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March 16, 2012

Mr. Mark E. Detterman, PG, CEG
Senior Hazardous Materials Specialist
Alameda County Health Care Services Agency
Environmental Health Department
1131 Harbor Bay Parkway, Suite 250
Alameda, California 94502-6577

RECEIVED

9:53 am, Mar 20, 2012

Alameda County
Environmental Health

Dear Mr. Detterman:

Attached for your review is a *Work Plan for Soil Vapor, Soil and Groundwater Investigation* for former Chevron Service Station No. 21-1283, located at 3810 Broadway, in Oakland, California. This report was prepared by ARCADIS, upon whose assistance and advice I have relied. I declare under penalty of perjury that the information and/or recommendations contained in the attached report are true and correct to the best of my knowledge.

If you should have any further questions, please do not hesitate to contact me.

Sincerely,

Liv Skan

Olivia Skance
Chevron Environmental Management Company

ARCADIS
Infrastructure · Water · Environment · Buildings

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ENVIRONMENT

Mr. Mark E. Detterman, PG, CEG
Senior Hazardous Materials Specialist
Alameda County Health Care Services Agency
Environmental Health Department
1131 Harbor Bay Parkway, Suite 250
Alameda, California 94502-6577

Subject:
Work Plan for Soil Vapor, Soil and Groundwater Investigation
Former Texaco Service Station No. 21-1283
3810 Broadway
Oakland, California
Fuel Leak Case No. RO0000056

Date:
March 16, 2012

Contact:
Thomas Potter

Phone:
916.985.2079 ext. 31

Email:
Thomas.Potter@
arcadis-us.com

Our ref:
B0060901.1238 0002

Dear Mr. Detterman:

ARCADIS has prepared this *Work Plan for Soil Vapor, Soil and Groundwater Investigation* on behalf of Chevron Environmental Management Company (Chevron), for former Texaco Station No. 21-1283, located at 3810 Broadway in Oakland, California (Figure 1). This work plan was prepared at the request of Alameda County Environmental Health (ACEH), in their letter dated December 15, 2011. It will serve as a revision to the previously submitted *Work Plan for Soil Vapor Survey* prepared by Conestoga-Rovers & Associates (CRA), dated June 26, 2009.

The proposed scope of work includes the installation and sampling of three permanent soil vapor probes, to evaluate the potential for vapor intrusion into offsite buildings, and the installation of five soil borings for soil and groundwater sample collection, to evaluate the potential for petroleum hydrocarbon offsite migration.

Site Description and Features

The site is an active service station and automobile repair shop located in a mixed commercial and residential area of Oakland, California; at the intersection of Broadway and 38th Street. The site is bounded on the west by Broadway, to the south by 38th Street, to the east by residential apartments and to the north by commercial and residential buildings. Current site features include a station building, automobile repair building, fuel dispenser islands and an underground storage tank (UST) complex.

Site Background

The site operated as a Texaco Service Station from approximately 1963 to 1985. Site features include four 6,000 gallon USTs and one 550 gallon waste oil UST that were removed in February 1980 and May 1991, respectively. A total of 12 soil borings and 13 groundwater monitoring wells have been installed at the site. Nine groundwater monitoring wells are currently a part of the monitoring and sampling program. [1] A complete summary of environmental investigations can be found in the 2009 CRA *Site Conceptual Model*.

Site Geology and Hydrogeology

The site is located in the East Bay Plain Groundwater Basin, which consists of unconsolidated sediments of Pleistocene and Holocene age overlying bedrock of Jurassic, Cretaceous and Tertiary age. The East Bay Plain overlies a flank of a broad Franciscan bedrock depression. Unconsolidated sediments in the basin vary in thickness up to 1,000 feet. These unconsolidated sediments are commonly referred to, from oldest to youngest, as Santa Clara Formation, Alameda Formation, Temescal and artificial fill. The site is underlain primarily by unconsolidated fill material overlying sandy silts and clays, interbedded with well sorted sands and silty sands.

The site is located in the Oakland Sub Basin of the East Bay Plain Groundwater Basin. The site is roughly 85 feet above mean sea level. The closest stream is Glen Echo Creek, located approximately 1,500 feet south of the site. The nearest surface water body is Lake Merritt, located approximately 1.3 miles to the south of the site.

Onsite depth to water (DTW) has historically ranged from approximately 13 feet to 34 feet below ground surface (bgs). Groundwater elevation beneath the site was significantly influenced in 2007 and 2008 due to local dewatering associated with

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[1] Conestoga-Rovers & Associates. 2009. *Work Plan for Soil Vapor Survey*. Prepared for Chevron Environmental Management Company, Former Texaco Service Station 21-1283, California (June 26, 2009).

Kaiser Permanente construction across Broadway.[1] Since December 2010, DTW measurements have ranged from 19.27 to 29.58 feet bgs, and have been at an average of 23.40 feet bgs. Groundwater flow direction varies considerably, including to the north, west and south. Groundwater mounding and groundwater depressions have also been observed.

Proposed Scope of Work

The proposed scope of work includes the installation and sampling of three soil vapor probes and five soil borings.

Pre-Field Activities

Site Specific Health and Safety Plan

ARCADIS will prepare a site-specific *Health and Safety Plan* for the scope of work detailed below, as required by the Occupational Health and Safety Administration (OSHA) Standard "Hazardous Waste Operations and Emergency Response" guidelines (29 CFR 1910.120) and by the California OSHA Standard “Hazardous Waste Operations and Emergency Response” guidelines (California Code of Regulations Title 8, Section 5192). The document will be reviewed and signed by ARCADIS personnel and subcontractors prior to performing work at the site.

Permitting

ARCADIS will obtain drilling permits from the Alameda County Public Works Agency (ACPWA) prior to commencing intrusive field activities. ARCADIS will coordinate field activities with the ACPWA and the ACEH, and schedule an ACPWA inspector if necessary, to document compliance with the permit requirements.

Underground Utility Line Locating

ARCADIS will notify Underground Service Alert (USA) at least 48 hours prior to commencing drilling activities in order to identify public utilities in the vicinity of the proposed soil vapor probes and soil borings. In addition, a private utility locating company will be utilized to further evaluate private and public underground utilities in the vicinity of the proposed soil vapor probes and soil borings.

Soil Vapor Probe Investigation

The goal of the investigation is to collect analytical data that may be used to evaluate the potential for vapor intrusion of onsite subsurface volatile constituents into adjacent offsite buildings. Soil vapor probe installation and sampling will follow the guidelines presented in the Department of Toxic Substance Control (DTSC) California Environmental Protection Agency (CalEPA) *Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air (Vapor Intrusion Guidance)* [October 2011].

Three permanent multilevel soil vapor probes (SV-1S/SV-1D, SV-2S/SV-2D, and SV-3S/SV-3D) are proposed to assess the potential for vapor intrusion of onsite volatile constituents into the indoor air of adjacent offsite buildings and structures. The proposed location for SV-1 is in the southwest corner of the site, southwest of the former UST complex and excavation area. The proposed location for SV-2 is along the northern edge of the property, between the UST complex and the nearest northernmost commercial/residential building. The proposed location for SV-3 is on the eastern edge of the site, near MW-6 and between the former UST complex and the nearest easternmost residential building.

The locations of soil vapor probes SV-1, SV-2 and SV-3 are expected to provide data that will be used for a risk assessment of potential vapor intrusion into offsite buildings and to construction workers in offsite trenches. The data will also b. The vapor probe locations are subject to change by the field team based on site accessibility, maneuverability and utility locations.

Vapor intrusion assessments to evaluate the potential for onsite workers to be exposed to petroleum hydrocarbons at an active service station are not typically conducted. The indoor air quality at these facilities is governed by California Code of Regulations, Title 8, and is covered under Section 5218, Subchapter 7, Section (a)(2)(A):

"The storage, transportation, distribution, dispensing, sale or use of gasoline, motor fuels, or other fuels containing benzene subsequent to their final discharge from bulk wholesale storage facilities, except that operations where gasoline or motor fuels are dispensed for more than 4 hours per day in an indoor location are covered by this section."

To be conservative ARCADIS will evaluate the results of the soil vapor investigation proposed within for onsite service station workers. ARCADIS will evaluate the need for sub-slab vapor installation and sampling based on the results of the soil vapor investigation proposed within.

Soil Vapor Probe Construction

The proposed soil vapor probes will be installed as permanent multilevel probes. Each vapor probe will contain two soil vapor screens set at depths of 5 and 10 feet bgs. The multiple depth intervals will assist in determining the soil vapor concentration gradient as well as the extent to which biodegradation of volatile constituents of possible concern (COPC) may be occurring. The soil vapor probe depths may be adjusted in the field based on soil properties.

Each soil vapor probe location will be manually cleared with a hand auger to approximately 10 feet bgs. When each respective boring has been advanced to its final depth of approximately 10 feet bgs, a 6 inch long, 0.375 inch outer diameter, stainless steel soil vapor screen will be set in a one foot interval of standard sand pack, allowing approximately 3 inches of sand above and below the screen. Teflon tubing (or equivalent) will be connected to the soil vapor screen and capped with a vapor-tight 2-way valve at the surface, eliminating the potential for barometric pressure fluctuations to induce vapor transport between the subsurface and the atmosphere. The 2-way valve will be installed in the closed position, allowing equilibration of soil vapor concentrations to commence immediately after installation.

A one foot interval of dry granular bentonite will be placed above the sand pack followed by hydrated granular bentonite to the depth of the next sample probe. Sand pack is used around the screened interval of each sample probe to allow soil vapor from the adjacent soil to reach the probes. Dry granular bentonite is used to ensure that the hydrated bentonite does not seal the vapor probe screen and inhibit the collection of soil vapor. This process will be repeated for the 5 foot soil vapor screen. The surface of each multilevel probe cluster location will be fitted with a concrete cap and a flush mounted, traffic rated well box with sufficient room to store the tubing lines and valves.

Soil Screening and Sampling

Soil samples will be collected using a hand-operated slide hammer and undisturbed core sampler and analyzed for geotechnical parameters for the potential use in vapor transport modeling. Samples will be collected at depths of approximately 5 and 10 feet bgs, at soil vapor probes locations SV-1, SV-2 and SV-3. The geotechnical soil samples will be analyzed for:

- Site specific physical properties such as soil dry bulk density, grain density, and soil moisture content
- Soil grain size distribution, to interpret the moisture content data and soil type

CalEPA recommended American Society for Testing and Materials (ASTM) analytical methods will be used for these parameters as follows:

• Dry bulk soil density	ASTM D2937
• Grain density	ASTMD854
• Soil moisture	ASTM D2216
• Grain size Distribution (Sieve Method)	ASTM D422

Results from grain density and dry bulk soil density will be used to calculate total soil porosity.

Additionally, at each proposed soil vapor probe location, soil samples will be collected during borehole clearance at approximate 2 foot intervals using a hand auger. The samples will be screened in the field, using a photoionization detector (PID), and will be described in the field by the supervising geologist, using visual and manual methods of the Unified Soil Classification System (USCS).

Soil Vapor Sampling

Soil vapor sampling will be conducted in accordance with the standard operating procedure (SOP) enclosed in Attachment 1. The highlights of the SOP, including the use of a sampling shroud, are discussed below.

Due to the introduction of atmospheric oxygen into the vadose zone during soil vapor probe installation, an equilibration time is required to allow the sand pack and tubing of the soil vapor probe to equilibrate with the subsurface. A minimum of 48 hours will be allowed for equilibration before purging and sampling of the soil vapor probes.

Purging will consist of removing approximately three volumes of stagnant soil vapor at a flow rate of ≤200 milliliters per minute (mL/min). The purge volume will be calculated based on the dimensions of the above ground gauges, tubing, sampling equipment, below ground tubing and soil vapor probe. Purge volume calculations, field conditions, flow rates, pump specifics and other applicable information will be recorded by field personnel on soil vapor sample collection logs.

A leak test using a sampling shroud will be conducted to ensure the integrity of the sampling system. The wellhead and entire sampling train (valves, tubing, gauges, manifold and sample canister) will be placed in an enclosure with pliable weather stripping along the base. A tracer check compound, laboratory grade helium, will be permitted into the enclosure and kept at a concentration of approximately 10 percent (%) by volume, measured with a portable helium detector. Analysis for the tracer compound in the soil vapor sample will serve to assess the integrity of the sampling system and determine if leakage occurred.

The soil vapor samples will then be collected using 1-Liter batch certified SUMMA™ canisters (or an acceptable alternative) at a flow rate of ≤200 mL/min. A vacuum of <10 inches of mercury (inHg) will be maintained throughout sampling. Soil vapor sampling will be stopped when the canister vacuum drops to no less than 5 inHg.

Additionally, for each day of sampling, a duplicate sample collected in-line with its respective parent sample and an equipment blank sample collected using a laboratory supplied air source will be submitted to the laboratory for quality assurance purposes.

The soil vapor samples will be shipped under appropriate chain of custody protocols to Air Toxics Ltd. in Folsom, California for analysis of the following:

- Total petroleum hydrocarbons as gasoline (TPH-GRO) by Modified United States Environmental Protection Agency (USEPA) Method TO-15

- Benzene, toluene, ethylbenzene and total xylenes (BTEX) by Modified USEPA Method TO-15

- Methyl tertiary butyl ether (MTBE), tertiary butyl alcohol (TBA), di-isopropyl ether (DIPE), ethyl tertiary butyl ether (ETBE), tertiary amyl methyl ether (TAME), 1,2-dichloroethane (1,2-DCA), ethylene dibromide (EDB) and naphthalene by Modified USEPA Method TO-15

- Fixed gases, including oxygen, carbon dioxide, methane and helium by Modified American Society for Testing and Materials Method D-1946

Soil Vapor Data Evaluation

Detected concentrations of constituents in soil vapor will be compared to health-based screening criteria. These screening criteria define levels that the regulatory agencies have deemed safe for human exposure under a vapor intrusion scenario. Soil vapor data collected from onsite probes will be compared to commercial/industrial and residential screening criteria to support risk-based decision making for the site.

Soil vapor data will be compared with the CalEPA California Human Health Screening Levels (CHHSLs) based on potential vapor intrusion concerns presented in the 2005 *Use of CHHSLs in the Evaluation of Contaminated Properties*. Constituent soil vapor data will also be compared with the San Francisco Regional Water Quality Control Board (SFRWQCB) Environmental Screening Levels (ESL) presented in the 2008 *Screening for Environmental Concerns at Sites with Contaminated Soil and Groundwater*. If constituent concentrations in soil vapor exceed their respective screening levels, then vapor intrusion of these constituents will be re-evaluated using DTSC’s version of the Johnson and Ettinger-based vapor intrusion model, incorporating site-specific soil properties analyzed during the investigation. If soil gas constituent concentrations result in estimated risks exceeding the USEPA and CalEPA established acceptable target risk range of one in one-million to one in ten-thousand (1 x 10-6 to 1 x 10-4), based on refined risk evaluation, then the need for additional vapor intrusion investigation at the site will be considered.

It is recognized that petroleum hydrocarbon vapors rapidly biodegrade in the soil column when sufficient oxygen is present. Aerobic biodegradation consumes oxygen and generates carbon dioxide. Comparison of fixed gas concentrations relative to atmospheric levels will be discussed as a qualitative evaluation of the degree to which hydrocarbon vapors may be biodegrading at the site.

Soil and Groundwater Sampling Investigation

Five cone penetrometer test (CPT) and soil borings (CPT-1, CPT-2, CPT-3, CPT-4 and CPT-5) are proposed to address the potential for offsite migration of the TPH-GRO and benzene concentrations observed in monitoring well MW-12, located in the backfilled excavation area. A CPT boring and a direct push boring will be advanced at each location.

The proposed location for CPT-1 is along the southern edge of the site, between MW-7 and MW-11. The proposed location for CPT-2 is in the southwestern corner of the site. The proposed locations for CPT-3 and CPT-4 are along the western edge of the site, between MW-10 and MW-9. The proposed location for CPT-5 is east of in the backfilled excavation area, between MW-6 and MW-1. The locations of the CPT and soil borings are shown on Figure 3.

The locations of CPT-1, CPT-2, CPT-3, CPT-4 and CPT-5 are expected to provide data that will be used to assess the potential for the concentrations observed in MW-12 to bypass the existing monitoring well network undetected. The proposed locations are subject to change by the field team based on site accessibility, maneuverability and utility locations.

Soil and groundwater samples will be collected above and below the one foot clay layer seen in the MW-12 boring log at approximately 26 feet bgs. The soil and groundwater sample depths are expected to provide data that will be used to assess the possibility that the current groundwater monitoring wells are screened across two water bearing zones.

CPT and Soil Boring Construction

Two soil borings will be advanced at each CPT and soil boring location. One boring will be a CPT boring used to assess subsurface lithology, and one boring will be a direct push boring used to visually confirm the CPT boring log and collect depth discrete groundwater and soil samples.

Prior to advancement, each CPT and soil boring location will be cleared to a minimum of 8 feet 1 inch bgs, using and air knife or a hand auger. The CPT and soil borings will be advanced to a final depth of approximately 35 feet bgs. The borings will be advanced far enough below the one foot clay layer seen in the MW-12 boring log at approximately 26 feet bgs to collect a groundwater sample. The CPT and soil borings will be sealed with grout to approximately 4 inches bgs and finished to match the existing surface.

The CPT borings will be conducted using piezocones connected by stainless steel rods to a hydraulic system, which will push the piezocones through the soil. The piezocone measures friction, tip resistance and pore pressure, which will be logged and used to evaluate soil types, resulting in a nearly continuous geologic log. The CPT borings will be performed in accordance with revised (2002) ASTM standards (D-5778-95).

The soil borings will be advanced using direct push technology drilling methods. A 4 inch outer casing and 2 inch inner casing will used to prevent the potential for cross contamination. The outer casing will be advanced to approximately 26 feet, into, but not through the clay layer seen in the MW-12 boring log. Prior to the advancement of the soil borings, the geologic logs obtained from the CPT borings will be charted in the field to obtain field geologic cross sections. The field geologic cross section will be used in conjunction with visual soil logging to target the clay layer.

A temporary well will be set above the clay layer, from approximately 19 feet to 24 feet, using a pre-packed, 0.010 inch slotted, PVC well screen. Following sample collecting, the soil boring will be advance to minimize the potential for cross contamination as detailed above, and a second temporary well will be set from approximately 30 feet bgs to 35 feet bgs. Again, a pre-packed, 0.010 inch slotted, PVC well screen will be used for temporary well construction.

Soil and Groundwater Sampling

The soil borings will be logged continuously and soil samples will be collected approximately every 2 feet. Soil samples will be collected using 1-1/4 inch diameter stainless steel sleeves. Two sleeves will be retained for each sample, one sleeve for soil screening using a PID and one sleeve for possible chemical analysis. The depths and number of soil samples retained from each borehole for chemical analysis will be based on PID screening, soil staining and soil discoloration. At a minimum, two soil samples from each boring will be submitted for laboratory analysis; one sample from above and one sample from below the clay layer seen in the MW-12 boring log at approximately 26 feet bgs.

The soil samples will be shipped under appropriate chain of custody protocols to Test America Laboratories, Inc. in Irvine, California for analysis of the following:

- Total petroleum hydrocarbons as diesel (TPH-DRO) [C_{13}-C_{23}] by USEPA Method 8015B, with silica gel clean-up

- TPH-GRO [C_4-C_{12}] by USEPA Method 8015B

- BTEX, MTBE, DIPE, ETBE, TAME, TBA and ethanol by USEPA Method 8260B

Two groundwater samples will be collected at each soil boring location, one at each temporary well depth. A purge volume of approximately three well casings will be removed from the temporary well before collecting a groundwater sample with a disposable bailer.

The groundwater samples will be shipped under appropriate chain of custody protocols to Test America Laboratories, Inc. in Irvine, California for analysis of the following:

- TPH-DRO [C_{13}-C_{23}] by USEPA Method 8015B, with silica gel clean-up

- TPH-GRO [C_4-C_{12}] by USEPA Method 8015B

- BTEX, MTBE, DIPE, ETBE, TAME, TBA and ethanol by USEPA Method 8260B

Investigation Derived Waste Disposal

Investigation derived waste (IDW) generated during the field activities will be containerized in 55-gallon drums and temporarily stored on site pending characterization for off-site disposal. A composite sample of IDW will be collected for waste profiling purposes. Following the receipt of waste characterization sampling results, the IDW will be transported to an appropriate disposal facility.

Reporting

Following completion of the investigation, a technical report will be prepared and submitted to the ACEH. This report will document the results of the soil vapor investigation and will include the following:

- Site conditions and background information
- A scaled site plan illustrating the soil vapor probe locations and other relevant site features
- Documentation of field activities performed in connection with the site assessment
- Results of the laboratory analyses performed on the soil vapor, water and soil samples
- Comparison of the soil vapor data to human health risk-based screening levels
- Use of the onsite soil vapor samples to assess risk for offsite buildings and construction/utility trench workers
- Well construction logs and concentration figures
- Qualitative evaluation of petroleum hydrocarbon biodegradation
- Conclusions and recommendations relevant to the assessment objectives

Schedule

ARCADIS is prepared to initiate pre-field activities upon receipt of work plan approval from the ACEH and procurement of a property access agreement between Chevron and the property owner. The technical report will be submitted following receipt of the final laboratory reports.

If you have any questions or comments regarding the contents of this letter, please contact Thomas Potter of ARCADIS at 916.985.2079 ext. 31 or Thomas.Potter@arcadis-us.com.

Sincerely,

Thomas M. Potter
Associate Project Manager

Melissa Blanchette, PG (CA 8531)
Project Geologist

PROFESSIONAL GEOLOGIST
MELISSA BLANCHETTE
No. 8531
Exp. 10/31/2012
STATE OF CALIFORNIA

Enclosures:

Figure 1	Site Location Map
Figure 2	Site Plan with Propose Soil Vapor Probe Locations
Figure 3	Site Plan with Proposed CPT and Soil Boring Locations
Attachment 1	Soil Vapor Sampling Standard Operating Procedure

Copies:

Mr. Robert Speer – Chevron, electronic copy
Mr. Joe Zadik

REFERENCE: BASE MAP USGS 7.5. MIN. TOPO. QUAD., OAKLAND WEST, CA, 1993.

0 1500' 3000'

Approximate Scale: 1 in. = 1500 ft.

FORMER TEXACO SERVICE STATION NO. 21-1283
3810 BROADWAY, OAKLAND, CA

SITE LOCATION MAP

ARCADIS

FIGURE
1

CITY:(SYRACUSE) DIV/GROUP:(ENV/IM-DV) DB:(DHOWES) LD:(Opt) PIC:(NA) PM:(BJWALL) TM:(Opt) LYR:(Opt)ON=*;OFF=*REF*
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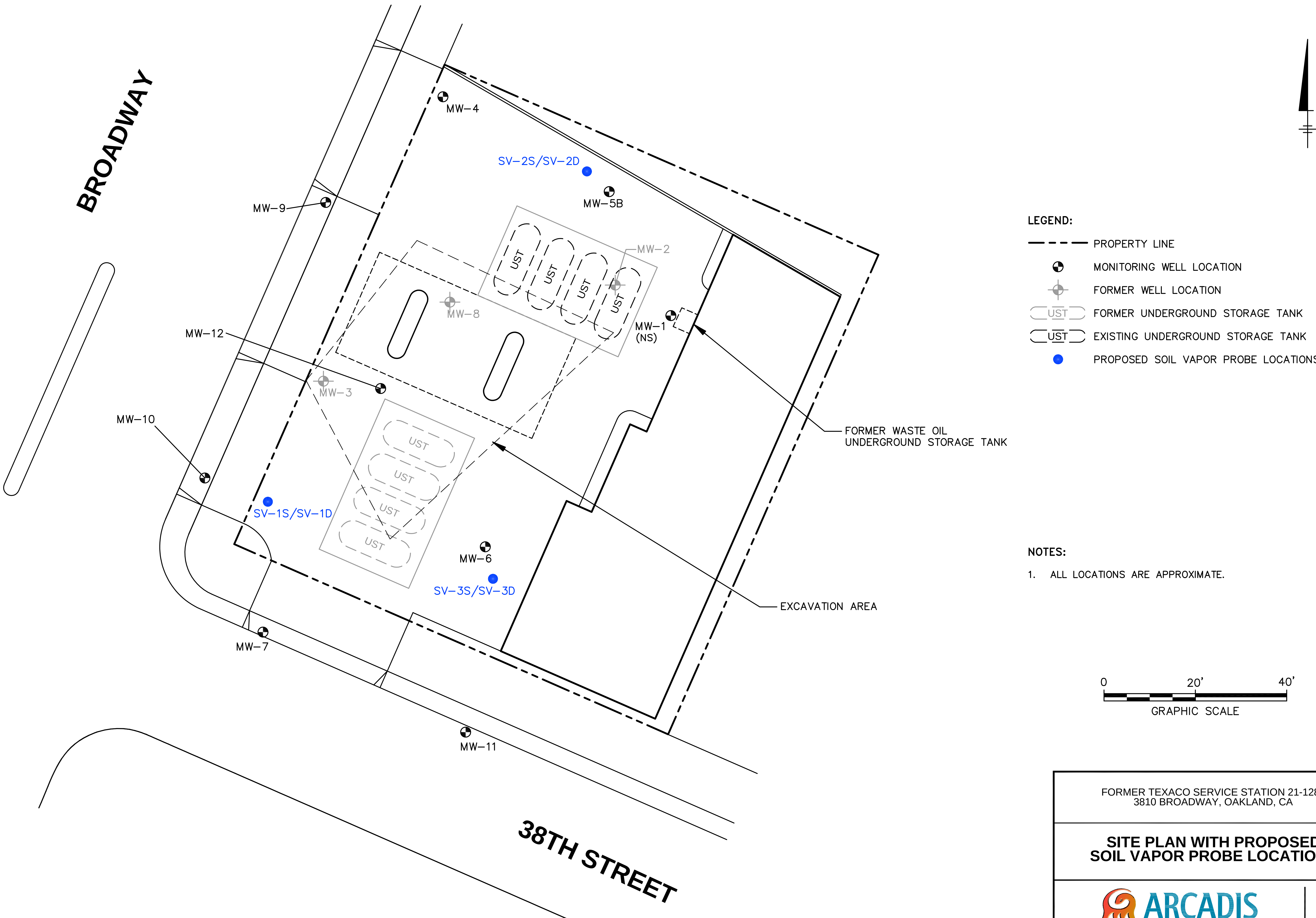
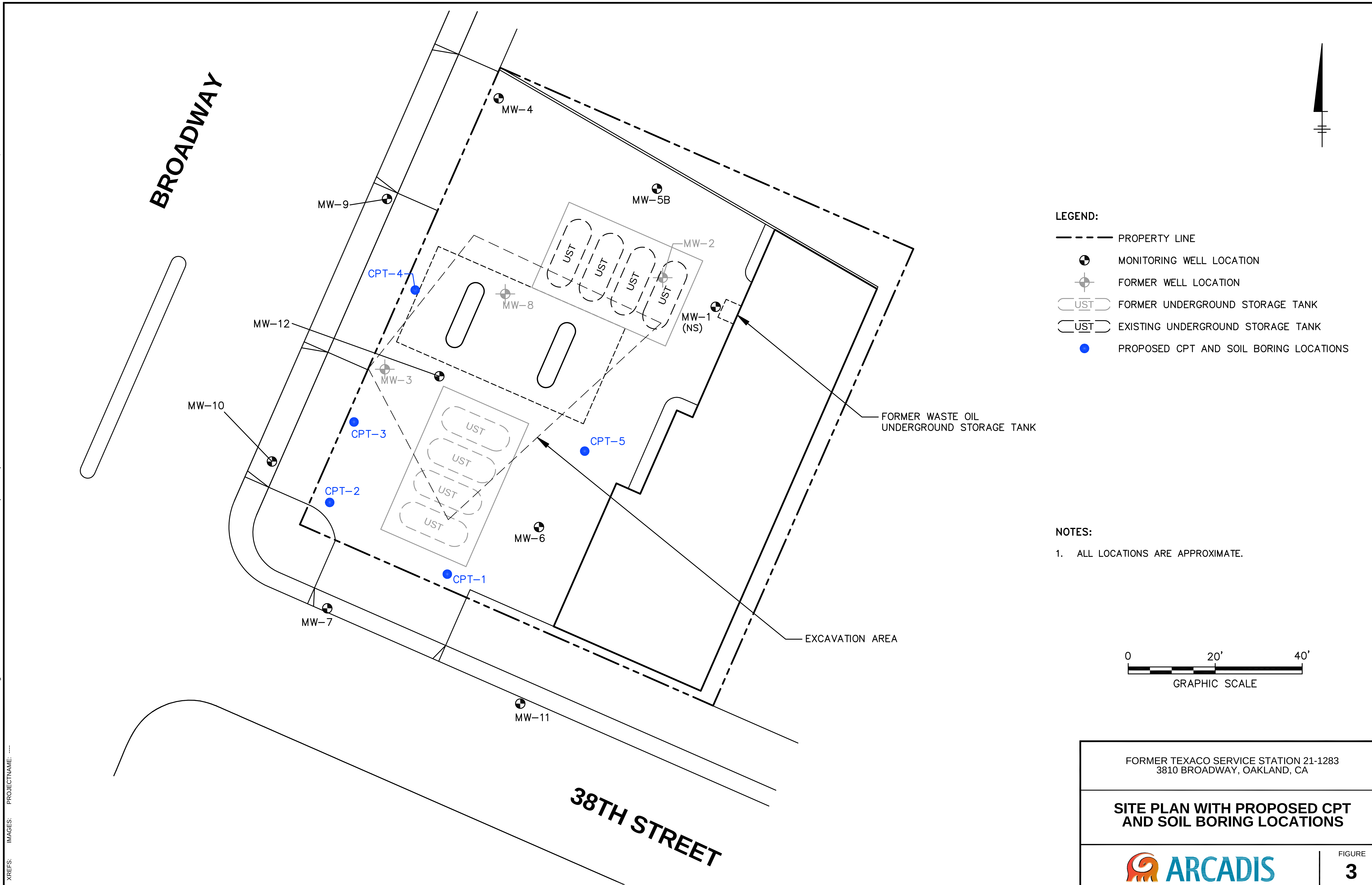


FORMER TEXACO SERVICE STATION 21-1283
3810 BROADWAY, OAKLAND, CA

SITE PLAN WITH PROPOSED SOIL VAPOR PROBE LOCATIONS

ARCADIS

FIGURE
2



FORMER TEXACO SERVICE STATION 21-1283
3810 BROADWAY, OAKLAND, CA

SITE PLAN WITH PROPOSED CPT AND SOIL BORING LOCATIONS

ARCADIS

FIGURE
3

CITY: SYRACUSE, NY DIV/GROUP: ENV/IM-DV DB: P. LISTER PM/TM: R. ANDRESEN TR: BJ WALL LYR: ON=*;OFF=REF
G:\ENVCAD\SYRACUSE\ACT\B0060901\1283\00002\DWG\60901C03.dwg LAYOUT: 3 SAVED: 2/27/2012 10:18 AM ACADVER: 18.0S (LMS TECH) PAGESETUP: B-PDF PLOTSTYLETABLE: PLTFULL.CTB PLOTTED: 2/27/2012 10:18 AM BY: KOWALCZYK, STEVE
XREFS: IMAGES: PROJECTNAME: ----

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Attachment 1

Soil Vapor Sampling Standard Operating Procedure

ARCADIS
Infrastructure, environment, facilities

Imagine the result

Soil-Gas Sampling and Analysis Using USEPA Method TO-17 and TO-15

SOP #112409

Rev. #: 1

Rev Date: July 9, 2010

Approval Signatures

Prepared by: ______________________ Date: 07/09/2010
Mitch Wacksman, Michael Strickler and Andrew Gutherz

Approved by: ______________________ Date: 07/09/2010
Christopher Lutes and Nadine Weinberg

I. Scope and Application

This document describes the procedures to collect subsurface soil-gas samples from sub-slab sampling ports and soil vapor monitoring points for the analysis of volatile organic compounds (VOCs) including volatile polyaromatic hydrocarbons (PAHs) by United States Environmental Protection Agency (USEPA) Method TO-17 (TO-17) and USEPA Method TO-15.

The TO-17 method uses a glass or stainless steel tube packed with a sorbent material. Sorbents of increasing strength and composition are packed within the tube. The specific sorbent material packed within each tube is selected based on the target compounds and desired reporting limits. A measured volume of soil-gas is passed through the tube during sample collection.

The TO-15 method uses 1-liter 3-liter or 6-liter SUMMA® passivated stainless steel canister. An evacuated SUMMA canister (less than 28 inches of mercury [Hg]) will provide a recoverable whole-gas sample of approximately 5 liters when allowed to fill to a vacuum of approximately 6 inches of Hg. The whole-air sample is then analyzed for VOCs using a quadrupole or ion-trap gas chromatograph/mass spectrometer (GS/MS) system to provide compound detection limits of 0.5 parts per billion volume (ppbv). Optionally the canister sample can also be analyzed for fixed gasses such as Helium, Carbon dioxide and oxygen. .

Following sample collection the TO-17 tube and TO-15 canister is sent to the laboratory where the sampling media is analyzed for the target compounds.

The following sections list the necessary equipment and provide detailed instructions for the collection of soil-gas samples for analysis using TO-17 and TO-15.

Soil vapor samples can be collected from sub-slab sample probes or soil-vapor ports. Refer to the appropriate standard operating procedure (SOP) from the ARCADIS SOP library for a description of construction methods.

II. Personnel Qualifications

ARCADIS field sampling personnel will have current health and safety training, including 40-hour HAZWOPER training, site supervisor training, site-specific training, first-aid, and cardiopulmonary resuscitation (CPR), as needed. ARCADIS field sampling personnel will be well versed in the relevant standard operating procedures (SOPs) and possess the required skills and experience necessary to successfully complete the desired field work. ARCADIS personnel responsible for leading soil-gas sample collection activities must have previous soil-gas sampling experience.

III. Health and Safety Considerations

All sampling personnel should review the appropriate health and safety plan (HASP) and job loss analysis (JLA) prior to beginning work to be aware of all potential hazards associated with the job site and the specific task. Field sampling equipment must be carefully handled to minimize the potential for injury and the spread of hazardous substances. For sub-slab vapor probe installation, drilling with an electric concrete impact drill should be done only by personnel with prior experience using such a piece of equipment and with the appropriate health and safety measures in place as presented in the JLA

IV Equipment List

The equipment required for collect soil-gas samples for analysis using method TO-15 and TO-17 is presented below:

- Appropriate personal protective equipment (PPE; as presented in the site specific HASP and the JLA)
- TO-17 tubes pre-packed by the laboratory with the desired sorbent. Specific sorbents will be recommended by the laboratory considering the target compound list and the necessary reporting limits;
- TO-17 sample flow rate calibration tubes (provided by the laboratory);
- Stainless steel SUMMA® canisters (1-liter, 3-liter, or 6-liter; order at least 5% extra, if feasible) (batch certified canisters or individual certified canisters as required by the project)
- Flow controllers with in-line particulate filters and vacuum gauges; flow controllers are pre-calibrated to specified sample duration (e.g., 30 minutes, 8 hours, 24 hours) or flow rate (e.g., 200 milliliters per minute [mL/min]); confirm with the laboratory that the flow controller comes with an in-line particulate filter and pressure gauge (order at least 5% extra, if feasible). Flow rate should be selected based on expected soil type (see below).
- Two decontaminated Swagelok or stainless-steel or comparable two-way ball or needle valve (sized to match sample tubing).
- 1/4-inch outer diameter (OD) tubing (Teflon® or Teflon-lined polyethylene);
- Stainless steel or comparable Swagelok® or equivalent compression fittings for 1/4-inch OD tubing;

- Stainless steel "T" fitting (if sample train will be assembled with an inline vacuum gauge a four-way fitting will be needed);
- Three Stainless steel duplicate "T" fittings ;
- 2 Portable vacuum pumps capable of producing very low flow rates (e.g., 10 to 200 mL/min) with vacuum gauge;
- Vacuum gauge if monitoring vacuum reading during sample collection is necessary and portable vacuum pump is not equipped with a vacuum gauge;
- Rotameter or an electric flow sensor if vacuum pump does not have a flow gauge (Bios DryCal or equivalent);
- Tracer gas testing supplies (refer to Adminstering Tracer Gas SOP #41699);
- Photoionization Detector (PID) (with a lamp of 11.7 eV);
- Appropriate-sized open-end wrench (typically 9/16-inch, 1/2-inch , and 3/4-inch);
- 2 Tedlar bags;
- Portable weather meter, if appropriate;
- Chain-of-custody (COC) form;
- Sample collection log;
- Gel ice; and
- Field notebook.

V. Cautions

The following cautions and field tips should be reviewed and considered prior to collecting soil-gas samples.

- Sampling personnel should not handle hazardous substances (such as gasoline), permanent marking pens (sharpies), wear/apply fragrances, or smoke cigarettes/cigars before and/or during the sampling event.

- Care should be taken to ensure that the appropriate sorbent is used in the TO-17 tube preparation. Sorbent should be selected in consultation with the analytical laboratory and in consideration of the target compound list, the necessary reporting limits and the expected range of concentrations in field samples. The expected range of concentrations in field samples may be estimated from previous site data, release history and professional judgment informed by the conceptual site model.

- Flow rates for sample collection with TO-17 sorbent tubes should be determined well in advance of field work in consultation with the laboratory.

- A Shipping Determination must be performed, by DOT-trained personnel, for all environmental samples that are to be shipped, as well as some types of environmental equipment/supplies that are to be shipped.

- At the sampling location, keep the tubes in their storage and transportation container to equilibrate with ambient temperature prior to attaching to the sample train.

- Always use clean gloves when handling sampling tubes.

- Seal clean, blank sorbent tubes and sampled tubes using inert, Swagelok®-type fittings and PTFE ferrules. Wrap capped tubes individually in uncoated aluminum foil. Use clean, sealable glass jars or metal cans containing a small packet of activated charcoal or activated charcoal/silica gel for storage and transportation of multiple tubes. This activated charcoal is not analyzed, but serves as a protection for the analytical sorbent tube. Store the multi-tube storage container in a clean environment at 4ºC.

- Keep the sample tubes inside the storage container during transportation and only remove them at the monitoring location after the tubes have reached ambient temperature. Store sampled tubes in a refrigerator at 4ºC inside the multi-tube container until ready for analysis.

- The purge flow rate of 100 ml/min should be suitable for a variety of silt and sand conditions but will not be achievable in some clays without excessive vacuum. A low vacuum (<10” of mercury) should be maintained. Record the measured flow rate and vacuum pressure during sample collection.

The cutoff value for vacuum differs in the literature from 10” of water column (ITRC 2007) to 136” of water column or 10” of mercury (http://www.dtsc.ca.gov/lawsregspolicies/policies/SiteCleanup/upload/SMBR_ADV_activesoilgasinvst.pdf). A detailed discussion of the achievable flow rates in various permeability materials can be found in Nicholson 2007. Related issues of contaminant partitioning are summarized in ASTM D5314-92. Passive sampling approaches can be considered as an alternative for clay soils. However most passive sampling approaches are not currently capable of quantitative estimation of soil gas concentration.

- It is important to record the canister pressure, start and stop times and ID on a proper field sampling form. You should observe and record the time/pressure at a mid-point in the sample duration. It is a good practice to lightly tap the pressure gauge with your finger before reading it to make sure it isn’t stuck.

- Ensure that there is still measureable vacuum in the SUMMA® after sampling. Sometimes the gauges sent from labs have offset errors, or they stick.

- When sampling carefully consider elevation. If your site is over 2,000’ above sea level or the difference in elevation between your site and your lab is more than 2,000’ then pressure effects will be significant. If you take your samples at a high elevation they will contain less air for a given ending pressure reading. High elevation samples analyzed at low elevation will result in more dilution at the lab, which could affect reporting limits. Conversely low elevation samples when received at high elevation may appear to not have much vacuum left in them. http://www.uigi.com/Atmos_pressure.html.

- If possible, have equipment shipped a two or three days before the sampling date so that all materials can be checked. Order replacements if needed.

- Requesting extra canisters and extra sorbent tubes from the laboratory should also be considered to ensure that you have enough equipment on site in case of an equipment failure.

- Shallow exterior soil-gas sampling should not proceed within 5 days following a significant rain event (1/2-inch of rainfall or more).

VI. Procedure

Soil-Gas Sample Preparation

<u>Selection of Sorbent and Sampling Volume (to be completed prior to sampling event)</u>

1. Identify the necessary final reporting limit for the target compound(s) in accordance with the project quality assurance plan and/or in consultation with the data end user.

2. Identify the necessary method reporting limit(s). The laboratory will be helpful in providing this information as it is typically specific to the sensitivity of the instrumentation.

3. The minimum sampling volume is the volume of soil-gas sample that must be drawn through the sorbent in order to achieve the desired final reporting limit. Calculate the minimum sampling volume using the following equation:

$$Minimum\ Sampling\ Volume\ (L) = \frac{Final\ Reporting\ Limit\ (\mu g)}{Action\ Level\ (\mu g/m^3)} \times \frac{1{,}000\ L}{m^3}$$

Where:

L = liters

µg = microgram

m = meter

4. If a timed sample duration is specified in the work plan, calculate the minimum flow rate. The minimum flow rate is the flow rate necessary to achieve the minimum sampling volume using the following formula:

$$Minimum\ Flow\ Rate\ (L/min) = \frac{Minimum\ Sampling\ Volume\ (L)}{Sample\ Duration\ (min)}$$

Where:

min = minutes

Then compare the minimum flow rate calculated to the requirements for maximum soil gas sampling without excessive danger of short circuiting, normally stated as 0.2 liters/minute, although it can be lower in tight soils. Soil vapor sampling flow rates should not exceed 200 ml/min.

5. Compare the minimum sampling volume to the safe sampling volume (SSV) for the sorbents selected. SSV for specific sorbents can be provide by the manufacture or the laboratory, being used (Table 1 and Appendix 1 in Method TO-17). Ensure that the compound will not breakthrough when sampling the volume calculated above.

Soil-Gas Sample Collection

Calibration of the sample pump prior to assembly of sampling train

1. Attach the sample flow rate calibration tube provided by the laboratory to the inlet of the sample pump using a section of tubing. Attach the flow calibrator to the inlet of the sample flow rate calibration tube. The sample flow rate calibration tube should be clearly marked by the laboratory with an arrow indicating flow direction (or as otherwise specified by the laboratory).

2. Turn on the sample pump and adjust the flow rate on the sample pump to achieve the desired minimum flow rate (calculated above) as measured by the flow calibrator.

3. Repeat until each sampling pump has been properly calibrated to its appropriate flow rate.

Assembly of combined TO-17 and TO-15 sampling train

1. Record the following information in the field notebook, if appropriate (contact the local airport or other suitable information source [e.g., site-specific measurements, weatherunderground.com] to obtain the information):

    a. wind speed and direction;

    b. ambient temperature;

    c. barometric pressure; and

    d. relative humidity.

2. If samples are being collected from temporary or permanent soil vapor points simply remove the cap or plug and proceed to step 3. When collecting samples from a sub-slab port remove the cap or plug from the sampling port. Connect a short piece of Teflon or Teflon-lined tubing to the sampling port using a Swagelok or equivalent stainless-steel or comparable compression fitting.

3. Connect the Teflon or Teflon-lined tubing to a stainless steel T fitting using a Swagelok or equivalent stainless-steel or comparableompression fitting.

4. Remove the brass cap from the SUMMA® canister and connect the flow controller with in-line particulate filter and vacuum gauge to the SUMMA® canister. Do not open the valve on the SUMMA® canister. Record in the field notebook and COC form the flow controller number with the appropriate SUMMA® canister number.

5. Connect the flow controller to the stainless steel T fitting using a Swagelok or equivalent stainless-steel or comparable compression fitting. The TO-15 leg of the combined sampling train is now complete.

6. Attach a length of Teflon or Teflon-lined tubing to the free end of the stainless steel T fitting using a Swagelok or equivalent stainless-steel or comparble compression fitting.

7. Complete the remainder of the sampling train as depicted in Figure 1.

Purge Sampling Assembly and Sampling Point Prior to Sample Collection.

1. Ensure the two-way valve next to the flow rate calibration tube is open and the two way valve next to the TO-17 sampling tubes is closed. Purge three volumes of air from the vapor probe and sampling line using the portable pump. Measure organic vapor levels with the PID. Lower flow rates may be necessary in silt or clay to avoid excessive vacuum. Vacuum reading greater than 136 inches of water column are clearly excessive. Other available sources cite a cutoff of greater than 10 inches of water column.

2. Check the seal established around the soil vapor probe and the sampling train fittings by using a tracer gas (e.g., helium) or other method established in applicable regulatory guidance documents. [Note: Refer to ARCADIS SOP "Administering Tracer Gas," adapted from NYSDOH 2005, for procedures on tracer gas use.]

3. When three volumes of air have been purged from the vapor probe and sampling line stop the purge pump and close the valve next to the flow rate calibration tube.

TO-15 Sample Collection

1. Open the SUMMA® canister valve to initiate sample collection. Record on the sample log (attached) the time sampling began and the canister pressure.

   If the initial vacuum pressure registered is not between -30 and -25 inches of Hg, then the SUMMA® canister is not appropriate for use and another canister should be used.

2. Take a photograph of the SUMMA® canister and surrounding area (unless photography is restricted by the property owner).

3. Check the SUMMA canister approximately half way through the sample duration and note progress on sample logs.

TO-15 Sample Termination

1. Arrive at the SUMMA® canister location at least 10 to 15 minutes prior to the end of the sampling interval.

2. Record the final vacuum pressure. Stop collecting the sample by closing the SUMMA® canister valves. The canister should have a minimum amount of vacuum (approximately 6 inches of Hg or slightly greater).

3. Record the date and time of valve closing in the field notebook, sample collection log, and COC form.

TO-17 Sample Collection

1. Record in the field notebook and COC form the tube number on the TO-17 tube.

2. Open the two-way valve next to the TO-17 tubes

3. Turn on the sample pump to begin sample collection. Use a stopwatch to ensure accuracy in pumping time. Record in the field notebook and the field sample log the time sampling began and the flow rate from each of the sample pumps.

<u>Termination of Sample Collection</u>

1. Stop the sample pumps after the desired volume of soil-gas has passed through the sorbent, and close the two-way valves next to the TO-17 sample tubes.

2. Record the stop time.

3. Detach the Tedlar bag from each sample pump and measure the helium concentration in the soil-gas collected by the Tedlar bag. Record any detections in the field book and sample collection log.

4. Open the two-way valve to permit flow through the flow rate calibration tube. Reconnect each of the sampling pumps and measure the flow rate. Record the post-sampling flow rates in the field log book and the sample collection logs. The post-sampling flow rate should match within 10% of the pre-sample flow rate. Average the pre-sampling and post-sampling flow rate and record in the field log book, and the sample collection log.

5. Calculate the sample volume using the average of the pre-sample and post-sample flow rate. Record the sample volume in the field log book, the sample collection log, and on the COC.

6. Package the tubes according to laboratory protocol on gel ice and ship to the laboratory for analysis.

VII. Waste Management

The waste materials generated during sampling activities should be minimal. PPE, such as gloves and other disposable equipment (i.e., tubing), will be collected by field personnel for proper disposal.

VIII. Data Recording and Management

Measurements will be recorded in the field notebook at the time of measurement with notations of the project name, sample date, sample start and finish time, sample location (e.g., GPS coordinates, distance from permanent structure), tube type and number and sample volume. Field sampling logs and COC records will be transmitted to the Project Manager.

IX. Quality Assurance

Duplicate samples should be collected in the field as a quality assurance step. Generally, duplicates are taken of 10% of samples, but project specific requirements should take precedence. Duplicate soil gas samples should be collected via a split sample train, allowing the primary and duplicate sample to be collected from the soil-gas probe simultaneously.

Quality assurance planning for method TO-17 should take careful note of the method requirement for distributed volume pairs. Although in some circumstances this requirement may be waived, this does constitute a deviation from the method as written. It is wise to discuss this decision with clients and/or regulators before sampling.

Soil-gas sample analysis will be performed using USEPA TO-17 methodology for a site specific constituent list defined in the work plan. Constituent lists and reporting limits must be discussed with the laboratory prior to mobilizing for sampling. Quality assurance parameters should be confirmed with the laboratory prior to sampling. Field quality assurance parameters should be defined in the site-specific work plan. A trip blank sample should accompany each shipment of soil-gas samples to the laboratory for analysis. Trip blanks assess potential sample contamination resulting from the transportation and storing of samples. Soil-gas sample analysis will generally be performed using USEPA TO-15 methodology or a project specific constituent list. Method TO-15 uses a quadrupole or ion-trap GC/MS with a capillary column to provide optimum detection limits (typically 0.5-ppbv for most VOCs).

X. References

New York State Department of Health (NYSDOH). 2005. DRAFT "Guidance for Evaluating Soil Vapor Intrusion in the State of New York" February 23, 2005.

AirToxics Ltd. "Sorbent & Solution Sampling Guide."

CITY: PETALUMA, CA DIV/GROUP: ENV DB: J. HARRIS LD:--- PIC:--- PM:(Reqd) TM:(Opt) LYR:(Opt)ON=*;OFF=*REF*
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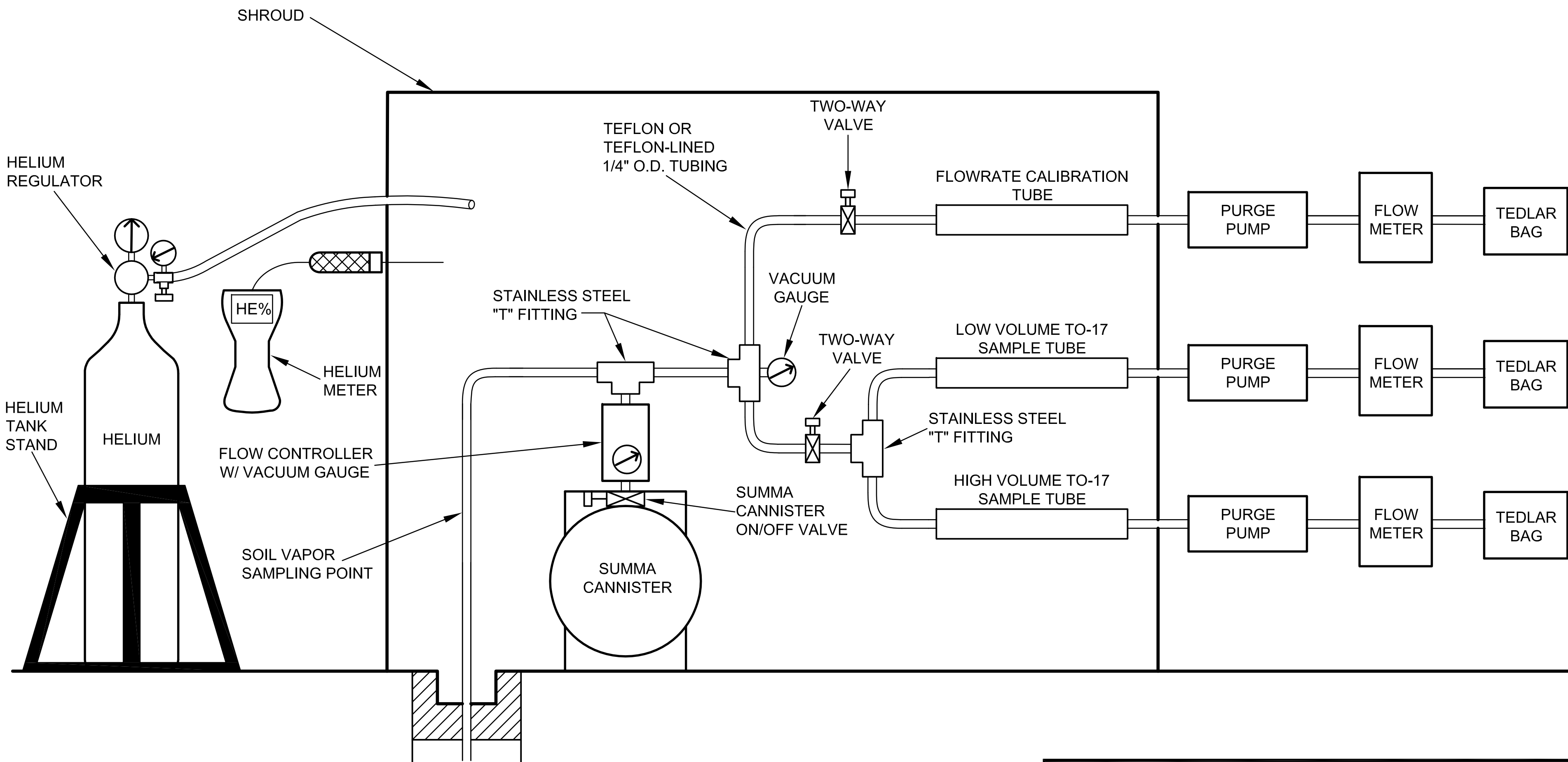

SOIL VAPOR SAMPLING EQUIPMENT ARRANGEMENT

ARCADIS

FIGURE
1