HYDRO ENVIRONMENTAL TECHNOLOGIES, INC.

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Alameda, CA 94501
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1-800-347-HETI
Massachusetts
New York

July 15, 1993 **9-038.2**

Ms. Juliet Shin
Alameda County Department of Environmental Health - Haz. Mat. Division
80 Swan Way, Room 200
Oakland, CA 94621

Re: BP Oil Facility No. 11104, 1716 Webster Street, Alameda, California

Dear Ms. Shin:

BP Oil Company (BP) has retained Hydro-Environmental Technologies, Inc. (HETI) to perform aquifer and soil vapor extraction tests at the above-referenced site. On behalf of BP, enclosed please find a copy of the Workplan for Aquifer and Soil Vapor Extraction Testing for your approval.

If you have any questions or require additional information regarding this workplan, please call me at (510) 521-2684.

Sincerely,
HYDRO-ENVIRONMENTAL TECHNOLOGIES, INC.

FRANCES MARONI

Frances H. Maroni
Project Manager

cc: Mr. Scott Hooton, BP Oil Company

HYDRO ENVIRONMENTAL TECHNOLOGIES, INC.

WORKPLAN FOR AQUIFER AND SOIL VAPOR EXTRACTION TESTING

BP Oil Company, U.S.A.
BP Oil Service Station No. 11104
1716 Webster Street
Alameda, California

Prepared for:

BP OIL COMPANY
Northwest Division
Southcenter Place Building
16400 Southcenter Parkway - Suite 301
Tukwila, Washington 98188

Prepared by:

HYDRO-ENVIRONMENTAL TECHNOLOGIES, INC.
2363 Mariner Square Drive, Suite 243
Alameda, California 94501
HETI Job No. 9-038

July 9, 1993

HYDRO ENVIRONMENTAL TECHNOLOGIES, INC.

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1.0 INTRODUCTION

1.1 Purpose

BP Oil Company retained Hydro-Environmental Technologies, Inc. (HETI) in June 1993 to perform aquifer and soil vapor extraction (SVE) tests at BP Oil Service Station No. 11104 located at 1716 Webster Street in Alameda, California. These tests will determine the feasibility of SVE as an appropriate remedial technology and obtain information to be used in the design of a remediation system for the site. The Site Location map is shown as Figure 1. This workplan contains a brief background, a description of proposed tasks, and a schedule for the completion of those tasks.

1.2 Background

BP Oil Service Station No. 11104 is located on the southeast corner of the intersection of Webster Street and Buena Vista Avenue in Alameda, California. The site is presently an operating service station with three underground gasoline storage tanks and one underground used oil tank. Figure 2, the Site Plan, shows the layout of the site and the locations of underground storage tanks and dispenser islands.

The product delivery lines and the dispenser islands were replaced in September 1990. Since that time, a total of five ground water monitoring wells have been installed in two phases. Soils beneath the site consist mostly of silty sand to a depth of 17 feet below grade Ground water exists at a depth of approximately five feet below grade. No separate phase hydrocarbons have been observed in any of the monitoring wells. Ground water flow direction is generally toward the north-northeast.

1.3 Proposed Scope of Work

The tasks performed under this aquifer/SVE test include the following:

- Permit and install one 6-inch diameter ground water and vapor extraction well, designated RW-1.
- Perform a step-drawdown test, approximately 2 to 3 hours in length.
- Perform an 8-hour constant discharge test.
- Perform a combined vapor extraction and constant discharge test.
- Analyze data/results and prepare a report presenting the findings of the field tests.

2.0 FIELD METHODS

The procedures and methods used during field activities are discussed below, and a detailed description of the sampling and testing protocols are included in Appendix A.

2.1 Ground Water Recovery Well Installation

HETI will supervise the installation of one ground water recovery well in the location shown on Figure 2. Well installation procedures will be conducted in accordance with standard HETI protocols which are consistent with local regulatory guidelines. Prior to commencement of drilling, HETI will obtain a well installation permit from the Alameda County Department of Environmental Health (ACDEH). A hollow stem auger drill rig will be used to drill the boring and install the well in accordance with the installation procedures presented in Appendix A and the construction detail attached as Figure 3.

The boring will be advanced at least 15 feet below the static ground water level in the well and terminated at that depth. The anticipated depth of the boring is 23 feet below grade. The well will be constructed with clean, 6-inch-diameter, flush threaded, Schedule 40, polyvinyl chloride (PVC) blank casing from the ground surface to 3 feet below grade and 0.020-inch slotted casing from 3 to 23 feet below grade. The annular space through the screened interval will be filled with clean uniform sand to a depth of 2 feet. A one foot thick hydrated bentonite seal will be placed above the sandpack, and the annular space above the seal will be filled with grout. The top of the well casing will be capped and locked with an expansion plug, and a traffic rated box will cemented in place over the well head. The dimensions of well construction described above and shown in Figure 3 are approximate, and may vary according to conditions encountered in the field.

Soil samples will be taken at five foot intervals using a California-modified spit-spoon sampler lined with brass tubes. A portion of each sample will be retained for visual description and screened in the field for the presence of organic vapors. One brass liner will be retained for laboratory analysis, the ends covered with Teflon® tape and sealed with plastic end caps. The samples will be labeled, documented on a chain-of-custody and placed in a cooler for transport to a state-certified analytical laboratory per HETI's standard protocol (Appendix A) to be analyzed for total petroleum hydrocarbons, calculated as gasoline (TPHg) and benzene, toluene, ethylbenzene and xylenes (BTEX) using EPA methods 8015 (DHS-modified) and 8020. Augers will be steam cleaned and the auger rinseate will be stored on site in labeled 55 gallon drums. Soil cuttings generated from drilling activities will also be stockpiled onsite and enveloped by visqueen plastic.

The well will be developed using a combination of surging and bailing. Development will proceed until the ground water being removed is relatively free of turbidity. HETI personnel will survey the elevation of the well head to the nearest 0.01 foot, relative to a temporary benchmark and existing wells, corrected for mean sea level.

Installation of vapor test points will be required as the screens of the surrounding monitoring wells are submerged. The effect of vacuum-assisted pumping will be demonstrated. The vapor points, designated VP-1 and VP-2, as shown on attached Figure 2, will be installed to a depth of 4 to 5 feet. These vapor points will be located approximately 10 and 15 feet, respectively from recovery well RW-1. They will be driven into place using the drill rig when recovery well RW-1 is installed and completed within a small well vault for later use.

2.2 Eight-hour Constant Discharge Test

An 8-hour constant discharge aquifer test will be conducted on newly installed recovery well RW-1. Well yield information, gathered from the step test, will be used to set the flow rate for the aquifer test. An electric submersible pump will be used to extract ground water from RW-1. Drawdown in the pumping well and several surrounding monitoring wells will be recorded at frequent, simultaneous intervals using a datalogger and pressure transducers. The flow rate from the pumping well will be recorded with either an analog or digital flowmeter. The aquifer test will last 8 hours, at which point a water sample will be collected from the discharge hose and analyzed for the presence of TPHg and BTEX.

The aquifer test data will be analyzed to determine the specific capacity and well yield of RW-1. The data will be further analyzed to estimate aquifer parameters such as transmissivity, hydraulic conductivity and radius of influence of the recovery well.

Extracted ground water will be stored in a portable tank onsite. A licensed waste hauler will be used for disposal of the water after sample results are received.

2.3 Combined Constant Discharge and Soil Vapor Extraction Test

A combined constant discharge and soil vapor extraction (SVE) test to evaluate subsurface conditions, provide information for the design of a remediation system, and to assess the feasibility of these two technologies in combination is proposed. Before beginning the test, HETI will obtain all required notifications for the air discharge from the Bay Area Air Quality Management District (BAAQMD). A copy of the permit or notification will be kept on site during the test.

Ground water will be pumped as soil vapor is extracted from recovery well RW-1. Gauges will be placed on surrounding wells to monitor the radial influence of vacuum or pressure and the change in that influence over time. The applied vacuum, extracted soil vapor flow rate, and the concentration of oxygen and volatile chemicals in the extracted vapor will be monitored for the duration of the test. The test may be performed at various vacuum levels and flowrates.

As the vacuum is applied, the extracted soil vapor will be treated with an internal combustion engine before being discharged to the atmosphere. This engine will be leased from a third party, and has been specially modified to treat extracted soil vapor. Samples of the extracted soil vapor will be obtained from the recovery well at the beginning and the end of the test, and analyzed for total petroleum hydrocarbons, calculated as gasoline (TPHg) and benzene, toluene, ethylbenzene and total xylenes (BTEX).

2.4 Reporting

Following well installation and field tests, HETI will prepare a brief report summarizing the tests and results.

3.0 PROPOSED SCHEDULE

The installation of the ground water recovery well can take place following approval of this workplan. Well permits can be applied for before this plan is approved. The following tentative schedule is proposed:

TASK	COMPLETION DATE
Install ground water recovery well	August 21, 1993
Perform step-drawdown test	August 24, 1993
Perform constant discharge test	August 25, 1993
Perform combined constant discharge and vapor extraction test	August 26, 1993
Submit report	September 24, 1993

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TECHNOLOGIES, INC.

CERTIFICATION

This workplan was prepared under the supervision of a registered professional engineer. All statements, conclusions and recommendations are based solely upon field observations and analytical analyses performed by a state-certified laboratory related to work performed by Hydro-Environmental Technologies, Inc.

It is possible that variations in soil or ground water conditions exist beyond the points explored in this investigation. Also, site conditions are subject to change at some time in the future due variations in rainfall, temperature, regional water usage, or other factors.

The service performed by Hydro-Environmental Technologies, Inc. has been conducted in a manner consistent with the level of care and skill ordinarily exercised by members of our profession currently practicing under similar conditions in the area of the site. No other warranty, expressed or implied, is made.

HYDRO-ENVIRONMENTAL TECHNOLOGIES, INC.

Prepared by:

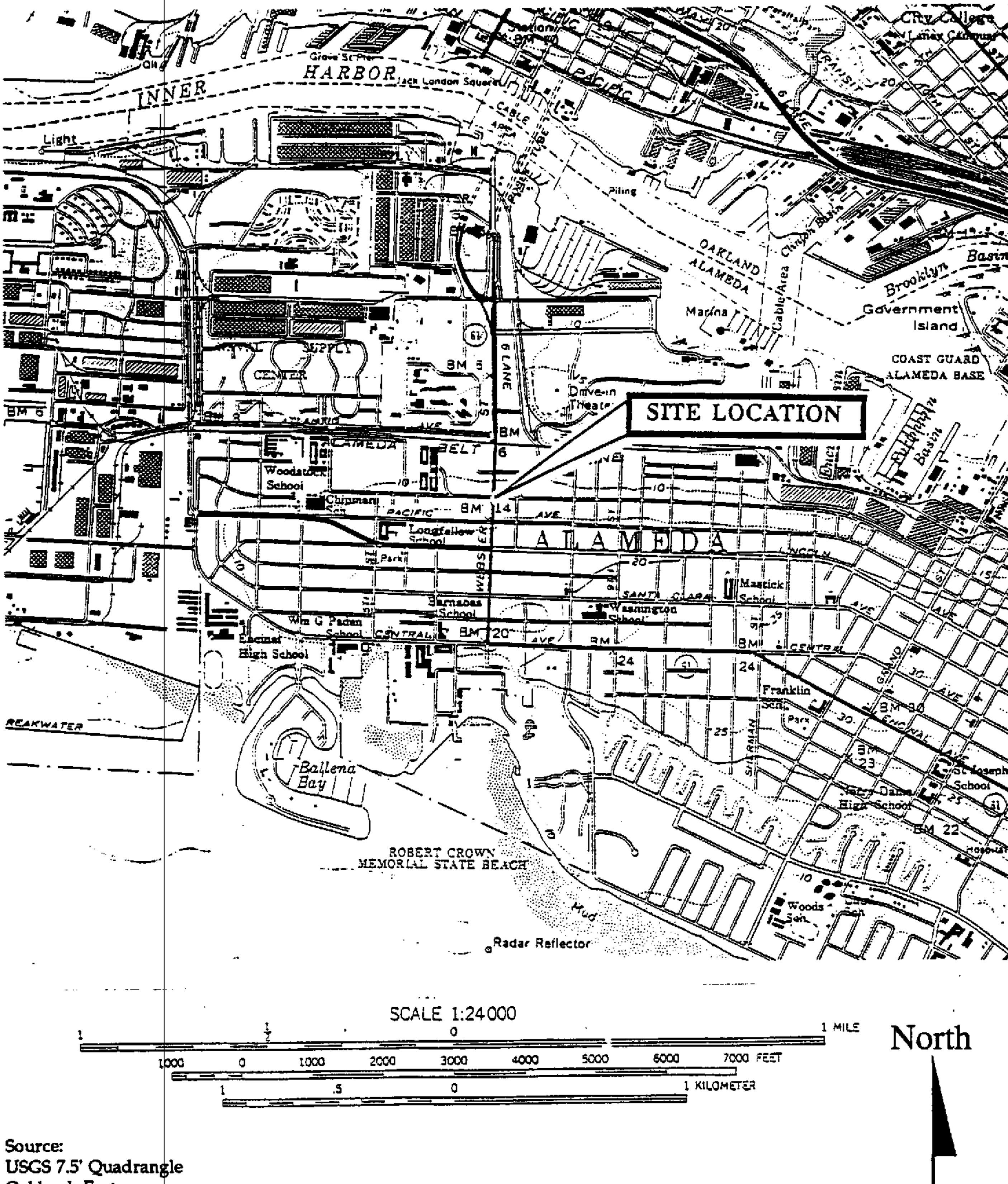
FRANCES MARONI

Frances Maroni
Project Engineer

Reviewed by:

John Turney, P.E.
Senior Engineer

FIGURES



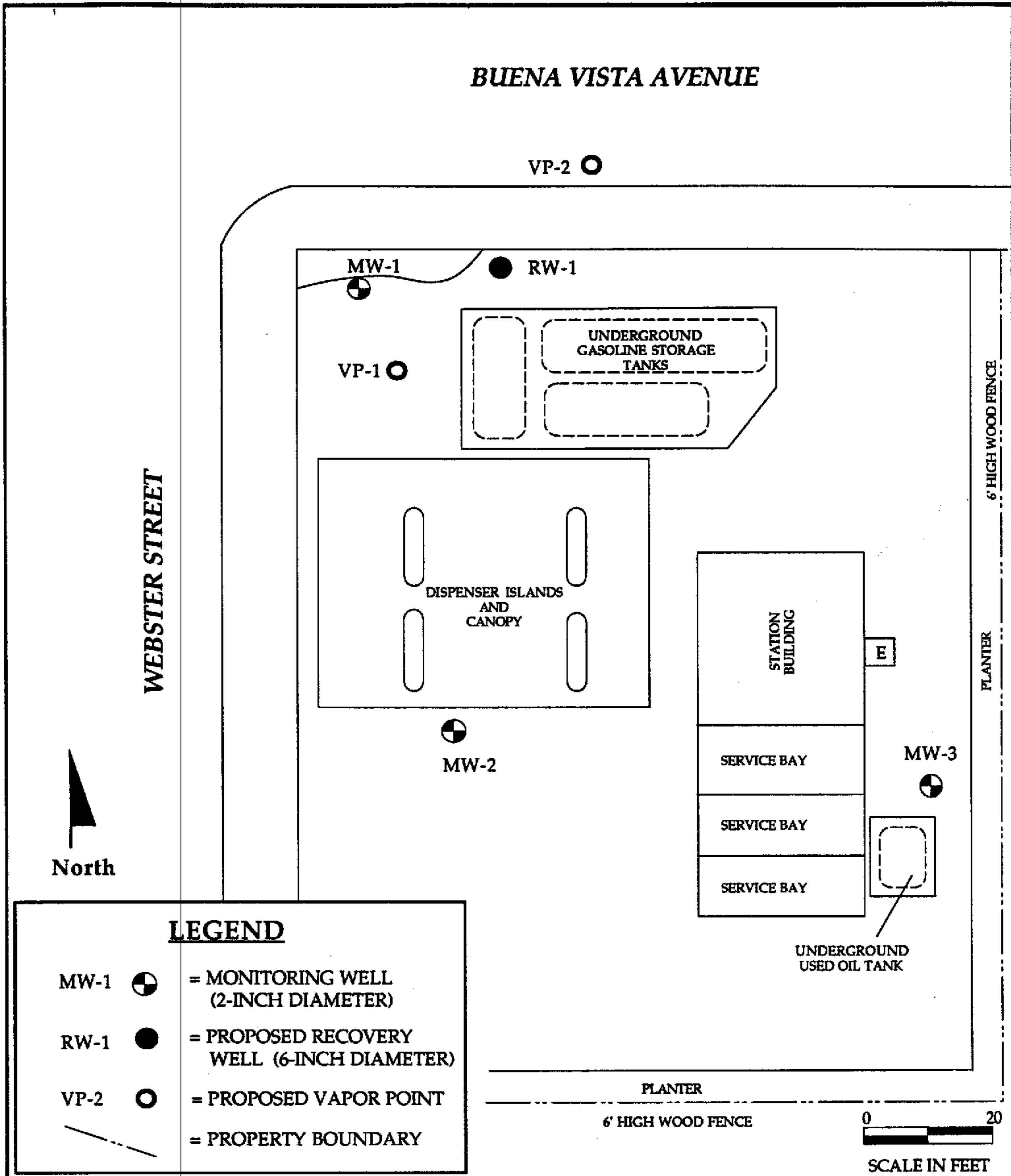
Source:
USGS 7.5' Quadrangle
Oakland, East

HYDRO-ENVIRONMENTAL TECHNOLOGIES, INC.

SITE LOCATION MAP

BP Oil Facility No. 11104
1716 Webster Street
Alameda, California

Job No.
9-038
Figure
1



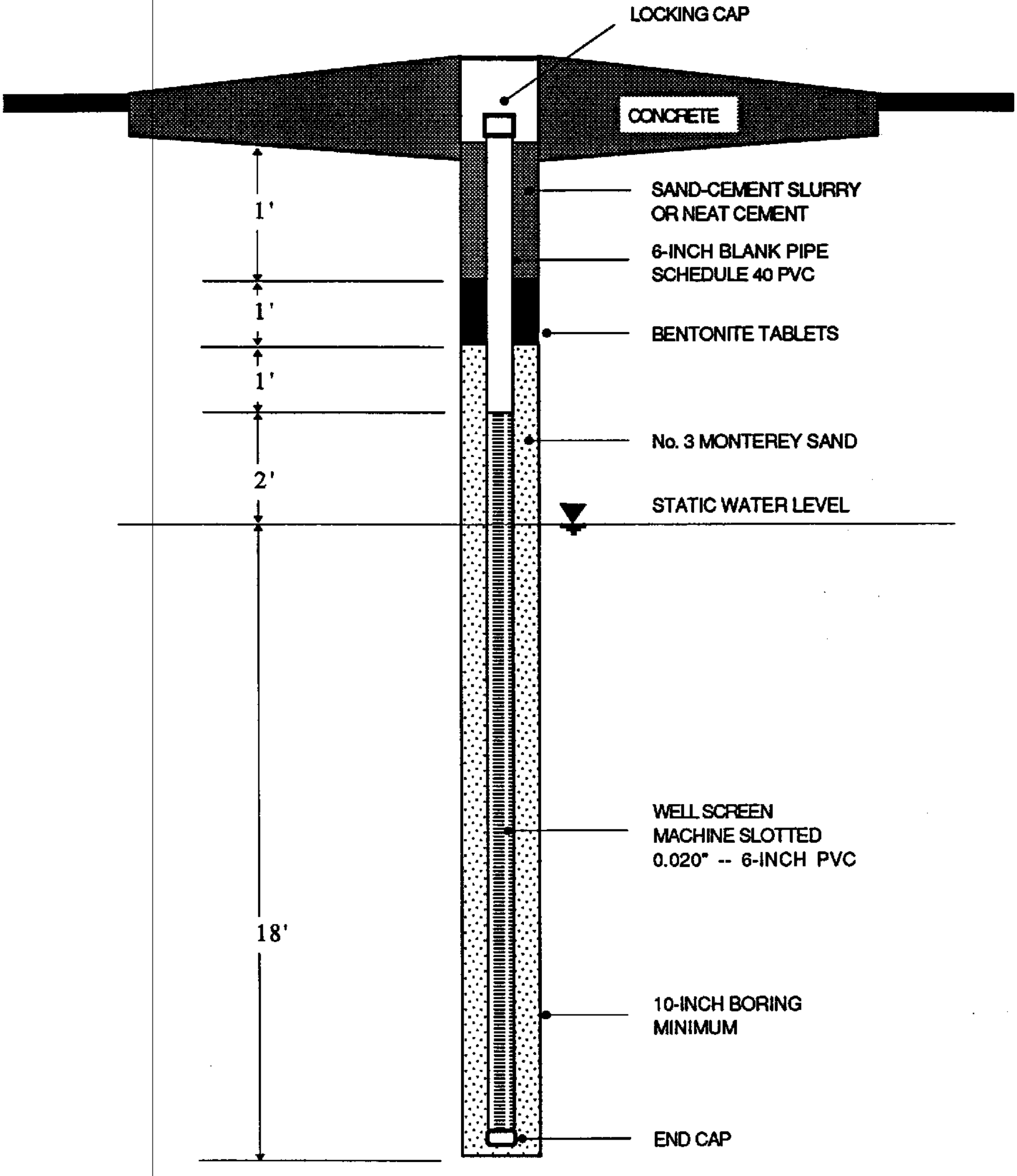
HYDRO-ENVIRONMENTAL TECHNOLOGIES, INC.

SITE PLAN

BP Oil Facility No. 11104
1716 Webster Street
Alameda, California

Job No. 9-038
Figure 2

7/8/93



NOT TO SCALE

HYDRO-ENVIRONMENTAL TECHNOLOGIES, INC.	**TYPICAL RECOVERY WELL CONSTRUCTION** BP Service Station No. 11104 1716 Webster Street Alameda, California	Job No. 9-038 Figure 3 7/9/93

APPENDIX A

HYDRO-ENVIRONMENTAL TECHNOLOGIES, INC.
CALIFORNIA

DRILLING
WELL CONSTRUCTION
AND
SAMPLING PROTOCOLS

November 1992

DRILLING, WELL CONSTRUCTION, AND SAMPLING PROTOCOLS

Drilling Protocol

Prior to any drilling activities, Hydro-Environmental Technologies, Inc. (HETI) will verify that necessary drilling permits have been secured.

Prior to drilling, underground and above ground utilities will be located using Underground Service Alert (USA) and site reconnaissance. To the extent possible, drilling will be conducted so that disruptions of normal business activities at the project site are minimized. HETI shall obtain and review available public data on subsurface geology and, if warranted, the location of wells within a quarter mile of the project site will be identified. Drilling equipment will be inspected for suitability and integrity prior to performing work.

Subsurface investigations are typically performed to assess the lateral and vertical extent of petroleum hydrocarbons or other contaminants which may be present in soils and groundwater. Drilling methods will be selected to optimize field data requirements and to be compatible with known or suspected subsurface geologic conditions.

Shallow soil borings will be drilled dry using a truck-mounted hollow-stem auger drilling rig, unless site conditions favor a different drilling method. Drilling and sampling methods will be consistent with ASTM Method D-1452-80. The auger size will be a minimum of 3-inches nominal outside diameter (O.D.) for borings not to be completed as wells. The auger size will be a minimum of 8-inches nominal O.D. for borings to be completed as wells. No drilling fluids will be used during this drilling method. All augers and drill rods will initially be thoroughly steam cleaned before arriving on-site, to prevent the introduction of contaminants from off-site, and augers and drill rods which are used will be steam cleaned between borings away from boring locations. Working components of the drilling rig (subs, collars and all parts of the rig chassis near the borehole) will also be steam cleaned. Cleaned augers, rods and other tools, if required, will be stored and covered when not in use. Decontamination of drilling equipment will consist of steam cleaning, and/or trisodium phosphate wash. Cleaning operations will be observed and supervised by a representative of HETI. The drilling rig will also be inspected by a representative of HETI to ensure that no fluids (hydraulic or lubricant) are leaking from the equipment.

Soil Sampling Protocol

Soil samples are typically collected at 5-foot intervals, from the ground surface to the total depth of the boring, with a California Modified split-spoon sampler driven 18 to 24 inches ahead of the lead auger by a 140-pound hammer falling a minimum of 30 inches. The sampler will be lined with clean brass or stainless steel tubes. The number of blows necessary to drive the sampler will be recorded on the boring log and well construction diagram (Plate A-1) to help evaluate the consistency of the materials encountered. Additional soil samples may be collected based on significant lithologic changes and/or potential chemical content. All equipment that contacts soil samples will be thoroughly cleaned prior to arrival at the project site and between each individual sample collection point on-site. New and used split-spoon samplers will be steam cleaned or washed with a trisodium phosphate or Alconox solution, rinsed with tap water, air dried or wiped dry with a clean towel. Soil removed from the top two liners (typically each 4 to 6 inches in length) and the end cone will be used for visual logging purposes and disposed with cuttings produced during the drilling operations. The bottom liner, if suitable, will be preserved for laboratory analysis. Soil samples from each sampling interval will be lithologically described, consistent with the Unified Soil Classification System, by a HETI geologist. The exact depth of all borings to the nearest 1/2-

foot will be determined in the field. Exploratory boring logs shall be prepared under the direction of a Registered Geologist or Professional Engineer.

Head-space analysis will be performed in the field to check for the presence of volatile organic compounds. Head-space analysis will be performed using an organic vapor meter (either flame-ionization or photo-ionization). The method used will be consistent with the method described by Fitzgerald (1989). Organic vapor concentrations will be recorded on the HETI Soil Boring Log (Figure 1). The selection of soil samples for chemical analysis are typically based on the following criteria:

a. Soil discoloration
b. Soil odors
c. Visual confirmation of chemical in soil
d. Depth with respect to underground tanks
e. Depth with respect to groundwater
f. Organic vapor meter reading

The soil sampler and liners will be cleaned with a trisodium-phosphate or Alconox solution, rinsed with clean tap water and air dried or wiped dry with a clean towel prior to each sampling event. Soil samples (full liners) selected for chemical analyses will be covered with aluminum foil or teflon tape and the ends will be sealed with plastic end caps. The end caps will then be taped to ensure a more secure seal. The samples will then be labeled and entered onto a Chain-of-Custody document, and placed in a cooler on blue ice (hard shell) for transport to a state certified analytical laboratory.

Where copper and zinc contamination are the subject of the investigation, stainless steel liners will be used in lieu of brass liners. Stainless steel liners will also be used when the client, additional sampling protocol or regulatory agencies require.

Soil borings will be backfilled (sealed) to the ground surface using either a neat cement or cement-bentonite grout mixture in accordance with appropriate local regulations.

Pending the outcome of the results of the laboratory analyses, excess drill cuttings will remain on-site and, when deemed necessary, covered with a plastic tarp or drummed. Confirmed uncontaminated soils may be appropriately disposed of on-site by the client. Soils found to contain concentrations of contaminants above applicable local or state limits will be placed in appropriately labeled 55-gallon D.O.T. drums or in a hazardous materials drop bin and left on-site for proper disposal by the client. At the clients request, HETI will act as the client's agent by assisting in the disposal of the contained material. In no case will HETI personel sign a Hazardous Waste Manifest.

<u>Well Construction</u>

Monitoring wells shall be installed using a truck-mounted hollow-stem auger drilling rig or an air or mud-rotary drilling rig. Typically, the hollow stem rig will be used for the installation of wells up to 100 feet deep, if subsurface conditions prove favorable. Wells greater than 100 feet in depth will typically be drilled using air or mud-rotary equipment. Mud-rotary equipment will typically be used when alternate methods have failed or proven ineffective.

Monitoring well casing and screen shall be constructed of a minimum of Schedule 40, flush joint, threaded, polyvinylchloride (PVC) pipe. The well screen will be factory mill-slotted. The screen length shall be determined in the field and shall be placed with the intent of setting the screened interval adjacent to the aquifer material. The screen length shall also be set with the intent of placing the top of the screened interval a minimum of 2 feet above the static water level. All screens and casings used will be in a contaminant-free condition when placed in the ground. No thread lubrication shall be used, other than teflon tape or distilled water, during the connection of individual lengths of screened and solid well casing. Screen shall not be placed in a borehole that creates hydraulic interconnection of two or more distinctly separate aquifer units. Screen slot size will be chosen to be compatible with the encountered aquifer materials. The screen slot size will be chosen to retain a high percentage of the filter pack or natural formation. The remainder of the well casing, above the screened interval, shall be of solid riser casing. A sand pack shall be placed in the remaining anular space surrounding the well casing to a minimum of 1 foot above the screened interval. Sand pack shall not be placed such that it interconnects two or more distinctly separate aquifer units. Sand pack shall be chosen to be compatible with both the aquifer materials and the screen slot size. Sand pack shall consist of clean, washed, kiln dried silica sand. A minimum 1-foot thick bentonite pellet or bentonite slurry seal shall be placed above the sand pack. All bentonite shall be hydrated by either formation water or steam-distilled water. The remaining annular space above the bentonite seal shall be grouted with a neat cement or bentonite-neat cement mixture and shall be placed from the top of the bentonite pellet seal to within 6 inches of the top of the well. If used, the bentonite content of the mixture shall not exceed 5 percent by weight. Sand pack, bentonite, and cement seal levels will be confirmed during construction by measuring the remaining anular space with a calibrated weighted tape. If shallow water table conditions prevail, the screen interval will be placed such that the screen height above the static water level is reduced and a maximum possible surface seal can be achieved. A field boring log and well construction diagram (Plate A-1) shall be prepared by a representative of HETI for each well completed. Monitoring and extraction wells shall be constructed with Class-A cement/bentonite grout or bentonite pellets tremied into position as a base for the well casing if necessary. The well casing will be set within the aquifer according to the proposed function of the well and the chemistry of the potential contaminants.

In the event a monitoring well is required to be installed in an aquifer unit underlying an existing, shallower aquifer, the well will be completed in the lower aquifer such that only water from the lower aquifer is drawn into the well. The upper aquifer will be sealed by installing a steel conductor casing which extends to the base of the shallow aquifer. The steel casing will be tremied into position with an annular neat cement or cement-bentonite grout seal placed between the outside wall of the casing and the wall of the borehole. The cement grout will be allowed a minimum of 72 hours to set prior to advancing the boring beyond the sealed conductor casing and into the next aquifer. After 72 hours, the boring will be advanced below the seal and completed as a well as described above but within the steel conductor casing.

The tops of all well casings will be sealed and placed in a vandal resistant, traffic rated box to prevent entry of surface contamination, unauthorized entry and tampering.

Monitoring wells will be surveyed to obtain north-end casing elevations to the nearest ± 0.01 foot. Water level measurements will be recorded with an interface probe to the nearest ± 0.01 foot and referenced to either a project datum or mean sea level (MSL). A project site datum is typically chosen such that it will remain in the event the project site undergoes a physical change as a result of construction or other cultural disturbance. Where required, the wells will be surveyed by a licensed land surveyor relative to the nearest bench mark and relative to mean sea level. Typically, the establishment of a known, on-site reference by a licensed survey, is enough to allow for the remaining well top elevations to be determined using a survey level and rod. Unless directed otherwise by local regulatory agencies, the well top elevations will be established in this manner.

Well Development

After installation, all monitoring wells shall be developed to remove fine grained sediments from the well and to stabilize sand, gravel and disturbed aquifer materials in the annular area around the screened interval. Well development will be accomplished by air-lift pump, suction-lift pump, submersible pump, bladder pump, surge block, bailer or any combination of the above. All well development equipment will be decontaminated prior to development using a steam cleaner and/or trisodium-phosphate solution wash, clean water rinse, and steam distilled water rinse. Well development will continue until each well is relatively free of turbidity. The adequacy of well development will be assessed by a HETI geologist. Where appropriate, indicator parameters (pH, specific conductance, temperature, and turbidity) will be monitored during well development. Field instrument calibrations will be performed prior to use according to manufacturers specifications.

Well Head Completion and Site Clean-up

Monitoring wells shall be completed below grade unless special conditions exist that require above grade design. Monitoring well casing (including the well locking seal and cap) will be completed approximately two inches below the vandal resistant traffic rated road box cover. Except in areas where snow plows might be used, the road box cover shall be completed approximately one inch above the existing grade surface to allow for precipitation runoff. All concrete work, both inside and outside the road box, shall be completed with a smooth finish.

Above ground completions will be set inside a 2 to 3 foot tall locking steel protective casing. If traffic conditions dictate, three 4-inch diameter steel pipes will be set in concrete in a triangular pattern to act as bumper posts. The posts will be set 2 feet deep and will be filled with concrete. A four foot square, 3-inch thick concrete pad which slopes away from the well will be set around each well. Both the protective steel well casing and the bumper posts will be painted yellow.

The project site shall be left as clean as possible. All soils and excess concrete produced from each monitoring well will be placed in appropriate areas to be disposed as previously described. All monitoring well locations will either be broomed or washed down such that staining of the existing surface cover is minimized.

GROUNDWATER SAMPLING AND ANALYSIS

Quality Assurance/Quality Control Objectives

The sampling and analysis procedures employed by HETI for groundwater sampling and monitoring follow specific Quality Assurance/Quality Control (QA/QC) guidelines. Quality Assurance (QA) objectives have been established by HETI to develop and implement procedures for obtaining field data and evaluating water quality in an accurate, precise and complete manner so that sampling procedures and field measurements provide information that is comparable and representative of the actual field conditions. Quality Control (QC) is maintained by HETI by using specific field protocols and requiring the analytical laboratory to perform internal and external QC checks. It is the goal of HETI to provide data that are accurate, precise, complete, comparable, and representative. The definitions for accuracy, precision, completeness, comparability, and representativeness are as follows:

1. Accuracy - the degree of agreement of a measurement with an accepted reference or true value.

2. Precision - a measure of agreement among individual measurements under similar conditions. Usually expressed in terms of standard deviation.

3. Completeness - the amount of valid data obtained from a measurement system compared to the amount that was expected to meet the project data goals.

4. Comparability - the confidence with which one data set can be compared with another.

5. Representativeness - the degree to which a sample or group of samples reflect the characteristics of a media at a given sampling point. Also includes the degree to which a sampling point represents the actual parameter variations which are under study.

As part of the HETI QA/QC program, applicable federal, state and local reference documents are to be followed. The procedures outlined in these regulations, manuals, handbooks, guidance documents and journals are incorporated into the HETI sampling procedures to assure that: (1) groundwater samples are properly collected, (2) groundwater samples are identified, preserved, and transported in a manner such that they are representative of field conditions, and (3) chemical analyses of samples are accurate and reproducible.

GUIDANCE AND REFERENCE DOCUMENTS USED TO COLLECT GROUNDWATER SAMPLES

U.S.E.P.A. - 339/9-51-002	NEIC Manual for Groundwater/ Subsurface Investigation at Hazardous Waste Sites
U.S.E.P.A. - 503/SW611	Procedures Manual for Groundwater Monitoring at Solid Waste Disposal Facilities (August, 1977)
U.S.E.P.A. - 600/4-79-020	Methods for Chemical Analysis of Water and Wastes (1983)
U.S.E.P.A. - 600/4-82-029	Handbook for Sampling and Sample Preservation of Water and Wastewater (1982)
U.S.E.P.A. - SW-846#, 3rd Edition	Test Methods for Evaluating Solid Waste - Physical/Chemical Methods (November, 1986) and latter additions
40 CFR 136.3e Table II	Required Containers, Preservation Techniques, and Holding Times
Resources Conservation and Recovery Act (OSWER 9950.1)	Groundwater Monitoring Technical Enforcement Guidance Document (September, 1986)
California Regional Water Quality Control Board (Central Valley Region)	A Compilation of Water Quality Goals (September, 1988); Updates (October, 1988)
California Regional Water Quality Control Board (North Coast, San Francisco Bay, and Central Valley)	Regional Board Staff Recommendations for Initial Evaluations and Investigation of Underground Tanks: Tri-Regional Recommendations (June, 1988)
California Regional Water Quality Control Board (Central Valley Region)	Memorandum: Disposal, Treatment, and Refuse of Soils Contaminated with Petroleum Fractions (August, 1986)
State of California Department of Health Services	Hazardous Waste Testing Laboratory Certification List (March, 1987)
State of California Water Resources Board	Leaking Underground Fuel Tank Control (LUFT) Field Manual (May, 1988), and LUFT Field Manual Revision (April, 1989)

State of California Water Resources 85), Control Board	Title 23 (Register #85.#33-8-17- Subchapter 16: Underground Tank Regulations; Article 3, Sections 2632 and 2634; Article 4, Section 2647 (October, 1986)
Santa Clara Valley Water District	Guidelines for Investigating Fuel Leaks (March, 1989)
Santa Clara Valley Water District	Guidelines for Preparing or Reviewing Sampling Plans for Soil and Groundwater Investigation of Fuel Contamination Sites (January, 1989)
Alameda County Water District	Groundwater Protection Program: Guidelines for Groundwater and Soil Investigations at Leaking Underground Fuel Tank Sites (most recent revision)
American Public Health Association	Standard Methods for the Examination of Water and Wastewaters, 16th Edition
Analytical Chemistry (journal)	Principles of Environmental Analysis Volume 55, pages 2212-18,December, 1983
American Petroleum Institute Environmental Affairs Dept., June, 1983	Groundwater Monitoring & Sample Bias
The Bay Area Air Quality Management District	Regulation 8 - Rule 40 & Rule 48

Because groundwater samples collected by HETI are analyzed in the parts per billion (ppb) range for many analytes, care is exercised to prevent contamination of samples. When volatile or semivolatile organic compounds are included for analysis, HETI sampling crew members will adhere to the following precautions in the field:

1. A new pair of clean, disposable, latex (or comparable material) gloves are to be worn for each well to be sampled.

2. When possible, samples will first be collected from wells known or suspected to contain the fewest contaminants, followed by wells in increasing order of degree of contamination.

3. All sample bottles and equipment are to be kept away from fuels and solvents. When possible, gasoline (used in generators and water pumps) is to be shipped to the project site in separate compartments of the same vehicle or in a separate vehicle as that in which sample bottles are shipped.

4. Sampling bailers are to be composed of polyethylene (when dedicated to the well), Teflon or stainless steel. Other materials, such as acrylic, may contain phthalate esters which can interfere with gas chromatography (GC) analyses. Well purging may be performed with PVC bailers.

5. Volatile organic groundwater samples are collected so that air passage through the sample does not occur or is minimal (to prevent volatiles from being stripped from the samples). Sample bottles are filled by slowly running the sample down the side of the bottle until there is a positive convex meniscus over the neck of the bottle. The Teflon side of the septum (in cap) is positioned against the meniscus and the cap is screwed on tightly. The sample is then inverted and lightly tapped while the sampler inspects the contents of the bottle for an air bubble. The absence of an air bubble indicates a successful seal. If a bubble is evident, the cap is removed and more water is added to the sample. The inspection procedure is repeated and if bubbles persist, the vial is discarded in a container designated for used and broken vials and bottles and the sample filling procedure is repeated with another vial.

6. Extra vials shall be available for use in the event of dropped bottles and/or caps. Any bottle which has come in contact with the ground shall be considered contaminated and shall not be used. When replacing septa, or if septa become inverted, care shall be taken to assure that the Teflon seal faces the interior of the bottle.

7. All preservatives shall be provided by the contract analytical laboratory.

Laboratory and field handling procedures of samples may be monitored by including QC samples for analysis with sample lots from a project site. QC samples may include any combination of the following:

1. Trip Blank - Used for purgable organic compounds only; QC samples shall be collected in 40 milliliter (ml) sample vials filled in the analytical laboratory with organic free water. Trip blanks should be sent to the project site, and travel with the samples from the project site. Trip blanks are <u>not</u> opened, and are returned from the project site with the samples from the project site for analysis.

2 Field Blank - Prepared in the field using steam-distilled water. Field blank QC samples shall accompany project site samples to the laboratory and shall be analyzed for the same chemical parameters as those samples taken from the project site.

3. Equipment Blank - Equipment Blank QC samples shall be prepared in the field using field equipment rinsate between two different wells after the equipment has been washed and rinsed. The equipment blank will consist of deionized water retained in the sampling equipment. These QC samples will only be taken when a dedicated bailer is not used for sampling.

4. Duplicates - Duplicate QC samples shall be collected "second samples" from a selected well and project site. Duplicates shall be collected as either split samples or second-run samples (i.e. later date) from the same well.

The number and types of QC samples shall be determined by HETI on a site-specific basis.

GROUNDWATER SAMPLE COLLECTION

This section describes the routine procedures followed by HETI while collecting groundwater samples for chemical analysis. These procedures include decontamination, water level measurements, well purging, physical parameter measurements, sample collection, sample preservation, and sample handling. Critical sampling objectives for HETI are to:

1. Collect groundwater samples which are representative of the sampled matrix.

2. Maintain sample integrity from the time of sample collection to delivery to the analytical laboratory.

Sample analyses, methods, containers, preservation, and holding times are presented in Table A-1.

Decontamination Procedures

All physical parameter measuring and sampling equipment shall be decontaminated prior to measurement and sample collection using a trisodium phosphate or Alconox solution wash, followed by two separate rinses in tap water, followed by one rinse in steam-distilled water. Any sampling equipment surfaces or parts that might absorb specific contaminants, such as plastic pump valves, impellers, etc., are to be cleaned in the same manner.

Sample bottles, bottle caps, and septa used for sampling volatile organics are thoroughly pre-cleaned in either the laboratory or the factory. All appropriate measures shall be taken to assure continued sterility of the containers issued by the contract laboratory prior to usage at the project site.

During field sampling, equipment which has been placed in a well shall be decontaminated by washing with a trisodium-phosphate or Alconox solution followed by two rinses in tap water and one rinse in steam-distilled water.

Water Level Measurements

Prior to purging and sampling any wells, the static-water level shall be measured by use of an electronic sounder and/or calibrated portable oil-water interface probe. Both static water level and separate phase product thickness shall be measured and noted to the nearest ±0.01 foot. Interface probe results shall be confirmed by sampling the top of the water column with a clear bailer and measuring any floating product thickness to the nearest ±0.01 foot with an engineers scale tape. In all cases a clear bailer sample will be taken from each well to check for color, sheen and undetected floating product. If floating product of any measureable thickness is observed, no sampling will be performed for that well. If visible product sheen is observed, sampling shall proceed under normal protocols.

The line used to lower the bailer shall be discarded after each use to preclude the possibility of cross contamination. Field observations (e.g., well integrity, product odor, turbidity, water color, odors, etc.) shall be recorded on the HETI Purge/Sample Sheet (Plate A-2). Before and after the use of the electric sounder, interface probe, non-dedicated bailer, or any other down well equipment, each will be decontaminated by washing in a trisodium phosphate or Alconox solution, followed by a double rinse with tap water, followed by a rinse with steam-distilled water.

Well Purging

Before sampling commences, well casing storage water and interstitial water in the artificial sand pack shall be purged from the well using: (1) a positive displacement bladder pump constructed of inert non-wetting Teflon and stainless steel; (2) a pneumatic-airlift pumping system; (3) a centrifugal pumping system; or (4) a PVC, Teflon or stainless steel bailer. Methods of purging will be assessed based on the well size, location, depth, accessibility, and known chemical conditions. Individual well purge volumes are calculated from the casing volumes. In general, a minimum of 3 to 5 casing volumes will be purged. Wells which dewater or demonstrate slow recharge capacities (i.e., low yield wells which only recover to 70 percent of initial water column height after 1 hour) during purging activities may be sampled after fewer than 3 to 5 purging cycles. If a low yield well is to be sampled, sampling shall not take place until at least 70 percent of the previously measured water column has been replaced by recharge. Monitoring wells shall be purged according to the protocol flowchart presented in Plate A-3. Water removed from the wells will either be disposed or stored in 55-gallon DOT drums for future disposal according to proceedures outlined for contaminated soil cuttings in the Soil Sampling Protocol section above. Where appropriate, physical parameters (pH, specific conductance, and temperature) will be monitored by HETI field crew during well purging operations. If necessary, purging may continue until all three physical parameters have stabilized. Stability shall be defined as a change of less than 0.2 pH units, less than 10 percent in micro mhos, and less than 1.0 degree Centigrade. The pH meters shall be read to the nearest ± 0.1 pH units. Specific conductance meters shall be read to the nearest ± 10 micro-mhos per centimeter. Both types of meters shall be calibrated daily to manufacturer's specifications. Temperature shall be read to the nearest ± 0.1 degree centigrade. Field data collected while developing, purging and sampling the wells will be entered onto the HETI Purge/Sample Sheet (Plate A-2). Copies of the Purge/Sample Sheets will be reviewed for accuracy and completeness for each well sampled.

DOCUMENTATION

Sample Container Labels

Each sample container shall be labeled immediately after the sample is collected and sealed. The label shall include:

- Company Name (HETI)
- Source (i.e., well number or code)
- Sampler's identification
- Project number
- Date and time of collection
- Type of preservation (if any) used

Field Sampling Data Sheets

In the field, the HETI sampling crew will record the following information on the Purge/Sample Sheet (Plate A-2) for each well sampled:

- Project number
- Client
- Location
- Source (i.e., well number or code)
- Time and date of development, purging and sampling
- Well accessibility and integrity
- Pertinent well data (e.g., total depth, product thickness, static water level)
- Physical parameters when appropriate (e.g., specific conductance, pH, temperature) - may be more than one reading
- Gallons and well casing volumes purged

Chain-of-Custody

A chain-of-custody record shall be completed and will accompany every shipment of samples to the analytical laboratory in order to establish documentation tracing sample possession from the time of collection until delivery to the laboratory. The record will contain the following information:

- Sample or station number or code (ID)
- Signature of the collector, sampler, or recorder
- Date and time of collection
- Place of collection (project address and name of business)
- Sample type (soil or water)
- Type of analysis requested
- Signatures of persons involved in chain of possession (in chronological order)
- Dates and times of individual possession (inclusive)
- Laboratory comments regarding the sample receptacle conditions

Samples will always be accompanied by a Chain-of-Custody record. When transferring the samples, the individuals relinquishing and receiving the samples will sign, date and note the time on the Chain-of-Custody record.

Sample Collection, Handling, Storage and Transport

All water samples will be collected in an order such that those parameters most sensitive to volatilization will be sampled first. A general order of collection for some common groundwater parameters is as follows:

- Volatile Organic Compounds (VOC's)
- Total Organic Halogens (TOH)
- Total Organic Carbon (TOC)
- Extractable Organics
- Total Metals
- Dissolved Metals
- Phenols
- Sulfate and Chloride
- Nitrate and Ammonia
- Turbidity

All samples from the same well shall be collected immediately after purging or when the well recovers to 70 percent of the original water column height. All samples from one sampling set from a single well should be collected on the same day.

All chemical sample handling and storage will be conducted under the direction of HETI's consulting analytical chemist. All laboratory chemical testing will be accomplished by a state approved analytical laboratory.

All water samples will be held at 4°C by packing them in a water-tight container inside an ice chest and covering with hard shelled "blue ice™". In no event shall the time between sample collection and delivery to the contract laboratory be greater than 72 hours. Preservatives will not be added to any sample by the sampling crew, unless instructed by the consulting analytical chemist. If added in the field, preservatives shall be supplied by the contract analytical laboratory. No one will open the samples other than laboratory personnel who will perform the specified chemical analyses.

If it is necessary for samples or sample ice chests to leave the immediate control of the sampling crew prior to delivery to the laboratory or laboratory courier, such as shipment by a common carrier (e.g., UPS™), a custody seal will be placed on each sample container and/or sample chest. Custody seals will be placed to ensure that the samples have not been tampered with during shipment and will contain the samplers signature, the date and time the seal was emplaced.

TABLE A-1

SAMPLE ANALYSIS METHODS, CONTAINERS, PRESERVATIVES, AND HOLDING TIMES

Parameter	Analytical Method	Reporting Units	Container*	Preservation†	Maximum Holding Time
Total Petroleum Hydrocarbons (low to med. b.p. i.e. gasoline)	EPA 8015 (DHS modified)	ppb ug/l	40ml glass vial, Teflon lined septum	4°C HCl to pH<2**	14 days
Benzene Toluene Ethylbenzene Xylenes (BTEX)	EPA 8020	ppb ug/l	40ml glass vial, Teflon lined septum	4°C HCl to pH<2**	7 days(w/o preservative) 14 days (w/preservative)
Oil & Grease	SM 503A&E	ppb ug/l	1L glass jar, Teflon lined cap	4°C H2SO4 to pH<2	28 days
Total Petroleum Hydrocarbons (high. b.p. i.e. diesel)	EPA 8015 (DHS modified)	ppb ug/l	1L glass jar, Teflon lined cap	4°C	14 days
Halogenated Volatile Organics (chlorinated solvents)	EPA 8010	ppb ug/l	40ml glass vial, Teflon lined septum	4°C	14 days
Non-Chlorinated Solvents	EPA 8020	ppb ug/l	as above	4°C	14 days
Volatile Organics (GC/MS)	EPA 8240	ppb ug/l	as above	4°C	14 days
Semi-Volatile Organics (GC/MS)	EPA 8270	ppb ug/l	as above	4°C	14 days
Metals	ICP-EPA 200.7 or A.A.EPA-	ppb ug/l	100 ml	4°C HNO3 to pH<2	6 months

* Containers listed are for water - soil containers are to be brass or stainless steel tubes with plastic end caps.

† Applies only to liquid samples.

** May vary depending on lab requirements.

HYDRO-ENVIRONMENTAL TECHNOLOGIES, INC.
CALIFORNIA

SOIL VAPOR EXTRACTION TEST PROTOCOL

July 1993

SOIL VAPOR EXTRACTION TEST PROTOCOL

Successful design of a Soil Vapor Extraction (SVE) system requires knowledge of the following:

- Contaminant composition
- Soil plume definition
- Vapor concentration and composition
- Flow rate vs applied vacuum
- Radius of Influence

The last three of these components are found by testing. The particular aspects of these items are expanded as follows:

Vapor Concentration and Composition

The determination of vapor concentration in the extracted air stream is important for two reasons: to calculate the removal efficiency of the test extraction well and to provide information necessary to specify the off-gas treatment equipment. Vapor samples should be taken at the beginning and end of the SVE test, which should be conducted for a long enough time to extract at least one pore volume of vapor from the contaminated soil zone. The initial vapor concentration is representative of the initial equilibrium vapor concentration, while the concentration measured after one pore volume has been extracted gives an indication of realistic removal rates.

The initial and final concentration measurements during the VET should be done using State DHS-certified laboratory analysis of vapor samples using methods 8015/8020 (modified). Samples will be collected in evacuated, one-liter Tedlar® bags from the undiluted vapor stream using a sample pump. The sample data will be entered onto a Chain-of-Custody form and each sample labeled with a unique designation. Following collection, the sample bag will be placed immediately into an opaque cooler to minimize exposure to light. Chilling is not required. Samples will be analyzed as soon as possible, but no more than 72 hours from collection.

A Gastech 1214S LEL/O_2 meter, or equivalent, should be used for intermediate measurements to follow progress. However, these instruments must be calibrated to an appropriate gas such as hexane or heptane.

The oxygen concentration in the extracted vapor stream must be taken, as this affects designs using a thermal or catalytic oxidizer, or internal combustion (IC) engine. A Gastech 1214S LEL/O_2 meter, or equivalent, should be used.

Flow Rate vs Applied Vacuum

To properly specify the vapor extraction blower, the actual flow rate and vacuum during the test must be known. The vapor flow rate should be measured using a Kurz Model 443 thermal anemometer, or equivalent.

Anemometers should be installed with 10 pipe diameters of straight pipe upstream and 5 diameters downstream. The upstream straight pipe may be shortened by installing straightening vanes. They should be mounted through a tight-fitting hole in the side of the pipe. Use of a tee fitting would disrupt flow, causing additional inaccuracy.

Since VETs are often conducted using existing monitoring wells, water table upwelling within the well must be considered when determining screen height. In a monitoring well, approximately one inch of screen height will be lost for every inch of vacuum applied.

The absolute atmospheric pressure should be assumed as the day's barometric reading obtained from the local newspaper and corrected for altitude.

Radius of Influence

Determining soil permeability and radius of influence (R_I) requires that we measure induced vacuum vs distance or induced vacuum vs time for several points. Induced vacuum vs time for several monitoring points is preferable because soil permeability may vary with direction. The data can be entered into Shell Oil Company's HyperVentilate® computer program to determine the soil air permeability.

Radial pressure from an extraction well can be simplified for a fixed P_w, P_{Atm}, R_w and R_I to the following form:

$$P(r) = Ar^b \qquad (5)$$

Where A and b are constants.

Plot P(r) vs r using a program such as Cricket Graph®, which will do a logarithmic curve fit, to determine an average A and b. Then solve for $r = R_I$ where $P(r) = P_{Atm}$.

Vapor Extraction Testing

Vapor extraction testing should be conducted using the attached Vapor Extraction Test Setup and Log sheets. Completion of these forms will provide a checklist for collection of all required information.

Vapor Well Installation Guidelines

Prior to any drilling activities, Hydro-Environmental Technologies, Inc. (HETI) will verify that necessary drilling permits have been secured.

Prior to drilling, underground and above ground utilities will be located using Underground Service Alert (USA) and site reconnaissance. To the extent possible, drilling will be conducted so that disruptions of normal business activities at the project site are minimized. Drilling equipment will be inspected for suitability and integrity prior to performing work.

Wells selected or installed for testing should, if possible, be wells that would be used for remediation. At least one well should be installed and screened in the heart of the plume. Wells screened through clean soils decrease the overall effectiveness of the system unless they will be used for air induction wells. Multiple wells are required for vapor extraction testing to allow measurement of induced pressure as a function of distance.

Well spacing is a function of soil type. Some guidelines for well spacing are:

Gravel	30 to 100 ft
Sand	25 to 75 ft
Silt	15 to 50 ft
Clay	5 to 40 ft

Each pair of wells used for measurements should be screened in the same horizon. The vertical permeability in undisturbed soils can be as little as 10% of the horizontal permeability. Care must be taken near the surface to prevent "short circuiting" of air flow either from the surface, tank field or through paving base rock.

Dedicated vapor extraction wells are normally screened with 2-inch or 4-inch diameter, 0.030-inch slotted casing. A coarse sand pack is used to minimize resistance to air flow. Typical air flow rates from a single well are 25 to 100 scfm.

Well installation protocols are found in HETI's "Drilling, Well Construction and Sampling Protocols." These will be followed.

Conducting The Test

Prior to any testing activities, HETI will verify that necessary air discharge permits have been secured or notifications made. To the extent possible, testing will be conducted so that disruptions of normal business activities at the project site are minimized. Testing equipment will be inspected for suitability and integrity prior to performing work.

1. Extracted soil vapor will be treated with an internal combustion engine before being discharged to the atmosphere. The engine will be rented from a third party that has specifically modified the engine to treat extracted soil vapor.
2. A Gastech 1214S LEL meter, or equivalent, will be used to measure the vapor concentration in each well. These readings will be recorded. Testing will begin with the well with the highest concentration.
3. The depth to water (and product) in each extraction and observation well will be measured and recorded.
4. A Magnehelic® or manometer will be connected to each observation well using the previously assembled wellhead risers. These instruments will be vented prior to beginning the test.
5. After applying vacuum to the extraction well, the vacuum and flow rate will be recorded. Within 5 minutes, a vapor sample will be collected from the well. Corresponding O_2 and LEL readings will be recorded.
6. A second person will record vacuum vs time in the nearest observation wells. Initial readings will be taken as frequently as possible until vacuum stabilizes. Vacuum may stabilize within the nearest observation well within minutes.
7. Readings of flow, vacuum, extraction well temperature, O_2 and vapor concentration from the extraction well will be recorded until one pore volume has been removed.
8. After one pore volume has been removed, a second vapor sample from the extraction well will be collected. A corresponding O_2 and LEL reading will be recorded.
9. Steps 4 through 8 may be repeated on other extraction wells, especially if screened at different vertical intervals.

HETI Vapor Extraction Test Setup

Client: ______________________ HETI Job Number: __________

Site Address: ______________________________

Tester(s): ______________________ Date: __________

Items To Be Completed Prior to Test:

1. ____ Determine wells to be tested. They are: ______________

2. ____ Calculate one pore volume on page 5. Calculate the time to remove one pore volume at:
   25 scfm __________
   50 scfm __________
   100 scfm __________

   ____ If the time to remove one pore volume will be over 4 hours, schedule someone for overtime to continue test on a second shift.

3. ____ Schedule internal combustion engine delivery. Use for multi-day or multi-site tests. Will fuel delivery be required? Do we know how to operate it?

4. ____ Complete known well data on sheet 5. Only depth to water should be measured in field.

5. ____ Schedule sample analysis with lab. Not all labs can do air samples. If we use other than the normal lab, a purchase order may be required. Air samples must be analyzed within 72 hours. Labs don't like to get samples on Friday afternoon. Confirm courier pickup or plan to deliver samples.

6. ____ Complete Sketch of Test Setup on Sheet 4. This should be drawn as a Piping and Instrumentation Diagram (P&ID). Have it reviewed.

7. ____ Do you have <u>all</u> of the fittings to piece together what you've sketched?

8. ____ Calibrate sample equipment (O_2/LEL). Calibrate LEL to heptane in nitrogen.

9. ____ Check the calibration of pressure test equipment.

10. ____ Plan layout of equipment at station. Consider traffic patterns and potential noise complaints.

11. ____ Notify station owner of test schedule, if applicable.

Client: ______________________________ HETI Job Number: __________

Site Address: ____

12. ____ Make up wellhead riser test connections for each well. These utilize socket couplings and silicone stop-cock grease (Remember chemistry lab?) to connect to the well.

13. ____ Charge the test equipment batteries.

14. ____ Complete the Site Safety Plan.

Equipment and Supplies to Bring to the Test

- ____ Interface probe
- ____ Tape measure
- ____ Wellhead risers from Item 12, above
- ____ Well lock keys
- ____ All the piping, hoses and fittings from Item 7, above.
- ____ Teflon® pipe thread tape
- ____ Pipe assembly tools
- ____ Pitot tube (with Magnehelic® and tubing), Kurz meter or venturi meter (with Magnehelic® and tubing).
- ____ Straight length of pipe for flow meter. See text for minimum length.
- ____ Drill and 1/8-inch or 1/4-inch pipe tap to install Pitot tube, Kurz meter and pressure gauges
- ____ Tedlar® air sample bags in cooler (Ice is not required, but samples must be kept in dark.)
- ____ Chain of custody forms
- ____ Magnehelic® for each observation well, including fittings and tubing to connect. Range should be 0 to 2.0 inches of water (in. WC).
- ____ LEL/O_2 meter
- ____ Vacuum gauge, 100 to 0 in. WC
- ____ Pager
- ____ Test setup forms
- ____ Test logs

Conducting The Test

1. Set up the internal combustion engine. Inspect testing equipment for suitability and integrity prior to performing work.
2. Use an LEL meter to measure the vapor concentration in each well. Record these readings. Start with the well with the highest concentration.
3. Measure the depth to water (and product) in each extraction and observation well.

Client: ______________________________ HETI Job Number: __________

Site Address: ____

4. Connect a Magnehelic® or manometer on each observation well using the previously assembled wellhead risers. Vent these prior to beginning the test.
5. Apply vacuum to the extraction well. Record the vacuum and flow rate. Within 5 minutes, collect a vapor sample from the well. Also collect an O_2 and LEL reading.
6. A second person should record vacuum vs time in the nearest observation wells. Initial readings should be taken as frequently as possible until vacuum stabilizes. Vacuum may stabilize within the nearest observation well within minutes.
7. Continue taking readings of flow, vacuum, extraction well temperature, carbon inlet temperature, O_2 and vapor concentration (using the LEL) from the extraction well until one pore volume has been removed.
8. After one pore volume has been removed, collect a second vapor sample from the extraction well.
9. If possible, operate on the extraction well at a second or third vacuum reading. Record the vacuum, flow rate and vapor concentration (using the LEL).
10. Repeat Steps 4 through 9 on other extraction wells, especially if screened at different intervals.

HETI Vapor Extraction Test Setup

Client: ______________________________ HETI Job Number: __________

Site Address: ____

Sketch of Test Setup — show all instruments and equipment.

HETI Vapor Extraction Test Setup

Client: ______________________ HETI Job Number: ____________

Site Address: ______________________

Vacuum Source: ______________________

Flow Measuring Instrument: ______________________

Barometer Reading: ________ Source: ____________ Site Elevation ________

Pore volume: $V_p = \varepsilon_A \pi R^2 H$

$=$ ______________________

$=$ ______________________

Where:

ε_A = the air-filled void fraction. If unknown, assume 0.3.
R = radius of the zone of contamination
H = the vertical thickness of the zone of contamination or the screen height, whichever is greater

Well No.	Well Dia. in.	Slot Width in.	Slot Spacing in.	Depth to Screen ft	Depth to Water ft	Depth to Bottom ft	Screened Interval ft

HETI Vapor Extraction Test Log

Client: ______________________ HETI Job Number: ______________________

Site Address: ____

Tester(s): ______________________________________ Date: ____________

Extraction Well: ______________

Time	Applied Vacuum in. WC	Extract'n. Rate	Sample - Type & Source	Mon. Pt. ____ Vac, " WC	Mon. Pt. ____ Vac, " WC	Mon. Pt. ____ Vac, " WC	Mon. Pt. ____ Vac, " WC	Comments
Distance from Extraction Well, ft								

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