2	Not Detected

Container Type: 1 Liter Summa Canister

Surrogates	% Recovery	Method Limits
Octafluorotoluene	**104**	**70-130**
Toluene-d8	**111**	**70-130**
4-Bromofluorobenzene	**115**	**70-130**

AIR TOXICS LTD.

SAMPLE NAME: SV-4 @ 11 ft

ID#: 9608280A-04A

EPA METHOD TO-14 GC/MS Full Scan

File Name:	**9082716**	**Date of Collection:**	**8/20/96**
Dil. Factor:	**8.36**	**Date of Analysis:**	**8/27/96**

Compound	Det. Limit (ppbv)	Amount (ppbv)
Benzene	4.2	Not Detected
Toluene	4.2	6.0
Ethyl Benzene	4.2	Not Detected
m,p-Xylene	4.2	Not Detected
o-Xylene	4.2	Not Detected

Container Type: 1 Liter Summa Canister

Surrogates	% Recovery	Method Limits
Octafluorotoluene	104	70-130
Toluene-d8	110	70-130
4-Bromofluorobenzene	114	70-130

AIR TOXICS LTD.

SAMPLE NAME: SV-4 @ 25 ft

ID#: 9608280A-05A

EPA METHOD TO-14 GC/MS Full Scan

File Name:	**9082808**	**Date of Collection:**	**8/20/96**
Dil. Factor:	**1860**	**Date of Analysis:**	**8/28/96**

Compound	Det. Limit (ppbv)	Amount (ppbv)
Benzene	930	38000
Toluene	930	140000
Ethyl Benzene	930	20000
m,p-Xylene	930	57000
o-Xylene	930	26000

Container Type: 1 Liter Summa Canister

Surrogates	% Recovery	Method Limits
Octafluorotoluene	**101**	**70-130**
Toluene-d8	**109**	**70-130**
4-Bromofluorobenzene	**116**	**70-130**

AIR TOXICS LTD.

SAMPLE NAME: SV-4 @ 25 ft Duplicate

ID#: 9608280A-05AA

EPA METHOD TO-14 GC/MS Full Scan

File Name:	**9082809**	**Date of Collection:**	**8/20/96**
Dil. Factor:	**1860**	**Date of Analysis:**	**8/28/96**

Compound	Det. Limit (ppbv)	Amount (ppbv)
Benzene	930	39000
Toluene	930	140000
Ethyl Benzene	930	22000
m,p-Xylene	930	60000
o-Xylene	930	27000

Container Type: 1 Liter Summa Canister

Surrogates	% Recovery	Method Limits
Octafluorotoluene	**104**	**70-130**
Toluene-d8	**109**	**70-130**
4-Bromofluorobenzene	**116**	**70-130**

AIR TOXICS LTD.

SAMPLE NAME: SV-5 @ 12 ft

ID#: 9608280A-06A

EPA METHOD TO-14 GC/MS Full Scan

File Name:	**9082718**	**Date of Collection:**	**8/20/96**
Dil. Factor:	**8.20**	**Date of Analysis:**	**8/27/96**

Compound	Det. Limit (ppbv)	Amount (ppbv)
Benzene	4.1	6.2
Toluene	4.1	32
Ethyl Benzene	4.1	11
m,p-Xylene	4.1	27
o-Xylene	4.1	12

Container Type: 1 Liter Summa Canister

Surrogates	% Recovery	Method Limits
Octafluorotoluene	**102**	**70-130**
Toluene-d8	**112**	**70-130**
4-Bromofluorobenzene	**118**	**70-130**

AIR TOXICS LTD.

SAMPLE NAME: SV-6 @ 3 ft

ID#: 9608280A-07A

EPA METHOD TO-14 GC/MS Full Scan

File Name:	**9082719**	**Date of Collection:**	**8/20/96**
Dil. Factor:	**11.8**	**Date of Analysis:**	**8/27/96**

Compound	Det. Limit (ppbv)	Amount (ppbv)
Benzene	5.9	29
Toluene	5.9	42
Ethyl Benzene	5.9	6.4
m,p-Xylene	5.9	18
o-Xylene	5.9	7.4

Container Type: 1 Liter Summa Canister

Surrogates	% Recovery	Method Limits
Octafluorotoluene	101	70-130
Toluene-d8	111	70-130
4-Bromofluorobenzene	117	70-130

AIR TOXICS LTD.

SAMPLE NAME: SV-7 @ 3 ft

ID#: 9608280A-08A

EPA METHOD TO-14 GC/MS Full Scan

File Name:	**9082720**	**Date of Collection:**	**8/20/96**
Dil. Factor:	**8.36**	**Date of Analysis:**	**8/27/96**

Compound	Det. Limit (ppbv)	Amount (ppbv)
Benzene	4.2	Not Detected
Toluene	4.2	5.1
Ethyl Benzene	4.2	Not Detected
m,p-Xylene	4.2	6.8
o-Xylene	4.2	Not Detected

Container Type: 1 Liter Summa Canister

Surrogates	% Recovery	Method Limits
Octafluorotoluene	**103**	**70-130**
Toluene-d8	**111**	**70-130**
4-Bromofluorobenzene	**123**	**70-130**

AIR TOXICS LTD.

SAMPLE NAME: SV-8 @ 3 ft

ID#: 9608280A-09A

EPA METHOD TO-14 GC/MS Full Scan

File Name:	**9082721**	**Date of Collection:**	**8/20/96**
Dil. Factor:	**8.52**	**Date of Analysis:**	**8/27/96**

Compound	Det. Limit (ppbv)	Amount (ppbv)
Benzene	4.3	40
Toluene	4.3	83
Ethyl Benzene	4.3	9.5
m,p-Xylene	4.3	38
o-Xylene	4.3	21

Container Type: 1 Liter Summa Canister

Surrogates	% Recovery	Method Limits
Octafluorotoluene	103	70-130
Toluene-d8	109	70-130
4-Bromofluorobenzene	119	70-130

AIR TOXICS LTD.

SAMPLE NAME: SV-1-3 ft

ID#: 9608280A-10A

EPA METHOD TO-14 GC/MS Full Scan

File Name:	**9082715**	**Date of Collection:**	**8/19/96**
Dil. Factor:	**8.52**	**Date of Analysis:**	**8/27/96**

Compound	Det. Limit (ppbv)	Amount (ppbv)
Benzene	4.3	Not Detected
Toluene	4.3	Not Detected
Ethyl Benzene	4.3	Not Detected
m,p-Xylene	4.3	Not Detected
o-Xylene	4.3	Not Detected

Container Type: 1 Liter Summa Canister

Surrogates	% Recovery	Method Limits
Octafluorotoluene	**104**	**70-130**
Toluene-d8	**110**	**70-130**
4-Bromofluorobenzene	**117**	**70-130**

AIR TOXICS LTD.

SAMPLE NAME: SV-2 @ 8 ft

ID#: 9608280A-11A

EPA METHOD TO-14 GC/MS Full Scan

File Name:	**9082717**	**Date of Collection:**	**8/19/96**
Dil. Factor:	**12.2**	**Date of Analysis:**	**8/27/96**

Compound	Det. Limit (ppbv)	Amount (ppbv)
Benzene	6.1	Not Detected
Toluene	6.1	Not Detected
Ethyl Benzene	6.1	Not Detected
m,p-Xylene	6.1	Not Detected
o-Xylene	6.1	Not Detected

Container Type: 1 Liter Summa Canister

Surrogates	% Recovery	Method Limits
Octafluorotoluene	**104**	**70-130**
Toluene-d8	**110**	**70-130**
4-Bromofluorobenzene	**117**	**70-130**

AIR TOXICS LTD.

SAMPLE NAME: SV-3 @ 8 ft

ID#: 9608280A-12A

EPA METHOD TO-14 GC/MS Full Scan

File Name:	**9082714**	**Date of Collection:**	**8/19/96**
Dil. Factor:	**8.80**	**Date of Analysis:**	**8/27/96**

Compound	Det. Limit (ppbv)	Amount (ppbv)
Benzene	4.4	Not Detected
Toluene	4.4	7.6
Ethyl Benzene	4.4	Not Detected
m,p-Xylene	4.4	6.7
o-Xylene	4.4	Not Detected

Container Type: 1 Liter Summa Canister

Surrogates	% Recovery	Method Limits
Octafluorotoluene	**101**	**70-130**
Toluene-d8	**113**	**70-130**
4-Bromofluorobenzene	**116**	**70-130**

AIR TOXICS LTD.

SAMPLE NAME: Method Spike

ID#: 9608280A-13A

EPA METHOD TO-14 GC/MS Full Scan

File Name:	**9082802**	**Date of Collection:**	**NA**
Dil. Factor:	**1.00**	**Date of Analysis:**	**8/28/96**

Compound	Det. Limit (ppbv)	% Recovery
Benzene	0.50	104
Toluene	0.50	103
Ethyl Benzene	0.50	92
m,p-Xylene	0.50	95
o-Xylene	0.50	92

Container Type: NA

Surrogates	% Recovery	Method Limits
Octafluorotoluene	101	70-130
Toluene-d8	115	70-130
4-Bromofluorobenzene	112	70-130

AIR TOXICS LTD.

SAMPLE NAME: Lab Blank

ID#: 9608280A-14A

EPA METHOD TO-14 GC/MS Full Scan

File Name:	**9082705**	**Date of Collection:**	**NA**
Dil. Factor:	**1.00**	**Date of Analysis:**	**8/27/96**

Compound	Det. Limit (ppbv)	Amount (ppbv)
Benzene	0.50	Not Detected
Toluene	0.50	Not Detected
Ethyl Benzene	0.50	Not Detected
m,p-Xylene	0.50	Not Detected
o-Xylene	0.50	Not Detected

Container Type: NA

Surrogates	% Recovery	Method Limits
Octafluorotoluene	**104**	**70-130**
Toluene-d8	**109**	**70-130**
4-Bromofluorobenzene	**117**	**70-130**

AIR TOXICS LTD.

SAMPLE NAME: Lab Blank

ID#: 9608280A-14B

EPA METHOD TO-14 GC/MS Full Scan

File Name:	**9082804A**	**Date of Collection: NA**	
Dil. Factor:	**1.00**	**Date of Analysis: 8/28/96**	

Compound	Det. Limit (ppbv)	Amount (ppbv)
Benzene	0.50	Not Detected
Toluene	0.50	Not Detected
Ethyl Benzene	0.50	Not Detected
m,p-Xylene	0.50	Not Detected
o-Xylene	0.50	Not Detected

Container Type: NA

Surrogates	% Recovery	Method Limits
Octafluorotoluene	**105**	**70-130**
Toluene-d8	**111**	**70-130**
4-Bromofluorobenzene	**114**	**70-130**

AIR TOXICS LTD.
AN ENVIRONMENTAL ANALYTICAL LABORATORY

180 BLUE RAVINE ROAD, SUITE B
FOLSOM, CA 95630-4719
(916) 985-1000 FAX: (916) 985-1020

CHAIN-OF-CUSTODY RECORD

No 008203

Contact Person: Tim Utterback
Company: Weiss Associates
Address: 5500 Shellmound St City: Emeryville State: CA Zip: 94608
Phone: (510) 450-6193 FAX: (510) 547-5043
Collected By: Signature: T. Utterback

Project info:
P.O. # 4-1129-70 TRM
Project # 4-1129-70
Project Name: Chevron CVII

Turn Around Time:
☑ Normal
☐ Rush _____ Specify

Lab I.D.	Field Sample I.D.	Date & Time	Analyses Requested	Canister Pressure / Vacuum Initial	Final	Receipt
01A	SV-3@25 FT	8/20/96 5 PM	TO-14 for BTEX and O_2, CO_2, CH_4 by ASTM D3416	<-30" Hg	~0" Hg	1.0 Kg
02A	SV-4@30 FT	2 PM		"	"	2.0 Kg
03A	SV-4@8 FT	2 PM		"	~-0.5" Hg	1.0 Kg
04A	SV-4@11 FT	3 PM		"	"	1.0 Kg
05A/AA	SV-4@25 FT	4 PM		"	~0" Hg	0.5" Kg
06A	SV-5@12 FT	4 PM		"	"	0 " Kg
07A	SV-6@3 FT	9 AM		"	-10" Hg	1.5" Kg
08A	SV-7@3 FT	11 AM		"	~-0.5" Hg	1.0" Kg
09A	SV-8@3 FT	2 PM		"	~0" Hg	1.5" Kg

Relinquished By: (Signature) Date/Time: T. Utterback 8/21/96 16:20 Print Name: Tim Utterback
Relinquished By: (Signature) Date/Time — Received By: (Signature) Date/Time
Relinquished By: (Signature) Date/Time — Received By: (Signature) Date/Time: Airborne Express 8/22/96 1030

Notes:

Lab Use Only	Shipper Name	Air Bill #	Opened By:	Date/Time	Temp. (°C)	Condition	Custody Seals Intact?	Work Order #
	UPS	0712 724 2805	JA	8/22/96 1030	AMBIENT	GOOD	Yes No (None) N/A	9608280A

Form 1293 rev. 06

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AN ENVIRONMENTAL ANALYTICAL LABORATORY

180 BLUE RAVINE ROAD, SUITE B
FOLSOM, CA 95630-4719
(916) 985-1000 FAX: (916) 985-1020

CHAIN-OF-CUSTODY RECORD

No 008205

Contact Person: Tim Utterback
Company: Weiss Associates
Address: 5500 Shellmound St City: Emeryville State: CA Zip: 94608
Phone: (510) 450-6193 FAX: (510) 547-5043
Collected By: Signature: Tim Utterback

Project info:
P.O. # 4-1129-70 TR1
Project # 4-1129-70
Project Name: Chevron CVII

Turn Around Time:
☒ Normal
☐ Rush _____ Specify

Lab I.D.	Field Sample I.D.	Date & Time	Analyses Requested	Canister Pressure / Vacuum Initial	Final	Receipt
10A	SV-1-3 FT	8/19/96, 10:00AM	TO-14 for BTEX and O_2, CO_2, CH_4 by ASTM D3416	<-30" Hg	~0.5-1" Hg	1.5" Hg
11A	SV-2 @ 8 FT	8/19/96, 13:30	↓	<-30" Hg	~0.5" Hg	1.5" Hg
12A	SV-3 @ 8 FT	8/19/96, 16:10	↓	<-30" Hg	~-2" Hg	2.5" Hg
						8/20/96

Relinquished By: (Signature) Date/Time: Tim Utterback 8/21/96 16:30 Print Name: Tim Utterback
Relinquished By: (Signature) Date/Time — Received By: (Signature) Date/Time
Relinquished By: (Signature) Date/Time — Received By: (Signature) Date/Time: Viola Airborne Air 8/22/96 1030

Notes:

Lab Use Only	Shipper Name	Air Bill #	Opened By	Date/Time	Temp. (°C)	Condition	Custody Seals Intact?	Work Order #
	UPS	0012 724 2805	JA	8/22/96 1030	AMBIENT	GOOD	Yes No (None) N/A	9608280

Form 1293 rev. 06

@ AIR TOXICS LTD.

AN ENVIRONMENTAL ANALYTICAL LABORATORY

WORK ORDER #: 9608280B

Work Order Summary

CLIENT: Mr. Tim Utterback
Weiss Associates
5500 Shellmound Street
Emeryville, CA 94608

BILL TO: Same

PHONE: 510-450-6193
FAX: 510-547-5043
DATE RECEIVED: 8/22/96
DATE COMPLETED: 9/13/96

INVOICE # 11617
P.O. # 4-1129-70 TRU
PROJECT # 4-1129-70 Chevron CU II
AMOUNT$: $900.00

FRACTION #	NAME	TEST	RECEIPT VAC./PRES.	PRICE
01A	SV-3 @ 25 ft	ASTM D-3416	1.0 "Hg	$75.00
02A	SV-4 @ 30 ft	ASTM D-3416	2.0 "Hg	$75.00
03A	SV-4 @ 8 ft	ASTM D-3416	1.0 "Hg	$75.00
04A	SV-4 @ 11 ft	ASTM D-3416	1.0 "Hg	$75.00
05A	SV-4 @ 25 ft	ASTM D-3416	0.5 "Hg	$75.00
05AA	SV-4 @ 25 ft Duplicate	ASTM D-3416	0.5 "Hg	NC
06A	SV-5 @ 12 ft	ASTM D-3416	0.5 "Hg	$75.00
07A	SV-6 @ 3 ft	ASTM D-3416	9.5 "Hg	$75.00
08A	SV-7 @ 3 ft	ASTM D-3416	1.0 "Hg	$75.00
09A	SV-8 @ 3 ft	ASTM D-3416	1.5 "Hg	$75.00
10A	SV-1-3 ft	ASTM D-3416	1.5 "Hg	$75.00
11A	SV-2 @ 8 ft	ASTM D-3416	1.5 "Hg	$75.00
12A	SV-3 @ 8 ft	ASTM D-3416	2.5 "Hg	$75.00
13A	Method Spike	ASTM D-3416	NA	NC
14A	Lab Blank	ASTM D-3416	NA	NC
14B	Lab Blank	ASTM D-3416	NA	NC

CERTIFIED BY: Jonathan Freeman
Laboratory Director

DATE: 9/13/96

180 BLUE RAVINE ROAD, SUITE B • FOLSOM, CA 95630
(916) 985-1000 • FAX (916) 985-1020

AIR TOXICS LTD.

SAMPLE NAME: SV-3 @ 25 ft
ID#: 9608280B-01A

Atmospheric Gases by Modified ASTM D-3416
GC/TCD/FID

File Name:	**3082817**	**Date of Collection:**	**8/20/96**
Dil. Factor:	**2.09**	**Date of Analysis:**	**8/28/96**

Compound	Det. Limit (%)	Amount (%)
Oxygen	0.021	21 B
Methane	0.002	0.004
Carbon Dioxide	0.002	0.58

B = Compound present in laboratory blank, background subtraction not performed.

Container Type: 1 Liter Summa Canister

AIR TOXICS LTD.

SAMPLE NAME: SV-4 @ 30 ft
ID#: 9608280B-02A

Atmospheric Gases by Modified ASTM D-3416
GC/TCD/FID

File Name:	**3082818**	**Date of Collection: 8/20/96**	
Dil. Factor:	**2.16**	**Date of Analysis: 8/28/96**	

Compound	Det. Limit (%)	Amount (%)
Oxygen	0.022	14 B
Methane	0.002	Not Detected
Carbon Dioxide	0.002	9.3

B = Compound present in laboratory blank, background subtraction not performed.

Container Type: 1 Liter Summa Canister

AIR TOXICS LTD.

SAMPLE NAME: SV-4 @ 8 ft
ID#: 9608280B-03A

Atmospheric Gases by Modified ASTM D-3416
GC/TCD/FID

File Name:	**3082819**	**Date of Collection:**	**8/20/96**
Dil. Factor:	**2.09**	**Date of Analysis:**	**8/28/96**

Compound	Det. Limit (%)	Amount (%)
Oxygen	0.021	21 B
Methane	0.002	Not Detected
Carbon Dioxide	0.002	0.35

B = Compound present in laboratory blank, background subtraction not performed.

Container Type: 1 Liter Summa Canister

AIR TOXICS LTD.

SAMPLE NAME: SV-4 @ 11 ft
ID#: 9608280B-04A

Atmospheric Gases by Modified ASTM D-3416
GC/TCD/FID

File Name:	**3082820**	**Date of Collection:**	**8/20/96**
Dil. Factor:	**2.09**	**Date of Analysis:**	**8/28/96**

Compound	Det. Limit (%)	Amount (%)
Oxygen	0.021	21 B
Methane	0.002	0.007
Carbon Dioxide	0.002	0.80

B = Compound present in laboratory blank, background subtraction not performed.

Container Type: 1 Liter Summa Canister

AIR TOXICS LTD.

SAMPLE NAME: SV-4 @ 25 ft
ID#: 9608280B-05A

Atmospheric Gases by Modified ASTM D-3416
GC/TCD/FID

File Name:	**3082821**	**Date of Collection: 8/20/96**	
Dil. Factor:	**2.05**	**Date of Analysis: 8/28/96**	

Compound	Det. Limit (%)	Amount (%)
Oxygen	0.021	21 B
Methane	0.002	0.002
Carbon Dioxide	0.002	0.37

B = Compound present in laboratory blank, background subtraction not performed.

Container Type: 1 Liter Summa Canister

AIR TOXICS LTD.

SAMPLE NAME: SV-4 @ 25 ft Duplicate
ID#: 9608280B-05AA

Atmospheric Gases by Modified ASTM D-3416
GC/TCD/FID

File Name:	**3082822**	**Date of Collection:**	**8/20/96**
Dil. Factor:	**2.05**	**Date of Analysis:**	**8/28/96**

Compound	Det. Limit (%)	Amount (%)
Oxygen	0.021	21 B
Methane	0.002	0.002
Carbon Dioxide	0.002	0.35

B = Compound present in laboratory blank, background subtraction not performed.

Container Type: 1 Liter Summa Canister

AIR TOXICS LTD.

SAMPLE NAME: SV-5 @ 12 ft
ID#: 9608280B-06A

Atmospheric Gases by Modified ASTM D-3416
GC/TCD/FID

File Name:	**3082823**	**Date of Collection: 8/20/96**	
Dil. Factor:	**2.05**	**Date of Analysis: 8/28/96**	

Compound	Det. Limit (%)	Amount (%)
Oxygen	0.021	22 B
Methane	0.002	Not Detected
Carbon Dioxide	0.002	0.091

B = Compound present in laboratory blank, background subtraction not performed.

Container Type: 1 Liter Summa Canister

AIR TOXICS LTD.

SAMPLE NAME: SV-6 @ 3 ft
ID#: 9608280B-07A

Atmospheric Gases by Modified ASTM D-3416
GC/TCD/FID

File Name:	**3082904**	**Date of Collection: 8/20/96**	
Dil. Factor:	**2.96**	**Date of Analysis: 8/29/96**	

Compound	Det. Limit (%)	Amount (%)
Oxygen	0.030	0.51 B
Methane	0.003	0.005
Carbon Dioxide	0.003	0.054

B = Compound present in laboratory blank, background subtraction not performed.

Container Type: 1 Liter Summa Canister

AIR TOXICS LTD.

SAMPLE NAME: SV-7 @ 3 ft
ID#: 9608280B-08A

Atmospheric Gases by Modified ASTM D-3416
GC/TCD/FID

File Name:	**3082905**	**Date of Collection:**	**8/20/96**
Dil. Factor:	**2.09**	**Date of Analysis:**	**8/29/96**

Compound	Det. Limit (%)	Amount (%)
Oxygen	0.021	21 B
Methane	0.002	Not Detected
Carbon Dioxide	0.002	0.47

B = Compound present in laboratory blank, background subtraction not performed.

Container Type: 1 Liter Summa Canister

AIR TOXICS LTD.

SAMPLE NAME: SV-8 @ 3 ft
ID#: 9608280B-09A

Atmospheric Gases by Modified ASTM D-3416
GC/TCD/FID

File Name:	**3082906**	**Date of Collection:**	**8/20/96**
Dil. Factor:	**2.13**	**Date of Analysis:**	**8/29/96**

Compound	Det. Limit (%)	Amount (%)
Oxygen	0.021	19 B
Methane	0.002	Not Detected
Carbon Dioxide	0.002	3.6

B = Compound present in laboratory blank, background subtraction not performed.

Container Type: 1 Liter Summa Canister

AIR TOXICS LTD.

SAMPLE NAME: SV-1-3 ft
ID#: 9608280B-10A

Atmospheric Gases by Modified ASTM D-3416
GC/TCD/FID

File Name:	**3082907**	**Date of Collection:**	**8/19/96**
Dil. Factor:	**2.13**	**Date of Analysis:**	**9/29/96**

Compound	Det. Limit (%)	Amount (%)
Oxygen	0.021	22 B
Methane	0.002	Not Detected
Carbon Dioxide	0.002	0.076

B = Compound present in laboratory blank, background subtraction not performed.

Container Type: 1 Liter Summa Canister

AIR TOXICS LTD.

SAMPLE NAME: SV-2 @ 8 ft
ID#: 9608280B-11A

Atmospheric Gases by Modified ASTM D-3416
GC/TCD/FID

File Name:	**3082908**	**Date of Collection:**	**8/19/96**
Dil. Factor:	**2.13**	**Date of Analysis:**	**8/29/96**

Compound	Det. Limit (%)	Amount (%)
Oxygen	0.021	1.4 B
Methane	0.002	0.010
Carbon Dioxide	0.002	28

B = Compound present in laboratory blank, background subtraction not performed.

Container Type: 1 Liter Summa Canister

AIR TOXICS LTD.

SAMPLE NAME: SV-3 @ 8 ft
ID#: 9608280B-12A

Atmospheric Gases by Modified ASTM D-3416
GC/TCD/FID

File Name:	**3082909**	**Date of Collection:**	**8/19/96**
Dil. Factor:	**2.20**	**Date of Analysis:**	**8/29/96**

Compound	Det. Limit (%)	Amount (%)
Oxygen	0.022	21 B
Methane	0.002	Not Detected
Carbon Dioxide	0.002	0.25

B = Compound present in laboratory blank, background subtraction not performed.

Container Type: 1 Liter Summa Canister

AIR TOXICS LTD.

SAMPLE NAME: Method Spike
ID#: 9608280B-13A

Atmospheric Gases by Modified ASTM D-3416
GC/TCD/FID

File Name:	**3082801**	**Date of Collection: NA**	
Dil. Factor:	**1.00**	**Date of Analysis: 8/28/96**	

Compound	Det. Limit (%)	% Recovery
Oxygen	0.010	97
Methane	0.001	86
Carbon Dioxide	0.001	104

Container Type: NA

AIR TOXICS LTD.

SAMPLE NAME: Lab Blank
ID#: 9608280B-14A

Atmospheric Gases by Modified ASTM D-3416
GC/TCD/FID

File Name:	**3082807**	**Date of Collection: NA**	
Dil. Factor:	**1.00**	**Date of Analysis: 8/28/96**	

Compound	Det. Limit (%)	Amount (%)
Oxygen	0.010	0.025
Methane	0.001	Not Detected
Carbon Dioxide	0.001	Not Detected

Container Type: NA

AIR TOXICS LTD.

SAMPLE NAME: Lab Blank
ID#: 9608280B-14B

Atmospheric Gases by Modified ASTM D-3416
GC/TCD/FID

File Name:	**3082903**	**Date of Collection: NA**	
Dil. Factor:	**1.00**	**Date of Analysis: 8/29/96**	

Compound	Det. Limit (%)	Amount (%)
Oxygen	0.010	0.010
Methane	0.001	Not Detected
Carbon Dioxide	0.001	Not Detected

Container Type: NA

AIR TOXICS LTD.
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180 BLUE RAVINE ROAD, SUITE B
FOLSOM, CA 95630-4719
(916) 985-1000 FAX: (916) 985-1020

CHAIN-OF-CUSTODY RECORD

Nº 008203

Contact Person: Tim Utterback
Company: Weiss Associates
Address: 5500 Shellmound St City: Emeryville State: CA Zip: 94608
Phone: (510) 450-6193 FAX: (510) 547-5043
Collected By: Signature: T. Utterback

Project Info:
P.O. # 4-1129-70 TRU
Project # 4-1129-70
Project Name: Chevron CVII

Turn Around Time:
☒ Normal
☐ Rush _____ Specify

Lab I.D.	Field Sample I.D.	Date & Time	Analyses Requested	Canister Pressure / Vacuum Initial	Final	Receipt
01A	SV-3 @ 2.5 FT	8/20/96 5 PM	TO-14 for BTEX and O_2, CO_2, CH_4 by ASTM D3416	<-30 "Hg	~0 "Hg	1.0 "Hg
02A	SV-4 @ 3.0 FT	2 PM		"	"	2.0 "Hg
03A	SV-4 @ 8 FT	2 PM		"	~-0.5 "Hg	1.0 "Hg
04A	SV-4 @ 11 FT	3 PM		"	"	1.0 "Hg
05A/AA	SV-4 @ 25 FT	4 PM		"	~0 "Hg	0.5 "Hg
06A	SV-5 @ 12 FT	4 PM		"	"	0.5 "Hg
07A	SV-6 @ 3 FT	9 AM		"	-10 "Hg	9.5 "Hg
08A	SV-7 @ 3 FT	11 AM		"	~-0.5 "Hg	1.0 "Hg
09A	SV-8 @ 3 FT	2 PM		"	~0 "Hg	1.5 "Hg

Relinquished By: (Signature) Date/Time: T. Utterback 8/21/96 16:20 Print Name: Tim Utterback
Relinquished By: (Signature) Date/Time — Received By: (Signature) Date/Time
Relinquished By: (Signature) Date/Time — Received By: (Signature) Date/Time: Airtech Airborne Air 8/22/96 1030

Notes:

Lab Use Only	Shipper Name	Air Bill #	Opened By:	Date/Time	Temp. (°C)	Condition	Custody Seals Intact?	Work Order #
	UPS	0912 124 2805	JA	8/22/96 1030	AMBIENT	GOOD	Yes No (None) N/A	960828OA

Form 1293 rev. 06

AIR TOXICS LTD.
AN ENVIRONMENTAL ANALYTICAL LABORATORY

180 BLUE RAVINE ROAD, SUITE B
FOLSOM, CA 95630-4719
(916) 985-1000 FAX: (916) 985-1020

CHAIN-OF-CUSTODY RECORD

Nº 008205
Page 1 of 2

Contact Person: Tim Utterback
Company: Weiss Associates
Address: 5500 Shellmound St City: Emeryville State: CA Zip: 94608
Phone: (510) 450-6193 FAX: (510) 547-5043
Collected By: Signature: Tim Utterback

Project Info:
P.O. #: 4-1129-70 TRU
Project #: 4-1129-70
Project Name: Chevron CVII

Turn Around Time:
☒ Normal
☐ Rush _____ Specify

Lab I.D.	Field Sample I.D.	Date & Time	Analyses Requested	Canister Pressure / Vacuum Initial	Final	Receipt
10A	SV-1-3 Ft	8/19/96, 10:00AM	TO-14 for BTEX and O_2, CO, CH_4 by ASTM D3416	<-30" Hg	~0.5-1" Hg	1.5" Hg
11A	SV-2 @ 8 Ft	8/19/96, 13:30	↓	<-30" Hg	~0.5" Hg	1.5" Hg
12A	SV-3 @ 8 Ft	8/19/96, 16:10	↓	<-30" Hg	~2" Hg	2.5" Hg
						8/20/96

Relinquished By: (Signature) Date/Time: Tim Utterback 8/21/96 16:30 Print Name: Tim Utterback
Relinquished By: (Signature) Date/Time — Received By: (Signature) Date/Time
Relinquished By: (Signature) Date/Time — Received By: (Signature) Date/Time: Scott Anderson ATL 8/22/96 1030

Notes:

Lab Use Only

Shipper Name	Air Bill #	Opened By:	Date/Time	Temp. (°C)	Condition	Custody Seals Intact?	Work Order #
UPS	0912 724 2805	da	8/22/96 1030	AMBIENT	GOOD	Yes No (None) N/A	960828PA

Sequoia Analytical

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819 Striker Avenue, Suite 8, Sacramento, CA 95834, (916) 921-9600, FAX (916) 921-0100

Weiss Associates
5500 Shellmound
Emeryville, CA 94608

Attention: Tim Utterback

Client Proj. ID: Chevron 9-5607, Castro Valley

Lab Proj. ID: 9608B72

Sampled: 08/19/96
Received: 08/20/96
Analyzed: see below

Reported: 09/06/96

LABORATORY ANALYSIS

Analyte	Units	Date Analyzed	Detection Limit	Sample Results
Lab No: 9608B72-02				
Sample Desc : **SOLID,SS-1 at 6'**				
Bulk Density	-			**Attached**
Porosity	-			**Attached**
Lab No: 9608B72-03				
Sample Desc : **SOLID,SS-1 at 10'**				
Bulk Density	-			**Attached**
Porosity	-			**Attached**
Lab No: 9608B72-05				
Sample Desc : **SOLID,SS-2 at 3'**				
Fraction Organic Carbon	%	08/27/96	0.025	0.30
Lab No: 9608B72-08				
Sample Desc : **SOLID,SS-2 at 15'**				
Fraction Organic Carbon	%	08/27/96	0.025	0.23
Lab No: 9608B72-10				
Sample Desc : **SOLID,SS-3 at 3'**				
Fraction Organic Carbon	%	08/27/96	0.025	0.20

alytes reported as N.D. were not present above the stated limit of detection.

SEQUOIA ANALYTICAL - ELAP #1210

ke Gregory
oject Manager

Sequoia Analytical

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819 Striker Avenue, Suite 8, Sacramento, CA 95834, (916) 921-9600, FAX (916) 921-0100

Weiss Associates
5500 Shellmound
Emeryville, CA 94608

Attention: Tim Utterback

Client Proj. ID: Chevron 9-5607, Castro Valley
Sample Descript: SS-1 at 5'
Matrix: SOLID
Analysis Method: 8015Mod/8020
Lab Number: 9608B72-01

Sampled: 08/19/96
Received: 08/20/96
Extracted: 08/22/96
Analyzed: 08/23/96
Reported: 09/06/96

QC Batch Number: GC082296BTEXEXA
Instrument ID: GCHP18

Total Purgeable Petroleum Hydrocarbons (TPPH) with BTEX

Analyte	Detection Limit mg/Kg	Sample Results mg/Kg
TPPH as Gas	1.0	N.D.
Benzene	0.0050	N.D.
Toluene	0.0050	N.D.
Ethyl Benzene	0.0050	N.D.
Xylenes (Total)	0.0050	N.D.
Chromatogram Pattern:		

Surrogates	Control Limits %		% Recovery
Trifluorotoluene	70	130	76

Analytes reported as N.D. were not present above the stated limit of detection.

SEQUOIA ANALYTICAL - ELAP #1210

Mike Gregory
Project Manager

Sequoia Analytical

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819 Striker Avenue, Suite 8, Sacramento, CA 95834, (916) 921-9600, FAX (916) 921-0100

Weiss Associates
5500 Shellmound
Emeryville, CA 94608

Attention: Tim Utterback

Client Proj. ID: Chevron 9-5607, Castro Valley
Sample Descript: SS-1 at 10'
Matrix: SOLID
Analysis Method: 8015Mod/8020
Lab Number: 9608B72-03

Sampled: 08/19/96
Received: 08/20/96
Extracted: 08/23/96
Analyzed: 08/23/96
Reported: 09/06/96

QC Batch Number: GC082296BTEXEXA
Instrument ID: GCHP18

Total Purgeable Petroleum Hydrocarbons (TPPH) with BTEX

Analyte	Detection Limit mg/Kg	Sample Results mg/Kg
TPPH as Gas	1.0	N.D.
Benzene	0.0050	N.D.
Toluene	0.0050	N.D.
Ethyl Benzene	0.0050	N.D.
Xylenes (Total)	0.0050	N.D.
Chromatogram Pattern:		

Surrogates	Control Limits %		% Recovery
Trifluorotoluene	70	130	74

Analytes reported as N.D. were not present above the stated limit of detection.

SEQUOIA ANALYTICAL - ELAP #1210

Mike Gregory
Project Manager

Sequoia Analytical

680 Chesapeake Drive, Redwood City, CA 94063, (415) 364-9600, FAX (415) 364-9233
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819 Striker Avenue, Suite 8, Sacramento, CA 95834, (916) 921-9600, FAX (916) 921-0100

Weiss Associates
5500 Shellmound
Emeryville, CA 94608

Attention: Tim Utterback

Client Proj. ID: Chevron 9-5607, Castro Valley
Sample Descript: SS-1 at 21'
Matrix: SOLID
Analysis Method: 8015Mod/8020
Lab Number: 9608B72-04

Sampled: 08/19/96
Received: 08/20/96
Extracted: 08/23/96
Analyzed: 08/26/96
Reported: 09/06/96

QC Batch Number: GC082296BTEXEXA
Instrument ID: GCHP07

Total Purgeable Petroleum Hydrocarbons (TPPH) with BTEX

Analyte	Detection Limit mg/Kg	Sample Results mg/Kg
TPPH as Gas	1.0	N.D.
Benzene	0.0050	N.D.
Toluene	0.0050	N.D.
Ethyl Benzene	0.0050	N.D.
Xylenes (Total)	**0.0050**	**0.014**
Chromatogram Pattern:		

Surrogates	Control Limits %		% Recovery
Trifluorotoluene	70	130	97

Analytes reported as N.D. were not present above the stated limit of detection.

SEQUOIA ANALYTICAL - ELAP #1210

Mike Gregory
Project Manager

Sequoia Analytical

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819 Striker Avenue, Suite 8, Sacramento, CA 95834, (916) 921-9600, FAX (916) 921-0100

Weiss Associates
500 Shellmound
Emeryville, CA 94608

Attention: Tim Utterback

Client Proj. ID: Chevron 9-5607, Castro Valley
Sample Descript: SS-2 at 3'
Matrix: SOLID
Analysis Method: 8015Mod/8020
Lab Number: 9608B72-05

Sampled: 08/19/96
Received: 08/20/96
Extracted: 08/23/96
Analyzed: 08/23/96
Reported: 09/06/96

QC Batch Number: GC082296BTEXEXA
Instrument ID: GCHP18

Total Purgeable Petroleum Hydrocarbons (TPPH) with BTEX

Analyte	Detection Limit mg/Kg	Sample Results mg/Kg
TPPH as Gas	1.0	N.D.
Benzene	0.0050	N.D.
Toluene	0.0050	N.D.
Ethyl Benzene	0.0050	N.D.
Xylenes (Total)	0.0050	N.D.
Chromatogram Pattern:		

Surrogates	Control Limits %		% Recovery
Trifluorotoluene	70	130	74

Analytes reported as N.D. were not present above the stated limit of detection.

SEQUOIA ANALYTICAL - ELAP #1210

Mike Gregory
Project Manager

Sequoia Analytical

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819 Striker Avenue, Suite 8, Sacramento, CA 95834, (916) 921-9600, FAX (916) 921-0100

Weiss Associates
5500 Shellmound
Emeryville, CA 94608

Attention: Tim Utterback

Client Proj. ID: Chevron 9-5607, Castro Valley
Sample Descript: SS-2 at 8'
Matrix: SOLID
Analysis Method: 8015Mod/8020
Lab Number: 9608B72-06

Sampled: 08/19/96
Received: 08/20/96
Extracted: 08/23/96
Analyzed: 08/23/96
Reported: 09/06/96

QC Batch Number: GC082296BTEXEXA
Instrument ID: GCHP18

Total Purgeable Petroleum Hydrocarbons (TPPH) with BTEX

Analyte	Detection Limit mg/Kg	Sample Results mg/Kg
TPPH as Gas	1.0	N.D.
Benzene	0.0050	N.D.
Toluene	0.0050	N.D.
Ethyl Benzene	0.0050	N.D.
Xylenes (Total)	0.0050	N.D.
Chromatogram Pattern:		

Surrogates	Control Limits %		% Recovery
Trifluorotoluene	70	130	77

Analytes reported as N.D. were not present above the stated limit of detection.

SEQUOIA ANALYTICAL - ELAP #1210

Mike Gregory
Project Manager

Sequoia Analytical

680 Chesapeake Drive, Redwood City, CA 94063, (415) 364-9600, FAX (415) 364-9233
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819 Striker Avenue, Suite 8, Sacramento, CA 95834, (916) 921-9600, FAX (916) 921-0100

Weiss Associates
5500 Shellmound
Emeryville, CA 94608

Attention: Tim Utterback

Client Proj. ID: Chevron 9-5607, Castro Valley
Sample Descript: SS-2 at 10'
Matrix: SOLID
Analysis Method: 8015Mod/8020
Lab Number: 9608B72-07

Sampled: 08/19/96
Received: 08/20/96
Extracted: 08/23/96
Analyzed: 08/23/96
Reported: 09/06/96

QC Batch Number: GC082296BTEXEXA
Instrument ID: GCHP18

Total Purgeable Petroleum Hydrocarbons (TPPH) with BTEX

Analyte	Detection Limit mg/Kg	Sample Results mg/Kg
TPPH as Gas	1.0	N.D.
Benzene	0.0050	N.D.
Toluene	0.0050	N.D.
Ethyl Benzene	0.0050	N.D.
Xylenes (Total)	0.0050	N.D.
Chromatogram Pattern:		

Surrogates	Control Limits %		% Recovery
Trifluorotoluene	70	130	73

Analytes reported as N.D. were not present above the stated limit of detection.

SEQUOIA ANALYTICAL - ELAP #1210

Mike Gregory
Project Manager

Sequoia Analytical

680 Chesapeake Drive, Redwood City, CA 94063, (415) 364-9600, FAX (415) 364-9233
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819 Striker Avenue, Suite 8, Sacramento, CA 95834, (916) 921-9600, FAX (916) 921-0100

Weiss Associates	Client Proj. ID: Chevron 9-5607, Castro Valley	Sampled: 08/19/96
5500 Shellmound	Sample Descript: SS-2 at 21'	Received: 08/20/96
Emeryville, CA 94608	Matrix: SOLID	Extracted: 08/23/96
	Analysis Method: 8015Mod/8020	Analyzed: 08/23/96
Attention: Tim Utterback	Lab Number: 9608B72-09	Reported: 09/06/96

QC Batch Number: GC082296BTEXEXA
Instrument ID: GCHP18

Total Purgeable Petroleum Hydrocarbons (TPPH) with BTEX

Analyte	Detection Limit mg/Kg	Sample Results mg/Kg
TPPH as Gas	1.0	N.D.
Benzene	0.0050	N.D.
Toluene	0.0050	N.D.
Ethyl Benzene	0.0050	N.D.
Xylenes (Total)	0.0050	N.D.
Chromatogram Pattern:		

Surrogates	Control Limits %		% Recovery
Trifluorotoluene	70	130	73

Analytes reported as N.D. were not present above the stated limit of detection.

SEQUOIA ANALYTICAL - ELAP #1210

Mike Gregory
Project Manager

Sequoia Analytical

680 Chesapeake Drive, Redwood City, CA 94063, (415) 364-9600, FAX (415) 364-9233
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819 Striker Avenue, Suite 8, Sacramento, CA 95834, (916) 921-9600, FAX (916) 921-0100

Weiss Associates	Client Proj. ID: Chevron 9-5607, Castro Valley	Sampled: 08/19/96
500 Shellmound	Sample Descript: SS-3 at 5'	Received: 08/20/96
Emeryville, CA 94608	Matrix: SOLID	Extracted: 08/23/96
	Analysis Method: 8015Mod/8020	Analyzed: 08/23/96
Attention: Tim Utterback	Lab Number: 9608B72-11	Reported: 09/06/96

QC Batch Number: GC082296BTEXEXA
Instrument ID: GCHP18

Total Purgeable Petroleum Hydrocarbons (TPPH) with BTEX

Analyte	Detection Limit mg/Kg	Sample Results mg/Kg
TPPH as Gas	1.0	N.D.
Benzene	0.0050	N.D.
Toluene	0.0050	N.D.
Ethyl Benzene	0.0050	N.D.
Xylenes (Total)	0.0050	N.D.
Chromatogram Pattern:		

Surrogates	Control Limits %		% Recovery
Trifluorotoluene	70	130	75

Analytes reported as N.D. were not present above the stated limit of detection.

SEQUOIA ANALYTICAL - ELAP #1210

Mike Gregory
Project Manager

Sequoia Analytical

680 Chesapeake Drive, Redwood City, CA 94063, (415) 364-9600, FAX (415) 364-9233
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819 Striker Avenue, Suite 8, Sacramento, CA 95834, (916) 921-9600, FAX (916) 921-0100

Weiss & Associates
5500 Shellmound
Emeryville, CA 94608
Attention: Tim Utterback

Client Project ID: Chevron 9-5607, Castro Valley
Matrix: Solid
Work Order #: 9608B72 -01, -03 -07, -09, -11
Reported: Sep 6, 1996

QUALITY CONTROL DATA REPORT

Analyte:	Benzene	Toluene	Ethyl Benzene	Xylenes
QC Batch#:	GC082296BTEXEXA	GC082296BTEXEXA	GC082296BTEXEXA	GC082296BTEXEXA
Analy. Method:	EPA 8020	EPA 8020	EPA 8020	EPA 8020
Prep. Method:	EPA 5030	EPA 5030	EPA 5030	EPA 5030
Analyst:	Y. Arteaga	Y. Arteaga	Y. Arteaga	Y. Arteaga
MS/MSD #:	9608999-10	9608999-10	9608999-10	9608999-10
Sample Conc.:	N.D.	N.D.	N.D.	N.D.
Prepared Date:	8/22/96	8/22/96	8/22/96	8/22/96
Analyzed Date:	8/22/96	8/22/96	8/22/96	8/22/96
Instrument I.D.#:	GCHP18	GCHP18	GCHP18	GCHP18
Conc. Spiked:	0.20 mg/kg	0.20 mg/kg	0.20 mg/kg	0.60 mg/kg
Result:	0.13	0.13	0.13	0.40
MS % Recovery:	65	65	65	67
Dup. Result:	0.21	0.21	0.21	0.65
MSD % Recov.:	105	105	105	108
RPD:	47	47	47	48
RPD Limit:	0-25	0-25	0-25	0-25

LCS #:	GBLK082296	GBLK082296	GBLK082296	GBLK082296
Prepared Date:	8/22/96	8/22/96	8/22/96	8/22/96
Analyzed Date:	8/22/96	8/22/96	8/22/96	8/22/96
Instrument I.D.#:	GCHP18	GCHP18	GCHP18	GCHP18
Conc. Spiked:	0.20 mg/kg	0.20 mg/kg	0.20 mg/kg	0.60 mg/kg
LCS Result:	0.18	0.18	0.18	0.54
LCS % Recov.:	90	90	90	90

MS/MSD LCS Control Limits	60-140 70-130	60-140 70-130	60-140 70-130	60-140 70-130

SEQUOIA ANALYTICAL

Mike Gregory
Project Manager

Please Note:
The LCS is a control sample of known, interferent-free matrix that is analyzed using the same reagents, preparation, and analytical methods employed for the samples. The matrix spike is an aliquot of sample fortified with known quantities of specific compounds and subjected to the entire analytical procedure. If the recovery of analytes from the matrix spike does not fall within specified control limits due to matrix interference, the LCS recovery is to be used to validate the batch.

** MS = Matrix Spike, MSD = MS Duplicate, RPD = Relative % Difference

Sequoia Analytical

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Weiss & Associates	Client Project ID:	Chevron 9-5607, Castro Valley	
5500 Shellmound	Matrix:	Solid	
Emeryville, CA 94608			
Attention: Tim Utterback	Work Order #:	9608B72 -05, -08, -10	Reported: Sep 6, 1996

QUALITY CONTROL DATA REPORT

Analyte:	Fractional Organic Carbon
QC Batch:	IN082796WALK00A
Analy. Method:	Walkley-Black
Prep Method:	N.A.

Analyst:	S. Fong
Duplicate Sample #:	9608C61-07
Prepared Date:	8/27/96
Analyzed Date:	8/27/96
Instrument I.D.#:	MANUAL
Sample Concentration:	0.14
Dup. Sample Concentration:	0.12
RPD:	15
RPD Limit:	0-20

SEQUOIA ANALYTICAL

Mike Gregory
Project Manager

** RPD = Relative % Difference

CORE LAB

ENVIRONMENTAL TESTING SERVICES

Mike Gregory
Sequoia Analytical
680 Chesapeake Dr.
Redwood City, CA 94063

September 11, 1996

Subject: Transmittal of Geotechnical Analysis Results
SA Project No. : 9608B72
Core Lab File No.: 57111-96232

Dear Mr Gregory:

Two samples from project number 9608B72 were submitted to our Bakersfield laboratory for total porosity and bulk density determinations. Accompanying this letter, please find the results of this study.

Porosities and bulk densities were determined and calculated as described in API RP-40, API Recommended Practice for Core-Analysis Procedure, 1960.

We appreciate this opportunity to be of service to you and to Sequoia Analytical, should you have any questions, or if we may be of further help in the future, please do not hesitate to contact us.

Very truly yours,

Jeffry L. Smith
Laboratory Supervisor - Rock Properties

JLS:nw
1 original report: Addressee

Core Laboratories, Inc.
3430 Unicorn Road, Bakersfield, California 93308, (805) 392-8600, Fax (805) 392-0824

CORE LABORATORIES

GEOTECHNICAL ANALYSIS RESULTS

SEQUOIA ANALYTICAL
SA PROJECT NO. 9608B72

CL FILE 57111-096232

PERFORMED BY:
CORE LABORATORIES
3430 UNICORN ROAD
BAKERSFIELD, CA 93308
(805) 392-8600

FINAL REPORT PRESENTED
SEPTEMBER 11, 1996

CORE LABORATORIES

Sequoia Analytical
SA Project Name : Weiss
SA Work Order No.: 96-08-B72

CL File No. 57111-96232

Geotechnical Analysis Results

Sample ID	Grain Density gm/cc	Bulk Density		Total Porosity %	Description
		Dry gm/cc	Natural gm/cc		
SS-1 @ 6'	2.68	1.94	2.21	27.7	Silt tan vfgr sand v clay
SS-1 @ 10'	2.69	1.84	2.16	31.5	Silt tan v clay

Total porosity and densities were determined as described in API RP-40, API Recommended Practice for Core-Analysis Procedure, 1960.

Fax copy of Lab Report and COC to Chevron Contact: ☐ Yes ☐ No

Chain-of-Custody-Record

Chevron U.S.A. Inc.
P.O. BOX 5004
San Ramon, CA 94583
FAX (510)842-9591

Chevron Facility Number: 9-5607
Facility Address: 5269 Crow Canyon Rd, Castro Valley
Consultant Project Number: 4-1129-70
Consultant Name: Weiss Associates
Address: 5500 Shellmound St, Emeryville, CA 94608
Project Contact (Name): Tim Utterback
(Phone) (510) 450-6193 (Fax Number) (510) 547-5043

Chevron Contact (Name): Brett Hunter
(Phone) (510) 842-8695
Laboratory Name: Sequoia
Laboratory Release Number: 2910610
Samples Collected by (Name): Tim Utterback
Collection Date: 8/19/96
Signature: Tim Utterback

9608572

Sample Number	Lab Sample Number	Number of Containers	Matrix S = Soil W = Water A = Air C = Charcoal	Type G = Grab C = Composite D = Discrete	Time	Sample Preservation	Iced (Yes or No)	BTEX + TPH GAS (8020 + 8015)	TPH Diesel (8015)	Oil and Grease (5520)	Purgeable Halocarbons (8010)	Purgeable Aromatics (8020)	Purgeable Organics (8240)	Extractable Organics (8270)	Metals Cd,Cr,Pb,Zn,Ni (ICAP or AA)	Density & Percent Porosity Sub to General Lab	Foc by Wartley Black				Remarks
SS-1@5'		1	S	G	10:05	N/A	Y	X													All TPH-G/BTEX at Lowest possible detection Limits
SS-1@6'		1	S		10:05											X					
SS-1@10'		2	S		10:50			X								X					
SS-1@21'		2	S		12:10			X													
SS-2@3'		2	S		13:05			X									X				TPH-G/BTEX and Fraction of Organic
SS-2@8'		1	S		13:30			X													
SS-2@10'		1	S		13:30			X													
SS-2@15'		1	S		13:55												X				Fraction of Organic Carbon + ~~TPH-TRH~~
SS-2@21'		1	S		14:30			X													12.5
SS-3@3		1	S		15:49												X				
SS-3@5		1	S	↓	15:49	↓	↓	X													
~~SS-3@10~~ TRH																					
~~SS-3@~~ TRH																					

Relinquished By (Signature)	Organization	Date/Time	Received By (Signature)	Organization	Date/Time
Tim Utterback	WA	8/20/96 7:50	Joyce Adams	WA	8/20/96 7:50
Joyce Adams	WA	8/20/96 10:55	J. Wright	SEQ	8/20/96 1252
[redacted]	[redacted]	[redacted] 1247	[redacted]	[redacted]	[redacted] 1736

Turn Around Time (Circle Choice)
24 Hrs.
48 Hrs.
5 Days
10 Days
As Contracted

COC-3.DWG/03 91/HCH

Sequoia Analytical

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819 Striker Avenue, Suite 8, Sacramento, CA 95834, (916) 921-9600, FAX (916) 921-0100

Weiss Associates
5500 Shellmound
Emeryville, CA 94608

Attention: Tim Utterback

Client Proj. ID: Chevron 9-5607, Castro Valley

Lab Proj. ID: 9608C61

Sampled: 08/20/96
Received: 08/21/96
Analyzed: see below

Reported: 08/28/96

LABORATORY ANALYSIS

Analyte	Units	Date Analyzed	Detection Limit	Sample Results
Lab No: 9608C61-03 Sample Desc : **SOLID,SS-3@21.5'**				
Fraction Organic Carbon	%	08/27/96	0.025	0.14
Lab No: 9608C61-04 Sample Desc : **SOLID,SS-4@5.0'**				
Fraction Organic Carbon	%	08/27/96	0.025	0.29
Lab No: 9608C61-07 Sample Desc : **SOLID,SS-4@23'**				
Fraction Organic Carbon	%	08/27/96	0.025	0.14

Analytes reported as N.D. were not present above the stated limit of detection.

SEQUOIA ANALYTICAL - ELAP #1210

Mike Gregory
Project Manager

Sequoia Analytical

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819 Striker Avenue, Suite 8, Sacramento, CA 95834, (916) 921-9600, FAX (916) 921-0100

Weiss Associates	Client Proj. ID: Chevron 9-5607, Castro Valley	Sampled: 08/20/96
5500 Shellmound	Sample Descript: SS-3@10'	Received: 08/21/96
Emeryville, CA 94608	Matrix: SOLID	Extracted: 08/23/96
	Analysis Method: 8015Mod/8020	Analyzed: 08/23/96
Attention: Tim Utterback	Lab Number: 9608C61-01	Reported: 08/28/96

QC Batch Number: GC082396BTEXEXA
Instrument ID: GCHP18

Total Purgeable Petroleum Hydrocarbons (TPPH) with BTEX

Analyte	Detection Limit mg/Kg	Sample Results mg/Kg
TPPH as Gas	1.0	N.D.
Benzene	0.0050	N.D.
Toluene	0.0050	N.D.
Ethyl Benzene	0.0050	N.D.
Xylenes (Total)	0.0050	N.D.
Chromatogram Pattern:		

Surrogates	Control Limits %		% Recovery
Trifluorotoluene	70	130	94

Analytes reported as N.D. were not present above the stated limit of detection.

SEQUOIA ANALYTICAL - ELAP #1210

Mike Gregory
Project Manager

Sequoia Analytical

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819 Striker Avenue, Suite 8, Sacramento, CA 95834, (916) 921-9600, FAX (916) 921-0100

Weiss Associates
5500 Shellmound
Emeryville, CA 94608

Attention: Tim Utterback

Client Proj. ID: Chevron 9-5607, Castro Valley
Sample Descript: SS-3@21'
Matrix: SOLID
Analysis Method: 8015Mod/8020
Lab Number: 9608C61-02

Sampled: 08/20/96
Received: 08/21/96
Extracted: 08/23/96
Analyzed: 08/26/96
Reported: 08/28/96

QC Batch Number: GC082396BTEXEXA
Instrument ID: GCHP07

Total Purgeable Petroleum Hydrocarbons (TPPH) with BTEX

Analyte	Detection Limit mg/Kg	Sample Results mg/Kg
TPPH as Gas	**1.0**	**17**
Benzene	**0.0050**	**0.67**
Toluene	**0.0050**	**0.74**
Ethyl Benzene	**0.0050**	**0.38**
Xylenes (Total)	**0.0050**	**1.2**
Chromatogram Pattern:		**Gas**

Surrogates	Control Limits %		% Recovery
Trifluorotoluene	70	130	96

Analytes reported as N.D. were not present above the stated limit of detection.

EQUOIA ANALYTICAL - ELAP #1210

Mike Gregory
Project Manager

Sequoia Analytical

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819 Striker Avenue, Suite 8, Sacramento, CA 95834, (916) 921-9600, FAX (916) 921-0100

Weiss Associates	Client Proj. ID: Chevron 9-5607, Castro Valley	Sampled: 08/20/96
500 Shellmound	Sample Descript: SS-4@6.0'	Received: 08/21/96
Emeryville, CA 94608	Matrix: SOLID	Extracted: 08/23/96
	Analysis Method: 8015Mod/8020	Analyzed: 08/26/96
Attention: Tim Utterback	Lab Number: 9608C61-05	Reported: 08/28/96

QC Batch Number: GC082396BTEXEXA
Instrument ID: GCHP07

Total Purgeable Petroleum Hydrocarbons (TPPH) with BTEX

Analyte	Detection Limit mg/Kg	Sample Results mg/Kg
TPPH as Gas	1.0	N.D.
Benzene	0.0050	N.D.
Toluene	0.0050	N.D.
Ethyl Benzene	0.0050	N.D.
Xylenes (Total)	**0.0050**	**0.012**
Chromatogram Pattern:		

Surrogates	Control Limits %		% Recovery
Trifluorotoluene	70	130	104

Analytes reported as N.D. were not present above the stated limit of detection.

SEQUOIA ANALYTICAL - ELAP #1210

Mike Gregory
Project Manager

Sequoia Analytical

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Weiss Associates	Client Proj. ID: Chevron 9-5607, Castro Valley	Sampled: 08/20/96
500 Shellmound	Sample Descript: SS-4@9.5'	Received: 08/21/96
Emeryville, CA 94608	Matrix: SOLID	Extracted: 08/23/96
	Analysis Method: 8015Mod/8020	Analyzed: 08/23/96
Attention: Tim Utterback	Lab Number: 9608C61-06	Reported: 08/28/96

QC Batch Number: GC082396BTEXEXA
Instrument ID: GCHP18

Total Purgeable Petroleum Hydrocarbons (TPPH) with BTEX

Analyte	Detection Limit mg/Kg	Sample Results mg/Kg
TPPH as Gas	1.0	N.D.
Benzene	0.0050	N.D.
Toluene	0.0050	N.D.
Ethyl Benzene	0.0050	N.D.
Xylenes (Total)	0.0050	N.D.
Chromatogram Pattern:		

Surrogates	Control Limits %		% Recovery
Trifluorotoluene	70	130	78

Analytes reported as N.D. were not present above the stated limit of detection.

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Mike Gregory
Project Manager

Sequoia Analytical

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Weiss Associates	Client Proj. ID: Chevron 9-5607, Castro Valley	Sampled: 08/20/96
500 Shellmound	Sample Descript: SS-4@23.5'	Received: 08/21/96
Emeryville, CA 94608	Matrix: SOLID	Extracted: 08/23/96
	Analysis Method: 8015Mod/8020	Analyzed: 08/23/96
Attention: Tim Utterback	Lab Number: 9608C61-08	Reported: 08/28/96

QC Batch Number: GC082396BTEXEXA
Instrument ID: GCHP07

Total Purgeable Petroleum Hydrocarbons (TPPH) with BTEX

Analyte	Detection Limit mg/Kg	Sample Results mg/Kg
TPPH as Gas	**2.0**	**97**
Benzene	**0.010**	**0.59**
Toluene	0.010	N.D.
Ethyl Benzene	**0.010**	**1.0**
Xylenes (Total)	**0.010**	**2.9**
Chromatogram Pattern:		**Gas**

Surrogates	Control Limits %		% Recovery
Trifluorotoluene	70	130	126

Analytes reported as N.D. were not present above the stated limit of detection.

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Mike Gregory
Project Manager

Sequoia Analytical

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Weiss Associates	Client Proj. ID: Chevron 9-5607, Castro Valley	Sampled: 08/20/96
5500 Shellmound	Sample Descript: SS-5@5'	Received: 08/21/96
Emeryville, CA 94608	Matrix: SOLID	Extracted: 08/23/96
	Analysis Method: 8015Mod/8020	Analyzed: 08/23/96
Attention: Tim Utterback	Lab Number: 9608C61-09	Reported: 08/28/96

QC Batch Number: GC082396BTEXEXA
Instrument ID: GCHP07

Total Purgeable Petroleum Hydrocarbons (TPPH) with BTEX

Analyte	Detection Limit mg/Kg	Sample Results mg/Kg
TPPH as Gas	1.0	N.D.
Benzene	0.0050	N.D.
Toluene	0.0050	N.D.
Ethyl Benzene	0.0050	N.D.
Xylenes (Total)	**0.0050**	**0.0054**
Chromatogram Pattern:		

Surrogates	Control Limits %		% Recovery
Trifluorotoluene	70	130	87

Analytes reported as N.D. were not present above the stated limit of detection.

SEQUOIA ANALYTICAL - ELAP #1210

Mike Gregory
Project Manager

Sequoia Analytical

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819 Striker Avenue, Suite 8, Sacramento, CA 95834, (916) 921-9600, FAX (916) 921-0100

Weiss Associates	Client Proj. ID: Chevron 9-5607, Castro Valley	Sampled: 08/20/96
5500 Shellmound	Sample Descript: SS-5@10'	Received: 08/21/96
Emeryville, CA 94608	Matrix: SOLID	Extracted: 08/23/96
	Analysis Method: 8015Mod/8020	Analyzed: 08/23/96
Attention: Tim Utterback	Lab Number: 9608C61-10	Reported: 08/28/96

QC Batch Number: GC082396BTEXEXA
Instrument ID: GCHP07

Total Purgeable Petroleum Hydrocarbons (TPPH) with BTEX

Analyte	Detection Limit mg/Kg	Sample Results mg/Kg
TPPH as Gas	1.0	N.D.
Benzene	0.0050	N.D.
Toluene	0.0050	N.D.
Ethyl Benzene	0.0050	N.D.
Xylenes (Total)	0.0050	N.D.
Chromatogram Pattern:		

Surrogates	Control Limits %		% Recovery
Trifluorotoluene	70	130	88

Analytes reported as N.D. were not present above the stated limit of detection.

SEQUOIA ANALYTICAL - ELAP #1210

Mike Gregory
Project Manager

Sequoia Analytical

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Weiss Associates	Client Proj. ID: Chevron 9-5607, Castro Valley	Sampled: 08/20/96
5500 Shellmound	Sample Descript: SS-5@24.5'	Received: 08/21/96
Emeryville, CA 94608	Matrix: SOLID	Extracted: 08/23/96
	Analysis Method: 8015Mod/8020	Analyzed: 08/26/96
Attention: Tim Utterback	Lab Number: 9608C61-11	Reported: 08/28/96

QC Batch Number: GC082396BTEXEXA
Instrument ID: GCHP22

Total Purgeable Petroleum Hydrocarbons (TPPH) with BTEX

Analyte	Detection Limit mg/Kg	Sample Results mg/Kg
TPPH as Gas	1.0	N.D.
Benzene	0.0050	N.D.
Toluene	0.0050	N.D.
Ethyl Benzene	0.0050	N.D.
Xylenes (Total)	0.0050	N.D.
Chromatogram Pattern:		

Surrogates	Control Limits %		% Recovery
Trifluorotoluene	70	130	92

Analytes reported as N.D. were not present above the stated limit of detection.

SEQUOIA ANALYTICAL - ELAP #1210

Mike Gregory
Project Manager

Sequoia Analytical

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Weiss Associates	Client Proj. ID: Chevron 9-5607, Castro Valley	Sampled: 08/20/96
5500 Shellmound	Sample Descript: SS-6@5'	Received: 08/21/96
Emeryville, CA 94608	Matrix: SOLID	Extracted: 08/23/96
	Analysis Method: 8015Mod/8020	Analyzed: 08/23/96
Attention: Tim Utterback	Lab Number: 9608C61-12	Reported: 08/28/96

QC Batch Number: GC082396BTEXEXA
Instrument ID: GCHP07

Total Purgeable Petroleum Hydrocarbons (TPPH) with BTEX

Analyte	Detection Limit mg/Kg	Sample Results mg/Kg
TPPH as Gas	1.0	N.D.
Benzene	0.0050	N.D.
Toluene	0.0050	N.D.
Ethyl Benzene	0.0050	N.D.
Xylenes (Total)	0.0050	N.D.
Chromatogram Pattern:		

Surrogates	Control Limits %		% Recovery
Trifluorotoluene	70	130	89

Analytes reported as N.D. were not present above the stated limit of detection.

SEQUOIA ANALYTICAL - ELAP #1210

Mike Gregory
Project Manager

Sequoia Analytical

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Weiss Associates
500 Shellmound
Emeryville, CA 94608

Attention: Tim Utterback

Client Proj. ID: Chevron 9-5607, Castro Valley
Sample Descript: SS-6@10'
Matrix: SOLID
Analysis Method: 8015Mod/8020
Lab Number: 9608C61-13

Sampled: 08/20/96
Received: 08/21/96
Extracted: 08/23/96
Analyzed: 08/23/96
Reported: 08/28/96

QC Batch Number: GC082396BTEXEXA
Instrument ID: GCHP07

Total Purgeable Petroleum Hydrocarbons (TPPH) with BTEX

Analyte	Detection Limit mg/Kg	Sample Results mg/Kg
TPPH as Gas	1.0	N.D.
Benzene	0.0050	N.D.
Toluene	0.0050	N.D.
Ethyl Benzene	0.0050	N.D.
Xylenes (Total)	0.0050	N.D.
Chromatogram Pattern:		

Surrogates	Control Limits %		% Recovery
Trifluorotoluene	70	130	75

Analytes reported as N.D. were not present above the stated limit of detection.

SEQUOIA ANALYTICAL - ELAP #1210

Mike Gregory
Project Manager

Sequoia Analytical

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819 Striker Avenue, Suite 8, Sacramento, CA 95834, (916) 921-9600, FAX (916) 921-0100

Weiss Associates
[illegible]500 Shellmound
Emeryville, CA 94608

Attention: Tim Utterback

Client Proj. ID: Chevron 9-5607, Castro Valley
Sample Descript: SS-6@25'
Matrix: SOLID
Analysis Method: 8015Mod/8020
Lab Number: 9608C61-14

Sampled: 08/20/96
Received: 08/21/96
Extracted: 08/23/96
Analyzed: 08/26/96
Reported: 08/28/96

[illegible]C Batch Number: GC082396BTEXEXA
[illegible]strument ID: GCHP07

Total Purgeable Petroleum Hydrocarbons (TPPH) with BTEX

Analyte	Detection Limit mg/Kg	Sample Results mg/Kg
[illegible]PPH as Gas	5.0	61
[illegible]enzene	0.025	0.85
Toluene	0.025	0.65
Ethyl Benzene	0.025	1.2
[illegible]ylenes (Total)	0.025	3.6
[illegible]hromatogram Pattern:		Gas

Surrogates	Control Limits %		% Recovery
[illegible]rifluorotoluene	70	130	96

Analytes reported as N.D. were not present above the stated limit of detection.

[illegible]EQUOIA ANALYTICAL - ELAP #1210

Mike Gregory
[illegible]oject Manager

Sequoia Analytical

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Weiss Associates
500 Shellmound
Emeryville, CA 94608

Attention: Tim Utterback

Client Proj. ID: Chevron 9-5607, Castro Valley
Sample Descript: SS-7@5'
Matrix: SOLID
Analysis Method: 8015Mod/8020
Lab Number: 9608C61-15

Sampled: 08/20/96
Received: 08/21/96
Extracted: 08/23/96
Analyzed: 08/26/96
Reported: 08/28/96

QC Batch Number: GC082396BTEXEXA
Instrument ID: GCHP22

Total Purgeable Petroleum Hydrocarbons (TPPH) with BTEX

Analyte	Detection Limit mg/Kg	Sample Results mg/Kg
TPPH as Gas	1.0	N.D.
Benzene	0.0050	N.D.
Toluene	0.0050	N.D.
Ethyl Benzene	0.0050	N.D.
Xylenes (Total)	0.0050	N.D.
Chromatogram Pattern:		

Surrogates	Control Limits %		% Recovery
Trifluorotoluene	70	130	92

Analytes reported as N.D. were not present above the stated limit of detection.

SEQUOIA ANALYTICAL - ELAP #1210

Mike Gregory
Project Manager

Sequoia Analytical

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Weiss Associates	Client Proj. ID: Chevron 9-5607, Castro Valley	Sampled: 08/20/96
5500 Shellmound	Sample Descript: SS-7@10'	Received: 08/21/96
Emeryville, CA 94608	Matrix: SOLID	Extracted: 08/23/96
	Analysis Method: 8015Mod/8020	Analyzed: 08/23/96
Attention: Tim Utterback	Lab Number: 9608C61-16	Reported: 08/28/96

QC Batch Number: GC082396BTEXEXA
Instrument ID: GCHP07

Total Purgeable Petroleum Hydrocarbons (TPPH) with BTEX

Analyte	Detection Limit mg/Kg	Sample Results mg/Kg
TPPH as Gas	1.0	N.D.
Benzene	0.0050	N.D.
Toluene	0.0050	N.D.
Ethyl Benzene	0.0050	N.D.
Xylenes (Total)	0.0050	N.D.
Chromatogram Pattern:		

Surrogates	Control Limits %		% Recovery
Trifluorotoluene	70	130	83

Analytes reported as N.D. were not present above the stated limit of detection.

SEQUOIA ANALYTICAL - ELAP #1210

Mike Gregory
Project Manager

Sequoia Analytical

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Weiss Associates
500 Shellmound
Emeryville, CA 94608

Attention: Tim Utterback

Client Proj. ID: Chevron 9-5607, Castro Valley
Sample Descript: SS-7@25'
Matrix: SOLID
Analysis Method: 8015Mod/8020
Lab Number: 9608C61-17

Sampled: 08/20/96
Received: 08/21/96
Extracted: 08/23/96
Analyzed: 08/26/96
Reported: 08/28/96

QC Batch Number: GC082396BTEXEXA
Instrument ID: GCHP07

Total Purgeable Petroleum Hydrocarbons (TPPH) with BTEX

Analyte	Detection Limit mg/Kg	Sample Results mg/Kg
TPPH as Gas	50	400
Benzene	0.25	2.3
Toluene	0.25	2.7
Ethyl Benzene	0.25	9.3
Xylenes (Total)	0.25	40
Chromatogram Pattern:		Gas

Surrogates	Control Limits %		% Recovery
Trifluorotoluene	70	130	95

Analytes reported as N.D. were not present above the stated limit of detection.

SEQUOIA ANALYTICAL - ELAP #1210

Mike Gregory
Project Manager

Sequoia Analytical

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Weiss Associates	Client Proj. ID: Chevron 9-5607, Castro Valley	Sampled: 08/20/96
5500 Shellmound	Sample Descript: SS-8@5'	Received: 08/21/96
Emeryville, CA 94608	Matrix: SOLID	Extracted: 08/23/96
	Analysis Method: 8015Mod/8020	Analyzed: 08/26/96
Attention: Tim Utterback	Lab Number: 9608C61-18	Reported: 08/28/96

QC Batch Number: GC082396BTEXEXA
Instrument ID: GCHP22

Total Purgeable Petroleum Hydrocarbons (TPPH) with BTEX

Analyte	Detection Limit mg/Kg	Sample Results mg/Kg
TPPH as Gas	1.0	N.D.
Benzene	0.0050	N.D.
Toluene	0.0050	N.D.
Ethyl Benzene	0.0050	N.D.
Xylenes (Total)	0.0050	N.D.
Chromatogram Pattern:		

Surrogates	Control Limits %		% Recovery
Trifluorotoluene	70	130	96

Analytes reported as N.D. were not present above the stated limit of detection.

SEQUOIA ANALYTICAL - ELAP #1210

Mike Gregory
Project Manager

Sequoia Analytical

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819 Striker Avenue, Suite 8, Sacramento, CA 95834, (916) 921-9600, FAX (916) 921-0100

Weiss Associates	Client Proj. ID: Chevron 9-5607, Castro Valley	Sampled: 08/20/96
500 Shellmound	Sample Descript: SS-8@10'	Received: 08/21/96
Emeryville, CA 94608	Matrix: SOLID	Extracted: 08/23/96
	Analysis Method: 8015Mod/8020	Analyzed: 08/26/96
Attention: Tim Utterback	Lab Number: 9608C61-19	Reported: 08/28/96

QC Batch Number: GC082396BTEXEXA
Instrument ID: GCHP22

Total Purgeable Petroleum Hydrocarbons (TPPH) with BTEX

Analyte	Detection Limit mg/Kg	Sample Results mg/Kg
TPPH as Gas	1.0	N.D.
Benzene	0.0050	N.D.
Toluene	0.0050	N.D.
Ethyl Benzene	0.0050	N.D.
Xylenes (Total)	0.0050	N.D.
Chromatogram Pattern:		

Surrogates	Control Limits %		% Recovery
Trifluorotoluene	70	130	91

Analytes reported as N.D. were not present above the stated limit of detection.

SEQUOIA ANALYTICAL - ELAP #1210

Mike Gregory
Project Manager

Sequoia Analytical

680 Chesapeake Drive, Redwood City, CA 94063, (415) 364-9600, FAX (415) 364-9233
404 N. Wiget Lane, Walnut Creek, CA 94598, (510) 988-9600, FAX (510) 988-9673
819 Striker Avenue, Suite 8, Sacramento, CA 95834, (916) 921-9600, FAX (916) 921-0100

Weiss Associates	Client Proj. ID: Chevron 9-5607, Castro Valley	Sampled: 08/20/96
500 Shellmound	Sample Descript: SS-8@24.5'	Received: 08/21/96
Emeryville, CA 94608	Matrix: SOLID	Extracted: 08/23/96
	Analysis Method: 8015Mod/8020	Analyzed: 08/26/96
Attention: Tim Utterback	Lab Number: 9608C61-20	Reported: 08/28/96

QC Batch Number: GC082396BTEXEXA
Instrument ID: GCHP22

Total Purgeable Petroleum Hydrocarbons (TPPH) with BTEX

Analyte	Detection Limit mg/Kg	Sample Results mg/Kg
TPPH as Gas	1.0	N.D.
Benzene	0.0050	N.D.
Toluene	0.0050	N.D.
Ethyl Benzene	0.0050	N.D.
Xylenes (Total)	0.0050	N.D.
Chromatogram Pattern:		

Surrogates	Control Limits %		% Recovery
Trifluorotoluene	70	130	95

Analytes reported as N.D. were not present above the stated limit of detection.

SEQUOIA ANALYTICAL - ELAP #1210

Mike Gregory
Project Manager

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819 Striker Avenue, Suite 8, Sacramento, CA 95834, (916) 921-9600, FAX (916) 921-0100

Weiss Associates
5500 Shellmound
Emeryville, CA 94608
Attention: Tim Utterback

Client Proj. ID: Chevron 9-5607, Castro Valley
Lab Proj. ID: 9608C61

Received: 08/21/96
Reported: 08/28/96

LABORATORY NARRATIVE

TPHGBS: Sample 9608C61-08 was diluted 2-fold.
Sample 9608C61-14 was diluted 5-fold.
Sample 9608C61-17 was diluted 50-fold.

SEQUOIA ANALYTICAL

Mike Gregory
Project Manager

Sequoia Analytical

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819 Striker Avenue, Suite 8, Sacramento, CA 95834, (916) 921-9600, FAX (916) 921-0100

Weiss & Associates	Client Project ID:	Chevron 9-5607, Castro Valley	
5500 Shellmound	Matrix:	Solid	
Emeryville, CA 94608			
Attention: Tim Utterback	Work Order #:	9608C61 -01, 02, 05-06, 08-20	Reported: Aug 28, 1996

QUALITY CONTROL DATA REPORT

Analyte:	Benzene	Toluene	Ethyl Benzene	Xylenes
QC Batch#:	GC082396BTEXEXA	GC082396BTEXEXA	GC082396BTEXEXA	GC082396BTEXEXA
Analy. Method:	EPA 8020	EPA 8020	EPA 8020	EPA 8020
Prep. Method:	EPA 5030	EPA 5030	EPA 5030	EPA 5030
Analyst:	Y. Arteaga	Y. Arteaga	Y. Arteaga	Y. Arteaga
MS/MSD #:	G9608999-11	G9608999-11	G9608999-11	G9608999-11
Sample Conc.:	N.D.	N.D.	N.D.	N.D.
Prepared Date:	8/23/96	8/23/96	8/23/96	8/23/96
Analyzed Date:	8/23/96	8/23/96	8/23/96	8/23/96
Instrument I.D.#:	GCHP18	GCHP18	GCHP18	GCHP18
Conc. Spiked:	0.20 mg/kg	0.20 mg/kg	0.20 mg/kg	0.60 mg/kg
Result:	0.13	0.16	0.18	0.51
MS % Recovery:	65	80	90	85
Dup. Result:	0.14	0.16	0.18	0.52
MSD % Recov.:	70	80	90	87
RPD:	7.4	0.0	0.0	1.9
RPD Limit:	0-25	0-25	0-25	0-25
LCS #:	BLK082396	BLK082396	BLK082396	BLK082396
Prepared Date:	8/23/96	8/23/96	8/23/96	8/23/96
Analyzed Date:	8/23/96	8/23/96	8/23/96	8/23/96
Instrument I.D.#:	GCHP18	GCHP18	GCHP18	GCHP18
Conc. Spiked:	0.20 mg/kg	0.20 mg/kg	0.20 mg/kg	0.60 mg/kg
LCS Result:	0.14	0.17	0.19	0.56
LCS % Recov.:	70	85	95	93
MS/MSD	60-140	60-140	60-140	60-140
LCS	70-130	70-130	70-130	70-130
Control Limits				

SEQUOIA ANALYTICAL

Mike Gregory
Project Manager

Please Note:
The LCS is a control sample of known, interferent-free matrix that is analyzed using the same reagents, preparation, and analytical methods employed for the samples. The matrix spike is an aliquot of sample fortified with known quantities of specific compounds and subjected to the entire analytical procedure. If the recovery of analytes from the matrix spike does not fall within specified control limits due to matrix interference, the LCS recovery is to be used to validate the batch.

** MS = Matrix Spike, MSD = MS Duplicate, RPD = Relative % Difference

Sequoia Analytical

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819 Striker Avenue, Suite 8, Sacramento, CA 95834, (916) 921-9600, FAX (916) 921-0100

Weiss & Associates	Client Project ID:	Chevron 9-5607, Castro Valley	
5500 Shellmound	Matrix:	Solid	
Emeryville, CA 94608			
Attention: Tim Utterback	Work Order #:	9608C61 -03, -04, -07	Reported: Aug 28, 1996

QUALITY CONTROL DATA REPORT

Analyte:	Fractional Organic Carbon
QC Batch:	IN082796WALK00A
Analy. Method:	Walkey-Black
Prep Method:	N.A.

Analyst:	S. Fong
Duplicate Sample #:	9608C61-07
Prepared Date:	8/27/96
Analyzed Date:	8/27/96
Instrument I.D.#:	MANUAL
Sample Concentration:	0.14
Dup. Sample Concentration:	0.12
RPD:	15
RPD Limit:	0-20

SEQUOIA ANALYTICAL

Mike Gregory
Project Manager

** RPD = Relative % Difference

Fax copy of Lab Report and COC to Chevron Contact: ☐ Yes ☒ No

Chain-of-Custody-Record

Chevron U.S.A. Inc.
P.O. BOX 5004
San Ramon, CA 94583
FAX (510)842-9591

Chevron Facility Number: 9-5607
Facility Address: 5269 Crow Canyon Rd, Castro Valley
Consultant Project Number: 4-1129-70
Consultant Name: Weiss Associates
Address: 5500 Shellmound St, Emeryville, CA 94608
Project Contact (Name): Tim Utterback
(Phone) (510) 450-6193 (Fax Number) (510) 547-5043

Chevron Contact (Name): Brett Hunter
(Phone): (510) 842-8695
Laboratory Name: Sequoia
Laboratory Release Number: 2910610
Samples Collected by (Name): Tim Utterback
Collection Date: 8/20/96
Signature: T. Utterback

9608C61

	Sample Number	Lab Sample Number	Number of Containers	Matrix S = Soil W = Water A = Air C = Charcoal	Type G = Grab C = Composite D = Discrete	Time	Sample Preservation	Iced (Yes or No)	Analyses To Be Performed: BTEX + TPH GAS (8020 + 8015)	TPH Diesel (8015)	Oil and Grease (5520)	Purgeable Halocarbons (8010)	Purgeable Aromatics (8020)	Purgeable Organics (8240)	Extractable Organics (8270)	Metals Cd,Cr,Pb,Zn,Ni (ICAP or AA)	Fraction of Organic Carbon Content in Black				Remarks
1-A	SS-3@10		1	S	G		N/A	Y	X												Lowest Detection Limits for TPH-G/BTEX.
2	SS-3@21		1						X												
3	SS-3@21.5		1														X				
4	SS-4@5.0		1														X				
5	SS-4@6.0		1						X												
6	SS-4@9.5		1						X												
7	SS-4@23		1														X				
8	SS-4@23.5		1						X												
9	SS-5@5		1						X												
10	SS-5@10		1						X												
11	SS-5@24.5		1						X												
12	SS-6@5		1						X												
13	SS-6@10		1						X												
14	SS-6@25		1						X												

	Organization	Date/Time		Organization	Date/Time
Relinquished By (Signature): T. Utterback	WA	8/21/96	9:41	Sequoia	8/21/96 9:41
Relinquished By (Signature):		8/21/96			
Relinquished By (Signature):					

Received By (Signature):
Received By (Signature):
Received For Laboratory By (Signature):

Turn Around Time (Circle Choice)
24 Hrs.
48 Hrs.
5 Days
10 Days
As Contracted

COC-3.DWG/03 91/HCW

Fax copy of Lab Report and COC to Chevron Contact: ☐ Yes ☐ No

Chain-of-Custody-Record

Chevron U.S.A. Inc.
P.O. BOX 5004
San Ramon, CA 94583
FAX (510)842-9591

Chevron Facility Number 9-5607
Facility Address 5264 Crow Canyon Road, Castro Valley, CA
Consultant Project Number 4-1129-70
Consultant Name Weiss Associates
Address 5500 Shellmound St. Emeryville
Project Contact (Name) Tim Utterback
(Phone) 510 450-6193 (Fax Number)

Chevron Contact (Name) Brett Hunter
(Phone) (510) 842-8645
Laboratory Name Sequoia
Laboratory Release Number 2910610
Samples Collected by (Name) Tim Utterback
Collection Date 8/20/96
Signature

Sample Number	Lab Sample Number	Number of Containers	Matrix S = Soil A = Air W = Water C = Charcoal	Type G = Grab C = Composite D = Discrete	Time	Sample Preservation	Iced (Yes or No)	Analyses To Be Performed: BTEX + TPH GAS (8020 + 8015)	TPH Diesel (8015)	Oil and Grease (5520)	Purgeable Halocarbons (8010)	Purgeable Aromatics (8020)	Purgeable Organics (8240)	Extractable Organics (8270)	Metals Cd,Cr,Pb,Zn,Ni (ICAP or AA)						Remarks
SS-7@5		1	S	G		N/A	Y	X													Lowest
SS-7@10		1																			DL's
SS-7@25		1																			
SS-8@5		1																			
SS-8@10		1																			
SS-8@24.5		1																			

Relinquished By (Signature)	Organization	Date/Time	Received By (Signature)	Organization	Date/Time	Turn Around Time (Circle Choice)
	WA	8/21/96 9:41		Sequoia	8/21/96 9:41	24 Hrs.
Relinquished By (Signature)	Organization	Date/Time	Received By (Signature)	Organization	Date/Time	48 Hrs.
		8/21/96				(5 Days)
Relinquished By (Signature)	Organization	Date/Time	Received For Laboratory By (Signature)		Date/Time	10 Days
					8/21/96 12:40	As Contracted

COC-3.DWG/03 91/HCH

Sequoia Analytical

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819 Striker Avenue, Suite 8, Sacramento, CA 95834, (916) 921-9600, FAX (916) 921-0100

Weiss Associates
5500 Shellmound
Emeryville, CA 94608

Attention: Tim Utterback

Client Proj. ID: Chevron 9-5607, Castro Valley
Sample Descript: WS-1
Matrix: LIQUID
Analysis Method: 8015Mod/8020
Lab Number: 9608B57-01

Sampled: 08/19/96
Received: 08/20/96

Analyzed: 08/25/96
Reported: 08/27/96

QC Batch Number: GC082596BTEX02A
Instrument ID: GCHP02

Total Purgeable Petroleum Hydrocarbons (TPPH) with BTEX

Analyte	Detection Limit ug/L	Sample Results ug/L
TPPH as Gas	**50**	**610**
Benzene	**0.50**	**28**
Toluene	**0.50**	**8.2**
Ethyl Benzene	**0.50**	**25**
Xylenes (Total)	**0.50**	**100**
Chromatogram Pattern:		**Gas**

Surrogates	Control Limits %		% Recovery
Trifluorotoluene	70	130	91

Analytes reported as N.D. were not present above the stated limit of detection.

SEQUOIA ANALYTICAL - ELAP #1210

Mike Gregory
Project Manager

Sequoia Analytical

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819 Striker Avenue, Suite 8, Sacramento, CA 95834, (916) 921-9600, FAX (916) 921-0100

Weiss & Associates
5500 Shellmound
Emeryville, CA 94608
Attention: Tim Utterback

Client Project ID: Chevron 9-5607, Castro Valley
Matrix: Liquid
Work Order #: 9608B57 -01
Reported: Aug 28, 1996

QUALITY CONTROL DATA REPORT

Analyte:	Benzene	Toluene	Ethyl Benzene	Xylenes
QC Batch#:	GC082596BTEX02A	GC082596BTEX02A	GC082596BTEX02A	GC082596BTEX02A
Analy. Method:	EPA 8020	EPA 8020	EPA 8020	EPA 8020
Prep. Method:	EPA 5030	EPA 5030	EPA 5030	EPA 5030
Analyst:	R. Burton	R. Burton	R. Burton	R. Burton
MS/MSD #:	G9608955-05	G9608955-05	G9608955-05	G9608955-05
Sample Conc.:	N.D.	N.D.	N.D.	N.D.
Prepared Date:	8/25/96	8/25/96	8/25/96	8/25/96
Analyzed Date:	8/25/96	8/25/96	8/25/96	8/25/96
Instrument I.D.#:	GCHP2	GCHP2	GCHP2	GCHP2
Conc. Spiked:	10 ug/L	10 ug/L	10 ug/L	30 ug/L
Result:	10	9.7	9.4	27
MS % Recovery:	100	97	94	90
Dup. Result:	8.3	8.0	8.1	24
MSD % Recov.:	83	80	81	80
RPD:	19	19	15	12
RPD Limit:	0-25	0-25	0-25	0-25

LCS #:	BLK082596	BLK082596	BLK082596	BLK082596
Prepared Date:	8/25/96	8/25/96	8/25/96	8/25/96
Analyzed Date:	8/25/96	8/25/96	8/25/96	8/25/96
Instrument I.D.#:	GCHP2	GCHP2	GCHP2	GCHP2
Conc. Spiked:	10 ug/L	10 ug/L	10 ug/L	30 ug/L
LCS Result:	9.4	9.0	9.3	29
LCS % Recov.:	94	90	93	97

MS/MSD	60-140	60-140	60-140	60-140
LCS	70-130	70-130	70-130	70-130
Control Limits				

SEQUOIA ANALYTICAL

Mike Gregory
Project Manager

Please Note:
The LCS is a control sample of known, interferent-free matrix that is analyzed using the same reagents, preparation, and analytical methods employed for the samples. The matrix spike is an aliquot of sample fortified with known quantities of specific compounds and subjected to the entire analytical procedure. If the recovery of analytes from the matrix spike does not fall within specified control limits due to matrix interference, the LCS recovery is to be used to validate the batch.

** MS = Matrix Spike, MSD = MS Duplicate, RPD = Relative % Difference

Fax copy of Lab Report and COC to Chevron Contact: ☐ Yes ☐ No

Chain-of-Custody-Record

Chevron U.S.A. Inc.
P.O. BOX 5004
San Ramon, CA 94583
FAX (510)842-9591

Chevron Facility Number 9-5607
Facility Address 5269 Crow Canyon Rd, Castro Valley
Consultant Project Number 4-1129-70
Consultant Name Weiss Associates
Address 5500 Shellmound St, Emeryville, CA 94608
Project Contact (Name) Tim Utterback
(Phone) (510) 450-6193 (Fax Number) (510) 547-5043

Chevron Contact (Name) Brett Hunter
(Phone) (510) 842-8695
Laboratory Name Sequoia
Laboratory Release Number
Samples Collected by (Name) Tim Utterback
Collection Date 8/19/96
Signature T. Utterback

Sample Number	Lab Sample Number	Number of Containers	Matrix S = Soil W = Water A = Air C = Charcoal	Type G = Grab C = Composite D = Discrete	Time	Sample Preservation	Iced (Yes or No)	Analyses To Be Performed: BTEX + TPH GAS (8020 + 8015)	TPH Diesel (8015)	Oil and Grease (5520)	Purgeable Halocarbons (8010)	Purgeable Aromatics (8020)	Purgeable Organics (8240)	Extractable Organics (8270)	Metals Cd,Cr,Pb,Zn,Ni (ICAP or AA)					Remarks
WS-1	01	3	W	G	15:00	HCL	Y	X												Lowest possible detection limits

9608B57

Relinquished By (Signature)	Organization	Date/Time	Received By (Signature)	Organization	Date/Time
T. Utterback	WA	8/20/96 7:50	Joyce Adams	WA	8/20/96 7:50
Joyce Adams	WA	8/20/96 10:55	[illegible]	SEQ	8/20/96 10:55
[illegible]	[illegible]	[illegible]	Received For Laboratory By (Signature)		Date/Time

Turn Around Time (Circle Choice)
24 Hrs.
48 Hrs.
5 Days
10 Days
As Contracted

COC-3.DWG/03 91/HCH

ATTACHMENT B

ASTM RBCA ANALYSIS

Weiss Associates *Environmental and Geologic Services*

5500 Shellmound Street, Emeryville, CA 94608-2411 *Fax: 510-547-5043* *Phone:* ***510-450-6000***

RISK-BASED CORRECTIVE ACTION

for

Former Chevron Service Station, #9-5607
5269 Crow Canyon Road,
Castro Valley, California

prepared for

Chevron Products Company
6001 Bollinger Canyon Road
P.O. Box 5004
San Ramon, California 94583-0804

January 20, 1997

Weiss Associates *Environmental and Geologic Services*

5500 Shellmound Street, Emeryville, CA 94608-2411 *Fax: 510-547-5043 Phone:* ***510-450-6000***

RISK-BASED CORRECTIVE ACTION

for

Former Chevron Service Station, #9-5607
5269 Crow Canyon Road,
Castro Valley, California

prepared by

Weiss Associates
5500 Shellmound Street
Emeryville, CA 94608

WA Job # 4-1129-70

Michael Cooke
Project Geologist

Tim Utterback
Senior Staff Engineer

Weiss Associates work for the Risk-Based Corrective Action, 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, and professional opinions were prepared solely for the use of Chevron Products Company in accordance with generally accepted professional engineering and geologic practice. We make no other warranty, either expressed or implied, and are not responsible for the interpretation by others of the contents herein.

REGISTERED PROFESSIONAL ENGINEER
JERRY McHUGH
No. C 46740
Exp. 1/20/97
CIVIL
STATE OF CALIFORNIA

1/20/97

Jerry McHugh, P.E. Date
Principal Engineer
No. C46740

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FIGURES

Figure 1. Site Location Map
Figure 2. Risk Based Corrective Action Process Flowchart
Figure 3. Site Plan
Figure 4. Exposure Scenario Evaluation Flowchart
Figure 5. Indoor Air Pathway Flowchart

TABLES

Table 1. Comparison of Representative Concentrations to Tier 1 RBSLs
Table 2. Summary of Tier 2 Risk Evaluation Results

APPENDICES

Appendix A. Tabulated Pore Vapor, Soil and Ground Water Analytical Data
Appendix B. Vapor Pathway Risk Calculations
Appendix C. Fate and Transport Analysis

SUMMARY

Weiss Associates (WA) and Chevron Products Company (Chevron) have completed a Risk-Based Corrective Action (RBCA) evaluation to determine the appropriate corrective action for subsurface petroleum hydrocarbons released from the former underground storage tanks (USTs) located at 5269 Crow Canyon Road in Castro Valley, California (Figure 1). This RBCA evaluation was performed to evaluate whether subsurface petroleum hydrocarbons pose significant risk to the residents living at the Forest Creek Townhomes residential area. The Forest Creek Townhomes are located at the corner of Crow Canyon Road and Waterford Place in Castro Valley, California (Figure 2) downgradient from the former USTs. The RBCA evaluation indicates that:

- The representative concentrations of toluene, ethylbenzene and xylenes in soil and ground water from the residential area were below conservative Tier 1 RBSLs for all of the open exposure pathways. The representative concentration of benzene in ground water was below the Tier 1 RBSL for benzene transport to outdoor air from impacted ground water.
- Tier 2 screening models indicate the risk associated with benzene transport from impacted soil or ground water to indoor and outdoor air is 3.75×10^{-9} and 4.67×10^{-12} respectively. These risk values are four and seven orders of magnitude below the risk range typically considered by the U.S. Environmental Protection Agency (EPA) to be acceptable , respectively.
- The direct ingestion pathway is conservatively addressed by selecting wells C-10B, C-15 and C-16 as Tier 2 alternative points of exposure based on evaluation of dissolved benzene concentrations and ground water use in the vicinity of the impacted area. The dissolved benzene SSTL concentrations at the alternative points of exposure are equal to the Tier 1 RBSL. Dissolved benzene concentrations are currently below this SSTL at the alternative points of exposure.
- Hydrocarbon transport to Crow Creek was conservatively addressed by evaluating the results of the fate and transport modeling previously performed by Sheldon Nelson, R.G. of Chevron Research and Technology Company. Mr. Nelson applied site-specific parameters to the widely accepted finite difference model MODFLOW and the results indicated that Crow Creek is not likely to be impacted by dissolved benzene concentrations above the California MCL (0.001 mg/L) regardless of whether ground water extraction is performed.

Therefore, the results of this RBCA evaluation indicate that there is no demonstratable short-term or long-term threat to human health, safety or sensitive environmental receptors. The petroleum hydrocarbons located below the Forest Creek Townhomes residential area can be managed through a ground water monitoring program and contingency plan. A proposed future action plan addressing monitoring and contingency for this site is presented in the cover letter to this report. The future action plan outlines a proposed monitoring schedule and response actions to be taken if future hydrocarbon concentrations in ground water exceed the RBSLs or SSTLs determined here.

1. INTRODUCTION

The objective of this RBCA assessment is to determine the potential risk to human health associated with the petroleum hydrocarbons present in the subsurface, using the framework and guidance of the American Society for Testing and Materials (ASTM) RBCA process. Health risk associated with environmental receptors such as indigenous animals and plants is not addressed. However, contaminant fate and transport to sensitive environmental receptors is addressed to ensure that dissolved hydrocarbon concentrations above the California maximum contaminant levels do not impact those receptors.

The ASTM RBCA framework is a tiered decision-making process whereby site contaminant levels, as determined by site assessment activities, are compared to conservatively derived screening level concentrations for contaminants of concern. The tiered decision-making process is depicted in flowchart form in Figure 2. The RBCA process begins with an initial site assessment summarizing the site and impacted area location, previous environmental activities, hydrogeologic conditions and a survey of local ground water use. Based on the site assessment information, an initial site classification is made to determine the level of urgency for initial corrective action. The initial classification is followed by a Tier 1 evaluation which includes identification of the contaminants of concern and a determination of potentially complete exposure pathways. Representative concentrations of the contaminants of concern are determined from the site assessment data and then compared to target Tier 1 Risk-Based Screening Levels (RBSLs) for the potentially complete exposure pathways. The ASTM guidance provides example RBSL look-up tables intended as a guide for state and local enforcement agencies; the RBSLs in the look-up tables are not intended to be stand-alone cleanup standards. Representative contaminant concentrations below the RBSLs represent human health risks less than the target level, and human health risk may reasonably be assumed to be insignificant if representative concentrations are below these target risk levels.

If the Tier 1 RBSLs are exceeded, the RBCA process provides several alternatives for subsequent action. These alternatives include a Tier 2 application of Tier 1 RBSLs at an alternative point of exposure, a Tier 2 analysis including development of site-specific target levels (SSTLs), the provision of institutional or engineering mechanisms to limit or reduce exposures, or remediation to Tier 1 RBSLs. A Tier 3 evaluation is also available for large or complex sites involving more sophisticated fate and transport issues or extensive data acquisition and analysis.

Following the RBCA framework described above, this report includes an initial site assessment and Tier 1 and Tier 2 evaluations. We opted to proceed to Tier 2 analysis for the exposure/pathways with representative site concentrations that exceeded the Tier 1 RBSLs. At Tier 2, the vapor inhalation exposure pathways were evaluated to determine whether benzene concentrations in vadose zone pore vapors pose significant risk to the potential residential receptors. Ingestion exposure pathway Tier 2 SSTLs were determined for alternative points of exposure based on ground water use in the residential area. Finally, hydrocarbon transport to the identified sensitive environmental receptor (Crow Creek) was addressed by evaluating the results of previous finite difference fate and transport modeling.

2. INITIAL SITE ASSESSMENT

2.1 Site Location and Use

The former Chevron Service Station is located on the southeast corner of Crow Canyon Road and Waterford Place in Castro Valley, California (Figure 3). The surrounding land consists of mixed commercial and residential use with the Forest Creek Townhomes residential property along the south and west borders of station property and commercial property along the east border. Privately owned open space is located to the north across Crow Canyon Road. Crow Creek is located approximately 250 feet to the west with the residential property located between the creek and the former USTs.

The former service station was operated by Chevron to dispense gasoline and service automobiles. The service station was in use from September 1971, when the USTs were installed to September 1, 1990, when the station was abandoned and the USTs and piping were removed. The former station property is currently used for automobile service and repair.

The local topography is hilly with a westward topographical gradient in the immediate vicinity of the site, adjacent residential property and Crow Creek.

2.2 Impacted Area

Dissolved petroleum hydrocarbon concentrations are highest on the west side of the former UST complex. On April 18, 1996, the dissolved benzene concentration in well C-3 was 26 mg/L. Dissolved hydrocarbon concentrations attenuate rapidly in the westward (downgradient) and southward (crossgradient) directions. Benzene concentrations in ground water in the vicinity of the Forest Creek Townhomes residential properties range from less than 0.0005 mg/L near Crow Creek to approximately 10 mg/l near the entrance to Waterford Place. Dissolved benzene concentrations are currently below 0.0005 mg/L between the impacted area and Crow Creek. In addition, dissolved benzene concentrations are below 0.0005 mg/l between the former service station and the commercial property to the East and the privately owned open space to the North. No separate-phase hydrocarbons (SPH) have been measured in the monitoring wells since 0.03 feet was measured in well C-3 on October 22, 1992.

2.3 Summary of Previous Site Activities

On February 26, 1985, a leak associated with the former USTs was discovered. In April 1985, the former USTs and piping were replaced with 3 double-walled fiberglass 10,000-gallon

gasoline USTs, 1 double-walled fiberglass 1,000-gallon waste oil tank and double walled fiberglass piping.

Between March 5 and March 21, 1985, Groundwater Technology Incorporated (GTI) of Concord, California installed ground water monitoring wells C-1 through C-8. GTI measured SPH in wells C-1 and C-3 and immediately began bailing SPH from those wells. No soil or ground water samples were collected for laboratory analysis.

On May 31 and June 24, 1985, GTI installed ground water monitoring wells RW-1 and C-9. GTI measured SPH in well RW-1 after installation and began SPH bailing on a bi-weekly basis. In addition, GTI connected a ground water extraction system to well RW-1 consisting of a submersible pump and carbon treatment. On July 29, 1985, the concentration of benzene in ground water from well C-9 was 0.52 mg/L. No soil samples were collected for laboratory analysis.

As of September 1987, product recovery records showed that at least 32 gallons of petroleum hydrocarbons were recovered due to SPH bailing.

On September 12, 1989, Pacific Environmental Group (PEG) of Santa Clara, California conducted a soil-gas investigation. The soil gas investigation was performed to delineate the extent of the impacted area. The depth interval of vapor sampling was between 8 and 20 feet. PEG measured total hydrocarbon vapors ranging from less than 1 part per million (ppm) to 505 ppm in the vicinity of the former USTs and adjacent residential property. Please note that this data is not acceptable for input into vapor transport risk models because it contains no information about chemical species.

On September 13, 1989, Chevron began monitoring site wells for dissolved hydrocarbon concentrations on a quarterly basis. The highest dissolved hydrocarbon concentrations have been measured in samples from the wells located immediately west (downgradient) of the former USTs. Hydrocarbon concentrations have been near or below laboratory detection limits in ground water samples from wells C-10A, C-10B, C-15 and C-16 located directly upgradient of Crow Creek. Wells C-8, C-13, C-14, C-10A, C-10B, C-15 and C-16 surround the upgradient and downgradient boundaries of the impacted area and sufficiently delineate the plume.

Between February 21 and February 24, 1990, PEG installed wells C-10A, C-10B, and C-11 through C-16. Benzene concentrations in soil borings from wells C-13 and C-15 were below laboratory detection limits. The benzene concentration in soil boring C-12 at approximately 15 feet below ground surface (bgs) was 1.7 mg/kg. The maximum benzene concentration in ground water from these newly installed wells was 0.23 mg/L in well C-12. The benzene concentrations in ground water from wells C-10A and C-13 were 0.0016 mg/L and 0.015 mg/L, respectively. Ground water in well C-10B was not sampled immediately after installation.

Between October 2 and October 11, 1990, Blaine Tech Services (Blaine Tech) of San Jose, California removed the tanks and piping previously installed in April 1985 and overexcavated impacted soil. The three double walled fiberglass 10,000 gallon gasoline USTs and associated piping were removed. Blaine Tech overexcavated approximately 300 cubic yards of impacted soil from the former tank pit area. The maximum remaining concentration of benzene in soil was 5.2

mg/kg taken from the northwest corner of the former tank pit at 22.5 feet below ground surface. As of October 1990, gasoline was longer stored or dispensed at the site.

In September 1991, the ground water extraction (GWE) system was expanded to draw ground water from well C-9. The current configuration of the GWE system consists of extraction from wells RW-1 and C-9 and treatment to remove dissolved hydrocarbons prior to discharge.

In August 1992 Chevron Research and Technology Company conducted a contaminant fate and transport assessment to determine whether dissolved benzene from the impacted area is likely to extend to Crow Creek under various scenarios. The scenarios included no engineered remediation; GWE from wells RW-1 and C-9; GWE from wells RW-1, C-6 and C-9; and GWE from wells RW-1, C-6, C-9 and an additional simulated well. The results of the fate and transport modeling indicated that increasing the number of extraction wells will reduce the downgradient extent of dissolved benzene. However, the results of the no engineered remediation scenario indicated that dissolved benzene concentrations are likely to remain below 0.001 mg/L in the vicinity of Crow Creek.

During October 1995, Sheldon Nelson, Chevron's hydrogeologist, evaluated the plume attenuation along the centerline of the plume to validate the assumptions used in the ground water fate and transport modeling performed in August 1992 and show that dissolved hydrocarbons were unlikely reach Crow Creek (Chevron Research and Technology Company, October 27, 1995). Evaluation of the attenuation of benzene down gradient of the site indicated that the plume was stable and that dissolved benzene concentrations should decline to values of less than 1 ppb at a distance of approximately 265 feet down gradient of well C-3. Evaluation of dissolved sulfate suggested that anaerobic biodegradation is locally occurring, and is limited by the absence of a suitable electron receptor compounds (such as oxygen). Dissolved ferrous iron concentrations in downgradient ground water wells suggested that there is an abundance of dissolved ferric iron present, which will have an inhibiting effect on the further migration of dissolved hydrocarbons.

On August 19 and 20, 1996, WA sampled soil vapors in the vicinity of the downgradient residential structures. WA supervised the installation of 8 direct push sample probes and collected samples of vadose zone pore vapor, vadose zone soil, and ground water. The maximum concentration of benzene in pore vapor was 38 parts per million by volume (ppmv) from boring location SV-4 at 25 feet bgs. The benzene concentrations in pore vapors at 11 feet bgs, 8 feet bgs and 3 feet bgs in boring SV-4 were all below laboratory detection limits. The highest benzene concentrations in soil pore vapor from shallow (3 feet bgs) samples were 0.029 ppmv and 0.040 ppmv from boring locations SV-6 and SV-8 respectively. Benzene concentrations in vadose zone soil were below laboratory detection limits in all samples collected at depths ranging from 3 feet to 10 feet bgs. The maximum benzene concentrations in soil were from boring locations SV-3, SV-4, SV-6 and SV-7 at depths ranging from 21 feet to 25 feet bgs within the likely saturated zone. Ground water was only encountered in boring location SV-1. The ground water benzene concentration in SV-1 was 0.028 mg/L.

2.4 Hydrogeologic Conditions

Sediments below the site and surrounding area consist of interbedded clays, silts and clayey sands down to an underlying rock formation located at depths ranging from 25 to 50 feet bgs. The rock formation has been described as weathered shale, claystone and siltstone. A layer of sandstone overlies the shale in some of the site boring logs. Ground water flows westward towards Crow Creek with a gradient of approximately 0.15 feet/foot. The depth to ground water ranges from approximately 10 feet bgs at the east border of the former service station to 20 feet bgs near the former USTs to about 15 feet bgs near the downgradient residential buildings and 10 feet bgs in wells C-15 and C-16 adjacent to Crow Creek.

2.5 Local Ground Water and Surface Water Use

No domestic drinking water wells, municipal supply wells or industrial supply wells are known to exist between the former service station site and Crow Creek. The nearest downgradient distance between the former Chevron USTs and Crow Creek is 270 feet. Crow Creek is a natural surface water creek that flows into San Lorenzo Creek and discharges into San Francisco Bay. Crow Creek is the nearest downgradient potential receptor of dissolved hydrocarbons from the former UST release. Other surface waters include Cull Canyon Reservoir which lies approximately 0.5 miles to the northwest and Don Castro Reservoir which lies approximately 0.6 miles to the south.

3. TIER 1 RBCA EVALUATION

3.1 Site Classification and Initial Response

Based on Table 1, *Example Site Classification and Initial Response Actions*, of the ASTM RBCA guidance document, classification level 3, potential long-term threat to human health, safety or sensitive environmental receptors, is the most appropriate classification for this site. The nearest term receptor of dissolved hydrocarbons is Crow Creek located approximately 270 feet downgradient of the former USTs. Dissolved hydrocarbon concentrations in wells C-10A, C-10B, C-15 and C-16 located between the release and Crow Creek have been near or below laboratory detection limits for approximately 6 years. Based on this data, continued ground water monitoring is an appropriate short-term initial response action.

The site classification and response action will be re-evaluated upon completion of this RBCA assessment.

3.2 Exposure Assessment

The purpose of this exposure assessment is to identify whether potential receptors may be exposed to hydrocarbons originating from the UST release. An exposure assessment is a means for determining whether chemicals are capable of transporting by various physical mechanisms from the initial release to potential exposure pathways for humans or environmental receptors. The identified potential receptors are the Forest Creek Townhomes residents and Crow Creek. An exposure scenario evaluation flowchart is attached as Figure 4. As indicated by the flowchart, the residential receptors may be exposed to the following potentially complete pathways:

- Volatilization of dissolved hydrocarbons in ground water to indoor building air;
- Volatilization of hydrocarbons in impacted subsurface soils to indoor building air;
- Volatilization of dissolved hydrocarbons in ground water to outdoor air;
- Volatilization of hydrocarbons in impacted subsurface soils to outdoor air;
- Direct ingestion of dissolved hydrocarbons; and,
- Direct ingestion of dissolved hydrocarbons originating from impacted soil.

The potentially complete pathway to Crow Creek is:

- Transport of dissolved hydrocarbons in ground water to recreation use/sensitive habitat.

The closed pathways are:

- Transport of impacted surficial soil to the ingestion, absorption, inhalation or recreational use/sensitive habitat pathways. The release was several feet bgs and no surficial soils are known to be impacted.

3.3 Selection of Representative Concentrations

The representative concentrations selected for this assessment were the maximum hydrocarbon concentrations detected in ground water, soil and soil vapor in the vicinity of the residential area. The representative concentrations were selected as follows:

- Well C-9 has historically contained the highest dissolved hydrocarbon concentrations in the residential area and January 16, 1996, was the most recent (current) ground water sample collection date for that well. On January 16, 1996, the concentrations of dissolved benzene, toluene, ethylbenzene and xylenes in well C-9 were 8.2 mg/l, 0.70 mg/l, 2.5 mg/l, and 2.1 mg/l, respectively. These dissolved concentrations are consistent with previous monitoring data.
- A ground water sample was collected from sample location SV-1 on August 19, 1996. The concentrations of dissolved benzene, toluene, ethylbenzene and xylenes from sample location SV-1 were 0.028 mg/l, 0.025 mg/l, 0.0082 mg/l, and 0.10 mg/l, respectively.
- The maximum concentrations of benzene, toluene, ethylbenzene and xylenes detected in soil in the residential area were 2.3 mg/kg, 2.7 mg/kg, 9.3 mg/kg and 40 mg/kg, respectively from sample location SV-7 collected on August 20, 1996, at 25 feet bgs (within the likely saturated zone).
- The maximum concentrations of benzene, toluene, ethylbenzene and xylenes in soil vapor between the source and residential receptor buildings, and nearest to the receptor buildings are 130 ug/m^3, 36 ug/m^3, 370 ug/m^3 and 260 ug/m^3 respectively from sample location SV-8 at 3 feet bgs. The rational for selecting vapor sample SV-8 as the representative soil vapor concentration is discussed in detail in the Tier 2 evaluation.

The representative concentrations are presented in tabular form in Table 1.

3.4 Comparison of Representative Concentrations to Tier 1 RBSL's

Table 1 compares the representative concentrations to Tier 1 risk-based screening levels. The RBSLs were derived from the equations presented in Tables X2.2, X2.3 and X2.5 of the ASTM RBCA guidance. WA calculated RBSLs for benzene based on a carcinogenic risk of 1 in 100,000

(10^{-5}) and the conservative California cancer slope factor of 0.1 kg-day/mg. The results of this Tier 1 comparison are:

- The representative concentrations of toluene, ethylbenzene and xylenes in ground water, soil and soil vapor were below all of the RBSLs for the potentially complete exposure pathways. *(Passed Tier 1)*
- The representative concentration of benzene in ground water from well C-9 was below the RBSL for volatilization to outdoor air. *(Passed Tier 1)*
- The representative concentration of benzene in ground water from sample location SV-1 was below the RBSL for vapor intrusion to buildings indicating a 4.06×10^{-6} risk level *(Passed Tier 1)*. Tier 1 risk calculation presented in spreadsheet form in Appendix B.
- The representative concentration of benzene in soil vapor from sample location SV-8 indicates a 3.24×10^{-6} risk level *(Passed Tier 1)*. Tier 1 risk calculation presented in spreadsheet form in Appendix B.
- The representative concentration of benzene in saturated zone soil was above the RBSLs for volatilization to outdoor air, vapor intrusion to buildings, and soil leaching to ground water for ingestion.
- The representative concentration of benzene in ground water from well C-9 was above the RBSLs for vapor intrusion to buildings (1.19×10^{-3} risk) and direct ingestion. The vapor intrusion to buildings Tier 1 risk calculation is presented in spreadsheet form in Appendix B.

3.5 Evaluation of Tier 1 Results

Based on the results of the Tier 1 evaluation WA upgraded the analysis to Tier 2 for a more complete evaluation of potential risk due to inhalation and ingestion of benzene. The potential transport of hydrocarbons to Crow Creek will be addressed in the Tier 2 evaluation. The representative concentrations of toluene, ethylbenzene and xylenes were below the Tier 1 RBSLs, indicating that they pose no significant health risk (i.e., further evaluation is unnecessary).

4. TIER 2 RBCA EVALUATION

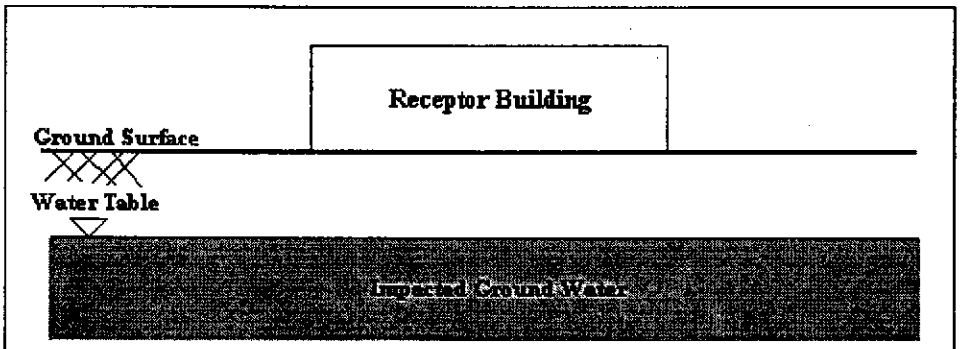
This Tier 2 evaluation addresses the risk to potential residential receptors from benzene vapors in indoor and outdoor air, dissolved benzene in ground water and the potential for dissolved hydrocarbon transport to Crow Creek. The risk from benzene vapors is addressed below followed by an evaluation of the direct ingestion pathway and the potential of impacting Crow Creek.

4.1 Inhalation Pathway Risk

Site specific soil bulk density (natural density), porosity, dry density, grain density and fraction of organic carbon parameters were determined from soil cores collected from sample locations SV-1, SV-2, SV-3 and SV-4 on August 19 and 20, 1996. The soil density and porosity parameters were used to calculate the site specific volumetric air content and water content and determine the site specific diffusivity which defines the rate of vapor transport between the hydrocarbon source and the ground surface. These site specific parameters were used to calculate the Tier 2 indoor air exposure pathway risk from ground water as a source using ground water and soil vapor data. The Tier 2 ground water-to-indoor-air risk evaluation is presented below followed by an evaluation of the indoor air pathway based on vapor concentrations collected between the source and receptor buildings as represented by vapor samples collected from sample point SV-8.

4.1.1 Tier 2 Ground-Water-to-Indoor-Air Risk Evaluation

The Tier 2 ground water-to-indoor-air risk was calculated using the equations presented in Tables X2.2, X2.3 and X2.5 of the ASTM RBCA guidance and the conceptual model presented below. This model calculates the rate of vapor transport from the ground water source through the overlying soil and building foundation and into the building. The building is treated as a well mixed container with a conservatively assumed ventilation rate that sweeps clean air in and discharges air with a concentration equivalent to the indoor air concentration.



Ground Water-to-Indoor-Air Conceptual Model

The representative maximum benzene concentration in ground water was assumed to extend below the entire potential receptor building. The extent of dissolved benzene was overestimated to provide a conservative conceptual model.

The Tier 2 ground water-to-indoor-air risk calculation using site specific soil parameters and the concentration of benzene in ground water from well C-9 indicates a 1.22×10^{-5} risk level. This risk level would be achieved if the 8.2 mg/L concentration of dissolved benzene in well C-9 extended below the entire receptor building. However, the concentration of benzene in ground water at sample location SV-1 (located closer to the receptor building than well C-9) was 0.028 mg/L indicating a 2.32×10^{-8} risk level. The calculations are presented in spreadsheet form in Appendix B and tabulated in Table 2.

Tier 2 application of site specific parameters and the dissolved benzene concentration in well C-9 indicates that the indoor air risk from impacted ground water is slightly above the acceptable 10^{-5} risk level. Further evaluation based on the ground water concentration at sample location SV-1 indicated considerably lower risk (2.32×10^{-8} risk). Sample location SV-1 was adjacent to the receptor building and should be more representative of dissolved benzene concentrations below the receptor building.

4.1.2 Tier 2 Soil Vapor-to-Indoor-Air Risk Evaluation

On August 19 and 20, 1996, WA collected vapor samples from 8 direct push soil sample locations to determine the hydrocarbon concentrations in pore space vapors. The data were collected to determine whether vapor eminating from soil and ground water occur at levels that could pose a risk to residential receptors. These vapor concentration data were then input into vapor transport risk models and used to characterize the vapor concentration profile between the source and the ground surface. The data chosen for model input were the vapor concentrations measured within the transport pathway and nearest the potential receptors (the shallowest sample at each location). Soil vapor concentrations at shallow depths are the most realistic measurement of contaminant transport from the source to the receptor because the total contaminant mass transporting to the receptor must first pass through shallow soil. Vapors measured closer to the source (deeper) are likely to attenuate during transport and are less likely to provide a realistic measurement of the contaminant mass that ultimately reaches the receptor. Therefore, vapor concentrations measured at depths greater than 12 feet bgs were used only to characterize the vapor concentration profile. The vapor concentration profile characterization is presented in a separate attachment (Attachment C). The vapor concentration data are presented in Appendix A.

The highest detected benzene concentration in shallow soil vapor was 0.040 ppmv in sample location SV-8 at 3 feet bgs. This 0.040 ppmv concentration was selected as the representative vapor concentration for the indoor and outdoor air risk analysis because it indicates the greatest potential for transport to the residential receptors.

Ground water benzene concentrations were not used in the Tier 2 vapor pathway evaluation because they are representative of the contaminant source concentrations and do not represent the vapor concentrations that ultimately reach the residential receptors. Significant attenuation of

contaminant mass during transport between the subsurface source and the ground surface was measured at this site. The contaminant loss due to attenuation is discussed in detail in Attachment C.

Indoor air risk was calculated using the vapor transport models presented in the ASTM RBCA guidance document. The calculation is presented in spreadsheet form in Appendix B. This indoor air model calculates vapor transport from the subsurface to the ground surface using the vapor flux formula:

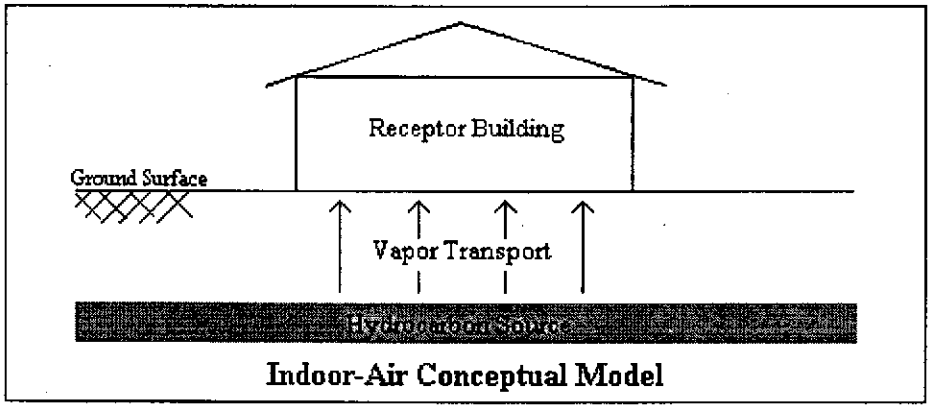
$$F_{max} = D_s^{eff} \frac{C_{v,measured}}{d}$$

where $C_{v,measured}$ is the concentration of benzene in pore space vapors, d is the depth to the measured benzene concentration and D^{eff}_S is the effective diffusivity coefficient for soil. Effective diffusivity is calculated from the formula:

$$D_s^{eff} = D^{air} \frac{\theta_{as}^{3.33}}{\theta_T^2} + D^{wat} \frac{1}{H} \frac{\theta_{ws}^{3.33}}{\theta_T^2}$$

where D^{air} and D^{wat} are the diffusion coefficients of benzene in air and water respectively, θ_{as}, θ_{ws} and θ_t are the air content, water content and total porosity, respectively and H is Henry's constant for benzene.

The concentration of benzene in indoor air is calculated based on the conceptual model presented below.



Indoor-Air Conceptual Model

As indicated by the conceptual model, subsurface vapors transport upward into the receptor building and accumulate to a steady state concentration based on the indoor air exchange rate and building size. The formula for calculating the indoor air concentration is:

$$C_{indoor} = \frac{F_{max}}{ER_{air-indoor} \times L_b}$$

where F_{max} is the previously determined vapor flux, $ER_{air-indoor}$ is the indoor air exchange rate, and L_b is the ratio of the building volume to the building floor area.

The dose a receptor may receive is the product of the indoor air concentration, the indoor air inhalation rate, the exposure frequency and exposure duration. Potential risk is calculated from the formula:

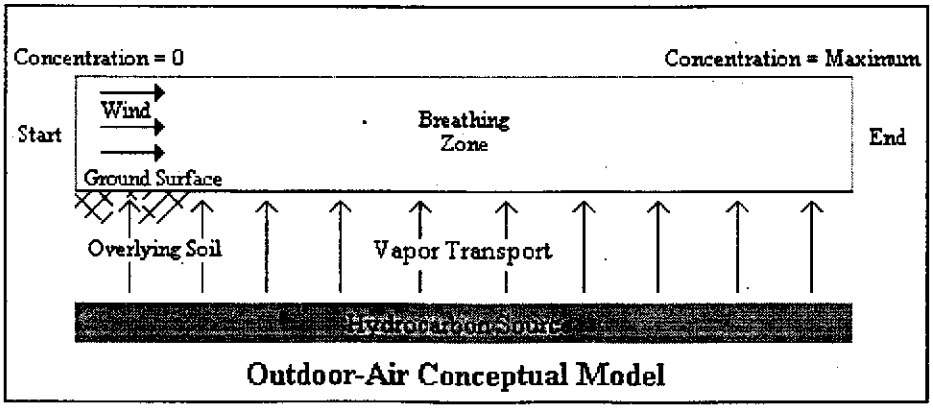
$$Risk = \frac{DoseSF_i}{BW \times AT}$$

where SF_i is the cancer slope factor for benzene, BW is the body weight of the receptor and AT is the averaging time for carcinogens.

The site-specific values used in this model were natural density, air content, water content, porosity, depth to detected benzene and benzene concentration in pore space vapors. The origin and conservativeness of these site-specific parameters is presented in the Discussion of Uncertainty/Conservatism section below. All other parameters used in this model were conservative Tier 1 default values from Tables X 2.4 and X2.6 of the ASTM RBCA guidance. Please note that we did not include attenuation of vapor flux due to the presence of a building foundation in this calculation. Subsurface vapors were conservatively assumed to transport directly from the subsurface into the receptor building with no barrier provided by the structural floor.

4.1.3 Tier 2 Soil Vapor-to-Outdoor-Air Risk Evaluation

The outdoor air model is nearly identical to the indoor air model except for calculation of the benzene concentration in air. The same expressions and parameters are used to determine the effective diffusivity, benzene vapor flux, dose and risk. The concentration of benzene in outdoor air is based on the conceptual model shown below.



Outdoor-Air Conceptual Model

As indicated by the outdoor air conceptual model, benzene vapors originate from the hydrocarbon source and transport through the overlying soil to outdoor air. The air is driven over the impacted area by the prevailing wind and the concentration in air accumulates until the maximum concentration is reached at the downwind end of the impacted area. The concentration in outdoor air at the downwind end is calculated from the formula:

$$C_{v,outdoor} = \frac{F_{max} \times W}{U_{air} \times \delta_{air}}$$

where F_{max} is the vapor flux, W is the width of the source area parallel to the wind direction, U_{air} is the average wind speed, and δ_{air} is the ambient air mixing zone height.

The site-specific parameters applied to this outdoor air model were the soil natural density, air content, water content, porosity, depth to detected benzene and the benzene concentration in soil pore space vapor. All other parameters were conservative ASTM RBCA Tier 1 default values. The conservatism of parameters applied to this model is discussed below.

4.1.4 Vapor Pathway Risk Calculation Results

The risk levels determined by this analysis for benzene in the indoor and outdoor air pathways are 3.75×10^{-9} and 4.67×10^{-12}, respectively. The indoor air risk level is nearly four orders of magnitude lower than the acceptable 10^{-5} target risk level for benzene and the outdoor air risk level is nearly seven orders of magnitude lower than the acceptable level. Therefore, it is reasonable to assume there is no significant risk to the residential receptors from benzene vapors originating in the subsurface.

4.1.5 Uncertainty/Conservatism of Air Models

Risk assessment uncertainty is a function of risk model input parameter uncertainty and the sensitivity of that model to the input parameters. The indoor and outdoor air models used in this analysis are most sensitive to the depth to detected benzene, the concentration of benzene in pore space vapor, and the air and water content in soil. Risk model uncertainty for each of these parameters is discussed below.

- *Depth to Detected Benzene* - The depth to detected benzene is the measured thickness of soil between the detected concentration in pore space vapors and the ground surface. We selected the shallowest depth that benzene was detected in pore space vapor samples for input into both indoor and outdoor air models. The selected depth is conservative because vapor flux is inversely proportional to the depth. Thus, a shallower depth parameter results in a greater predicted vapor flux from subsurface hydrocarbons which ultimately results in the maximum possible dose and most conservative risk value. The depth used in

this analysis was 3 feet bgs corresponding to the vapor sample collected from soil boring SV-8.

- *Concentration of Benzene in Pore Space Vapor* - The concentration of benzene in pore space vapor was measured by collecting vapor samples from various locations and depths surrounding the potential residential receptor buildings and submitting the samples to a laboratory specializing in air contaminant analysis. Direct measurement of benzene concentrations in pore vapors provides the most realistic site characterization data for performing a Tier 2 risk evaluation of the vapor inhalation pathways. The ASTM RBCA guidance determines pore vapor concentrations from mathematical expressions relating the pore vapor concentration to the measured concentration in soil or ground water. However, these expressions may not accurately describe the contaminant mass transfer from the source medium to soil vapor. In addition, loss mechanisms may be actively destroying contaminant mass between the source and the ground surface. These problems are avoided by measuring the pore vapor concentration at depths close to the ground surface. Thus, the most realistic risk value is determined. We used the highest benzene concentration in pore vapors measured at the shallowest depth. This is the most conservative (and realistic) combination because vapor flux is maximum at the location with the highest concentration at the shallowest depth.

- *Air and Water Content in Soil* - The air and water content in soil are parameters that define the expression for effective diffusivity of a soil (See D_S^{eff} in Table X2.5 of the ASTM RBCA guidance document). Effective diffusivity is the rate constant that determines the vapor transport speed through soil to the ground surface. The effective diffusivity expression predicts much greater (faster) transport in soils with high air content (typically sandy soils) than in soils with high water contents (clays and silts). We collected two soil cores from sample location SV-1 during the soil vapor survey to determine the air and water contents in soil near the potential receptor building. These cores were submitted to a geotechnical laboratory for density and porosity analysis. The reported dry density, natural density and porosity values were used to calculate the air content and water content. Air and water content calculations are presented in Appendix B. The laboratory results from both soil core samples indicated a high water content and very little air content. We selected the sample containing the highest air content ($\theta_{as} = 0.01$) for input in our air pathway risk models. The conservative ASTM RBCA Tier 1 default values were not used because they represent dry soils and all of the soils recorded in the boring logs from the soil vapor survey were damp clays and silts. Based on the boring logs, the air content in boring location SV-1 is representative of conditions surrounding the receptor buildings. However, if the air content in site soils vary by as much as an order of magnitude ($\theta_{as} = 0.10$), the indoor air pathway risk becomes 2.48×10^{-7} and the outdoor air pathway risk becomes 3.09×10^{-10}. Thus, the indoor and outdoor air pathway risk values remain well below the acceptable 10^{-5} risk level. The actual diffusivity of benzene through soil at the subject site is expected to be much slower than predicted by the expression

provided in the ASTM RBCA guidance. The diffusivity expression is based on an empirical curve fit to data from experiments on a clean sand. The predominantly fine sediments at this site are likely to produce an actual diffusivity that is much less than values predicted by the effective diffusivity expression.

4.2 The Direct Ingestion Pathway

Ingestion of benzene in impacted ground water may occur if a drinking water supply well is located within the impacted area or in a near downgradient location that will be impacted by contaminant transport. Benzene in ground water has transported downgradient of the former USTs, westward across the residential area and attenuates to below laboratory detection limits in the vicinity of the wells bordering Crow Creek. On September 11, 1996, WA requested a 1/2 mile radius well survey from Alameda County Department of Public Works to determine the location of wells that may be used for drinking water consumption. We found no drinking water supply wells located between the former USTs and Crow Creek or nearby vicinity. Future drinking water well installations between the former USTs and Crow Creek are unlikely due to the current use and availability of municipal water. Therefore it is reasonable to move the points of exposure to wells C-10B, C-15 and C-16 with SSTLs equal to the Tier 1 RBSLs. This program will protect potential receptors from ingesting water that may transport to Crow Creek and feed wells at a downstream location. Benzene concentrations in ground water from wells C-10A, C-10B, C-15 and C-16 have been below the Tier 1 RBSL for ingestion of dissolved benzene (0.0085 mg/l) since October 7, 1994. Thus, the dissolved benzene concentrations are currently below the SSTL developed here. The potential for hydrocarbon transport to Crow Creek is presented below.

4.3 Transport to Sensitive Receptors - Crow Creek

Sheldon Nelson, R.G., of Chevron Research and Technology Company prepared an in depth evaluation of hydrocarbon fate and transport to determine whether hydrocarbons originating from the former USTs are likely to impact Crow Creek. The evaluation is presented in Appendix C. Mr. Nelson used the program MODFLOW, developed by the US Geological Survey to predict contaminant fate and transport in ground water. Parameters such as hydraulic conductivity, porosity, aquifer recharge, source concentration, longitudinal and traverse dispersion, contaminant half life, and other parameters are entered into the model in a grid pattern placed over the site to determine transport between the "nodes" of the grid. The model was run to determine dissolved benzene transport over a period of 10 years with four different remediation scenarios. The four scenarios were:

1) No engineered remediation (Remediation by Natural Attenuation);
2) Ground water extraction from two wells (the current configuration of the ground water extraction system);
3) Ground water extraction from three wells; and,

4) Ground water extraction from four wells.

The results indicated that benzene concentrations in ground water above 0.001 mg/L (the California MCL) will not reach Crow Creek under any of the four scenarios. However, increasing the number of ground water extraction wells caused a decrease in distance between the creek and the 0.001 mg/L isoconcentration boundary.

The fate and transport assessment results indicate that it is reasonable to leave the ground water extraction system off and still protect the creek from dissolved benzene concentrations. However, the ground water extraction system should remain in place, as a contingency, to be restarted if future monitoring indicates the creek is likely to be impacted.

Dissolved benzene concentrations have been below laboratory detection limits in wells C-10A, C-10B and C-16 since April 24, 1995. Based on the ground water monitoring data, the dissolved benzene isoconcentration contour of 0.001 mg/l is currently located upgradient of the wells bordering Crow Creek. Therefore, it is reasonable to shut down the ground water extraction system indefinitely unless future monitoring data indicates otherwise.

4.4 Evaluation of Tier 2 Results

The results of this Tier 2 RBCA analysis indicate that indoor air risk is nearly four orders of magnitude lower than acceptable levels and outdoor air risk is nearly seven orders of magnitude lower than acceptable levels. We did not develop benzene SSTL concentrations in soil and ground water for the air pathways because risk was calculated directly from pore vapor concentrations. However, it is reasonable to assume benzene concentrations in soil or ground water must increase several orders of magnitude before the acceptable risk level is exceeded because pore vapor concentration is generally proportional to soil and ground water concentration.

The potential health risk due to contaminant transport to indoor air was evaluated following the process illustrated by Figure 5. Representative concentrations of benzene in ground water and soil were found to exceed Tier 1 RBSL concentrations for the indoor air pathway. Soil physical parameters, soil vapor and ground water sample results collected on August 19 and 20, 1996 were then used to conduct a site specific Tier 2 evaluation of the indoor air pathway. Using the site specific parameters and the dissolved benzene concentrations in well C-9 and sample location SV-1 the Tier 2 evaluation indicated 1.22×10^{-5} and 2.32×10^{-8} risk levels, respectively. The indoor air risk was further evaluated using soil vapor data measured between the source medium and the ground surface[1]. The worst case soil vapor data collected from sample location SV-8 indicated 3.75×10^{-9} risk due to benzene in the indoor air pathway. The results of the evaluation indicated that no further action was necessary with respect to the indoor air pathway and that hydrocarbon concentrations remaining in ground water and soil below the residential buildings pose no significant risk to the residents.

[1] Subsurface vapors were conservatively assumed to transport directly from the subsurface into the receptor building with no barrier provided by the building floor.

Alternative points of exposure were selected for benzene for the direct ingestion pathway based on evaluation of dissolved concentrations and ground water use in the vicinity of the impacted area. Wells C-10B, C-15 and C-16 were selected as alternative points of exposure with SSTLs equal to the Tier 1 RBSL concentrations to protect down gradient receptors. Dissolved benzene concentrations in wells C-10B, C-15 and C-16 are currently below the SSTLs developed here and no ground water use is anticipated upgradient of these wells within the known extent of the dissolved hydrocarbon plume. As long as the dissolved hydrocarbon concentrations in wells C-10B, C-15 and C-16 remain below the Tier 1 RBSLs, no potential health risk to receptors down gradient of these wells, risk below 10^{-5} , is predicted by ASTM RBCA protocol.

Hydrocarbon transport to Crow Creek was addressed by evaluating the results of fate and transport modeling performed by Sheldon Nelson, R.G., of Chevron Research and Technology Company. The model results indicate that Crow Creek is not likely to be impacted by dissolved benzene concentrations above the California MCL (0.001 mg/L), regardless of whether ground water extraction is performed. Furthermore, evaluation of the plume attenuation indicates that natural attenuation processes have stabilized the plume.

A tabulated comparison of representative benzene concentrations to Tier 2 SSTLs is presented in Table 2.

5. RBCA CONCLUSIONS

The site characterization data and Tier 1 and Tier 2 RBCA evaluations indicate that subsurface hydrocarbons located below the Forest Creek Townhomes residential properties pose no significant risk to the residents. Hydrocarbon concentrations in soil and ground water are below the RBSL for the ground water to outdoor air exposure pathway and below the SSTLs determined in this analysis for all other potential exposure scenarios specified in the ASTM RBCA guidance. Tier 2 screening models indicated that indoor and outdoor air risk levels were 3.75×10^{-9} and 4.67×10^{-12}, respectively. In addition, hydrocarbon concentrations in ground water are expected to remain below California MCL's in the vicinity of Crow Creek.

The conclusions of the RBCA evaluation indicate that the subsurface petroleum hydrocarbons remaining in the residential area pose no demonstratable long-term threat to human health, safety or sensitive environmental receptors. This conclusion corresponds to site classification level 4 as indicated in Table 1 of the ASTM RBCA guidance. Therefore, a program of continued ground water monitoring is the only necessary action to manage the risk associated with subsurface hydrocarbons at this time. A future action plan to address the possibility of exceeding RBSLs or SSTLs is presented in the cover letter to this report.

6. REFERENCES

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Groundwater Technology Inc., 1985 (undated). Gasoline Recovery at Chevron Service Station #9-5607, 5269 Crow Canyon Road, Castro Valley, California.

PEG Environmental Group Inc., May 8, 1990. Progress Report Updating Investigative Activities, Chevron Service Station #9-5607, 5269 Crow Canyon Road, Castro Valley, California.

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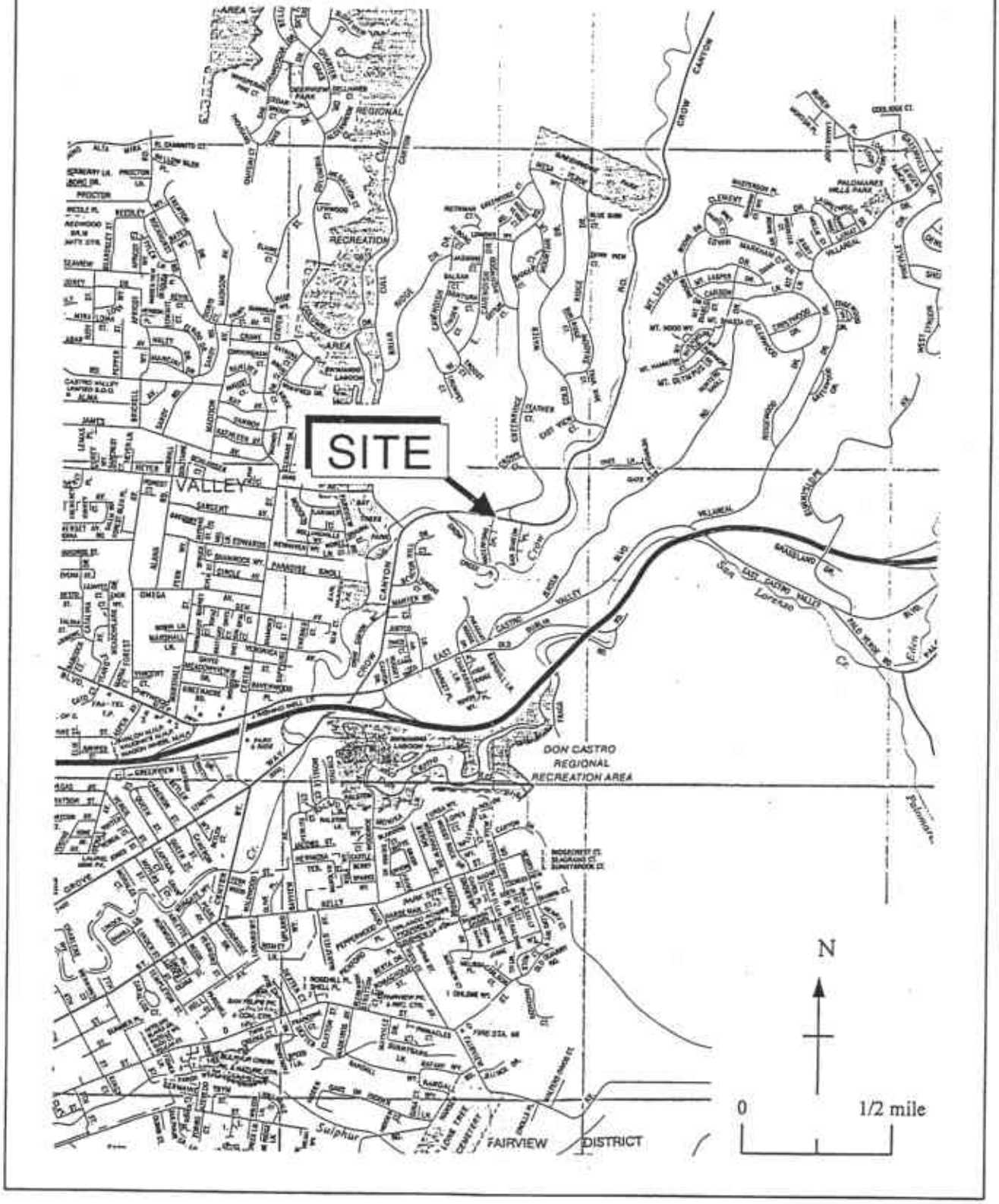

Figure 1. Site Location Map - Former Chevron Service Station #9-5607, 5269 Crow Canyon Road, Castro Valley, California

Risk-Based Corrective Action Process Flow Chart

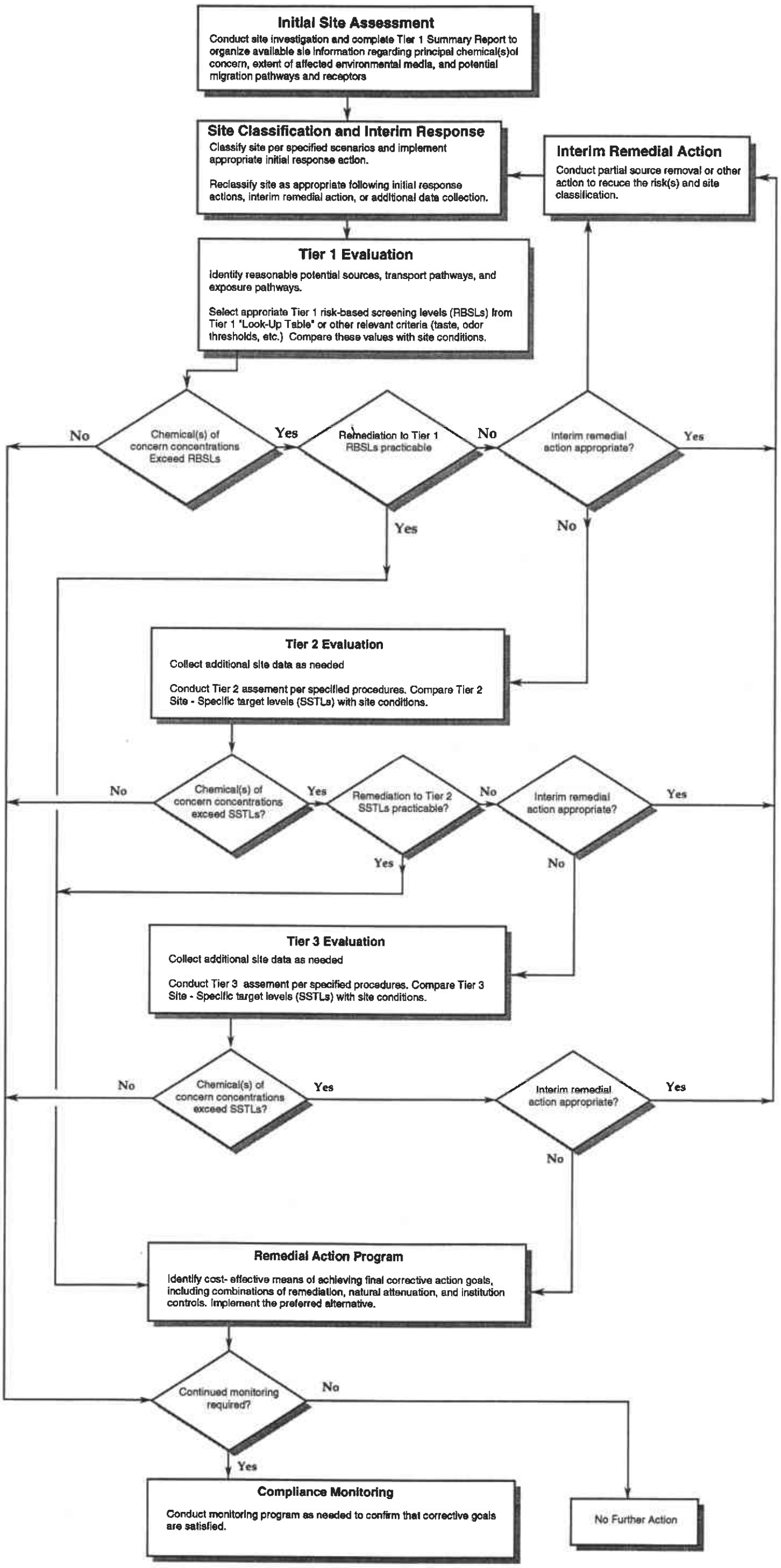

Figure 2. Risk-Based Corrective Action Process Flow Chart

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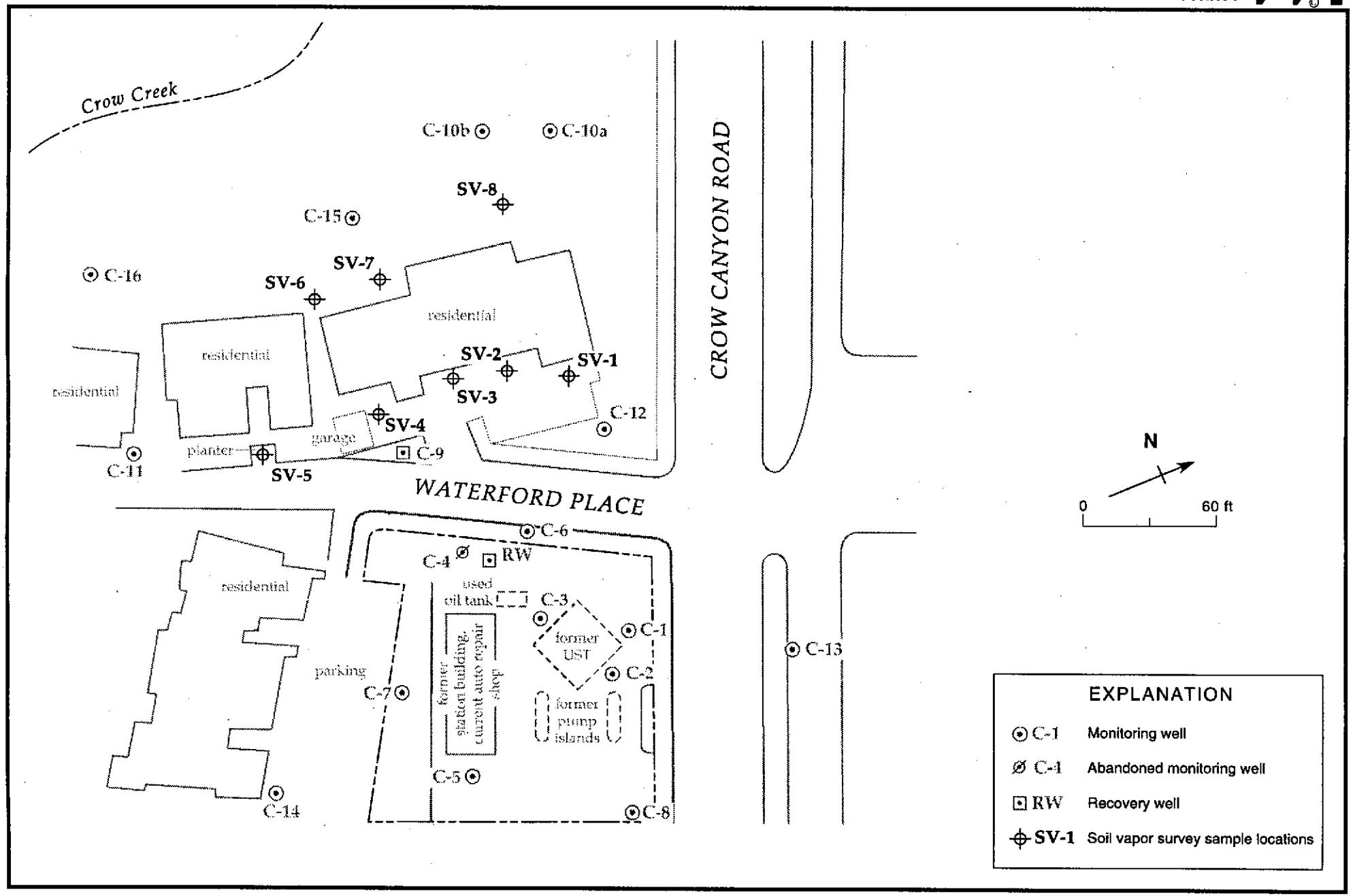
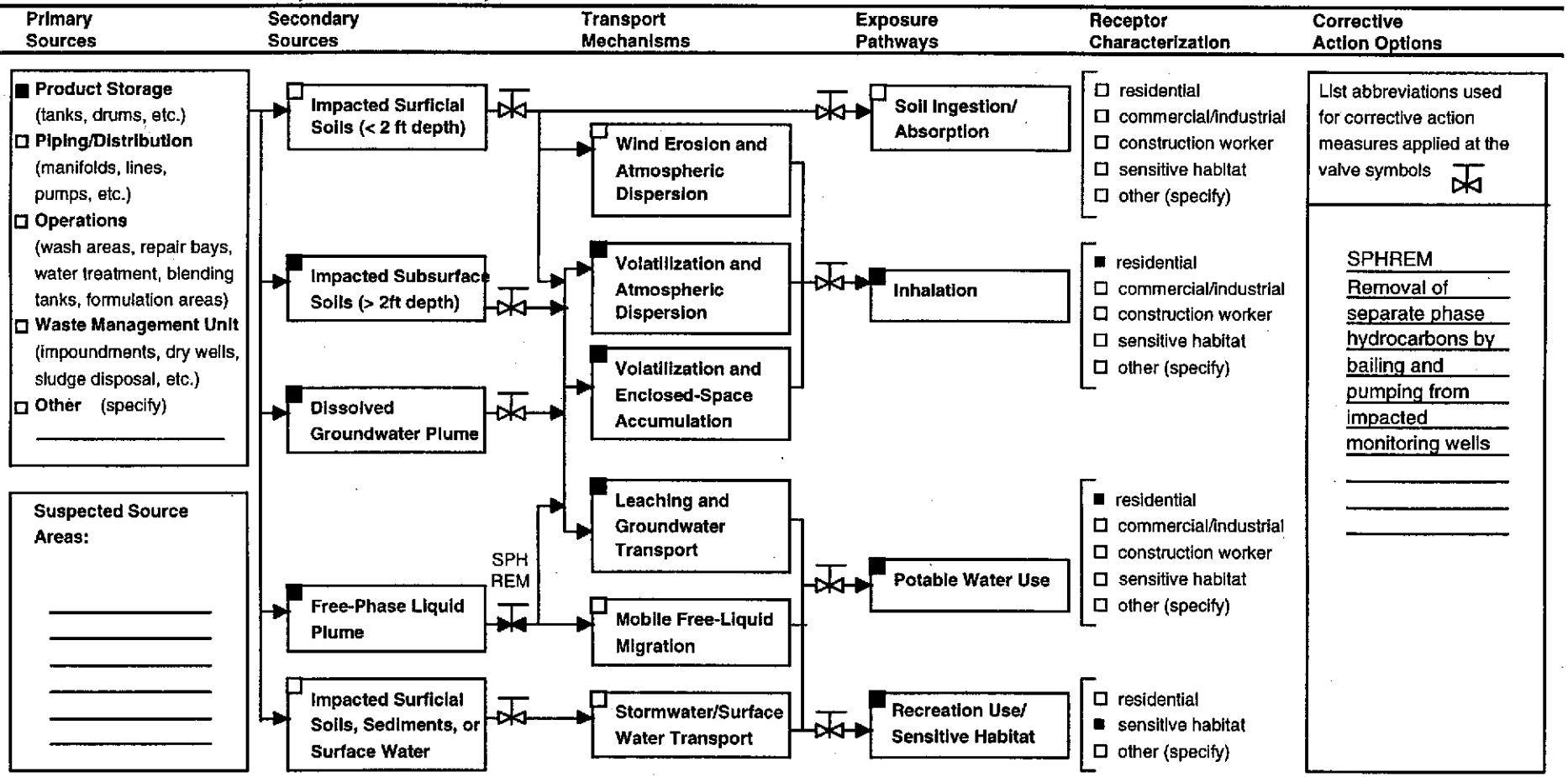


Figure 3. Site Plan - Chevron Station 9-5607, 5269 Crow Canyon Road, Castro Valley, California

RBCA SITE ASSESSMENT

Site Name: Former Chevron Service Station 9-5607
Site Location: 5269 Crow Canyon Road, Castro Valley, California



Step 1: Characterize Site Source and Exposure Pathways
- complete Tier 1 worksheets
- fill applicable boxes for sources, release mechanisms, and actual or imminent exposure pathways (☐ or ■)

Step 2: Identify Receptors, Compare Site Conditions with Tier 1 Levels
- identify receptors
- fill applicable boxes for potential receptors and RBSL value(s) exceeded (☐ or ■)

Step 3: Identify Potential Corrective Measures
- complete Tier 1 summary report
- fill in exposure pathway shut-off valves (⋈ or ⋈)
- record the abbreviation for the corrective measure above the valve, and record the abbrev. on the right-hand side of the table.

Figure 4. Exposure Scenario Evaluation Flowchart

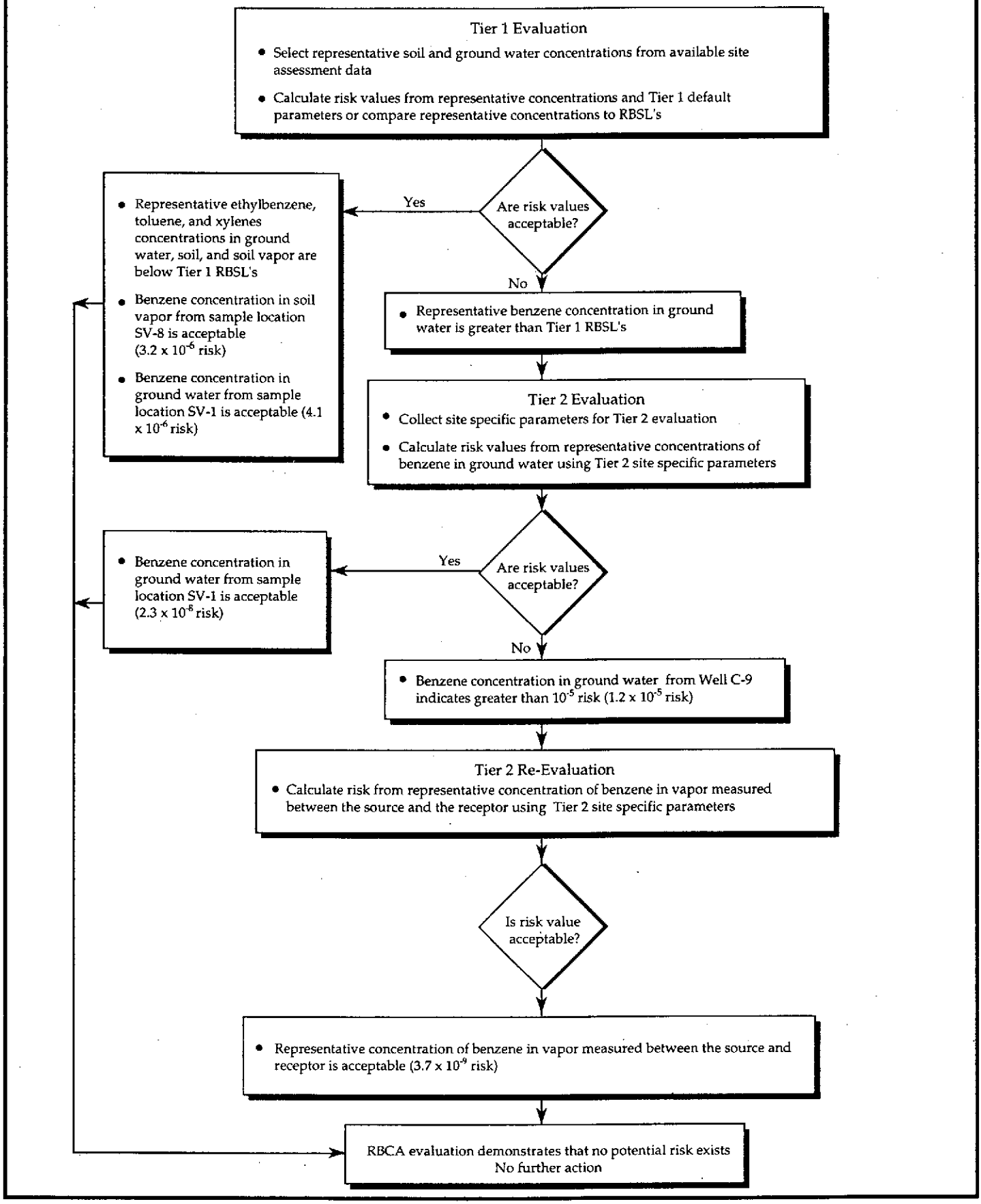


Figure 5. Risk Evaluation Process Flowchart

Table 1. **Residential Receptors** - Comparison of Representative Concentrations to Tier 1 Risk-Based Screening Levels - Former Chevron Service Station, 9-5607, 5269 Crow Canyon Road, Castro Valley, California

Source Medium	Exposure Pathway	Potentially Complete Pathway?	Benzene		Ethylbenzene		Toluene		Xylenes	
			Representative Concentration (RISK)[a]	RBSL[b]	Representative Concentration	RBSL[c]	Representative Concentration	RBSL[c]	Representative Concentration	RBSL[c]
Soil (mg/kg)	Volatilization to Outdoor Air	Y	**2.3**[d]	0.79	9.3[d]	RES	2.7[d]	RES	40[d]	RES
	Vapor Intrusion to Buildings	Y	**2.3**[d]	0.015	9.3[d]	427	2.7[d]	20.6	40[d]	RES
	Surficial Soil (0-3 ft depth): Ingestion/Dermal/Inhalation	N	N/A	16.8	N/A	7,830	N/A	13,300	N/A	145,000
	Leachate to Ground Water for Ingestion	Y	**2.3**[d]	0.05	9.3[d]	575	2.7[d]	129	40[d]	RES
Ground Water (mg/l)	Volatilization to Outdoor Air	Y	8.2[e]	31.9	2.5[e]	>S	0.70[e]	>S	2.1[e]	>S
	Ingestion	Y	**8.2**[e]	0.0085	2.5[e]	3.65	0.70[e]	7.30	2.1[e]	73.0
	Vapor Intrusion to Buildings	Y	**8.2**[e] (1.19×10^{-3})	0.069	2.5[e]	77.5	0.70[e]	32.8	2.1[e]	>S
	Vapor Intrusion to Buildings	Y	0.028[f] (4.06×10^{-6})	0.069	0.0082[f]	77.5	0.025[f]	32.8	0.10[f]	>S
Soil Vapor ($\mu g/m^3$)	Vapor Intrusion to Buildings	Y	130[g] (3.24×10^{-6})[i]	1.14[h]	370[g]	1,390[h]	36[g]	556[h]	260[g]	9,730[h]

Table 1. **Residential Receptors** - Comparison of Representative Concentrations to Tier 1 Risk-Based Screening Levels - Former Chevron Service Station, 9-5607, 5269 Crow Canyon Road, Castro Valley, California (Continued)

Notes:

RBSL = ASTM RBCA Tier 1 Risk-Based Screening Level
RES = Selected risk level is not exceeded for pure compound present at any concentration in soil.
>S = At pure compound solubility (mg/l), selected risk level is not exceeded.
ppbv = Parts per billion by volume.
--- = Not Applicable/Not Calculated.
a = Risk values calculated from representative concentrations and Tier 1 default parameters - presented in brackets.
b = The RBSLs used for benzene are based on a carcinogenic risk of 1 in 100,000 (10^{-5}) and California's standard cancer slope factor of 0.1 mg/kg-day.
c = The RBSLs used for non-carcinogenic compounds are based on a chronic hazard quotient of 1.0.
d = Representative concentration in residential area soil are the maximum concentrations detected in soil boring samples. The representative soil sample was collected on 8/20/96 from 25 ft depth in soil boring SV-7. This soil sample was collected at a depth that is likely below the water table during all or most of the year. Concentrations of benzene in soil samples collected above the water table were below lowest laboratory detection limits.

Notes (continued):

e = Representative concentration in ground water from well C-9, collected on January16, 1996. Well C-9 contains the maximum dissolved hydrocarbon concentrations in the downgradient residential area.
f = Representative concentration in ground water from sample location SV-1, collected on 8/19/1996.
g = Representative concentration in soil vapor from sample location SV-8, collected on 8/20/1996.
h = Indoor air screening levels for inhalation exposure.
i = Risk calculated using diffusive vapor flux equations presented in ASTM '95 and Tier 1 default parameters. Calculation presented in spreadsheet form in Appendix B.

Table 2. **Residential Receptors** - Summary of Tier 2 Risk Evaluation Results - Representative Risk and SSTL Values - Former Chevron Service Station, 9-5607, 5269 Crow Canyon Road, Castro Valley, California

Source Medium	Exposure Pathway	Potentially Complete Pathway?	Benzene			
			Representative Concentration	SSTL	Representative Risk[g]	Acceptable Risk
Soil Vapor (ppbv)	Volatilization to Outdoor Air	Y	40[a]	---	4.67×10^{-12}	10^{-5}
	Vapor Intrusion to Buildings Sample Location SV-8	Y	40[a]	---	3.75×10^{-9}	10^{-5}
Ground Water (mg/l)	Vapor Intrusion to Buildings Well C-9	Y	8.2[b]	---	1.22×10^{-5}	10^{-5}
	Vapor Intrusion to Buildings Sample Location SV-1	Y	0.028[c]	---	2.32×10^{-8}	10^{-5}
	Ingestion	Y	<0.0005[d]	0.0085[e]	---	10^{-5}
	Transport to Crow Creek	Y	<0.0005[d]	0.001[f]	---	---

Notes:

SSTL = ASTM RBCA Tier 1 Risk-Based Screening Level
--- = Not Applicable/Not Calculated.
a = Representative concentration in soil vapor from sample location SV-8, collected on 8/20/1996.
b = Representative concentration in ground water from well C-9, collected on 1/16/1996.
c = Representative concentration in ground water from sample location SV-1, collected on 8/19/1996.
d = The representative concentration for ground water ingestion and transport to Crow Creek applies to alternative points of exposure wells C-10B, C-15, and C-16. Ground water samples collected on April 18, 1996.
e = The SSTL for ingestion of dissolved benzene is based on a carcinogenic risk of 1 in 100,000 (10^{-5}) and California's standard cancer slope factor of 0.1 mg/kg-day.
f = The SSTL for ground water transport to Crow Creek is Based in the California MCL of 0.001 mg/L.
g = Risk values calculated from representative concentrations and site specific parameters.

APPENDIX A

PORE VAPOR, SOIL AND GROUND WATER ANALYTICAL DATA

Table 1. Analytic Results for Vapor Samples - Chevron Service Station #9-5607, 5269 Crow Canyon Road, Castro Valley, California.

Sample ID	Sample Depth (ft)	B	E	T	X	O_2	CO_2	CH_4
		←parts per billion by volume (ppbv)→				←percent by volume→		
SV-1	3	<4.3	<4.3	<4.3	<8.6	22	0.076	<0.002
SV-2	8	<6.1	<6.1	<6.1	<12.2	1.4	28	0.010
SV-3	8	<4.4	7.6	<4.4	6.7	21	0.25	<0.002
SV-3	25	2,100	3,800	680	2,300	21	0.58	0.004
SV-4	3	<4.3	<4.3	<4.3	<4.6	14	9.3	<0.002
SV-4	8	<4.2	<4.2	<4.2	5.7	21	0.35	<0.002
SV-4	11	<4.2	6.0	<4.2	<8.4	21	0.80	0.007
SV-4	25	38,000	140,000	20,000	83,000	21	0.37	0.002
SV-4	25^{dup}	39,000	140,000	22,000	87,000	21	0.35	0.002
SV-5	12	6.2	32	11	39	22	0.091	<0.002
SV-6	3	29	42	6.4	25.4	0.51	0.054	0.005
SV-7	3	<4.2	5.1	<4.2	6.8	21	0.47	<0.002
SV-8	3	40	83	9.5	59	19	3.6	<0.002

Abbreviations:

B = Benzene by EPA Method TO-14
E = Ethylbenzene by EPA Method TO-14
T = Toluene by EPA Method TO-14
X = Xylenes by EPA Method TO-14
O_2 = Oxygen by ASTM Method D3416
CO_2 = Carbon dioxide by ASTM Method D3416
CH_4 = Methane by ASTM Method D3416
<n = Not detected at detection limits of n ppbv

Notes:

Samples collected on 8/19/96 and 8/20/96 by Weiss Associates and analyzed by Air Toxics, Folsom, California.

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Table 2. Analytic Results for Soil Samples - Chevron Service Station #9-5607, 5269 Crow Canyon Road, Castro Valley, California.

Sample ID	Depth Collected Below Ground Surface (ft)	TPH-G	B	E	T	X
		← parts per million (mg/kg) →				
SV-1	5	<1.0	<0.005	<0.005	<0.005	<0.005
SV-1	10	<1.0	<0.005	<0.005	<0.005	<0.005
SV-1	21	<1.0	<0.005	<0.005	<0.005	0.014
SV-2	3	<1.0	<0.005	<0.005	<0.005	<0.005
SV-2	8	<1.0	<0.005	<0.005	<0.005	<0.005
SV-2	10	<1.0	<0.005	<0.005	<0.005	<0.005
SV-2	21	<1.0	<0.005	<0.005	<0.005	<0.005
SV-3	5	<1.0	<0.005	<0.005	<0.005	<0.005
SV-3	10	<1.0	<0.005	<0.005	<0.005	<0.005
SV-3	21	17	0.67	0.74	0.38	1.2
SV-4	6	<1.0	<0.005	<0.005	<0.005	0.012
SV-4	9.5	<1.0	<0.005	<0.005	<0.005	<0.005
SV-4	23.5	97	0.59	<0.010	1.0	2.9
SV-5	5	<1.0	<0.005	<0.005	<0.005	<0.005
SV-5	10	<1.0	<0.005	<0.005	<0.005	<0.005
SV-5	24.5	<1.0	<0.005	<0.005	<0.005	<0.005
SV-6	5	<1.0	<0.005	<0.005	<0.005	<0.005
SV-6	10	<1.0	<0.005	<0.005	<0.005	<0.005
SV-6	25	61	0.85	0.65	1.2	3.6
SV-7	5	<1.0	<0.005	<0.005	<0.005	<0.005
SV-7	10	<1.0	<0.005	<0.005	<0.005	<0.005
SV-7	25	400	2.3	2.7	9.3	40

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Table 2. Analytic Results for Soil Boring Samples - Chevron Service Station #9-5607, 5269 Crow Canyon Road, Castro Valley, California.

Sample ID	Depth Collected Below Ground Surface (ft)	TPH-G	B	E	T	X
		← parts per million (mg/kg) →				
SV-8	5	<1.0	<0.005	<0.005	<0.005	<0.005
SV-8	10	<1.0	<0.005	<0.005	<0.005	<0.005
SV-8	25	<1.0	<0.005	<0.005	<0.005	<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
<n = Not detected at detection limits of n ppb

Notes:

Samples collected on 8/19/96 and 8/20/96 by Weiss Associates and analyzed by Sequoia Analytical, Redwood City, California.

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Table 3. Physical Property Measurements for Soil Samples - Chevron Service Station #9-5607, 5269 Crow Canyon Road, Castro Valley, California.

Sample ID	Depth Collected Below Ground Surface (ft)	foc %	Dry Density (g/cc)	Natural Density (g/cc)	Grain Density (g/cc)	Porosity (cc/cc)
SV-1	6	---	1.94	2.21	2.68	0.277
SV-1	10	---	1.84	2.16	2.69	0.315
SV-2	3	0.30	---	---	---	---
SV-2	15	0.23	---	---	---	---
SV-3	3	0.20	---	---	---	---
SV-3	21.5	0.14	---	---	---	---
SV-4	5	0.29	---	---	---	---
SV-4	23	0.14	---	---	---	---

Abbreviations:

foc = Fraction of Organic Carbon by Watley-Black Method
g/cc = grams per cubic centimeter
cc/cc = porous volume/total volume of soil
Dry density by American Petroleum Institute RP-40
Natural density by American Petroleum Institute RP-40
Grain density by American Petroleum Institute RP-40
Porosity by American Petroleum Institute RP-40

Notes:

Samples collected on 8/19/96 and 8/20/96 by Weiss Associates and analyzed by Sequoia Analytical, Redwood City, California and Core Laboratories, Bakersfield, California.

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Weiss Associates

Copied from: Pacific Environmental Group Inc., May 8, 1990. Progress Report Updating Investigative Activities, Chevron Service Station #9-5607, 5269 Crow Canyon Road, Castro Valley, California.

TABLE 3

SUMMARY OF SOIL ANALYTICAL RESULTS

Low-Boiling Hydrocarbons

(Sampled Date: February 22 through 24, 1990)

Boring No.	Sample Date	Gasoline (ppm)	Benzene (ppm)	Toluene (ppm)	Ethyl-Benzene (ppm)	Xylenes (ppm)
C-12	02/22/90	200	1.7	4.7	3.4	18
C-13	02/23/90	ND	ND	ND	ND	ND
C-15	02/24/90	10	ND	0.10	ND	ND

Notes: ppm - parts per million
ND - none detected
detection limits shown on attached certified analytical reports

Table 4. Analytic Results for Ground Water Samples - Chevron Service Station #9-5607, 5269 Crow Canyon Road, Castro Valley, California.

Boring Location	Sample ID	TPH-G	B	E	T	X
		← parts per million (mg/L) →				
SV-1	WS-1	0.610	0.028	0.0082	0.025	0.10

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

Notes:

Sample collected on 8/19/96 by Weiss Associates and analyzed by Sequoia Analytical, Redwood City, California.

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Weiss Associates

Cumulative Table of Well Data and Analytical Results

Vertical Measurements are in feet. Analytical results are in parts per billion (ppb)

DATE	Well Head Elev.	Ground Water Elev.	Depth To Water	Notes	TPH-Gasoline	Benzene	Toluene	Ethyl-Benzene	Xylene	MTBE	Organic Lead
C-1											
03/26/85	283.46	260.63	22.83	--	--	--	--	--	--	--	--
07/03/86	283.46	259.88	23.58	--	--	--	--	--	--	--	--
03/26/87	283.46	262.96	20.50	--	--	--	--	--	--	--	--
03/28/88	283.46	257.46	26.00	--	--	--	--	--	--	--	--
03/10/89	283.46	267.60	15.86	--	--	--	--	--	--	--	--
04/03/89	283.46	266.61	16.85	--	--	--	--	--	--	--	--
05/08/89	283.46	260.78	22.68	--	--	--	--	--	--	--	--
06/05/89	283.46	258.80	24.66	--	--	--	--	--	--	--	--
07/12/90	283.46	257.90	25.56	--	--	--	--	--	--	--	--
08/10/90	283.46	257.57	25.89	--	--	--	--	--	--	--	--
09/13/89	283.46	256.91	26.55	--	22,000	3600	1100	1000	3500	--	--
10/04/89	283.46	258.22	25.24	--	--	--	--	--	--	--	--
11/03/89	283.46	258.43	25.03	--	--	--	--	--	--	--	--
12/04/89	283.46	257.09	26.37	--	13,000	2000	550	610	1600	--	--
03/07/90	283.46	260.98	22.48	--	--	--	--	--	--	--	--
03/09/90	283.46	--	--	--	--	--	--	--	--	--	--
06/12/90	283.46	259.11	24.35	--	21,000	3500	1400	840	4000	--	--
09/20/90	283.46	257.19	26.27	--	23,000	2100	1200	860	5000	--	--
12/20/90	283.46	260.87	22.59	--	8200	760	410	260	1100	--	--
03/27/91	283.46	264.38	19.08	--	--	--	--	--	--	--	--
06/18/91	283.46	256.35	27.11	--	--	--	--	--	--	--	--
09/12/91	283.46	255.24	28.22	--	--	--	--	--	--	--	--
01/23/92	283.46	256.81	26.65	--	--	--	--	--	--	--	--
04/13/92	283.46	261.30	22.16	--	38,000	3100	1300	850	3100	--	--
08/03/92	283.46	257.31	26.15	--	13,000	1300	470	550	1600	--	ND
10/22/92	283.46	256.67	26.79	--	24,000	3500	1400	1500	4300	--	--
01/18/93	283.46	264.86	18.60	--	370,000	6900	8900	3100	23,000	--	--
04/19/93	283.46	262.34	21.12	--	51,000	8000	7000	1400	10,000	--	--
07/21,22/93	283.46	260.18	23.28	--	22,000	3400	1000	990	3100	--	--
10/25/93	283.46	258.80	24.66	--	14,000	2000	550	790	2300	--	--
01/21/94	283.46	262.99	20.47	--	1100	350	6.0	3.0	15	--	--
04/18/94	283.46	260.36	23.10	--	24,000	3200	1000	1000	3100	--	--
07/06-07/94	283.46	260.56	22.90	--	65,000	6500	4200	1600	9300	--	--
10/07/94	283.46	258.75	24.71	--	27,000	5100	1200	1400	4300	--	--

CONTINUED ON NEXT PAGE

Cumulative Table of Well Data and Analytical Results

Vertical Measurements are in feet. Analytical results are in parts per billion (ppb)

DATE	Well Head Elev.	Ground Water Elev.	Depth To Water	Notes	TPH-Gasoline	Benzene	Toluene	Ethyl-Benzene	Xylene	MTBE	Organic Lead
C-1(CONT'D)											
01/11/95	283.46	265.16	18.30	--	29,000	1300	1200	930	4000	--	--
04/24/95	283.46	266.52	16.94	--	75,000	8900	5000	1700	8400	--	--
07/31/95	283.46	262.90	20.56	--	56,000	11,000	2600	2500	11,000	--	--
10/02/95	283.46	272.88	10.58	--	44,000	7900	1100	2100	6500	--	--
01/16/96	283.46	261.71	21.75	--	29,000	5300	460	1000	2800	<500	--
04/18/96	283.46	264.51	18.95	--	59,000	7100	3000	2000	7600	<250	--
07/22/96	283.46	262.46	21.00	--	26,000	6100	610	1800	4700	<250	--
10/10/96	283.46	261.46	22.00	--	24,000	7100	600	1700	3200	<250	--

Cumulative Table of Well Data and Analytical Results

Vertical Measurements are in feet. Analytical results are in parts per billion (ppb)

DATE	Well Head Elev.	Ground Water Elev.	Depth To Water	Notes	TPH-Gasoline	Benzene	Toluene	Ethyl-Benzene	Xylene	MTBE	Organic Lead
C-2											
03/26/85	284.37	--	--	--	--	--	--	--	--	--	--
07/03/86	284.37	264.68	19.69	--	--	--	--	--	--	--	--
03/26/87	284.37	268.92	15.45	--	--	--	--	--	--	--	--
03/28/88	284.37	263.45	20.92	--	--	--	--	--	--	--	--
03/10/89	284.37	271.57	12.80	--	--	--	--	--	--	--	--
04/03/89	284.37	270.11	14.26	--	--	--	--	--	--	--	--
05/08/89	284.37	265.95	18.42	--	--	--	--	--	--	--	--
06/05/89	284.37	264.28	20.09	--	--	--	--	--	--	--	--
07/12/90	284.37	263.58	20.79	--	--	--	--	--	--	--	--
08/10/90	284.37	262.97	21.40	--	--	--	--	--	--	--	--
09/13/89	284.37	262.51	21.86	--	320	62	4.0	10	14	--	--
10/04/89	284.37	264.48	19.89	--	--	--	--	--	--	--	--
11/03/89	284.37	263.61	20.76	--	--	--	--	--	--	--	--
12/04/89	284.37	263.55	20.82	--	1000	240	37	66	130	--	--
03/07/90	284.37	266.54	17.83	--	--	--	--	--	--	--	--
03/09/90	284.37	266.54	17.83	--	390	280	35	27	50	--	--
06/12/90	284.37	264.48	19.89	--	700	260	34	28	55	--	--
09/20/90	284.37	262.40	21.97	--	--	--	--	--	--	--	--
12/20/90	284.37	266.64	17.73	--	--	--	--	--	--	--	--
03/27/91	284.37	269.27	15.10	--	--	--	--	--	--	--	--
06/18/91	284.37	261.69	22.68	--	--	--	--	--	--	--	--
09/12/91	284.37	260.45	23.92	--	--	--	--	--	--	--	--
01/23/92	284.37	263.13	21.24	--	--	--	--	--	--	--	--
04/13/92	284.37	266.83	17.54	--	1100	120	76	17	72	--	--
08/03/92	284.37	262.32	22.05	--	--	--	--	--	--	--	--
10/22/92	284.37	261.34	23.03	--	--	--	--	--	--	--	--
01/18/93	284.37	269.51	14.86	--	70	6.4	ND	ND	ND	--	--
04/19/93	284.37	267.57	16.80	--	--	--	--	--	--	--	--
07/21,22/93	284.37	265.12	19.25	--	--	--	--	--	--	--	--
10/25/93	284.37	264.72	19.65	--	--	--	--	--	--	--	--
01/21/94	284.37	258.80	25.57	--	43,000	5100	1800	2000	6800	--	--
04/18/94	284.37	274.61	9.76	--	--	--	--	--	--	--	--
07/06-07/94	284.37	265.61	18.76	--	--	--	--	--	--	--	--
10/07/94	284.37	264.20	20.17	--	--	--	--	--	--	--	--

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Cumulative Table of Well Data and Analytical Results

Vertical Measurements are in feet. Analytical results are in parts per billion (ppb)

DATE	Well Head Elev.	Ground Water Elev.	Depth To Water	Notes	TPH-Gasoline	Benzene	Toluene	Ethyl-Benzene	Xylene	MTBE	Organic Lead
C-2 (CONT'D)											
01/11/95	284.37	270.33	14.04	Sampled annually	780	290	9.1	19	58	--	--
04/24/95	284.37	272.03	12.34	--	--	--	--	--	--	--	--
07/31/95	284.37	266.82	17.55	--	--	--	--	--	--	--	--
10/02/95	284.37	265.39	18.98	--	--	--	--	--	--	--	--
01/16/96	284.37	268.37	16.00	--	260	29	2.9	5.7	21	6.1	--
04/18/96	284.37	270.47	13.90	--	--	--	--	--	--	--	--
07/22/96	284.37	266.63	17.74	--	--	--	--	--	--	--	--
10/10/96	284.37	265.46	18.91	--	--	--	--	--	--	--	--

Cumulative Table of Well Data and Analytical Results

Vertical Measurements are in feet. Analytical results are in parts per billion (ppb)

DATE	Well Head Elev.	Ground Water Elev.	Depth To Water	Notes	TPH-Gasoline	Benzene	Toluene	Ethyl-Benzene	Xylene	MTBE	Organic Lead
C-3											
03/26/85	285.98	--	--	--	--	--	--	--	--	--	--
07/03/86	285.98	259.94	26.04	--	--	--	--	--	--	--	--
03/26/87	285.98	260.34	25.64	--	--	--	--	--	--	--	--
03/28/88	285.98	257.16	28.82	--	--	--	--	--	--	--	--
03/10/89	285.98	263.20	22.78	--	--	--	--	--	--	--	--
04/03/89	285.98	263.27	22.71	--	--	--	--	--	--	--	--
05/08/89	285.98	260.03	25.95	--	--	--	--	--	--	--	--
06/05/89	285.98	258.36	27.62	--	--	--	--	--	--	--	--
07/12/90	285.98	257.69	28.29	--	--	--	--	--	--	--	--
08/10/90	285.98	257.52	28.46	--	--	--	--	--	--	--	--
09/13/89	285.98	256.65	29.33	--	60,000	1400	6800	2300	10,000	--	--
10/04/89	285.98	257.01	28.97	--	--	--	--	--	--	--	--
11/03/89	285.98	257.26	28.72	--	--	--	--	--	--	--	--
12/04/89	285.98	256.97	29.01	--	56,000	1300	3300	1400	2700	--	--
03/07/90	285.98	258.29	27.69	--	--	--	--	--	--	--	--
03/09/90	285.98	258.29	27.69	--	42,000	1100	5700	1600	7900	--	--
06/12/90	285.98	257.89	28.09	--	160,000	1400	7100	3400	16,000	--	--
09/24/90	285.98	256.80	29.18	--	53,000	850	7700	2000	10,000	--	--
12/20/90	285.98	257.71	28.27	--	520	1200	5400	5400	33,000	--	--
03/27/91	285.98	261.18	24.80	--	92,000	1300	3100	1200	11,000	--	--
06/18/91	285.98	255.14	30.84	--	--	--	--	--	--	--	--
09/12/91	285.98	254.34	31.64	Free Product (0.03')	--	--	--	--	--	--	--
01/23/92	285.98	255.46	30.52	Sheen	--	--	--	--	--	--	--
04/13/92	285.98	259.04	26.94	Free Product (0.01')	--	--	--	--	--	--	--
08/03/92	285.98	255.98	30.00	--	220,000	1300	2800	3100	17,000	--	ND
10/22/92	285.98	255.38	30.62	Free Product (0.03')	--	--	--	--	--	--	--
01/18/93	285.98	262.07	23.91	--	1,000,000	2400	5300	10,000	61,000	--	--
04/19/93	285.98	260.98	25.00	--	94,000	33,000	22,000	1600	9200	--	--
07/21,22/93	285.98	259.43	26.55	--	44,000	2600	5500	1300	6900	--	--
10/25/93	285.98	257.26	28.72	--	35,000	3900	2400	1100	6600	--	--
01/21/94	285.98	256.32	29.66	--	120,000	4200	2200	2000	11,000	--	--
04/18/94	285.98	259.24	26.74	--	29,000	1200	310	520	2000	--	--
07/06-07/94	285.98	259.62	26.36	--	84,000	2700	1400	1400	9700	--	--
10/07/94	285.98	257.49	28.49	--	40,000	1600	390	1200	6100	--	--

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Cumulative Table of Well Data and Analytical Results

Vertical Measurements are in feet. Analytical results are in parts per billion (ppb)

DATE	Well Head Elev.	Ground Water Elev.	Depth To Water	Notes	TPH-Gasoline	Benzene	Toluene	Ethyl-Benzene	Xylene	MTBE	Organic Lead
C-3 (CONT'D)											
01/11/95	285.98	262.84	23.14	--	34,000	4200	910	720	3800	--	--
04/24/95	285.98	266.10	19.88	--	210,000	43,000	28,000	2400	13,000	--	--
07/31/95	285.98	261.30	24.68	--	110,000	33,000	17,000	2300	12,000	--	--
10/02/95	285.98	258.84	27.14	--	69,000	6700	4000	2000	11,000	--	--
01/16/96	285.98	261.60	24.38	--	40,000	2400	440	1200	5500	<500	--
04/18/96	285.98	265.31	20.67	--	66,000	26,000	17,000	2200	12,000	<1250	--
07/22/96	285.98	261.32	24.66	--	69,000	21,000	8800	1800	9900	<1000	--
10/10/96	285.98	260.75	25.23	--	53,000	12,000	2600	1900	9300	<500	--

Cumulative Table of Well Data and Analytical Results

Vertical Measurements are in feet. Analytical results are in parts per billion (ppb)

DATE	Well Head Elev.	Ground Water Elev.	Depth To Water	Notes	TPH-Gasoline	Benzene	Toluene	Ethyl-Benzene	Xylene	MTBE	Organic Lead
C-4											
03/26/85	273.01	257.87	15.14	--	--	--	--	--	--	--	--
07/03/86	273.01	257.64	15.37	--	--	--	--	--	--	--	--
03/26/87	273.01	--	--	--	--	--	--	--	--	--	--
03/28/88	273.01	254.97	18.04	--	--	--	--	--	--	--	--
03/10/89	273.01	--	--	--	--	--	--	--	--	--	--
04/03/89	273.01	259.67	13.34	--	--	--	--	--	--	--	--
05/08/89	273.01	257.41	15.60	--	--	--	--	--	--	--	--
06/05/89	273.01	256.50	16.51	--	--	--	--	--	--	--	--
07/12/90	273.01	256.02	16.99	--	--	--	--	--	--	--	--
08/10/90	273.01	255.74	17.27	--	--	--	--	--	--	--	--
09/13/89	273.01	254.85	18.16	--	57,000	21,000	3100	3200	11,000	--	--
10/04/89	273.01	254.77	18.24	--	--	--	--	--	--	--	--
11/03/89	273.01	254.84	18.17	--	--	--	--	--	--	--	--
12/04/89	273.01	254.56	18.45	--	48,000	17,000	2200	2800	9800	--	--
03/07/90	273.01	255.81	17.20	--	--	--	--	--	--	--	--
03/09/90	273.01	255.81	17.20	--	43,000	20,000	2300	2800	11,000	--	--
06/12/90	273.01	256.35	16.66	--	82,000	21,000	2400	4000	16,000	--	--
09/24/90	273.01	254.90	18.11	--	--	--	--	--	--	--	--
12/20/90	273.01	--	--	Abandoned	--	--	--	--	--	--	--

Cumulative Table of Well Data and Analytical Results

Vertical Measurements are in feet. Analytical results are in parts per billion (ppb)

DATE	Well Head Elev.	Ground Water Elev.	Depth To Water	Notes	TPH-Gasoline	Benzene	Toluene	Ethyl-Benzene	Xylene	MTBE	Organic Lead
C-5											
03/26/85	287.95	262.62	25.33	--	--	--	--	--	--	--	--
07/03/86	287.95	261.54	26.41	--	--	--	--	--	--	--	--
03/26/87	287.95	262.99	24.96	--	--	--	--	--	--	--	--
03/28/88	287.95	258.15	29.80	--	--	--	--	--	--	--	--
03/10/89	287.95	262.06	25.89	--	--	--	--	--	--	--	--
04/03/89	287.95	263.57	24.38	--	--	--	--	--	--	--	--
05/08/89	287.95	260.15	27.80	--	--	--	--	--	--	--	--
06/05/89	287.95	258.53	29.42	--	--	--	--	--	--	--	--
07/12/90	287.95	258.09	29.86	--	--	--	--	--	--	--	--
08/10/90	287.95	258.18	29.77	--	--	--	--	--	--	--	--
09/13/89	287.95	257.00	30.95	--	310	ND	ND	ND	ND	--	--
10/04/89	287.95	256.47	31.48	--	--	--	--	--	--	--	--
11/03/89	287.95	256.63	31.32	--	--	--	--	--	--	--	--
12/04/89	287.95	256.25	31.70	--	ND	ND	ND	ND	ND	--	--
03/07/90	287.95	257.67	30.28	--	--	--	--	--	--	--	--
03/09/90	287.95	257.67	30.28	--	ND	ND	ND	ND	ND	--	--
06/12/90	287.95	257.47	30.48	--	90	ND	ND	ND	ND	--	--
09/24/90	287.95	256.17	31.78	--	ND	ND	ND	ND	ND	--	--
12/20/90	287.95	254.66	33.29	--	170	ND	ND	1.0	0.7	--	--
03/27/91	287.95	259.97	27.98	--	--	--	--	--	--	--	--
06/18/91	287.95	255.43	32.52	--	--	--	--	--	--	--	--
09/12/91	287.95	254.58	33.37	--	--	--	--	--	--	--	--
01/23/92	287.95	255.28	32.67	--	--	--	--	--	--	--	--
04/13/92	287.95	259.47	28.48	--	140	ND	ND	0.7	ND	--	--
08/03/92	287.95	255.45	32.50	--	ND	ND	ND	ND	ND	--	ND
10/22/92	287.95	253.97	33.98	--	--	--	--	--	--	--	--
01/18/93	287.95	260.93	27.02	--	230	6.6	2.2	3.4	2.2	--	--
04/19/93	287.95	263.14	24.81	--	--	--	--	--	--	--	--
07/21,22/93	287.95	258.89	29.06	--	130	ND	0.6	ND	ND	--	--
10/25/93	287.95	257.00	30.95	--	--	--	--	--	--	--	--
01/21/94	287.95	256.04	31.91	--	ND	ND	ND	ND	ND	--	--
04/18/94	287.95	257.80	30.15	--	--	--	--	--	--	--	--
07/06-07/94	287.95	258.91	29.04	--	ND	ND	ND	ND	ND	--	--
10/07/94	287.95	256.11	31.84	--	--	--	--	--	--	--	--

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Cumulative Table of Well Data and Analytical Results

Vertical Measurements are in feet. Analytical results are in parts per billion (ppb)

DATE	Well Head Elev.	Ground Water Elev.	Depth To Water	Notes	TPH-Gasoline	Benzene	Toluene	Ethyl-Benzene	Xylene	MTBE	Organic Lead
C-5 (CONT'D)											
01/11/95	287.95	262.97	24.98	Sampled biannually	700	1.1	6.0	1.5	2.1	--	--
04/24/95	287.95	266.17	21.78	--	--	--	--	--	--	--	--
07/31/95	287.95	--	--	Inaccessible	--	--	--	--	--	--	--
10/02/95	287.95	257.77	30.18	--	--	--	--	--	--	--	--
01/16/96	287.95	261.23	26.72	--	200	<0.5	<0.5	<0.5	1.3	<2.5	--
04/18/96	287.95	266.15	21.80	--	--	--	--	--	--	--	--
07/22/96	287.95	--	--	Inaccessible	--	--	--	--	--	--	--
10/10/96	287.95	261.17	26.78	--	--	--	--	--	--	--	--

Cumulative Table of Well Data and Analytical Results

Vertical Measurements are in feet. Analytical results are in parts per billion (ppb)

DATE	Well Head Elev.	Ground Water Elev.	Depth To Water	Notes	TPH-Gasoline	Benzene	Toluene	Ethyl-Benzene	Xylene	MTBE	Organic Lead
C-6											
03/26/85	--	--	16.74	--	--	--	--	--	--	--	--
07/03/86	275.28	257.82	17.46	--	--	--	--	--	--	--	--
03/26/87	275.28	256.91	18.37	--	--	--	--	--	--	--	--
03/28/88	275.28	245.44	29.84	--	--	--	--	--	--	--	--
03/10/89	275.28	260.84	14.44	--	--	--	--	--	--	--	--
04/03/89	275.28	260.84	14.44	--	--	--	--	--	--	--	--
05/08/89	275.28	258.12	17.16	--	--	--	--	--	--	--	--
06/05/89	275.28	256.77	18.51	--	--	--	--	--	--	--	--
07/12/90	275.28	256.57	18.71	--	--	--	--	--	--	--	--
08/10/90	275.28	255.96	19.32	--	--	--	--	--	--	--	--
09/13/89	275.28	255.33	19.95	--	47	5600	3000	2400	10,000	--	--
10/04/89	275.28	255.41	19.87	--	--	--	--	--	--	--	--
11/03/89	275.28	255.93	19.35	--	--	--	--	--	--	--	--
12/04/89	275.28	255.69	19.59	--	40,000	8100	1800	1700	7500	--	--
03/07/90	275.28	256.89	18.39	--	--	--	--	--	--	--	--
03/09/90	275.28	256.89	18.39	--	73,000	23,000	5900	3400	17,000	--	--
06/12/90	275.28	256.41	18.87	--	85,000	19,000	6500	3400	16,000	--	--
09/24/90	275.28	255.29	19.99	--	72,000	15,000	3200	2600	11,000	--	--
12/20/90	275.28	253.71	21.57	--	100,000	11,000	4200	3400	16,000	--	--
03/27/91	275.28	258.96	16.32	--	100,000	11,000	4400	2300	11,000	--	--
06/18/91	275.28	251.95	23.33	--	--	--	--	--	--	--	--
09/12/91	275.28	251.32	23.96	--	--	--	--	--	--	--	--
01/23/92	275.28	263.20	12.08	--	--	--	--	--	--	--	--
04/13/92	275.28	255.43	19.85	Sheen	--	--	--	--	--	--	--
08/03/92	275.28	260.56	14.72	--	120,000	16,000	1100	2300	15,000	--	ND
10/22/92	275.28	260.37	14.91	--	63,000	7400	920	1800	14,000	--	--
01/18/93	275.28	259.84	15.44	--	77,000	13,000	1600	2700	12,000	--	--
04/19/93	275.28	266.03	9.25	--	56,000	14,000	1100	2400	9100	--	--
07/21,22/93	275.28	257.93	17.35	--	38,000	6600	610	1500	5800	--	--
10/25/93	275.28	254.25	21.03	--	42,000	11,000	800	2200	8200	--	--
01/21/94	275.28	253.71	21.57	--	57,000	11,000	940	2300	9800	--	--
04/18/94	275.28	257.17	18.11	--	48,000	9800	830	1900	7500	--	--
07/06-07/94	275.28	258.28	17.00	--	46,000	6800	610	900	6200	--	--
10/07/94	275.28	256.09	19.19	--	35,000	5900	410	1400	3800	--	--

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Cumulative Table of Well Data and Analytical Results

Vertical Measurements are in feet. Analytical results are in parts per billion (ppb)

DATE	Well Head Elev.	Ground Water Elev.	Depth To Water	Notes	TPH-Gasoline	Benzene	Toluene	Ethyl-Benzene	Xylene	MTBE	Organic Lead
C-6 (CONT'D)											
01/11/95	275.28	256.64	18.64	--	54,000	1200	1100	2100	9500	--	--
04/24/95	275.28	262.72	12.56	--	81,000	12,000	1500	2400	9900	--	--
07/31/95	275.28	259.54	15.74	--	75,000	12,000	1200	2800	11,000	--	--
10/02/95	275.28	257.56	17.72	--	59,000	13,000	990	2800	10,000	--	--
01/16/96	275.28	259.81	15.47	--	63,000	10,000	650	2200	7500	<500	--
04/18/96	275.28	259.33	15.95	--	56,000	9800	590	1500	5800	660	--
07/22/96	275.28	--	--	Inaccessible	--	--	--	--	--	--	--
10/10/96	275.28	--	--	Inaccessible	--	--	--	--	--	--	--

Cumulative Table of Well Data and Analytical Results

Vertical Measurements are in feet. Analytical results are in parts per billion (ppb)

DATE	Well Head Elev.	Ground Water Elev.	Depth To Water	Notes	TPH-Gasoline	Benzene	Toluene	Ethyl-Benzene	Xylene	MTBE	Organic Lead
C-7											
03/26/85	--	--	9.61	--	--	--	--	--	--	--	--
07/03/86	270.70	259.96	10.74	--	--	--	--	--	--	--	--
03/26/87	270.70	260.62	10.08	--	--	--	--	--	--	--	--
03/28/88	270.70	256.91	13.79	--	--	--	--	--	--	--	--
03/10/89	270.70	260.28	10.42	--	--	--	--	--	--	--	--
04/03/89	270.70	261.56	9.14	--	--	--	--	--	--	--	--
05/08/89	270.70	258.79	11.91	--	--	--	--	--	--	--	--
06/05/89	270.70	259.16	11.54	--	--	--	--	--	--	--	--
07/12/90	270.70	257.25	13.45	--	--	--	--	--	--	--	--
08/10/90	270.70	257.33	13.37	--	--	--	--	--	--	--	--
09/13/89	270.70	256.10	14.60	--	410	1.3	ND	10	ND	--	--
10/04/89	270.70	255.53	15.17	--	--	--	--	--	--	--	--
11/03/89	270.70	255.42	15.28	--	--	--	--	--	--	--	--
12/04/89	270.70	255.00	15.70	--	1000	1.0	ND	5.0	ND	--	--
03/07/90	270.70	256.48	14.22	--	--	--	--	--	--	--	--
03/09/90	270.70	256.48	14.22	--	590	2.8	2.4	3.5	2.0	--	--
06/12/90	270.70	256.52	14.18	--	1200	ND	5	8.2	3.2	--	--
09/24/90	270.70	255.26	15.44	Sheen	400	1.4	1.9	1.4	2.2	--	--
09/24/90	270.70	255.26	15.44	Duplicate	580	ND	2.4	1.4	1.5	--	--
12/20/90	270.70	253.62	17.08	--	2300	ND	6.5	4.7	9.3	--	--
03/27/91	270.70	258.05	12.65	--	980	ND	2.4	9.1	3.0	--	--
06/18/91	270.70	254.26	16.44	--	--	--	--	--	--	--	--
09/12/91	270.70	253.65	17.05	--	1200	ND	3.1	6.5	2.7	--	--
01/23/92	270.70	253.78	16.92	--	--	--	--	--	--	--	--
04/13/92	270.70	257.70	13.00	--	830	ND	1.0	7.8	1.2	--	--
08/03/92	270.70	--	--	--	--	--	--	--	--	--	--
10/22/92	270.70	--	--	Could not locate	--	--	--	--	--	--	--
01/18/93	270.70	--	--	Could not locate	--	--	--	--	--	--	--
04/19/93	270.70	--	--	Could not locate	--	--	--	--	--	--	--
07/21,22/93	270.70	257.76	12.94	--	890	0.9	3.0	4.0	4.0	--	--
10/25/93	270.70	255.87	14.83	--	--	--	--	--	--	--	--

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Cumulative Table of Well Data and Analytical Results

Vertical Measurements are in feet. Analytical results are in parts per billion (ppb)

DATE	Well Head Elev.	Ground Water Elev.	Depth To Water	Notes	TPH-Gasoline	Benzene	Toluene	Ethyl-Benzene	Xylene	MTBE	Organic Lead
C-7 (CONT'D)											
01/21/94	270.70	254.76	15.94	--	660	ND	6.0	1.0	3.0	--	--
04/18/94	270.70	255.72	14.98	--	--	--	--	--	--	--	--
07/06-07/94	270.70	257.76	12.94	--	960	ND	5.8	4.2	8.2	--	--
10/07/94	270.70	254.87	15.83	--	--	--	--	--	--	--	--
01/11/95	270.70	261.45	9.25	Sampled biannually	900	<0.5	<0.5	2.3	1.3	--	--
04/24/95	270.70	264.00	6.70	--	--	--	--	--	--	--	--
07/31/95	270.70	259.46	11.24	--	690	<1.2	<1.2	<1.2	<1.2	--	--
10/02/95	270.70	256.68	14.02	--	--	--	--	--	--	--	--
01/16/96	270.70	259.48	11.22	--	<50	<0.5	<0.5	<0.5	<0.5	<2.5	--
04/18/96	270.70	264.05	6.65	--	--	--	--	--	--	--	--
07/22/96	270.70	259.60	11.10	--	360	4.4	2.0	<0.5	<0.5	17	--
10/10/96	270.70	259.35	11.35	--	--	--	--	--	--	--	--

Cumulative Table of Well Data and Analytical Results

Vertical Measurements are in feet. Analytical results are in parts per billion (ppb)

DATE	Well Head Elev.	Ground Water Elev.	Depth To Water	Notes	TPH-Gasoline	Benzene	Toluene	Ethyl-Benzene	Xylene	MTBE	Organic Lead
C-8											
03/26/85	--	--	8.68	--	--	--	--	--	--	--	--
07/03/86	288.40	274.51	13.89	--	--	--	--	--	--	--	--
03/26/87	288.40	282.39	6.01	--	--	--	--	--	--	--	--
03/28/88	288.40	277.74	10.66	--	--	--	--	--	--	--	--
03/10/89	288.40	281.79	6.61	--	--	--	--	--	--	--	--
04/03/89	288.40	281.94	6.46	--	--	--	--	--	--	--	--
05/08/89	288.40	279.43	8.97	--	--	--	--	--	--	--	--
06/05/89	288.40	277.52	10.88	--	--	--	--	--	--	--	--
07/12/90	288.40	276.25	12.15	--	--	--	--	--	--	--	--
08/10/90	288.40	275.94	12.46	--	--	--	--	--	--	--	--
09/13/89	288.40	275.62	12.78	--	ND	ND	ND	ND	ND	--	--
10/04/89	288.40	275.89	12.51	--	--	--	--	--	--	--	--
11/03/89	288.40	273.77	14.63	--	--	--	--	--	--	--	--
12/04/89	288.40	278.81	9.59	--	64	0.6	0.6	ND	1.0	--	--
03/07/90	288.40	279.60	8.80	--	--	--	--	--	--	--	--
03/09/90	288.40	279.60	8.80	--	ND	ND	ND	ND	ND	--	--
06/12/90	288.40	279.46	8.94	--	120	2.5	1.2	1.0	1.4	--	--
09/24/90	288.40	274.86	13.54	--	--	--	--	--	--	--	--
12/20/90	288.40	279.07	9.33	--	--	--	--	--	--	--	--
03/27/91	288.40	282.30	6.10	--	54	0.7	ND	0.7	1.9	--	--
06/18/91	288.40	276.44	11.96	--	--	--	--	--	--	--	--
09/12/91	288.40	274.80	13.60	--	ND	ND	ND	ND	ND	--	--
09/12/91	288.40	274.80	13.60	Duplicate	ND	ND	ND	ND	ND	--	--
01/23/92	288.40	264.20	24.20	--	--	--	--	--	--	--	--
04/13/92	288.40	280.05	8.35	--	ND	ND	ND	ND	ND	--	--
08/03/92	288.40	275.82	12.58	--	ND	ND	ND	ND	ND	--	ND
10/22/92	288.40	275.30	13.10	--	ND	ND	ND	ND	ND	--	--
01/18/93	288.40	282.28	6.12	--	ND	ND	ND	ND	ND	--	--
04/19/93	288.40	281.35	7.05	--	ND	ND	ND	ND	ND	--	--
07/21,22/93	288.40	277.05	11.35	--	ND	ND	ND	ND	ND	--	--
10/25/93	288.40	275.55	12.85	--	ND	ND	ND	ND	ND	--	--

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Cumulative Table of Well Data and Analytical Results

Vertical Measurements are in feet. Analytical results are in parts per billion (ppb)

DATE	Well Head Elev.	Ground Water Elev.	Depth To Water	Notes	TPH-Gasoline	Benzene	Toluene	Ethyl-Benzene	Xylene	MTBE	Organic Lead
C-8 (CONT'D)											
01/21/94	288.40	277.85	10.55	--	ND	ND	ND	ND	ND	--	--
04/18/94	288.40	278.89	9.51	--	ND	1.2	0.9	ND	1.6	--	--
07/06-07/94	288.40	277.02	11.38	--	ND	ND	ND	ND	ND	--	--
10/07/94	288.40	275.48	12.92	--	ND	ND	ND	ND	ND	--	--
01/11/95	288.40	283.04	5.36	--	<50	<0.5	<0.5	<0.5	<0.5	--	--
04/24/95	288.40	281.82	6.58	--	<50	<0.5	0.61	<0.5	0.51	--	--
07/31/95	288.40	278.94	9.46	--	<50	<0.5	<0.5	<0.5	<0.5	--	--
10/02/95	288.40	276.56	11.84	--	<50	<0.5	<0.5	<0.5	<0.5	--	--
01/16/96	288.40	281.40	7.00	--	<50	<0.5	<0.5	<0.5	<0.5	5.4	--
04/18/96	288.40	281.77	6.63	--	<50	<0.5	<0.5	<0.5	<0.5	<2.5	--
07/22/96	288.40	280.49	7.91	--	<50	<0.5	<0.5	<0.5	<0.5	<2.5	--
10/10/96	288.40	279.71	8.69	--	<50	<0.5	<0.5	<0.5	<0.5	<2.5	--

Cumulative Table of Well Data and Analytical Results

Vertical Measurements are in feet. Analytical results are in parts per billion (ppb)

DATE	Well Head Elev.	Ground Water Elev.	Depth To Water	Notes	TPH-Gasoline	Benzene	Toluene	Ethyl-Benzene	Xylene	MTBE	Organic Lead
C-9											
07/03/86	268.46	254.57	13.89	--	--	--	--	--	--	--	--
03/26/87	268.46	254.72	13.74	--	--	--	--	--	--	--	--
03/28/88	268.46	253.47	14.99	--	--	--	--	--	--	--	--
03/10/89	268.46	255.07	13.39	--	--	--	--	--	--	--	--
04/03/89	268.46	255.62	12.84	--	--	--	--	--	--	--	--
05/08/89	268.46	254.08	14.38	--	--	--	--	--	--	--	--
06/05/89	268.46	253.10	15.36	--	--	--	--	--	--	--	--
07/12/90	268.46	252.81	15.65	--	--	--	--	--	--	--	--
08/10/90	268.46	252.66	15.80	--	--	--	--	--	--	--	--
09/13/89	268.46	251.93	16.53	--	42,000	14,000	1100	2800	4200	--	--
10/04/89	268.46	251.94	16.52	--	--	--	--	--	--	--	--
11/03/89	268.46	251.95	16.51	--	--	--	--	--	--	--	--
12/04/89	268.46	251.67	16.79	--	36,000	11,000	670	2500	3800	--	--
03/07/90	268.46	252.24	16.22	--	--	--	--	--	--	--	--
03/09/90	268.46	252.24	16.22	--	28,000	12,000	940	3000	4700	--	--
06/12/90	268.46	253.58	14.88	--	39,000	11,000	1600	2300	4800	--	--
09/24/90	268.46	252.16	16.30	--	120,000	13,000	1600	3700	6800	--	--
12/20/90	268.46	251.23	17.23	--	51,000	9300	560	2800	3300	--	--
12/20/90	268.46	251.23	17.23	Duplicate	44,000	12,000	580	2800	3500	--	--
03/27/91	268.46	254.68	13.78	--	56,000	3400	5000	1600	5600	--	--
06/18/91	268.46	249.82	18.64	--	--	--	--	--	--	--	--
09/12/91	268.46	--	--	Inaccessible	--	--	--	--	--	--	--
10/24/95	268.46	250.39	18.07	--	30,000	7200	440	2500	1600	--	--
01/16/96	268.46	252.18	16.28	--	36,000	8200	700	2500	2100	<500	--

NO LONGER MONITORED OR SAMPLED

Cumulative Table of Well Data and Analytical Results

Vertical Measurements are in feet. Analytical results are in parts per billion (ppb)

DATE	Well Head Elev.	Ground Water Elev.	Depth To Water	Notes	TPH-Gasoline	Benzene	Toluene	Ethyl-Benzene	Xylene	MTBE	Organic Lead
C-10A											
03/07/90	264.84	244.63	20.21	--	--	--	--	--	--	--	--
03/09/90	264.84	--	--	--	ND	1.6	0.7	0.8	3.5	--	--
06/12/90	264.84	245.14	19.70	--	ND	ND	ND	ND	ND	--	--
09/24/90	264.84	245.30	19.54	--	ND	ND	ND	ND	ND	--	--
12/20/90	264.84	245.00	19.84	--	ND	ND	ND	ND	ND	--	--
03/27/91	264.84	246.83	18.01	--	--	--	--	--	--	--	--
06/18/91	264.84	244.68	20.16	--	ND	ND	ND	ND	ND	--	--
09/12/91	264.84	244.27	20.57	--	ND	ND	ND	ND	ND	--	--
01/23/92	264.84	244.17	20.67	--	ND	ND	ND	ND	ND	--	--
04/13/92	264.84	245.44	19.40	--	53	0.9	1.3	ND	1.0	--	--
08/03/92	264.84	245.03	19.81	--	ND	ND	ND	ND	ND	--	ND
10/22/92	264.84	245.01	19.83	--	ND	ND	ND	ND	0.5	--	--
01/18/93	264.84	247.80	17.04	--	ND	ND	ND	ND	ND	--	--
04/19/93	264.84	247.07	17.77	--	ND	ND	ND	ND	ND	--	--
04/19/93	264.84	247.28	17.56	--	ND	ND	ND	ND	ND	--	--
10/25/93	264.84	247.07	17.77	--	ND	ND	ND	ND	ND	--	--
01/21/94	264.84	246.93	17.91	--	ND	ND	ND	ND	ND	--	--
04/18/94	264.84	247.81	17.03	--	ND	3.0	3.0	1.4	5.5	--	--
07/06-07/94	264.84	248.06	16.78	--	ND	ND	ND	ND	ND	--	--
10/07/94	264.84	247.63	17.21	--	ND	ND	ND	ND	ND	--	--
01/11/95	264.84	248.78	16.06	--	<50	<0.5	<0.5	<0.5	<0.5	--	--
04/24/95	264.84	248.32	16.52	--	<50	<0.5	<0.5	<0.5	<0.5	--	--
07/31/95	264.84	245.82	19.02	--	<50	<0.5	<0.5	<0.5	<0.5	--	--
10/02/95	264.84	245.14	19.70	--	<50	<0.5	<0.5	<0.5	<0.5	--	--
01/16/96	264.84	246.21	18.63	--	<50	<0.5	<0.5	<0.5	<0.5	<2.5	--
04/18/96	264.84	247.19	17.65	--	<50	<0.5	<0.5	<0.5	<0.5	<2.5	--
07/22/96	264.84	245.99	18.85	--	<50	<0.5	<0.5	<0.5	<0.5	<2.5	--
10/10/96	264.84	245.40	19.44	--	<50	<0.5	<0.5	<0.5	<0.5	<2.5	--

Cumulative Table of Well Data and Analytical Results

Vertical Measurements are in feet. Analytical results are in parts per billion (ppb)

DATE	Well Head Elev.	Ground Water Elev.	Depth To Water	Notes	TPH-Gasoline	Benzene	Toluene	Ethyl-Benzene	Xylene	MTBE	Organic Lead
C-10B											
03/07/90	264.85	243.41	21.44	--	--	--	--	--	--	--	--
06/12/90	264.85	244.91	19.94	--	ND	ND	ND	ND	ND	--	--
09/24/90	264.85	245.08	19.77	--	ND	ND	ND	ND	ND	--	--
12/20/90	264.85	244.85	20.00	--	ND	ND	ND	ND	ND	--	--
03/27/91	264.85	246.62	18.23	--	--	--	--	--	--	--	--
06/18/91	264.85	244.41	20.44	--	--	--	--	--	--	--	--
09/12/91	264.85	244.03	20.82	--	ND	ND	ND	ND	ND	--	--
01/23/92	264.85	243.93	20.92	--	ND	ND	ND	ND	ND	--	--
04/13/92	264.85	245.17	19.68	--	ND	ND	ND	ND	ND	--	--
08/03/92	264.85	244.78	20.07	--	ND	ND	ND	ND	ND	--	ND
10/22/92	264.85	244.73	20.12	--	ND	ND	ND	ND	ND	--	--
01/18/93	264.85	247.49	17.36	--	60	3.3	11	2.1	8.9	--	--
04/19/93	264.85	246.95	17.90	--	ND	ND	ND	ND	ND	--	--
07/21,22/93	264.85	246.99	17.86	--	ND	ND	ND	ND	ND	--	--
10/25/93	264.85	246.75	18.10	--	ND	ND	ND	ND	ND	--	--
01/21/94	264.85	246.62	18.23	--	ND	ND	ND	ND	ND	--	--
04/18/94	264.85	247.49	17.36	--	ND	ND	ND	ND	0.5	--	--
07/06-07/94	264.85	247.80	17.05	--	ND	ND	ND	ND	ND	--	--
10/07/94	264.85	247.31	17.54	--	ND	ND	ND	ND	ND	--	--
01/11/95	264.85	248.61	16.24	--	<50	<0.5	<0.5	<0.5	<0.5	--	--
04/24/95	264.85	247.95	16.90	--	<50	<0.5	<0.5	<0.5	<0.5	--	--
07/31/95	264.85	245.57	19.28	--	<50	<0.5	<0.5	<0.5	<0.5	--	--
10/02/95	264.85	244.91	19.94	--	<50	<0.5	<0.5	<0.5	<0.5	--	--
01/16/96	264.85	246.25	18.60	--	<50	<0.5	<0.5	<0.5	<0.5	<2.5	--
04/18/96	264.85	246.87	17.98	--	<50	<0.5	<0.5	<0.5	<0.5	<2.5	--
07/22/96	264.85	245.75	19.10	--	<50	<0.5	<0.5	<0.5	<0.5	<2.5	--
10/10/96	264.85	245.14	19.71	--	<50	<0.5	<0.5	<0.5	<0.5	<2.5	--

Cumulative Table of Well Data and Analytical Results

Vertical Measurements are in feet. Analytical results are in parts per billion (ppb)

DATE	Well Head Elev.	Ground Water Elev.	Depth To Water	Notes	TPH-Gasoline	Benzene	Toluene	Ethyl-Benzene	Xylene	MTBE	Organic Lead
C-11											
03/07/90	265.30	242.56	22.74	--	--	--	--	--	--	--	--
03/09/90	265.30	--	--	--	ND	1.2	0.7	ND	1.4	--	--
06/12/90	265.30	243.32	21.98	--	ND	ND	ND	ND	ND	--	--
09/24/90	265.30	243.42	21.88	--	ND	ND	ND	ND	ND	--	--
12/20/90	265.30	242.12	23.18	--	ND	ND	ND	ND	ND	--	--
03/27/91	265.30	243.78	21.52	--	ND	ND	ND	ND	1.5	--	--
06/18/91	265.30	243.40	21.90	--	--	--	--	--	--	--	--
09/12/91	265.30	242.60	22.70	--	ND	ND	ND	ND	ND	--	--
01/23/92	265.30	241.84	23.46	--	ND	ND	ND	ND	ND	--	--
04/13/92	265.30	243.73	21.57	--	ND	ND	ND	ND	ND	--	--
08/03/92	265.30	242.63	22.67	--	ND	ND	ND	ND	ND	--	ND
10/22/92	265.30	242.01	23.29	--	ND	ND	ND	ND	ND	--	--
01/18/93	265.30	243.94	21.36	--	ND	ND	1.2	ND	2.2	--	--
04/19/93	265.30	245.33	19.97	--	ND	ND	ND	ND	ND	--	--
07/21,22/93	265.30	244.65	20.65	--	ND	ND	ND	ND	ND	--	--
10/25/93	265.30	244.55	20.75	--	ND	ND	ND	ND	ND	--	--
01/21/94	265.30	243.69	21.61	--	ND	ND	ND	ND	ND	--	--
04/18/94	265.30	244.52	20.78	--	ND	ND	ND	ND	ND	--	--
07/06-07/94	265.30	244.88	20.42	--	ND	ND	ND	ND	ND	--	--
10/07/94	265.30	243.70	21.60	--	ND	ND	ND	ND	ND	--	--
01/11/95	265.30	245.28	20.02	--	<50	<0.5	<0.5	<0.5	<0.5	--	--
04/24/95	265.30	247.58	17.72	--	<50	<0.5	<0.5	<0.5	<0.5	--	--
07/31/95	265.30	246.12	19.18	--	<50	<0.5	<0.5	<0.5	<0.5	--	--
10/02/95	265.30	244.88	20.42	--	<50	<0.5	<0.5	<0.5	<0.5	--	--
01/16/96	265.30	245.48	19.82	--	<50	<0.5	<0.5	<0.5	<0.5	<2.5	--
04/18/96	265.30	248.30	17.00	--	260	7.9	6.9	5.3	23	11	--
07/22/96	265.30	248.40	16.90	--	<50	<0.5	<0.5	<0.5	<0.5	<2.5	--
10/10/96	265.30	245.74	19.56	--	130	32	2.7	4.3	14	3.4	--

Cumulative Table of Well Data and Analytical Results

Vertical Measurements are in feet. Analytical results are in parts per billion (ppb)

DATE	Well Head Elev.	Ground Water Elev.	Depth To Water	Notes	TPH-Gasoline	Benzene	Toluene	Ethyl-Benzene	Xylene	MTBE	Organic Lead
C-12											
03/07/90	269.66	254.74	14.92	--	--	--	--	--	--	--	--
03/09/90	269.66	--	--	--	1400	230	140	33	180	--	--
06/12/90	269.66	254.87	14.79	--	720	190	71	18	73	--	--
09/24/90	269.66	253.94	15.72	--	ND	1.1	ND	ND	0.6	--	--
12/20/90	269.66	254.40	15.26	--	810	210	26	8.2	23	--	--
03/27/91	269.66	257.55	12.11	--	2900	350	220	52	210	--	--
06/18/91	269.66	253.28	16.38	--	--	--	--	--	--	--	--
09/12/91	269.66	252.11	17.55	--	350	59	12	4.5	8.5	--	--
01/23/92	269.66	252.55	17.11	--	450	110	31	7.9	22	--	--
04/13/92	269.66	255.26	14.40	--	5000	1100	76	100	200	--	--
08/03/92	269.66	253.83	15.83	--	520	200	21	13	25	--	ND
10/22/92	269.66	253.52	16.14	--	1300	310	66	35	56	--	--
01/18/93	269.66	257.96	11.70	--	5600	1200	430	220	610	--	--
04/19/93	269.66	256.61	13.05	--	2000	600	99	96	170	--	--
07/21,22/93	269.66	256.82	12.84	--	540	95	36	18	56	--	--
10/25/93	269.66	255.63	14.03	--	350	90	29	20	50	--	--
01/21/94	269.66	255.51	14.15	--	450	73	18	14	37	--	--
04/18/94	269.66	256.71	12.95	--	370	70	21	12	39	--	--
07/06-07/94	269.66	257.35	12.31	--	840	200	35	28	66	--	--
10/07/94	269.66	256.31	13.35	--	830	85	29	17	63	--	--
01/11/95	269.66	258.43	11.23	--	2100	570	190	98	390	--	--
04/24/95	269.66	259.34	10.32	--	820	120	28	23	61	--	--
07/31/95	269.66	256.92	12.74	--	520	79	13	16	42	--	--
10/02/95	269.66	255.26	14.40	--	400	50	5.3	11	29	--	--
01/16/96	269.66	256.94	12.72	--	1900	490	32	60	120	<25	--
04/18/96	269.66	258.91	10.75	--	2900	640	54	100	190	68	--
07/22/96	269.66	256.46	13.20	--	730	150	13	26	75	9.5	--
10/10/96	269.66	255.95	13.71	--	270	58	4.4	7.7	31	<2.5	--

Cumulative Table of Well Data and Analytical Results

Vertical Measurements are in feet. Analytical results are in parts per billion (ppb)

DATE	Well Head Elev.	Ground Water Elev.	Depth To Water	Notes	TPH-Gasoline	Benzene	Toluene	Ethyl-Benzene	Xylene	MTBE	Organic Lead
C-13											
03/07/90	284.32	273.14	11.18	--	--	--	--	--	--	--	--
03/09/90	284.32	--	--	--	ND	15	3.7	1.0	6.2	--	--
06/12/90	284.32	273.62	10.70	--	ND	2.6	ND	ND	ND	--	--
09/24/90	284.32	272.72	11.60	--	ND	2.4	ND	ND	ND	--	--
12/20/90	284.32	274.16	10.16	--	ND	1.6	ND	ND	ND	--	--
03/27/91	284.32	276.68	7.64	--	--	--	--	--	--	--	--
06/18/91	284.32	273.00	11.32	--	--	--	--	--	--	--	--
09/12/91	284.32	272.48	11.84	--	ND	ND	ND	ND	ND	--	--
01/23/92	284.32	273.77	10.55	--	--	--	--	--	--	--	--
04/13/92	284.32	273.36	10.96	--	ND	1.0	ND	ND	ND	--	--
08/03/92	284.32	273.42	10.90	--	ND	ND	ND	ND	ND	--	ND
10/22/92	284.32	273.14	11.18	--	--	--	--	--	--	--	--
01/18/93	284.32	276.92	7.40	--	290	54	10	5.4	12	--	--
04/19/93	284.32	275.39	8.93	--	--	--	--	--	--	--	--
07/21,22/93	284.32	273.57	10.75	--	ND	ND	ND	ND	ND	--	--
10/25/93	284.32	273.47	10.85	--	--	--	--	--	--	--	--
01/21/94	284.32	273.27	11.05	--	ND	ND	ND	ND	ND	--	--
04/18/94	284.32	273.61	10.71	--	--	--	--	--	--	--	--
07/06-07/94	284.32	273.67	10.65	--	ND	0.5	ND	ND	ND	--	--
10/07/94	284.32	273.24	11.08	--	--	--	--	--	--	--	--
01/11/95	284.32	278.94	5.38	Sampled bi-annually	120	15	<0.5	3.1	2.7	--	--
04/24/95	284.32	276.54	7.78	--	--	--	--	--	--	--	--
07/31/95	284.32	274.38	9.94	--	<50	<0.5	<0.5	<0.5	<0.5	--	--
10/02/95	284.32	273.74	10.58	--	--	--	--	--	--	--	--
01/16/96	284.32	274.52	9.80	--	<50	<0.5	<0.5	<0.5	<0.5	<2.5	--
04/18/96	284.32	276.57	7.75	--	--	--	--	--	--	--	--
07/22/96	284.32	274.82	9.50	--	59	18	<0.5	1.0	<0.5	<2.5	--
10/10/96	284.32	273.63	10.69	--	--	--	--	--	--	--	--

Cumulative Table of Well Data and Analytical Results

Vertical Measurements are in feet. Analytical results are in parts per billion (ppb)

DATE	Well Head Elev.	Ground Water Elev.	Depth To Water	Notes	TPH-Gasoline	Benzene	Toluene	Ethyl-Benzene	Xylene	MTBE	Organic Lead
C-14											
03/07/90	270.74	255.56	15.18	--	--	--	--	--	--	--	--
03/09/90	270.74	--	--	--	ND	ND	ND	ND	ND	--	--
06/12/90	270.74	257.32	13.42	--	ND	ND	ND	ND	ND	--	--
09/24/90	270.74	257.90	12.84	--	ND	ND	ND	ND	ND	--	--
12/20/90	270.74	254.02	16.72	--	ND	1.7	0.7	ND	0.7	--	--
03/27/91	270.74	262.74	8.00	--	ND	ND	ND	ND	1.3	--	--
06/18/91	270.74	255.53	15.21	--	--	--	--	--	--	--	--
09/12/91	270.74	255.13	15.61	--	ND	ND	ND	ND	ND	--	--
01/23/92	270.74	246.10	24.64	--	--	--	--	--	--	--	--
04/13/92	270.74	258.53	12.21	--	ND	ND	ND	ND	ND	--	--
08/03/92	270.74	256.10	14.64	--	ND	ND	ND	ND	ND	--	ND
10/22/92	270.74	253.80	16.94	--	--	--	--	--	--	--	--
01/18/93	270.74	265.64	5.10	--	ND	ND	ND	ND	ND	--	--
04/19/93	270.74	263.86	6.88	--	--	--	--	--	--	--	--
07/21,22/93	270.74	259.58	11.16	--	ND	ND	ND	ND	ND	--	--
10/25/93	270.74	256.87	13.87	--	--	--	--	--	--	--	--
01/21/94	270.74	255.42	15.32	--	ND	ND	ND	ND	ND	--	--
04/18/94	270.74	254.85	15.89	--	--	--	--	--	--	--	--
07/06-07/94	270.74	258.66	12.08	--	ND	ND	ND	ND	ND	--	--
10/07/94	270.74	255.45	15.29	--	--	--	--	--	--	--	--
01/11/95	270.74	266.94	3.80	Sampled bi-annually	<50	<0.5	<0.5	<0.5	<0.5	--	--
04/24/95	270.74	265.68	5.06	--	--	--	--	--	--	--	--
07/31/95	270.74	260.34	10.40	--	<50	<0.5	<0.5	<0.5	<0.5	--	--
10/02/95	270.74	257.20	13.54	--	--	--	--	--	--	--	--
01/16/96	270.74	259.62	11.12	--	<50	<0.5	<0.5	<0.5	<0.5	<2.5	--
04/18/96	270.74	265.78	4.96	--	--	--	--	--	--	--	--
07/22/96	270.74	259.89	10.85	--	<50	<0.5	<0.5	<0.5	<0.5	<2.5	--
10/10/96	270.74	261.44	9.30	--	--	--	--	--	--	--	--

Cumulative Table of Well Data and Analytical Results

Vertical Measurements are in feet. Analytical results are in parts per billion (ppb)

DATE	Well Head Elev.	Ground Water Elev.	Depth To Water	Notes	TPH-Gasoline	Benzene	Toluene	Ethyl-Benzene	Xylene	MTBE	Organic Lead
C-15											
03/07/90	246.15	235.05	11.10	--	--	--	--	--	--	--	--
03/09/90	246.15	--	--	--	410	ND	1.4	0.5	0.6	--	--
06/12/90	246.15	235.37	10.78	--	420	11	ND	ND	ND	--	--
09/24/90	246.15	235.22	10.93	--	430	ND	1.5	ND	ND	--	--
12/20/90	246.15	235.07	11.08	--	300	1.3	1.1	0.6	1.5	--	--
03/27/91	246.15	237.65	8.50	--	520	4.6	1.1	ND	1.0	--	--
06/18/91	246.15	235.32	10.83	--	290	ND	1.1	ND	ND	--	--
06/18/91	246.15	235.32	10.83	Duplicate	320	ND	1.3	ND	ND	--	--
09/12/91	246.15	235.10	11.05	--	330	ND	0.9	ND	ND	--	--
01/23/92	246.15	235.35	10.80	--	210	ND	0.6	ND	ND	--	--
01/23/92	246.15	235.35	10.80	Duplicate	190	1.2	0.8	ND	ND	--	--
04/13/92	246.15	236.57	9.58	--	430	1.8	ND	ND	ND	--	--
08/03/92	246.15	234.94	11.21	--	640	ND	2.1	0.7	1.3	--	ND
10/22/92	246.15	234.50	11.65	--	420	ND	ND	ND	0.8	--	--
01/18/93	246.15	239.03	7.12	--	640	7.0	3.0	2.9	6.7	--	--
04/19/93	246.15	237.22	8.93	--	260	6.0	2.0	0.7	ND	--	--
07/21,22/93	246.15	236.37	9.78	--	580	ND	8.0	ND	0.6	--	--
10/25/93	246.15	236.41	9.74	--	240	ND	12.0	ND	0.6	--	--
01/21/94	246.15	235.78	10.37	--	420	0.6	ND	0.6	ND	--	--
04/18/94	246.15	236.19	9.96	--	550	1.0	4.6	0.6	ND	--	--
07/06-07/94	246.15	235.92	10.23	--	660	0.7	ND	ND	0.7	--	--
10/07/94	246.15	235.47	10.68	--	440	13	0.8	ND	1.2	--	--
01/11/95	246.15	238.84	7.31	--	750	2.5	<0.5	<0.5	0.6	--	--
04/24/95	246.15	237.41	8.74	--	850	<0.5	<0.5	<0.5	<0.5	--	--
07/31/95	246.15	235.41	10.74	--	640	<0.5	1.6	<0.5	<0.5	--	--
10/02/95	246.15	234.83	11.32	--	560	<0.5	<0.5	<0.5	<0.5	--	--
01/16/96	246.15	235.58	10.57	--	740	<0.5	<0.5	<0.5	<0.5	<2.5	--
04/18/96	246.15	237.55	8.60	--	760	<0.5	<0.5	<0.5	<0.5	<2.5	--
07/22/96	246.15	235.57	10.58	--	690	<0.5	1.6	<0.5	<0.5	7.9	--
10/10/96	246.15	234.97	11.18	--	870	7.0	2.1	<0.5	<0.5	11	--

Cumulative Table of Well Data and Analytical Results

Vertical Measurements are in feet. Analytical results are in parts per billion (ppb)

DATE	Well Head Elev.	Ground Water Elev.	Depth To Water	Notes	TPH-Gasoline	Benzene	Toluene	Ethyl-Benzene	Xylene	MTBE	Organic Lead
C-16											
03/07/90	246.69	228.19	18.50	--	--	--	--	--	--	--	--
03/09/90	246.69	--	--	--	ND	ND	ND	ND	ND	--	--
06/12/90	246.69	235.27	11.42	--	ND	ND	ND	ND	ND	--	--
09/24/90	246.69	235.30	11.39	--	ND	ND	ND	ND	ND	--	--
12/20/90	246.69	235.12	11.57	--	ND	ND	ND	ND	0.7	--	--
03/27/91	246.69	237.93	8.76	--	ND	ND	ND	ND	1.3	--	--
03/27/91	246.69	237.93	8.76	Duplicate	ND	ND	ND	ND	1.2	--	--
06/18/91	246.69	235.51	11.18	--	ND	ND	ND	ND	ND	--	--
09/12/91	246.69	234.74	11.95	--	ND	ND	ND	ND	ND	--	--
01/23/92	246.69	234.28	12.41	--	ND	ND	ND	ND	ND	--	--
04/13/92	246.69	236.00	10.69	--	ND	ND	ND	ND	ND	--	--
08/03/92	246.69	234.49	12.20	--	ND	ND	ND	ND	ND	--	ND
10/22/92	246.69	234.09	12.60	--	ND	ND	ND	ND	ND	--	--
01/18/93	246.69	237.69	9.00	--	ND	ND	ND	ND	ND	--	--
04/19/93	246.69	236.80	9.89	--	ND	ND	ND	ND	ND	--	--
07/21,22/93	246.69	236.44	10.25	--	ND	ND	ND	ND	ND	--	--
10/25/93	246.69	235.73	10.96	--	ND	ND	ND	ND	ND	--	--
01/21/94	246.69	234.93	11.76	--	ND	ND	0.7	ND	1.0	--	--
04/18/94	246.69	235.47	11.22	--	ND	ND	ND	ND	ND	--	--
07/06-07/94	246.69	235.32	11.37	--	ND	ND	ND	ND	ND	--	--
10/07/94	246.69	234.30	12.39	--	ND	ND	ND	ND	ND	--	--
01/11/95	246.69	237.73	8.96	--	<50	<0.5	<0.5	<0.5	<0.5	--	--
04/24/95	246.69	236.31	10.38	--	<50	<0.5	<0.5	<0.5	<0.5	--	--
07/31/95	246.69	235.37	11.32	--	<50	<0.5	<0.5	<0.5	<0.5	--	--
10/02/95	246.69	234.29	12.40	--	<50	<0.5	<0.5	<0.5	<0.5	--	--
01/16/96	246.69	235.15	11.54	--	<50	<0.5	<0.5	<0.5	<0.5	<2.5	--
04/18/96	246.69	236.09	10.60	--	<50	<0.5	<0.5	<0.5	<0.5	<2.5	--
07/22/96	246.69	235.12	11.57	--	<50	<0.5	<0.5	<0.5	<0.5	<2.5	--
10/10/96	246.69	234.25	12.44	--	<50	<0.5	<0.5	<0.5	<0.5	<2.5	--

Cumulative Table of Well Data and Analytical Results

Vertical Measurements are in feet. Analytical results are in parts per billion (ppb)

DATE	Well Head Elev.	Ground Water Elev.	Depth To Water	Notes	TPH-Gasoline	Benzene	Toluene	Ethyl-Benzene	Xylene	MTBE	Organic Lead
RW											
12/04/89	--	--	--	--	62,000	29,000	1700	1800	8800	--	--
03/07/90	274.52	256.02	18.50	--	--	--	--	--	--	--	--
06/12/90	274.52	256.03	18.49	--	31,000	15,000	2000	560	3100	--	--
09/24/90	274.52	--	--	--	--	--	--	--	--	--	--
12/20/90	274.52	--	--	--	ND	0.5	ND	ND	1.2	--	--
03/27/91	274.52	--	--	--	--	--	--	--	--	--	--
06/18/91	274.52	--	--	--	--	--	--	--	--	--	--
09/12/91	274.52	--	--	Insufficient water	--	--	--	--	--	--	--
01/23/92	274.52	--	--	Insufficient water	--	--	--	--	--	--	--
04/13/92	274.52	--	--	Insufficient water	--	--	--	--	--	--	--
08/03/92	274.52	--	--	Insufficient water	--	--	--	--	--	--	--
10/22/92	274.52	--	--	Insufficient water	--	--	--	--	--	--	--
01/18/93	274.52	--	--	Insufficient water	--	--	--	--	--	--	--
04/19/93	274.52	--	--	Insufficient water	--	--	--	--	--	--	--
07/21,22/93	274.52	--	--	Insufficient water	--	--	--	--	--	--	--
10/25/93	274.52	--	--	--	--	--	--	--	--	--	--
01/21/94	274.52	--	--	--	--	--	--	--	--	--	--
04/18/94	274.52	--	--	--	--	--	--	--	--	--	--
07/06-07/94	274.52	--	--	--	--	--	--	--	--	--	--
10/07/94	274.52	--	--	--	--	--	--	--	--	--	--
10/24/95	274.52	256.63	17.89	--	37,000	11,000	380	1100	3000	--	--
01/16/96	274.52	259.09	15.43	--	59,000	17,000	660	1600	5400	<1000	--

NO LONGER MONITORED OR SAMPLED

Cumulative Table of Well Data and Analytical Results

Vertical Measurements are in feet. Analytical results are in parts per billion (ppb)

DATE	Well Head Elev.	Ground Water Elev.	Depth To Water	Notes	TPH-Gasoline	Benzene	Toluene	Ethyl-Benzene	Xylene	MTBE	Organic Lead
TRIP BLANK											
01/11/95	--	--	--	--	<50	<0.5	<0.5	<0.5	<0.5	--	--
04/24/95	--	--	--	--	<50	<0.5	<0.5	<0.5	<0.5	--	--
07/31/95	--	--	--	--	<50	<0.5	<0.5	<0.5	<0.5	--	--
10/02/95	--	--	--	--	<50	<0.5	<0.5	<0.5	<0.5	--	--
01/16/96	--	--	--	--	<50	<0.5	<0.5	<0.5	<0.5	--	--
04/18/96	--	--	--	--	<50	<0.5	<0.5	<0.5	<0.5	--	--
07/22/96	--	--	--	--	<50	<0.5	<0.5	<0.5	<0.5	--	--
10/10/96	--	--	--	--	<50	<0.5	<0.5	<0.5	<0.5	--	--

Note: Blaine Tech Services, Inc. began routine monitoring of the groundwater wells at this site on November 1, 1994. Earlier field data and analytical results are drawn from the November 4, 1994 Groundwater Technology, Inc. report.

ABBREVIATIONS:
TPH = Total Petroleum Hydrocarbons
ND = Not detected at or above the minimum quantitation limit. See laboratory reports for minimum quantitation limits.
MTBE = Methyl t-butyl ether

APPENDIX B

VAPOR PATHWAY RISK CALCULATIONS

TIER 1 - Ground Water to Indoor Air Risk - Monitoring Well C-9

Chevron Service Station 9-5607, 5269 Crow Canyon Road, Castro Valley, California

	Soil Specific Parameters		
ASTM 95	ρ_s	1.7	Bulk Density(g/cm^3)
ASTM 95	θ_{as}	0.26	Air Content (v/v)
ASTM 95	θ_{ws}	0.12	Water Content (v/v)
ASTM 95	θ_t	0.38	Porosity (v/v)
ASTM 95	θ_{acap}	0.038	Capillary Fringe Air Content (v/v)
ASTM 95	θ_{wcap}	0.342	Capillary Fringe Water Content (v/v)
ASTM 95	θ_{acrack}	0.26	Air Content in Foundation/Wall Cracks(v/v)
ASTM 95	θ_{wcrack}	0.12	Water Content in Foundation/Wall Cracks(v/v)
ASTM 95	h_v	295	Thickness of Vadose Zone (cm)
ASTM 95	h_{cap}	5	Thickness of Capillary Fringe (cm)
	Diffusivity Parameters		
ASTM 95	H	0.22	Henry's Constant for Benzene
ASTM 95	D^{air}	9.30E-02	Air Diffusion Coefficient (cm^2/s)
ASTM 95	D^{wat}	1.10E-05	Water Diffusion Coefficient (cm^2/s)
Calculated	D^{eff}_s	0.007258	Effective Diffusion Coefficient soil (cm^2/s)
Calculated	D^{eff}_{cap}	2.17E-05	Capillary Fringe Effective Diffusion Coefficient soil (cm^2/s)
Calculated	D^{eff}_{crack}	0.007258	Effective Diffusion Coefficient thru Foundation Cracks (cm^2/s)
Calculated	D^{eff}_{ws}	0.001108	Effective Diffusion Coefficient between ground water and soil surface (cm^2/s)
	Flux and Indoor Air Concentration		
Measured	C_w	8.2	Benzene concentration in ground water (mg/L)
unit conv	C_w	0.0082	Benzene concentration in ground water (mg/cm^3)
Calculated	$C_{v,eq}$	0.001804	Benzene conc. in vapor at ground water interface (mg/cm^3)
Calculated	F_{max}	6.66E-09	Maximum Diffusive Vapor Flux (mg/cm^2 sec)
ASTM 95	Lcrack	15	Enclosed Space Foundation or Wall Thickness (cm)
ASTM 95	n	0.01	Areal Fraction of Cracks in Foundation (cm^2/cm^2)
ASTM 95	Lb	200	Enclosed Space Volume/Infiltration Area Ratio (cm)
ASTM 95	ER_{air}-indoor	0.00014	Enclosed Space Air Exchange Rate (sec^{-1})
Calculated	C_{indoor}	1.35E-07	Indoor air concentration (mg/cm^3)
	Dose		
ASTM 95	IR_{air}-indoor	15	Indoor air inhalation rate - residential (m^3/day)
ASTM 95	EF	350	Exposure frequency - residential (day/yr)
ASTM 95	ED	30	Exposure duration - residential (yr)
Calculated	Dose	21254.3	Dose (mg)
	Risk		
ASTM 95	SFi	0.1	Benzene cancer slope factor (kg-day/mg)
ASTM 95	BW	70	Body weight (kg)
ASTM 95	ATc	70	Averaging time for carcinogens (yr)
Calculated	**Risk**	**1.19E-03**	**Ground water to indoor air Risk**

Notes:

ASTM 95 = American Society for Testing and Materials,1995. Standard Guide for Risk Based Corrective Action Applied at Petroleum Release Sites, E 1739-95.

Measured: Concentration of benzene in ground water from monitoring well C-9, collected on 1/16/1996.

Calculations: All calculations taken from ASTM 95 guidance. Formulas presented below.

TIER 1 - Ground Water to Indoor Air Risk - Monitoring Well C-9

Chevron Service Station 9-5607, 5269 Crow Canyon Road, Castro Valley, California

Formulas

$$D_s^{eff} = D^{air}\frac{\theta_{as}^{3.33}}{\theta_T^2} + D^{wat}\frac{1}{H}\frac{\theta_{ws}^{3.33}}{\theta_T^2}$$

$$D_{cap}^{eff} = D^{air}\frac{\theta_{acap}^{3.33}}{\theta_T^2} + D^{wat}\frac{1}{H}\frac{\theta_{wcap}^{3.33}}{\theta_T^2}$$

$$D_{crack}^{eff} = D^{air}\frac{\theta_{acrack}^{3.33}}{\theta_T^2} + D^{wat}\frac{1}{H}\frac{\theta_{wcrack}^{3.33}}{\theta_T^2}$$

$$D_{ws}^{eff} = \frac{\left(h_{cap} + h_v\right)}{\left[\frac{h_{cap}}{D_{cap}^{eff}} + \frac{h_v}{D_s^{eff}}\right]}$$

$$C_{v,eq} = H \times C_w$$

$$F_{max} = D_{ws}^{eff}\frac{C_{v,eq}}{h_v + h_{cap}}$$

$$C_{indoor} = \frac{F_{max} / \left(ER_{air-indoor} \times L_b\right)}{\left(1 + \left[\frac{D_{ws}^{eff} / \left(h_v + h_{cap}\right)}{ER \times L_b}\right] + \left[\frac{D_{ws}^{eff} / \left(h_v + h_{cap}\right)}{\left(D_{crack}^{eff} / L_{crack}\right) n}\right]\right)}$$

$$Dose = C_{indoor} \times IR_{air-indoor} \times EF \times ED$$

$$Risk = \frac{Dose \times SF_i}{BW \times AT}$$

TIER 1 - Ground Water to Indoor Air Risk - Sample Location SV-1

Chevron Service Station 9-5607, 5269 Crow Canyon Road, Castro Valley, California

	Soil Specific Parameters		
ASTM 95	ρ_s	1.7	Bulk Density(g/cm^3)
ASTM 95	θ_{as}	0.26	Air Content (v/v)
ASTM 95	θ_{ws}	0.12	Water Content (v/v)
ASTM 95	θ_t	0.38	Porosity (v/v)
ASTM 95	θ_{acap}	0.038	Capillary Fringe Air Content (v/v)
ASTM 95	θ_{wcap}	0.342	Capillary Fringe Water Content (v/v)
ASTM 95	θ_{acrack}	0.26	Air Content in Foundation/Wall Cracks(v/v)
ASTM 95	θ_{wcrack}	0.12	Water Content in Foundation/Wall Cracks(v/v)
ASTM 95	h_v	295	Thickness of Vadose Zone (cm)
ASTM 95	h_{cap}	5	Thickness of Capillary Fringe (cm)
	Diffusivity Parameters		
ASTM 95	H	0.22	Henry's Constant for Benzene
ASTM 95	D^{air}	9.30E-02	Air Diffusion Coefficient (cm^2/s)
ASTM 95	D^{wat}	1.10E-05	Water Diffusion Coefficient (cm^2/s)
Calculated	D^{eff}_s	0.007258	Effective Diffusion Coefficient soil (cm^2/s)
Calculated	D^{eff}_{cap}	2.17E-05	Capillary Fringe Effective Diffusion Coefficient soil (cm^2/s)
Calculated	D^{eff}_{crack}	0.007258	Effective Diffusion Coefficient thru Foundation Cracks (cm^2/s)
Calculated	D^{eff}_{ws}	0.001108	Effective Diffusion Coefficient between ground water and soil surface (cm^2/s)
	Flux and Indoor Air Concentration		
Measured	C_w	0.028	Benzene concentration in ground water (mg/L)
unit conv	C_w	0.000028	Benzene concentration in ground water (mg/cm^3)
Calculated	$C_{v,eq}$	6.16E-06	Benzene conc. in vapor at ground water interface (mg/cm^3)
Calculated	F_{max}	2.28E-11	Maximum Diffusive Vapor Flux (mg/cm^2 sec)
ASTM 95	Lcrack	15	Enclosed Space Foundation or Wall Thickness (cm)
ASTM 95	n	0.01	Areal Fraction of Cracks in Foundation (cm^2/cm^2)
ASTM 95	Lb	200	Enclosed Space Volume/Infiltration Area Ratio (cm)
ASTM 95	ER_{air}-indoor	0.00014	Enclosed Space Air Exchange Rate (sec^{-1})
Calculated	C_{indoor}	4.61E-10	Indoor air concentration (mg/cm^3)
	Dose		
ASTM 95	IR_{air}-indoor	15	Indoor air inhalation rate - residential (m^3/day)
ASTM 95	EF	350	Exposure frequency - residential (day/yr)
ASTM 95	ED	30	Exposure duration - residential (yr)
Calculated	Dose	72.6	Dose (mg)
	Risk		
ASTM 95	SFi	0.1	Benzene cancer slope factor (kg-day/mg)
ASTM 95	BW	70	Body weight (kg)
ASTM 95	ATc	70	Averaging time for carcinogens (yr)
Calculated	**Risk**	**4.06E-06**	**Ground water to indoor air Risk**

Notes:

ASTM 95 = American Society for Testing and Materials, 1995. Standard Guide for Risk Based Corrective Action Applied at Petroleum Release Sites, E 1739-95.

Measured: Concentration of benzene in ground water from sample location SV-1, collected on 8/19/1996.

Calculations: All calculations taken from ASTM 95 guidance. Formulas presented below.

TIER 1 - Ground Water to Indoor Air Risk - Sample Location SV-1

Chevron Service Station 9-5607, 5269 Crow Canyon Road, Castro Valley, California

Formulas

$$D_s^{eff} = D^{air}\frac{\theta_{as}^{3.33}}{\theta_T^2} + D^{wat}\frac{1}{H}\frac{\theta_{ws}^{3.33}}{\theta_T^2}$$

$$D_{cap}^{eff} = D^{air}\frac{\theta_{acap}^{3.33}}{\theta_T^2} + D^{wat}\frac{1}{H}\frac{\theta_{wcap}^{3.33}}{\theta_T^2}$$

$$D_{crack}^{eff} = D^{air}\frac{\theta_{acrack}^{3.33}}{\theta_T^2} + D^{wat}\frac{1}{H}\frac{\theta_{wcrack}^{3.33}}{\theta_T^2}$$

$$D_{ws}^{eff} = \frac{(h_{cap} + h_v)}{\left[\frac{h_{cap}}{D_{cap}^{eff}} + \frac{h_v}{D_s^{eff}}\right]}$$

$$C_{v,eq} = H \times C_w$$

$$F_{max} = D_{ws}^{eff}\frac{C_{v,eq}}{h_v + h_{cap}}$$

$$C_{indoor} = \frac{F_{max} / (ER_{air-indoor} \times L_b)}{\left(1 + \left[\frac{D_{ws}^{eff} / (h_v + h_{cap})}{ER \times L_b}\right] + \left[\frac{D_{ws}^{eff} / (h_v + h_{cap})}{(D_{crack}^{eff} / L_{crack})\, n}\right]\right)}$$

$$Dose = C_{indoor} \times IR_{air-indoor} \times EF \times ED$$

$$Risk = \frac{Dose}{BW \times AT} \times SF_i$$

TIER 1 - Indoor Air Risk Predicted by Soil Vapor Data - Sample Location SV-8

Former Chevron Service Station 9-5607, 5269 Crow Canyon Road, Castro Valley, California

	Soil Specific Parameters		
ASTM 95	ρ_s	1.7	Bulk Density(g/cm^3) or (kg/L)
ASTM 95	θ_{as}	0.26	Air Content (v/v)
ASTM 95	θ_{ws}	0.12	Water Content (v/v)
ASTM 95	θ_t	0.38	Porosity (v/v)
	d	91	Depth to (location of) vapor sample (cm) - 3 foot depth
	Diffusivity Parameters		
ASTM 95	H	0.22	Henry's Constant for Benzene
ASTM 95	D^{air}	9.30E-02	Air Diffusion Coefficient (cm^2/s)
ASTM 95	D^{wat}	1.10E-05	Water Diffusion Coefficient (cm^2/s)
Calculated	D^{eff}_s	0,007258	Effective Diffusion Coefficient soil (cm^2/s)
	Prediction of Flux From Benzene Concentration in Soil Vapor		
Lab Data	$C_{v,measured}$	40	Measured Benzene Concentration in Vapor (ppbv) - SV-8
Unit Conv	$C_{v,measured}$	0.13	Measured Benzene Concentration in Vapor (ug/L)
Calculated	F_{max}	1.03E-08	Maximum Diffusive Vapor Flux Predicted by Benzene Concentration in Soil Vapor (ug/cm^2-sec)
	Indoor Air Concentration		
ASTM 95	Lb	200	Enclosed Space Volume/Infiltration Area Ratio (cm)
ASTM 95	ER_{air}-indoor	0.00014	Enclosed Space Air Exchange Rate (sec^{-1})
Calculated	C_{indoor}	3.68E-07	Enclosed Space Air Concentration (ug/cm^3)
	Dose		
ASTM 95	IR_{air}-indoor	15	Daily Indoor Inhalation Rate (m^3/day)
ASTM 95	EF	350	Exposure Frequency (days/year)
ASTM 95	ED	30	Exposure Duration (years)
Calculated	Dose	57.909	Dose (mg)
	Risk		
CAL EPA	SF_i	0.1	California Cancer Slope Factor for Benzene (kg-day/mg)
ASTM 95	BW	70	Adult Body Weight (kg)
ASTM 95	AT_c	70	Averaging Time for Carcinogens (years)
Calculated	Risk	3.24E-06	Risk (positives/population)

Formulas

$$D_s^{eff} = D^{air}\frac{\theta_{as}^{3.33}}{\theta_T^2} + D^{wat}\frac{1}{H}\frac{\theta_{ws}^{3.33}}{\theta_T^2}$$

$$F_{max} = D_s^{eff}\frac{C_{v,measured}}{d}$$

$$C_{indoor} = \frac{F_{max}}{ER_{air-indoor} \times L_b}$$

$$Dose = C_{indoor} \times IR_{air-indoor} \times EF \times ED$$

$$Risk = \frac{Dose \times SF_i}{BW \times AT}$$

Notes:

ASTM 96 = American Society for Testing and Materials, 1995. Standard Guide for Risk Based Corrective Action Applied at Petroleum Release Sites, E 1739-95.

Lab Data: Benzene concentration in Soil Vapor determined by laboratory analysis of pore space vapor from soil boring SV-8 at 3 feet bgs.

Calculations: Effective diffusivity, diffusive vapor flux, enclosed space air concentration, dose and risk calculations from ASTM 95 guidance. Formulas presented above.

TIER 2 - Ground Water to Indoor Air Risk - Monitoring Well C-9

Chevron Service Station 9-5607, 5269 Crow Canyon Road, Castro Valley, California

	Soil Specific Parameters		
Lab Data	ρ_s	2.21	Bulk Density(g/cm^3)
Calculated	θ_{as}	0.01	Air Content (v/v)
Calculated	θ_{ws}	0.27	Water Content (v/v)
Lab Data	θ_t	0.28	Porosity (v/v)
Calculated	θ_{acap}	0.01	Capillary Fringe Air Content (v/v)
Calculated	θ_{wcap}	0.27	Capillary Fringe Water Content (v/v)
Calculated	h_v	386	Thickness of Vadose Zone (cm)
ASTM 95	h_{cap}	5	Thickness of Capillary Fringe (cm)
	Diffusivity Parameters		
ASTM 95	H	0.22	Henry's Constant for Benzene
ASTM 95	D^{air}	9.30E-02	Air Diffusion Coefficient (cm^2/s)
ASTM 95	D^{wat}	1.10E-05	Water Diffusion Coefficient (cm^2/s)
Calculated	D^{eff}_s	8.41E-06	Effective Diffusion Coefficient soil (cm^2/s)
Calculated	D^{eff}_{cap}	8.41E-06	Capillary Fringe Effective Diffusion Coefficient soil (cm^2/s)
Calculated	D^{eff}_{ws}	8.41E-06	Effective Diffusion Coefficient between ground water and soil surface (cm^2/s)
	Flux and Indoor Air Concentration		
Lab Data	C_w	8.2	Benzene concentration in ground water (mg/L)
unit conv	C_w	0.0082	Benzene concentration in ground water (mg/cm^3)
Calculated	$C_{v,eq}$	0.001804	Benzene conc. in vapor at ground water interface (mg/cm^3)
ASTM 95	Lb	200	Enclosed Space Volume/Infiltration Area Ratio (cm)
ASTM 95	ER_{air}-indoor	0.00014	Enclosed Space Air Exchange Rate (sec^{-1})
Calculated	F_{max}	3.88E-11	Maximum Diffusive Vapor Flux (mg/cm^2 sec)
Calculated	C_{indoor}	1.38E-09	Indoor air concentration (mg/cm^3)
	Dose		
ASTM 95	IR_{air}-indoor	15	Indoor air inhalation rate - residential (m^3/day)
ASTM 95	EF	350	Exposure frequency - residential (day/yr)
ASTM 95	ED	30	Exposure duration - residential (yr)
Calculated	Dose	218.0	Dose (mg)
	Risk		
ASTM 95	SFi	0.1	Benzene cancer slope factor (kg-day/mg)
ASTM 95	BW	70	Body weight (kg)
ASTM 95	ATc	70	Averaging time for carcinogens (yr)
Calculated	**Risk**	**1.22E-05**	**Ground water to indoor air Risk**

TIER 2 - Ground Water to Indoor Air Risk - Monitoring Well C-9

Chevron Service Station 9-5607, 5269 Crow Canyon Road, Castro Valley, California

Formulas

$$D_s^{eff} = D^{air}\frac{\theta_{as}^{3.33}}{\theta_T^2} + D^{wat}\frac{1}{H}\frac{\theta_{ws}^{3.33}}{\theta_T^2}$$

$$D_{cap}^{eff} = D^{air}\frac{\theta_{acap}^{3.33}}{\theta_T^2} + D^{wat}\frac{1}{H}\frac{\theta_{wcap}^{3.33}}{\theta_T^2}$$

$$D_{ws}^{eff} = \frac{\left(h_{cap} + h_v\right)}{\left[\frac{h_{cap}}{D_{cap}^{eff}} + \frac{h_v}{D_s^{eff}}\right]}$$

$$C_{v,eq} = H \times C_w$$

$$F_{\max} = D_{ws}^{eff}\frac{C_{v,eq}}{h_v + h_{cap}}$$

$$C_{indoor} = \frac{F_{\max}}{ER_{air-indoor} \times L_b}$$

$$Dose = C_{indoor} \times IR_{air-indoor} \times EF \times ED$$

$$Risk = \frac{Dose \times SF_i}{BW \times AT}$$

Notes:

ASTM 95 = American Society for Testing and Materials,1995. Standard Guide for Risk Based Corrective Action Applied at Petroleum Release Sites, E 1739-95.

Lab Data: Bulk Density and Porosity determined by laboratory analysis of soil from boring SV-1 at 6 feet below ground surface (bgs). Concentration of benzene in ground water from monitoring well C-9, collected on 1/16/1996.

Calculations: Vadose zone thickness = shallowest depth to ground water in monitoring well C-9 minus ASTM default capillary zone thickness (capillary zone thickness not measured). Air content and water content calculated from dry density and natural density in soil from boring SV-1 at 6 feet bgs (Calculation attached). All remaining calculations taken from ASTM 95 guidance. Formulas presented above.

TIER 2 - Ground Water to Indoor Air Risk - Sample Location SV-1

Chevron Service Station 9-5607, 5269 Crow Canyon Road, Castro Valley, California

	Soil Specific Parameters		
Lab Data	ρ_s	2.21	Bulk Density(g/cm^3)
Calculated	θ_{as}	0.01	Air Content (v/v)
Calculated	θ_{ws}	0.27	Water Content (v/v)
Lab Data	θ_t	0.28	Porosity (v/v)
Calculated	θ_{acap}	0.01	Capillary Fringe Air Content (v/v)
Calculated	θ_{wcap}	0.27	Capillary Fringe Water Content (v/v)
Calculated	h_v	696	Thickness of Vadose Zone (cm)
ASTM 95	h_{cap}	5	Thickness of Capillary Fringe (cm)
	Diffusivity Parameters		
ASTM 95	H	0.22	Henry's Constant for Benzene
ASTM 95	D^{air}	9.30E-02	Air Diffusion Coefficient (cm^2/s)
ASTM 95	D^{wat}	1.10E-05	Water Diffusion Coefficient (cm^2/s)
Calculated	D^{eff}_s	8.41E-06	Effective Diffusion Coefficient soil (cm^2/s)
Calculated	D^{eff}_{cap}	8.41E-06	Capillary Fringe Effective Diffusion Coefficient soil (cm^2/s)
Calculated	D^{eff}_{ws}	8.41E-06	Effective Diffusion Coefficient between ground water and soil surface (cm^2/s)
	Flux and Indoor Air Concentration		
Measured	C_w	0.028	Benzene concentration in ground water (mg/L)
unit conv	C_w	0.000028	Benzene concentration in ground water (mg/cm^3)
Calculated	$C_{v,eq}$	6.16E-06	Benzene conc. in vapor at ground water interface (mg/cm^3)
ASTM 95	Lb	200	Enclosed Space Volume/Infiltration Area Ratio (cm)
ASTM 95	ER_{air}-indoor	0.00014	Enclosed Space Air Exchange Rate (sec^{-1})
Calculated	F_{max}	7.39E-14	Maximum Diffusive Vapor Flux (mg/cm^2 sec)
Calculated	C_{indoor}	2.64E-12	Indoor air concentration (mg/cm^3)
	Dose		
ASTM 95	IR_{air}-indoor	15	Indoor air inhalation rate - residential (m^3/day)
ASTM 95	EF	350	Exposure frequency - residential (day/yr)
ASTM 95	ED	30	Exposure duration - residential (yr)
Calculated	Dose	0.4	Dose (mg)
	Risk		
ASTM 95	SFi	0.1	Benzene cancer slope factor (kg-day/mg)
ASTM 95	BW	70	Body weight (kg)
ASTM 95	ATc	70	Averaging time for carcinogens (yr)
Calculated	**Risk**	**2.32E-08**	**Ground water to indoor air Risk**

TIER 2 - Ground Water to Indoor Air Risk - Sample Location SV-1

Chevron Service Station 9-5607, 5269 Crow Canyon Road, Castro Valley, California

Formulas

$$D_s^{eff} = D^{air}\frac{\theta_{as}^{3.33}}{\theta_T^2} + D^{wat}\frac{1}{H}\frac{\theta_{ws}^{3.33}}{\theta_T^2}$$

$$D_{cap}^{eff} = D^{air}\frac{\theta_{acap}^{3.33}}{\theta_T^2} + D^{wat}\frac{1}{H}\frac{\theta_{wcap}^{3.33}}{\theta_T^2}$$

$$D_{ws}^{eff} = \frac{\left(h_{cap} + h_v\right)}{\left[\frac{h_{cap}}{D_{cap}^{eff}} + \frac{h_v}{D_s^{eff}}\right]}$$

$$C_{v,eq} = H \times C_w$$

$$F_{\max} = D_{ws}^{eff}\frac{C_{v,eq}}{h_v + h_{cap}}$$

$$C_{indoor} = \frac{F_{\max}}{ER_{air-indoor} \times L_b}$$

$$Dose = C_{indoor} \times IR_{air-indoor} \times EF \times ED$$

$$Risk = \frac{Dose}{BW \times AT} \times SF_i$$

Notes:

ASTM 95 = American Society for Testing and Materials, 1995. Standard Guide for Risk Based Corrective Action Applied at Petroleum Release Sites, E 1739-95.

Measured: Bulk Density and Porosity determined by laboratory analysis of soil from boring SV-1 at 6 feet below ground surface (bgs). Concentration of benzene in ground water from sample location SV-1, collected on 8/19/1996.

Calculations: Vadose zone thickness = depth to ground water at sample location SV-1 minus ASTM default capillary zone thickness (capillary zone thickness not measured). Air content and water content calculated from dry density and natural density in soil from boring SV-1 at 6 feet bgs (Calculation attached). All remaining calculations taken from ASTM 95 guidance. Formulas presented above.

Tier 2 - Indoor Air Risk Predicted by Soil Vapor Data - Sample Location SV-8

Former Chevron Service Station 9-5607, 5269 Crow Canyon Road, Castro Valley, California

	Soil Specific Parameters		
Lab Data	ρ_s	2.21	Bulk Density(g/cm^3) or (kg/L)
Calculated	θ_{as}	0.01	Air Content (v/v)
Calculated	θ_{ws}	0.27	Water Content (v/v)
Lab Data	θ_t	0.28	Porosity (v/v)
Site Spec	d	91	Depth to detected benzene (cm)
	Diffusivity Parameters		
ASTM 96	H	0.22	Henry's Constant for Benzene
ASTM 96	D^{air}	9.30E-02	Air Diffusion Coefficient (cm^2/s)
ASTM 96	D^{wat}	1.10E-05	Water Diffusion Coefficient (cm^2/s)
Calculated	D^{eff}_s	8.41E-06	Effective Diffusion Coefficient soil (cm^2/s)
	Prediction of Flux From Benzene Concentration in Soil Vapor		
Lab Data	$C_{v,measured}$	40	Measured Benzene Concentration in Vapor (ppbv)
Unit Conv	$C_{v,measured}$	0.13	Measured Benzene Concentration in Vapor (ug/L)
Calculated	F_{max}	1.19E-11	Maximum Diffusive Vapor Flux Predicted by Benzene Concentration in Soil Vapor (ug/cm^2-sec)
	Indoor Air Concentration		
ASTM 96	Lb	200	Enclosed Space Volume/Infiltration Area Ratio (cm)
ASTM 96	ER_{air}-indoor	0.00014	Enclosed Space Air Exchange Rate (sec^{-1})
Calculated	C_{indoor}	4.26E-10	Enclosed Space Air Concentration (ug/cm^3)
	Dose		
ASTM 96	IR_{air}-indoor	15	Daily Indoor Inhalation Rate (m^3/day)
ASTM 96	EF	350	Exposure Frequency (days/year)
ASTM 96	ED	30	Exposure Duration (years)
Calculated	Dose	0.067091	Dose (mg)
	Risk		
CAL EPA	SF_i	0.1	California Cancer Slope Factor for Benzene (kg-day/mg)
ASTM 96	BW	70	Adult Body Weight (kg)
ASTM 96	AT_c	70	Averaging Time for Carcinogens (years)
Calculated	Risk	3.75E-09	Risk (positives/population)

Formulas

$$D_s^{eff} = D^{air}\frac{\theta_{as}^{3.33}}{\theta_T^2} + D^{wat}\frac{1}{H}\frac{\theta_{ws}^{3.33}}{\theta_T^2}$$

$$F_{max} = D_s^{eff}\frac{C_{v,measured}}{d}$$

$$C_{indoor} = \frac{F_{max}}{ER_{air-indoor} \times L_b}$$

$$Dose = C_{indoor} \times IR_{air-indoor} \times EF \times ED$$

$$Risk = \frac{Dose \times SF_i}{BW \times AT}$$

Notes:

ASTM 96 = American Society for Testing and Materials, March 5, 1996. Standard Guide for Risk Based Corrective Action Applied at Petroleum Release Sites, E 1739-95.

Site Spec: Depth to detected benzene in the soil vapor sample from boring location SV-8.

Lab Data: Bulk density and porosity determied by laboratory analysis of soil from boring SV-1 at 6 feet below ground surface (bgs). Benzene concentration in Soil Vapor determined by laboratory analysis of pore space vapor from soil boring SV-8 at 3 feet bgs.

Calculations: Air content and water content calculated from dry density and natural density in soil from boring SV-1 at 6 feet bgs (Calculation attached). Effective diffusivity, diffusive vapor flux, enclosed space air concentration, dose and risk calculations from ASTM 96 guidance. Formulas presented above.

Outdoor Air Risk Predicted by Soil Vapor Data

Former Chevron Service Station 9-5607, 5269 Crow Canyon Road, Castro Valley, California

	Soil Specific Parameters		
Lab Data	ρ_s	2.21	Bulk Density(g/cm^3) or (kg/L)
Calculated	θ_{as}	0.01	Air Content (v/v)
Calculated	θ_{ws}	0.27	Water Content (v/v)
Lab Data	θ_t	0.28	Porosity (v/v)
Site Spec	d	91	Depth to detected benzene (cm)
	Diffusivity Parameters		
ASTM 96	H	0.22	Henry's Constant for Benzene
ASTM 96	D^{air}	9.30E-02	Air Diffusion Coefficient (cm^2/s)
ASTM 96	D^{wat}	1.10E-05	Water Diffusion Coefficient (cm^2/s)
Calculated	D^{eff}_s	8.41E-06	Effective Diffusion Coefficient soil (cm^2/s)
	Prediction of Flux From Benzene Concentration in Soil Vapor		
Lab Data	$C_{v,measured}$	40	Measured Benzene Concentration in Vapor (ppbv)
Unit Conv	$C_{v,measured}$	0.13	Measured Benzene Concentration in Vapor (ug/L)
Calculated	F_{max}	1.19E-11	Maximum Diffusive Vapor Flux Predicted by Benzene Concentration in Soil Vapor (ug/cm^2-sec)
	Outdoor Air Concentration		
ASTM 96	Uair	225	Air velocity (cm/sec)
ASTM 96	W	1500	Width of plume parallel to velocity (cm)
ASTM 96	δair	200	Ambient air mixing height (cm)
Calculated	$C_{v,outdoor}$	3.98E-13	Outdoor Air Concentration (ug/cm^3)
	Dose		
ASTM 96	IR_{air}-outdoor	20	Daily Outdoor Air Inhalation Rate (m^3/day)
ASTM 96	EF	350	Exposure Frequency (days/year)
ASTM 96	ED	30	Exposure Duration (years)
Calculated	Dose	8.35E-05	Dose (mg)
	Risk		
CAL EPA	SF_i	0.1	California Cancer Slope Factor for Benzene (kg-day/mg)
ASTM 96	BW	70	Adult Body Weight (kg)
ASTM 96	AT_c	70	Averaging Time for Carcinogens (years)
Calculated	$Risk_{sv}$	4.67E-12	Outdoor Air Risk Predicted by Soil Vapor Data

Formulas

$$D_s^{eff} = D^{air}\frac{\theta_{as}^{3.33}}{\theta_T^2} + D^{wat}\frac{1}{H}\frac{\theta_{ws}^{3.33}}{\theta_T^2}$$

$$F_{max} = D_s^{eff}\frac{C_{v,measured}}{d}$$

$$C_{v,outdoor} = \frac{F_{max} \times W}{U_{air} \times \delta_{air}}$$

$$Dose = C_{v,outdoor} \times IR_{air-indoor} \times EF \times ED$$

$$Risk_{sv} = \frac{Dose \times SF_i}{BW \times AT}$$

Notes:

ASTM 96 = American Society for Testing and Materials, March 5, 1996. Standard Guide for Risk Based Corrective Action Applied at Petroleum Release Sites, E 1739-95.

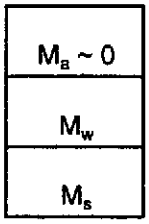
Site Spec: Depth to detected benzene in the soil vapor sample from boring location SV-8.

Lab Data: Porosity determied by laboratory analysis of soil from boring SV-1 at 6 feet below ground surface (bgs). Benzene concentration in Soil Vapor determined by laboratory analysis of pore space vapor from soil boring SV-8 at 3 feet bgs.

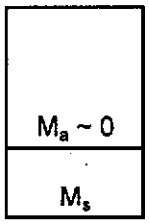
Calculations: Air content and water content calculated from dry density and natural density in soil from boring SV-1 at 6 feet bgs (Calculation attached). Effective diffusivity, diffusive vapor flux, outdoor air concentration, dose and risk calculations from ASTM 96 guidance. Formulas presented above.

Calculation of Air Content and Water Content

Former Chevron SS # 9-5607, 5269 Crow Canyon Road, Castro Valley, CA



$\rho_{natural} = (M_s + M_w) / V_t$



$\rho_{dry} = M_s / V_t$

Sample: SS-1 @ 6'

$\rho_{solids} = M_s / V_s = 2.68$ g/cc

Let $V_t = 1$cc

$\rho_{dry} = M_s / V_t = 1.94$ g/cc

$M_s = 1.94$g/cc x 1cc = 1.94 g

$\rho_{natural} = (M_s + M_w) / V_t = 2.21$ g/cc

$M_w = 2.21$ g/cc x 1cc - 1.94g = 0.27g

$M_w / V_w = 1$ g/cc

$V_w = 0.27$g / (1g/cc) = 0.27cc

$\theta_t = (V_a + V_w) / V_t = 0.28$ cc/cc

$V_a = 0.28$ cc/cc x 1 cc - 0.27 cc = 0.01 cc

$\theta_w = V_w / V_t$
$\theta_a = V_a / V_t$

Results
$\theta_t = 0.28$
$\theta_w = 0.27$
$\theta_a = 0.01$

Sample: SS-1 @ 10'

$\rho_{solids} = M_s / V_s = 2.69$ g/cc

Let $V_t = 1$cc

$\rho_{dry} = M_s / V_t = 1.84$ g/cc

$M_s = 1.84$g/cc x 1cc = 1.84 g

$\rho_{natural} = (M_s + M_w) / V_t = 2.16$ g/cc

$M_w = 2.16$ g/cc x 1cc - 1.84g = 0.32g

$M_w / V_w = 1$ g/cc

$V_w = 0.27$g / (1g/cc) = 0.32cc

$\theta_t = (V_a + V_w) / V_t = 0.32$ cc/cc

$V_a = 0.32$ cc/cc x 1 cc - 0.32 cc = 0.00 cc

$\theta_w = V_w / V_t$
$\theta_a = V_a / V_t$

Results
$\theta_t = 0.32$
$\theta_w = 0.32$
$\theta_a = 0.00$

APPENDIX C

FATE AND TRANSPORT ANALYSIS

MEMORANDUM

Richmond, California
August 13, 1992

Former Chevron Service Station No. 9-5607
5269 Crow Canyon Rd.
Castro Valley, CA.

Mr. C.B. Rogers,

As you requested, I have evaluated the present groundwater remediation system at former Chevron Service Station No. 9-5607 and make the following predictions concerning the fate and transport of dissolved benzene (see Site Map - Figure 1).

Paul Hildebrandt (CRTC) has used a numerical model to predict concentrations of dissolved benzene at the site. Various well placement options were incorporated into the models, to determine the most effective strategy to remediate the dissolve phase BTEX which has migrated off-site.

Benzene was the component considered for the model due to the following characteristics of the compound:

(a) it is considered a carcinogen, and as such is a primary substance to consider for site assessment and remediation activity.

(b) dissolved benzene is the most mobile of the BTEX compounds. As a means of comparison, Table 1, provides a list of pure phase solubility values and the organic carbon partition coefficient (Koc) of the BTEX components. The water solubility is the amount of a chemical that can dissolve in pure water at a specific temperature and pressure. The Koc is a measure of dissolved phase mobility, as the coefficient reflects the affinity of the compound to adsorb onto organic carbon within the sediment matrix.

Therefore, because benzene more readily dissolves in water and adheres less to the soil, it is more mobile than the other BTEX compounds.

Table 1

	Water Solub. (mg/L)	Koc (ml/g)
Benzene	1791	97
Toluene	535	300
Ethylbenzene	152	1100
Xylenes	130	240

Groundwater flow and contaminant fate of dissolved benzene, in the vicinity of the former Chevron facility, was modeled using MODFLOW/MT3D. MODFLOW is a finite difference model, developed by the U.S. Geological Survey for the purpose of simulating groundwater flow. MT3D is a finite difference model, developed in part by Konikow and Bredehoft of the U.S. Geological Survey, which simulates the fate and transport of dissolved compounds. This method of simulating partical movement has survived legal scrutiny at such sites as Rocky Flats, Colorado, and has been readily accepted by various federal and state regulatory agencies.

A finite difference model involves the approximation of the partial derivatives, which describe site conditions, by a series of algebraic expressions. As a result of the approximation, the partial differential equation describing the problem is replaced by a finite number of easier to compute algebraic equations. The values at selected points, the nodes on the finite difference grid (see Section a, below), become the unknowns which are solved by the series of algebraic equations.

The groundwater flow and contaminant fate and transport model presented in this memo is a combined MODFLOW/MT3D simulation. The groundwater flow simulation, using MODFLOW, is constructed first. The MODFLOW results are then stored for access by MT3D, the contaminant fate and transport portion of the model. The contaminant fate and transport model then accesses the groundwater flow data to generate a combined simulation.

The basic parameters used to construct the groundwater flow and contaminant fate model are shown on Tables A and B.

(a) Finite difference grid - The grid spacing represents the nodes used for the algebraic calculations of the model. The grid is constructed of 28 columns and 30 rows, with the nodes separated by 15 foot uniform spacing in the x and y directions.

(b) Specified head boundaries - depth to groundwater at the site is defined as 288 feet above sea level along the bottom row of

the grid (eastern portion of map), and 235 feet above sea level along Crow Creek, at the upper portion of the grid (western portion of the map).

The specified head boundaries define the groundwater gradient, which is based on groundwater elevations regularly measured at monitor wells C-1 to -3, -5 to -8, and -10 to -16. Groundwater elevation data has been unavailable from C-4 since September 24, 1990, as the well has not been located. Groundwater depth measurements are also not available for C-9 and RW-1 since June 18, 1991 and June 12, 1990, respectively, due to groundwater extraction at these wells.

(c) Aquifer thickness - the unconfined saturated thickness of the silts and clays are defined by information contained in the well installation logs. The installation logs are provided by Chevron consultants Groundwater Technology, Inc. (monitor wells C-1 to -9 and RW-1), and Pacific Environmental Group (monitor wells C-10 to -16).

Within the primary area of concern, between Crow Creek and the eastern boundary of the grid, the aquifer thickness is maintained at a constant 20 foot thickness.

(d) Bottom elevation - The bottom of the aquifer (sediment/bedrock interface), along with the measured groundwater elevation, defines the thickness of the aquifer. The depth to bedrock is available from the well installation logs.

(e) Hydraulic conductivity - the hydraulic conductivity is a measurement of the ability of a fluid to pass through a porous medium. The higher the hydraulic conductivity, the greater the ability of the liquid to pass through the medium. In this case, the value reflects the ability of water to flow through the silts and clays characterizing the saturated zone at the site.

The hydraulic conductivity values used in the model (clay - 0.0279 ft/day, = 1.0×10^{-5} cm/sec; silt - 0.2790 ft/day, =1.0×10^{-4} cm/sec) are based on published values for these specific soil types (Table 2.2, Groundwater, Freeze and Cherry, 1979, Prentice Hall).

(f) Specific porosity - the specific porosity reflects the percentage of the sediment composed of interconnected pore space, which will allow groundwater to flow. The value used in the model, 10%, is based on published numbers for silts and clays.

(g) Recharge - The Castro Valley area is characterized as a region of low annual rainfall, and little if any irrigation. Recharge, or net addition of surface water to the aquifer, is therefore neglected for the model.

(h) Evapotransportation - Depth to local groundwater is 20 feet below ground level. At this depth evaporation will be minimal and the factor was therefore not considered for the model.

(i) Source concentration - the presence of liquid phase hydrocarbon (LHC) in on-site groundwater indicates that a continual dissolved benzene source exists at the site.

The benzene source concentration is calculated as the product of the pure phase solubility (1791 mg/l) and the weight percent of benzene in gasoline. The pure phase solubility is a compound specific constant, at specific temperature and pressure conditions, and is readily available in published tables. The weight percent of benzene as a gasoline component has varied over time, and is assumed in this study to constitute 1.3% of the LHC present in on-site groundwater. A 1.3% benzene gasoline component is consistent with the 0.12-3.5% range stated in Appendix G of the California LUFT Manual as the weight percent of benzene in gasoline.

The source concentration is therefore calculated as 1791 mg/l x 0.013 = 24 mg/l (=24 ppm).

(j) Longitudinal dispersion - the dispersivity is an estimate of the degree of heterogeneity of the subsurface. The 15-30 foot values used in the model fall within the published range of clay/silt sediment, based on field studies.

(k) Transverse dispersion - published accounts of field studies suggest that the transverse dispersivity is commonly 0.1-0.2 of the longitudinal dispersion. The transverse dispersivity is a measurement of the subsurface heterogeneity, as it influences groundwater flow moving perpendicular to the gradient direction.

(l) Dry bulk density - a dry bulk density of 1.57 g/cm^3 was used in the calculations of contaminant fate. The 1.57 g/cm^3 is within the range of published values for a silt/clay sediment water bearing zone.

(m) Distribution coefficient - the distribution coefficient, K_d, is defined as the amount of compound (in mg) which will adsorb to 1 mg of soil. The distribution coefficient is calculated as the product of the adsorption coefficient (Koc), described above, and the total organic carbon content (TOC) of the soil.

The adsorption coefficient is a compound specific constant (Koc benzene = 97 ml/g), which is available in published texts. The TOC is estimated to be 0.05% (500 ppm) based on characteristic values for silt and clay sediment.

(n) Biodegradation half-life - the biodegradation half-life estimates the amount of time necessary to degrade 1/2 of the dissolved benzene in groundwater due to biologic activity. The

biodegradation half-life is dependent primarily on the amount of available oxygen in the saturated zone and the nature of the aquifer. In general, the greater the amount of dissolved oxygen and the more permeable the aquifer, the greater the rate of biodegradation and the smaller the half-life value.

Published values of benzene biodegradation half-life vary from approximately 60 to 730 days. The 110 day half-life used in the model is based on calibration of the model to measured dissolved benzene concentrations, and is consistent with published values of benzene half-life in a silt/clay saturated zone.

Results of computer generated model

1) Figure 2 shows the areal grid used to generate the groundwater flow model. Each box within the grid has the dimensions of 15 x 15 feet.

2) Figure 3 is a site map exhibiting the areas characterized as having a hydraulic conductivity of 0.0279 ft/day (unshaded area on map). The hydraulic conductivity of 0.0279 ft/day is consistent with the clay sedimentary matrix observed at the level of the water table at on-site and off-site monitor wells.

The shaded area of the map is calculated as having a hydraulic conductivity of 0.279 ft/day, based on the presence of predominantly silts at the level of the water table, in monitor well C-12. Subsurface sediment data is available in the well installation logs of the site assessment reports prepared for Chevron.

The shape of the shaded (silt) area on the map was varied until simulated benzene concentrations in downgradient monitor wells C-12, -10A and -10B approximated the actual benzene concentration measured from these wells.

3) Figure 4 shows the groundwater flow as simulated by the MODFLOW flow model. The groundwater flow pattern in Figure 4 is based on groundwater elevations measured on-site April 13, 1992.

The anomalous flow pattern near monitor well C-12 is the result of the higher permeable sediment present in this portion of the site, thereby influencing the groundwater flow.

4) The shaded area of Figure 5 represents the initial (1986) area of the site containing liquid phase hydrocarbon (LHC). The areal extent of the LHC is the source area of the dissolved benzene. As stated above, the concentration of dissolved benzene within the source area is 24 ppm.

The extent of the shaded area is based on the measurable presence

of LHC in MW-3 (GTI letter, March 7, 1985), recovery well RW-1 (GTI Update Report, July 31, 1986) and by calibration of the model to groundwater analytical data. The shape of the shaded area was varied slightly, until the simulated areal pattern of dissolved benzene approximated the observed dissolved benzene concentrations measured at the site.

5) Figure 6 represents 1992 dissolved benzene concentrations as predicted by the MODFLOW/MT3D computer generated groundwater flow and fate model. The initiation of the model simulation is 1986, with Figure 6 representing site conditions 6 years after initial site parameters were established (shown in Figure 5).

It should be noted that Figure 6 results assume no groundwater pumping at the site (see Table C for assumptions). A "no-pumping" situation represents a conservative set of parameters, which if anything, will tend to over-represent the downgradient extent of the dissolved benzene plume.

Comparison of the simulated results to actual dissolved benzene concentrations measured from groundwater samples (shown in bold type on Figure 6), provided the mechanism to calibrate the accuracy of the model. Figure 6 calibration was based on a comparison to April 13, 1992 groundwater analytical data.

The model predicts that the 1 ppb dissolved benzene contour does not presently reach Crow Creek. A biodegradation equilibrium front is present several feet downgradient of monitor wells MW-10A and -15. This equilibrium front is where biodegradation removes benzene at a rate which is equivalent to dissolution of benzene in the source area. Simply stated, benzene at the equilibrium front is degraded before it has a chance to migrate further.

6) Figure 7 shows predicted dissolved benzene concentrations 10 years after initial site conditions are established (corresponding to 1996 site conditions). As in Figure 6 results, this interpretation also assumes no groundwater extraction at the site.

The model predicts that under "steady state" conditions there is no net advance of dissolved benzene downgradient. Steady state conditions are defined as no fluctuations in the flow or water table elevations.

Dissolved benzene concentrations in downgradient monitor wells MW-10A, -10B and -15 have remained virtually unchanged since sampling began on these wells on March 7, 1990; further supporting these modeled results.

7) The data shown on Figure 8 represents the projected dissolved benzene concentrations in 1996, incorporating the effect of groundwater pumping from RW-1 and C-9 (see Table D). A pumping rate of 0.05-0.1 gpm is calculated into the model to simulate actual

site conditions. Groundwater extraction data are routinely supplied to Chevron by the consultant, Geraghty and Miller.

As stated on Table D, the model begins at Time = 0, corresponding to 1986. Extraction well RW-1 begins pumping 1490 days into the model (1990) at a rate of 0.1 gpm. At 1830 days (1991), the pumping rate of RW-1 is reduced to 0.05 gpm. Extraction well C-9 begins pumping at 1990 days (1991) at a rate of 0.1 gpm. At 2330 days (1992), the pumping rate is reduced to 0.05 gpm.

The variable pumping rates used in the model reflect the changing pumping rates observed on-site.

The total run time of the results displayed in Figure 8 corresponds to Time = 3650 days (1996).

The model suggests that the present groundwater extraction configuration, utilizing wells RW-1 and C-9, will have a minimal effect on reducing the downgradient benzene concentration over the next 4 years.

8) Figures 9 and 10 show model simulated groundwater elevation contour lines in response to pumping 1 and 2 wells, respectively (see Table D). Figure 9 contains only the groundwater extraction effect of pumping RW-1 at 0.1 gpm for 1 year. Figure 10 shows the effect of pumping RW-1 for 2 years (at 0.1 gpm - year 1, 0.05 gpm - year 2), and C-9 for 1 year at 0.1 gpm.

The estimated groundwater capture radius, based on model simulations, is 20-25 feet.

9) Figure 11 presents the groundwater elevation contour pattern in response to pumping RW-1, C-9 and C-6 (see Table E).

Figure 11 represents site conditions simulated for 1995, with RW-1, C-9 and C-6 pumping at 5, 4 and 3 years, respectively. The pumping rates of the 3 wells are listed on Table E. The pumping rates are shown to decrease with time due to the simulated dewatering effect that groundwater extraction has on the relatively low permeable aquifer.

10) Figure 12 shows model simulated groundwater elevation contour lines in response to pumping RW-1, C-9, RW-2 and C-6 (see Table F). RW-2 is located along the western property boundary, 40 feet from RW-1. Figure 12 represents site groundwater conditions in 1995, with RW-1, C-9, RW-2 and C-9 pumping 5, 4, 3 and 3 years, respectively. The pumping rates of the 4 wells are shown on Table F.

11) Figures 13 and 14 display the simulated dissolved benzene concentrations in response to pumping RW-1, C-9 and C-6. The pumping rates and other conditions concerning these figures are

presented on Table E. Figures 13 and 14 simulate conditions for 1994 and 1996, respectively.

It is apparent from the data presented in Figures 13 and 14 that the effect of pumping RW-1, C-9 and C-6, along with the biodegradation process, will reduce the concentration of downgradient hydrocarbons and "shrink" the dissolved hydrocarbon plume. The 3 pumping wells provide a partial barrier to off-site benzene migration as observed in the decreasing concentrations in the downgradient portion of the modeled area. The upgradient portion of the area, near the source, will still likely be characterized by elevated concentrations of dissolved benzene.

12) Figures 15 to 16 show simulated dissolved benzene concentrations in response to pumping RW-1, C-9, C-6 and RW-2. The pumping rates and other conditions concerning these wells are present in Table F. Figures 15 and 16 simulate site conditions for 1994 and 1996, respectively.

The simulations presented in Figures 15 and 16 indicate that the 4 pumping well model establishes a more effective benzene migration barrier than the previously discussed 3 pumping well model (compare Figures 14 and 15). Downgradient benzene concentrations are further reduced due to the more effective inhibition of off-site benzene migration.

It should be noted, however, that upgradient concentrations will still be elevated. The low attainable pumping rates, due to the relatively low permeability of the soil, make it difficult to establish a truly effective migration barrier.

In both the 3 and 4 pumping well cases, it is apparent that the potential impact of dissolved benzene on Crow Creek will be eliminated.

Summary

The MODFLOW/MT3D computer generated groundwater flow and contaminant fate model indicates the following:

(A) Dissolved benzene, originating from a source at the former Chevron facility, will not apparently impact Crow Creek. A no impact simulation is shown regardless of whether groundwater is pumped or not (Figures 6, 7 and 8).

(B) The present groundwater extraction system (RW-1 and C-9) does not provide sufficient capture to effectively limit the off-site migration of dissolved benzene (Figure 7 and 8).

(C) The 4 year simulation of a 3 pumping well situation indicates that the off-site migration of dissolved benzene is

reduced, as observed in the decreased concentrations in the downgradient portion of the modeled area. Upgradient concentrations, near the source, are still elevated.

The effect of the additional pumping well (C-6) is observed by comparing the pair of 1996 simulations presented in Figure 8 (pumping wells RW-1 and C-9) and Figure 14 (pumping wells RW-1, C-9 and C-6).

(D) The 4 year simulation of a 4 pumping well situation indicates that the off-site dissolved benzene migration is further inhibited by the addition of a hypothetical pumping well (RW-2). The effect of the various pumping configurations may be observed by comparing the 1996 simulations in Figures 8 (pumping wells RW-1 and C-9), Figure 14 (pumping wells RW-1, C-9 and C-6), and Figure 16 (pumping wells RW-1, C-9, C-6 and RW-2).

If you wish to discuss this site further, please contact me at CTN 242-1383.

Sheldon N. Nelson

cc: T.E. Buscheck
P.L. Hildebrandt
J.L. Pease
J.W. Hartwig

Table A **Title: GROUNDWATER FLOW MODEL PARAMETERS**

Flow Model	MODFLOW
Transport Model	MT3D
Problem Statement (Flow Model)	
Finite difference grid	28 columns by 30 rows
Grid spacing	15 foot uniform spacing in the x and y directions
Specified head boundaries	Constant head defined as 288 feet above sea level along the bottom row (east) and 235 feet above sea level along Crow Creek, at the top of the grid (west)
Layers	1 (unconfined aquifer)
Aquifer thickness	Set to 20 feet in transport model
Bottom elevation	Set at 268 feet along bottom row; thereafter, each successive row is set 2 feet less than the preceeding row
Hydraulic conductivity	Clay-0.0279 ft/d ($1x10^{-5}$ cm/sec) Silt-0.2790 ft/d ($1x10^{-4}$ cm/sec)
Porosity	10%
Recharge	Neglected
Evapotranspiration	Neglected

Table B Title: Benzene Fate Model Parameters

Problem Statement (Transport Model)	
Source concentration	24 ppm benzene
Dispersion (longitudinal)	15 feet (30 feet for first run w/no source removal)
Dispersion (transverse)	1.5 feet
Dry bulk density of soil	1.57 g/cm^3
K_d (distribution coefficient)	0.0485
K_{oc} (benzene)	97 ml/g
TOC (total organic carbon)	0.05% (500 ppm)
Biodegradation half-life ($t_{1/2}$)	110 days

Table C Title: Benzene Concentrations With No Pumping Simulation #1

Simulation #1

Assumptions

No pumping wells

Total run time is 10 years (1986-1996)

Constant benzene source (no source removal)

Area of source constant from start to finish

No change in constant head elevations

Table D **Title: Benzene Concentrations Including Effect of Pumping Simulation #2**

Simulation #2

Assumptions

Two pumping wells

	RW-1	C-9
Begin	1490 days (1990) 0.1 gpm	1990 days (1991) 0.1 gpm
Change in pumping rate	1830 days (1991) 0.05 gpm	2330 days (1992) 0.05 gpm

Total run time is 10 years, time = 0-3650 days (1986-1996)

Constant benzene source (no source removal)

Area of source constant from start to finish

No change in constant head elevations

Table E Benzene Concentrations Including Effect of Pumping Simulation #3

Simulation #3

Assumptions

Three pumping wells

	RW-1	C-9	C-6
Begin	1990 0.1 gpm	1991 0.1 gpm	1992 0.04 gpm
Change in pumping rate	1991 0.05 gpm	1992 0.05 gpm	1995 0.03 gpm
	1992 0.04 gpm	1995 0.045 gpm	
	1995 0.035 gpm		

Total run time is 13 years (1986-1999)

Constant source (no source removal)

Area of source constant from start to finish

No change in constant head elevations

Table F **Benzene Concentrations Including Effect of Pumping Simulation #6**

Simulation #6

Assumptions

Four pumping wells (add RW-2 as pumping well at same time as C-6).

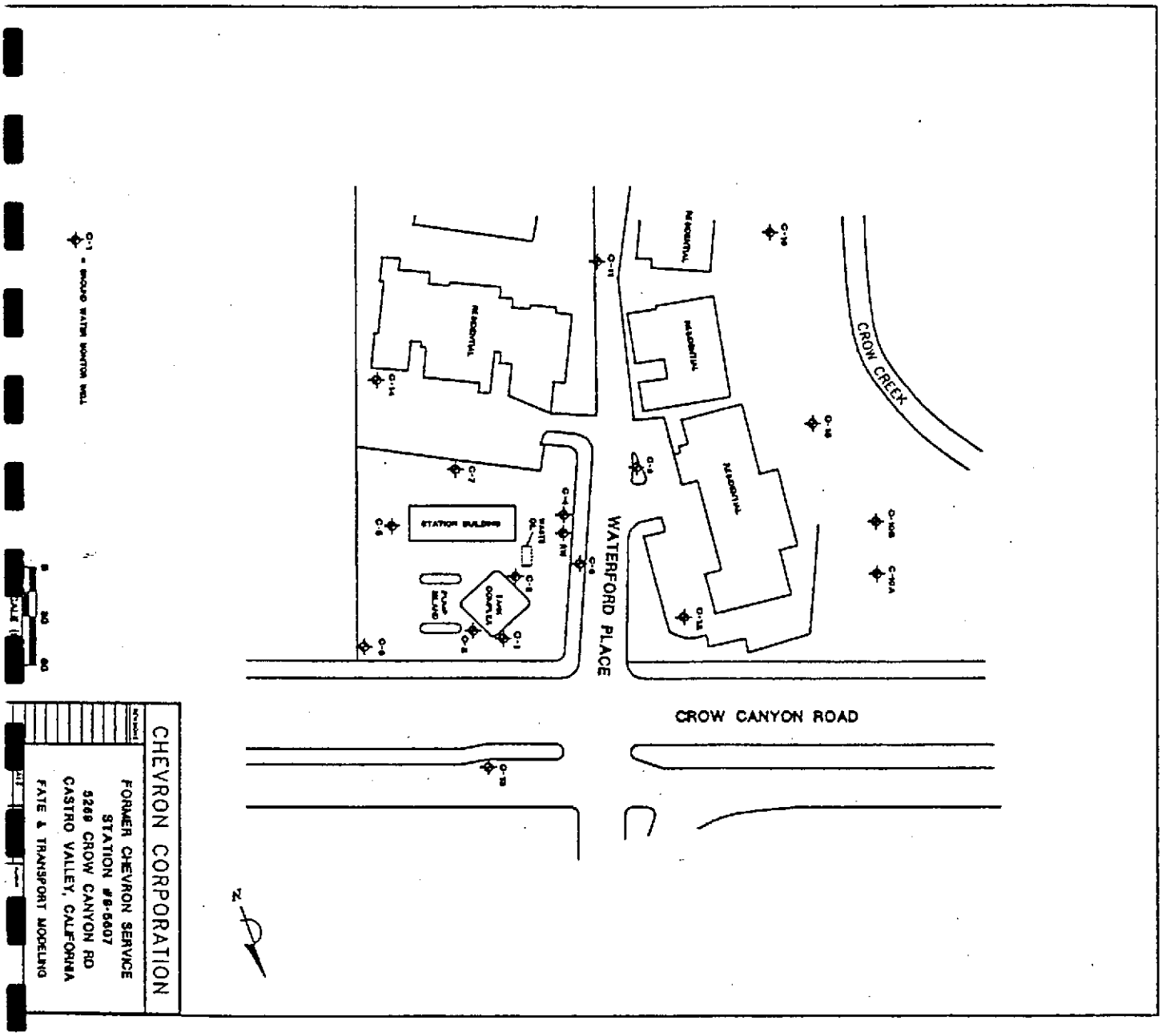
	RW-1	C-9	RW-2	C-6
Begin	1990 0.1 gpm	1991 0.1 gpm	1992 0.04 gpm	1992 0.03 gpm
Change in pumping rate	1991 0.05 gpm	1992 0.05 gpm	1995 0.02 gpm	1995 0.02 gpm
	1992 0.04 gpm	1995 0.045 gpm		
	1995 0.035 gpm			

Total run time is 13 years (1986-1999)

Constant source (no source removal)

Area of source constant from start to finish

No change in constant head elevations



Title: SITE PLAN

Figure 1

Figure 2

Title: AREAL GRID USED FOR MODEL

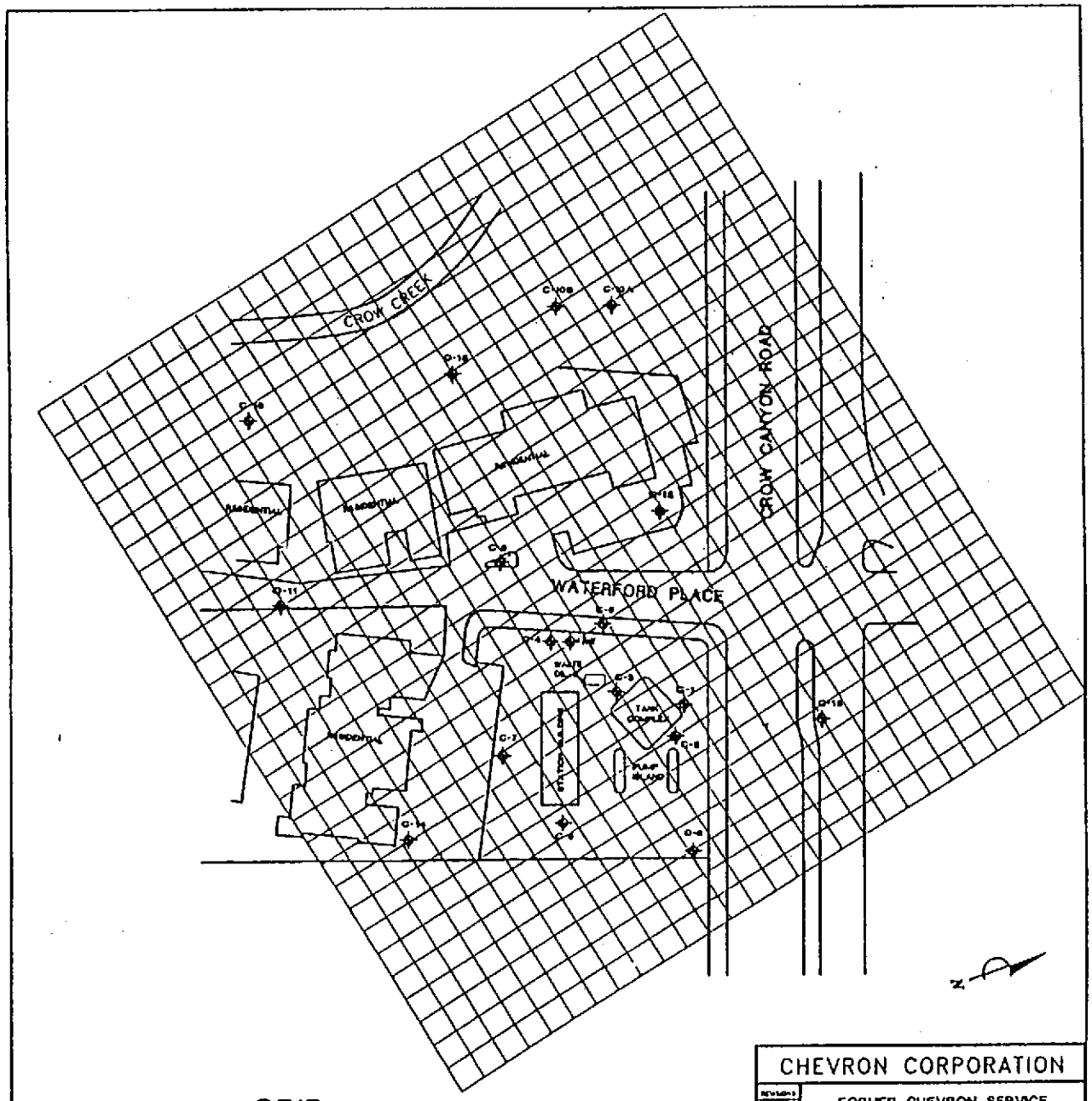


Figure 3.

Title: ILLUSTRATION OF HETEROGENEOUS HYDRAULIC CONDUCTIVITY IN SUBSURFACE

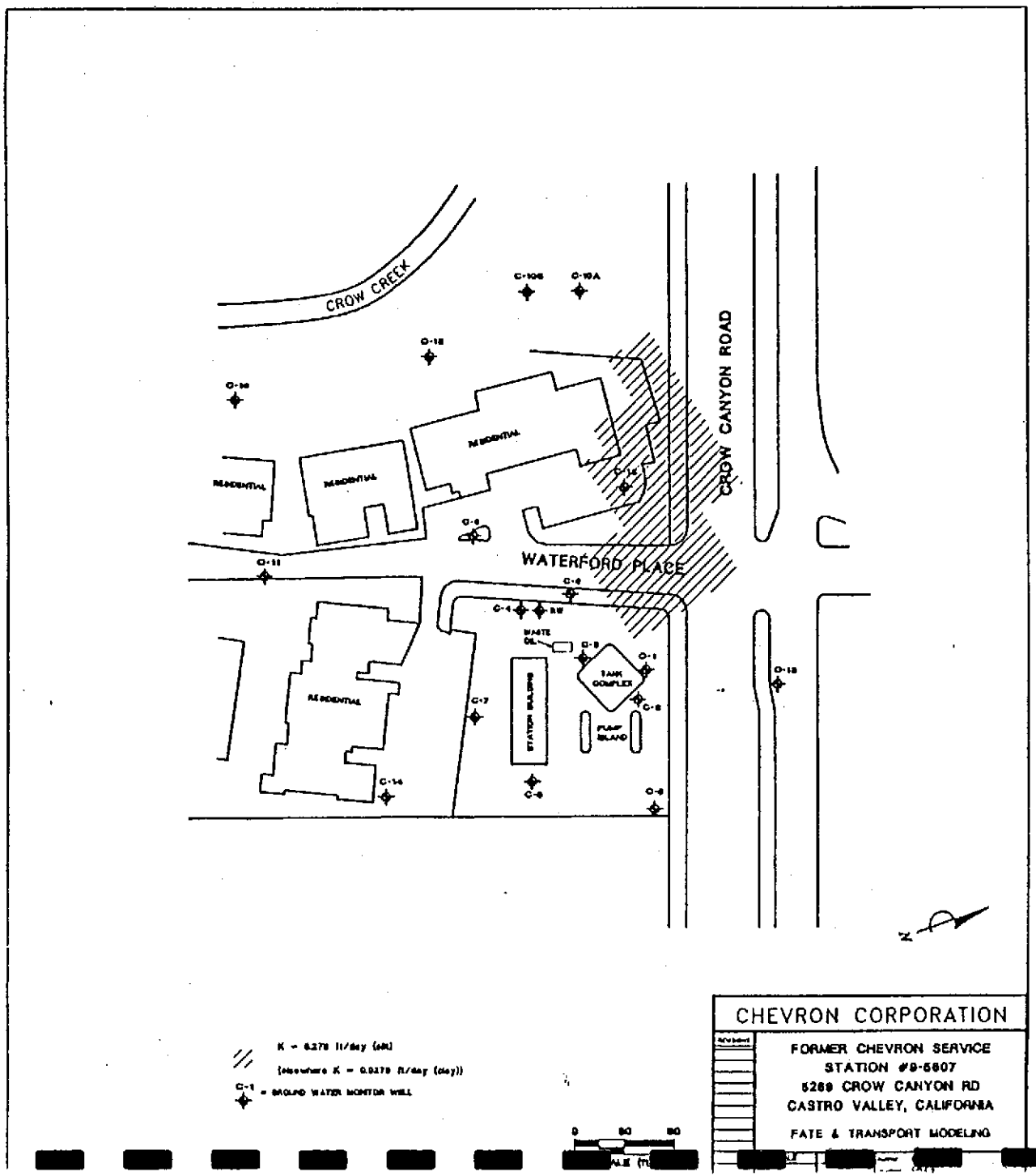


Figure 4

Title: GROUNDWATER ELEVATION CONTOURS - MODELED FROM 1992 FIELD DATA

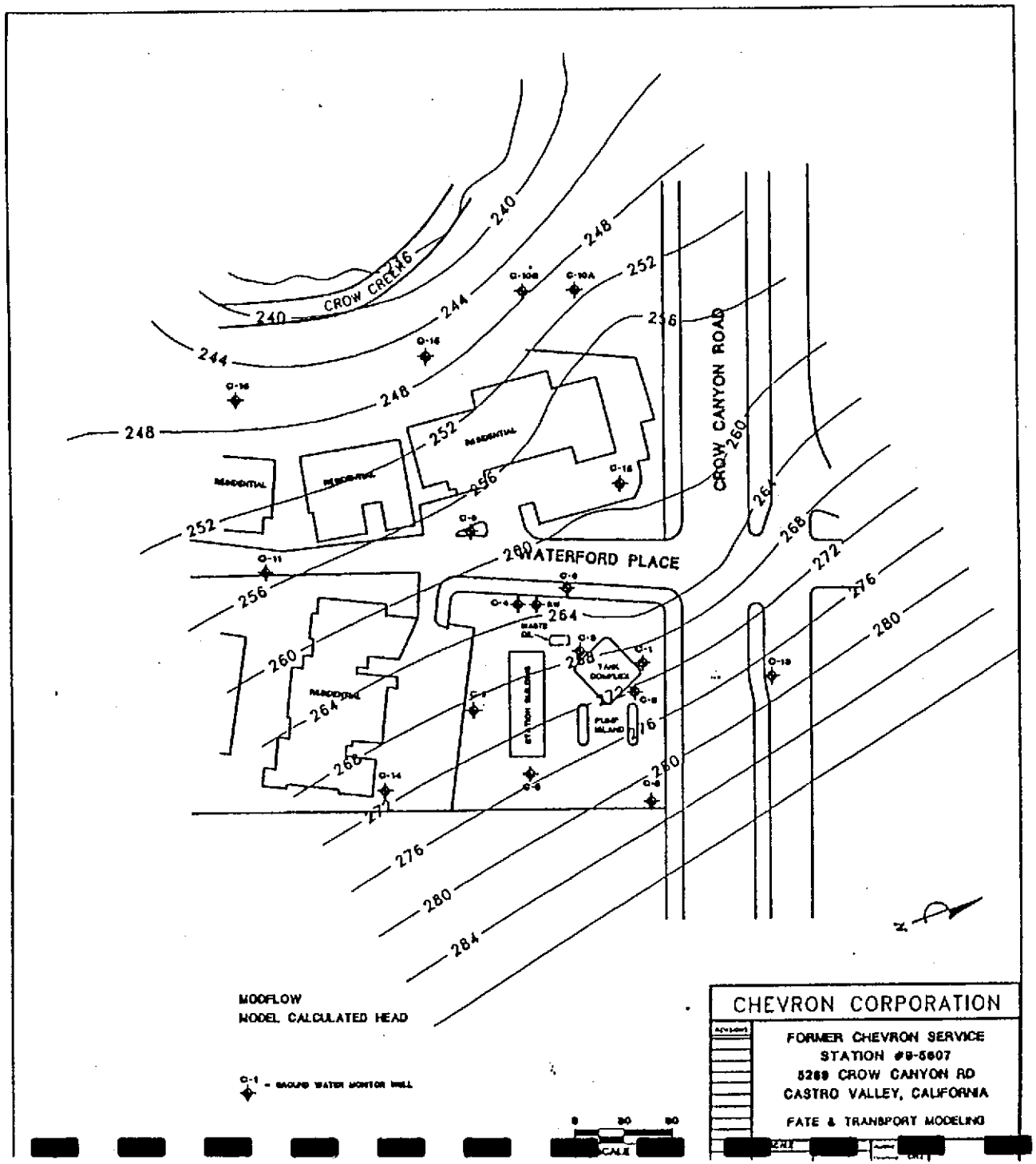


Figure 5.

Title: INITIAL LIQUID PHASE HYDROCARBON SOURCE AREA - 1986

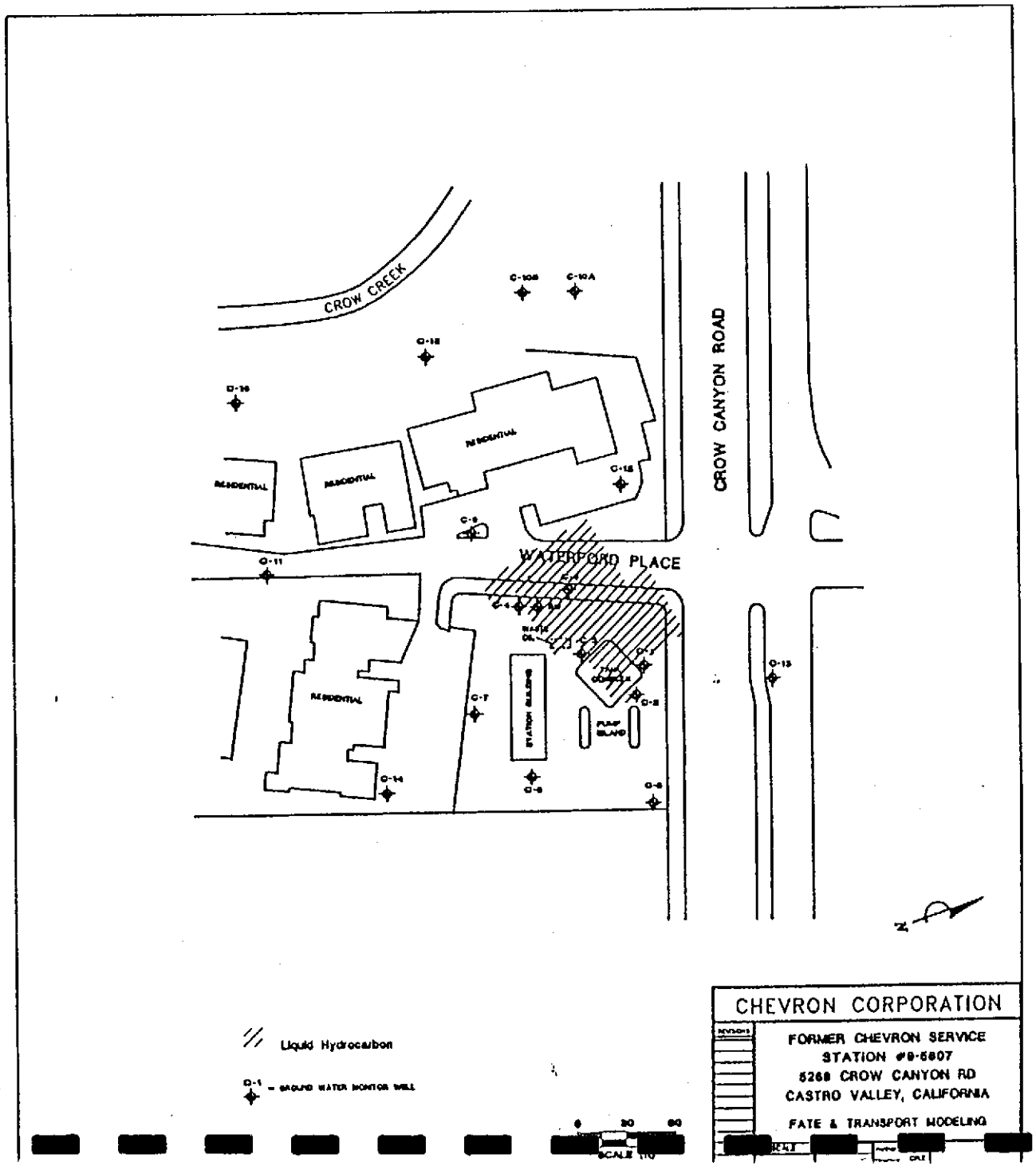
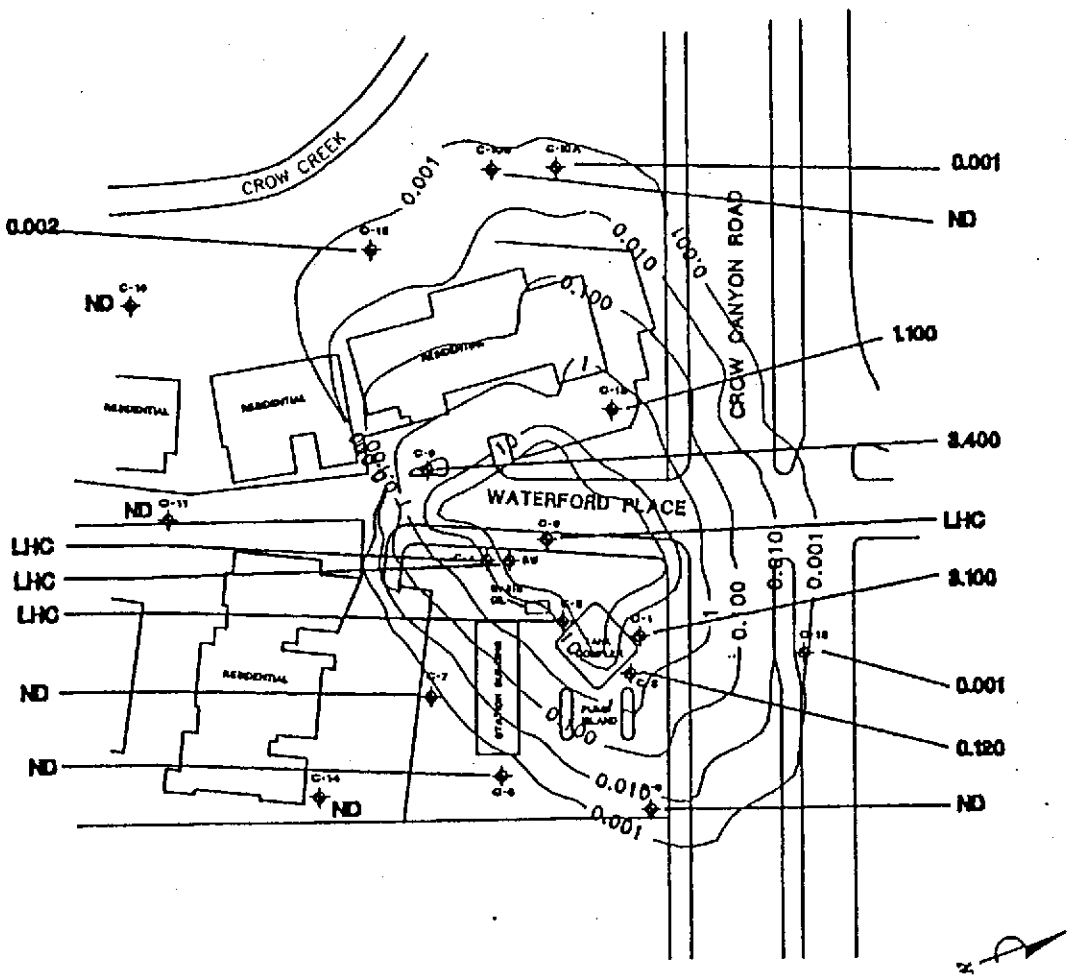


Figure 6.

Title: DISSOLVED BENZENE CONCENTRATIONS - 1992
[illegible] - STATION #1



MODFLOW/MTSD MODELS
CONSTANT SOURCE (24 PPM)
HALF LIFE = 110 DAYS
TIME = 6 YEARS

C-1 = GROUND WATER MONITOR WELL

3.100 = BENZENE CONCENTRATION (PPM)
4/13/92

0 30 60
SCALE

CHEVRON CORPORATION

FORMER CHEVRON SERVICE
STATION #9-5607
5259 CROW CANYON RD
CASTRO VALLEY, CALIFORNIA

FATE & TRANSPORT MODELING

Figure 7.

Title: DISSOLVED BENZENE CONCENTRATIONS - 1996
NO PUMPING WELLS - SIMULATION #1

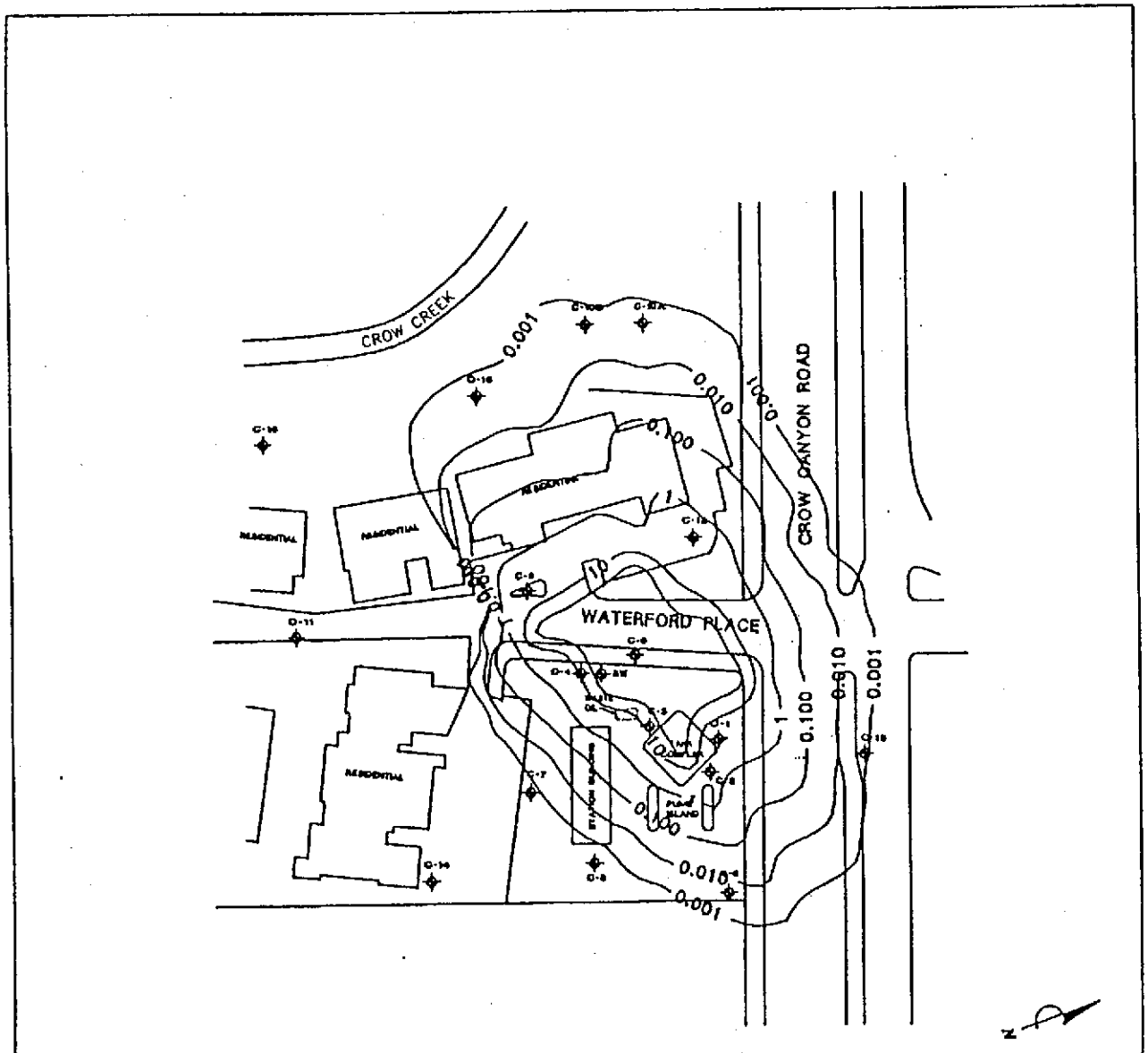
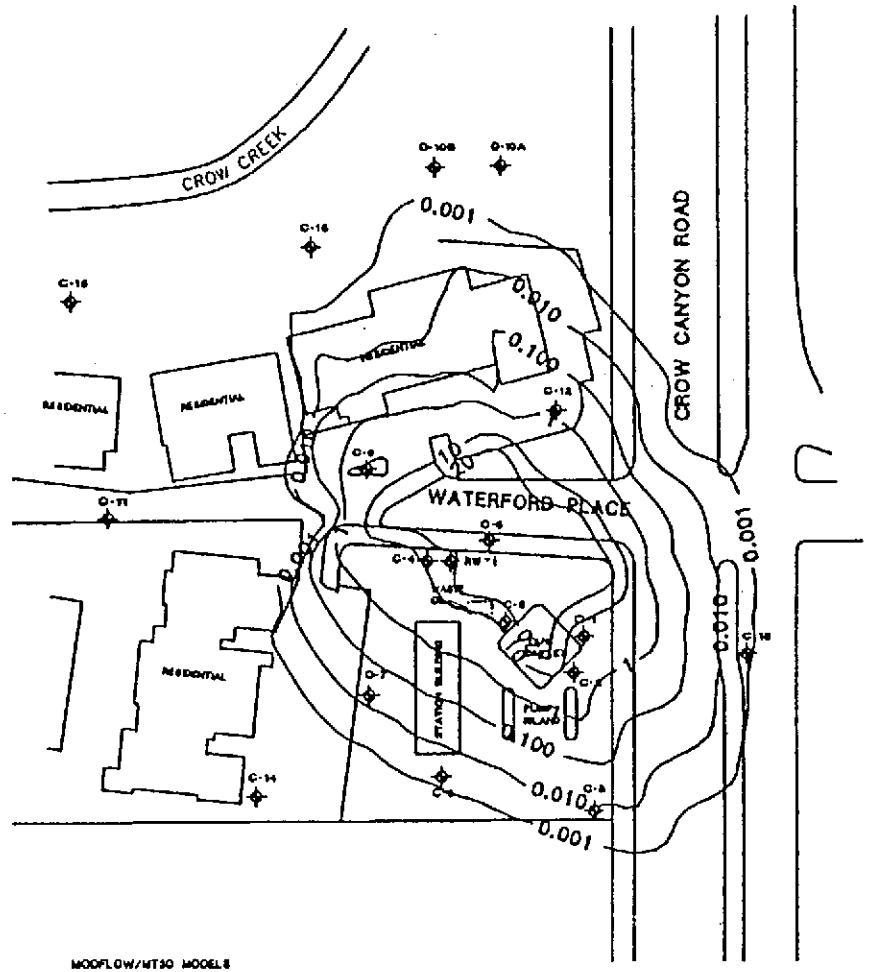


Figure 8.

Title: DISSOLVED BENZENE CONCENTRATIONS - 1996
2 PUMPING WELLS (RW-1 AND C-9) - SIMULATION #2



MODFLOW/MT3D MODELS
CONSTANT SOURCE (24 PPM BENZENE)
HALF LIFE = 10 DAYS
TIME: 10 YEARS TOTAL
FIRST WELL BEGINS PUMPING AT 1410 DAYS
SECOND WELL BEGINS PUMPING AT 1990 DAYS

FOUR YEARS FROM PRESENT

C-1 = GROUND WATER MONITOR WELL

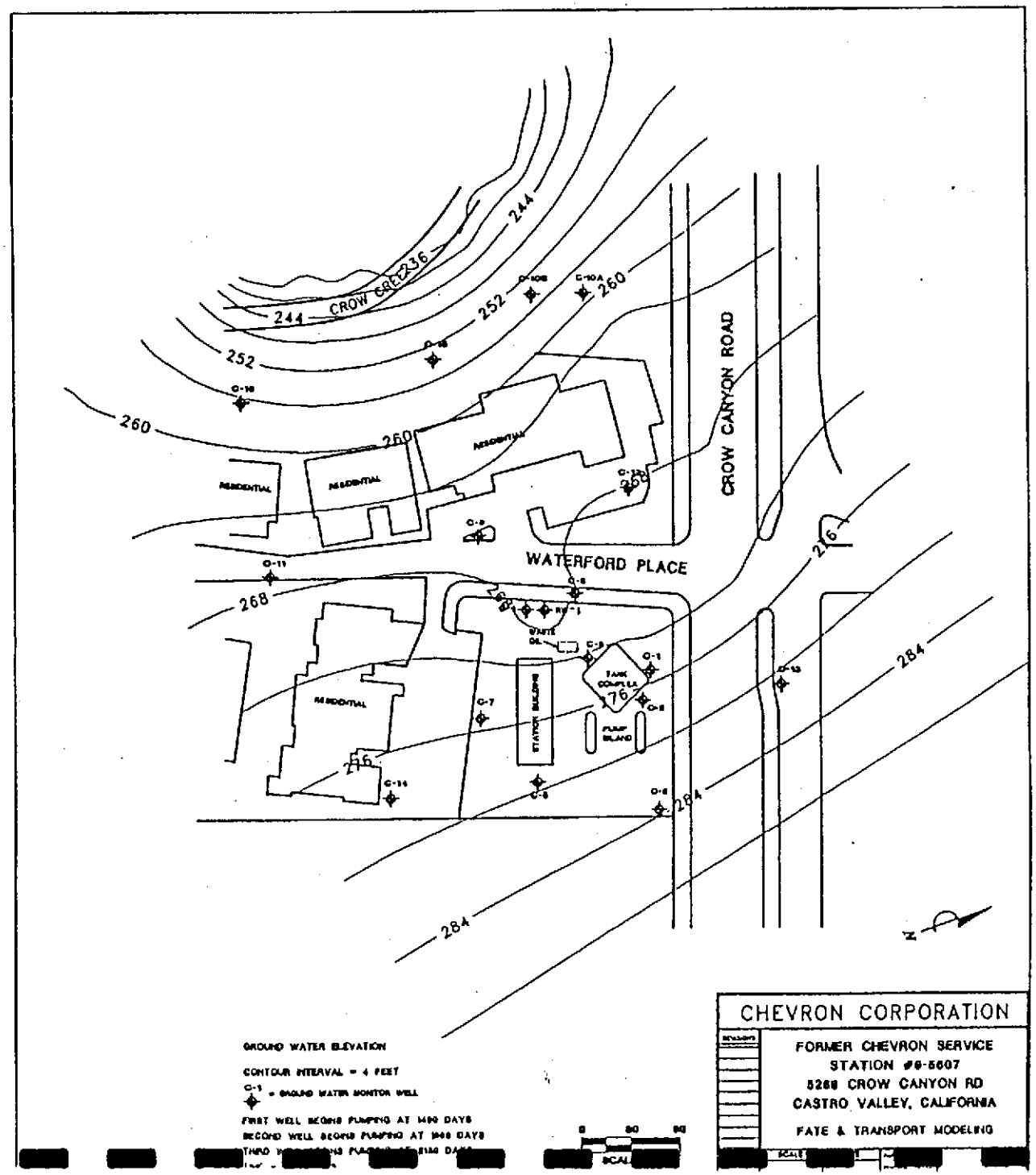
0 50 100
SCALE

CHEVRON CORPORATION

FORMER CHEVRON SERVICE
STATION #9-5607
5269 CROW CANYON RD
CASTRO VALLEY, CALIFORNIA

FATE & TRANSPORT MODELING

Figure 9.



Title: GROUNDWATER ELEVATION CONTOURS
EFFECT OF ONE PUMPING WELL (RW-1)

Figure 10.

Title: GROUNDWATER ELEVATION CONTOURS
EFFECT OF TWO PUMPING WELLS (RW-1 AND C-9)

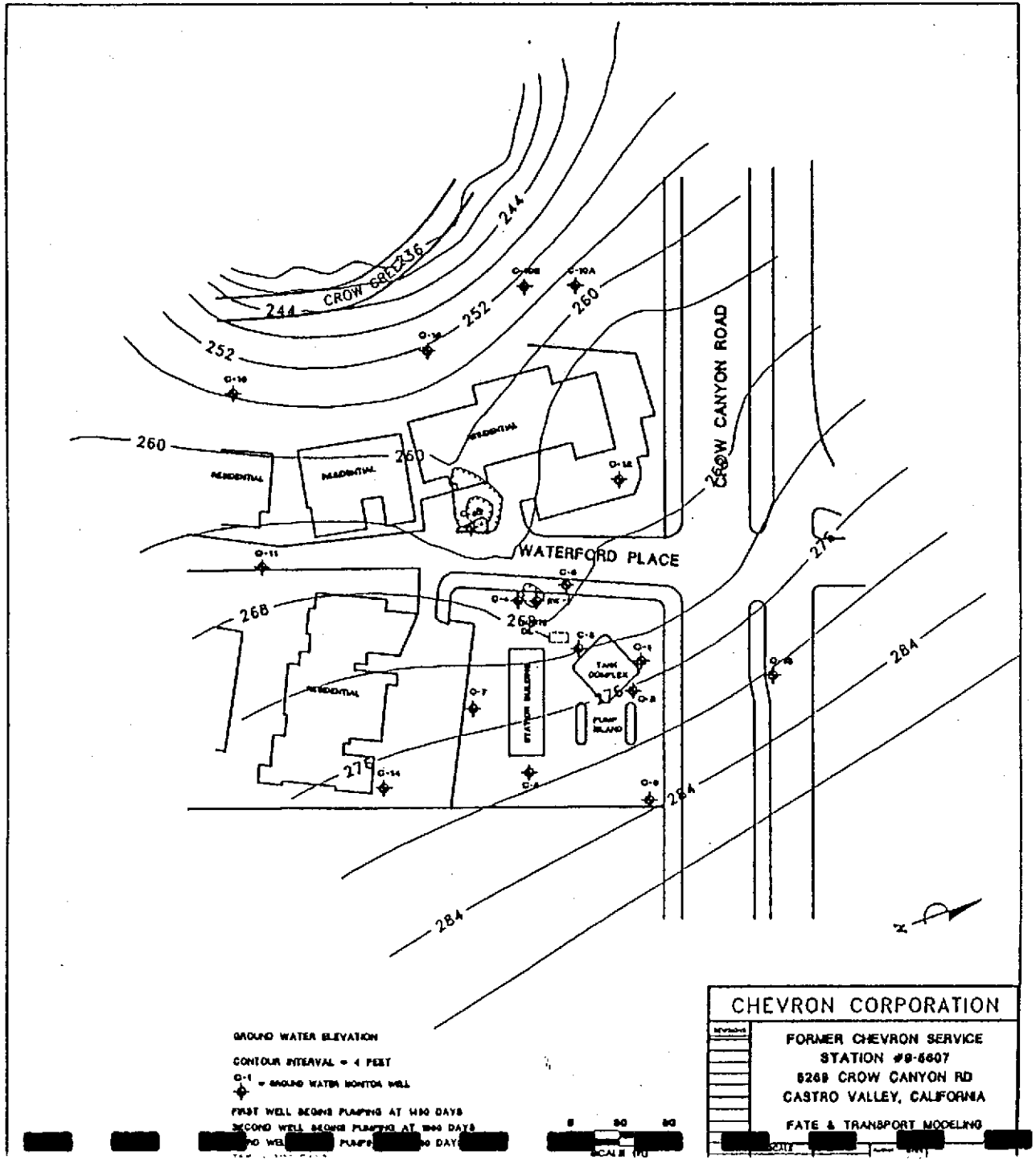
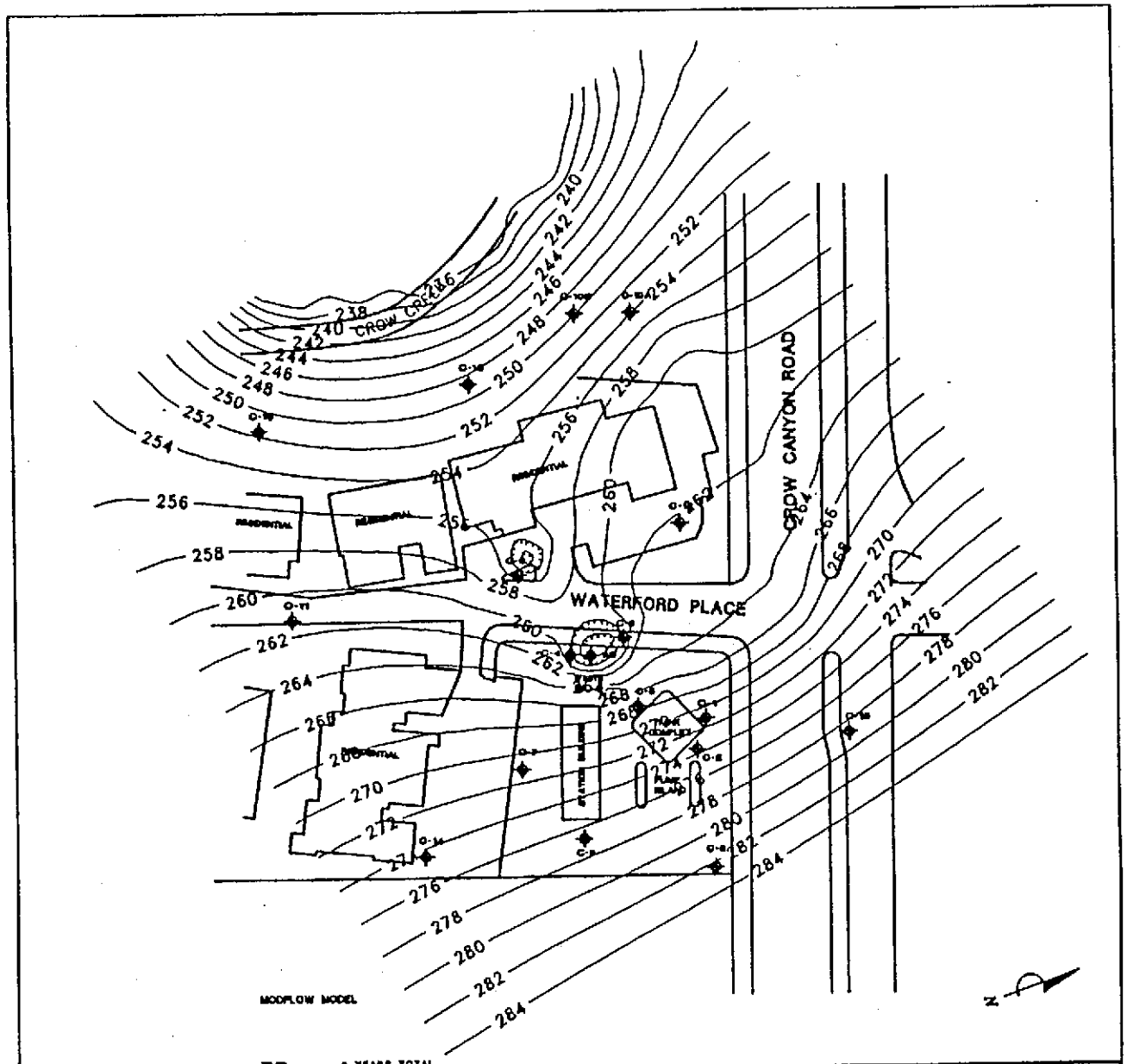
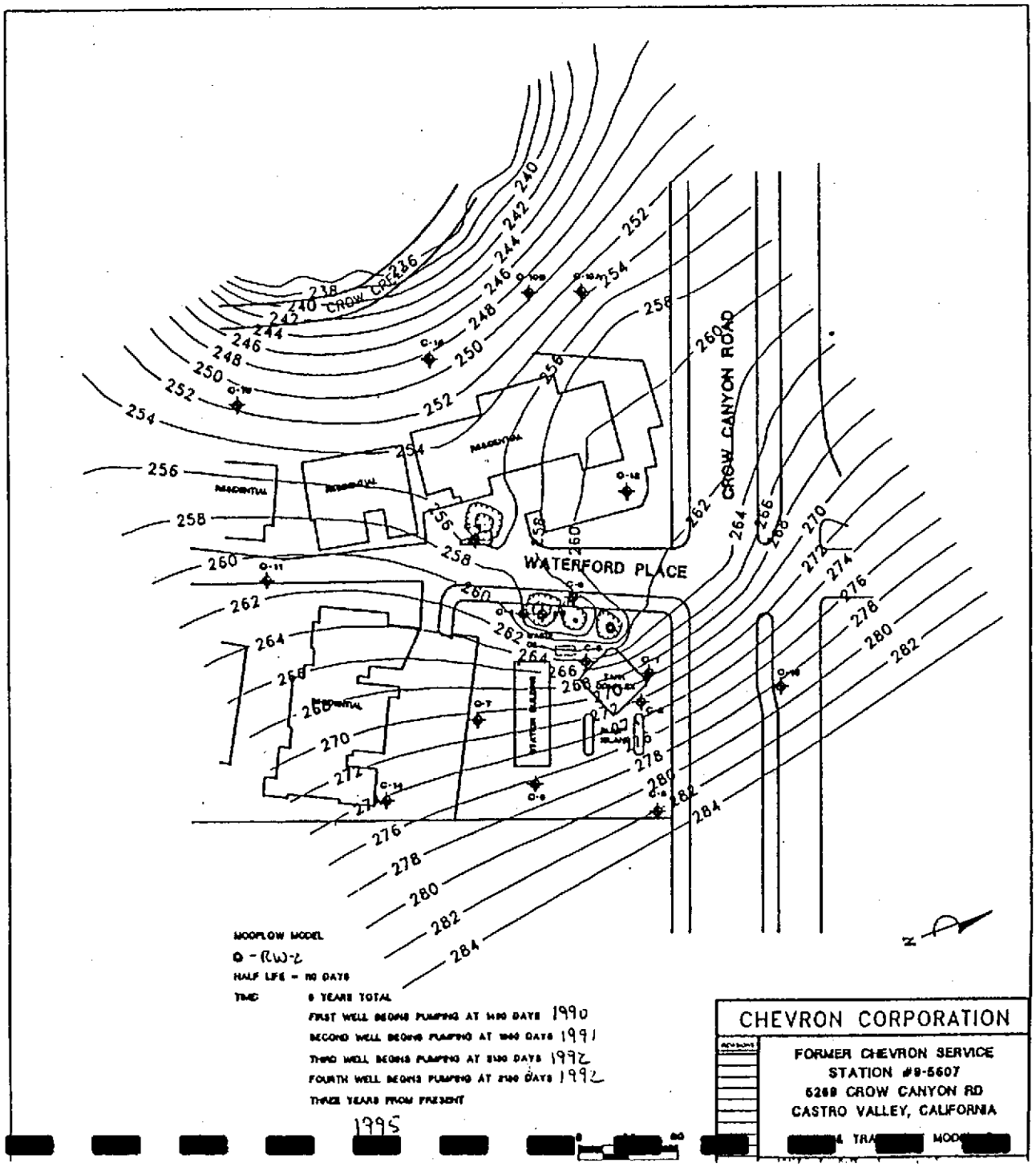


Figure 11.

Title: GROUNDWATER ELEVATION CONTOURS
EFFECT OF THREE PUMPING WELLS (RW-1, C-9 AND C-6)
1995

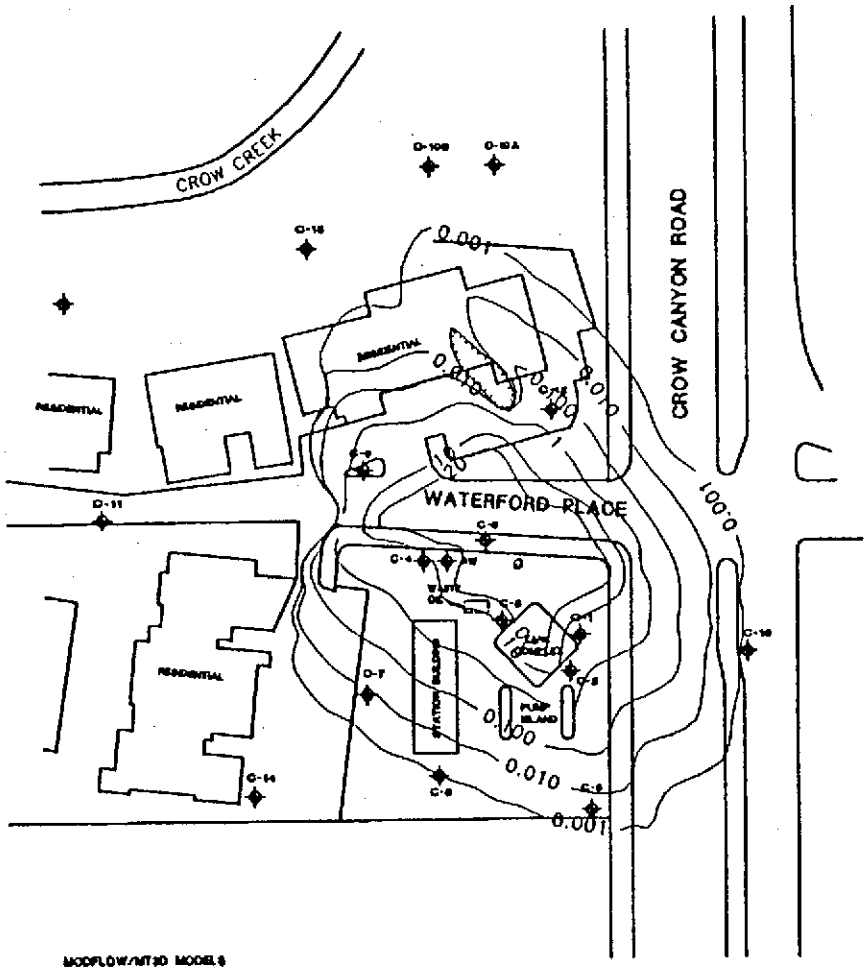




Title: GROUNDWATER ELEVATION CONTOURS

Figure 13

Title: DISSOLVED BENZENE CONCENTRATIONS
THREE PUMPING WELLS (RW-1, C-9 AND C-6)
1994



MODFLOW/MT3D MODELS
CONSTANT SOURCE (24 PPM BENZENE)
HALF LIFE = 70 DAYS
TIME: 6 YEARS TOTAL
FIRST WELL BEGINS PUMPING AT 1460 DAYS 1990
SECOND WELL BEGINS PUMPING AT 1825 DAYS 1991
THIRD WELL BEGINS PUMPING AT 2190 DAYS 1992.

TWO YEARS FROM PRESENT

1994

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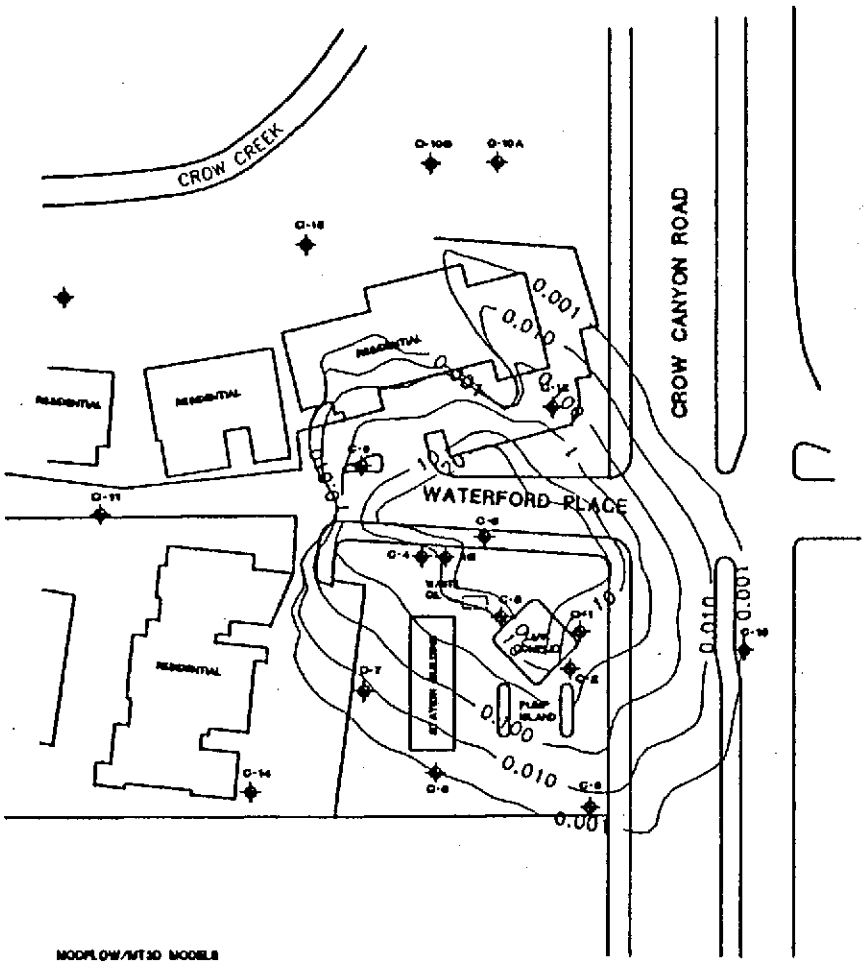
Figure 14.



MODFLOW/MT3D MODELS
CONSTANT SOURCE (24 PPM BENZENE)
HALF LIFE = 110 DAYS
TIME 10 YEARS TOTAL
FIRST WELL BEGINS PUMPING AT 1100 DAYS 1993
SECOND WELL BEGINS PUMPING AT 1600 DAYS 1991
THIRD WELL BEGINS PUMPING AT 2100 DAYS 1992

FOUR YEARS FROM PRESENT
1996

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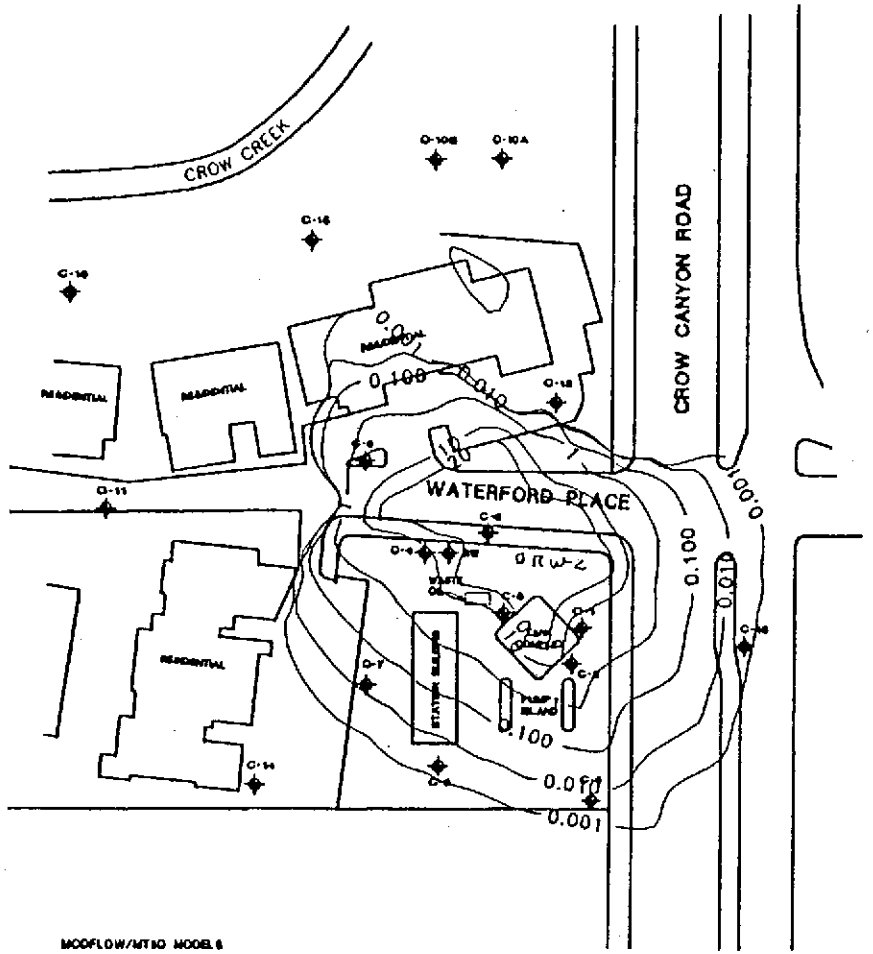
Title: DISSOLVED BENZENE CONCENTRATIONS
THREE PUMPING WELLS (RW-1, C-9 AND C-6)
1996

Figure 15.

Title: DISSOLVED BENZENE CONCENTRATIONS
FOUR PUMPING WELLS (RW-1, C-9, RW-2 AND C-6)
1994



MODFLOW/MT3D MODELS
CONSTANT SOURCE (24 PPM BENZENE)
HALF LIFE = 10 DAYS
TIME: 8 YEARS TOTAL
FIRST WELL BEGINS PUMPING AT 1460 DAYS (4 YRS)
SECOND WELL BEGINS PUMPING AT 1860 DAYS (5 YRS)
THIRD WELL BEGINS PUMPING AT 2160 DAYS (6 YRS)
FOURTH WELL BEGINS PUMPING AT 2190 DAYS (7 YRS)
TWO YEARS FROM PRESENT
1994

0 50 80
SCALE

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STATION #9-5607
5288 CROW CANYON RD
CASTRO VALLEY, CALIFORNIA

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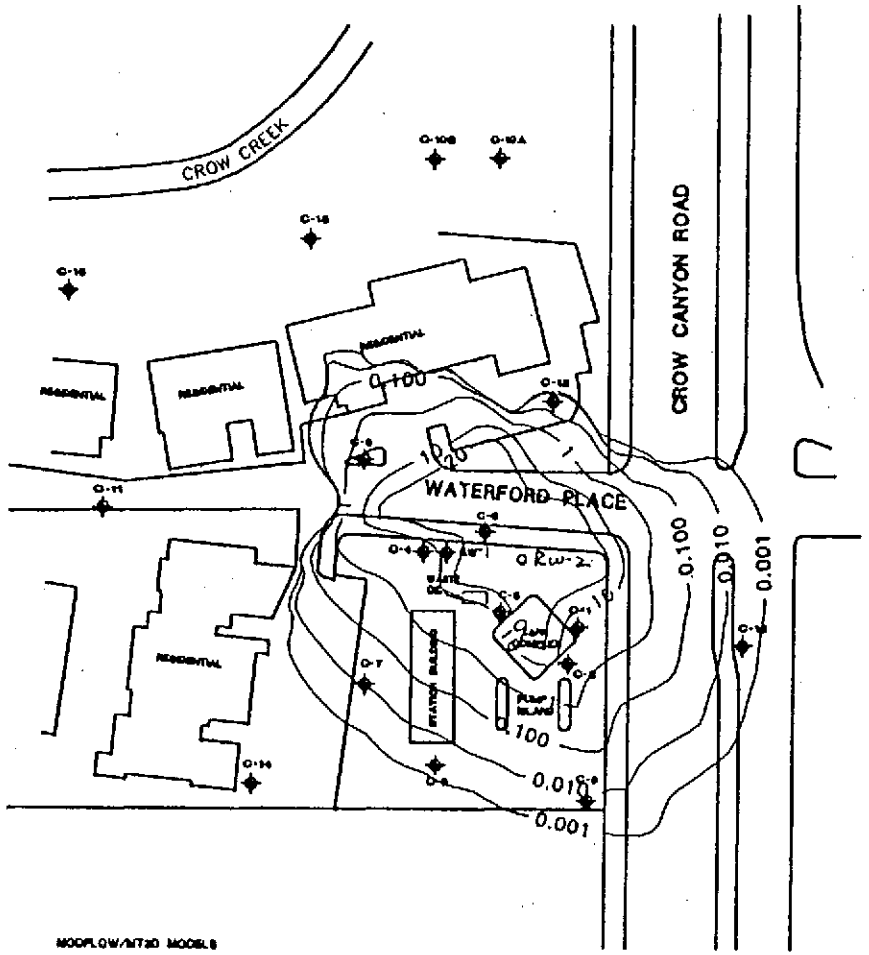
Figure 16.

Title: DISSOLVED BENZENE CONCENTRATIONS
FOUR PUMPING WELLS (RW-1, C-9, RW-2 AND C-6)
1996



MODFLOW/MT3D MODELS
CONSTANT SOURCE (24 PPM BENZENE)
HALF LIFE = 730 DAYS
TIME: 10 YEARS TOTAL
FIRST WELL BEGINS PUMPING AT 1460 DAYS 1990
SECOND WELL BEGINS PUMPING AT 1640 DAYS 1991
THIRD WELL BEGINS PUMPING AT 2190 DAYS 1992
FOURTH WELL BEGINS PUMPING AT 2190 DAYS 1992
FOUR YEARS FROM PRESENT

1996

CHEVRON CORPORATION

FORMER CHEVRON SERVICE
STATION #9-5607
6269 CROW CANYON RD
CASTRO VALLEY, CALIFORNIA

FATE & TRANSPORT MODELING

ATTACHMENT C

VAPOR CONCENTRATION PROFILE COMPARISON

ATTACHMENT C

VAPOR CONCENTRATION PROFILE COMPARISON

The purpose of this attachment is to compare the vapor concentrations measured during the August 19 and 20, 1996 soil vapor survey at the subject site to ASTM vapor transport model predictions and to present an alternative model for calculating Tier 2 SSTLs. The comparison of predicted and measured vapor concentrations is presented below followed by a mass balance calculation of vapor concentrations and a presentation of the alternative vapor transport model for calculating Tier 2 SSTLs.

Vapor Concentration Profile Comparison

Soil vapor concentrations at shallow depths downgradient of former Chevron Service Station #9-5607 were considerably lower than predicted by the ASTM vapor transport models. The models predict a linear concentration gradient from the depth of the impacted soil and ground water to the ground surface. The vapor concentration in equilibrium with impacted soil is calculated using the expression:

$$C_{v,eq} = \frac{H \times C_{soil} \times \rho_s}{\theta_{ws} + f_{oc} \times k_{oc} \times \rho_s + H \times \theta_{as}} \qquad \text{(ASTM 1995)}$$

while the vapor concentration in equilibrium with impacted ground water is calculated using the expression

$$C_{v,eq} = HC_w \qquad \text{(ASTM 1995)}$$

where $C_{v,eq}$ is the equilibrium vapor concentration, H is Henry's constant for the contaminant, ρ_s is the bulk density of the soil, θ_{ws} is the water content of the soil, f_{oc} is the fraction of organic carbon in the soil, k_{oc} is the chemical specific carbon-water sorption coefficient and θ_{as} is the air content in the soil. The vapor flux to the ground surface is calculated using the expression:

$$F_{\max} = D_s^{eff} \frac{C_{v,eq}}{d} \qquad \text{(ASTM 1995)}$$

where F is the diffusive vapor flux, D_s^{eff} is the effective diffusivity, and d is the depth to impacted soil or ground water . The effective diffusivity is determined from the expression:

$$D_s^{eff} = D^{air}\frac{\theta_{as}^{3.33}}{\theta_T^2} + D^{wat}\frac{1}{H}\frac{\theta_{ws}^{3.33}}{\theta_T^2} \qquad \text{(ASTM 1995)}$$

where D^{air} and D^{wat} are the chemical specific diffusion coefficients in air and water respectively and θ_t is the total porosity. Rearranging the vapor flux expression we arrive at an expression to calculate the vapor concentration at various depths:

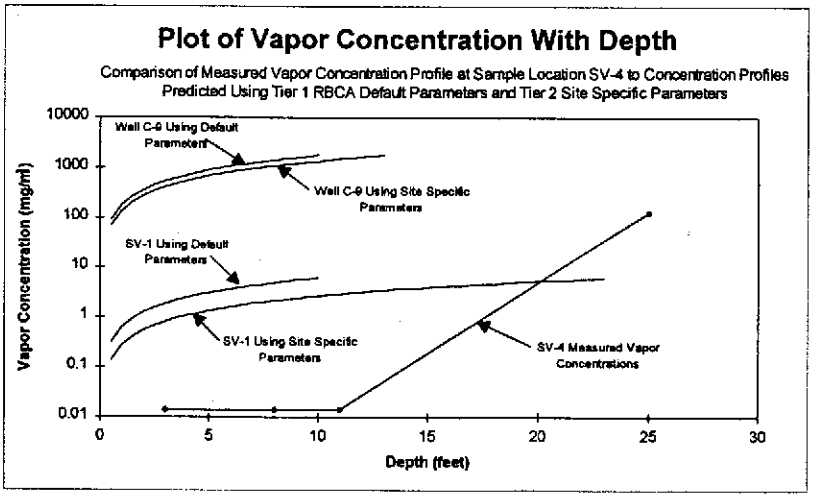
$$C_v = \frac{F_{max} \times d_{shallow}}{D_s^{eff}} = \frac{C_{v,eq} \times d_{shallow}}{d}$$

where $C_{v,eq}$ is calculated from the previous expression for vapor concentration within the soil plume, d is the depth to impacted soil or ground water and $d_{shallow}$ is the depth to various points above the impacted soil or ground water.

Vapor Concentration From Ground Water Source Example

The concentration of benzene in ground water from well C-9 collected on January 16, 1996 and sample location SV-1 collected on August 19, 1996 was 8.2 mg/l and 0.028mg/l respectively. The above expression for $C_{v,eq}$, in equilibrium with impacted ground water and Henry's constant for benzene predicts vapor concentrations of 1800 mg/m^3 and 6.2 mg/m^3 at the water table near well C-9 and sample location SV-1.

The measured benzene concentration in pore vapor from sample location SV-4 at 25 ft bgs was 39,000 parts per billion by volume. Converting the measured vapor concentration to units of mg/m^3 we arrive at 130 mg/m^3. A plot of measured vapor concentration profiles for sample location SV-4 and predicted vapor concentration profiles in the vicinity of well C-9 and sample location SV-1 are presented below. These data were plotted with concentration on a logarithmic scale to enable visual comparisons on the same plot. The vapor concentration profiles of predicted data are linear when plotted on a linear vertical scale.



The vapor concentration at 25 ft bgs (near the water table) at sample location SV-4 was in the range of the equilibrium vapor concentrations predicted by well C-9 and sample location SV-1 data. The concentration of benzene in soil vapor from sample location SV-4 was below laboratory detection limits at 11, 8 and 3 foot depths indicating a rapid attenuation of vapor concentration above the ground water source. The measured vapor concentrations at sample location SV-3 were similar in profile to location SV-4. However, the predicted profiles of vapor concentration with depth are linear and do not attenuate rapidly above the ground water source. The predictions were plotted using the Tier 1 default depth to ground water (9.8 feet) and the Tier 2 site specific depths to ground water measured at the subject site. The vapor concentration profiles change only slightly with application of the site specific depth. None of the predicted profiles reflect the real attenuation of vapor concentration measured at sample locations SV-3 and SV-4.

The above comparison indicates that the application of the diffusive vapor flux equation as presented in the ASTM RBCA guidance document is not representative of conditions at this site. Benzene vapor concentrations at depths shallower than the water table are much lower than predicted by the ASTM model. The lower than predicted benzene concentrations are likely due to bioattenuation of benzene during vapor transport towards the surface, which is not considered in the ASTM models. Concentrations of oxygen, carbon dioxide and methane indicated biological activity at most of the soil vapor survey sample locations. The effect of biodegradation on the vapor concentration profile is discussed below.

Mass Balance Prediction of Vapor Concentrations

The attenuation of vapor concentrations can be explained by performing a mass balance on the shallow soil above the ground water or soil source. The mass balance equation follows the form:

$$V\frac{dC}{dt} = A(Flux_{in}) - A(Flux_{out}) - (bioattenuation)$$

The mass balance is constructed by dividing the shallow zone into subintervals and looking at an intermediate subinterval to arrive at the mass balance expression:

$$\theta_{as} \cdot A \cdot \Delta z \frac{dC_n}{dt} = A \cdot D_s^{eff} \frac{C_{n-1} - C_n}{\Delta z} - A \cdot D_s^{eff} \frac{C_n - C_{n+1}}{\Delta z} - \theta_{as} \cdot A \cdot \Delta z \cdot R \cdot C_n$$

where θ_{as} is the air content, A is the area of the subinterval, Δz is the height of the subinterval, C_{n-1}, C_n, and C_{n+1} are the vapor concentrations in subintervals n-1, n and n+1, D_s^{eff} is the effective diffusivity and R is the chemical specific first order decay rate constant. Assuming that vapor concentration fluctuations at the nth subinterval are small with respect to time, the mass balance expression can be solved for vapor concentration. The expression for vapor concentration is:

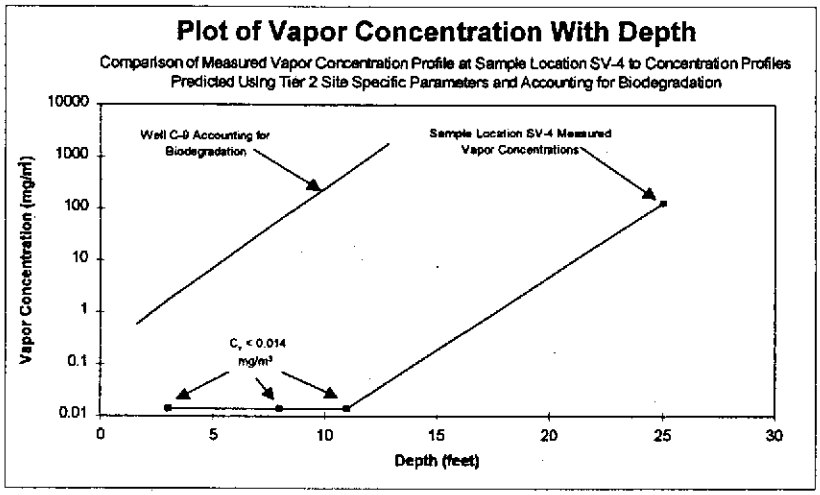
$$C_n = \frac{D_s^{eff}\left[C_{n-1} + C_{n+1}\right]}{2D_s^{eff} + \theta_{as} \cdot \Delta z^2 \cdot R}$$

Knowing the vapor concentration at the depth of impacted soil and conservatively assuming the vapor concentration is near zero at the upper boundary results in an equal number of equations and unknowns. The system of linear equations is then solved for the vapor concentration profile above the impacted soil. An example of a 5 subinterval system of equations is presented below:

$$\begin{bmatrix} 1 & -X & 0 & 0 \\ X & -1 & X & 0 \\ 0 & X & -1 & X \\ 0 & 0 & -X & 1 \end{bmatrix} \times \begin{bmatrix} C_1 \\ C_2 \\ C_3 \\ C_4 \end{bmatrix} = \begin{bmatrix} C_{v,eq} X \\ 0 \\ 0 \\ C_{ambient} X \sim 0 \end{bmatrix} \quad \text{Where } X = \frac{D_s^{eff}}{2D_s^{eff} + \theta_{as} \cdot \Delta z^2 \cdot R}$$

Please note that j subintervals results in j-1 equations to satisfy the boundary conditions. This approach can also be used to depict vapor concentration profiles in stratified lithology. This is done by determining the site specific diffusivity in each lithologic unit and applying the determined diffusivities to the mass balance equation in each subinterval.

A plot of measured vapor concentration with depth at sample location SV-4 and the predicted vapor concentration profile in the vicinity of well C-9 using the mass balance approach is depicted below.



The mass balance prediction is similar to the vapor concentration profile measured at sample location SV-4. Actual attenuation may be more rapid at location SV-4 because the measured concentration of benzene in soil vapor at 11 ft bgs is an unknown value below 0.014 mg/m^3. However, rapid vapor concentration attenuation above the source is demonstrated by the mass balance prediction when biodegradation is taken into account.

Rapid vapor concentration attenuation was also reported in a recent study of hydrocarbon vapor transport to indoor air from a retail service station release (Fischer, 1996[1]). The study showed rapid attenuation of measured vapor concentrations above the ground water source occurring within a thin, low diffusivity sediment layer and attributed the attenuation to biodegradation during vertical transport. Measured isopentane, methane and oxygen concentrations were used to verify the stoichiometry of the biodegradation reactions[2]. They calculated the biodegradation rate using a mass balance approach that is very similar to the approach presented above. Fisher et al assumed the concentration below the low diffusivity layer was very large compared to the concentration above and solved for biodegradation using mass balance and assuming all of the biodegradation occurred within the thin, low diffusivity layer. By comparison, the majority of sediments below the Forest Creek Townhomes are likely to have diffusivities in the range of the low diffusivity layer studied at the Alameda site by Fischer et al. Therefore, rapid attenuation of vapor concentrations due to biodegradation can be predicted to occur a short distance above the ground water source in the vicinity of the Forest Creek Townhomes residential area. The soil vapor concentrations measured in the vicinity of the ForestCreek Townhomes verify this prediction.

Proposed Alternative to the ASTM Vapor Transport Models

WA adapted the ASTM RBCA vapor model to incorporate the concentration profile predicted by the above mass balance equation and matrix solution. An **example** SSTL calculation using the system of linear equations is presented in spreadsheet form on page 7 of this attachment (this example SSTL calculation is not to be confused with results of the RBCA analysis for the subject site). The effective diffusivity and equilibrium vapor concentration within the soil plume were calculated using the ASTM vapor model formulas. WA calculated the matrix coefficient X assuming a conservative vadose zone half life for benzene and dividing the soil above the plume into n subintervals (n=8 for this example). The system of linear equations was solved using the matrix solver program in a Hewlett Packard 48G calculator. The resulting vapor concentrations in each subinterval are displayed in tabular and graphical form on the spreadsheet. The vapor concentration in the shallowest subinterval was then applied to the ASTM formula for diffusive vapor flux. The shallowest subinterval is used to determine the flux because only the benzene mass passing through the shallowest subinterval will reach the surface. Standard ASTM vapor model formulas were used to calculate the indoor air concentration, dose and indoor air risk. The benzene SSTL concentration in soil was then calculated by multiplying the measured benzene concentration in soil to the ratio of acceptable risk and determined risk. The SSTL can be calculated this way because soil

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[1] Fischer M. L., Bentley A. J., Dunkin K. A., Hodgson A. T., Nazaroff W. W., Sextro R. G., Daisey J. M., Environmental Science & Technology 1996. Factors Affecting Indoor Air Concentrations of Volatile Organic Compounds at a Site of Subsurface Gasoline Contamination. Vol. 30, No 10, pp 2948 - 2957.

[2] The sediments at the study site were mostly sandy fill material dredged from the Alameda channel that did not likely contain significant quantities of naturally degrading biological material (leaves, roots, etc.) to interfere with the stoichiometry. A stoichiometric approach to verifying biodegradation would be inconclusive at the Forest Creek Townhomes site due to interference from the likely presence of naturally degrading material in shallow soil (< 8 ft bgs). However, elevated CO2 and methane concentrations indicate biological activity in the vicinity of the measured hydrocarbon vapors.

concentration and risk are linearly proportional. Site specific air content, water content, porosity and fraction of organic carbon parameters were used in this calculation. The **example** SSTL for benzene in soil is 91 mg/kg.

An example SSTL for benzene in ground water was calculated in the same manner as the SSTL for soil. The differences between the soil-to-indoor-air model and the ground-water-to-indoor-air model are the depth to the contaminant source and the equation to calculate $C_{v,eq}$. We used the depth to ground water for the source depth and calculated $C_{v,eq}$ by multiplying the concentration of benzene in ground water by Henry's constant. This ground-water-to-indoor-air model does not calculate diffusivity in the same manner as ASTM. The ASTM ground-water-to-indoor-air model uses a capillary fringe diffusivity and a vadose zone diffusivity to calculate a weighted average diffusivity based on capillary zone and vadose zone thickness. The ASTM ground-water-to-indoor-air model is not conservative because it treats the capillary zone as a subsurface barrier to vapor transport. We used only the vadose zone diffusivity. The **example** SSTL for benzene in ground water is 2,597 mg/L.

If the ASTM default values for air content, water content and porosity are applied to the modified vapor transport models, the vapor concentration profile becomes linear. The ASTM default values are representative of a sandy soil with low water content. The vapor concentration profile in a sandy soil does not attenuate because diffusive vapor flux is much faster than conservative biodegradation rates. Thus, the vapor pathway is of concern at sites with dry soils and high air filled porosity.

This modified vapor transport model can be used to determine SSTLs for sites with known soil air content, water content and porosity and where the presence of biological activity is verified. Soil air content, water content and porosity are easily determined by obtaining a soil sample and sending it to a geotechnical laboratory for analysis. The analytical cost is approximately $50.00 per sample. Biological activity can be verified either by measuring vadose zone O_2 and CO_2 concentrations or inferring that it is occurring based on increases in dissolved ferrous iron (Fe^{+2}) and manganese (Mn^{+2}) or CO_2 in ground water within the dissolved plume as compared to background ground water concentrations.

Modification of ASTM 95 Vapor Pathway Model - Vadose Zone Bioattenuation by Finite Difference

Indoor Air Risk Predicted by Soil Data

Former Chevron Service Station 9-5607, 5269 Crow Canyon Road, Castro Valley, California

Standard ASTM Calculations

Soil Specific Parameters

Lab Data	ρ_s	2.21	Bulk Density(g/cm^3) or (kg/L)
Calculated	θ_{as}	0.01	Air Content (v/v)
Calculated	θ_{ws}	0.27	Water Content (v/v)
Lab Data	θ_t	0.28	Porosity (v/v)
Site Spec	d	305	Depth to Subsurface Soil Source (cm)

Diffusivity Parameters

ASTM 95	H	0.22	Henry's Constant for Benzene
ASTM 95	D^{air}	9.30E-02	Air Diffusion Coefficient (cm^2/s)
ASTM 95	D^{wat}	1.10E-05	Water Diffusion Coefficient (cm^2/s)
Calculated	D^{eff}_s	8.4083E-06	Effective Diffusion Coefficient soil (cm^2/s)

Calculation of Vapor Concentration Within Impacted Soil

Lab Data	$C_{s,measured}$	2.3	Benzene Concentration in Soil (mg/kg)
Lab Data	f_{oc}	0.0014	Fraction of Organic Carbon (g_{carbon}/g_{soil})
ASTM 95	k_{oc}	38	Carbon - Water Sorption Coefficient (L/kg)
Calculated	$C_{v,eq}$	2.87	Equilibrium Vapor Concentration in Soil Plume (mg/L)

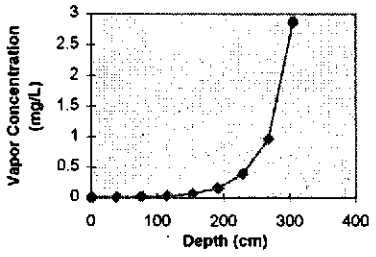
WA - Calculation of Vapor Concentration Profile

Howard	Thalf	16	Contaminant Half Life (days)
Calculated	R	5.0141E-07	First order Rate Constant (sec^{-1})
Accuracy	n	8	Number of Subintervals
Calculated	Δz	38	Subinterval Height (cm)
Calculated	X	0.34896372	Matrix Coefficient (unitless)
Calculated	$C_{v,eq}X$	1.0011806	(mg/L)

Matrix of linear equations solved using HP 48G calculator matrix solver program.
Results displayed below.

Subinterval	Depth (cm)	Vapor Conc (mg/L)
Surface	0	0
8	38	0.0036453
7	76	0.01444987
6	114	0.02628303
5	152	0.06486455
4	191	0.1595753
3	229	0.392371
2	267	0.9646975
1	305	2.87

Vapor Concentration Profile



Standard ASTM Calculations Continued

Vapor Flux From Shallowest Subinterval to Surface

Calculated	F	8.04E-10	Diffusive Vapor Flux (ug/cm^2-sec)

Indoor Air Concentration

ASTM 95	Lb	200	Enclosed Space Volume/Infiltration Area Ratio (cm)
ASTM 95	ER_{air}-indoor	0.00014	Enclosed Space Air Exchange Rate (sec^{-1})
Calculated	C_{indoor}	2.873E-08	Enclosed Space Air Concentration (ug/cm^3)

Dose

ASTM 95	IR_{air}-indoor	15	Daily Indoor Inhalation Rate (m^3/day)
ASTM 95	EF	350	Exposure Frequency (days/year)
ASTM 95	ED	30	Exposure Duration (years)
Calculated	Dose	4.53	Dose (mg)

SSTL

CAL EPA	SF_i	0.1	California Cancer Slope Factor for Benzene (kg-day/mg)
ASTM 95	BW	70	Adult Body Weight (kg)
ASTM 95	AT_c	70	Averaging Time for Carcinogens (years)
Calculated	$Risk_s$	2.53E-07	Risk - Soil to indoor air
	$Risk_{acc}$	1.00E-05	Acceptable Risk - Soil to indoor air
	SSTL	**91**	**SSTL Concentration of Benzene in Soil (mg/kg)**

ASTM Formulas

$$D_s^{eff} = D^{air}\frac{\theta_{as}^{3.33}}{\theta_T^2} + D^{wat}\frac{1}{H}\frac{\theta_{ws}^{3.33}}{\theta_T^2} \qquad C_{indoor} = \frac{F}{ER_{air-indoor} \times L_b}$$

$$C_{v,eq} = \frac{H \times C_{s,measured} \times \rho_s}{\theta_{ws} + f_{oc} \times k_{oc} \times \rho_s + H \times \theta_{as}} \qquad Dose = C_{indoor} \times IR_{air-indoor} \times EF \times ED$$

$$F = D_s^{eff}\frac{C_{v,sub-1}}{\Delta z} \qquad Risk = \frac{Dose \times SF_i}{BW \times AT}$$

WA Formulas

$$\Delta z = \frac{d}{n} \qquad R = \frac{-Ln(0.5)}{t_{half}} \qquad X = \frac{D_s^{eff}}{\left[2D_s^{eff} + \theta_{as} \times \Delta z^2 \times R\right]}$$

$$SSTL = C_{s,measured}\frac{RISK_{acc}}{RISK_s}$$

Notes:

ASTM 96 = American Society for Testing and Materials, March 5, 1996. Standard Guide for Risk Based Corrective Action Applied at Petroleum Release Sites, E 1739-95.

Site Spec: Depth to subsurface soil source. Conservatively assuming soil contamination is located just below 10 foot depth. All soil samples collected at 10 feet bgs were ND for benzene.

Lab Data: Benzene concentration in soil boring SV-7 at 25 feet bgs (Max benzene concentration detected in site soil).

Accuracy: Number of subintervals depends on the accuracy desired.

Calculations: Effective diffusivity, diffusive vapor flux, equilibrium vapor concentration within impacted soil, diffusive vapor flux, enclosed space air concentration, dose and risk calculations from ASTM 96 guidance. Vapor concentration profile calculated by subinterval matrix calculation. SSTL calculated by interpolation. Formulas presented above.

Modification of ASTM 95 Vapor Pathway Model - Vadose Zone Bioattenuation by Finite Difference

Indoor Air Risk Predicted by Ground Water Data

Former Chevron Service Station 9-5607, 5269 Crow Canyon Road, Castro Valley, California

Standard ASTM Calculations

Soil Specific Parameters

Lab Data	ρ_s	2.21	Bulk Density(g/cm^3) or (kg/L)
Calculated	θ_{as}	0.01	Air Content (v/v)
Calculated	θ_{ws}	0.27	Water Content (v/v)
Lab Data	θ_t	0.28	Porosity (v/v)
Site Spec	d	391	Depth to Ground Water Source (cm) (C-9, 12.84 ft, 4/3/89)

Diffusivity Parameters

ASTM 95	H	0.22	Henry's Constant for Benzene
ASTM 95	D^{air}	9.30E-02	Air Diffusion Coefficient (cm^2/s)
ASTM 95	D^{wat}	1.10E-05	Water Diffusion Coefficient (cm^2/s)
Calculated	D^{eff}_s	8.4083E-06	Effective Diffusion Coefficient soil (cm^2/s)

Calculation of Vapor Concentration Within Impacted Soil

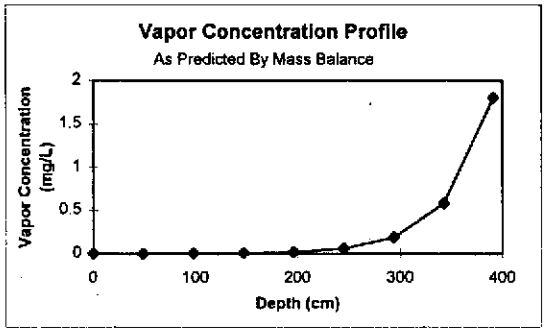
Lab Data	$C_{w,measured}$	8.2	Benzene Concentration in Ground Water (mg/L)
Calculated	$C_{v,eq}$	1.80	Equilibrium Vapor Concentration at GW Table (mg/L)

WA - Calculation of Vapor Concentration Profile

Howard	Thalf	16	Contaminant Vadose Zone Half Life (days)
Calculated	R	5.0141E-07	First order Rate Constant (sec^{-1})
Accuracy	n	8	Number of Subintervals
Calculated	Δz	49	Subinterval Height (cm)
Calculated	X	0.29179003	Matrix Coefficient (unitless)
Calculated	$C_{v,eq}X$	0.52638922	(mg/L)

Matrix of linear equations solved using HP 48G calculator matrix solver program.
Results displayed below.

Subinterval	Depth (cm)	Vapor Conc (mg/L)
Surface	0	0
8	49	0.00058408
7	98	0.00200029
6	147	0.00626621
5	196	0.01945934
4	245	0.06037537
3	294	0.18730562
2	343	0.58108224
1	391	1.8



Standard ASTM Calculations Continued

Vapor Flux From Shallowest Subinterval to Surface

Calculated	F	1.00E-10	Diffusive Vapor Flux (ug/cm^2-sec)

Indoor Air Concentration

ASTM 95	Lb	200	Enclosed Space Volume/Infiltration Area Ratio (cm)
ASTM 95	ER_{air}-indoor	0.00014	Enclosed Space Air Exchange Rate (sec^{-1})
Calculated	C_{indoor}	3.585E-09	Enclosed Space Air Concentration (ug/cm^3)

Dose

ASTM 95	IR_{air}-indoor	15	Daily Indoor Inhalation Rate (m^3/day)
ASTM 95	EF	350	Exposure Frequency (days/year)
ASTM 95	ED	30	Exposure Duration (years)
Calculated	Dose	0.56	Dose (mg)

SSTL

CAL EPA	SF_i	0.1	California Cancer Slope Factor for Benzene (kg-day/mg)
ASTM 95	BW	70	Adult Body Weight (kg)
ASTM 95	AT_c	70	Averaging Time for Carcinogens (years)
Calculated	**$Risk_s$**	**3.16E-08**	**Risk - Ground Water to Indoor Air**
	$Risk_{acc}$	1.00E-05	Acceptable Risk - Ground Water to Indoor Air
	SSTL	2,597	SSTL Benzene in Ground Water (mg/L)

ASTM Formulas

$$D_s^{eff} = D^{air}\frac{\theta_{as}^{3.33}}{\theta_T^2} + D^{wat}\frac{1}{H}\frac{\theta_{ws}^{3.33}}{\theta_T^2}$$

$$C_{indoor} = \frac{F}{ER_{air-indoor} \times L_b}$$

$$C_{v,eq} = H \times C_{w,measured}$$

$$Dose = C_{indoor} \times IR_{air-indoor} \times EF \times ED$$

$$F = D_s^{eff}\frac{C_{v,sub-1}}{\Delta z}$$

$$Risk = \frac{Dose \times SF_i}{BW \times AT}$$

WA Formulas

$$\Delta z = \frac{d}{n}$$

$$R = \frac{-Ln(0.5)}{t_{half}}$$

$$X = \frac{D_s^{eff}}{\left[2D_s^{eff} + \theta_{ws} \times \Delta z^2 \times R\right]}$$

$$SSTL = C_{w,measured}\frac{RISK_{acc}}{RISK_s}$$

Notes:

ASTM 96 = American Society for Testing and Materials, March 5, 1996. Standard Guide for Risk Based Corrective Action Applied at Petroleum Release Sites, E 1739-95.
Site Spec: Depth to ground water. Shallowest depth to ground water in well C-9.
Lab Data: Benzene concentration in ground water from well C-9 on January 16, 1996.
Accuracy: Number of subintervals depends on the accuracy desired.
Calculations: Effective diffusivity, diffusive vapor flux, equilibrium vapor concentration just above water table, diffusive vapor flux, enclosed space air concentration, dose and risk calculations from ASTM 96 guidance. Vapor concentration profile calculated by subinterval matrix calculation. SSTL calculated by interpolation. Formulas presented above.