JOHN BEERY ORGANIZATION
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July 22, 1994
Juliet Shin
Hazardous Materials Specialist
Alameda County Health Care Services Agency
Department of Environmental Health
1131 Harbor Bay Parkway
Alameda, California 94502

RE: INVESTIGATIONS AT 2415 MARINER SQUARE DRIVE, ALAMEDA, CALIFORNIA

Ms, Shin,

Enclosed please find the workplan prepared by our consultant, McLaren/Hart Environmental Engineering Corporation, for the Supplemental Site Investigation at the Mariner Square property. The work will begin within one month following your approval of this work plan.

If you have any questions regarding this project, please contact me at (510) 521-2730 or our consultant at (510) 521-5200.

Sincerely,

John C. Beery, Jr.

2236 Mariner Square Drive Alameda, California 94501 510 / 521-2726 FAX 510 / 523-0391

General Partner / Management:
Alameda Cattle Co. Alameda Gateway, Ltd. John Beery Corp. Mariner Development Mariner Land Co. Mariner Square Park St. Landing

McLaren Hart™

WORKPLAN FOR
SUPPLEMENTAL SITE
INVESTIGATION
MARINER SQUARE
ALAMEDA, CALIFORNIA

July 21, 1994

Prepared For:

Mariner Square
2415 Mariner Square Drive
Alameda, California

Prepared By:

McLaren/Hart Environmental Engineering
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1.0 INTRODUCTION

This Workplan details the tasks to be performed by McLaren/Hart at the Mariner Square site located at 2415 Mariner Square Drive in Alameda, California. The scope of work to be performed was originally described in the proposal entitled "Supplemental Site Investigation, Mariner Square" dated February 22, 1994, and subsequently modified based on discussions between Mariner Square and Associates, Texaco Inc., Southern Pacific Lines, and Phillips Petroleum Company (the Mariner Square Technical Committee) and detailed in the letter entitled "Revisions to McLaren/Hart's Proposal to Conduct Supplemental Investigations at Mariner Square, Alameda, California" dated March 2, 1994.

The proposed tasks are designed to provide additional data to:

- verify groundwater flow direction;
- better define the extent of petroleum hydrocarbons in soil and groundwater;
- better define the lateral and horizontal extent of metals in soil;
- better define the extent of vinyl chloride in groundwater; and
- evaluate potential remedial actions.

The proposed scope of work will be evaluated by representatives of the Alameda County Health Care Services Agency Department of Environmental Health, and the results of the Supplemental Investigation will be presented to, and reviewed by the Department.

2.0 SITE BACKGROUND

Investigations had been performed at the subject site previously by others, and results of the investigations were provided to McLaren/Hart for evaluation. The reports provided for review, and which formed the basis for knowledge of the site included the following:

- Historic Resources Inventory, State of California Department of Parks and Recreation, May 27, 1988;
- Environmental Engineering Services, Mariner Boat Yard Gasoline Tank, Subsurface Consultants, Inc., February 20, 1991;
- Environmental Assessment, Allwest Environmental, Inc., December 3, 1991;
- Subsurface Investigation Report, Allwest Environmental, Inc., May 1, 1992;
- Groundwater Investigation, Subsurface Consultants, Inc., November 13, 1992;
- Quarterly Groundwater Monitoring Report, Subsurface Consultants, Inc., December 23, 1992;
- Results of Lead Analysis in Soil; Subsurface Consultants, Inc., December 24, 1992; and
- Groundwater Sampling and Testing, Subsurface Consultants, Inc., November 8, 1993.

The proposed scope of work is designed to supplement the data collected previously at the site by others and will allow for the evaluation of potential remedial alternatives.

2.1 Site History

The site was marshland prior to filling with "hydraulic fill" in the late 1800's, and was then the site of bulk fuel storage and distribution activities as early as 1916. Bulk storage and distribution, primarily of refined oils, motor lubricants and fuel oils for use by ships continued at the site until 1972. Since 1972 the site had been used as mixed office, restaurant and marine sales and repair.

At the height of operations, the site consisted of an office building, a loading shed, a long garage, a reinforced concrete oil warehouse, 16 liquid storage tanks of varying capacity, a fire wall surrounding the tank storage area, a mixing tank, pump house, two tool sheds, a storage building and a pipeline wharf. Several of these facilities, including one large aboveground oil storage tank, the oil warehouse, part of the firewall, and part of the wharf remain today.

2.2 Site Geology

The upper 7 to 13 feet of the site is composed of clayey to silty sands, characterized as "hydraulic fill". Below the fill, highly organic clayey silt referred to as "Bay Mud" occurs at a thickness of 13 to 30 feet. Deep boreholes drilled on the site to depths of greater than 100 feet prior to the construction of the Posey Tube in the 1920's indicate that the Bay Mud is underlain by lenses of well-sorted sands, silts and clayey silts. No bedrock was encountered in these deep borings which were drilled to a maximum depth of 180 feet below grade.

2.3 Site Hydrogeology

Review of the available information has indicated that the probable groundwater flow direction is to the southeast towards the Webster Street tube, with the concrete seawall at the estuary and the curtain wall parallel to the tunnel acting as hydraulic barriers and directing the groundwater flow inland.

McLaren/Hart has interviewed California Department of Transportation (CalTrans) personnel and reviewed construction drawings of the Webster Street tube. A dewatering and sump drainage system is located within the Webster Street tunnel system. Due to leakage from joints near the surface of the tunnel at the Alameda anchorage, this system collects and pumps approximately 1,200 gallons of water per day. These leaking joints are found approximately 300 feet to the west of the site. According to CalTrans personnel, the point at which water enters the cracks rises with rising tides.

The Webster Tube was constructed with precast concrete tubes roughly 38 feet in diameter, and dropped into position. Shoring was driven and trenches were cut into the Alameda and Oakland sides of the tunnel, and then the trenches dewatered. The concrete tubes were then laid onto a concrete base which was placed on coarse gravel fill. Following dewatering of the trench and placement of the tubes, the trench was filled with dense imported backfill. Along the Mariner Square Property, the top of the Webster Tube is approximately 50 feet below ground surface.

Because the Webster Tube is underlain and overlain by coarse and dense backfill materials which are suspected to be relatively more permeable than native soils, it is suspected that groundwater flow is affected by the presence of the Webster Tube.

TABLE 1 GROUNDWATER ELEVATIONS MARINER SQUARE ALAMEDA, CALIFORNIA						
Well Number	**Date**	**TOC**	**DTW**	**DTP**	**FPT**	**Water Elevation**
MW-1	6/13/94	11.99	5.69	---	---	6.30
MW-2	6/13/94	15.21	5.92	---	---	9.29
MW-3	6/13/94	14.19	4.91	---	---	9.28
MW-4	6/13/94	13.95	4.50	---	---	9.45
MW-5	6/13/94	14.60	5.30	---	---	9.30
MW-6	6/13/94	14.81	5.96	5.94	0.02*	8.87

TOC = Top of casing elevation in feet relative to mean sea level
DTW = Depth to water in feet
DTP = Depth to product in feet
FPT = Free product thickness in feet
* = Thickness of free product not great enough to require correction of water elevation.

2.4 Well Survey and Confirmatory Groundwater Flow Direction Evaluation

The top-of-casing elevations of the six monitoring wells at the site were measured on June 13, 1994 by a state licensed surveyor. Depth to water measurements were collected at the time of the well survey, and are compiled in Table 1. The groundwater flow direction observed on June 13, 1994 is shown on Figure 1. As demonstrated previously, the groundwater flow direction is primarily to the southeast. **Free-product was encountered in well MW-6 at a thickness of 0.02 feet and was described as a fresh oil.**

2.5 Previous Investigation Results

Concentrations of total recoverable petroleum hydrocarbons (TRPH) or total extractable hydrocarbons (TEH) were detected in soil and/or groundwater samples collected from most of the borings and monitoring wells drilled at the site. The greatest concentrations of petroleum hydrocarbons in soil were present in the samples collected within or immediately adjacent to the former fuel storage area located within the firewall. **Concentrations of TRPH were detected at 13,000 parts per million (ppm) in the soil sample collected at a depth of 4.5 feet below grade from boring MS-4, located adjacent to and downgradient of the fire wall.** Concentrations of benzene, toluene and volatile organic compounds (VOCs) have not been detected in soil samples collected at the site. Ethylbenzene and xylenes have been detected at up to 21 ppm and 10 ppm, respectively in a soil sample collected from well MW-2 drilled in the vicinity of the former fuel pipeline near the fueling dock. **Concentrations of soluble lead have been detected in soil above California Code of Regulations Title 22 Soluble Threshold Limit Concentrations (STLCs) in shallow samples collected from wells MW-2 and MW-5.**

Groundwater samples collected from the six monitoring wells located at the site have all contained detectable concentrations of **TEH up to 2,400 parts per billion (ppb). Benzene,** toluene, ethylbenzene and xylenes (BTEX) and the **VOCs vinyl chloride and Freon-113** have been detected in groundwater samples from the following wells at the following maximum concentrations:

- benzene, 31 ppb, MW-4;
- toluene, 12 ppb, MW-5;
- ethylbenzene, 49 ppb, MW-5,
- xylenes, 26 ppb, MW-5;
- Freon-113, 4 ppb, MW-2; and
- vinyl chloride, 13 ppb, MW-4.

3.0 SCOPE OF WORK

Our project approach includes the installation of three additional monitoring wells: one well on-site on a mid-gradient point along the southern fenceline, a second on-site well in the presumed hydrocarbon source area, and one well off-site downgradient of monitoring well MW-1. A total of ten soil borings will also be drilled and soil samples analyzed to better define physical soil characteristics, the nature of the petroleum hydrocarbon within the suspected source area, and metals concentrations in shallow soil. Data collected from these three new monitoring wells and ten soil borings will provide information which will aid in selecting the proper remediation strategy.

All soil and groundwater sample analysis will be performed by state-certified analytical laboratories under chain-of-custody protocol.

3.1 Installation of Groundwater Monitoring Wells and Collection of Soil and Groundwater Samples

McLaren/Hart has reviewed the soil and groundwater sampling data from previous investigations provided by Mariner Square and Associates. We believe that a reasonably complete site characterization has already been performed. Supplemental focused site characterization is required to evaluate remediation options and costs.

Proposed monitoring well MW-7 will be installed onsite between monitoring wells MW-4 and MW-1 along the south fenceline. Well MW-7 will be installed as a 4-inch diameter well to allow for possible future use for migration control. Existing data shows relatively low but detectible levels of hydrocarbons in the groundwater collected from MW-1 and MW-4. If the groundwater from MW-7 shows similar levels, this would indicate that these wells, near the south property boundary, might be located near the edge of the hydrocarbon plume.

Proposed monitoring well MW-8 will be installed approximately 100 feet downgradient of well MW-1. In addition to confirming the groundwater flow direction in the vicinity of the Webster Tunnel, groundwater analytical results from proposed well MW-8 may indicate whether impacted groundwater extends downgradient of the subject site. Well MW-8 will be installed using 2-inch diameter well casing materials.

Proposed monitoring well MW-9 will be located within the hydrocarbon impacted area inside of the fire wall surrounding the former aboveground storage tanks. This monitoring well is proposed to be completed in one of the three soil borings (see Section 3.2 of this Workplan) used to characterize soil lithology and hydrocarbon speciation. During drilling, drill cuttings and soil samples will be continuously screened using visual and odor observations, along with the use of a photoionization or flame ionization detector to measure hydrocarbon vapors. The boreholes will be left open for a few hours to allow groundwater to enter the borehole. The boring containing the highest hydrocarbon vapor concentrations in soil (or presence of hydrocarbons at the groundwater table) during drilling would be deepened and developed into a well. Well MW-9 will be installed using 4-inch diameter well casing materials.

The placement of the three proposed monitoring wells is shown on Figure 1.

3.2 Installation Techniques

McLaren/Hart will contact Underground Service Alert (USA) at least 48 hours prior to the initiation of the field activity so that utility companies can mark the locations of the service lines on and in the vicinity of the site. In addition, all drilling locations will be cleared by a technician utilizing a magnetometer.

Monitoring well installation permits will be acquired from the Alameda County Flood Control and Water Conservation District Zone 7. Site access for the offsite well installation will involve acquiring encroachment permission from CalTrans, owners of the property immediately adjacent to south of the site.

All drilling equipment will be steam cleaned prior to entering the site to remove any residual materials. This cleaning process will be repeated between borings to eliminate the possibility of cross-contamination between sampling events. All sampling equipment will be cleaned using a non-phosphate detergent, tap water rinse, and a final rinse with distilled water.

Each of the three monitoring wells will be installed using hollow stem auger drilling equipment on a truck-mounted rig. The boreholes will be drilled utilizing an 8-inch outside diameter auger to approximately 10 feet into the water bearing zone, which is expected to be encountered at approximately 5 feet below grade. Soil samples will be collected continuously for lithologic description and for potential laboratory analysis using either a California Modified split spoon sampler lined with brass tubes, or a 5-foot core barrel sampler fitted with 2-inch by 6-inch stainless steel tube inserts. Several soil samples collected within the suspected source area (within the firewall area) will be submitted for analysis of total petroleum hydrocarbons (TPH) by EPA Method 8015 Modified, for BTEX by EPA Method 8020, and for total organic carbon (TOC) by EPA Method 9060. Several soil samples will also be submitted for analysis of porosity, bulk density, horizontal permeability to air, and biological plate counts to better define remedial alternative parameters. Samples will be selected for analysis based on field evidence of hydrocarbon impact. All soil samples collected for analysis of BTEX and TOC will be appropriately labeled and shipped to MBT Environmental Laboratories in Rancho Cordova, California for analysis following chain-of-custody and EPA-recommended sample preservation techniques. MBT Environmental Laboratories is a division of McLaren/Hart, and is licensed by the State of California as a hazardous waste and drinking water laboratory. Soil samples collected for TPH speciation analysis will be shipped under chain-of custody protocol to Friedman & Bruya Laboratories in Seattle, Washington.

Lithologic descriptions will be performed using the Unified Soil Classification System format. In addition, organic vapor readings will be measured using a photoionization or flame ionization detector.

The exact well design will be determined during drilling, and will be based on the encountered interval of saturated transmissive material. The well design, based upon encountering groundwater at approximately 5 feet below grade, will incorporate the following criteria:

- wells will be constructed using flush-threaded PVC casing and factory-slotted PVC screen sections;

- the well screen will not exceed 10 feet in length, will cover the first transmissive zone encountered, and extend approximately 1 foot above the saturated zone to allow for water elevation fluctuations;

- a graded sand filter pack will be placed across the screened interval and extend up to 1 foot above the top of the slotted interval;

- the interval below the well screen interval will be filled with granular bentonite;

- a one foot thick bentonite seal will be placed above the filter pack;

- the well will be sealed by placing portland cement with 5% bentonite from the seal to surface grade; and

- each well will be completed with a locking cap and a traffic-rated vault box cemented to 1/2-inch above grade.

The initial 8-inch diameter borehole will be enlarged using 11-inch outside diameter hollow stem augers for the 4-inch diameter monitoring wells. A section for a typical 4-inch diameter well, which is constructed similarly to a 2-inch diameter well, is shown in Figure 2.

Soil cuttings generated during drilling, decontamination fluids, and groundwater generated during drilling and sampling will be placed in 55-gallon drums and stored on site. Each monitoring well installed will be surveyed for top-of-casing elevation relative to mean sea level.

3.3 Well Development

Monitoring well development will begin at least 24 hours following well installation. The wells will be developed by a combination of surging, bailing and pumping. Surging with a sealed plunger will be performed over the entire screen length, and is performed to increase the hydraulic communication between the well, filter pack and surrounding soils. After surging, the well will be bailed to remove fine-grained sediments, and the well will then be pumped until at least 10 casing-volumes of water have been recovered or turbidity is measured at less than 100 NTU. During well development, physical parameters including temperature, electrical conductivity, pH and turbidity will be monitored after each casing-volume has been removed.

If free-phase hydrocarbons (i.e., free product) are encountered in the well the Mariner Square Technical Committee will be immediately notified and available options will be discussed. These options may include additional purging and bailing of the well until free product is no longer observed, and collecting a groundwater sample following standard procedures.

3.4 Groundwater Sampling

The objective of groundwater sampling is to obtain a volume of water that is representative of formation water. Meeting this objective requires the following:

- All stagnant water must be removed from the casing so that fresh water from the aquifer is entering the well at the time of sample collection.

- The sample must be extracted from the well with as little disturbance and as little exposure to the atmosphere as possible.

- The sample must not be allowed to come into contact with any materials which may adsorb or leach constituents into solution, or alter the sample in any way.

- Physical parameters which would change with exposure to air during containerization, transport, storage or laboratory analysis and cannot be preserved must be measured at the time of sample collection.

- Portions of the sample must be treated to preserve those parameters which would otherwise be altered in transport to the laboratory.

McLaren/Hart will purge all wells prior to sampling using centrifugal or peristaltic pumps. Disposable polyethylene tubing will be used on the suction side of the pumps with the intake end positioned at the top of the well screen. If the well yield is not sufficient to maintain a water level above the well screen, the intake will be lowered to an appropriate depth within the well to maintain a constant pumping rate.

During the purging process, electrical conductivity, pH, temperature, and turbidity will be monitored and values recorded during the removal of each well casing volume. In high to medium yielding wells, purging will continue until a minimum of three casing-volumes have been removed and until stabilization of the parameters listed above. Parameter stability is defined as shown in Table 2.

Low yielding wells are those which are unable to maintain a constant pumping rate, are fully evacuated during the purging process, and are unable to achieve 80% recovery in 30 minutes. If a low yielding well is encountered, no further purging will be performed and the sample will be collected following at least 50% recovery but before the well fully recovers.

Table 2 "Stability" for Purposes of Well Purging	
Parameter	**Value**
Turbidity	less than 100 NTH
Electrical Conductivity	less than 5% difference between successive casing volumes
pH	less than 0.15 units difference between successive casing volumes
Temperature	less than 1.0° F difference between successive casing volumes

After the well has been purged, samples will be collected using a disposable polyethylene bailer. The bailers are equipped with a low flow sample port to facilitate controlled sample collection. Groundwater samples collected for metals analyses will be field-filtered using a peristaltic pump with 45-micron filter to remove suspended sediments. Quality control samples will include trip blanks. Trip blanks will accompany every volatile compound sample shipment that occurs during a sampling event. Since the only equipment entering the monitoring well is disposed of between monitoring wells, no equipment blanks will be collected during the sampling event.

3.5 Groundwater Analysis

Groundwater samples will be collected from the six existing and three newly-installed monitoring wells to enhance the baseline groundwater quality information for the site and to determine the extent of the petroleum hydrocarbon plume. The following analyses will be performed:

- Total Petroleum Hydrocarbons as diesel, gasoline and motor oil by EPA Method 8015 Modified from wells MW-1 through MW-9.

- Benzene, toluene, ethylbenzene and xylenes (BTEX) by EPA Method 8020 from wells MW-1 through MW-9.

- Vinyl chloride by EPA Method 8240 from wells MW-4, MW-6, MW-7 and MW-9.

- Total Dissolved Solids (TDS) by EPA Method 160.1 from wells MW-2, MW-4 and MW-8.

- Priority pollutant metals by EPA Series 6010/7000 Methods (filtered) from wells MW-1 through MW-9.

The presence of vinyl chloride in well MW-4 only and not in any other groundwater or soil samples from the site suggests that this compound may be migrating from an off-site, upgradient direction.

All groundwater samples will be appropriately labeled and shipped to MBT Environmental Laboratories in Rancho Cordova, California for analysis following chain-of-custody and EPA-recommended sample preservation techniques. MBT Environmental Laboratories is a division of McLaren/Hart, and is licensed by the State of California as a hazardous waste and drinking water laboratory.

3.6 Drilling of Soil Borings and Soil Sample Collection

Proposed soil boring locations are shown on Figure 1. Soil samples will be collected from eight soil borings to be drilled in the parking area to the north of the former fuel storage area. Samples will be collected from depths of 1.5 feet and 3.0 feet for analysis of CAM 17 metals concentrations. A sampling depth of 1.5 feet was selected because lead in excess of the 5 parts per million Soluble Threshold Limit Concentration (STLC) specified in 22 CCR 66261.24 has been previously detected at this depth. A sampling depth of 3.0 feet was selected as a mid-point between the shallow sampling depth of 1.5 feet and the expected groundwater level at approximately 5-7 feet. Two of these eight borings will be drilled adjacent to the two underground storage tanks present at the northwestern corner of the site, and soil samples collected from these two borings will also be submitted for analysis of TPH and BTEX. (only)

Soil samples collected from the 1.5 feet depth will be submitted for analysis, and the soil samples collected at 3.0 feet will be archived. Based on review of the analytical results of the 1.5 foot depth sample, the deeper samples may be submitted for analysis. Three soil samples from the 1.5 foot depth interval will also be analyzed for soluble lead, and a ratio of total lead to soluble lead will be developed.

Sample selection for analysis will be determined by visual inspection (e.g. staining), odor and photoionization or flame ionization detector readings. As noted in Section 3.1 above, three additional soil borings will be advanced within the apparent source area for the hydrocarbons (inside the fire wall) to determine hydrocarbon species present, assess indigenous biological activity, and obtain soil lithologic profiles. Three locations will be selected in the vicinity of MS-4, MS-15, and MS-18, areas where previous work at the site noted highest concentrations of petroleum hydrocarbons. These borings will be continuously logged to first groundwater to obtain lithologic data. During the drilling, organic vapor concentrations in the air will be monitored using either a photoionization or flame ionization detector.

3.7 Soil Sampling Methods

Soil borings will be drilled with a hollow-stem, 6-inch outside diameter auger on a truck-mounted rig to first groundwater, approximately 7 feet below ground surface. We propose to use a drill rig as opposed to hand auger because the rig will already be on site for the drilling of the wells, as well as the increased speed of drilling and efficiency of cutting through the asphalt. During drilling soil samples will be collected with either a California Modified Split Spoon sampler lined with brass tubes, or a 5-foot core barrel sampler fitted with 2-inch by 6-inch stainless steel tube inserts. The sampling equipment will be driven into the ground by a 140-pound hammer.

The soil sampling tubes will be immediately sealed with teflon sheeting and plastic end caps, and the end caps secured to the sampling tube with duct tape. After labelling, the samples will be secured in plastic zip-lock bags, placed into a cooler containing ice, and delivered to the analytical laboratory by courier under chain-of-custody procedures. As with the groundwater samples, soil samples will be analyzed by MBT Environmental Laboratories on a two-week turnaround basis.

3.10 Prepare Investigation Report

McLaren/Hart will prepare a remedial investigation report as the final work product of the project. The report will contain four elements:

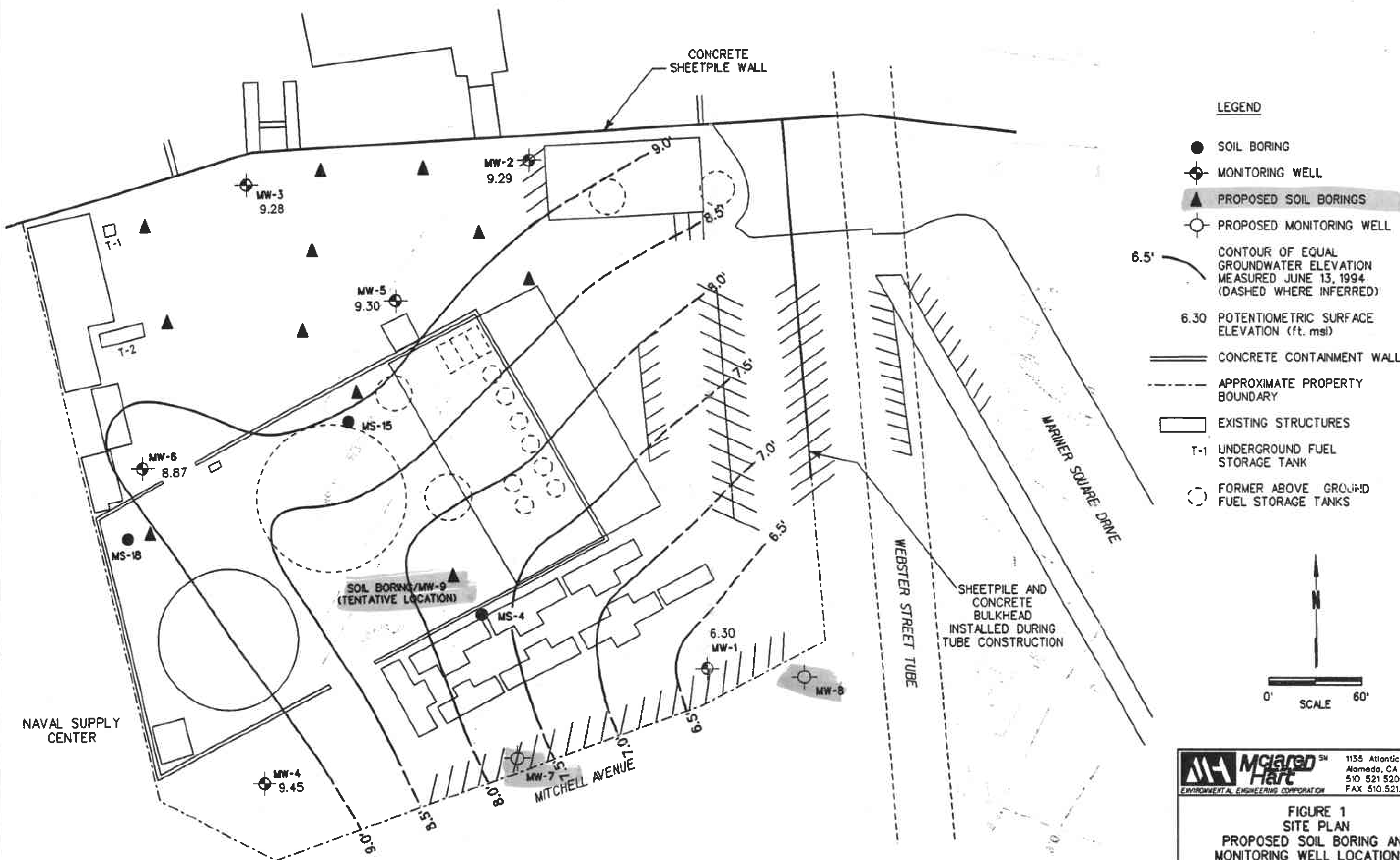
1. Results of the additional site investigations;

2. Technical evaluation of site characterization data;

3. Discussion of the remedial action objectives developed on the basis of the site data, including assessment of the applicable regulations and potential health and environmental impacts; and

4. Evaluation of potential remedial actions.

A first draft of the remedial investigation report will be prepared and submitted to Mariner Square and Associates for review and comment. After receiving comments on the first draft, a final draft report will be prepared for submission to Alameda County after review and approval by Mariner Square and Associates. Following County review, the final report will be prepared. This final report will incorporate all comments and will be distributed to Mariner Square and Associates and Alameda County.



McLaren Hart
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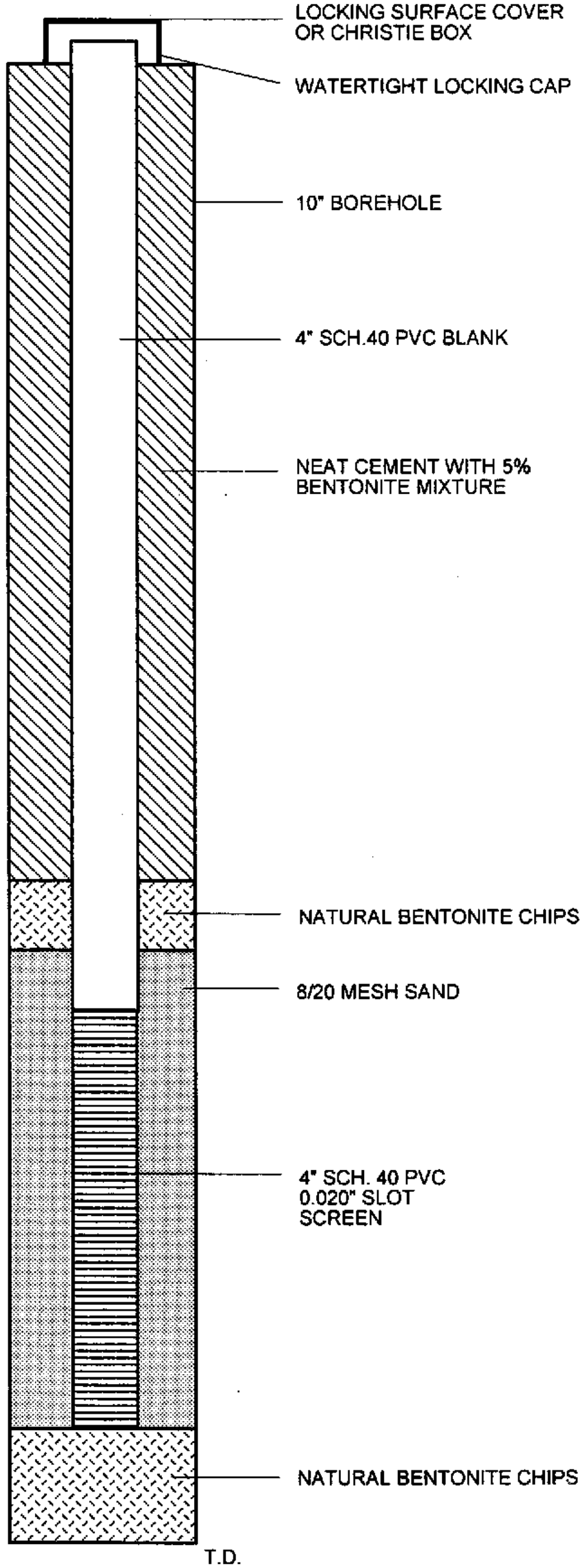
FIGURE 1
SITE PLAN
PROPOSED SOIL BORING AND MONITORING WELL LOCATIONS
MARINER SQUARE ALAMEDA, CA

Mner794P/01.dgn; Rev: 07-21-94

FIGURE 2
TYPICAL MONITORING WELL



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McLaren Hart[sm]
ENVIRONMENTAL ENGINEERING CORPORATION

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All equipment used for drilling and sampling will be pre-cleaned prior to arrival at the site. The sampling equipment will be washed between each sampling event using a non-phosphate detergent, and a de-ionized water rinse.

3.8 Monitoring of Groundwater Levels

Accurate groundwater elevation data is essential to determine gradients, flow direction and predicted chemical migration paths. Two rounds of groundwater level measurements will be taken after all wells have been installed. Depth to groundwater will be measured from all wells at the time of groundwater sampling and one month later, using electronic water level sounding instruments calibrated to 0.01 foot. In combination with the accurate well casing elevations surveyed on June 13, 1994, these measurements will allow preparation of accurate water elevation contour maps.

3.9 Evaluation of Potential Remedial Actions

The analytical results of the soil and groundwater samples collected in this supplemental investigation will be used with the results of prior investigations to evaluate potential remedial alternatives for soil and groundwater. Conceptual designs will be prepared for those alternatives which appear to be technically and economically feasible for implementation. The bases for the evaluation will include the following criteria:

- effectiveness in achieving remedial strategies and objectives (i.e., can these actions achieve the desired results);
- administrative and technical implementability (i.e., how likely is it that these methods can be approved by the regulatory agency, and how difficult will the techniques be to use); and
- overall cost to achieve the desired end point.

This evaluation will be conducted in a stepwise, logical manner. The first step in the process of evaluation of remedial alternatives will be to identify the constraints imposed upon the analysis. Specifically, the objectives of the remediation must be clearly identified. The cleanup levels that are required will be based on the constituents of concern, their potential health and environmental impacts, and the regulatory clean-up standards that will be applied.
A preliminary analysis of remedial technologies that are potentially applicable to the constituents of concern will be performed. Only those potential remedial actions which show promise of being cost-effective for achieving the remedial objectives will be retained for further consideration. The primary method of this preliminary analysis will be professional judgement and experience, coupled with rough calculations of costs. By performing a screening step early in the analytical process, alternatives that are not promising will not continue to be evaluated.

Once promising alternatives for remediation are identified, conceptual designs will be prepared. These conceptual designs will be used to present a more detailed evaluation based on the criteria presented above, namely effectiveness, implementability, and cost. Costs will be estimated with detail and accuracy consistent with the degree of definition of the conceptual designs. Overall costs will be calculated on a *present worth* basis. Should indefinite periods be encountered with ongoing costs (for example, monitoring of groundwater in place as an alternative to treatment) we will assume 10 years unless directed otherwise.

Evaluation of remedial strategies will be based upon:

- containment of the impacted groundwater plume while the site is still occupied with final remediation of soil and groundwater deferred until the site is no longer occupied; and

- in-situ remediation of soil and groundwater during current site occupancy.