MEMORANDUM

To: Mark Chandler, Vice President Environmental Services, TOC Holdings Co. (TOC)
2737 W. Commodore Way; Seattle, Washington 98199

From: Craig Hultgren

Date: February 5, 2016

Subject: TOC Holdings Co; Facility No. 01-323; 301 North Central Avenue; Kent, Washington
Tier II Vapor Assessment Workplan

Background

HydroCon Environmental LLC (HydroCon) completed a subsurface investigation and additional subsurface investigation (SI and ASI) at the subject property (the Property) in 2015[1,2] for the purpose of determining the extent of petroleum-hydrocarbon contamination that resulted from the historical uses of the Property for fuel storage and dispensing. An additional objective (HydroCon 2015b) was to conduct a Tier I Vapor Assessment (VA) in accordance with the latest state and federal guidance[3,4]. The regional location of the Property is shown in Figure 1.

This Tier II VA Work Plan was prepared in response to the findings of the Tier I VA conducted by HydroCon as part of the ASI completed in December 2015. The Tier I VA revealed petroleum hydrocarbon concentrations in soil gas at the Property that exceed the current Washington State Department of Ecology (Ecology) sub-slab soil gas screening levels (Ecology 2009). The combined findings of the SI and ASI for all sampled media (soil, groundwater, soil gas, and indoor air) will be incorporated into a draft remedial investigation/feasibility study (RI/FS) report being prepared by HydroCon for publication during the First Quarter of 2016. A summary of the historical site operations that are the sources for the observed petroleum hydrocarbon contamination is provided in the footnoted documents (HydroCon 2015a, 2015b).

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[1] *HydroCon. 2015a. Subsurface Investigation Report; TOC Holdings Co. Site 01-323; 301 North Central Avenue, Kent, Washington. November 5.*

[2] *HydroCon. 2015b. Additional Subsurface Investigation Scope of Work; TOC Holdings Co. Facility No. 01-323; 301 North Central Avenue; Kent, Washington. November 23.*

[3] *Washington State Department of Ecology (Ecology). 2009. Guidance for Evaluating Soil Vapor Intrusion in the Washington State – Investigation and Remedial Action; Publication No. 09-09-047. Toxics Cleanup Program. October. Table B-1 Updated April 2015.*

[4] *U.S. Environmental Protection Agency (EPA). 2015. Technical Guide for Addressing Petroleum Vapor Intrusion at Leaking Underground Storage Tank Sites (EPA -510-R-15-001). Office of Underground Storage Tanks. June.*

The Tier I VA soil gas sample locations (SG01, SG02, and SG03) are shown on the site plan provided in Figure 2. A summary of the analytical results for these samples compared to the Ecology sub-slab soil gas screening levels is provided in Table 1. The analytical results reveal concentrations of petroleum hydrocarbons in soil gas significantly higher than the Ecology sub-slab soil gas screening levels. According to Ecology guidance (2009), if the Tier I assessment indicates that there are volatile toxic substances at the site, that the subsurface contamination is close to one or more occupied or future buildings, and that the contamination is significant enough to pose a threat to indoor air quality, investigators should continue the pathway [indoor air] assessment. Based on affirmative findings for all of these criteria from the Tier I VA, HydroCon recommends that TOC conduct a Tier II VA. The Tier II assessment, which is the subject of this work plan, involves determining the concentrations of volatile chemicals indoors for comparison to concentrations deemed "acceptable" based on Ecology's risk-based exposure concentrations.

Scope of Work

The proposed work breakdown structure for the Tier II VA consists of four primary tasks that are described in the following subsections:

- Refine Conceptual Site Model
- Prepare Sampling and Analysis Plan (SAP)
- Implement Stakeholder-Approved SAP
- Reporting

Refine Conceptual Site Model

HydroCon will compile data needed to refine a conceptual site model (CSM). The CSM is used to organize and communicate information about site characteristics for the purpose of streamlining future data collection efforts. Data to be compiled to prepare the CSM includes:

- Historical property uses including chemicals of concern and their physical and chemical properties;
- Site soils, geology, and hydrogeology;
- Locations on the Property where releases of chemicals are documented;
- Current site improvements (buildings, parking, utilities);
- Building location and ownership;
- Building characteristics;
- Adjacent property uses;
- Building materials and construction foundation characteristics (e.g. concrete slab-on-grade; crawl space; spread footings, basement, wood frame);
- Building heat, ventilation and air conditioning (HVAC) methods and air flow;

- Inventory of products in use in the building that have the potential to affect indoor air quality;
- Types and locations of utilities;
- Detailed floor plan(s) for building(s); and
- Locations of preferential or potential indoor vapor migration pathways in floor or foundation (e.g. cracks in floor, pipe or other utility penetrations

HydroCon's General Building Survey form found in the Vapor/Indoor Air (VIA) Standard Operating Procedure (SOP) 4, "Indoor Air Sampling" (Attachment) will be used to compile and document data with which to refine the CSM. The CSM will be completed prior the preparation of the final Tier II VA SAP.

Prepare Sampling and Analysis Plan

HydroCon will prepare a draft and final SAP based on the refined CSM completed in the previous task. The types, locations, and numbers of samples to be collected will be defined in the final SAP, together with the sampling procedures and analytical methods. The sampling and analytical protocols will be according to current state and federal guidelines (Ecology 2009, updated April 2015; EPA 2015). Although the SAP is not able to be finalized until the CSM is completed, the following activities are likely to be included in the SAP:

- Collecting indoor air samples in one or more rooms of the existing site building.
- Collecting indoor air samples from the vicinity of selected utility penetrations through the concrete slab foundation of the building (if construction is slab-on-grade).
- Collecting an HVAC system intake manifold sample from the building.
- Collecting outdoor ambient air samples from up-wind breathing zones adjacent to exterior walls of the building and at an upwind onsite location remote from the building.
- Collecting sub-slab soil gas samples if the building has a slab-on-grade construction.
- Collecting meteorological data (i.e. wind speed and direction, and barometric pressure) for selected sampling areas both within and outside the building complex.

Preliminary sampling activities and sampling locations for each of the proposed sample types are presented below.

Indoor Air Samples

HydroCon will collect one or more indoor air samples inside the existing restaurant building. Indoor air samples will be collected in six-liter SUMMA canisters in accordance with VIA SOP 4 for Indoor Air Sampling (Attachment). Samples will be collected in locations where no chemicals that may contain VOCs are stored.

Indoor Air Samples – Concrete Slab Utility Penetration Areas

HydroCon will collect indoor air samples in locations biased towards observed slab or foundation penetrations for utilities or floor drains. Indoor air samples will be collected in six-liter SUMMA canisters in accordance with VIA SOP 4 for Indoor Air Sampling. Possible sample locations are the following:

- Restrooms, maintenance and utility rooms, and chemical storage locations.

Outdoor Air Samples – Rooftop HVAC System Intake and Exhaust Areas

HydroCon will collect an outdoor air sample where the HVAC system intake manifolds are located. The outdoor air sample will be collected in a six-liter SUMMA canister in accordance with VIA SOP 5, “Ambient Outdoor Air Sampling” (see Attachment). Sample height will be dependent on the intake vent feature selected for sampling. Sample location will be dependent on the prevailing wind direction on the day of the field activities.

Outdoor Air Samples – Upwind Exterior Breathing Zone Areas

HydroCon will collect outdoor air samples at an undetermined number of upwind locations. One or more sample locations will be adjacent to the exterior walls of the building. Other samples will be situated away from the building near the upwind property boundary. Outdoor air samples will be collected in six-liter SUMMA canisters in accordance with VIA SOP 5 for ambient outdoor air sampling. Sample heights will be within the average breathing zone between three to six feet above ground surface. Sample locations will be dependent on the prevailing wind direction on the day of the field activities.

Sub-Slab Soil Vapor Samples

HydroCon will collect sub-slab soil gas samples where minimal disturbance to flooring materials (e.g. carpet or tile) will be necessary. Locations will be selected based on their proximity to indoor air sample locations discussed above. Sub-slab soil vapor samples will be collected in one-liter SUMMA canisters in accordance with VIA SOP 1 and 2 for soil gas sampling and sub-slab probe installation (Attachment).

Barometric Pressure Monitoring

HydroCon will collect barometric pressure data at selected indoor and outdoor locations for an eight-hour period during the monitoring event. Data collected during the pressure monitoring event will be used to determine if positive, negative, or neutral pressure conditions exist in the building.

Laboratory Analytical Methods

Indoor air, outdoor air, and sub-slab vapor samples will be submitted to the Eurofins Air Toxics Laboratory in Folsom, California under chain-of-custody for VOC analysis by EPA Method TO-15 SIM and the Ecology volatile petroleum hydrocarbons (VPH) and airborne petroleum hydrocarbon (APH) methods. Table 2 summarizes the VOCs to be analyzed, the analytical method and the required minimum method reporting limits.

Stakeholders will have an opportunity to review and comment on the draft SAP. HydroCon will prepare the final SAP including the proposed sampling and reporting schedule based on the stakeholder review comments on the draft SAP.

Implement Stakeholder-Approved Sampling and Analysis Plan

HydroCon will implement the approved SAP in accordance with the required schedule.

Reporting

HydroCon will prepare a draft Tier II VA Report that includes the results of the above tasks for stakeholder review and finalize the report to incorporate stakeholder comments.

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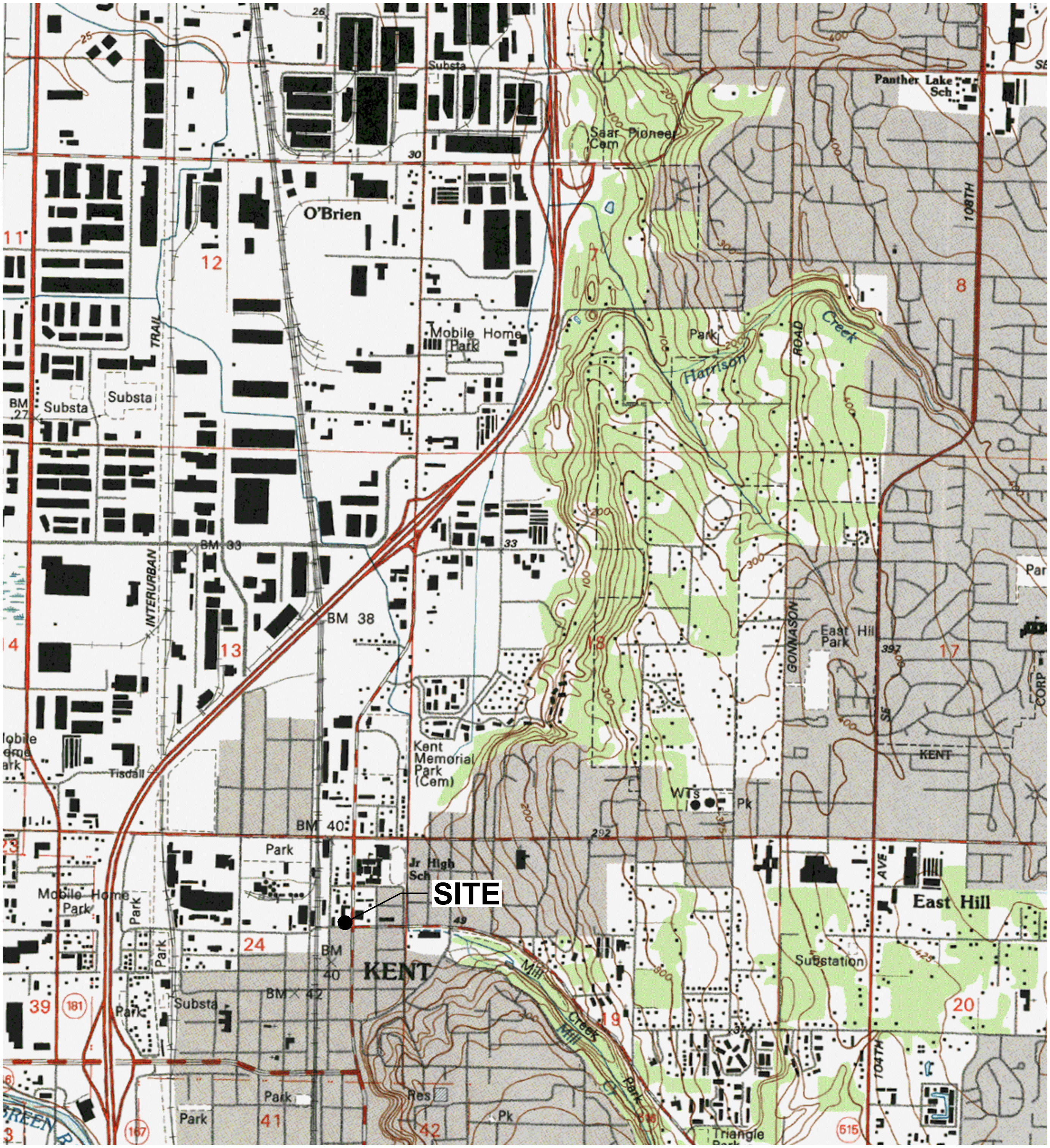
FIGURES



NOTE(S):
USGS, RENTON QUADRANGLE
WASHINGTON-KING CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)

0 2000 4000
SCALE IN FEET
1" = 2000'

N
W E
S

Hydro Con

DATE: 9-8-15
DWN: JJT
CHK: NV
APPROVED: CH
PRJ. MGR: RH
PROJECT NO:
01-323

FIGURE 1
SITE LOCATION MAP

TOC HOLDING CO. FACILITY NO. 01-323
301 N CENTRAL AVE
KENT, WA.

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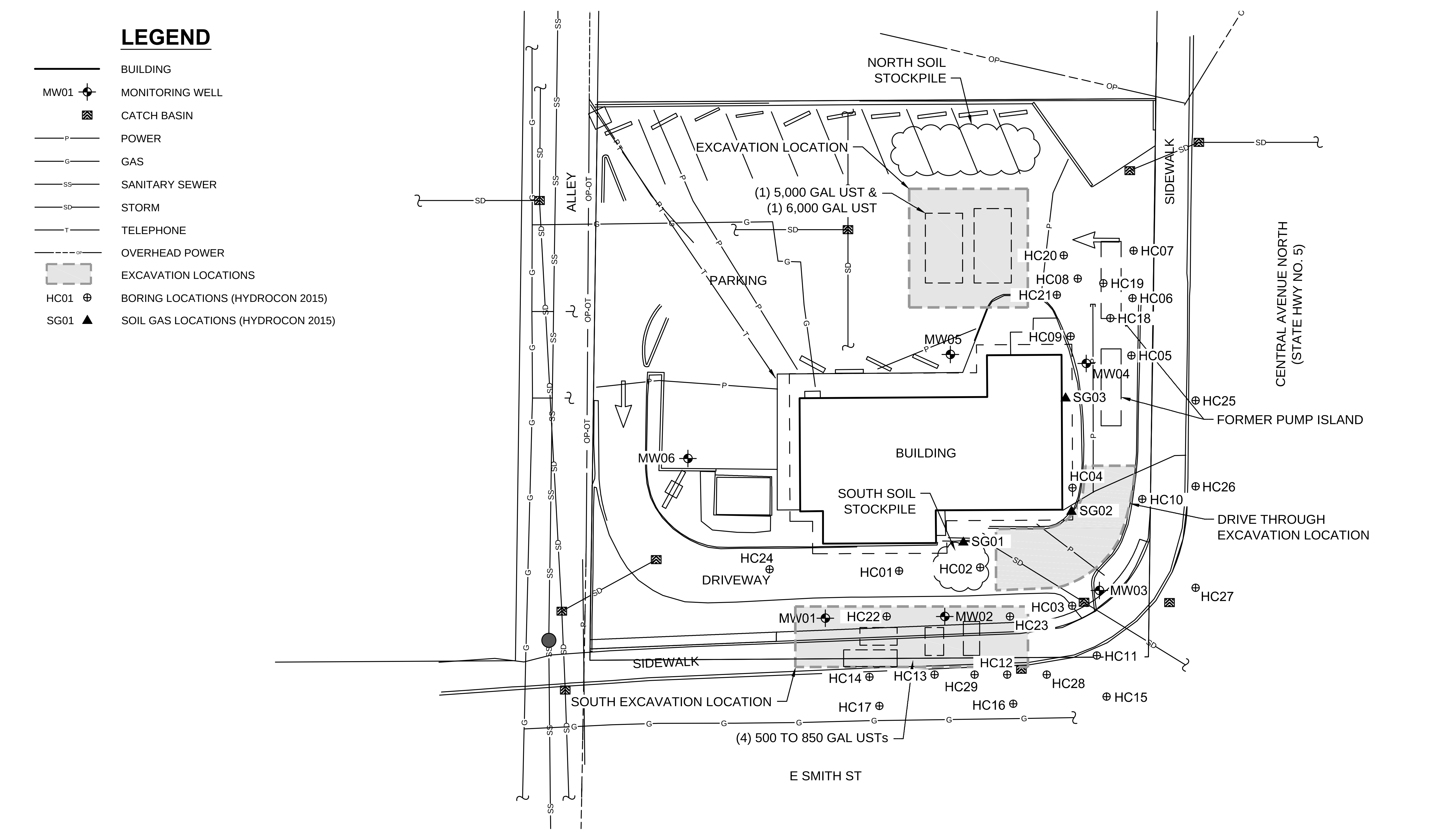

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N W E S

0 20 40
SCALE IN FEET
1" = 20'

Hydro Con
510 Allen St. Suite B Kelso, Wa 98626, Ph(360)-703-6086

DATE: 2-2-16
DWN: JJT
CHK: NV
APPROVED: CH
PRJ. MGR: CH
PROJECT NO: 01-323

FIGURE 2
SITE FEATURES AND UTILITIES

TOC HOLDING CO. FACILITY NO. 01-323
301 N CENTRAL AVE
KENT, WA.

TABLES

Table 1
Summary of Tier I Soil Gas Analytical Results
TOC Holdings Co. Facility No. 01-323
301 North Central Avenue; Kent, Washington

		Analytical Results ($\mu g/m^3$)					Washington State Department of Ecology Screening Levels[1]	
		Sample IDs						
	Sample Date	12/28/2015	12/28/2015	12/28/2015	12/28/2015			
Analyte	Method	SG-01	SG-01 1/200	SG-02 1/1000	SG-03	APH Method Blank	Sub-Slab Soil Gas Screening Level Method B Noncancer ($\mu g/m^3$)	Sub-Slab Soil Gas Screening Level Method B Cancer ($\mu g/m^3$)
benzene	EPA TO-15	**1,200 ve**	**6,600**	**6,600**	3.4	<0.64	4.57E+02	1.07E+01
dichloroethane;1,2- (EDC)	EPA TO-15	**63**	<320	<1,600	<1.6	<1.6	1.07E+02	3.21E+00
ethylbenzene	EPA TO-15	260 ve	860	**36,000**	6.2	<1.7	1.52E+04	
ethylene dibromide (EDB)	EPA TO-15	<0.77 j	<154 j	<770 j	<0.77 j	<0.77 j	1.37E+02	1.39E-01
hexane; n-	EPA TO-15	9,900 ve	**110,000 ve**	**820,000 ve**	170	<7	1.07E+04	
methyl tert-butyl ether	EPA TO-15	<1.4	<290	<1,400	<1.4	<1.4	4.57E+04	3.21E+02
naphthalene	EPA TO-15	<2.1	<420	<2,100	**2.6**	<2.1	4.57E+01	2.45E+00
toluene	EPA TO-15	1,900 ve	9,200	2,900	8.5		7.62E+04	
trimethylbenzene; 1,2,4-	EPA TO-15	85	<400	<3,900	<3.9	<3.9	1.07E+02	
xylene; m-[2]	EPA TO-15	**1,600 ve**	**4,800**	**7,600**	27	<3.5	1.52E+03	
xylene; o-	EPA TO-15	630 ve	**1,700**	<1,700	10	<1.7	1.52E+03	
APH [EC5-8 aliphatics] fraction	APH		**2,300,000 ve**	**140,000,000 ve**	1,200 ve	<23	9.00E+04	
APH [EC9-12 aliphatics] fraction	APH		**200,000 ve**	**54,000,000 ve**	3,800 ve	<35	4.70E+03	
APH [EC9-10 aromatics] fraction	APH		830	**410,000**	39	<5	6.00E+03	

Bold red = result exceeds the Ecology subslab soil gas screening level concentration

[1] Washington State Department of Ecology (Ecology). 2009. Guidance for Evaluating Soil Vapor Intrusion in the Washington State – Investigation and Remedial Action; Publication No. 09-09-047. Toxics Cleanup Program. October. Table B-1 Updated April 2015.

[2] Referenced Ecology screening level is for only m-xylene; analytical result reports the sum of m- and p-xylenes

ve = the analyte response exceeded the valid instrument calibration range. The value reported is an estimate

j = the analyte concentration is reported below the lowest calibration standard. The value reported is an estimate.

Table 2
Tier II Vapor Assessment Analyte List and Required Detection Limits
TOC Holdings Co. Facility No. 01-323
301 North Central Avenue; Kent, Washington

Analyte	Analytical Method	Ecology Screening and Cleanup Levels Applicable to the Tier II Vapor Assessment [1]			
		2015 Indoor Air Cleanup Level[2] Method B Noncancer (µg/m³)	2015 Indoor Air Cleanup Level[2] Method B Cancer (µg/m³)	2015 Sub-Slab Soil Gas Screening Level[3] Method B Noncancer (µg/m³)	2015 Sub-Slab Soil Gas Screening Level[3] Method B Cancer (µg/m³)
benzene	EPA TO-15	1.37E+01	3.21E-01	4.57E+02	1.07E+01
dichloroethane;1,2- (EDC)	EPA TO-15	3.20E+00	9.62E-02	1.07E+02	3.21E+00
ethylbenzene	EPA TO-15	4.57E+02		1.52E+04	
ethylene dibromide (EDB)	EPA TO-15	4.11E+00	4.17E-03	1.37E+02	1.39E-01
hexane; n-	EPA TO-15	3.20E+02		1.07E+04	
methyl tert-butyl ether	EPA TO-15	1.37E+03	9.62E+00	4.57E+04	3.21E+02
naphthalene	EPA TO-15	1.37E+00	7.35E-02	4.57E+01	2.45E+00
toluene	EPA TO-15	2.29E+03		7.62E+04	
trimethylbenzene; 1,2,4-	EPA TO-15	3.20E+00		1.07E+02	
xylene; m-	EPA TO-15	4.57E+01		1.52E+03	
xylene; o-	EPA TO-15	4.57E+01		1.52E+03	
VPH [EC5-6 aliphatics + EC6-8 aliphatics] fraction	VPH	2.70E+03			
VPH [EC8-10 aliphatics + EC 10-12 aliphatics] fraction	VPH	1.40E+02			
VPH [EC8-10 aromatics + EC10-12 aromatics] fraction minus [naphthalene]	VPH	1.80E+02			
APH [EC5-8 aliphatics] fraction	APH	2.70E+03		9.00E+04	
APH [EC9-12 aliphatics] fraction	APH	1.40E+02		4.70E+03	
APH [EC9-10 aromatics] fraction	APH	1.80E+02		6.00E+03	

[1] Washington State Department of Ecology (Ecology). 2009. Guidance for Evaluating Soil Vapor Intrusion in the Washington State – Investigation and Remedial Action; Publication No. 09-09-047. Toxics Cleanup Program. October. Table B-1 Updated April 2015.

[2, 3] If there are two cleanup levels for an analyte, the lower of the two is the required mininum detection limit for the analytical method requested

ATTACHMENTS

STANDARD OPERATING PROCEDURE
SOIL GAS (VAPOR) MONITORING AND SAMPLING
VIA SOP 1

This vapor intrusion assessment (VIA) standard operating procedure (SOP) describes procedures for performing soil gas (vapor) monitoring and sampling using direct-push drilling technology. Because each site is unique, these procedures should be viewed as guidelines and will likely require modification based on site and subsurface conditions present.

Personnel performing the soil gas monitoring and sampling will follow site safety procedures as specified in the site-specific Health and Safety Plan.

EQUIPMENT

Soil gas monitoring and sampling will be performed using direct push sampling equipment. The direct push probe will be advanced using either a truck- or track-mounted Geoprobe rig, or for limited access areas, using portable methods such as rotary hammer drill (rotohammer).

Coring/probe installation equipment which may be used includes the following: a rotohammer or truck-mounted Geoprobe rig, ½-inch to 2-inch diameter concrete coring drill bit, cloth (for dust suppression during drilling), Geoprobe drill rods, ¼-inch diameter tubing (nylon, stainless steel, or Teflon®), fine-grained (20-40) silica sand, granular bentonite grout or alternative, and possibly cement in cases where the formation has a very low permeability.

Leak check equipment using helium or other pre-approved non-reactive tracer gas may include: helium tank, piping, three-way valve, leak check enclosure (shroud), helium detector, paper towels or rags, and nitrile gloves.

Monitoring/sampling equipment which may be used includes the following: Summa canister (may be a one-liter or six-liter Summa canister with valve), certified flow controller, steel filter, three-way valve, extra miscellaneous valves, photo ionization detector (PID), low flow vacuum pump, vacuum gauge, barometer/thermometer/wind speed indicator.

CORING/PROBE INSTALLATION PROCEDURES

Prior to drilling or coring, an attempt will be made to locate utility lines and if inside a building, to determine whether or not the building has an existing vapor barrier or a tensioned slab.

When samples are collected beneath buildings, a minimum of one sample and one sample duplicate will be collected from beneath each building. If possible, the samples will be located in the central portion of the slab, away from the floor slab/perimeter foundation junction, where dilution is more likely to occur.

In each sample location, a small diameter (½-inch to one-inch) hole will be drilled in the foundation using a rotohammer, truck-mounted Geoprobe rig, or concrete corer. When drilling the hole, no water should be used and care should be taken not to puncture the surface of soil underneath. If dust prevention is necessary, cover the location with a cloth or towel and drill through a pre-cut small hole in the cloth.

The probes are typically advanced to a depth of five feet below ground surface (bgs), however, other site-specific depths or multiple depths for vertical soil gas profiling may be targeted by the work plan. At target depth, the probe rod will be withdrawn approximately three to six inches to disengage the expendable probe tip and minimize the terminal void space volume. New, dedicated disposable nylon, stainless steel, or Teflon® tubing would then be fitted with a barbed steel end nut, pushed into the base of the probe rod, and threaded onto a downhole terminal fitting sealed with an O-ring to prevent vapor short-circuiting to the surface through the rod annulus.

Once the sampling probe is lowered to target depth and probe tip is exposed, the borehole shall be backfilled with sand to a depth of 2 feet above the sampling probe. The area above the sand and immediately around the probe rods shall be grouted using hydrated bentonite grout (if temporary installation) or cement (if permanent installation). Wait 30 minutes prior to sampling for bentonite or cement to congeal. VOC-free modeling clay may also be used to seal around the probe rods to prevent vapor short-circuiting to the surface.

Procedures for leak checking, soil gas purging, and sampling are described in the section below.

Following the completion of sampling, the soil boreholes will be filled with hydrated granular or powdered bentonite grout. If a building slab or pavement is present, the hole(s) will be patched with cement and finished flush with the surface.

SYSTEM SETUP

Inspect the laboratory-provided Summa canister for damage prior to use. Do not use a canister that has visible damage.

Using a wrench, remove the brass cap above the valve on the top of the Summa canister. Measure and record the initial vacuum of Summa canister. If using an external vacuum gauge, cap the gauge and attach it to the canister using a wrench. Open the canister valve only after verifying the gauge is properly capped.

Verify that the vacuum pressure of the canister is equal to that indicated on the laboratory supplied tag. If the vacuum does not match, the canister has likely leaked and should not be used. Record the initial vacuum pressure on the sample collection form.

The canister will then be fitted with the laboratory-provided steel filter. The sampling train (steel-filter, flow-controller (if used), and Summa canister) will be attached to a T-connector with an in-line vacuum gauge and vacuum tight flow valves at each end. All valves should be closed on the T-connector at this time. The valve connected to the sampling train is referred to as the sampling valve. The vacuum pump (truck-mounted or otherwise) is then attached to the second end of the T with the valve closed (referred to as the purge valve).

Lastly, the sample tubing is threaded through the leak-check shroud and connected to the soil gas sampling point and the third closed valve on the T-connector. The leak-check shroud should then be sealed against the surface (see "Leak Check – Probe Point Surface Seal" below).

LEAK CHECKING - APPARATUS

The method described below shall be used to check for leaks in the lines and fittings of the above-ground sampling apparatus:

After the sampling system is set up, make sure all valves are closed.

Open the purge valve (the valve connecting the purge pump to the apparatus, all other valves remain closed), turn on the purge pump, and apply approximately ten inches of vacuum into the T-connector and valves. Close the purge valve and check to verify that there is no loss of vacuum within the sampling apparatus (T-connector and valves) over a one-minute period of time. If there is a loss of vacuum, this indicates a leak in the purge/sample system train that must be remedied.

If necessary, recheck the system to verify that there is no leakage as described above.

Document the date and time the leak check(s) were performed. Close all valves.

LEAK CHECKING – PROBE POINT SURFACE SEAL

In addition to checking for leaks in the apparatus, the probe point surface seal also needs to be checked for leakage. The preferred method uses helium gas as a tracer and permits checking for and correcting potential leaks in the field prior to sampling. Other tracer gases may be used but approval of their use should be verified prior to the start of the work. The helium tracer gas method is listed in the Interstate Technology & Regulatory Council's (ITRC) "Technical and Regulatory Guidance, Vapor Intrusion Pathway: A Practical Guideline" and "Petroleum Vapor

Intrusion – Fundamentals of Screening, Investigation, and Management" guidance documents (2007 and 2014, respectively).

The ITRC guidance from which the text below is derived is also consistent with California Environmental Protection Agency and Oregon Department of Environmental Quality guidance (CalEPA 2005 and 2010; DEQ 2010).

Helium Leak Check Method

- Insert sample tubing through the leak check enclosure (also referred to as a shroud) and complete sample tubing connections to the other apparatus (previously described above).
- Place the enclosure flush with the ground surface, placing hydrated bentonite around the shroud to seal the shroud around the sample point.
- Attach helium tubing from the helium tank regulator to the enclosure (the "helium in" tubing).
- Attach the exhaust tubing ("helium out") to the enclosure and locate the discharge end of the tubing as far as possible from the helium detector.
- Attach the helium detector on the exhaust line from the sample pump.
- Make sure the sample valve (from the sampling probe point) is closed.
- Open the helium tank valve and set the flow to approximately 200 milliliters/minute (ml/min); let it flow for about one minute to fill the leak check enclosure.
- Do an initial check to make sure the helium detector is not detecting any helium.
- Begin purging of soil gas as described in the section on purging below. During purging, continue monitoring helium detector, record readings. If helium is detected at over 5%, this indicates leakage; check/tighten all seals and fittings and repeat procedure. The helium exhaust line should also be monitored so that additional helium can be added to the shroud during sampling if needed.
- Close valves from the probe sampling point and purge pump lines, and turn pump off.
- If the helium detector reading is less than 5%, the system is considered leak free and sampling can be performed (see sampling section below).
- If the helium detector reading continues to be above 5%, leakage is indicated and the probe hole abandoned.
- Record helium monitoring measurements in field notes.

SOIL GAS PURGING PROCEDURES

Purging and sampling will be accomplished at a low flow rate (100 to 200 ml/min) to minimize the potential for inducing leakage. Therefore, the flow rate of a pump used for this purpose must be known. Flow rates should not exceed 200 ml/min. Purging can be accurately completed using a graduated syringe and a 3-way valve. This will ensure that samples are representative of subsurface vapors. Do not over purge, this can lead to breakthrough or collecting samples from an unknown volume.

Slowly open the vacuum pump purge valve and purge three volumes of vapor from the line, then close the purge valve.

The volume of the purge is the volume of the tubing and the sand pack. The purge volume can be calculated as shown:

Tubing Volume = $\pi * r^2 * L$

Plus

Sand Pack Volume = $(\Phi * \pi * r_1^2 * L_1) - (\pi * r_2^2 * L_2)$

Where Φ = sand pack porosity, typically estimated at 30%

Π = PI 3.14

r = radius of tubing

L = length of tubing

r_1 = radius of sand pack

L_1 = length of sand pack

r_2 = inner radius of tubing (half of inner diameter)

L_2 = length of tubing within the sand pack

1 in^3 = 16.4 ml

Example

1/4–inch inner diameter tubing, 5 feet below ground and 5 feet above ground:

$3.14*(0.125^2)\ in^2*12\ in*16.4\ ml/in^3 = 9.6\ ml/ft * 10\ ft = 96\ ml$

2-inch sand pack, 1-in sample probe, 2 ft sand pack:

.$[(0.30 * 3.14 * (1^2)\ in^2 * 12\ in) – (3.14 * 0.5^2 in^2 * 12\ in)] * 16.4\ ml/in^3 = 30.9\ ml/ft * 2\ ft = 62\ ml$

Total single purge volume: 96ml + 62 ml = 158 ml

During purging, check for leaks as described in the section on leak checks above. Record PID measurements of purge vapors on the field form. Oxygen and carbon dioxide concentrations may be monitored in the soil gas stream if desired by the work plan. At the conclusion of purging, immediately close the purge valve and then shut off the purge pump.

SOIL GAS SAMPLING PROCEDURES

Atmospheric conditions (barometric pressure, temperature, wind speed and direction) will be recorded prior to and after sampling. A portable weather station equipped with a data logger is preferred to log site-specific conditions over the duration of sampling. However, if a weather station cannot be set-up on site, record atmospheric data from the closest weather station.

After leak testing and soil gas purging, soil gas sampling may be performed.

After purging, the purge valve will be closed prior to opening the sampling valve. The sample valve will then be opened followed by slowly opening the Summa canister valve. The canister's valve should be closed when the vacuum gauge shows a vacuum of 5 inches of mercury (inches Hg) (pressure of -5 inches Hg). The sample valve should then be closed.

Ensure the canister valve is tightly closed. The sample train should be immediately disassembled by removing the steel particulate filter, flow controller, and the Summa canister. Immediately cap the Summa canister fitting. The final vacuum reading from the canister should be recorded on the chain of custody, sample collection form, and canister identification tag. If the final canister vacuum is less than 0.1 inches Hg (more than -0.1 inches Hg of pressure, or is a positive pressure), then the sample should be disregarded and a new sample collected.

Soil vapor samples will be shipped to a certified laboratory for analysis.

FIELD RECORDS

The field technician maintains the Soil Gas Collection Form to record the following:

- Sample Location.
- Sample Identification.
- Date and time of sample collection.
- Sampling depth.
- Tubing type, length, and volume.
- Purge Data (i.e. pump used, volume, PID screening information, purge start and stop time, purge vacuum reading).
- Weather conditions.
- Sampling methods and devices.
- Volume of sampling device.
- Sampling start and end date/time.
- Vacuum of canisters before and after samples collected.
- Apparent moisture content (dry, moist, or saturated, etc.) of the sampling zone.
- Chain of custody protocols and records used to track samples from sampling point to analysis.
- Other notes as applicable to site specific observations, sampling issues and mitigation of problems encountered.

REFERENCES

Cal EPA. *2005 (February 7 rev.). Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air.* Department of Toxic Substances Control, Interim Final. California Environmental Protection Agency.

Cal EPA. 2010 (March). *Advisory – Active Soil Gas Investigation (Draft).* California Environmental Protection Agency.

DEQ. 2010 (March 25). *Guidance for Assessing and Remediating Vapor Intrusion in Buildings.* Oregon Department of Environmental Quality.

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EPA, 2015 (June). *OSWER Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air.* U.S. Environmental Protection Agency.

Soil Gas Sample Collection Form

Sample I.D. _______________ Project Name _______________
Sample Location _______________ Project # _______________
Date _______________ Sampler _______________
Indoor/Outdoor (circle one) Apparent Soil Moisture (dry, moist, saturated)

EQUIPMENT INFORMATION

Canister ID # _______________ Flow Controller ID # _______________
Canister Size _______________ Tubing Diameter and Length _______________

WEATHER CONDITIONS

Initial

Temperature (^{o}F) _____________ Wind Direction _____________
Humidity _____________ Atmospheric Pressure _____________

Final

Temperature (oF) _____________ Wind Direction _____________
Humidity _____________ Atmospheric Pressure _____________

LEAK AND PURGE CHECK DATA

Sample Train Equipment Check

Start Time _______________
Vacuum Pressure __________(inches Hg)
End Time ____________
Vacuum Pressure __________(inches Hg)

Helium Leak Check

Maximum Detection of Helium (%) ___
Pass or Fail (circle one)

Purge Vapors

Volume of Air to Purge – (¼" ID tube) 9.6 ml/ft * ______ ft = _________ml
+ Sandpack volume (2" boring) 30.9 ml/ft * _______ ft = _________ ml = ______ ml
Syringe, pump (circle one)
Purge Rate (ml/min) ___________ Minutes to Purge (volume/rate) _______
Purge Start Time _________ Purge Stop Time _________

Ambient PID Reading (ppmv) __________________
PID Reading during purge (ppmv) __________________ ______________

SAMPLE INFORMATION

Start Time _______________ Initial Vacuum Pressure (in Hg) _______________
End Time _______________ Final Vacuum Pressure (in Hg) _______________

LABORATORY INFORMATION

Laboratory: ____________________ Analytical Method: _______________

NOTES/COMMENTS:

____
____
____
____
____

Sampler's Signature ____________________ Date _______________

STANDARD OPERATING PROCEDURE
SUB-SLAB VAPOR PROBE CONSTRUCTION
VIA SOP 2

This Standard Operating Procedure (SOP) describes the method for installation of temporary or permanent sub-slab soil vapor sampling and monitoring probes.

MATERIALS

- Tubing: Nylon, Teflon™, or stainless steel tubing with nominally ⅛-inch or ¼-inch outer diameter (OD). Polyethylene tubing should not be used due to its higher potential to introduce background analytes, absorb contaminants, and decrease sample recovery. Nylon and Teflon™ tubing are more flexible and easier to work with than stainless steel tubing; however, stainless steel tubing is preferred, especially for permanent installations.
- Vapor Sampling Point: Stainless steel, aluminum, ceramic, or plastic. Stainless steel screened points can be put on the end if desired to give a longer screen interval. Points are typically used in permanent installations.
- Surface Termination: Swagelok® fittings and valves are preferred. The selection often depends on whether the probes are temporary or permanent and whether they need to be installed flush with the surface. All vapor sampling points should be constructed following the same technique/protocol, which should be explicitly outlined in the site specific work plan.

PROBE INSTALLATION PROTOCOL

Note that if sub-slab and deeper subsurface soil gas samples are to be collected, they should be collected from separate boring locations in order to maintain a proper seal unless nested points are constructed in the same boring.

Sub-Slab Vapor Probe Construction

- Insure all sub-slab utilities (public and building specific) are marked prior to installation. This includes contacting the public utility notification service and identifying private utilities on-site.
- Review as-built construction logs of existing vapor monitoring points as applicable.
- Sub-slab sample locations should be located in the central portion of the slab, away from the floor slab/perimeter foundation junction, where dilution is more likely to occur. The site specific work-plan should provide justification for all sample locations.
- Determine the desired surface termination (flush, recessed, or protruding). If a flush or recessed surface termination is required, a larger diameter hole (one inch) in the upper inch of the slab may be useful to leave enough room for the fitting on the probe tubing.
- During the course of probe installation, it is important to minimize disturbance of the sub-slab region by not applying significant pressures that might affect vapor concentrations. Pressure sources include the running of appliances or fans, excessive opening/closing of interior doors, and opening/closing exterior doors and windows.
- Drill a ½- to one-inch outer diameter hole through the slab using a rotary hammer drill or other similar device. Do not use water. If dust prevention is necessary, cover the location with a towel/cloth and drill through a pre-cut hole in the cloth. Care should be taken not to penetrate beyond the sub-slab material (e.g. beyond the sub-slab fill material).

- Measure slab thickness. Cut the tubing to the desired length, such that the vapor sampling point reaches the material immediately below the slab. Stainless steel tubing is preferred and if possible should be pre-cut to desired lengths (if slab thickness is known prior to installation).
- Insert tubing. Add silica sand to cover tip (tubing end or vapor sampling point) with approximately one inch of sand above the tip.
- Grout to the surface using bentonite, modeling clay, or other non-VOC containing and non-shrinking products (if temporary installation) or cement (if permanent installation) to seal the boring and prevent infiltration of ambient air.
- Wait a minimum of 30 minutes prior to sampling for bentonite/cement seal to congeal.
- Refer to Standard Operating Procedure VIA SOP 3 Sub-Slab Vapor Sample Collection for monitoring and sampling for leak detection, purging, and sampling procedures and documentation.
- If the sample point is temporary, remove all sampling equipment after sampling is complete and patch the hole(s) in the concrete slab with cement finishing flush with the concrete surface.

STANDARD OPERATING PROCEDURE
SUB-SLAB VAPOR SAMPLE COLLECTION
VIA SOP 3

This Vapor Intrusion Assessment (VIA) Standard Operating Procedure (SOP) describes the method for sub-slab vapor sample collection from both temporary and permanently installed soil vapor probes (implants). Sub-Slab probe installation/construction methods are detailed in VIA SOP 2. Because each site is unique, these procedures should be viewed as guidelines and will likely require modification based on site and subsurface conditions present.

Personnel performing the soil gas monitoring and sampling will follow site safety procedures as specified in the site-specific Health and Safety Plan.

EQUIPMENT/MATERIALS

- Tubing: ⅛-inch or ¼-inch outer diameter (OD) inert, impermeable tubing such as nylon (Nylaflow®), Teflon® tubing, or stainless steel.
- Sample Containers: Stainless steel Summa canisters (one-liter Summa canisters are preferred; however, the site specific work plan may justify another appropriate size), syringe, or tedlar bag.
- Monitoring and sampling equipment may include the following: Certified flow controllers (if flow controllers are used, ensure flow controllers are dedicated to the canister/sample location), stainless steel t-fitting, stainless-steel particulate filter, photoionization detector (PID), low flow vacuum pump, vacuum gauge, portable weather station, and/or barometric pressure data loggers.
- Leak check equipment using helium or other pre-approved non-reactive tracer gas may include: helium tank, piping, and valve, leak check enclosure (shroud), helium detector, paper towels or rags, and nitrile gloves. Tracer gas should be laboratory grade and the grade noted on the sample form (e.g. 100% pure helium by volume).

COLLECTION PROTOCOL

Since sub-slab sampling is from very shallow depths (typically two to six-inches below surface), minimum purge volumes and low volume samples are preferred to minimize potential breakthrough from the surface. Regardless of sample depth, a 30 minute flow controller (minimum) should be used. Tracer/leak gas (helium is preferred) will be used to ensure breakthrough does not occur. Note that if sub-slab and deeper subsurface soil gas samples are to be collected, they should be collected from separate boring locations in order to maintain a proper seal. Constructing nested sampling points is possible, but breakthrough is more likely and nested construction is not preferred. If possible, shallow samples should be collected prior to deeper samples to ensure surface seal.

Syringe Grab Samples

If only syringe samples are to be collected, connect syringe to probe tubing using the T-valve. If the syringe is connected directly to the probe implant, no purging is required. If a connecting tube is used between the syringe and the implant, purge out one to two dead-volumes of the connecting tubing (approximately one cubic centimeter per foot (cc/ft) for ⅛-inch OD tubing and five cc/ft for ¼-inch OD tubing). Leave syringe connected to implant the tubing. Sample by extracting soil gas via the syringe plunger.

Summa Canisters

Inspect the laboratory-provided Summa canister for damage prior to use. Do not use a canister that has visible damage.

Using a wrench, remove the brass cap above the valve on the top of the Summa canister. Measure and record the initial vacuum of Summa canister. If using an external vacuum gauge, cap the gauge and attach it to the canister using a wrench. Open the canister valve only after verifying the gauge is properly capped.

Verify that the vacuum pressure of the canister is equal to that indicated on the laboratory supplied tag. If the vacuum does not match, the canister has likely leaked and should not be used. Record the vacuum pressure on the sample collection form.

The canister will then be fitted with the laboratory-provided steel filter. The sampling train (steel-filter, flow-controller (if used), and Summa canister) will be attached to a T-connector with an in-line vacuum gauge and vacuum tight flow valves at each end. All valves should be closed on the T connector at this time. The valve connected to the sampling train is referred to as the sampling valve. The vacuum pump (truck-mounted or otherwise) is then attached to the second end of the T with the valve closed (referred to as the purge valve).

Lastly, the sample tubing is threaded through the leak-check shroud and connected to the sub-slab sampling point and the third closed valve on the T-connector. The leak-check shroud should then be sealed against the slab surface (see “Leak Check – Probe Point Surface Seal” below).

Leaking Checking - Apparatus

The method described below shall be used to check for leaks in the lines and fittings of the above ground sampling apparatus:

After the sampling system is set up, double check all valves are closed.

Open the purge valve (the valve connecting the purge pump to the apparatus, all other valves remain closed), turn on the purge pump, and apply approximately ten inches of vacuum into the T-connector and valves. Close the purge valve and check to verify that there is no loss of vacuum within the sampling apparatus (T-connector and valves) over a one minute period of time. If there is a loss of vacuum, this indicates a leak in the purge/sample system train that must be remedied.

If necessary, recheck the system to verify that there is no leakage as described above.

Document the date and time the leak check(s) were performed on the sampling form. Ensure all valves remain closed.

Leaking Checking – Probe Point Surface Seal

In addition checking for leaks in the apparatus, the probe point surface seal also needs to be checked for leakage. The preferred method uses helium gas as a tracer and permits checking for and correcting potential leaks in the field prior to sampling. Other tracer gases may be used but approval of their use should be verified prior to the start of the work. The helium tracer gas method is listed in ITRC’s “Technical and Regulatory Guidance, Vapor Intrusion Pathway: A Practical Guideline” dated January 2007 (ITRC, 2007), and as described below. The ITRC guidance from which the text below is derived is consistent with California Environmental Protection Agency and Oregon Department of Environmental Quality guidance (CalEPA, 2005, 2010; DEQ 2010).

Helium Leak Check Method

- Insert sample tubing through the leak check enclosure (also referred to as a shroud) and complete sample tubing connections to the other apparatus (previously described above).

- Place the enclosure shroud flush with the ground surface, placing hydrated bentonite around the shroud to seal the shroud around the sample point.
- Attach helium tubing from the helium tank regulator to the enclosure (the “helium in” tubing).
- Attach the exhaust tubing (“helium out”) to the enclosure and locate the discharge end of the tubing as far as possible from the helium detector.
- Attach the helium detector on the exhaust line from the sample pump.
- Make sure the sample valve (from the sampling probe point) is closed.
- Open the helium tank valve and set the flow at 200 milliliter per minute (ml/min) or less; let it flow for about one minute to fill the leak check enclosure.
- Do an initial check to make sure the helium detector is not detecting any helium.
- Begin purging of soil gas as described in the section on purging below. During purging, continue monitoring helium detector, record readings. If helium is detected at over 5%, this indicates leakage; check/tighten all seals and fittings and repeat procedure. The helium exhaust line should also be monitored so that additional helium can be added to the shroud during sampling if needed.
- Close valves from the probe sampling point and purge pump lines, and turn pump off.
- If the helium detector reading is less than 5%, the system is considered leak free and sampling can be performed (see sampling section below).
- If the helium detector reading continues to be above 5%, leakage is indicated and the sub-slab abandoned.
- Record helium monitoring measurements in field notes.

Soil Gas Purging Procedures

Purging and sampling will be accomplished at a low flow rate (100 to 200 ml/min) to minimize the potential for inducing leakage. Flow rates should not exceed 200 ml/min. Purge vapors will be monitored using a PID for the presence of volatile organic compounds.

Slowly open the vacuum pump purge valve and purge three volumes of vapor from the dead space (volume of tubing and sand pack combined), then close the purge valve. Tubing volume can be estimated at 44 milliliters per foot (mm/ft) of 0.25-inch inner diameter (ID) tubing. For the sand pack volume calculation it is important to note that 1 cubic inch is equivalent to 16.387 milliliters. The sand pack volume can be calculated as shown:

Sand pack volume = $(\Phi*\pi*r_1^2*L_1) - (\pi*r_2^2*L_2)$

Where Φ = sand pack porosity, typically estimated at 30%

r_1 = radius of sand pack

L_1 = length of sand pack

r_2 = outer radius of tubing (half of outer diameter)

L_2 = length of tubing within the sand pack

Care will be taken not to purge an excessive volume, or at an excessive rate, so as to minimize the chances of inducing leakage from the surface. The pump will also be monitored for signs that it is laboring, a possible indication of a clogged probe or tubing.

During purging, check for leaks as described in the section on leak checks above. Record PID measurements of purge vapors on the field form. At the conclusion of purging, immediately close the purge valve and then shut off the purge pump.

Soil Gas Sample Collection Procedures - Grab Sampling

Atmospheric conditions (barometric pressure, temperature, wind speed and direction) will be recorded prior to and after sampling. A portable weather station equipped with a data logger is preferred to log site-specific conditions over the duration of sampling. However, if a weather station cannot be set-up on site, record atmospheric data from the closest weather station.

After leak testing and soil gas purging, soil gas sampling may be performed.

After purging, the purge valve will be closed prior to opening the sampling valve. The sample valve will then be opened followed by slowly opening the Summa canister valve. The canister's valve should be closed when the vacuum gauge shows a vacuum of 5 inches of mercury (in Hg) (pressure of -5 in Hg). The sample valve should then be closed.

Ensure the canister valve is tightly closed. The sample train should be immediately disassembled by removing the steel particulate filter, and the Summa canister. Immediately cap the Summa canister fitting. The final vacuum reading from the canister should be recorded on the chain of custody, sample collection form, and canister identification tag. If the final canister vacuum is less than 0.1 in Hg (more than -0.1 in Hg of pressure, or is a positive pressure), then the sample should be disregarded and a new sample collected.

Soil vapor samples will be shipped to a certified laboratory for analysis.

Sampling Procedures using a flow controller

The sampling procedure is the same as above except that a laboratory certified in-line flow controller for a pre-specified sampling time (i.e. 30 minutes) will be used. The flow controller fits between the laboratory provided steel particulate filter and the Summa canister. The entire sample train (laboratory-provided steel particulate filter, flow-controller, and summa canister) should be pre-assembled prior to connecting to the sampling valve.

Other Collection Notes

For larger canisters (greater than one liter), sample flow rates are not to exceed 200 milliliters per minute (ml/min) to minimize potential for vacuum extraction of contaminants from the soil phase. If large volume canisters is used (three or more liters) without a flow controller to ensure the flow rate remains below 200 ml/min, a purge volume test may be required to ensure sample dilution from other zones is not occurring.

FIELD RECORDS

The field technician maintains a log sheet summarizing:

- Sample Location.
- Sample Identification.
- Date and time of sample collection.
- Sampling depth.
- Tubing type, length, and volume.

- Purge Data (i.e. pump used, volume, PID screening information, purge start and stop time, purge vacuum reading).
- Weather conditions.
- Sampling methods and devices.
- Volume of sampling device.
- Sampling start and end date/time.
- Vacuum of canisters before and after samples collected.
- Apparent moisture content (dry, moist, or saturated, etc.) of the sampling zone.
- Chain of custody protocols and records used to track samples from sampling point to analysis.
- Other notes as applicable to site specific observations, sampling issues and mitigation of problems encountered.

REFERENCES

Cal EPA. *2005 (February 7 rev.). Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air.* Department of Toxic Substances Control, Interim Final. California Environmental Protection Agency.

Cal EPA. 2010 (March). *Advisory – Active Soil Gas Investigation (Draft).* California Environmental Protection Agency.

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Soil Gas Sample Collection Form

Hydro Con

Sample I.D. ________________ Project Name ________________
Sample Location ________________ Project # ________________
Date ________________ Sampler ________________
Indoor/Outdoor (circle one) Apparent Soil Moisture (dry, moist, saturated)

EQUIPMENT INFORMATION

Canister ID # _______________ Flow Controller ID # ________________
Canister Size _______________ Tubing Diameter and Length ________________

WEATHER CONDITIONS

Initial

Temperature (^oF) _____________ Wind Direction _____________
Humidity _____________ Atmospheric Pressure _____________

Final

Temperature (oF) _____________ Wind Direction _____________
Humidity _____________ Atmospheric Pressure _____________

LEAK AND PURGE CHECK DATA

Sample Train Equipment Check

Start Time _______________
Vacuum Pressure __________(inches Hg)
End Time ____________
Vacuum Pressure __________(inches Hg)

Helium Leak Check

Maximum Detection of Helium (%) ___
Pass or Fail (circle one)

Purge Vapors

Volume of Air to Purge – (¼" ID tube) 9.6 ml/ft * ______ ft = _________ml
+ Sandpack volume (2" boring) 30.9 ml/ft * ________ ft = _________ ml = ______ ml
Syringe, pump (circle one)
Purge Rate (ml/min) ___________ Minutes to Purge (volume/rate) _______
Purge Start Time _________ Purge Stop Time _________

Ambient PID Reading (ppmv) __________________
PID Reading during purge (ppmv) __________________ ______________

SAMPLE INFORMATION

Start Time ________________ Initial Vacuum Pressure (in Hg) _______________
End Time ________________ Final Vacuum Pressure (in Hg) _______________

LABORATORY INFORMATION

Laboratory: ____________________ Analytical Method: ________________

NOTES/COMMENTS:

____
____
____
____
____

Sampler's Signature ____________________ Date ________________

STANDARD OPERATING PROCEDURE
INDOOR AIR SAMPLING
VIA SOP 4

This vapor intrusion assessment (VIA) standard operating procedure (SOP) describes procedures for collecting indoor air samples. This SOP describes the collection of time-integrated samples from the human breathing zones of areas potentially impacted by volatile environmental contaminants. Because each site is unique, these procedures should be viewed as guidelines and will likely require modification based on site and surface conditions present.

Personnel performing the air sampling will follow site safety procedures as specified in the site-specific Health and Safety Plan.

PRE-SAMPLING BUILDING SURVEY

The physical layout and environment of the building, including potential sample locations, should be evaluated a minimum of two weeks prior to collecting indoor air samples. The purpose of the pre-sampling inspection is to identify conditions that may affect or interfere with sample collection and, as feasible, temporarily mitigate those conditions. This will minimize the potential for background sources to influence sample results. Details of the building survey, including a generic building survey form are attached. The building survey is a vital part of indoor air sample collection and must be completed prior to conducting sampling. If the building poses complications outside of the scope of the generic form attached to this SOP, the site-specific work plan may develop survey forms for individual buildings or individual rooms, as warranted.

EQUIPMENT/MATERIALS

Indoor air sampling generally requires the following equipment:

- Certified clean and evacuated Summa canister, typically six-liter (based on analytical method and desired reporting limits).
- Certified clean flow controller, set at desired sampling rate, typically between eight and 24 hours based on project-specific work scope.
- Shipping container suitable for protection of Summa canisters during shipment.
- Wrenches and tools appropriate for connecting fittings and making adjustments to the flow controller, if necessary.
- Negative pressure (vacuum) gauge (oil free and clean) either installed within the sample train or an external gauge used to check canister vacuum prior to and after sampling is complete. In-line gauges are preferred.
- Field data sheets including air sample collection form and daily field notes form.
- Timepiece (to record start and end time of sample collection).
- On-site weather station and barometric pressure data loggers, if available.

INDOOR AIR SAMPLING PROCEDURE

In general, the air sample should be collected under normal seasonal building conditions (i.e. ventilation or heating systems operating normally for routine building occupation). Normally, buildings will be inventoried and products containing volatile chemicals will be removed with the building ventilated at least 48 hours prior to indoor air sampling. However, the site specific work plan should explicitly state the desired building conditions at the time of sampling as some situations may require windows be closed and ventilation systems be shut-off prior to collecting samples.

Clean sampling procedures must be followed at all times when handling and collecting samples. This includes care in packaging, storing, shipping, and use of the sampling equipment. Individuals performing the sampling must not smoke, must not wear perfume or strong deodorants, and must wear clean clothing (not dry cleaned) and proper personal protective equipment.

Sample Preparation

The following steps should be followed when preparing to collect indoor air samples:

- Inspect the canister for damage. Do not use a canister that has visible damage.
- Using a wrench, remove the brass cap above the valve on the top of the Summa canister.
- If using an external vacuum gauge, cap the gauge and attach it to the canister using a wrench. Open the canister valve only after verifying the gauge is properly capped.
- Verify that the vacuum pressure of the canister is equal to that indicated on the laboratory supplied tag. If the vacuum does not match, the canister has likely leaked and should not be used. Record the vacuum pressure on the sample collection form.
- Close the canister valve and remove the vacuum gauge if the flow controller is fitted with an independent gauge. Otherwise, leave the gauge in place.
- On the sample collection form, record the sample location, sample date, sample collection height, and canister and flow controller serial numbers. Record notes regarding sample location (i.e. room number/identifier, sample number, location relative to pertinent building infrastructure, etc.). Also note any other observations which could influence analytical results.
- Connect the laboratory certified flow controller to the canister. Pay special attention to air flow arrows or “OUT” notation on the flow controller so that it is correctly fitted to the canister. Tighten the fitting, as to be leak free but do not over tighten (¼ turn past finger snug is usually sufficient).
- Place the canister(s) at locations within the structure where representative sampling will occur in the breathing zone (typically between three and five feet above ground surface). The occupants and uses of the building should be considered. For example, a daycare with small children should be sampled closer to the ground. The site specific work plan should have incorporated these considerations and specify a sample collection height.
- Remove all work articles that will not remain with the sampling apparatus from the sampling area, including tools, vehicles, personnel, and any other equipment.

Sample Collection

When ready to begin sample collection follow the steps listed below:

- Record the sample start time on the sample collection form.

- Slowly open the valve on the canister approximately one full turn.
- Document pertinent weather information on the sample collection form, including temperature, wind speed and direction, humidity, atmospheric pressure, and overall outdoor weather conditions (sunny, cloudy, rainy, etc.). If a weather station is not set-up on site, record this information from the closest weather station.
- At the end of the sample period, verify residual vacuum remains in sample canister (optimally 5 inches Mercury [in Hg] vacuum [-5 in Hg total pressure]), then close the canister valve finger tight. If using an external vacuum gauge one must remove the closed canister from the sample train, securely fix the external vacuum gauge to the canister, and open the canister to verify the vacuum. Immediately close the canister after recording the final vacuum pressure. If the final canister vacuum is less than 0.1 in Hg (more than -0.1 in Hg total pressure, or is a positive pressure), then the sample should be disregarded and a new sample collected. Record the sample end time on the collection form and record the final weather conditions.
- Ensure the canister valve is tightly closed. Remove the flow controller and external vacuum gauge, if used. Document the final canister vacuum on the sample collection form. The Summa canister should have remaining vacuum, optimally -5 in Hg total pressure, but at a minimum less than -0.1 in Hg. Replace the brass cap and tighten gently.
- Record on the sample tag the sample date, time, project number, sample location/name, initial and final canister vacuum, and attach it to the canister.
- Prepare the chain-of-custody form and indicate analysis requested to be performed by the lab. Initial and final canister vacuum should be noted on the chain-of-custody.
- When packaging for shipment, verify that the valve and valve caps are snug and use sufficient clean packaging to prevent the valves from rubbing against any hard surfaces.

INDOOR AIR SAMPLE COLLECTION

Sample I.D. ______________________________ Project Name______________________________
Sample Location_________________________ Project #__________________________________
Date______________________________________ Sampler__________________________________

WEATHER CONDITIONS

Initial Time: __________
Temperature ___________ Wind Direction _____________
Humidity ___________ Atmospheric Pressure _____________
Final Time: ___________
Temperature ___________ Wind Direction _____________
Humidity ___________ Atmospheric Pressure _____________

EQUIPMENT INFORMATION

Canister ID #__________________________ Flow Controller ID #___________________________
Canister Size __________________________
Initial Vacuum ________(in Hg)

SAMPLE INFORMATION

Start Time (date/time) _______________________ Initial Vacuum _______________(in Hg)
End Time (date/time) ___________________________Final Vacuum _______________(in Hg)

LABORATORY INFORMATION

Laboratory: ____

Analytical Method: ____

NOTES/COMMENTS:

____
____
____
____
____

Sampler's Signature____Date__________________________

General Building Survey

Prepared By:______________________________ Date/Time Prepared:______________________

Project:___________________________________ Location/Building:_________________________

A. OCCUPANT: Interviewed: Y / N (circle)

Last Name:_____________________________ First Name:________________________________

Address:____

County:____

Home/Business Phone:_____________________Alternate Phone:___________________________

Number of Occupants/persons at this location:_________ Age of Occupants:_________________

B. OWNER OR LANDLORD: (Check if same as occupant__): Interviewed: Y / N

Last Name:_______________________________ First Name:______________________________

Address:____

County:____

Home/Business Phone:_____________________ Alternate Phone:__________________________

C. BUILDING CHARACTERISTICS:

1. Type of Building: (Circle appropriate response):

Residential	School	Commercial/Multi-use	Strip Mall
Industrial	Church	Other:________________________	

2. If the property is residential, building type? (Circle appropriate response)

Bungalow	Ranch	Colonial	2-Family
Four Square	Raised Ranch	Split Level	3-Family
Cape Cod	English Cottage	Contemporary	Mobile Home
Duplex	Apartment House	Townhouse/Condos	
Modular	Log Home	Other:______________________________	

3. If multiple units, how many?____
4. General Building construction (circle): wood frame concrete stone brick steel
5. If the property is commercial, type?

   Business Name and Type:____

   Does it include residences (i.e., multi-use)? Y / N If yes, how many? _______________

6. Other characteristics:

   Number of floors:___________________ Building age: ____________________________

7. Is the building insulated Y/N? How air tight? Tight Average Not Tight

D. BASEMENT & CONSTRUCTION CHARACTERISTICS (Circle all that apply):

1. Does property have a:
   basement crawlspace slab-on-grade

2. What is the condition of the basement or slab-on-grade?

   Good (few or no small cracks) Fair (several small cracks, no large cracks)
   Poor (large cracks present) Unknown

3. Basement floor/concrete slab/crawlspace:

   Unsealed Sealed Dirt Covered with:______________________

4. Basement floor/concrete slab/crawlspace:

   Wet Damp Dry Moldy

5. The basement is: Finished Unfinished partially finished

6. Basement/Lowest level estimated depth below exterior ground surface:_________(feet)

7. Does the basement/crawlspace have air vents leading out of the structure? Y / N

   If yes, are these vents always open, always closed, or seasonally opened and closed?

   ____

8. Does the floor/basement/crawlspace have floor drains leading out of the room? (Y / N)

   If yes, list each drain:____

   ____

   ____

9. Where do utilities enter the building? (e.g. basement, concrete slab, walls, floors)

   List each one:____

   ____

   ____

10. Are there liners/vapor barriers in the basement/crawlspace or within the floor slab? Y / N

    If yes, describe: ____

11. Foundation walls: poured block stone other:_________

12. Foundation walls: unsealed sealed sealed with:_________________

13. Are Sumps present in building/basement? Y / N / Unknown

14. If sumps are present, describe each including information on contents/typical use:

    ____

    ____

15. Are the sumps concrete lined or open to the sub-surface (i.e. are soils exposed?)

____

16. Are elevator shafts present? Y / N How many?________

If so, describe each: ____

____

17. Has the original structure of the building been altered by construction? For example, have half basements or spaces under the building been constructed? If so, describe:

____

E. HEATING, VENTING & AIR CONDITIONING (Circle all that apply)

1. Type of heating system(s) used in this building: (circle all that apply – note primary)

Hot air circulation	Heat pump	Hot water baseboard
Space heaters	Stream radiation	Radiant floor
Electric baseboard	Wood stove	Outdoor wood boiler

Other: ____

2. The primary type of fuel for heating is:

Natural gas	Fuel oil	Kerosene
Electric	Propane	Solar
Wood	Coal	Other:______________

3. Hot water heated by:

Natural gas   Fuel oil   Other:______________

4. Boiler/furnace located in:

Basement   Outdoors   Main Floor   Other:______________

5. Air conditioning:

Heat Pump   Central air   Window units   Open windows   None

6. Are there air distribution ducts present? Y / N

7. Does the site have a back-up generator, or use a generator for any purposes? _________

If so, how is the generator(s) fueled?   Gas   Diesel   Electric   Other_________

8. Has the building been weatherized with any of the following (circle any that apply)?

Insulation   Storm Windows   Energy Efficient Windows   Other_________

9. If building is insulated, what type of insulation is used in the building (Circle all that apply)?

Fiberglass   Mineral wool   Polyurethane foam   Polystyrene

Wood fiber   Insulating concrete forms

Other:____

F. OCCUPANCY

List occupants or, if a large commercial facility, general occupant roles (e.g. warehouse, office, etc.)

Age (if under 18)	Sex	Occupation	Number of years working or living here	Number of hours spent in building per day

Is basement/lowest level occupied? Full-time Occasionally Seldom Almost Never

Level General use of each floor (e.g., family-room, bedroom, workshop, storage)

Basement ____________________

1st Floor ____________________

2nd Floor ____________________

3rd Floor ____________________

4th Floor ____________________

G. FACTORS THAT MAY INFLUENCE INDOOR AIR QUALITY

1. Is there an attached garage? Y / N
2. Does the garage have a separate heating unit? Y / N N/A
3. Are petroleum-powered equipment stored in the garage (e.g. lawnmower, ATV, car) Y / N
   Please specify type of equipment:____________________
4. Are there any parts cleaners used at the site (manufacturing, garage, hobby area)? Y / N
   If yes, what is done with the spent solvent/solvent cans? ____________________
   ____
5. Is there a drum storage area on the property? Y / N
   If yes, what type of chemicals are stored in drums?____________________
   ____
   ____
6. Does the building have a fireplace? Y / N Where?____________________
7. Has the building ever had a fire? Y / N When____________________

8. Does the building have a refuse burning area? Y / N Where?________________

9. Is a kerosene or unvented gas space heater present? Y / N Where & Type?__________

10. Is there a workshop or hobby/craft area? Y / N Where & Type?__________

11. Is there smoking in the building? Y / N How Frequently?_________

12. How often are cleaning products used? Daily Weekly Monthly

13. Are cosmetic products used at property? Y / N

    When & Type?____

14. Does the building/business apply paint or chemicals? Y / N

    If yes, what products are applied?____

    ____

15. Do media blasting practices occur at the property? Y / N

    If yes, what type of materials are being sandblasted?__________________________________

    ____

16. Has painting/staining been done to the building in the last six months? Y / N

    Where & When?____

17. Is there new carpet, drapes or other textiles? Y / N

    Where & When?____

18. Are air fresheners used? Y / N

    When & Type?____

19. Is there a kitchen exhaust fan? Y / N

    If yes, where vented?____

20. Is there a bathroom exhaust fan? Y / N

    If yes, where vented?____

21. Is there a clothes dryer? Y / N

    If yes, is it (circle one)? Electric Natural Gas Propane Vented outside? Y / N

22. Are there odors in the building? Y / N

    If yes please describe: ____

    ____

23. Has the building undergone any recent renovations/upgrades (e.g. building addition, re-roofing, remodeling, floor refinishing)? Y / N

    If yes, please describe:____

    ____

24. Are there any pressed wood products in the building (e.g. hardwood, plywood, wall paneling, particleboard or fiberboard)? Y / N

    If yes, please describe their location:____

    ____

25. Has the Building been treated with any insecticides, pesticides, fungicides, and/or biocides (mold treatment)? Y / N

If so, what chemicals are used and how often are they applied?______________________

____

26. Do any of the building occupants use solvents at work? Y / N

(e.g., chemical mfg., laboratory, auto mechanic/auto body shop, painting, fuel oil delivery, boiler mechanic, pesticide application, cosmetologist)

If yes, what type of solvents are used?____

If yes, are their clothes washed at work? Y / N

27. Do any of the building occupants regularly use or work at a dry-cleaning service? (check appropriate response)

_______No

_______Yes, use dry-cleaning regularly (weekly)

_______Yes, use dry-cleaning infrequently (monthly or less)

_______Yes, work at a dry-cleaning service

28. Is there a radon mitigation system for the building/structure? Y / N

Date of Installation:___________________. Is the system active or passive? Active/Passive

H. ENVIRONMENTAL CONCERNS (AIR, WATER, & SEWAGE)

1. Does the property have a private well? Y / N

If Yes, is it in use? When was it last used?______________________________________

____

2. What is the well construction? (circle one) Drilled Dug Driven

Notes:____

3. Does the property owner have a well log for the well? Y / N

4. Source of potable water (circle): City water supply Private Well Other:_____________

5. Source of irrigation water (circle): City water supply Private Well Other:____________

6. Sewage Disposal:

Public sewer Septic tank Leach field Dry well Other:_______________

7. Does the building/business have an NPDES Permit? Y / N

If yes, what chemicals and volumes are being discharged? _________________________

____

8. Are there any dry wells on the property? Y / N

9. Are there any french drains (water diversion trench) present at the site? Y / N

10. Are there underground storage tanks (USTs) on the property? Y / N How Many_____

If so, describe each one (size, contents, location, etc.)______________________________

____

____

11. Does the building/business have an air permit with a local air-permitting agency? Y / N

If yes, what agency, and what chemicals are being discharged into the atmosphere?____

____

____

Note: *The information and questions on this form were compiled from the following states and agencies: Washington, California, Delaware, Maine, Massachusetts, New Jersey, New York, Oregon, Vermont, and ASTM International.*

STANDARD OPERATING PROCEDURE
AMBIENT OUTDOOR AIR SAMPLING
VIA SOP 5

This vapor intrusion assessment (VIA) standard operating procedure (SOP) describes procedures for collecting ambient outdoor air samples. This SOP describes the collection of time-integrated samples from the human breathing zone and/or other areas potentially impacted by environmental contaminants. Because each site is unique, these procedures should be viewed as guidelines and will likely require modification based on site and surface conditions present.

Personnel performing the outdoor air sampling will follow site safety procedures as specified in the site-specific Health and Safety Plan.

EQUIPMENT/MATERIALS

Outdoor air sampling generally requires the following equipment:

- Wind sock, flag, or other device for observing wind direction. An on-site weather station capable of logging weather conditions (i.e. temperature, wind speed, wind direction, barometric pressure, humidity) over the sampling period is preferred.
- Certified clean and evacuated Summa canister, typically six-liter (based on analytical method and desired reporting limits).
- Certified clean flow controller, set at desired sampling rate, typically between eight and 24 hours based on project-specific work scope.
- Shipping container suitable for protection of Summa canisters during shipment.
- Wrenches and tools appropriate for connecting fittings and making adjustments to the flow controller if necessary.
- Negative pressure (vacuum) gauge (oil free and clean) either installed on the canister or used externally to check canister vacuum.
- Field data sheets including air sample collection form and daily field notes form.
- Timepiece (to record start and end time of sample collection).

OUTDOOR AIR SAMPLING PROCEDURE

As a general practice, when outdoor air samples are collected as part of an indoor vapor intrusion evaluation, one or more outdoor air samples should be collected upwind from the building at the same time as indoor air samples are collected. The site-specific work plan will include sampling rationale and related details. Clean sampling procedures must be followed at times when handling and collecting samples. This includes care in packaging, storing, shipping, and use of the sampling equipment. Individuals performing the sampling must not smoke, must not wear perfume or strong deodorants, and must wear clean clothing (not dry cleaned) and proper personal protective equipment.

Sample Preparation

The following steps should be followed when preparing to collect outdoor air samples:

- If raining/snowing or dusty environment, sample canister and air intake should be adequately protected from the elements.

- Use the on-site weather station, or if unavailable, a wind sock, flag, or other device as appropriate to verify and observe wind direction. Unless otherwise specified, the outdoor air sample(s) should be collected in an unobstructed upwind location relative to the building of concern.
- Inspect the Summa canister for damage. Do not use a Summa canister that has visible damage.
- Using a wrench, remove the brass cap above the valve on the top of the Summa canister.
- If using an external vacuum gauge, cap the gauge and attach it to the canister using a wrench. Open the canister valve only after verifying the gauge is properly capped.
- Verify that the vacuum pressure of the canister is equal to that indicated on the laboratory supplied tag. If the vacuum does not match, the canister has likely leaked and should not be used. Record the vacuum pressure on the sample collection form.
- Close the canister valve and remove the vacuum gauge if the flow controller is fitted with an independent gauge. Otherwise, leave the gauge in place.
- On the sample collection form, record the sample location, sample date, sample collection height, and canister and flow controller serial numbers. Record notes regarding sample location (i.e. under an awning, near a fence post, southwest corner of the building, etc.) and nearby buildings/business (i.e. gas stations, industrial/manufacturing plants, dry cleaners, etc.) which could influence analytical results.
- Connect the laboratory certified flow controller to the canister. Pay special attention to air flow arrows or “OUT” notation on the flow controller so that it is correctly fitted to the canister. Tighten the fitting, as to be leak free but do not over tighten (¼ turn past finger snug is usually sufficient).
- Place the canister(s) at a height representative of the breathing zone (typically between three and five feet above ground surface). The occupants and uses of the outdoor space and adjacent buildings should be considered. For example, if a daycare with small children is adjacent to the outdoor sample location, samples should be collected closer to the ground. The site specific work plan should have incorporated these considerations and specify a sample collection height.
- Remove all work articles that will not remain with the sampling apparatus from the sampling area, including tools, vehicles, personnel, and any other equipment.

Sample Collection

When ready to begin sample collection follow the steps listed below:

- Record the sample start time on the sample collection form.
- Slowly open the valve on the canister approximately one full turn.
- Document pertinent weather information on the sample collection form, including temperature, wind speed and direction, humidity, and atmospheric pressure on the Outdoor Air Sample Collection form. If a weather station is not set-up on site, record this information from the closest weather station.

- At the end of the sample period, verify residual vacuum remains in sample canister (optimally 5 inches Mercury [in Hg vacuum]), then close the canister valve finger tight. If the final canister vacuum is less than 0.1 in Hg (or is a positive pressure), then the sample should be disregarded and a new sample collected. Record the sample end time on the collection form and record the final weather conditions.
- Remove the flow controller and external vacuum gauge, if used. Document the final canister vacuum on the sample collection form. The Summa canister should have some remaining vacuum, preferably between approximately -0.1 and -5 in Hg. Replace the brass cap and tighten gently.
- Record on the sample tag the sample date, time, project number, and sample location/name and attach it to the canister.
- Prepare the chain-of-custody form and indicate analysis requested to be performed by the lab.
- When packaging for shipment, verify that the valve and valve caps are snug and use sufficient clean packaging to prevent the valves from rubbing against any hard surfaces.

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OUTDOOR AIR SAMPLE COLLECTION

Sample I.D. ______________________________ Project Name_____________________________
Sample Location_________________________ Project #_________________________________
Date_______________________________________ Sampler__________________________________

WEATHER CONDITIONS

Initial Time ___________
Temperature ___________ Wind Direction ______________
Humidity ___________ Atmospheric Pressure ______________
Final Time ___________
Temperature ___________ Wind Direction ______________
Humidity ___________ Atmospheric Pressure ______________

EQUIPMENT INFORMATION

Canister ID #_________________________ Flow Controller ID #_________________________
Canister Size _________________________
Initial Vacuum________(in Hg)

SAMPLE INFORMATION

Start Time (date/time) ______________________ Initial Vacuum______________(in Hg)
End Time (date/time) __________________________Final Vacuum_______________(in Hg)

LABORATORY INFORMATION

Laboratory: ____

Analytical Method: ____

NOTES/COMMENTS:

____
____
____
____
____

Sampler's Signature____Date__________________________