

Recommended approach for evaluating the vapor intrusion pathway using soil gas sampling

Soil gas samples may be collected to evaluate the potential for vapor intrusion into enclosed structures. Soil gas sampling should follow the model screening procedure when determining if a volatile compound is a concern at a site. If vapor intrusion associated with subsurface contamination appears to be a concern based on a comparison of soil and/or groundwater data to enclosed structure standards present in RECAP Tables 2 or 3 or site-specific standards developed using Appendix H, soil gas samples may be collected to evaluate site conditions.

The principal objective of soil gas sampling is to obtain an upper-bound representation of the source concentration beneath the structure that will allow for a conservative estimation of the potential exposure and health risk associated with vapor intrusion. To achieve this objective, baseline samples must be collected under conditions expected to give rise to maximum soil gas concentrations. Such site-specific conditions that may influence soil gas concentrations include meteorological conditions (temperature, barometric pressure, and precipitation), hydrogeological conditions (periods of high groundwater levels), and gravitational effects (tides). These conditions shall be noted and discussed in the submittal.

Sample Collection:

Sufficient samples are to be collected to estimate the COC concentrations based on spatial and temporal scales. Dependent on site-specific conditions, multiple sampling events may be necessary to adequately characterize the upper bound soil gas COC concentration contributing to indoor air exposure. A work plan addressing the following items shall be submitted for approval before soil gas sampling is performed at a site. Soil vapor sampling issues specific to UST sites are discussed at the end of this section.

- (a) Soil gas samples may be taken immediately adjacent to (perimeter sample) or from beneath the slab in the area of highest subsurface contamination. In general, both perimeter and sub-slab soil gas samples should be collected as close as possible to exterior walls. The depth and volume of the soil gas sample shall be adequate to prevent the leakage of atmospheric air into the sample. Perimeter samples should be collected at multiple depths to provide a vertical soil gas profile. A minimum of two intervals should be sampled, e.g., five feet and three feet, four feet and two feet, etc., based on site geology and peak water table elevation. When collecting sub-slab samples, at least one additional sample shall be collected from an interior location near the center of the slab. Samples taken from beneath the slab may be obtained by drilling directly through the slab or by angle-drilling and should be collected within twelve inches of the bottom of the slab in the most permeable material present in the zone. If sampling directly beneath the slab is not possible, sufficient samples shall be collected adjacent to the structure to allow for estimation of the COC concentration in the soil and/or groundwater beneath the structure based on spatial and temporal scales. For sites with a seasonally high water table less than ten feet below ground surface, soil gas sampling shall coincide with seasonal peak water table elevations.
- (b) Gas probe installation methods may include hand equipment (hand auger, hammer drill, etc.), hydraulically advance probes, or other approved equipment. Sampling points should consist of small diameter tubing extending from the sampling zone to the surface equipped with an appropriate screen (sampling tip or other approved material). Use of small diameter (e.g. 1/8 inch) tubing is encouraged to reduce purge volume and prevent leakage/breakthrough. Materials of construction shall not adversely affect sample integrity and may include such materials as stainless steel, nylon, or Teflon. Sampling points shall be provided with an annular seal to prevent vertical contaminant migration, infiltration, and atmospheric intrusion during sampling.

- (c) Sample collection shall be by an active whole-air sampling method. Unless otherwise approved, a minimum of three dead volumes shall be purged prior to sample collection. Samples should be collected in low volume canisters (generally < 1L) or other method-specific container. Samples for semi-volatile analysis may be collected on a polyurethane foam (PUF) plug. Sample collection by other methods shall receive Department approval.
- (d) Leakage of atmospheric air into the samples shall be checked using an appropriate tracer gas to determine sample reliability.
- (e) Soil classifications shall be performed for all soil gas samples and shall describe the soil type at each sampling location.
- (f) Perimeter sampling points shall include the most permeable unsaturated zone in accordance with the previously described requirements.**
- (g) Flow rates into the Summa canister shall be less than 200 mL/min.
- (h) Samples shall be analyzed within 48 hours.
- (i) Samples shall not be chilled during storage.
- (j) Vertical soil profiles used for the purpose of documenting site-specific bioattenuation shall include, at a minimum: 1) samples obtained from two locations at a depth between 1 to 5 ft bgs; and 2) measurements of oxygen, methane, and carbon dioxide.

Soil Gas Sampling Issues Specific to UST Sites:

Due to business-related activities, equipment, and space limitations, sub-slab soil vapor sampling may not be practical or possible at typical UST sites. As an alternative, LDEQ will consider the use of soil vapor samples collected immediately adjacent to the structure to determine if vapors from contaminated subsurface soil or groundwater are adversely impacting indoor air quality. The following items shall be addressed in all non-sub-slab soil-vapor sampling work plans submitted for UST sites:

- (a) Selection of sampling points – the number and locations of sampling points shall be capable of providing information considered to be representative of sub-slab soil vapor conditions and address the potential for vapor entry into all parts of the structure exposed to subsurface contamination.
- (b) Construction of sampling points – all sampling points shall be: 1) installed in a manner that does not adversely affect the collection of representative samples; 2) constructed of materials that will not adversely impact sample integrity; 3) sealed with an appropriate material to prevent vertical vapor migration along the annulus; and 4) capable of providing a vertical profile of soil vapor (e.g., sample locations shall include multiple vapor probes screened at different intervals below ground surface).
- (c) Sample collection – sample collection shall meet the following requirements: 1) the sampling protocol shall ensure that all sampling equipment is contaminant-free; 2) sampling probes shall be purged of a minimum of three volumes while exercising care to avoid excessive purging; 3) soil vapor sample volumes shall be limited to ensure a representative sample of the zone of interest (generally < 500 cc); 4) the sampling protocol shall include a tracer compound to verify annular seal integrity; and 5) vapor samples shall conform to RECAP stipulated QA/QC protocol for preservation, shipping, and handling.

- (d) Sample analysis – analytical procedures shall conform to RECAP requirements for applicability and detection limits. In addition to the petroleum-related constituents of concern identified from Table D-1 of Appendix D of RECAP, the analyte list should include oxygen, carbon dioxide, and methane to allow for the evaluation of bioattenuation under site-specific conditions.

Quality Assurance/Quality Control protocol:

- (a) See RECAP Section 2.4
- (b) Collect data on ambient conditions that could influence soil gas results.

Analytical Methods:

Volatile samples may be analyzed using either: 1) EPA Reference Method TO-15; or 2) EPA Method 8260 if appropriate for the COC (i.e., method SQL is less than the level of concern). Constituents collected on a PUF plug shall be analyzed using EPA Method TO-10. The use of any other analytical procedure shall be justified in the work plan.

Application of Soil Gas Data:

1. Compare the maximum detected concentration and the 95%UCL-AM concentration for the soil gas data and identify the lower of these two values as the soil gas AOIC for the evaluation of the vapor intrusion pathway.
2. Identify the soil gas standard from the attached table (Table H5*alpha).
3. Compare the soil gas AOIC to the soil gas standard:

If the AOIC for all of the COC are less than or equal to soil gas standards, then typically no further action is required for the vapor intrusion pathway.

If the AOIC for a COC is greater than the soil gas standard, then the submitter shall further evaluate the vapor intrusion pathway or remediate the soil and/or groundwater to a COC concentration that will not result in an unacceptable COC concentration in indoor air. To further evaluate the vapor intrusion pathway, the Submitter may conduct indoor air sampling at the AOI and compare the indoor air AOIC to the C_a in accordance with Appendix B and Sections H1.1.3.5 and H2.3 of Appendix H. It should be noted that Departmental approval is required prior to conducting indoor air sampling.

Note: The soil gas standards presented in the attached table represent the acceptable COC concentrations in soil gas that will not result in unacceptable COC concentrations in indoor air. These values were derived by adjusting the acceptable indoor air concentrations (C_a) (Table H-5 of Appendix

H of RECAP 2003) to account for attenuation (reduction) of the COC concentration in soil gas associated with migration from the subsurface to the interior of the enclosed structure. In accordance with EPA guidance/recommendations (*Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils*, EPA 2002; EPA Region VI Vapor Attenuation Workshop April 2004) a default alpha factor of 0.1 (i.e., attenuation factor of 10) was applied. Based on literature recommendations (Blayne Hartman, Ph.D.) and EPA recommendations (EPA Region VI Vapor Attenuation Workshop April 2004), an alpha of 100 was applied to petroleum-related constituents. If it is determined by the Department that the

default alpha factor applied in Table H5*alpha is not representative of site-specific conditions, the soil gas standards presented in the Table H5*alpha may not be used for the evaluation of the vapor intrusion pathway and/or for site management decisions.

Example:

1. The concentration reported for benzene in the soil gas is 900 ug/m³.
2. The soil gas standard for benzene is 1200 ug/m³ (refer to TableH5*alpha).
3. Compare the soil gas concentration to the soil gas standard:

900 ug/m³ < 1200 ug/m³ therefore no further evaluation of the soil vapor intrusion pathway is required for benzene

LDEQ RECAP SOIL GAS STANDARDS
MANAGEMENT OPTION 2
Table H5 Ca*ALPHA
(ug/m3)

		Cani C-O	Cani N-O		Cai C-O	Cai N-O	
COMPOUND	CAS #	(ug/m3)	(ug/m3)	Note	(ug/m3)	(ug/m3)	Note
Acenaphthene	83-32-9		2.2E+03	J		3.1E+03	J
Acenaphthylene	208-96-8		2.2E+03	J		3.1E+03	J
Acetone	67-64-1		3.7E+03	J		5.1E+03	J
Aldrin	309-00-2						
Aniline	62-53-3						
Anthracene	120-12-7		1.1E+04	J		1.5E+04	J
Antimony	7440-36-0						
Arsenic	7440-38-2						
Barium	7440-39-3						
Benzene	71-43-2	1.2E+03		K	1.2E+03		K
Benz(a)anthracene	56-55-3						
Benzo(a)pyrene	50-32-8						
Benzo(b)fluoranthene	205-99-2						
Benzo(k)fluoranthene	207-08-9						
Beryllium	7440-41-7						
Biphenyl,1,1-	92-52-4		2.4E+02	K		2.4E+02	K
Bis(2-chloroethyl)ether	111-44-4	3.0E+00		K	3.0E+00		K
Bis(2-chloroisopropyl)ether	108-60-1	1.9E+00	1.5E+03	J	4.1E+00	2.0E+03	J
Bis(2-ethyl-hexyl)phthalate	117-81-7						
Bromodichloromethane	75-27-4	1.1E+00	7.3E+02	J	2.3E+00	1.0E+03	J
Bromoform	75-25-2	1.7E+01	7.3E+02	J	3.7E+01	1.0E+03	J
Bromomethane	74-83-9		5.2E+01	J		7.3E+01	J
Butyl benzyl phthalate	85-68-7						
Cadmium	7440-43-9						
Carbon Disulfide	75-15-0		7.1E+02	K		7.1E+02	K
Carbon Tetrachloride	56-23-5	6.7E+01		K	6.7E+01		K

NOTE: See end of Table for designation of letter symbols and footnotes.

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COMPOUND	CAS #	(ug/m3)	(ug/m3)	Note	(ug/m3)	(ug/m3)	Note
Chlordane	57-74-9						
Chloroaniline,p-	106-47-8						
Chlorobenzene	108-90-7		1.1E+04	K		1.1E+04	K
Chlorodibromomethane	124-48-1	7.9E-01	7.3E+02	J	1.7E+00	1.0E+03	J
Chloroethane (Ethylchloride)	75-00-3		6.3E+05	K		6.3E+05	K
Chloroform	67-66-3	4.3E+01		K	4.3E+01		K
Chloromethane	74-87-3	5.6E+02		K	5.6E+02		K
Chloronaphthalene,2-	91-58-7		2.9E+03	J		4.1E+03	J
Chlorophenol,2-	95-57-8		1.8E+02	J		2.6E+02	J
Chromium(III)	16065-83-1						
Chromium(VI)	18540-29-97						
Chrysene	218-01-9						
Cobalt	7440-48-4						
Copper	7440-50-8						
Cyanide (free)	57-12-5						
DDD	72-54-8						
DDE	72-55-9						
DDT	50-29-3						
Dibenz(a,h)anthracene	53-70-3						
Dibenzofuran	132-64-9		1.5E+02	J		2.0E+02	J
Dibromo-3-chloropropane,1,2-	96-12-8						
Dichlorobenzene,1,2-	95-50-1		2.1E+03	J		2.9E+03	J
Dichlorobenzene,1,3-	541-73-1		3.3E+01	J		4.6E+01	J
Dichlorobenzene,1,4-	106-46-7		1.4E+04	K		1.4E+04	K
Dichlorobenzidine,3,3-	91-94-1						
Dichloroethane,1,1-	75-34-3		5.2E+03	J		7.3E+03	J

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COMPOUND	CAS #	Cani C-O (ug/m3)	Cani N-O (ug/m3)	Note	Cai C-O (ug/m3)	Cai N-O (ug/m3)	Note
Dichloroethane,1,2-	107-06-2	3.9E+01		K	3.9E+01		K
Dichloroethene,1,1-	75-35-4		2.1E+03	J		2.9E+03	J
Dichloroethene,cis,1,2-	156-59-2		3.7E+02	J		5.1E+02	J
Dichloroethene,trans,1,2-	156-60-5		7.3E+02	J		1.0E+03	J
Dichlorophenol,2,4-	120-83-2						
Dichloropropane,1,2-	78-87-5		8.3E+04	K		8.3E+04	K
Dichloropropene,1,3-	542-75-6		1.1E+03	K		1.1E+03	K
Dieldrin	60-57-1						
Diethylphthalate	84-66-2						
Dimethylphenol,2,4-	105-67-9						
Dimethylphthalate	131-11-3						
Di-n-octylphthalate	117-84-0						
Dinitrobenzene,1,3-	99-65-0						
Dinitrophenol,2,4-	51-28-5						
Dinitrotoluene,2,6-	606-20-2						
Dinitrotoluene,2,4-	121-14-2						
Dinoseb	88-85-7						
Endosulfan	115-29-7						
Endrin	72-20-8						
Ethyl benzene	100-41-4		1.0E+06	K		1.0E+06	K
Fluoranthene	206-44-0						
Fluorene	86-73-7		1.5E+03	J		2.0E+03	J
Heptachlor	76-44-8						
Heptachlor epoxide	1024-57-3						
Hexachlorobenzene	118-74-1	2.0E+00		K	2.0E+00		K
Hexachlorobutadiene	87-68-3						

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COMPOUND	CAS #	(ug/m3)	(ug/m3)	Note	(ug/m3)	(ug/m3)	Note
Hexachlorocyclohexane,alpha	319-84-6						
Hexachlorocyclohexane,beta	319-85-7						
Hexachlorocyclohexane,gamma	58-89-9						
Hexachlorocyclopentadiene	77-47-4		2.1E+00	J		2.9E+00	J
Hexachloroethane	67-72-1	2.5E+02		K	2.5E+02		K
Indeno(1,2,3-cd)pyrene	193-39-5						
Isobutyl alcohol	78-83-1						
Isophorone	78-59-1						
Lead (inorganic)	7439-92-1						
Mercury (inorganic)	7487-94-7						
Methoxychlor	72-43-5						
Methylene chloride	75-09-2	2.1E+03		K	2.1E+03		K
Methyl ethyl ketone	78-93-3		1.4E+05	K		1.4E+05	K
Methyl isobutyl ketone	108-10-1		4.9E+04	K		4.9E+04	K
Methylnaphthalene,2-	91-57-6		3.1E+01	J		4.4E+01	J
MTBE (methyl tert-butyl ether)	1634-04-4		3.1E+05	J		4.4E+05	J
Naphthalene	91-20-3		3.1E+01	J		4.4E+01	J
Nickel	7440-02-0						
Nitrate	14797-55-8						
Nitrite	14797-65-0						
Nitroaniline,2-	88-74-4		1.1E+00	J		1.5E+00	J
Nitroaniline,3-	99-09-2		1.1E+02	J		1.5E+02	J
Nitroaniline,4-	100-01-6						
Nitrobenzene	98-95-3		1.2E+03	K		1.2E+03	K
Nitrophenol,4-	100-02-7						
Nitrosodi-n-propylamine,n-	621-64-7						

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COMPOUND	CAS #	Cani C-O (ug/m3)	Cani N-O (ug/m3)	Note	Cai C-O (ug/m3)	Cai N-O (ug/m3)	Note
N-nitrosodiphenylamine	86-30-6						
Pentachlorophenol	87-86-5						
Phenanthrene	85-01-8		1.1E+04	J		1.5E+04	J
Phenol	108-95-2		1.1E+04	J		1.5E+04	J
Polychlorinated biphenyls	1336-36-3						
Pyrene	129-00-0		1.1E+03	J		1.5E+03	J
Selenium	7782-49-2						
Silver	7440-22-4						
Styrene	100-42-5		1.0E+04	K		1.0E+04	K
Tetrachlorobenzene,1,2,4,5-	95-94-3						
Tetrachloroethane,1,1,1,2-	630-20-6	1.0E+00		K	1.0E+00		K
Tetrachloroethane,1,1,2,2-	79-34-5	1.7E+01		K	1.7E+01		K
Tetrachloroethylene	127-18-4	1.1E+03		K	1.1E+03		K
Tetrachlorophenol,2,3,4,6-	58-90-2						
Thallium	7440-28-0						
Toluene	108-88-3		4.0E+04	K		4.0E+04	K
Toxaphene	8001-35-2						
Trichlorobenzene,1,2,4-	120-82-1		2.1E+03	J		2.9E+03	J
Trichloroethane,1,1,1-	71-55-6		1.0E+04	J		1.5E+04	J
Trichloroethane,1,1,2-	79-00-5	6.3E+01		K	6.3E+01		K
Trichloroethene	79-01-6	5.9E+02		K	5.9E+02		K
Trichlorofluoromethane	75-69-4		7.3E+03	J		1.0E+04	J
Trichlorophenol,2,4,5-	95-95-4						
Trichlorophenol,2,4,6-	88-06-2						
Vanadium	7440-62-2						
Vinyl chloride	75-01-4	1.2E+01		K	1.2E+01		K

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Xylene(mixed)	1330-20-7		1.1E+04	J		1.5E+04	J
Zinc	7440-66-6						
Aliphatics C6-C8	NA		1.9E+06	J		1.9E+06	J
Aliphatics >C8-C10	NA		1.1E+05	J		1.1E+05	J
Aliphatics >C10-C12	NA		1.1E+04	J		1.1E+04	J
Aliphatics >C12-C16	NA		1.1E+04	J		1.1E+04	J
Aliphatics >C16-C35	NA						
Aromatics >C8-C10	NA		2.2E+04	J		2.2E+04	J
Aromatics >C10-C12	NA		2.2E+03	J		2.2E+03	J
Aromatics >C12-C16	NA		2.2E+03	J		2.2E+03	J
Aromatics >C16-C21	NA						
Aromatics >C21-C35	NA						
TPH-GRO	NA		2.2E+04			2.2E+04	
TPH-DRO	NA						
TPH-ORO	NA						
J - Developed using risk-based value calculated with one of the equations EQ 56 thru 59.							
K - Developed using Louisiana Toxic Air Pollutant Ambient Air Standards (LAC 33:III.5112 Table 51.2).							
Alpha = 100 for the following compounds: Benzene, Ethyl benzene, MTBE, Toluene, Xylene(mixed), Aliphatics C6-8,							
Aliphatics >C8-10, Aromatics >C8-10, and TPH-GRO. Alpha = 10 for all other constituents.							

NOTE: See end of Table for designation of letter symbols and footnotes.