5/15/91

Applied GeoSystems 3315 Almaden Expressway, Suite 34, San Jose, CA 95118 (408) 264-7723

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May 15, 1991
AGS 69038-6

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

Subject: Transmittal of Work Plan for Subsurface Investigations and Remediation at ARCO Station 4494, 566 Hegenberger Road, Oakland, California.

Mr. Carmel:

As requested by ARCO Products Company (ARCO), RESNA/Applied GeoSystems (AGS) 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 AGS' approach, field methods, and project tasks and approach to work recommended to perform subsurface investigations and remediation at this site. The proposed work includes drilling and sampling additional soil borings, installing ground-water monitoring wells, developing and sampling the monitoring wells, laboratory analysis of soil and ground-water samples, performing hydrogeologic investigations, remediating soil and ground water, if needed, and preparing reports of the findings, interpretations, and conclusions. Recommendations will be included under separate cover as requested by ARCO.

AGS recommends performing these project tasks to delineate the lateral and vertical extent of petroleum hydrocarbons in the soil and ground water and to remediate these compounds in both soil and ground water at the site as needed. The work involved and schedule to perform specific project tasks will be described in detail in addenda to this work plan submitted to ARCO and the regulatory agencies prior to performing additional subsurface work. Modifications to these tasks may be made depending on information obtained from subsequent investigations at the site.

AGS recommends that copies of this Work Plan be sent to the following regulatory agencies:

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

Mr. Barney Chan
Alameda County Health Care Services Agency
Hazardous Materials Division
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\Applied GeoSystems

Ken Mateik jc

Ken Mateik
Project Geologist

Enclosure: Work Plan

cc: H.C. Winsor, ARCO Products Company

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WORK PLAN
for
SUBSURFACE INVESTIGATIONS AND REMEDIATION
at
ARCO Station 4494
566 Hegenberger Road
Oakland, California

AGS 69038-6

Prepared for
ARCO Products Company
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May 15, 1991

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WORK PLAN
for
SUBSURFACE INVESTIGATIONS
AND REMEDIATION
at
ARCO Station 4494
566 Hegenberger Road
Oakland, California

for
ARCO Products Company

INTRODUCTION

This Work Plan summarizes work previously performed by RESNA/Applied GeoSystems (AGS) and others, and describes the project tasks proposed to evaluate and remediate the lateral and vertical extent of petroleum hydrocarbons in the soil and ground water (as necessary) at the subject site. ARCO Products Company (ARCO) requested that AGS prepare this work plan for review and approval by the Regional Water Quality Control Board (RWQCB) and the Alameda County Health Care Services Agency (ACHCSA).

The proposed work includes the following tasks:

Task 1: drill and sample soil borings;
Task 2: drill step-out borings to further delineate the extent of gasoline hydrocarbons in soil (as necessary);
Task 3: prepare a soil remediation feasibility study and addendum to work plan (if necessary);
Task 4: design and construct soil remediation facilities (if necessary);

Task 5: install, develop, and sample onsite ground-water monitoring wells, submit ground-water samples for laboratory analysis from the wells, and perform quarterly ground-water monitoring of wells;
Task 6: conduct hydrogeologic tests and research (as necessary);
Task 7: install, develop, and sample offsite wells (if necessary);
Task 8: prepare a ground-water remediation feasibility study and addendum to work plan (if necessary);
Task 9: design and construct ground-water remediation facilities (if necessary);
Task 10: prepare and implement site closure plan.

This Work Plan is intended to serve as a general technical guide to approach site remediation and closure. Specific work descriptions for each project phase, and any necessary modifications to these tasks, will be included in addenda to this Work Plan which will be submitted prior to performing each phase of site work. Field tasks described above will be performed in accordance with AGS Field Protocol in Appendix A and an AGS Site Safety Plan (AGS, March 4, 1991). The work plan addenda, investigation report(s), remediation feasibility study(ies), and remediation plan(s) will be submitted as separate documents. These documents will also be submitted to the RWQCB and the ACHCSA for their review and approval prior to continuing work at the site.

SITE DESCRIPTION AND BACKGROUND

General

The site is an operating gasoline station at 566 Hegenberger Road on the northeastern corner of the intersection of Hegenberger Road and Edes Avenue in Oakland, California, as shown on the Site Vicinity Map (Plate 1). The site is on a relatively flat lot at an elevation of approximately 5 feet above mean sea level. The site is situated in a commercial/industrial area of the City of Oakland, approximately 1,000 feet east of Interstate Highway 880. This commercial/industrial area is occupied by a wide variety of businesses including fast food restaurants, the Oakland SPCA, union halls, tool manufacturers, trucking firms, construction firms, sign painting firms, motels, and inns. The Oakland-Alameda County Coliseum complex is located approximately 1/2-mile northwest of the site. The site is bounded by a restaurant to the north, a parking lot for a restaurant to the east, restaurants to the west across Hegenberger Road, and a Shell Oil service station across Edes Avenue to the south.

Before its development in 1969, the subject property was covered by a sparse growth of native grasses and weeds, and was situated on reclaimed tidal marshlands covered by approximately four feet of artificial fill (Soil Mechanics and Foundation Engineers [SMFE], 1968). The fill material was described by SMFE as heterogeneous sandy gravelly clay containing construction debris, including pieces of concrete, asphalt, and metallic slag. The source of the construction debris was unknown. Below the fill material was marshland soil and bay mud deposits. SMFE reported that the site may contain a buried tidal slough crossing the southern portion of the site. This slough was filled in between 1947 and 1953, based on observations of aerial photographs from those years, and replaced with an excavated drainage channel (Pacific Aerial Surveys, 1947 and 1953). This drainage channel was then filled in and replaced with a 72-inch storm drain pipeline sometime after 1968. The buried channel is approximately located on the Generalized Site Plan (Plate 2) from information provided by the City of Oakland. Three pipelines were reported by SMFE in 1968 to cross the central portion of the property in a northeast-southwest direction, including the 72-inch-diameter storm drain, a 48-inch-diameter sanitary sewer, and an abandoned sanitary sewer pipeline. Approximate locations of the storm drain and sewer lines based on plans supplied by the City of Oakland Public Works are shown on Plate 2.

Microfiche plans at the City of Oakland Building Inspection Department (OBID) indicate that the site was originally developed by Gulf Oil Company (Gulf) as a service station in

1969. Building plans for the Gulf station show three underground storage tanks (UST) east of the station building, and a fourth tank (possibly a waste-oil tank) may have been located adjacent to the east wall of the station building just south of the USTs. Records of the Oakland Fire Department indicate that Gulf removed and replaced one 10,000-gallon UST in 1975. No record of soil sampling to document possible leakage from the tank(s) was found.

AGS understands from information supplied by ARCO, that ARCO purchased the site from Gulf in 1977, and that one 280-gallon waste-oil storage tank was located west of the station building. On December 16, 1988, the 280-gallon waste-oil storage tank was excavated and removed from the site by Crosby and Overton of Oakland, California. Three 10,000-gallon underground gasoline-storage tanks are at the site: one regular gasoline-storage tank, one super-unleaded gasoline-storage tank, and one regular-unleaded gasoline-storage tank. It is also AGS' understanding that ARCO plans to remodel the site and replace the existing gasoline-storage tanks in 1991.

REGIONAL AND LOCAL HYDROGEOLOGY

Geology

The site is located along the eastern margin of San Francisco Bay within the East Bay Plain, in the northwestern portion of the San Leandro Cone near the boundary of the Oakland Alluvial Plain (Hickenbottom, 1988). The East Bay Plain lies within the Coast Range geomorphic province and is characterized by broad alluvial fan margins sloping westward into San Francisco Bay.

The site area formerly was occupied by shallow tidal marshes, and a channelized tidal slough which is still located directly across Hegenberger Road from the site. Helley (1979) mapped the earth materials underlying the site area as Holocene-age Bay Mud estaurine deposits composed of unconsolidated, water-saturated, dark plastic clay and silty clay rich in organic materials, with local lenses and stringers of well-sorted silt, fine sand, and peat. These estaurine materials, known locally as Bay Mud, were deposited primarily in brackish- to salt-water marshes along the margins and beneath the waters of San Francisco Bay during interglacial periods before and after the Wisconsin Glaciation in late Pleistocene time (Goldman, 1969). The estuarine Bay Mud materials interfinger with Holocene-age fine-grained alluvium deposited by standing floodwaters that periodically inundate the low interfluvial basin areas and fresh-water marshes (Helley, 1979).

Hydrogeology

Alameda County uses ground water as part of its domestic water supply. The remainder of the water supply is derived from surface reservoirs and from imported water that is transported in from the Mokelumne Aqueduct, the State Water Project, and the Hetch Hetchy Aqueduct (Hickenbottom, 1988).

Ground-water quality in the water-bearing units of the San Leandro Cone is generally good (meets recommended primary and secondary standards for drinking water). The most productive water wells in the San Leandro Cone are those completed within the older alluvium units. The older alluvium units consist of permeable alluvial fan deposits characterized by poorly consolidated to unconsolidated gravel, sand, silt and clay (Hickenbottom, 1988). These units contain appreciable quantities of ground water, and are therefore considered to be the principal ground-water reservoir in the East Bay Plain area. Smaller amounts of ground water occur in the younger alluvium, fluvial deposits, interfluvial basin deposits, and Bay Mud estaurine deposits. These deposits generally are relatively thin (less than 120 feet thick), and generally yield only small amounts of ground water to wells. The Bay Mud unit is important to the ground-water resources of the East Bay Plain because of the low permeability of the Bay Mud functions as a barrier to the vertical movement of salt water from San Francisco Bay into the older alluvium. The Bay Mud is generally water-saturated because most of it lies below the water table. However, it is not considered as a useable source of ground water to wells because of its low permeability and because it is believed to contain mostly salt water (Hickenbottom, 1988).

The inferred direction of ground-water flow in the vicinity of the site is to the west\southwest based on regional and local topography and drainage patterns. The depth to first ground water has been measured to be approximately 5 to 15 feet in the area of the site (Alameda County Public Works, 1990).

The site is located approximately 3,500 feet east of San Leandro Bay, which is a smaller portion of San Francisco Bay. The nearest streams to the site are Elmhurst Creek, which is located approximately 1,300 feet north of the site, and San Leandro Creek which is located approximately 6,500 feet south of the site. Both creeks originate in the East Bay Hills, which are a part of the Diablo mountain range, and drain directly into San Leandro Bay. Water enters these creeks by direct runoff from rural and urban areas, through numerous small tributaries, and through numerous storm drain outlets originating in the urbanized areas. Water also enters the much larger San Leandro Creek from overflow from the East Bay Municipal Utility District's Lake Chabot reservoir located in the East Bay Hills north of the City of Castro Valley.

PREVIOUS WORK

Cumulative laboratory results of soil samples collected during previous environmental investigations at the site are summarized in Tables 1 and 2, while cumulative laboratory results of water samples collected from the wells at the site during previous environmental investigations are summarized in Tables 3 and 4. Cumulative measurements of ground-water elevations and subjective field analyses are summarized in Table 5. Plate 2 shows the locations of previous soil borings and existing ground-water monitoring wells.

Initial Subsurface Investigation-December 1988 to January 1989

An initial environmental investigation at the site was conducted by Pacific Environmental Group (Pacific) of Santa Clara, California, and Crosby & Overton, Inc. (C&O) of Oakland, California, during December 1988 and January 1989. This work consisted of the removal of a 280-gallon waste-oil tank, collection of soil samples for laboratory analyses, and removal of stockpiled soil to a Class I hazardous waste facility by C&O. Pacific reported that the tank showed no visible signs of leakage, but a strong product odor was noted in the soil beneath the tank. The tank pit was excavated to a depth of 7 feet below grade. Pacific collected a soil sample (WO-1) at this depth (two feet below the bottom of the former waste-oil tank) beneath the fill end of the tank. Pacific also collected a soil sample (WO-2) at a depth of 10 feet below grade directly beneath the location of sample WO-1. The soil samples were analyzed for: (1) total oil and grease (TOG), (2) high boiling point hydrocarbons (HBPH) (calculated as oil and diesel), (3) semi-volatile organic compounds, (4) volatile organic compounds (VOCs), and (5) cadmium (Cd), chromium (Cr), lead (Pb), and zinc (Zn) at International Technology Corporation (State-certified Hazardous Materials testing laboratory No. 137) in San Jose, California.

Soil sample WO-1, collected at a depth of 7 feet, indicated 4,500 parts per million (ppm) TOG, 4,800 ppm HBPH (calculated as oil), and 370 ppm HBPH (calculated as diesel), respectively. Soil sample WO-2, collected at a depth of 10 feet, indicated nondetectable levels (less than 20 ppm) TOG, nondetectable levels (less than 10 ppm) HBPH (calculated as oil), and nondetectable levels (less than 10 ppm) HBPH (calculated as diesel), respectively.

On January 4, 1989, the pit was further excavated to a depth of 10 feet below grade where Pacific reported no noticeable hydrocarbon odor in the soil. Four sidewall soil samples (WOSW-N, WOSW-E, WOSW-S, and WOSW-W) were collected at a depth of 7 feet from the enlarged excavation. Results of laboratory analysis of these samples indicated:

(1) levels of TOG at 200 ppm, 190 ppm, <10 ppm, and <10 ppm (nondetectable), respectively;
(2) HBPH (calculated as oil) at 400 ppm, 50 ppm, <10 ppm (nondetectable), and <10 ppm,respectively; and
(3) HBPH (calculated as diesel) at 33 ppm, <10 ppm, <10 ppm, and <10 ppm, respectively.

On January 18, 1989, the waste-oil tank excavation was extended 3-1/2 feet on the north side to remove hydrocarbon contamination beyond sidewall sample WOSW-N. Additional excavation of the eastern wall was not possible because of the wall's proximity to the station building. Sidewall sample WOSW-N2 was obtained from the north wall of the extended pit at an approximate depth of 7 feet. Results of laboratory analysis of this sample indicated 10 ppm TOG, <10 ppm HBPH (calculated as diesel), and <10 ppm HBPH (calculated as oil) (Pacific, 1989).

Limited Subsurface Investigation-October through December 1989

In October 1989, AGS drilled and sampled two soil borings (B-1 and B-2), and installed and sampled two ground-water monitoring wells (MW-1 and MW-2, respectively). Earth materials encountered during the drilling of the soil borings consisted primarily of sandy to silty clay. Artificial fill material consisting predominantly of damp, brown silty clay was encountered from immediately below the asphalt and baserock covering the site to a depth of approximately 4 feet. Artificial fill consisting of a wide variety of materials such as metallic slag, sandy gravel to gravel, and concrete debris was encountered at depths of approximately 4 to 6 feet. Beneath these heterogeneous fill materials, a relatively homogeneous damp to moist, gray silty clay was encountered to a depth of approximately 12-1/2 feet. Beneath the relatively homogeneous silty clay, ground water was encountered in a moist to wet, olive-brown to gray silty to sandy clay, which extended to a depth of approximately 18 feet. Ground water was encountered in borings B-1 and B-2 at a depth of approximately 13 feet. Damp to moist, brown to gray silty clay was encountered beneath the wet silty to sandy clay to the bottom of the borings. During drilling and sampling boring B-2/well MW-2 at the site, a black hydrocarbon product was noted in the soil and ground water.

Laboratory results for the soil and water samples collected from the boring/well indicate predominantly degraded gasoline hydrocarbons. Laboratory analysis of soil samples collected from the borings for the total metals Cd, Cr, Pb, and Zn reported detectable levels below the Total Threshold Limit Concentration Values (TTLC) for soil of Title 22 of the California Administrative Code, recorded January 1988, for these respective metals.

Laboratory analysis of the ground-water samples collected from well MW-1 for the above total metals reported detectable levels slightly above the Maximum Contaminant Levels

(MCLs) for Drinking Water as specified by the California State Department of Health Services (DHS) recorded in October 1990 for these respective metals. **A black hydrocarbon product ranging between 2 and 11 inches in thickness was reported in well MW-2 at the time of drilling and well installation.** In addition, base neutral and acid extractables (BNAs) and volatile organic compounds (VOCs) do not appear to have impacted soil or ground water near the former waste-oil tank since soil and water samples collected from boring B-1/MW-1 indicated nondetectable concentrations of BNAs and VOCs.

The inferred direction of ground-water flow is to the west towards San Francisco Bay. This direction is based on topography, but may be influenced locally by tidal actions. Based on the discovery of the black hydrocarbon product in well MW-2 and the inferred direction of ground-water flow, the ongoing subsurface investigation was temporarily stopped until an environmental records search was completed to evaluate potential offsite contaminant sources in the inferred upgradient direction. This environmental records search was requested by Ms. Katherine Chesick of the ACDEH in February 1990, and was completed in the fall of 1990.

1990 Records Search

An environmental records search was performed by AGS within an approximately 1/2-mile radius of the site using information supplied by ARCO, Alameda County Flood Control and Water Conservation District (Zone 7), and the California Department of Water Resources (DWR) (AGS, September 1990). Presented below is a summary of the findings:

- o Before its development, the subject property was covered by a sparse growth of native weeds, and was situated on reclaimed tidal marshlands covered by approximately four feet of artificial fill. The fill material was described as heterogeneous sandy gravelly clay containing construction debris, including pieces of concrete, asphalt, and metallic slag. The source of the construction debris was not known. Below the fill material, the marshland soil was described as firm to soft organic silty clay (Bay Mud) containing thin lenses of silty sand and gravel (Soil Mechanics and Foundation Engineers [SMFE], 1968).

- The site contains a buried slough crossing the southern side of the site near the corner of Hegenberger Road and Edes Avenue (SMFE, 1968). This slough was channelized at some time in the past, and the modified channel is approximately located on Plate 2.

- Three sewer lines were reported by SMFE in 1968 to cross the central portion of the property in a northeast-southwest direction, including a 72-inch-diameter storm-sewer drain, a 48-inch-diameter sanitary sewer, and an abandoned sewer pipeline. Approximate locations of these sewer lines are shown on Plate 2.

- The site is surrounded (within 1/2-mile radius) by various industrial facilities which may at one time have been interconnected with the subject property by surface water drainage channels. Two gasoline service stations and several industrial facilities, which currently use or have historically used underground storage tanks for fuels and solvents are located within a 1/2-mile radius of the site.

- Several facilities in the site area are under investigation for soil and ground-water contamination, including solvents, metals, and petroleum hydrocarbons. These facilities are concentrated in the light industrial sector bounded by Baldwin Avenue, 85th Avenue, and Enterprise Drive, and the heavy industrial areas located along the railroad tracks. These facilities include Ran Rob Tool and Die and West Coast Wire Rope and Rigging east and southeast of the site, and the Transamerica Delaval facility south of the site.

- Numerous facilities in the site area have used underground storage tanks for storage of fuels and solvents, many of which were removed in the 1970's and early 1980's when there were few requirements for testing of soil and ground water during underground storage tank removals. These facilities include several immediately surrounding the site, including the Shell gasoline station to the south; the GMC truck dealership, Castle Golf and Games miniature golf course and predecessor the Malibu Grand Prix racetrack, and Digas gasoline station to the west; Alta Freight, Beava Chemical Company, Conspec Roofing, Golden Gate Freight Lines, and Ran Bob Tool and Die facilities in the light industrial sector to the east and southeast; and former Chevron gasoline station and Transamerica Delaval facility to the south.

Limited Subsurface Investigation (continued)-August 1990 through February 1991

In August 1990, AGS renewed work on the subsurface environmental investigation at the site by drilling and sampling three soil borings (B-3, B-4, and B-5), and installing and sampling two ground-water monitoring wells (MW-3 and MW-4) in borings B-3 and B-4 (AGS, February 13, 1991). Earth materials encountered during the drilling of borings B-3 and B-4 were very similar to the materials encountered in borings B-1 and B-2. In boring B-3, an approximately one-foot-thick lens of moist to wet, black clayey sand was encountered between the depths of 8 to 9 feet. Perched water was encountered in this clayey sand at a depth of approximately 9 feet.

Laboratory results for the soil and water samples collected from the borings/wells are reported in Tables 1 and 2, and indicate predominantly degraded gasoline hydrocarbons. The lateral extent of gasoline hydrocarbons in the soil and ground water associated with the gasoline-storage tanks at the site have been delineated to the northwest, west, and south, but may extend further towards the property boundary to the east and north. The vertical extent of the gasoline hydrocarbons in the soil associated with the gasoline-storage tanks at the site has been delineated to nondetectable levels, as indicated by the laboratory results for soil samples collected from boring B-2 below 19 feet. Laboratory analysis of soil samples collected from the borings for the total metals Cd, Cr, Pb, and Zn are reported in Table 2 and indicated detectable levels below the Total Threshold Limit Concentration Values (TTLC) for soil of Title 22 of the California Administrative Code, recorded January 1988, for these respective metals.

Laboratory analysis of the ground-water samples collected from wells MW-1, MW-3, and MW-4 for the above total metals reported detectable levels slightly above the Maximum Contaminant Levels (MCLs) for Drinking Water as specified by the California State

Department of Health Services (DHS) recorded in October 1990 for these respective metals. A black hydrocarbon product ranging between 2 and 11 inches in thickness was reported in well MW-2 between June and September 1990. The results of laboratory analyses of ground-water samples and of subjective evaluations are reported in Tables 3, 4, and 5.

In addition, BNAs and VOCs do not appear to have impacted soil or ground water near the former waste-oil tank since soil and water samples collected from boring B-1/MW-1 indicated nondetectable concentrations of BNAs and VOCs. The vertical extent of waste-oil hydrocarbons in the soil associated with the former waste-oil-storage tank at the site has been delineated below 100 ppm, as indicated by the laboratory results for soil samples collected from the waste-oil tank pit excavation and borings B-1 and B-5. A level of TOG of 110 ppm in a soil sample from boring B-4 may be isolated and associated with the fill materials present beneath the site. The lateral extent of waste-oil hydrocarbons in the soil associated with the former waste-oil-storage tank at the site has not been laterally delineated below 100 ppm, as indicated by a soil sample collected from boring B-1 which reported 1,600 ppm TOG at a depth of approximately 5 feet.

During the preparation of the site history assessment (AGS, 1990), it was revealed that the shallow earth materials beneath the site appear to consist of imported fill materials, as evidenced by the presence of metallic slag, concrete, and gravel materials encountered during drilling of borings B-1 through B-4. An earlier geotechnical report (SMFE, 1968) indicated that the fill material consisted of imported sandy gravelly clay, concrete, melted glass, metallic slag, and construction debris, and was imported from unknown sources. These fill materials may be a potential source of the gasoline and diesel hydrocarbons encountered within borings B-2 or B-4 drilled in the inferred upgradient direction of the underground gasoline-storage tanks and near the southern corner of the site.

Another potential source of the hydrocarbon product may have resulted from leakage or over-spilling associated with the onsite underground gasoline-storage tanks prior to purchase of the site by ARCO. This conclusion is based on the fact that Gulf Oil Company removed and replaced a 10,000-gallon underground gasoline-storage tank at the site in the late 1970's, and that no soil sampling data was obtained to demonstrate that leakage and/or overfilling of the tank had not occurred.

Measurements of the ground-water elevations beneath the site between June 6 and November 29, 1990, indicate that the direction of ground-water flow is towards the northeast (away from San Francisco Bay). This direction is opposite from the inferred ground-water gradient direction based on topography, and data presented by Hickenbottom (1988). Evidence uncovered during the site history assessment indicates that a buried tidal slough was present at the site before filling and development took place, and may be influencing the ground-water gradient. The presence of a tidal slough is suggested by the very soft, wet organic materials encountered in boring B-3 between the depths of 9 to 19 feet, and immediately underlying the artificial fill materials.

SMFE also reported in 1968 that shallow perched water was present in the fill materials at a depth of approximately three feet. Commonly, in areas with artificial fill, perched water generally will occur along the boundary between the fill materials and the native soil. This condition may occur seasonally beneath the site.

After artificial filling of the tidal slough at the site occurred, a channel was excavated to provide storm water drainage at the site (City of Oakland, 1968). This channel was then, in turn, filled in with artificial fill around 1969, and replaced with a 72-inch diameter concrete storm drain pipeline. This pipeline was noted in SMFE's report, as well as a 48-inch-diameter sanitary sewer pipeline and a 39-inch-diameter abandoned sanitary sewer pipeline. Based on plans supplied by the City of Oakland, the elevations of these pipelines have been calculated, and graphic representations are shown on Geologic Cross Sections A-A' through F-F' (Plates 3 through 8). The elevations suggest that these subsurface lines are higher than the water-bearing materials encountered in borings B-1, B-2, and B-4. However, these subsurface lines might act as conduits enabling gasoline and diesel hydrocarbons to migrate horizontally through the fill materials.

It is inferred that tidal influences within the bay channel probably are not transmitted through the sand or gravel packs surrounding the storm drain and sewer lines beneath the site, due to the interpreted elevations of these subsurface lines from plans supplied by the City of Oakland. Due to the proximity of the site to San Francisco Bay, the direction of ground-water flow may be influenced by tidal actions.

A survey of active, inactive, and destroyed water supply wells and monitoring wells listed with the County of Alameda Public Works Agency (CAPWA) within a 1/2-mile radius of the site was performed as part of the investigation. According to the CAPWA records data base, currently there are no active public-use or domestic-use water producing wells, two industrial-use wells, one irrigation well, and 39 monitoring wells (including 4 extraction wells) within a 1/2-mile radius of the site. In addition, there are at least 13 wells of unknown use and 10 destroyed or abandoned wells. The depths of the industrial wells are 448 and 600 feet below the ground surface (bgs), with the level of static water at approximately 59 and 69 feet bgs. The depth of the irrigation well is 175 feet, but the level of static water is unavailable. Monitoring wells located within a 1/2-mile radius of the site range in depth between 20 and 62 feet, and static water levels range in depth between 4 and 15 feet bgs. The depths of the destroyed or abandoned water wells were between 5 and 1,000 feet depth. Additional well research was performed outside the 1/2-mile radius of the site to a distance of approximately one mile from the site toward the northeast. This additional work was performed after the ground-water flow direction beneath the site was evaluated to be towards the northeast. This additional research yielded one industrial water supply well approximately 400 feet deep with a static water level of approximately 69 feet bgs, and three irrigation water supply wells with depths of 35, 128, and 90 feet bgs, and static water levels of 2, 78, and 8 feet bgs, respectively.

4th Quarter 1990 Ground-Water Monitoring

Quarterly monitoring for the fourth quarter 1990 was performed on November 29, 1990. Laboratory analysis of ground-water samples obtained from wells MW-1, MW-3, and MW-4 during this episode of quarterly ground-water monitoring by AGS reported nondetectable levels of dissolved gasoline hydrocarbons in the water samples collected from these three wells, except for 0.7 ppb of toluene in the water sample collected from well MW-1 (Table 3). A heavy sheen of black hydrocarbon product was reported in monitoring well MW-2, which consequently was not sampled.

Static water elevations as measured in wells MW-1, MW-3, and MW-4 have decreased slightly since the ground-water monitoring wells were installed. The ground-water gradient evaluated from ground-water elevation data collected in November and December 1990 has remained relatively consistent since August 1990, ranging from 0.010 to 0.012 to the northeast (away from San Francisco Bay).

1st Quarter 1991 Ground-Water Monitoring

Quarterly monitoring for the first quarter 1991 was performed on March 7, 1991. Laboratory analysis of ground-water samples obtained from wells MW-1, MW-3, and MW-4 during this episode of quarterly ground-water monitoring by AGS reported nondetectable levels of dissolved gasoline hydrocarbons in the water samples collected from these three wells. A sheen of hydrocarbon product was reported in monitoring well MW-2, which consequently was not sampled.

Static water elevations as measured in wells MW-1 through MW-4 decreased slightly between June and November 1990. Monthly monitoring of ground-water levels since December 1990 through March 1991 has indicated a gradual increase in static water elevations, probably a result of seasonal precipitation and infiltration. The ground-water gradient evaluated from ground-water elevation data collected between December 1990 and March 1991 has remained relatively consistent since August 1990, ranging from 0.009 to 0.012 to the northeast (away from San Francisco Bay).

1991 Tank Replacement Assessment

On March 11 and 26, 1991, AGS conducted a preliminary tank replacement assessment at the site by drilling and sampling twelve soil borings (B-6 through B-17), and analyzing selected soil samples from the borings. ARCO Products Company (ARCO) requested that AGS assess the shallow subsurface area (above first-encountered water) near three existing underground gasoline-storage tanks near the east-central portion of the site, and the proposed location of the new tanks near the south-central portion of the site. The purpose of this assessment was to evaluate petroleum hydrocarbons in the soil before removal from and replacement of the existing tanks from the site. The report of results is currently in progress and will be submitted as a separate document at a later date.

The shallow earth materials beneath the site appear to consist of a heterogeneous mixture of imported fill materials, as evidenced by the presence of silty to sandy clay with metallic slag, glass fragments, concrete, and sand and gravel materials encountered during drilling of borings B-6 through B-17. These materials were also encountered during the earlier AGS investigation while drilling borings B-1 through B-5. The depth to first-encountered ground water varied beneath the site between the depths of 7 to 12-1/2 feet during drilling of borings B-6 through B-17. The water encountered in borings B-6 and B-16 in the southern portion of the site at depths of 6 to 7 feet appears to be seasonally perched water occurring along the boundary between the fill materials and the underlying native soil. The water encountered in borings B-7 through B-15 and B-17 at depths of 8 to 12-1/2 feet appear to be ground water under semi-confined or confined conditions since the water level rose in most of the borings to approximately 7 feet during drilling.

Laboratory results for the soil samples collected from borings B-6 through B-17 indicated low levels of gasoline hydrocarbons (total petroleum hydrocarbons as gasoline [TPHg] and benzene, toluene, ethylbenzene, and total xylenes [BTEX]). The black hydrocarbon product noted in the soil and ground water during drilling and sampling of boring B-2/well MW-2 in October 1989 was not observed during the drilling of borings B-7 through B-10, suggesting that this black hydrocarbon product is limited laterally to the area of boring B-2. ?

The soil above first-encountered ground water in the area of the proposed underground gasoline-storage tanks has not been impacted by gasoline hydrocarbons based on nondetectable levels of TPHg and BTEX. However, the former waste-oil storage tank was located in the southern end of the proposed tank pit, and therefore, residual levels of TOG and total petroleum hydrocarbons as diesel (TPHd) may be encountered in this area during excavation, as indicated by laboratory results of a soil sample collected from boring B-1 in October 1989.

The soil above first-encountered ground water in the area of the proposed station building has not been impacted by gasoline or diesel hydrocarbons based on nondetectable levels of

TPHg, BTEX, and TPHd. However, the soil above first-encountered ground water in the eastern area of the proposed station building has been impacted by heavy hydrocarbons based on detectable levels of TOG in soil samples collected at a depth of 5 feet in borings B-11, B-14, and B-15. The heterogeneous materials used for artificial filling of the former drainage ditch that crossed the site prior to the site's development may be a potential source of the TOG encountered in this area of the site. The soil above first-encountered ground water in the northwestern portion of the site has also been impacted by gasoline and oil and grease hydrocarbons.

PROJECT TASKS

AGS proposes the following project Tasks 1 through 10 listed below as a method of approach to delineate the vertical and horizontal extent of petroleum hydrocarbons and to remediate petroleum hydrocarbons in soil and ground water at the site. Field work involved with the following project tasks will be performed in accordance with the attached AGS Field Protocol in Appendix A and the Site Safety Plan. Reports summarizing work performed, field work and procedures, laboratory methods and results, and conclusions and recommendations will be prepared following each phase of work. Plate 9, Project Tasks Decision Tree for Tasks 1 through 10, graphically presents AGS' investigative site approach. The tasks shown in Plate 9 are discussed in detail below. A Remediation Options Decision Tree is also attached (Plate 10) and depicts potential remediation alternatives for soil and ground water at this site.

TASK 1

Additional soil borings will be drilled and sampled as necessary to evaluate the lateral and vertical extent of gasoline and waste-oil hydrocarbons at the site. Specific locations of these soil borings will be selected and presented as needed for regulatory review. Soil samples will be submitted for laboratory analyses for the gasoline components BTEX and TPHg using modified Environmental Protection Agency (EPA) methods 8020 and 5030/8015, respectively. Soil samples collected near the former waste-oil tank will be analyzed for TOG by Standard Method 5520 D&F and for the metals Cd, Cr, Pb, and Zn, as necessary, by EPA methods 7130, 7190, 7420, and 7450, respectively. VOCs will also be analyzed in a representative soil sample collected from near the former waste-oil tank using EPA Method 8240. These laboratory analyses will be performed at a State-certified laboratory. Chain of Custody protocol will be followed for samples submitted for analysis.

TASK 2

Additional step-out borings will be drilled and soil samples tested as necessary to further delineate the extent of petroleum hydrocarbons in the soil at the site (and offsite, if necessary).

TASK 3

If it is found that remediation of the soil is necessary at the site, a Feasibility Study and addendum to Work Plan will be prepared to evaluate clean-up levels and corrective actions for petroleum hydrocarbons in soil. This study will include remediation options and recommendations for the apparent best remediation alternative to be implemented. Plate 10 lists some of the typical soil remediation options which might be applicable to this site. A minimum of two or three viable disposal, or treatment and disposal alternatives would be selected for cost analysis.

TASK 4

After regulatory approval of the recommended remediation alternative and addendum to Work Plan for the site, construction Plans and Specifications will be prepared as needed. In some instances, simple excavation and disposal of contaminated soil to an appropriate landfill may be adequate, with clean backfill used to replace the excavated soil. If construction of treatment facilities is necessary, construction permits and operating permits will be obtained and Plan and Specification approval will be secured from the local Public Works Department, as necessary. A soil remediation system will then be installed and soil remediation will be performed.

TASK 5

Onsite ground-water monitoring wells will be installed, developed, and sampled to delineate the lateral and vertical extent of petroleum hydrocarbons in ground water onsite. Ground-water samples will be submitted for laboratory analysis for BTEX and TPHg using the equivalent EPA methods for ground-water samples discussed in Task 1 above at a State-certified laboratory. Water samples obtained from wells near the former waste-oil tank will be analyzed for TOG (as necessary) using Standard method 5520 C&F, for VOCs using EPA method 624, and for the metals Cd, Cr, Pb, and Zn by EPA methods 7130, 7190, 7420, and 7450, respectively. Quarterly ground-water monitoring will be performed to evaluate changes in petroleum hydrocarbon concentrations in ground water and changes in ground-water gradient and flow direction over time.

TASK 6

Hydrogeologic tests and research will be performed as necessary to evaluate the potential migration of petroleum hydrocarbons, potential beneficial use of ground water, and general hydrogeologic characteristics as they pertain to possible ground-water remediation and investigation.

TASK 7

After regulatory approval of an offsite ground-water investigation plan (Addendum to Work Plan), offsite wells will be installed, developed, and sampled as described in Task 5 above, and in accordance with the field methods described in Appendix A.

TASK 8

As necessary, a ground-water remediation Feasibility Study and Addendum to Work Plan will be prepared to evaluate corrective actions for petroleum hydrocarbons and heavy metals in ground water. Task 8 can be conducted in conjunction with Task 3, the soil remediation Feasibility Study and Work Plan. Clean-up levels and corrective actions for petroleum hydrocarbons in ground-water, including a minimum of two to three alternatives for treatment and two to three alternatives for treated ground-water disposal, would be analyzed for technical and cost-effectiveness feasibility. Plate 10 lists some typical ground-water remediation alternatives which may be applicable to this site.

TASK 9

After regulatory approval of the remediation Feasibility Study and Addendum to Work Plan, a ground-water remediation system will be designed and installed; the necessary permits will be obtained; and ground-water remediation will be performed and monitored.

TASK 10

After soil and ground-water remediation has been performed to clean-up levels, a site closure plan will be prepared for regulatory review and approval.

SCHEDULE OF OPERATIONS

Preliminary time schedules to perform additional phases of work will be included with the addenda to work plans presented for regulatory review. AGS can initiate work at the site within one week after receiving authorization to proceed. A preliminary estimate to perform the tasks described in this Work Plan (Task 1 through Task 10), including remediation, is approximately two to five years.

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 (C.E. 044600) 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. Ken Mateik, Project Geologist, will be responsible for the day-to-day field and office operations of the project. AGS employs a staff of geologists and technicians who will assist with the project.

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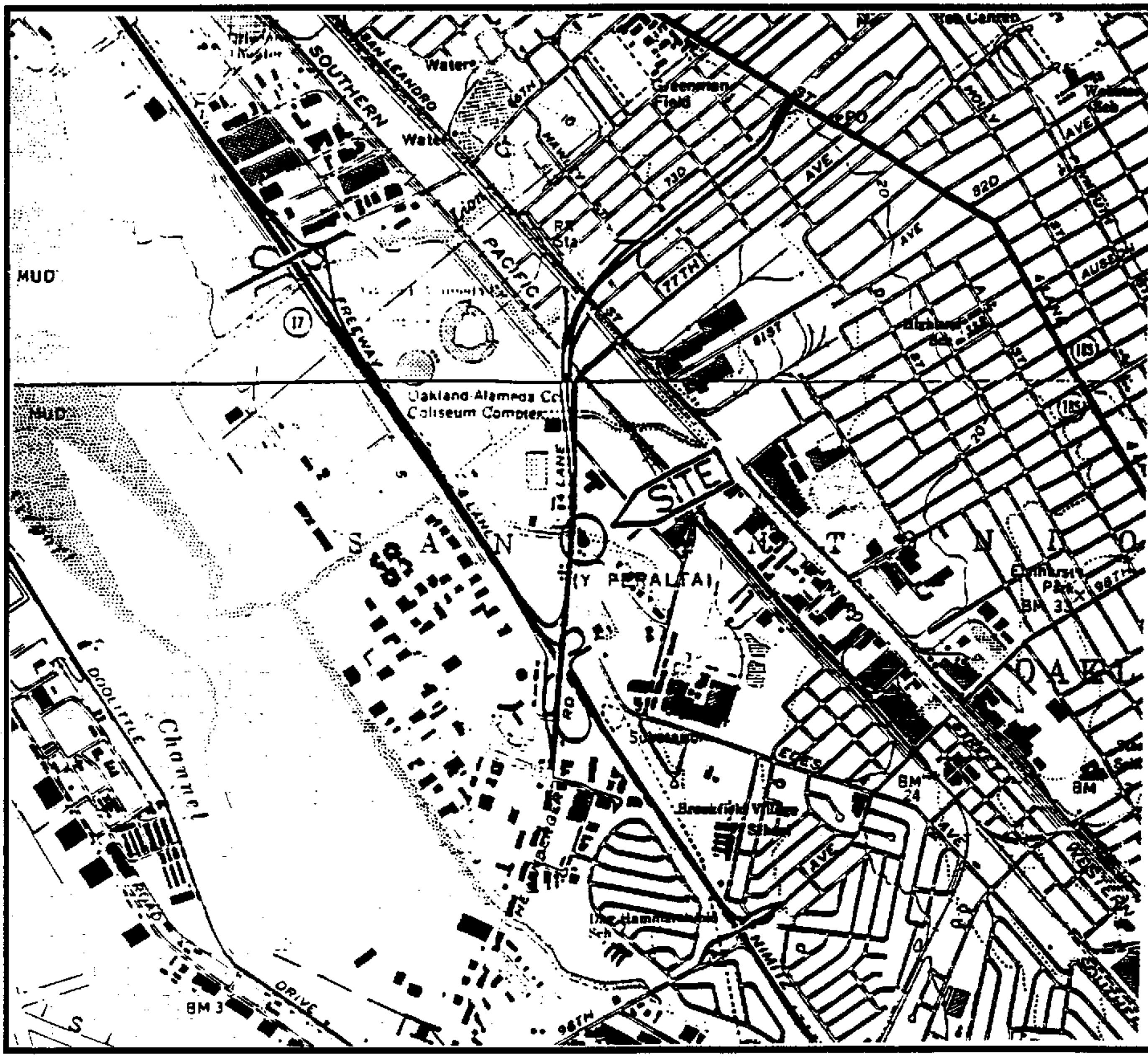

Source: U.S. Geological Survey
7.5-Minute Quadrangle
Oakland East/San Leandro,
California
Photorevised 1980

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PROJECT 69038-6

SITE VICINITY MAP
ARCO Service Station 4494
566 Hegenberger Road
Oakland, California

PLATE
1

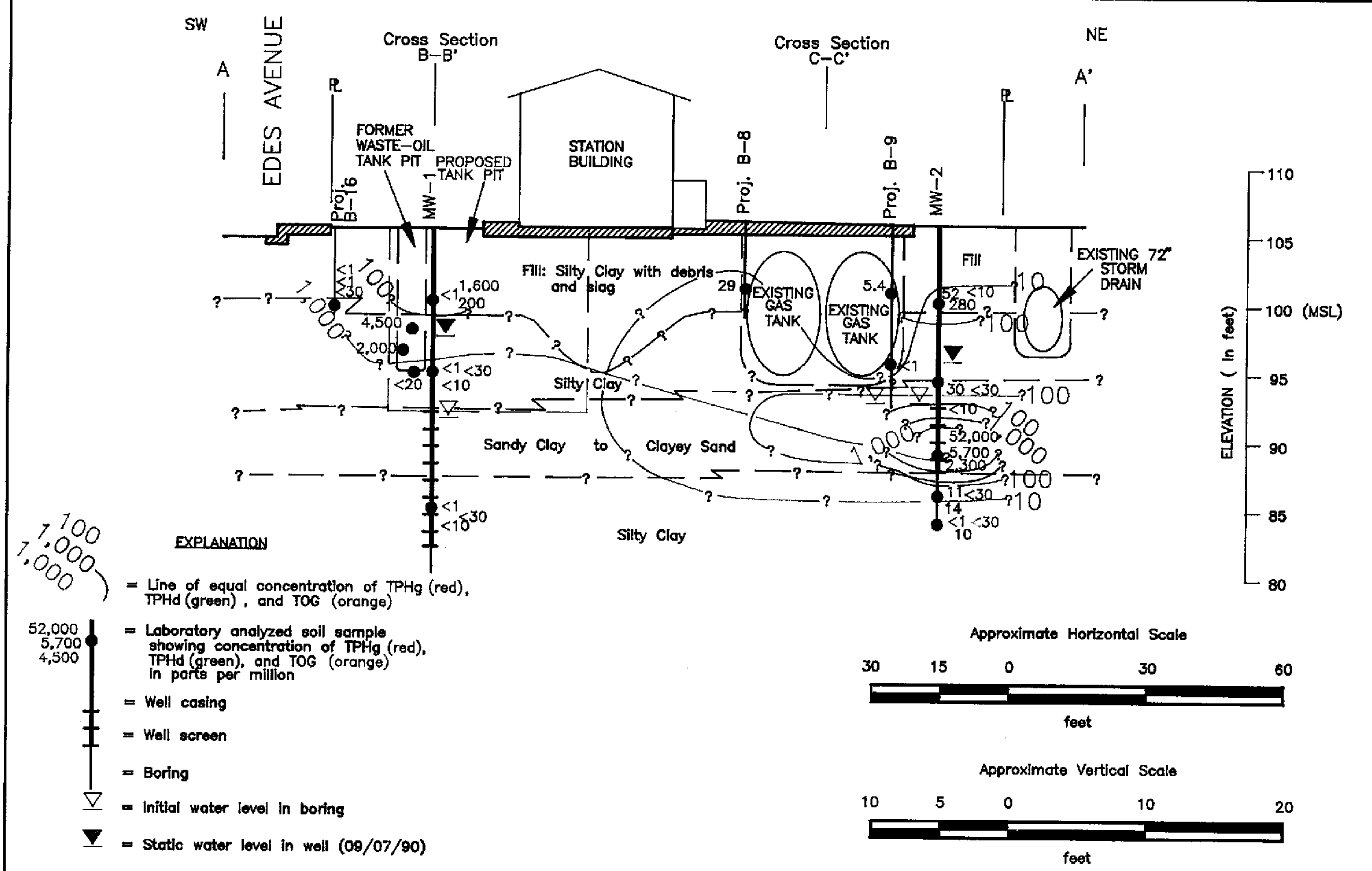
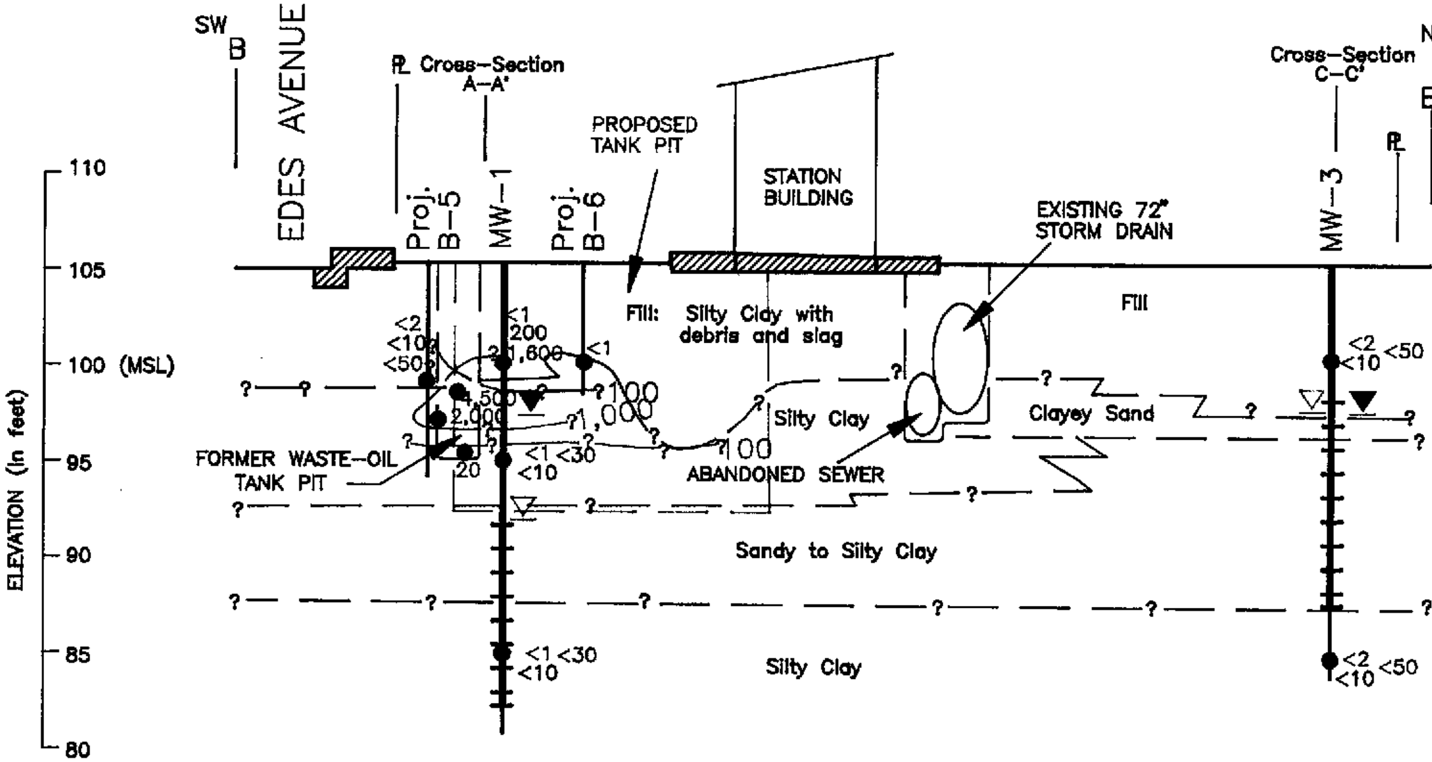


PLATE	
3	**GEOLOGIC CROSS SECTION A-A'** **ARCO Service Station 4494** **566 Hegenberger Road** **Oakland, California**

Applied GeoSystems

PROJECT 69038-6



EXPLANATION

100 / 1,000 = Line of equal concentration of TPHd (green), and TOG (orange)

<2 / 200 / 1,600 = Laboratory analyzed soil sample showing concentration of TPHg (red), TPHd (green), and TOG (orange) in parts per million

= Well casing

= Well screen

= Boring

= Initial water level in boring

= Static water level in well (09/07/90)

Approximate Horizontal Scale: 30 15 0 30 60 feet

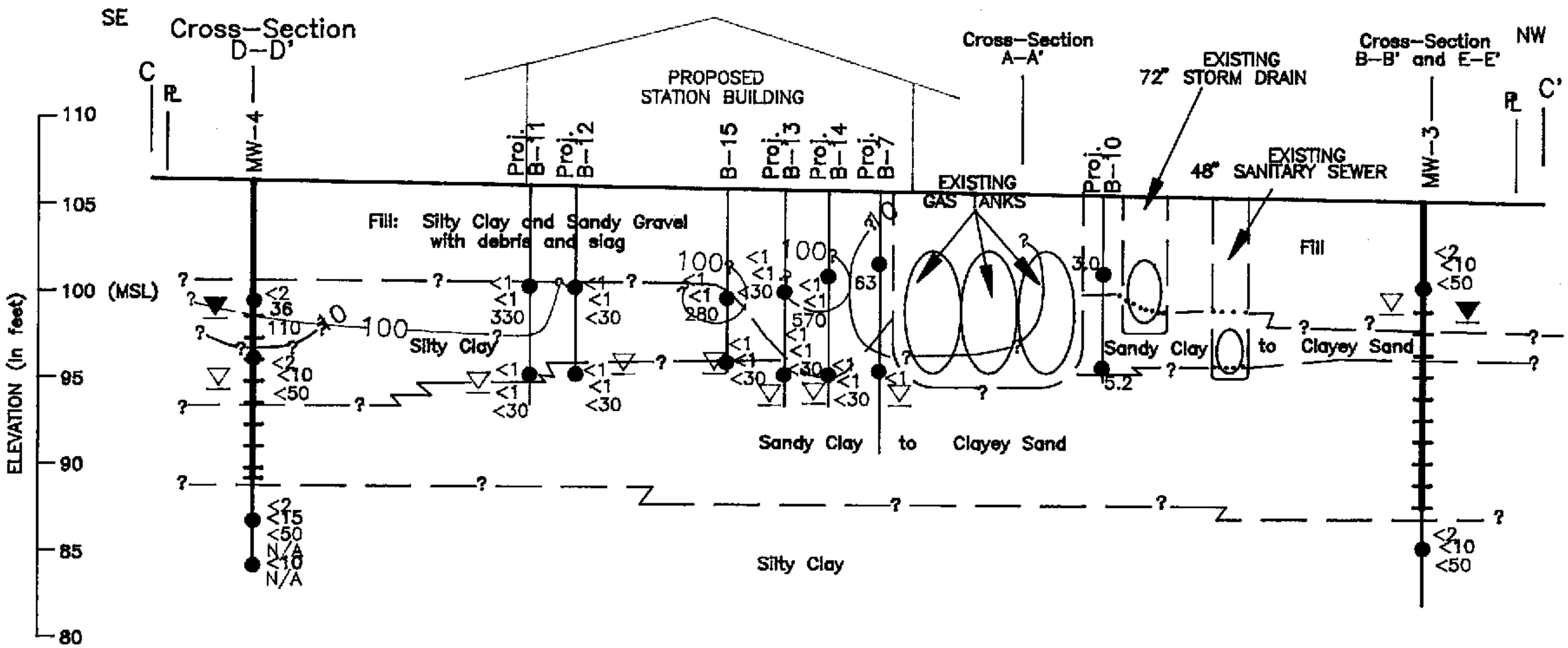
Approximate Vertical Scale: 10 5 0 10 20 feet

PLATE 4

GEOLOGIC CROSS SECTION B-B'
ARCO Service Station 4494
566 Hegenberger Road
Oakland, California

Applied GeoSystems

PROJECT 69038-6



EXPLANATION

10 / 10 / 100 = Line of equal concentration of TPHg (red), TPHd (green), and TOG (orange)

<2 / 36 / 570 = Laboratory analyzed soil sample showing concentration of TPHg (red), TPHd (green), and TOG (orange) in parts per million

= Well casing

= Well screen

= Boring

= Initial water level in boring

= Static water level in well (09/07/90)

Approximate Horizontal Scale

30 15 0 30 60

feet

Approximate Vertical Scale

10 5 0 10 20

feet

PLATE 5	GEOLOGIC CROSS SECTION C-C' ARCO Service Station 4494 566 Hegenberger Road Oakland, California	Applied GeoSystems PROJECT 69038-6

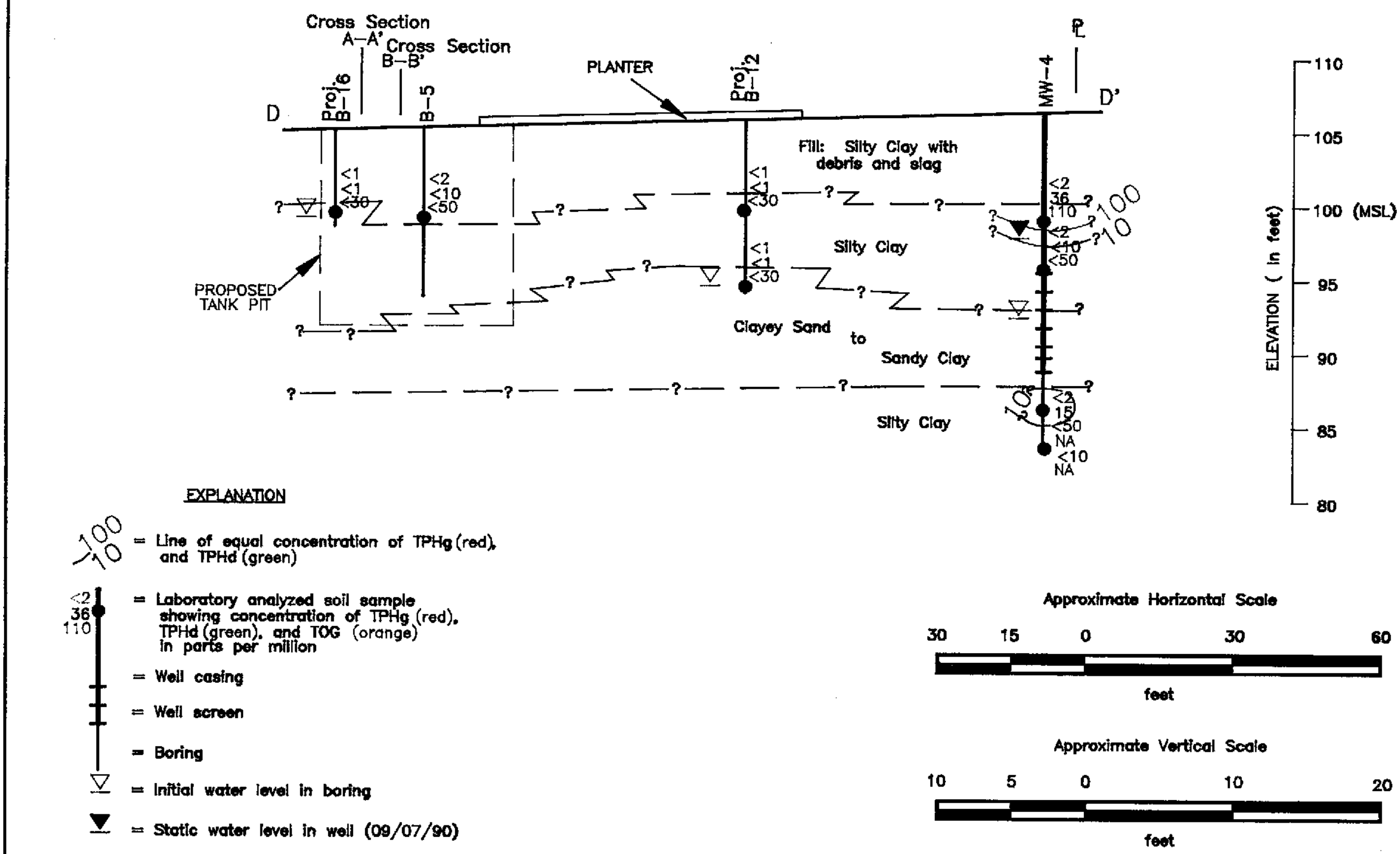


PLATE 6	GEOLOGIC CROSS SECTION D-D' ARCO Service Station 4494 566 Hegenberger Road Oakland, California	Applied GeoSystems PROJECT 69038-6

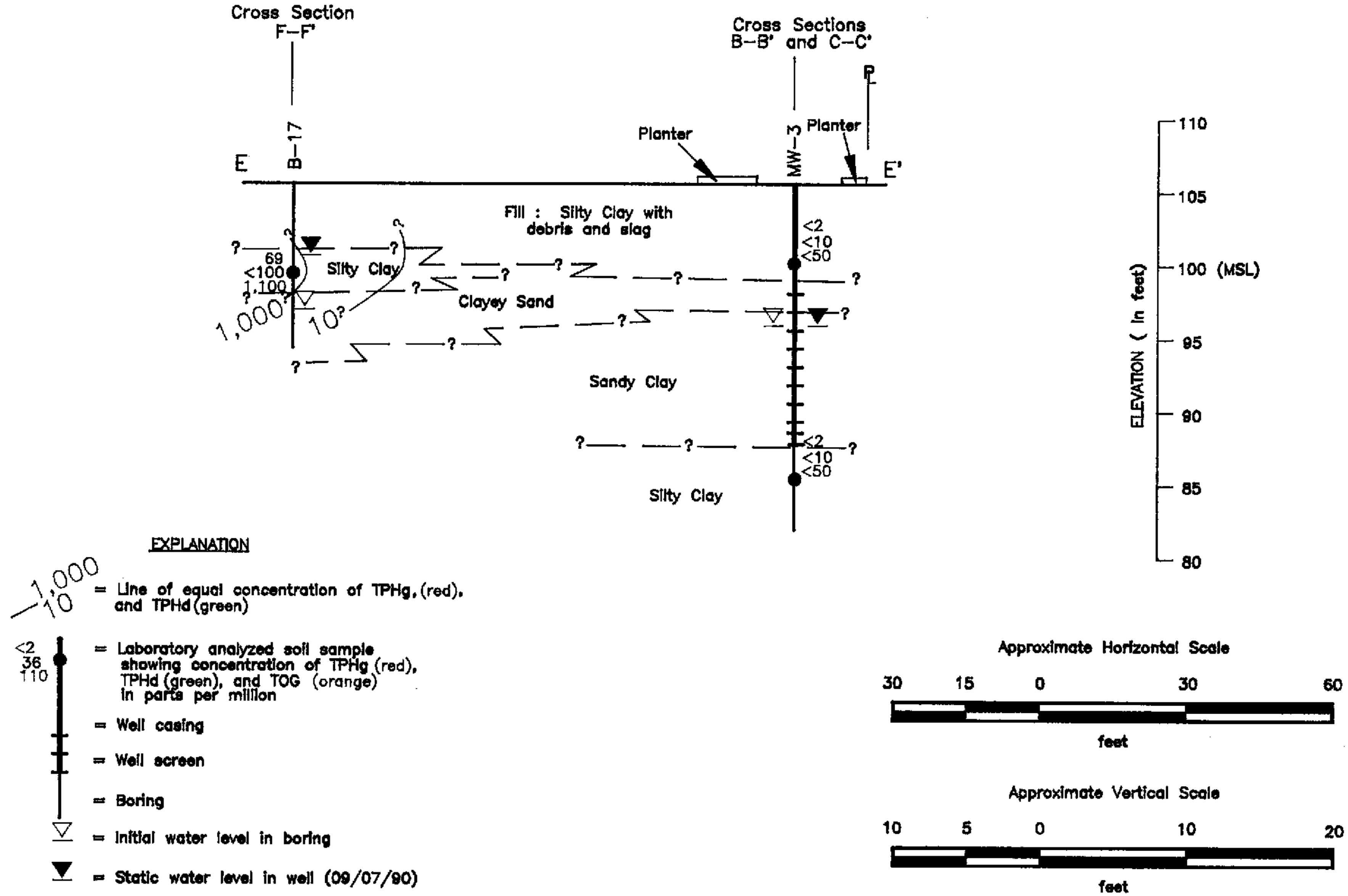
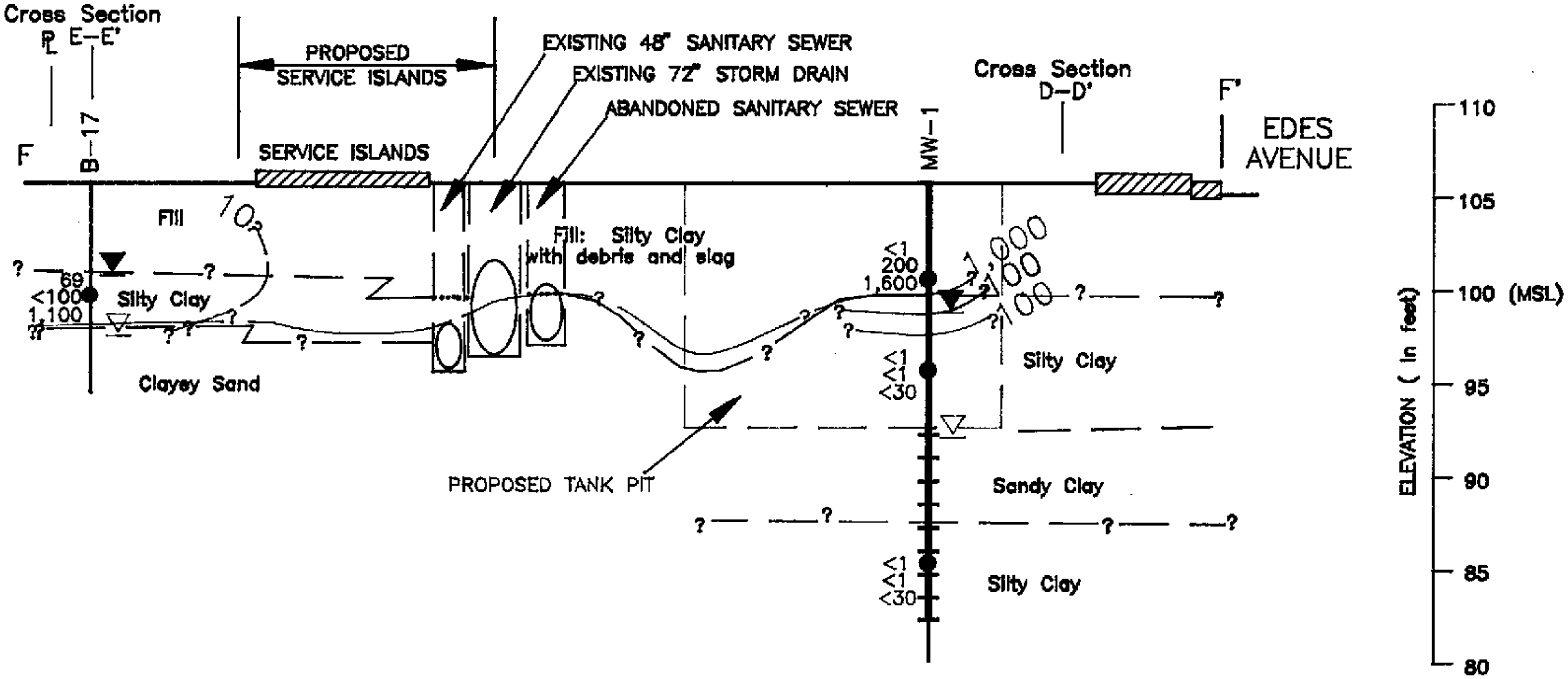


PLATE 7

GEOLOGIC CROSS SECTION E-E'
ARCO Service Station 4494
566 Hegenberger Road
Oakland, California

Applied GeoSystems

PROJECT 69038-6



EXPLANATION

- 1,000 / 100 / 10 = Line of equal concentration of TPHg (red), and TPHd (green)
- 69 / 200 / 1,600 = Laboratory analyzed soil sample showing concentration of TPHg (red), TPHd (green), and TOG (orange) in parts per million
- = Well casing
- = Well screen
- = Boring
- ▽ = Initial water level in boring
- ▼ = Static water level in well (09/07/90)

Approximate Horizontal Scale

30 15 0 30 60

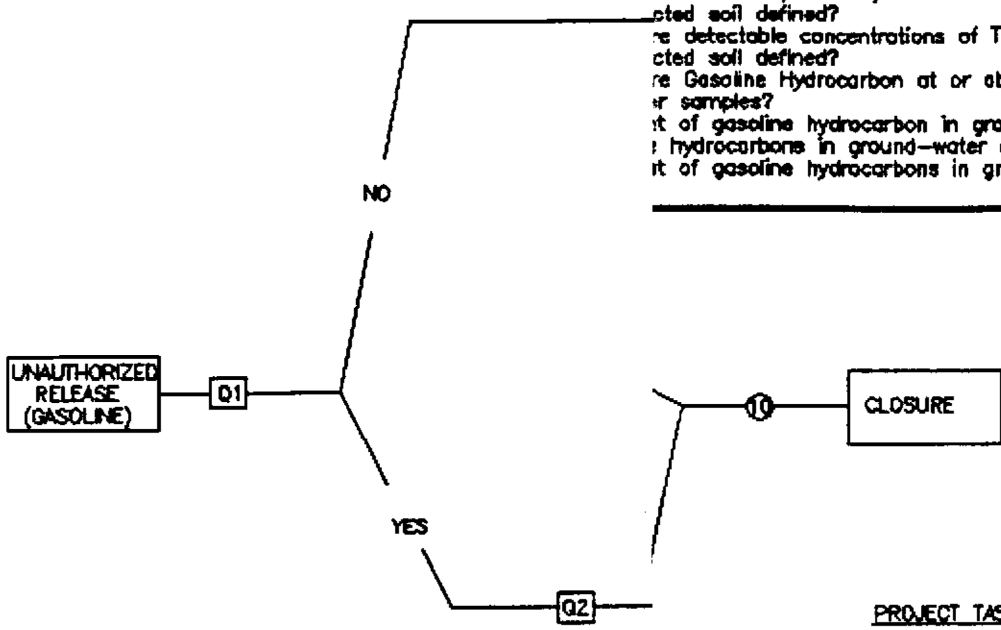
feet

Approximate Vertical Scale

10 5 0 10 20

feet

PLATE 8	GEOLOGIC CROSS SECTION F-F' ARCO Service Station 4494 566 Hegenberger Road Oakland, California	Applied GeoSystems PROJECT 69038-6



QUESTION

:mpacted by release?
:d-water impacted by release?
:cted soil defined?
:e detectable concentrations of TPHg in the soil?
:cted soil defined?
:e Gasoline Hydrocarbon at or above detectable concentrations
:r samples?
:t of gasoline hydrocarbon in ground-water characterized onsite?
: hydrocarbons in ground-water extend offsite?
:t of gasoline hydrocarbons in ground-water characterized offsite?

PROJECT TASKS

SOIL INVESTIGATION

Task ① Drill and sample Soil Borings
Task ② Drill Step-Out Borings

SOIL REMEDIATION (if necessary)

Task ③ Prepare Soil Remediation Feasibility Study and Action Plan (If necessary)
Task ④ Remedial Soil (if necessary)

ONSITE GROUND-WATER INVESTIGATION

Task ⑤ Install/Develop Ground-water Monitoring wells and Sample/Analyze Ground-water
Task ⑥ Conduct Hydrology Tests and Research

OFFSITE GROUND-WATER INVESTIGATION (if necessary)

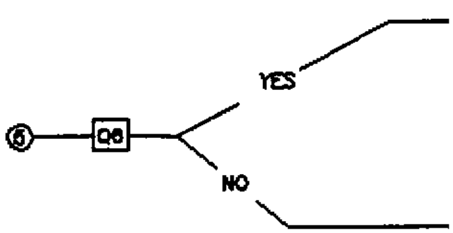
Task ⑦ Install Offsite Well(s), Sample/Analyze

GROUND-WATER REMEDIATION (if necessary)

Task ⑧ Prepare Ground-Water Remediation Feasibility Study and Action Plan
Task ⑨ Remediate Ground-Water

SITE CLOSURE

Task ⑩ Prepare site closure plan



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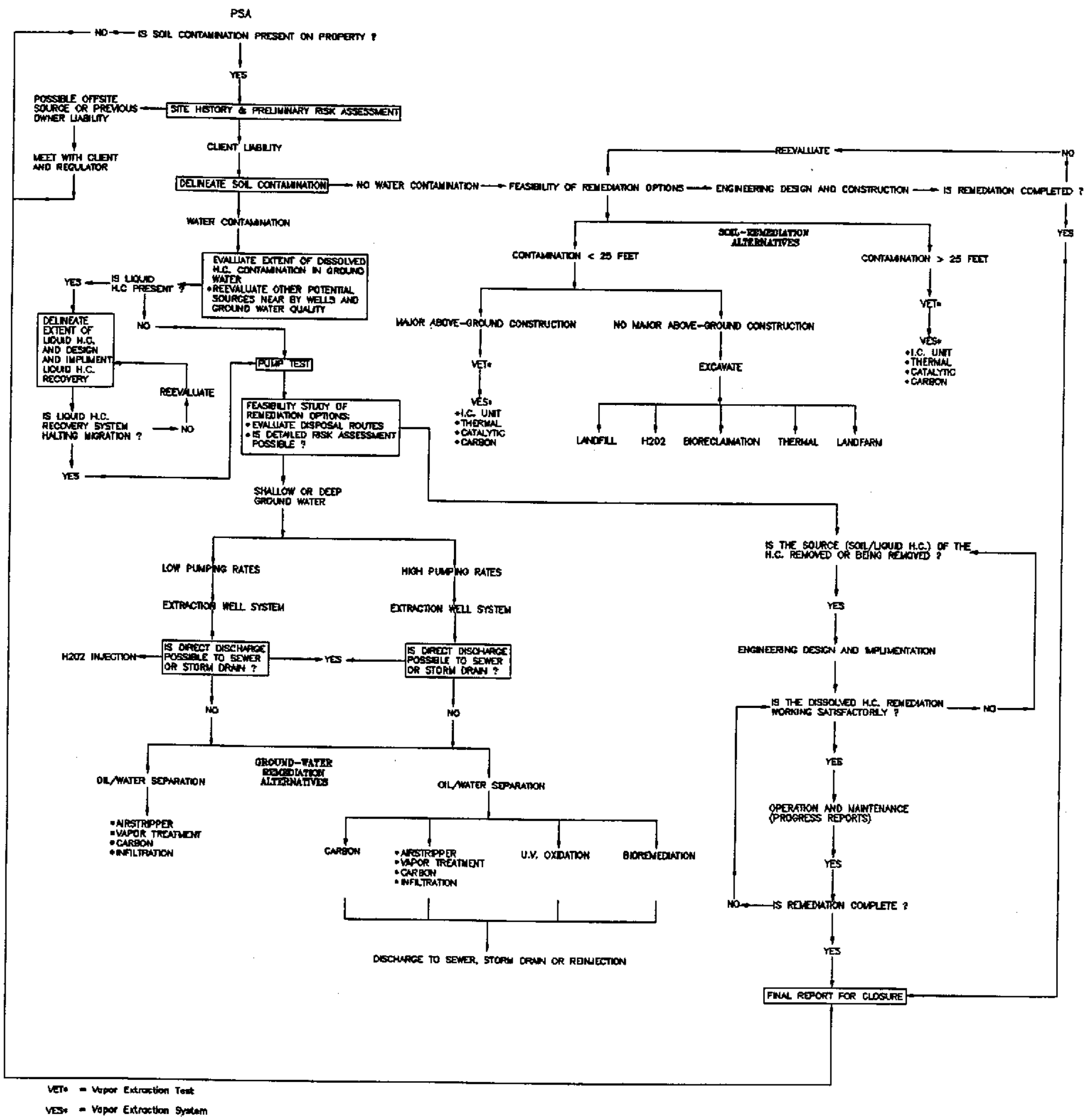
PROJECT 69038-6

PLATE 9



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PROJECT	69038-6

REMEDIATION OPTIONS DECISION TREE

ARCO Service Station 4494
566 Hegenberger Road
Oakland, California

PLATE 10

TABLE 1
CUMULATIVE RESULTS OF LABORATORY ANALYSIS OF
SOIL SAMPLES FOR HYDROCARBONS
ARCO Station 4494
Oakland, California
(Page 1 of 3)

Sample Identifier	TPHg	TPHd	Benzene	Toluene	Ethyl-benzene	Total Xylenes	TOG
December 16, 1988 - Waste-Oil Tank Excavation							
WO-1	11.*	370.+**	NA	NA	NA	NA	4,500 (4,800)
WO-2	<5.*	<10.**	NA	NA	NA	NA	<20
January 4, 1989 - Excavation Sidewall Samples							
WOSW-E	NA	<10.**	NA	NA	NA	NA	190 (50)
WOSW-S	NA	<10.**	NA	NA	NA	NA	<10 (<10)
WOSW-W	NA	<10.**	NA	NA	NA	NA	<10 (<10)
WOSW-N	NA	33.**	NA	NA	NA	NA	200 (400)
January 18, 1989							
WOSW-N2	NA	<10.**	NA	NA	NA	NA	10 (<10)
October 1989							
S-5-B1	<1.0	200	<0.005	<0.005	<0.005	<0.005	1,600
S-10-B1	<1.0	<10	<0.005	<0.005	<0.005	<0.005	<30
S-20-B1	<1.0	<10	<0.005	<0.005	<0.005	<0.005	<30
S-5-B2	52	<10	1.8	0.25	0.48	2.6	280
S-11-B2	30	<10	0.75	0.51	0.43	2.7	<30
S-16-B2	52,000	5,700	<100	1,400	440	2,700	2,300
S-16-B2#	—	—	(120)	(930)	(490)	(3,200)	—
S-19-B2	11	14	0.25	1.2	0.22	1.5	<30
S-21-B2	<1.0	<10	<0.005	0.012	<0.005	0.021	<30
S-24-B2	<1.0	<10	<0.005	<0.005	<0.005	<0.005	<30
S-5-B3	<2.0	<10	<0.050	<0.050	<0.050	<0.050	<50
S-20-B3	<2.0	<10	<0.050	<0.050	<0.050	<0.050	<50
August 1990							
S-7-B4	<2.0	36	<0.050	<0.050	<0.050	<0.050	110
S-10-B4	<2.0	<10	<0.050	<0.050	<0.050	<0.050	<50
S-19.5-B4	<2.0	15	<0.050	<0.050	<0.050	<0.050	<50
S-22-B4	NA	<10	NA	NA	NA	NA	NA
S-6-B5	<2.0	<10	<0.050	<0.050	<0.050	<0.050	<50

See notes on page 3 of 3.

TABLE 1
CUMULATIVE RESULTS OF LABORATORY ANALYSIS OF
SOIL SAMPLES FOR HYDROCARBONS
ARCO Station 4494
Oakland, California
(Page 2 of 3)

Sample Identifier	TPHg	TPHd	Benzene	Toluene	Ethyl-benzene	Total Xylenes	TOG
March 1991							
S-5-B6	<1.0	NA	<0.005	<0.005	<0.005	<0.005	NA
S-5-B7	63	NA	1.0	0.23	0.86	1.8	NA
S-10-B7	<1.0	NA	<0.005	<0.005	<0.005	0.006	NA
S-5-B8	29	NA	0.86	0.088	0.36	0.21	NA
S-5-B9	5.4	NA	0.66	0.035	0.31	0.11	NA
S-10-B9	<1.0	NA	0.037	<0.005	0.011	0.036	NA
S-5-B10	3.0	NA	0.28	0.013	<0.005	0.023	NA
S-10-B10	5.2	NA	0.53	0.036	0.096	0.23	NA
S-6-B11	<1.0	<1.0	<0.005	<0.005	<0.005	<0.005	330
S-11-B11	<1.0	<1.0	<0.005	<0.005	<0.005	<0.005	<30
S-6-B12	<1.0	<1.0	<0.005	<0.005	<0.005	<0.005	<30
S-11-B12	<1.0	<1.0	<0.005	<0.005	<0.005	<0.005	<30
S-6-B13	<1.0	<1.0	<0.005	<0.005	<0.005	<0.005	<30
S-11-B13	<1.0	<1.0	<0.005	<0.005	<0.005	<0.005	<30
S-5-B14	<1.0	<1.0	<0.005	<0.005	<0.005	<0.005	570
S-11-B14	<1.0	<1.0	<0.005	<0.005	<0.005	<0.005	<30
S-6-B15	<1.0	<1.0	<0.005	<0.005	<0.005	<0.005	280
S-10-1/2-B15	<1.0	<1.0	<0.005	<0.005	<0.005	<0.005	<30
S-5-1/2-B16	<1.0	<1.0	<0.005	<0.005	<0.005	<0.005	<30
S-6-B17	69	<100	1.3	1.7	1.0	2.2	1,100
June 1990 - Composite Soil Sample (Borings B-1 and B-2)							Pb
SP-0619-1A							
SP-0619-1B							
SP-0619-1C	19	110	<0.050	<0.050	0.087	0.67	<0.5
SP-0619-1D							
August 1990 - Composite Soil Sample (Borings B-3 and B-4)							
S-B3-1							
S-B3-2							
S-B4-1	<2.0	<10	<0.050	<0.050	<0.050	<0.050	<0.5
S-B4-2							
S-B4-3							

See notes on page 3 of 3.

TABLE 1
CUMULATIVE RESULTS OF LABORATORY ANALYSIS OF
SOIL SAMPLES FOR HYDROCARBONS
ARCO Station 4494
Hegenberger Road and Edes Avenue
Oakland, California
(Page 3 of 3)

Sample Identifier	TPHg	TPHd	Benzene	Toluene	Ethyl-benzene	Total Xylenes	Pb
April 1991 - Composite Soil Sample (Borings B-6 through B-17)							
S-0411-1A S-0411-1B S-0411-1C S-0411-1D	<1.0	NA	<0.0050	0.0080	0.0098	0.017	0.11†

Results in milligrams per kilogram (mg/kg), or parts per million (ppm).
TPHg: Total petroleum hydrocarbons as gasoline by EPA Method 8015/3050.
TPHd: Total petroleum hydrocarbons as diesel by EPA Method 8015/3550.
TOG: Total oil and grease by EPA Standard Method 503 A/E.
* : Analyzed as low boiling hydrocarbons as gasoline (LBHC-g).
** : Analyzed as high boiling hydrocarbons as diesel (HBHC-d).
(4,800): Analyzed as high boiling hydrocarbons as oil (HBHC-o).
+ : Chromatographic pattern of compounds detected and calculated as diesel does not match that of the diesel standard used for calibration.
# : Results of analysis by EPA Method 8240.
Benzene: 120 ppm Toluene: 930 ppm Ethylbenzene: 490 ppm Total Xylenes: 3,200 ppm
Naphthalene: 11 ppm 2-Methylnaphthalene: 6 ppm
Di-n-Octyl Phthalate: 0.60 ppm Butylbenzylphthalate: 0.77 ppm
Pb: Organic Lead by EPA Method 7420.
†: Analyzed as Organic Lead by California LUFT Manual Method (December 1987).

Soil Sample Identification:

```
S-12-B10
| |  └──────   Boring number
| └────────   Approximate sample depth in feet
└──────────   Soil sample
```

Composite Soil Sample Identifications:

```
S-B4-3
| | └──────   Storage drum number
| └────────   Boring number
└──────────   Soil sample

S(P)-0411-1D
|     |  └──   Composite soil sample location
|     └────   Date
└──────────   Stockpile soil sample
```

TABLE 2
CUMULATIVE RESULTS OF LABORATORY ANALYSIS
OF SOIL SAMPLES FOR VOCs AND METALS
ARCO Station 4494
Oakland, California

Sample Identifier	VOCs	Total Cadmium	Total Chromium	Total Lead	Total Zinc
October 1989					
S-5-B1	NA	<0.5	46.8	29.8	67.3
S-10-B1	NA	<0.5	31.2	<1.0	48.5
S-20-B1	NA	<0.5	39.2	<1.0	62.5
S-24-B1	NA	0.757	48.2	<1.0	81.5
S-5-B2	NA	<0.5	32.4	19.9	64.1
S-11-B2	NA	<0.5	22.4	2.16	33.4
S-16-B2	NA	<0.5	27.6	10.2	43.3
S-19-B2	NA	<0.5	40.6	<1.0	60.1
S-21-B2	NA	<0.5	51.2	<1.0	126
S-5-B3	NA	1.1	49	66	48
S-20-B3	NA	2.1	55	79	45
August 1990					
S-7-B4	NA	4.8	85	170	31
S-10-B4	NA	2.7	63	88	44
S-19.5-B4	NA	2.3	66	94	52
S-6-B5	ND	3.4	58	84	41
TTLC		**100**	**2,500**	**1,000**	**5,000**

Results in milligrams per kilogram (mg/kg), or parts per million (ppm).
NA: Not analyzed.
ND: Below the detection limit; see laboratory data sheets for detection limits.
TTLC: Total Threshold Limit Concentration values (Title 22 of California Administrative Code, January 1988).

Sample Identification:
S-6-B5
- B5 — Boring number
- 6 — Approximate sample depth in feet
- S — Soil sample

TABLE 3
CUMULATIVE RESULTS OF LABORATORY ANALYSES
OF WATER SAMPLES FOR HYDROCARBONS
ARCO Station 4494
566 Hegenberger Road
Oakland, California

Well Date	TPHg	TPHd	Benzene	Toluene	Ethyl- benzene	Total Xylenes	TOG
MW-1							
06/19/90	<50	<100	<0.5	<0.5	<0.5	<0.5	<5,000
08/16/90	<20	NA	<0.5	<0.5	<0.5	<0.5	NA
09/07/90	NA	NA	NA	NA	NA	NA	<5,000
11/29/90	<50	NA	<0.5	0.7	<0.5	<0.5	NA
03/07/91	<50	NA	<0.3	<0.3	<0.3	<0.5	NA
MW-3							
08/16/90	<20	NA	<0.5	<0.5	<0.5	<0.5	NA
11/29/90	<50	NA	<0.5	<0.5	<0.5	<0.5	NA
03/07/91	<50	NA	<0.3	<0.3	<0.3	<0.5	NA
MW-4							
08/16/90	<20	NA	<0.5	<0.5	<0.5	<0.5	NA
11/29/90	<50	NA	<0.5	<0.5	<0.5	<0.5	NA
03/07/91	<50	NA	<0.3	<0.3	<0.3	<0.5	NA

Results in micrograms per liter (ug/l), or parts per billion (ppb).
TPHg: Total petroleum hydrocarbons as gasoline by EPA Methods 5030 and 8015.
TPHd: Total petroleum hydrocarbons as diesel by EPA Methods 3550 and 8015.
BTEX: Benzene, toluene, ethylbenzene, and total xylene isomers by EPA Method 5030 and 8020.
TOG: Total oil and grease by EPA Standard Method 503E.

NA: Not Analyzed.

TABLE 4
CUMULATIVE RESULTS OF LABORATORY ANALYSIS
OF WATER SAMPLES FOR VOCs AND METALS
ARCO Station 4494
566 Hegenberger Road
Oakland, California

Well Date	BNA's	VOC's	Total Cadmium	Chromium	Lead	Zinc
MW-1						
06/19/90	ND	ND	0.024	ND	0.10	0.049
08/16/90	NA	NA	NA	NA	NA	NA
11/29/90	NA	NA	NA	NA	NA	NA
03/07/91	NA	NA	NA	NA	NA	NA
MW-3						
08/16/90	ND	ND	ND	0.06	0.07	0.07
11/29/90	NA	NA	NA	NA	NA	NA
03/07/91	NA	NA	NA	NA	NA	NA
MW-4						
08/16/90	ND	ND	ND	ND	ND	0.03
03/07/91	NA	NA	NA	NA	NA	NA
11/29/90	NA	NA	NA	NA	NA	NA
03/07/91	NA	NA	NA	NA	NA	NA
DWALs/MCLs	—	—	**0.010**	**0.05**	**0.05**	**5.0**

Results in milligrams per liter (mg/l), or parts per million (ppm).
NA: Not Analyzed.
ND: Below the detection limit; see laboratory data sheets for detection limits.

DWALs: Drinking Water Action Levels (California Department of Health Services, Office of Drinking Water, October 1990).
MCLs: Maximum Contaminant Levels (California Department of Health Services, Office of Drinking Water, October 1990).

TABLE 5
CUMULATIVE GROUND-WATER MONITORING DATA
ARCO Station 4494
Oakland, California
(Page 1 of 2)

Well Date	Elevation of Wellhead	Depth to Water	Water Elevation	Product Evidence
MW-1				
06/06/90	105.31	6.65	98.66	None
08/16/90		7.00	98.31	None
08/21/90		7.05	98.26	None
09/07/90		7.24	98.07	None
11/20/90		7.46	97.85	None
11/29/90		7.40	97.91	None
12/19/90		6.99	98.32	None
01/29/91		7.23	98.08	None
02/27/91		7.45	97.86	None
03/07/91		6.96	98.35	None
03/26/91		6.02	99.29	None
05/02/91		7.04	98.27	None
MW-2				
06/06/90	105.78	9.00*	96.78*	11" of Black Product
08/16/90		NM	--.--	2" of Black Product
08/21/90		NM	--.--	2" of Black Product
09/07/90		9.17*	96.61*	2" of Black Product
11/20/90		9.20*	96.58*	Heavy Sheen
11/29/90		9.92*	95.86*	Heavy Sheen
12/19/90		8.95	96.83	Obvious Odor
01/29/91		9.01	96.77	Sheen
02/27/91		9.14	96.64	Sheen
03/07/91		8.94	96.84	Sheen
03/26/91		8.11	97.67	Sheen
05/02/91		8.72	97.06	Obvious Odor

See notes on page 2 of 2.

TABLE 5
CUMULATIVE GROUND-WATER MONITORING DATA
ARCO Station 4494
Oakland, California
(Page 2 of 2)

Well Date	Elevation of Wellhead	Depth to Water	Water Elevation	Product Evidence
MW-3				
08/16/90	105.51	8.87	96.64	None
08/21/90		8.85	96.66	None
09/07/90		8.98	96.53	None
11/20/90		9.10	96.41	None
11/29/90		9.05	96.46	None
12/19/90		8.67	96.84	None
01/29/91		8.96	96.55	None
02/27/91		8.71	96.80	None
03/07/91		8.49	97.02	None
03/26/91		7.65	97.86	None
05/02/91		8.62	96.89	None
MW-4				
08/16/90	106.61	8.16	98.45	None
08/21/90		8.22	98.39	None
09/07/90		8.39	98.22	None
11/20/90		8.57	98.04	None
11/29/90		8.53	98.08	None
12/19/90		8.13	98.48	None
01/29/91		8.66	97.95	None
02/27/91		8.44	98.17	None
03/07/91		8.18	98.43	None
03/26/91		7.56	99.05	None
05/02/91		8.25	98.36	None

Depth measurements in feet. * = Floating Product present in well. NM = Not measured.
Elevations of wells from topographic survey of wellheads on August 19, 1989,
by Ron Archer Civil Engineer, Inc., of Pleasanton, California.
Elevations in feet above mean sea level (plus one hundred feet to avoid negative ground-water elevations).

APPENDIX A

FIELD PROTOCOL

FIELD PROTOCOL

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

Site Safety Plan

The Site Safety Plan describes the safety requirements for the evaluation of gasoline hydrocarbons in soil, ground-water, and the vadose-zone at the site. The site Safety Plan is applicable to personnel of Applied GeoSystems and its subcontractors. Applied GeoSystems personnel and subcontractors of 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 ground water is encountered in the excavation, ground water samples are collected from the excavation using a clean Teflon® bailer. The ground water samples are collected as described below under "Ground-Water 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 ground-water 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 ground-water monitoring wells are placed to allow monitoring during seasonal fluctuations of ground-water 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.

<u>Ground-Water Monitoring Well Development</u>

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.

<u>Ground-Water Sampling</u>

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 dewatered, the water level is allowed to recover to at least 80 percent of the initial water level. Prior to the collection of each ground water 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 ground water levels.