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October 12, 2012

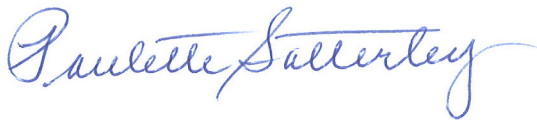
Ms. Barbara Jakub
Alameda County Environmental Health Services
1131 Harbor Bay Parkway, Suite 250
Alameda, CA 94502

Re: Fuel Leak Case No: RO0000133

Enclosed please find the *Pilot Test Work Plan* dated 10-11-2012 and the *2012 Second Semi-Annual Groundwater Monitoring Report* dated 10-12-2012. These reports were prepared by Taber Consultants of West Sacramento, California.

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

Sincerely,



Paulette Satterley

RECEIVED

10:17 am, Oct 31, 2012

Alameda County
Environmental Health

PILOT TEST WORK PLAN

Former City of Paris Cleaners
3516 Adeline Street
Oakland, California 94608

USTCF Claim #002192

Prepared For:

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Taber Consultants Project No. 2011-0107

October 11, 2012

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1.0 INTRODUCTION

1.1 Project Description

On behalf of the responsible party, Taber Consultants has prepared this *Pilot Test Work Plan* for submittal to the San Francisco Bay Regional Water Quality Control Board (SFBRWQCB) and Alameda County Health Care Services Agency (ACHSA). The proposed scope of work complies with the April 10, 2012, ACHSA directive requesting a pilot test work plan to test a remedial strategy at the site.

1.2 Site Location and Description

The former City of Paris Cleaners, located at 3516 Adeline St., Oakland, California, is located at the southeastern corner of the intersection of 35th Street and Adeline Street in the northwest portion of the City of Oakland, California. Elevation at the site is approximately 30 feet above mean sea level (amsl). The site location is shown on Figure 1. A site plan is shown on Figure 2.

The site was a former dry cleaning, laundry and dyeing operation. The facility operated as City of Paris Cleaners and Dyers for about 40 years until the 1960's, but cleaning materials and tanks were not completely removed from the site until 1992. The site buildings remained vacant for a number of years following the closure of the dry cleaning operation, and then the owner converted them to residential and light commercial use. Ms. Debra Runyon acquired the property in July 2000. The site buildings have since been used as on-site living quarters and the City of Paris Studios (a workshop for art, art restoration, collectibles and hobbies).

1.3 Chronological Site History and Subsurface Investigations

In 1987, Frank Champion, the owner at that time, applied for permits to remove storage tanks at the site. Mr. Champion applied for five permits, obtaining permission to remove two 1000-gallon tanks, a 500-gallon tank, a 250-gallon tank and a 150-gallon tank. The underground storage tanks at the site were used to store Stoddard Solvent, the dry cleaning solvent used during operation of the dry cleaning facility until the 1960s when the facility was closed.

On October 4, 1990, Semco Company of San Mateo excavated and reported removing one 750-gallon and two 1,000-gallon underground tanks used to store Stoddard Solvent. Six soil samples were collected in conjunction with the UST removal.

On July 31 and August 1 and 2, 1991, Uriah Inc. (UES) performed a soil vapor survey at the site using photoionization technology (a Photovac TIP I) in an attempt to define the approximate boundaries of soil impacted by Stoddard Solvent. Soil vapors were found to be widely distributed across the site, but due to physical impediments posed by site structures, sidewalks, etc., the full extent of the impacted soil was not defined.

UES contracted W.A. Craig to over excavate the eastern portion of the tank pit on August 30, 1991. Approximately 44 cubic yards were excavated and placed in a cell for on-site bioremediation of the impacted soil. During over excavation, EUS reports that the contractor discovered an additional 250-gallon UST containing "a small volume of liquid" that was stored in a 55-gallon drum on site after removing an aliquot for analysis. This UST was removed and disposed by W. A. Craig on October 31, 1991. An additional 15 cubic yards was over excavated from the tank pit by W.A. Craig on January 27, 1992 and added to the on-site bioremediation cell.

On March 31, 1992, composite samples of the on-site bioremediated soil were analyzed to verify that sufficient hydrocarbon removal had occurred to reuse as fill on the site. No additional soils were excavated due to safety concerns regarding building foundation integrity; however soil samples were collected from the tank pit side walls. ACHCSA approved use of the bioremediated soil as backfill, and W. A. Craig backfilled the tank pit with bioremediated soil and clean fill on April 21, 1992.

On October 29 and 30, 1992, UES supervised on-site installation of ground water monitoring wells. Soils Exploration Services of Vacaville, California, installed three 30-foot monitoring wells. Initial depth to groundwater measurements in the wells ranged from 13 to 14 feet below grade. Beginning November 18, 1992, groundwater samples were analyzed for Total Petroleum Hydrocarbons as Stoddard Solvent (TPH-SS), TPH as diesel (TPH-D), TPH as gasoline (TPH-G), methyl tertiary butyl ether (MTBE), and benzene, toluene, ethyl benzene and total xylenes (BTEX). Samples from all three monitoring wells contained TPH-SS ranging from 630 parts per billion (ppb) in MW-2 to 11,000 ppb in MW-3. TPH-D, TPH-G, MTBE and BTEX concentrations were below laboratory detection limits.

On March 19, 1998, Dugan Associates of San Jose, California (Dugan) advanced six on and off-site soil borings to a total depth of 18 feet below grade. Five of the soil borings were advanced on the north side of 35th Street in the projected downgradient direction from the site (EB-2 through EB-6). One soil boring was advanced on-site to the northwest of the former UST location (EB-1). At each soil boring, Dugan collected a soil sample at 5, 10 and 15 feet below grade and one grab-groundwater sample at 18 feet below grade. The on-site soil boring (EB-1) groundwater sample concentration was 270,000 ppb TPH-SS, with one off-site groundwater sample (EB-5) reporting 780 ppb TPH-SS. Concentrations of analytes for all other groundwater samples from the soil borings were below laboratory detection limits. Soil samples at EB-1 contained 310 and 340 ppb of TPH-SS at 10 and 15 ft. below grade, respectively, and trace amounts of total xylenes and/or toluene.

In September, 1999, ACHSA issued a directive letter which required groundwater analysis for semi-volatile organics (SVOCs) and volatile organics (VOCs) historically associated with dry cleaning operations. In December 1999, using EPA method 625 and 3510, or 8270 and 3550, 1,2-dichlorobenzene (DCB), 1,1-dichloroethane (1,1 DCA), 2-methylnaphthalene and naphthalene were detected in samples from one or more wells. Concentrations of other SVOC and VOC analytes were below laboratory detection limits, including denser than aqueous phase

liquids (DNAPLs, i.e. pentachlorophenol (PCP)). At that time Dugan defined a north-trending groundwater gradient at 0.003 ft./ft.

In their September, 1999 letter, the ACHSA also noted that according to a database search they believed a 97-foot industrial well had been drilled at the site. The well was located southeast of Monitoring Well 3 (Figure 2).

In March 2002, in compliance with an ACHSA directive letter, WellTest, Inc. (formerly Dugan and Associates) redeveloped the three monitoring wells (by purging 10 well-volumes) and sampled the three wells pursuant to quarterly monitoring responsibilities. WellTest, Inc. also sampled the industrial well on-site. The analytical results of the sampling indicated up to 11,000 micrograms per liter ($\mu\text{g/L}$) of TPH-SS in the sample from MW-1, no BTEX above laboratory detection limits, up to 31 $\mu\text{g/L}$ MTBE in the sample from MW-3, 0.61 $\mu\text{g/L}$ DCB in the sample from MW-1, and 130 $\mu\text{g/l}$ Naphthalene in MW-1. The groundwater gradient was also defined to the southeast at 0.14 ft./ft., which appears to be an anomalously steep gradient for this site. This steep gradient may be a result of sediment blocking some or all of the screened section of one or more well. When Dugan redeveloped the wells in 2002, they appear to have adversely impacted the ability of the wells to adjust to changing water levels.

Taber Consultants, formerly Western Resource Management (WRM), assumed environmental consulting responsibilities for the site commencing in June 2007. Taber performed groundwater monitoring at the site for the first and second semi-annual periods of 2009. In response to a query by ACHSA, Taber submitted a well completion report request to the California Department of Water Resources, in which undated well boring logs for a well at the City of Paris Cleaners, at 3516 Adeline Street, indicated a 97-foot industrial well on the site. Taber also found well drilling information for another industrial well drilled in 1927 for the City of Paris Cleaners, drilled to 295 feet. The location of this well is unknown, and the well could have been covered by buildings constructed after the well was taken out of service.

July 28, 2009, ACHCSA advised Responsible Parties that The California State Water Resources Control Board (State Water Board) had approved Resolution No. 2009-0042, which reduced quarterly groundwater monitoring requirements to semi-annual or less frequent monitoring at all sites. In 2009, Taber reduced monitoring at the City of Paris Cleaners site to two semi-annual monitoring events at the site in February and August. Corresponding reports were the First Semi-annual and Second Semi-annual Monitoring Reports.

In August of 2009 Taber Consultants evaluated using the HydraSleeve[®] no-purge sampling protocol at the site. With verbal authorization from Barbara Jakub of ACHCSA, on March 17, 2010, Taber Consultants implemented ongoing use of the HydraSleeve[®] sampling protocol for all wells at the site.

In March 2011 Taber Consultants resurveyed top of well casings during groundwater monitoring activities. In May 2011 Taber Consultants conducted site investigation activities which included: video well logging to evaluate well screen and casing condition; hydrogeology characterization using cone penetrometer testing (CPT), the GeoProbe[®] hydraulic profiling tool (CPT),

continuous push soil borings; assessing distribution of impacted soil by analyzing soil samples and grab groundwater samples; and assessing site groundwater chemistry by analyzing grab groundwater samples for natural attenuation parameters. The findings of the investigation are detailed in the *Site Investigation Report*, *Human Health Risk Assessment Report*, and *Natural Attenuation Analysis Report* dated February 1, 2012.

2.0 PURPOSE

This *Pilot Test Work Plan* is intended to present a remedial method appropriate for conditions at the site as well as the scope of work required for the pilot test implementation at the City of Paris Cleaners as directed by ACHSA's April 10, 2012 letter.

The primary purpose of this work plan is to present procedures for performing a sulfate injection remedial event as an interim remedial action to reduce TPH-SS mass in soil and in on-site groundwater. In addition, the work plan also presents methods to track progress during the injection event as well as before and after sampling strategy to evaluate effectiveness of the injection.

3.0 SITE HYDROGEOLOGIC CONDITIONS

3.1 Site Lithology And Hydrogeology

During the May 2011 site investigation, site hydrogeologic conditions were observed as follows. Soil from near ground surface (approximately 6-inches below asphalt or concrete and road base) to an average depth of approximately 10 feet bgs consists predominantly of clay, sandy clay and gravelly clay. Soil from an average depth between approximately 10 and 20 feet bgs consists of clayey gravel and clayey sand. Soil from an average depth between approximately 20 feet bgs and 30 feet bgs consists predominately of clay. Soil from an average depth between approximately 30 and 40 feet bgs consists of clayey gravel and clayey sand. Soil from an average depth of approximately 40 feet bgs to 50 feet bgs (the maximum depth investigated) consists predominately clay. Figures 3, 4, 5 and 6 provide cross-sections depicting the observed lithology during the May 2011 site investigation.

The results of the May 2011 investigation indicate that two water-bearing zones potentially exist within approximately 40 feet beneath the site and vicinity. The upper groundwater zone is located in the clayey sand and clayey gravel between approximately 10 and 20 feet bgs. Based on measurements in the borings during grab groundwater sampling, water levels in the upper groundwater zone indicate unconfined or semi-confined conditions. The lower groundwater zone is located in the clayey sand and gravel between approximately 30 and 40 feet bgs. Based on measurements after completing sampling of the borings, the lower groundwater zone water levels were between approximately 13 and 25 feet bgs, well above the top of the sand and gravel unit at 30 feet bgs indicating that the lower unit is confined.

Based on monitoring results of wells in the upper groundwater zone at four nearby UST release sites, groundwater in the area flows west-southwest. Three of the sites are to the east and up-gradient of the subject site and one site is to the north-northwest and cross-gradient to up-gradient of the site. Based on historical monitoring results, groundwater flow direction beneath the site is not consistent with other environmental sites in the general area which are conducting groundwater monitoring. This is due, at least partially, to the close spacing of the monitoring wells on the site. Historical site information also indicates that the former consultant may have damaged the well filter pack during redevelopment of the onsite monitoring wells in 2002 and this has resulted in anomalous water level data since that event. Based on the shape of the plume however, it appears that at least some of the time, groundwater in the upper groundwater flows north and north-northwest, resulting in a roughly horse-shoe shaped plume, possibly as a result of preferential flow through more conductive material.

3.2 TPH-SS, Weathered TPH-SS, and Groundwater/Soil Impacts

Although petroleum hydrocarbon compounds were detected in groundwater samples in the TPH-G range as quantified in the February 2012 *Site Investigation Report*, the analytical laboratory noted that the chromatogram pattern was irregular with respect to the location and amplitude of typical TPH-G peaks. As discussed in Taber Consultant's June 15, 2010, 2010

First Semi-Annual Monitoring Report, weathered TPH-SS appears in the TPH-G range due to weathering of more volatile constituents by volatilization and degradation processes. Chromatograms of the laboratory analyses are included in Appendix D of the February 2012 *Site Investigation Report*.

Review of the chromatograms confirms similarities in samples registering TPH-SS concentrations and peak shapes in samples reporting TPH-G-range concentrations. With distance, analytical detection of TPH-SS in groundwater samples falls below method detection limits, however weathered TPH-SS that appears in the TPH-G range is still detected. TPH-SS detections in the upper groundwater zone were present in groundwater samples from GP-4, 8, 9 and 10. Detections quantified as TPH-G in the upper groundwater zone were present in samples from GP-4, 8, 9, 10, 16 and 18. TPH-SS detections in the lower groundwater zone are only present in groundwater samples from GP-10, close to the source area where the tanks were excavated. Detections quantified as TPH-G in the lower groundwater zone were present in samples from GP-8, 10 and 12. The approximate extent of TPH-SS and TPH-G combined in groundwater is shown on Figures 3, 4 and 5.

Concentrations of TPH-SS are greatest near the source area near the former USTs (i.e. MW-1 and GP-10), groundwater does not appear to be impacted with TPH SS east of GP-10 or north of GP-4 on 35th Street. Low concentrations reported as TPH-G were present in groundwater samples collected from GP-18, the northern most boring, but not further east than GP-4 and GP-10. Groundwater samples were not collected west of GP-12 due to restrictions on excavation permits which did not allow sampling on Adeline Street. Although soil sample GP-12-16, collected in the saturated zone, contained 630 mg/kg weathered TPH-SS reported as TPH-G, a shallow groundwater sample could not be obtained in the zone between 10 and 20 feet bgs. As a result, the extent of TPH in groundwater west of GP-12 was not identified by analytical data but was estimated based on concentrations in nearby GP-8, GP-9 and GP-1, as shown on Figure 3. Tables 1 and 2 present summaries of the soil and groundwater sample concentrations observed during the May 2011 site investigation.

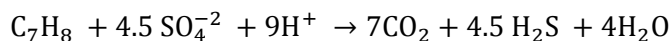
The bottom of the former tank excavation appears to have intersected the top of the shallow groundwater zone, located at an approximate depth of 13 feet bgs in this area of the site. Impacted soil above the shallow groundwater appears to be limited to the vicinity of the former tank excavation. Several soil samples were obtained within the shallow and deeper groundwater zones (in the saturated zones). The approximate extent of combined TPH-SS and TPH-G detections in soil above the shallow groundwater zone is shown on Figures 4 and 6. Figure 5 shows the locations and concentrations of combined TPH-SS and TPH-G in soil samples collected from the tank excavation and adjacent borings that represent conditions at the time of sampling (excavation sidewall samples S1-9, W1-9, E1-7 and N1-9; and soil samples from borings EB-1, MW-1 and MW-2).

4.0 REMEDIAL SULFATE INJECTION

Taber Consultants proposes this pilot test methodology to assess the effectiveness of sulfate injection as a remedial method to reduce the mass of the TPH-SS plume at the site. As reported in the February 1, 2012 *Site Investigation Report*, the TPH-SS is located predominately within the upper groundwater zone at approximately 15 feet bgs.

Based on the February 2012 *Natural Attenuation Analysis* prepared by Taber Consultants, terminal electron acceptors such as oxygen, nitrate, and sulfate are depleted within the plume. The oxygen-reduction potential (ORP) in groundwater within the plume ranges from -91.4 to -202.7, which favors anaerobic reduction of petroleum hydrocarbons (Table 4).

Sulfate injection is the most practical remedial method to enhance natural attenuation of TPH-SS at the site because sulfate reduction is effective at ORP values observed within the plume, without requiring a change of oxidation-reduction state as would be required for oxygen or nitrate as electron acceptors. Additionally, the solubility of sulfate as magnesium sulfate is high (>1,000 milligrams per liter (mg/l)) compared to oxygen (between 9 and 40 mg/l). The stoichiometric balance for sulfate in biodegradation is as follows:



The BTEX degradation model proposed by Lyle Bruce and Arati Kolhatkar of BP America (Appendix A) can be used to estimate the quantity of sulfate required to degrade TPH at the site using historical groundwater monitoring data (Table 3) and information obtained during the May 2011 site investigation (Tables 4, 5 and 6). The TPH-SS at the site is composed of aliphatic and aromatic hydrocarbons as presented by Taber Consultants in the February 1, 2012 *Human Health Risk Assessment* prepared for the site.

Carbon Range	TPH Fraction
Aliphatic C8-C10	40%
Aliphatic C10-C12	40%
Aromatic C8-C10	10%
Aromatic C10-C12	10%

Using the BTEX numbers in the Bruce and Kolhatkar model as a surrogate for TPH-SS, Taber Consultants estimates the current degradation capacity of the terminal electron acceptors at the site is approximately 49 mg/d of BTEX. By supplementing the existing groundwater chemistry in the plume area with aqueous sulfate solution the degradation capacity could be raised to as much as 586 mg/d BTEX. Because TPH-SS is largely composed of aliphatic compounds, degradation kinetics of TPH-SS should be more rapid than BTEX.

Assuming a 60 foot x 60 foot plume area with a 10 foot saturated thickness, 482 gallons of a 140,000 mg/l sulfate solution could be injected into the subsurface at about 15 feet bgs and not exceed a target *in situ* sulfate concentration of 250 mg/l, the California Department of Public

Health (CDPH) Secondary Maximum Contaminant Level. Because the total volume of water in the upper groundwater zone is likely greater than the plume volume, the maximum *in situ* sulfate concentration will be less than 250 mg/l sulfate.

$$V_i * C_i / (V_{is} + V_i) = C_{is}$$

Where:

V_i = Volume of water injected (1825 l),
 C_i = Concentration of solution injected (140,000 mg/l)
 V_{is} = Volume of water *in situ* (1019407 l), and
 C_{is} = Concentration of *in situ* solution (250 mg/l)

Water units are in liters, and concentration units are in mg/l.

Injecting the sulfate solution under pressure will exploit the preferential pathway flow of the upper groundwater zone, so that the sulfate solution should permeate the plume area near the monitoring wells. Groundwater in the monitoring wells should show a response to the sulfate solution injection with increased electrical conductivity and raised groundwater elevations.

5.0 FIELD ACTIVITIES AND SCOPE OF WORK

5.1 General

Taber Consultants proposes to conduct the following tasks during the remedial action pilot test:

- Advance pre-injection GeoProbe® borings to approximately 15 feet in four or five (4 or 5) locations within the proposed injection grid immediately north of the plume source area to collect soil samples from five (5) feet bgs and upper zone grab groundwater samples to document pre-injection concentrations of TPH-SS.
- Analyze groundwater samples for TPH-SS and TPH-G by EPA Method 8015B and BTEX, MTBE by EPA Method 8260B and natural attenuation parameters (methods listed in Appendix B).
- Monitor natural attenuation field parameters (dissolved oxygen, ORP, EC and temperature) during GeoProbe® activities.
- Advance twelve (12) injection borings in a 4x3 grid, approximately 60 feet long to the east-west and 30 feet to the north-south, in order to inject sulfate solution.
- Pump a sulfate solution, approximately 140,000 mg/l sulfate, into the upper groundwater zone.
- Monitor groundwater elevation, electrical conductivity and natural attenuation field parameters in groundwater monitoring wells at the site to assess impacts from sulfate injection pumping.
- To monitor post-injection effectiveness, advance four or five (4 or 5) GeoProbe® borings to approximately 15 feet in four locations within the former injection grid immediately north of the plume source area to collect upper zone groundwater samples to document post-injection concentrations of TPH-SS at six (6) months and twelve (12) months following sulfate injection.
- Analyze groundwater samples for TPH-SS and TPH-G by EPA Method 8015B and BTEX, MTBE by EPA Method 8260B and natural attenuation parameters (methods listed in Appendix B).
- Monitor natural attenuation field parameters (dissolved oxygen, ORP, EC and temperature) during post-injection GeoProbe® monitoring and subsequent groundwater monitoring.

All work will be performed in accordance with Alameda County regulations, California Code of Regulations, Title 23, Section 2647 and 2648, and the California Department of Water Resources Bulletins 74-81 and 74-90. Drilling activities will be overseen by a California Professional Geologist.

Prior to initiating field work at the site, a site specific Health and Safety Plan (HASP) will be developed and will include safety procedures for the work to be performed, chemical hazard information, site safety officers, and directions to the nearest emergency medical facility. The HASP will be kept on-site at all times during field activities.

5.2 Target Cleanup Goals

Groundwater at the site is not currently used for drinking water. Groundwater cleanup standards for the site are based on applicable water quality objectives for drinking water and the protection of ecological receptors, prevention of nuisance conditions and the projection of human health under a residential exposure scenario. The objective the proposed remedial action of a sulfate injection is to promote the anaerobic degradation of TPH-SS at the site.

5.3 Permits and Preliminary Work

Taber Consultants will obtain the required soil boring permits from the ACHSA and discharge permits (if required) from the San Francisco Bay Regional Water Quality Control Board. In addition, excavation and obstruction permits will be obtained from the City of Oakland.

Underground Service Alert (USA) will be notified 48 hours prior to boring advancement to locate any utilities in the vicinity of the planned well locations. As an additional precaution against encountering any buried utilities, the first five feet of each boring will be hand-augered.

All drill cuttings, rinsate water, and decontamination water will be stored in separate 55-gallon drums for temporary off-site storage, pending waste profiling and proper disposition. Waste disposition will be based on the analytical results of soil and groundwater samples collected and analyzed during the field investigation.

5.4 Field Screening

During activities in which soil boring samples will be collected, a portable photo-ionization detector (PID) will be used to monitor for the presence of organic vapors in drill cuttings and drive samples. The PID measures relative concentrations of VOCs and is calibrated to an isobutylene standard.

The field screening will consist of filling a sealable plastic bag to about one-third capacity with soil and sealing the container. After allowing sufficient time for the soil vapor to equilibrate with the container's headspace, the bag will be slightly opened or pierced to allow for insertion of the PID probe.

The concentrations of organic vapors detected by the PID will be recorded on the boring logs. Field screening will also include documenting visual indications for the presence of petroleum hydrocarbon impacts, such as staining, odors, discoloration, and/or chemical sheens.

5.5 Injection method and locations

5.5.1 Sulfate Injection Grid

Taber Consultants will advance twelve (12) injection borings in a 4x3 grid, approximately 60 feet long to the east-west and 30 feet to the north-south, in order to inject sulfate solution. The injection borings will be advanced to approximately 15 feet bgs using a GeoProbe® rig equipped with direct push injection technology.

5.5.2 Chemical Staging Area

In order to minimize the potential for spills, leaks, and any other form of unwanted discharge of the sulfate mixture to the ground surface, a chemical staging work area and exclusion zone will be fashioned using appropriate barriers, equipment or enclosures such that the exclusion zone will be approximately 20% larger than the work area. The work area and exclusion zone will limit access to the injection area to properly trained personnel associated with the remedial pilot test.

Every effort will be made to minimize spills and leaks, and precautionary measures will be taken to minimize and contain any injected solution that breaks through to the ground surface. Prior to mixing reagents at the site, secondary containment systems or appropriate berm material will be placed around mixing equipment, transfer hoses, and injection points. Additional containment or berming materials will be available onsite in the case sulfate solution reaches the ground surface. All liquids associated with the reagent injection will be kept onsite and within the exclusion zone. Containment/berming materials within will be positioned upstream of drainage channels and storm drains.

5.5.3 Injection System

The direct push injection (DPI) rig will advance small diameter hollow steel rods into the target zone. Each DPI point consists of a series of threaded 3-5 foot long stainless steel drive rods that are advanced via series of connected rod joints to the desired application depth prior to injection of the sulfate solution. A pressurized pump is used to inject the solution into the subsurface. Injection rates will be determined by hydraulic conductivity of the upper groundwater zone.

During injection breakthrough is possible in previous borings, therefore during injection the former boring locations will be observed to mitigate sulfate solution break through. Should breakthrough be observed, hydrated bentonite chips will used to pack the former borehole seals.

5.6 Injection Monitoring

5.6.1 Baseline (Pre-Injection)

Pre-injection conditions will be monitored by advancing four or five (4 or 5) soil borings to 15 feet bgs (the upper groundwater zone). The primary function of the borings is to collect grab

groundwater samples, however in order to provide information regarding shallow soils at the site, two (2) soil samples will be taken at 5 feet bgs in close proximity to the former tank area. Borings will be logged to soil sample depth. Soil samples will be analyzed for constituents of concern (COCs) TPH-SS, TPH-G, BTEX, and MTBE by EPA Methods 8015B and 8260B.

Grab groundwater samples will be collected from the borings. Groundwater samples from approximately 15 feet bgs will be collected using a Geopump and new disposable tubing. The groundwater samples will be collected in laboratory-supplied containers, labeled, stored and transported in an iced cooler under chain-of-custody documentation to a State of California-certified testing laboratory for analysis on a standard turn-around time. Groundwater samples will be analyzed for the following constituents of concern (COCs): TPH-SS, TPH-G, BTEX, and MTBE by EPA Methods 8015B and 8260B, as well as natural attenuation parameters: ferrous iron (Fe^{2+}), total iron (Fe), manganese (Mn^{2+}), methane (CH_4), nitrate (NO_3^-) sulfate (SO_4^{2-}), carbon dioxide (CO_2), sulfide (H_2S), phosphorus (P), and total nitrogen (TKN) and alkalinity (natural attenuation parameter Methods listed in Appendix B).

5.6.2 Event (Groundwater Elevation Monitoring and System Electrical Conductivity)

Injection of the sulfate solution into the saturated zone will result in the mixing and displacement of the aquifer water present. During this displacement the volume of fluid injected will temporarily cause a localized rise (mounding) in the water level. As the initial aquifer water is displaced the mounding dissipates. The rate at which the mounding dissipates is primarily dependent on the hydraulic conductivity (or permeability) of the soil in the aquifer. Taber Consultants will monitor the mounding and rate of dissipation by monitoring groundwater levels in monitoring wells MW-1, MW-2 and MW-3 on an hourly basis during the injection. Additionally, electrical conductivity of the groundwater is expected to rise as injection sulfate solution mixes with local groundwater, which will be monitored hourly using an electrical conductivity meter.

5.6.3 Performance Monitoring (Post Injection)

Two post-injection monitoring events will be conducted at six (6) months and twelve (12) months following sulfate injection. Post-injection conditions will be monitored by advancing four or five (4 or 5) soil borings to 15 feet bgs (the upper groundwater zone). Grab groundwater samples will be collected from the four (4) borings. Groundwater samples from approximately 15 feet bgs will be collected using a Geopump and new disposable tubing. The groundwater samples will be collected in laboratory-supplied containers, labeled, stored and transported in an iced cooler under chain-of-custody documentation to a State of California-certified testing laboratory for analysis on a standard turn-around time. Groundwater samples will be analyzed for the following constituents of concern (COCs): TPH-SS, TPH-G, BTEX, and MTBE by EPA Methods 8015B and 8260B, as well as natural attenuation parameters: ferrous iron (Fe^{2+}), total iron (Fe), manganese (Mn^{2+}), methane (CH_4), nitrate (NO_3^-) sulfate (SO_4^{2-}), carbon dioxide (CO_2), sulfide (H_2S), phosphorus (P), and total nitrogen (TKN) and alkalinity (natural attenuation parameter Methods listed in Appendix B).

5.7 Waste Management

Any decontamination and purge water generated by site investigation activities will be placed in DOT-approved 55-gallon drums and labeled accordingly. The drums will be stored at the driller contractor facility pending laboratory analyses and selection of an appropriate disposition. Disposal of the cuttings and water will be completed by the drilling contractor. Drill cutting and water disposal is expected to be completed within 60 days of the receipt of the analytical results.

5.8 Quality Assurance and Quality Control

5.8.1 Analytical Procedures

Taber Consultants will employ the services of State of California Certified Analytical Laboratories who use USEPA-approved Test Methods.

5.8.2 Field Quality Assurance/Quality Control

The sampling equipment will be steam cleaned or thoroughly scrubbed with alconox solution followed by a distilled water rinse prior to being brought on site and between samples.

Down-hole drilling tools will be decontaminated between borings to avoid the potential for cross contamination. The decontamination process will consist of multiple wash and rinse cycles using potable water and a non-phosphate detergent.

5.8.3 Chain of Custody Program

Chain of custody protocol will follow for all samples from the time of collection to the time of arrival at the off-site laboratory. The chain-of-custody program allows for the tracing of possession and handling of individual samples from the time of field collection through laboratory analysis. The document will include the signature of the collector, date and time of collection, sample number, number and type of sample containers including preservatives, parameters requested for analysis, signatures of persons and inclusive dates involved in the chain of possession. Upon delivery to the laboratory the document information will also include the name of the person receiving the samples, laboratory sample number (if different from the field number), and date, time and condition of sample upon receipt.

5.8.4 Laboratory Quality Assurance/Quality Control

All laboratory analyses will be performed at a laboratory certified by the State of California Department of Health Services to perform the requested services and all containers used in the collection of groundwater samples will be provided by the contract laboratory. Upon request from the ACHSA, duplicate samples or field split samples will be provided to evaluate the variability of analytical results.

The purpose of a quality assurance/quality control program is to follow standard field sampling and laboratory handling procedures that will allow the generated data to be scientifically valid, defensible, and of appropriate quality. The laboratory has documented procedures for handling, preparing, and testing samples for the various types of compounds for which that laboratory is certified to test. Copies of these procedures are available at the laboratory and will be provided upon request.

The laboratory will check analytical results, as necessary, by analyzing field blanks or duplicate samples. Field blanks or duplicate split samples may be “blind” and randomly supplied to the laboratory under separate sample numbers. Duplicate samples may also be submitted to different laboratories for testing to cross check analytical results. Laboratory reports will be reviewed to check that analyses are completed within the recommended sample holding times and that proper sample preservation, preparation, and extraction techniques have been used. Measurements of percent recovery for spiked samples will be evaluated for compliance with established laboratory control limits. Data identified as being of sufficient quality will be used; suspected data will be identified as such.

5.9 Reporting

Following completion of the pilot test field activities, a report will be prepared summarizing the results of the pilot test. The report will be completed within 60 days of receipt of the post-injection analytical results and will include pre-injection GeoProbe® borings analyses, tables and figures presenting soil and groundwater sample results including TPH-SS, TPH-G, BTEX, MTBE and natural attenuation field and analytical parameters. The report will include injection activity field reports, tables and figures, including quantities and concentrations of sulfate solution injected, groundwater elevation, electrical conductivity and natural attenuation field parameters in groundwater monitoring wells.

Following the six (6) month post-injection monitoring event, a pilot test monitoring report will be completed within 60 days of receipt of the analytical results and will include post-injection GeoProbe® borings analysis, tables and figures presenting soil and groundwater sample results, including TPH-SS, TPH-G, BTEX, MTBE and natural attenuation field and analytical parameters.

Following the twelve (12) month post-injection monitoring event, the final pilot test monitoring report will be completed within 60 days of receipt of the analytical results and will include post-injection GeoProbe® borings analysis, tables and figures presenting soil and groundwater sample results, including TPH-SS, TPH-G, BTEX, MTBE and natural attenuation field and analytical parameters. This report will include analysis of the effectiveness of the sulfate injection method to reduce the TPH-SS concentrations at the site and compare remaining TPH-SS concentrations to water quality objectives. If TPH-SS concentrations are effectively diminished, Taber Consultants will include a No Further Action Request for the site with this report.

5.10 Schedule

Permitting for the pilot test will commence immediately upon approval of the work plan by ACHSA. The pilot test is expected to be completed within 270 days of work plan approval (60 days to execute pre-injection GeoProbe® sampling and sulfate injection, and 210 days to collect post-injection GeoProbe® groundwater samples), depending upon drill rig availability. The *Pilot Test Report* will be submitted within 45 days of the completion of remedial activities.

6.0 REPORT DISTRIBUTION

Ms. Paulette Satterley
14601 Guadalupe Drive
Rancho Murieta, CA 95683

Paula Champion-Braig
280 Mountain Ave.
Piedmont, Ca. 94611-3506

Ms. Barbara Jakub
Alameda County Health Care Services Agency
1131 Harbor Parkway, Suite 250
Alameda CA, 94502

Ms. Cherie McCaulou
San Francisco Bay Regional Water Quality Control Board
1515 Clay St., Suite 1400
Oakland, CA 94612

7.0 REMARKS AND SIGNATURE

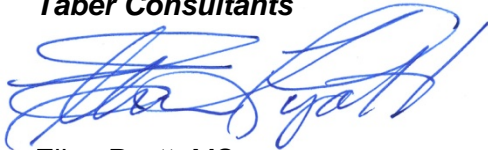
The interpretations and/or conclusions contained in this report represent our professional opinions and are based in part on information supplied by the client. These opinions are based on currently available information and were developed in accordance with currently accepted geologic, hydrogeologic, and engineering practices in Alameda County in 2012. Other than this, no warranty is implied or intended.

This report has been prepared solely for the use of Ms. Paulette Satterley. Any reliance on this report by third parties shall be at such parties' sole risk. The work described herein was performed under the direct supervision of the professional geologist, registered with the State of California, whose signature appears below.

We appreciate the opportunity to provide you with geologic, engineering and environmental consulting services and trust this report meets your needs. If you have any questions or concerns, please call us at (916) 371-1690.

Sincerely,

Taber Consultants



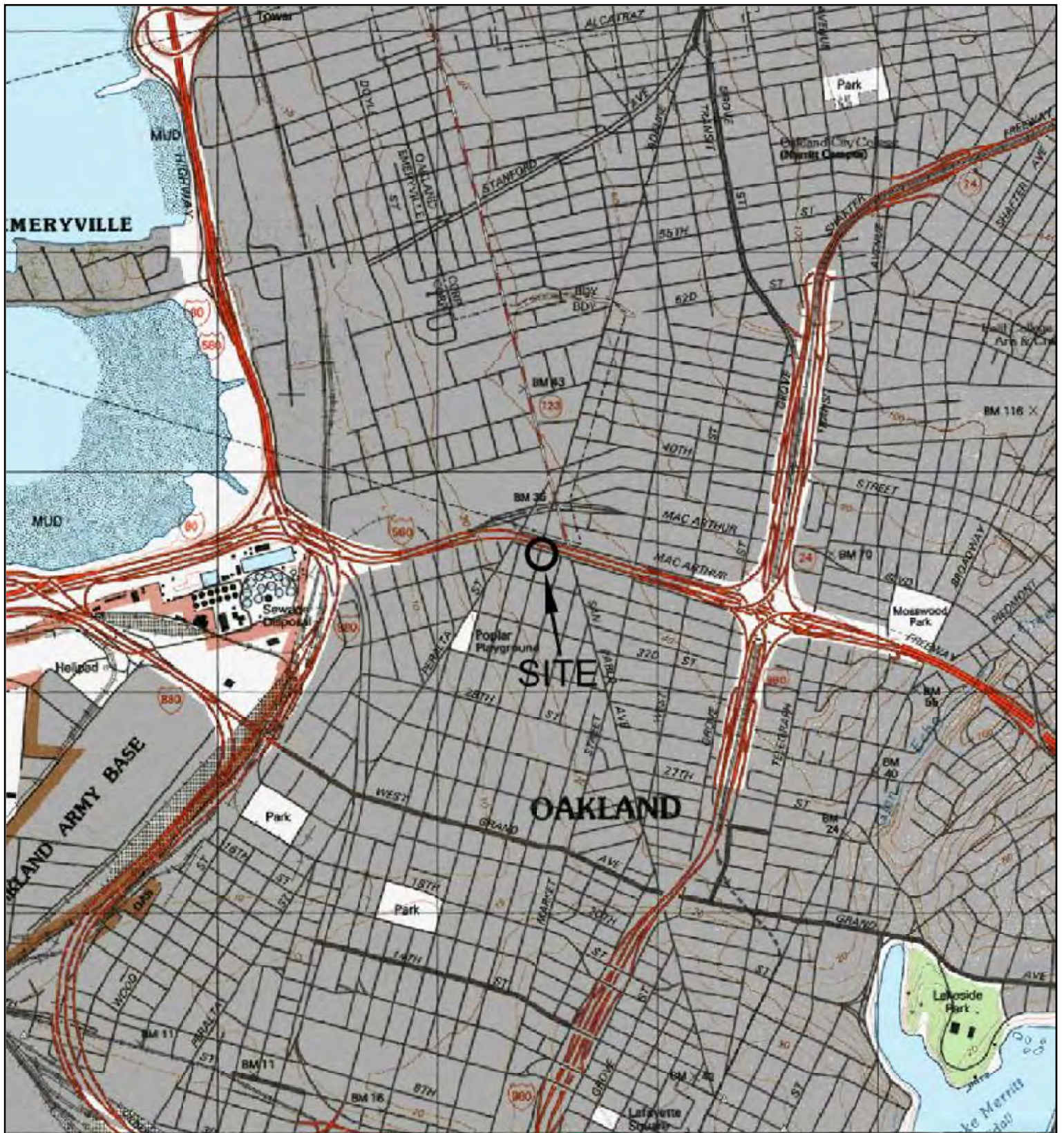
Ellen Pyatt, MSc.
Project Geologist



Thomas E. Ballard, P.G. #7299, C.H.G. #961
Principal Hydrogeologist



FIGURES



Scale: 1:24,000

Source:
 USGS West Oakland
 Quadrangle Topographic Map
 Report, 7.5 Minute Series
 (topographic), dated 1993

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Former City of Paris Cleaners

3516 Adeline Street
 Oakland, California

Vicinity Map

2011-0107

April 2012

Figure 1

EB-2



EB-3



EB-4



EB-5

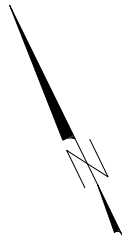
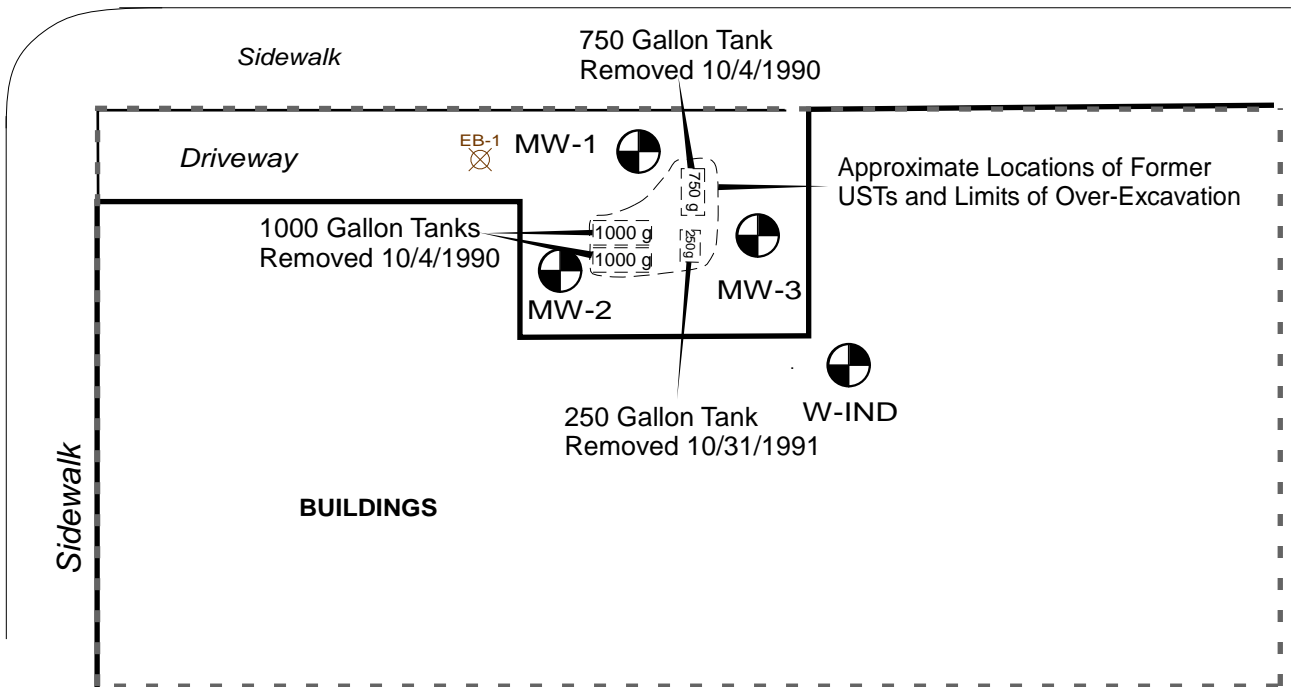


EB-6



35TH STREET

ADELINE STREET



0 10 20

Approximate Scale in Feet
1 inch = 20 feet

LEGEND

- EB-1 Soil Boring (1998)
- MW-2 Groundwater Monitoring Well
- W-IND Industrial Well
- Approximate Locations Former Underground Storage Tanks
- Approximate Site Boundary (Assessor's Parcel Number 5-478-23)

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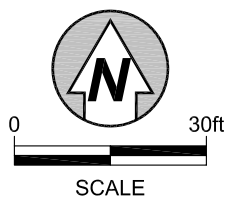
3516 Adeline Street
Oakland, California

Site Map

2011-0107

April 2012

Figure 2



LEGEND:

- Cross Section Location
- Approximate Lateral extent of TPH-SS in soil (includes concentrations quantified by the laboratory as TPH-G, but noted as non-typical TPH pattern in gasoline range)
- Approximate Lateral extent of TPH-SS in groundwater (includes concentrations quantified by the laboratory as TPH-G, but noted as non-typical TPH pattern in gasoline range)
- Soil Boring May 2011 (Taber Consultants)
- Soil Boring 3-19-98
- Sidewalk Soil Sample, Final Excavation Limits 1-27-92
- Approximate Location of Well
- Approximate Location of Utility Pole
- Approximate Location of Light Pole
- Approximate Location of Water Line
- Approximate Location of Gas Line
- Approximate Location of Sanitary Sewer Line
- Approximate Location of Storm Drain
- Approximate Location of Unknown Discontinuous Signal
- Approximate Location of Fence
- Approximate Site Boundary
- Inlet for Storm Drain
- Proposed Injection Points and Treatment Area
- Approximate Pre-Injection and Post-Injection GeoProbe Locations

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Former City of Paris Cleaners

**3516 Adeline Street
 Oakland, California**

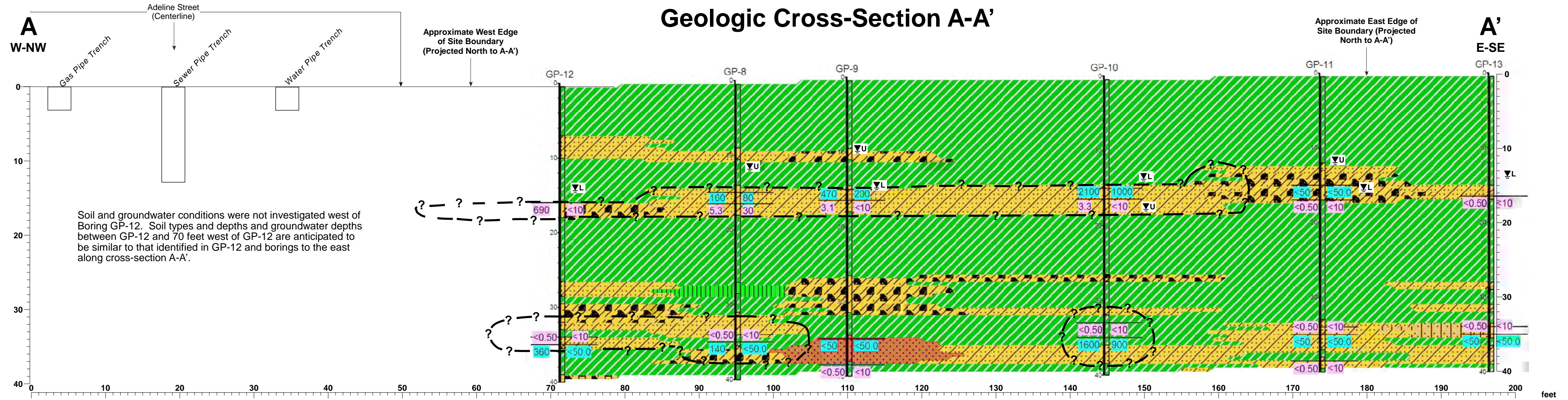
Proposed Injection Locations and Treatment Area

2011-0107	September 2012	Figure 3
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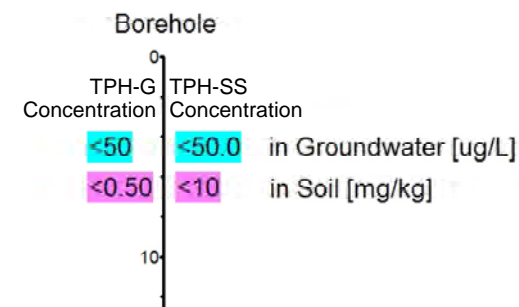
V:\Job Archive\2011-0107 City of Paris\Reports\2011\Site Investigation\2011-0107 Utility Location Map_GRL_01092012_recover.dwg

NOTES
 1. All locations are approximate and are referenced from existing site features.
 2. Water and sanitary sewer lines to property site were not identified by locator or from records search. However they are shown here based on field observation and approximation of main lines located on Adeline Street.

Geologic Cross-Section A-A'



Explanation



Vertical Scale 1"=10'
Horizontal Scale 1"=10'

Lithology Index

- GW Clean gravel
- GM Gravel with fines
- GC Gravel with fines
- SW Clean sand
- SP Clean sand
- SM Sand with fines
- SC Sand with fines
- ML Silt
- CL Clay

- TPH-SS = total petroleum hydrocarbons as Stoddard Solvent
- TPH-G = total petroleum hydrocarbons as gasoline
- All TPH-G results for soil and groundwater reported by the laboratory as "non-typical pattern for gasoline range." The reported TPH-G is likely TPH-SS.
- ug/L = micrograms per liter
- mg/kg = milligrams per kilogram
- <50 = not detected at or above indicated laboratory reporting limit
- Unless otherwise noted all soil samples shown were collected in the saturated zone of the upper and lower groundwater zones.
- ▽U Upper zone groundwater level. Measured in boring after sampling. May not represent static water level (upper unconfined zone) because sufficient time for water level stabilization may not have occurred before backfilling borings.
- ▽L Lower zone groundwater level. Measured through direct-push sample pipe after sampling. May not represent potentiometric surface of water (lower confined zone) because sufficient time for water level stabilization may not have occurred before backfilling borings.
- ?- Approximate extent of TPH-SS in groundwater (includes concentration quantified by the laboratory as TPH-G noted as not typical of gasoline).

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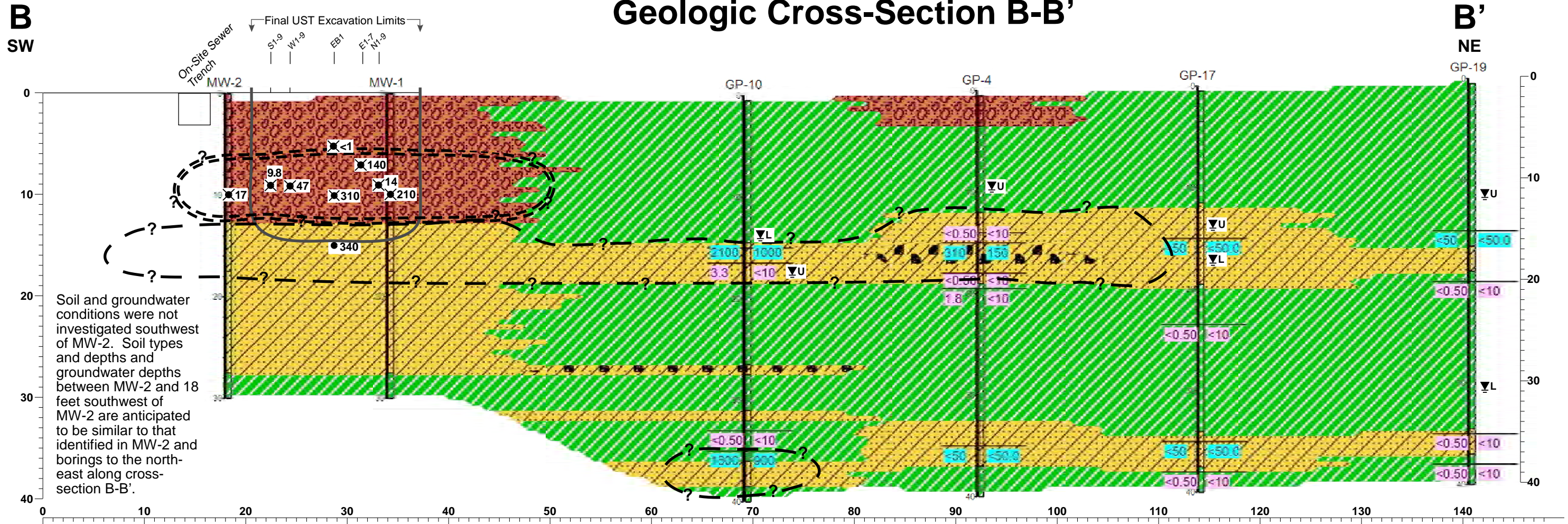
FORMER CITY OF PARIS CLEANERS

3516 Adeline Street
 Oakland, CA 94608

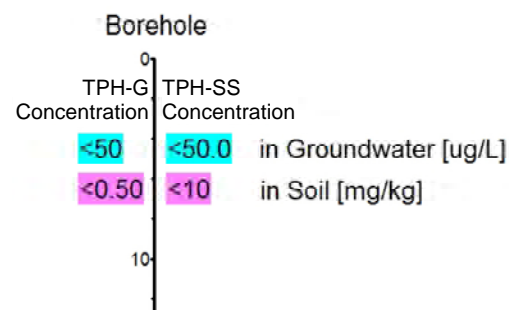
Geologic Cross-Section A-A'

2011-0107	July 2012	Figure 4
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Geologic Cross-Section B-B'



Explanation



Lithology Index	
	GW Clean gravel
	GM Gravel with fines
	GC Gravel with fines
	SW Clean sand
	SP Clean sand
	SM Sand with fines
	SC Sand with fines
	ML Silt
	CL Clay

TPH-SS = total petroleum hydrocarbons as Stoddard Solvent

TPH-G = total petroleum hydrocarbons as gasoline

All TPH-G results for soil and groundwater reported by the laboratory as "non-typical pattern for gasoline range." The reported TPH-G is likely TPH-SS.

ug/L = micrograms per liter

mg/kg = milligrams per kilogram

<50 = not detected at or above indicated laboratory reporting limit

Unless otherwise noted all soil samples shown were collected in the saturated zone of the upper and lower groundwater zones.

▽U Upper zone groundwater level. Measured in boring after sampling. May not represent static water level (upper unconfined zone) because sufficient time for water level stabilization may not have occurred before backfilling borings.

▽L Lower zone groundwater level. Measured through direct-push sample pipe after sampling. May not represent potentiometric surface of water (lower confined zone) because sufficient time for water level stabilization may not have occurred before backfilling borings.

—?— Approximate extent of TPH-SS in groundwater (includes concentration quantified by the laboratory as TPH-G noted as not typical of gasoline).

== Approximate extent of TPH-SS in soil. Includes bioremediated TPH-SS soil used as excavation backfill.

S1-9, W1-9, E1-7, and N1-9 are post-excavation sidewall samples representative of soil conditions at the time of final excavation.

EB-1 is a post-excavation characterization soil boring near the final excavation boundary.

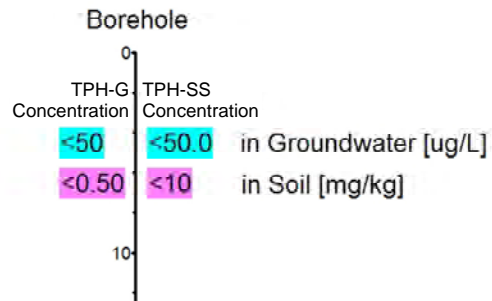
✕ Soil sample in unsaturated zone and TPH-SS concentration in mg/kg

• Soil sample in saturated zone and TPH-SS concentration in mg/kg

Vertical Scale 1"=10'
Horizontal Scale 1"=10'

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<p>FORMER CITY OF PARIS CLEANERS</p>		
<p>3516 Adeline Street Oakland, CA 94608</p>		
<p>Geologic Cross-Section B-B'</p>		
2011-0107	July 2012	Figure 5

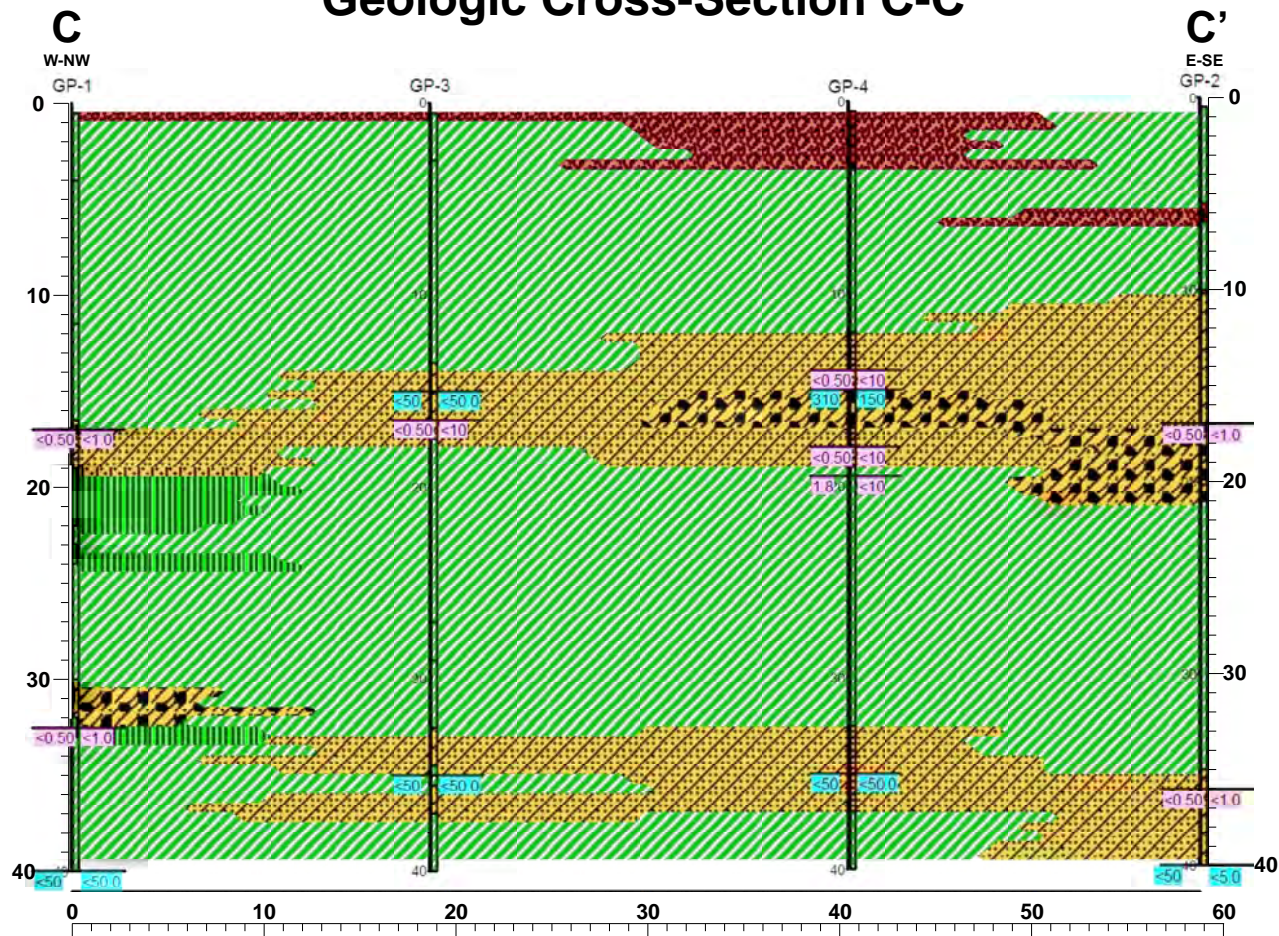
Explanation



Lithology Index

- GW Clean gravel
- GM Gravel with fines
- GC Gravel with fines
- SW Clean sand
- SP Clean sand
- SM Sand with fines
- SC Sand with fines
- ML Silt
- CL Clay

Geologic Cross-Section C-C'



TPH-SS = total petroleum hydrocarbons as Stoddard Solvent

TPH-G = total petroleum hydrocarbons as gasoline

All TPH-G results for soil and groundwater reported by the laboratory as "non-typical pattern for gasoline range." The reported TPH-G is likely TPH-SS.

ug/L = micrograms per liter

mg/kg = milligrams per kilogram

<50 = not detected at or above indicated laboratory reporting limit

Unless otherwise noted all soil samples shown were collected in the saturated zone of the upper and lower groundwater zones.

Vertical Scale 1"=10'
Horizontal Scale 1"=10'

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Geologic Cross-Section C-C'

2011-0107

July 2012

Figure 6

TABLES

TABLE 1
SOIL SAMPLE ANALYTICAL RESULTS
SITE INVESTIGATION 2011
Former City of Paris Cleaners
3516 Adeline Street, Oakland, California 94608

Boring Identification	Sample Identification	Sample Date	TPH-SS	TPH-G	TPH-D	TPH-FO	TPH-MO	TPH-K	Benzene	Toluene	Ethyl benzene	Xylenes	MTBE
			(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)
GP-1	GP-1-17	5/2/2011	<1.0	<0.50	NA	NA	NA	NA	<1.0	<1.0	<1.0	<1.0	<0.50
	GP-1-32.5	5/2/2011	<1.0	<0.50	NA	NA	NA	NA	<1.0	<1.0	<1.0	<1.0	<0.50
GP-2	GP-2-17	5/2/2011	<1.0	<0.50	NA	NA	NA	NA	<1.0	<1.0	<1.0	<1.0	<0.50
	GP-2-36	5/2/2011	<1.0	<0.50	NA	NA	NA	NA	<1.0	<1.0	<1.0	<1.0	<0.50
GP-3	GP-3-16.5	5/6/2011	<10	<0.50	NA	<10	NA	NA	<1.0	<1.0	<1.0	<1.0	<0.50
GP-4	GP-4-14	5/6/2011	<10	<0.50	NA	NA	NA	NA	<1.0	<1.0	<1.0	<1.0	<0.50
	GP-4-18	5/6/2011	<10	<0.50	NA	NA	NA	NA	<1.0	<1.0	<1.0	<1.0	<0.50
	GP-4-19-5 ^a	5/6/2011	<10	1.8	NA	NA	NA	NA	<1.0	<1.0	<1.0	<1.0	<0.50
GP-5	GP-5-6.5	5/5/2011	<10	<0.50	<1.0	<10	<10	<1.0	<1.0	<1.0	<1.0	<1.0	<0.50
	GP-5-28	5/5/2011	<10	<0.50	<1.0	<10	<10	<1.0	<1.0	<1.0	<1.0	<1.0	<0.50
GP-6	GP-6-11.5	5/5/2011	<10	<0.50	<1.0	<10	<10	<1.0	<1.0	<1.0	<1.0	<1.0	<0.50
GP-7	GP-7-8	5/6/2011	<10	<0.50	<1.0	<10	<10	<1.0	<1.0	<1.0	<1.0	<1.0	<0.50
	GP-7-16	5/6/2011	NA	<0.50	<1.0	<10	<10	<1.0	<1.0	<1.0	<1.0	<1.0	<0.50
GP-8	GP-8-16.5 ^a	5/12/2011	30	5.3	<1.0	<10	NA	NA	<1.0	<1.0	<1.0	<1.0	<0.50
	GP-8-34	5/12/2011	<10	<0.50	<1.0	<10	NA	NA	<1.0	<1.0	<1.0	<1.0	<0.50
GP-9	GP-9-16.5 ^a	5/12/2011	<10	3.1	<1.0	<10	NA	NA	<1.0	<1.0	<1.0	<1.0	<0.50
	GP-9-38.5	5/12/2011	<10	<0.50	<1.0	<10	NA	NA	<1.0	<1.0	<1.0	<1.0	<0.50
GP-10	GP-10-16.5 ^a	5/13/2011	<10	3.3	NA	NA	NA	NA	<1.0	<1.0	<1.0	<1.0	<0.50
	GP-10-33	5/13/2011	<10	<0.50	NA	NA	NA	NA	<1.0	<1.0	<1.0	<1.0	<0.50
GP-11	GP-11-17	5/13/2011	<10	<0.50	NA	NA	NA	NA	<1.0	<1.0	<1.0	<1.0	<0.50
	GP-11-34	5/13/2011	<10	<0.50	NA	NA	NA	NA	<1.0	<1.0	<1.0	<1.0	<0.50
	GP-11-38.5	5/13/2011	<10	<0.50	NA	NA	NA	NA	<1.0	<1.0	<1.0	<1.0	<0.50
GP-12	GP-12-16 ^a	5/19/2011	<10	690	<1.0	<10	NA	NA	<1000	<1000	<1000	<1000	<500
	GP-12-34	5/19/2011	<10	<0.50	<1.0	<10	NA	NA	<1.0	<1.0	<1.0	<1.0	<0.50
GP-13	GP-13-16.5	5/19/2011	<10	<0.50	<1.0	<10	NA	NA	<1.0	<1.0	<1.0	<1.0	<0.50
	GP-13-34	5/19/2011	<10	<0.50	<1.0	<10	NA	NA	<1.0	<1.0	<1.0	<1.0	<0.50
GP-16	GP-16-19 ^a	5/17/2011	<10	20	<1.0	<10	NA	NA	<1.0	<1.0	<1.0	3.0	<0.50
	GP-16-38	5/17/2011	<10	<0.50	<1.0	<10	NA	NA	<1.0	<1.0	<1.0	<1.0	<0.50

TABLE 1
SOIL SAMPLE ANALYTICAL RESULTS
SITE INVESTIGATION 2011
Former City of Paris Cleaners
3516 Adeline Street, Oakland, California 94608

Boring Identification	Sample Identification	Sample Date	TPH-SS	TPH-G	TPH-D	TPH-FO	TPH-MO	TPH-K	Benzene	Toluene	Ethyl benzene	Xylenes	MTBE
			(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)
GP-17	GP-17-23.5	5/17/2011	<10	<0.50	<1.0	<10	NA	NA	<1.0	<1.0	<1.0	<1.0	<0.50
	GP-17-38	5/17/2011	<10	<0.50	<1.0	<10	NA	NA	<1.0	<1.0	<1.0	<1.0	<0.50
GP-18	GP-18-19	5/17/2011	<10	<0.50	<1.0	<10	NA	NA	<1.0	<1.0	<1.0	<1.0	<0.50
	GP-18-38	5/17/2011	<10	<0.50	<1.0	<10	NA	NA	<1.0	<1.0	<1.0	<1.0	<0.50
GP-19	GP-19-20	5/17/2011	<10	<0.50	<1.0	<10	NA	NA	<1.0	<1.0	<1.0	<1.0	<0.50
	GP-19-38	5/17/2011	<10	<0.50	<1.0	<10	NA	NA	<1.0	<1.0	<1.0	<1.0	<0.50

Explanation:

TPH-SS = Total petroleum hydrocarbons as Stoddard Solvent

TPH-G = Total petroleum hydrocarbons as gasoline

TPH-D = Total petroleum hydrocarbons as diesel

TPH-FO = Total petroleum hydrocarbons as fuel oil

TPH-MO = Total petroleum hydrocarbons as motor oil

TPH-K = Total petroleum hydrocarbons as kerosene

MTBE = Methyl tertiary-butyl ether

mg/kg = milligrams per kilogram

ug/kg = micrograms per kilogram

<1.0 = Not detected at or above indicated laboratory reporting limit

NA = Not Analyzed.

TABLE 2
GRAB GROUNDWATER SAMPLE ANALYTICAL RESULTS
SITE INVESTIGATION 2011
Former City of Paris Cleaners
3516 Adeline Street, Oakland, California 94608

Boring Identification	Sample Identification	Sample Date	TPH-SS	TPH-G	Benzene	Toluene	Ethyl		MTBE
							benzene	Xylenes	
			(ug/l)						
Upper (Shallow) Groundwater Zone									
GP-3	GP-3-15	5/6/2011	<50	<50	<1.0	2.3	<1.0	<1.0	<0.50
GP-4	GP-4-15 ^a	5/6/2011	150	310	<1.0	2.2	<1.0	<1.0	<0.50
GP-8	GP-8-15 ^a	5/12/2011	80	160	<1.0	<1.0	<1.0	<1.0	<0.50
GP-9	GP-9-15 ^a	5/12/2011	200	470	<1.0	<1.0	<1.0	<1.0	1.5
GP-10	GP-10-15 ^a	5/13/2011	1000	2100	<1.0	<1.0	<1.0	<1.0	<0.50
GP-11	GP-11-15	5/13/2011	<50	<50	<1.0	<1.0	<1.0	<1.0	0.6
GP-16	GP-16-15 ^a	5/17/2011	<50	130	<1.0	<1.0	<1.0	1.1	<0.50
GP-17	GP-17-15	5/17/2011	<50	<50	<1.0	<1.0	<1.0	<1.0	<0.50
GP-18	GP-18-15 ^a	5/17/2011	<50	80	<1.0	<1.0	<1.0	<1.0	<0.50
GP-19	GP-19-15	5/19/2011	<50	<50	<1.0	<1.0	<1.0	<1.0	0.7
Lower (Deeper) Groundwater Zone									
GP-1	GP-1	5/2/2011	<50	<50	<1.0	<1.0	<1.0	<1.0	<0.50
GP-2	GP-2	5/2/2011	<5.0	<50	<1.0	<1.0	<1.0	<1.0	<0.50
GP-3	GP-3-35	5/6/2011	<50	<50	<1.0	<1.0	<1.0	<1.0	<0.50
GP-4	GP-4-35	5/6/2011	<50	<50	<1.0	<1.0	<1.0	<1.0	<0.50
GP-5	GP-5 ^b	5/5/2011	<50	<50	<1.0	<1.0	<1.0	<1.0	10
GP-8	GP-8-35 ^a	5/12/2011	<50	140	<1.0	<1.0	<1.0	<1.0	<0.50
GP-9	GP-9-35	5/12/2011	<50	<50	<1.0	<1.0	<1.0	<1.0	<0.50
GP-10	GP-10-35 ^a	5/13/2011	900	1600	<1.0	<1.0	<1.0	<1.0	<0.50
GP-11	GP-11-35	5/13/2011	<50	<50	<1.0	<1.0	<1.0	<1.0	<0.50
GP-12	GP-12-35 ^a	5/19/2011	<50	360	<1.0	<1.0	<1.0	<1.0	0.5
GP-13	GP-13-35	5/19/2011	<50	<50	<1.0	<1.0	<1.0	<1.0	0.6
GP-16	GP-16-35	5/17/2011	<50	<50	<1.0	<1.0	<1.0	<1.0	<0.50
GP-17	GP-17-35	5/17/2011	<50	<50	<1.0	<1.0	<1.0	<1.0	<0.50
GP-18	GP-18-35	5/17/2011	<50	<50	<1.0	<1.0	<1.0	<1.0	<0.50
GP-19	GP-19-35	5/17/2011	<50	<50	<1.0	<1.0	<1.0	<1.0	<0.50

Explanation:

TPH-SS = Total petroleum hydrocarbons as stoddard solvent

TPH-G = Total petroleum hydrocarbons as gasoline

MTBE = Methyl tertiary-butyl ether

ug/l = micrograms per liter.

<1.0 = Not detected at or above indicated laboratory reporting limit

TPH-SS and TPH-G were analyzed by EPA Test Method 8015B

Benzene, toluene, ethylbenzene, total xylenes, MTBE, 1,2-DCB, 1,1-DCA, 2-Methyl-Naphthalene and Naphthalene were analyzed by EPA Test Method 8;

^aNon-typical TPH pattern present in gas range.

^bNote: GP-5 was also analyzed for TPH as kerosene and fuel oil which were not detected at or above the laboratory reporting limit of 50 ug/l.

**TABLE 3
GROUNDWATER ELEVATION AND ANALYTICAL RESULTS
SUMMARY**

City of Paris Cleaners
3516 Adeline Street, Oakland, California 94608

		Elevation Summary			Analytical Summary										
Well ID	Date	Top of Casing Elevation (amsl)	Depth to Water BTOC)	Groundwater Elevation (feet amsl)	TPH-SS	TPH-G	Benzene	Toluene	Ethyl benzene	Xylenes (ug/l)	MTBE	1,2-DCB	1,1-DCA	2-Methyl-Naphthalene	Naphthalene
Groundwater Sample Locations															
EB1-18	03/19/98	18' bgs	Groundwater	Grab Sample	270000	--	<5.0	93	66	1700	<100	--	--	--	--
EB2-18	03/19/98	18' bgs	Groundwater	Grab Sample	<1.0	--	<0.5	<0.5	<0.5	<0.5	<5.0	--	--	--	--
EB3-18	03/19/98	18' bgs	Groundwater	Grab Sample	<1.0	--	<0.5	<0.5	<0.5	<0.5	<5.0	--	--	--	--
EB4-18	03/19/98	18' bgs	Groundwater	Grab Sample	<1.0	--	<0.5	<0.5	<0.5	<0.5	<5.0	--	--	--	--
EB5-18	03/19/98	18' bgs	Groundwater	Grab Sample	780	--	<0.5	<0.5	<0.5	2	<5.0	--	--	--	--
EB6-18	03/19/98	18' bgs	Groundwater	Grab Sample	<1.0	--	<0.5	<0.5	<0.5	<0.5	<5.0	--	--	--	--
MW-1	11/18/92	17.44	13.99	3.45	1800	NA	<0.5	<0.5	<0.5	<0.5	NA	--	--	--	--
MW-1	11/4/1993	17.44	16.79	0.65	2000	<50	<0.5	<0.5	<0.5	<0.5	NA	--	--	--	--
MW-1	3/8/1994	17.44	14.14	3.3	150	NA	35	40	72	120	NA	--	--	--	--
MW-1	8/2/1994	17.44	13.18	4.26	2100	<50	<0.5	<0.5	<0.5	<0.5	NA	--	--	--	--
MW-1	2/8/1995	17.44	10.92	6.52	620	<50	<0.5	<0.5	<0.5	<0.5	NA	--	--	--	--
MW-1**	7/8/1996	17.44	11.62	5.82	37000	110000	1.6	<0.5	<0.5	74	7.9	--	--	--	--
MW-1	10/9/1996	17.44	14.11	3.33	42000	NA	<0.5	5	<0.5	<0.5	NA	--	--	--	--
MW-1	3/18/1997	17.44	12.37	5.07	2600	NA	<0.5	1.5	1.5	9.6	<6.0	--	--	--	--
MW-1	6/19/1997	17.44	13.26	4.18	660	NA	<0.5	<0.5	1.2	0.71	<5.0	--	--	--	--
MW-1	11/14/1997	17.44	11.45	5.99	10000	NA	<0.5	<0.5	110	1.2	<5.0	--	--	--	--
MW-1	12/15/1999	17.44	11.31	6.13	<20	<50	<0.5	<0.5	<0.5	<0.5	NA	<0.5	0.59	<0.5	<0.5
MW-1	03/22/02	17.44	8.97	8.47	11000	--	--	--	--	--	<5.0	--	--	--	130
MW-1	04/15/03	17.44	9.23	8.21	3900	--	<2.5	<2.5	<2.5	3	9	--	--	--	--
MW-1	03/26/04	17.44	10.32	7.12	30000	24000	<50	<50	<50	<50	<500	--	--	--	--
MW-1	09/30/04	17.44	11.53	5.91	3800	2600	<0.5	<0.5	<0.5	2.7	<5	--	--	--	--
MW-1	09/09/05	17.44	13.63	3.81	15000	11000	c	<5	<5	15	<50	--	--	--	--
MW-1	11/30/07	17.44	13.95	3.49	--	--	--	--	--	--	--	--	--	--	--
MW-1	12/20/07	17.44	11.51	5.93	45000	110000	20	50	20	100	<5	--	--	--	--
MW-1	05/23/08	17.44	14.14	3.3	4200	<500	<1	<1	<1	20	<0.50	--	--	--	--
MW-1	08/12/08	17.44	13.78	3.66	4000	12000	<1	<1	<1	<1	<0.50	--	--	--	--
MW-1	12/18/08	17.44	10.71	6.73	9900	2700	<1	<1	<1	<1	<0.50	--	--	--	--
MW-1	02/19/09	17.44	8.91	8.53	500	3100	<10	<10	<10	<10	<5	--	--	--	--
MW-1	08/11/09	17.44	13.35	4.09	13000	7800	<10	<10	<10	<10	5.9	--	--	--	--

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SUMMARY**

City of Paris Cleaners
3516 Adeline Street, Oakland, California 94608

		Elevation Summary			Analytical Summary										
Well ID	Date	Top of Casing Elevation (amsl)	Depth to Water BTOC)	Groundwater Elevation (feet amsl)	TPH-SS	TPH-G	Benzene	Toluene	Ethyl benzene	Xylenes (ug/l)	MTBE	1,2-DCB	1,1-DCA	2-Methyl-Naphthalene	Naphthalene
<i>MW-1 NP</i>	08/11/09	17.44	13.35	4.09	6000	10000	<10	<10	<10	<10	<5	--	--	--	--
MW-1	03/17/10	17.44	9.31	8.13	4000	12000	<20	<20	<20	20	<10	--	--	--	--
MW-1	08/18/10	17.44	12.65	4.79	2000	6900	<100	<100	<100	<100	<50	--	--	--	--
MW-1	03/23/11	31.30	6.75	24.55	8800	8100	<10	<10	<10	<10	<5	--	--	--	--
MW-1 ^a	08/25/11	31.30	11.35	19.95	2100	7200	<1	<1	<1	<1	2.1	--	--	--	--
MW-1	02/22/12	31.30	11.35	19.95	5000	4200	<100	<100	<100	<100	<50	--	--	--	--
MW-2	11/18/92	17.31	13.18	4.13	630	NA	<0.5	<0.5	<0.5	<0.5	NA	--	--	--	--
MW-2	11/04/93	17.31	14.84	2.47	3200	<50	<0.5	<0.5	<0.5	<0.5	NA	--	--	--	--
MW-2	03/08/94	17.31	11.5	5.81	45	NA	1.4	2	11	19	NA	--	--	--	--
MW-2	08/02/94	17.31	13.14	4.17	170	<50	<0.5	<0.5	<0.5	<0.5	NA	--	--	--	--
MW-2	02/08/95	17.31	8.18	9.13	570	<50	<0.5	<0.5	<0.5	<0.5	NA	--	--	--	--
MW-2**	07/08/96	17.31	11.06	6.25	1800	2800	<0.5	2.6	15	24	6.3	--	--	--	--
MW-2	10/09/96	17.31	12.38	4.93	4100	NA	<0.5	0.57	<0.5	<0.5	NA	--	--	--	--
MW-2	03/18/97	17.31	10.61	6.7	240	<0.5	0.57	<0.5	<0.5	5.3	NA	--	--	--	--
MW-2	06/19/97	17.31	11.68	5.63	2500	NA	<0.5	<0.5	9.1	<0.5	<5.0	--	--	--	--
MW-2	11/14/97	17.31	10.61	6.7	130	NA	<0.5	<0.5	0.9	1.2	<5.0	--	--	--	--
MW-2	12/15/99	17.31	10.97	6.34	<20	<50	<0.5	<0.5	<0.5	<0.5	NA	<0.5	0.53	<0.5	49
MW-2	03/22/02	17.31	8.82	8.49	170	13000	410	1000	210	1100	<5.0	--	--	--	<10
MW-2	04/15/03	17.31	8.52	8.79	99	--	<0.5	<0.5	<0.5	0.76	10	--	--	--	--
MW-2	03/26/04	17.31	9.32	7.99	120	93	<0.5	<0.5	<0.5	0.76	5.4	--	--	--	--
MW-2	09/30/04	17.31	11.62	5.69	<50	<50	<0.5	<0.5	<0.5	<0.5	<5	--	--	--	--
MW-2	09/09/05	17.31	12.75	4.56	120	98	<0.5	<0.5	<0.5	<0.5	<5	--	--	--	--
MW-2	11/30/07	17.31	11.06	6.25	--	--	--	--	--	--	--	--	--	--	--
MW-2	12/20/07	17.31	9.95	7.36	<50	3000	<1	1.6	<1	2.4	2.9	--	--	--	--
MW-2	05/23/08	17.31	12.46	4.85	300	1100	<1	<1	<1	<1	3.5	--	--	--	--
MW-2	08/12/08	17.31	12.08	5.23	2200	350	<1	<1	<1	<1	<0.50	--	--	--	--
MW-2	12/18/08	17.31	10.58	6.73	300	<50	<1	<1	<1	<1	7.3	--	--	--	--
MW-2	02/19/09	17.31	8.22	9.09	300	300	<1	<1	<1	<1	3.4	--	--	--	--
MW-2	08/11/09	17.31	13.00	4.31	600	610	<1	<1	<1	<1	3.8	--	--	--	--
MW-2	03/17/10	17.31	8.95	8.36	<50	<50	<1	<1	<1	<1	1.8	--	--	--	--
MW-2	08/18/10	17.31	12.15	5.16	<50.0	70	<1.0	<1.0	<1.0	<1.0	2.4	--	--	--	--
MW-2	03/23/11	31.03	6.22	24.81	200	<50	<1.0	<1.0	<1.0	<1.0	3.6	--	--	--	--

**TABLE 3
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SUMMARY**

City of Paris Cleaners
3516 Adeline Street, Oakland, California 94608

		Elevation Summary			Analytical Summary										
Well ID	Date	Top of Casing	Depth to	Groundwater	TPH-SS	TPH-G	Benzene	Toluene	Ethyl benzene	Xylenes (ug/l)	MTBE	1,2-DCB	1,1-DCA	2-Methyl-	
		Elevation (amsl)	Water BTOC)	Elevation (feet amsl)										Naphthalene	Naphthalene
MW-2	08/25/11	31.03	11.06	19.97	<50	<50	<1.0	<1.0	<1.0	<1.0	1.5	--	--	--	--
MW-2	02/22/12	31.03	10.61	20.42	400	250	<1.0	<1.0	<1.0	<1.0	<0.50	--	--	--	--
MW-3	11/18/92	17.44	13.93	3.51	11000	NA	<0.5	<0.5	<0.5	<0.5	NA	--	--	--	--
MW-3	11/04/93	17.44	15.16	2.28	320	<50	<0.5	<0.5	<0.5	<0.5	NA	--	--	--	--
MW-3	03/08/94	17.44	13.43	4.01	45	NA	0.8	0.9	5	10	NA	--	--	--	--
MW-3	08/02/94	17.44	12.82	4.62	<20	<50	<0.5	<0.5	<0.5	<0.5	NA	--	--	--	--
MW-3	02/08/95	17.44	7.62	9.82	<20	<50	<0.5	<0.5	<0.5	<0.5	NA	--	--	--	--
MW-3**	07/08/96	17.44	10.97	6.47	2500	2200	1	<0.5	8.8	8	10	--	--	--	--
MW-3	10/09/96	17.44	11.84	5.6	2600	NA	<0.5	<0.5	<0.5	<0.5	NA	--	--	--	--
MW-3	03/18/97	17.44	10.16	7.28	2500	NA	<0.5	0.61	0.63	5.2	NA	--	--	--	--
MW-3	06/19/97	17.44	11.40	6.04	21000	NA	<0.5	<0.5	11	<0.5	<5.0	--	--	--	--
MW-3	11/14/97	17.44	10.71	6.73	1,400	NA	<0.5	<0.5	28	28	<5.0	--	--	--	--
MW-3	12/15/99	17.44	10.96	6.48	<20	<50	<0.5	<0.5	<0.5	<0.5	NA	0.87	0.57	25	88
MW-3	03/22/02	17.44	10.97	6.47	420	<50	<0.5	<0.5	<0.5	<0.5	31	--	--	--	<50
MW-3	04/15/03	17.44	8.31	9.13	2700	--	<0.5	<0.5	<0.5	<0.5	40	--	--	--	--
MW-3	03/26/04	17.44	8.61	8.83	2700	1900	<1.7	<1.7	<1.7	4.3	<17	--	--	--	--
MW-3	09/30/04	17.44	11.1	6.34	3900	2600	<0.5	<0.5	<0.5	3.2	<10	--	--	--	--
MW-3	09/09/05	17.44	13.75	3.69	4000	2600	<0.5	<0.5	0.57	2.7	12	--	--	--	--
MW-3	11/30/07	17.44	13.9	3.54	--	--	--	--	--	--	--	--	--	--	--
MW-3	12/20/07	17.44	10.79	6.65	18000	12000	<1	1.6	1.1	2.4	9.2	--	--	--	--
MW-3	05/23/08	17.44	15.2	2.24	900	3000	<1	<1	<1	<1	9.1	--	--	--	--
MW-3	08/12/08	17.44	14.14	3.3	1900	4300	<1	<1	<1	<1	6.5	--	--	--	--
MW-3	12/18/08	17.44	12.53	4.91	5000	610	<1	1	<1	<1	20	--	--	--	--
MW-3	02/19/09	17.44	11.11	6.33	1500	1300	<1	1	<1	<1	9	--	--	--	--
MW-3	08/11/09	17.44	15.22	2.22	1000	2200	<10	<10	<10	<10	7.3	--	--	--	--
MW-3 NP	08/11/09	17.44	15.22	2.22	3000	6700	<10	<10	<10	<10	<5	--	--	--	--
MW-3	03/17/10	17.44	11.94	5.5	3000	4600	<10	<10	<10	<10	9.4	--	--	--	--
MW-3	08/18/10	17.44	12.86	4.58	1000	3500	<50	<50	<50	<50	<25	--	--	--	--
MW-3 ^a	03/23/11	31.13	3.58	27.55	500	<50	<1.0	<1.0	<1.0	<1.0	<0.50	--	--	--	--
MW-3	08/25/11	31.13	11.85	19.28	<50	2300	<1.0	<1.0	<1.0	<1.0	4.5	--	--	--	--
MW-3	02/22/12	31.13	10.84	20.29	2000	1900	<10	<10	<10	<10	<5.0	--	--	--	--

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3516 Adeline Street, Oakland, California 94608

		Elevation Summary			Analytical Summary										
Well ID	Date	Top of Casing Elevation (amsl)	Depth to Water BTOC	Groundwater Elevation (feet amsl)	TPH-SS	TPH-G	Benzene	Toluene	Ethyl benzene	Xylenes (ug/l)	MTBE	1,2-DCB	1,1-DCA	2-Methyl-Naphthalene	Naphthalene
W-IND	03/22/02	NA	--	--	<50	190	<0.5	<0.5	<0.5	0.8	<5.0	--	--	--	--
W-IND	04/15/03	NA	--	--	--	--	--	--	--	--	--	--	--	--	--
W-IND	03/26/04	NA	--	--	500	200	<0.5	<0.5	<0.5	<0.5	<5	--	--	--	--
W-IND	09/30/04	NA	--	--	<50	<50	<0.5	<0.5	<0.5	<0.5	<5	--	--	--	--
W-IND	09/09/05	NA	--	--	<50	<50	<0.5	<0.5	<0.5	<0.5	<5	--	--	--	--
W-IND	11/30/07	NA	12.92	--	--	--	--	--	--	--	--	--	--	--	--
W-IND	12/20/07	NA	11.68	--	<50	500	<1	1	<1	2.2	<.50	--	--	--	--
W-IND	05/23/08	NA	12.72	--	300	250	<1	3.7	<1	2.4	<0.50	--	--	--	--
W-IND	08/12/08	NA	13.42	--	<50	<50.0	<1	<1	<1	<1	<0.50	--	--	--	--
W-IND	12/18/08	NA	12.65	--	<50	<50	<1	<1	<1	<1	0.7	--	--	--	--
W-IND	02/19/09	NA	9.74	--	<50	<50	<1	<1	<1	<1	<0.5	--	--	--	--
W-IND	08/11/09	NA	14.13	--	<50	<50	<1	<1	<1	<1	<0.5	--	--	--	--
W-IND	03/17/10	NA	9.78	--	<50	<50	<1	<1	<1	<1	<0.5	--	--	--	--
W-IND	08/18/10	NA	12.84	--	<50	<50	<1.0	<1.0	<1.0	<1.0	<0.50	--	--	--	--
W-IND	03/23/11	32.48	8.32	24.16	<50	<50	<1.0	<1.0	<1.0	<1.0	<0.50	--	--	--	--
W-IND	08/25/11	32.48	12.34	20.14	<50	<50	<1.0	<1.0	<1.0	<1.0	<0.50	--	--	--	--
W-IND	02/22/12	32.48	11.84	20.64	<50	<50	<1.0	<1.0	<1.0	<1.0	<0.50	--	--	--	--

Explanation:

TPH-G = Total petroleum hydrocarbons as gasoline, analyzed by EPA Method 8015B.
 TPH-SS = Total petroleum hydrocarbons as stoddard solvent, analyzed by the 8015B.
 Benzene, toluene, ethylbenzene, and total xylenes analyzed by EPA Method 8260B.
 MTBE = Methyl tertiary-butyl ether, analyzed by EPA Method 8260B.

amsl = Above mean sea level.
 BTOC = Below top of casing.
 -- = not analyzed

ug/l - Micrograms per liter.
 <1.0 = Not detected at or above indicated laboratory reporting limit.

NA = Data not available

•• Components found in the gasoline range, however they are not characteristic of gasoline components.

NP = HydraSleeve® no purge protocol

On March 17, 2010, Taber Consultants implemented the HydraSleeve® no purge protocol for all wells.

On March 23, 2011, Taber Consultants resurveyed top of casing elevations for all wells.

MW-3^a During the 3/23/11 monitoring event, Taber Consultants replaced a damaged well cap. See First Semiannual Monitoring Report 2011 for discussion.

TABLE 4
GROUNDWATER FIELD READINGS - NATURAL ATTENUATION PARAMETERS
SITE INVESTIGATION 2011

Former City of Paris Cleaners
3516 Adeline St, Oakland, CA 94608

Sample Location	Sample Identification	Sample Date	Dissolved Oxygen (DO)	Dissolved Oxygen (DO)	Oxygen Reduction Potential (ORP)	pH	Electrical Conductivity (EC)	Temperature
			(%)	(mg/l)	(mV)		(uS/cm)	(° C)
Upper (Shallow) Groundwater Zone								
GP-3	GP-3-15	5/6/2011	99.7	8.7	27.9	6.65	1195	21.06
GP-4	GP-4-15	5/6/2011	73.9	6.59	-124.6	7.08	1017	20.34
GP-8	GP-8-15	5/12/2011	3.4	0.33	-176.5	7.84	1380	21.40
GP-9	GP-9-15	5/12/2011	2.2	0.24	-144.2	7.44	1299	23.20
GP-11	GP-11-15	5/13/2011	27.5	3.18	-91.4	7.93	960	22.30
MW-1	MW-1	5/12/2011	11.4	1.36	-202.6	7.21	1831	15.40
MW-2	MW-2	5/12/2011	23.4	2.83	-116.7	5.54	1857	15.90
MW-3	MW-3	5/12/2011	12.7	1.56	-202.7	7.27	667	15.70
Lower (Deeper) Groundwater Zone								
GP-1	GP-1	5/2/011	60.2	6.29	75.1	6.14	1069	21.00
GP-2	GP-2	5/2/011	35.4	3.29	-165.7	6.98	774	22.07
GP-3	GP-3-35	5/6/2011	39.6	3.6	-57.0	6.19	814	20.23
GP-4	GP-4-35	5/6/2011	42.7	3.86	38.0	7.21	699	18.94
GP-5	GP-5	5/5/2011	28.3	2.38	-281.5	8.20	956	23.70
GP-8	GP-8-35	5/12/2011	8.5	0.99	-108.3	6.91	1068	20.90
GP-9	GP-9-35	5/12/2011	20.6	1.43	-91.4	6.38	938	20.90
GP-11	GP-11-35	5/13/2011	19.9	2.21	-107.1	7.56	924	23.90
W-IND	W-IND	5/12/2011	50.6	6.45	18.1	7.04	1077	15.80

Explanation:

% = percent

mg/l = milligrams per liter.

mV = milli-volts.

uS/cm = microSiemens per centimeter.

Siemens (S) is a unit of the electrical conductivity. The conductivity of water is measured within a certain distance thus the input is in S/cm or uS/cm.

(°C) = Celcius

APPENDICES

APPENDIX A.
SULFATE DEGRADATION MASS ESTIMATION WORKSHEETS, BRUCE AND KOHATKAR

Estimating mass of dissolvable contamination in the source zone

This does not include plumes with measurable LNAPL

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There is considerable uncertainty involved with estimating the mass of dissolvable contaminants in the source zone. Nevertheless, in order to estimate treatment volumes, or simply to model the plume behavior, an estimate must be made. Gallagher (1995) proposed that the source area be divided into three zones: 1) the vadose zone, 2) the smear zone (residual in the phreatic zone) and 3) the dissolved phase zone in the source area of the phreatic zone. For practical purposes, the vadose zone will be handled by means other than adding electron acceptors to groundwater, and the dissolved phase in groundwater is accounted elsewhere in this document. Therefore, for our purposes, we will concentrate on estimating the mass of dissolveable contaminants in the smear zone. This is defined as the zone from the top of the current (or highest) water table elevation and the lowest groundwater table elevation since the time of the release.

Estimating dissolvable mass in the smear zone (after Gallagher, 1995).*

Step 1. Contour the concentration of total dissolved BTEX in the groundwater plume.

Step 2. Define the area greater than 3,000 ppb total BTEX and measure or estimate the square feet. (A different concentration contour may be used based on site specific conditions.)

Step 3. Obtain total TPH in soil from below the water table in this zone. Note that at least three representative analyses would be best, but lacking that, use what you have, or estimate. For example, 10,000 ppb total BTEX may stem from a TPH range of 200 to 500 mg/kg GRO depending on the dissolvable fraction (personal experience.)

Step 4. Calculate volume as follows: $V = (Tx * Cx * Ax)$

where Tx = Thickness of the smear zone in ft

Cx = Average contaminant concentration in soil in mg/kg

Ax = Area within the 3000 ppb contour in ft² (A different contour value may be used on a site specific basis.)

Step 5. Multiply Volume soil density factor: Mass (mg) = $p * V$

where p = soil density in kg/ft³ (approximately 65 kg/ft³)

Tx	8	ft	input
Cx	30	mg/kg	input
Ax	1,800	ft ²	input
p	65	kg/ft ³	given
V	432,000	mg/kg/ft ³	calculated
Mass	28,080,000	mg	calculated

(Note: This value is automatically connected and input to line 22 in Tab 2 of this spreadsheet)

* Gallagher, M.N., et al.,1995, Mass Based Corrective Action, NGWA Petroleum Hydrocarbons Conference, Houston, TX, November 1995, p. 453-465.

Line
Number

Smear Zone as Source: Mass calculation and estimated sulfate required to degrade it				
21				
22	Estimated mass of contaminants in milligrams calculated in the Source Zone Worksheet (tab 1). This is dissolved phase, adsorbed phase and residual NAPL in the smear zone source. Does not account for mobile LNAPL if present.	28,080,000	Smear zone source mass in mg	Automatically input from tab 1. Calculated mass based on soil analyses or based on GW analyses and Gallagher method (Calculated in Source Zone worksheet). Dissolved phase and smear zone as source. Does not account for measurable LNAPL if present.
23	BTEX degraded/mass of sulfate	0.22	mg/mg	Based on stoichiometry for benzene and sulfate
24	Stoichiometric Sulfate Demand	127,636,364	milligrams sulfate	Mass of sulfate required to degrade estimated mass of contaminants.
25	Safety Factor for sulfate demand (over stoichiometric)	2	Safety factor	Assume 1 to 4
26	Stoichiometric Sulfate Demand w/safety factor	255,272,727	milligrams sulfate w/safety factor	With safety factor of 2 to 4 may account for dissolved and smear zone source. Does not account for LNAPL if present.
27	Concentration of sulfate in treatment water	140,000	mg/l SO ₄	
28	Volume total fluid to be applied (liters)*	1,823	liters (no safety factor)	Based on demand with safety factor divided by concentration of solution
29	Volume total fluid to be applied (gallons)*	482	gallons (with safety factor)	Liters converted to gallons
30	Volume of dry Epsom Salts if desired*	722	pounds dry weight of crystals or pellets without the safety factor	Based on estimated sulfate needed to degrade the contaminant mass converted to mass of Epsom crystals based on molar ratio.
31	Volume of dry Epsom Salts if desired*	1,443	pounds dry weight of crystals or pellets with the safety factor	Based on estimated sulfate needed times the safety factor converted to mass of Epsom crystals based on molar ratio.
	Volume of dry Gypsum if desired*	502	pounds dry weight of crystals or pellets without the safety factor	Based on estimated sulfate needed to degrade the contaminant mass converted to mass of gypsum crystals based on molar ratio.
31	Volume of dry Gypsum if desired*	1,005	pounds dry weight of crystals or pellets with the safety factor	Based on estimated sulfate needed times the safety factor converted to mass of gypsum crystals based on molar ratio.
32	Method of Application (wells, trenches, dry)			

*Application may be made wet using a solution of given concentration or dry using Epsom salts, gypsum or other sulfate salt minerals.

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Hydrogeologic and Contaminant Data				Cells in YELLOW require data input and BLUE cells are output/calculated values
Line number	Site Information			Comments/Basis
1	Site Name/ID			
2	Location (city, state)			
3	Data Required (includes hydrogeology data, plume details)		Units	
4	Hydraulic Conductivity Estimate (K)	0.028	ft/d (input)	Preferably based on slug test or pump test data
5	Thickness of impacted saturated zone	10	ft (input)	Contaminated GW zone
6	Hydraulic gradient (I)	0.02	ft/ft (input)	Measured dh/dl
7	Porosity (n)	0.38	dimensionless (input)	Site specific measurement or literature value based on site geology
8	Width of GW plume being addressed	68	ft (input)	Lateral extent of proposed treatment (e.g. row of wells)
9	Maximum BTEX concentration (dissolved phase)	5.00	mg/l (input)	Total BTEX concentration or TPH if available, which is greater
10				
11	Through flow of GW, Contamination, and Degradation Capacity based on mass flux.			
12	Groundwater Seepage Velocity ($V = K I / n$)	1	ft/y (calculated)	$VGW = K \cdot I / n$
13	Total groundwater volumetric flux ($Q = K I A$)	0	ft ³ /d	$Q = K I A$
14	Total groundwater volumetric flux (Q in gal/d)	3	gal/d	$Q = K I A * 7.48 \text{ gal/ft}^3$
15	Total groundwater volumetric flux (Q in L/d)	11	L/d	$\text{gal/d} * 3.7854$
16	Mass flux of dissolved BTEX Through Treatment Zone	54	mg BTEX/d (does not include adsorbed phase)	$\text{GW gpd} * \text{BTEX conc} * 3.7854 \text{ l/gal}$
17		2	(multiply by 2 or 4 to account for adsorbed phase)	
18	Mass of dissolved BTEX including adsorbed phase	108	mg/d	Safety factor of 2 or more includes adsorbed phase
19	Mass degradation capacity of TEAs available from background	49	mg/d	Automatically input from Tab 4. Based on amount of electron acceptors available from background and their utilization factors (Calculated in Natural TEA Availability Worksheet)
20	Note: If line 19 is greater than line 16 and the plume is NOT shrinking, there is substantial contribution of contaminaton from a source			

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This page calculates the natural degradation capacity of gw flowing through the plume area.
 This is based on terminal electron acceptors (TEAs) available.

TEA	GW Flow* l/d	Background Concentration mg/l**	Available to Plume mg/d	Utilization Factor	BTEX equivalent degraded mg/d	Cells in YELLOW require data input and BLUE cells are output/calculated values
DO	11	0.33	4	3.14	1	
Nitrate	11	0.025	0	4.9	0	
Iron***	11	0	0	21.8	0	
Sulfate	11	16	173	4.7	37	
methane***	11	0.81	9	0.78	11	
sum					49	

mg/d

(Automatically entered to line 19
of Tab 3)

* GW flow in dissolved contaminant layer calculated in in Tab 2 and automatically entered here.

** If unknown or not measured, a zero is posted for computation purposes

*** Note that dissolved iron (Fe²⁺) and methane are degradation products not TEAs. The utilization factor is based on the mass of degradation product present in the plume.

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This page calculates the natural degradation capacity of gw flowing through the plume area.
 This is based on terminal electron acceptors (TEAs) available.

TEA	GW Flow* l/d	Background Concentration mg/l**	Available to Plume mg/d	Utilization Factor	BTEX equivalent degraded mg/d	Cells in YELLOW require data input and BLUE cells are output/calculated values
DO	11	0.33	4	3.14	1	
Nitrate	11	0.025	0	4.9	0	
Iron***	11	0	0	21.8	0	
Sulfate	11	250	2,696	4.7	574	
methane***	11	0.81	9	0.78	11	
sum					586	

mg/d

(Automatically entered to line 19
of Tab 3)

* GW flow in dissolved contaminant layer calculated in in Tab 2 and automatically entered here.

** If unknown or not measured, a zero is posted for computation purposes

*** Note that dissolved iron (Fe2) and methane are degradation products not TEAs. The utilization factor is based on the mass of degradation product present in the plume.

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APPENDIX B
NATURAL ATTENUATION METHODS

CO₂- Carbon Dioxide completed using EPA Method 4500-C02 C
Phosphorus analyses completed using EPA Method 365.3
TKN - Total Kjeldahl Nitrogen analyses completed using EPA Method 351.2
Alkalinity as Calcium Carbonate analyses completed using EPA method SM
2320B
Sulfate and nitrate analyses completed using EPA method 300.0
Ferrous iron analyses completed using EPA method 6101610/SM 3500
Ferric iron analyses completed using EPA Method 6010A
Manganese analyses completed using EPA method 6010B
Methane, ethane, and ethene analyses completed using EPA Method RSK-175
Sulfide analyses completed using EPA method 376.2/4500-S 2-G