HAGEMAN-AGUIAR, INC.
Underground Contamination Investigations, Groundwater Consultants, Environmental Engineering

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PROPOSED WORKPLAN FOR SUBSURFACE INVESTIGATION

RIX INDUSTRIES
6460 Hollis Street
Emeryville, California

April 1, 1994

3732 Mt. Diablo Blvd. Suite 372 Lafayette, California 94549 (510) 284-1661 FAX (510) 284-1664

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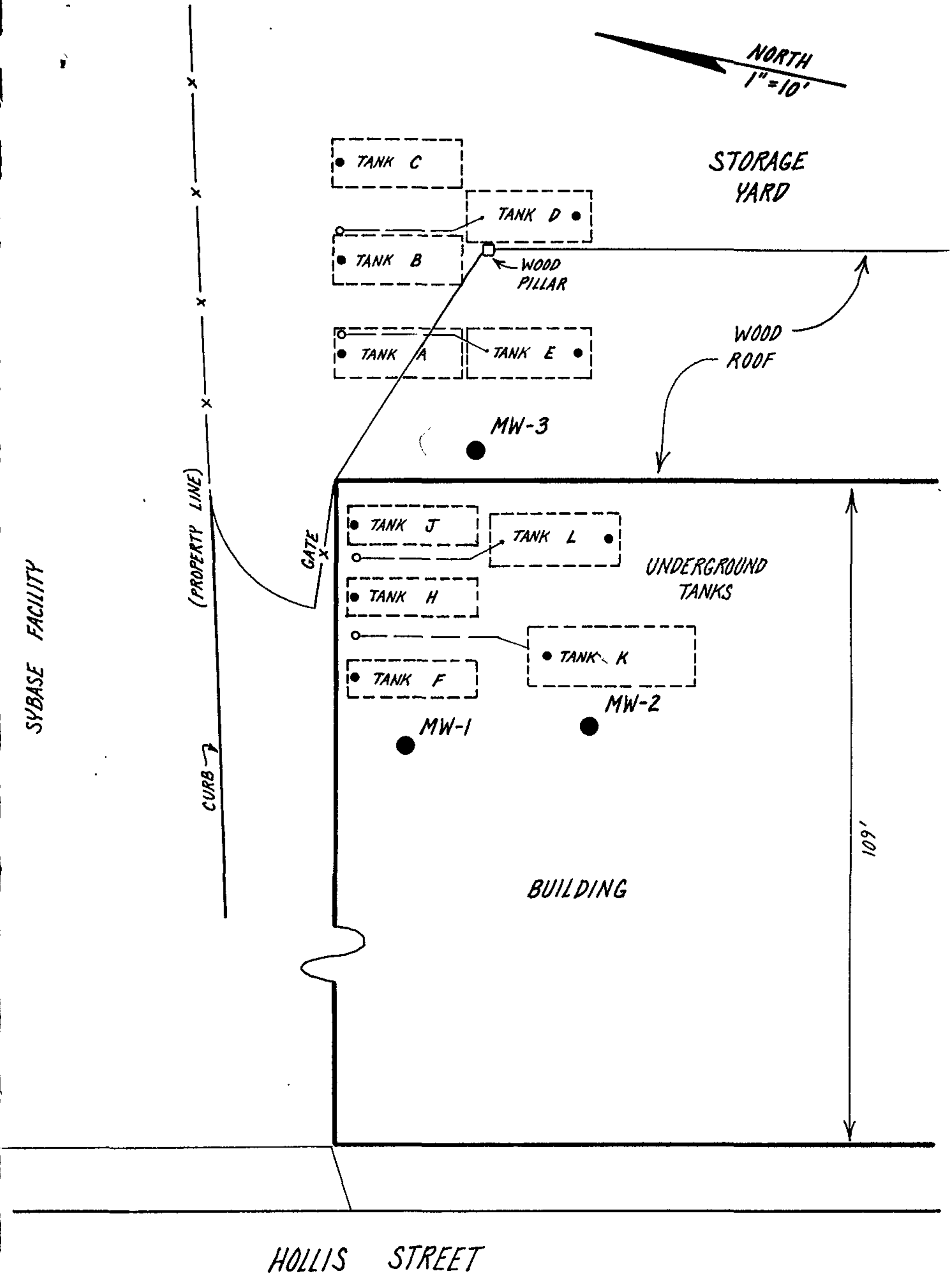
I. INTRODUCTION

The site location is the property at 6460 Hollis Street in Emeryville, California. The location of the site is shown in Figure 1.

The current occupant of the property, Rix Industries, has been present for more than twenty years. The current Rix industries operation involves the construction of compressor parts, as well as compressor performance testing. In conjunction with a previous paint formulation plant that occupied the property prior to Rix Industries, ten (10) underground chemical storage tanks have been present for a number of years on the property. Five of the underground storage tanks are present within the existing Rix Industries fabrication building, where limited access is an obvious problem in regard to conducting field work at the site (drilling, excavation, etc.). The layout of the site is shown in Figure 2.

On June 27, 1992, a subsurface investigation was conducted by Hageman-Aguiar, Inc., with respect to the five underground storage tanks located within the fabrication building (tanks "F" through "K"). The scope of work involved 1) sampling the contents of the underground tanks located within the building, 2) collection of soil samples from hand borings adjacent to the underground tanks located within the building and 3) installation and sampling of three shallow groundwater monitoring wells. The results of the investigation were presented in the "Report of Soil and Groundwater Investigation" by Hageman-Aguiar, Inc., dated July 24, 1992.

FIGURE 1.
Site Location Map.


NORTH
1"=10'
STORAGE YARD
TANK C
TANK D
TANK B
WOOD PILLAR
TANK A
TANK E
WOOD ROOF
MW-3
(PROPERTY LINE)
GATE
TANK J
TANK L
UNDERGROUND TANKS
TANK H
TANK K
TANK F
MW-2
MW-1
SYBASE FACILITY
CURB
109'
BUILDING
HOLLIS STREET

Purpose of Investigation

The purpose of this proposed subsurface investigation is to install and sample three (3) additional shallow groundwater monitoring wells in order to determine any impact upon the quality of the shallow groundwater in the immediate vicinity of the five underground storage tanks located outside of the fabrication building (tanks "A" through "E"), as well as any groundwater quality degradation down-gradient of all ten underground storage tanks. These data will be used in conjunction with groundwater sampling data from the three existing shallow groundwater monitoring wells in order to assess the overall shallow groundwater quality beneath the subject property.

II. SITE DESCRIPTION

Hydrogeologic Setting

The soils beneath the site consist of Quaternary Alluvium overlying Franciscan bedrock (Geologic Map of California, San Francisco Sheet, State of California Division of Mines and Geology, 1980). Bedrock is likely to occur at a depth of greater than 50 feet beneath the site. On this portion of the low-lying Bay Plain in close proximity to San Francisco Bay, the soils beneath the site can be expected to consist primarily of fine grain soils (silts and clays), with the majority of shallow groundwater movement occurring in thin sand and gravel layers and/or "stringers".

Based upon the surface topography, as well as the various hydrologic features shown on the vicinity map, the general regional shallow groundwater can be expected to flow from the Berkeley Hills (area of groundwater recharge) and move westward toward San Francisco Bay (area of discharge). The original placement of the existing three shallow groundwater monitoring wells was based upon this assumption of the groundwater flow direction.

Shallow Groundwater Flow Direction.

The most recent shallow water table elevations were measured on July 7, 1992. Figure 3 presents a contour map for the shallow groundwater table beneath the site. As shown in this figure, the data from these monitoring wells indicate that the shallow groundwater flow beneath the site is in the westerly direction.

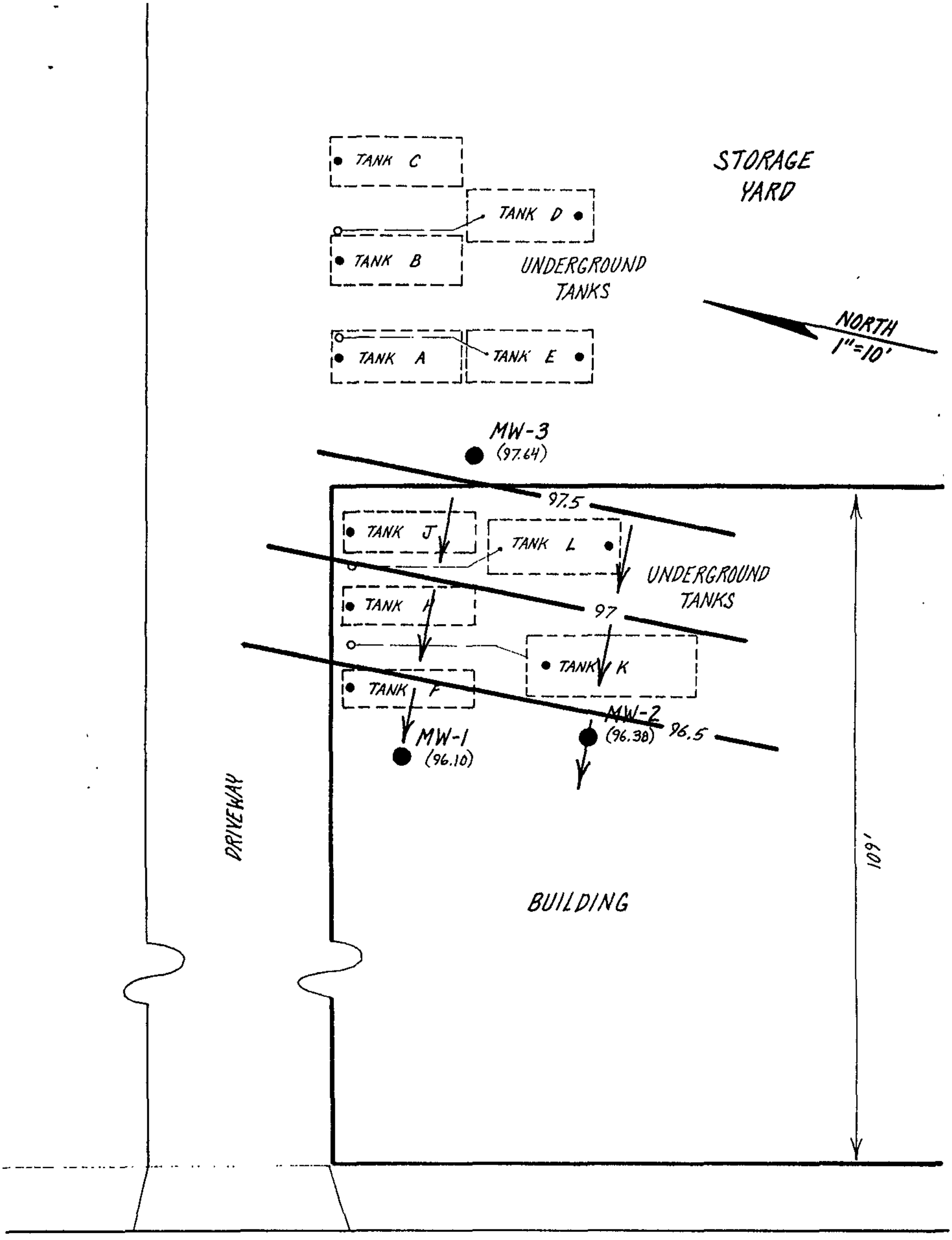


FIGURE 3. Shallow Groundwater Table Contour Map (July 7, 1992).

As shown in this figure 3, the shallow groundwater table beneath the site appears to be somewhat steep, with a calculated hydraulic gradient of dH/dL = 1'/16' = 0.065

Tank Contents

A map of the site is shown in Figure 2. This map shows the layout of the facility, along with the apparent locations of ten underground storage tanks. As shown in Figure 2, five of the tanks are located within the existing facility building. Based upon a field reconnaissance conducted by Hageman-Aguiar, Inc., personnel on January 30, 1992, the previous tanks were found to be labeled as containing the following:

TANK A - Chlorinated Solvents ✓
TANK B - Tank Empty (no label)
TANK C - Tank Empty (no label)
TANK D - Tank Empty (no label)
TANK E - Mostly Water (no label)
TANK F - sec-Butyl Alcohol
TANK H - Isopropyl Alcohol
TANK J - Methyl Ethyl Ketone (MEK)
TANK K - Ethyl Silicate
TANK L - sec-Butyl Alcohol

The results of the laboratory analyses that were presented in the "Report of Soil and Groundwater Investigation" by Hageman-Aguiar, Inc., dated July 24, 1992, indicate that the following four tanks currently store, or have been used to store in the past, the following chemicals:

TANK F - Diesel
sec-Butanol

TANK H - Diesel

TANK J - Mineral Spirits

TANK L - Mineral Spirits
Methyl Isobutyl Ketone (MIBK)
Tetrachloroethene
sec-Butanol

Previous Analytical Results: Groundwater

Tables 1 and 2 present the results of the laboratory analysis of the groundwater samples collected from monitoring wells MW-1, MW-2, and MW-3.

As shown in Table 1, significant levels of Total Petroleum Hydrocarbons as Gasoline, Diesel, Kerosene and Mineral Spirits were found in all of the shallow groundwater samples at concentrations of up to 1,400 μg/L (ppb), 17,000 μg/L (ppb), 17,000 μg/L (ppb) and 21,000 μg/L (ppb), respectively.

Along with the elevated concentrations of petroleum hydrocarbons in the shallow groundwater, there appears to be present significant Xylenes concentrations. Concentrations of meta-, para- and ortho-Xylene were found in all of the shallow groundwater samples at concentrations of up to 1,100 μg/L (ppb), 290 μg/L (ppb) and 520 μg/L (ppb), respectively.

TABLE 1. Previous Groundwater Sampling Results (July 7, 1992).

Chemical		MW-1	MW-2	MW-3
Gasoline	(ug/L)	680	1,400	9,300
Diesel	(ug/L)	6,100	17,000	20,000
Kerosene	(ug/L)	6,100	17,000	20,000
Mineral Spirits	(ug/L)	6,400	20,000	21,000
Benzene	(ug/L)	3.8	ND	ND
Toluene	(ug/L)	ND	12	3,600
Ethyl Benzene	(ug/L)	38	69	ND
m-Xylene	(ug/L)	270	1,100	530
o-Xylene	(ug/L)	290	260	210
p-Xylene	(ug/L)	240	520	430
Methyl Ethyl Ketone (MEK)	(ug/L)	ND	ND	ND
Methyl Isobutyl Ketone (MIBK)	(ug/L)	ND	ND	ND
Oil & Grease	(ug/L)	14	19	28

ND = not detected

TABLE 2. Previous Groundwater Sampling Results (July 7, 1992).

Chemical		MW-1	MW-2	MW-3
Carbon Tetrachloride	(ug/L)	ND	ND	980
1,1-Dichloroethane	(ug/L)	36	22	30
1,2-Dichloroethane	(ug/L)	ND	ND	450
cis-1,2-Dichloroethene	(ug/L)	ND	99	630
Tetrachloroethene	(ug/L)	ND	52	2,200
1,1,1-Trichloroethane	(ug/L)	ND	ND	81
Trichloroethene (TCE)	(ug/L)	ND	21	300
Vinyl Chloride	(ug/L)	ND	46	ND

ND = not detected

As shown in Table 2, the following Halogenated Volatile Organic Compounds were detected in the shallow groundwater samples collected from wells MW-1, MW-2 and MW-3:

Tetrachloroethene
1,1-Dichloroethane
Cis-1,2-Dichloroethene
Trichloroethene
Carbon Tetrachloride
1,2-Dichloroethane
1,1,1-Trichloroethane
Vinyl Chloride

III. PROPOSED FIELD WORK

Placement of Monitoring Wells

The proposed locations of the three additional shallow groundwater monitoring wells are shown in Figure 4. The locations have been selected based upon 1) locations of underground storage tanks, 2) the known shallow groundwater flow direction, and 3) what is believed to be good spacing between data points in order to achieve reasonable plume definitions of any contaminants that may be present in the shallow groundwater beneath the site.

Monitoring Well Installations

Each well will be installed with a truck-mounted drill rig using 8-inch hollow-stem augers. During the drilling, soil samples for chemical analyses will be collected at 5-foot intervals until the shallow water table is encountered at an expected depth of approximately 4 to 5 feet below the ground surface. Each soil sample will be collected by driving directly into the native soil below the augers with a 2-inch split-barrel sampler fitted with clean brass liners. All samples will be immediately placed on ice, then transported under chain-of-custody to the laboratory by the end of the work day.

The well borings will extend to approximately 10 feet below the shallow water table, expected at a depth of approximately 4 to 5 feet below ground surface. Each well will be cased to

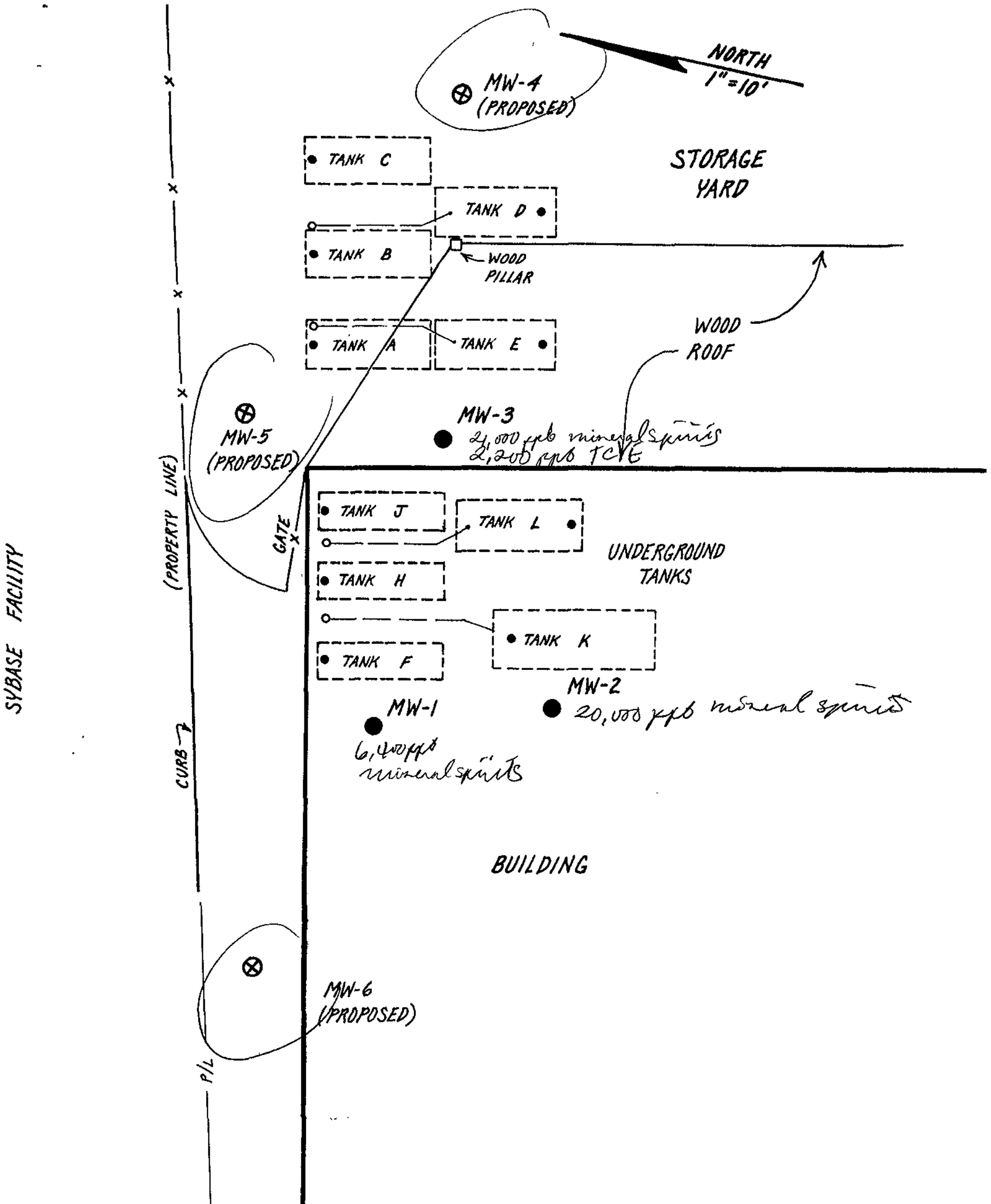


FIGURE 4.
Proposed Monitoring Well Locations.

approximately two feet above the shallow water table with 2-inch PVC slotted screen pipe (0.01" slots). The annular space of each well will be packed to one foot above the slotted section with #2/12 Monterey Sand.

At least one foot of wetted bentonite pellets will be placed upon the sand pack, followed by a neat cement/bentonite seal up to the ground surface. Each well will be fitted with a locking steel traffic lid. A typical well construction diagram is shown in Figure 5.

Boring Logs

The borings will be logged in the field by a qualified geologist under the direct supervision of Gary Aguiar, Registered Civil Engineer #34262.

Sand Pack Grain Size Selection

In the case of the two proposed additional shallow monitoring wells, the selection of the screen slot size and sand pack grain size was based upon typical shallow aquifer material encountered in the previous on-site monitoring well borings (clayey sand and clayey sand & gravel).

A well pack design of 0.01" slots and #2/12 Monterey sand is generally acceptable for small-diameter monitoring well installations in very fine grained soils, considering: 1) generally adequate filtering-out of silt-size particles, 2) potential for sand pack and screen clogging, 3) small-diameter casing well losses, and 4) local availability of monitoring well materials.

MONITORING WELL

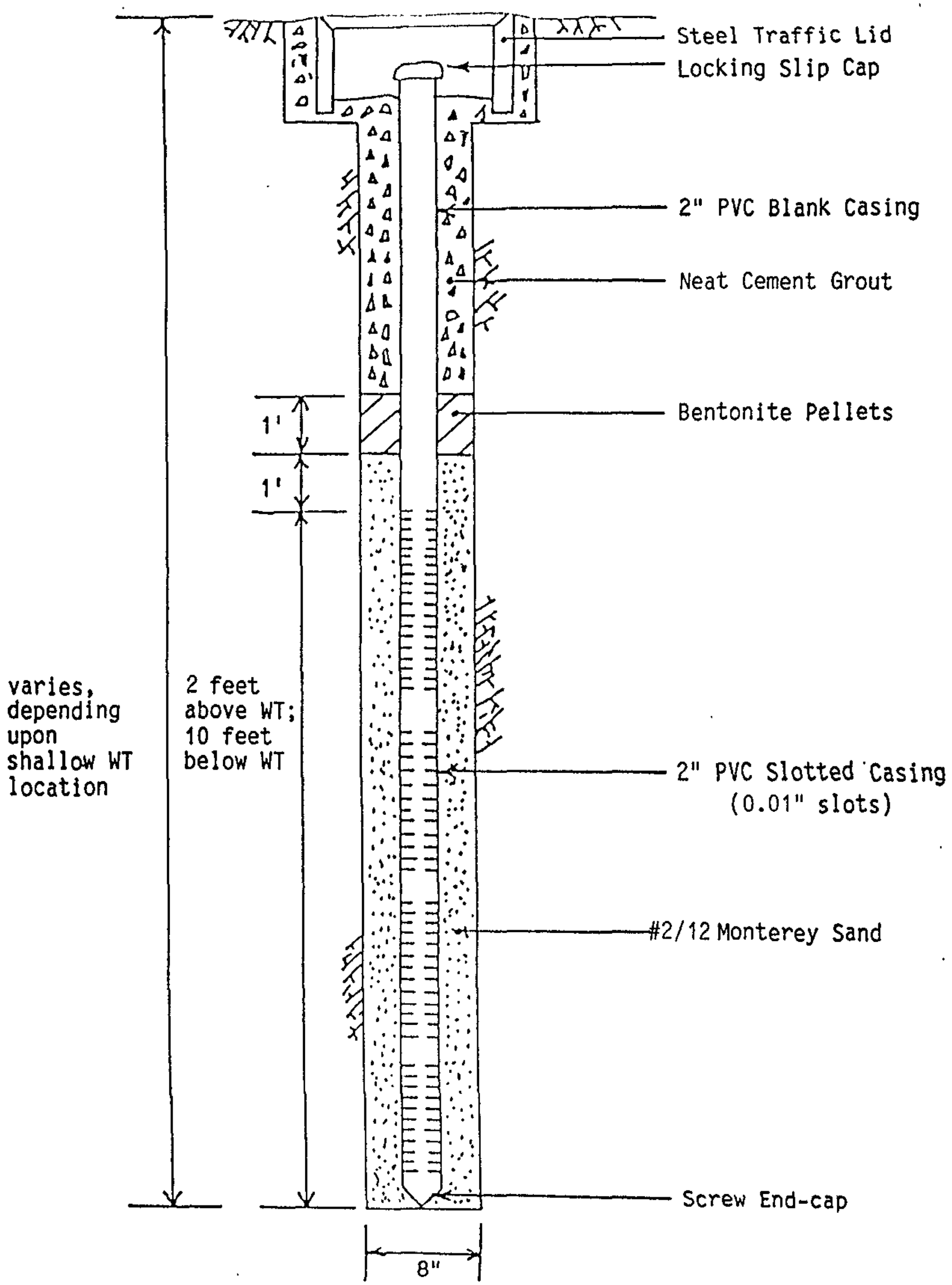


FIGURE 5.
Typical Monitoring
Well Construction.

Decontamination

Prior to the installation of each well, all drilling equipment, including augers, drill stem, and split barrel samplers, will be steam-cleaned on-site. Prior to the installation of each well, all drilling equipment, including augers, drill stem, and split barrel samplers, will be steam-cleaned.

All on-site steam-cleaning will be conducted within a temporary bermed area, covered by a plastic liner. Wash water collected in this area will subsequently be transferred into appropriate 55-gallon drums, and stored on-site until the results of laboratory analyses of water samples are obtained. Depending upon these results, the water will be sewered as a non-hazardous liquid waste in accordance with local sewering agency permit requirements, or else it will be transported as a hazardous liquid waste under proper manifest to an appropriate TSD facility for treatment and disposal.

Groundwater Sampling Plan

The development of the newly installed monitoring wells will not occur for at least 72 hours after construction. It is proposed that each well will be developed by removing water with a mechanical air-lift pump until the water is relatively clear, or until the apparent turbidity of the water being removed has stabilized. In the event that pumping does not appear to be providing adequate well development, a well development service truck can be brought to the site in order to attempt further development with mechanical surge block and bailer.

Groundwater sampling shall not occur less than 24 hours after well development. Prior to groundwater sampling, the two new monitoring wells and the existing three on-site monitoring wells will be purged by bailing 4 to 10 casing volumes of water. Field conductivity, temperature, and pH meters will be present on-site during the monitoring well sampling. As the purging process proceeds, these three parameters will be monitored. Purging must continue until readings appear to have reasonably stabilized. After the water level has attained 80% or more of the original static water level in a particular monitoring well, a groundwater sample will be collected using a clean teflon bailer. The water sample will be placed inside appropriate 40 mL VOA vials free of any headspace. The sample will immediately be placed on crushed ice, then transported under chain-of-custody to the laboratory at the end of the work day.

At the time each monitoring well is sampled, the following information will be recorded in the field: 1) depth-to-water prior to purging, using an electrical well sounding tape, 2) identification of any floating product, sheen, or odor prior to purging, using a clear teflon bailer, 3) sample pH, 4) sample temperature, and 5) specific conductance of the sample.

Waste Generation

All drill cuttings will be stockpiled and stored on-site until the results of laboratory analyses are obtained. Depending upon these results, the cuttings will be disposed of as either a non-hazardous waste, or else transported as a hazardous waste under proper manifest to an appropriate TSD facility. In the case of contaminated soil, it may be possible to remove residual Gasoline concentrations by aeration under permit from the Bay Area Air Quality

Management District (BAAQMD), and thereby facilitate disposal as a non-hazardous waste.

All water removed from the well during development and purging will be drummed and stored on-site until the results of laboratory analyses are obtained. Depending upon these results, the water will be sewered as a non-hazardous liquid waste in accordance with local sewering agency permit requirements, or else it will be transported as a hazardous liquid waste under proper manifest to an appropriate TSD facility for treatment and disposal.

Top-of-Casing Survey

In order to determine groundwater flow direction, the top-of-casing elevation at each monitoring well will be surveyed to within 0.01 feet Mean Sea Level (MSL) of an established City of Emeryville or County of Alameda bench mark.

IV. LABORATORY ANALYSIS

All analyses will be conducted by a California State DOHS certified laboratory in accordance with EPA recommended procedures. The proposed laboratory will be Priority Analytical Laboratory in Milpitas, California (State of California certificate #1708).

<u>**Soil samples**</u> will be analyzed for:

1) EPA method 5030/8015: sec-Butanol
Isopropanol
Acetone
Methy Ethyl Ketone
Methyl Isobutyl Ketone
Gasoline

2) EPA method 5030/8020: Benzene
602 (H_2O) Toluene
Ethylbenzene
Total Xylenes

3) EPA method 3550/8015: Diesel
Kerosene
Mineral Spirits

4) EPA method 5030/8010: Halogenated Volatile Organics
601 (H_2O)

Groundwater samples will be analyzed for:

1) EPA method 5030/8015:
    - sec-Butanol
    - Isopropanol
    - Acetone
    - Methy Ethyl Ketone
    - Methyl Isobutyl Ketone
    - Gasoline

2) EPA method 5030/602:
    - Benzene
    - Toluene
    - Ethylbenzene
    - Total Xylenes

3) EPA method 3550/8015:
    - Diesel
    - Kerosene
    - Mineral Spirits

4) EPA method 601: Halogenated Volatile Organics

V. REPORT

A report will be written that will provide a description of all field work, present the geologic log, and present all laboratory results. The report will include, but not be limited to, the following:

1) a map showing well locations and elevations.
2) soil and formation conditions.
3) geologic logs.
4) depths to groundwater.
5) shallow groundwater contour map.
6) report of presence of free product.
7) results of laboratory analyses.
8) contaminant plume definitions.
9) contaminant source identification.
10) recommendations for further investigation and/or remediation, if deemed necessary.

VI. SITE SAFETY PLAN

A site-specific set of health and safety operating procedures is included in Attachment A. In order to maintain a safe working environment for field personnel, a copy of these operating procedures will be kept on-site during the field operations, and will be followed in accordance with the magnitude of petroleum contamination encountered.

PROPOSED WORKPLAN FOR SUBSURFACE INVESTIGATION
RIX INDUSTRIES
6460 Hollis Street, Emeryville, CA.

April 1, 1994

REGISTERED PROFESSIONAL ENGINEER
GARY H. AGUIAR
No. C-34262
CIVIL
STATE OF CALIFORNIA

EXP. 9-30-95

Gary Aguiar **RCE 34262**

ATTACHMENT A

HEALTH & SAFETY PLAN

SITE HAZARD INFORMATION

FC 1006 (05-11-90)

***PLEASE PROVIDE THE FOLLOWING INFORMATION FOR THE SITE**

Owners Name: Frank DeWolf

Site Address: 6460 Hollis Street
Emeryville, CA

Directions to Site: Site location map follows this site hazard information

Consultant On Site: Hageman-Aguiar, Inc. Phone Number: (510) 284-1661

Site Safety Officer: Gary Aguiar Phone Number: (510) 284-1661

Type of Facility: compressor machine shop Mobile: (415)710-2844

Site Activities: ☒ Drilling ☐ Construction ☐ Tank Excavation ☐ Soil Excavation ☐ Work in Traffic Area
☐ Groundwater Extraction ☐ Vapor Extraction ☐ In Situ Remediation ☐ Above Ground Remediation
☐ Other:

Hazardous Substance

Name (CAS#)	Expected Concentration ☐ Soil ☒ Water ☐ Air	Health Affects
Gasoline	9,300 ug/L (ppb)	
Diesel, Kerosene, Mineral Spirits	20,000 ug/L (ppb)	
Halogenated Solvents	see attached data	

Physical Hazards

☒ Noise
☐ Traffic
☐ Underground Hazards
☐ Overhead Hazards

☐ Excavations/Trenches
☐ Other

Potential Explosion and Fire Hazards (Flammable Range = 1% to 10% Gas Vapor):

Level Of Protection Equipment

☐ A ☐ B ☒ C ☒ D ☐ See Personal Protective Equipment

Personal Protective Equipment

R = Required A = As Needed

R	Hard Hat	R	Safety Eyewear (Type)
R	Safety Boots	A	Respirator (Type) half-face
	Orange Vest		Filter (Type) organic vapor (carbon)
R	Hearing Protection	R	Gloves (Type)
R	Tyvek Coveralls		Other
	5 Minute Escape Respirator		

TABLE 1. Previous Groundwater Sampling Results (July 7, 1992).

Chemical		MW-1	MW-2	MW-3
Gasoline	(ug/L)	680	1,400	9,300
Diesel	(ug/L)	6,100	17,000	20,000
Kerosene	(ug/L)	6,100	17,000	20,000
Mineral Spirits	(ug/L)	6,400	20,000	21,000
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Toluene	(ug/L)	ND	12	3,600
Ethyl Benzene	(ug/L)	38	69	ND
m-Xylene	(ug/L)	270	1,100	530
o-Xylene	(ug/L)	290	260	210
p-Xylene	(ug/L)	240	520	430
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Methyl Isobutyl Ketone (MIBK)	(ug/L)	ND	ND	ND
Oil & Grease	(ug/L)	14	19	28

ND = not detected

TABLE 2. Previous Groundwater Sampling Results (July 7, 1992).

Chemical		MW-1	MW-2	MW-3
Carbon Tetrachloride	(ug/L)	ND	ND	980
1,1-Dichloroethane	(ug/L)	36	22	30
1,2-Dichloroethane	(ug/L)	ND	ND	450
cis-1,2-Dichloroethene	(ug/L)	ND	99	630
Tetrachloroethene	(ug/L)	ND	52	2,200
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Trichloroethene (TCE)	(ug/L)	ND	21	300
Vinyl Chloride	(ug/L)	ND	46	ND

ND = not detected

SITE HAZARD INFORMATION

FC 1006 (05-11-90)

Monitoring Equipment on Site

☒ Organic Vapor Analyzer
☒ Oxygen Meter
☒ Combustible Gas Meter
☐ H_2S Meter
☐ W.B.G.T.

☒ PID with lamp of 10.0 eV
☐ Draeger Tube
☐ Passive Dosimeter
☐ Air Sampling Pump
☐ Filter Media

Site Control Measures FID & PID meters on-site. Public access restricted by existing perimeter fencing and yellow tape.

Decontamination Procedures Equipment steam-cleaned on-site. Rinseate stored in DOT 17H drums. Gloves, tyvek suits to be disposed of with drill cuttings. Personnel to wash with soap and water prior to eating and/or leaving site.

Hospital/Clinic Alta Bates Hospital Phone (510) 540-4444

Hospital Address 3001 Colby at Ashby, Berkeley

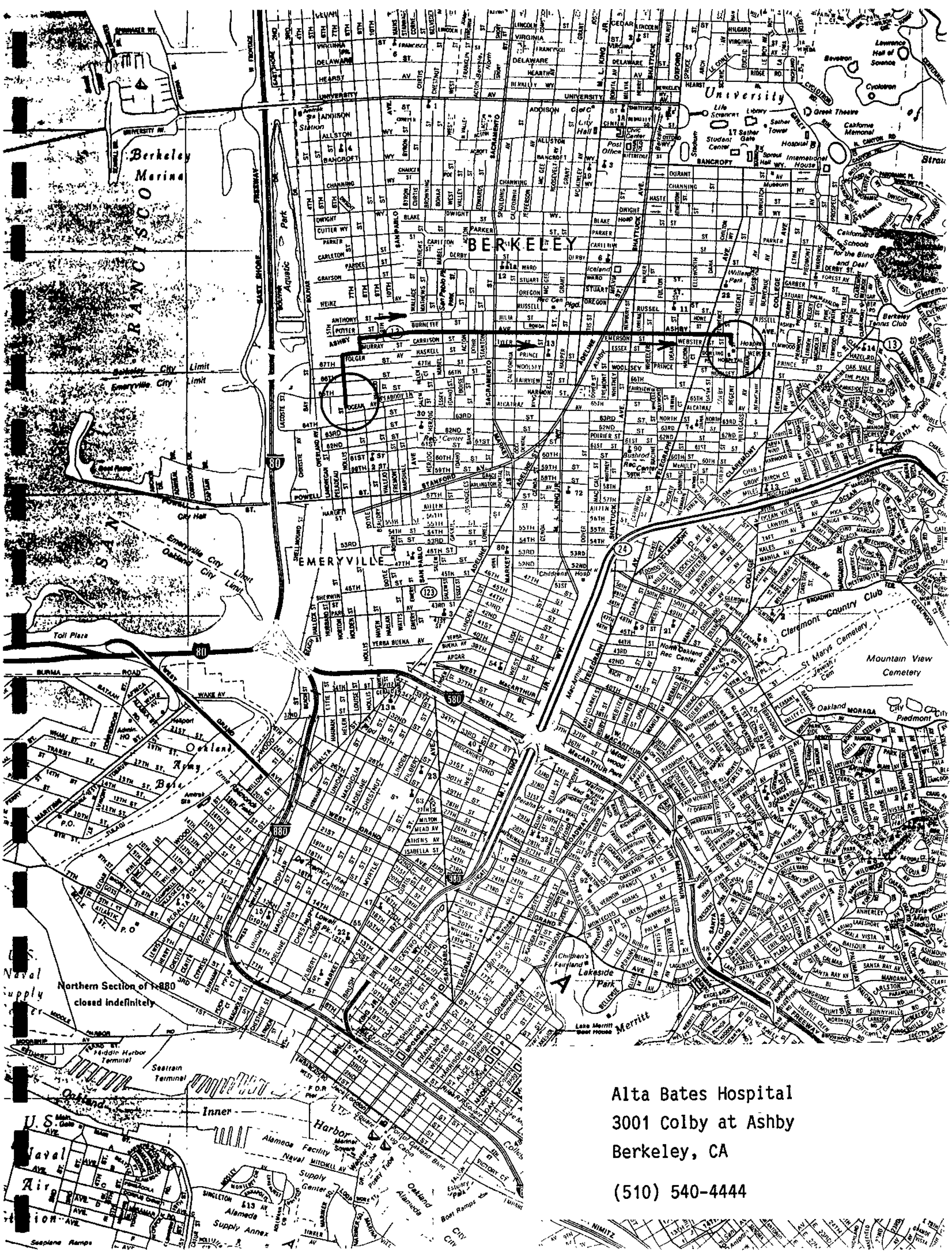
Paramedic 911 Fire Dept. 911 596-3771 Police Dept. 911 596-3737

Emergency/Contingency Plans & Procedures

Site Hazard Information Provided By: Gary Aguiar
Print
Gary Aguiar
Signature

Phone Number: 510) 284-1661

Date: 4/1/94



Alta Bates Hospital
3001 Colby at Ashby
Berkeley, CA

(510) 540-4444

HAGEMAN-AGUIAR, INC.
Underground Contamination Investigations, Groundwater Consultants, Environmental Engineering

HEALTH AND SAFETY PROCEDURES
FOR
FIELD INVESTIGATION OF UNDERGROUND SPILLS OF MOTOR OIL AND PETROLEUM DISTILLATE FUEL

August 1993

3732 Mt. Diablo Blvd. Suite 372 Lafayette, California 94549 (510) 284-1661 FAX (510) 284-1664

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1. PURPOSE

This operating procedure established minimum procedures for protecting personnel against the hazardous properties of motor oil and petroleum distillate fuels during the performance of field investigations of known and suspected underground releases of such materials. The procedure was developed to enable health and safety personnel and project managers to quickly prepare and issue site safety plans for investigations of such releases.

2. APPLICABILITY

This procedure is applicable to field investigations of underground releases of the substances listed below and involving one or more of the activities listed below:

2.1 Substances

Motor oil (used and unused)
Leaded and unleaded gasoline
No. 1 Fuel oil (kerosene, JP-1)
No. 1-D Fuel oil (light diesel)
No. 2 Fuel oil (home heating oil)
No. 2-D Fuel oil (medium diesel)
No. 4 Fuel oil (residual fuel oil)
No. 5 Fuel oil (residual fuel oil)
No. 6 Fuel oil (Bunker C fuel oil)
JP-3, 4 & 5 (jet fuels)
Gasahol

2.2 Activities

-- Collection of samples of subsurface soil with aid of truck-mounted drill rig, hand-held power auger or hand auger.

-- Construction, completion and testing of groundwater monitoring wells.

-- Collection of groundwater samples from new and existing wells.

- Observing removal of underground fuel pipes and storage tanks.

This procedure must not be used for confined space entry (including trench entry).

No safety plans needed for non-intrusive geophysical surveys, reconnaissance surveys and collection of surface soil, surface water and biota.

3. RESPONSIBILITY AND AUTHORITY

Personnel responsible for project safety are the Business Unit Health and Safety Officer (**HSO**), the Project Manager (**PM**) and the Site Safety Officer (**SSO**).

The **HSO** is responsible for reviewing and approving site safety plans and any addenda and for advising both PM and SSO on health and safety matters. The **HSO** has the authority to audit compliance with the provisions of site safety plans, suspend work or modify work practices for safety reasons, and to dismiss from the site any individual whose conduct on site endangers the health and safety of others.

The **PM** is responsible for having site safety plans prepared and distributed them to all field personnel and to an authorized representative of each firm contracted to assist with on-site work. The **PM** is also responsible for ensuring that the provisions of safety plans and their addenda are carried out.

The **SSO** is responsible for assisting the **PM** with on site implementation of site safety plans. Responsibilities include:

1. Maintaining safety equipment supplies.

2. Performing or supervising air quality measurements.

3. Directing decontamination operations and emergency response operations.

4. Setting up work zone markers and signs if such zones are specified in the site safety plan.

5. Reporting all accidents, incidents and infractions of safety rules and requirements.

6. Directing other personnel to wear protective equipment when use conditions (described in **Section 5.0**) are met.

The **SSO** may suspend work anytime he/she determines that the provisions of the site safety plan are inadequate to ensure worker safety and inform the **PM** and **HSO** of individuals whose on-site behavior jeopardizes their health and safety of the health and safety of others.

4. HAZARD EVALUATION

Motor oil and petroleum distillate fuels are mixtures of aliphatic and aromatic hydrocarbons. The predominant classes of compounds in motor oil, gasoline, kerosene and jet fuels are the paraffins (e.g., benzene, toluene). Gasoline contains about 80 percent paraffins, 6 percent naphthenes, and 14 percent aromatic. Kerosene and jet fuels contain 42-48 percent paraffins, 36-38 percent naphthenes, and 68-78 percent non-volatile aromatic. These heavier fuels contain almost no volatile aromatic compounds. Chemicals are usually added to automotive and aviation fuels to improve their burning properties. Examples are tetraethyl-lead and ethylene dibromide. Most additives are proprietary materials.

4.1 Flammability

Crude oil and petroleum distillate fuels possess two intrinsic hazardous properties, namely, flammability and toxicity. The flammable property of the oil and fuels presents a far grater hazard to field personnel than toxicity because it is difficult to protect against and can result in catastrophic consequences. Being flammable, the vapors of volatile components of crude oil and the fuels can be explosive when confined.

The lower flammable or explosive limits (LFL or LEL) of the fuels (listed in Section 2.1) range from 0.6 percent for JP-5 to 1.4 percent for gasoline. LFL and LEL are synonyms. Flash points range from -36°F for gasoline to greater than 150°F for No. 6 fuel oil. JP-5 has a flash point of 140°F.

Although it has a lower LEL than gasoline, it can be considered less hazardous because its vapors must be heated to a higher temperature to ignite.

Crude oil and petroleum distillate fuels will not burn in the liquid form; only the vapors will burn and only if the vapor concentration is between the upper and lower flammable limits, sufficient oxygen is present, and an ignition source is present. If these conditions occur in a confined area an explosion may result.

The probability of fire and explosion can be minimized by eliminating any one of the three factors needed to produce combustion. Two of the factors -- ignition source and vapor concentration -- can be controlled in many cases. Ignition can be controlled by prohibiting open fires and smoking on site, installing spark arrestors on drill rig engines, and turning the engines off when LELs are approached. Vapor concentrations can be reduced by using fans. In fuel tanks, vapor concentrations in the head space can be reduced by introducing dry ice (solid carbon dioxide) into the tank; the carbon dioxide gas will displace the combustible vapors.

4.2 Toxicity

Crude oil and petroleum distillate fuels exhibit relatively low acute inhalation and dermal toxicity. Concentrations of 160 to 270 ppm gasoline vapor have been reported to cause eye, node and throat irritation after several hours of exposure. Levels of 500 to 900 ppm can cause irritation and dizziness in one hour, and 2000 ppm produces mild anesthesia in 30 minutes. Headaches have been reported with exposure to 25 ppm or more of gasoline vapors measured with a photoionization meter. Must fuels, particularly gasoline, kerosene and jet fuels are capable of causing skin irritation after several hours of contact with the skin.

Petroleum fuels exhibit moderate oral toxicity. The lethal dose of gasoline in children has been reported to be as low as 10-15 grams (2-3 teaspoons). In adults, ingestion of 20-50 grams of gasoline may produce severe symptoms of poisoning. If liquid fuel aspirated (passes into the lungs), gasoline and other petroleum distillate fuels may cause secondary pneumonia.

Some of the additives to gasoline, such as ethylene dichloride, ethylene dibromide, tetraethyl and tetramethyl lead, are highly toxic; however, they are present in such low concentrations that their contribution to the overall toxicity of gasoline and other fuels is negligible in most instances.

OSHA has not developed permissible workplace exposure limits for crude oil and petroleum distillate fuels. It recommends using permissible exposure limits for individual components, such as benzene. The American Conference of Government Industrial Hygienists (ACGIH) has established a permissible exposure limit of 300 ppm for gasoline. The limit took into consideration the average concentration of benzene in gasoline (one percent) as well as its common additives. Exposure limits established by other countries range from 250 to 500 ppm. Chemical data sheets, prepared for the U.S. Coast Guard's Chemical Hazard Information System (CHRIS), list 200 ppm as the permissible exposure limit for kerosene and jet fuels. This limit was not developed by NIOSH/OSHA or ACGIH.

5. HEALTH AND SAFETY DIRECTIVES

5.1 Site-Specific Safety Briefing

Before field work begins, all field personnel, including subcontractor employees, must be briefed on their work assignments and safety procedures contained in this document.

5.2 Personal Protective Equipment

The following equipment should be available on-site to each member of the field team:

- NIOSH-approved full or half-face respirator with organic vapor cartridges (color coded black)
- Saranex or polyethylene-coated Tyvek coveralls
- Splash-proof safety goggles
- Nitrile or neoprene gloves
- Neoprene or butyl boots, calf-length with steel toe and shank
- Hardhats

5.2.1 Equipment Usage

Chemical-resistant safety boots must be worn during the performance of work where surface soil is obviously contaminated with oil or fuel, when product quantities of oil or fuel are likely to be encountered, and within 10 feet of operating heavy equipment.

Respirators must be worn whenever total airborne hydrocarbon levels in the breathing zone of field personnel reach or exceed a 15-minute average of 25 ppm. If total airborne hydrocarbons in the breathing zone exceeds 100 ppm, work must be suspended, personnel directed to move a safe distance from the source, and the HSO or designee consulted.

Chemical resistant gloves must be worn whenever soil or water known or suspected of containing petroleum hydrocarbons is collected or otherwise handled.

Chemical resistant coveralls must be worn whenever product quantities of fuel are actually encountered and when oil for fuel-saturated soil is handled.

Safety goggles must be worn when working within 10 feet of any operating heavy equipment (e.g., drill rig, backhoe). Splash-proof goggles or face shields must be worn whenever product quantities of oil or fuel are encountered.

Hardhats must be worn when working within 10 feet of an operating drill rig, backhoe or other heavy equipment.

Operators of some facilities, such as refineries, often require all personnel working within facility boundaries to wear certain specified safety equipment. Such requirements shall be strictly observed.

5.3 Vapor Monitoring

5.3.1 Required Equipment

--- Organic vapor meter the flame or photoionization detector

--- Combustible gas meter

5.3.2 Monitoring Requirements and Guidelines

Vapor monitoring shall be performed as often as necessary and whenever necessary to protect field personnel from hazardous vapors. Monitoring must be performed by individuals trained in the use and care of the monitoring equipment.

During drilling operations, vapor emissions from boreholes must be measured whenever the auger is removed from the boring and whenever flights are added or removed from hollow-stem augers. This requirement does not apply to borings less than five feet deep and borings of any depth made to install monitoring wells in uncontaminated solid. Measurements should be made initially with an organic vapor meter, followed with a combustible gas meter if vapor levels exceed the highest concentration measurable with the organic vapor meter.

Initially measurements shall be made about 12 inches from the bore hole, both upwind and downwind positions. If the total hydrocarbon concentrations exceed the respirator use action level, measurements must be made in the breathing zone of the individual(s) working closest to the borehole. Decisions regarding respiratory protection should be made using vapor concentrations in the breathing zone.

Organic vapor meter capable of being operated continuously without attention may be operated in that fashion if desired. However, the instrument must be equipped with an alarm set to sound when vapor concentrations reach 25 ppm and must be protected against physical damage and spoilage.

If total organic vapor concentrations within 12 inches of the borehole exceed the capacity of the organic vapor meter, a combustible gas meter (CGM) must be used to determine if explosive conditions exist. Operations must be suspended, the drill rig motor shot down, and corrective action taken if combustible gas concentrations reach 40 percent of LEL within a 12-inch radius of the borehole of 10 percent of LEL at a distance greater than 24 inches from the borehole. This procedure must also be followed whenever the organic vapor meter goes off-scale at its highest range and no CGM is available. If corrective action cannot be taken, field personnel and all other individuals in the vicinity of the borehole must be directed to move to a safe area and the local fire department and facility management must be alerted.

Organic vapor meter with flame ionization detectors (FID) are much more sensitive to paraffins, with the major component of gasoline, kerosene, and jet fuels, then are meters with 10.0 or 10.2 eV photoionization detectors. As the data in Table 1 show, an FID instrument, such as the Century Systems OVA (Foxboro Analytical), will detect 70-90 percent of actual paraffin concentrations, whereas PID instruments, such as the HNU Model PI-101, AID Model 580, and Photovac TIP with 10.0 to 10.2 eV lamp will detect only 17-25 percent of actual paraffin concentrations when calibrated with benzene and only 24-35 percent when calibrated with isobutylene. Both types of meters are equally sensitive to most aromatic, including benzene, toluene, xylene and ethylbenzene. For these compounds, meter readings equal or exceed 100 percent of actual concentrations. PIDs with 11.7 eV lamps are extremely sensitive to paraffins and aromatic. When calibrated to isobutylene, an 11.7 eV PID will register about twice actual paraffin concentrations and 100 percent or more of actual concentrations of benzene, toluene, and xylene.

An FID meter, recently calibrated with methane and in good working condition, can be expected to provide readings close enough to actual petroleum hydrocarbon concentrations to make corrections unnecessary. Value obtained with a PID must be corrected when measured for paraffins. For 10.0 and 10.2 eV PIDs, the meter reading should be multiplied by 5 if the instrument is calibrated with benzene. If the instrument is calibrated with isobutylene, the meter readings should be multiplied by 3. If the instrument is equipped with an 11.7 eV probe and is calibrated with isobutylene, the meter reading should be divided by 2.

5.4 Area Control

Access to hazardous and potential hazardous areas of spill sites must be controlled to reduce the probability of occurrence of physical injury and chemical exposure of field personnel, visitors and the public. A hazardous or potentially hazardous area includes any area where:

1. Field personnel are required to wear respirators.
2. Borings are being drilled with powered augers.

3. Excavating operations with heavy equipment are being performed.

The boundaries of hazardous and potentially hazardous areas must be identified by cordons, barricades, or emergency traffic cones or posts, depending on conditions. If such areas are left unattended, signs warning of the danger and forbidding entry must be placed around the perimeter if the areas are accessible to the public. Trenches and other large holes must be guarded with wooded or metal barricades spaced no further than 20 feet apart and connected with yellow or yellow and black nylon tape not less than 3/4-inches wide. The barricades must be placed no less than two feet from the edge of the excavation or hole.

Entry to hazardous areas shall be limited to individuals who must work in those areas. Unofficial visitors must not be permitted to enter hazardous areas while work in those areas are in progress. Official visitors should be discouraged from entering hazardous areas, but may be allowed to enter only if the agree to abide by the provisions of this document, follow orders issued by the site safety officer and are informed of the potential dangers that could be encountered in the areas.

5.5 Decontamination

Field decontamination of personnel and equipment is not required except when contamination is obvious (visually or by odor). Recommended decontamination procedures follow:

5.5.1 Personnel

Gasoline, kerosene, jet fuel, heating oil, gasahol and diesel oil should be removed from skin using a mild detergent and water. Hot water is more efficient than cold. Liquid dishwashing detergent is more effective than hand soap. Motor oil and the heavier fuel oils (No. 4-6) can be removed with dishwashing detergent and hot water also; however, if weathered to an asphaltic condition, mechanic's waterless hand cleaner is recommended for initial cleaning followed by detergent and water.

5.5.2 Equipment

Gloves, respirators, hardhats, boots and goggles should be cleaned as described under personnel. If boots do not become clean after washing with detergent and water, wash them with a strong solution of trisodium phosphate and hot water.

Sampling equipment, augers, vehicle undercarriages and tires should be steam cleaned. The steam cleaner is a convenient source of hot water for personnel and protective equipment cleaning.

5.6 Smoking

Smoking and open flames are strictly prohibited at sites under investigation.

TABLE 1
RELATIVE SENSITIVITIES OF FID AND PID INSTRUMENTS TO SELECTED COMPONENTS OF OILS AND PETROLEUM DISTILLATE FUELS

	Sensitivity in Percent of Standard		
	FID	PID	
Component		10.2 eV[a]	11.7 eV[b]
Paraffins			
Pentane	65	--	141
Hexane	70	22 (31)	189
Heptane	75	17 (24)	221
Octane	80	25 (35)	---
Nonane	90	--	---
Decane	75	--	---
Napthenes			
Cyclopentane	--	--	---
Methylcyclopentane	80	--	---
Cyclohexane	85	34 (40)	---
Methylcyclohexane	100	--	---
Aromatic			
Benzene	150	100 (143)	122
Toluene	110	100 (143)	100
Ethylbenzene	100	---	---
p-Xylene	116	114 (60)	---
Cumene	100	---	---
n-Propylbenzene	---	---	---
Napthaeine	---	---	---

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[a] Values are relative to benzene standard. Values in parentheses are relative to isobutylene standard and were calculated.

[b] Values are relative to isobutylene standard.