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July 21, 1994

Mr. Scott Seery
Senior Hazardous Materials Specialist
ALAMEDA COUNTY HEALTH CARE SERVICES
1131 Harbor Bay Parkway, Second Floor
Alameda, California 94502

RE: **FEASIBILITY STUDY REPORT**
Unocal Service Station 5367
500 Bancroft Avenue
San Leandro, California

Dear Mr. Seery:

Enclosed please find the Feasibility Study Report for the above-referenced site. GeoResearch is submitting this report on behalf of the Unocal Environmental Remediation and Technology Division.

Please feel free to contact this office at (510) 785-1111 if you have any questions or require any further information.

Sincerely,

Frank Poss
Associate Hydrogeologist

Enclosure

cc: Tina Berry (Unocal)

FP:sc

FEASIBILITY STUDY REPORT
FOR GROUND WATER
UNOCAL SERVICE STATION 5367
500 BANCROFT AVENUE
SAN LEANDRO, CALIFORNIA

Prepared for
Unocal Corporate Environmental Remediation and Technology
2000 Crow Canyon Place, Suite 400
San Ramon, California 94583

Prepared by

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July 22, 1994
9480600100

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STATEMENT OF LIMITATIONS AND PROFESSIONAL CERTIFICATION

Information provided in this Feasibility Study Report for GeoResearch Project Number 9480600100 is intended exclusively for the use of Unocal Corporate Environmental Remediation and Technology (Unocal CERT) to evaluate remedial alternatives for the ground water containing petroleum hydrocarbons beneath the subject site and migrating off-site, based on the information provided to GeoResearch at the time of this report. The professional services provided have been performed in accordance with practices generally accepted by other geologists, hydrologists, hydrogeologists, engineers, and scientists practicing in this field. No other warranty, either expressed or implied, is made. GeoResearch is not an insurer and makes no guarantee or warranty that the services supplied will avert or prevent occurrences or the consequences therefrom which service is designed to detract or avert. The attached report has been reviewed by a professional engineer licensed in the State of California and whose signature and license number appear below.

Frank R. Poss, R.E.A.
Associate Hydrogeologist

Lisa A. Hall

Lisa A. Hall, P.E. #M26700
Senior Mechanical Engineer

1.0 INTRODUCTION

GeoResearch was contracted by Unocal Corporate Environmental Remediation and Technology (CERT) to conduct a feasibility study for the mitigation of petroleum-hydrocarbon-impacted ground water beneath and to the west of Unocal service station 5367 (site), 500 Bancroft Avenue, San Leandro, California (Figure 1). The purpose of the feasibility study was to identify and evaluate the technical feasibility and cost effectiveness of alternatives available for the remediation of ground water beneath the site and off-site to the west. As part of this study, an aquifer test was conducted and the data obtained from the aquifer test was used as input for ground-water modeling. The ground-water modeling results were evaluated to determine the most effective pumping scenario to capture and mitigate dissolved petroleum hydrocarbons in ground water beneath and west of the site. A biosuitability study was also conducted to evaluate the effectiveness of bioremediation technologies on petroleum-hydrocarbon-impacted ground water in the site vicinity.

2.0 SITE BACKGROUND

Unocal service station 5367 is at the east corner of the intersection of Bancroft Avenue and Dowling Boulevard in San Leandro, California (Figure 2). Two underground storage tanks (USTs) were removed from the site in 1987 and replaced with new USTs at the same location. Approximately 250 cubic yards of total petroleum hydrocarbons as gasoline (TPH-G)-impacted soil were excavated from the former UST location prior to UST replacement. The impacted soil was remediated on site by aeration and, upon verification of successful treatment, was transported off site for disposal (Applied GeoSystems, 1987).

Eight soil borings were completed in the site vicinity and converted to ground-water monitoring wells between 1987 and 1990. Five borings/wells were completed within the subject property boundaries and three borings/wells were completed off-site to the west and southwest of the site (Applied GeoSystems, 1987, 1988, 1990).

Soil samples collected during drilling indicate TPH-G and benzene, toluene, ethylbenzene, and total xylenes (BTEX) concentrations in soil between 25 and 30 feet below ground surface (bgs). The highest concentration of TPH-G detected was 3,690 milligrams per kilogram (mg/kg) and the highest concentration of benzene detected was 22 mg/kg. Both of these concentrations were detected in soil samples collected at 35 feet bgs and are associated with the capillary fringe.

Ground-water samples collected from the eight monitoring wells indicate TPH-G has impacted ground water beneath the site, in the vicinity of the former USTs and pump islands. The impacted ground water appears to have migrated off-site to the west. The ground-water flow direction in the site vicinity is generally to the west towards MW-8 (Applied GeoSystems, 1987, 1988, 1990 and MPDS, 1993, 1994).

The highest concentrations of TPH-G and benzene detected in ground water were collected from MW-1, immediately west of the former USTs (99 milligrams per Liter [mg/L] TPH-G and 3.8 mg/L benzene) (MPDS, 1994). Ground-water samples collected from MW-1, MW-2, MW-3, and MW-8, during quarterly monitoring, contained average concentrations of TPH-G and benzene above the laboratory detection limits. The average concentrations of TPH-G and benzene detected in ground-water samples collected from MW-4, MW-5, MW-6, and MW-7 were below the laboratory detection limits, indicating the lateral limits of the dissolved-petroleum-hydrocarbon plume. Figure 3 illustrates the most recent ground-water monitoring results and the inferred extent of benzene in ground water in the site vicinity (MPDS, 1994).

In a letter dated July 1, 1994 from the Alameda County Health Care Services Agency (ACH), ACH requested that additional assessment be completed to the north of the UST area and to the southwest of monitoring well MW-8. Additional assessment at the property will be addressed in Section 8.0 of the report.

3.0 SITE GEOLOGY/HYDROGEOLOGY

Subsurface soils beneath and west of the site, as observed during drilling activities, are predominantly silty clay with occasional sand and silt lenses. Sand content appears to increase with depth below the ground-water interface.

The site elevation is approximately 58 feet above mean sea level (msl). Ground-water elevations beneath and west of the site, as observed in monitoring wells, have varied between 20 and 32 feet above msl (26 to 38 feet bgs) over the past 6 years. The ground-water flow direction is generally to the west. The hydraulic gradient was most recently measured in March, 1994, at 0.0008 foot per foot (ft/ft).

4.0 AQUIFER TEST

To optimize a ground-water remediation system, the hydraulic parameters of the aquifer system must be evaluated. Many of these parameters can be calculated by measuring the change in ground-water elevation with time after withdrawing or injecting a known volume into a monitoring well. This type of aquifer test is commonly referred to as a slug withdrawal or slug injection test. Data obtained from a slug test can be used to calculate the hydraulic conductivity of the aquifer. The transmissivity of the aquifer can then be calculated using an estimated aquifer thickness and the hydraulic conductivity.

GeoResearch conducted slug tests on monitoring wells MW-2, MW-3, and MW-5 at the site on January 27, 1994. These three wells were selected for testing because of their placement relative to the ground-water flow direction and each other would provide the most information regarding the aquifer in the site vicinity. In addition, these three wells also contained sufficient ground water to conduct the slug tests.

Hydraulic conductivities of 1.47×10^{-5} feet per second (ft/sec), 1.77×10^{-5} ft/sec, and 7.13×10^{-5} ft/sec for wells MW-2, MW-3, and MW-5, respectively, were calculated from the slug withdrawal data using the Bouwer & Rice Method. The calculated hydraulic conductivities indicate the aquifer is comprised of silty clays, which concurs with visual observations recorded on the boring logs during drilling (Applied Geosystems 1987, 1988, 1990). Slug test data is provided in Table 1 and Appendix A.

The transmissivity of the aquifer can be calculated from the hydraulic conductivities obtained from the slug test data and using an aquifer thickness of 20 feet. The transmissivity calculated for MW-2, MW-3 and MW-5 are 2.94×10^{-4} feet squared per second (ft^2/sec), 3.54×10^{-4} ft^2/sec, and 1.42×10^{-4} ft^2/sec, respectively.

5.0 GROUND-WATER MODELING

To determine the most effective pumping scenario for the remediation of petroleum hydrocarbons in ground water beneath the site, GeoResearch utilized a ground-water flow model. Ground-water modeling uses data obtained from ground-water measurements and the slug tests to create a mathematical representation of the aquifer system. Upon completion of the mathematical representation, the correct number of recovery wells and the ideal pumping rates are selected by completing several hypothetical pumping scenarios and examining the resultant ground-water elevations in the site vicinity. Ground-water elevation contours illustrating the affects of the pumping scenario on the aquifer are then mapped onto a site plan.

GeoResearch utilized the United States Geological Survey (USGS) "Modular Three-Dimensional Finite-Difference Ground-Water Flow Model" (MODFLOW) written by Mr. Michael McDonald and Mr. Arlen Harbaugh. The mathematical representation was formulated using relevant site data. Boundary conditions were specified at a sufficient distance from the site to have no effect on the evaluated pumping scenarios. Ground-water elevations were varied at the boundaries until the steady-state conditions of the ground-water model matched the ground-water elevations measured at the site.

As stated above, the purpose of ground-water modeling was to define the most effective pumping scenario to remediate the petroleum-hydrocarbon-impacted ground water in the site vicinity. The following parameters were used to establish the most effective pumping scenario:

- utilization of existing wells as extraction wells,
- pumping rates that would not draw ground-water levels below the bottom of the wells within a three month time frame,
- utilization of existing wells within the dissolved-petroleum-hydrocarbon plume, and
- coordination of pumping rates and specified pumping wells that would contain the dissolved-petroleum-hydrocarbon-impacted ground water.

The scenario deemed most effective utilized MW-2 and MW-3 as extraction wells, each pumping at a rate of 0.5 gallons per minute (gpm). This pumping scenario produced the ground-water elevation map shown in Figure 4, and indicated that the entire petroleum-hydrocarbon-impacted ground-water plume would be captured. Ground-water modeling data is provided in Appendix B.

6.0 BIOSUITABILITY STUDY

Ground-water samples collected from MW-2 and MW-3 were analyzed for biochemical oxygen demand (BOD), chemical oxygen demand (COD), pH, total nitrogen, total ortho-phosphate, hydrocarbon oxidizing microorganisms population, and total heterotrophic plate count to assess the potential for natural biodegradation. The most probable number (mpn) of hydrocarbon-oxidizing microorganisms population per milliliter (ml) of ground-water sample analyzed was estimated at 70 x 10^2 mpn/ml and 21 x 10^3 for MW-2 and MW-3, respectively. Low concentrations of total nitrogen (1.5 and 5.8 mg/L) and ortho-phosphate (0.3 and 2.0 mg/L) were also detected.

The biochemical data suggest that the hydrocarbon-oxidizing microorganism population is sufficient for the metabolism of hydrocarbons. Low concentrations of total inorganic nitrogen indicate nutrient levels for microorganisms are low. Nutrients such as nitrogen and phosphate help stimulate the metabolism of the microorganisms.

Research indicates that the biodegradation of petroleum hydrocarbons in ground water is primarily dependent on the available concentrations of dissolved oxygen rather than nutrients.

7.0 FEASIBILITY STUDY FOR GROUND WATER

The objective of this feasibility study was to evaluate remedial alternatives for the mitigation of petroleum-hydrocarbon-impacted ground water beneath the site and migrating off-site to the west. Remedial technologies for ground water were initially screened taking into consideration: (1) the chemical and physical properties of the contaminant(s) of concern, (2) characteristics of the aquifer, (3) technical feasibility of implementation at the site, and (4) estimated time and cost to complete remediation. Feasible remedial technologies were then combined, if appropriate, to formulate viable remedial alternatives. Feasible remedial alternatives were then evaluated and compared based on the advantages, disadvantages, estimated duration of cleanup, and estimated cost to complete remediation. Duration and costs for each remedial alternative are estimates and should be used for comparative purposes only. Remediation systems were not designed as part of this study, but were only evaluated on a preliminary basis.

7.1 SITE PARAMETERS

The environmental and geologic/hydrogeologic parameters, engineering constraints, and regulatory requirements for the site were included in the evaluation of the feasible remedial technologies. Environmental parameters include the type, extent, and chemical and physical properties of the contaminant(s) of concern detected in the ground water. Geologic/hydrogeologic parameters include the site-specific geology and hydrogeology that may influence fluid transport, contaminant migration, and therefore, remedial effectiveness. Engineering constraints pertain to the logistical concerns related to the design and construction of a remediation system. Regulatory requirements include permits, notifications, and agency criteria that may impact the selection and operation of a remediation system.

7.1.1 Environmental

The contaminants of concern detected in ground water beneath the site are TPH-G and BTEX (MPDS, 1994). Floating product, ranging from 0.01 to 0.38 inches, was detected in MW-1 between September, 1987, and April, 1988. Floating product has not been detected in MW-1 since that time. Floating product has not been detected in any other monitoring wells installed in the site vicinity. Therefore, this feasibility study assumes floating product is not a concern at the site.

Benzene was selected as the indicator of the extent of the dissolved-petroleum-hydrocarbon plume in ground water due to its high solubility in ground water and low California Code of Regulations (CCR) Title 23 Maximum Contaminant Level (MCL) for drinking water (0.001 mg/L).

During the first quarter ground-water monitoring of 1994, the highest concentration of benzene (3.8 mg/L) was detected in MW-1 (MPDS, 1994). Average benzene concentrations detected in ground-water samples collected from MW-1, MW-2, MW-3, and MW-8 are 3.8 mg/L, 0.006 mg/L, 1.2 mg/L, and 0.085 mg/L, respectively (Appendix D). Figure 3 indicates isoconcentrations of ~~benzene~~ TPH based on ground-water monitoring data obtained in March 1994.

It is important to note that TPH-G and BTEX concentrations in ground water increase significantly when the ground-water elevation increases (depth-to-ground water decreases). Since the first monitoring wells were installed in 1987, high ground-water elevations have only been measured during the past year. The highest concentrations of TPH-G and benzene were detected when the ground-water elevation was between 25 to 32 feet above msl (26 to 33 feet bgs). The increase in TPH-G concentrations at high ground-water elevations is most likely due to the "smearing" of TPH-G in soil overlying the water table. This "smearing" occurs when TPH-G in ground water is adsorbed to soil particles and remains adsorbed even after the water table has lowered. This assumption is supported by low concentrations of TPH-G in soil samples collected above 25 feet bgs (33 feet above msl).

7.1.2 Geologic/Hydrogeologic

The subsurface soils in the site vicinity are predominantly silty clay with occasional sand and silt lenses. Clays typically have low permeabilities and therefore are not amenable to vapor extraction. Because the feasibility of air sparging and bioventing depends on high soil permeabilities, these technologies were not considered as remedial alternatives for the site.

Based on ground-water monitoring data, the ground-water flow direction is to the west with an average hydraulic gradient of 0.0023 ft/ft. The average hydraulic conductivity of the aquifer is 1.6 x 10^{-5} ft/sec or 1.38 feet per day (ft/day), based on the slug test data. The average hydraulic conductivity indicates the aquifer is comprised of silty clays.

Ground-water modeling results indicate that a pumping rate of 0.5 gpm from MW-2, MW-3, and MW-8, should generate a capture zone which would encompass the benzene plume in ground water in the site vicinity.

7.1.3 Structural

The site is currently an active service station. There is sufficient space to the south of the service station building for the placement of remediation equipment. Two USTs are at the northwest corner of the site, and the dispensers islands are to the west of the service station building. Underground product piping, vent lines, and utilities are located throughout the site. Recent blueprints should be reviewed prior to designing underground remediation piping. If recent blueprints are not available, a geophysical survey of the site may be required to locate underground utilities.

7.1.4 Engineering Constraints

As the service station is currently active, utilities such as electricity and natural gas, which are necessary for the operation of remediation equipment, are readily available. Pacific Gas and Electric would need to be contacted regarding any additions or modifications to the facility's current services.

Treated ground water generated during remediation may be discharged into the sanitary sewer or storm drain, pending agency approval. Both a sanitary sewer connection and storm drain are accessible to the site.

The site is within a residential area therefore noise abatement measures or a limited operational schedule may be required for remediation equipment. The remediation system would be enclosed to satisfy security, noise abatement, and aesthetic concerns.

A three-well pumping scenario would require connecting MW-8, located west of the site across Bancroft Avenue, to the remediation system on-site. Underground piping would be installed from MW-8, underneath Bancroft Avenue, to the southwest corner of the site, pending agency approval and the appropriate traffic control.

7.1.5 Regulatory Requirements

Remedial activities at the site would be conducted under the jurisdiction of the Alameda County Department of Environmental Health, Hazardous Materials Division (County). A Remedial Action Plan (RAP) must be prepared and submitted to the County for review and approval prior to initiating remedial action. The County acts on the authority of the San Francisco Bay Regional Water Quality Control Board (RWQCB) regarding the protection of ground water. The RAP would outline the remedial alternative selected, clean-up levels proposed, anticipated duration for remediation, ground-water monitoring schedule, and verification sampling.

All enclosures, piping, and sewer connections must be constructed in accordance with City of San Leandro Planning and Engineering Department requirements. In addition, an encroachment permit and traffic control would be required for installation of conveyance piping from MW-8, underneath Bancroft Avenue, to the site.

Discharge of treated ground water to the sanitary sewer would require a permit from the City of San Leandro Sanitation District, Environmental Compliance group. An estimate of the flow rate would be required and drinking water limits would have to be met for discharge into the sanitary sewer. Quarterly sampling would be required initially, which may be reduced to biannual sampling after two years of meeting discharge requirements.

Discharge of the treated ground water to the storm drain would require the issuance of a National Pollutant Discharge Elimination System (NPDES) permit by the RWQCB. The NPDES permit would specify discharge and sampling requirements.

Any device that emits hydrocarbons in air requires a permit from the Bay Area Air Quality Management District (BAAQMD). A Permit to Construct (PTC) is issued upon review of system specifications, if necessary. Then upon successful operation of the hydrocarbon-emitting device(s) BAAQMD evaluates the system and issues a Permit to Operate (PTO). Air strippers that may emit hydrocarbons must be permitted through the BAAQMD. Bioreactor and ultraviolet (UV)/oxidation system specifications may require review by the BAAQMD to determine if permitting is necessary.

7.1.6 Assumptions and Limitations

In order to complete this feasibility study, several assumptions were made with regard to the site conditions. Soil contamination was not addressed because site assessment data indicates appreciable concentrations of TPH-G are not present in soil above 25 feet bgs. The residual TPH-G in soil above the ground-water table is most likely due to the smearing of TPH-G as the water table rises and falls over time. Additionally, the source of the soil contamination has been removed, and contaminated soil was excavated to a depth of 22 feet bgs, aerated and removed from the site during tank replacement activities.

The areal extent of the dissolved-petroleum-hydrocarbon plume in ground-water is based on quarterly monitoring data obtained from the eight monitoring wells drilled in the site vicinity. Ground-water samples which did not contain detectable TPH-G and benzene were collected from MW-5 to the south, MW-6 to the west, MW-7 to the west, and MW-4 to the east. However, the extent of TPH-G and benzene in ground water to the north of the site is inferred as no well has been installed north of MW-3.

The limits of the dissolved-petroleum-hydrocarbon plume are assumed to be the monitoring wells where benzene has not been detected in ground-water samples. The detection limit for benzene is 0.0005 mg/L, which is below the drinking water MCL of 0.001 mg/L. This is a worst case scenario for estimating the areal extent and volume of the benzene plume in ground water in the site vicinity. The volume of water requiring remediation is an estimate and may affect the estimated remediation costs. However, this volume estimate should not affect the comparison of appropriate remedial alternatives.

The ground-water model for the three-well pumping scenario assumes that 0.5 gpm can be pumped from MW-8, as a slug test was not conducted on this well. MW-8 is a 2-inch diameter well which may not be capable of supporting this pumping rate. Therefore, this feasibility study presumes MW-8 would be reinstalled as a 4-inch diameter well. The subsurface lithology observed during installation of MW-8 was similar to the lithology observed during installation of the wells which were tested. Therefore, MW-8 should be capable of supporting a 0.5 gpm flow rate if reinstalled as a 4-inch well.

7.2 REMEDIAL ALTERNATIVES

Pump and treat is the most common ex-situ remedial alternative for the mitigation of petroleum hydrocarbons in ground water. Ground water is extracted from the aquifer, treated above ground, and then disposed. A two-well pumping scenario was evaluated to be the most effective for capturing the dissolved-petroleum-hydrocarbon plume.

Remedial technologies reviewed for the treatment of extracted ground water include carbon adsorption, air stripping, bioremediation, and UV/oxidation. Alternatives for the disposal of treated water include discharge to the sanitary sewer and discharge to the storm drain. On-site storage and off-site disposal of untreated ground water was not considered because storage of the large volumes of water which would be generated during pumping would not be feasible.

In-situ remedial alternatives have been typically considered experimental and their effectiveness has not been consistently demonstrated. However, these alternatives have the advantage of not generating pumped and treated ground water requiring disposal.

In-situ bioremediation was evaluated for the mitigation of petroleum hydrocarbons in ground water in the site vicinity. Air sparging and bioventing were not considered due to the low permeability clays which overlay the aquifer, therefore limiting the effectiveness of extracting air from the subsurface.

7.2.1 Pump and Treat

The pump-and-treat alternative consists of pumping ground water from wells and treating the ground water using an above-ground treatment system. Ground water is removed from the aquifer at a rate dependent upon the hydraulic parameters of the aquifer and the capacity of the selected pump. If the aquifer has a sufficient hydraulic conductivity, the pumping well can influence the flow direction of the contaminated ground water. Contaminated ground water drawn into the well is removed and can be treated above ground.

At the estimated total pumping rate of 1.0 gpm (2 wells at 0.5 gpm each), the minimum time required to treat the estimated volume of petroleum-hydrocarbon-impacted ground water would be 3.25 years (Appendix D). This is a best case estimate because it is probable that pumping will not be continuous.

Residual petroleum hydrocarbons in the soil above the water table account for the highest concentrations of petroleum hydrocarbons in ground water. Therefore, these petroleum hydrocarbons must be "washed" from the soil and the resulting contaminated water pumped from the aquifer and treated. Ground-water pump and treat should be conducted primarily when the ground water elevation is between 25 and 32 feet above msl. The slow pumping rate would minimize drawdown and increase the effectiveness of "washing" residual contaminants from the soil. Also, ground water could be intermittently pumped from the aquifer; pumping would continue until the capture zone has been achieved and then discontinued to allow the ground water to return to static levels in the pumping well. When static ground-water elevations were reached in the pumping well, pumping would be reinitiated and the cycle continued.

For this site, pneumatic pumps are proposed because they operate efficiently at slow pumping rates. Pumps would be installed in each of the two proposed pumping wells, MW-2 and MW-3. The pneumatic pumps are operated using an air compressor which would be located in the treatment area. The treatment area would most likely be to the south of the service station building. Pumped ground water would be transported via underground piping to a holding tank in the treatment area. High- and low-level switches would control the flow of ground water through the treatment system and to the discharge point. Feasible ground-water treatment systems are discussed in the following sections.

Once treated, ground water would be discharged to the storm drain or sanitary sewer. Both alternatives would require periodic sampling, as specified in the respective permit, to ensure constituent concentrations do not exceed discharge limits. However, NPDES discharge limits which pertain to discharge to the storm drain are stricter than drinking water MCLs which pertain to discharge to the sanitary sewer. Additionally, the fee for an NPDES permit is $1,000 per year as compared to an estimated $300 per year for discharge to the sanitary sewer, and typically sampling requirements are less stringent for sewer discharges. Therefore, the proposed remedial alternatives include the discharge of treated ground water to the sanitary sewer, pending agency approval (excluding in-situ bioremediation alternative which does not require any discharges).

7.2.1.1 Carbon Adsorption

Adsorption is a natural process in which molecules of liquid are attached to and then held at the surface of a solid by surface tension. Granular activated carbon (GAC) is an excellent adsorbent of hydrocarbons and therefore a feasible remedial alternative for the removal of petroleum hydrocarbons in ground water. GAC can continue to remove contaminants from the ground water until the available surface area of the carbon is completely occupied.

The advantage of carbon adsorption is that GAC is a proven and effective method for removal of petroleum hydrocarbons. A GAC system is relatively easy to construct and requires minimal maintenance. Contaminated vapors are not typically generated therefore, BAAQMD permitting and vapor abatement is not required. The disadvantage of using GAC is the cost associated with the disposal or regeneration of spent carbon. Also, GAC will adsorb all solids in the ground water stream being treated. High concentrations of total dissolved solids (TDS) and microorganisms in the ground water will cause the GAC to become saturated at a faster rate (Appendix D). Due to the low pumping rate and relatively low concentrations of petroleum hydrocarbons, TDS, and microorganisms in the ground water, GAC can be a cost-effective remedial alternative.

The estimated cost for implementation of the ground-water extraction and carbon adsorption remedial alternative plus one quarter operations and maintenance (O&M), O&M for an additional 3 years, and site closure activities is $249,000. This cost includes 2 carbon canisters in series and a total of 12,500 pounds of carbon estimated to remediate the estimated volume of petroleum-hydrocarbon-impacted ground water (Table 2).

7.2.1.2 Air Stripping

Air stripping is the process of transferring volatile organic compounds (VOCs) from the liquid phase to the vapor phase. This transfer is commonly achieved by using a countercurrent flow scheme. Water enters at the top of a tower and flows downward through packing or trays, which provide a large surface area. An airstream flows upward through the tower and entrains the VOCs. The large surface area of the packing or trays allows optimum transfer of VOCs to the vapor phase.

Air stripping is effective for both low and high pumping rates. However, because air stripping is a mass transfer process only, another system may be required to treat the contaminated vapor. However, due to the low pumping rate estimated for the site, the mass extraction rate of VOCs may be below BAAQMD emission limits (Appendix D). Therefore, treatment of the off-gas may not be required for the entire estimated duration of cleanup.

Ground-water remediation costs using an air stripper to capture and remediate the entire dissolved-petroleum-hydrocarbon plume are estimated to be $236,000. This cost includes implementation of the remedial alternative, O&M for 3.0 years, and site closure activities. Treatment of the vapor discharge with GAC, if required, would cost an additional $15,000 (Table 2).

7.2.1.3 Above-Ground Bioremediation

Above-ground bioremediation of ground water is a batch process which takes place in a specially designed bioreactor. The bioreactor consists of a tank (reactor) containing a highly permeable plastic material. The contaminated ground water flows continuously through the tank. After an initial period of acclimation of the microbial population, biological growth occurs on the plastic media. The organic contaminants are adsorbed and degraded into carbon dioxide and water by the microorganisms attached to the plastic media. Air bubbled into the base of the reactor provides constant mixing and the necessary oxygen to support microbial growth. Nutrients are also added to the reactor to enhance biological growth. The size of the bioreactor is dependent on the flow rate and the retention time necessary for degradation. The effluent stream may require a final polish using GAC before it can be discharged into the sanitary sewer or storm drain. The microbial population in the reactor, and therefore in the effluent stream, is removed by chlorine disinfection prior to discharge or polishing.

The advantage of above-ground bioremediation is minimal O&M costs. Operation and maintenance of the bioreactor would be limited to occasional monitoring to confirm that the aeration system is working and adequate nutrients are being supplied to the reactor. Disadvantages of bioremediation is the uncertainty in length of time needed for the microorganisms to acclimate to the environment within the bioreactor, the retention time to facilitate degradation, and the effectiveness for complete removal of contaminants as concentrations approach non-detect and the microorganism populations diminish due to starvation.

The estimated cost for implementation of an above-ground bioremediation system, O&M for 3 years, and site closure activities is $262,000. This cost also includes biofeasibility studies to obtain additional information on the appropriate concentrations of nutrients and oxygen to add to the bioreactor. Polishing of the treated ground-water, if required, using GAC would cost an additional $15,000. Treatment of the off-gases, if required, using GAC would also cost an additional $15,000.

7.2.1.4 UV/Oxidation

The basis for UV/oxidation systems is that many organic compounds absorb UV radiation and undergo a change in their chemical structure or become more reactive to chemical oxidants. UV radiation reacts with oxidants such as hydrogen peroxide or ozone to form hydroxyl radicals that react with organic compounds in water and produce end products of carbon dioxide and water.

The advantages of UV/oxidation systems are that there are no hydrocarbon emissions and minimal maintenance. O&M requirements include periodic cleaning and replacement of UV lamps. The disadvantage of these systems is the high capital cost. However, UV/oxidation systems can be leased for short-term projects or used at more than one site, which may reduce the cost of the system on a per site basis. The estimated cost for UV/oxidation of the extracted ground water is $344,000. This cost estimate includes implementation of the remedial alternative, O&M for 3 years, and site closure activities.

7.2.2 In-situ Bioremediation

In-situ bioremediation of ground water is the biological destruction of contaminants without permanent removal of water from the aquifer. Movement of ground water in the aquifer must be hydraulically controlled to maintain a consistent configuration of the contaminant plume and to supply a source of nutrients and oxygen as well as a medium on which bacteria can grow. To provide this hydraulic control, ground water is pumped from a well or wells centrally located within the contaminant plume, mixed with nutrients, oxygen, and bacteria, and reinjected at the fringes of the plume. Because the ground water that is recharged into the aquifer may also contain contaminants, care must be taken to avoid reinjection beyond the zone of influence of the extraction well(s). This process of extraction and reinjection is continued until treatment objectives are met.

In-situ bioremediation of ground water is still in the experimental stages. The costs associated with bioremediation are expected to be more expensive than a conventional pump-and-treat system because of the additional implementation and operation costs associated with reinjecting ground water. A biofeasibility study and pilot test are recommended before in-situ bioremediation is selected as the most appropriate remedial

however, no GAC or discharge permits/ hook-ups are required

— infiltration gallery must be designed to pass "fortified" water through contaminated zone

alternative. Analysis of ground-water samples for microbial population indicate that sufficient populations of hydrocarbon-oxidizing microorganisms are present naturally. However, nutrient and oxygen levels may need to be enhanced.

The advantage of in-situ bioremediation is that treated ground-water is not generated for disposal. Also, in-situ bioremediation may be more effective at remediating ground water in the site vicinity. Injected ground water, that has been enhanced with nutrients and oxygen, may biodegrade residual TPH-G adsorbed to soil particles in the capillary fringe above the water table. Among the disadvantages of in-situ bioremediation are the difficulty monitoring and controlling remediation, and uncertainty of treatment effectiveness. In addition, agency approval may not be attainable due to the irrigation wells in the site vicinity.

The estimated cost for in-situ bioremediation is $318,000. This cost estimate includes implementation of the remedial alternative, O&M for 3 years, and site closure. Due to the experimental nature of in-situ bioremediation, these costs and the duration of cleanup can only be gross estimates.

7.3 COMPARATIVE ANALYSIS

Table 2 summarizes the feasible remedial alternatives for petroleum-hydrocarbon-impacted ground water in the site vicinity. The least expensive remedial alternatives are ground-water extraction and carbon adsorption, and ground-water extraction and air stripping. The most expensive remedial alternative is ground-water extraction and UV/oxidation, primarily due to the high capital cost for the UV/oxidation system.

A carbon adsorption system is the easiest to install, but will require periodic carbon replacement. An air stripper may only require periodic cleaning, but permitting through the BAAQMD may increase the effort required to implement this remedial alternative. Additionally, treatment of the vapor effluent may be required if the system operates 24 hours per day. Even with treatment of the vapor effluent, air stripping and carbon adsorption are cost competitive ground-water treatment technologies.

UV/oxidation, like air stripping, may only require periodic cleaning of the system and replacement of UV lamps. However, the capital cost of a UV/oxidation system is the highest of the treatment systems evaluated. Leasing a UV/oxidation system may reduce this capital cost, but not enough to be competitive with air stripping. Purchasing a UV/oxidation system for use at several sites may make this alternative more cost effective.

A cost estimate for above-ground bioremediation is more difficult to provide. Biofeasibility studies are required to evaluate the nutrients, oxygen, and residence time required to remediate ground water to the specified clean-up levels. Without these studies, it is not certain that clean-up levels can be achieved by bioremediation alone. Therefore, polishing of the treated ground water using GAC may be required at an added cost. The BAAQMD, upon review of the system specifications, may require treatment of the vapor effluent, also at an added cost. Should the biofeasibility studies and consultation with BAAQMD indicate polishing of the ground water effluent and vapor emission control is not required, above-ground bioremediation would be comparable in cost to carbon adsorption.

In-situ bioremediation is an experimental remedial alternative and should therefore be considered for research and development purposes. As with all in-situ remedial technologies, it is difficult to monitor and control remediation. Agency approval of the reinjection of petroleum-hydrocarbon-impacted ground-water is questionable, and if reinjection is approved it must be strictly monitored. As with above-ground bioreactors, biofeasibility studies are required and treatment of the vapor effluent may be necessary. An in-situ bioremediation pilot test is recommended prior to implementing full-scale in-situ bioremediation at the site. Biofeasibility studies, an in-situ bioremediation pilot test, and consultation with the agencies would be required to better evaluate the feasibility of this remedial alternative.

8.0 SUPPLEMENTAL INVESTIGATION

In a letter to Unocal from the ACH dated July 1, 1994, ACH requested that additional assessment be completed to the north of the UST area and to the southwest of monitoring well MW-8. To address this issue, GeoResearch will drill and install two additional monitoring wells in the locations depicted in Figure 5. The proposed monitoring well locations were chosen based on previously collected soil and ground-water data and the location of surface and subsurface obstructions. The two monitoring wells will be drilled to approximately 50 feet bgs with a mobile drilling rig equipped with 10-inch hollow-stem augers. The drilling will be conducted under the direct supervision of a GeoResearch geologist. Soil samples for laboratory analysis will be collected from the ground-water interface. The monitoring wells will be constructed with 2-inch PVC casing, Number 3 Monterey Sand, and 30 feet of 0.02-inch slotted screen. The drilling and well installation will be conducted in general accordance with the field procedures presented in Appendix D.

Each well will be developed by surging the well with a surge block for approximately 10 to 15 minutes and purging the well with a bailer for approximately 1-hour and/or until 3 to 5 well casing volumes of water are purged from the wells. The development will be conducted in general accordance with the field procedures presented in Appendix D.

The two newly constructed wells will be surveyed for vertical elevation and horizontal location to an accuracy of 0.01 foot by a California-licensed land surveyor. The elevation of the wells will be surveyed relative to a benchmark, and reported in feet above mean sea level.

Soil samples collected will be analyzed by Sequoia Analytical of Redwood City, California, a state of California certified hazardous waste laboratory. The samples will be analyzed for total petroleum hydrocarbons as gasoline (TPH-G) in accordance with DOHS Method for TPH-G characterization and benzene, toluene, ethylbenzene, total xylenes (BTEX) in accordance with EPA Method 8020. Ground-water samples will be collected and analyzed as part of the quarterly ground-water monitoring activities at the site.

9.0 SUMMARY AND CONCLUSIONS

The following summarizes the findings of this feasibility study with regard to the remediation of TPH-G- and BTEX-impacted ground water beneath and to the west of Unocal service station 5367.

- Slug test data and the resulting ground-water modeling indicate that a two-well pumping scenario will capture the dissolved-petroleum-hydrocarbon-plume in the site vicinity. The two wells would pump ground-water at a rate of 0.5 gpm.

- Of the four ground-water extraction remedial alternatives, air stripping is the least expensive. However, if treatment of the vapor effluent from the air stripper is required, carbon adsorption is comparable in cost. Above-ground bioremediation may also be comparable in cost, however, biofeasibility studies would be required in order to better evaluate this remedial alternative.

- Ground-water extraction and UV/oxidation may be a cost effective remedial alternative if the system could also be used at additional sites.

- In-situ bioremediation may be the most effective for remediating the dissolved-petroleum-hydrocarbon plume and TPH-G adsorbed to soil within the capillary fringe. However, there are several uncertainties with this remedial alternative including agency acceptance, and remediation effectiveness and duration.

- Two additional monitoring wells will be installed to further define the extent of gasoline impacted ground water.

10.0 REFERENCES

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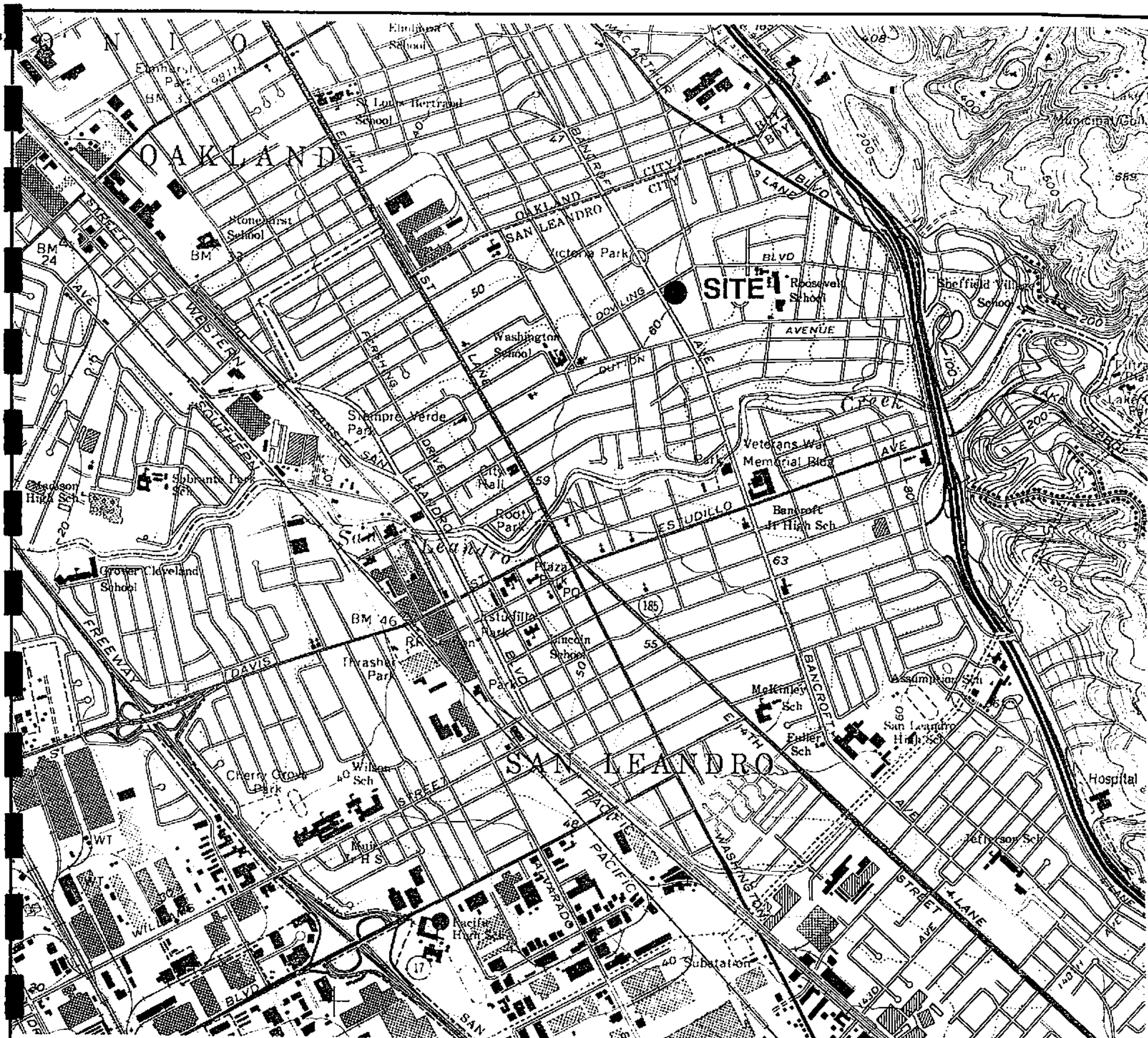
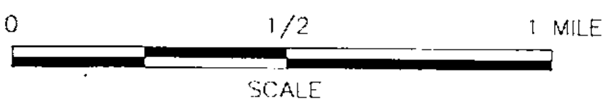


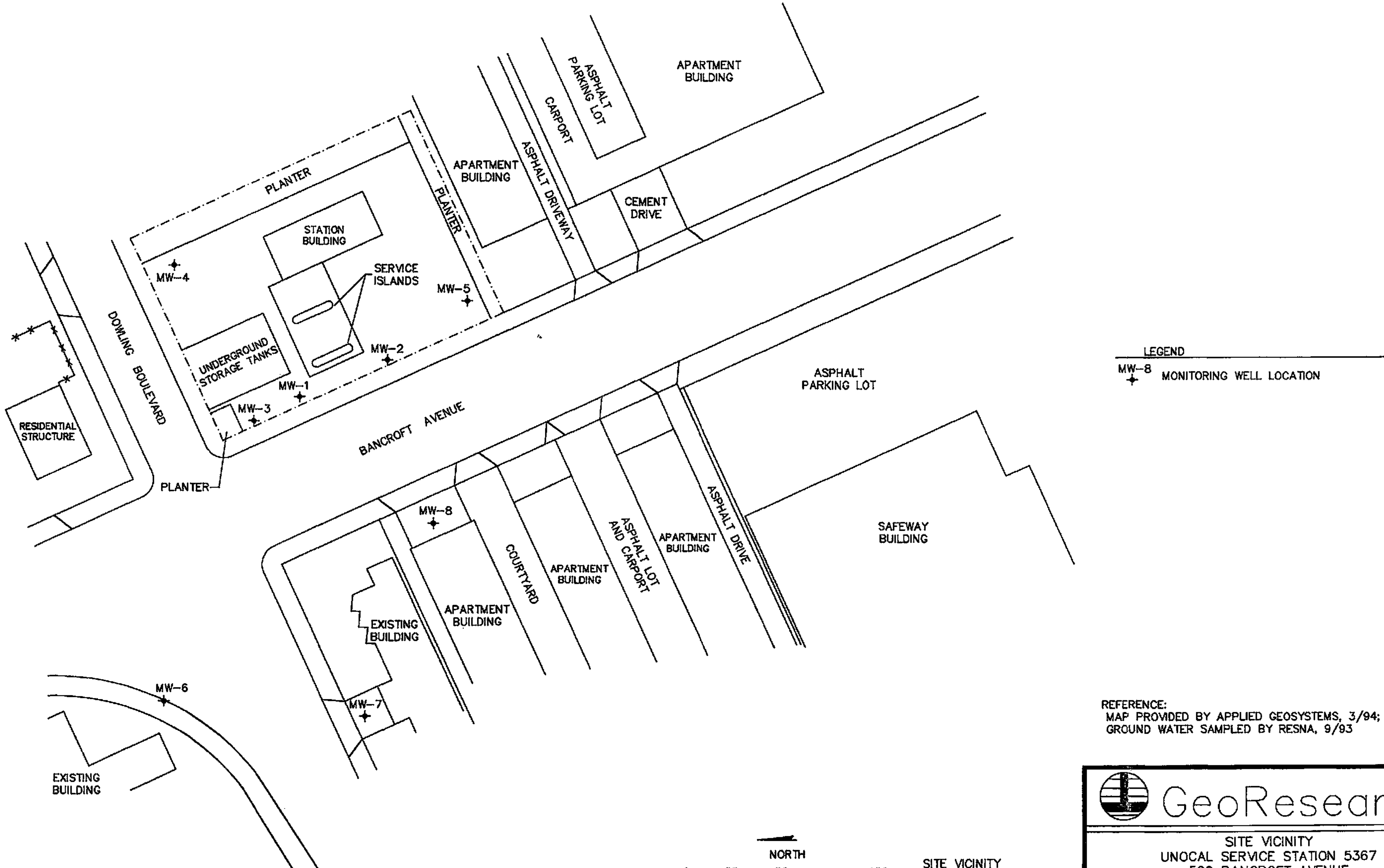


REFERENCE:
U.S.G.S. SAN LEANDRO QUADRANGLE, 1959, PHOTOREVISED 1980

GeoResearch

SITE LOCATION
UNOCAL SERVICE STATION 5367
500 BANCROFT AVENUE
SAN LEANDRO, CALIFORNIA
PROJECT NUMBER: 9480600100

DATE: 3/15/94	CKD BY:	FIGURE NO: 1
FILE NO: A1		DRAWN BY: S.NASH

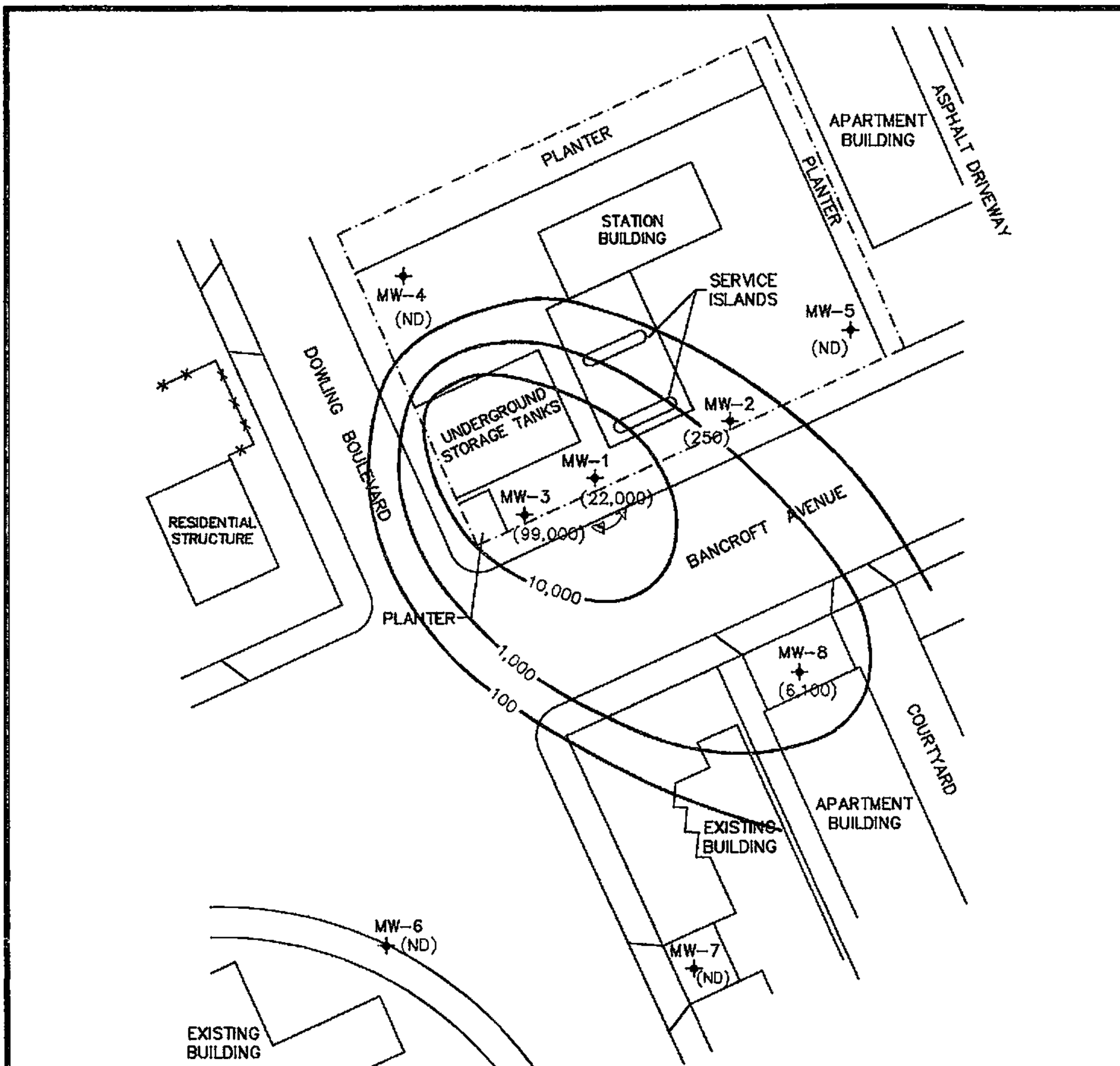


REFERENCE:
MAP PROVIDED BY APPLIED GEOSYSTEMS, 3/94;
GROUND WATER SAMPLED BY RESNA, 9/93

GeoResearch

SITE VICINITY
UNOCAL SERVICE STATION 5367
500 BANCROFT AVENUE
SAN LEANDRO, CALIFORNIA
PROJECT NUMBER: 9480600100

DATE: 7/22/94	CKD BY:	FIGURE NO.: 2
FILE NO: C1		DRAWN BY: S.NASH



REFERENCE:
MAP PROVIDED BY APPLIED GEOSYSTEMS, 3/94;
GROUND WATER SAMPLED BY RESNA, 3/94

NORTH

0 25 50 100

APPROXIMATE SCALE IN FEET

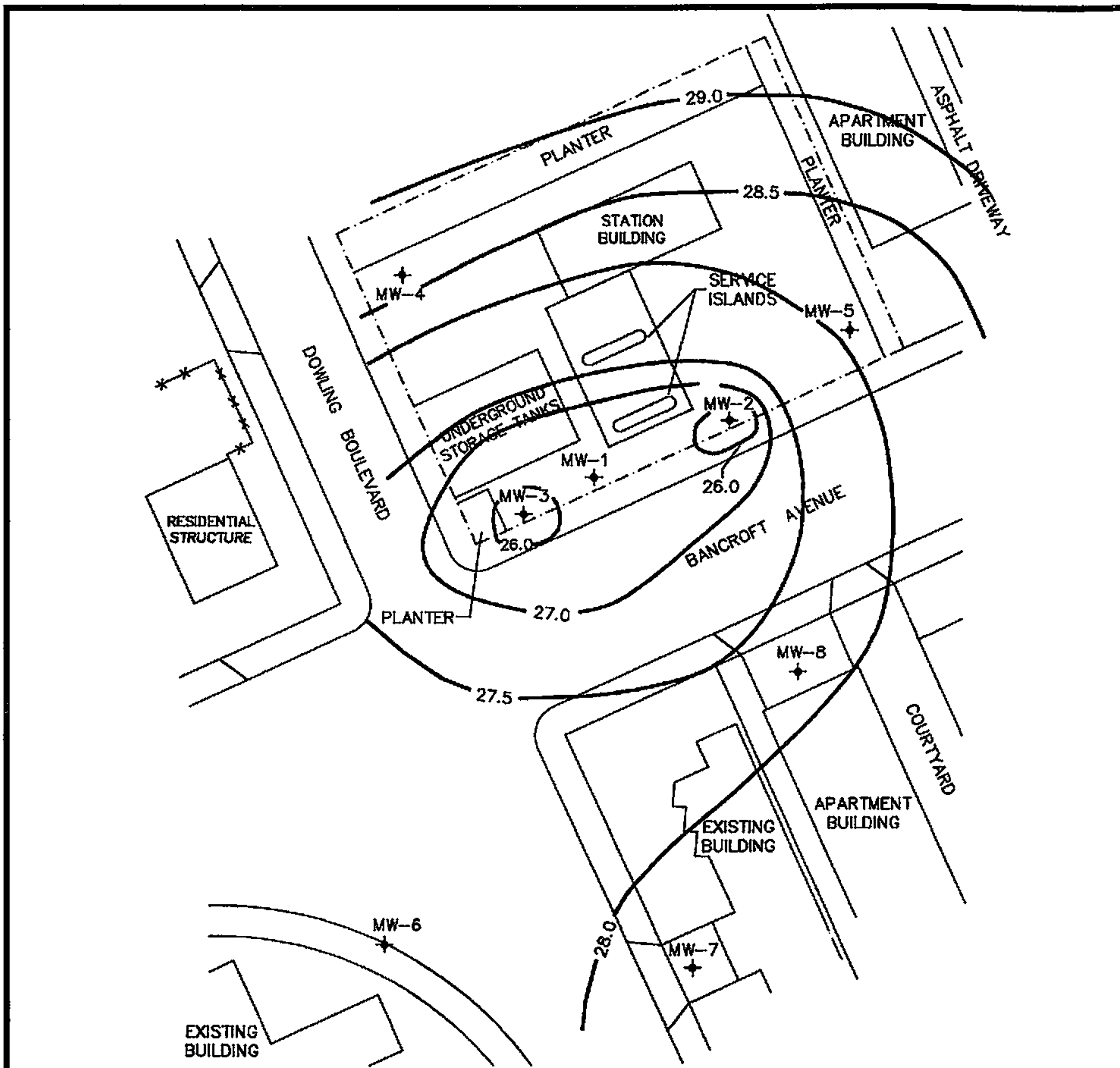
LEGEND

MW-8	MONITORING WELL LOCATION
(6,100)	TPH-G ~~BENZENE~~ CONCENTRATION IN MICROGRAMS PER LITER (ug/L)
(ND)	NOT DETECTED
100	INFERRED LINE OF EQUAL BENZENE CONCENTRATION IN ug/L

GeoResearch

TPH-G ~~BENZENE~~ ISOCONCENTRATIONS – 3/94
UNOCAL SERVICE STATION 5367
500 BANCROFT AVENUE
SAN LEANDRO, CALIFORNIA
PROJECT NUMBER: 9480600100

DATE: 7/22/94	CKD BY:	FIGURE NO.: 3
FILE NO: D1		DRAWN BY: S.NASH



REFERENCE:
MAP PROVIDED BY APPLIED GEOSYSTEMS, 3/94;
GROUND WATER SAMPLED BY RESNA, 3/94

NORTH

0 25 50 100

APPROXIMATE SCALE IN FEET

LEGEND

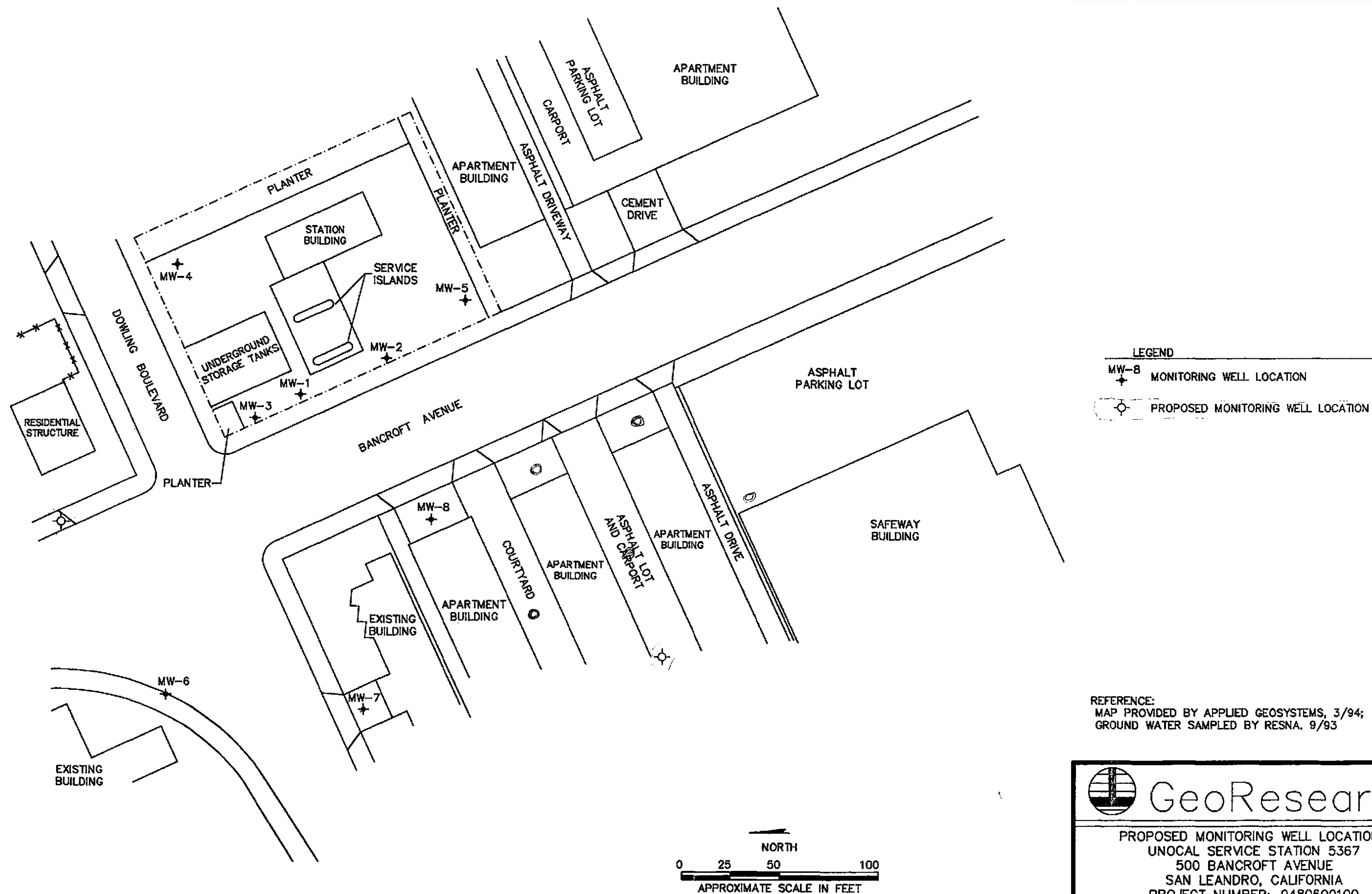
MW-8 MONITORING WELL LOCATION

27.0 LINE OF EQUAL GROUND-WATER ELEVATION IN FEET ABOVE MEAN SEA LEVEL AFTER 1 (ONE) YEAR OF PUMPING

GeoResearch

GROUND-WATER MODEL TWO-WELL PUMPING SYSTEM
UNOCAL SERVICE STATION 5367
500 BANCROFT AVENUE
SAN LEANDRO, CALIFORNIA
PROJECT NUMBER: 9480600100

DATE: 7/22/94	CKD BY:	FIGURE NO.: 4
FILE NO: D1		DRAWN BY: S.NASH



REFERENCE:
MAP PROVIDED BY APPLIED GEOSYSTEMS, 3/94;
GROUND WATER SAMPLED BY RESNA, 9/93

GeoResearch

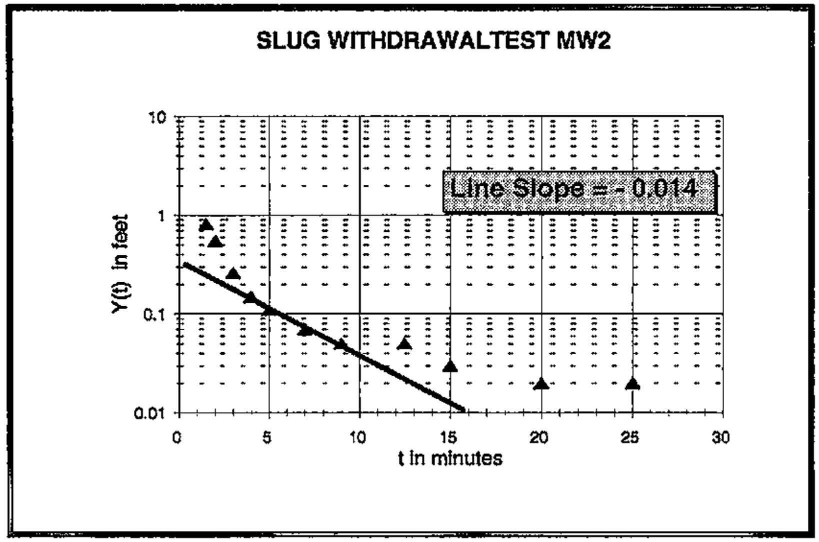
PROPOSED MONITORING WELL LOCATIONS
UNOCAL SERVICE STATION 5367
500 BANCROFT AVENUE
SAN LEANDRO, CALIFORNIA
PROJECT NUMBER: 9480600100

DATE: 7/22/94	CKD BY:	FIGURE NO.: 5
FILE NO: C1		DRAWN BY: S.NASH

TABLE 1

SLUG TEST DATA MW2
UNOCAL SERVICE STATION # 5367
SAN LEANDRO, CALIFORNIA

ELASPED INJECTION TIME (t)	ELASPED WITHDRAWAL TIME (t)	DEPTH TO WATER	CHANGE IN WATER LEVEL (Yt)
NA	0	32.77	0.00
NA	1.5	33.58	0.81
NA	2	33.32	0.55
NA	3	33.03	0.26
NA	4	32.92	0.15
NA	5	32.88	0.11
NA	7	32.84	0.07
NA	9	32.82	0.05
NA	12.5	32.82	0.05
NA	15	32.80	0.03
NA	20	32.79	0.02
NA	25	32.79	0.02



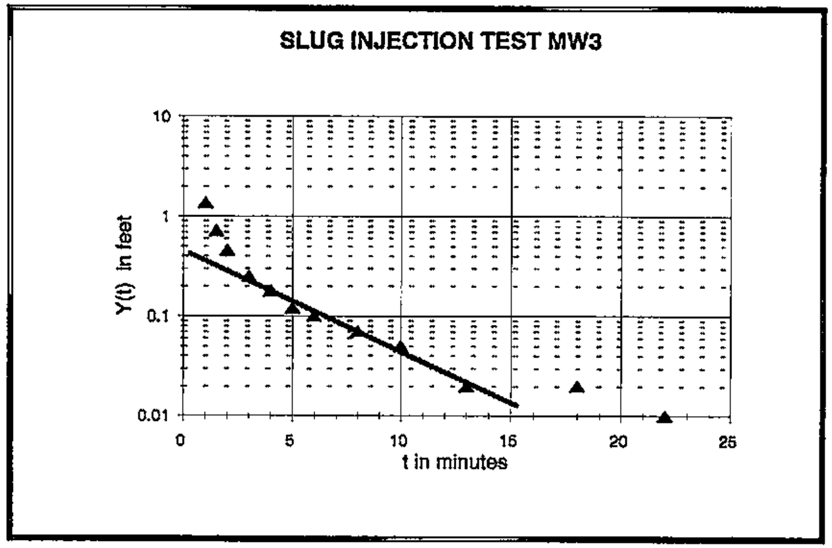
NOTES:

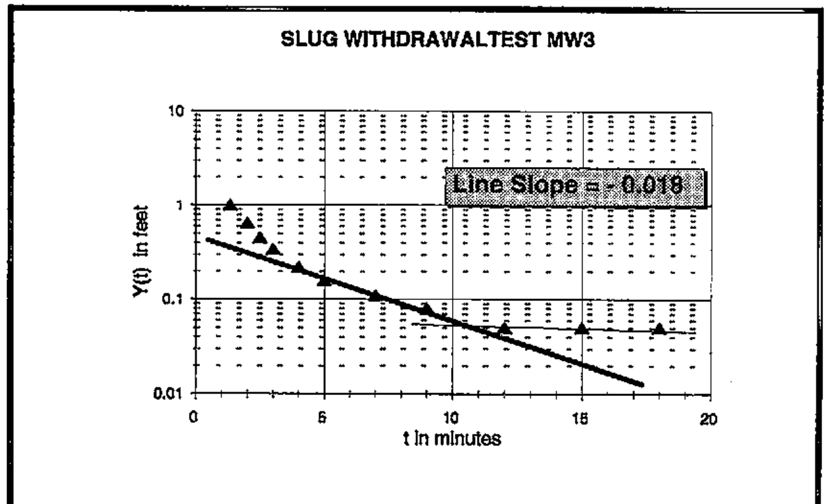
1. Time reported in minutes and length values reported in feet.
2. Depth to water measured from the top of casing.
3. Absolute change in water level (Yt) = static water level- water level measured at time (t).
4. NA = Not applicable

TABLE 1

SLUG TEST DATA MW3
UNOCAL SERVICE STATION # 5367
SAN LEANDRO, CALIFORNIA

ELASPED INJECTION TIME (t)	ELASPED WITHDRAWAL TIME (t)	DEPTH TO WATER	CHANGE IN WATER LEVEL (Yt)
0	NA	32.52	0.00
1	NA	31.15	1.37
1.5	NA	31.80	0.72
2	NA	32.06	0.46
3	NA	32.27	0.25
4	NA	32.34	0.18
5	NA	32.40	0.12
6	NA	32.42	0.10
8	NA	32.45	0.07
10	NA	32.47	0.05
13	NA	32.50	0.02
18	NA	32.50	0.02
22	NA	32.51	0.01
NA	1.33	33.52	1.00
NA	2	33.17	0.65
NA	2.5	32.97	0.45
NA	3	32.86	0.34
NA	4	32.74	0.22
NA	5	32.68	0.16
NA	7	32.63	0.11
NA	9	32.60	0.08
NA	12	32.57	0.05
NA	15	32.57	0.05
NA	18	32.57	0.05





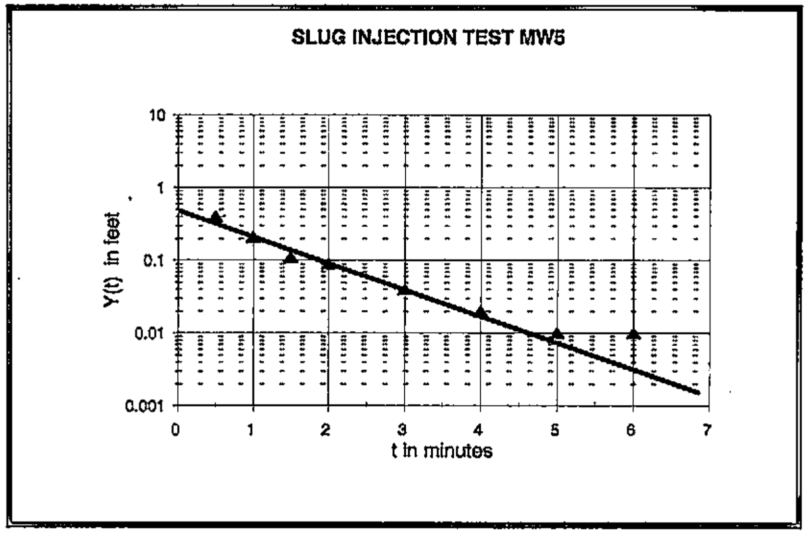
NOTES:

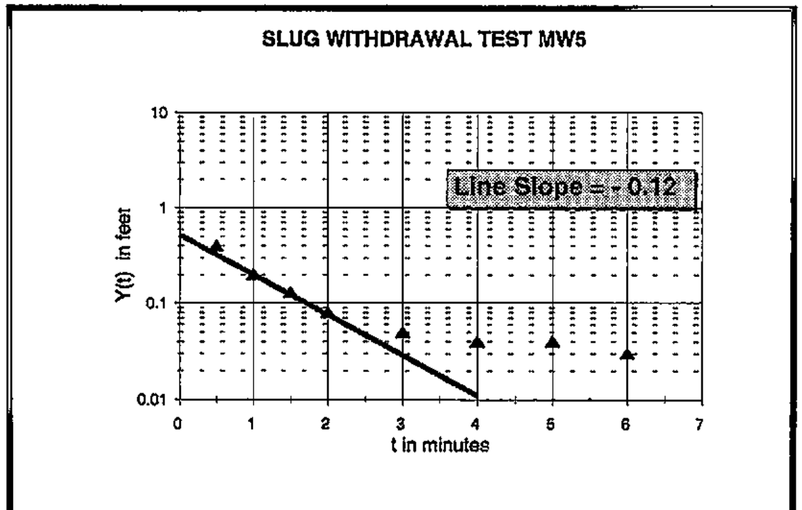
1. Time reported in minutes and length values reported in feet.
2. Depth to water measured from the top of casing.
3. Absolute change in water level (Yt) = static water level- water level measured at time (t).
4. NA = Not applicable

TABLE 1

SLUG TEST DATA MW5
UNOCAL SERVICE STATION # 5367
SAN LEANDRO, CALIFORNIA

ELASPED INJECTION TIME (t)	ELASPED WITHDRAWAL TIME (t)	DEPTH TO WATER	CHANGE IN WATER LEVEL (Yt)
0	NA	33.10	0.00
0.5	NA	32.70	0.40
1	NA	32.89	0.21
1.5	NA	32.99	0.11
2	NA	33.01	0.09
3	NA	33.06	0.04
4	NA	33.08	0.02
5	NA	33.09	0.01
6	NA	33.09	0.01
NA	0.5	33.50	0.40
NA	1	33.30	0.20
NA	1.5	33.23	0.13
NA	2	33.18	0.08
NA	3	33.15	0.05
NA	4	33.14	0.04
NA	5	33.14	0.04
NA	6	33.13	0.03





NOTES:

1. Time reported in minutes and length values reported in feet.
2. Depth to water measured from the top of casing.
3. Absolute change in water level (Yt) = static water level- water level measured at time (t).
4. NA = Not applicable

TABLE 2
FEASIBLE GROUND-WATER REMEDIAL ALTERNATIVES
UNOCAL SERVICE STATION 5367, SAN LEANDRO, CALIFORNIA
GEORESEARCH PROJECT 9480600100

REMEDIAL ALTERNATIVE	ESTIMATED REMEDIATION COST[1]	QUARTERLY O&M COSTS[2]	ADVANTAGES	DISADVANTAGES
Ground-Water Extraction and Carbon Adsorption	$249,000	$6000	• Easy to implement. • Minimal O&M. • No VOC emissions. • No polishing of treated ground water required.	• Pumping only efficient for hydrocarbon removal when the water table is high. • New carbon must be periodically installed. • Spent carbon must be disposed of or regenerated.
Ground-Water Extraction and Air Stripping	$236,000 additional $15,000 for vapor effluent treatment, if required	$6,500	• Easy to implement. • Minimal O&M. • No polishing of treated ground water required.	• Pumping only efficient for hydrocarbon removal when the water table is high. • PTO/PTC required. • May require effluent vapor treatment.
Ground-Water Extraction and Above-Ground Bioremediation	$262,000 additional $15,000 for vapor effluent treatment, if required additional $15,000 for polishing, if required	$6,500	• Minimal O&M. • Destructive remedial technology.	• Pumping only efficient for hydrocarbon removal when the water table is high. • Biofeasibility studies required. • May require effluent vapor treatment. • Greater uncertainty of treatment duration and efficiency. • Polishing of treated ground water may be required.
Ground-Water Extraction and UV/Oxidation	$344,000	O&M = $7,000	• Easy to implement. • Minimal O&M. • Destructive remedial technology. • No VOC emissions. • No polishing of treated ground water required.	• Pumping only efficient for hydrocarbon removal when the water table is high. • High capital cost.

TABLE 2 (continued) FEASIBLE GROUND-WATER REMEDIAL ALTERNATIVES UNOCAL SERVICE STATION 5367, SAN LEANDRO, CALIFORNIA				
REMEDIAL ALTERNATIVE	ESTIMATED REMEDIATION COST[1]	QUARTERLY O&M COSTS[2]	ADVANTAGES	DISADVANTAGES
Ground-Water Extraction/Infiltration and In-situ Bioremediation	$318,000	$6,500	• Injection and extraction is more efficient at capturing entire hydrocarbon plume. • May provide a mechanism to remediate hydrocarbons adsorbed to soil within the capillary fringe. • No disposal of treated ground water required.	• Agencies may not approve reinjection of contaminated ground water processed with nutrients, oxygen, and/or hydrocarbon-oxidizing microorganisms. • Biofeasibility studies and pilot test required to determine feasibility of alternative.

Notes:
[1]Total remediation cost includes implementation of specified remedial alternative and one quarter of O&M, O&M for an additional 3.0 years, and site closure activities.
[2]Quarterly O&M cost provided if the duration of remediation extends beyond the estimated minimum duration for cleanup of 3..25 years.

APPENDIX A

AQUIFER TEST RESULTS

WELL MW2

WELL DETAILS

	inches	feet	radius
well dia	4	0.333	0.167
borehole	10	0.833	0.417
bot. casing	--------	48	--------
depth GW	--------	32.77	--------

VARABLES

	Feet	No units	H2O rising in screen	H20 rising in casing
rc=	--------	--------	0.267	0.087
rw =	0.417	--------	--------	--------
L =	15.2	(where L= H)	-----	--------
H=	15.2	--------	--------	--------
A=	--------	2.55	--------	--------
B=	--------	0.45	--------	--------
C=	--------	0.00	--------	--------
1/t ln Yo/Yt=	--------	0.014	--------	--------

BOUWER & RICE EQUATIONS

Re EQUATION

where D = infinite; ln[(D-H)/rw] =			6
L/rw	--------	36.55	
ln(Re/rw) =	0.449		

K EQUATION

	H2O rising in screen	H20 rising in casing
K =	**1.477E-05**	

WELL MW3

WELL DETAILS

	inches	feet	radius
well dia	4	0.333	0.167
borehole	10	0.833	0.417
bot. casing	--------	48.53	--------
depth GW	--------	32.52	--------

VARABLES

	Feet	No units	H2O rising in screen	H20 rising in casing
rc=	--------	--------	0.267	0.087
rw =	0.417	--------	--------	--------
L =	16.0	(where L= H)	-----	--------
H=	16.0	--------	--------	--------
A=	--------	2.65	--------	--------
B=	--------	0.45	--------	--------
C=	--------	0.00	--------	--------
1/t ln Yo/Yt=	--------	0.018	--------	--------

BOUWER & RICE EQUATIONS

Re EQUATION

where D = infinite; ln[(D-H)/rw] =			6
L/rw	--------	38.42	
ln(Re/rw) =	0.441		

K EQUATION

	H2O rising in screen	H20 rising in casing
K =	1.77E-05	

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WELL MW 5

WELL DETAILS

	inches	feet	radius
well dia	2	0.167	0.083
borehole	8	0.667	0.333
bot. casing	--------	47	--------
depth GW	--------	33.1	--------

VARABLES

	Feet	No units	H2O rising in screen	H20 rising in casing
rc=	--------	--------	0.195	0.022
rw =	0.333	--------	--------	--------
L =	13.9	(where L= H)	-----	--------
H=	13.9	--------	--------	--------
A=	--------	2.75	--------	--------
B=	--------	0.50	--------	--------
C=	--------	0.00	--------	--------
1/t ln Yo/Yt=	--------	0.120	--------	--------

BOUWER & RICE EQUATIONS

Re EQUATION

where D = infinite; ln[(D-H)/rw] = 6

L/rw	--------	41.7	
ln(Re/rw) =	0.433		

K EQUATION

	H2O rising in screen	H20 rising in casing
K =	7.13E-05	

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APPENDIX B

GROUND-WATER MODELING DATA

GROUND-WATER MODELING
AQUIFER PARAMETERS

U.S.G.S. 3-DIMENSIONAL FINITE DIFFERENCE MODEL
HARBAUGH AND MCDONALD

The following aquifer parameters were utilized in the ground-water model to create the ground-water elevation map presented in Figure 4.

Length: 1720 Feet

Width: 1720 Feet

Aquifer Thickness: 20 Feet

Pumping Rate in All Wells: 0.0011 Feet/Second (0.5 Gallons/Minute)

Storativity 0.1

Transmissivity: 4×10^{-4} Feet^2/Second

Hydraulic Conductivity: 2×10^{-5} Feet/Second

Pumping Wells: MW2 and MW3

Time Duration: 1 Year

CENTER FOR ENVIRONMENTAL MICROBIOLOGY, INC.

1660 CHICAGO AVE., SUITE M-2 • RIVERSIDE, CA 92507 • (909) 788-0808 • FAX (909) 788-1691

Attn: Frank Poss

Date: 02/02/94

Client: GEO RESEARCH
3777 Depot
Hayward, CA. 94545
(510)785-1111 FAX (510)785-1192

Job No.: 1134

Project: UNOCAL
PROJECT #9480600100

Date Received: 01/25/94

Date Analyzed: 01/25/94 to 02/01/94

Samples Received: 2 water

LABORATORY RESULTS

Sample	pH	NH_4-N ($mg\ L^{-1}$)	NO_3-N ($mg\ L^{-1}$)	Ortho-phosphate-P ($mg\ L^{-1}$)	Hydrocarbon oxidizing population ($mpn\ mL^{-1}$)	Total heterotrophic plate count ($cfu\ mL^{-1}$)
MW-3	7.03	<1	1.5	2.0	21×10^3	110×10^3
MW-2	7.16	<1	5.8	0.3	70×10^2	120×10^2

Respectfully submitted,
CENTER FOR ENVIRONMENTAL MICROBIOLOGY, INC.

W. T. Frankenberger

W. T. Frankenberger, Jr., Ph.D.
Laboratory Director

BACTERIOLOGY
WATER TESTING
HAZARDOUS WASTE TESTING
CA DHS CERTIFICATION 1156

LABORATORIES
6100 QUAIL VALLEY COURT, RIVERSIDE

E.S. BABCOCK
& SONS, INC.
ESTABLISHED 1906

909/653-3351
FAX 909/653-1662

P.O. BOX 432
RIVERSIDE, CA 92502

02/03/94

To: **Center/Environmt. Microbiology**
Attn: W.T. Frankenberger
1660 Chicago Ave. Suite M-2
Riverside, CA 92507

Lab No.	**940125-1569**
Invoice No.	**99771**

Sample Marked:
Unocal Proj.#9480600100
MW-2 Water

Submitted	Sampled
WTF 01/25/94 12:00	WTF 01/24/94

Chain of Custody on file: Y

Parameter Name	Results	Parameter Name	Results
Biochemical Oxygen Demand[5]	210 mg/L		
Chemical Oxygen Demand	50 mg/L		

Date analysis completed: 01/31/94

Notes: COD results incompatible with BOD results. Volatile nature of matrix suspected.

cc:

Edward S. Babcock & Sons, Inc.

BACTERIOLOGY
WATER TESTING
HAZARDOUS WASTE TESTING
CA DHS CERTIFICATION 1156

LABORATORIES
6100 QUAIL VALLEY COURT, RIVERSIDE

E.S. BABCOCK & SONS, INC.
ESTABLISHED 1906

909/653-3351
FAX 909/653-1662

P.O. BOX 432
RIVERSIDE, CA 92502

02/03/94

To: Center/Environmt. Microbiology
Attn: W.T. Frankenberger
1660 Chicago Ave. Suite M-2
Riverside, CA 92507

Lab No.	940125-1570
Invoice No.	99771

Sample Marked:
Unocal Proj.#9480600100
MW-3 Water

Submitted	Sampled
WTF 01/25/94 12:00	WTF 01/24/94

Chain of Custody on file: Y

Parameter Name	Results	Parameter Name	Results
Biochemical Oxygen Demand[5]	180 mg/L		
Chemical Oxygen Demand	65 mg/L		

Date analysis completed: 01/31/94

Notes: COD results incompatible with BOD results. Volatile nature of matrix suspected.

cc:

Edward S. Babcock & Sons, Inc.

UNOCAL 76

❑ 680 Chesapeake Drive • [redacted] 940[redacted] (415) 3[redacted]00 | [redacted] 1893[redacted]h Ave[redacted], Sui[redacted] • Bot[redacted]A 98[redacted] (206)[redacted]200 [redacted]

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❑ 1900 Bates Ave., Suite LM • Concord, CA 94520 • (510) 686-9600 | ❑ 15055 S.W. Sequoia Pkwy, Suite 110 • Portland, OR 97222 • (503) 624-9800

Company Name: GeoResearch	Project Name: Unocal
Address: 3777 Depot	UNOCAL Project Manager: Tina Berry
City: Hayward State: Ca Zip Code: 94545	Project # 9480600100
Telephone: (510) 785-1111 FAX #: (510) 785-1192	Site #: 5367
Report To: Frank Poss Sampler: Frank Poss / Mike Guy	QC Data: ☒ Level A (Standard) ❑ Level B ❑ Level C ❑ Level D

Turnaround Time: ❑ 10 Working Days ❑ 5 Working Days ❑ 3 Working Days ❑ 2 Working Days ❑ 24 Hours ❑ 2 - 8 Hours ☒ STD

❑ Drinking Water ❑ Waste Water ❑ Other

Analyses Requested

	Client Sample I.D.	Date/Time Sampled	Matrix Desc.	# of Cont.	Cont. Type	Laboratory Sample #	610 Parameters	Fe/Mn BOD	Ca/Mg COD	~~Total Hardness~~						Comments
1.	MW3	1/24/94 12:00	H2O	2	8oz Glass		X	X	X	~~X~~						
2.	MW2	↓	↓	↓	↓		X	X	X	~~X~~						
3.																
4.																
5.																
6.																
7.																
8.																
9.																
10.																

Relinquished By: [signature]	Date: 1/24/94	Time: 3:00	Received By: [signature]	Date: 1/25/94	Time: 11:30 AM
Relinquished By:	Date:	Time:	Received By:	Date:	Time:
Relinquished By:	Date:	Time:	Received By Lab:	Date:	Time:

Were Samples Received in Good Condition? ❑ Yes ❑ No Samples on Ice? ❑ Yes ❑ No Method of Shipment________

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To be completed upon receipt of report:

1) Were the analyses requested on the Chain of Custody reported? ❑ Yes ❑ No If no, what analyses are still needed?________
2) Was the report issued within the requested turnaround time? ❑ Yes ❑ No If no, what was the turnaround time?________

Approved by: ________ Signature: ________ Company: ________ Date: ________

Pink - Client
Yellow - Sequoia
White - Sequoia