Soon I. Kwon and Hwa S. Kwon
600 Mountain Blvd.
Oakland, CA 94611

Ms. Barbara Jakub
Alameda County Environmental Health
Department of Environmental Health
1131 Harbor Bay Parkway, 2nd Floor
Alameda, CA 94502-6577

RECEIVED
By Alameda County Environmental Health at 3:50 pm, May 31, 2013

Re: 2834 East 7th Street
Oakland, California
ACEH File No. RO0002608

Dear Ms. Jakub:

The Kwons have retained Pangea Environmental Services, Inc. (Pangea) as the environmental consultant for the project referenced above. Pangea is submitting the attached report on our behalf.

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.

Sincerely,

Soon Kwon

5-9-13

PANGEA

VIA ALAMEDA COUNTY FTP SITE

December 10, 2012

Ms. Barbara Jakub
Alameda County Enviornmental Health Department
1131 Harbor Bay Parkway, Suite 250
Alameda, California 94502-6577

Re: **Workplan for Groundwater and Soil Gas Sampling**
2834 East 7th Street
Oakland, California
ACEH Fuel Leak Case No. RO0002608

Dear Ms. Jakub:

On behalf of Steve Oelschlaegel and Gunter Kitsch, Pangea Environmental Services, Inc. has prepared this *Workplan for Groundwater and Soil Gas Sampling* (Workplan) as requested in your letters dated February 28, 2011 and May 31, 2012. As requested, the Workplan proposes a temporary onsite boring to assess groundwater beneath the site and a temporary soil gas probe to evaluate vapor intrusion potential.

Assessment results will be compared to criteria established by the State Water Resources Control Board's *Low Threat Closure Policy* (LTCP), which became effective in August 2012. If assessment results meet media-specific criteria, Pangea will request regulatory case closure.

If you have any questions or comments, please call me at (510) 435-8664.

Sincerely,
Pangea Environmental Services, Inc.

Bob Clark-Riddell, P.E.
Principal Engineer

Attachment: *Workplan for Groundwater and Soil Gas Sampling*

cc: Steve Oelschlaegel, Hans and Gunter Roofing Company, 1432 Via Lucas, San Lorenzo, CA 94580
Gunter Kitsch, Hans and Gunter Roofing Company, 2325 Belvedere Avenue, San Leandro, CA 94577
Soon Il Kwon and Hwa Shim Kwon, 600 Mountain Boulevard, Oakland, CA 94611
SWRCB (Geotracker)

PANGEA

WORKPLAN FOR GROUNDWATER AND SOIL GAS SAMPLING

Steve Oelschlaegel and Gunter Kitsch
2834 East 7th Street
Oakland, California

December 10, 2012

Prepared for:

Steve Oelschlaegel and Gunter Kitsch
2834 East 7th Street
Oakland, California

Prepared by:

Pangea Environmental Services, Inc.
1710 Franklin Street, Suite 200
Oakland, California 94612

Written by:

REGISTERED PROFESSIONAL ENGINEER
ROBERT G. CLARK-RIDDELL
No. C 049629
Exp. SEPT 2014
CIVIL
STATE OF CALIFORNIA

Tina de la Fuente
Staff Scientist

Bob Clark-Riddell, P.E.
Principal Engineer

PANGEA Environmental Services, Inc.

1710 Franklin Street, Suite 200, Oakland, CA 94612 Telephone 510.836.3700 Facsimile 510.836.3709 www.pangeaenv.com

INTRODUCTION

On behalf of Steve Oelschlaegel and Gunter Kitsch, Pangea Environmental Services, Inc. has prepared this *Workplan for Groundwater and Subslab Gas Sampling* (Workplan) for the above-referenced site. The workplan was prepared in response to the February 28, 2011 and May 31, 2012 letters from Alameda County Environmental Health (ACEH). The purpose of the workplan is to assess groundwater and soil gas beneath the site.

Assessment results will be compared to criteria established by the State Water Resources Control Board's *Low Threat Closure Policy* (LTCP), which became effective in August 2012. If assessment results meet media-specific criteria, Pangea will request regulatory case closure.

SITE BACKGROUND

Site Description and Historical Use

The site is located in a mixed commercial/residential area of Oakland, California (Figure 1). The former UST was reportedly used for gasoline storage during the gasoline crisis in the 1970's. According to ACEH letter dated July 25, 2008, the site is zoned for single family residential land use. The *site is currently being used for a commercial enterprise*, with only two onsite buildings: one office building and a storage building with auto bays. Neighboring properties are a mix of residential and commercial. The property located adjacent to the site is an empty lot with storage containers trailers.

Site Investigation History

Between July and December 2003, Cambria advanced three temporary soil borings (B-1 through B-3) within the former underground storage tank (UST) cavity. The contaminant impact appears to be located within a very thin zone of silty/clayey soil beneath the bottom of the former UST. The maximum hydrocarbon concentrations detected were 270 mg/Kg TPHg and 68 mg/Kg TPHd at 10.5' depth in boring B-2. A concentration of 0.0094 mg/Kg 1,2-dibromoethane (EDB) was also detected in this sample. No other hydrocarbons or gasoline-related compounds were detected in site soil. No groundwater was encountered in the borings. Boring locations are shown on Figure 1. Soil analytical results are summarized on Table 1.

PROPOSED INVESTIGATION

The objectives of the proposed investigation are to assess groundwater and soil gas vapor beneath the site. Our proposed phased scope of work to accomplish the investigation objectives are detailed below. All field activities will be conducted in general accordance with the Standard Operating Procedures (SOPs) provided in Appendix A.

Task 1 - Pre-Field Activities

Prior to initiating field activities, Pangea will conduct the following tasks:

- Obtain drilling permits from Alameda County Public Works as necessary;
- Pre-mark the sampling locations with white paint, and notify Underground Service Alert (USA) of the drilling and sampling activities at least 48 hours before work begins;
- Prepare a site-specific health and safety plan to educate personnel and minimize their exposure to potential hazards related to site activities; and
- Coordinate with drilling and laboratory subcontractors and with involved parties.

Task 2 – Grab Groundwater Sampling

To assess groundwater, Pangea plans to advance one onsite soil boring (GW-1). As shown on Figure 1, boring GW-1 will be advanced near the former UST cavity near the former impacted boring B-2. The boring will be installed to first encountered groundwater, anticipated between 3 and 10 ft below grade surface (bgs) based on depth to water measurements from a site located across the street. A single grab groundwater sample will be collected from the sampling point using either a temporary PVC casing or a discrete-depth sampler. To help control cost, the boring will likely be completed using hand auger tools.

Pangea has noted that groundwater was not encountered in the previous deeper borings performed at the site. Therefore, Pangea will be prepared to leave the boring open for several hours or overnight, if necessary to await groundwater infiltration. If the borehole is left open overnight, Pange will secure the open borehole using a metal plate. Assuming workplan approval within 60 to 90 days, sampling can be performed within the rainy season to enhance the chances of obtaining a shallow groundwater sample. To help avoid rainwater intrusion, the boring will not be conducted if rain is forecasted within 48 hours.

Groundwater samples will be analyzed for total petroleum hydrocarbons as gasoline (TPHg), and total petroleum hydrocarbons as diesel (TPHd) by EPA Method 8015C, and for benzene, toluene, ethylbenzene, xylenes (BTEX), methyl-tertiary butyl ether (MTBE), 1,2-dibromoethane (EDB), and naphthalene by EPA Method 8260B.

Task 3 – Soil Gas Sampling

Pangea proposes to install one temporary soil gas probe (SG-1). As shown on Figure 1, the soil gas probe is proposed near the onsite office building and adjacent to the former UST. Soil gas sampling will be performed in general accordance with Pangea's Standard Operating Procedures (SOPs) for Soil Gas Sampling (Appendix A) and the *FINAL Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air* (Vapor Intrusion Guidance) prepared by California Environmental Protection Agency, Department of Toxic Substance Control (Cal/EPA) dated October 2011. The soil gas sample will be collected within a Summa canister and submitted to a state-certified laboratory for analysis. The soil gas sample will be analyzed by modified Total Organics Method 15 (TO-15) for total petroleum hydrocarbons as gasoline (TPHg); benzene, toluene, ethylbenzene, xylene(s) (BTEX), methyl-tertiary butyl ether (MTBE), 1,2-dibromoethane (EDB), naphthalene, and isopropyl alcohol (leak check compound), and for percent oxygen by ASTM D-1946. Percent oxygen is required to evaluate applicable media-specific scenarios of the LTCP.

The overall soil gas probe installation procedure involves advancing solid extensions to drill a hole to approximately 5.5 ft bgs, removing the extensions and advancing hollow extensions with new sample tubing and sampling tip to approximately 6 ft bgs, pulling the sample tip open to expose the subsurface formation, removing the hollow extensions, placing approximately 3 inches of sand around the sample tip followed by 6-inches of dry granular bentonite and hydrated bentonite to the surface. If wet soil or shallow groundwater is encountered at 6 ft bgs, the soil gas prove will be installed shallower into dry soil.

An analytical laboratory will provide sampling assemblies and certified Summa canisters for sampling and purging. The Summa canisters will come under a complete vacuum of approximately 30 inches of mercury. Prior to sample collection a vacuum/leak test will be conducted on the sampling assembly with the purging summa canister to confirm no leak and the maintenance of the initial vacuum (approximately 30 inches of mercury) in the sampling manifold system. After a minimum of 5 minutes of vacuum/leak testing, the sampling summa canister will be opened for sample collection. The pre-set valve will regulate the vapor flow to approximately 150 milliliters of air per minute, which equates to approximately 5 to 7 minutes to fill the 1-liter canister. Sample collection is typically discontinued when the vacuum decreases to below 5 inches of mercury, but not below 3 inches of mercury.

To further evaluate potential leakage within the sampling system, a leak-check enclosure will be placed over the sampling assembly, and an absorbent material will be lightly moistened with isopropyl alcohol and placed within the leak-check enclosure. A photo-ionization detector (PID) will be used to monitor the concentration of isopropyl alcohol within the enclosure during sample collection. This method allows Pangea to calculate the volume of air from within the enclosure (if any) that enters the sample summa canister by dividing the concentration of isopropyl alcohol in the sample canister by the concentration detected in the leak check Summa canister, and multiplying the resultant ratio by the volume of the sample canister.

Task 4 – Waste Management and Disposal

Soil cuttings and other investigation-derived waste will be stored onsite in appropriate containers. The investigation-derived waste will be held onsite pending laboratory analytical results. Upon receipt of the analytical reports, the waste will be transported to an appropriate disposal/recycling facility.

Task 5 – Report Preparation

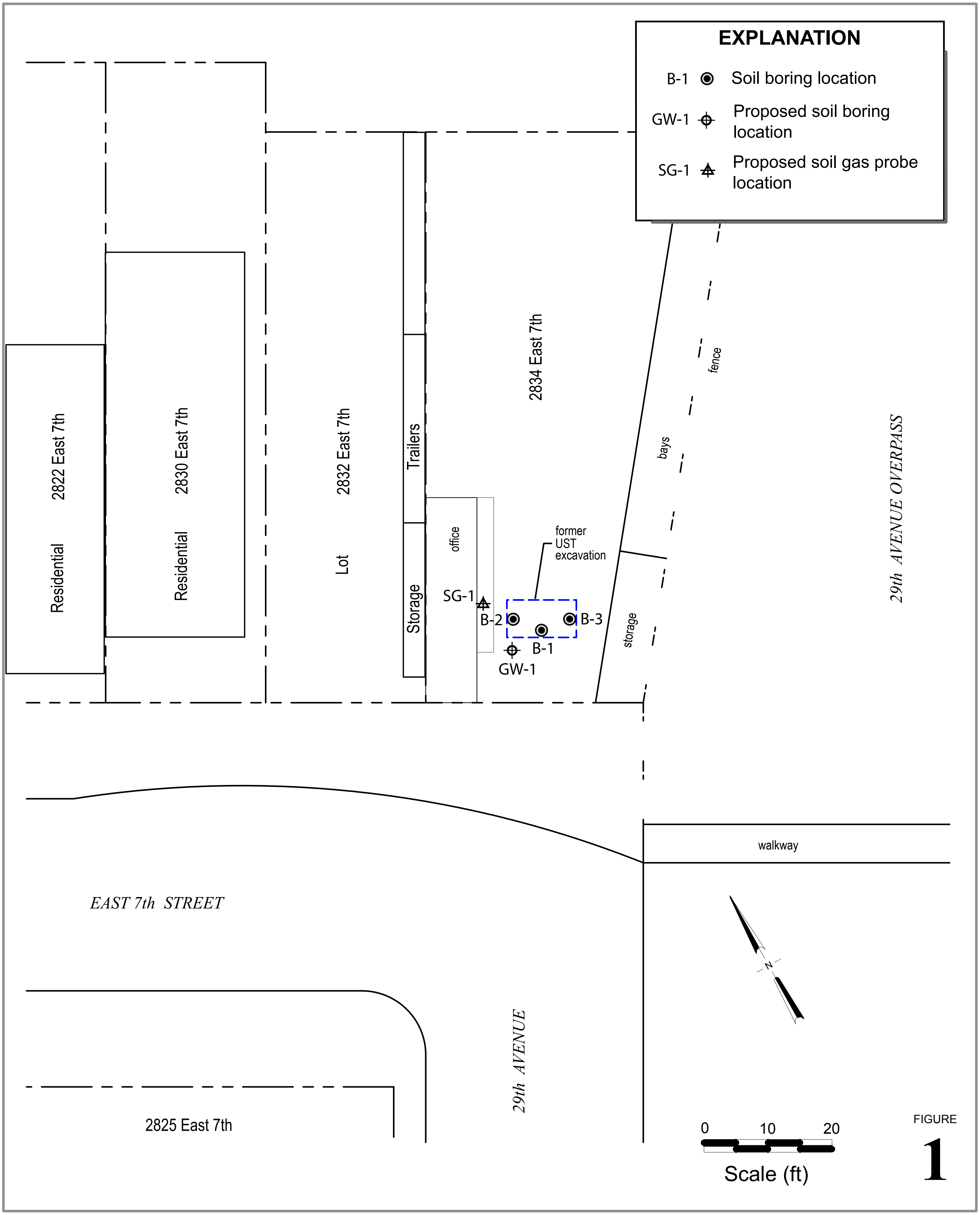
Upon completion of the proposed groundwater and soil gas sampling, Pangea will prepare a technical report. The technical report will describe the investigation activities, present analytical data, and offer conclusions and recommendations. Assessment results will be compared to criteria established by the State Water Resources Control Board's *Low Threat Closure Policy* (LTCP). If assessment results meet media-specific criteria, Pangea will request regulatory case closure. Pangea will upload the technical report to the Alameda County FTP site and State Geotracker database.

ATTACHMENTS

Figure 1 – Proposed Groundwater and Soil Gas Sampling Locations

Table 1 – Soil Analytical Data

Appendix A – Standard Operating Procedures



Former Hans & Gunther Roofing
2834 East 7th Street
Oakland, California

PANGEA

Proposed Groundwater and Soil Gas Sampling Locations

Table 1: Soil Analytical Data - Petroleum Hydrocarbons, Volatile Organic Compounds, and Metals: 2834 East 7th Street, Oakland, California

Sample ID	Date Sampled	Sample Depth (ft)	TPHg	TPHd	TPHmo	Benzene	Toluene	Ethyl-benzene	Xylenes	MTBE	Oxygenated VOCs & EDB, 1,2-DCA	VOCs	SVOCs	Cadmium	Chromium	Nickel	Lead	Zinc
			← mg/kg →			← µg/kg →								← mg/kg →				
B-1@10.5	07/29/03	10.5	< 1.0	< 1.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	--	ND	ND	<0.5	49	121	10	42
B-1@14.5	07/29/03	14.5	< 1.0	< 1.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	--	ND	--	--	--	--	--	--
B-2@8.5	12/05/03	8.5	<1.0	<1.0	<5.0	<5.0	--	--	--	<5.0	ND	--	--	--	--	--	--	--
B-2@10.5	12/05/03	10.5	**270**	68	<5.0	<5.0	--	--	--	<5.0	**9.4** EDB	--	--	--	--	--	<5.0	--
B-2@12.5	12/05/03	12.5	<1.0	<1.0	<5.0	<5.0	--	--	--	<5.0	ND	--	--	--	--	--	--	--
B-3@8.5	12/05/03	8.5	<1.0	<1.0	<5.0	--	--	--	--	--	--	--	--	--	--	--	--	--
B-3@10.5	12/05/03	10.5	91	48	<5.0	<5.0	--	--	--	<5.0	ND	--	--	--	--	--	10	--
B-3@12.5	12/05/03	12.5	<1.0	<1.0	<5.0	--	--	--	--	--	--	--	--	--	--	--	--	--
Water is a potential source of drinking water:																		
Final ESLs for Commercial Use, Soil <9.8 ft:			**83**	83	5,000	44	2,900	3,300	2,300	23	0.33 EDB	--	--	39	2,500	260	750	2,500
Ceiling Value			5,000	5,000	5,000	870,000	650,000	400,000	420,000	500,000	500,000 EDB	--	--	2,500	2,500	2,500	2,500	2,500
Direct Exposure			4,200	4,200	12,000	12,000	650,000	210,000	420,000	2,800,000	700 EDB	--	--	39	--	260	750	230,000
GW Protection (Soil Leaching)			83	83	--	44	2,900	3,300	2,300	23	390 EDB	--	--	--	--	--	--	--
Final ESLs-Comm Use, Soil >9.8 ft-Non DW:			**180**	180	5,000	2,000	9,300	5,000	11,000	23	4.4 EDB	--	--	39	5,000	260	--	5,000

Abbreviations and Methods:

ft = measured in feet

TPHg = Total petroleum hydrocarbons as gasoline (C6-C16) by analytical method SW8015Cm

TPHd = Total petroleum hydrocarbons as diesel (C10-23) by analytical method SW8015C with silica gel cleanup

TPHmo = Total petroleum hydrocarbons as motor oil (C18+) by analytical method SW8015C with silica gel cleanup

Benzene, toluene, ethylbenzene, and xylenes by analytical method SW8260B

MTBE = Methyl tertiary butyl ether by analytical method SW8260B

Oxygenated VOCs & EDB, 1,2-DCA = Oxygenated volatile organics (MTBE, DIPE, TAME, TBA, ETBE), plus 1,2-Dibromoethane (EDB) and 1,2-Dichloroethane (1,2-DCA) by analytical method SW8260B

VOCs = Volatile organics by analytical method SW8260B

SVOCs = Semi-volatile organics by analytical method SW8270D

µg/kg = Micrograms per kilogram

mg/kg = Milligrams per kilogram

ND = analyte not detected above laboratory limit. See report laboratory report for limits.

-- = Not analyzed or not applicable

EDB = 1,2-Dibromoethane by analytical method SW8260B

ESL = Environmental Screening Levels for deep soil with commercial land use where groundwater is a current or potential drinking water resource from Table C-2, established by the SFBRWQCB, Interim Final - November 2007 (Revised May 2008).

APPENDIX A

Standard Operating Procedures

STANDARD FIELD PROCEDURES FOR SOIL BORINGS

This document describes Pangea Environmental Services' standard field methods for drilling and sampling soil borings. These procedures are designed to comply with Federal, State and local regulatory guidelines. Specific field procedures are summarized below.

Objectives

Soil samples are collected to characterize subsurface lithology, assess whether the soils exhibit obvious hydrocarbon or other compound vapor odor or staining, estimate ground water depth and quality, and to submit samples for chemical analysis.

Soil Classification/Logging

All soil samples are classified according to the Unified Soil Classification System by a trained geologist, scientist or engineer working under the supervision of a California Registered Engineer, California Registered Geologist (RG) or a Certified Engineering Geologist (CEG). The following soil properties are noted for each soil sample:

- Principal and secondary grain size category (i.e. sand, silt, clay or gravel)
- Approximate percentage of each grain size category,
- Color,
- Approximate water or product saturation percentage,
- Observed odor and/or discoloration,
- Other significant observations (i.e. cementation, presence of marker horizons, mineralogy), and
- Estimated permeability.

Soil Boring and Sampling

Soil borings are typically drilled using hollow-stem augers or hydraulic-push technologies. At least one and one half ft of the soil column is collected for every five ft of drilled depth. Additional soil samples are collected near the water table and at lithologic changes. With hollow-stem drilling, samples are collected using lined split-barrel or equivalent samplers driven into undisturbed sediments beyond the bottom of the borehole. With hydraulic-push drilling, samples are typically collected using acetate liners. The vertical location of each soil sample is determined by measuring the distance from the middle of the soil sample tube to the end of the drive rod used to advance the split barrel sampler or the acetate tube. All sample depths use the ground surface immediately adjacent to the boring as a datum. The horizontal location of each boring is measured in the field from an onsite permanent reference using a measuring wheel or tape measure.

Drilling and sampling equipment is steam-cleaned prior to drilling and between borings to prevent cross-contamination. Sampling equipment is washed between samples with trisodium phosphate or an equivalent EPA-approved detergent.

Sample Storage, Handling and Transport

Sampling tubes or cut acetate liners chosen for analysis are trimmed of excess soil and capped with Teflon tape and plastic end caps. Soil samples are labeled and stored at or below 4°C on either crushed or dry ice, depending upon local regulations. Samples are transported under chain-of-custody to a State-certified analytic laboratory.

Field Screening

Soil samples collected during drilling will be analyzed in the field for ionizable organic compounds using a photo-ionization detector (PID) with a 10.2 eV lamp. The screening procedure will involve placing an undisturbed soil sample in a sealed container (either a zip-lock bag, glass jar, or a capped soil tube). The container will be set aside, preferably in the sun or warm location. After approximately fifteen minutes, the head space within the container will be tested for total organic vapor, measured in parts per million on a volume to volume basis (ppmv) by the PID. The PID instrument will be calibrated prior to boring using hexane or isobutylene. PID measurements are used along with the field observations, odors, stratigraphy and ground water depth to select soil samples for analysis.

Water Sampling

Water samples collected from borings are either collected from the open borehole, from within screened PVC inserted into the borehole, or from a driven Hydropunch-type sampler. Groundwater is typically extracted using a bailer, check valve and/or a peristaltic pump. The ground water samples are decanted into the appropriate containers supplied by the analytic laboratory. Samples are labeled, placed in protective foam sleeves, stored on crushed ice at or below 4°C, and transported under chain-of-custody to the laboratory.

Pangea often performs electrical conductivity (EC) logging and/or continuous coring to identify potential water-bearing zones. Hydropunch-type sampling is then performed to provide discrete-depth grab groundwater sampling within potential water-bearing zones for vertical contaminant delineation. Hydropunch-type sampling typically involves driving a cylindrical sheath of hardened steel with an expendable drive point to the desired depth within undisturbed soil. The sheath is retracted to expose a stainless steel or PVC screen that is sealed inside the sheath with Neoprene O-rings to prevent infiltration of formation fluids until the desired depth is attained. The groundwater is extracted using tubing inserted down the center of the rods into the screened sampler.

Duplicates and Blanks

Blind duplicate water samples are collected usually collected only for monitoring well sampling programs, at a rate of one blind sample for every 10 wells sampled. Laboratory-supplied trip blanks accompany samples collected for all sampling programs to check for cross-contamination caused by sample handling and transport. These trip blanks are analyzed if the internal laboratory QA/QC blanks contain the suspected field contaminants. An equipment blank may also be analyzed if non-dedicated sampling equipment is used.

Grouting

If the borings are not completed as wells, the borings are filled to the ground surface with cement grout poured or pumped through a tremie pipe.

Waste Handling and Disposal

Soil cuttings from drilling activities are usually stockpiled onsite on top of and covered by plastic sheeting. At least four individual soil samples are collected from the stockpiles for later compositing at the analytic laboratory. The composite sample is analyzed for the same constituents analyzed in the borehole samples. Soil cuttings are transported by licensed waste haulers and disposed in secure, licensed facilities based on the composite analytic results.

Ground water removed during sampling and/or rinsate generated during decontamination procedures are stored onsite in sealed 55 gallon drums. Each drum is labeled with the drum number, date of generation, suspected contents, generator identification and consultant contact. Disposal of the water is based on the analytic results for the well samples. The water is either pumped out using a vacuum truck for transport to a licensed waste treatment/disposal facility or the individual drums are picked up and transported to the waste facility where the drum contents are removed and appropriately disposed.

APPENDIX A

STANDARD OPERATING PROCEDURE FOR SOIL VAPOR SAMPLING

1.0 PURPOSE

This standard operating procedure (SOP) describes the procedures for collecting soil vapor samples using temporary and semi-permanent soil gas probes/wells and evacuated, stainless-steel Summa canisters. The SOP is modified from procedures and information presented in Cal/EPA 2011; Cal/EPA 2012; DiGiulio and others, 2006; DiGiulio, 2003; and discussions with laboratory director with K-Prime of Santa Rosa, California (September 2006). For any conflicts between procedures described in the SOP and guidance documents, the *Advisory-Active Soil Investigations* (Cal/EPA 2012) supercedes the SOP.

2.0 REQUIRED EQUIPMENT

- Hammer drill with fittings for installing and removing vapor probes (for direct push vapor probes)
- Vapor probes with retractable or dedicated drop-off tips (e.g. AMS SGVP) (for direct push vapor probes).
- Hand auger (for soil vapor wells)
- Tubing with Swagelok or similar threaded compression-fittings and vapor-tight caps
- Screens (for soil vapor wells)
- Filter-pack sand (for dedicated tips and soil vapor wells)
- Powdered or granular bentonite
- VOA vials
- 6-Liter Summa canister (evacuated with approximately 30” Hg vacuum) with vacuum gauge for purging and leak testing
- 1-Liter Summa canister with vacuum gauge for each sample
- Stainless-steel sampling manifold with vacuum gauges and critical orifice flow restrictor (Figure 1)
- Leak-check compound (e.g. isopropyl alcohol)
- Sampling jar and absorbent material (e.g. gauze) for leak-check compound
- Calibrated photoionization detector (PID)
- Leak-check enclosure(s) (large plastic tub with flexible weather stripping and openings for sampling enclosure atmosphere).
- Record-keeping materials
- Latex or nitrile gloves

3.0 PROCEDURES

3.1 Boring Clearance

Prior to installing soil vapor probes, ensure that a utility clearance has been conducted.

3.2 Semi-permanent Direct-Push Vapor Probe Installation

1. Use a rotary hammer drill or concrete-coring equipment to core any paved surfaces.
2. The drive rod is driven to a predetermined depth and then removed, leaving a disposable drop-off tip in the hole. The hole should be sufficiently deep that there is a minimum of 5 feet between the surface and the top of the dry bentonite overlying the sand pack (see below for details). If possible, remove the drive rod and place 3” of sand in the hole before placing the drop-off tip.
3. The inner soil gas pathway from probe tip to the surface should be continuously sealed (e.g., a sampling tube attached to the probe tip with a barbed fitting or a screw adapter with an o-ring) to prevent leakage. If a screw adapter with o-ring is used, inspect the o-ring to ensure that it is not flawed and use rigid tubing that can be tightened from the surface. The volume of the sampling

apparatus should be minimized. DTSC guidance requires that tubing should be no greater than ¼” nominal diameter.

4. Cover the probe tip with at least 3”of sand (resulting in a minimum 6” sand pack), followed by at least 6” of dry granular bentonite. Fill the remainder of the boring with hydrated bentonite. VOA vials are useful for measuring and placing these materials because they have approximately the same inside diameter as the drive rod outer diameter.

5. Equilibration Time: After probe installation, tightly cap the tubing, record probe installation time/date, and wait at least **2 hours** before conducting purge volume tests, leak tests, or soil gas sampling -- if the there is a minimum of 5 feet between the surface and the top of the dry bentonite overlying the sand pack. If there is less than 5 feet between the surface and the top of the dry bentonite overlying the sand pack, wait at least **48 hours** after probe installation and capping before conducting purge volume tests, leak tests, or soil gas sampling. If hand augering was performed to clear the probe location and there is less than 5 feet between the bottom of the auger depth and the top of the dry bentonite overlying the sand pack, wait at least **48 hours** after probe installation and capping before conducting purge volume tests, leak tests, or soil gas sampling.

6. Decontamination: Decontaminate drive rods and other reusable components between sample locations by washing equipment with a non-phosphate detergent and rinsing with tap water and/or by steam-cleaning. Use new flexible tubing for each sample point (do not reuse).

3.3 Semi-permanent Augered Vapor Well Installation

1. Use a rotary hammer drill or concrete-coring equipment to core any paved surfaces.

2. Auger to a depth sufficient to allow a minimum of 5 feet between the surface and the top of the dry bentonite overlying the sand pack (see below for details). It is recommended to use the smallest diameter auger feasible to minimize future purging volumes and optimize representativeness of soil gas data.

3. Install small diameter tubing with a short (<6” long) screened section close to the bottom of the hole. The soil gas pathway from screen to the surface should be continuously sealed (e.g., a sampling tube attached to the probe tip with a barbed fitting or a screw adapter with an o-ring) to prevent leakage. If a screw adapter with o-ring is used, inspect the o-ring to ensure that it is now flawed and use rigid tubing that can be tightened from the surface. The volume of the sampling apparatus should be minimized. DTSC guidance requires that tubing should be no greater than ¼” nominal diameter.

4. For deep wells (>10 feet) install a down-hole rod or other support to ensure that the screened section remains at the proper depth.

5. Cover the screened section with at least 6” of sand, followed by at least 6” of dry granular bentonite. Ensure that the screened section is near the center of the sand pack. Fill the remainder of the boring with hydrated bentonite. The bentonite should be hydrated at the surface and poured into the borehole.

6. Equilibration Time: After probe installation, tightly cap the tubing, record probe installation time/date, and wait at least **48 hours** before conducting purge volume tests, leak tests, or soil gas sampling:

7. Decontamination: Decontaminate drive rods and other reusable components between sample locations by washing equipment with a non-phosphate detergent and rinsing with tap water and/or by steam-cleaning. Use new flexible tubing for each sample point (do not reuse).

3.4 Temporary Vapor Probe Installation Using Post Run Tubing Method

1. This method should only be used for qualitative assessments due to the possibility of vapor leaks along the drive rods. This method should not be used when sampling in coarse granular materials due to potential leakage along the probe.
2. Use a rotary hammer drill or concrete-coring equipment to core any paved surfaces.
3. The drive rod is driven to a predetermined depth (generally 5.5 feet minimum) and then pulled back to expose the inlets of the soil gas probe by exposing a short screened section.
4. The inner soil gas pathway from probe tip to the surface should be continuously sealed (e.g., a sampling tube attached to the probe tip with either a barbed fitting or a screw adapter with an o-ring) to prevent leakage. If a screw adapter with o-ring is used, replace o-rings daily and inspect them for flaws before installing each probe. Use rigid tubing that can be tightened from the surface to ensure that the o-ring is properly sealed. The volume of the sampling apparatus should be minimized. DTSC guidance requires that tubing should be no greater than ¼" nominal diameter.
5. Hydrated bentonite should be used to seal around the drive rod at the ground surface to prevent ambient air intrusion
6. Equilibration Time: After probe installation, tightly cap the tubing, record probe installation time/date, wait at least **2 hours** before conducting purge volume tests, leak tests, or soil gas sampling.

3.5 Vapor Sample Collection

During vapor sampling, record all valve open/close times and canister/manifold vacuum readings at each step. Do not conduct sampling within **5 days following a significant rain event** (0.5 inches of rainfall during any 24-hour period).

<u>Setup</u>

1. **Calculate volume of probe and sampling setup.** Calculate and record the volume of the sampling assembly, tubing, vapor probe, and any permeable air-, sand-, or dry bentonite-filled annular space around the vapor probe tip.

   One Purge Volume = $\prod * r^2 * L = 3.14 \times (1/2*ID) \times (1/2*ID) * L$,

   where ID = tubing or manifold inside diameter and L = length of tubing/manifold/borehole segment.

   - 1/8" ID tubing volume = 2.4 ml/ft,
   - 1/4" ID tubing volume = 9.7 ml/ft,
   - 1/4" OD (0.17" ID) tubing volume = 4.5 ml/ft
   - 2-1/8" auger boring volume = 697 ml/ft * 0.4 = 278 ml/ft (sand) minus tubing volume
   - 2-1/8" auger boring volume = 697 ml/ft * 0.5 = 349 ml/ft (dry bentonite) minus tubing volume
   - 3-1/4" auger boring volume = 1631 ml/ft * 0.4 = 652 ml/ft (sand) minus tubing volume
   - 3-1/4" auger boring volume = 1631 ml/ft * 0.5 = 816 ml/ft (dry bentonite) minus tubing volume

Sample Purge Volumes

Item	One Purge Volume (approx)	Three Purge Volumes	Ten Purge Volumes
¼" ID tubing (10 ft)	100 ml	300 ml	1,000 ml
¼" ID tubing (10 ft) with 6" dry bentonite and 6" sand, inside 3-1/4" diameter auger boring	830 ml	2,500 ml	8,300 ml
¼" ID tubing (10 ft) with 1 ft dry bentonite and 1 ft sand, inside 3-1/4" diameter auger boring	1,550 ml	4,650 ml	15,550 ml

2. Wear latex or nitrile gloves while handling sampling equipment. Change gloves whenever a new sample is collected and after handling leak-check compound.
3. Replace the vapor probe cap with a closed Swagelok valve. Connect the sampling manifold to the vapor probe, *sample* Summa canister *and purge* Summa canister using Swagelok fittings and stainless-steel, nylon, or Teflon tubing. Check all fittings for tightness (do not over-tighten).
4. Close all valves. Record pre-test vacuum readings on both canisters.

<u>Manifold Shut-In Leak Check</u>

1. Open both manifold valves and valve on purge Summa canister. Do *not* open valve on sample port. Allow manifold/tubing vacuum to stabilize at approximately 30" Hg.
2. Close purge canister valve and conduct a shut-in test by waiting at least 5 minutes. Monitor manifold vacuum gauge to test for leaks. If the vacuum decreases, rectify the leak before proceeding.

<u>Purge, Sample and Leak Check</u>

1. **Calculate purge volume and duration**. Determine the desired total purge volume and purging duration for the equipment setup. As shown on Figure 1, a critical orifice flow restrictor is intended to limit the maximum purge and sampling flow rate (approximately 120 ml/min). Purge volumes should be determined in one of the following ways:

   a) For vapor sampling in support of risk-assessments for regulatory review, a step-purge test should be conducted at a "worst case" sampling point, using 1, 3 and 10 purge volumes (including tubing, sampling assembly and annular space) to determine the appropriate volume that yields the highest target compound concentration.

   b) For collecting samples from depths of 5 feet or less, or if step purge tests yield no detectable target compounds, use a default purge of approximately 3 purge volumes (including tubing, sampling assembly and annular space).

   c) For semi-permanent wells subject to frequent sampling, purge 1 volume only of the tubing and manifold volume (not including the dry bentonite or sand pack section) after waiting at least 2 weeks following the previous sampling event.

   Example purge time calculation: Assume 1 purge volume of 831 ml (¼" ID tubing (10 ft) with 6" dry bentonite and 6" sand, inside 3-1/4" diameter auger boring). To purge 3 purge volumes of initial 831 ml purge volume, total purge volume is 3 x 831 ml = approx. 2,500 ml. 2,500 ml divided by 120 ml/min = 21 minutes.

2. **Conduct purging.** Open purge-canister valve and vapor probe valve. Do *not* over-purge. Monitor the vacuum on the probe-side and purge canister-side vacuum gauges. If the probe-side vacuum remains below approximately 7” Hg, then sufficient flow is present to collect a representative sample (Cal/EPA 2012) and continue purging for the planned purge duration.
3. If the probe-side vacuum exceeds approximately 7” Hg, then insufficient flow is present to collect a representative sample and this condition should be noted (Cal/EPA 2012). Refer to Cal/EPA 2012 for guidance regarding collecting samples under low flow conditions. A sample may be collected for qualitative screening purposes only. For more representative sampling, conduct additional purging and allow two weeks of re-equilibration before then purging 1 tubing volume and collecting a soil gas sample.
4. Optional flow check. If the probe-side vacuum exceeds approximately 7” Hg, temporarily close the canister valve and record the elapsed time after valve closure for the manifold vacuum to drop to 5” Hg vacuum. This information can be used to estimate the probe vacuum and flow rate. Also, if no significant flow is attained, either the sampling line is plugged or the vapor probe is positioned in an impermeable or saturated layer. If the probe cap is opened for probe inspection, record the inspection procedures and duration. If purging and sampling is resumed after opening the probe cap this information will help determine the representativeness of the sample. This flow check can be performed at the beginning, middle and/or end of the purging process.
5. When purge duration complete and ready to discontinue purging, close purge canister valve.
6. **Leak-check enclosure.** Place absorbent materials (e.g., gauze) moistened with leak-check compound (isopropyl alcohol) in an open container (i.e.uncapped sampling jar) adjacent to the vapor probe. Do not allow liquid to come in direct contact with tubing or sampling assembly.
7. Place leak-check enclosure over vapor probe, floor/ground penetration, Summa canister/manifold assembly, and leak check container, and seal to floor using weatherstripping or duct tape or weight so that perimeter is sealed to ground surface.
8. Measure and record the observed PID reading for the leak-check vapor through a small hole in the leak-check enclosure. If the PID reading is below 2 ppm, reapply leak-check compound. Note that the isopropyl alcohol response factor is approximately 5.6 (i.e. a reading of 2 ppm on a PID calibrated with isobutylene indicates 5.6 x 2 = 11.2 ppm of isopropyl alcohol in the sample).
9. **Sample collection.** Once at least a 2 ppm PID reading has been reached, open sample canister valve. Sampling should take approximately 5 minutes for a 1-liter Summa canister and 30 minutes for a 6-liter canister.
10. Record PID reading for leak-check enclosure approximately every 2 minutes during purging and sampling. Slowly reapply leak-check compound if PID reading drops more than 20% below initial readings.
11. Close sampling canister valve when vacuum decreases to between 3” and 5” mercury. Do *not* allow vacuum to fall below this range.
12. If quantitative leak information is desired, use a 1-liter Summa canister and sampling manifold to collect a sample from the leak-check enclosure during the same period that sampling is conducted. Submit this canister to laboratory ‘on hold’. If significant leak check compound detected by laboratory in the sampling canister, request laboratory analysis for leak-check compound only within this leak-check canister.
13. Disassemble sampling assembly, and cap (or remove and restore) vapor sampling point.
14. Fill out chain-of-custody form, including analysis for chemicals of concern and leak-check compound. Also analyze for oxygen. Include final vacuum reading and serial numbers of canister and flow restrictor.

15. For vapor sampling in support of risk-assessments for regulatory review, collect at least one duplicate sample per site per sampling event from the sampling point with the anticipated highest vapor concentrations. The duplicate sample should be collected by attaching a fresh sample canister following collection of the initial sample. If a new manifold is used, follow the same purging and sampling procedures used for the original sample. If the same manifold is used, collect a sample without further purging, using the same sampling procedures used for the original sample.

Decontamination and Decommissioning

16. Use a decontaminated sampling manifold and new tubing for each sample location. Return equipment to laboratory for decontamination.
17. Backfill any open soil vapor probe holes with bentonite slurry.

REFERENCES

Cal/EPA, 2011, Guidance for the evaluation and mitigation of subsurface vapor intrusion to indoor air (vapor intrusion guidance), California Environmental Protection Agency, Department of Toxic Substances Control, October).

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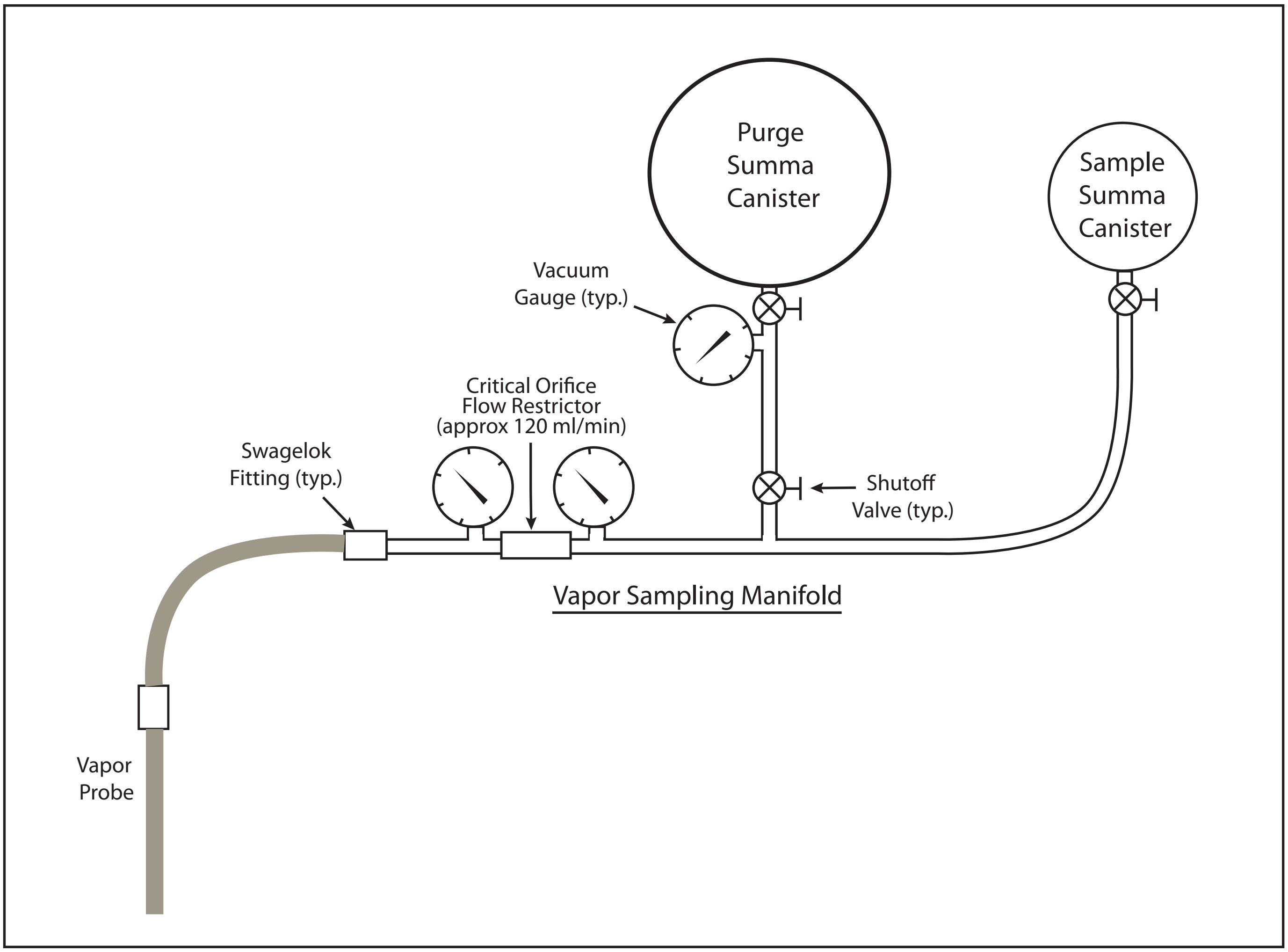

Figure 1. Soil Vapor Sampling Manifold Schematic