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May 11, 2012

Mr. Keith Nowell
Alameda County Health Care Services Agency
1131 Harbor Bay Parkway, Suite 250
Alameda, CA 94502-6577

RECEIVED

11:53 am, May 17, 2012

Alameda County
Environmental Health

Subject: **Work Plan**

Site: **76 Service Station No. 5325**
3220 Lakeshore Avenue
Oakland, California
Fuel Leak Case No. RO0000229

Dear Mr. Nowell;

I declare under penalty of perjury that to the best of my knowledge the information and/or recommendations contained in the attached report is/are true and correct.

If you have any questions or need additional information, please call:

Brian Whalen
Platinum Energy
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Sincerely,

PLATINUM ENERGY

BRIAN WHALEN

Attachment

Work Plan

Surfactant Infiltration and Batch Extraction
76 Service Station No. 5325
3220 Lakeshore Avenue
Oakland, California 94601

Alameda County Health Care Services Agency
Fuel Leak Case No. RO0000229
San Francisco Bay Regional Water Quality Control Board
No. 01-1588
GeoTracker Global ID No.T0600101463
Antea Group Project No. I40255325
May 11, 2012

Prepared for:
Mr. Keith Nowell
Alameda County Environmental Health
1131 Harbor Bay Parkway,
Suite 250
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Prepared by:
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Work Plan

Surfactant Infiltration and Batch Extraction
76 Service Station No. 5325

1.0 INTRODUCTION

Antea Group hereby proposes to perform a series of three surfactant infiltration events using Ivey-sol surfactant and three corresponding batch extraction events. Ivey-sol is a chemical product that is comprised of several nonionic surfactant formulations that have the ability to selectively desorb and liberate a range of absorbed and adsorbed contaminants, many of which are contaminants of concern (COC) present at the site, including petroleum hydrocarbons, methyl tertiary-butyl ether (MTBE), and tertiary-butyl alcohol (TBA). Further information on Ivey-sol products is presented as **Appendix A.**

This work is proposed in an effort to remove petroleum hydrocarbon impacted groundwater from the underground storage tank (UST) basin and other subsurface areas of the site, as well as removing petroleum hydrocarbon contaminants from subsurface soils at the site.

1.1 Site Description

The site is located at the southeastern corner of the intersection of Lakeshore Avenue and Lake Park Avenue in Oakland, California. Station facilities include two gasoline USTs, two dispenser islands under a single canopy, a third dispenser island under a separate canopy, and a station building with a single repair bay (**Figures 1 and 2**).

1.2 Previous Assessment

1.2.1 Summary of Previous Environmental Investigations

<u>May 1990</u>: Three exploratory soil borings were advanced adjacent to the UST complex to depths ranging from 10 to 12.5 feet below ground surface (bgs). Soil samples were analyzed for total petroleum hydrocarbons as gasoline (TPH-G) and benzene, toluene, methylbenzene, and xylenes (BTEX). The samples contained TPH-G concentrations ranging from 2 to 7,500 parts per million (ppm) and benzene concentrations ranging from 0.14 to 13 ppm.

June 1990: Two 10,000-gallon gasoline USTs, one 550-gallon waste oil UST, and related product dispensers were replaced. Soil samples from the UST excavation sidewalls and bottom and product line trenches were reported to contain TPH-G and benzene at concentrations ranging from 12 to 2,800 ppm and 0.008 to 11 ppm, respectively. Approximately 250 cubic yards of soil and backfill material were aerated onsite to reduce concentrations to below 100 ppm TPH-G, then transported to an appropriate soil disposal facility. Groundwater was encountered at approximately 7.5 feet bgs.

September 1990: Monitoring wells U-1, U-2, and U-3 were installed. TPH-G was detected in soil samples collected from the capillary fringe in well borings U-1 and U-2 at levels of 110 and 480 ppm, respectively. Benzene was detected in the soil sample from well boring U-1 at a level of 4.5 ppm. Petroleum hydrocarbons were not detected in soil or groundwater samples from U-3. Groundwater samples collected from wells U-1 and U-2 were reported to contain 690 and 38 parts per billion (ppb) TPH-G and 780 and 27 ppb benzene, respectively.

June 1990: Monitoring wells U-4, U-5, and U-6 were installed. TPH-G and benzene were detected in the capillary fringe soil sample collected from boring U-5 at levels of 400 ppm and 1.9 ppm, respectively. TPH-G and benzene were not detected in soil samples collected from borings U-4 and U-6. Groundwater levels stabilized at depths between 8.8 and 9.2 feet bgs.

November 1996: One 550-gallon waste oil UST was removed and the product lines and dispensers were replaced. A soil sample collected from the sidewall of the waste oil UST excavation contained 1.5 ppm total petroleum hydrocarbons as diesel (TPH-D) and 78 ppm total oil and grease (TOG). TPH-G, benzene, methyl tertiary butyl ether (MTBE), halogenated volatile organic compounds (HVOCs), and semi-volatile organic compounds (SVOCs) were not detected. Product line trench excavation and over excavation samples were reported to contain petroleum hydrocarbon levels ranging from non-detect to 880 ppm of TPH-G, non-detect to 3.6 ppm of benzene, and non-detect to 23 ppm of MTBE. Approximately 276 tons of excavated soil was transported to an appropriate disposal facility.

June 1997: Two exploratory borings (U-D and U-E) and one UST observation well were installed. U-D was advanced offsite on Lakeshore Avenue. TPH-G, BTEX, and MTBE were detected in one or all of the soil samples collected at the capillary fringe from the soil borings. TPH-G and MTBE were detected at a maximum of 450 ppm and 1.1 ppm, respectively, in U-D.

October 2003: Site environmental consulting responsibilities were transferred to TRC.

April 2006: Three ozone sparge wells (C-1 through C-3) were installed by TRC in the vicinity of U-2 for the purpose of an ozone pilot study. Total purgeable petroleum hydrocarbons (TPPH) were detected at a maximum of 4,600 milligrams per kilograms (mg/kg) in the five feet below grade (fbg) soil sample collected from C-1.

June through August 2006: A 3-month ozone sparge event was completed on sparge points C-1 through C-3 located in the vicinity of Site well U-2 using a mobile ozone sparge treatment system.

October 2007: Site environmental consulting responsibilities were transferred to Delta Consultants.

January 2011: Delta Consultants rebranded to Antea Group.

1.3 Sensitive Receptors Survey

Lake Merritt is located approximately 0.3 miles down-gradient. No domestic water wells are located within a one mile distance of the site.

1.4 Site Hydrogeology

The site is located in the Santa Clara Valley Groundwater Basin, East Bay Plain Subbasin. The site is underlain by estuarine deposits consisting primarily of unconsolidated clay and silt rich in organic material.

Based on previous investigations, the site is underlain by clay and silt to depths of approximately 25 feet bgs. Discontinuous units of sand and gravel were observed beneath the site at varying depths. The water-bearing unit, composed of sand and silt, is encountered at depths ranging from 6 to 17 feet bgs.

Currently, six groundwater monitoring wells (U-1 through U-6) are purged and sampled on a semi-annual basis during the second and fourth quarters at the site. During the most recent groundwater monitoring event (June 2011), groundwater was reported between 5.12 and 11.15 feet below top of casing (BTOC) in the site monitoring wells. The location of the monitoring wells is shown on **Figure 2,** construction details and boring logs are presented as **Appendix B**.

2.0 PROPOSED ACTIVITIES

2.1 Health and Safety

Before commencing field activities Antea Group will prepare a Health and Safety Plan in accordance with state and federal requirements for use during remediation activities. Field activities will at all times conform to the health and safety requirements and practices specified in Antea Group Standard operating Procedures, presented in **Appendix C.**

2.2 Baseline Groundwater Sampling

Prior to initial infiltration of Ivey-sol surfactant, groundwater samples will be collected from monitoring wells U-1, U-2, U-3, U-4, U-5, and U-6 to determine baseline levels of petroleum hydrocarbon contamination. These samples will be analyzed for TPHg by the CA LUFT Method, benzene, toluene, methylbenzene, total xylenes (BTEX), and MTBE by EPA Method 8260.

2.3 Surfactant Infiltration

Infiltration of Ivey-sol surfactant will be performed using monitoring wells U-1 and U-2. During each infiltration event, a specified quantity of surfactant will be infiltrated, followed by fifty gallons of potable water. Depth to water will be monitored at the closest well to each infiltration well during the infiltration of the potable water in order to determine the radius of diffusion for each infiltration well. The quantity of fresh water may be adjusted in the field based on this information. A surge block will be utilized as needed to insure the dispersal of the surfactant into the formation. The surfactant will be allowed to work in-situ for a minimum of 10 days, after which a batch extraction event will be performed to remove both surfactant and possibly petroleum hydrocarbon impacted groundwater.

2.4 Groundwater Extraction

Batch extraction will be performed using wells U-1, U-2, TW-1, TW-2, C-1, C-2, and C-3 by a vacuum truck. Extraction of groundwater will commence using the most impacted well (U-1), and then progress in descending order of impact to the least impacted well (C-1). In each case the extraction wells are expected to run dry, at which point a further ten minutes of extraction in the dewatered state will be performed before moving to the next well. Upon completion of one extraction cycle for each well, the procedure will be repeated until the proposed quantity of impacted groundwater has been extracted. Impacted groundwater extracted from the wells will be transported off-site for proper disposal. Batch extraction will occur a minimum of 10 days after each surfactant infiltration. Additional groundwater samples will be collected approximately 5 days after each extraction event and analyzed for TPHg by the CA LUFT Method, benzene, toluene, ethylbenzene, total xylenes (BTEX), and MTBE by Environmental Protection Agency (EPA) Method 8260.

2.5 Repetition of Soil Washing Procedures

The process of infiltrating surfactant and subsequently performing a batch extraction event will be performed a minimum of three times, after which subsurface petroleum hydrocarbon concentrations will be assessed by groundwater sampling and the possibility of further remediation work evaluated.

Each repetition of the soil washing procedure will consist of the following: infiltration of Ivey-sol; minimum ten days working (contact) time for the surfactant; batch extraction; minimum 5 days settling time; and groundwater sampling. A minimum of five days will be allowed between each repetition to maximize efficacy of the procedure.

2.6 Disposal of Waste Water

Purge water generated during batch extraction activities will be profiled using previous groundwater sampling data. The purged groundwater will be transported to, and disposed of at, an approved facility.

2.7 Semi-Annual Groundwater Sampling

In addition to the soil washing-specific sampling detailed above, the current groundwater monitoring and sampling schedule will remain unchanged.

2.8 Reporting

A summary of the surfactant infiltration and batch extraction event will be submitted in a report no later than 60 days after the field work has been completed. Required electronic submittals will be uploaded to the State Geotracker database.

3.0 REMARKS

The recommendations contained in this report represent Antea USA, Inc.'s professional opinions based upon the currently available information and are arrived at in accordance with currently accepted professional standards. This report is based upon a specific scope of work requested by the client. For any reports cited that were not generated by Delta or Antea Group, the data from those reports is used "as is" and is assumed to be accurate. Antea Group does not guarantee the accuracy of this data for the referenced work performed nor the inferences or conclusions stated in these reports. The contract between Antea USA, Inc. and its client outlines the scope of work, and only those tasks specifically authorized by that contract or outlined in this report were performed. This report is intended only for the use of Antea USA, Inc.'s client and anyone else specifically identified in writing by Antea USA, Inc. as a user of this report. Antea USA, Inc. will not and cannot be liable for unauthorized reliance by any other third party. Other than as contained in this paragraph, Antea USA, Inc. makes no express or implied warranty as to the contents of this report.

Prepared by:

Joshua L. Wolff, E.I.T.
Staff Engineer

For
Josh Mahoney
Senior Project Manager

Information, conclusions, and recommendations provided by Antea Group in this document regarding the site have been prepared under the supervision of and reviewed by the licensed professional whose signature appears below.

Licensed Approver:

Dennis S. Dettloff

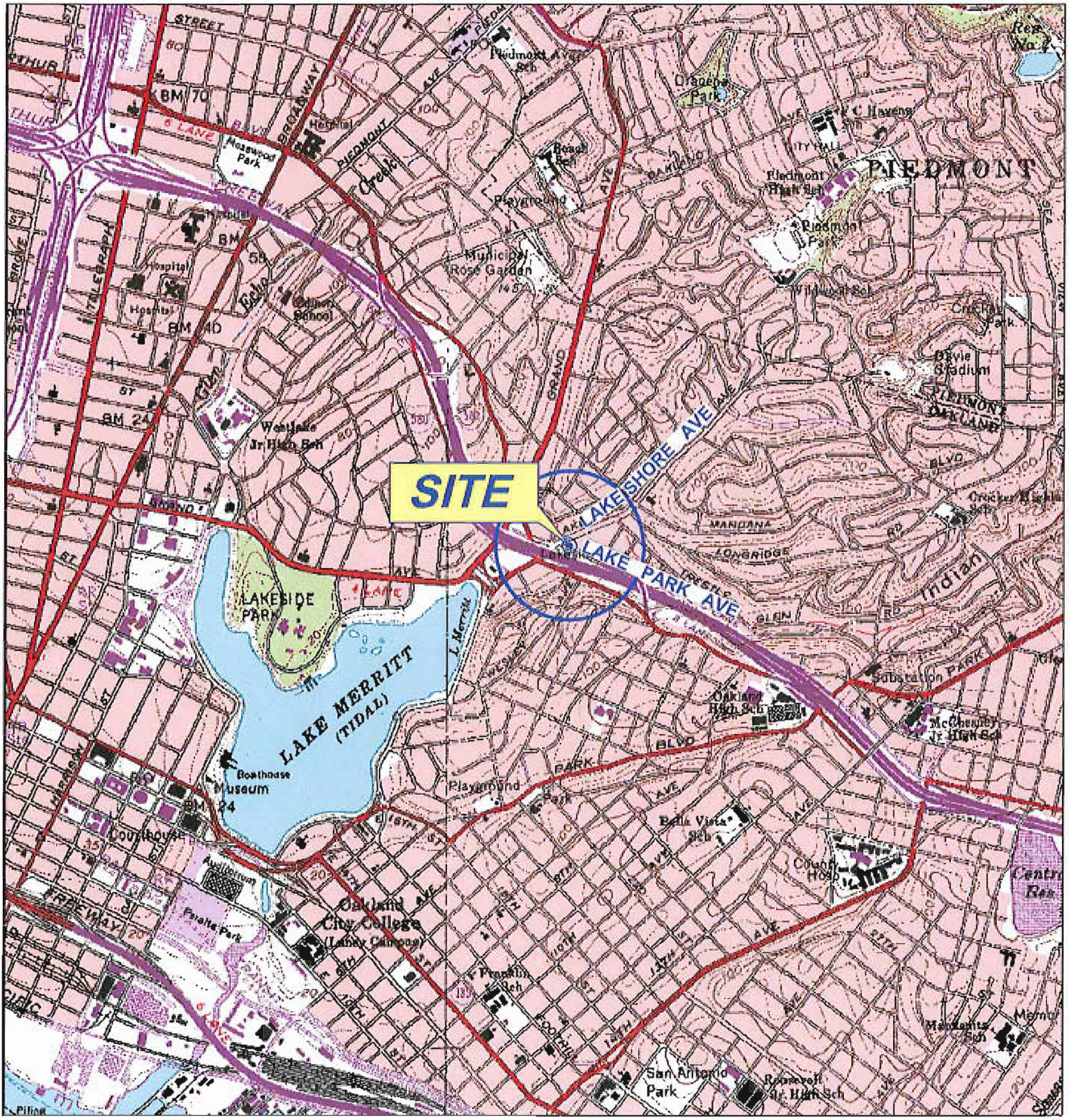
DENNIS SHANNON DETTLOFF
No. 7480

Date: May 11, 2012

Dennis S. Dettloff
Project Manager
California Registered Professional Geologist No. 7480

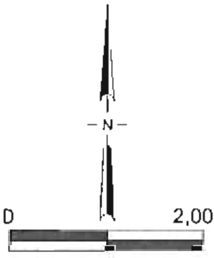
cc: GeoTracker (upload)

Figures



GENERAL NOTES:
BASE MAP FROM 3-D TOPO QUADS
OAKLAND WEST & OAKLAND EAST, CA. QUADRANGLE
7.5 MINUTE TOPOGRAPHIC MAP

SITE LOCATION



SCALE

FIGURE 1
SITE LOCATION MAP

76 SERVICE STATION NO. 5325
3220 LAKESHORE AVENUE
OAKLAND, CALIFORNIA

PROJECT NO. 140255325		DRAWN BY JH
FILE NO. 5325–SLM		PREPARED BY EW
DATE 28 JAN 11	REV. 2	REVIEWED BY

anteagroup

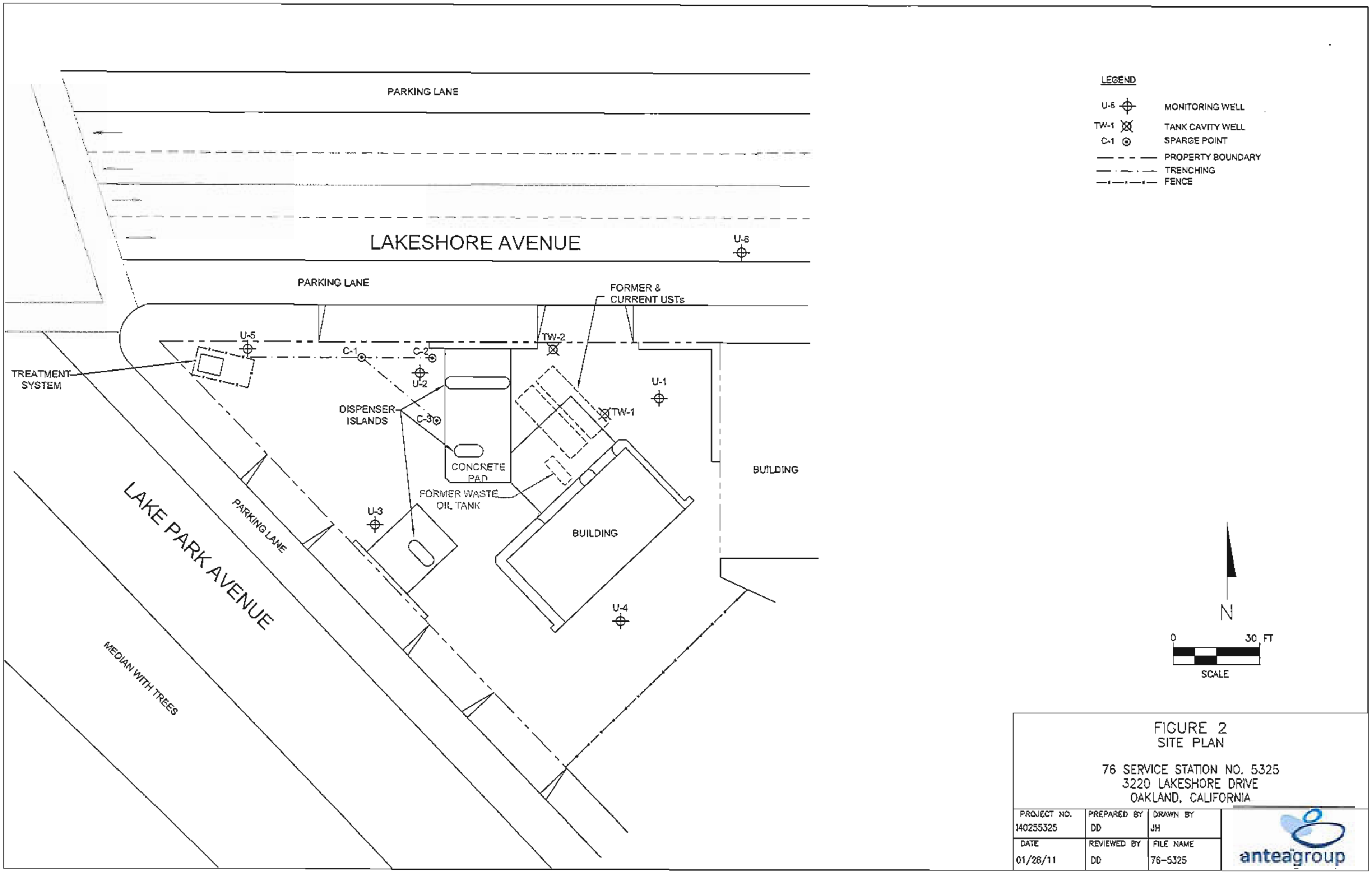


FIGURE 2
SITE PLAN

76 SERVICE STATION NO. 5325
3220 LAKESHORE DRIVE
OAKLAND, CALIFORNIA

PROJECT NO. 140255325	PREPARED BY DD	DRAWN BY JH
DATE 01/28/11	REVIEWED BY DD	FILE NAME 76-5325

anteagroup

Appendix A

Ivey-sol Data

Paper No: E6326

Surfactant Enhanced Aquifer Remediation (SEAR) Using Ivey-sol® Surfactant Technology

George A. Ivey, Ivey International Inc., budivey@island.net

Executive Summary

This paper will focus on the application of Ivey-sol® non-ionic surfactant technology to improve the in-situ remediation of petroleum hydrocarbon contamination is soil and bedrock aquifers.

Normally hydrophobic organic chemicals (HOC) exhibit limited solubility in groundwater as the contaminants tend to partition onto the soil and bedrock matrix. This partitioning can account for as much as 90-95% or more of the total contaminant mass. As a consequence, the hydrocarbon contaminants exhibit moderate to poor recovery during pump and treatment; limited bioavailability to microorganisms; and limited availability to oxidative and reductive chemicals when applied to in-situ and or ex-situ applications. Hence certain HOC's can persist in the soil and or bedrock matrix for long periods of time.

The sorption (i.e., adsorption and adsorption) of contamination onto solids is often considered the principal limiting factor affecting the effectiveness of the many remediation technologies. This coupled with complex site geology; including sands and gravels, to fine grained silts and clays and fractured bedrock; only further complicate their application.

Ivey-sol® is a non-ionic surfactant technology, comprised of several proprietary formulations, are capable of selectively desorbing and dissolving contaminants as microscopic 'surfactant-hydrocarbon-water' partial encapsulations, called partial micelles, well below their critical micelle concentration (CMC). In addition, Ivey-sol can lower the surface tension of water from 72 dynes to less than 30 dynes increasing the wetting and permeability properties of water in fine grain soils and fractured bedrock.

Ivey-sol® surfactants affect the sorption of HOC and surfactants at the solid-liquid interface (i.e., the surface–H_2O–NAPL interface). As a result, they increase the solubility of the contaminants in the groundwater for the improved removal by P&T, or treatment by bioremediation, and or chemical oxidative or reductive treatment processes.

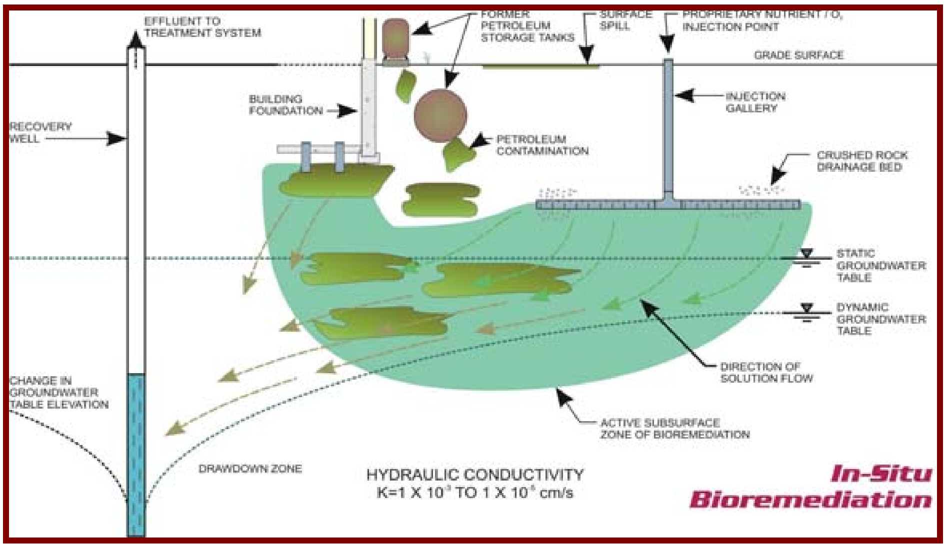
Through desorbing contamination and lowering the surface tension, Ivey-sol formulations address two principal factors affecting the successful application of remediation technology. They overcome the contaminant absorption limitations, and improve the transitivity of the water by reducing the surface tension allowing greater effective water penetration into and through finer grained less permeable, soil substrate.

1.0 SURFACTANT ENHANCES AQUIFER REMEDIATION (SEAR)

Bioremediation can be defined as any process that uses microorganisms or their enzymes to remove and or neutralize contaminants within the environment (i.e., within soil and water) to their original condition. Bioremediation can be employed to remediate specific types of contaminants such as; petroleum hydrocarbons, polycyclic aromatic hydrocarbons (PAH), polychlorinated biphenyl's (PCB), chlorinated solvents, and chlorinated pesticides, all of which can be degraded by bacteria**.**

Generally, bioremediation technologies can be classified as In-situ or Ex-situ approaches. In-situ techniques are defined as those that are applied to soil and groundwater at the site with minimal disturbance. Ex-situ techniques are those that are applied to soil and groundwater at the site which has been removed from the site via excavation (soil) or pumping (water). In-situ bioremediation involves treating the contaminated material in-place at the site while Ex-situ bioremediation involves the removal of the contaminated material to be treated elsewhere. This paper will focus of in-situ Aquifer (Groundwater) surfactant remediation applications only.

Enhanced Bioremediation can be defined as the application and regulation of certain biochemical and physicochemical properties to enhance the conditions within the aquifer to aid the mineralization of contaminants by the microbial population present. This includes adjusting biochemical parameters such as: oxygen, phosphorus, nitrogen, pH, Eh, moisture, temperature and their associated application rates.



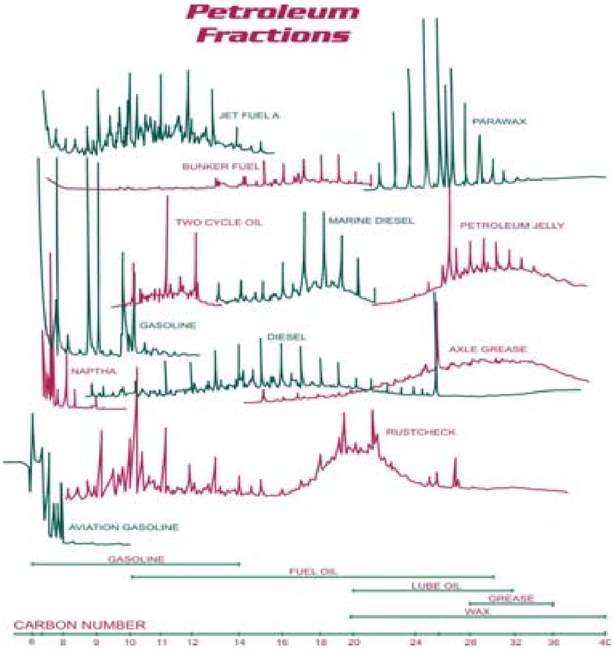
In-situ Bioremediation: Subsurface bioremediation of target aquifer contamination. This may or may not include a dynamic pump and treatment system.

Typically 90 to 95% of most hydrocarbon contaminants are absorbed onto surfaces (i.e. soil and bedrock) within the aquifer matrix (Ivey, G.A. et al., 2005). The surface sorption and low solubility of the certain hydrocarbons, such as the PAH benzo[a]pyrene), exhibit low bioavailability as a result.

Changing the physicochemical properties of the aquifer contaminants can be achieved through the addition of Ivey-sol® surfactants which are non-ionic surfactants formulations which can selectively desorb and dissolve a broad range of petroleum hydrocarbons including PAH, PCB's. The addition of Ivey-sol® to improve the physicochemical properties and biodegradation of contamination in groundwater is known as Surfactant Enhance Aquifer Remediation (SEAR).

1.1 Composition of hydrocarbon contaminants

Gasoline and fuel oil are complex mixtures of hydrocarbons that include n-alkanes, branched alkanes, cycloalkanes and aromatic compounds. The approximate composition of gasoline and fuel oil is 60% aliphatic - 40% aromatic and 80% aliphatic-20% aromatic respectively.



This GCMS Scan illustrates the complex range of petroleum hydrocarbon compound in commercial use.

Polycyclic aromatic hydrocarbons (PAHs) are a large group of compounds exhibiting similar characteristics: they are large, high-molecular-weight compounds with low water solubility, and two to five condensed aromatic rings. Common PAH's include: anthracene, benzo-(a) pyrene, chrysene, naphthalene and pyrene. Most PAH's exhibit moderate to good biodegradation with SEAR. Some PAH compounds are present in gasoline and fuel oils.

1.2 Bioremediation Mechanisms

1.2.1 Hydrocarbon Structure and Biodegradation

Hydrocarbon compound structure is important in bio-degradability. The n-alkanes (straight chain) and n-alkyl- aromatics (substituted aromatic) in the C10 to C22 range are considered to be of low toxicity and the most biodegradable (Bossert and Bartha, 1984). Hydrocarbons above C22 have lower toxicity and are generally considered less biodegradable due to their physical characteristics, which include low water solubility, sorption onto surfaces, and a solid to semi-solid state at 35°C.

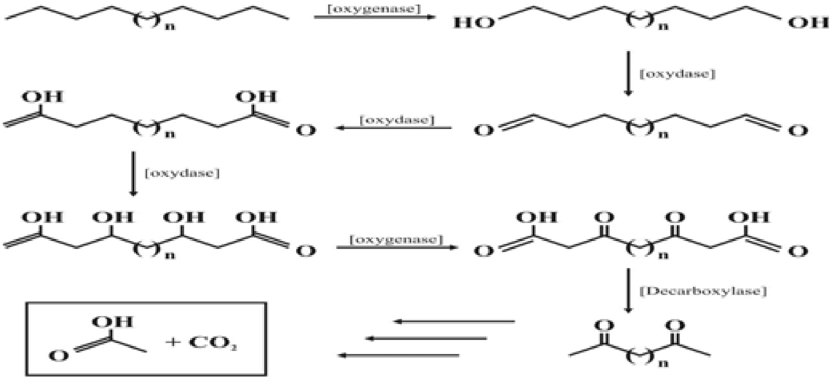
Compounds in the C1 to C4 range are gaseous and considered to be biodegradable, but this is not the typical mechanism employed to remove these. Counterparts in the C5 to C9 range have high solvent-membrane toxicity to microorganisms, but in low concentration they are considered to be easily biodegradable.

Branched n-alkanes and cyclo-alkanes are less biodegradable as their tertiary and quaternary carbon atoms inhibit the ß-oxidation step required for degradation. Aromatic hydro-carbons are biodegradable, but the bioavailability of high molecular weight compounds such as PAH's decreases dramatically as the number of condensed rings increases. These compounds exhibiting lower biodegradability due to surface absorption and low solubility are commonly referred to as recalcitrant or xenibiotic.

1.2.2 N-Alkane

The biological degradation pathway for n-alkane (straight chain) and branched alkanes has been well established and reported extensively in literature. The biodegradation pathway for n-alkane is shown below (Grubbs and Molnaa, 1987)

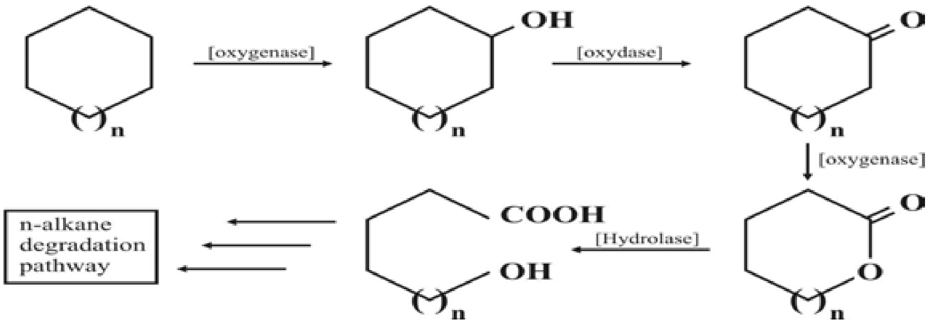
Typically, the degradation pathway consists of the following steps:
- Initial enzyme catalyzed oxidation to produce primary fatty alcohol.
- Sequential oxidation of the alcohol to fatty acid.
- Oxidation of the ß-carbon to produce a ß-keto acid.
- Decarboxylation to produce a degraded alkane.



Clearly all resultant intermediates in this mineralization process should possess a low to very low toxicity since only naturally occurring fatty acids are being produced.

1.2.3 Cyclic Alkanes

Even though cyclic alkanes are very similar in structure to n-alkanes, their biodegradation pathway appears to be fundamentally different.



Biodegradation pathway for cyclic alkanes (adapted from Bartha, 1986)

Although not fully characterized, it has been reported (Bartha, 1986) that the following Steps are required:
- Sequential enzyme mediated oxidation of the ring to form a cycloalkanone
- Baeyer-Villiger type oxidation of the cyclic ketone by an as yet uncharacteristic second oxygenase enzyme to produce a lactone

- Hydrolysis, resulting in ring fission, to generate what amounts to an oxidized n-alkyl fatty acid that can be further degraded by the mechanism outlined in the n-alkane pathway.

1.2.4 Aromatics

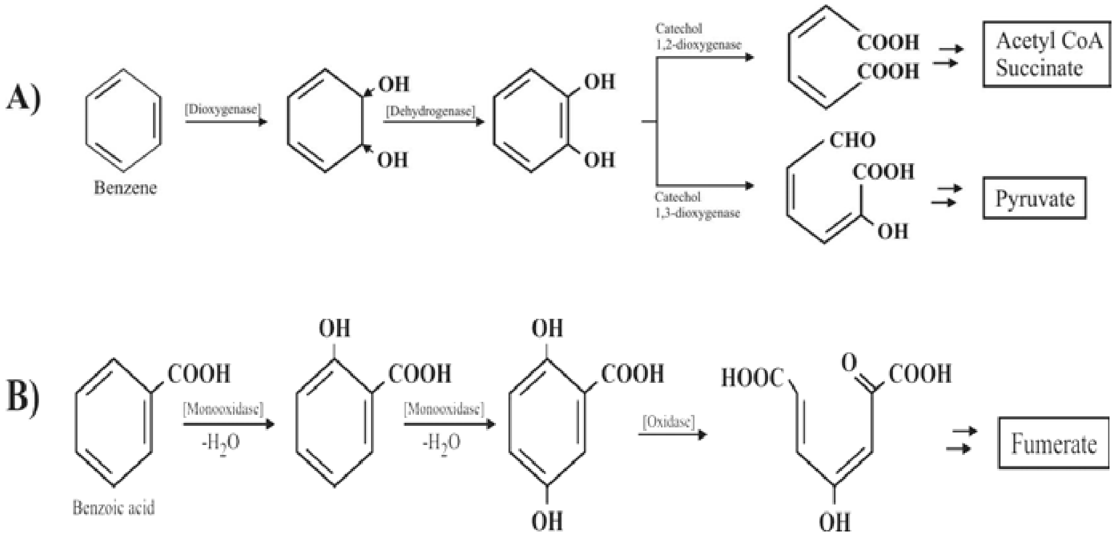
Simple aromatic or "benzenoid type" compounds generally pose no resistance to microbial degradation for a large variety of microorganisms (Fewson, 1981).

The key factor in the degradation of aromatic compounds by these ring fission enzymes is their ability to destroy the resonance contained within the ring. This can be accomplished, however, only by the initial positioning of at least two hydroxyl groups, either ortho or para, relative to each other.

The biodegradation of aromatic compounds proceeds via two well-established pathways: a) catechol and b) gentisate (illustrated below, Leisinger and Burner, 1987).

In both pathways, ring activation is followed by ring cleavage and the subsequent transformation of the fission products.

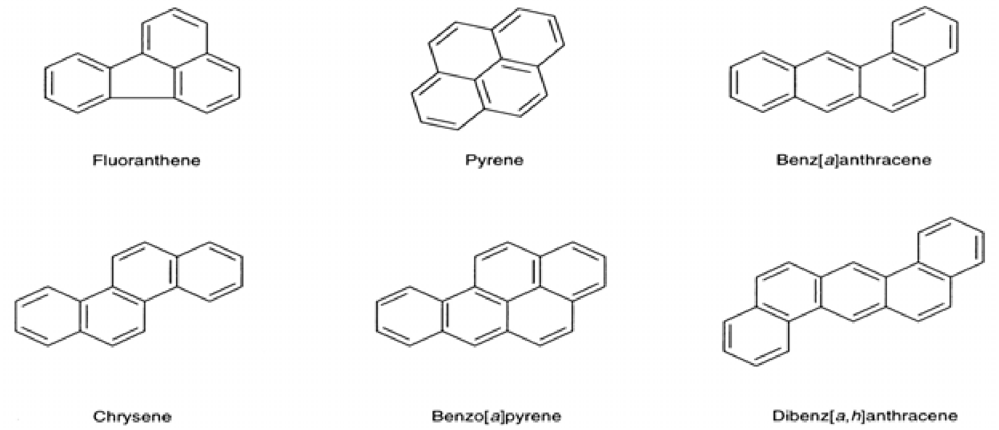
The degradation of substituted aromatics, such as ethyl- benzene and toluene, would also proceed via an analogous pathway. These products, once generated, would then follow a similar microbial mineralization as outlined in the n-alkane pathway.



Biodegradation of simple aromatics, (A) the catechol pathway, and (B) the gentisate pathway (adapted from Leisinger and Burner, 1987)

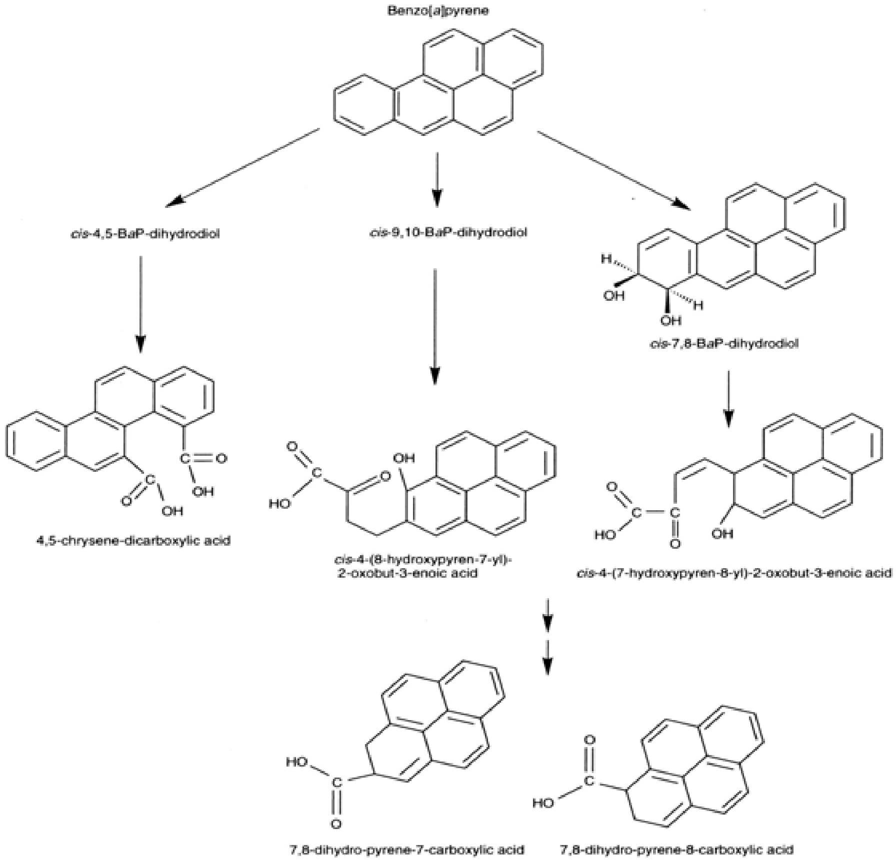
1.2.5 Polycyclic Aromatic Hydrocarbons (PAH)

Polycyclic Aromatic Hydrocarbons (PAHs) are hydrocarbon compounds with multiple benzene rings. PAHs are typical components of asphalts, fuels, oils, and greases. They are also called polynuclear aromatic hydrocarbons. The bacterial degradation of PAHs with more than three rings, often referred to a high molecular weight (HMW) PAHs, are often challenging to mineralize by microorganisms. This is related to their low solubility and high affinity to solid surfaces and organic liquids, which generally limits their bioavailability to microorganisms present in soils (J.J Ortega-Calvo, 2004). Surfactant-enhanced bioremediation of soils containing low soluble hydrocarbons is a promising biodegradation technique (P.R. Jaffe, 2000)



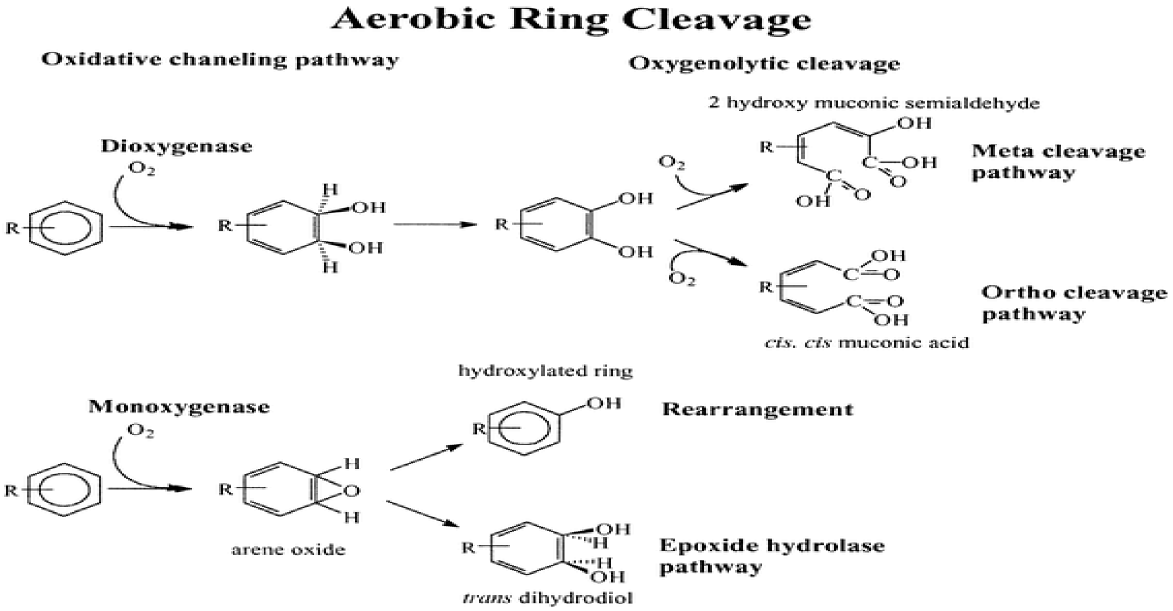
Typical High Molecular Weight PAH Compounds

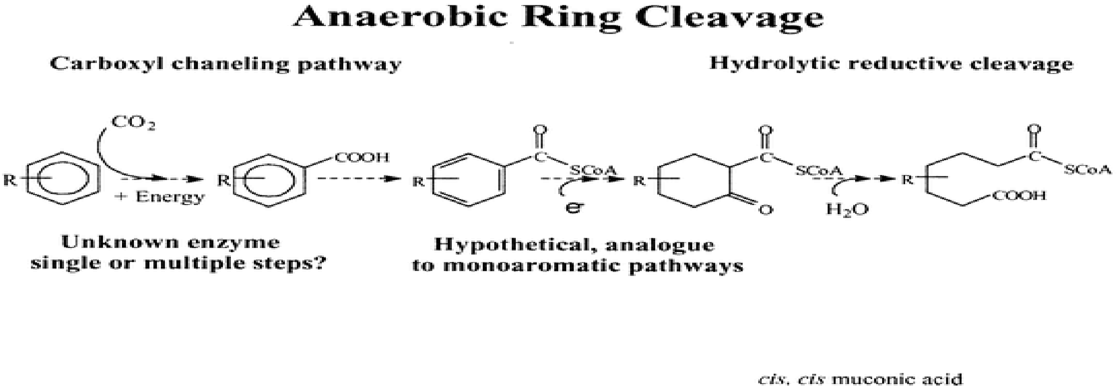
The biodegradation of high molecular weight PAH aromatic compounds has been well described (Gibson, D.T., and V. Subramanian, 1984). The initial step in the aerobic catabolism of a PAH molecule occurs via oxidation of the PAH to a dihydrodiol by a multi-component enzyme system. The dihydrodiol intermediates may then proceed through either an ortho cleavage type pathway or a meta cleavage pathway, leading to central intermediates such as protocatechuates and catechols, which are further converted to tricarboxilyic acid cyclic intermediates (J.A. an der Meer et al, 1992).



Biodegradation pathway for Benzo[a] pyrene.

The mechanism for PAH ring cleavage under aerobic conditions and anaerobic conditions is described below.





2.0 SURFACTANT ENHANCE AQUIFER REMEDIATION (SEAR) OF HYDROPHOBIC ORGANIC CHEMICALS (HOC)

Surfactant Enhanced Aquifer Remediation (SEAR) using Ivey-sol® involves the use of Ivey-sol® surfactant formulations which are non-ionic surfactant mixtures used in the in-situ and ex-situ treatment of petroleum hydrocarbons, heavy metals, and more recently radioactive type contaminated waste. These surfactant formulations have the ability to enhance aquifer biodegradation. During In-situ aquifer bioremediation, the effectiveness of the bioremediation process is a function of balancing several physical and chemical parameters to achieve effective bio-mineralization and reclamation of the target contaminants. The addition of Ivey-sol® to the substrate can aid in the controlled de-sorption of the contaminants from the soil and or bedrock making them more bioavailable to the bacteria. As a result, the duration for of hydrophobic organic chemicals (HOC) bioremediation can be reduced by as much as 40 to 60%, or more.

Normally hydrophobic organic chemicals (HOC) exhibit limited bioavailability to microorganisms as the contaminants tend to partition onto the soil matrix. This partitioning can account for as much as 95% or more of the total contaminant mass. Thus this limits the concentration of HOC available to the microbial population. Hence certain HOC's such a Polycyclic Aromatic Hydrocarbons (PAH) and Polychlorinated Biphenyl's (PCB's) can persist in the aquifer soils and bedrock for extended periods of time. The use of Ivey-sol® surfactant formulations, as part of a well designed bioremediation process, will provide a mechanism to mobilize the target contaminants from the soil and bedrock surfaces to make them more available to the microbial population.

Ivey-sol surfactants enhance key factors that influence the effectiveness of HOC bioremediation in aquifers. In particular, they increase the HOC's desorption rate and available solubility within the aquifer matrix. Thus as the HOC become more bioavailable, as the Ivey-sol surfacants improving the accessibility of the HOC substrate for the microorganisms present.

Bioavailability is governed by the substrate concentration that the cell membrane comes in contact with (i.e., what the microorganisms 'see') as well as the rate of mass transfer from potentially bioavailable (e.g., non-aqueous HOC's) phase to the directly bioavailability (e.g., surfactant-aqueous HOC) phase. SEAR affects the sorption of HOC and surfactants at the solid-liquid interface (i.e., the surface–H_2O–NAPL interface). This mechanism is in-part responsible for the increased bioavailability of the HOC and surface-bound nutrients. SEAR using Ivey-sol® is effective at low surfactant concentrations. It expedites bioremediation of the sorbed contamination and positively affects the surfactant–soil–NAPL systems (e.g., mass transfer of HOCs, cell hydrophobicity, and cell attachment at interfaces) while averting the inhibiting and/or microbial toxic effects associated with some surfactants (i.e., catonic and anionic) which are only effective at much higher concentrations. The SEAR mechanisms, by which Ivey-sol surfactants influence these processes is illustrated below.

2.1 Ivey-sol® Surfactant Technology (How It Works)

An illustration of how the SEAR - Ivey-sol technology works, (i.e., the mechanism) has been illustrated below. This should be used to augment one's present knowledge of bioremediation to appreciate the Ivey-sol surfactants effects on a microscopic scale in improving the controlled liberation of hydrocarbons and nutrients (i.e., surfactant-aqueous HOC's and nutrients-aqueous) and their controlled availability for mineralization by the microorganisms present.

This illustration demonstrates how the Ivey-sol Technology desorbs the contaminants off the soil and or bedrock surfaces, dissolves them, making them more Bio-Available and as a result and expedite the biodegradation process.

This mechanism can be described as follows:

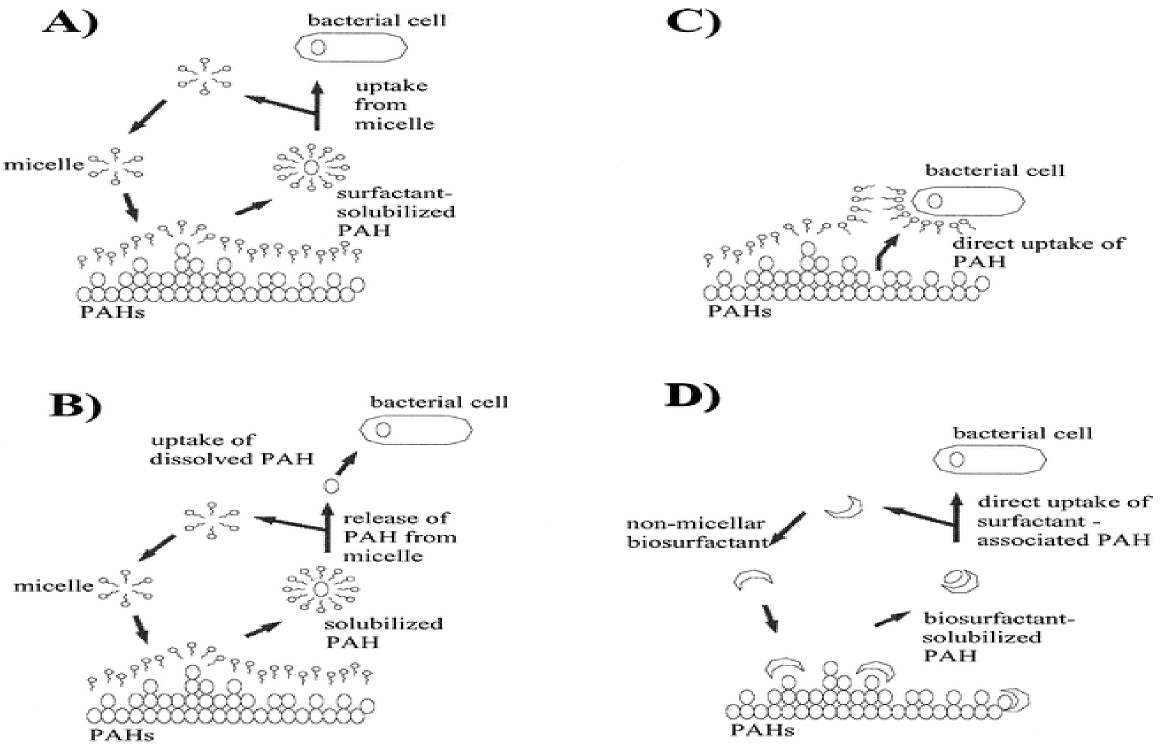
i) When HOC (i.e., petroleum product) is absorbed on a soil grain or bedrock surface, water alone will not remove it from the surface. This is a function of the hydrophobic characteristics of the HOC, which repels the water at its surface and its inherent low water solubility.

ii) With the addition of Ivey-sol surfactants, the Ivey-sol hydrophobic grouping is repelled by the water but attracted to the HOC on the surface. At the same time, the Ivey-sol hydrophilic grouping is attracted to the water molecules.

iii) These opposing forces loosen the HOC from the surface matrix and suspends it in the aquifer (groundwater) phase. Once dissolved, the suspended HOC is more visible to the microbial population present.
iv) Once liberated in low concentration in a ‘surfactant-aqueous HOC’ microscopic outward appearance, it is more bioavailable to the microbial population.

2.1 Ivey-sol® Bioavailability Enhancement Mechanism

The mechanism for PAH bioavailability enhancement using Ivey-sol surfactants are as follows. (A) Direct uptake of the PAH from partial micelle, (B) uptake for PAH from aqueous phase after release from partial micelle, (C) facilitated direct uptake of PAH via cell-surfactant-PAH contact, and (D) hypothesized non-micellular biosurfactant enhancement of PAH solubilization (A & C adapted from Schippers et al, 2000).



2.2 SEAR Improving Pump and Treatment, and SEO (Surfactant Enhanced Oxidation) Using Ivey-sol® Surfactants

As the HOC are desorbed and their concentration in the groundwater increased, they are more hydraulically available for removal by pump and treatment systems. Increases in rates of contaminant recovery of greater than 400% have been reported using the Ivey-sol SEAR process (D. Smith, Handex of CT, Monro Case Study, 2002). Ivey-sol has been effectively employed to improve the performance of chemical oxidation of HOC’s such as PCB’s. Ivey-sol desorbed the PCB’s permitting greater contact and improved reaction kinetics and corresponding oxidation of the PCB’s to well within regulatory limits.

Ivey-sol, have proven to enhance the effectiveness of In-situ aquifer bioremediation by increasing the HOC’s hydraulic availability for pump and treatment, it’s bioavailability for bioremediation, and it’s chemical availability for oxidative or reductive chemical treatment.

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The No. 1 Choice For Improving The Performance of Soil and Groundwater Remediation

Adsorption of Contamination

The number one challenge associated with most site remediation designs and methodologies is that 90% to 95% of all environmental contaminants; including hydrocarbons (LNAPL), chlorinates (DNAPL), and heavy metals; are present in a sorbed (i.e., absorbed or adsorbed) phase onto soil, sediment and bedrock surfaces within both saturated and unsaturated zones. As such, these absorbed contaminants have reduced mobility and low water solubility, factors which greatly limit the 'Availability' of the subject contamination for extraction or treatment during In-situ and/or Ex-situ remediation treatment.

This condition is further exacerbated when the contamination is present in fine-grain soil media (i.e., silty sand, silts and clays) with greatly reduced permeability, i.e., K=1x10^{-5} to 1x10^{-6} cm/sec, and a corresponding increased surface area onto which the contaminants may be sorbed. Consequently, the sorbed contamination will exhibit reduced mobility and limited 'Availability' for treatment using many commonly employed in-situ and ex-situ remediation technologies and processes. The site remediation usually takes much longer than desired, exceed best cost estimates, and/or simply fail; a source of considerable frustration for many clients.

Among the many commonly employed remedial technologies negatively affected by contaminant absorption include, but are not limited to:

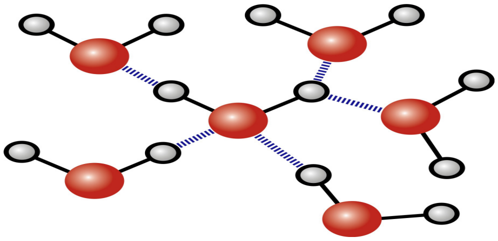
- **Pump and Treatment (In-situ) and Soil Washing (Ex-situ);**
- **Bioremediation of Recalcitrant Compounds (In-situ and Ex-situ);**
- **Chemical Oxidation and Chemical Reduction (In-situ and Ex-situ);**
- **Steam Injection Mobilization or Vaporization (In-situ and Ex-situ);**
- **VES - Vapor Extraction Systems (In-situ and Ex-situ);**
- **High Vacuum Duel-Phase Extraction; and**
- **Reactive Barrier Wall Technology (In-situ)**

Opportunity

If we can overcome contaminant sorption, we can improve soil and groundwater remediation.

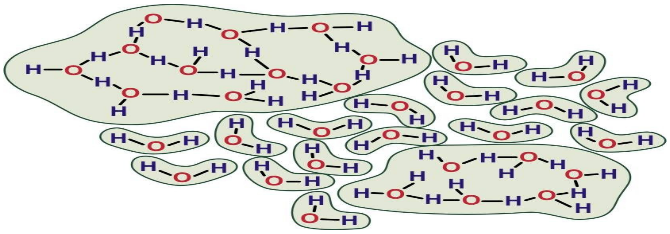
Water Clusters and Surface Tension

Water is often viewed to be a single molecule of H_2O by many Engineers and Scientists, when in fact it is not. It is actually a conglomeration of water molecules called *'Clusters'* (See Figure Below) due to the attractive force called '*Hydrogen Bonding*' that exists between neighboring water molecules. Hydrogen Bonding gives rise to water's *Surface Tension* explaining why water beads on a surface and why it hurts when you do a Belly-Flop onto a pool of water. Water has a surface tension of 72 dynes which is very strong for a liquid.



Hydrogen bonding between individual water molecules gives rise to surface tension and formation of water clusters.

The Permeability K value for water in a given soil type is a function of the water's surface tension, i.e., it's tendency to bead and act as a small *Clusters*, i.e., like a small spheres. Water's surface tension and clustering directly affect the associated permeability (K) of water in all soil types.



The formation of water clusters directly affects water permeability (K) in soil and bedrock. If water clusters did not form, water would have the ability to flow more freely in finer grain soils and bedrock fractures

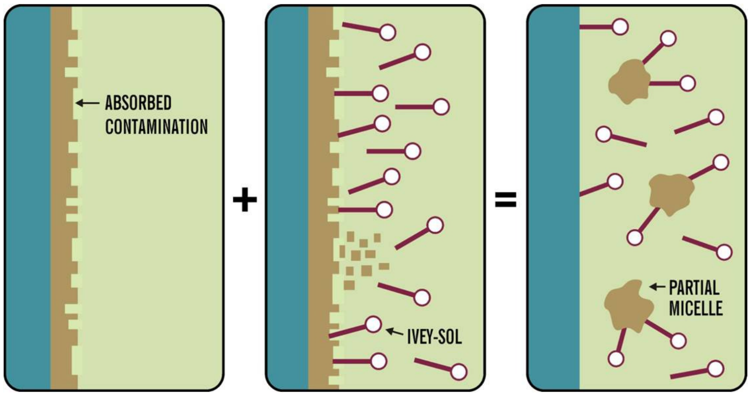
Opportunity

If we could reduce the size of water clusters and lower surface tension, the effective permeability (K) of water would increase for fine grain soil and bedrock.

Ivey-Sol Surfactant Technology (An Innovative Opportunity)

Ivey-sol® Surfactant Technology is comprised of several nonionic surfactant formulations that have the unique ability to selectively desorb and liberate petroleum hydrocarbons (gasoline, fuel oil, diesel, etc.); Polycyclic Aromatic Hydrocarbons (PAH), and Poly Chlorinated Biphenyl's (PCB) contaminants from soil and fractured bedrock surfaces, and into solution. This technology has also proven very effective at liberating chlorinated solvents (PCE, TCE, DCE, DCB, etc.), MTBE, TBA, NORM, and Metals for treatment.

Ivey-sol® makes the de-sorbed contaminants more *'Hydraulically Available'* for extraction by Pump and Treatment; more *'Bio Available'* for bioremediation (In-situ or Ex-situ); and by increasing the dissolved aqueous-phase contaminant concentration, it improves their *'Chemical Availability'* for Oxidative and or Reductive treatment (In-situ & Ex-situ).



Ivey-sol shown desorbing contamination off a surface. Once liberated, the desorbed contaminants have increased available improving the associated remediation method.

In summary, Ivey-sol® surfactants, when introduced into contaminated soil and groundwater regimes, can reduce the surface tension of water from 72 dynes to as low as <30 dynes. Thus improves the wetting ability of the water and its *Effective Permeability* (K). Furthermore; Ivey-sol® surfactants reduce the size of the Water Clusters allowing the water to penetrate less permeable soils such as: silty sand, silt and clay, and fractured bedrock.

Hence, Ivey-sol accomplishes two feats; first it overcomes the challenges associated with contaminant adsorption; and secondly, it lowers the surface tension of water improving both its wetting and associated permeability (K) properties.

Ivey-sol surfactant technology is an innovative tool for with a significant opportunity improving in-situ and ex-situ soil and groundwater remediation.

Ivey International Inc. **MSDS NUMBER: 080123-01**

MATERIAL SAFETY DATA SHEET
Ivey-sol ® Surfactant Technology

SECTION 1: CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Name:	Ivey-sol
Chemical Name:	Not Applicable (mixture)
Chemical Family:	Non-ionic Surfactants
Formula:	Not Applicable (mixture)
Synonym(s):	Ivey-sol 103, Ivey-sol 106, and Ivey-sol 108

COMPANY IDENTIFICATION

Ivey International (USA) Inc.	26 Berkeley Place, Newington, CT USA 06111
Ivey International (CAN) Inc	PO Box 706 Campbell River BC Canada V9W 6J3
Prepared By:	Technical Products Department
Telephone Number:	(250)923-6326 or Toll Free 1-800-246-2744
Prepared (Last Updated):	January 23, 2008

Ivey International Inc. (III) urges each customer or receipt of this MSDS to study it carefully to become aware of and understand the proper use and handling of the subject product. The reader should consider consulting reference materials, and/or III technical support personal, and/or other recognized experts, as necessary or appropriate to the use and understanding of the data contained in this MSDS. To promote the safe handling, storage and use of this product, each customer or recipient should (1) notify his employees, agents, contractors, and others whom he knows or believes will use this product, of the information in this MSDS and any other information regarding product use, storage and handling, (2) furnish this same information to each of his customers for the product, and (3) request his customers to notify their employees, customers, and other users of the product, and of this information.

SECTION 2: COMPOSITION INFORMATION

Components:	Ivey-sol 103 - 3 Molar Concentration In Water
Generic Description:	Water based biodegradable wetting agents and surfactants.

Ivey-sol® / SPT® Technology - Stock Mixtures. Patented and or proprietary blends. Information in this MSDS is applicable for all component products listed.

SECTION 3: HAZARDS IDENTIFICATION

Effects of A Single Exposure:

Swallowing:	Non to slightly toxic. May cause abdominal discomfort and nausea for some individuals.
Skin Absorption:	No evidence of harmful effects.
Inhalation:	No evidence of harmful effects.
Skin Contact:	Brief contact should not result in any significant effects. Prolong exposure may cause mild irritation with local itching and redness for individuals with sensitive skin.
Eye Contact:	May cause mild to moderate irritation.
Effects Of Repeated Exposure:	Repeated skin contact may cause mild dermatitis (dryness of skin).
Medical Conditions:	Existing dermatitis may be aggravated through repeated skin contact.
Other Effects:	None currently known.

Section 4: FIRST AID MEASURES

Swallowing:	If patient if fully conscious, give two glasses of water
Skin Absorption:	Wash with soap and water. Obtain medical attention if irritation or dermatitis persists. Wash any exposed clothing before reuse.
Inhalation:	Not applicable.
Eye Contact:	Immediately flush eyes with water and continue to flush as required. Remove any contact lenses, if worn. Obtain medical attention if deemed necessary.
Note To Physician:	There is no required antidote. Treatment should be directed tat the control of symptoms and the clinical condition of the patient.

Section 5: FIRE FIGHTER MEASURES

Flammability:	Not Flammable
Auto Ignition Temp.	Not Available
Upper Flammable Limit	Not Established
Lower Flammable Limit	Not Established
Explosive Date:	Explosive Power - Not Available Rate of Burning - Not Available

Hazardous Combustion Products:	Not applicable.
Special Protective Equipment:	Not Applicable.
Extinguishing Media:	Not Applicable.
Extinguishing Media To Be Avoided:	Not Applicable.
Special Fire Fighting Procedures:	Not Applicable.

Section 6: ACCIDENTAL RELEASE MEASURES

Step To Be Taken If Material Is Released or Spilled: Eliminate and/or contain source with inert material (sand, earth, absorbent pads, etc.). Wear basic eye and skin protection. Floor may be slightly slippery; so use care to avoid falling. Avoid discharge to natural waters, and/or dilute with water. Transfer liquids to suitable containers for recovery, re-use or disposal. Contact III for technical assistance if required.

Section 7: HANDLING AND STORAGE

Handling Procedures:	Avoid contact with eyes, skin, and clothing. Do not swallow. Keep containers closed or sealed when not in use. Wash thoroughly after handling.
Storage:	Keep closed or sealed when not in use. Do not allow to freeze, keep > 0^{o}C (32^{o}F).
Ventilation:	General (mechanical) room ventilation is expected to be satisfactory.

Section 8: EXPOSURE CONTROLS/PERSONAL PROTECTION

Gloves / Type Gloves / Type:	Latex, or similar would be sufficient.
Respiratory / Type:	None expected to be needed. However, if an engineered / industrial application where vapors and/or misting may occur, wear MSHA/NIOSH approved half mask air purifying respirator.
Eye / Type:	Mono Goggles or similar.
Footwear / Type:	No special requirements.
Clothing / Type:	Wear an apron and /or coveralls.
Other / Type:	Eye bath.
Engineering Controls:	General (mechanical) room ventilation is expected to be satisfactory.

Section 9:   PHYSICAL AND CHEMICAL PROPERTIES

Physical state:	Water Based Liquid
Appearance:	Clear to slightly Cloudy White Color
Odor:	Mild
Molecular Weight:	Mixture (Not Applicable)
Boiling Point:	Not Applicable
Freezing Point:	Around 0^{o}C (32 ^{o}F)
Pour Point:	Not Applicable
Melting Point:	Not Applicable
Specific Gravity:	0.99-1.04 (Water = 1.0)
Vapor Pressure:	<0.01 mm Hg
Vapor Density:	> 1 (Air = 1.00)
pH:	Not Available (Typically 6.5-7.5 Range)
Solubility In Water:	100%
Evaporation Rate:	<0.01
Coefficient of Oil/Water Distribution	Not Determined

Section 10:   STABILITY AND REACTIVITY

Stability:	Stable
Conditions To Avoid:	Prolonged excessive heat may cause product decomposition. Freezing should also be avoided as it may cause product decomposition. In some cases it may cause irreversible changes.
Incompatible Materials:	Normally un-reactive; however avoid strong bases at high temperatures, strong acids, strong oxidizing agents, and materials with reactive hydroxyl compounds. These compounds would damage the mixture and reduce its effectiveness during application.
Hazardous Decomposition Products:	Not applicable.
Hazardous Polymerization:	Will not occur.

Section 11:   TOXICOLOGICAL INFORMATION

Exposure Limit of Material:	Not Established
LD/50:	Not Available
LC/50:	Not Available
EL:	Not Established
Carcinogenicity of Material:	None Known
Reproductive Effects:	Not Available.
Irritancy of Material:	See Section 3
Sensitizing Capability:	Not Available
Synergistic Materials:	Not Available

LD: Lethal Dose   LC: Lethal Concentration   EL: Exposure Limit

Section 12: ECOLOGICAL CONSIDERATIONS

Environmental Toxicity:	Low Potential to affect aquatic organisms*
Biodegradability:	>90% in 28 days**
LC/50:	48 Hour: 0.11 %,Species: Daphnia magna
LC/50:	96 Hour: 0.07695% Species: Rainbow Trout

* When used in accordance with Ivey International Inc. In-situ and Ex-situ Remediation Application Guidelines.

** Based on actual testing or on data for similar material(s). Degradation Biodegradation reached in Modified OECD Screening Test (OECD Test No.301 E) after 28 days: 90 %. Biodegradation reached in CO2 Evolution Test (Modified Sturm Test, OECD Test No. 301 B) after 28 days: 70 %.

All available ecological data have been taken into account for the development of the hazard and precautionary information contained in this Material safety data Sheet.

Section 13: DISPOSAL CONSIDERATIONS

Waste Disposal Method:	For aqueous Ivey-sol mixture solutions; aerobic biological wastewater treatment systems are effective in treating said mixtures. Ivey-sol does not have any known negative affect on coagulant or flocculent water treatment processes.

Section 14: TRANSPORTATION INFORMATION

UN Number:	Not Applicable
TDG Classification:	Not Required
Shipping Name:	Ivey-sol (a.k.a. Selective Phase Transfer Mixtures)
Packing Group:	Not Applicable
Special Shipping Instructions:	Do not allow to freeze

Section 15: REGULATORY INFORMATION

WHMIS Classification:	Not Controlled as per WHMIS Regulation.
CPR Compliance:	This product has been classified in accordance with the hazard criteria of the CPR, and the MSDS contains all the information required by the CPR.
CEPA Compliance:	All ingredients of this product are listed on a DSL.

Section 16: OTHER INFORMATION

Available Literature and Brochures:	Additional information on this product may be obtained by calling our customer service representatives at (800) 246-2744 or (250) 923-6326.
Recommended Uses and restrictions:	For the application of air, soil, groundwater, shoreline, and off-shore spill petroleum reclamations purposes. Secondary recoveries of petroleum products form crude-oil, oil-shale, and oil-sands. Additional information on uses can be made available by contacting out technical sales director in your area by visiting www.ivey-sol.com, or by calling toll free (800) 246-2744 or (250) 923-6326.

Legend:

TS	- Trade Secret
D2B	- Toxic Material causing Other Effects.
mm	- Millimeters
LD	- Lethal Dose
LC	- Lethal Concentration
EL	- Exposure Limit
Hg	- Mercury (760 mm Hg = 1 Atmosphere, Sea Level)

Ref:Ivey-sol/MSDS/080123-01(Revised January 23, 2008)

Appendix B

Boring Logs and Well Construction Data

Field location of boring:

(See Plate 2)

Project No.: 7814
Date: 09/24/90
Boring No: U-1
Client: UNOCAL Service Station
Location: 3220 Lakeshore
City: Oakland, California
Sheet 1 of 2
Logged by: RAL
Driller: Bayland
Casing installation data: (See Well Construction Detail)
Drilling method: Hollow Stem Auger
Hole diameter: 8-Inches
Top of Box Elevation:
Datum:

Water Level	10.0'	10.0'		
Time	09:30	13:20		
Date	09/24/90	09/24/90		

PID (ppm)	Blows/ft. or Pressure (psi)	Type of Sample	Sample Number	Depth (ft.)	Sample	Well Detail	Soil Group Symbol (USCS)	Description
				0				
								PAVEMENT SECTION - 1.0 foot
				1				
								FILL - Sandy Silt (ML) - yellowish brown (10YR 5/4),
				2				medium stiff, moist; 70% silt; 30% fine to coarse sand;
								strong chemical odor.
				3				
								CLAYEY SILT with SAND (ML/CL) - very dark gray (10YR
				4				3/1), stiff, moist, medium plasticity; 50% silt; 30% clay;
								20% fine sand; moderate chemical odor.
				5				
466	350	S&H			■			
	400		U1-	6	■			SANDY SILT (ML) - dark gray (N4/0), medium stiff, moist;
	450		6.5		■			75% silt; 25% fine sand; strong chemical odor.
				7				
				8				
				9				
				10		▽ ▼		saturated; increasing clay to 25%; 10% peat; 10%
	1	S&H			■			dispersed gravel; no chemical odor.
13	2		U1-	11	■			
	3		11.5		■			
				12				
								hard drilling at 12.5 feet.
				13				
				14				
				15				
	9	S&H	U1-		■			SAND with GRAVEL (SW) - light olive brown (10YR 5/4),
2	10		16.5	16	■			medium dense, saturated; 85% fine to coarse sand; 15%
	13				■			fine to coarse gravel; no chemical odor.
				17				
				18				
				19				

Remarks:

GSI GeoStrategies Inc.

Log of Boring

BORING NO. U-1

JOB NUMBER 7814
REVIEWED BY RG/CEG
DATE 09/90
REVISED DATE
REVISED DATE

Field location of boring: (See Plate 2)	Project No.:	7814	Date:	09/24/90	Boring No:	U-1
	Client:	UNOCAL Service Station				
	Location:	3220 Lakeshore				
	City:	Oakland, California			Sheet	2
	Logged by:	RAL	Driller:	Bayland	of	2
	Casing installation data:					
Drilling method: Hollow Stem Auger						
Hole diameter: 8-Inches	Top of Box Elevation:			Datum:		

Water Level				
Time				
Date				

PID (ppm)	Blows/ft. or Pressure (psi)	Type of Sample	Sample Number	Depth (ft.)	Sample	Well Detail	Soil Group Symbol (USCS)	Description
	7	S&H	U1-		■		░	
2	5		21.5	20	■		░	
	7				■		░	
				21			░	
							▨	CLAY (CL) - greenish gray (5G 4/1), stiff, moist; 100%
				22			▨	clay; no chemical odor.
							▨	
				23			▨	
							▨	
				24			▨	
							▨	
				25			▨	
1	7				■		▨	
	13	SPT		26	■		▨	very stiff; no chemical odor.
	17				■		▨	
				27				
								Bottom of sample at 26.5 feet.
				28				Bottom of boring at 26.5 feet.
								09/24/90
				29				
				30				
				31				
				32				
				33				
				34				
				35				
				36				
				37				
				38				
				39				

Remarks:

GSI GeoStrategies Inc.

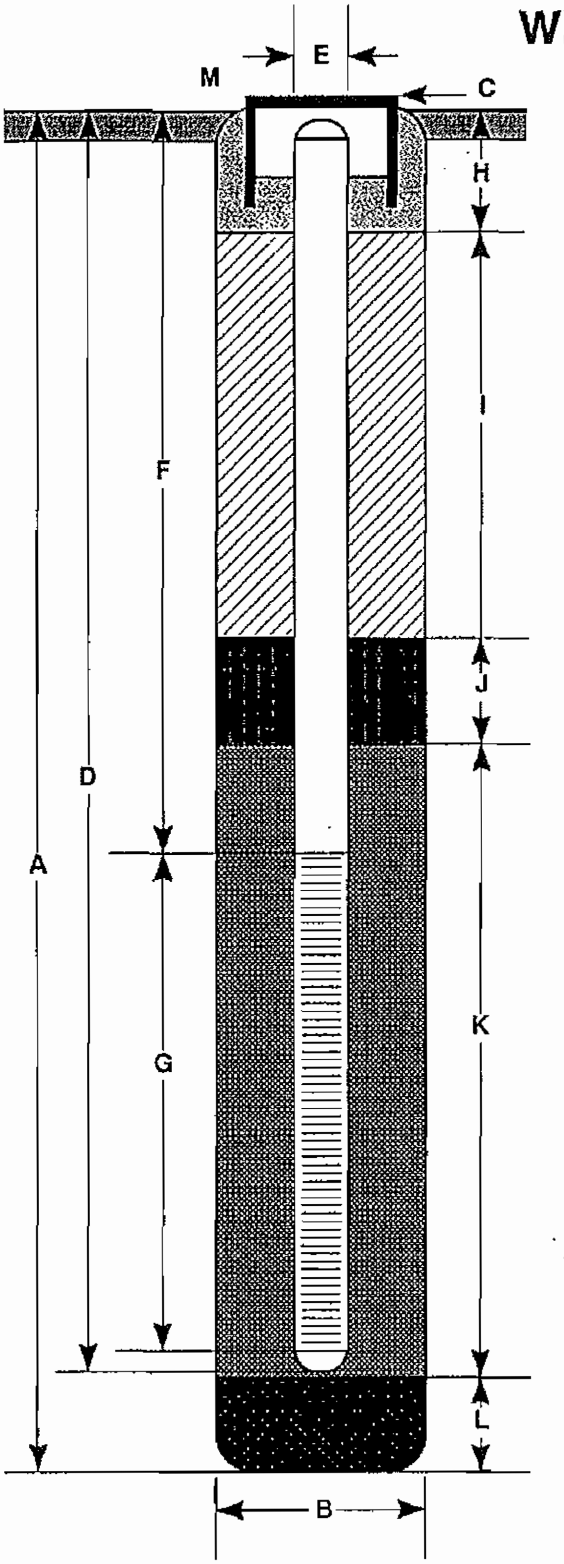
Log of Boring

BORING NO.

U-1

JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
7814		09/90		

WELL CONSTRUCTION DETAIL



A Total Depth of Boring 26.5 ft.

B Diameter of Boring 8.0 in.
Drilling Method Hollow Stem Auger

C Top of Box Elevation ______ ft.
☐ Referenced to Mean Sea Level
☐ Referenced to Project Datum

D Casing Length 20.5 ft.
Material Schedule 40 PVC

E Casing Diameter 3.0 in.

F Depth to Top Perforations 5.0 ft.

G Perforated Length 15.0 ft.
Perforated Interval from 5.0 to 20.0 ft.
Perforation Type Machine Slot
Perforation Size 0.020 in.

H Surface Seal from 0 to 1.5 ft.
Seal Material Concrete

I Backfill from 1.5 to 3.0 ft.
Backfill Material Concrete

J Seal from 3.0 to 4.0 ft.
Seal Material Bentonite

K Gravel Pack from 4.0 to 20.0 ft.
Pack Material Lonestar #2/12 Sand

L Bottom Seal 3.0 ft.*
Seal Material Bentonite

M Vault with locking well cap and lock.

* Slough from 23.0 to 26.5 feet.

Note: Depth measured from initial ground surface.
Bottom 1.0 foot of casing is blank.

GSI GeoStrategies Inc.

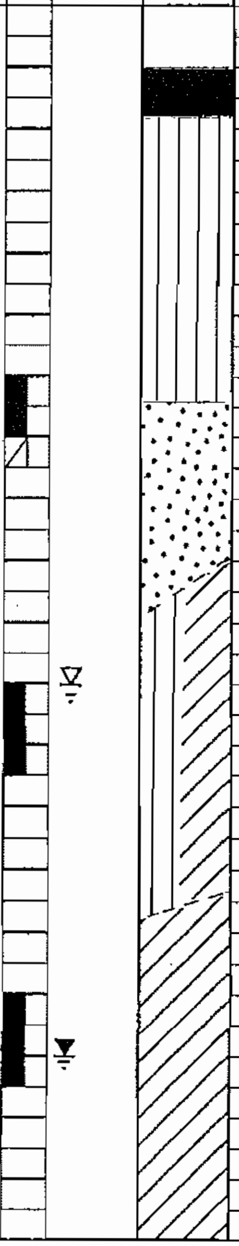
Well Construction Detail

WELL NO.
U-1

JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
7814		09/90		

Field location of boring: (See Plate 2)	Project No.: 7814	Date: 09/24/90	Boring No: U-2
	Client: UNOCAL Service Station		
	Location: 3220 Lakeshore		
	City: Oakland, California		Sheet 1 of 2
	Logged by: RAL	Driller: Bayland	
	Casing installation data: (See Well Construction Detail)		
Drilling method: Hollow Stem Auger			
Hole diameter: 8-Inches	Top of Box Elevation:	Datum:	

Water Level	10.0'	18.0'	16.0'	
Time	11:15	11:45	13:10	
Date	09/24/90	09/24/90	09/24/90	



PID (ppm)	Blows/ft. or Pressure (psi)	Type of Sample	Sample Number	Depth (ft.)	Well Detail	Description
				0		
						PAVEMENT SECTION - 1.0 foot
				1		
						SANDY SILT (ML) - dark greenish gray (5G 4/1), medium
				2		stiff, moist, non plastic; 70% silt; 30% fine sand;
						moderate chemical odor.
				3		
				4		
				5		
846	350	S&H	U2-			
	400		6.0	6		SAND with GRAVEL (SW) - dark greenish gray (5GY 4/1),
	450					medium dense, moist; 85% fine sand; 15% fine gravel;
				7		strong chemical odor.
				8		
				9		
				10	∇	CLAYEY SILT with SAND (ML/CL) - very dark gray (10YR
	3	S&H	U2-			3/1), medium stiff, saturated; 45% silt; 30% clay; 25% fine
66	2		11.5	11		to coarse sand; sand evenly dispersed; roots and
	4					rootholes; moderate chemical odor.
				12		
				13		
				14		
				15		
	4	S&H				CLAY (CL) - light olive brown (2.5Y 5/4), stiff, moist;
1	6		U2-	16	▼	100% clay; trace fine to coarse gravel interspersed; no
	9		16.5			chemical odor.
				17		
				18		
				19		

Remarks:

GSI GeoStrategies Inc.

Log of Boring

BORING NO.
U-2

JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
7814		09/90		

Field location of boring:

(See Plate 2)

Project No.: 7814
Date: 09/24/90
Boring No: U-2
Client: UNOCAL Service Station
Location: 3220 Lakeshore
City: Oakland, California
Sheet 2 of 2
Logged by: RAL
Driller: Bayland
Casing installation data:
Drilling method: Hollow Stem Auger
Hole diameter: 8-Inches
Top of Box Elevation:
Datum:

Water Level				
Time				
Date				

PID (ppm)	Blows/ft. or Pressure (psi)	Type of Sample	Sample Number	Depth (ft.)	Sample	Well Detail	Soil Group Symbol (USCS)	Description
							▨	
				20			▨	no chemical odor.
2	3	S&H			■		▨	
	6		U2-	21	■		▨	
	15		21.5		■		▨	
				22				Bottom of sample at 21.5 feet.
								Bottom of boring at 21.5 feet.
				23				09/24/90
				24				
				25				
				26				
				27				
				28				
				29				
				30				
				31				
				32				
				33				
				34				
				35				
				36				
				37				
				38				
				39				

Remarks:

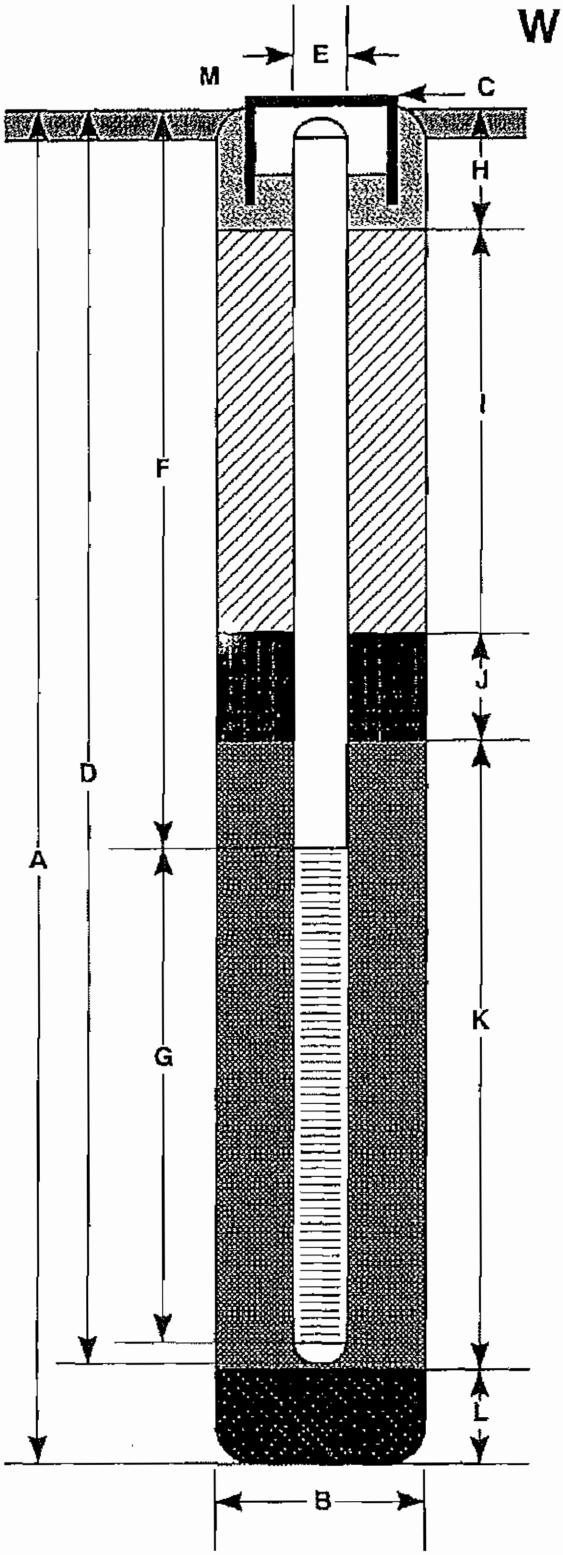
GSI GeoStrategies Inc.

Log of Boring

BORING NO.
U-2

JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
7814		09/90		

WELL CONSTRUCTION DETAIL



A Total Depth of Boring 21.5 ft.

B Diameter of Boring 8.0 in.
Drilling Method Hollow Stem Auger

C Top of Box Elevation ft.
☐ Referenced to Mean Sea Level
☐ Referenced to Project Datum

D Casing Length 20.5 ft.
Material Schedule 40 PVC

E Casing Diameter 3.0 in.

F Depth to Top Perforations 5.0 ft.

G Perforated Length 15.0 ft.
Perforated Interval from 5.0 to 20.0 ft.
Perforation Type Machine Slot
Perforation Size 0.020 in.

H Surface Seal from 0 to 1.5 ft.
Seal Material Concrete

I Backfill from 1.5 to 3.0 ft.
Backfill Material Concrete

J Seal from 3.0 to 4.0 ft.
Seal Material Bentonite

K Gravel Pack from 4.0 to 20.0 ft.
Pack Material Lonestar #2/12 Sand

L Bottom Seal 1.5 ft.
Seal Material Native Material

M Vault with locking well cap and lock.

Note: Depths measured from initial ground surface.
Bottom 1.0 foot of casing is blank.

GSI GeoStrategies Inc.

Well Construction Detail

WELL NO.
U-2

JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
7814		09/90		

Field location of boring: (See Plate 2)	Project No.: 7814	Date: 09/24/90	Boring No: U-3
	Client: UNOCAL Service Station		
	Location: 3220 Lakeshored		
	City: Oakland, California		Sheet 1
	Logged by: RAL	Driller: Bayland	of 2
	Casing installation data: (See Well Construction Detail)		
Drilling method: Hollow Stem Auger			
Hole diameter: 8-Inches	Top of Box Elevation:		Datum:

Water Level	10.5'	14.0'		
Time	12:30	13:30		
Date	09/24/90	09/24/90		

PID (ppm)	Blows/ft. or Pressure (psi)	Type of Sample	Sample Number	Depth (ft.)	Sample	Well Detail	Soil Group Symbol (USCS)	Description
				0				
								PAVEMENT SECTION - 1.0 foot
				1				
				2				SANDY SILT (ML) - very dark gray (5Y 3/1); 70% silt;
								30% fine to coarse sand; weak chemical odor.
				3				
				4				
				5				
	300	S&H	U3-					no chemical odor.
3	400		6.5	6				
	450							
				7				
				8				
				9				
				10				
	0		U3-			▽		
2	2	S&H	11.5	11				SILTY SAND (SM) - dark greenish gray (5GY 4/1), loose,
	2							*saturated; 75% fine sand; 25% silt; no chemical odor.*
				12				
				13				
				14		▼		
				15				SILT with SAND (ML) - light olive brown (2.5Y 5/4), stiff,
	300							very moist; 80% silt; 20% fine sand; no chemical odor.
1	500	S&H	U3-	16				
	500		16.5					
				17				
				18				
				19				

Remarks:

GSI GeoStrategies Inc.

Log of Boring

BORING NO.
U-3

JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
7814		09/90		

Field location of boring: (See Plate 2)	Project No.:	7814	Date:	09/24/90	Boring No: U-3
	Client:	UNOCAL Service Station			
	Location:	3220 Lakeshore			
	City:	Oakland, California			Sheet 2
	Logged by:	RAL	Driller:	Bayland	of 2
	Casing installation data:				
Drilling method: Hollow Stem Auger					
Hole diameter: 8-Inches	Top of Box Elevation:			Datum:	

Water Level				
Time				
Date				

PID (ppm)	Blows/ft. or Pressure (psi)	Type of Sample	Sample Number	Depth (ft.)	Sample	Well Detail	Soil Group Symbol (USCS)	Description
				20				
	300		U3-		■			no chemical odor.
1	500	S&H	21.5	21	■			
	600				■			
				22				
								Bottom of sample at 21.5 feet.
				23				Bottom of boring at 21.5 feet.
								09/24/90
				24				
				25				
				26				
				27				
				28				
				29				
				30				
				31				
				32				
				33				
				34				
				35				
				36				
				37				
				38				
				39				

Remarks:

GSI GeoStrategies Inc.

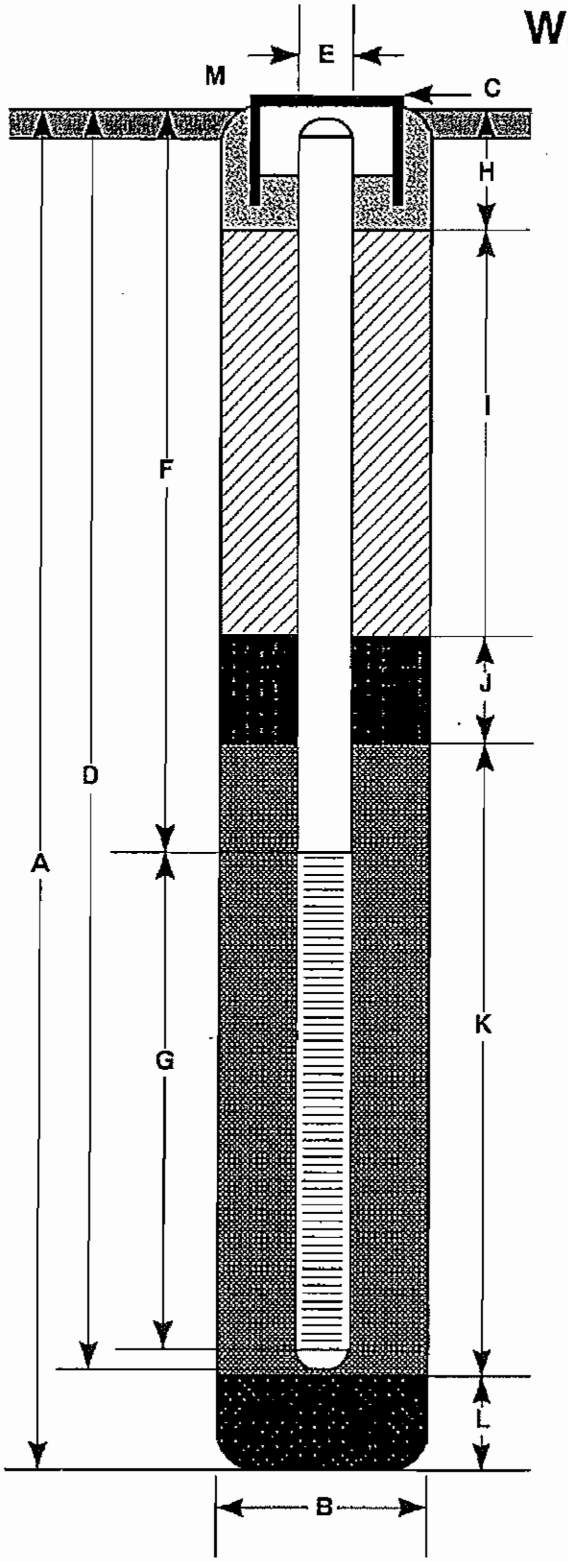
Log of Boring

BORING NO.

U-3

JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
7814		09/90		

WELL CONSTRUCTION DETAIL



A Total Depth of Boring 21.5 ft.

B Diameter of Boring 8.0 in.
Drilling Method Hollow Stem Auger

C Top of Box Elevation ______ ft.
☐ Referenced to Mean Sea Level
☐ Referenced to Project Datum

D Casing Length 20.5 ft.
Material Schedule 40 PVC

E Casing Diameter 3.0 in.

F Depth to Top Perforations 5.0 ft.

G Perforated Length 15.0 ft.
Perforated Interval from 5.0 to 20.0 ft.
Perforation Type Machine Slot
Perforation Size 0.020 in.

H Surface Seal from 0 to 1.5 ft.
Seal Material Concrete

I Backfill from 1.5 to 3.0 ft.
Backfill Material Concrete

J Seal from 3.0 to 4.0 ft.
Seal Material Bentonite

K Gravel Pack from 4.0 to 20.0 ft.
Pack Material Lonestar #2/12 Sand

L Bottom Seal 1.5 ft.
Seal Material Native Material

M Vault with locking well cap and lock.

Note: Depths measured from initial ground surface.
Bottom 1.0 foot of casing is blank.

GSI GeoStrategies Inc.

Well Construction Detail

WELL NO.
U-3

JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
7814		09/90		

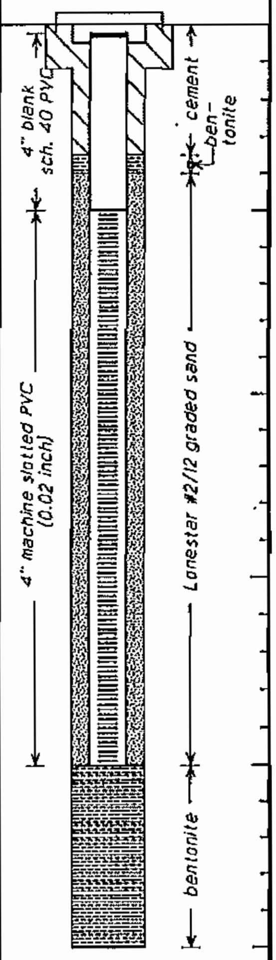
GSI GeoStrategies, Inc.

Log of Boring U-4

PROJECT: *UNOCAL STATION #5325*
LOCATION: *3220 Lakeshore Avenue, Oakland, CA.*
GSI PROJECT NO.: *4814.702*
CASING ELEVATION: *11.15 MSL*
DATE STARTED: *6/2/94*
WL (ft. bgs): *10* DATE: *6/2/94* TIME: *07:46*
DATE FINISHED: *6/2/94*
WL (ft. bgs): *19.2* DATE: *6/2/94* TIME: *14:25*
DRILLING METHOD: *10 in. Hollow Stem Auger*
TOTAL DEPTH: *25 Feet*
DRILLING COMPANY: *Gregg Drilling Co.*
GEOLOGIST: *R. Mallory*

DEPTH feet	PID (ppm)	BLOWS/FT. *	SAMPLE NUMBER	SAMPLE INT.	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION
							PAVEMENT
						ML	SANDY SILT (ML) - very dark grayish brown (10YR 3/2), stiff, medium plasticity, damp, 75% silt, 20% fine to coarse sand, 5% clay. Stiff at 3.5 feet.
5	0	11	U-4-4.0				
							COLOR CHANGE to olive brown (2.5YR 4/4), decrease sand to 5% at 8.5 feet.
10	0	44	U-4-9.5			SM	∇ SILTY SAND (SM) - yellowish brown (10Y 5/4), dense, saturated, 65% medium to fine sand, 35% silt.
						ML	SANDY SILT WITH GRAVEL (ML) - light olive brown (2.5Y 5/4), hard, low plasticity, moist, 60% silt, 25% fine to coarse sand, 15% gravel, black spherical nodules.
15	0	39	U-4-15.0				
							▼ COLOR CHANGE to brownish yellow (10YR 6/8), decrease sand to 10%, decrease gravel to 0%, pale yellow (2.5Y 7/4) caliche deposits at 18.5 feet.
20	0	26	U-4-20.0				
							COLOR CHANGE to pale olive (5Y 6/3) at 23.5 feet.
25	0	22	U-4-25.0				
							Bottom of boring at 25 feet. 6/2/94 (* - converted to equivalent standard penetration blows/ft.)
30							
35							

WELL DIAGRAM



JOB NUMBER: *4814.702*

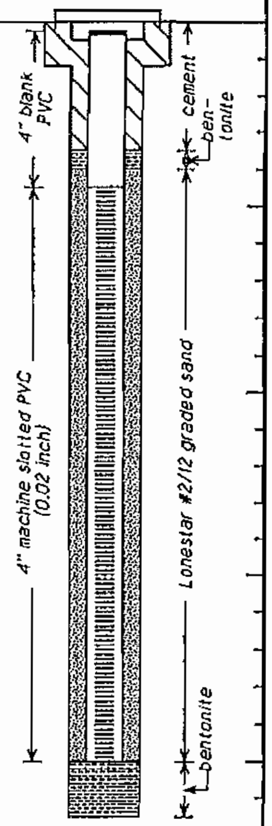
GeoStrategies, Inc.

Log of Boring U-5

PROJECT: *UNOCAL STATION #5325*	LOCATION: *3220 Lakeshore Avenue, Oakland, CA.*
GSI PROJECT NO.: *4814.702*	CASING ELEVATION: *6.98 MSL*
DATE STARTED: *6/2/94*	WL (ft. bgs): *6.25* DATE: *6/2/94* TIME: *11:32*
DATE FINISHED: *6/2/94*	WL (ft. bgs): *10.6* DATE: *6/2/94* TIME: *14:00*
DRILLING METHOD: *10 in. Hollow Stem Auger*	TOTAL DEPTH: *21.5 Feet*
DRILLING COMPANY: *Gregg Drilling Co.*	GEOLOGIST: *R. Mallory*

DEPTH feet	PID (ppm)	BLOWS/FT. *	SAMPLE NUMBER	SOIL CLASS	GEOLOGIC DESCRIPTION
					PAVEMENT
				SP	SAND (SP) - olive gray (5YR 4/2), loose, damp, 100% medium sand, brick fragments (fill).
				ML	SILT (ML) - dark greenish gray (5GY 4/1), stiff, medium plasticity, moist, 90% silt, 10% fine sand, organic matter.
5					
	568	15	U-5-6.0	SP	▽ SAND (SP) - dark greenish dray (5GY 4/1), medium dense, saturated, 95% sand, 5% silt.
				ML/CL	
10					▼ SILTY CLAY (ML/CL) - very dark grayish brown (10YR 3/2), medium stiff, high plasticity, saturated, 60% clay, 40% silt, rootholes, roots.
	110	4	U-5-11.5		
				CL	CLAY (CL) - very dark grayish brown (10YR 3/2), stiff, medium plasticity, saturated, 60% clay, 30% silt, rootholes, roots.
15					
	0	15	U-5-16.5		
20					Increase fine sand to 15% at 20 feet. COLOR CHANGE to light olive brown (2.5Y 5/4) at 21 feet.
	0	10	U-5-21.5		
					Bottom of boring at 21.5 feet. 6/2/94
25					(* - converted to equivalent standard penetration blows/ft.)
30					
35					

WELL DIAGRAM

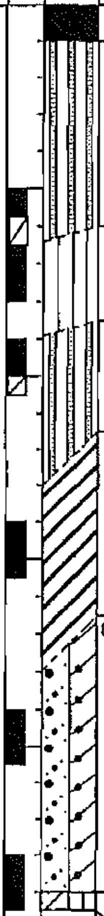


GeoStrategies, Inc.

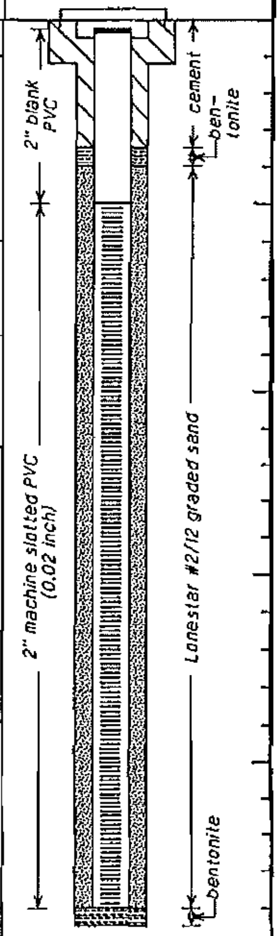
Log of Boring U-6

PROJECT: *UNOCAL STATION #5325*	LOCATION: *3220 Lakeshore Avenue, Oakland, CA.*
GSI PROJECT NO.: *4814.702*	CASING ELEVATION: *7.14 MSL*
DATE STARTED: *6/2/94*	WL (ft. bgs): *7* DATE: *6/2/94* TIME: *04:35*
DATE FINISHED: *6/2/94*	WL (ft. bgs): *8.8* DATE: *6/2/94* TIME: *14:05*
DRILLING METHOD: *8 in. Hollow Stem Auger*	TOTAL DEPTH: *24.5 Feet*
DRILLING COMPANY: *Gregg Drilling Co.*	GEOLOGIST: *R. Mallory*

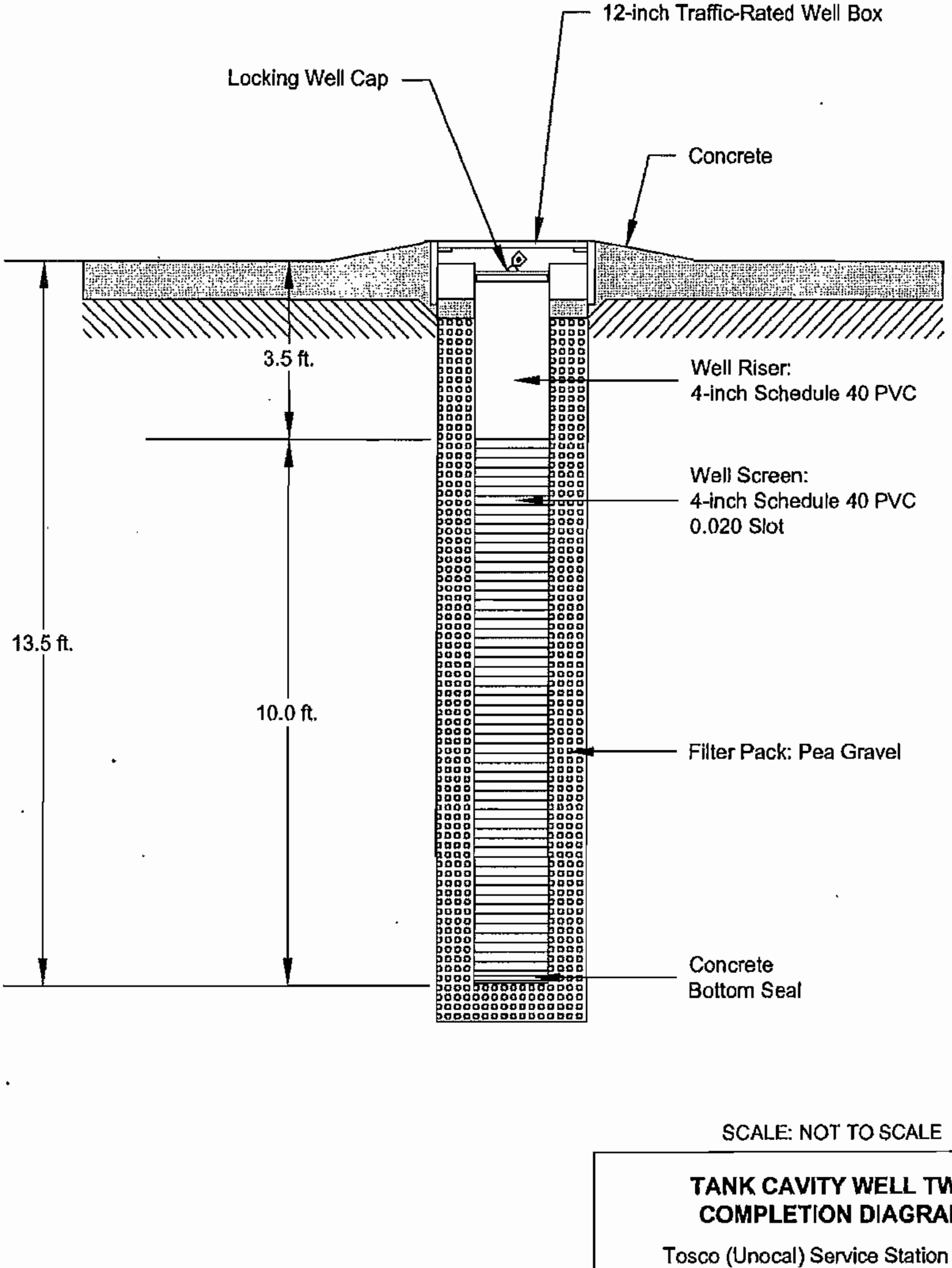
DEPTH feet	PID (ppm)	BLOWS/FT. *	SAMPLE NUMBER	SOIL CLASS	GEOLOGIC DESCRIPTION
					PAVEMENT
				SM	
5	0		U-6-5.5		SILTY SAND (SM) - dark brown (10YR 3/2), medium dense, damp, 80% medium sand, 15% silt, 5% gravel, trace brick fragments (fill).
		11		ML	
	0	11	U-6-8.0		SILT WITH SAND (ML) - dark greenish gray (6GY 4/1), stiff, low plasticity, saturated, 70% silt, 25% fine sand, 5% clay.
				SM	
10	0	5	U-6-10.0		CLAY (CH) - very dark gray (10YR 3/1), soft to medium stiff, high plasticity, saturated, 90% clay, 10% silt, trace organic matter.
				CH	
15	0	88	U-6-15.0		SILTY SAND (SM) - dark greenish gray (5GY 4/1), loose, saturated, 70% fine to medium sand, 30% silt. COLOR CHANGE to dark yellowish brown (10YR 4/4), medium to corase sand, decreasing silt at 15 feet.
				GW-GC	
20	0	30	U-6-20.5		GRAVEL WITH CLAY AND SAND (GW-GC) - dark grayish brown (2.5Y 4/2), dense, saturated, 65% fine to medium gravel, 25% fine to coarse sand, 10% clay.
					decrease clay to 5% at 23 feet.
	0	44	U-6-24.5	CL/ML	CLAYEY SILT (CL/ML) - greenish gray (5G 5/1), hard, low plasticity, damp, 60% silt, 30% clay, 10% fine to medium sand.
25					
					Bottom of boring at 24.5 feet. 6/2/94
					(* - converted to equivalent standard penetration blows/ft.)
30					
35					



WELL DIAGRAM



JOB NUMBER: *4814.702*



SCALE: NOT TO SCALE

TANK CAVITY WELL TW-1
COMPLETION DIAGRAM

Tosco (Unocal) Service Station 5325
3220 Lakeshore Avenue
Oakland, California

TRC

FIGURE 2

PROJECT NO.: 42-0137-07
LOCATION: 76 Station #5325
3200 Lakeshore Ave.
Oakland, California

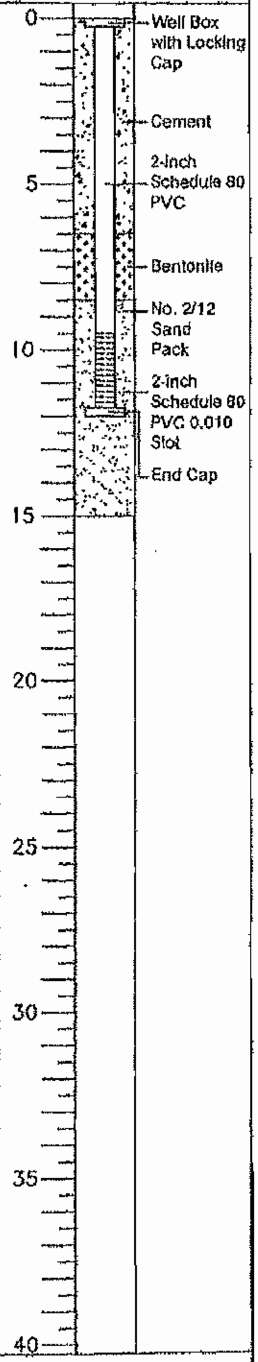
DATE DRILLED: 4/12/06
LOGGED BY: R. Dunn
APPROVED BY: K. Woodburne, RG
DRILLING CO.: Woodward Drilling

NORTHING: NOT SURVEYED
EASTING: NOT SURVEYED
ELEVATION: NOT SURVEYED

DRILLING METHOD: 8-inch Hollow-Stem Auger
SAMPLER TYPE: 2-inch Split Spoon
TOTAL DEPTH: Boring - 15.0 feet; Well - 12.0 feet
DEPTH TO WATER: 6.0 feet

PID/FID (ppm)	BLOWS PER 6 INCHES	RECOVERY	DEPTH (feet below grade)	DESCRIPTION	USCS
			0	Vacuum cleared to 5'.	
683	2 2 3 2	1.0/2.0	5	SANDY SILT (ML): Dark greenish gray (GLEY1 4/10Y), 85% fines, 15% fine-grained sand, nonplastic, soft, wet, slight hydrocarbon odor.	∇ ML
275	1 2 1 1	1.0/2.0		- @ 7': sand increases to 25%.	
43.0	0 2 2 2	2.0/2.0	10	- @ 10.5': becomes stiffer.	
33.0	6 2 3 4	2.0/2.0		- @ 11.5': color change to greenish gray (GLEY1 5/5GY), sand decreases to 10%, stiff.	
2.9	2 3 5 8	2.0/2.0		CLAY (CL): Greenish gray (GLEY1 6/10Y), 95% fines, 5% fine-grained sand, medium plastic, stiff, wet.	CL
			15		
			20		
			25		
			30		
			35		
			40		

WELL CONSTRUCTION DETAIL



TRC

SPARGE POINT INSTALLATION LOG

C-1
PAGE 1 OF 1

PROJECT NO.: 42-0137-07
LOCATION: 76 Station #5325
3200 Lakeshore Ave.
Oakland, California

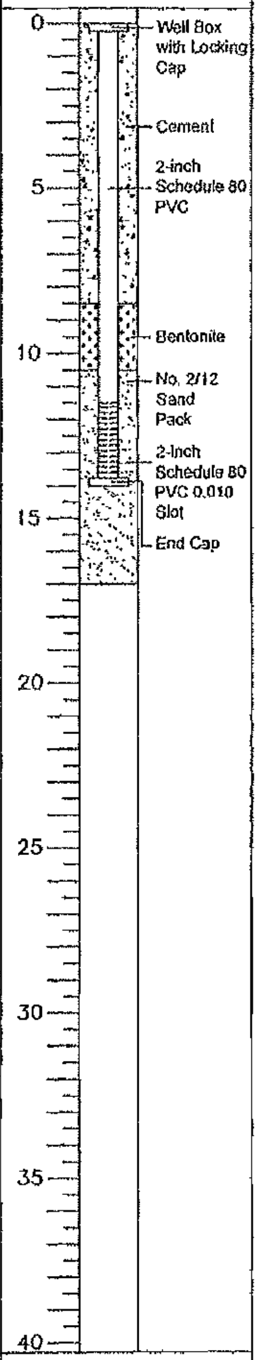
DATE DRILLED: 4/12/06
LOGGED BY: R. Dunn
APPROVED BY: K. Woodburne, RG
DRILLING CO.: Woodward Drilling

NORTHING: NOT SURVEYED
EASTING: NOT SURVEYED
ELEVATION: NOT SURVEYED

DRILLING METHOD: 8-inch Hollow-Stem Auger
SAMPLER TYPE: 2-inch Split Spoon
TOTAL DEPTH: Boring - 17.0 feet; Well - 14.0 feet
DEPTH TO WATER: 6.0 feet

PID/FID (ppm)	BLOWS PER 6 INCHES	RECOVERY	SAMPLE	DEPTH (feet below grade)	DESCRIPTION	USCS	LITHOLOGY
				0	Vacuum cleared to 5'.		
608	3 2 ~~3~~ 2 2	0.5/ 2.0		5	SILTY SAND (SM): Very dark greenish gray (GLEY1 3/5GY), 30% fines, 70% fine-grained sand, loose, wet.	▽ SM	
17.1	2 3 2 2	1.0/ 2.0					
17.3	1 1 2 2	2.0/ 2.0		10	SANDY SILT (ML): Very dark greenish gray (GLEY1 3/10Y), 70% fines, 30% fine- to medium-grained sand, nonplastic, soft, wet.	ML	
2.8	2 3 3 4	1.0/ 2.0					
2.4	1 3 4 5	2.0/ 2.0			CLAY (CL): Greenish gray (GLEY1 6/10Y), 90% fines, 10% fine-grained sand, medium plastic, stiff, wet. - @ 16': color change to pale brown (10YR 6/3).	CL	
0.7	2 3 5 8	2.0/ 2.0		15			
				20			
				25			
				30			
				35			
				40			

WELL CONSTRUCTION DETAIL



TRC

SPARGE POINT INSTALLATION LOG

C-2
PAGE 1 OF 1

PROJECT NO.: 42-0137-07
LOCATION: 76 Station #5325
3200 Lakeshore Ave.
Oakland, California

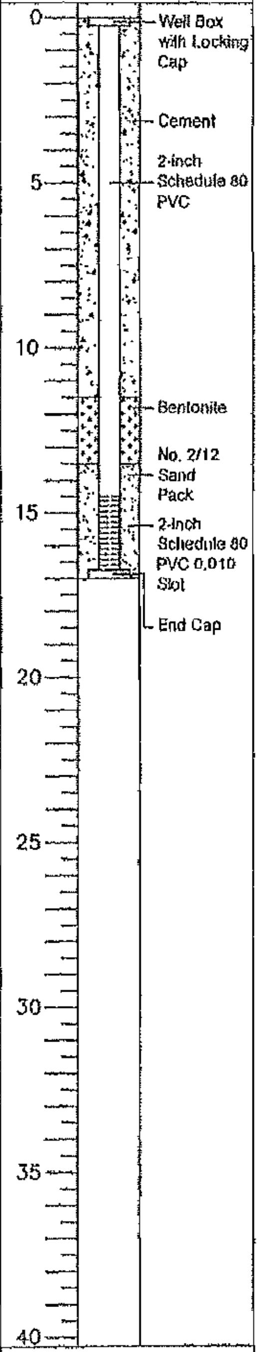
DATE DRILLED: 4/12/06
LOGGED BY: R. Dunn
APPROVED BY: K. Woodburne, RG
DRILLING CO.: Woodward Drilling

NORTHING: NOT SURVEYED
EASTING: NOT SURVEYED
ELEVATION: NOT SURVEYED

DRILLING METHOD: 8-inch Hollow-Stem Auger
SAMPLER TYPE: 2-inch Split Spoon
TOTAL DEPTH: Boring - 17.0 feet; Well - 17.0 feet
DEPTH TO WATER: 6.0 feet

PID/FID (ppm)	BLOWS PER 6 INCHES	RECOVERY	DEPTH (feet below grade)	DESCRIPTION	USCS
			0	Vacuum cleared to 5'.	
17.5	0 4 3 9	2.0/2.0	5	SAND (SM): Greenish black (GLEY1 2.5/10Y), 30% fines, 70% fine-grained sand, loose, wet, hydrocarbon odor.	▽ SM
2.1	1 1 3 3	1.0/2.0		SANDY SILT (ML): Very dark greenish gray (GLEY1 3/10Y), 80% fines, 20% fine-grained sand, nonplastic, soft, wet.	
5.7	1 1 2 4	2.0/2.0	10	- @ 10': color change to dark greenish gray (GLEY1 4/10Y), fine- to medium-grained sand, stiff, moist.	ML
1.2	2 3 4 4	2.0/2.0			
0.0	2 4 4 5	2.0/2.0		SILTY SAND (SM): Pale brown (10YR 6/3), 20% fines, 80% fine-grained sand, dense, wet.	
4.0	2 2 3 5	2.0/2.0	15		SM
			20		
			25		
			30		
			35		
			40		

WELL CONSTRUCTION DETAIL



TRC

SPARGE POINT INSTALLATION LOG

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Appendix C

Antea Group Standard Operating Procedures

STANDARD OPERATING PROCEDURES

Utility Locating

Prior to drilling, boring and excavation locations and an approximate 15-foot by 15-foot box are marked with white paint or other distinct marking and cleared for underground utilities through Underground Service Alert (USA). In addition, Antea Group will contract an independent locator services to clear boring or excavation locations of subsurface assets. The first five feet (or more in instances where utilities are suspected in close proximity) of each borehole are air-knifed, or carefully advanced with a hand auger if shallow soil samples are necessary, to help evaluate the borehole location for underground structures or utilities in accordance with Antea Group's subsurface hazard avoidance policy.

Subsurface Investigation Methods – GeoProbe®, Sonic, Hollow Stem Auger Drilling, Sampling, and Borehole Completion

Borehole Advancement using Single-Wall GeoProbe®

Pre-cleaned push rods (typically one to two inches in diameter) are advanced using a hydraulic direct push-type rig for the purpose of collecting samples and evaluating subsurface conditions. The sample barrel located at the leading end of the drill rod serves as a soil sampler, and an acetate liner is inserted into the sample barrel rod prior to advancement of the push rod. Once the sample is collected, the rods and sampler are retracted and the acetate sample tubes are removed from the sampler. The sample barrel is then cleaned, filled with clean sample tubes, inserted into the borehole and advanced to the next sampling point where the sample collection process is repeated.

Undisturbed soil samples selected for laboratory analysis are cut away from the acetate sample liner using a hacksaw, or equivalent tool, in sections approximately 6 inches in length. The 6 inch samples are lined at each end with Teflon® sheets and capped with plastic caps. Labels documenting project number, borehole identification, collection date, and depth are affixed to each sample. The samples are then placed into an ice-filled cooler for delivery under chain-of-custody to a laboratory certified by the State of California for analysis. The remaining collected soil that has not been selected for laboratory analysis is logged using the United Soil Classification System (USCS) under the direction of a State Registered Professional Geologist, and is field screened for organic vapors using a photo ionization detector (PID), or an equivalent tool.

Borehole Advancement using Sonic Drilling

Pre-cleaned heavy-walled down-hole casings (typically 6 to 8 inches in diameter) are advanced using a sonic head. A smaller diameter core barrel (typically 4 to 6 inches in diameter) is advanced through the inside of the down-hole casings to remove the soil cuttings from the borehole for sample collection and evaluation of subsurface conditions.

During drilling, soil samples are collected continuously using the sonic core barrel. A physical description of soil characteristics (i.e. moisture content, consistency or density, odor, color, and plasticity), drilling difficulty, and soil type as a function of depth are described on boring logs. The soil cuttings are classified in accordance with the USCS and field screened for organic vapors using a PID.

Borehole Advancement using Hollow Stem Auger

Pre-cleaned hollow stem augers (typically 8 to 10 inches in diameter) are advanced using a drill rig for the purpose of collecting samples and evaluating subsurface conditions. A pre-cleaned split spoon sampler is lined with three 6-inch long brass or stainless steel tubes and attached to the drill rods. The sampler is then driven 18 inches into the underlying soils at the target sample interval by repeatedly dropping a 140-pound hammer over a 30-inch free fall distance. The number of blow counts to drive the sampler each 6-inch interval of sampler advancement are recorded on the field logs. The sampler is driven 18 inches or until the sampler has met refusal (typically 50 blows per six inches), then the sampler is retrieved. Alternatively, soil samples are retrieved by driving the sampler using a pneumatic hammer, when using a limited access rig.

Generally the bottom sample tube is selected for laboratory analysis. The middle tube is extruded for logging and PID screening, and the top tube is considered slough caved off from the sides of the boring prior to sampling.

The retained sample is carefully packaged for chemical analysis by capping each end of the sample with a Teflon sheet followed by a tight-fitting plastic cap and stored in a zip-type plastic bag. A label is affixed to the sample indicating the sample identification number, borehole number, sampling depth, sample collection date, and job number. The sample is then annotated on a chain-of-custody form and placed in an ice-filled cooler for transport to the laboratory.

During the drilling process, a physical description of the encountered soil characteristics (i.e. moisture content, consistency or density, odor, color, and plasticity), drilling difficulty, and soil type as a function of depth are described on boring logs. The soil cuttings are classified in accordance with the USCS.

Grab Groundwater Sample Collection

Once the target groundwater sampling depth has been reached, a Hydropunch™ tip is placed on leading end of the sampling rods. The Hydropunch™ tip is advanced approximately 2 feet to place the sample port within the target groundwater sampling zone (effort is made to position the center of the Hydropunch™ screen across the water table surface, if appropriate), and retracted to expose the Hydropunch™ screen. Grab groundwater samples are collected by lowering a pre-cleaned, single-sample polypropylene, disposable bailer or pre-cleaned stainless steel bailer down the inside of the sampler rod. The groundwater sample is decanted from the bailer to the sample container through a bottom emptying flow control valve to minimize volatilization. Alternatively, groundwater samples are collected by lowering a disposable bailer through the sampler rod or into the borehole.

Collected water samples are decanted directly into laboratory provided, pre-cleaned, vials or containers and sealed with Teflon-lined septum, screw-on lids. Labels documenting sample number, well identification, collection date, and type of preservative (if applicable, i.e. HCl for GRO, BTEX, and fuel oxygenates) are affixed to each sample. The samples are then placed into an ice-filled cooler for delivery under chain-of-custody to a laboratory certified by the State of California to perform the specified tests.

Borehole Completion

Upon completion of drilling and sampling, the inner casing rods are retracted. Neat cement grout, mixed at a ratio of 6 gallons of water per 94 pounds of Portland cement, is introduced via a tremie pipe to displace standing water in the borehole, through the annulus of the outer casing rods. The outer rods are retracted as the grout is introduced to bottom of the boring to prevent the cross contamination of encountered water bearing zones. Displaced groundwater is collected at the surface and placed into DOT approved 55-gallon steel drums, or an equivalent storage container. In areas where the borehole penetrates asphalt or concrete, the borehole is capped with an equivalent thickness of asphalt or concrete patch to match finished grade.

Well Construction (typical)

Selected borings will be converted to groundwater monitoring wells by the installation of 2-inch or 4-inch diameter Schedule 40 polyvinyl chloride well casing with 0.020-inch factory slotted well screen as stated in the body of the work plan. A filter pack of Monterey #3 grade sand (or equivalent) will be placed in the annular space of the monitoring well borings, extending from the bottom of each well casing to approximately 2-feet above the top of the screened casing. A sanitary seal consisting of a 2-foot bentonite will be placed on above the filter sand and charged with water to create a seal. Neat cement grout, mixed at a ratio of 6 gallons of water per 94 pounds of Portland cement, is introduced via a tremie pipe to displace standing water in the well annulus bentonite to within two feet of the ground surface. Antea Group will install a minimum of a 5-foot annual seal. A traffic-rated well box will be installed on each well to protect and finish the well to surface grade.

The groundwater monitoring wells will be allowed to stabilize for a minimum of 72 hours after installation prior to development. Following development, the wells will be allowed stabilize for a minimum of 48 hours prior to the collection of any groundwater samples.

Organic Vapor Procedures

Soil samples are collected for analysis in the field for ionizable organic compounds using a PID with a 10.2 eV lamp. The test procedure involves measuring approximately 30 grams from an undisturbed soil sample, placing this sub-sample in a Zip-type bag. The container is warmed for approximately 20 minutes in the sun; then the head-space within the container is tested for total organic vapor, measured in parts per million as benzene (ppm; volume/volume). The instrument is calibrated prior to drilling. The results of the field-testing are noted on the boring logs. PID readings are useful as a qualitative indication of relative levels of contamination, but cannot be used to quantify petroleum hydrocarbon concentrations with the confidence of laboratory analyses.

Equipment Decontamination

Equipment that could potentially come in contact subsurface media and compromise the integrity of the samples is carefully decontaminated prior to drilling and sampling. Drilling auger and other large pieces of equipment are decontaminated using high pressure hot water spray. Soil and groundwater sampling apparatus, groundwater pumps, liners and other equipment are decontaminated in an Alconox scrub solution and double rinsed in clean tap water rinse followed by a final distilled water rinse.

The rinsate and other wastewater are contained in 55-gallon DOT-approved drums, labeled (to identify the contents, generation date and project) and stored on-site pending waste profiling and disposal.

Waste Handling and Disposal *(Soil Cuttings and Rinsate/Purge Water)*

Soil cuttings and rinsate/purge water generated during drilling and sampling are stored on-site in DOT-approved 55-gallon steel drums pending characterization. A label is affixed to the drums indicating the contents of the drum, suspected contaminants, date of generation, and the boring number from which the waste is generated. The drums are removed from the site by a licensed waste disposal contractor to an appropriate facility for treatment/recycling.

SOIL VAPOR WELLS STANDARD FIELD AND SAMPLING PROCEDURES

Utility Locating

Prior to drilling, boring and excavation locations and an approximate 15-foot by 15-foot box are marked with white paint or other distinct marking and cleared for underground utilities through Underground Service Alert (USA). In addition, Antea Group will contract an independent locator services to clear boring or excavation locations of subsurface assets. Soil vapor wells are not air-knifed, and are instead carefully advanced using hand auger drilling techniques.

Borehole Advancement using Hand Auger

A pre-cleaned hand auger (typically three inches in diameter) is advanced by hand for the purpose of collecting samples and evaluating subsurface conditions. If required, soil samples are collected into one 6-inch brass or stainless steel tube inserted into the hand auger during advancement. Soil samples may also be collected into pre-cleaned certified laboratory-provided glass jars.

The retained sample is carefully packaged for chemical analysis by capping each end of the sample with a Teflon sheet followed by a tight-fitting plastic cap and stored in a zip-type plastic bag. A label is affixed to the sample indicating the sample identification number, borehole number, sampling depth, sample collection date, and job number. The sample is then annotated on a chain-of-custody form and placed in an ice-filled cooler for transport to the laboratory.

During the drilling process, a physical description of the encountered soil characteristics (i.e. moisture content, consistency or density, odor, color, and plasticity), drilling difficulty, and soil type as a function of depth are described on boring logs. The soil cuttings are classified in accordance with the USCS.

Soil Vapor Well Completion (Typical)

Shallow soil vapor well borings are typically advanced to 5.5 feet below ground surface (bgs), but may be completed deeper if necessary or shallower if groundwater is present. The borings will be completed into soil vapor wells by placing one foot of Monterey #3 or #30 sand into the borehole. A soil vapor probe connected to seven feet of 0.25-inch outside diameter Teflon® tubing and installed in center of the sand pack at a depth of five feet bgs. A one foot interval of dry granular bentonite transition seal is placed on top of the sand pack. A neat cement sanitary seal is placed on top of the transition seal to approximately one foot bgs. Concrete is placed from 1.0 feet bgs to approximately 4 inches below the surface and a traffic-rated well box is installed at the surface. The well is completed by installing a Swagelok® valve on the terminating end of the Teflon® tubing.

Organic Vapor Procedures

Soil samples are collected for analysis in the field for ionizable organic compounds using a PID with a 10.2 eV lamp. The test procedure involves measuring approximately 30 grams from an undisturbed soil sample, placing this sub-sample in a Zip-type bag. The container is warmed for approximately 20 minutes in the sun; then the head-space within the container is tested for total organic vapor, measured in parts per million as benzene (ppm; volume/volume). The instrument is calibrated prior to drilling. The results of the field-testing are noted on the boring logs. PID readings are useful as a qualitative indication of relative levels of contamination, but cannot be used to quantify petroleum hydrocarbon concentrations with the confidence of laboratory analyses.

Equipment Decontamination

Equipment that could potentially come in contact subsurface media and compromise the integrity of the samples is carefully decontaminated prior to drilling and sampling. Drilling auger and other large pieces of equipment are decontaminated using high pressure hot water spray. Soil and groundwater sampling apparatus, groundwater pumps, liners and other equipment are decontaminated in an Alconox scrub solution and double rinsed in clean tap water rinse followed by a final distilled water rinse.

The rinsate and other wastewater are contained in 55-gallon DOT-approved drums, labeled (to identify the contents, generation date and project) and stored on-site pending waste profiling and disposal.

Waste Handling and Disposal (Soil Cuttings and Rinsate/Purge Water)

Soil cuttings and rinsate/purge water generated during drilling and sampling are stored on-site in DOT-approved 55-gallon steel drums pending characterization. A label is affixed to the drums indicating the contents of the drum, suspected contaminants, date of generation, and the boring number from which the waste is generated. The drums are removed from the site by a licensed waste disposal contractor to an appropriate facility for treatment/recycling.

Soil Vapor Well Sampling

Following installation, the soil vapor wells will be allowed to equilibrate for a minimum of three days and then sampled using the standard operating procedure described below:

1. One-foot sections of 0.25-inch outside diameter Teflon® tubing will be used to connect the Swagelok® wellhead valve to a Swagelok® T-union fitting, one 6-liter Summa canister (purge), and one 1-liter or 6-liter Summa canister (sample). Each Summa canister will be outfitted with its own particulate filter, vacuum gauge, and flow regulator calibrated to a

flow rate of between 100 and 200 milliliters per minute (ml/min). With the exception of the 6-liter purge Summa canister, dedicated equipment and materials will be used at each well to avoid cross-contamination.

2. Once the sampling train is assembled, a vacuum test will be performed to ensure the integrity of the sampling train. With the Swagelok® wellhead valve closed, the 6-liter purge Summa canister will be opened for a minimum of 10 minutes. If a vacuum is not maintained for at least 10 minutes, the fittings will be tightened and the vacuum test repeated.
3. Once the integrity of the sampling train has been verified by the vacuum test, the well will be purged. The purge amount will be based on Department of Toxic Substances Control (DTSC) guidelines, which involves purging three dead space volumes (tubing volume + void space of the sand pack). Assuming a total well and sampling train tubing length of 10 feet and 35% porosity of the well's sand pack, the well will be purged approximately 1.4 liters (1,400 ml). Assuming a sustained flow rate of 150ml/min, a purging time of 9 minutes and 20 seconds should be anticipated. Total purge times may be adjusted based on actual flow rates observed in the field.
4. After purging activities are complete, Antea Group will construct a sampling shroud and place it over the well and wellhead valve. A paper towel with isopropyl alcohol applied to it will be placed underneath the shroud to be used as a leak check compound. The shroud will then be sealed to the ground surface with hydrated granular bentonite to ensure an air-tight connection. If 1,1-difluoroethane (1,1-DFA) is used as a leak check compound in lieu of isopropyl alcohol, it will be introduced underneath the sampling shroud prior to sealing with bentonite.
5. Upon completion of shroud construction, the sample Summa canister will be opened and sample collected. If isopropyl alcohol is used as a leak check compound, a PID will be used to monitor the concentration under the shroud at approximately 30-second intervals. Once the sample Summa canister is filled to -5 inches mercury (in Hg), the canister will be closed. All general sampling information, purge times, sample times, and PID readings will be recorded on field sampling forms.
6. After sampling, the Swagelok wellhead valve will be returned to the closed position. Collected samples will be given unique sample names and transported under chain of custody protocol to a California-certified analytical laboratory. Analyzed compounds will include the constituents of concern and the leak check compound used during sampling.