** This document is for the purpose of discussion only **
June 11, 2003 Meeting of the Vapor Intrusion Subcommittee
DEPARTMENT OF ENVIRONMENTAL PROTECTION
Bureau of Land Recycling and Waste Management

DOCUMENT NUMBER: 253-0300-100

TITLE: Land Recycling Program Technical Guidance Manual- Section IV.A.4. Vapor Intrusion into Buildings from Groundwater and Soil under the Act 2 Statewide Health Standard.

ANTICIPATED EFFECTIVE DATE: October 26, 2002

AUTHORITY:

The Land Recycling and Environmental Remediation Standards Act (Act 2 of 1995) (35 P.S. §§6026.101 et seq.) and the regulations issued pursuant to that legislation at 25 PA Code Chapter 250.

POLICY:

It is the policy of the Department to implement Act 2 in accordance with the regulations contained in Chapter 250 of the PA Code and as described in this guidance manual.

PURPOSE:

The Department has developed a technical guidance manual to assist remediators in satisfying the requirements of Act 2 and the regulations published in Chapter 250 of the PA Code. This specific guidance, which is to be incorporated into the technical manual, is to provide additional attainment screening requirements in some cases, to prevent risk of unacceptable risk being present as result of vapor intrusion of contaminants from soil and/or groundwater into indoor structures.

APPLICABILITY:

The guidance is applicable to any person or persons conducting a site remediation under Act 2 under the Statewide Health Standard.

DISCLAIMER:

The policies and procedures outlined in this guidance document are intended to supplement existing requirements. Nothing in the policies or procedures will affect regulatory requirements.

The policies and procedures herein are not an adjudication or a regulation. There is no intent on the part of the Department to give these rules that weight or deference. This document establishes the framework, within which DEP will exercise its administrative discretion in the future. DEP reserves the discretion to deviate from this policy statement if circumstances warrant.

PAGE LENGTH: 24 pages

LOCATION: Volume 5 Tab 32

DEFINITIONS: See 25 Pa. Code Chapter 250

Introduction

Indoor air quality from the vapor intrusion of contaminants into buildings from groundwater and soil is not specifically detailed in the Act 2, Chapter 250 regulations. This document provides guidance for assessing the potential for indoor vapor intrusion pathways under Statewide health standard (SHS) .

This document provides guidance for assessing subsurface vapor intrusion of volatile organic ~~and semivolatile~~ contaminants into buildings from contaminated groundwater and soils. When releases occur near buildings, volatilization of contaminants from the dissolved or pure phases in the subsurface can result in the intrusion of vapor-phase contaminants into indoor air.

Decision matrices for consideration of indoor air quality were developed for groundwater and soil under a Statewide health or generic approach. The matrices apply under the specific conceptual model conditions used in their development. Hence, users are cautioned to make sure that the conditions at the site are applicable.

In these matrices, several options are provided for determining if indoor air quality (IAQ) is a concern. These include:

- Comparison of media concentration to previously available soil and groundwater medium specific concentrations (MSCs). This option allows one to determine when a constituent is not of potential concern for indoor air if certain available MSCs are met (see Tables 1-2, Groundwater; Tables 4-5, Soil). Specifically, with the exception of some volatile ~~three~~ compounds, none of the regulated substances for which a nonuse aquifer standard is listed in Chapter 250 would be a concern in groundwater if the MSCs for nonuse aquifers are met. The same is true for soil meeting a used aquifer standard, with only a few regulated substances being a concern at levels below the used aquifer standards published in Chapter 250. Although the currently available MSC have their specific points of compliance (e.g., GW at the property boundary) use of the MSC for the vapor intrusion pathway must meet the applicable conditions for the pathway (e.g., with 100' of an occupied building).

- Comparison to conservative default screening values for groundwater and soil ~~soil and groundwater~~ (see Tables 1-2 and Tables 4-5) calculated using Pennsylvania-specific parameters and the Johnson and Ettinger (J&E) Vapor Intrusion model (USEPA, 2001). These values are used to identify chemicals of potential indoor air concern (COPIACs) when this calculated screening level is lower than an MSC. However, the values can also be used to screen the concentration of COPIACs in a given medium to determine if additional evaluation or mitigation is warranted. For example, the residential screening value for chloroform in groundwater is 410 µg/L (see Table 1). Based on this value, groundwater concentrations that meet the used aquifer MSC would not be of concern for the indoor air pathway. However, concentrations above 410 µg/L (including groundwater that meets the nonuse aquifer MSC) would require further evaluation.

- Comparison to soil gas values derived using the MSC_{IAQ} and a transfer factor to account for attenuation between the outside and inside of buildings. This allows one to measure vapor concentrations outside the buildings and extrapolate to estimated levels inside the building. See Table 3.
- Comparison to MSC developed for IAQ (MSC_{IAQ}) using measured indoor air concentrations. See Table 3.

If indoor air quality is determined to be a concern based on the use of these matrices, one may address (mitigate) the contamination or perform a site-specific evaluation.

General Considerations

There are basically two prerequisites that must be met for the vapor intrusion pathway to be of potential concern. First, inhabited buildings must be close to a source of volatile~~/semivolatile~~ source and, second, the source must be above some "threshold or screen ~~trigger~~" concentration. Through a series of modeling exercises and professional judgment these conditions were incorporated into the guidance.

The distance at which concentrations are negligible is a function of the mobility, toxicity and persistence of the chemical, as well as the geometry of the source, subsurface materials, and characteristics of the building of concern. One hundred (100) feet horizontally from the source to receptor (inhabited building) was chosen as the criterion to define when sites were close enough and so needed to be addressed for vapor intrusion. Vertically separation distances, based on the modeling exercises, are discussed in later sections of the Guidance. Screening ~~Trigger~~ values were also defined on the basis of the modeling exercise and are discussed in appropriate sections.

In addition, under SHS, if separate phase liquid (SPL – see definitions) is encountered beneath the site or within 100 feet of the receptor, soil gas or indoor air sampling are required. The model used does not account for SPL. The presence of preferential exposure pathways (see definitions) also limits the further use of the matrix, i.e., the model used to develop default screening levels cannot account for preferential pathways. In this case, not only is it not possible to predict contaminant concentrations but it is not possible to determine where the material will end up. Hence, sampling is required to meet SHS, if preferential pathways are present.

Evaluating the vapor intrusion pathway into buildings, on a generic basis, is extremely difficult. For example, even though reasonable Pennsylvania-specific assumptions (Table 8) were used, the J&E model as applied uses conservative processes (e.g., infinite source, no degradation). This tends to produce conservative screening values that may indicate a potential IAQ problem where there is not one. It was decided to err on the side of conservatism, since the option exists to further evaluate on a site-specific basis if believed warranted. Another important concern is the prevalence of other sources of volatile organics (particularly indoors) that can complicate interpretation of sampling results. A remediator should use caution when making decisions based on both indoor air and soil gas analyses.

If a property does not currently have dwellings (non-residential) and it is possible that future development will consist of occupied buildings (residential), the deed acknowledgment requirements shall apply pursuant to Chapter 250.303(g).

Application To the Site-Specific Standard

The development of the indoor air-specific concentrations (MSC_{iaq}) for volatile chemicals under the statewide health standard (SHS) has been entirely focused on the individual chemicals. No pre-planned effort was made to address the cumulative effects of the chemicals under the SHS, consistent with Act 2. The reason for this is that the process used to develop the indoor air MSC is so highly conservative. For example, the maximum acceptable risk level under Act 2 that is employed in the site-specific standard (SSS) is 10-4. The MSC intended for use in the SHS were derived using a potential cancer risk of 10-5. It is apparent here that there is a 10-fold additional factor of protectiveness in this aspect of the derivation alone. For the reasons of sufficient conservatism already incorporated, additional consideration of cumulative indoor air effects in the SHS is considered unwarranted, again consistent with Act 2. The same rationale applies to non-carcinogens at a Hazard Quotient of 1.

For the SSS, it is appropriate to use a similar screening process as used to identify potential indoor air concerns at the statewide health standard. This is consistent with the purpose of the screening, which is to eliminate chemicals from quantitative consideration if they are present at concentrations that clearly do not pose a potential for unacceptable risk. However, additional considerations are warranted for the indoor air pathway (as for all pathways) under the SSS. The cumulative effects of chemicals, which are present at concentrations exceeding their respective indoor air MSC are considered in the SSS by summing those potential risks for each receptor from all appropriate chemicals (separately for both cancer and non-cancer effects) and pathways. This methodology is consistent with general standard USEPA approaches under the RCRA and CERCLA programs.

Also under the SSS, the ~~indoor air~~ intrusion pathway from groundwater to indoor air cannot be considered as incomplete based on the groundwater "screen-out" criterion. The groundwater criterion says that the inhabited building or structure below grade occupies space ~~is~~ separated vertically from the source by at least 30 feet of sand or 15 feet of soil other than sand. The ~~indoor air~~ intrusion pathway from soil to indoor air also cannot be used as a ~~considered as incomplete based on the~~ "screen-out" criterion. The soil screen out criterion says that the inhabited building is separated vertically from the source by at least 10 feet of sand or soil-like (fill) material. These two "screen-out" criteria in the IAQ decision matrices for SHS are not available under the SSS. These two criteria were developed based on the assumption that the site would meet all other requirements of the SHS prior to consideration of the "screen out" criteria. Hence, these ~~Such~~ assumptions are not ~~is no longer~~ valid under the SSS.

Process for Groundwater

In the Groundwater IAQ Decision Matrix for SHS (Figure 1), the receptor location and type of soil are critical. The pathway is only relevant if inhabited buildings are proximate to the source. Further, under SHS, if separate phase liquid (SPL – see SHS definitions) is encountered beneath the site or within 100 feet of the receptor at or above the water table, soil gas sampling or indoor air sampling is required. ~~If a site has SPL within 100 feet of the receptor and samples collected at 50 feet from the receptor indicate no SPL, then further soil gas sampling would not be required at the receptor. If SPL is found within 50 feet of the receptor, soil gas would be required at the receptor.~~ In addition, the presence of preferential exposure pathways (see SHS definitions) limits the further use of the matrix. Hence, additional sampling is required to meet the SHS if preferential exposure pathways are present and pass through the source or occur within 30 feet of the source.

For residential land uses ~~receptors~~, if the levels of chlorodibromomethane, chloroethane, chloroform, free cyanide, 1,1-dichloroethylene, ethylbenzene, naphthalene, 1,1,1,2-tetrachloroethane, 1,2,3-trichloropropane, and xylenes do not exceed the residential groundwater MSC (MSCgw) for used aquifers, and other regulated substances in groundwater do not exceed the residential MSCgw for a nonuse aquifer, no further site evaluation is required. See Table 1 for groundwater residential values.

For non-residential land uses ~~receptors~~, if the levels of benzotrichloride, chlorodibromomethane, chloroethane, chloroform, free cyanide, ethylbenzene and 1,2,3-trichloropropane do not exceed the nonresidential MSCgw for used aquifers and other regulated substances do not exceed the nonresidential MSCgw for nonuse aquifers, no further site evaluation is required. No regulated substances were identified as being of concern when Occupational Safety and Health (OSHA) endpoints (i.e., permissible exposure limits or PELs) were used with standard worker exposure assumptions. The OSHA-derived screen (~~USEPA~~ PA defaults) may be used as an alternate to the default EPA-derived screen when OSHA regulations are fully implemented (e.g., notification, monitoring) and documented in a workplace building. In addition, the permissible exposure limits (PELs) prescribe concentrations that cannot be exceeded during a workday. See Table 2 for groundwater nonresidential values.

When the appropriate MSC_{GW} is exceeded, a potentially complete pathway exists if an inhabited building or below grade occupied space is:

- Within 100 feet of a source horizontally, and
- The groundwater concentration is greater than the MSC_{GW} for a nonuse aquifer and is not separated vertically from the source by at least 30 feet (of sand) or 15 feet (of soil other than sand).

For a potentially complete pathway, if the groundwater concentrations are less than the J&E PA default screening levels (Table 1 – residential, Table 2 – non-residential) and the groundwater is greater than or equal to 5 feet from the receptor, then no further IAQ activity for groundwater is required. Note: When screening groundwater concentrations, the decision to proceed in the screen is based on a non-exceedence rule, NOT the use of the 75%/10x rule.

If the groundwater concentration is greater than the J&E PA default screening levels or if groundwater is less than five feet below the receptor, then the need to further evaluate or mitigate can be determined by comparison of:

- measured soil gas concentrations to soil gas MSC (MSC_{SG}), or
- measured indoor air concentrations to indoor air MSC (MSC_{IAQ}).

The MSC_{IAQ} are found in Table 3 and MSC_{SG} (see SHS definition - soil gas) is a function of the MSC_{IAQ} and a transfer (or attenuation) factor of 0.01, from outside to inside the building.

If MSC_{SG} or MSC_{IAQ} is exceeded for these SHS evaluations, then risk management (mitigation) activities are warranted, including another comparison to MSC_{IAQ} of either soil gas or measured indoor levels after mitigation. However, one may proceed to a site-specific risk analysis (including using the J&E model with site-specific input) in lieu of additional efforts under SHS. If MSC_{SG} or MSC_{IAQ} is not exceeded, then no further activity for groundwater is warranted.

Process for Soil

In the Soil IAQ Decision Matrix for SHS (Figure 2), the receptor location and type of soil are critical. The pathway is only relevant if inhabited buildings are proximate to the source. Further, if SPL is encountered beneath or within 100 feet of an inhabited building or below grade occupied space at or above the water table, this moves the process to soil gas sampling or indoor air sampling. ~~If a site has SPL within 100 feet of the receptor and samples collected at 50 feet from the receptor indicate no SPL, then further soil gas sampling would not be required at the receptor. If SPL is found within 50 feet of the receptor, soil gas would be required at the receptor.~~ Also, if preferential exposure pathways are present and pass through the source or occur within 30 feet of the source, then the decision matrix requires that soil gas or indoor air sampling be performed.

The following chemicals were identified as COPIACs because their presence in soil even below the $MSC_{soil\ to\ gw}$ for used aquifers may lead to indoor air concerns. A responsible party must ~~needs only to~~ sample and analyze for those constituents pertaining to the particular release at the site that are on the COPIAC list or in Tables 1, 2, 4, 5. If the constituent is not listed in the tables and it is found to be a concern at a particular site, then a site-specific analysis should be used. The COPIACs identified in soil based on specific receptors are as follows:

Residential	**Non-Residential (Commercial/Industrial) Using USEPA Toxicity Endpoints**	**Non-Residential (Commercial/Industrial) Using OSHA Endpoints***
Ammonia	Ammonia	1-Chloro-1,1-Difluoroethane
Benzene	Bis(2-chloro-isopropyl)ether	1,-Chlorobutane
Bis(2-chloro-isopropyl)ether	Bromodichloromethane	Cumene
Bromodichloromethane	1,3-Butadiene	Cyanide, Free

Bromomethane 1,3-Butadiene Carbon Disulfide Carbon Tetrachloride Chloro-1,1-Difluoroethane,1- Chloro-1-Propene,3-(Allyl Chloride) Chlorobenzene 1-Chlorobutane Chloroethane Chloroform Chloroprene 2-Chloropropane Cumene Cyanide, Free Dibromochloromethane 1,4 –Dichlorobenzene ~~Dichlorodifluoromethane (Freon 12)~~ 1,1 – Dichloroethane 1,2-Dichloroethane 1,1 – Dichloroethene (EDC) cis – 1,2 – Dichloroethene trans – 1,2 – Dichloroethene 1,2-Dichloropropane 1,3-Dichloropropene Ethylbenzene ~~Fluorotrichloromethane (Freon 11)~~ Furan Hexane Methylstyrene (Mixed Isomers) Methylstyrene, alpha n-Propylbenzene 1,1,1,2-Tetrachloroethane Toluene Trichloro-1,2,2-Trifluoroethane, 1,1,2- Trichloroethylene 1,2,3-Trichloropropane 1,2,3-Trichloropropene Vinyl Bromide (Bromoethene) Vinyl Chloride Xylenes	Carbon Disulfide Carbon Tetrachloride Chloro-1,1-Difluoroethane,1- Chloro-1-Propene,3-(Allyl Chloride) 1-Chlorobutane Chloroethane Chloroform Chloroprene 2-Chloropropane Cumene Cyanide, Free Dibromochloromethane 1,4-Dichloro-2-Butene ~~Dichlorodifluoromethane (Freon 12)~~ 1,1 – Dichloroethane 1,1 – Dichloroethene (EDC) cis – 1,2 – Dichloroethene trans – 1,2 – Dichloroethene 1,3-Dichloropropene Dicyclopentadiene Ethylbenzene ~~Fluorotrichloromethane (Freon 11)~~ Furan Hexane Methylstyrene,(Mixed Isomers) Methylstyrene, alpha n-Propylbenzene Trichloro-1,2,2-Trifluoroethane, 1,1,2- Trichloroethylene 1,1,2-Trichloropropane 1,2,3-Trichloropropane 1,2,3-Trichloropropene Vinyl Bromide (Bromoethene) Vinyl Chloride Xylenes	Hexane n-Propylbenzene 1,1,2-Trichloro-1,2,2- trifluoroethane Xylenes

* The OSHA-derived screen may be used as an alternate to the default EPA-derived screen when OSHA regulations are fully implemented (e.g., notification, monitoring) and documented in a workplace building.

If any of these COPIACs are present at the site or if other volatile constituents exceed the MSC $_{soil\ to\ gw}$ (Tables 4 & 5) for a used aquifer, a potentially complete pathway exists if an inhabited building is:

- Within 100 feet of a source horizontally, and
- the soil concentration is ~~must be~~ greater than the MSC $_{soil\ to\ gw}$ for a nonuse aquifer and there is less than or equal to 10 feet of uncontaminated sand/soil or soil-like[1] (fill) materials between the receptor point and contamination vertically.

If either of these conditions is not met, then the pathway is not complete and no further IAQ activity for soil is required. Note that the soils elsewhere at the site (including below 10 feet) must meet the applicable soil MSC and SHS for a nonuse aquifer on the property. If these conditions are met, the evaluation should continue to examine potentially complete exposure pathways.

For a potentially complete exposure pathway, if the soil concentrations are less than the J-E PA default screening levels (Table 4 – residential, Table 5 – nonresidential) and the contamination is greater than or equal to five feet from the receptor, then no further IAQ activity for soil is required. Note: When screening soil concentrations, the decision to proceed in the screen is based on a non-exceedence rule, NOT the use of the 75%/10x rule.

The OSHA-derived screen (USEPA-PA defaults) may be used when OSHA regulations are fully implemented and documented in a workplace building. In addition, the permissible exposure limits (PELs) would also prescribe concentrations that cannot be exceeded during a workday.

If the soil concentration is greater than the J&E PA default screening levels or the source is less than five feet below the receptor, then the need to further evaluate or mitigate can be determined by comparison of:

- measured soil gas concentrations to soil gas MSC (MSC_{SG}), or
- measured indoor air concentrations to indoor air MSC (MSC_{IAQ}).

The MSC_{IAQ} are found in Table 3 and MSC_{SG} (see SHS definition- soil gas) is a function of the MSC_{IAQ} and a transfer (or attenuation) factor of 0.01, from outside to inside the building.

If MSC_{SG} or MSC_{IAQ} is exceeded for these SHS evaluations, then risk management (mitigation) activities are warranted, including another comparison to MSC_{IAQ} of either soil gas or measured indoor levels after mitigation. However, one may proceed to a site-specific risk analysis (including using the J&E model with site-specific input) in lieu of additional efforts under SHS. If MSC_{SG} or MSC_{IAQ} is not exceeded, then no further activity for soil is warranted.

Sampling

[1] Soil-like material is defined as a conglomeration of soils and residuals such as ash from the residential burning of wood or coal, incinerator ash, coal ash, slag and dredged material and other similarly sized solid inert material.

For either matrix, under SHS the presence of SPL requires sampling of either soil gas or indoor air at the location of the receptor for levels of regulated substances that may be present. In addition, the existence of preferential exposure pathways (see SHS Definitions) moves the process to sampling.

- Approaches for soil gas screening and interpretation and IAQ sampling and interpretation are listed briefly in Table 6. Note that when sampling indoor air, many regulated substances have multiple sources and may be present in indoor air due to outdoor ambient levels or sources within the building rather than due to presence in groundwater or soil (e.g., benzene, chloroform). Sources are found in a variety of household products such as paints, fuels, varnishes and cleaning solutions, from personal habits (e.g., smoking) or hobbies (e.g., glues and adhesives). Use caution in taking indoor air samples and interpreting the results in this context.
- Sampling soil gas and indoor air is complex and should be approached with caution. A plan should be developed to assist in addressing data quality objectives before beginning sampling.

Odors

Odor perception is highly subjective and not directly a human health concern~~. however, it has been potentially linked to perceived health issues and psychological disorders.~~ Odor was evaluated during the development of the MSC_{IAQ} because some substances can be detected by odor (odor threshold) at low concentrations in air, much lower than those that would cause a health concern. ~~For some compounds, one can detect the odors at levels that are lower than any human health concern. (e.g., MSC_{IAQ}).~~ A comparison of the odor thresholds from literature sources to the corresponding MSC_{IAQ} was done. ~~Except for styrene and toluene, odor thresholds were higher than the MSC_{IAQ}.~~ The odor thresholds of approximately 12% of the compounds listed on Table 3 are lower than the residential MSC_{IAQ}. Because there is not a substantial difference between the odor thresholds and MSC_{IAQ}, odors were not considered further in the IAQ scheme under SHS (Table 3). ~~Therefore, because there is not a substantial difference in values, odors were not considered further in the IAQ scheme under SHS (Table 3).~~

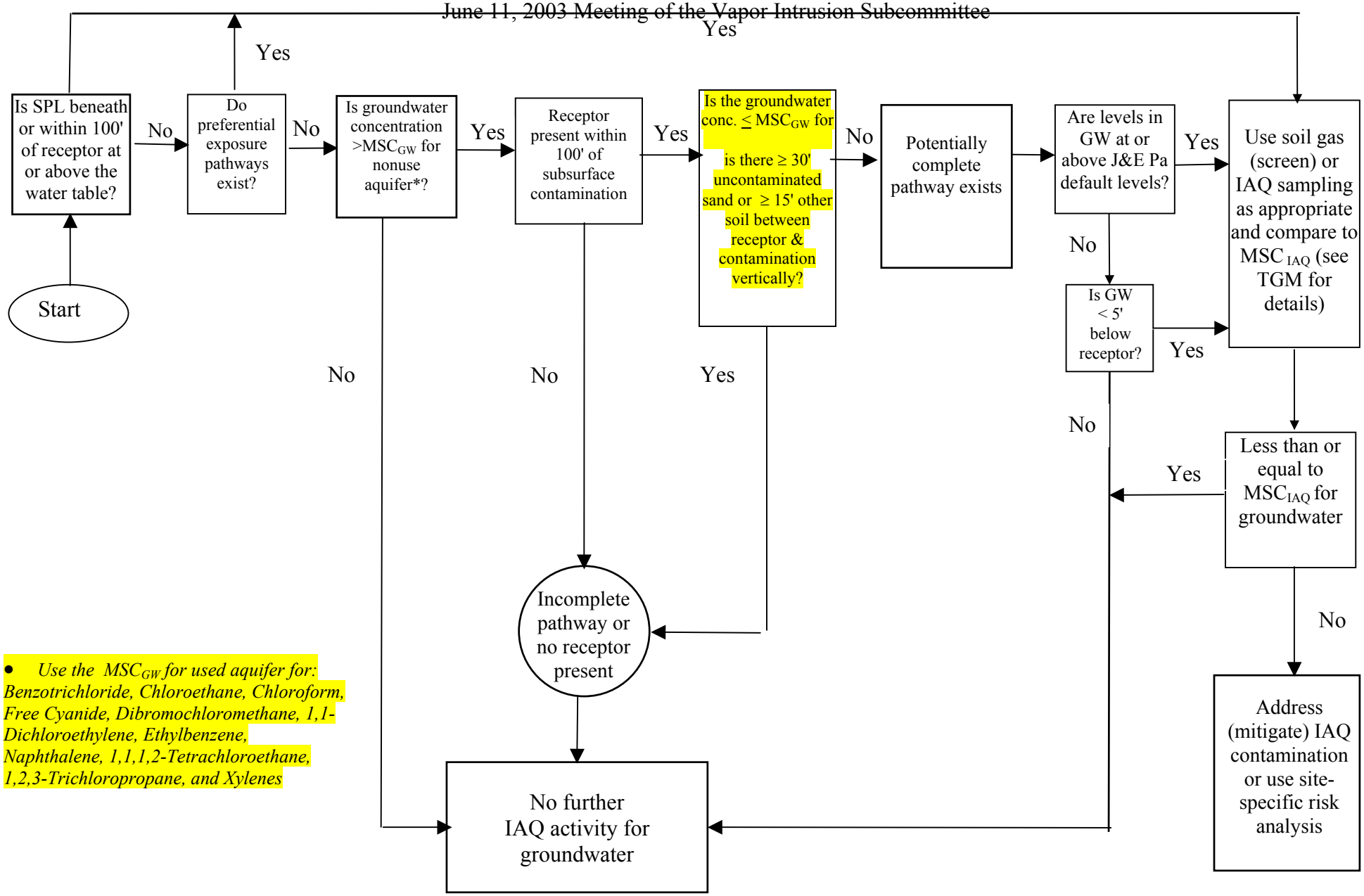

Figure 1. Groundwater IAQ Decision Matrix for SHS

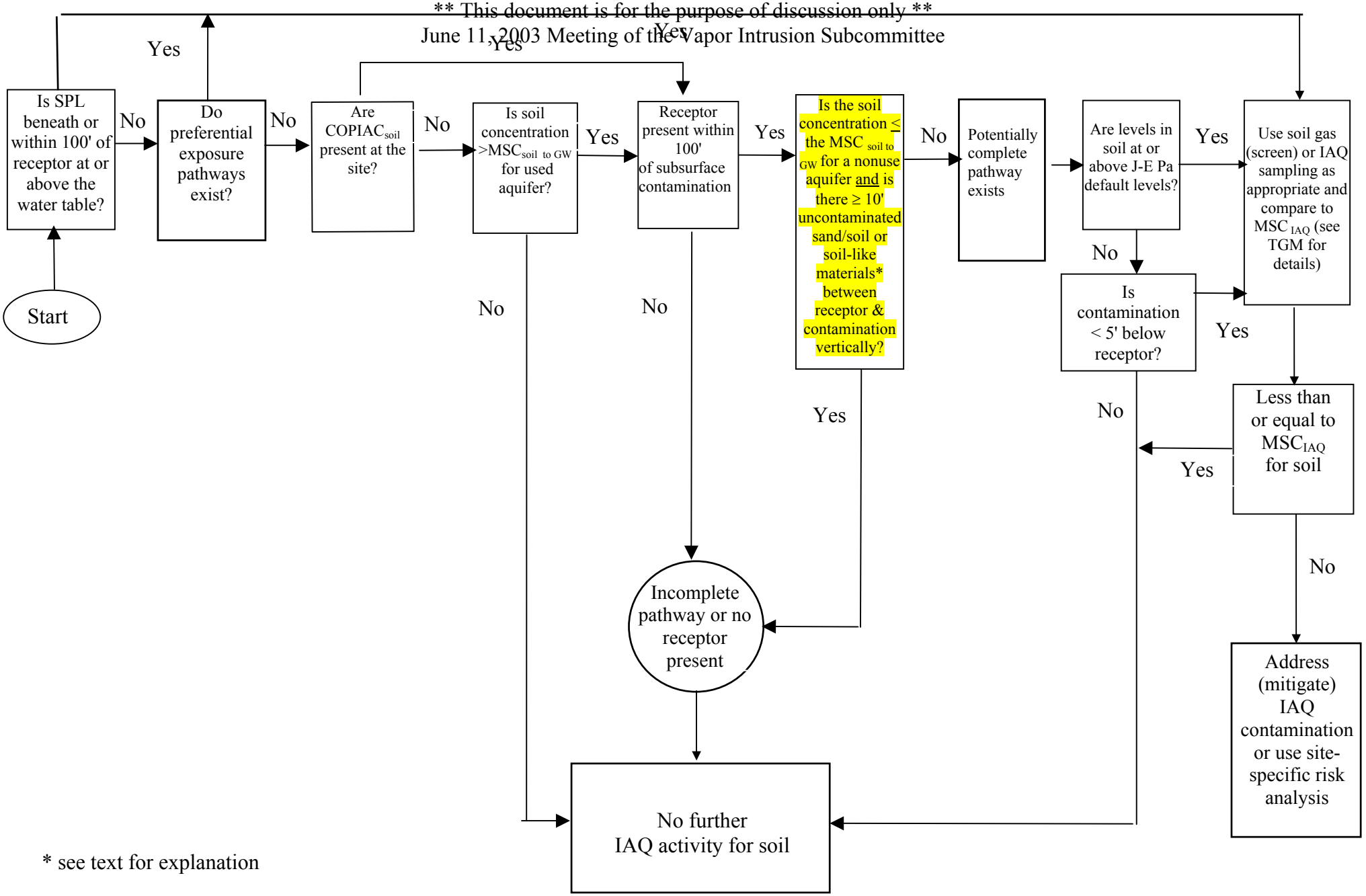

Figure 2. Soil IAQ Decision Matrix for SHS

Table 1
Groundwater Screening Criteria (ug/L) for Protection of Indoor Air - Residential

CAS Number	Regulated Substance	Pennsylvania GW MSC Used Aquifer	Pennsylvania GW MSC Nonuse Aquifer	PA Defaults Residential Volatilization to Indoor Air Screen*
83-32-9	ACENAPHTHENE	2200	3800	NOC
208-96-8	ACENAPHTHYLENE	2200	16000	NOC
75-07-0	ACETALDEHYDE	19	19	260000
67-64-1	ACETONE	3700	37000	NOC
75-05-8	ACETONITRILE	170	1700	3700000
98-86-2	ACETOPHENONE	3700	3700	NOC
107-02-8	ACROLEIN	0.055	0.55	350
79-06-1	ACRYLAMIDE	0.033	0.033	97000
79-10-7	ACRYLIC ACID	2.8	280	3900000
107-13-1	ACRYLONITRILE	0.63	63	7300
107-18-6	ALLYL ALCOHOL	49	4900	9100000
7664-41-7	AMMONIA	30000	30000	9700000
62-53-3	ANILINE	2.8	2.8	1400000
120-12-7	ANTHRACENE	66	66	NOC
71-43-2	BENZENE	5	500	3500
98-07-7	BENZOTRICHLORIDE	0.051	51	95
100-44-7	BENZYL CHLORIDE	0.87	87	4000
92-52-4	BIPHENYL, 1,1-	1800	7200	NOC
111-44-4	BIS(2-CHLOROETHYL)ETHER	0.13	13	13000
108-60-1	BIS(2-CHLORO-ISOPROPYL)ETHER	300	30000	55000
542-88-1	BIS(CHLOROMETHYL)ETHER	0.00069	0.069	5
74-97-5	BROMOCHLOROMETHANE	90	90	84000
75-27-4	BROMODICHLOROMETHANE	100	100	1600
74-83-9	BROMOMETHANE	10	1000	4500
106-99-0	BUTADIENE, 1,3-	0.15	15	470
71-36-3	BUTYL ALCOHOL, N-	970	9700	NOC
104-51-8	BUTYLBENZENE, N-	1500	1500	NOC
135-98-8	BUTYLBENZENE, SEC-	1500	1500	NOC
98-06-6	BUTYLBENZENE, TERT-	1500	1500	NOC
75-15-0	CARBON DISULFIDE	1900	1900	550000
56-23-5	CARBON TETRACHLORIDE	5	50	1400
75-68-3	CHLORO-1,1-DIFLUOROETHANE, 1-	140000	140000	NOC
107-05-1	CHLORO-1-PROPENE, 3- (ALLYL CHLORIDE)	2.8	280	860
108-90-7	CHLOROBENZENE	100	10000	27000
109-69-3	CHLOROBUTANE, 1-	15000	15000	NOC
124-48-1	**CHLORODIBROMOMETHANE**	100	10000	**3800**
75-45-6	CHLORODIFLUOROMETHANE	100	100	NOC
75-00-3	**CHLOROETHANE**	230	23000	**22000**
67-66-3	**CHLOROFORM**	100	1000	**410**
91-58-7	CHLORONAPHTHALENE, 2-	2900	2900	NOC
95-57-8	CHLOROPHENOL, 2-	40	40	160000
126-99-8	CHLOROPRENE	19	1900	5500
75-29-6	CHLOROPROPANE, 2-	280	280	83000
95-49-8	CHLOROTOLUENE, O-	100	100	120000
1319-77-3	CRESOL(S)	180	18000	NOC

Table 1
Groundwater Screening Criteria (ug/L) for Protection of Indoor Air - Residential

CAS Number	Regulated Substance	Pennsylvania GW MSC Used Aquifer	Pennsylvania GW MSC Nonuse Aquifer	PA Defaults Residential Volatilization to Indoor Air Screen*
95-48-7	CRESOL, O- (METHYLPHENOL, 2-)	1800	180000	NOC
4170-30-3	CROTONALDEHYDE	0.079	7.9	7700
123-73-9	CROTONALDEHYDE, TRANS-	0.079	7.9	5100
98-82-8	CUMENE	1100	50000	NOC
57-12-5	**CYANIDE, FREE**	200	200000	**34000**
108-94-1	CYCLOHEXANONE	49000	49000	NOC
96-12-8	DIBROMO-3-CHLOROPROPANE, 1,2-	0.2	20	4300
106-93-4	DIBROMOETHANE, 1,2- (ETHYLENE DIBROMIDE)	0.05	5	620
74-95-3	DIBROMOMETHANE	97	9700	130000
764-41-0	DICHLORO-2-BUTENE, 1,4-	0.016	0.016	11
95-50-1	DICHLOROBENZENE, 1,2-	600	60000	NOC
541-73-1	DICHLOROBENZENE, 1,3-	600	60000	NA
106-46-7	DICHLOROBENZENE, P-	75	7500	8100
~~75-71-8~~	~~DICHLORODIFLUOROMETHANE (FREON 12)~~	~~1000~~	~~100000~~	~~110000~~
75-34-3	DICHLOROETHANE, 1,1-	27	270	16000
107-06-2	DICHLOROETHANE, 1,2-	5	50	2800
75-35-4	**DICHLOROETHYLENE, 1,1-**	7	70	**53**
156-59-2	DICHLOROETHYLENE, CIS-1,2-	70	700	42000
156-60-5	DICHLOROETHYLENE, TRANS-1,2-	100	1000	59000
75-09-2	DICHLOROMETHANE (METHYLENE CHLORIDE)	5	500	77000
78-87-5	DICHLOROPROPANE, 1,2-	5	50	3900
542-75-6	DICHLOROPROPENE, 1,3-	6.6	660	5100
75-99-0	DICHLOROPROPIONIC ACID (DALAPON), 2,2-	200	20000	NOC
77-73-6	DICYCLOPENTADIENE	0.55	0.55	250
121-69-7	DIMETHYLANILINE, N,N-	73	7300	400000
123-91-1	DIOXANE, 1,4-	5.6	56	1500000
106-89-8	EPICHLOROHYDRIN	2.8	280	84000
110-80-5	ETHOXYETHANOL, 2- (EGEE)	550	55000	720000000
141-78-6	ETHYL ACETATE	8700	870000	59000000
140-88-5	ETHYL ACRYLATE	3.1	310	14000
100-41-4	**ETHYL BENZENE**	700	70000	**27000**
759-94-4	ETHYL DIPROPYLTHIOCARBAMATE, S- (EPTC)	910	910	NOC
60-29-7	ETHYL ETHER	1900	1900	1700000
97-63-2	ETHYL METHACRYLATE	870	870	1700000
107-21-1	ETHYLENE GLYCOL	14000	1400000	NOC
86-73-7	FLUORENE	1500	1900	NOC
~~75-69-4~~	~~FLUOROTRICHLOROMETHANE (FREON 11)~~	~~2000~~	~~200000~~	~~520000~~
50-00-0	FORMALDEHYDE	1000	100000	3700000
64-18-6	FORMIC ACID	19000	190000	NOC
110-00-9	FURAN	9.7	970	3400
98-01-1	FURFURAL	110	110	40000000
110-54-3	HEXANE	550	550	NOC
302-01-2	HYDRAZINE/HYDRAZINE SULFATE	0.0088	0.088	10000
78-83-1	ISOBUTYL ALCOHOL	2900	290000	NOC
126-98-7	METHACRYLONITRILE	1.9	1.9	7200

Table 1
Groundwater Screening Criteria (ug/L) for Protection of Indoor Air - Residential

CAS Number	Regulated Substance	Pennsylvania GW MSC Used Aquifer	Pennsylvania GW MSC Nonuse Aquifer	PA Defaults Residential Volatilization to Indoor Air Screen*
67-56-1	METHANOL	4900	490000	850000000
109-86-4	METHOXYETHANOL, 2-	37	37	80000000
79-20-9	METHYL ACETATE	37000	37000	68000000
96-33-3	METHYL ACRYLATE	1100	110000	1300000
74-87-3	METHYL CHLORIDE	3	300	17000
78-93-3	METHYL ETHYL KETONE	2800	280000	49000000
108-10-1	METHYL ISOBUTYL KETONE	190	19000	540000
80-62-6	METHYL METHACRYLATE	1900	190000	6000000
25013-15-4	METHYL STYRENE (MIXED ISOMERS)	220	220	43000
1634-04-4	METHYL TERT-BUTYL ETHER (MTBE)	20	200	380000
91-57-6	METHYLNAPHTHALENE, 2-	730	730	NOC
98-83-9	METHYLSTYRENE, ALPHA	680	680	59000
91-20-3	**NAPHTHALENE**	100	30000	**25000**
98-95-3	NITROBENZENE	18	18000	290000
88-75-5	NITROPHENOL, 2-	290	290000	NOC
79-46-9	NITROPROPANE, 2-	0.016	0.16	190
55-18-5	NITROSODIETHYLAMINE, N-	0.001	0.01	440
62-75-9	NITROSODIMETHYLAMINE, N-	0.0031	0.031	3800
924-16-3	NITROSO-DI-N-BUTYLAMINE, N-	0.027	2.7	12000
11104-28-2	PCB-1221 (AROCLOR)	1.3	1.3	NA
85-01-8	PHENANTHRENE	1100	1100	NOC
108-95-2	PHENOL	4000	400000	NOC
103-65-1	PROPYLBENZENE, N-	1500	1500	NOC
75-56-9	PROPYLENE OXIDE	2.8	2.8	180000
110-86-1	PYRIDINE	9.7	97	750000
100-42-5	STYRENE	100	10000	NOC
630-20-6	**TETRACHLOROETHANE, 1,1,1,2-**	70	7000	**6400**
79-34-5	TETRACHLOROETHANE, 1,1,2,2-	0.3	30	3700
127-18-4	TETRACHLOROETHYLENE (PCE)	5	50	8500
108-88-3	TOLUENE	1000	100000	490000
75-25-2	TRIBROMOMETHANE (BROMOFORM)	100	10000	180000
76-13-1	TRICHLORO-1,2,2-TRIFLUOROETHANE, 1,1,2-	83000	170000	NOC
120-82-1	TRICHLOROBENZENE, 1,2,4-	70	44000	NOC
108-70-3	TRICHLOROBENZENE, 1,3,5-	40	40	NOC
71-55-6	TRICHLOROETHANE, 1,1,1-	200	2000	NOC
79-00-5	TRICHLOROETHANE, 1,1,2-	5	50	5400
79-01-6	TRICHLOROETHYLENE (TCE)	5	50	210
598-77-6	TRICHLOROPROPANE, 1,1,2-	180	180	180000
96-18-4	**TRICHLOROPROPANE, 1,2,3-**	40	4000	**110**
96-19-5	TRICHLOROPROPENE, 1,2,3-	180	180	19000
95-63-6	TRIMETHYLBENZENE, 1,3,4- (TRIMETHYLBENZENE, 1,2,4-)	16	1600	8600
108-67-8	TRIMETHYLBENZENE, 1,3,5-	16	16	7200
108-05-4	VINYL ACETATE	550	550	1100000
593-60-2	VINYL BROMIDE (BROMOETHENE)	1.4	14	520

Table 1
Groundwater Screening Criteria (ug/L) for Protection of Indoor Air - Residential

CAS Number	Regulated Substance	Pennsylvania GW MSC Used Aquifer	Pennsylvania GW MSC Nonuse Aquifer	PA Defaults Residential Volatilization to Indoor Air Screen*
75-01-4	VINYL CHLORIDE	2	20	1800
1330-20-7	**XYLENES (TOTAL)**	10000	180000	**130000**

* PA defaults using USEPA J&E GWSCREEN.XLS version 2.3 03/01; PA Soils parameters; 15 cm to bottom of enclosed space; 150 cm to water table; RL = 10^{-5} ; HQ=1

NOC - Not of concern, value above constituent water solubility

NA - Not available

Note: Bold face values indicate a COPIAC

Table 2
Groundwater Screening Criteria (ug/L) for Protection of Indoor Air:
Non-Residential (Commercial/Industrial)

CAS Number	Regulated Substance	Pennsylvania GW MSC Used Aquifer	Pennsylvania GW MSC Nonuse Aquifer	~~USEPA~~ PA Defaults Nonresidential Volatilization to Indoor Air Screen[1]	~~USEPA~~ PA Defaults Nonresidential PELs Volatilization to Indoor Air Screen[2]
83-32-9	ACENAPHTHENE	3800	3800	NOC	NOC
208-96-8	ACENAPHTHYLENE	6100	16000	NOC	NOC
75-07-0	ACETALDEHYDE	52	52	360000	NOC
67-64-1	ACETONE	10000	100000	NOC	NOC
75-05-8	ACETONITRILE	350	3500	5200000	NOC
98-86-2	ACETOPHENONE	10000	10000	NOC	NOC
107-02-8	ACROLEIN	0.12	1.2	480	4200000
79-06-1	ACRYLAMIDE	0.14	0.14	160000	1600000000
79-10-7	ACRYLIC ACID	5.8	580	5400000	NOC
107-13-1	ACRYLONITRILE	2.7	270	12000	NOC
107-18-6	ALLYL ALCOHOL	100	10000	13000000	NOC
7664-41-7	AMMONIA	30000	30000	14000000	NOC
62-53-3	ANILINE	5.8	5.8	1900000	NOC
120-12-7	ANTHRACENE	66	66	NOC	NOC
71-43-2	BENZENE	5	500	5900	NOC
98-07-7	**BENZOTRICHLORIDE**	0.2	200	**160**	NOC
100-44-7	BENZYL CHLORIDE	3.7	370	6700	NOC
92-52-4	BIPHENYL, 1,1-	5100	7200	NOC	NOC
111-44-4	BIS(2-CHLOROETHYL)ETHER	0.55	55	22000	NOC
108-60-1	BIS(2-CHLORO-ISOPROPYL)ETHER	300	30000	92000	NOC
542-88-1	BIS(CHLOROMETHYL)ETHER	0.0029	0.29	8.4	NOC
74-97-5	BROMOCHLOROMETHANE	90	90	120000	NOC
75-27-4	BROMODICHLOROMETHANE	100	100	2700	NOC
74-83-9	BROMOMETHANE	10	1000	6300	NOC
106-99-0	BUTADIENE, 1,3-	0.65	65	800	NOC
71-36-3	BUTYL ALCOHOL, N-	2000	20000	NOC	NOC
104-51-8	BUTYLBENZENE, N-	4100	4100	NOC	NOC
135-98-8	BUTYLBENZENE, SEC-	4100	4100	NOC	NOC
98-06-6	BUTYLBENZENE, TERT-	4100	4100	NOC	NOC
75-15-0	CARBON DISULFIDE	4100	4100	770000	NOC
56-23-5	CARBON TETRACHLORIDE	5	50	2400	NOC
75-68-3	CHLORO-1,1-DIFLUOROETHANE, 1-	290000	290000	NOC	NOC
107-05-1	CHLORO-1-PROPENE, 3- (ALLYL CHLORIDE)	5.8	580	1200	2500000
108-90-7	CHLOROBENZENE	100	10000	38000	NOC
109-69-3	CHLOROBUTANE, 1-	41000	41000	NOC	NOC
124-48-1	**CHLORODIBROMOMETHANE**	100	10000	**6300**	NOC
75-45-6	CHLORODIFLUOROMETHANE	100	100	NOC	NOC
75-00-3	**CHLOROETHANE**	900	90000	**37000**	NOC
67-66-3	**CHLOROFORM**	100	1000	**580**	NOC
91-58-7	CHLORONAPHTHALENE, 2-	8200	8200	NOC	NOC
95-57-8	CHLOROPHENOL, 2-	40	40	230000	NOC
126-99-8	CHLOROPRENE	41	4100	7700	NOC
75-29-6	CHLOROPROPANE, 2-	580	580	120000	NOC
95-49-8	CHLOROTOLUENE, O-	100	100	170000	NOC
1319-77-3	CRESOL(S)	510	51000	NOC	NOC
95-48-7	CRESOL, O- (METHYLPHENOL, 2-)	5100	510000	NOC	NOC

Table 2
Groundwater Screening Criteria (ug/L) for Protection of Indoor Air:
Non-Residential (Commercial/Industrial)

CAS Number	Regulated Substance	Pennsylvania GW MSC Used Aquifer	Pennsylvania GW MSC Nonuse Aquifer	~~USEPA~~ PA Defaults Nonresidential Volatilization to Indoor Air Screen[1]	~~USEPA~~ PA Defaults Nonresidential PELs Volatilization to Indoor Air Screen[2]
4170-30-3	CROTONALDEHYDE	0.34	34	13000	NOC
123-73-9	CROTONALDEHYDE, TRANS-	0.34	34	8500	NOC
98-82-8	CUMENE	2300	50000	NOC	NOC
57-12-5	**CYANIDE, FREE**	200	200000	**47000**	2300000
108-94-1	CYCLOHEXANONE	100000	100000	NOC	NOC
96-12-8	DIBROMO-3-CHLOROPROPANE, 1,2-	0.2	20	6000	200000
106-93-4	DIBROMOETHANE, 1,2- (ETHYLENE DIBROMIDE)	0.05	5	1000	NOC
74-95-3	DIBROMOMETHANE	200	20000	180000	NOC
764-41-0	DICHLORO-2-BUTENE, 1,4-	0.069	0.069	18	NOC
95-50-1	DICHLOROBENZENE, 1,2-	600	60000	NOC	NOC
541-73-1	DICHLOROBENZENE, 1,3-	600	60000	NA	NA
106-46-7	DICHLOROBENZENE, P-	75	7500	14000	NOC
~~75-71-8~~	~~DICHLORODIFLUOROMETHANE (FREON 12)~~	~~1000~~	~~100000~~	~~160000~~	~~NOC~~
75-34-3	DICHLOROETHANE, 1,1-	110	1100	26000	NOC
107-06-2	DICHLOROETHANE, 1,2-	5	50	4600	NOC
75-35-4	DICHLOROETHYLENE, 1,1-	7	70	89	NOC
156-59-2	DICHLOROETHYLENE, CIS-1,2-	70	700	59000	NOC
156-60-5	DICHLOROETHYLENE, TRANS-1,2-	100	1000	83000	NOC
75-09-2	DICHLOROMETHANE (METHYLENE CHLORIDE)	5	500	130000	NOC
78-87-5	DICHLOROPROPANE, 1,2-	5	50	6500	NOC
542-75-6	DICHLOROPROPENE, 1,3-	26	2600	8600	NOC
75-99-0	DICHLOROPROPIONIC ACID (DALAPON), 2,2-	200	20000	NOC	NOC
77-73-6	DICYCLOPENTADIENE	1.2	1.2	350	NOC
121-69-7	DIMETHYLANILINE, N,N-	200	20000	560000	NOC
123-91-1	DIOXANE, 1,4-	24	240	2500000	NOC
106-89-8	EPICHLOROHYDRIN	5.8	580	120000	NOC
110-80-5	ETHOXYETHANOL, 2- (EGEE)	1200	120000	NOC	NOC
141-78-6	ETHYL ACETATE	18000	1800000	NOC	NOC
140-88-5	ETHYL ACRYLATE	13	1300	24000	NOC
100-41-4	**ETHYL BENZENE**	700	70000	**45000**	NOC
759-94-4	ETHYL DIPROPYLTHIOCARBAMATE, S- (EPTC)	2600	2600	NOC	NOC
60-29-7	ETHYL ETHER	4100	4100	2400000	NOC
97-63-2	ETHYL METHACRYLATE	1800	1800	2400000	NOC
107-21-1	ETHYLENE GLYCOL	14000	1400000	NOC	NOC
86-73-7	FLUORENE	1900	1900	NOC	NOC
~~75-69-4~~	~~FLUOROTRICHLOROMETHANE (FREON 11)~~	~~2000~~	~~200000~~	~~730000~~	~~NOC~~
50-00-0	FORMALDEHYDE	1000	100000	6300000	NOC
64-18-6	FORMIC ACID	41000	410000	NOC	NOC
110-00-9	FURAN	20	2000	4700	NOC
98-01-1	FURFURAL	290	290	56000000	NOC
110-54-3	HEXANE	1200	1200	NOC	NOC
302-01-2	HYDRAZINE/HYDRAZINE SULFATE	0.038	0.38	17000	NOC
78-83-1	ISOBUTYL ALCOHOL	6100	610000	NOC	NOC

Table 2
Groundwater Screening Criteria (ug/L) for Protection of Indoor Air:
Non-Residential (Commercial/Industrial)

CAS Number	Regulated Substance	Pennsylvania GW MSC Used Aquifer	Pennsylvania GW MSC Nonuse Aquifer	~~USEPA~~ PA Defaults Nonresidential Volatilization to Indoor Air Screen[1]	~~USEPA~~ PA Defaults Nonresidential PELs Volatilization to Indoor Air Screen[2]
126-98-7	METHACRYLONITRILE	4.1	4.1	10000	NOC
67-56-1	METHANOL	10000	1000000	NOC	NOC
109-86-4	METHOXYETHANOL, 2-	100	100	110000000	NOC
79-20-9	METHYL ACETATE	100000	100000	95000000	NOC
96-33-3	METHYL ACRYLATE	3100	310000	1800000	NOC
74-87-3	METHYL CHLORIDE	3	300	28000	NOC
78-93-3	METHYL ETHYL KETONE	5800	580000	69000000	NOC
108-10-1	METHYL ISOBUTYL KETONE	410	41000	760000	NOC
80-62-6	METHYL METHACRYLATE	4100	410000	8300000	NOC
25013-15-4	METHYL STYRENE (MIXED ISOMERS)	610	610	60000	NOC
1634-04-4	METHYL TERT-BUTYL ETHER (MTBE)	20	200	640000	NOC
91-57-6	METHYLNAPHTHALENE, 2-	2000	2000	NOC	NOC
98-83-9	METHYLSTYRENE, ALPHA	1400	1400	83000	NOC
91-20-3	NAPHTHALENE	100	30000	NOC	NOC
98-95-3	NITROBENZENE	51	51000	410000	NOC
88-75-5	NITROPHENOL, 2-	820	820000	NOC	NOC
79-46-9	NITROPROPANE, 2-	0.068	0.68	320	NOC
55-18-5	NITROSODIETHYLAMINE, N-	0.0043	0.043	740	NOC
62-75-9	NITROSODIMETHYLAMINE, N-	0.013	0.13	6400	NOC
924-16-3	NITROSO-DI-N-BUTYLAMINE, N-	0.11	11	21000	NOC
11104-28-2	PCB-1221 (AROCLOR)	5.2	5.2	NA	NA
85-01-8	PHENANTHRENE	1100	1100	NOC	NOC
108-95-2	PHENOL	4000	400000	NOC	NOC
103-65-1	PROPYLBENZENE, N-	4100	4100	NOC	NOC
75-56-9	PROPYLENE OXIDE	11	11	300000	NOC
110-86-1	PYRIDINE	20	200	1100000	NOC
100-42-5	STYRENE	100	10000	NOC	NOC
630-20-6	TETRACHLOROETHANE, 1,1,1,2-	70	7000	11000	NOC
79-34-5	TETRACHLOROETHANE, 1,1,2,2-	0.3	30	6200	NOC
127-18-4	TETRACHLOROETHYLENE (PCE)	5	50	14000	NOC
108-88-3	TOLUENE	1000	100000	NOC	NOC
75-25-2	TRIBROMOMETHANE (BROMOFORM)	100	10000	310000	NOC
76-13-1	TRICHLORO-1,2,2-TRIFLUOROETHANE, 1,1,2-	170000	170000	NOC	NOC
120-82-1	TRICHLOROBENZENE, 1,2,4-	70	44000	NOC	NOC
108-70-3	TRICHLOROBENZENE, 1,3,5-	40	40	NOC	NOC
71-55-6	TRICHLOROETHANE, 1,1,1-	200	2000	NOC	NOC
79-00-5	TRICHLOROETHANE, 1,1,2-	5	50	9000	NOC
79-01-6	TRICHLOROETHYLENE (TCE)	5	50	360	NOC
598-77-6	TRICHLOROPROPANE, 1,1,2-	510	510	250000	NOC
96-18-4	**TRICHLOROPROPANE, 1,2,3-**	40	4000	**190**	NOC
96-19-5	TRICHLOROPROPENE, 1,2,3-	510	510	27000	NOC
95-63-6	TRIMETHYLBENZENE, 1,3,4- (TRIMETHYLBENZENE, 1,2,4-)	35	3500	12000	NOC
108-67-8	TRIMETHYLBENZENE, 1,3,5-	35	35	10000	NOC
108-05-4	VINYL ACETATE	1200	1200	1500000	NOC
593-60-2	VINYL BROMIDE (BROMOETHENE)	5.8	58	870	NOC
75-01-4	VINYL CHLORIDE	2	20	3000	1600000
1330-20-7	XYLENES (TOTAL)	10000	180000	NOC	NOC

Table 2
Groundwater Screening Criteria (ug/L) for Protection of Indoor Air:
Non-Residential (Commercial/Industrial)

CAS Number	Regulated Substance	Pennsylvania GW MSC Used Aquifer	Pennsylvania GW MSC Nonuse Aquifer	~~USEPA~~ PA Defaults Nonresidential Volatilization to Indoor Air Screen[1]	~~USEPA~~ PA Defaults Nonresidential PELs Volatilization to Indoor Air Screen[2]

[1]PA defaults using USEPA J&E Version 2.3; 03/01, Non-Residential receptor, RL = 10^{-5}, HQ = 1
[2]PA defaults using USEPA J&E Version 2.3; 03/01, Non-Residential receptor; Use this OSHA-derived Screen when OSHA regulations are fully implemented and documented inside a workplace building.
NA - Not available
NOC - Not of concern, value above constituent water solubility
Note: Bold face values indicate a COPIAC

Table 3
Indoor Air Criteria and Odor Thresholds

CAS Number	Regulated Substance	Residential MSC_{iag} (mg/m^3)	Nonresidential MSC_{iag} (mg/m^3)	EPA Region III RBC (mg/m^3)*	ACGIH TLV (mg/m^3)	OSHA PEL (mg/m^3)	Odor Threshold (mg/m^3)
83-32-9	ACENAPHTHENE	0.29	0.61	0.22			0.50
208-96-8	ACENAPHTHYLENE	0.29	0.61				
75-07-0	ACETALDEHYDE	0.0095	0.027	0.0081	180	360	0.38
67-64-1	ACETONE	43	91	0.37	1188	2400	237
75-05-8	ACETONITRILE	0.083	0.17	0.062	67	70	70
98-86-2	ACETOPHENONE	0.49	1	0.000021	49		0.01-0.025
107-02-8	ACROLEIN	0.000028	0.000058	0.000021	0.23	0.25	0.48
79-06-1	ACRYLAMIDE	0.000016	0.000063	0.000014	0.03	0.3	
79-10-7	ACRYLIC ACID	0.0014	0.0029		5.9		0.28
107-13-1	ACRYLONITRILE	0.00031	0.0012	0.00026	4.3	4.34	46.4
107-18-6	ALLYL ALCOHOL	0.024	0.051		1.2	5	1.95
7664-41-7	AMMONIA	0.14	0.29	0.10	17	35	0.0266
62-53-3	ANILINE	0.0014	0.0029	0.0011	7.6	19	7.6
120-12-7	ANTHRACENE	1.5	3.1	1.1			
71-43-2	BENZENE	0.0027	0.011	0.0022	1.6	3.19	2.7
98-07-7	BENZOTRICHLORIDE	0.0000056	0.000022				
100-44-7	BENZYL CHLORIDE	0.00043	0.0017	0.00037	5.2	5	0.24
92-52-4	BIPHENYL, 1,1-	0.24	0.51	0.18	1.3	1	0.005
111-44-4	BIS(2-CHLOROETHYL)ETHER	0.000064	0.00025	0.000057	29	ceiling limit: 90	90
108-60-1	BIS(2-CHLORO-ISOPROPYL)ETHER	0.0021	0.0082	0.0018			2.2
542-88-1	BIS(CHLOROMETHYL)ETHER	0.00000034	0.0000013	0.00000028	0.0047		
74-97-5	BROMOCHLOROMETHANE	0.049	0.1		1060	1050	2100
75-27-4	BROMODICHLOROMETHANE	0.00057	0.0022	0.0010			1680
74-83-9	BROMOMETHANE	0.0068	0.014	0.0051	20	ceiling limit: 80	80
106-99-0	BUTADIENE, 1,3-	0.00067	0.0026	0.000035	4.4	2.2	4
71-36-3	BUTYL ALCOHOL, N-	0.49	1	0.37	152	300	2.5
104-51-8	BUTYLBENZENE, N-	0.19	0.41	0.15			
135-98-8	BUTYLBENZENE, SEC-	0.19	0.41	0.15			
98-06-6	BUTYLBENZENE, TERT-	0.19	0.41	0.15			
75-15-0	CARBON DISULFIDE	0.97	2	0.73	31	62	0.30
56-23-5	CARBON TETRACHLORIDE	0.0014	0.0055	0.0012	31	62.9	135

Table 3
Indoor Air Criteria and Odor Thresholds

CAS Number	Regulated Substance	Residential MSC_{iag} (mg/m^3)	Nonresidential MSC_{iag} (mg/m^3)	EPA Region III RBC (mg/m^3)*	ACGIH TLV (mg/m^3)	OSHA PEL (mg/m^3)	Odor Threshold (mg/m^3)
75-68-3	CHLORO-1,1-DIFLUOROETHANE, 1-	70	150	51			
107-05-1	CHLORO-1-PROPENE, 3- (ALLYL CHLORIDE)	0.0014	0.0029		3	3	1.5
108-90-7	CHLOROBENZENE	0.024	0.051	0.062	46	350	1.0
109-69-3	CHLOROBUTANE, 1-	1.9	4.1	1.5			3.3352
124-48-1	CHLORODIBROMOMETHANE	0.00078	0.003	0.00075			
75-45-6	CHLORODIFLUOROMETHANE	68	140	51	3540		
75-00-3	CHLOROETHANE	0.025	0.099	0.022	2640	2600	10-12
67-66-3	CHLOROFORM	0.00044	0.00092	0.00031	49	Ceiling limit: 240	415
91-58-7	CHLORONAPHTHALENE, 2-	0.39	0.82	0.29			
95-57-8	CHLOROPHENOL, 2-	0.024	0.051	0.018			0.11
126-99-8	CHLOROPRENE	0.0097	0.02	0.0073	36	90	55
75-29-6	CHLOROPROPANE, 2-	0.14	0.29	0.11			
95-49-8	CHLOROTOLUENE, O-	0.097	0.2	0.073	255		1.1
1319-77-3	CRESOL(S)	0.024	0.051		22	22	0.012
95-48-7	CRESOL, O- (METHYLPHENOL, 2-)	0.24	0.51	0.18	22	22	
4170-30-3	CROTONALDEHYDE	0.000039	0.00015		0.85	6	1.4
123-73-9	CROTONALDEHYDE, TRANS-	0.000039	0.00015	0.000033	0.85	6	1.4
98-82-8	CUMENE	0.54	1.1	0.40	245	245	0.06
57-12-5	CYANIDE, FREE	0.097	0.2	0.073	5	5	0.62
108-94-1	CYCLOHEXANONE	24	51	18	100	200	0.48
96-12-8	DIBROMO-3-CHLOROPROPANE, 1,2-	0.00028	0.00058	0.00021		0.0097	0.3
106-93-4	DIBROMOETHANE, 1,2- (ETHYLENE DIBROMIDE)	0.000095	0.00037	0.000082		153.8	192
74-95-3	DIBROMOMETHANE	0.049	0.1	0.037			
764-41-0	DICHLORO-2-BUTENE, 1,4-	0.0000079	0.000031	0.0000067	0.026		
95-50-1	DICHLOROBENZENE, 1,2-	0.19	0.41	0.15	150	ceiling limit: 300	12-24
541-73-1	DICHLOROBENZENE, 1,3-			0.11			0.12
106-46-7	DICHLOROBENZENE, P-	0.0033	0.013	0.0028	60	450	180-360
~~75-71-8~~	~~DICHLORODIFLUOROMETHANE (FREON 12)~~	~~0.24~~	~~0.51~~	~~0.18~~	~~4950~~	~~4950~~	
75-34-3	DICHLOROETHANE, 1,1-	0.013	0.05	0.51	405	400	490-810
107-06-2	DICHLOROETHANE, 1,2-	0.00081	0.0031	0.00069	40	202.5	24-160

Table 3
Indoor Air Criteria and Odor Thresholds

CAS Number	Regulated Substance	Residential MSC_{iag} (mg/m^3)	Nonresidential MSC_{iag} (mg/m^3)	EPA Region III RBC (mg/m^3)*	ACGIH TLV (mg/m^3)	OSHA PEL (mg/m^3)	Odor Threshold (mg/m^3)
75-35-4	DICHLOROETHYLENE, 1,1-	0.000061	0.00024	0.00036	20		2000-4000
156-59-2	DICHLOROETHYLENE, CIS-1,2-	0.049	0.1	0.037	793	790	0.34
156-60-5	DICHLOROETHYLENE, TRANS-1,2-	0.097	0.2	0.073	793	790	0.3357
75-09-2	DICHLOROMETHANE (METHYLENE CHLORIDE)	0.044	0.17	0.038	174	86.75	712-1070
78-87-5	DICHLOROPROPANE, 1,2-	0.002	0.0079	0.00092	347	350	231
542-75-6	DICHLOROPROPENE, 1,3-	0.0052	0.02	0.0063	4.5		14
75-99-0	DICHLOROPROPIONIC ACID (DALAPON), 2,2-	0.15	0.31	0.11	5		2500
77-73-6	DICYCLOPENTADIENE	0.00028	0.00058	0.00022	27		0.02
121-69-7	DIMETHYLANILINE, N,N-	0.0097	0.02	0.0073	25	25	0.064
123-91-1	DIOXANE, 1,4-	0.0027	0.011	0.0057	90	360	612
106-89-8	EPICHLOROHYDRIN	0.0014	0.0029	0.0010	7.6	19	38
110-80-5	ETHOXYETHANOL, 2- (EGEE)	0.28	0.58	0.21	18	740	460
141-78-6	ETHYL ACETATE	4.4	9.2	3.3	1440	1400	2.2
140-88-5	ETHYL ACRYLATE	0.0015	0.006		20	100	0.004
100-41-4	ETHYL BENZENE	0.019	0.073	1.1	434	435	608
759-94-4	ETHYL DIPROPYLTHIOCARBAMATE, S- (EPTC)	0.12	0.26				
60-29-7	ETHYL ETHER	0.97	2	0.73	1210	1200	1.00
97-63-2	ETHYL METHACRYLATE	0.44	0.92	0.33			0.40
107-21-1	ETHYLENE GLYCOL	9.7	20	7.3	100		60.3
86-73-7	FLUORENE	0.19	0.41	0.15			
~~75-69-4~~	~~FLUOROTRICHLOROMETHANE (FREON 11)~~	~~0.97~~	~~2~~	~~0.73~~	~~5620~~	~~5600~~	~~28~~
50-00-0	FORMALDEHYDE	0.0016	0.0063	0.0014	0.37	0.92	1.47
64-18-6	FORMIC ACID	9.7	20	7.30	9.4	9	53
110-00-9	FURAN	0.0049	0.01	0.0037			
98-01-1	FURFURAL	0.07	0.15	0.037	7.9	20	0.024
110-54-3	HEXANE	0.28	0.58	0.21	176	1800	458
302-01-2	HYDRAZINE/HYDRAZINE SULFATE	0.0000043	0.000017	0.0000037	0.13	1.3	4.8
78-83-1	ISOBUTYL ALCOHOL	1.5	3.1	1.1	152	300	121
126-98-7	METHACRYLONITRILE	0.00097	0.002	0.00073	2.7		5.8
67-56-1	METHANOL	2.4	5.1	1.8	262	260	5.6
109-86-4	METHOXYETHANOL, 2-	0.028	0.058		16	80	2.8

Table 3
Indoor Air Criteria and Odor Thresholds

CAS Number	Regulated Substance	Residential MSC_{iag} (mg/m^3)	Nonresidential MSC_{iag} (mg/m^3)	EPA Region III RBC (mg/m^3)*	ACGIH TLV (mg/m^3)	OSHA PEL (mg/m^3)	Odor Threshold (mg/m^3)
79-20-9	METHYL ACETATE	4.9	10	3.7	606	610	606
96-33-3	METHYL ACRYLATE	0.15	0.31	0.11	35	35	0.017
74-87-3	METHYL CHLORIDE	0.012	0.045	0.018	103	206	21
78-93-3	METHYL ETHYL KETONE	1.4	2.9	1	590	590	6
108-10-1	METHYL ISOBUTYL KETONE	0.097	0.2	0.073	205	410	0.41
80-62-6	METHYL METHACRYLATE	0.97	2	0.73	410	410	0.86
25013-15-4	METHYL STYRENE (MIXED ISOMERS)	0.049	0.1	0.037	242	480	240
1634-04-4	METHYL TERT-BUTYL ETHER (MTBE)	0.081	0.31	3.1	144		0.19-0.69
91-57-6	METHYLNAPHTHALENE, 2-	0.0042	0.0088	0.073			0.06
98-83-9	METHYLSTYRENE, ALPHA	0.049	0.1	0.26	242	ceiling limit: 480	0.25
91-20-3	NAPHTHALENE	0.0042	0.0088	0.0033	50	50	0.02
98-95-3	NITROBENZENE	0.0029	0.0061	0.0022	5	5	0.0235
88-75-5	NITROPHENOL, 2-	0.039	0.082				0.0012
79-46-9	NITROPROPANE, 2-	0.0000078	0.00003	0.0000067	36	90	17.5
55-18-5	NITROSODIETHYLAMINE, N-	0.00000049	0.0000019	0.00000042			
62-75-9	NITROSODIMETHYLAMINE, N-	0.0000015	0.0000058	0.0000012			
924-16-3	NITROSO-DI-N-BUTYLAMINE, N-	0.000013	0.000051	0.000011			
11104-28-2	PCB-1221 (AROCLOR)	0.001	0.0041	0.000031			
85-01-8	PHENANTHRENE	1.5	3.1				
108-95-2	PHENOL	1.5	3.1	1.1	19	19	0.062
103-65-1	PROPYLBENZENE, N-	0.19	0.41	0.15			
75-56-9	PROPYLENE OXIDE	0.0056	0.022		48	240	475
110-86-1	PYRIDINE	0.0049	0.01	0.0037		15	0.068
100-42-5	STYRENE	1.4	2.9	1	85	426	0.630
630-20-6	TETRACHLOROETHANE, 1,1,1,2-	0.0028	0.011	0.0024			
79-34-5	TETRACHLOROETHANE, 1,1,2,2-	0.00036	0.0014	0.00031	6.9	35	3
127-18-4	TETRACHLOROETHYLENE (PCE)	0.0073	0.029	0.031	170	678	31.7
108-88-3	TOLUENE	0.56	1.2	0.42	188	754	0.64
75-25-2	TRIBROMOMETHANE (BROMOFORM)	0.019	0.074	0.016	5.2	5	13
76-13-1	TRICHLORO-1,2,2-TRIFLUOROETHANE, 1,1,2-	42	88	31	7670	7600	342
120-82-1	TRICHLOROBENZENE, 1,2,4-	0.02	0.079	0.0037	37		22

Table 3
Indoor Air Criteria and Odor Thresholds

CAS Number	Regulated Substance	Residential MSC_{iag} (mg/m^3)	Nonresidential MSC_{iag} (mg/m^3)	EPA Region III RBC (mg/m^3)*	ACGIH TLV (mg/m^3)	OSHA PEL (mg/m^3)	Odor Threshold (mg/m^3)
108-70-3	TRICHLOROBENZENE, 1,3,5-	0.28	0.58				
71-55-6	TRICHLOROETHANE, 1,1,1-	2.9	6.1	2.3	1910	1900	545
79-00-5	TRICHLOROETHANE, 1,1,2-	0.0013	0.0051	0.0011	55	45	
79-01-6	TRICHLOROETHYLENE (TCE)	0.00018	0.00072	0.01	269	537	115
598-77-6	TRICHLOROPROPANE, 1,1,2-	0.024	0.051	0.018	60		
96-18-4	TRICHLOROPROPANE, 1,2,3-	0.00001	0.000041	0.000031	60	300	
96-19-5	TRICHLOROPROPENE, 1,2,3-	0.024	0.051	0.018			
95-63-6	TRIMETHYLBENZENE, 1,3,4- (TRIMETHYLBENZENE, 1,2,4-)	0.0083	0.017	0.0062	125		
108-67-8	TRIMETHYLBENZENE, 1,3,5-	0.0083	0.017	0.0062	125		
108-05-4	VINYL ACETATE	0.28	0.58	0.21	35		0.0235
593-60-2	VINYL BROMIDE (BROMOETHENE)	0.00067	0.0026	0.00057	2.2		
75-01-4	VINYL CHLORIDE	0.0024	0.0095	0.00072	2.5	2.56	664
1330-20-7	XYLENES (TOTAL)	0.14	0.3	7.3	434	435	2

* EPA Region III RBCs were adjusted to cancer risk of 10^{-5} or HQ of 1.

TABLE 6

SAMPLING INDOOR AIR AND SOIL GAS

There are significant difficulties with sampling indoor air and soil gas. Therefore, it is beyond the scope of this document to fully define processes for sampling these media. The intent of this table is to identify a few key issues/considerations for each area and provide references that could serve as protocols or be useful in addressing these key issues.

Indoor air sampling

Indoor air sampling provides the most direct measure of whether there is (or is not) an indoor air quality (IAQ) concern. However, it is recognized that there can be significant ambient (general outdoor) and indoor (from consumer products) sources that can make it difficult to definitively conclude that the source of the IAQ concern is actually from a contaminated site. Indeed, particularly in urban areas, ambient sources may be well above the calculated "unacceptable" risk levels and indoor sources from use of consumer products are sometimes much higher than outdoor sources. Further, IAQ is subject to building conditions and spatial and temporal variability.

Sampling to address vapor intrusion should be designed to identify incremental exposures. Therefore, background concentrations should be characterized and subtracted from the indoor air concentrations to limit the assessment to only those vapors that may be attributable to subsurface vapor sources. This is typically very challenging and may require an extensive monitoring program (USEPA, 2001). In addition, the sampling of subslab foundation air and ambient (outdoor) air in conjunction with indoor air is intended to distinguish the exposures that originate from the subsurface contaminant vapor intrusion from those due to background sources. Subslab vapor is defined as the soil gas in contact with the building envelope immediately beneath or within the sub-floor construction materials. Subslab samples are recommended to be, but do not need to be, collected via holes through the flooring as close to the center of the floor space as possible (USEPA, 2003).

A plan should be developed to assist in addressing data quality objectives before beginning sampling. In a typical sampling plan, multiple samples may be collected over a target time period (e.g., 2 hours to 3 weeks) to determine indoor air concentrations. It is recommended that samples be collected using either a pumped air collection method with adsorbent media tubes or evacuated canisters. It should be noted that samples collected under applied pressure do not produce data that are reflective of steady-state subslab conditions and are not useful for accurate determination of existing soil gas concentrations. Such samples may be used as general indicators (worse than worst case) of the magnitude of the volatile substances in the airborne component subsurface soil since the sampling process may actually force transfer of soil-associated components to soil air at a rate greater than naturally occurs. Also, samples collected in such a manner cannot be used in a risk assessment since they do not provide an accurate exposure point concentration. For longer term duration (e.g., three weeks), passive diffusion

badges suitable for the volatile constituents targeted in the study may be used. Tedlar bags are not recommended for sampling of indoor air. Due to time constraints and cost, at least 2 quarterly samples (spring and winter to account for seasonal variations) must be collected during times when reasonable worst-case conditions exist (i.e. nighttime).

To meet minimum data quality, a field blank and at least one duplicate sample will be needed with each data set submitted for laboratory analysis. Analysis using laboratory equipment (e.g., GC – GC/MS) will be needed to attain the required specificity and sensitivity.

The Massachusetts Department of Environmental Protection has developed a comprehensive guide to address sampling IAQ. This document suggests the following steps in designing and implementing a sampling plan for IAQ.

- Define Study Objective
- Identify Chemicals of Concern
- Identify Required Sampling Duration
- Choose Sampling Method
- Check if Adequate Limit of Detection
- Define QA/QC Indicators for Sampling/Analysis
- Do Pre-Sampling Investigation
- Establish Appropriate Sampling Conditions and Conduct Sampling
- Analyze Samples
- Evaluate Data and Calculate Health Risks

The guide is available for free download at:
http://www.state.ma.us/dep/bwsc/files/sac/sac0402.htm

Under Indoor Air Sampling and Evaluation Guide

Useful guides are available from the New Jersey Department of Environmental Protection (NJDEP, 1999) and New York Department of Health (NY DOH, 2001).

Soil gas sampling

Soil gas sampling can be used both as an alternative to sampling indoor air and to better determine the source term for the Johnson and Ettinger model.

The mobility of volatile chemicals in soil primarily depends on soil porosity, i.e., the most significant determining factor is available connected air-filled porosity. Thus, even small changes in soil lithology can result in changes in vapor transport. This presents a major difficulty in getting representative vapor concentration. In addition, environmental conditions that can fluctuate significantly with time (such as seasonal variation in moisture content, time since the last rainfall and atmospheric pressure) are also important determinants of vapor concentrations. This means that multiple concentration measurement events are typically needed to develop a representative soil vapor concentration.

The typical method to collect soil gas is with narrow diameter probes that are installed in the ground for multiple sampling events. The American Petroleum Institute (API, 1998) is developing a resource on the issue. Some of the recommendations include:

- sampling devices should intersect small vertical sections of the vadose zone
- sampling devices should be sealed from short-circuiting from the surface
- probes may be installed in nested groups at various elevations
- at least 2 quarterly samples (spring & winter to account for seasonal variations) must be collected during ~~evening hours~~ times when reasonable worst-case conditions exist.
- the soil vapor sampling point should be purged of stagnant air before the samples are acquired
- sampling equipment is appropriately contaminant-free
- samples to be sent to a laboratory for analysis should be collected in SUMMA canisters
- Tedlar bags may be used if an onsite laboratory will analyze the samples.

In addition to concentrations of chemicals of concern, concentrations of oxygen and carbon dioxide are often measured to develop the information needed to support biodegradation demonstrations. So, field analyzers may be used for some parameters such as oxygen and carbon dioxide.

References:

API 1998. Assessing the Significance of Subsurface Contaminant Vapor Migration to Enclosed Spaces, Site-Specific Alternatives to Generic Estimates. Health and Environmental Sciences Department, Publication Number 4674. Washington, D.C.

Massachusetts Department of Environmental Protection - Office of Research and Standards. Indoor Air Sampling and Evaluation Guide. Draft Version. February 1, 2001. http://www.state.ma.us/dep/new.htm

New Jersey Department of Environmental Protection. 1999. Indoor Air Sampling Guide for Volatile Organic Chemicals.

New York Department of Health (2001) : Sampling Indoor Air and Analysis Guidance, August.

USEPA. 1992. Air/Superfund National technical Guidance Study Series. Assessing Potential Indoor Air Impacts from Superfund Sites. EPA-451/R-92-002

USEPA. 2001. Supplemental guidance for evaluating the vapor intrusion to indoor air pathway. Partial response to question 3 of 02/05/99 RCRA Corrective Action Environmental Indicator RCRIS Code (CA725). Draft for comment. 10/23/01.

USEPA. 2003. EPA Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils.

Table 7

Inhalation of chemicals volatilized into indoor air from soil or groundwater (Development of MSCs for Indoor Air -- MSC_{IAQ})

Non-carcinogens:

$$MSC(mg/m^3) = \frac{THQ \times RfD_i \times BW \times At_{nc} \times 365\ days/yr}{Abs \times ET \times EF \times ED \times IR}$$

Carcinogens:

$$MSC\ (mg/m^3) = \frac{TR \times AT_c \times 365 days/yr}{CSF_i \times Abs \times ET \times EF \times IF_{adj}}$$

Recommended Exposure Assumptions				
Term		Residential		Nonresidential (Onsite Worker)
		Non carcinogens[1]	Carcinogens[2]	
THQ	Target Hazard Quotient	1	N/A	1
RfD_i	Inhalation Reference Dose (mg/kg-day)	Chemical-specific	N/A	Chemical-specific
BW	Body Weight (kg)	70	N/A	70
At_{nc}	Averaging Time for noncarcinogens (yr)	30	N/A	25
Abs	Absorption (unitless)	*	*	*
ET	Exposure Time (hr/day)	24	24	8
EF	Exposure Frequency (days/yr)	350	350	250
ED	Exposure Duration (yr)	30	N/A	25
IR	Inhalation Rate (m^3/hr)	0.625	N/A	1.25
TR	Target Risk	HQ = 1	1×10^{-5}	1×10^{-5}
CSF_i	Inhalation Cancer Slope Factor $(mg/kg\text{-}day)^{-1}$	N/A	Chemical-specific	Chemical-specific
AT_c	Averaging Time for carcinogens (yr)	N/A	70	70
IF_{adj}	Inhalation Factor [(3)] (m^3-yr/kg-hr)	N/A	0.4	0.4

Notes: Modified from USEPA (1995).
N/A = not applicable.
1 Residential exposure to noncarcinogens is based on adult exposure, consistent with USEPA (1991)
2 Residential exposure to carcinogens is based on combined childhood and adult exposure.
3 The inhalation factor for the residential scenario is calculated using the equation $IF_{adj} = ED_c x IR_c/BW_c + ED_a x IR_a/BW_a$, where ED_c= 6 yr. $IR_c = 0.5 m^3$/hr, BW_c = 15 kg, ED_a = 24 yr. IR_a = 0.625 m^3/hr and BW_a = 70 kg. The inhalation factor for the nonresidential scenario is calculated using the equation IF_{adj} = EDxIR/BW, where ED = 25 yr, IR = 1.25 m^3/hr and BW = 70 kg.
* Inhalation absorption factors *will be provided at a later date*. Default = 1. In cases where the inhalation RfD or CSF is based on absorbed dose, this factor *to be provided* can be applied in the exposure algorithm.

TABLE 8

Summary of Selected PA Input Parameters

EPA's Johnson and Ettinger Model (Version 2.3, 2001)

Parameter	Soil Model (SL-SCREEN)	Groundwater Model (GW-SCREEN)
Depth below grade to bottom of enclosed space floor (15 or 200 cm)	15	15
Depth below grade to top of contamination (cm)	150	NA
Depth below grade to water table (cm)	NA	150
SCS soil type directly above water table	NA	SCL
Average soil temperature (C)	11.1	11.1
Vadose zone SCS soil type	SCL	SCL
Vadose zone soil dry bulk density (g/cm^3)SCS soil type	1.8	1.8
Vadose zone soil total porosity (cm^3/cm^3)	0.32	0.34
Vadose zone soil water-filled porosity (cm^3/cm^3)	0.2	0.2
Vadose zone air-filled porosity (cm^3/cm^3), input on "Intercalc" sheet	0.12	0.14
Vadose Zone soil organic carbon fraction (unitless)	0.0025	NA
Target risk for carcinogens	1.00E-05	1.00E-05
Target hazard quotient for noncarcinogens	1	1
Averaging time for carcinogens (yrs)	70	70
Averaging time for noncarcinogens (yrs) Residential, non-residential	30, 25	30, 25
Exposure duration (yrs) Residential, non-residential	30, 25	30, 25
Exposure frequency (days/yr) Residential, non-residential	350, 250	350, 250

SHS Definitions for IAQ Decision Matrix
(see Figures 1 and 2)

Receptor	A receptor (humans in this case) is located in an occupied or potentially occupiable home or building built on a slab or below grade basement or area.
COPIAC	Contaminant (substance) of potential indoor air concern. Determined using contaminant lists from nearby states and PA-specific Johnson and Ettinger IAQ modeling.
COPIACs for soil	COPIACs (those that should always be addressed) identified in soil based on specific receptors are as follows:

Residential
Ammonia
Benzene
Bis(2-chloro-isopropyl)ether
Bromodichloromethane
Bromomethane
1,3-Butadiene
Carbon Disulfide
Carbon Tetrachloride
Chloro-1,1-Difluoroethane,1-
Chloro-1-Propene,3-(Allyl Chloride)
Chlorobenzene
1-Chlorobutane
Chloroethane
Chloroform
Chloroprene
2-Chloropropane
Cumene
Cyanide, Free
Dibromochloromethane
1,4 –Dichlorobenzene
~~Dichlorodifluoromethane (Freon 12)~~
1,1 – Dichloroethane
1,2-Dichloroethane
1,1 – Dichloroethene (EDC)
cis – 1,2 – Dichloroethene
trans – 1,2 – Dichloroethene
1,2-Dichloropropane
1,3-Dichloropropene
Ethylbenzene

~~Fluorotrichloromethane (Freon 11)~~
Furan
Hexane
Methylstyrene (Mixed Isomers)
Methylstyrene, alpha
n-Propylbenzene
1,1,1,2-Tetrachloroethane
Toluene
Trichloro-1,2,2-Trifluoroethane, 1,1,2-
Trichloroethylene
1,2,3-Trichloropropane
1,2,3-Trichloropropene
Vinyl Bromide (Bromoethene)
Vinyl chloride
Xylenes

Nonresidential
Ammonia
Bis(2-chloro-isopropyl)ether
Bromodichloromethane
1,3-Butadiene
Carbon Disulfide
Carbon Tetrachloride
Chloro-1,1-Difluoroethane,1-
Chloro-1-Propene,3-(Allyl Chloride)
1-Chlorobutane
Chloroethane
Chloroform
Chloroprene
2-Chloropropane
Cumene
Cyanide, Free
Dibromochloromethane
1,4-Dichloro-2-Butene
~~Dichlorodifluoromethane (Freon 12)~~
1,1 – Dichloroethane
1,1 – Dichloroethene (EDC)
cis – 1,2 – Dichloroethene
trans – 1,2 – Dichloroethene
1,3-Dichloropropene
Dicyclopentadiene
Ethylbenzene
~~Fluorotrichloromethane (Freon 11)~~
Furan
Hexane

	Methylstyrene (Mixed Isomers) Methylstyrene, alpha n-Propylbenzene Trichloro-1,2,2-Trifluoroethane, 1,1,2- Trichloroethylene 1,1,2-Trichloropropane 1,2,3-Trichloropropane 1,2,3-Trichloropropene Vinyl Bromide (Bromoethene) Vinyl Chloride Xylenes
COPIACs for groundwater	**Residential** Chloroethane Chloroform Cyanide,Free Dibromochloromethane 1,1-Dichloroethylene Ethylbenzene Naphthalene 1,1,1,2-Tetrachloroethane 1,2,3-Trichloropropane Xylenes **Nonresidential** Benzotrichloride Chloroethane Chloroform Cyanide,Free Dibromochloromethane Ethylbenzene 1,2,3-Trichloropropane
Potentially complete exposure pathway	An exposure pathway is the course a regulated substance(s) takes from the source area(s) to a species of concern including absorption or intake into the organism; a pathway must include a source or release from a source, a point of exposure, and an exposure route into the organism to be potentially complete. Completed exposure pathways need to be present for exposure of the receptor to occur. An exposure pathway must exist between substance and receptor.
Preferential exposure pathway	A preferential pathway is defined as a natural (e.g.,

shallow rock or vertically fractured soil) or manmade (e.g., buried utilities) feature that creates a sufficiently direct pathway from a source to a receptor to make the use of the default model for predicting indoor air concentrations unacceptable. Such pathways must be shown to significantly reduce the ability of the natural environment to attenuate the concentrations of VOCs at any point from the source to the receptor and to do so in a manner or to an extent that is not accounted for in the model assumptions and would substantially alter the default model's accuracy in predicting conservative indoor air concentrations. Shallow utilities buried at a depth that is insignificant with respect to the column of soil between the slab and the source do not automatically constitute a preferential pathway, nor should this definition include surface paving outside the building or the presence of crushed stone beneath the slab as normally placed for slab foundation material. If such a feature does not pass through the source, it must occur within 30 feet of the source in order to constitute a potential preferential pathway.

Soil gas

Because sampling VOCs in indoor air can be complicated by sources of VOCs within a home or building, soil gas measurements can be taken at a distance not to exceed 5 feet from the slab or basement edge and compared to MSCs for soil gas, where MSCs for soil gas would be calculated as follows:

$$MSC_{SG} = \frac{MSC_{IAQ}}{TF}$$

Where:

MSC_{SG} = Medium-specific concentration for soil gas (mg/m^3);

MSC_{IA} = Medium-specific concentration for indoor air (mg/m^3); and

TF = Transfer factor from soil gas to indoor air,
= 0.01 (a conservative value relating concentrations in indoor air to concentrations in soil gas adjacent to a building based on data report in Management of Manufactured Gas Plant Sites, Volume III: Risk Assessment, Gas Research Institute, 1987, pages 6-

	30 and 6-31. To use such a procedure, a method or methods for taking soil gas samples and performing soil gas analysis must be specified or suggested.
Johnson-Ettinger Vapor Intrusion Model (USEPA Version 2.3)	Johnson and Ettinger (1991) developed a model which coupled steady-state diffusion from a planar source to vapor intrusion into basements of buildings via advection and diffusion processes. The model is based on permeation through cracks in the foundation/floor with the planar source at a finite depth, with a boundary around the building referred to as the "building zone of influence". The USEPA although initially attempting to develop generic soil screening levels (SSLs) for volatiles, has adopted the Johnson-Ettinger model to examine subsurface vapor intrusion into buildings via a site-specific approach. Degradation of the contaminant is not considered nor is convective water movement in the soil column. The model is one-dimensional, providing an estimated attenuation coefficient that associates indoor vapor concentration to the vapor concentration at the source and is based on soil building pressure differentials (USEPA 2001b).
IAQ sampling	Indoor air samples are to be taken from the home or building beneath or adjacent to an occupied or potentially occupied home or building (where adjacent to is defined as within 15 feet of the home or building perimeter). Passive badge samplers, direct measurement using a FID or PID, adsorption onto activated charcoal, or direct sample collection using evacuated SUMMA-passivated canisters (USEPA Method TO-15 or TO-14) with analytical testing at a laboratory certified by USEPA for such analyses. Direct air sampling using SUMMA canisters is often preferred by the USEPA and other agencies. Acrylonitrile and 1,3-Dichloropropane are not part of the TO-14/TO-15 analyte list, however they can be added if they are contaminants of concern. Factors such as cost, sensitivity, data reliability and the data quality objectives should be considered prior to selecting a method that best encompasses the contaminants of concern. Other considerations include but are not limited to duration of sample collection, sample

	locations, analytes/contaminants of concern, number of samples, atmospheric conditions, ambient (background) air quality, and structural considerations. Rigorous indoor air quality monitoring programs can become quite expensive to implement. These results are to be compared to the following criteria. For residential exposures, the criteria are medium specific concentrations (MSCs) for indoor air calculated using the equations presented in Table 7. For nonresidential exposures, if, for any selected VOC at the site, OSHA regulates the chemical at the site and OSHA has jurisdiction over the site, then OSHA applies for that chemical and continued monitoring and reporting should occur to ensure continued compliance under OSHA. For all other chemicals, the criteria are medium-specific concentrations (MSCs) for indoor air calculated using the equations for nonresidential exposures presented in Table 7. Indoor air samples are to be taken from basements in those locations where the highest routine exposures are expected and the concentrations must be below the MSCs for indoor air. This procedure is only to be applied to homes and buildings with basements.
Separate phase liquid (SPL)	SPL is that component of contaminated environmental media comprised of interstitial non-aqueous phase liquid which is not adsorbed onto or diffused into the soil matrix or dissolved in groundwater. There are two principal modes of occurrence of SPL in soil: zones of accumulation and residual zones. Both can occur in the unsaturated and saturated zones, but accumulation zones are more commonly present at the water table and below the water table (for DNAPLs). A value of 10,000 mg/kg in soil can be used as a guideline to determine the presence of SPL.
Source	The vapor source, which is the contaminated soil or groundwater with volatile constituents at concentrations equal to or above the limits related to PQLs as specified in 25 Pa. Code, Section 250.4. ~~Soil or groundwater containing COPIACs at concentrations exceeding the acceptable levels specified in this document, or at any concentration if present at a depth of less than five feet below a~~

~~receptor~~.