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TRANSMITTAL

TO: MR. LARRY SETO
ALAMEDA COUNTY HEALTH CARE SERVICES
AGENCY, HAZARDOUS MATERIALS DIV.
80 SWAN WAY, ROOM 200
OAKLAND, CALIFORNIA 94621

FROM: JOEL COFFMAN
TITLE: ASST. PROJECT GEOLOGIST

DATE: 4/29/91
PROJECT NUMBER: 69036-2
SUBJECT: ARCO STATION 2035, ALBANY, CALIFORNIA

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1	4/29/91	69036-2	WORK PLAN FOR SUBSURFACE INVESTIGATION AND REMEDIATION AT THE ABOVE SITE. (FINAL)
1	4/29/91	69036-2	ADDENDUM ONE TO THE ABOVE WORK PLAN. (FINAL).

THESE ARE TRANSMITTED as checked below:

[ ] For review and comment [ ] Approved as submitted [ ] Resubmit ___ copies for approval

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REMARKS: THIS REPORT IS BEING FORWARDED TO YOU BY COURIER AT THE REQUEST OF MR. CHUCK CARMEL OF ARCO PRODUCTS COMPANY.

Copies: 1 to AGS project file no. 69036-2

SAN JOSE READER'S FILE

*Revision Date: 10/15/90
*File Name: TRANSMT.PRJ

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WORK PLAN
for
SUBSURFACE INVESTIGATIONS AND REMEDIATION
at
ARCO Station 2035
1001 San Pablo Avenue
Albany, California

AGS 69036-2

Prepared for
ARCO Products Company
P.O. Box 5811
San Mateo, California 94402
by
RESNA/Applied GeoSystems

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Assistant Project Geologist

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General Manager

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No. C 044600
Exp. 3-31-94
CIVIL
STATE OF CALIFORNIA

April 29, 1991

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WORK PLAN
for
SUBSURFACE INVESTIGATIONS
AND REMEDIATION
at
ARCO Station 2035
1001 San Pablo Avenue
Albany, 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. 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

ARCO Station 2035 is an operating service station located southeast of the intersection of Marin and San Pablo Avenues at 1001 San Pablo Avenue, Albany, California. The location of the site is shown on Plate 1, Site Vicinity Map. The site is a relatively flat, asphalt- and concrete-covered lot.

ARCO has supplied information that one 6,000-gallon underground gasoline-storage tank (T1), two 4,000-gallon underground gasoline-storage tanks (T2 and T3), and one 10,000-gallon underground gasoline-storage tank (T4) are at the site. We also understand that one

550-gallon waste-oil tank was removed from the site in 1977 during ARCO's conversion of the station to a mini-market. The approximate locations of the underground storage tanks (USTs), former waste-oil tank, and other pertinent features at the site are shown on Plate 2, Generalized Site Plan.

REGIONAL AND LOCAL HYDROGEOLOGY

ARCO Station 2035 is located within the East Bay Plain in the north-central portion of the Berkeley Alluvial Plain (Hickenbottom and Muir, 1988). The active Hayward Fault is approximately 2 miles east of the site. Helley et al. (1979) mapped the earth materials underlying the site area as older Quaternary alluvium deposits composed of a heterogeneous mixture of poorly consolidated to unconsolidated clay, silt, sand and gravel. The site is less than 1,200 feet north of the Codornices Creek and approximately 1 mile east of Fleming Point on the eastern shoreline of the San Francisco Bay. The direction of ground-water flow in the vicinity of the site is inferred to be to the west-southwest, based on regional and local topography and drainage patterns.

PREVIOUS WORK

August 1989

On August 9, 1989, AGS performed a limited environmental site assessment to evaluate possible gasoline hydrocarbons in the soil in the vicinity of the four underground gasoline-storage tanks (AGS, 1990). Five soil borings (B-1 through B-5) were drilled and sampled, and soil samples were described and analyzed for total petroleum hydrocarbons as gasoline (TPHg) and the gasoline constituents benzene, toluene, ethylbenzene and total xylenes (BTEX). Locations of the borings (B-1 through B-5) are shown on Plate 2. Soils encountered in the borings consisted primarily of interbedded layers of silty to gravelly clay and silty to sandy gravel. A graphic representation of the earth materials encountered in the borings is shown on Plate 3, Geologic Cross Section A-A'.

Ground water was encountered in all of the boreholes at depths between 17 and 18 feet below ground surface, except in boring B-5 where ground water was not encountered to a depth of 20-1/2 feet below ground surface. **Free hydrocarbon product was not encountered in any of the five boreholes; however, a sheen was observed on water from borings B-1 and B-4.**

Results of laboratory analyses of selected soil samples from borings B-1 through B-5 showed concentrations of TPHg which ranged from nondetectable to 2,400 parts per million (ppm). Concentrations of BTEX ranged from nondetectable to 33 ppm benzene, 140 ppm toluene, 40 ppm ethylbenzene, and 220 ppm total xylenes. Table 1, Results of Laboratory Analyses of Soil Samples, presents the results of laboratory analyses.

It was concluded that shallow soils near the four underground gasoline-storage tanks have been impacted by gasoline hydrocarbons, and shallow ground water beneath the site appears to have been impacted by gasoline 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 4, Project Tasks Decision Tree for Tasks 1 through 10, graphically presents AGS' investigative site approach. The tasks shown in Plate 4 are discussed in detail below. A Remediation Options Decision Tree is also attached (Plate 5) 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 total oil and grease (TOG) by Standard Method 5520 D&F and for the metals cadmium (Cd), chromium (Cr), lead (Pb), and zinc (Zn), as necessary, by EPA methods 7130, 7190, 7420, and 7450, respectively. Volatile organic compounds (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 5 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 cadmium (Cd), chromium (Cr), lead (Pb), and zinc (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.

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 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 5 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 and depicted in Plate 6, Preliminary Time Schedule.

PROJECT STAFF

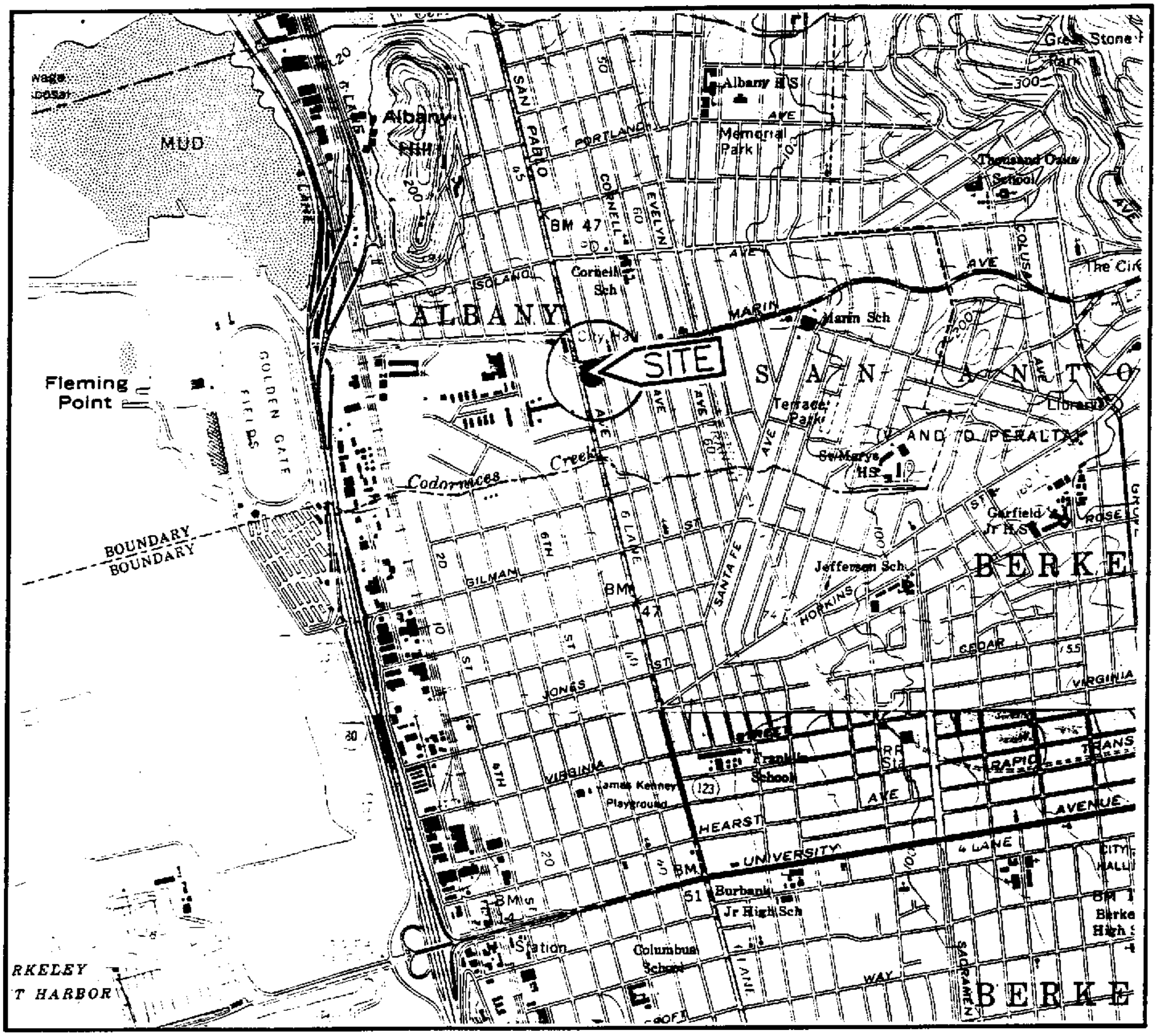
Ms. Diane Barclay, a Certified Engineering Geologist (C.E.G. 1366) in the State of California, will be in overall charge of hydrogeologic facets, and Dr. Joan E. Tiernan, Ph.D., a Registered Civil Engineer (C.E. 044600) will be in overall charge of engineering facets of this project. Mr. Greg Barclay, General Manager, will provide supervision of field and office operations of the project. Mr. Joel Coffman, Assistant 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.

REFERENCES

Applied GeoSystems. January 24, 1990. Limited Environmental Site Assessment at ARCO Station No. 2035, AGS Report 96036-1.

Helley, E. S., K. R. Lajoie, W. E. Spangle, and M. L. Blair. 1979. Flatland Deposits of the San Francisco Bay Region, California, U.S. Geological Survey Professional Paper 943.

Hickenbottom, K. and Muir, K. 1988. Geohydrology And Groundwater-Quality Overview, East Bay Plain Area, Alameda County, California 205(J) Report. Alameda County Flood Control and Water Conservation District, California.



Source: U.S. Geological Survey
7.5–Minute Quadrangles
Richmond/Oakland West
California.
Photorevised 1980

Approximate Scale

2000 1000 0 2000 4000

feet

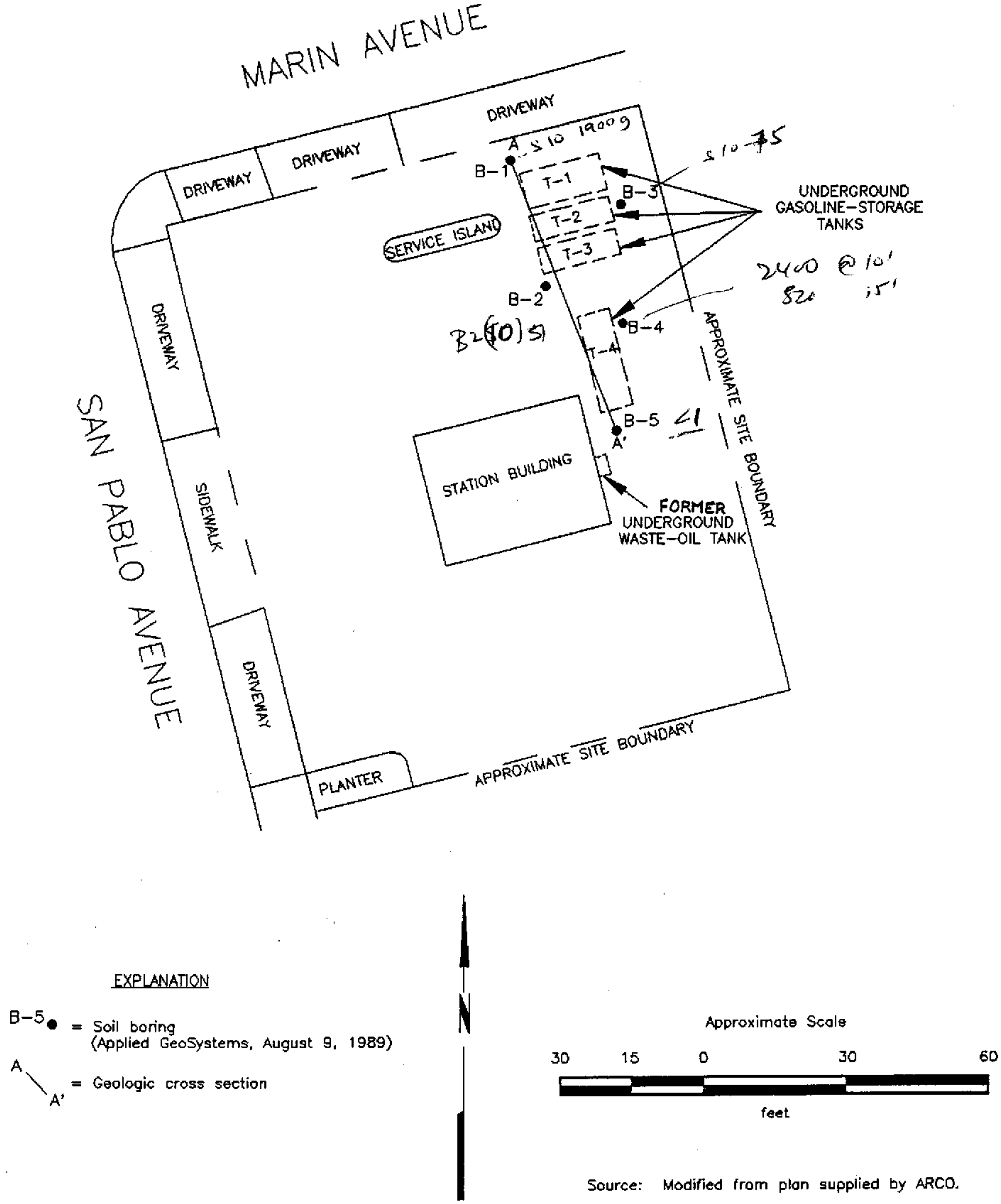
Applied GeoSystems

PROJECT 69036-2

SITE VICINITY MAP
ARCO Station 2035
1001 San Pablo Avenue
Albany, California

PLATE

1



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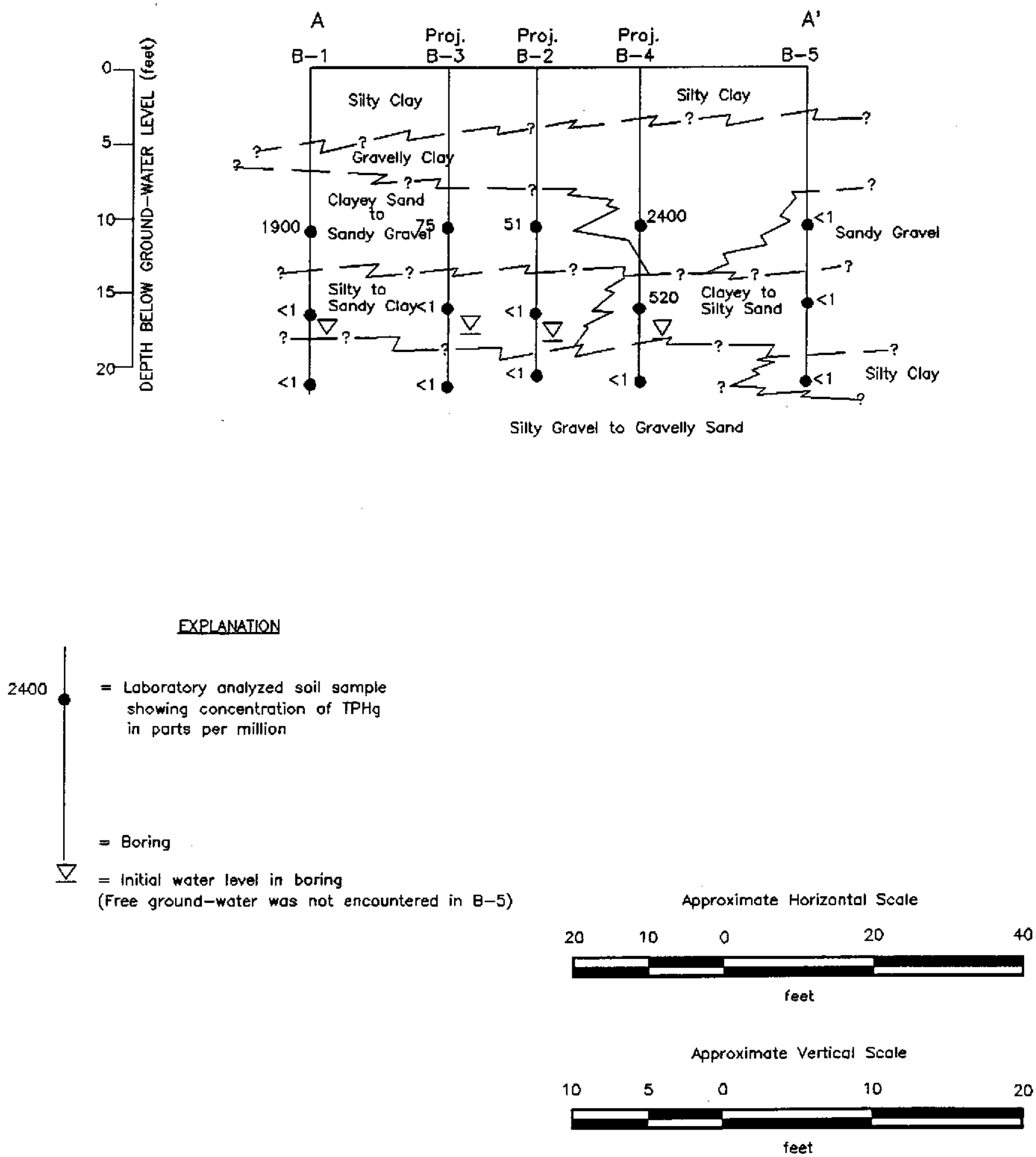
PROJECT 69036-2

GENERALIZED SITE PLAN
ARCO Station 2035
1001 San Pablo Avenue
Albany, California

PLATE 2



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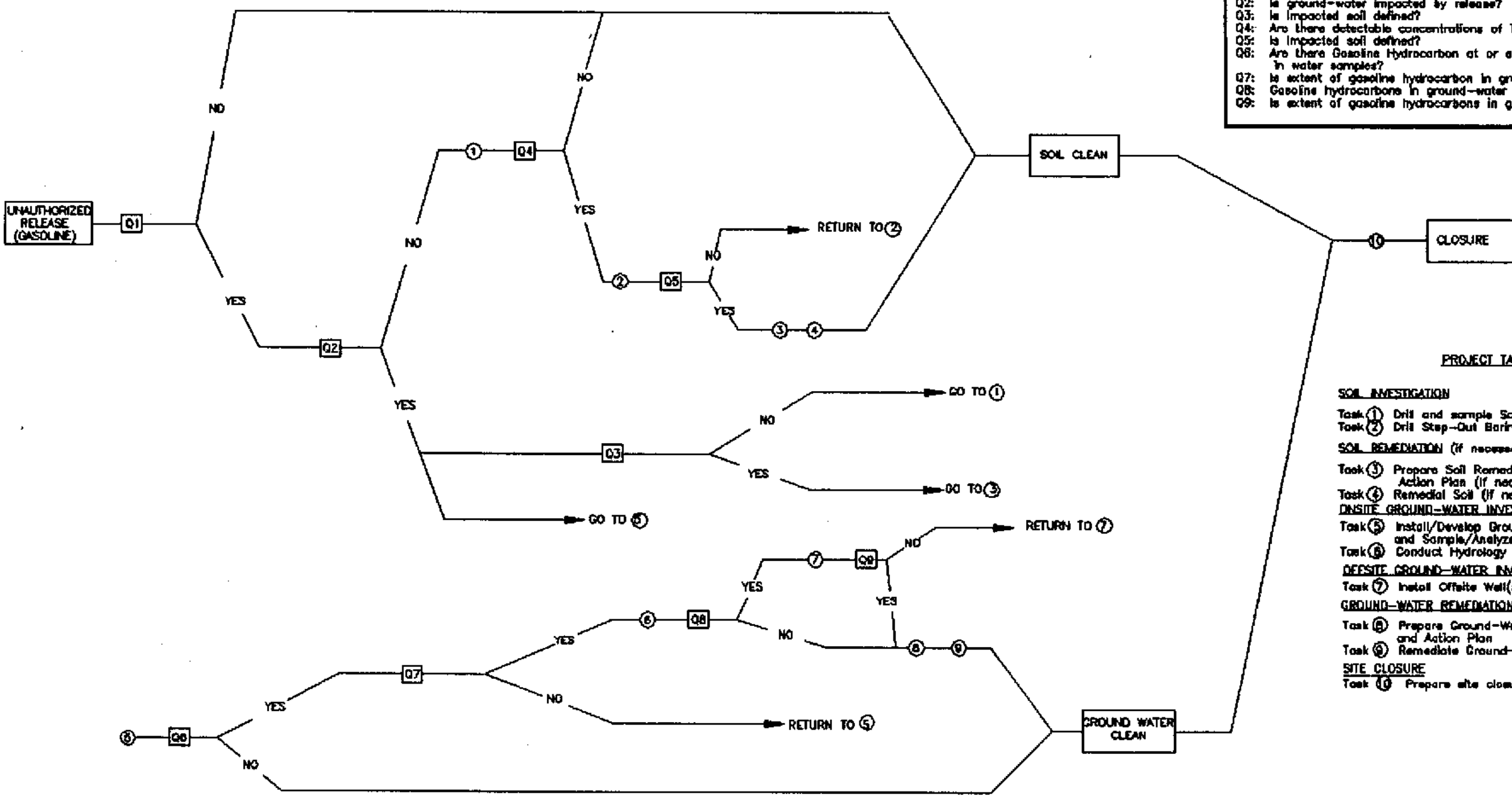
PROJECT 69036-2

GEOLOGIC CROSS SECTION A-A'
ARCO Station 2035
1001 San Pablo Avenue
Albany, California

PLATE 3

QUESTION

Q1: Is soil impacted by release?
Q2: Is ground-water impacted by release?
Q3: Is impacted soil defined?
Q4: Are there detectable concentrations of TPHg in the soil?
Q5: Is impacted soil defined?
Q6: Are there Gasoline Hydrocarbon at or above detectable concentrations in water samples?
Q7: Is extent of gasoline hydrocarbon in ground-water characterized onsite?
Q8: Gasoline hydrocarbons in ground-water extend offsite?
Q9: Is extent 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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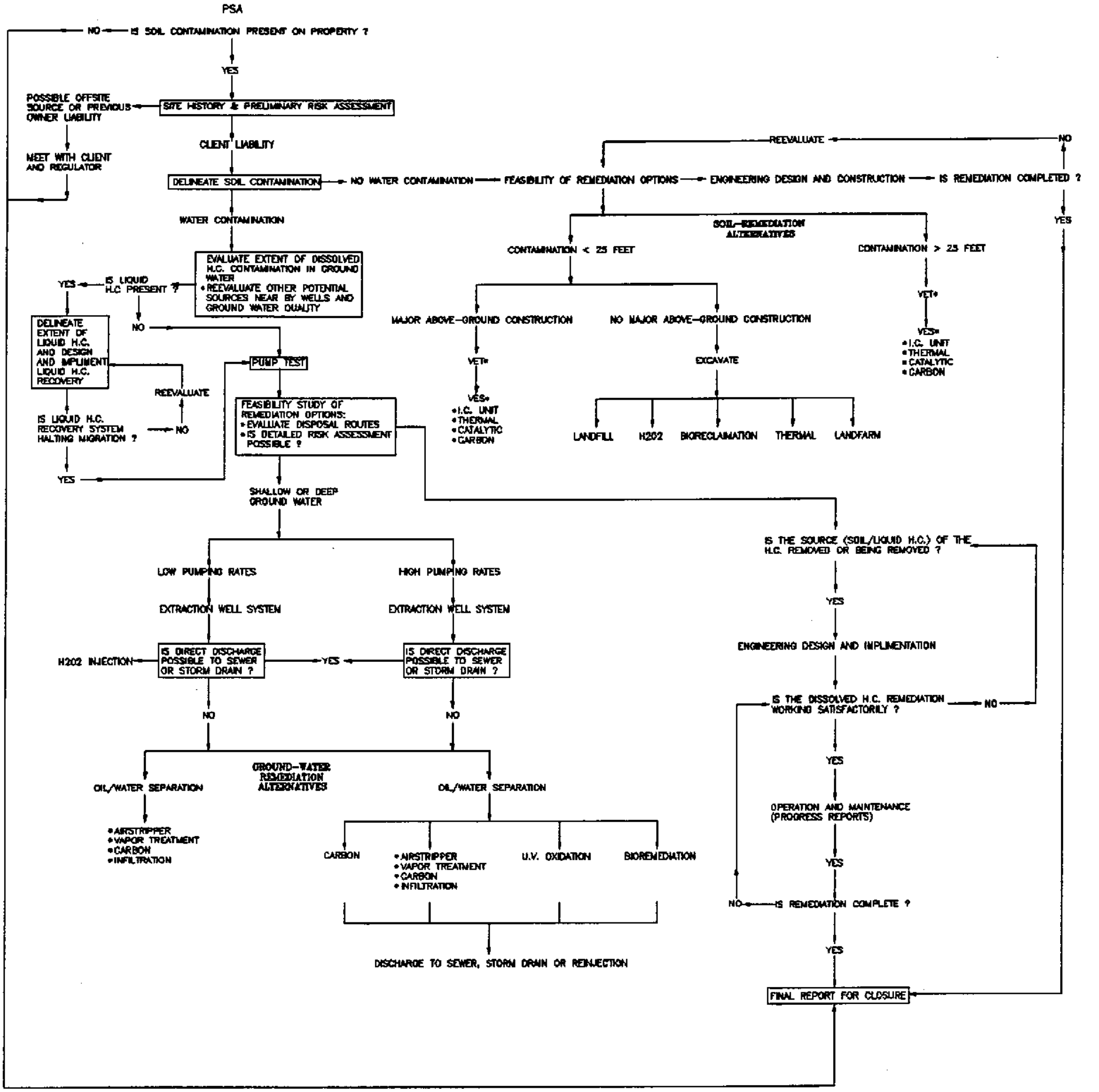
PROJECT 69036-2

PROJECT TASK DECISION TREE
ARCO Station 2035
1001 San Pablo Avenue
Albany, California

PLATE 4



VET* = Vapor Extraction Test

VES* = Vapor Extraction System

Applied GeoSystems	REMEDIATION OPTIONS DECISION TREE ARCO Station 2035 1001 San Pablo Avenue Albany, California	PLATE 5
PROJECT 69036-2		

TASK 1:
Drill and Sample soil borings

TASK 2:
Drill Step-Out borings

TASK 3:
Prepare Soil Remediation Feasibility Study and Action Plan (if necessary)

TASK 4:
Remediate Soil (if necessary)

TASK 5:
Install/Develop Ground-Water Monitoring Wells and Sample/Analyze Ground-Water

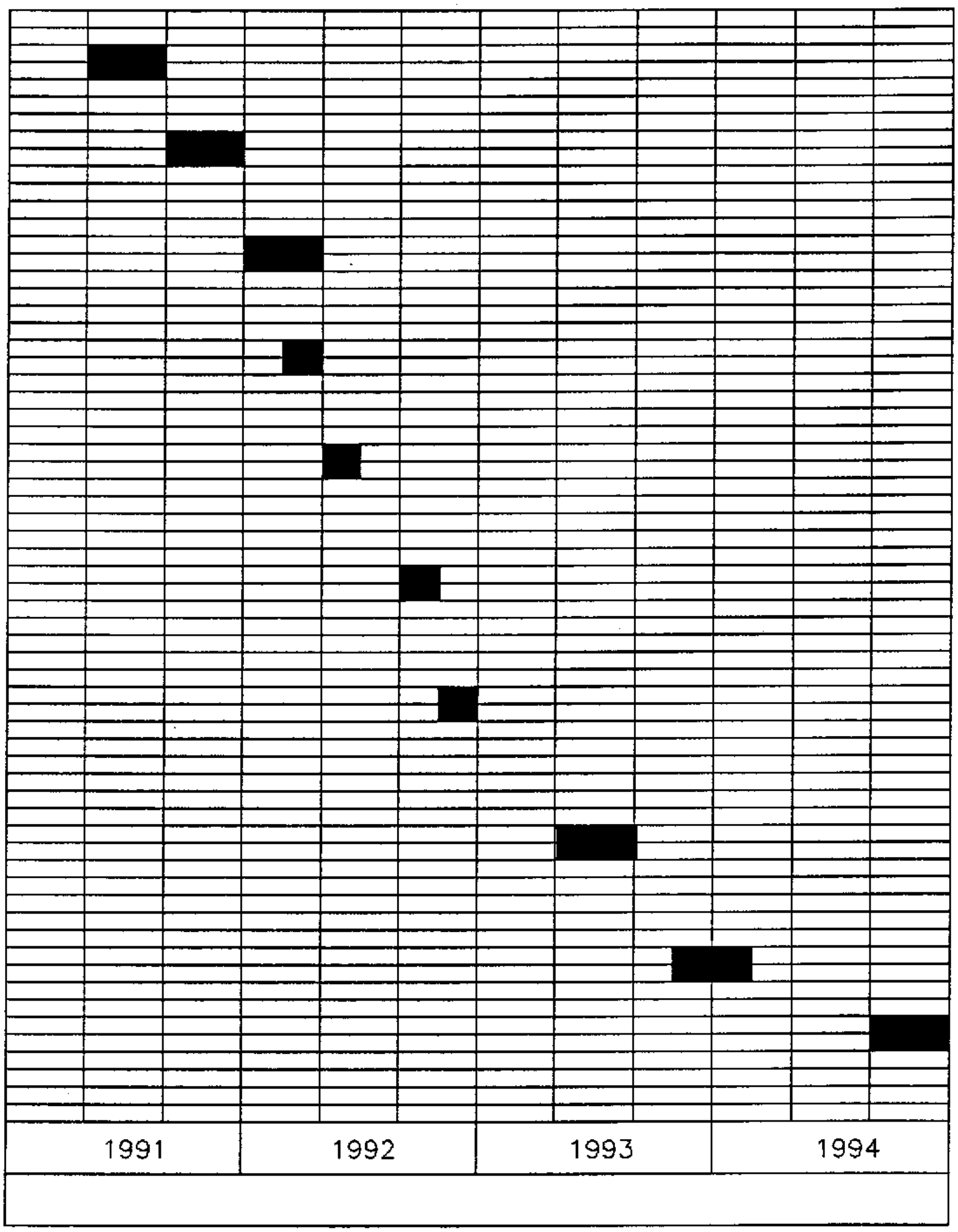
TASK 6:
Conduct Hydrology Tests and Research

TASK 7:
Install Offsite Well(s), Sample/Analyze

TASK 8:
Prepare Ground-Water Remediation Feasibility Study and Action Plan

TASK 9:
Remediate Ground-Water

TASK 10:
Prepare Site Closure Plan



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PROJECT 69036-2

PRELIMINARY TIME SCHEDULE
ARCO Station 2035
1001 San Pablo Avenue
Albany, California

PLATE
6

TABLE 1
RESULTS OF LABORATORY ANALYSES OF SOIL SAMPLES
ARCO Station No. 2035
1001 San Pablo Avenue
Albany, California
August 9, 1989

Sample Identifier	TPHg	B	T	E	X
S-10-B1	1,900	<4	15	8	53
S-15-B1	<1	<.005	.006	.006	<.005
S-19-1/2-B1	<1	<.005	<.005	<.005	<.005
S-10-B2	51	1.9	.35	.81	4.0
S-14-1/2-B2	<1	.063	<.005	<.005	<.005
S-20-B2	<1	.039	.044	.007	.041
S-10-B3	75	3.1	8.2	1.8	11.0
S-14-1/2-B3	<1	.21	<.025	<.025	.039
S-20-B3	<1	<.005	<.005	<.005	<.005
S-10-B4	2,400	33	140	40	220
S-15-B4	520	<1	6.9	6.2	6.3
S-19-B4	<1	<.005	.007	<.005	<.005
S-9-1/2-B5	<1	.007	.006	<.005	<.005
S-15-B5	<1	<.005	.006	<.005	<.005
S-20-B5	<1	<.005	<.005	<.005	<.005

Results in milligrams per kilogram (mg/kg), or parts per million (ppm).
TPHg: Total petroleum hydrocarbons as gasoline.
B: benzene E: ethylbenzene T: toluene X: total xylene isomers
<: Indicates less than the laboratory reported detection limit.
Sample identification:
S-10-B5

- B5 — Boring number
- 10 — Approximate sample depth in feet
- S — Soil sample

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.

Ground-Water 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.

Ground-Water 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 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.