Applied GeoSystems, Inc.
A RESNA Company

RESNA
Working To Restore Nature

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WORK PLAN
for
ADDITIONAL SUBSURFACE INVESTIGATION AND DESIGN AND PERMITTING OF VAPOR EXTRACTION SYSTEM
at
ARCO Station 2152
22141 Center Street
Castro Valley, California 10/22/91

RESNA 69013.08

Prepared by
RESNA

Prepared for
ARCO Products Company
P.O. Box 5811
San Mateo, California 94402

Joel Coffman
Project Geologist

Joan Tiernan
Registered Civil Engineer No. 044600

October 22, 1991

REGISTERED PROFESSIONAL ENGINEER
JOAN E. TIERNAN
No. C 044600
Exp. 3-31-94
CIVIL
STATE OF CALIFORNIA

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TRANSMITTAL

TO: MR. SCOTT SEERY
ACHCSA
DEPT. OF ENVIRONMENTAL HEALTH
80 SWAN WAY, ROOM 200
OAKLAND, CA 94621

DATE: 10/21/91
PROJECT NUMBER: 69013.08
SUBJECT: WORK PLAN

FROM: JOEL COFFMAN
TITLE: PROJECT GEOLOGIST

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1	10/21/91	69013.08	WORK PLAN FOR ADDITIONAL SUBSURFACE INVESTIGATION
			AND DESIGN AND PERMITTING OF VAPOR EXTRACTION
			SYSTEM AT ARCO STATION 2152, 22141 CENTER STREET,
			CASTRO VALLEY, CA.

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REMARKS:
PER ARCO'S AUTHORIZATION WORK PLAN HAS BEEN FORWARDED
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*File Name: TRANSMT.PRJ

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October 22, 1991
69013.08

Mr. Chuck Carmel
Environmental Engineer
ARCO Products Company
P.O. Box 5811
San Mateo, California 94402

Subject: Transmittal of Work Plan for Additional Subsurface Investigation and Design and Permitting of Vapor-Extraction System at ARCO Station 2152, 22141 Center Street, Castro Valley, California.

Mr. Carmel:

As requested by ARCO Products Company (ARCO), RESNA has prepared the attached Work Plan for review and approval by ARCO, the Regional Water Quality Control Board (RWQCB), and the Alameda County Health Care Services Agency (ACHCSA). This Work Plan summarizes previous work performed at the subject site and RESNA's approach, field methods, and project tasks recommended to perform continued subsurface investigations and remediation at this site. The proposed work includes drilling and sampling additional soil borings, possible installation of vapor-extraction wells, laboratory analysis of soil samples, design and permitting of a vapor extraction system, and preparing a report of our findings, interpretations, and conclusions. Recommendations will be included under separate cover as requested by ARCO.

RESNA recommends performing these project tasks to evaluate the lateral and vertical extents of gasoline hydrocarbons in the soil and so that remediation of these compounds in both soil and groundwater at the site can be performed as needed. The work involved to perform the proposed project steps are described in detail in this work plan.

We recommend that copies of this Work Plan be sent to the following:

Mr. Lester Feldman
Regional Water Quality Control Board
San Francisco Bay Region
2101 Webster Street, Suite 500
Oakland, California 94612

Mr. Scott Seery
Alameda County Health Care Services Agency
Department of Environmental Health
80 Swan Way, Room 200
Oakland, California 94621

If you should have any questions or comments about this work plan, please call us at (408) 264-7723.

Sincerely,
RESNA

Joel Coffman
Project Geologist

Enclosure: Work Plan

cc: H.C. Winsor, ARCO Products Company

TABLE OF CONTENTS

PLATES

RESNA

CONTENTS
(Continued)

TABLES

APPENDICES

Applied GeoSystems, Inc.
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for
ARCO Products Company

INTRODUCTION

At the request of ARCO Products Company (ARCO), and in response to the Alameda County Health Care Services Agency (ACHCSA) letter dated September 4, 1991, RESNA/Applied GeoSystems (RESNA) has been contracted to perform further subsurface investigation and design and permit a vapor extraction system at ARCO Station 2152, 22141 Center Street, Castro Valley, California. ARCO requested that RESNA prepare this work plan for review and regulatory approval by the Regional Water Quality Control Board (RWQCB) and the ACHCSA. In the Supplemental Subsurface and Remedial Investigation, the use of a vapor-extraction system (VES) at this site was recommended as a feasible method of soil and groundwater remediation. The purpose of this vapor extraction system is to remediate gasoline hydrocarbons impacting soil and groundwater. In the ACHCSA letter dated September 4, 1991, the ACHCSA agrees "in principle that soil venting/vapor extraction may be a reasonable approach" to remediate fuel hydrocarbon impacted soils.

Work includes drilling two soil borings, collecting soil samples from the borings, installing vapor wells (as necessary), designing and permitting a vapor extraction system, and preparing a report.

After a Supplemental Subsurface and Remedial Investigation performed during January through April 1991, RESNA recommended that two additional vapor wells be installed at the site to further evaluate the extent of gasoline hydrocarbons in the soil at the site. This

Work Plan summarizes work previously performed by RESNA, and describes project steps proposed for further subsurface investigation and for design and permitting of a VES at the subject site. ARCO requested that RESNA prepare this Work Plan for submittal to the ACHCSA.

SITE DESCRIPTION AND BACKGROUND

General

ARCO Station 2152 is an operating service station located southwest of the intersection of Center Street and Grove Way in Castro Valley, California. The location of the site is shown on the Site Vicinity Map, Plate 1. The site is a relatively flat, asphalt- and concrete-covered lot at an elevation of approximately 217 feet above mean sea level. Local topography near the vicinity at the site slopes gently to the southwest. Residential areas are southeast and west-southwest of the site, and commercial developments are northwest across Grove Way and northeast across Center Street.

From data supplied by ARCO, one underground 12,000-gallon gasoline-storage tank (designated T1) and four underground 6,000-gallon gasoline-storage tanks (T2 through T5) previously existed at the site. Former tank T1 was installed in 1983 and stored unleaded supreme gasoline, tanks T2 through T4 were installed in 1976 and stored unleaded regular gasoline, and tank T5 was installed in 1976 and stored leaded regular gasoline. These tanks were removed, and three underground fiberglass 12,000-gallon gasoline-storage tanks were installed in the former tank pit at the site, in August 1989. The product dispenser lines and product line sump associated with the former tanks were replaced in October 1989. The approximate locations of the former tanks, existing tanks, and other pertinent site facilities are shown on the Generalized Site Plan, Plate 2.

Geology and Hydrogeology

Regionally, the site is in the Castro Valley Basin with the Diablo Range to the east and the Hayward Fault to the west. The site lies within an area of unconsolidated Pleistocene alluvium consisting of a heterogenous mixture of poorly consolidated clay, silt, sand, and gravel derived from the Diablo Range (Helley, et. al., 1979). Earth materials encountered during our previous subsurface investigations at the site consisted of silty to sandy clay and clayey sand to sandy gravel. Groundwater was encountered within clayey sand to sandy gravel at depths of approximately 52 to 58 feet. Hard dry claystone was encountered at depths of approximately 58 to 60 feet (Applied GeoSystems [AGS], November 1990). The direction of groundwater flow is toward the southwest based on groundwater monitoring data collected from the wells at the site between June 1990 and January 1991 (RESNA, March 1991).

PREVIOUS WORK

May 1989 Limited Site Assessment

AGS performed a limited site assessment (AGS, May 26, 1989) to evaluate the presence of gasoline hydrocarbons in soil near the underground gasoline-storage tanks prior to ARCO's planned tank replacement at the site. The work involved drilling three soil borings (B-1 through B-3) close to the fill ends of the tanks. The locations of these borings are shown on Plate 2. Results of laboratory analysis of soil samples from the borings indicated nondetectable concentrations (<5.0 ppm) of gasoline hydrocarbons, with the exception of two samples collected from depths of 30 and 35 feet in boring B-1 (5.1 ppm total petroleum hydrocarbons as gasoline [TPHg]) and two samples collected from depths of 5 and 10 feet in boring B-3 (460 and 5.6 ppm TPHg, respectively). Groundwater was not encountered in the borings to a depth of 45 feet. Results of laboratory analyses of soil samples collected during the drilling are summarized in Table 1, Cumulative Results of Laboratory Analysis of Soil Samples.

August through October 1989 Tank Removal and Replacement

The former underground gasoline-storage tanks and product-dispenser lines were removed from the site by Paradiso Construction Company on August 17, 1989 and from September 9 through October 4, 1989, respectively (AGS, January 1990). No holes were noted in the tanks during removal. AGS was present to collect soil samples from the former tank pit from depths of 14 to 22 feet. The results of the laboratory analyses of soil samples from the gasoline-tank pit indicated elevated concentrations (up to 37,000 ppm) of TPHg in soil at depths of 14 and 22 feet beneath the former product line sump. AGS also collected soil samples from beneath the former product-dispenser lines. TPHg concentrations ranging from <2.0 ppm to 73 ppm were reported in 11 soil samples collected from beneath the lines at a depth of approximately three feet, and TPHg concentrations of 100 to 190 ppm were reported in soil samples from the southwestern ends of the dispenser islands near Grove Way and Center Street. Results of laboratory analyses of the samples collected from the former tank pit and beneath the former product lines are presented on Tables 2 and 3.

Approximately 1,850 cubic yards of soil excavated from the gasoline-tank pit and the product-dispenser line trenches was aerated onsite between August 21 and October 10, 1989 in accordance with Regulation 8, Rule 40 of the Bay Area Air Quality Management District (BAAQMD). AGS collected composite soil samples from the aerated soil to verify TPHg concentrations of 100 ppm or lower. Paradiso arranged for the soil to be transported to Redwood Landfill in Novato, California by Conrad Trucking of Escalon, California. Three new 12,000-gallon fiberglass tanks were installed at the site by others along with new product delivery lines in September 1989. It is understood that four 12-inch diameter polyvinyl chloride (PVC) conductor casings were positioned between the tanks to provide access for future exploratory drilling and/or well installation.

It was concluded that the vertical extent of gasoline hydrocarbons in soil beneath the former tanks had not been delineated. It was also concluded that the lateral extent of gasoline hydrocarbons in the area of the former tanks above depths of approximately 14 feet appeared to be limited to the tank-pit area, with the possible exception of the northwestern side of the tank pit, and that the extent of gasoline hydrocarbons was not delineated near the southwestern ends of the dispenser islands. Therefore a subsurface investigation was proposed to delineate the gasoline hydrocarbons onsite.

June through September 1990 Subsurface Investigation

In June 1990, AGS conducted a subsurface investigation to evaluate the extent of gasoline hydrocarbons in soil and groundwater beneath the site. This work included drilling six soil borings (B-4 through B-7, B-10, and B-11), constructing four 4-inch-diameter groundwater monitoring wells (MW-1 through MW-4), constructing two 2-inch-diameter vadose zone monitoring wells (VW-1 and VW-2), collecting soil samples for laboratory analysis, developing the wells, collecting water samples for laboratory analysis, evaluating the groundwater flow direction and gradient, performing a well search, and preparing a report documenting the findings and conclusions. A summary of the field methods and procedures employed by RESNA is included in Appendix A.

Based on the results of the subsurface investigation, it was concluded that:

- elevated concentrations of gasoline hydrocarbons previously reported beneath the former gasoline-storage tanks and product line sump appear to be limited laterally to the tank pit area, with the possible exception of the areas northwest of the tank pit near boring B-3, and the northeastern corner of the tank pit;

- the vertical extent of gasoline hydrocarbons in soil beneath the former tank pit, and the lateral and vertical extent of gasoline hydrocarbons by the dispenser islands have not been delineated; and

- the June 25 and 26, 1990 groundwater sampling episode indicated the presence of low levels of gasoline hydrocarbons as suggested by concentrations of TPHg (27 to

64 ppb) in wells MW-1 through MW-3, benzene (0.63 and 0.65 ppb) in wells MW-1 and MW-3, and toluene (1.5 ppb) and total xylenes (2.0 ppb) in well MW-3. These levels are below regulatory action levels. The September 26, 1990 sampling indicated nondetectable levels of gasoline hydrocarbons in MW-1 through MW-4 (see Table 4).

January through April 1991 Supplemental Subsurface and Remediation Investigation

Nine soil borings (B-8, B-9, and B-12 through B-18) were drilled on January 14 through 17, and February 21, 1991. A summary of the field methods and procedures employed by RESNA is included in Appendix A. Borings B-12 and B-14 were drilled northwest and northeast of the former tank pit to delineate the lateral extent of gasoline hydrocarbons in soil in these areas. Borings B-15 through B-18 were drilled in the area of and southwest of the former product lines to evaluate the extent of gasoline hydrocarbons in soil in these areas and in the downgradient direction of groundwater flow from these areas. Because elevated concentrations of gasoline hydrocarbons were detected in the subsurface soil beneath the former tank pit, borings B-8 and B-9 (VW-3 and VW-4) were drilled through polyvinyl chloride (PVC) conductor casing, which had been installed by others within the tank pit during tank replacement activities. In September 1989, B-8 and B-9 were installed to evaluate the lateral and vertical extent of gasoline hydrocarbons in soil in the tank pit and to provide for future vapor extraction. The earth materials encountered during this investigation consisted primarily of silty to sandy clay and clayey sand to sandy gravel (see Geologic Cross Sections A-A' through D-D,' Plates 3 through 6). In general, silty to sandy clay with some interbeds of clayey sand to sandy gravel up to 20 feet thick was encountered beneath the surface asphalt and minor fill between depths of approximately 1-1/2 feet to 42 feet. In addition, the tank pit is backfilled with pea gravel to approximately 20 feet below grade. Clayey sand to sandy gravel was encountered between the depths of approximately 42 to 58 feet. Groundwater was encountered within the clayey sand to sandy gravel at depths of approximately 52 to 56 feet. Hard, dry claystone bedrock was encountered beneath the clayey sand to sandy gravel to the bottom of the deepest boring.

Three vapor-extraction wells (VW-3 through VW-5) were constructed in soil borings B-8, B-9, and B-13, respectively, for purposes of performing a vapor-extraction test (VET) and for potential future use in an operation VES. Wells VW-3 and VW-4 were constructed through 12-inch diameter PVC conductor casing previously installed within the tank pit during tank replacement activities at the site. The wells were completed with 4-inch-diameter PVC casing. Well casings were set in the wells to depths of approximately 32 to 39 feet. The screened casings for the monitoring wells consist of 4-inch-diameter machine-slotted PVC with 0.020-inch-wide slots set from the total depth of the well to approximately

24 to 28 feet below the ground surface. Solid casing was set from the top of the screened casing to a few inches below the ground surface.

Vapor Extraction Test

RESNA performed a VET onsite on February 15, 1991. The VET had two objectives: (1) to collect operational data to evaluate the efficiency and practicality of vapor extraction as a soil remediation alternative; and (2) to select the most appropriate off-gas treatment alternative, if the operational data suggest that vapor-extraction is recommended.

The vapor-extraction equipment consisted of: (1) a six-cylinder internal combustion (I.C.) engine; (2) instrumentation for measuring air flow, air velocity, air pressure, temperature, electrical current, and volatile organic compound (VOC) concentrations; and (3) polyvinyl chloride (PVC) piping, fittings, and wellhead connections.

Five vapor-extraction wells installed onsite were used for the VET. The location of these wells, as well as other pertinent site features, are shown on the Generalized Site Plan, Plate 2. RESNA operated the VET for approximately six hours. We operated the vapor-extraction equipment for twenty-minutes each on vapor-extraction wells VW-1, VW-2, and VW-3 before collecting a sample from each well.

RESNA then operated the vapor-extraction equipment on vapor-extraction well VW-5 for approximately two hours while monitoring the change in vacuum at observation wells VW-2, VW-3, VW-4, and VW-1. The distances between vapor-extraction well VW-5 and VW-2, VW-3, VW-4, and VW-1 are 29.0, 27.7, 48.5, and 61.9 feet respectively. Air flow rate, vacuum, VOC concentration, and temperature were monitored at the influent to the I.C. engine. One influent air sample was collected after system stabilization, and a second influent and an effluent sample were taken after two hours of operation. The effluent sample was taken to verify the destruction efficiency of the I.C. engine of both benzene and TPHg.

RESNA then operated the vapor-extraction equipment on vapor-extraction well VW-1 for approximately two hours while monitoring the change in vacuum at wells VW-2, VW-3, VW-4, and VW-5. The distances between vapor-extraction well VW-1 and VW-2, VW-3, VW-4, and VW-5 are 61.3, 34.5, 17.7 and 61.9 feet respectively. Air flow rate, vacuum, VOC concentration, and temperature were monitored at the influent to the I.C. engine. One influent air sample was collected after system stabilization, and a second influent sample were taken after two hours of operation.

The results of the investigation are as follows:

- laboratory analysis of soil samples collected from borings B-8 and B-9, drilled through the conductor casing in the former tank pit, indicated nondetectable concentrations of TPHg (below method detection limit [mdl] of 1.0 parts per million [ppm]), with the exception of 680 ppm TPHg reported in a sample collected from a depth of 22 feet in boring B-9;

- laboratory analysis of soil samples collected from borings B-12, B-13, and B-14, drilled north and northeast of the former tank pit, indicated nondetectable concentrations of TPHg at depths of approximately 15 to 45 feet;

- laboratory analysis of soil samples collected from borings B-15 through B-18, drilled at and downgradient (southwest) of the former product lines, indicated nondetectable concentrations of TPHg, with the exception of 1.7 ppm TPHg reported in a sample collected from a depth of 2 feet in boring B-16, and 50 ppm, 220 ppm, and 170 ppm from depths of 4, 8, and 15-1/2 feet in boring B-18. Laboratory analysis for organic lead of samples from borings B-17 and B-18 indicated nondetectable (mdl of 0.5 ppm) concentrations;

- the vacuum impact across the 20 foot deep pea gravel backfill in the tank pit was determined to be greater than 61 feet at a vapor extraction test vacuum of 40 to 48 inches of water and an extraction point flow rate greater than 50 cubic feet per meter (cfm). The pea gravel exhibits very high porosity to air flow and impacted field test results;

- the vacuum impact in the silty clay layer of native soil below the tank pit backfill was determined to be less than 10 feet at the same vacuum and air flow rates above;

- well VW-2 showed no measurable vacuum impact in either test run primarily because it is screened in the silty clay layer and is not sufficiently close to the pea gravel backfill to be impacted at the test vacuums and air flow rates tested; and

- TPHg vapor concentrations from the wells ranged from nondetectable to 3,600 ppm.

The results from the vapor-extraction tests on VW-1 through VW-5 are presented on Table 5, Vapor-Extraction Test Field Monitoring Data and Table 6, Vapor Extraction Test Laboratory Analytical Data.

3rd Quarter Groundwater Sampling Results

Results of the 3rd quarter groundwater monitoring and analytical results performed on July 7, 1991 for wells MW-1 through MW-4 indicate:

- fairly annual consistent groundwater gradient over the site (see plates 7 and 8);
- detectable TPHg concentrations in all four wells, ranging from 30 parts per billion (ppb) in well MW-2 to 120 ppb in MW-1; and
- detectable benzene, toluene, ethylbenzene, and total xylene isomers (BTEX) concentrations in all four wells, ranging from 0.42 ppb in MW-2 to 9.6 ppb in MW-1. Benzene exceeded the State Maximum Contaminant Level (MCL) in wells MW-1 and MW-4 (see plate 9). These two wells are downgradient from the former underground storage tanks.

Quarterly groundwater analytical results are presented on Table 4, Cumulative Results of Laboratory Analyses.

Conclusions

RESNA concluded the following based on the results of the subsurface investigation, vapor-extraction test and Quarterly Monitoring Report:

- elevated concentrations of gasoline hydrocarbons previously reported beneath the former gasoline-storage tanks and product line sump appear to be limited laterally to the tank pit area and have been delineated onsite;
- the lateral and vertical extent of gasoline hydrocarbons beneath the former product lines and downgradient of the former product lines nearest Grove Way (northern portion of the site) have been delineated, as suggested by nondetectable concentrations of TPHg and BTEX (with the exception of 0.007 total xylenes) reported in the samples from borings B-15 and B-17. The lateral extent of gasoline hydrocarbons in soil downgradient of the former product lines along Center Street has been delineated, based on nondetectable concentrations of TPHg and BTEX in samples from boring B-

16; however, the vertical extent of gasoline hydrocarbons in soil beneath these product lines is not delineated based on reported concentrations of TPHg (50, 220, and 170 ppm) at 4, 8, and 15-1/2 feet, respectively, in boring B-18;

- the third quarter groundwater analytical results detected low concentrations of dissolved phase petroleum hydrocarbons in all monitoring wells, while petroleum hydrocarbons in the second quarter groundwater analytical results were not detected. Therefore the vapor-phase is impacting the groundwater, and vapor-extraction may reverse this trend; ??

- it is important to realize that it is not practical to induce a significant vacuum or an extraction flow rate over an area that includes clean soil. Ideally, a well designed and placed vapor-extraction system should only affect the area of concern. The change in vacuum observed at the vapor-extraction monitoring wells were produced with vapor-extraction flow rates and extraction pressures that are less than an operational vapor-extraction system. This suggests that the use of vapor extraction at this site is a practical and efficient choice as a soil remediation alternative. Three existing 4-inch vapor-extraction wells; VW-3, VW-4, and VW-5, and one 2-inch vapor extraction well (VW-2), can be used in a vapor-extraction system to affect areas of concern. We estimate that an extraction rate of approximately 100 cfm and 100 inches of water column vacuum from each vapor-extraction well will create a radius of influence of approximately 20 feet from most wells (Plate 10), based on a four-month operation period for the vapor-extraction system;

- the use of a VES at this site is a feasible method of soil remediation; and

- it is estimated that the VES will need to operate at least four months before extracted vapor concentrations are nondetectable.

BACKGROUND DISCUSSION ON VAPOR EXTRACTION

Government and private research studies have established that soil vapor-extraction systems substantially decrease the concentration of petroleum hydrocarbons in soil. A 90 percent reduction from initial hydrocarbon vapor concentration levels typically occurs within the first two or three months of operation of the vapor-extraction system. The petroleum hydrocarbons in the soil at this site exist primarily in three states; as liquid product, as droplets adsorbed onto soil particles, and in vapor form in the air space surrounding the soil particles. The large reduction from initial hydrocarbon concentrations in the early stages of remediation is due primarily to the effect of the vapor-extraction system on the liquid and vapor states of petroleum hydrocarbons.

Reduction in hydrocarbon concentration continues as the vapor-extraction system acts upon the absorbed hydrocarbons, however at a slower rate. The soil-vapor extraction system for this site will operate until the hydrocarbon concentrations in the soil have been reduced to acceptable levels. It is important to realize that it is not practical to induce a significant vacuum or an extraction rate over an area that includes clean soil. Ideally, a well designed and placed vapor-extraction system should only affect the area of concern. By inducing a vacuum at each vapor-extraction well, with location and screened interval based on assessment information, volatile organic hydrocarbons can be removed from the soil beneath the site. The TPHg concentration of the combined extracted hydrocarbon-bearing vapors can be monitored at the remediation compound. Valves in the vapor-extraction piping can be adjusted to change the extraction rate from the individual wells to maximize the rate at which hydrocarbons are removed from the soil.

Soil volume and average TPHg concentrations are used to calculate the length of time that a vapor-extraction system using appropriate vacuum and flow rates as described above will need to be operated. Our estimation of the duration of the project is based on the total pounds of hydrocarbons that still remain in the soil and the type of soil encountered at this site. Confirmation of clean-up levels through laboratory analysis of soil samples collected from confirmation borings (sometimes called verification borings) can be performed at this time.

will

Vapor Extraction System Description

RESNA used the results of previous investigations, including the results of the pump test and vapor-extraction test, organic vapor concentrations, and soil consistency information contained in boring logs, to select the most appropriate remediation alternative. RESNA recommended using activated carbon and four vapor-extraction wells for the interim remediation system to be installed at this site. Additionally, AGS recommends the use of this vapor-extraction and off-gas treatment system may enhance the volatilization of petroleum hydrocarbons from the soil above and directly adjacent to groundwater.

An I.C. engine may be used for the first few days to treat the high initial hydrocarbon concentrations. Because of the expected low concentrations of petroleum hydrocarbons vapors, the type of soil, and the vacuum and flow rates characteristic of the subject site, the off-gas treatment system will be modified to a vapor-phase activated-carbon system after this significant reduction in gasoline hydrocarbon concentrations in the off-gas stream has been achieved. It is estimated that the vapor-extraction system will be required to operate for a minimum of four months, or until concentrations of TPHg in the off-gas fall below 30 parts per million by volume (ppmv). This is a typical detection limit for gasoline petroleum hydrocarbon in vapor. The system may be shut down sooner if this detection limit is reached sooner, or if it is not required for groundwater treatment.

The TPHg concentration of the combined extracted hydrocarbon-bearing vapors will be monitored at the remediation compound. Valves in the vapor-extraction piping can be adjusted to change the extraction rate from the individual wells to maximize the rate at which hydrocarbons are removed from the soil. A layout of the remediation compound is shown on Plate 4. Typical trench and wellhead details are shown on Plate 5. Activated carbon has previously shown a removal rate of over 97 percent when operated under the conditions as described above. A Process and Instrumentation Drawing for this remediation system is shown on Plate 6. An electrical one-line diagram is shown on Plate 7. no.

this is a X section B-B' X-section D-D' this is a X-section C-C'

PROJECT STEPS

RESNA proposes the following project steps 1 through 8 listed below as a method of approach to work to delineate the vertical and horizonal extent of gasoline hydrocarbons and to remediate soils impacted by gasoline hydrocarbons at the site. Field work involved with the following project steps will be performed in accordance with the attached RESNA Field Protocol in Appendix A and the Site Safety Plan to be updated prior to field work being performed.

Step 1 Complete system design and permitting. It is our understanding that permits or other approval will be required for this remediation system through the Bay Area Air Quality Management District, the California Regional Water Quality Control Board (San Francisco Bay Region), Hazardous Materials Division of the Alameda County Health Care Services Agency, the City of Castro Valley Fire Marshall, and the City of Castro Valley Fire, Building, and Planning Departments. RESNA is currently preparing a design for this remediation system and will be submitting appropriate permit applications and work plans to the above agencies (as required) in the near future.

Step 2 Upon completion of the design of the remediation system, RESNA will address the impact on station operations during the installation and operation of the system, and subsequent borings.

Step 3 Update Site Safety Plan and obtain well permits from the Alameda County Flood Control and Water Conservation District.

Step 4 Drill two borings (B-19 and B-20) near the former product lines along Center Street to delineate the horizonal and vertical extent of petroleum hydrocarbons in the soil. If petroleum hydrocarbons are encountered in any one, or both of these wells, the impacted boring(s) will be completed as vapor-extraction wells and added to the vapor-extraction system. Locations for proposed borings are shown on Plate 2, Generalized Site Plan.

Step 5 Submit selected soil samples from the borings to an Arco contracted State-certified laboratory for analysis of TPHg and BTEX by EPA Methods 5030/8015/8020.

Step 6 Upon receipt of regulatory approval, RESNA will issue a bid package to subcontractors for installation of the vapor extraction system and supervise and perform start-up and source tests for the vapor-extraction system.

Step 7 Collect vapor samples according to BAAQMD permit to operate. Continue quarterly groundwater monitoring to evaluate the effectiveness of the vapor-extraction system.

Step 8 RESNA will modify the vapor-extraction system as needed over the course of its operation to insure effective performance.

Additional work plans will be issued for regulatory review as site conditions and information gathered prove this to be necessary.

SCHEDULE OF OPERATIONS

OK

Plate 11 is a preliminary time schedule to perform the proposed work (project steps 1 through 8) in this Work Plan. RESNA can initiate work at the site within two weeks after receiving authorization to proceed.

PROJECT STAFF

Ms. Diane Barclay, a Certified Engineering Geologist (C.E.G. 1366) in the State of California, will be in overall charge of hydrogeologic facets, and Dr. Joan E. Tiernan, a Registered Civil Engineer will be in overall charge of engineering facets of this project. Mr. Greg Barclay, General Manager, will provide supervision of field and office operations of the project. Mr. Joel Coffman, Project Geologist, will be responsible for the day-to-day field and office operations of the project. RESNA employs a staff of geologists and technicians who will assist with the project.

LIMITATIONS

This work plan was prepared in accordance with generally accepted standards of environmental geological practice in California at the time this investigation was performed. This investigation was conducted solely for the purpose of evaluating environmental conditions of the soil with respect to hydrocarbon-product contamination at the subject site in the immediate area of and related to the gasoline-storage tanks and the tank of unknown use or origin found during station rebuild operations. No soil engineering or geotechnical implications are stated or should be inferred. Evaluation of the geologic conditions at the site for the purpose of this investigation is made from a limited number of observation points. Subsurface conditions may vary away from the data points available. Additional work, including further subsurface investigation, can reduce the inherent uncertainties associated with this type of investigation.

REFERENCES

Applied GeoSystems. May 26, 1989. Limited Environmental Site Assessment, 22141 Center Street, Castro Valley, California, AGS Report 69013-1.

Applied GeoSystems. January 18, 1990. Limited Subsurface Environmental Investigation Related to Underground Tank Removal, 22141 Center Street, Castro Valley, California: AGS Report 69013-2.

Applied GeoSystems. March 20, 1990. Site Safety Plan, 22141 Center Street, Castro Valley, California: AGS 69013-7S.

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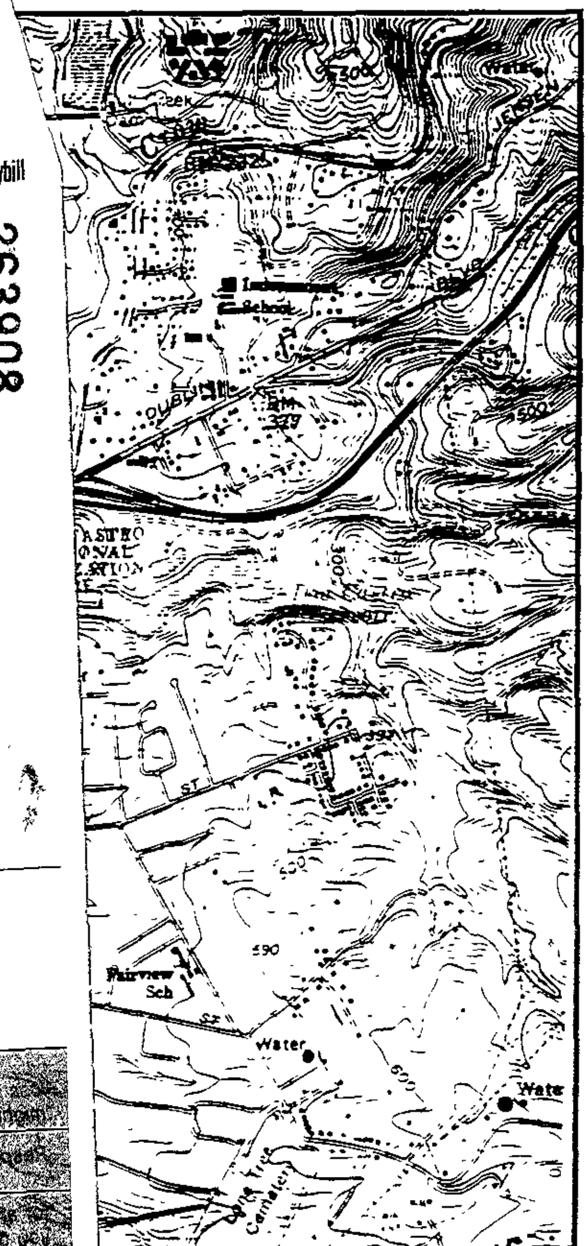


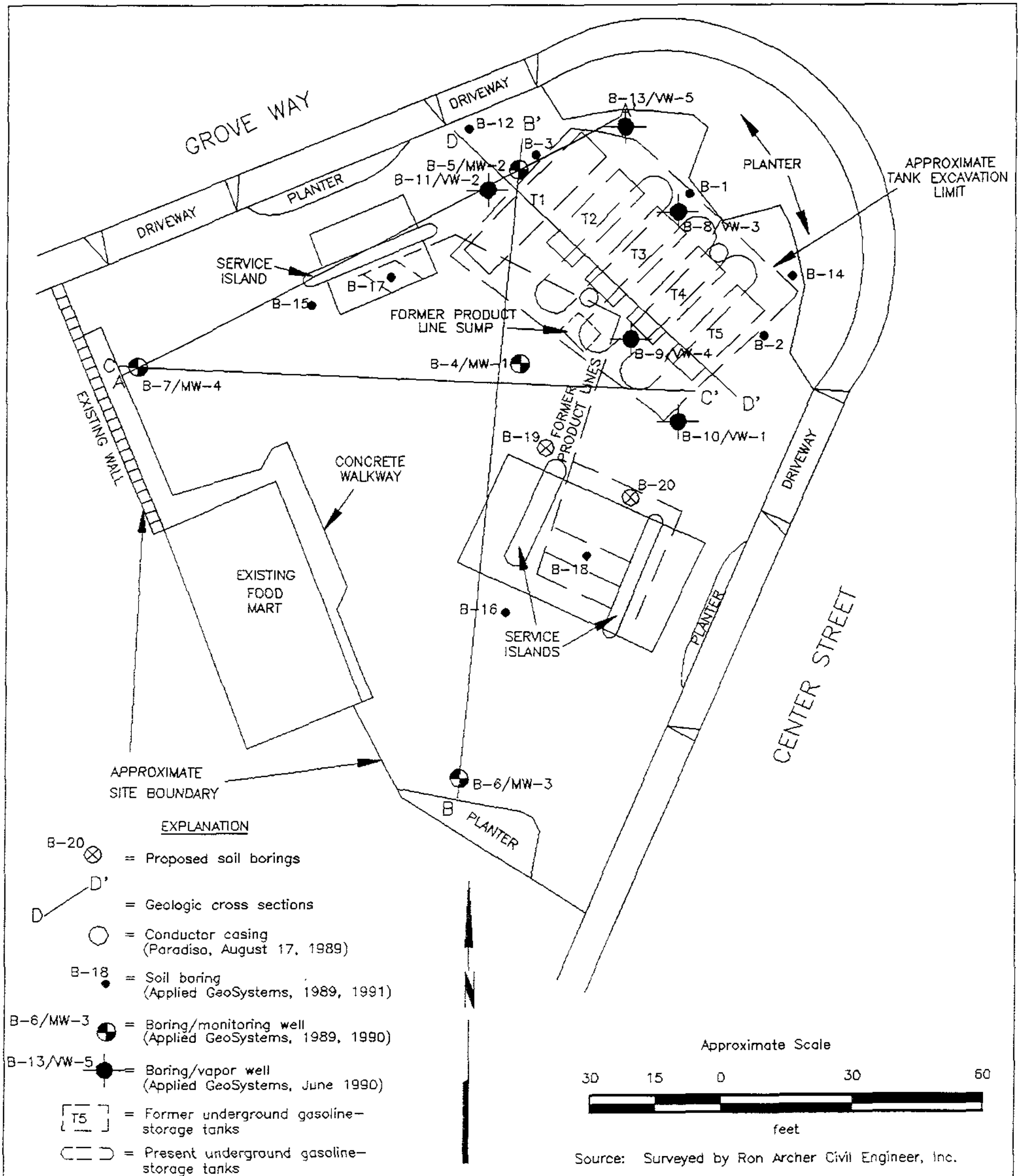
(•) = Site Location

Approximate Scale

2000 1000 0 2000 4000

feet

RESNA	SITE VICINITY MAP ARCO Station 2152 22141 Center Street Castro Valley, California	PLATE 1
PROJECT 69013.08		

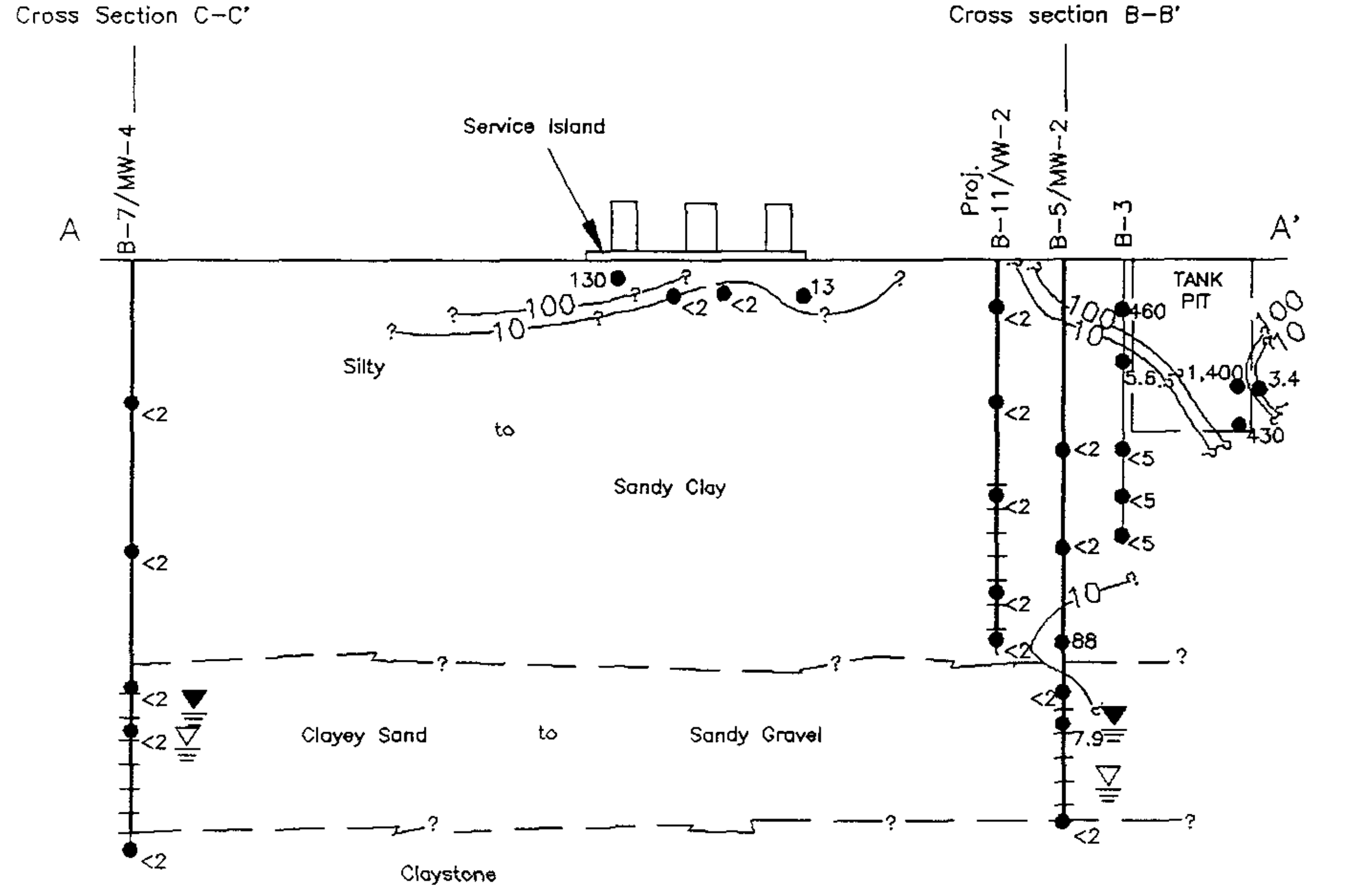


RESNA

PROJECT **69013.08**

GENERALIZED SITE PLAN
ARCO Station 2152
22141 Center Street
Castro Valley, California

PLATE
2



EXPLANATION

?——100 = Line of equal concentration of TPHg

1,400 ● = Laboratory analyzed soil sample around product lines and beneath the tank showing concentration of TPHg in parts per million

88 ● = Laboratory analyzed soil sample showing concentration of TPHg in parts per million

= Well casing

= Well screen

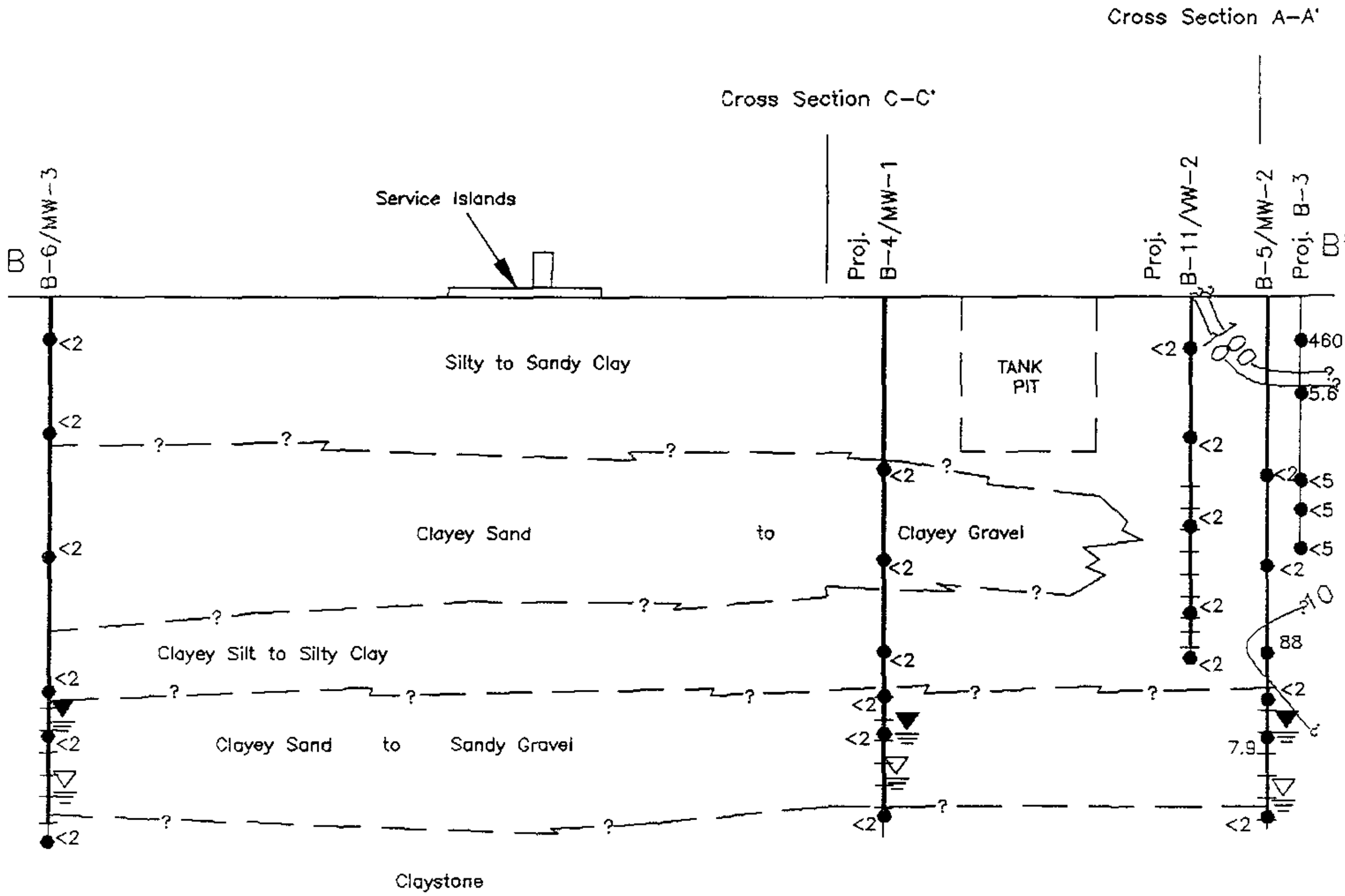
= Boring

= Initial water level in boring

= Static water level in well (6/25/90)

Approximate Horizontal and Vertical Scale

RESNA	**GEOLOGIC CROSS SECTION A-A'** **ARCO Station 2152** **22141 Center Street** **Castro Valley, California**	**PLATE** **3**
PROJECT 69013.08		



EXPLANATION

= Line of equal concentration of TPHg

= Laboratory analyzed soil sample showing concentration of TPHg in parts per million

= Well casing

= Well screen

= Boring

= Initial water level in boring

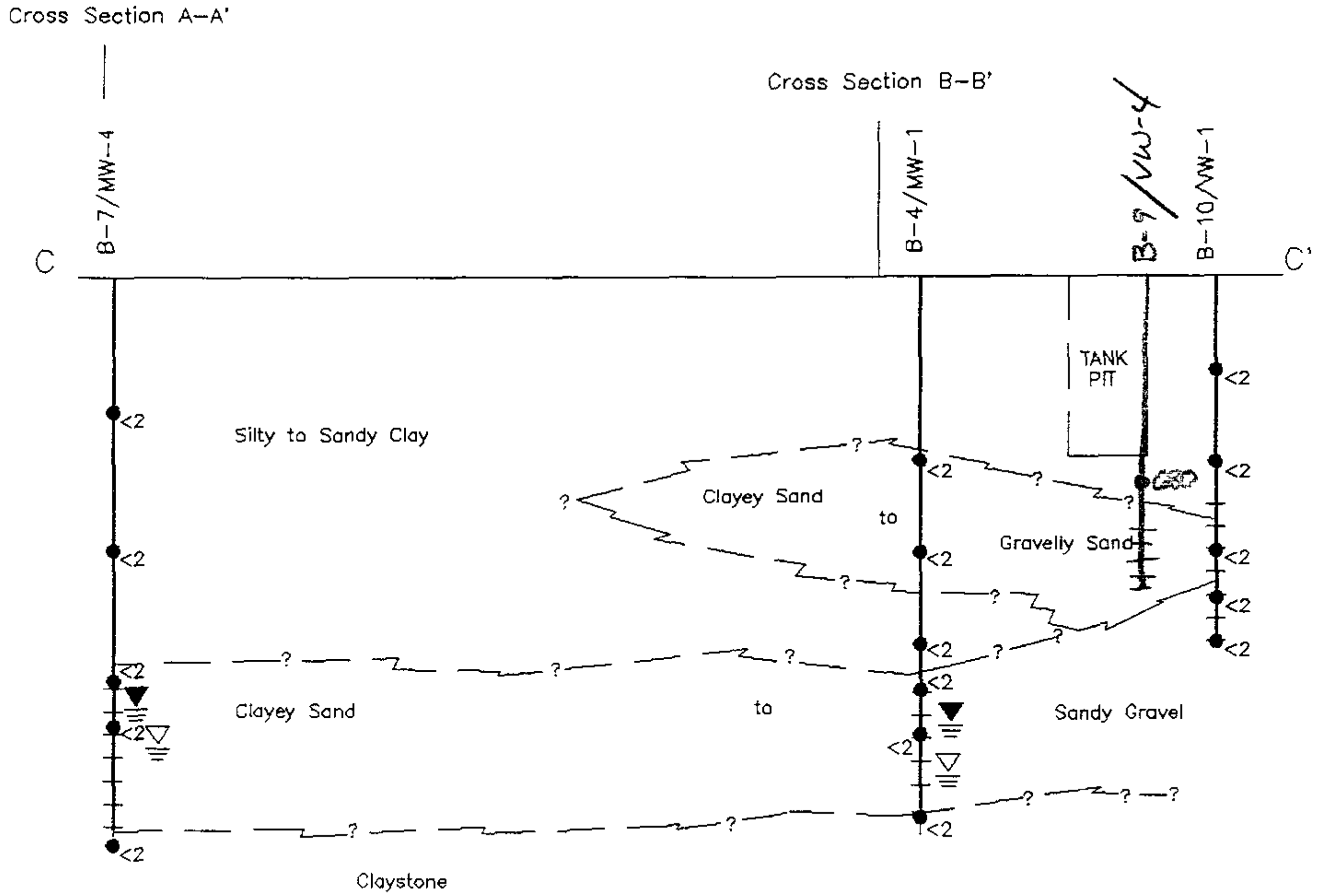
= Static water level in well (6/25/90)

Approximate Horizontal and Vertical Scale

20 10 0 20 40

feet

RESNA	GEOLOGIC CROSS SECTION B-B' ARCO Station 2152 22141 Center Street Castro Valley, California	PLATE 4
PROJECT 69013.08		



EXPLANATION

- <2 = Laboratory analyzed soil sample showing concentration of TPHg in parts per million
- = Well casing
- = Well screen
- = Boring
- = Initial water level in boring
- = Static water level in well (6/25/90)

Approximate Horizontal and Vertical Scale

20 10 0 20 40

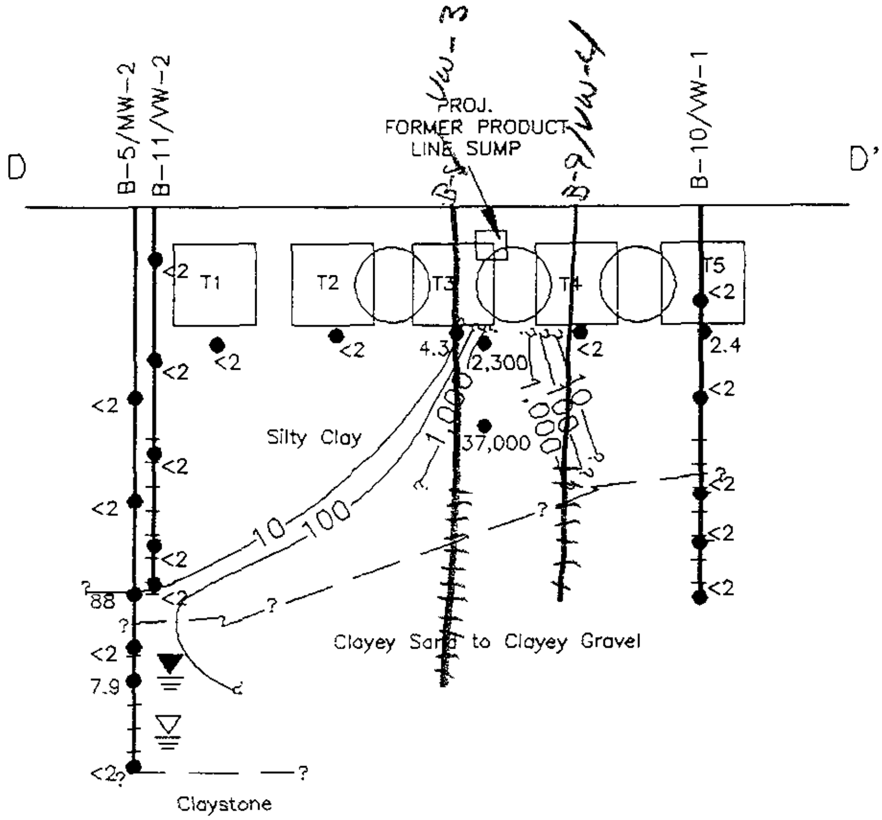
feet

RESNA

PROJECT 69013.08

GEOLOGIC CROSS SECTION C-C'
ARCO Station 2152
22141 Center Street
Castro Valley, California

PLATE 5



EXPLANATION

= Existing underground gasoline storage tanks

T5 = Former underground gasoline storage tanks

1,000 = Line of equal concentration of TPHg

37,000 ● = Concentration of TPHg in ppm for soil sample collected 8/89

88 = Laboratory analyzed soil sample showing concentration of TPHg in parts per million

= Well casing

= Well screen

= Boring

= Initial water level in boring

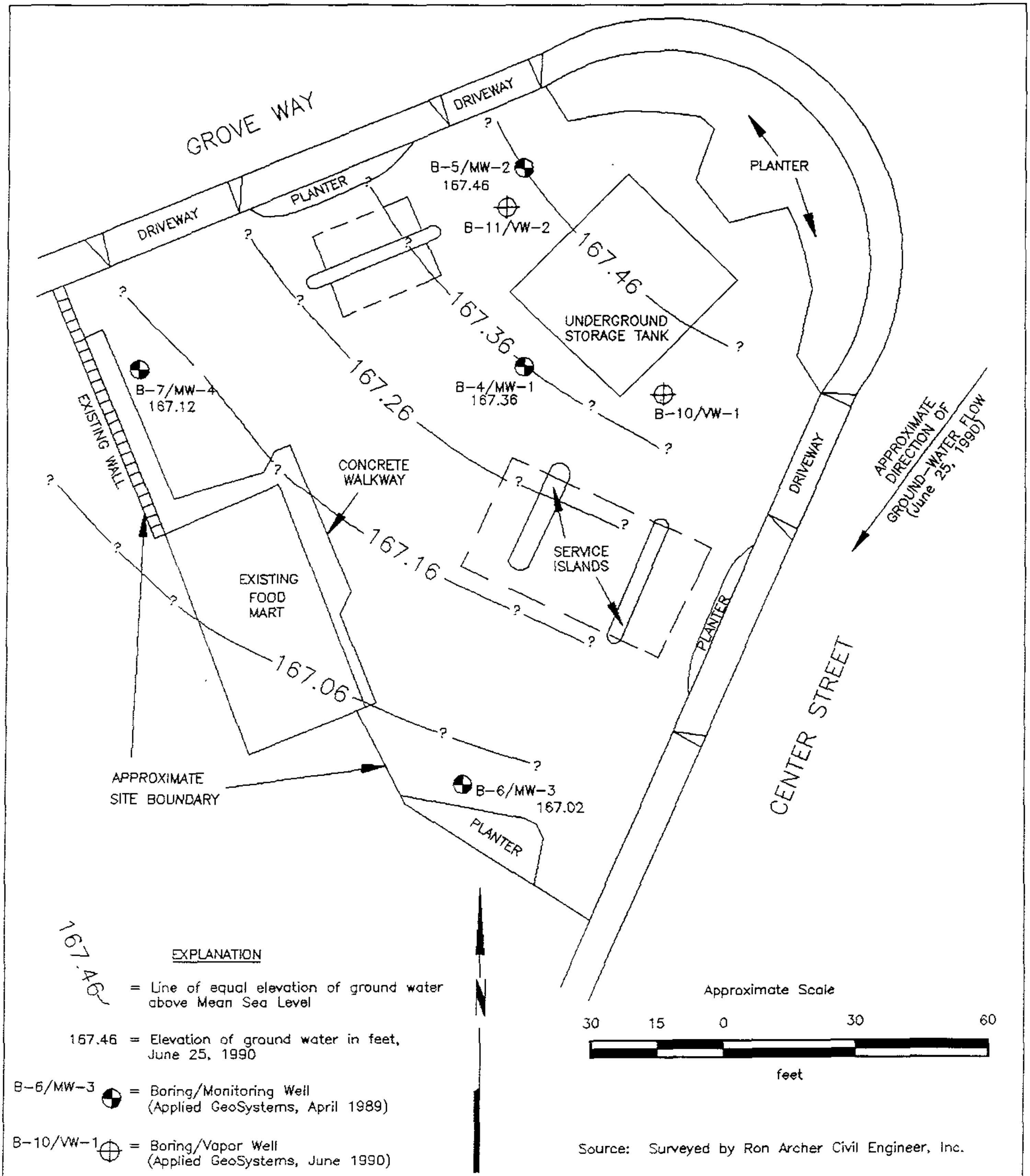
= Static water level in well (6/25/90)

Approximate Horizontal and Vertical Scale

20 10 0 20 40

feet

RESNA	**GEOLOGIC CROSS SECTION D-D'** **ARCO Station 2152** **22141 Center Street** **Castro Valley, California**	**PLATE** **6**
PROJECT 69013.08		



EXPLANATION

167.46 = Line of equal elevation of ground water above Mean Sea Level

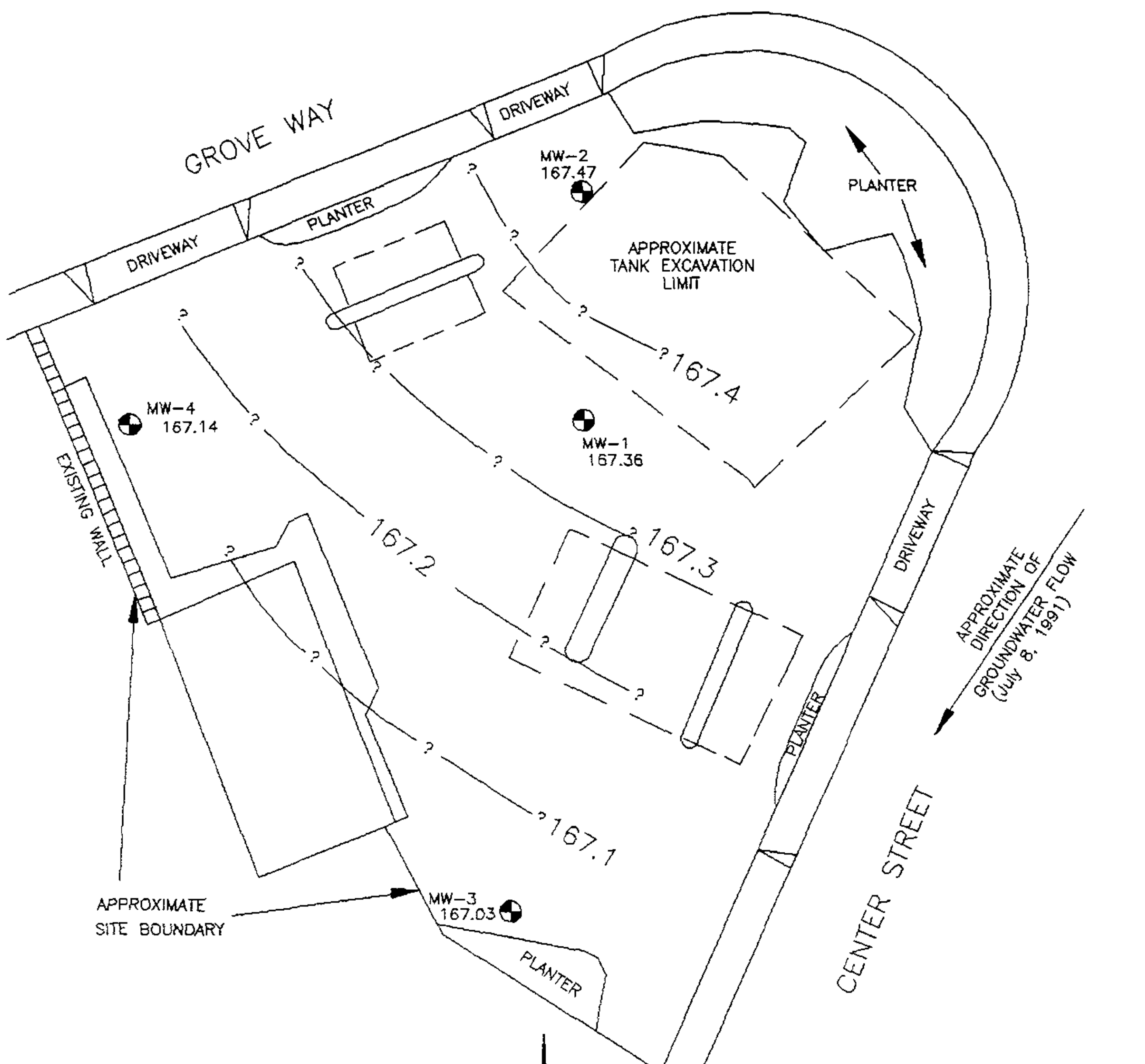
167.46 = Elevation of ground water in feet, June 25, 1990

B-6/MW-3 = Boring/Monitoring Well (Applied GeoSystems, April 1989)

B-10/VW-1 = Boring/Vapor Well (Applied GeoSystems, June 1990)

Source: Surveyed by Ron Archer Civil Engineer, Inc.

RESNA	GROUNDWATER GRADIENT MAP ARCO Station 2152 22141 Center Street Castro Valley, California	PLATE 7
PROJECT 69013.08		



EXPLANATION

167.4 = Line of equal elevation of groundwater above mean sea level (MSL)

167.47 = Elevation of groundwater in feet (MSL), July 8, 1991

MW-4 = Boring/monitoring wells (RESNA, 1990)

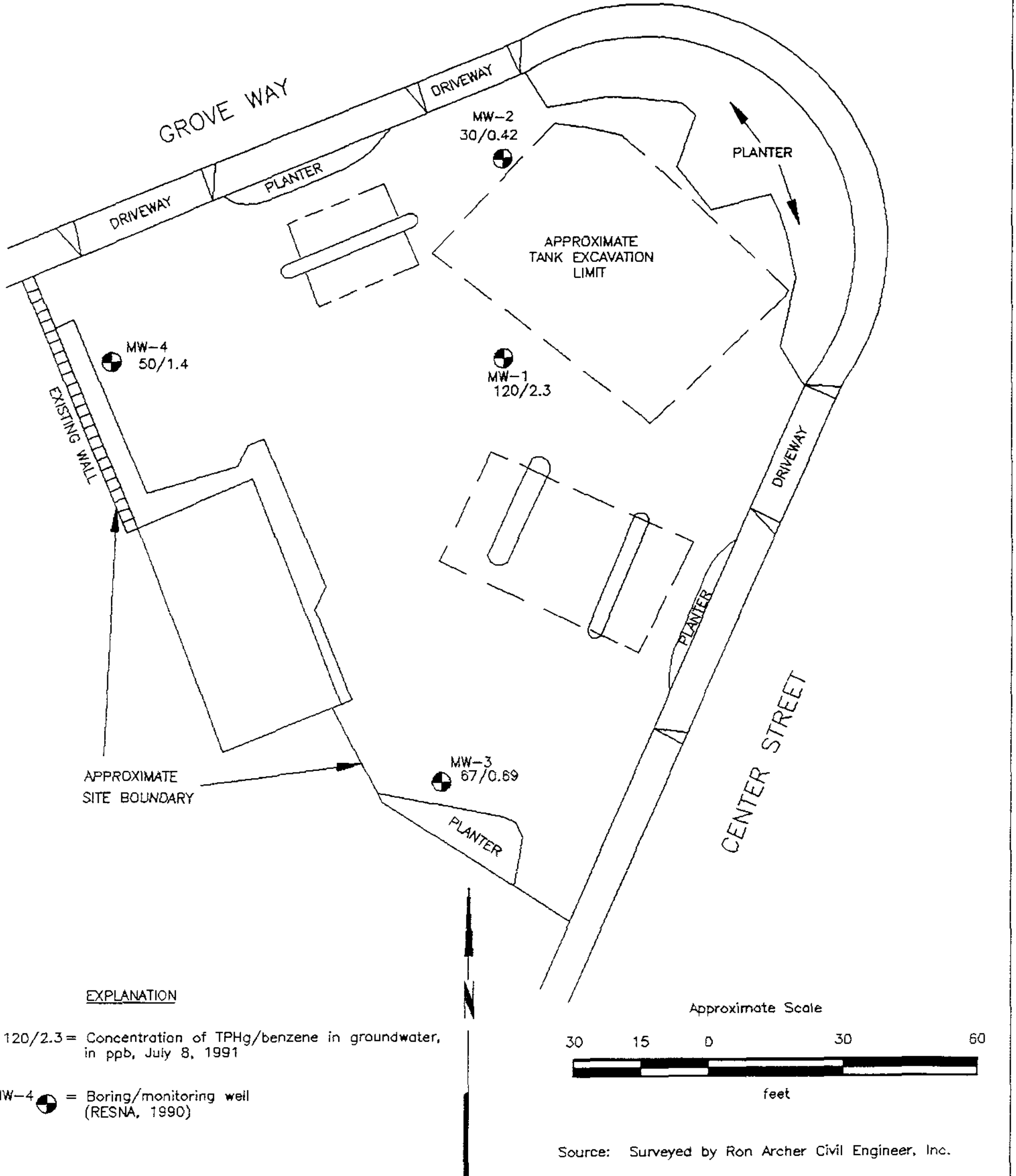
Approximate Scale

30 15 0 30 60

feet

Source: Surveyed by Ron Archer Civil Engineer, Inc.

RESNA	GROUNDWATER GRADIENT MAP ARCO Station 2152 22141 Center Street Castro Valley, California	PLATE 8
PROJECT 69013.08		



EXPLANATION

120/2.3 = Concentration of TPHg/benzene in groundwater, in ppb, July 8, 1991

MW-4 = Boring/monitoring well (RESNA, 1990)

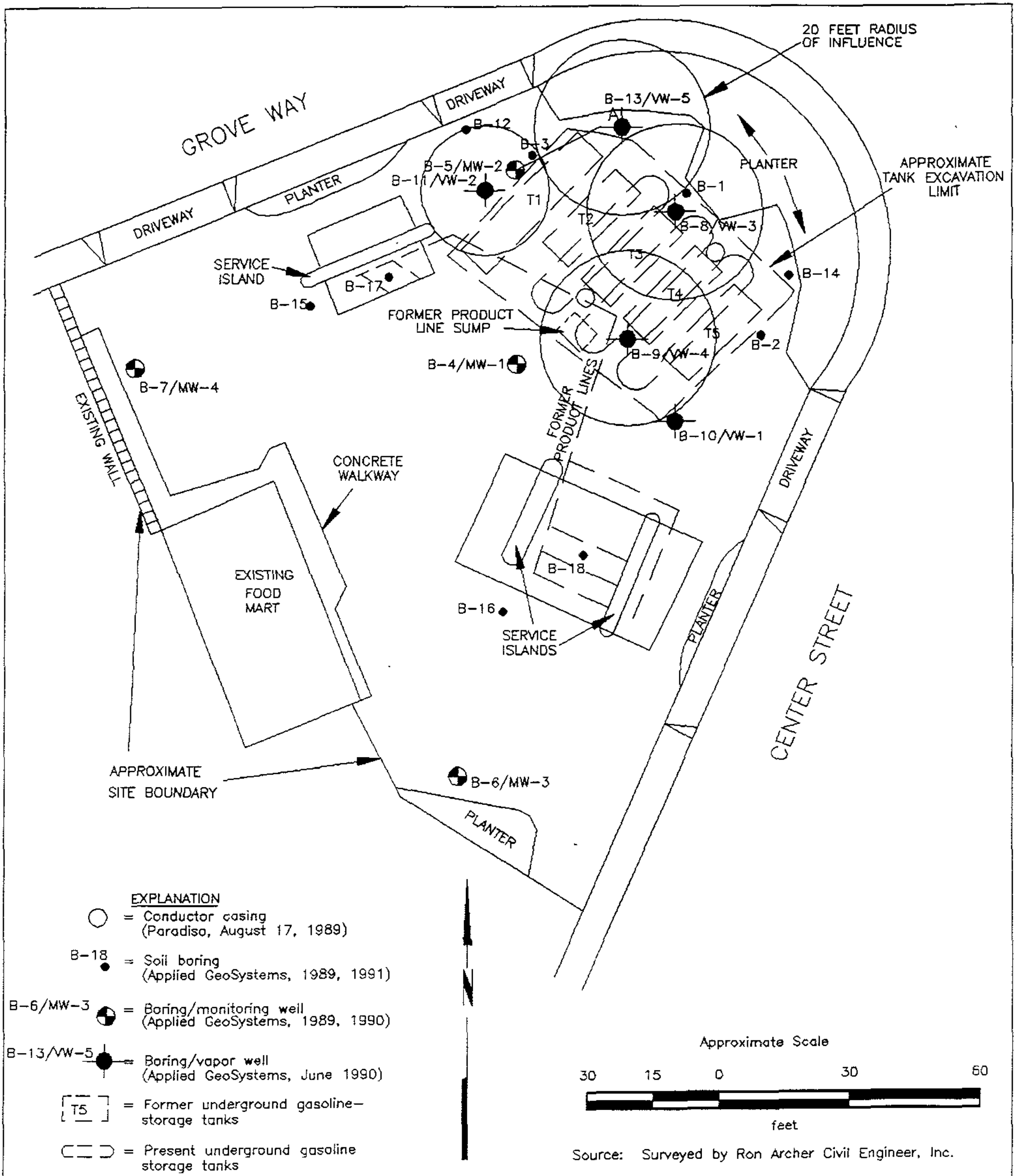
Approximate Scale

30 15 0 30 60

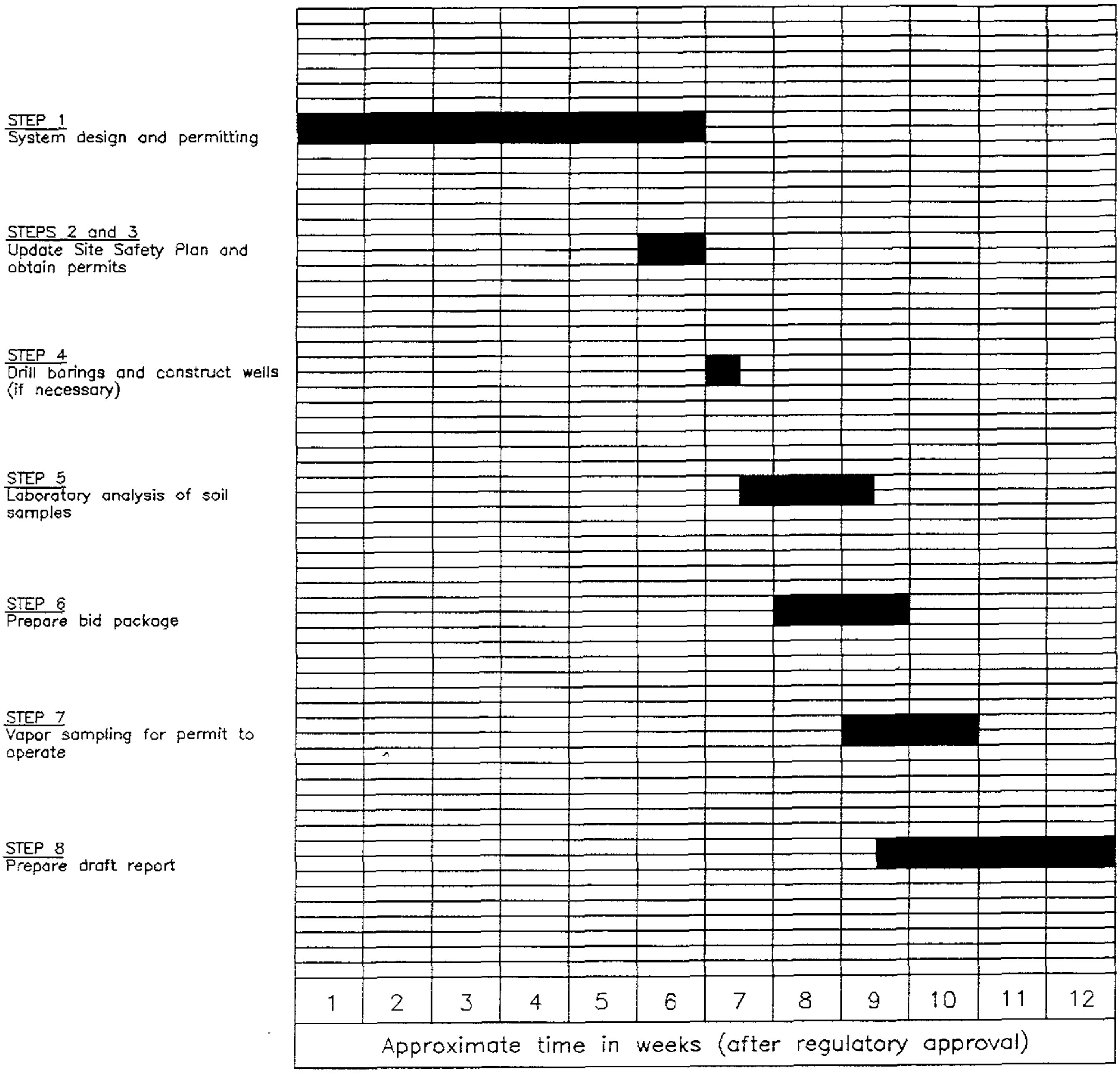
feet

Source: Surveyed by Ron Archer Civil Engineer, Inc.

RESNA	TPHg/BENZENE CONCENTRATION IN GROUNDWATER ARCO Station 2152 22141 Center Street Castro Valley, California	PLATE 9
PROJECT 69013.08		



RESNA	ESTIMATED RADIUS OF INFLUENCE MAP ARCO Station 2152 22141 Center Street Castro Valley, California	PLATE 10
PROJECT 69013.08		



RESNA

PROJECT 69013.08

PRELIMINARY TIME SCHEDULE
ARCO Station 2152
22141 Center Street
Castro Valley, California

PLATE

11

TABLE 1
CUMULATIVE RESULTS OF LABORATORY ANALYSIS OF SOIL SAMPLES
ARCO Station 2152
Castro Valley, California
Page 1 of 3

Date	Sample ID	TPHg	B	T	E	X
4/13/89	S-10-B1	<2.0	<0.050	<0.050	<0.050	<0.050
4/13/89	S-20-B1	<2.0	0.11	0.15	<0.050	0.19
4/13/89	S-25-B1	<2.0	0.22	0.34	0.088	0.38
4/13/89	S-30-B1	5.1	0.42	0.89	0.11	0.56
4/13/89	S-35-B1	5.1	0.40	0.72	0.094	0.42
4/13/89	S-40-B1	<2.0	0.10	<0.050	<0.050	<0.050
4/13/89	S-45-B1	<2.0	<0.050	<0.050	<0.050	<0.050
4/13/89	S-10-B2	<2.0	<0.050	<0.050	<0.050	<0.050
4/13/89	S-20-B2	<2.0	<0.050	<0.050	<0.050	<0.050
4/13/89	S-25-B2	<2.0	<0.050	<0.050	<0.050	<0.050
4/13/89	S-30-B2	<2.0	<0.050	<0.050	<0.050	<0.050
4/13/89	S-5-B3	460	5.1	34	9.6	51
4/13/89	S-10-B3	5.6	<0.050	0.11	<0.050	1.0
4/13/89	S-20-B3	<2.0	<0.050	<0.050	0.055	0.068
4/13/89	S-25-B3	<2.0	<0.050	<0.050	0.17	0.16
4/13/89	S-30-B3	<2.0	<0.050	<0.050	<0.050	<0.050
6/15/90	S-20-B4	<2.0	<0.050	<0.050	<0.050	<0.050
6/15/90	S-29.5-B4	<2.0	<0.050	<0.050	<0.050	<0.050
6/15/90	S-40-B4	<2.0	<0.050	<0.050	<0.050	<0.050
6/15/90	S-44.5-B4	<2.0	<0.050	<0.050	<0.050	<0.050
6/15/90	S-49.5-B4	<2.0	<0.050	<0.050	<0.050	<0.050
6/15/90	S-59-B4	<2.0	<0.050	<0.050	<0.050	<0.050
6/14/90	S-20-B5	<2.0	<0.050	<0.050	<0.050	0.077
6/14/90	S-30-B5	<2.0	0.17	<0.050	<0.050	0.16
6/14/90	S-40-B5	88	2.1	7.2	1.8	13
6/14/90	S-45-B5	<2.0	<0.050	<0.050	<0.050	<0.050
6/14/90	S-49.5-B5	7.9	<0.050	<0.050	<0.050	0.096
6/14/90	S-59-B5	<2.0	<0.050	<0.050	<0.050	<0.050
6/12/90	S-5-B6	<2.0	<0.050	<0.050	<0.050	<0.050
6/12/90	S-15-B6	<2.0	<0.050	<0.050	<0.050	<0.050
6/12/90	S-29.5-B6	<2.0	<0.050	<0.050	<0.050	<0.050
6/12/90	S-44.5-B6	<2.0	<0.050	<0.050	<0.050	<0.050
6/12/90	S-49.5-B6	<2.0	<0.050	<0.050	<0.050	<0.050
6/12/90	S-62-B6	<2.0	<0.050	<0.050	<0.050	<0.050

See notes on page 3 of 3.

TABLE 1
CUMULATIVE RESULTS OF LABORATORY ANALYSIS OF SOIL SAMPLES
ARCO Station 2152
Castro Valley, California
Page 2 of 3

Date	Sample ID	TPHg	B	T	E	X
6/13/90	S-5-B7	<2.0	<0.050	<0.050	<0.050	<0.050
6/13/90	S-15-B7	<2.0	<0.050	<0.050	<0.050	<0.050
6/13/90	S-30-B7	<2.0	<0.050	<0.050	<0.050	<0.050
6/13/90	S-44.5-B7	<2.0	<0.050	0.10	<0.050	0.093
6/13/90	S-49-B7	<2.0	<0.050	<0.050	<0.050	<0.050
6/13/90	S-61-B7	<2.0	<0.050	<0.050	<0.050	<0.050
1/16/91	S-20-B8	<1.0	<0.005	<0.005	<0.005	<0.005
1/16/91	S-15-B8	<1.0	<0.005	<0.005	<0.005	<0.005
1/16/91	S-33-B8	<1.0	0.006	<0.005	<0.005	<0.005
1/16/91	S-39-B8	<1.0	<0.005	<0.005	<0.005	<0.005
1/16/91	S-22-B9	680	<0.005	19	16	91
1/16/91	S-26-B9	<1.0	<0.005	<0.005	<0.005	<0.005
1/16/91	S-29-B9	<1.0	0.006	<0.005	<0.005	<0.005
1/16/91	S-33-B9	<1.0	<0.005	<0.005	<0.005	<0.005
6/18/90	S-10-B10	<2.0	<0.05	<0.05	<0.05	<0.05
6/18/90	S-20-B10	<2.0	<0.05	<0.05	<0.05	<0.05
6/18/90	S-30-B10	<2.0	<0.05	<0.05	<0.05	<0.05
6/18/90	S-35-B10	<2.0	<0.05	<0.05	<0.05	<0.05
6/18/90	S-40-B10	<2.0	<0.05	<0.05	<0.05	<0.05
6/18/90	S-5-B11	<2.0	<0.05	<0.05	<0.05	<0.05
6/18/90	S-15-B11	<2.0	<0.05	<0.05	<0.05	<0.05
6/18/90	S-25-B11	<2.0	<0.05	<0.05	<0.05	<0.05
6/18/90	S-35-B11	<2.0	<0.05	<0.05	<0.05	<0.05
6/18/90	S-40-B11	<2.0	<0.05	<0.05	<0.05	<0.05
1/16/91	S-15-B12	<1.0	<0.005	<0.005	<0.005	<0.005
1/16/91	S-30-B12	<1.0	<0.005	<0.005	<0.005	<0.005
1/16/91	S-35-B12	<1.0	<0.005	<0.005	<0.005	<0.005
1/16/91	S-40-B12	<1.0	0.028	<0.005	<0.005	<0.005
1/16/91	S-47-B12	<1.0	0.028	<0.005	<0.005	0.006
1/16/91	S-15-B13	<1.0	<0.005	<0.005	<0.005	<0.005
1/16/91	S-20-B13	<1.0	<0.005	<0.005	<0.005	<0.005
1/16/91	S-25-B13	<1.0	<0.005	<0.005	<0.005	<0.005
1/16/91	S-30-B13	<1.0	0.033	<0.005	<0.005	0.018
1/16/91	S-35-B13	<1.0	0.030	<0.005	<0.005	<0.005
1/16/91	S-40-B13	<1.0	0.096	<0.005	<0.005	<0.005
1/16/91	S-45-B13	<1.0	<0.005	<0.005	<0.005	<0.005

See notes on page 3 of 3.

TABLE 1
CUMULATIVE RESULTS OF LABORATORY ANALYSIS OF SOIL SAMPLES
ARCO Station 2152
Castro Valley, California
Page 3 of 3

Date	Sample ID	TPHg	B	T	E	X
1/16/91	S-15-B14	<1.0	<0.005	<0.005	<0.005	<0.005
1/16/91	S-20-B14	<1.0	<0.005	<0.005	<0.005	<0.005
1/16/91	S-30-B14	<1.0	<0.005	<0.005	<0.005	<0.005
1/16/91	S-40-B14	<1.0	<0.005	<0.005	<0.005	0.007
1/16/91	S-45-B14	<1.0	<0.005	<0.005	<0.005	<0.005
1/16/91	S-5-B15	<1.0	<0.005	<0.005	<0.005	<0.005
1/16/91	S-10-B15	<1.0	<0.005	<0.005	<0.005	<0.005
1/16/91	S-2-B16	1.7	0.037	<0.005	0.080	<0.005
1/16/91	S-5-B16	<1.0	<0.005	<0.005	<0.005	<0.005
1/16/91	S-10-B16	<1.0	<0.005	<0.005	<0.005	<0.005
2/14/91	S-5½-B17*	<1.0	<0.005	<0.005	<0.005	0.007
2/14/91	S-10-B17*	<1.0	<0.005	<0.005	<0.005	<0.005
2/14/91	S-4-B18*	50	0.12	1.2	0.62	4.3
2/14/91	S-8-B18*	220	0.31	7.3	5.5	36
2/14/91	S-15½-B18*	170	0.84	9.0	4.4	24
1/29/91	S-0129-SP1,2,3,4*	<0.5	<0.005	<0.005	<0.005	<0.005
4/11/91	S-0411-1A,B,C,D	<1.0	<0.0050	<0.0050	<0.0050	<0.0050

Results in parts per million (ppm).
TPHg: Total petroleum hydrocarbons as gasoline (analyzed by EPA Method 5030).
B:benzene T:toluene E:ethyl benzene X:total xylene isomers
BTEX analyzed by EPA Method 8020.
*: Selected samples analyzed for Organic Lead (by California Luft method [12/87]) and nondetectable concentrations (see lab sheets for detection limits) were reported in all samples.

Sample ID: S-40-B11
- Boring number (B11)
- Approximate sample depth in feet (40)
- Soil Sample (S)

S-0129-SP1,2,3,4
- Composite sample (SP1,2,3,4)
- Sample date (0129)
- Soil Sample (S)

TABLE 2
RESULTS OF LABORATORY ANALYSES OF TANK-PIT SOIL SAMPLES
ARCO Station 2152
Castro Valley, California

Date	Sample #	TPHg	B	T	E	X
Tank-Pit Excavation						
08/18/89	S-14-T1S	<2	0.24	<0.05	<0.05	<0.05
08/18/89	S-13-T2S	<2	<0.05	<0.05	<0.05	<0.05
08/18/89	S-13-T3S	4.3	0.09	<0.05	<0.05	<0.05
08/18/89	S-13-T4S	<2	<0.05	<0.05	<0.05	<0.05
08/18/89	S-13-T5S	2.4	<0.05	<0.05	<0.05	<0.05
08/18/89	S-14-T1N	1,400	0.72	6.1	11	130
08/18/89	S-13-T2N	<2	0.076	<0.05	1.1	8.5
08/18/89	S-13-T3N	12	0.29	0.29	0.22	1.3
08/18/89	S-13-T4N	4.4	<0.05	<0.05	<0.05	0.23
08/18/89	S-13-T5N	700	4.6	2.0	4.6	83
08/18/89	S-18-T1N	430	<0.05	<0.05	1.1	8.5
08/18/89	S-18-T2N	<2	0.076	<0.05	<0.05	0.092
08/18/89	S-19-T3N	93	0.11	0.11	0.74	3.5
08/18/89	S-19-T4N	<2	<0.05	<0.05	<0.05	<0.05
08/18/89	S-19-T5N	3,800	<0.05	15	18	150
08/24/89	S-22-T5N	6.5	<0.05	0.36	0.093	0.82
08/22/89	S-14-NW1	<2	<0.05	<0.05	<0.05	<0.05
08/22/89	S-14-EW1	<2	<0.05	<0.05	<0.05	<0.05
08/30/89	S-14-NW2	3.4	<0.005	<0.005	<0.005	.030
08/30/89	S-14-WW1	<1	<0.005	<0.005	<0.005	<0.005
08/30/89	S-14-SF1	<1	<0.005	<0.005	<0.005	<0.005
08/30/89	S-14-SF2	<1	<0.005	<0.005	<0.005	<0.005
08/30/89	S-14-VR1	2,300	<2	<2	19	146
08/30/89	S-22-VR1	37,000	<40	510	38	2,600

Results in milligrams per kilogram (mg/kg) or parts per million (ppm).
TPHg: Total petroleum hydrocarbons as gasoline
B: Benzene T: Toluene E: Ethyl benzene X: Total xylenes
<: Less than the detection limit for the analysis method.

Sample Identification: S-14-T1S
- T1S — Area of sample (See Plate A1)
- 14 — Approximate sample depth in feet below grade
- S — Soil sample

TABLE 3
RESULTS OF LABORATORY ANALYSES OF PRODUCT-LINE SOIL SAMPLES
ARCO Station 2152
Castro Valley, California

Date	Sample #	TPHg	B	T	E	X
Center Street Dispensers						
09/06/89	S-4-PL3	43	1.0	3.2	0.74	4.0
09/06/89	S-2-PL9	4.9	0.24	0.18	0.16	0.64
09/06/89	S-4-PL10	3.4	0.21	0.18	0.11	0.25
09/06/89	S-3.5-PL11	43	1.0	3.2	0.74	4.0
09/06/89	S-2-PL12	73	0.13	<0.050	0.60	3.6
09/11/89	S-3-PL14	<2	<0.050	<0.050	<0.050	<0.050
09/11/89	S-3.5-PL15	<2	<0.050	<0.050	<0.050	0.087
09/15/89	S-3-PL16	21	0.14	0.84	0.42	2.5
09/15/89	S-3-PL17	190	0.85	7.4	2.3	14
09/15/89	S-3-PL18	100	0.72	3.3	1.2	7.2
09/15/89	S-2.5-PL19	<2	<0.050	<0.050	<0.050	<0.050
09/15/89	S-3-PL20	<2	<0.050	<0.050	<0.050	<0.050
09/15/89	S-5-PL21	<2	<0.050	<0.050	<0.050	<0.050
09/15/89	S-3-PL22	<2	<0.050	<0.050	<0.050	<0.050
Grove Street Dispensers						
09/06/89	S-1.5-PL1	130	1.6	3.8	2.4	13
09/19/89	S-4-PL22	13	0.20	0.97	0.16	1.2
10/04/89	S-3-PL25	<2	<0.050	<0.05	<0.050	<0.050
10/04/89	S-3-PL26	<2	<0.050	<0.050	<0.050	<0.050

Results in milligrams per kilogram (mg/kg) or parts per million (ppm).
TPHg: Total petroleum hydrocarbons as gasoline
B: Benzene T: Toluene E: Ethyl benzene X: Total xylenes
<: Less than the detection limit for the analysis method.
Sample identification:

S-4-PL3
- PL3 — Area of sample (See Plate A2)
- 4 — Approximate sample depth in feet below grade
- S — Soil sample

TABLE 4
CUMULATIVE RESULTS OF LABORATORY ANALYSES
OF GROUNDWATER
ARCO Station 2152
Castro Valley, California

Well	Date	TPHg	B	T	E	X
MW-1	06/26/90	64	0.63	<0.50	<0.50	<0.50
	09/26/90	<50	<0.50	<0.50	<0.50	<0.50
	01/08/91	<50	<0.50	<0.50	<0.50	<0.50
	04/02/91	<50	<0.05	<0.05	<0.05	<0.05
	07/08/91	120	2.3	4.6	1.3	9.6
MW-2	06/26/90	27	<0.50	<0.50	<0.50	<0.50
	09/26/90	<50	<0.50	<0.50	<0.50	<0.50
	01/08/91	<50	<0.50	<0.50	<0.50	<0.50
	04/02/91	<50	<0.05	<0.05	<0.05	<0.05
	07/08/91	30	0.42	0.47	<0.30	0.89
MW-3	06/25/90	52	0.65	1.5	<0.50	2.0
	09/26/90	<50	<0.50	<0.50	<0.50	<0.50
	01/08/91	<50	<0.50	<0.50	<0.50	<0.50
	04/02/91	<50	<0.05	<0.05	<0.05	<0.05
	07/08/91	67	0.69	1.5	0.65	4.7
MW-4	06/25/90	<20	<0.50	<0.50	<0.50	<0.50
	09/26/90	<50	<0.50	<0.50	<0.50	<0.50
	01/08/91	<50	<0.50	<0.50	<0.50	<0.50
	04/02/91	<50	<0.05	<0.05	<0.05	<0.05
	07/08/91	50	1.4	2.4	0.62	4.2

Results in parts per billion (ppb).
TPHg: Total petroleum hydrocarbons as gasoline
B:benzene T:toluene E:ethyl benzene X:total xylene isomers

TABLE 5
VAPOR-EXTRACTION TEST FIELD MONITORING DATA
ARCO Station 2152
Castro Valley, California

Extraction Point VW-5

	Influent Air Stream			Observation Wells			
Flow	Concen-tration	Vacuum	Temp.	VW-2 Vacuum	VW-3 Vacuum	VW-4 Vacuum	VW-1 Vacuum
>50	<400	40	72	<0.01	.04	<0.01	<0.01
>50	400	42	72	<0.01	.04	<0.01	<0.01
>50	400	42	72	<0.01	.04	<0.01	<0.01
>50	<400	42	72	<0.01	.04	<0.01	<0.01
>50	<400	42	72	<0.01	.04	<0.01	<0.01
Distance from extraction well VW-5 (feet):				29.0	27.7	48.4	61.9

Extraction Point VW-1

	Influent Air Stream			Observation Wells			
Flow	Concen-tration	Vacuum	Temp.	VW-2 Vacuum	VW-3 Vacuum	VW-4 Vacuum	VW-5 Vacuum
>50	200	42	72	<0.01	<0.01	.08	.01
>50	200	48	72	<0.01	<0.01	.09	.01
>50	<200	48	72	<0.01	<0.01	.08	.01
>50	<200	48	70	<0.01	0.01	.08	.01
>50	<200	48	70	<0.01	0.01	.08	.01
Distance from extraction well VW-1 (feet):				61.3	34.5	17.7	61.9

Flow measured in cubic feet per minute (cfm).
Concentration measured in parts per million by volume (ppmv) on Photoionization Meter.
Vacuum measured in inches of water column vacuum.
Temperature measured in degrees Fahrenheit.

TABLE 6
VAPOR-EXTRACTION TEST LABORATORY ANALYTICAL DATA
ARCO Station 2152
Castro Valley, California

Vapor Sample number	Taken from	Elapsed time	Benzene	Toluene	Ethyl-benzene	Xylenes	TPH
AS-0215-1	VW-1 inf	20	<85	340	140	840	43
AS-0215-2	VW-2 inf	20	<85	13,000	2,500	5,800	3,400
AS-0215-3	VW-3 inf	20	<85	<250	68	430	<30
AS-0215-4	VW-5 inf	15	3,600	480	1,600	6,100	170
AS-0215-5	VW-5 inf	120	400	<250	230	880	36
AS-0215-6	VW-5 eff	125	<85	<250	230	1,700	<30
AS-0215-7	VW-1 inf	5	92	<250	140	1,000	<30
AS-0215-8	VW-1 inf	120	<85	620	270	1,400	110

All measurements are in parts per billion by volume (ppbv); except 1) Time, which is measured in minutes, and 2) TPH, which is measured in parts per million by volume (ppmv).

APPENDIX A

FIELD PROTOCOL

APPENDIX A

FIELD PROTOCOL

The following presents RESNA/Applied GeoSystems' protocol for a typical site investigation involving gasoline hydrocarbon-impacted soil and/or groundwater.

Site Safety Plan

The Site Safety Plan describes the safety requirements for the evaluation of gasoline hydrocarbons in soil, groundwater, and the vadose-zone at the site. The site Safety Plan is applicable to personnel of RESNA/Applied GeoSystems and its subcontractors. RESNA/Applied GeoSystems personnel and subcontractors of RESNA/Applied GeoSystems scheduled to perform the work at the site are be briefed on the contents of the Site Safety Plan before work begins. A copy of the Site Safety Plan is available for reference by appropriate parties during the work. A site Safety Officer is assigned to the project.

Soil Excavation

Permits are acquired prior to the commencement of work at the site. Excavated soil is evaluated using a field calibrated (using isobutylene) Thermo-Environmental Instruments Model 580 Organic Vapor Meter (OVM). This evaluation is done upon arrival of the soil at the ground surface in the excavator bucket by removing the top portion of soil from the bucket, and then placing the intake probe of the OVM against the surface of the soil in the bucket. Field instruments such as the OVM are useful for measuring relative concentrations of vapor content, but cannot be used to measure levels of hydrocarbons with the accuracy of laboratory analysis. Samples are taken from the soil in the bucket by driving laboratory-cleaned brass sleeves into the soil. The samples are sealed in the sleeves using aluminum foil, plastic caps, and aluminized duct tape; labeled; and promptly placed in iced storage. If field subjective analyses suggest the presence of hydrocarbons in the soil, additional excavation and soil sampling is performed, using similar methods. If groundwater is encountered in the excavation, groundwater samples are collected from the excavation using a clean Teflon® bailer. The groundwater samples are collected as described below under "Groundwater Sampling". The excavation is backfilled or fenced prior to departure from the site.

Sampling of Stockpiled Soil

One composite soil sample is collected for each 50 cubic yards of stockpiled soil, and for each individual stockpile composed of less than 50 cubic yards. Composite soil samples are obtained by first evaluating relatively high, average, and low areas of hydrocarbon concentration by digging approximately one to two feet into the stockpile and placing the intake probe of a field calibrated OVM against the surface of the soil; and then collecting one sample from the "high" reading area, and three samples from the "average" areas. Samples are collected by removing the top one to two feet of soil, then driving laboratory-cleaned brass sleeves into the soil. The samples are sealed in the sleeves using aluminum foil, plastic caps, and aluminized duct tape; labeled; and promptly placed in iced storage for transport to the laboratory, where compositing will be performed.

Soil Borings

Prior to the drilling of borings and construction of monitoring wells, permits are acquired from the appropriate regulatory agency. In addition to the above-mentioned permits, encroachment permits from the City or State are acquired if drilling of borings offsite in the City or State streets is necessary. Copies of the permits are included in the appendix of the project report. Prior to drilling, Underground Services Alert is notified of our intent to drill, and known underground utility lines and structures are approximately marked.

The borings are drilled by a truck-mounted drill rig equipped with 8- or 10-inch-diameter, hollow-stem augers. The augers are steam-cleaned prior to drilling each boring to minimize the possibility of cross-contamination. After drilling the borings, monitoring wells are constructed in the borings, or neat-cement grout with bentonite is used to backfill the borings to the ground surface.

Borings for groundwater monitoring wells are drilled to a depth of no more than 20 feet below the depth at which a saturated zone is first encountered, or a short distance into a stratum beneath the saturated zone which is of sufficient moisture and consistency to be judged as a perching layer by the field geologist, whichever is shallower. Drilling into a deeper aquifer below the shallowest aquifer can begin only after a conductor casing is properly installed and allowed to set, to seal the shallow aquifer.

Drill Cuttings

Drill cuttings subjectively evaluated as having hydrocarbon contamination at levels greater than 100 parts per million (ppm) are separated from those subjectively evaluated as having hydrocarbon contamination levels less than 100 ppm. Evaluation is based either on subjective evidence of soil discoloration, or on measurements made using a field calibrated OVM. Readings are taken by placing a soil sample into a ziplock type plastic bag and allowing volatilization to occur. The intake probe of the OVM is then inserted into the headspace created in the plastic bag immediately after opening it. The drill cuttings from the borings are placed in labeled 55-gallon drums approved by the Department of Transportation; or on plastic at the site, and covered with plastic. The cuttings remain the responsibility of the client.

Soil Sampling in Borings

Soil samples are collected at no greater than 5-foot intervals from the ground surface to the total depth of the borings. The soil samples are collected by advancing the boring to a point immediately above the sampling depth, and then driving a California-modified, split-spoon sampler containing brass sleeves through the hollow center of the auger into the soil. The sampler and brass sleeves are laboratory-cleaned, steam-cleaned, or washed thoroughly with Alconox® and water, prior to each use. The sampler is driven with a standard 140-pound hammer repeatedly dropped 30 inches. The number of blows to drive the sampler each successive six inches are counted and recorded to evaluate the relative consistency of the soil.

The samples selected for laboratory analysis are removed from the sampler and quickly sealed in their brass sleeves with aluminum soil, plastic caps, and aluminized duct tape. The samples are then be labeled, promptly placed in iced storage, and delivered to a laboratory certified by the State of California to perform the analyses requested.

One of the samples in brass sleeves not selected for laboratory analysis at each sampling interval is tested in the field using an OVM that is field calibrated at the beginning of each day it is used. This testing is performed by inserting the intake probe of the OVM into the headspace created in the plastic bag containing the soil sample as described in the Drill Cuttings section above. The OVM readings are presented in Logs of Borings included in the project report.

Logging of Borings

A geologist is present to log the soil cuttings and samples using the Unified Soil Classification System. Samples not selected for chemical analysis, and the soil in the sampler shoe, are extruded in the field for inspection. Logs include texture, color, moisture, plasticity, consistency, blow counts, and any other characteristics noted. Logs also include subjective evidence for the presence of hydrocarbons, such as soil staining, noticeable or obvious product odor, and OVM readings.

Monitoring Well Construction

Monitoring wells are constructed in selected borings using clean 2- or 4-inch-diameter, thread-jointed, Schedule 40 polyvinyl chloride (PVC) casing. No chemical cements, glues, or solvents are used in well construction. Each casing bottom is sealed with a threaded end-plug, and each casing top with a locking plug. The screened portions of the wells are constructed of machine-slotted PVC casing with 0.020-inch-wide (typical) slots for initial site wells. Slot size for subsequent wells may be based on sieve analysis and/or well development data. The screened sections in groundwater monitoring wells are placed to allow monitoring during seasonal fluctuations of groundwater levels.

The annular space of each well is backfilled with No. 2 by 12 sand, or similar sorted sand, to approximately two feet above the top of the screened casing for initial site wells. The sand pack grain size for subsequent wells may be based on sieve analysis and/or well development data. A 1- to 2-foot-thick bentonite plug is placed above the sand as a seal against cement entering the filter pack. The remaining annulus is then backfilled with a slurry of water, neat cement, and bentonite to approximately one foot below the ground surface.

An aluminum utility box with a PVC apron is placed over each wellhead and set in concrete placed flush with the surrounding ground surface. Each wellhead cover has a seal to protect the monitoring well against surface-water infiltration and requires a special wrench to open. The design discourages vandalism and reduces the possibility of accidental disturbance of the well.

Groundwater Monitoring Well Development

The monitoring wells are developed by bailing or over-pumping and surge-block techniques. The wells are either bailed or pumped, allowed to recharge, and bailed or pumped again until the water removed from the wells is determined to be clear. Turbidity measurements (in NTUs) are recorded during well development and are used in evaluating well development. The development method used, initial turbidity measurement, volume of water removed, final turbidity measurement, and other pertinent field data and observations are included in reports. The wells are allowed to equilibrate for at least 48 hours after development prior to sampling. Water generated by well development will be stored in 17E Department of Transportation (DOT) 55-gallon drums on site and will remain the responsibility of the client.

Groundwater Sampling

The static water level in each well is measured to the nearest 0.01-foot using a Solinst® electric water-level sounder or oil/water interface probe (if the wells contain floating product) cleaned with Alconox® and water before use in each well. The liquid in the onsite wells is examined for visual evidence of hydrocarbons by gently lowering approximately half the length of a Teflon® bailer (cleaned with Alconox® and water) past the air/water interface. The sample is then retrieved and inspected for floating product, sheen, emulsion, color, and clarity. The thickness of floating product detected is recorded to the nearest 1/8-inch.

Wells which do not contain floating product are purged using a submersible pump. The pump, cables, and hoses are cleaned with Alconox® and water prior to use in each well. The wells are purged until withdrawal is of sufficient duration to result in stabilized Ph, temperature, and electrical conductivity of the water, as measured using portable meters calibrated to a standard buffer and conductivity standard. If the well becomes de-watered, the water level is allowed to recover to at least 80 percent of the initial water level. Prior to the collection of each groundwater sample, the Teflon® bailer is cleaned with Alconox® and rinsed with tap water and deionized water, and the latex gloves worn by the sampler changed. Hydrochloric acid is added to the sample vials as a preservative (when applicable). A sample method blank is collected by pouring distilled water into the bailer and then into sample vials. A sample of the formation water is then collected from the surface of the water in each of the wells using the Teflon® bailer. The water samples are then gently poured into laboratory-cleaned, 40-milliliter (ml) glass vials, 500 ml plastic bottles or 1-liter glass bottles (as required for specific laboratory analysis) and sealed with Teflon®-lined caps, and inspected for air bubbles to check for headspace, which would allow volatilization to occur. The samples are then labeled and promptly placed in iced storage. A field log of well evacuation procedures and parameter monitoring is maintained. Water generated by the purging of wells is stored in 17E DOT 55-gallon drums onsite and remains the responsibility of the client.

Vadose-Zone Sampling

Vapor readings are made with a field calibrated OVM, which has a lower detection limit of 0.1 ppm. Prior to purging each vadose-zone monitoring well, an initial reading is taken inside the well by connecting the tubing of the OVM to a tight fitting at the top of the well. Each vadose-zone monitoring well is then purged for approximately 60 seconds using an electric vacuum pump connected to the tight fitting. Ambient readings of the air at the site are taken with the OVM after each well is purged. The OVM is then connected to the well fitting, and the reading recorded. The well is then again purged for approximately 30 seconds, and again measured using the OVM. These purging and measuring procedures are repeated until two consecutive OVM readings are within ten percent of each other.

Sample Labeling and Handling

Sample containers are labeled in the field with the job number, sample location and depth, and date, and promptly placed in iced storage for transport to the laboratory. A Chain of Custody Record is initiated by the field geologist and updated throughout handling of the samples, and accompanies the samples to a laboratory certified by the State of California for the analyses requested. Samples are transported to the laboratory promptly to help ensure that recommended sample holding times are not exceeded. Samples are properly disposed of after their useful life has expired.

Aquifer Testing

Bailer Test

The initial water level is measured in the test well, and water bailed from the test well using a Teflon® bailer and cable cleaned with Alconox® and water. Pressure transducers are used to measure water levels in the test well during drawdown and partial recovery phases, over a minimum period of approximately one to two hours. The bailing rate for the designated test well is recorded.

Pumping Test

The initial water levels in wells to be used during the test are measured prior to commencement of pumping. The flow rate of the pump is adjusted to the desired pumping rate, and water levels allowed to recover to initial levels. Pumping then begins, and the starting time of pumping is recorded. Drawdowns in observation wells are recorded at intervals throughout pumping using pressure transducers. Evacuated water is stored in a storage tank at the site and remains the responsibility of the client. After the pump is shut off, recovery measurements are taken in the wells until recovery is at least 80 percent of the initial water level. Barometric pressure and tidal information are collected for the time interval of the pumping test to allow screening of possible effects of atmospheric pressure and tidal fluctuations on the groundwater levels.