GEOMATRIX

WORK PLAN FOR PHASE I INVESTIGATION

B&C Gas Mini Mart
2008 First Street
Livermore, California

Prepared for

B&C Gas Mini Mart
2008 First Street
Livermore, California

April 1997
Project No. 4069

Geomatrix Consultants

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11 April 1997
Project 4069

Ms. Eva Chu
Alameda County Health Care Services Agency
Hazardous Materials Division
1131 Harbor Bay Parkway
Alameda, CA 94502-6577

Subject: Work Plan For Phase I Investigation
B&C Gas Mini Mart
2008 First Street
Livermore, California

Dear Ms. Chu:

On behalf of Mr. Balaji Angle, Geomatrix Consultants, Inc. (Geomatrix), has prepared the enclosed Work Plan for Phase I Investigation for the B&C Gas Mini Mart located at 2008 First Street in Livermore, California. In accordance with our 6 March 1997 "Revised Scope of Services and Cost Estimate" that was approved by the Alameda County Health Care Services Agency (ACHCSA) and the California State Water Resources Control Board (SWRCB) Underground Storage Tank (UST) Cleanup Fund, we have obtained and reviewed available data from ACHCSA files and we have developed this work plan to investigate petroleum hydrocarbons in soil and groundwater based on the results of our data review.

Please call either of the undersigned if you have any questions regarding this report.

Sincerely,

GEOMATRIX CONSULTANTS, INC.

Gary R. Foote, R.G.
Senior Geologist

Nancy T. Rice, C.E.G.
Principal Hydrogeologist
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Elizabeth A. Nixon, P.E.
Senior Engineer

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Enclosure

cc: Mr. Balaji Angle (three copies)

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1.0 INTRODUCTION

Geomatrix Consultants, Inc. (Geomatrix), has prepared this work plan to perform a Phase I Investigation at and in the vicinity of the B&C Gas Mini Mart site (the site) located at 2008 First Street in Livermore, California. In accordance with our 6 March 1997 "Revised Scope of Services and Cost Estimate" that was approved by the Alameda County Health Care Services Agency (ACHCSA) and the California State Water Resources Control Board (SWRCB) Underground Storage Tank (UST) Cleanup Fund, we have obtained and reviewed available data from ACHCSA files and we have developed this work plan to investigate petroleum hydrocarbons in soil and groundwater based on the results of our data review. This work plan and the project approach that has been developed herein is consistent with the California Regional Water Quality Control Board - San Francisco Bay Region (RWQCB) Interim Guidance for Petroleum Sites (RWQCB, 1996).

ACHCSA has requested a work plan for further investigation of petroleum hydrocarbons that have been detected in groundwater at a relatively significant distance downgradient (approximately west-northwest) of the site. Benzene and methyl tertiary-butyl ether (MtBE) have been detected at concentrations up to 3 and 15 milligrams per liter (mg/l), respectively, in groundwater 1000 feet downgradient of the site. Because these chemicals may migrate in groundwater toward municipal wells that are located approximately 2300 feet downgradient of the site, ACHCSA has requested that an investigation be performed as soon as possible. The following sections present: (1) background information about the site and other nearby sites where investigations have been performed (Section 2.0); (2) a summary of hydrogeologic and chemical data based on our file review (Section 3.0); (3) a description of the project objectives and approach (Section 4.0); and (4) our proposed scope of work for the Phase I Investigation (Section 5.0).

2.0 SITE AND VICINITY BACKGROUND

The site is located on the northeast corner of First and South "L" Street in Livermore, California (Figure 1) and consists of a mini-market and automobile service station that was owned by Desert Petroleum from at least 1988 until January 1994, when the site was sold to Mr. Balaji Angle. According to site records, gasoline fuels have been dispensed from two pump islands and fuels have been contained in two 10,000-gallon underground storage tanks (USTs) and one 8000-gallon UST.

Investigation activities have been performed at or near the site since 1988, when the release of gasoline fuels into the subsurface was first recognized. According to summary notes prepared by ACHCSA, petroleum-affected soil was identified in May 1988 and soil samples collected during installation of a monitoring well (MW-1) in September 1988 contained total petroleum hydrocarbons quantified as gasoline (TPHg) at concentrations up to 1600 milligrams per kilogram (mg/kg). Subsequent sampling of well MW-1 in 1990 indicated that groundwater was impacted by TPHg (24 mg/l) and associated mono-aromatic compounds (e.g., benzene at 1.3 mg/l). Prior to 1995, groundwater samples from the site were not analyzed for MtBE (RSI, 1995). Investigation activities to date have included drilling of soil borings, installation of six groundwater monitoring wells (MW-1 through MW-6) and soil and groundwater sampling. A more detailed site investigative history from the ACHCSA files is included in Appendix A.

Remediation activities at the site have included removal of a 280-gallon waste-oil tank, two hydraulic hoists, and 25 cy of soil in March 1994 (Western Geo-Engineers, 1994). Additionally, the three gasoline USTs were removed and replaced and 700 cubic yards (cy) of petroleum-affected soil was removed in July 1996. The soil was transported to Browning-Ferris Industries' Vaso Road Landfill (Livermore, California) for disposal. During tank removal, a previously unknown 1000-gallon UST was discovered; this tank was abandoned in place by filling it with cement-sand grout (Touchstone, 1996). Removal of the gasoline USTs was approved by ACHCSA, and costs were pre-approved by SWRCB in a 10 July 1996 letter from Mr. Christopher Stevens to Mr. Balaji Angle. In addition to these remediation activities, separate-phase product has been removed from monitoring well MW-2. The site layout, locations of the five former USTs, and locations of the six monitoring wells are shown on Figure 2.

Based on information in ACHCSA files, the area around the site is primarily commercial and several nearby properties have had known or possible chemical releases. Two municipal water supply wells are located approximately 2300 feet west-northwest of the site. The locations of the nearby properties and municipal wells (3S/2E 8P1 and 3S/2E 8P2) are shown on Figure 3 and information about the nearby properties is summarized below:

- Abandoned gasoline station and auto repair. This property is located approximately 300 feet south of the site on South "L" Street. It appears that no environmental investigations have been performed at this property.

- Groth Property. This property occupies most of the block on the west side of South "L" Street across from the site. A car dealership and sales lot occupy the south half of the property and the north half of the property is a vacant lot. Although information about this property has not been reviewed by Geomatrix, ACHCSA files indicate that grab groundwater samples were collected from the north half of the property (vacant lot); petroleum hydrocarbons were detected in the grab groundwater samples (locations G-1 through G-4, Figure 3).

- Mill Springs Park Apartments. This property is located at 1809 Railroad Avenue, approximately 1000 feet west of the site. The property was a bulk fuel plant in the 1920's and 1930's and was a vacant lot until the Mill Springs Park Apartments were built in 1992. In 1989, four USTs, a concrete vault, and petroleum affected soil were removed. Based on the results of groundwater monitoring, the site was approved for closure by the RWQCB in December 1993. When preparing to abandon monitoring well MW-01 (Figure 3) in 1995, floating product was observed in the well.

- Livermore Arcade Shopping Center. This property is located on the block bound by South "P" Street, First Street, and Railroad Avenue, and is approximately 2000 feet west of the site and 200 to 400 feet south of the municipal wells. Although information about this property has not been reviewed by Geomatrix, ACHCSA has indicated that there has been a release of chlorinated volatile organic compounds (VOCs).

3.0 SUMMARY OF EXISTING DATA

Geomatrix reviewed reports for the site and nearby properties that were prepared by others. The reports reviewed include the following: Remediation Service International (RSI; 1994), Western Geo-Engineers (1994); RSI (1995), RSI (1996), Touchstone Developments (1996); Earth Tech (1995). The following is a summary of the hydrogeologic setting and distribution of chemicals based on our review.

3.1 HYDROGEOLOGIC SETTING

The site is located within the Livermore Valley groundwater basin, an alluvial basin within the Coast Range Geomorphic Province. To provide a visual presentation of the area hydrogeology, a hydrogeologic cross section (Figure 4) was constructed using available lithologic logs from the site and other nearby properties; the location of the cross section is shown on Figure 3. Based on the available data, the site and vicinity are underlain by predominantly coarse-grained alluvial sediments (sand and gravel) to a depth of at least 60 feet below ground surface (bgs). Thin to thick, discontinuous fine-grained units (silt and clay) are present across the site at varying depths. The deposits appear to vary laterally and may include channel deposits.

Figures 4 and 5 present the groundwater potentiometric surface based on data collected within a one-week period in September 1995 from temporary wells installed at the Mill Springs Park Apartment property and the six site monitoring wells. Depth to groundwater in September 1995 was about 30 feet bgs. As shown, the groundwater flow direction appears to be west to northwest and the horizontal hydraulic gradient is approximately 0.010 to 0.012 foot per foot.

3.2 DISTRIBUTION OF CHEMICALS IN SOIL AND GROUNDWATER

Soil sampling has been performed at the site in conjunction with the removal of the waste-oil tank (Western Geo-Engineers, 1994), the replacement of the three gasoline USTs and associated piping (Touchstone Development, 1996) and during other phases of investigation (RSI, 1994 and 1995). Review of the data indicates that petroleum-affected soil was removed in the area of the former waste-oil tank. Soil to a depth of 13 to 14 feet bgs (approximately 700 cy) was removed during replacement of the three former gasoline USTs. Soil samples collected at the bottom of this excavation (approximately 13 to 14 feet bgs) and one sample collected at a depth of 21 feet indicate the presence of gasoline constituents in soil beneath the former USTs (up to 96 mg/kg MtBE, 61 mg/kg benzene, and 8500 mg/kg TPHg); it appears that no additional soil removal has been performed in the vicinity of the former gasoline USTs. Based on our review of the soil data collected to date, we do not currently anticipate that further soil sampling will be necessary for site evaluation. A summary of the soil analytical data will be presented in the Phase I Investigation report to be completed following implementation of this work plan.

Table 1 presents a summary of the historical groundwater analytical data for the site and nearby properties. Previous groundwater sampling has indicated the presence of separate-phase product as well as dissolved-phase gasoline constituents (benzene, toluene, ethylbenzene, and xylenes [BTEX] and MtBE) in groundwater at and downgradient of the site. Separate-phase product has been reported in on-site well MW-2 and monitoring well MW-01 located at the Mill Springs Park Apartment property. Figure 6 presents benzene and MtBE concentrations detected in the most recently collected groundwater samples at each location (1995 and 1996). As shown, dissolved constituents have been detected at concentrations greater than 1 mg/l at a distance of more than 1000 feet downgradient of the site.

4.0 PROJECT OBJECTIVES AND APPROACH

Based on our review of the available data, we have developed the following four objectives for this project:

1. Delineate the vertical and lateral extent of chemicals in groundwater
2. Evaluate the potential for future migration of chemicals in groundwater especially to municipal wells

3. Assess whether other sources of petroleum hydrocarbons may contribute to separate-phase or dissolved-phase constituents detected downgradient of the site

4. Evaluate potential risk to human health due to chemicals in soil or groundwater.

To address these objectives, the work will be performed in a phased approach. Figure 7 shows the anticipated project approach and the work that is anticipated to be performed during the Phase I Investigation (this workplan) and future phases of work. As shown on Figure 7, work will be performed during Phase I to address the first three objectives; data collected during the first two phases of investigation ultimately will be used to evaluate potential risk to human health and to municipal wells (Objective 4). Specific tasks that are proposed to be performed during the Phase I Investigation are summarized as follows.

<u>Objective 1: Delineate vertical and lateral extent of chemicals in groundwater.</u>

- Task 1: Collect grab groundwater samples from six borings to be drilled downgradient of the known lateral extent of dissolved constituents in groundwater.

- Task 2: Sample two municipal wells and obtain well construction and pumping data for the wells.

<u>Objective 2: Evaluate potential for future migration of chemicals in groundwater.</u>

- Task 3: Perform specific capacity tests at the six site wells to estimate hydraulic parameters that can be used to understand chemical transport potential.

- Task 4: Review public records from the Livermore Arcade Shopping Center property, where an evaluation of the potential migration of VOCs may have been performed. Hydraulic data from this property may be useful for evaluating the potential migration of petroleum hydrocarbons from the site.

- Task 5: Obtain data to evaluate potential biodegradation of chemicals in groundwater.

<u>Objective 3: Assess whether there are other contributing sources of petroleum hydrocarbons.</u>

- Task 6: Review public records from the Groth property to assess whether there are potential sources of petroleum hydrocarbons associated with the auto sales lot or vacant lot on this property.

- Task 7: Collect grab groundwater samples from three borings to be drilled downgradient of the abandoned gas station and auto repair located 300 feet south of the site to assess whether there has been a release associated with this property.

- Task 8: Perform a hydrocarbon fingerprint characterization and age dating analysis on samples of product from the Mill Springs Park Apartment property (well MW-01) and from the site (well MW-2).

Reporting of results to ACHCSA.

- Task 9: Prepare written report documenting results of the Phase I Investigation.

- Task 10: Conduct meeting with ACHCSA to discuss results of Phase I Investigation and develop scope for Phase II work.

5.0 SCOPE OF WORK FOR PHASE I INVESTIGATION

Geomatrix proposes the following scope of work for each of the ten tasks described above.

Task 1: Conduct Downgradient Shallow Groundwater Investigation

This task includes drilling six borings to collect shallow grab groundwater samples to evaluate the lateral downgradient extent of dissolved constituents in groundwater. The proposed boring locations (B-1 through B-6) are shown on Figure 7. Prior to drilling, Geomatrix will prepare a health and safety plan and obtain drilling permits from Alameda County Flood Control and Water Conservation District (ACFCWCD) Zone 7 and encroachment permits from the City of Livermore. A check for underground utilities will be performed by calling Underground Service Alert (USA) and contracting a private utility locator to clear boring locations.

It is anticipated that borings will be advanced using a direct push (DP) or hollow stem auger drilling method. Each boring will be continuously cored and a lithologic log will be prepared by a Geomatrix geologist. After each boring is advanced to a depth of approximately 10 feet below the water table (approximate total depth of 40 feet), a 1-inch diameter PVC temporary well will be installed in the borehole; the well will be constructed with a 5- or 10-foot-long screen.

Grab groundwater samples will be collected from the temporary wells using a bailer and the samples will be sent under Geomatrix chain-of-custody procedures to a State-of-California certified laboratory. Samples will be analyzed for TPHg using EPA Method 8015, BTEX and MtBE using EPA Method 8020, and intrinsic biodegradation parameters (see Task 5). For selected groundwater samples with MtBE detections, confirmation analyses may be performed using gas chromatography with mass spectrometer (GC/MS; i.e., EPA Method 8240 or 8260). Selected samples with TPHg detections also will be analyzed for potential associated water-soluble additives (i.e., ethylene dibromide [EDB] and 1,2-dichloroethane [1,2-DCA]) using EPA Method 8240/8260.

After groundwater samples are collected, the boreholes will be backfilled with a cement/bentonite grout using the temporary PVC well as a tremie. Investigation-derived waste (soil cuttings and decontamination water) will be appropriately disposed. Geomatrix protocols for drilling soil borings and collecting groundwater samples are included in Appendix B.

Task 2: Sample Municipal Water Supply Wells and Obtain Well Records

Geomatrix proposes to collect samples from each of the two municipal water supply wells to evaluate whether measurable petroleum hydrocarbon constituents are likely present in deeper groundwater near the wells. Samples will be analyzed for BTEX and MtBE using GC/MS (EPA Method 8240 or 8260). Based on preliminary conversations with the City of Livermore Water Department, we anticipate that it will be relatively simple to obtain access for sampling the wells. Water sampling may be performed in conjunction with the City's routine biennial water quality sampling, which we understand is scheduled to be performed in 1997. In addition to sampling the wells, Geomatrix proposes to obtain well records from the City of Livermore or ACFCWCD Zone 7 including: lithologic and/or geophysical logs, well construction data, and well pumping data. This information will be used to assess potential for future impact to the wells (Objective 2).

Task 3: Perform Specific Capacity Tests

Geomatrix proposes to perform short term pumping tests (specific capacity tests) at three site wells to estimate hydraulic parameters that will assist with the understanding of chemical transport potential. It is anticipated that water will be pumped into 55-gallon drums or a temporary holding tank. Drawdown and recharge will be measured with a downhole pressure transducer. Purge water generated during the specific capacity tests will be appropriately disposed. Geomatrix protocols for aquifer testing are included in Appendix B.

Task 4: Obtain and Review Records from Livermore Arcade Shopping Center

Based on our conversations with Eva Chu of the ACHCSA, we understand that groundwater at the Livermore Arcade Shopping Center has been impacted by chlorinated VOCs and that shallow and deep groundwater monitoring wells have been installed as part of investigation activities that have been overseen by RWQCB. Because this property is only 200 to 400 feet south of the municipal supply wells, it is likely that previous work was performed at this property to evaluate the potential for chemical migration to the water supply wells. Data used in such an evaluation (e.g., horizontal and vertical hydraulic conductivity and gradients, deeper lithologic information) may be useful for assessing migration of petroleum hydrocarbons from the project site. Therefore, Geomatrix proposes to review RWQCB records for this property.

Task 5: Obtain Data to Evaluate Potential Biodegradation

To obtain data for evaluating whether intrinsic biodegradation of petroleum hydrocarbons in groundwater is occurring, Geomatrix proposes analyzing selected groundwater samples for biodegradation indicators, including: oxygen-reduction potential (field measurement), dissolved oxygen (field measurement), nitrate, sulfate, manganous species of manganese, ferrous species of iron, and carbon dioxide. We propose that groundwater samples from three of the six downgradient temporary wells (Task 1) and three of the site monitoring wells (MW-1, MW-4, and MW-6) be analyzed for the biodegradation indicators. Samples from these locations will allow for a comparison of data upgradient (MW-4), within (MW-1 and MW-6), and downgradient (three Task 1 temporary wells) of the significant detections of petroleum hydrocarbons.

Task 6: Obtain and Review Records from Groth Property

Geomatrix proposes to review records pertaining to the site history and previous investigations at the automobile dealership and vacant lot on the Groth property. The purpose of this review is to identify other potential hydrocarbon sources that may contribute to constituents in groundwater.

Task 7: Conduct Shallow Groundwater Investigation Near Abandoned Gas Station

This task includes drilling three borings to collect shallow grab groundwater samples to assess whether the abandoned gas station located south of the site is a potential source of petroleum hydrocarbons to groundwater. Grab groundwater samples collected in 1995 between the abandoned gas station and the project site (borings H-4 and H-5, Figure 6) contained benzene, suggesting that the abandoned gas station may be an additional source of petroleum hydrocarbons; these samples were not analyzed for MtBE. We propose that three borings (B-7 through B-9) be drilled along the downgradient side of the abandoned gas station as shown on Figure 7. Drilling and sampling procedures will be the same as those described under Task 1 and we anticipate that these borings will be drilled at the same time that the six Task 1 borings are drilled.

Task 8: Characterize Petroleum Hydrocarbons

Earth Tech (1995) performed a characterization of product from monitoring well MW-01 at the Mill Springs Park Apartment complex and compared it to product dispensed from the site. Results from this characterization indicated that both samples were gasoline that appeared to be similar. More complete forensic testing of product from the Mill Springs Park Apartment complex and from the site will facilitate a better understanding of the likely source(s) of the product detected at the apartment complex, the extent of degradation, the approximate age of the product, chemical characteristics, and likely mobility in the subsurface. Therefore, we propose collecting a sample of product from MW-01 and site monitoring well MW-2 for additional forensic testing (hydrocarbon fingerprint characterization and age-dating) to be performed by Friedman & Bruya Associates of Seattle, Washington. To further assess the petroleum hydrocarbons at the site, we also propose that a sample from site monitoring well

MW-6 be analyzed for potential water-soluble additives associated with leaded gasoline (EDB and 1,2-DCA); no previous samples from the site have been analyzed for these constituents.

Task 9: Prepare Phase I Investigation Report

We will evaluate data collected during the Phase I Investigation and prepare a report that presents the results of the investigation and recommendations for Phase II. The report will include a description of field and analytical methods, an evaluation of the data, tabular summaries of data, figures illustrating the results, copies of boring logs, and laboratory analytical reports. For completeness, the report also will include a presentation of existing soil analytical data.

Task 10: Meet With ACHCSA

After submission of the data report to ACHCSA, we will attend a meeting to discuss the Phase I results.

6.0 COST ESTIMATE AND SCHEDULE

Within three weeks of approval of this work plan by ACHCSA, Geomatrix will prepare a cost estimate and schedule for implementation of the work. This cost estimate and schedule will be submitted along with the approved work plan to SWRCB UST Cleanup Fund for pre-approval of costs.

7.0 REFERENCES

California Regional Water Quality Control Board, San Francisco Bay Region (RWQCB), 1996, Supplemental Instructions to State Water Board, 8 December 1995, Interim Guidance on Regional Cleanup at Low Risk Fuel Sites, Letter from Loretta K. Barsamian to San Francisco Bay Area Agencies Overseeing UST Cleanup, 5 January.

Earth Tech, 1995, Final Report, LNAPL Assessment and Groundwater Characterization, Mill Springs Park Apartments, Livermore, California, October.

Remediation Service, International, 1994, Soil & Groundwater Investigation Report for 2008 First Street, Livermore, California, Prepared for Desert Petroleum, Inc., 22 July.

Remediation Service, International, 1995, Soil & Groundwater Investigation Report and Fourth Quarterly Report of 1995 Groundwater Sampling and Monitoring, British Petroleum Service Station, 2008 First Street, Livermore, California, Prepared for Desert Petroleum, Inc., 8 December.

Remediation Service, International, 1996, Quarterly Report of February 29, 1996 Groundwater Sampling and Water Quality Monitoring, 2008 First Street, Livermore, California, Prepared for Desert Petroleum, Inc., March.

Touchstone Developments, 1996, UST and Product Piping Removal Soil Sampling Report, B&C Gas Mini Mart, 2008 First Street, Livermore, California, 22 August.

Western Geo-Engineers, 1994, Waste Oil UST and Hydraulic Hoist Removal, Over-Excavation Sample Report, 26 April.

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TABLE 1

SUMMARY OF HISTORICAL GROUNDWATER ANALYTICAL RESULTS

2008 First Street
Livermore, California

Results in milligrams per liter (mg/l)

Well ID	Date Sampled	Benzene[1]	Toluene[1]	Ethyl-benzene[1]	Total Xylenes[1]	MtBE[2]	TPHd[3]	TPHfo[4]	TPHg[5]
G-1	8/11/95	<0.0005	<0.0005	<0.0005	<0.0005	<0.002	----[6]	----	<0.05
G-1	10/11/95	0.061	0.0008	<0.0005	0.0015	0.08	----	----	0.38
G-2	10/11/95	0.0025	<0.0005	<0.0005	<0.0005	0.0094	----	----	0.014
G-3	10/11/95	11	18	2.2	11	18	----	----	92
G-4	10/11/95	0.046	0.024	0.008	0.028	0.15	----	----	8
H-01	8/11/95	<0.0005	<0.0005	<0.0005	<0.0005	<0.002	<0.05	<1.3	<0.05
H-01	9/13/95	<0.0005	<0.0005	<0.0005	<0.0005	<0.002	----	----	<0.05
H-02	8/14/95	<0.0005	<0.0005	<0.0005	0.0054	<0.002	<0.05	<1.3	<0.05
H-03	8/11/95	0.01	<0.0005	<0.0005	<0.0005	0.026	<0.05	<1.3	<0.05
H-04	8/14/95	0.0092	<0.0005	<0.0005	0.0048	0.029	<0.05	<1.3	0.21
H-05	8/11/95	1.3	0.27	0.043	0.35	14	0.074	<1.3	4
H-05	8/16/95	0.34	<0.005	<0.005	0.08	4.8	<0.05	<1.3	0.97
H-06	8/14/95	7.7	1.1	0.12	0.8	67	0.54	<1.3	16
H-07	8/11/95	3.2	0.82	0.74	1.9	14	0.62	<1.3	17
H-07	9/13/95	2.8	0.077	0.28	0.51	11	----	----	5.8
H-08	8/11/95	3	0.089	0.14	0.23	15	0.087	<1.3	7.3
H-08	9/13/95	2.2	0.061	0.042	0.12	8	----	----	4
H-09	8/14/95	<0.0005	<0.0005	<0.0005	0.0008	<0.002	0.26	<1.3	<0.05
H-09	8/16/95	<0.0005	<0.0005	<0.0005	<0.0005	<0.002	<0.05	<1.3	<0.05
H-10	8/14/95	<0.0005	<0.0005	<0.0005	<0.0005	<0.002	<0.05	<1.3	<0.05
H-11	8/14/95	<0.0005	<0.0005	<0.0005	<0.0005	<0.002	<0.05	<1.3	<0.05
H-4	3/8/95	0.057	0.033	0.0094	0.042	----	----	----	1.5
H-5	3/8/95	0.022	0.024	0.008	0.042	----	----	----	0.62
MW-01	8/14/95	0.19	0.26	0.11	0.9	0.21	1.1	<1.3	11
MW-1	8/2/90	1.3	1.3	0.4	2.7	----	----	----	24
MW-1	10/10/91	0.43	0.71	0.1	0.29	----	----	----	2.2
MW-1	1/8/92	0.2	0.12	0.03	0.15	----	----	----	1.2
MW-1	5/11/93	0.066	0.008	0.041	0.09	----	----	----	1
MW-1	9/21/93	0.311	0.118	0.0338	0.112	----	----	----	1.9
MW-1	5/22/94	0.69	1.1	0.34	1.2	----	----	----	10
MW-1	8/26/94	0.29	0.69	0.12	0.67	----	----	----	13
MW-1	11/22/94	0.4	0.77	0.23	1.3	----	----	----	19
MW-1	3/13/95	0.9	0.1	0.98	0.74	----	----	----	6
MW-1	6/21/95	0.21	0.38	0.053	0.28	13	----	----	2.4
MW-1	9/14/95	0.069	1.3	0.22	1.2	2	----	----	7.8
MW-1	2/29/96	0.0042	0.0047	0.0014	0.0056	0.014	----	----	0.12
MW-2	6/19/94	18	36	4.6	26	----	----	----	290
MW-2[7]	8/26/94	----	----	----	----	----	----	----	----
MW-2[7]	11/22/94	----	----	----	----	----	----	----	----

TABLE 1

SUMMARY OF HISTORICAL GROUNDWATER ANALYTICAL RESULTS
2008 First Street
Livermore, California

Results in milligrams per liter (mg/l)

Well ID	Date Sampled	Benzene[1]	Toluene[1]	Ethyl-benzene[1]	Total Xylenes[1]	MtBE[2]	TPHd[3]	TPHfo[4]	TPHg[5]
MW-2[7]	3/13/95	----	----	----	----	----	----	----	----
MW-2	6/21/95	2.3	3.4	0.72	3.1	16	----	----	25
MW-2	2/29/96	2.5	3.7	0.65	3.1	6.5	----	----	57
MW-3	6/19/94	0.64	0.58	0.27	0.79	----	----	----	11
MW-3	8/26/94	1.6	2.3	0.33	1.8	----	----	----	41
MW-3	11/22/94	8	10	0.9	5	----	----	----	18
MW-3	3/13/95	1.6	1.3	5	6.6	----	----	----	44
MW-3	6/21/95	0.6	1.9	0.49	2.6	4.2	----	----	15
MW-3	9/14/95	0.71	1.1	0.18	0.87	2.7	----	----	8.1
MW-3	2/29/96	0.23	0.2	0.2	1.1	1.5	----	----	13
MW-4	6/19/94	0.012	0.025	<0.005	0.022	----	----	----	0.81
MW-4	8/26/94	0.037	0.051	0.095	0.035	----	----	----	0.85
MW-4	11/22/94	0.11	0.11	0.0058	0.058	----	----	----	1.7
MW-4	3/13/95	0.18	0.008	0.052	0.077	----	----	----	1.3
MW-4	6/21/95	0.003	0.001	ND[8]	0.001	ND	----	----	ND
MW-4	9/14/95	0.00069	<0.0005	<0.0005	<0.0005	<0.0025	----	----	<0.05
MW-4	2/29/96	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	----	----	0.087
MW-5	10/26/95	16	26	3.1	15	39	----	----	120
MW-5	2/29/96	3.4	4.2	0.86	4.1	20	----	----	47
MW-6	10/26/95	9.9	22	3.2	17	47	----	----	110
MW-6	2/29/96	2	2.9	0.46	2.6	6.3	----	----	23

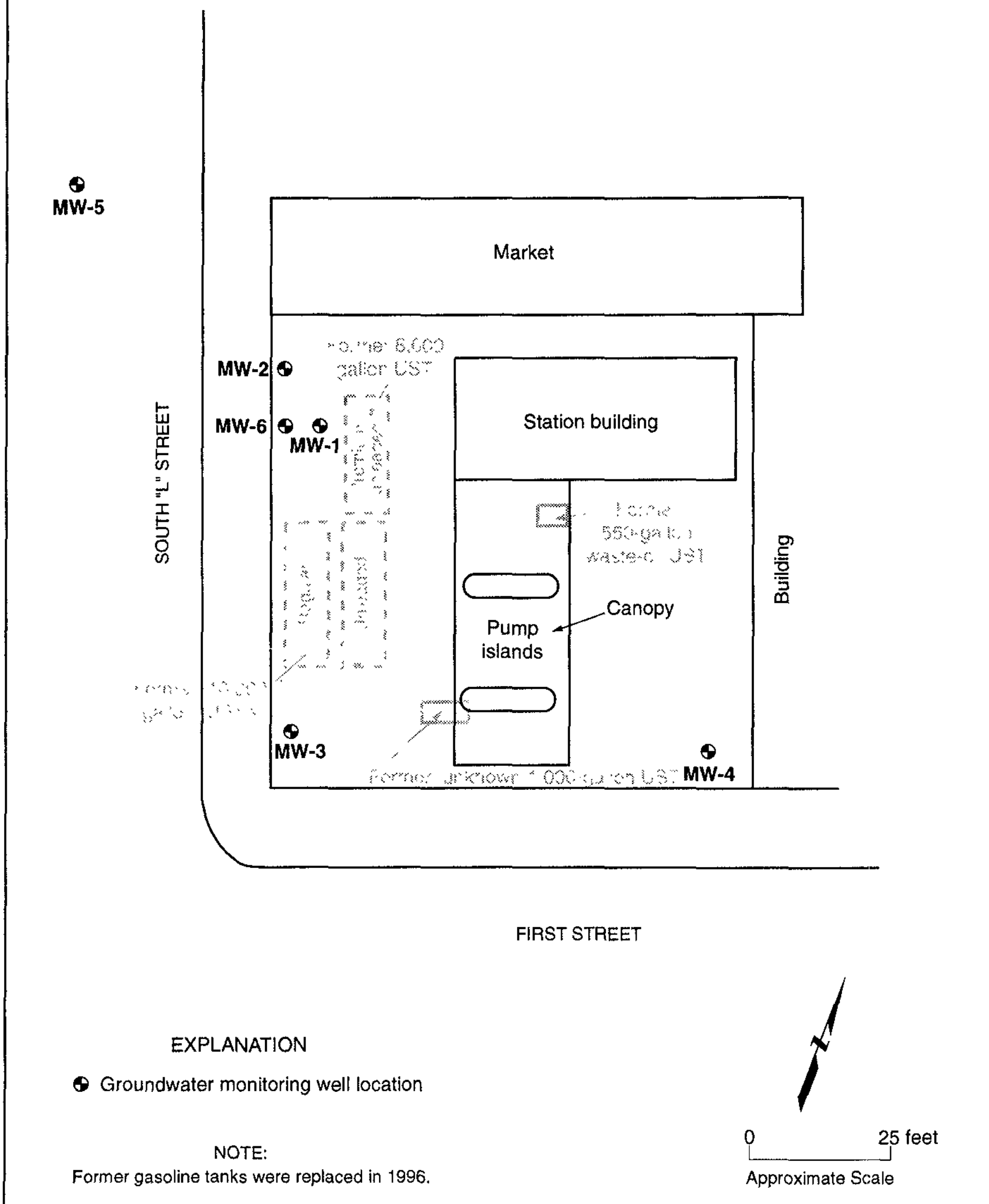
Notes:

References for information sources are presented on Figure 3 and in text.
1. Benzene, toluene, ethylbenzene, and xylenes analyzed by EPA Method 8020.
2. MTBE = Methyl tertiary butyl ether by EPA Method 8020.
3. TPHd = Total petroleum hydrocarbons quantified as diesel by EPA Method 8015.
4. TPHfo = Total petroleum hydrocarbons quantified as fuel oil by EPA Method 8015.
5. TPHg = Total petroleum hydrocarbons quantified as gasoline by EPA Method 8015.
6. ---- = Not analyzed.
7. Not analyzed because free product was present in the well.
8. ND = Constituent not detected above reporting limit; reporting limit not available.

Base map from *The Thomas Guide, 1997 Alameda/Contra Costa Counties Edition.* Reproduced with permission granted by THOMAS BROS. MAPS®. This map is copyrighted by THOMAS BROS. MAPS® It is unlawful to copy or reproduce all or any part thereof, whether for personal use or resale, without permission.

0 1/2 mile

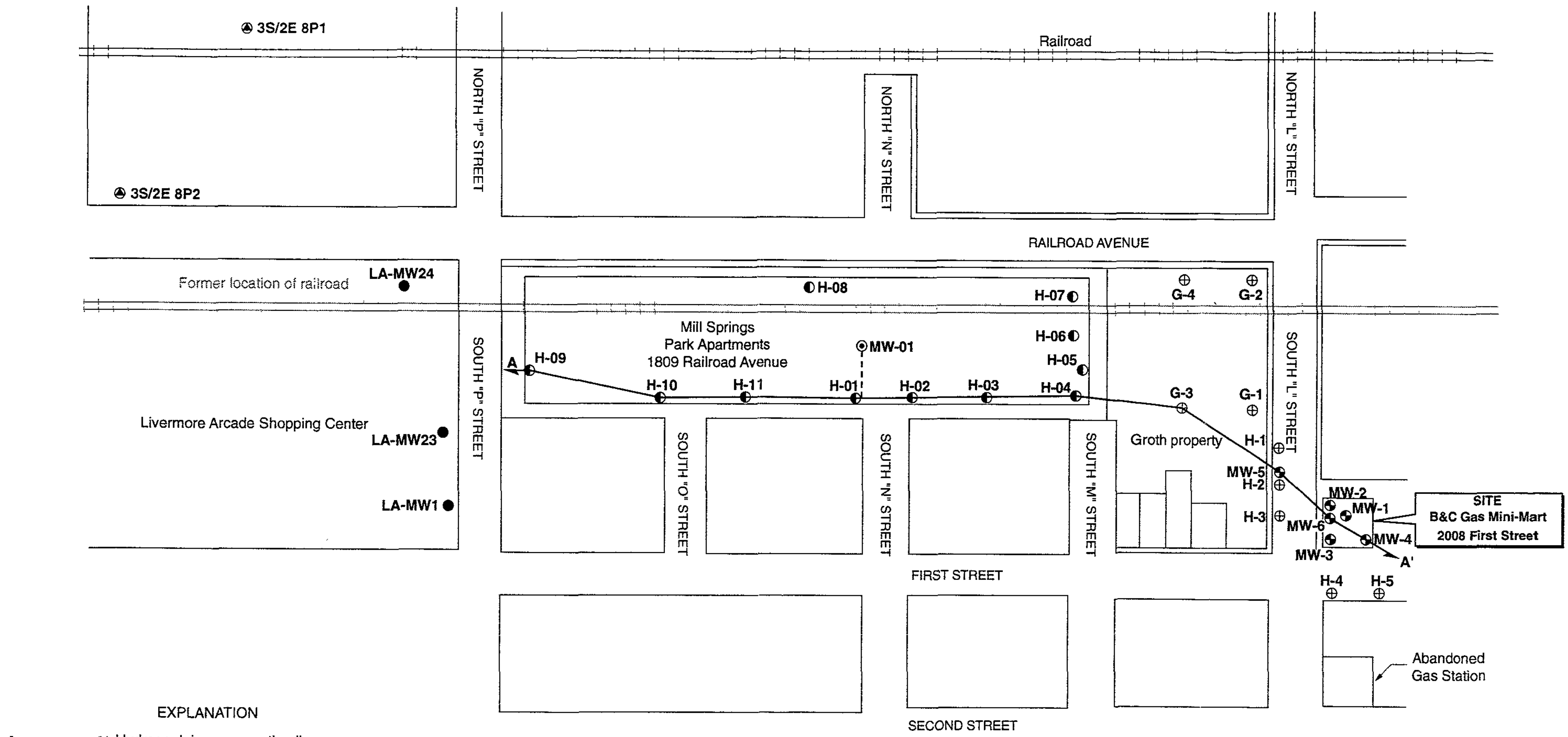
GEOMATRIX	SITE LOCATION MAP 2008 First Street Livermore, California	Figure 1 Project No. 4069



Source: Remediation Service Int'l (RSI), Figure 2 Plot Plan, Soil and Groundwater Investigation Report, July 1994.

GEOMATRIX	SITE DETAIL MAP 2008 First Street Livermore, California	Figure 2 Project No. 4069A

4069A 002



EXPLANATION

A ◄——► A' Hydrogeoloic cross-section line

MW-5 B&C monitoring well (Remediation Service International, 1995)

H-1 or G-1 B&C soil boring with grab groundwater sample (Remediation Service International, 1995)
Only soil samples (no groundwater samples) were collected from borings H-1, H-2, and H-3

MW-01 Earth Tech monitoring well (Earth Tech, 1995)

H-01 Earth Tech temporary piezometer (Earth Tech 1995)

3S/2E8PI Municipal well

LA-MW1 Livermore Arcade Shopping Center Monitoring Well (RWQCB, 1996)

0 200 Feet

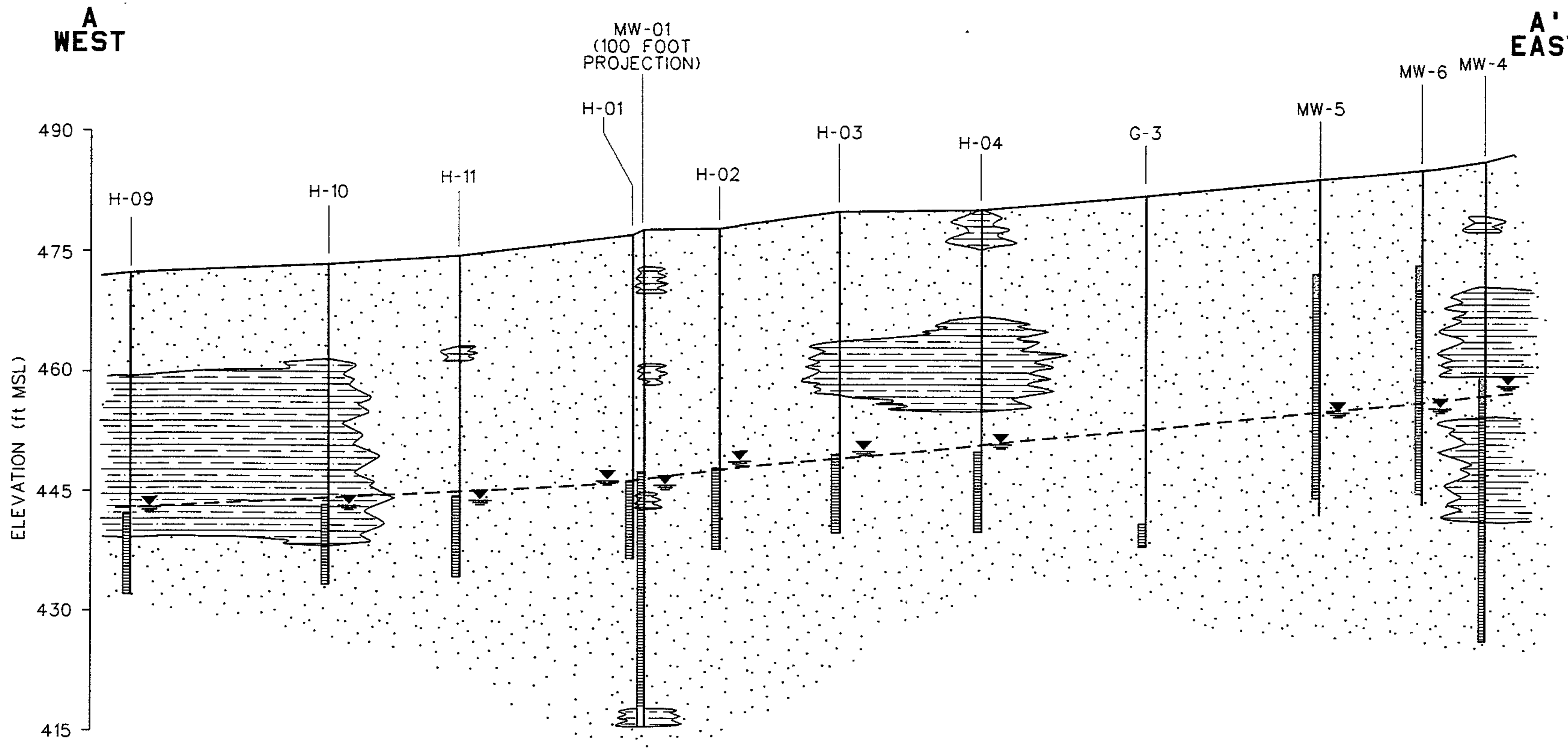
Well location is approximate

Source Figure 2 Vicinity map Soil and Groundwater Investigation Report and Fourth Quarterly Report of 1995 Groundwater Sampling and Monitoring, Remediation Services Int'l (RSI), December 8 1995

REGIONAL SITE PLAN
2008 First Street
Livermore, California

GEOMATRIX

Project No	Figure
4069A	3



NOTES:

1. The geologic units between borings have been inferred and are based on interpolation between widely spaced points. For clarity, solid lines are used to represent contacts between units but these are not meant to imply certainty.

2. Section line shown on Figure 3.

3. Source
   Data for MW-01, H-01, H-02, H-03, H-04, H-09, H-10, H-11 are from Final Report LNAPL assessment Earth Tech 10/9/95. Screen interval for MW-01 based on summary notes Alameda County Health Care Services Agency files.
   Data for G-3, MW-4, MW-5 and MW-6 are from Soil and Groundwater Investigation Report and Fourth Quarterly report in 1995 Groundwater sampling and monitoring PS 12/8/95.

4. Ground surface elevation assumed to be the same as well head elevation. Elevation for MW-6 was unavailable, assumed same as MW-4. Ground surface elevations unavailable for G-3 and MW-5 and were inferred.

5. MW-01, MW-5, MW-6, MW-4 are permanent monitoring wells. H-01, H-02, H-03, H-04, H-09, H-10, H-11 were temporary piezometers and G-3 was a temporary hydropunch borehole.

EXPLANATION

- SAND FILTER PACK
- SCREEN AND SAND FILTER PACK
- APPROXIMATE POTENTIOMETRIC SURFACE (SEPTEMBER 1995)
- PREDOMINANTLY FINE-GRAINED SEDIMENTS (SILT OR CLAY WITH LESS THAN 50 PERCENT SAND AND GRAVEL)
- PREDOMINANTLY COARSE-GRAINED SEDIMENTS (SAND OR GRAVEL WITH LESS THAN 50 PERCENT SILT AND CLAY)
- GROUNDWATER ELEVATION DATA, SEPTEMBER 1995 (SEE FIGURE 5)

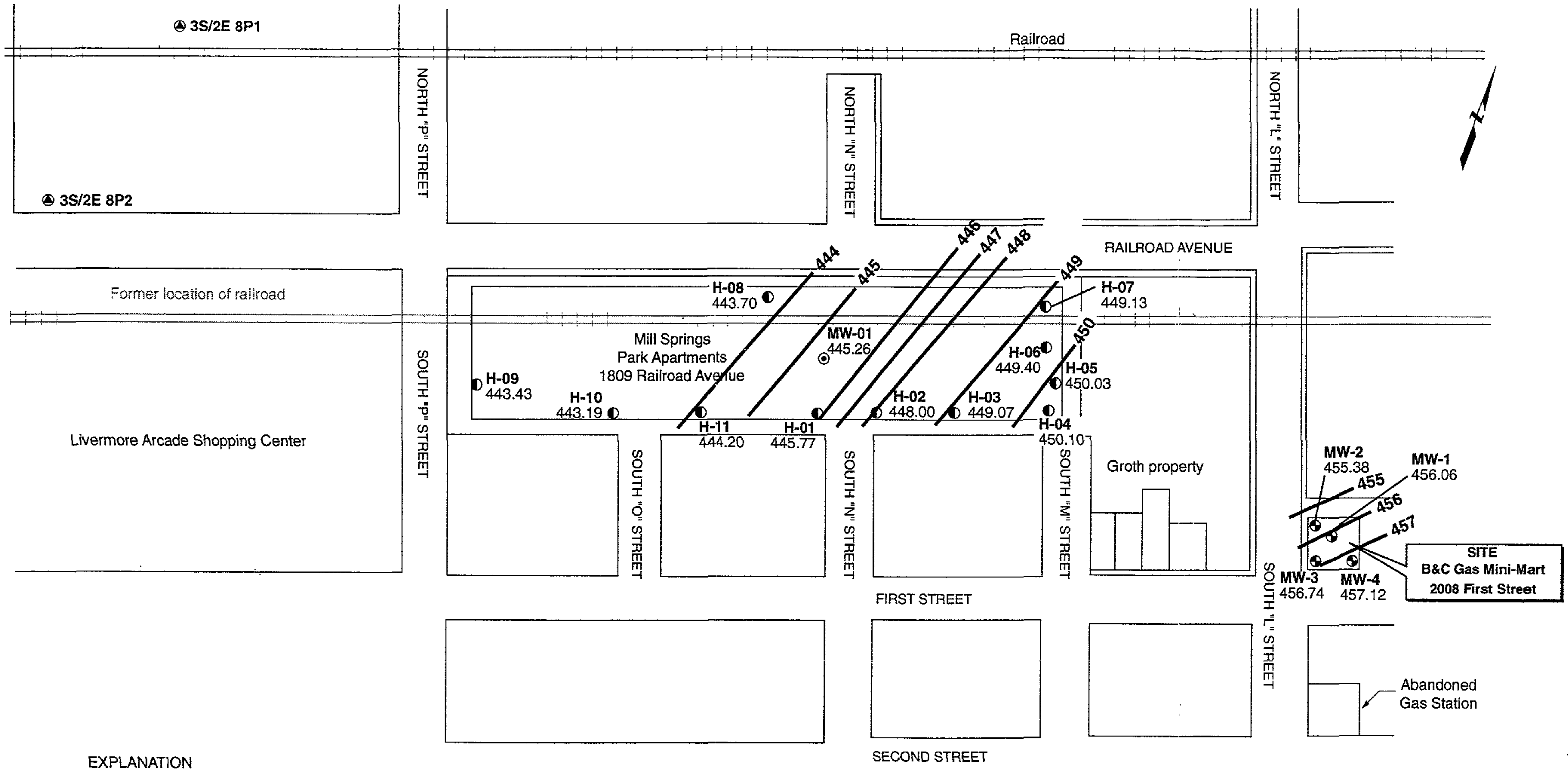
15

0 — 150

VERTICAL EXAGGERATION=10x

SCHEMATIC HYDROGEOLOGIC CROSS SECTION A-A'
2008 First Street
Livermore, California

GEOMATRIX	Project No. 4069	Figure 4



Well location is approximate

EXPLANATION

MW-4 ⊕ **B&C monitoring well (Remediation Service International, 1995). Monitoring wells MW-5 and MW-6 shown on Figure 3 had not yet been installed in September 1995.**

MW-01 ⦿ Earth Tech monitoring well (Earth Tech, 1995)

H-01 ◐ Earth Tech temporary piezometer (Earth Tech, 1995)

3S/2E8PI ⊕ Municipal well

445 ——— Line of equal elevation of potentiometric surface (in feet above mean sea level) based on linear interpolation of the water-level elevations in 16 wells used for control. Contour interval is 1 foot

NOTES

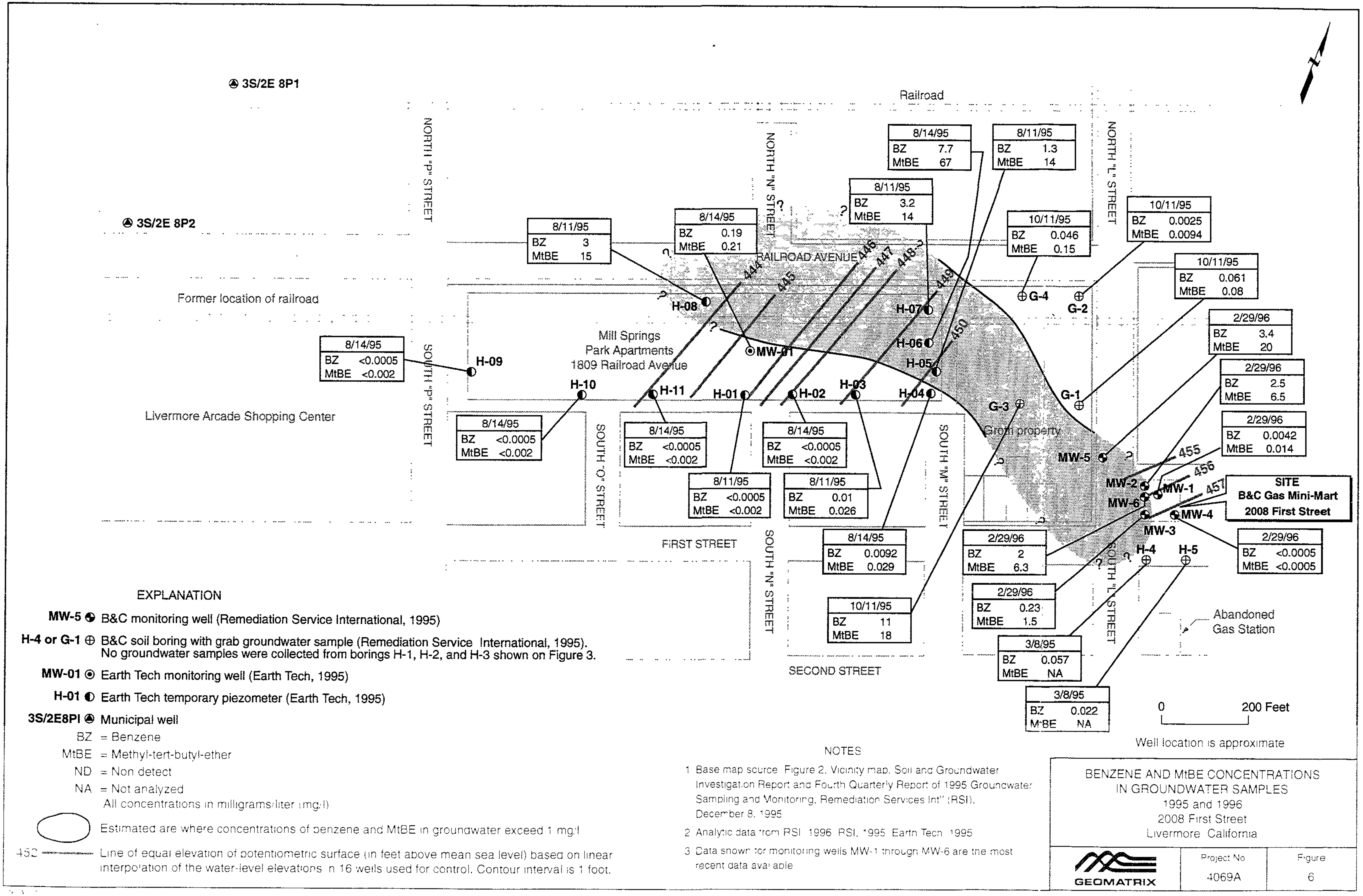
1 Water-level elevations in wells MW-1 (2008 First St.), MW-2, MW-3 and MW-4 were taken on September 14, 1995

2 Water-level elevations in wells MW-1 (1809 Railroad Ave.) and H-01 through H-11 were taken on September 21, 1995

3 Base map source: Figure 2, Vicinity map, Soil and Groundwater Investigation Report and Fourth Quarterly Report of 1995 Groundwater Sampling and Monitoring, Remediation Services Int'l (RSI), December 8, 1995

POTENTIOMETRIC SURFACE MAP
SEPTEMBER 1995
2008 First Street
Livermore, California

GEOMATRIX	Project No.	Figure
	4069A	5



3S/2E 8P1
3S/2E 8P2
Railroad
NORTH "P" STREET
NORTH "N" STREET
NORTH "L" STREET
RAILROAD AVENUE
Former location of railroad
Mill Springs Park Apartments 1809 Railroad Avenue
Livermore Arcade Shopping Center
SOUTH "P" STREET
SOUTH "O" STREET
SOUTH "N" STREET
SOUTH "M" STREET
SOUTH "L" STREET
FIRST STREET
SECOND STREET
Groth property
Abandoned Gas Station
SITE B&C Gas Mini-Mart 2008 First Street
H-01 H-02 H-03 H-04 H-05 H-06 H-07 H-08 H-09 H-10 H-11
MW-01
G-1 G-2 G-3 G-4
MW-1 MW-2 MW-3 MW-4 MW-5 MW-6
H-4 H-5
444 445 446 447 448 449 450 455 456 457
8/14/95 BZ 7.7 MtBE 67
8/11/95 BZ 1.3 MtBE 14
8/11/95 BZ 3.2 MtBE 14
8/14/95 BZ 0.19 MtBE 0.21
8/11/95 BZ 3 MtBE 15
10/11/95 BZ 0.046 MtBE 0.15
10/11/95 BZ 0.0025 MtBE 0.0094
10/11/95 BZ 0.061 MtBE 0.08
2/29/96 BZ 3.4 MtBE 20
2/29/96 BZ 2.5 MtBE 6.5
2/29/96 BZ 0.0042 MtBE 0.014
8/14/95 BZ <0.0005 MtBE <0.002
8/14/95 BZ <0.0005 MtBE <0.002
8/14/95 BZ <0.0005 MtBE <0.002
8/14/95 BZ <0.0005 MtBE <0.002
8/11/95 BZ <0.0005 MtBE <0.002
8/11/95 BZ 0.01 MtBE 0.026
8/14/95 BZ 0.0092 MtBE 0.029
10/11/95 BZ 11 MtBE 18
2/29/96 BZ 2 MtBE 6.3
2/29/96 BZ 0.23 MtBE 1.5
2/29/96 BZ <0.0005 MtBE <0.0005
3/8/95 BZ 0.057 MtBE NA
3/8/95 BZ 0.022 MtBE NA
0 200 Feet
Well location is approximate
EXPLANATION
MW-5 B&C monitoring well (Remediation Service International, 1995)
H-4 or G-1 B&C soil boring with grab groundwater sample (Remediation Service International, 1995). No groundwater samples were collected from borings H-1, H-2, and H-3 shown on Figure 3.
MW-01 Earth Tech monitoring well (Earth Tech, 1995)
H-01 Earth Tech temporary piezometer (Earth Tech, 1995)
3S/2E8PI Municipal well
BZ = Benzene
MtBE = Methyl-tert-butyl-ether
ND = Non detect
NA = Not analyzed
All concentrations in milligrams/liter (mg/l)
Estimated are where concentrations of benzene and MtBE in groundwater exceed 1 mg/l
452 Line of equal elevation of potentiometric surface (in feet above mean sea level) based on linear interpolation of the water-level elevations in 16 wells used for control. Contour interval is 1 foot.
NOTES
1 Base map source Figure 2, Vicinity map, Soil and Groundwater Investigation Report and Fourth Quarterly Report of 1995 Groundwater Sampling and Monitoring, Remediation Services Int'l (RSI), December 8, 1995
2 Analytic data from RSI 1996 RSI, 1995 Earth Tech 1995
3 Data shown for monitoring wells MW-1 through MW-6 are the most recent data available
BENZENE AND MtBE CONCENTRATIONS IN GROUNDWATER SAMPLES
1995 and 1996
2008 First Street
Livermore California
GEOMATRIX
Project No 4069A
Figure 6

FIGURE 7
PROJECT INVESTIGATION APPROACH
2008 First Street, Livermore, California

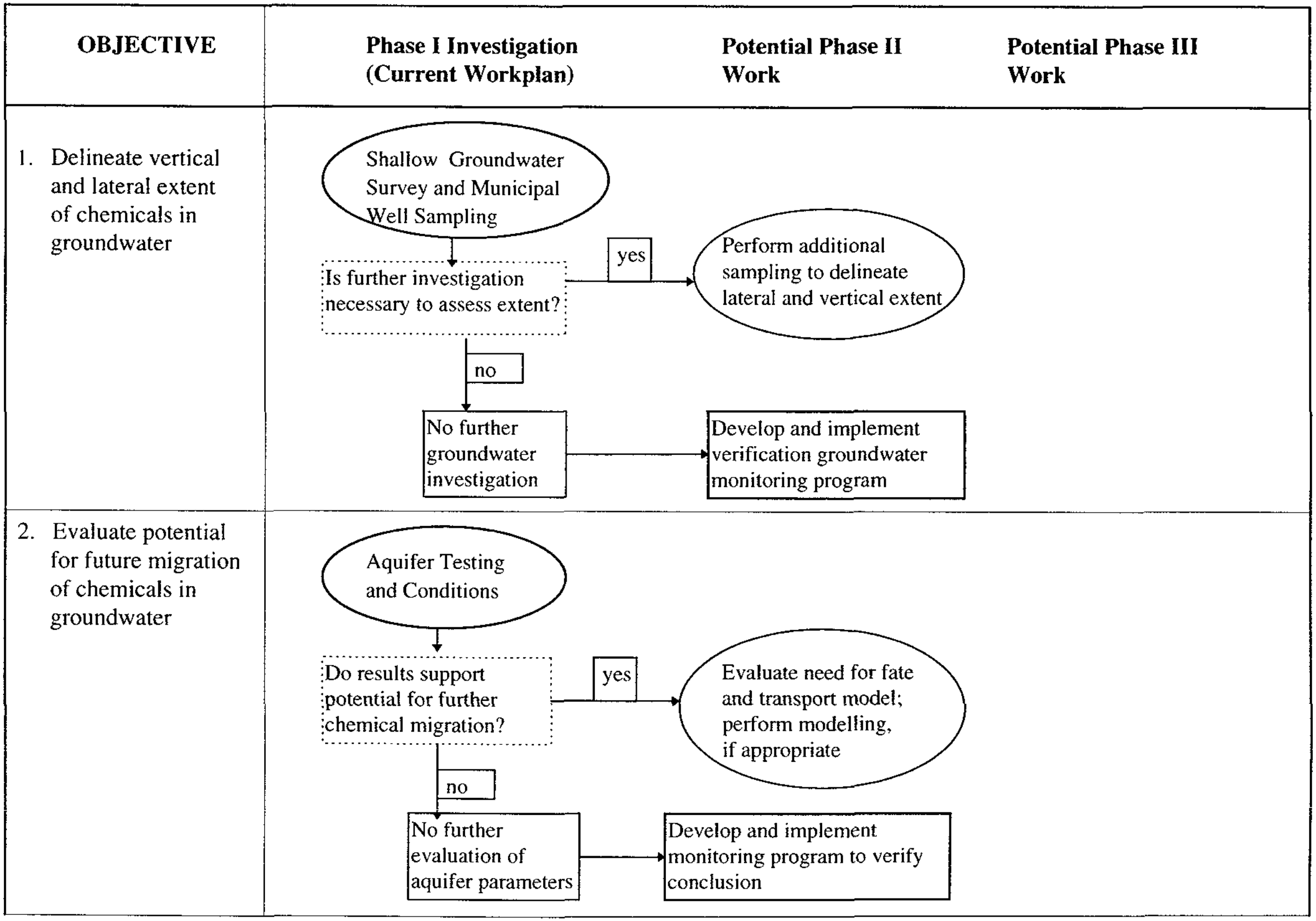
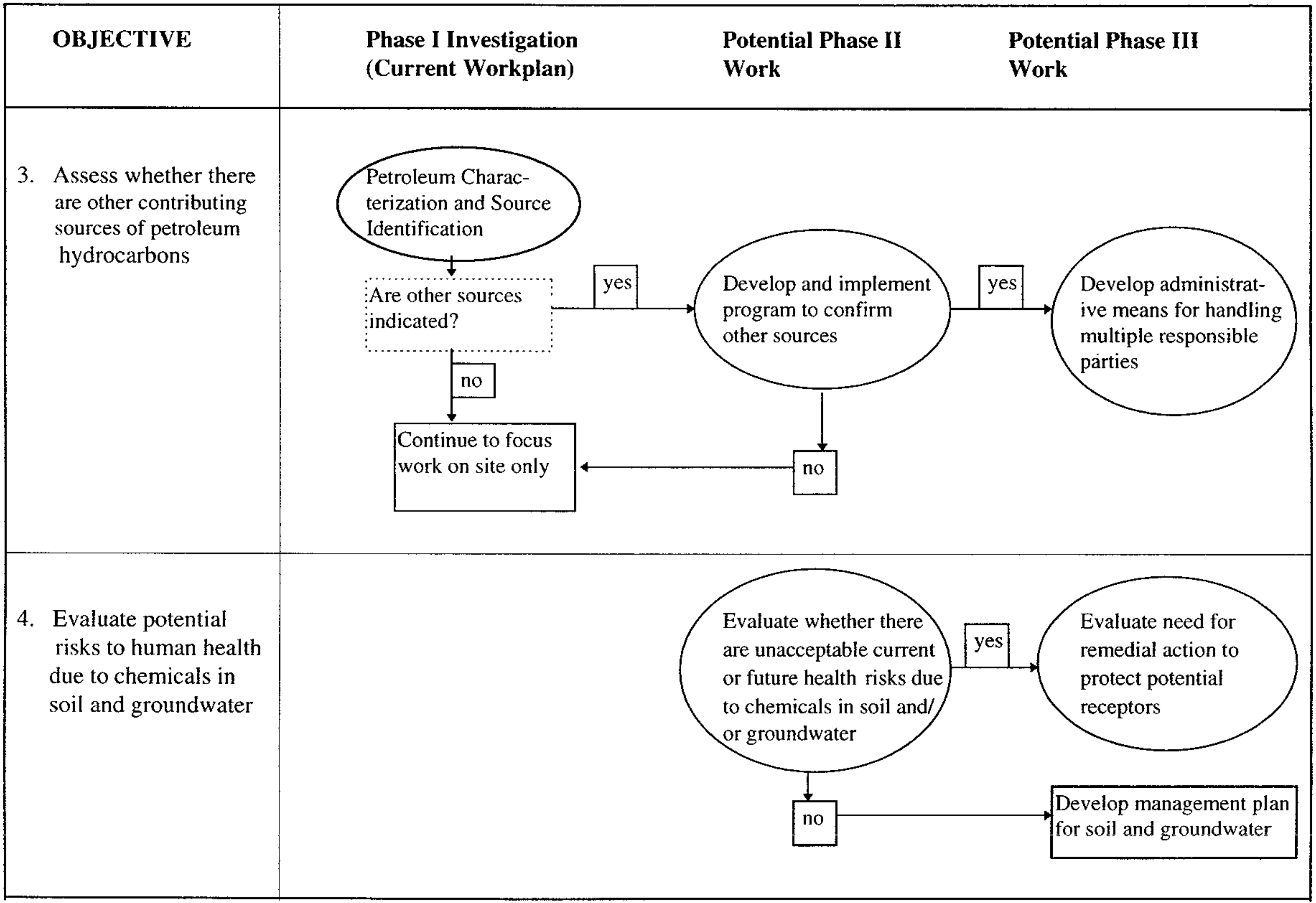
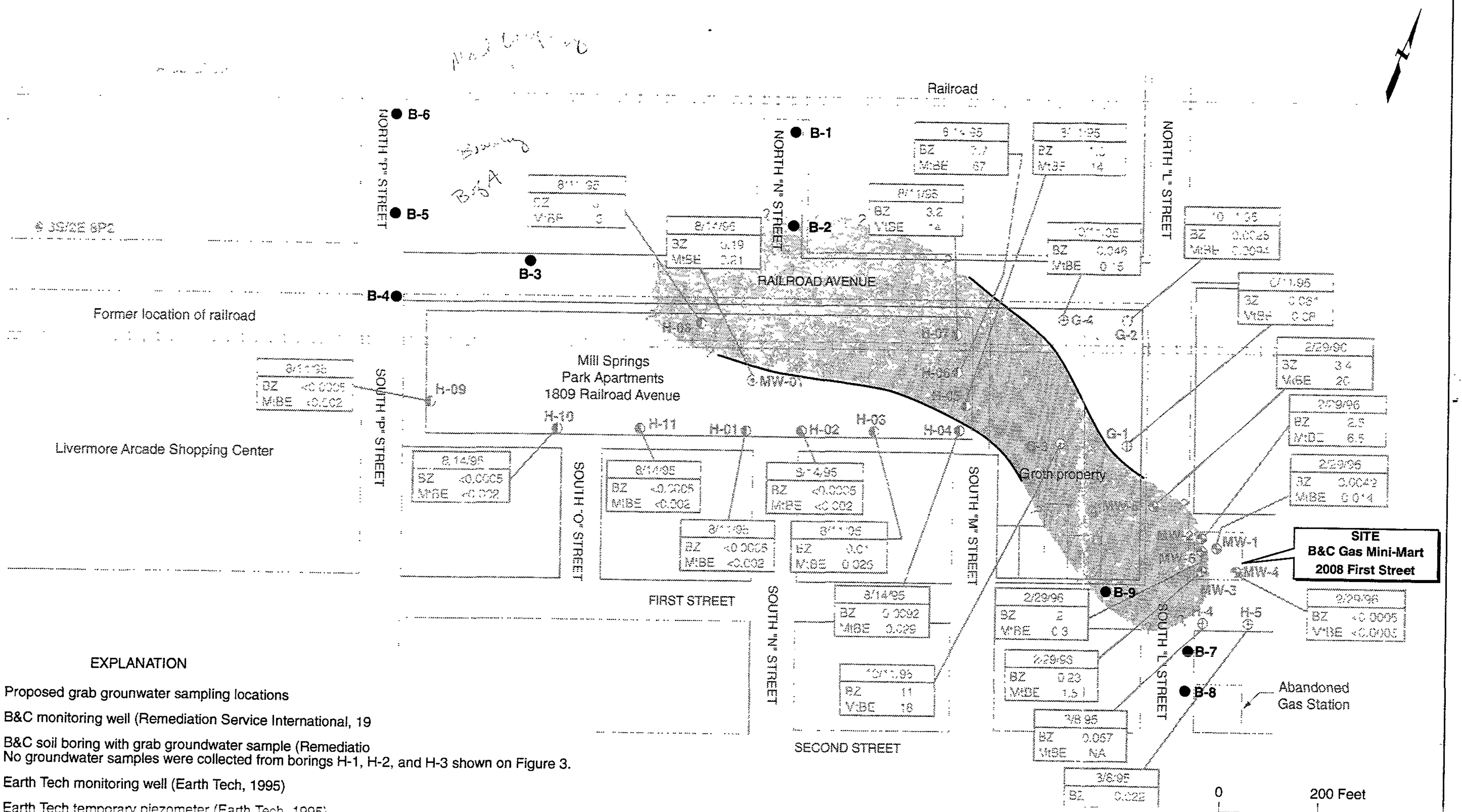


FIGURE 7
PROJECT INVESTIGATION APPROACH
(Continued)





EXPLANATION

B-1 ● Proposed grab grounwater sampling locations

MW-5 B&C monitoring well (Remediation Service International, 19

H-4 or G-1 B&C soil boring with grab groundwater sample (Remediatio
No groundwater samples were collected from borings H-1, H-2, and H-3 shown on Figure 3.

MW-01 Earth Tech monitoring well (Earth Tech, 1995)

Earth Tech temporary piezometer (Earth Tech, 1995)

Municipal well

= Benzene

= Methyl-tert-butyl-ether

= Non detect

= Not analyzed

All concentrations in milligrams/liter (mg/l)

Estimated are where concentrations of benzene and MTBE in groundwater exceed 1 mg/l

NOTES

1. Base map source: Figure 2. Vicinity map. Soil and Groundwater Investigation Report and Fourth Quarterly Report of 1995 Groundwater Sampling and Monitoring, Remediation Services Int'l (RSI). December 8, 1995
2. Analytic data from RSI 1996, RSI, 1995, Earth Tech 1995
3. Data shown for monitoring wells MW-1 through MW-6 are the most recent data available

PROPOSED GRAB GROUNDWATER SAMPLING LOCATIONS
1995 and 1996
2008 First Street
Livermore California

GEOMATRIX	Project No	Figure
	4069A	8

APPENDIX A

Site Investigation History

StID 1689 - **2008 1st Street, Livermore 94550**

HISTORY

May 1988	Geonomics report contaminated soil noted in backfill, at approximately 15' depth, around USTs. This phase of investigation was to install vadose monitoring wells. ACDEH request add'l info on release; quantity, results of investigations to date, proposed cleanup, etc.
Jun 1988	**Letter from DP that they will proceed w/ site assessment.**
Sep 1988	**3 soil borings advanced (DPL-5, 6) to 46.5' depth. GX-136 (MW-1) converted to monitoring well. DPL-5 at 31' with 33ppm TPH-G, .71 ppm Benzene DPL-6 at 36' with 1600 ppm TPH-G, ND benzene. 46' with 100 ppm TPH-G, ND benzene. GX-136 at 38.5' with 72 ppm TPH-G, ND benzene GX-136 grab groundwater sample was ND for TPH-G, BTEX** DTW 55.5'
Jun 1990	**ACDEH letter for add'l investigation to delineate extent of soil and possibly groundwater contamination.**
Aug 1990	QMR. **GW with 24,000 ppb TPH-G, 1,300 ppb benzene.** Workplan submitted to install 4 add'l MWs. DTW 48.10
Jan 1991	DP request to delay implementation of WP until after USTs are removed. Tank closure plan approved fro removal of 3 gasoline USTs and 1 WO tank.
May 1991	**ACDEH letter requesting update on UST removal.**
Jun 1991	DP wants 6 mo. extension to remove USTs and to install new USTs. Having $ problems.
Oct 1991	QMR. **3,200 ppb TPH-G, 430 ppb benzene.** DTW [illegible]
Mar 1992	Letter from attorney that DP filed Ch. 11 Bankruptcy
May 1993	SWI requested by ACDEH
Jun 1993	Convs. w/ J. Rutherford for SWI DP has no $ to continue. Hope to get $ from cleanup fund [illegible]

Jul 1993	2NOV
Oct 1993	QMR [illegible]
Nov 1993	Fiberglass UST relined
(Dec 1993 [illegible]	Mill Springs [illegible])
Jan 1994	WP for 3 add'l MWs. Amended and approved. **Balagi Angle new property and tank owner.**
Mar 1994	Removed W.O. tank
Jun 1994	QMR for Mar 22, 1994 DTW 33.57 3 add'l MWs installed (**MW 2, 3, and 4**)
Aug 1994	**Free product in MW-2.** Free product removal (bailing) on a weekly basis.
Sep 1994	QMR for Aug 25, 1994 DTW ~43' WP for offsite investigation. **3 HPs proposed on other side of L St, and 2 HPs upgradient on 1st St.**
Nov 1994	Request extension to implement **WP due to permitting problem with Caltrans**
Dec 1994	QMR, **free product removal ongoing on a weekly basis.**
Mar 1995	**Free product in monitoring well at Mill Springs Apt at 1809 Railroad.** HPs advanced. **FP in auger of HPs on west site of L Street,** approximately 75' downgradient of **BP site.** Increase in free product thickness at **MW-2,** suggesting a secondary release. **Release from "union" between tank and product line,** in manway. Unknown quantity, possibly 400 to 500 gallons.
Apr 1995	QMR
May 1995	Letter to DP to delineate extent of FP plume (since it may be going to Mill Springs Apt) Letter from DP attorney that current property owner may have contributed to FP plume.
Sep 1995	FRP UST **failed integrity test** and reconciliation records suggest loss of product. FRP UST is emptied, and taken out of service.

GEOMATRIX

APPENDIX B

Geomatrix Protocols

PROTOCOL
DRILLING AND DESTRUCTION OF SOIL BORINGS

1.0 INTRODUCTION

This protocol describes the procedures to be followed during drilling and destruction of soil borings. The soil borings will provide information about geologic conditions, soil engineering properties, and/or soil quality. If the soil boring is utilized for well installation, the well will be installed in accordance with the protocol INSTALLATION OF WELLS.

The procedures presented herein are intended to be of general use and may be supplemented by a work plan and/or health and safety plan. As the work progresses and if warranted, appropriate revisions may be made by the project manager. Detailed procedures in this protocol may be superseded by applicable regulatory requirements.

If required, permits for drilling of soil borings will be acquired from the appropriate agency(s) before drilling is initiated, and an underground utility check will be conducted before drilling begins. An underground utility check will, at a minimum, consist of contacting a local utility alert service, if available.

2.0 DRILLING

A DAILY FIELD RECORD will be completed for each day of fieldwork, and the original will be kept in the project files.

The soil borings will be drilled using rotary, hollow stem auger, direct-push, or other appropriate method. In all rotary borings, compressed air will be filtered to remove oils before being circulated into the borehole. In mud rotary borings, appropriate drilling fluid additives, such as bentonite, will be used to maintain an open hole and to carry cuttings to the surface. However, organic drilling fluid additives will only be used with prior project manager approval. The drilling mud will be circulated into a settling tank or basin located near the boring. The viscosity of the drilling fluid will be assessed periodically by the driller and will be controlled throughout the drilling operation to achieve the required results (hole stability, sample return, and mud cake thickness along borehole wall). Only potable water will be used as makeup water for drilling fluid. Exploratory borings drilled using the hollow stem auger method generally do not require the use of drilling fluid. If required, potable water from a municipal supply will be used to maintain boring stability.

The planned depth of each soil boring will be determined by the project manager before drilling. The Geomatrix field geologist/engineer will specify to the drill rig operator the depth of soil sample collection, method of sample retrieval, and other matters pertaining to the satisfactory completion of the borings. Geomatrix staff will observe the volume of drill cuttings returned to assess whether significant cavitation has occurred. Drill cuttings, unused soil samples, and drilling fluids generated during drilling of soil borings will be stored properly for future disposal by the client, unless other arrangements have been made.

The drill rods, augers, hoses, bits, and other components that fluids and cuttings contact will be steam-cleaned before drilling each boring, as well as at the beginning of each project and at the completion of field activities. Drive samplers will be cleaned with Alconox and water or steam-cleaned before each sampling event. Only potable water from a municipal supply will be used for decontamination of drilling equipment. Decontamination rinsate will be collected and stored properly for future disposal by the client, unless other arrangements have been made.

3.0 SAMPLING AND LOGGING

3.1 OBTAINING SAMPLES

Borings will be continuously cored or sampled at depth intervals specified by the project manager, based on the intended use of the boring. Continuous sampling is recommended; however, samples and/or cuttings will be obtained for logging purposes at least every 5 feet for all borings. Drive samples will be used to log hollow stem auger borings if continuous cores are not collected. The samples and/or drill cuttings will be collected and described. A lithologic log of these samples will be made. Samples for chemical analysis will be collected in accordance with the protocol SOIL SAMPLING FOR CHEMICAL ANALYSIS.

3.1.1 Discrete Sampling

For discrete sampling of mud rotary or auger borings, sampling will be accomplished by driving or pushing a split-barrel sampler or Shelby tube. The field geologist/engineer will record information on the BORING LOG pertaining to the sampling, such as rate of penetration, hydraulic ram pressure or drive-hammer blow count, coring smoothness, and sample recovery. In general, the split-barrel sampler will be opened for observation and logging of the retrieved core.

At selected depth intervals, the split-barrel sampler may be fitted with brass or stainless steel liners for collection of soil samples for possible subsequent chemical or physical testing. Samples may be retained for future review and/or preserved for chemical or physical testing, as specified by the project manager. The samples will be stored and labeled to show project number, boring number, and cored interval denoted either by depth or a sequential numbering system. Procedures for preservation and transport of soil samples retained for chemical analysis are presented in the protocol SOIL SAMPLING FOR CHEMICAL ANALYSIS.

3.1.2 Collecting Drill Cuttings

The field geologist/engineer may observe drill cuttings from the drilling fluid return for lithologic information to supplement discrete sampling. Sampling and logging cuttings will be performed as follows:

1. The height of the drilling table above ground surface, lengths of the drill bit, sub and drill collars, and length of drill rods should be taken into account in calculating the depth of penetration.

2. In mud rotary drilling, a small-diameter, fine mesh hand screen will be used to obtain a sample of the cuttings from the borings by holding the screen directly in the flow of the drill fluid return line. In air rotary drilling, cuttings will be collected after discharge from the cyclone.

3. In rotary drilling, a composite sample may be obtained from the return line by leaving the screen in place during the time it takes the driller to advance the boring to a preselected depth.

4. In rotary drilling, the travel time for cuttings to reach the surface may be estimated each time the driller adds a new length of drill rod by timing the first arrival of cuttings after circulation is resumed. This travel time can be used along with the depth of penetration to estimate the start and finish of each 5-foot sampling interval.

3.2 LOGGING OF EXPLORATORY BORINGS

The observations of the field geologist/engineer will be recorded on a BORING LOG OR WELL LOG at the time of drilling. The drill rig operator and the field geologist/engineer will discuss significant changes in material penetrated, drilling conditions, hydraulic pressure, drilling action, and drilling fluid circulation rate. The field geologist/engineer will be present during drilling of soil borings and will observe and record such changes by time and depth.

Drill cuttings and core samples will be observed in the field. A lithologic description will be recorded on the BORING LOG using the Unified Soil Classification System (USCS) as described in the American Society of Testing and Materials (ASTM) Standard D 2488-90. This description will include the USCS soil type, grain sizes and estimated percentages of each, moisture content, color according to the Munsell color charts (Kollmorgen Instruments Corp.), plasticity for fine-grained materials, consistency, and other pertinent information, such as degree of induration, calcareous content, presence of fossils and other distinctive materials.

The original field logs will be retained by the Geomatrix office for review by the responsible professional and for storage in the project files.

4.0 GEOPHYSICAL LOGS

Following completion of drilling, downhole geophysical logs may be performed after the drilling fluid has been circulated to decrease the amount of suspended sediment in the return fluid. Geophysical methods and equipment will be selected to provide stratigraphic or hydrogeologic data appropriate for the project. Geophysical logging will be done as quickly and promply after drilling as feasible, while the boring sidewall is still in stable condition, to reduce the possibility of bridging. Instruments on the logging unit will be adjusted to try to give the maximum definition of strata boundaries. All downhole geophysical equipment will be cleaned before and after use in each borehole.

5.0 FIELD SCREENING

Soil samples collected from the borings may be screened using a portable meter such as a photoionization detector (PID), a flame ionization detector (FID), a lower explosion limit (LEL) meter or other organic vapor meter. The meter may be used to assess the presence of volatile organic compounds (VOCs) or other gases in soil samples. Additional field screening techniques for chemical characterization of soils may include x-ray fluorescence (XRF) and thin-layer chromatography (TLC). Procedures for field screening are described in the protocol SOIL SAMPLING FOR CHEMICAL ANALYSIS.

6.0 DESTROYING SOIL BORINGS

Soil borings that are not completed as monitoring wells will be destroyed by filling the holes with a neat cement grout, cement/sand grout, or cement/bentonite grout. A high-solids bentonite grout may be used if appropriate. Geomatrix field staff will calculate the borehole volume and compare it to the volume of grout used to evaluate whether bridging has occurred. These calculations and the actual volume emplaced will be noted on the BORING LOG. The grout will be placed in continuous lifts from the bottom of the boring to a depth of 20 feet above the water table. The grout will be emplaced by pumping it through the hollow stem augers, drill pipe, tremie pipe, or flexible hose initially lowered to the bottom of the borings and raised incrementally as placement proceeds. If hollow stem augers are used, the augers should be raised incrementally as grout emplacement proceeds. Augers will not be raised in increments greater than 20 feet or greater than allowed by borehole stability. Borings that are terminated above the water table and not greater than 20 feet deep may be destroyed by continuous lifts originating at the ground surface. The grout will be pumped or poured until a return of fresh grout is visible at the surface. Additional grout may need to be added to the soil boring if significant settlement has occurred after the grout has set.

Attachments: Daily Field Record
Boring Log
Well Log

DAILY FIELD RECORD

GEOMATRIX

Project and Task Number:	Date:
Project Name:	Field Activity:
Location:	Weather:
Time of OVM Calibration:	

PERSONNEL: Name	Company	Time In	Time Out

PERSONAL SAFETY CHECKLIST

	Steel-toed Boots		Hard Hat		Tyvek Coveralls
	Rubber Gloves		Safety Goggles		1/2-Face Respirator

DRUM I.D.	DESCRIPTION OF CONTENTS AND QUANTITY	LOCATION

TIME	DESCRIPTION OF WORK PERFORMED

DAILY FIELD RECORD (continued)

GEOMATRIX

Page ______ of ______

Project and Task Number: ______________________ Date: ______________________

Time	Description of Work Performed

Log of Boring No.

PROJECT:		
BORING LOCATION:	ELEVATION AND DATUM:	
DRILLING CONTRACTOR:	DATE STARTED:	DATE FINISHED:
DRILLING METHOD:	TOTAL DEPTH:	MEASURING POINT:
DRILLING EQUIPMENT:	DEPTH TO WATER: FIRST	COMPL.
SAMPLING METHOD:	LOGGED BY:	
HAMMER WEIGHT: DROP:	RESPONSIBLE PROFESSIONAL:	REG. NO.

DEPTH (feet)	SAMPLES Sample No.	Sample	Blows/ Foot	OVM Reading (ppm)	DESCRIPTION NAME (USCS Symbol) color, moist, % by weight., plast., consistency, structure, cementation, react w/HCl geo. inter. Surface Elevation:	REMARKS

B-1 (12/95)

Project No.	**Geomatrix Consultants**	Figure

B-1 (Blank)

PROJECT:

Log of Boring No.

DEPTH (feet)	SAMPLES: Sample No.	SAMPLES: Sample	SAMPLES: Blows/ Foot	OVM Reading (ppm)	DESCRIPTION NAME (USCS Symbol) color, moist, % by weight., plast., consistency, structure, cementation, react. w/HCl geo inter.	REMARKS

B-2 (12/95)

Project No.	**Geomatrix Consultants**	Figure

B-2 (Blank)

PROJECT:		Log of Well No.		
BORING LOCATION:		ELEVATION AND DATUM:		
DRILLING CONTRACTOR:		DATE STARTED:		DATE FINISHED:
DRILLING METHOD:		TOTAL DEPTH:		SCREEN INTERVAL:
DRILLING EQUIPMENT:		DEPTH TO WATER:	FIRST / COMPL.	CASING:
SAMPLING METHOD:		LOGGED BY:		
HAMMER WEIGHT:	DROP:	RESPONSIBLE PROFESSIONAL:		REG. NO.

DEPTH (feet)	SAMPLES			OVM Reading (ppm)	DESCRIPTION NAME (USCS Symbol) color, moist, % by weight., plast , consistency, structure, cementation, react. w/HCl geo. inter	WELL CONSTRUCTION DETAILS AND/OR DRILLING REMARKS
	Sample No.	Sample	Blows/ Foot		Surface Elevation:	

W-1 (12/95)

Project No.	Geomatrix Consultants	Figure

W-1 (Blank)

PROJECT:	**Log of Well No.**

DEPTH (feet)	SAMPLES: Sample No.	SAMPLES: Sample	SAMPLES: Blows/ Foot	OVM Reading (ppm)	DESCRIPTION NAME (USCS Symbol): color, moist, % by weight , plast., consistency, structure, cementation, react w/HCl geo. inter	WELL CONSTRUCTION DETAILS AND/OR DRILLING REMARKS

W-2 (12/95)

Project No.	**Geomatrix Consultants**	Figure

W-2 (Blank)

PROTOCOL

SAMPLING OF GROUNDWATER MONITORING WELLS AND WATER SUPPLY WELLS

1.0 INTRODUCTION

This protocol describes the procedures to be followed during sampling of groundwater monitoring wells and water supply wells for laboratory chemical analysis. The laboratory must be certified by the appropriate regulating agency for the analyses to be performed.

The procedures presented herein are intended to be of general use and may be supplemented by a work plan and/or health and safety plan. As the work progresses and if warranted, appropriate revisions may be made by the project manager. Detailed procedures in this protocol may be superseded by applicable regulatory requirements.

2.0 SAMPLING

2.1 SAMPLE COLLECTION

A. Monitoring Wells

Methods for purging and sampling monitoring wells with dedicated and non-dedicated equipment are described in this Section. When practical, the purging and sampling technique adopted for a given site will remain consistent from one sampling event to the next.

A.1 Purging Monitoring Wells

A submersible pump, diaphragm pump, positive displacement pump, which may contain a bladder, or a bailer will be used for evacuating (purging) the monitoring well casing. If the well is to be sampled using equipment that must be separately introduced into the well, the purge intake will be located near the top of the water column for removal of at least one casing volume to remove stagnant water above the screened interval in the well casing: the pump may then be moved to the midscreen interval to complete the purging progress, if required. If a bailer is used to purge the monitoring well, it will be gently lowered into the well to reduce the potential for aeration of water. Purging will progress at a rate intended to minimize differential drawdown between the interior of the well screen and the filter material to limit cascading water along the inside of the well casing. Procedures for purging slowly recharging wells are discussed in Section A.3.

A minimum of four well casing volumes or one saturated borehole volume, whichever is greater, will be removed to purge the well prior to collection of groundwater samples if the well will be purged with non-dedicated equipment. If a low-flow capacity pump is dedicated in the well, the micropurge method described in Section A.4 may be used to reduce the purge volume. If the well goes dry before four casing volumes are removed, the procedure discussed in Section A.3 will be followed. The saturated borehole volume is the volume of water in the well casing plus the volume of water in the filter pack. For a well with a dedicated pump and packer, a casing volume is defined as the volume of water in the well casing below the inflated packer.

Periodic observations of turbidity and measurements of temperature, pH, and specific electrical conductance (SEC) will be made with field equipment during purging to evaluate whether the water samples are representative of the target zone. Samples will be collected when: (1) a minimum of four sets of parameter readings have been taken; and (2) the temperature, pH, and SEC reach relatively constant values, and the turbidity has stabilized.

A.2 Sampling Monitoring Wells

The sampler will wear clean gloves appropriate for the chemicals of concern while collecting the sample. Samples will be collected directly in laboratory-prepared bottles from the sampling device.

Each sampling episode or day should generally begin with the well having the least suspected concentrations of target compounds. Successive wells should generally be sampled in sequence of increasing suspected concentration.

A Teflon® bailer, new disposable bailer, stainless steel positive displacement Teflon® bladder pump with Teflon® tubing, or a clean electric submersible pump with low-flow sampling capacity will be used to collect the water samples for laboratory chemical analysis.

If a bailer is being used to collect the sample, it will be gently lowered into the well below the point where the purge device was located. Samples will collected in the following order: (1) volatile organic compounds; (2) semi-volatile organic compounds; (3) metals; (4) other analytes.

If a bladder pump or electric submersible pump is being used to sample the well for volatile compounds, the flow rate will be adjusted to either 1) approximately 100 milliliters per minute; 2) a rate specifically selected for the well based on groundwater flow rates and well hydraulic conditions; or 3) as low as possible. This rate will be maintained until the discharge line has been purged and the sample collected.

A.3 Purging and Sampling Wells With Slow Recharge

Wells that recharge very slowly may be purged dry once, allowed to recharge, and then sampled as soon as sufficient water is available. In this case, at least two sets of parameter readings of field water quality should be taken, one initially and one after recharge.

A.4 Purging and Sampling Wells Using "Micropurge" Sampling Method

Based on current research, a low-flow-rate, reduced purge method may be used to purge and sample a well with a dedicated pump (Barcelona et al., 1994; Kearl et al., 1994). This method may be used if acceptable to applicable agencies. This method assumes the water within the screened interval is not stagnant, and a small change to the natural flow rate in the screened interval will result in samples with particulates and colloidal material representative of groundwater. The pump should be preset in the screen interval at least 24 hours before the sampling event. A minimum of two pump plus riser pipe volumes should be purged at a flow rate of approximately 100 milliliters per minute or as low as possible based on groundwater flow and well hydraulic conditions. Purging should progress until water quality parameters (pH, SEC, temperature) have reached relatively constant values. Dissolved oxygen readings are recommended, if practical.

B. Water Supply Wells

Water supply wells will be sampled by purging the wells for a period of time adequate to purge the pump riser pipe. Alternatively, if the volume of the riser pipe is unknown, the pressure tank will be drained until the pump cycles on, or the well may be purged until three successive field measurements performed 5 to 10 minutes apart have stabilized. If the well is currently pumping, the sample can be taken without purging the well. Water samples will then be collected from the discharge point nearest the well head. Samples will be collected directly into laboratory-prepared bottles.

C. Extraction Wells

Extraction wells will be sampled while extraction is occurring. Samples will be collected from an in-line sampling port after purging the sampling line. Samples will be collected directly into laboratory-prepared bottles.

A WELL SAMPLING AND/OR DEVELOPMENT RECORD will be used to record the following information:

- Sample I.D.
- Duplicate I.D., if applicable
- Date and time sampled
- Name of sample collector
- Well designation (State well numbering system for water supply wells, and unique sequential number for other wells)
- Owner's name, or other common designation for water supply wells
- Well diameter
- Depth to water on day sampled
- Casing volume on day sampled
- Method of purging (bailing, pumping, etc.)
- Amount of water purged
- Extraordinary circumstances (if any)
- Results of instrument calibration/standardization and field measurements (temperature, pH, specific electrical conductance) and observed relative turbidity
- Depth from which sample was obtained
- Number and type of sample container(s)
- Purging pump intake depth
- Times and volumes corresponding to water quality measurement
- Purge rate

2.2 SAMPLE CONTAINERS AND PRESERVATION

Appropriate pre-cleaned sample containers and preservatives for the analyses to be performed will be obtained from the subcontracted analytical laboratory. Frequently requested analyses and sample handling requirements are listed in Table 1.

2.3 SAMPLE LABELING

Sample containers will be labeled before or immediately after sampling with self-adhesive tags having the following information written in waterproof ink:

- Geomatrix
- Project number
- Sample I.D. number
- Date and time sample was collected
- Initials of sample collector

2.4 QUALITY CONTROL SAMPLES

In order to evaluate the precision and accuracy of analytical data, quality control samples, such as duplicates and blanks, will be periodically prepared. These samples will be collected or prepared and analyzed by the laboratory, as specified in the project Quality Assurance Project Plan (QAPP) or by the project manager.

2.5 HANDLING, STORAGE, AND TRANSPORTATION

Efforts will be made to handle, store, and transport supplies and samples safely. Exposure to dust, direct sunlight, high temperature, adverse weather conditions, and possible contamination will be avoided. Immediately following collection, samples will be placed in a clean chest that contains ice or blue ice (if cooling is required), and will be transported to the subcontracted laboratory as soon as practical, or in accordance with the project QAPP.

3.0 FIELD MEASUREMENTS

Field measurements of temperature, pH, and SEC will be performed on aliquots of groundwater that will not be submitted for laboratory analysis. Field water quality measurements and instrument calibration details will be recorded on the WELL SAMPLING AND/OR DEVELOPMENT RECORD.

3.1 TEMPERATURE MEASUREMENTS

Temperature measurements will be made with a mercury-filled thermometer or an electronic thermistor, and all measurements will be recorded in degrees Celsius.

3.2 pH MEASUREMENT

The pH measurement will be made as soon as possible after collection of the sample, generally within a few minutes. The pH will be measured by immersing the pH probe into an aliquot of groundwater.

The pH meter will be calibrated at the beginning of and once during each sampling day and whenever appropriate, in accordance with the equipment manufacturer's specifications, as outlined in the instruction manual for the specific pH meter used. Two buffers (either pH-4 and pH-7, or pH-7 and pH-10, whichever most closely bracket the anticipated range of groundwater conditions) will be used for instrument calibration.

3.3 SPECIFIC ELECTRICAL CONDUCTANCE MEASUREMENT

SEC will be measured by immersing the conductivity probe into an aliquot of groundwater. The probes used should automatically compensate for the temperature of the sample. Measurements will be reported in units of micro-Siemens (μS) per square centimeter (equivalent to micromhos or μmhos) at 25 degrees Celsius.

The SEC meter will be calibrated at the beginning and once during each sampling day in accordance with the equipment manufacturer's specifications, as outlined in the instruction manual for the SEC meter used. The SEC meter will be calibrated with the available standardized potassium chloride (KCl) solution that is closest to the SEC expected in groundwater below the site.

4.0 DOCUMENTATION

4.1 FIELD DATA SHEETS

A DAILY FIELD RECORD will be completed for each day of fieldwork. A WELL SAMPLING AND/OR DEVELOPMENT RECORD will be used for each well to record the information collected during water quality sampling. Samples may also be recorded on a SAMPLE CONTROL LOG SHEET or in the DAILY FIELD RECORD as a means of identifying and tracking the samples. Following review by the project manager, the original records will be kept in the project file.

4.2 CHAIN-OF-CUSTODY PROCEDURES

After samples have been collected and labeled, they will be maintained under chain-of-custody procedures. These procedures document the transfer of custody of samples from the field to the laboratory. Each sample sent to the laboratory for analysis will be recorded on a CHAIN-OF-CUSTODY RECORD, which will include instructions to the laboratory for analytical services.

Information contained on the triplicate CHAIN-OF-CUSTODY RECORD will include:

- Project number
- Signature of sampler(s)
- Date and time sampled
- Sample I.D.
- Number of sample containers
- Sample matrix (water)
- Analyses required

- Remarks, including preservatives, special conditions, or specific quality control measures
- Turnaround time and person to receive laboratory report
- Method of shipment to the laboratory
- Release signature of sampler(s), and signatures of all people assuming custody.
- Condition of samples when received by laboratory

Blank spaces on the CHAIN-OF-CUSTODY RECORD will be crossed out between the last sample listed and the signatures at the bottom of the sheet.

The field sampler will sign the CHAIN-OF-CUSTODY RECORD and will record the time and date at the time of transfer to the laboratory or to an intermediate person. A set of signatures is required for each relinquished/reserved transfer, including transfer within Geomatrix. The original imprint of the chain-of-custody record will accompany the sample containers. A duplicate copy will be placed in the project file.

If the samples are to be shipped to the laboratory, the original CHAIN-OF-CUSTODY will be sealed inside a plastic bag within the ice chest, and the chest will be sealed with custody tape which has been signed and dated by the last person listed on the chain-of-custody. U.S. Department of Transportation shipping requirements will be followed and the sample shipping receipt will be retained in the project files as part of the permanent chain-of-custody document. The shipping company (e.g., Federal Express, UPS, DHL) will not sign the chain-of-custody forms as a receivor; instead the laboratory will sign as a receivor when the samples are received.

5.0 EQUIPMENT CLEANING

Bailers, sampling pumps, purge pumps, and other non-dedicated purging or sampling apparatus will be cleaned before and after sampling each well. Factory new and sealed disposable bailers may be used for sampling, but may not be reused. Thermometers, pH electrodes, and SEC probes that will be used repeatedly will be cleaned before and after sampling each well and at any time during sampling if the object comes in contact with foreign matter.

Purged waters and solutions resulting from cleaning of purging or sampling equipment will be collected and stored properly for future disposal by the client, unless other arrangements have been made.

Cleaning of reusable equipment that is not dedicated to a particular well will consist of the following:

- Bailers - the inside and outside of bailers will be cleaned in a solution of laboratory-grade detergent and potable water, followed by a rinse with deionized (DI) water. They may also be steam-cleaned, followed by a DI water rinse. If samples are to be collected for metals analysis, the Teflon® bailer may be rinsed with a pH2 nitric acid solution followed by a double DI rinse.

- Purge Pumps - All downhole, reusable portions of purge pumps will be steam-cleaned on the outside. If the pump does not have a backflow check valve, the inside of the pump and tubing also should be steam-cleaned. For a purge pump with a backflow check valve, the interior of the pump and tubing may be cleaned by pumping a laboratory-grade detergent and potable water solution through the system followed by a potable water rinse, or by steam-cleaning.

- Water Quality Meters - All meters will be cleaned by rinsing the probe portions in DI water, and allowing to air dry.

- Bailer Tripod - The tripod cable will be steam-cleaned or rinsed with DI water.

Sample bottles and bottle caps will be cleaned by the subcontracted laboratory using standard EPA-approved protocols. Sample bottles and bottle caps will be protected from contact with solvents, dust, or other contamination. Sample bottles will not be reused.

6.0 REFERENCES

Barcelona, M.J., et al., 1994, Reproducible Well-Purging Procedures and VOC Stabilization Criteria for Ground-Water Sampling: *Groundwater*, January-February.

Kearl, P.M., et al., 1994, Field Comparison of Micropurging vs. Traditional Ground Water Sampling: *Ground Water Monitoring Review*, Fall.

Attachments:
- Water and Soil Analytical Methods and Sample Handling
- Well Sampling and/or Development Record
- Daily Field Record
- Chain-of-Custody Record
- Sample Control Log Sheet

TABLE 1

WATER AND SOIL ANALYTICAL METHODS AND SAMPLE HANDLING

Parameter	Method	Water Containers[1]	Preservation[1]	Maximum Holding Time[1]
Total Petroleum Hydrocarbons: • as diesel • as gasoline	GCFID (3550)[2] GCFID (5030)[2]	2 - 1 liter amber glass 2 - 40 ml VOA glass	cool on ice HCL to pH 2 in water samples: cool on ice	14 days (unacidified water, 7 days) 14 days (unacidified water, 7 days)
Benzene, Toluene, Xylene, and Ethylbenzene	EPA 8020	2 - 40 ml VOA glass	HCL to pH 2 in water samples: cool on ice	14 days (unacidified water, 7 days)
Oil and Grease	5520 E & F (soil)[3] 5520 C & F (water)[3]	2 - 1 liter amber glass	H_2SO_4 to pH <2 in water samples: cool on ice	28 days
Volatile Organics	EPA 8010 EPA 8240[5]	2 - 40 ml VOA glass 2 - 40 ml VOA glass	cool on ice[4] HCL to pH 2 in water samples: cool on ice	14 days (unacidified water, 7 days) 14 days (unacidified water, 7 days)
Semi-volatile Organics	EPA 8270	2 - 1 liter amber glass	cool on ice	7 days for extraction, water 14 days for extraction, soil 40 days for analysis
Polynuclear Aromatic Hydrocarbons	EPA 8310	2 - 40 ml VOA glass	cool on ice	7 days, water 14 days, soil
Metals (dissolved)	EPA 7000 series for specific metal	1 - 500 ml plastic	Water Samples: field filtration (0.45 micron filter) and field acidify to pH 2 with HNO_3 except: Cr^{+6} - cool on ice	6 months, except: Hg - 28 days Cr^{+6} - 24 hours, water; 24 hours after prep, soil

Notes:

1 All soil samples should be collected in full, clean brass liners, capped with aluminum foil or Teflon and plastic caps, and sealed with tape. If soil samples are to be analyzed for metals, they may be placed in laboratory-prepared clean glass jars. Soil should be cooled as indicated under "preservation" and maximum holding times apply to both soil and water unless otherwise noted.

2 For analysis in California, use California DHS recommended procedure as presented in LUFT manual using gas chromatography with a flame ionization detector. In other states, local requirements should be followed.

3 Method to be used in California Regional Water Quality Control Board North Coast and Central Valley Regions. In other areas, local requirements should be followed.

4 If EPA Methods 8010 and 8020 are to be run in sequence, HCL may be added. Check with the project manager before adding acid.

5 Chloroethylvinylether may be detected at concentrations below 50 parts per billion due to degradation of HCL.

References:

U.S. EPA, 1986, Test Methods for Evaluating Solid Waste - Physical/Chemical Methods - SW-846, Third Edition, July, and final amendments.

California State Water Resources Control Board, 1989, Leaking Underground Fuel Tank (LUFT) Field Manual, Tables 3-3 and 3-4, October.

California Regional Water Quality Control Boards, North Coast, San Francisco Bay, and Central Valley Regions, 1990, Regional Board Staff Recommendations for Initial Evaluation and Investigation of Underground Tanks, 10 August.

WELL SAMPLING AND/OR DEVELOPMENT RECORD

GEOMATRIX

Well ID: ____________________ Initial Depth to Water: ____________________

Sample ID: __________ Duplicate ID: __________ Depth to Water after Sampling: ____________________

Sample Depth: ____________________ Total Depth of Well: ____________________

Project and Task No.: ____________________ Well Diameter: ____________________

Project Name: ____________________ 1 Casing/Borehole Volume = ____________________ (Circle one)

Date: ____________________

Sampled By: ____________________ 4 Casing/Borehole Volumes = ____________________ (Circle one)

Method of Purging: ____________________

Method of Sampling: ____________________ Total Casing/Borehole Volumes Removed: ____________________

Time	Intake Depth	Rate (gpm)	Cum. Vol. (gal.)	Temp. (°C)	pH (units)	Specific Electrical Conductance (µS/cm)	Remarks (color, turbidity, and sediment)

pH CALIBRATION (choose two)				
Buffer Solution	pH 4.0	pH 7.0	pH 10.0	
Temperature °C				
Instrument Reading				

Model or Unit No.:

SPECIFIC ELECTRICAL CONDUCTANCE – CALIBRATION			
KCL Solution (µS/cm = µmhos/cm)			
Temperature °C			
Instrument Reading			

Model or Unit No.:

Notes: ____________________

DAILY FIELD RECORD

GEOMATRIX

Project and Task Number:	Date:
Project Name:	Field Activity:
Location:	Weather:
Time of OVM Calibration:	

PERSONNEL: Name	Company	Time In	Time Out

PERSONAL SAFETY CHECKLIST

	Steel-toed Boots		Hard Hat		Tyvek Coveralls
	Rubber Gloves		Safety Goggles		1/2-Face Respirator

DRUM I.D.	DESCRIPTION OF CONTENTS AND QUANTITY	LOCATION

TIME	DESCRIPTION OF WORK PERFORMED

Forms(PF) 004 (Revised 12/95)

DAILY FIELD RECORD (continued)

GEOMATRIX

Page ____ of ____

Project and Task Number: ____________________ Date: ____________________

Time	Description of Work Performed

Forms(PF) 005 (Revised 12/95)

CHAIN-OF-CUSTODY RECORD

Nº

Date:

Page of

Project No.:

Samplers (Signatures):

			ANALYSES																			REMARKS				
Date	Time	Sample Number	EPA Method 8010	EPA Method 8020	EPA Method 8020 (BTEX only)	EPA Method 8240	EPA Method 8270	TPH as gasoline	TPH as diesel													Cooled	Soil (S), Water (W), or Vapor (V)	Acidified	Number of containers	Additional Comments

Turnaround time:

Results to:

Total No. of containers:

Relinquished by (signature):	Date:	Relinquished by (signature):	Date:	Relinquished by (signature):	Date:	Method of Shipment:
Printed Name:	Time:	Printed Name:	Time:	Printed Name:	Time:	Laboratory Comments and Log No.:
Company:		Company:		Company:		
Received by (signature):	Date:	Received by (signature):	Date:	Received by (signature):	Date:	
Printed Name:	Time:	Printed Name:	Time:	Printed Name:	Time:	GEOMATRIX
Company:		Company:		Company:		

SAMPLE CONTROL LOG

GEOMATRIX

Project Name: ______________________ Laboratory: ______________________

Project and Task No.: ______________________ Page _____ of _____

Sampling Date	Sampling Time	Sample Number (ID)	C.O.C. Number	Analyses Requested	Turnaround Time, Sample Location, Handling Notes, Chain-of-Custody Remarks, et. (Duplicate, blank info, etc.)	Date Sent to Lab	Date Results Due

PROTOCOL

AQUIFER TESTING

1.0 INTRODUCTION

This protocol describes the procedures to be followed for conducting step-drawdown, constant discharge, and slug aquifer tests and specific capacity tests. The procedures presented herein are intended to be of general use and may be supplemented by a work plan and/or health and safety plan. As the work progresses and if warranted, appropriate revisions may be made by the project manager. Detailed procedures in the protocol may be superseded by applicable regulatory requirements.

A DAILY FIELD RECORD will be completed for each day of fieldwork. Weather conditions, proximity of surface water bodies, irrigation, or other observations that may affect results of the aquifer testing will be noted on the DAILY FIELD RECORD.

An AQUIFER TEST DATA FORM will be completed for each well observed during the test, during both drawdown and recovery phases. Alternatively, a data-logger may be used in each well, and the set-up parameters determined by the project hydrogeologist should be recorded on a form developed for this purpose. If a data-logger is used, data should be transferred to a computer as soon as possible after collection. As data is collected, it will be checked periodically in the field for accuracy and completeness.

During aquifer testing, care must be taken to contain or direct the discharged water to avoid recharge of the aquifer during the test. Water discharge from the aquifer will be collected and stored properly for future disposal by the client, unless other arrangements have been made.

2.0 STEP-DRAWDOWN TEST

The step-drawdown aquifer test is performed to estimate a maximum sustainable discharge rate for the pumping well. The pretest phase, conducted prior to the aquifer test, will consist of water level measurements taken in the pumped well and observation wells that are to be monitored throughout the duration of the test. The water level measurements will be taken using electric sounders or pressure transducers and a data logger, and will be recorded for the appropriate well.

The pumping phase of the step-drawdown test will consist of: (1) pumping the well at successively higher pumping rates (steps) specified by the responsible professional, with an approximate duration of two to four hours per step; (2) periodically and at similar times measuring the water levels in the pumped well and observation wells during each step; (3) measuring the instantaneous and cumulative discharge from the pumped well using a flow meter or other appropriate means; and (4) recording the time at which all measurements were taken.

The pumping rate for each step will be maintained relatively constant. The rate will be checked periodically (at least hourly) and adjusted if necessary. The accuracy of the flow meter also may be verified periodically using the sweep needle on the flow meter, if available, and a stopwatch. The accuracy of the flow meter will be checked using a container of known volume and a stopwatch.

The recovery phase of the step-drawdown test begins immediately after the pump is shut off at the completion of the final step of the pumping phase. Recovery water-level measurements will be made periodically in the pumped well and observation wells. Water level measurements will conclude when one of the following is satisfied: (1) the water level in the pumped well has recovered to pre-test level; (2) the water level in the pumped well has remained constant for at least 2 hours; or (3) 24 hours has elapsed since the time of pump shut-off.

3.0 CONSTANT DISCHARGE TEST

During the pretest phase, water level measurements will be taken in the pumped well and all observation wells that are to be monitored throughout the duration of the test. Water level measurements will be taken with electric sounders, pressure transducers with a data-logger, or a steel tape. All pretest water level measurements for the pumping well and observation wells will be recorded for the appropriate well.

3.1 PUMPING PHASE

During the pumping phase of the aquifer test, the following measurements will be made: (1) water levels in the pumped well and the observation wells; (2) instantaneous and cumulative discharge from the pumped well; and (3) time at which measurements are taken.

The duration of the pumping phase will be established prior to the start of the aquifer test. Time-drawdown curves for the observation wells may be plotted in the field on semi-logarithmic graph paper during the pumping phase to evaluate the progress of the test. If the plots indicate steady-state conditions in the aquifer, the test may be ended before its planned conclusion if approval is given by the responsible professional. Likewise, the pumping phase of the test may be extended at the discretion of the responsible professional.

The water levels in the pumped well and the observation wells will be measured simultaneously on a pre-determined time schedule. An example time schedule is outlined below.

Time Since Pump Started (min.)		Time Intervals Between Measurements (min.)
0-2		0.25
2-5		0.50
5-15		1
15-60		5
60-240	**(EXAMPLE)**	30

240-Conclusion	60

Discharge from the pumped well will be measured using a flow meter and a stopwatch or other appropriate methods. Accuracy of the flow meter may be verified periodically using the sweep needle, if available, and the stopwatch. Discharge will be maintained at a relatively constant rate. The discharge rate will be checked and adjusted (if necessary, at 10-minute intervals during the first hour of pumping and 1-hour intervals thereafter). Rate of discharge, cumulative gallons discharged, and time of measurement will be recorded.

3.2 ABORTED TEST

Failure of pumping operations (mechanical breakdown of generator, pump, etc.) for a period greater than 2 percent of the elapsed pumping time may require postponement of the test. The pumping phase of the test may be resumed when one of the following conditions has been reached: (1) the water level in the pumped well has recharged to within 5 percent of the pretest water level; or (2) the well has not been pumped for a period at least equal to the elapsed pumping time of the test before postponement.

3.3 RECOVERY PHASE

At completion of the pumping phase of the test, the pump will be shut off. In the recovery phase, water level measurements will be taken simultaneously in the pumped well and the observation wells immediately following pump shut-off according to a predetermined schedule. An example time schedule is presented below.

Time Since Pump Stopped (min.)		Time Intervals Between Measurements (min.)
0-2		0.25
2-5		0.50
5-15		1
15-60		5
60-240	**(EXAMPLE)**	30
240-Conclusion		60

Water level measurements will be concluded when one of the following conditions applies: (1) the water level in the pumped well has recovered to the pretest water level; (2) the water level in the pumped well has remained constant for at least 2 hours; or (3) 24 hours has elapsed from the time the pump was shut off.

4.0 SLUG TESTS

Slug tests involve a single well in which the response to an "instantaneous" raising or lowering of the water level is measured. Slug tests are generally of short duration, usually less than 5 minutes, with the first 30 seconds being most important. As such, measurement of water levels during the test should be measured using a pressure transducer and data logger. If the formation is relatively low yielding, the test period may be longer and manual measurement methods may be used.

During the pretest phase, the static water level is measured. Then a known volume of water is either bailed from or added to the well, or a weighted slug of known volume is lowered into or raised from the well. The water level is measured immediately after the slug or water is added or removed, and then the change in water level with time is measured in pre-determined increments. The water level measurements and time at which the measurements will be recorded.

5.0 SPECIFIC CAPACITY TESTS

A specific capacity test is a constant discharge-constant drawdown pumping test. The purpose of specific capacity testing is to determine the specific capacity (SC) of the pumping well and to estimate transmissivity (T) by using an established empirical relationship between SC and T (see Driscoll, 1986). These estimates can be used as a quick check on hydraulic parameters collected during long-term pumping tests or as a preliminary estimate of T when long-term pumping tests have not been performed.

The practical requirement of the field method is to achieve a stabilized drawdown in the pumping well at a constant pumping rate. The pumping rate should be low enough for the results to be indicative of aquifer properties and not overly influenced by losses due to well efficiency. The stabilized drawdown condition ($\pm$0.05 foot) should be achieved at a constant pumping rate for a duration of at least 30 minutes. Water levels are measured to the nearest 0.01 foot using an electric sounder or pressure transducer. Pumping rate is measured in gallons per minute (gpm). Cumulative gallons pumped should be recorded at the time water level measurements are taken. Time should be measured in seconds with a stopwatch. Pumping rate in gpm can be calculated after the test is completed. Static and pumping water levels, pumping rate and/or cumulative gallons removed, and time at which measurements were taken will be recorded.

6.0 REFERENCES

Driscoll, F.G., 1986, *Groundwater and Wells*, 2nd edition, Johnson Division.

Attachments: Daily Field Record
Aquifer Test Data Form

DAILY FIELD RECORD

GEOMATRIX

Project and Task Number:	Date:
Project Name:	Field Activity:
Location:	Weather:
Time of OVM Calibration:	

PERSONNEL: Name	Company	Time In	Time Out

PERSONAL SAFETY CHECKLIST

	Steel-toed Boots		Hard Hat		Tyvek Coveralls
	Rubber Gloves		Safety Goggles		1/2-Face Respirator

DRUM I.D.	DESCRIPTION OF CONTENTS AND QUANTITY	LOCATION

TIME	DESCRIPTION OF WORK PERFORMED

AQUIFER TEST DATA

GEOMATRIX

Well No.: ________ Project Name: ____________ Project No.: ________

Owner ____________ Address ____________ County ________ State ______

Date ________ Company Performing Test ____________ Measured By ________

Well No. ________ Distance from Pumping Well ________ Type of Test ________ Test No. ______

Pumping Well _____ Observation Well _____ Measurement Equipment ____________

TIME DATA	WATER LEVEL DATA	DISCHARGE DATA
Pump on: Date ______ Time ______ (t_0)	Static Water Level ________	How Q Measured ________
Pump off: Date ______ Time ______ (t'_0)	Measuring Point ________	Depth of Pump/Air Line ________
Duration of aquifer test:	Elevation of Measuring Point ________	Previous Pumping? Yes ____ No ____
Pumping ______ Recovery ______		Duration ______ End ______

Date	Clock Time	Time Since Pump Started t	Time Since Pump Stopped t'	t/t'	Water Level Measurement	Correction or Conversion	Water Level	Water Level Change s or s'	Discharge Measurement	Discharge Rate	Recorded By	COMMENTS ON FACTORS AFFECTING TEST DATA